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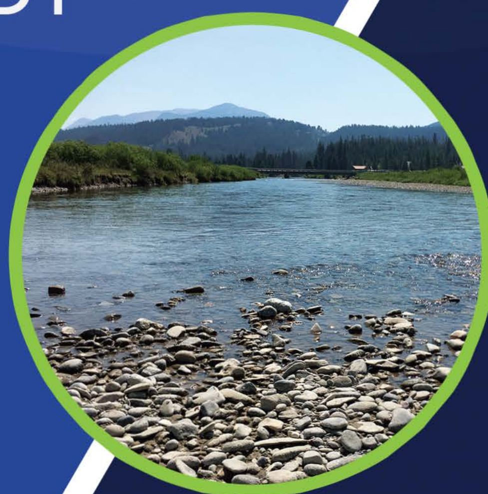
NOVEMBER 1, 2016

FINAL UPPER SNAKE RIVER LEVEL I WATERSHED STUDY

VOLUME I



PREPARED FOR:

WYOMING WATER DEVELOPMENT COMMISSION

TETON CONSERVATION DISTRICT

PREPARED BY:

OLSSON ASSOCIATES

IN ASSOCIATION WITH:

STEADY STREAM HYDROLOGY

AND RON E. VORE, PHD

OLSSON® ASSOCIATES

FINAL

Upper Snake River
Level I Watershed Study

WWDC Contract Number RN052616/F

November 1, 2016

I hereby certify that this report was prepared by us or under our direct supervision and that we are duly licensed professional geologists and engineers under the laws of the state of Wyoming.

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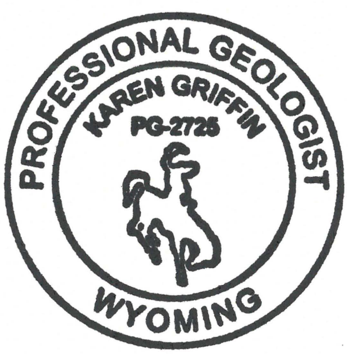

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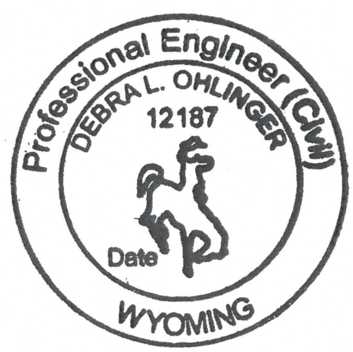

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1. INTRODUCTION

This Level I watershed study was prepared under contract to the Wyoming Water Development Commission (WWDC). The Teton Conservation District (TCD) in Jackson, Wyoming, is the project sponsor, and the plan was prepared on behalf of the landowners, land managers, stewards, and visitors of the remarkable Upper Snake River watershed. Olsson Associates completed the study in collaboration with Steady Stream Hydrology Inc. of Sheridan, Wyoming, and Ron E. Vore, Ph.D. of Sundance, Wyoming.

1.1. Watershed Study Overview

1.1.1. What is a Watershed Study?

A watershed study is holistic evaluation of an area that is interconnected by water. A Level I watershed study evaluates the current condition of an area and looks at opportunities for water improvement projects that will restore, maintain, and enhance healthy watershed function. Specifically, a Level I watershed study looks for projects, programs, or activities that support sustainable, beneficial water use for current and future watershed residents – be they human, animal, or plant. The study is comprehensive in that it evaluates many aspects of the natural setting in order to ensure that any proposed projects that are beneficial to one, are indeed beneficial to the watershed as a whole. A holistic approach to watershed management is a keystone to the program developed by the WWDC when the watershed program was developed.

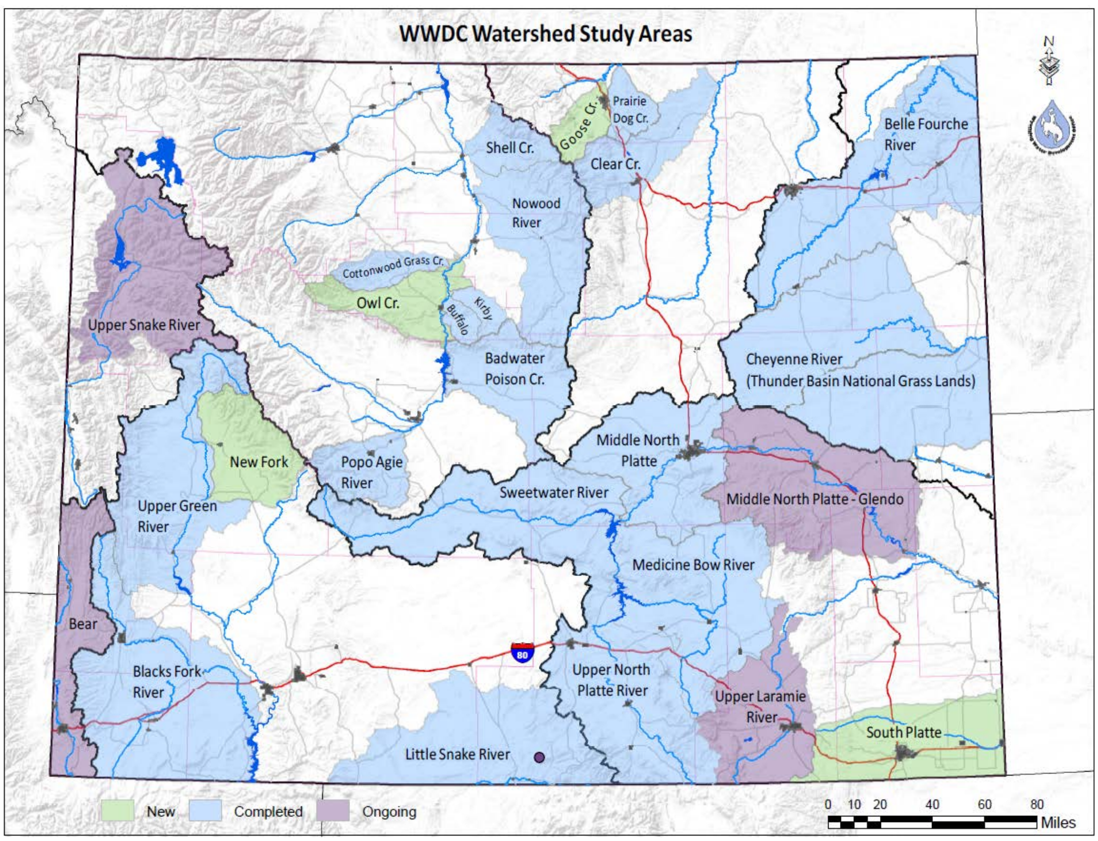


Figure 1.1.1-1 Wyoming Water Development Commission Watershed Study Areas

Since the program was initiated, the Wyoming Legislature has authorized watershed studies across the state of Wyoming as illustrated in Figure 1.1.1-1. The studies are initiated to assist project sponsors, prioritize watershed management improvements and ensure that any proposed projects are feasible, cost effective and will indeed provide a positive benefit to the area.

In a recent WWDC newsletter, the four main issues for consideration in a watershed information and review study include water storage, irrigation infrastructure, upland water development and stream channel condition. As stated in the newsletter, “A watershed study, providing management and rehabilitation plans for water storage, irrigation systems and upland water development, can help empower a community to proactively enhance their watershed. Conservation by watershed can be an effective holistic approach to embracing the natural resource challenges and opportunities facing a community. A watershed study can provide the information to meet those challenges” (WWDC 2009).

1.1.2. The Upper Snake River Watershed Study Area

The Upper Snake River watershed, located primarily in Teton County, covers over 1.7 million acres. The watershed is defined by the interconnected stream drainage area of the Snake River and its numerous tributaries including the Gros Ventre River, Flat Creek, Fish Creek, Buffalo Fork, Pacific Creek, Spread Creek, and Fall Creek. As illustrated in Figure 1.1.2-1, from the north, the watershed study area includes the headwaters of the Snake River in Yellowstone National Park south to the confluence of the Snake and the Hoback rivers at Hoback Junction. The Upper Snake River watershed covers the area from the east at the continental divide at Togwotee Pass on Highway 26 west to the top of the Grand Teton mountain range. The watershed is connected by the surface water drainages since any raindrop or snowflake that falls within this geographic area, will flow out of the study area at the southern tip of the watershed near Hoback Junction.

As described, the watershed study area is not defined by political subdivisions or boundaries such as counties or roads but by the water system that sustains it. The project sponsor, TCD, developed this definition of the Upper Snake River watershed because it encompasses an area that has specific and often common issues that need to be identified and addressed.

1.2. Key Issues in the Watershed

The TCD requested this Level I watershed be conducted to address specific issues that are affecting the area. Initially, the TCD board of directors was asked to identify their top concerns. Discussions along these lines were held at the TCD monthly board meetings, and a list was generated to use in the application for the watershed study. Additionally, since approximately 97 percent of the land in the Upper Snake River watershed is comprised of public land managed by agencies including the Grand Teton National Park (GTNP), Yellowstone National Park, Bridger-Teton National Forest (BTNF), and the National Elk Refuge, the managing agencies were asked to identify both the concerns and opportunities for the area. Twice a year, the water planning coordinator in the Interstate Streams Division of the Wyoming State Engineer’s Office (WSEO) coordinates an interagency meeting to discuss topics related to the Snake River including operations of the major reservoirs, research activities, water rights, and invasive species to name a few. At these meetings, the agencies were asked to provide input on the issues and opportunities they are currently working to address on the lands they manage. Finally, throughout development of this watershed study, public meetings were held at the Teton County Library in Jackson, Wyoming, where landowners, ranchers, and interested citizens were invited to identify potential water development projects that would benefit their properties, their operations, and/or the area. The following lists summarize the recurring themes and issues identified in the agency and public meetings.

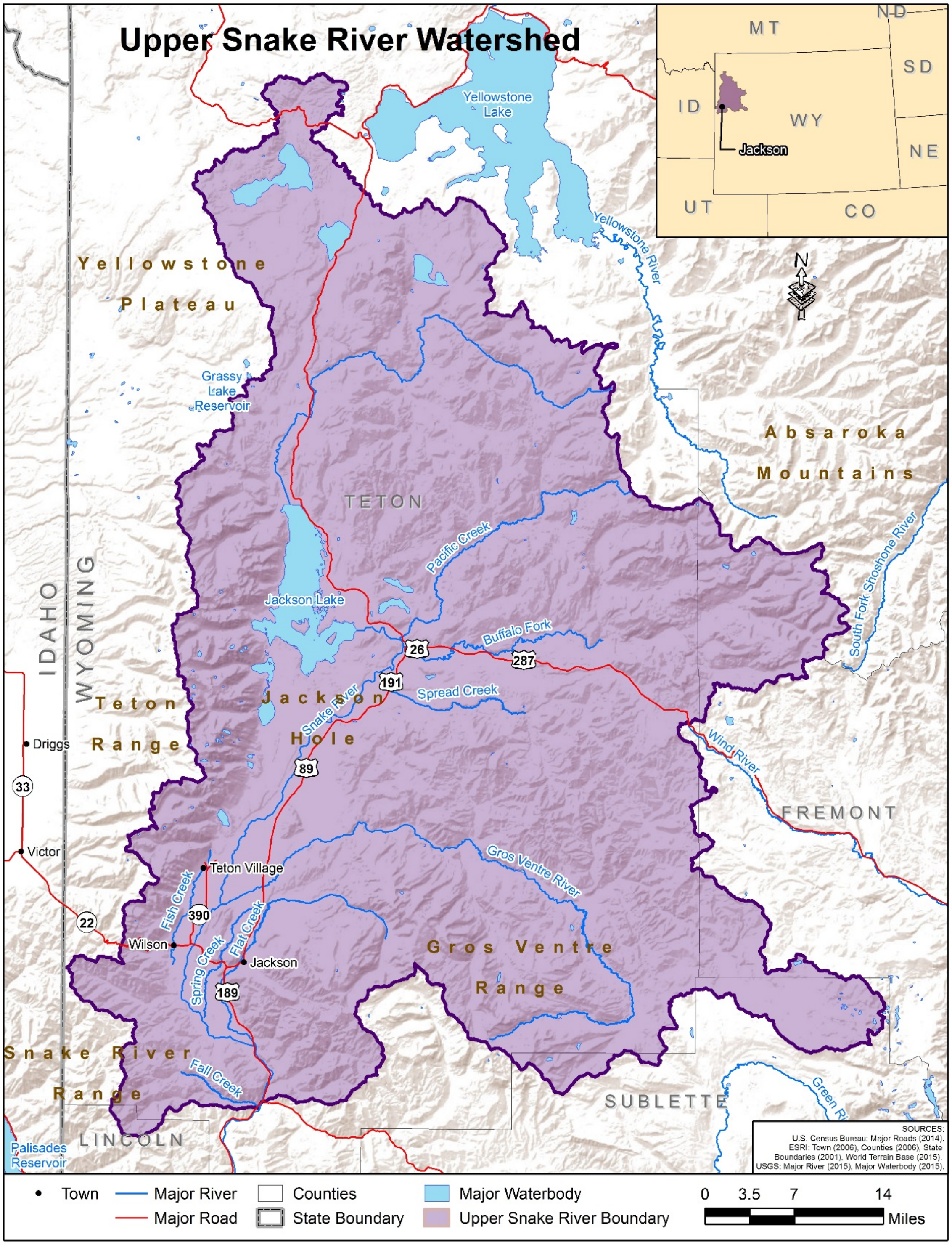


Figure 1.1.2-1 Upper Snake River Watershed Study Area

1.2.1. Agency-Identified Issues and Opportunities

- A comprehensive Geographic Information System (GIS) dataset needs to be developed and accessible by all groups working in the area.
- A geomorphic classification of the streams in the Upper Snake River watershed is important to complete as a foundation to watershed improvement projects.
- Some of the engineered wetlands designed as mitigation for projects in the watershed need to be addressed.
- There is a need to evaluate fish entrainment and fish passage along irrigation ditches to protect and enhance the habitat of native species.
- Winter flooding along Flat Creek continues to be a problem for the residents of Jackson.
- Additional water supply is needed for fire suppression and possibly for some subdistricts, the southern part of Jackson and potentially the ski resort in Jackson (Snow King Mountain).
- Habitat enhancement is needed for specific species of interest and/or threatened and endangered species.
- Irrigation system improvements are needed for leases and allotments on public land.
- Flood protection that is needed may be accomplished through levee improvements.

1.2.2. Private Landowner Issues and Opportunities

- There are water quality issues in Fish Creek related to septic systems.
- Historic control structures that feed irrigation ditches from the main stem of the Snake River are no longer functioning adequately because of changes in river dynamics over time.
- Control structures along irrigation ditches need to be modified to allow for safer operations, enhancements to fish habitat, and better operations for irrigated fields.
- High water table issues in certain areas of Jackson.
- Control structure replacements where damage has occurred.
- Irrigation management optimization is needed.
- Stream stabilization may be needed in specific areas.
- There are concerns of the cumulative impacts of small ponds on hydrology of the area.
- There are irrigation improvements needed to minimize sedimentation to streams and enhance water quality.

1.3. Purpose and Scope

The purpose of this Level I watershed study and management plan is to describe the Upper Snake River watershed in its current condition, to suggest resolutions for any water-related issues, and to provide insight into opportunities for improvements.

1.3.1. Review of Existing Data and Digital Library

The first step of every watershed study is to collect and review existing scientific and engineering data on the watershed as a whole. Since the scope includes a description and inventory of scientific information on geology, hydrology, soils, climate, land use, plant communities, wildlife habitat, infrastructure, and the geomorphic characteristics of the watershed stream system, to name a few, this first step in the watershed evaluation can be very wide-ranging. Specifically, for the Upper Snake River watershed, the area has been extensively studied because of its unique geologic, environmental, and ecological aspects. The primary sources of information used in this study were published scientific reports and datasets from the following federal and state agencies as well as local organizations:

- U.S. Environmental Protection Agency (EPA)
- U.S. Department of the Interior
  - Bureau of Land Management (BLM)
  - U.S. Geological Survey (USGS)
  - U.S. Fish and Wildlife Service (USFWS)
  - U.S. Bureau of Reclamation
- U.S. Department of Agriculture (USDA)
  - Farm Service Agency (FSA)
  - Forest Service (USFS)
  - Natural Resources Conservation Service (NRCS)
- Wyoming Department of Environmental Quality (WDEQ)
- Wyoming Game and Fish Department (WGFD)
- Wyoming Geographic Information Science Center (WyGISC)
- Wyoming Oil and Gas Commission
- Wyoming State Engineer's Office (WSEO)
- Wyoming State Geological Survey (WSGS)
- Wyoming Water Development Commission (WWDC)
- Wyoming Wildlife and Natural Resources Trust
- Jackson Hole Land Trust (JHLT)
- Teton County Weed and Pest
- Teton County
- Teton Conservation District (TCD)
- The City of Jackson
- Trout Unlimited (TU)

The information gathered is presented in Sections 2 and 3, Watershed Description and Inventory, respectively. Electronic copies of the references, maps, images, spreadsheets, and datasets were assembled into a digital library that was provided to the project sponsor upon completion of the project. The digital library includes a list of documents that is hyperlinked so the documents can be viewed by clicking the links for easy access.

1.3.2. Geographic Information System

The information gathered as part of the Level I watershed study is compiled into a GIS dataset. The GIS dataset is an electronic repository of the information gathered during the description and inventory phase of the project. The information includes mapped datasets on soil, geology, vegetation, wildlife, and infrastructure that is represented in a series of layers that can be evaluated spatially. With the GIS datasets, the TCD and the agencies that manage the public lands in the Upper Snake River watershed will have the opportunity to overlay a series of maps to discern patterns, site proposed projects, and/or refine project plans based on the information presented in the digital map sets. A list of the GIS layers developed for this project is provided in Data Summary 1.2-1 (in Appendix A). The maps themselves are included in Volume 2 of this report.

As specified in the contract, the GIS data is provided in electronic format using ESRI's ArcGIS version 10.4, which is the current industry standard for GIS datasets. Each map in this report contains a list of the data sources; the sources of information also are listed electronically in the metadata files. The two-dimensional maps represent three-dimensional features and, therefore, the datasets were transformed using the Universal Transverse Mercator System (UTM), Zone 13 north.

1.3.3. Watershed Management Plans and More

Ultimately, the final objective of this Level I watershed study is to provide plans for watershed management and rehabilitation that are practical, technically sound, feasible, and cost effective. Section 4 presents the watershed management plans for the Upper Snake River watershed that incorporate a wide variety of project types including:

- Irrigation System Improvements
- Livestock/Wildlife Upland Watering Improvements
- Surface Water Flood and Storage Improvements
- Stream Channel Condition and Stability Improvements
- Other Watershed Management Opportunities

The conceptual plans for the improvements were developed in collaboration with the Olsson project team of scientists and engineers with input from the local agencies and partners described throughout this document. Collaboration was important to ensure that the proposed projects were practical and feasible in the unique ecological setting and regulatory environment of the Upper Snake River watershed. Certain project improvements will require permitting and, therefore, Section 6 describes many of the permits that will be required to complete specific enhancements. Since the projects cannot be completed without adequate funding, opportunities for project financing through local, state, and federal agencies are presented in Section 7.

As stated in Governor Matthew Mead's Wyoming Water Strategy (2015), "Since the creation of the Wyoming Water Development Commission in 1975, the state has invested approximately $1.2 billion in programs for water development in Wyoming…Wyoming's 34 Conservation Districts develop partnerships with federal agencies like the USDA Natural Resources Conservation Service, then work directly with private landowners, homeowners, and Wyoming's communities to implement practices to reduce water consumption, improve water quality and protect water resources for future generations. These partnerships are responsible for millions of dollars of investment each year in on-the-ground voluntary conservation…

Where water and its opportunities exist, communities benefit."

2. WATERSHED DESCRIPTION

The first part of a Level I watershed study is to provide a description of the natural environmental features and resources of the area. The following sections provide this description as gathered from the cited sources and accompanying maps. Coincidentally, during development of this watershed study, National Geographic published an entire issue dedicated to the Yellowstone area, Figure 2.0-1 (National Geographic 2016). In over 127 years of publication, National Geographic has never dedicated an entire issue of the magazine to one area. So first, before the detailed descriptions begin, we want to point out that the Upper Snake River watershed sits in the center of the greater Yellowstone ecosystem. Because of its central location, the role of the Upper Snake River watershed is fundamental to the health and function of this extraordinary area. Information in this watershed study report and that from the National Geographic publication provides the Upper Snake River community with a width and breadth of information about the natural resources and environment that is unparalleled in recent history.

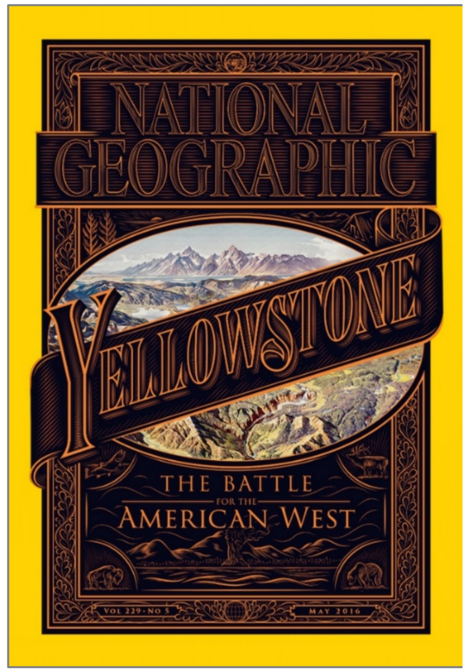


Figure 2.0-1 National Geographic Cover, Volume 229, Number 5, 2016

2.1. Setting and the Natural Environment

The Upper Snake River watershed covers approximately 2,771 square miles, or nearly 3 percent of Wyoming's surface area (Map 1, Watershed Location[1]). The Upper Snake River watershed, located in northwestern Wyoming, stretches across two national parks (Yellowstone and Grand Teton) and the BTNF, and it encompasses the entire National Elk Refuge (Map 2, Study Area). The watershed covers 60 percent of Teton, 1.7 percent of Fremont, 1.4 percent of Sublette, and 0.1 percent of Lincoln counties. Jackson is the largest municipality with a current population of 10,135 (U.S. Census Bureau 2016).

With a 9.4 percent growth rate in the past five years, Jackson is one of the fastest growing rural areas in the United States. *Along with this growing population, there has also been a significant increase in tourism. In 2015, over 4 million people visited Yellowstone National Park and the Upper Snake River watershed. In 2015, tourism is estimated to have generated $911 million in economic revenue for the area (U.S. Census Bureau 2016; National Geographic 2016).*

The Town of Jackson and the Teton County Commissioners developed a comprehensive plan in 2012 that seeks to balance growth and environmental stewardship. The Greater Yellowstone Ecosystem – the largest intact ecosystem in the lower 48 states – transcends the physical boundaries of Jackson and Teton County. As stated, their vision includes preserving and protecting this unique ecosystem in order to ensure a healthy environment, community and economy for current and future generations. Their plan goes on to say that ecosystem stewardship is a common value of community character in and of itself. However, wildlife, natural and scenic resources,

[1] Note that all maps are included in Volume II.

open space, and climate are also integral to growth management and quality of life common values. They recognize that the quality of this ecosystem has attracted numerous visitors throughout the years and is the primary reason many residents live in the Jackson area. The quality of life depends on many factors, but the primary factor is the continued health and viability of the ecosystem. Similarly, making the most ecologically suitable places for development the most desirable places to live is the core of the growth management common value that is at the core of the Teton County Comprehensive Plan (Teton County 2012).

2.1.1. Watershed Topography and Description

One of the most striking aspects of the Upper Snake River watershed is the topography. With the Grand Tetons to the west and the Snake River valley cutting through the center, the topography of the Upper Snake River watershed is very diverse (Map 3, Watershed Topography). The Upper Snake River watershed is surrounded by mountain ranges including Yellowstone Plateau to the north, the Absaroka Range to the northeast, the Wind River Range and Gros Ventre Range to the east and southeast, the Teton Range to the west, and the Snake River Range to the south and southwest (Young 1982). Stretching north-south through the watershed is Jackson Hole, a valley, where the city gets its name, which is characterized mostly by valley relief, including several terrace levels and glacial moraines (Young 1982).

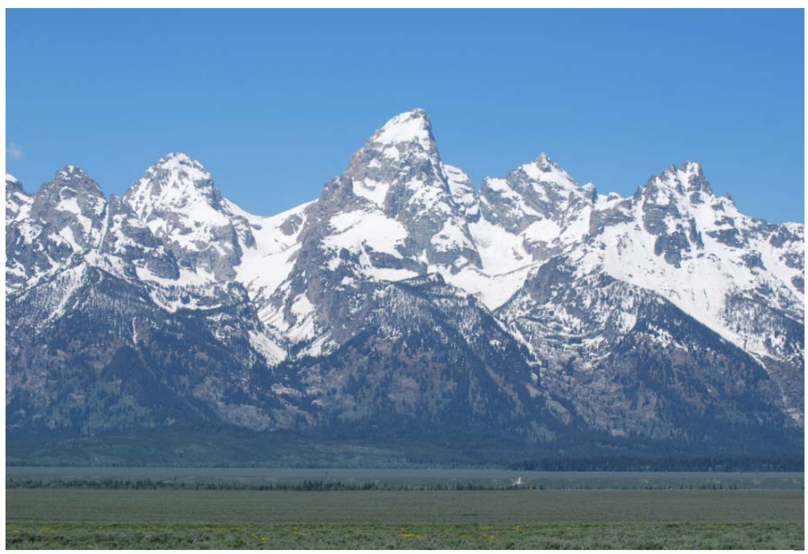


Photo 1 The Grand Tetons

The elevation within the watershed ranges from a low point of approximately 5,900 feet above mean sea level at the confluence of the Snake River and Fall Creek to over 13,700 feet in the Teton Range (Map 3, Watershed Topography). The surface drainages across the Upper Snake River watershed are controlled by this dramatic topography. The perennial streams in the area receive much of their water from overland flow resulting from snowmelt and rainfall in the mountainous headwater regions (WSGS 2014). Ephemeral streamflow results mostly from springtime snowmelt and intense storm events. Streamflows are also influenced by groundwater connectedness, vegetation, temperature, and man-made diversions (WSGS 2014). The geologic history and surface water hydrology of the watershed are described in greater detail in Sections 2.1.5 (Geology) and 2.1.7 (Surface Water Hydrology).

The Upper Snake River watershed includes Jackson Lake, Leigh Lake, and Jenny Lake as well as the following significant streams and rivers: Snake River, Pacific Creek, Buffalo Fork, Spread Creek, Gros Ventre River, Fish Creek, Flat Creek, Spring Creek, and Fall Creek. The Upper Snake River watershed is part of a larger surface water basin known as the Snake Headwaters (Map 4, Surrounding Watershed Basins). Other surrounding basins include the Missouri Headwaters and Upper Yellowstone to the north, Big Horn to the east, Upper Snake to the west, and the Upper Green to the south.

2.1.2. Climate

The climate of the Upper Snake River watershed is typified by long, cold winters and variable precipitation. For most of the area, precipitation mainly falls in the form of snow. Summers are typically short and cool. These climatic conditions are classified as Continental Subarctic, which is also known as Boreal. Specifically, the entire study area is classified as a Dfc (snow, fully humid, cool summer) climate zone under the Köppen-Geiger climate classification (Kottek et al. 2006).

2.1.2.1. *Weather Stations and Historic Precipitation Records*

A number of National Oceanic and Atmospheric Administration (NOAA) Cooperative Weather Stations are located in or near the Upper Snake River watershed study area. Six of these stations had adequate historical data (greater than 30 years) available and continue to operate today. Historical climate data for these six stations was obtained from the Western Regional Climate Center website (http://www.wrcc.dri.edu/). Table 2.1.2-1 shows the average maximum temperature, average minimum temperature, and average precipitation on a monthly and annual basis for each station (Western Regional Climate Center 2016).

Mean monthly temperatures are relatively cool in the summer months, with the warmest average temperatures around 80 degrees Fahrenheit (80° F). Summer and early fall months tend to be relatively dry, with one to two inches of precipitation per month on average. Winter months are cold, with average low temperatures near or below zero degrees Fahrenheit (0° F). In general, though not for all stations, precipitation amounts tend to be higher in the winter and spring months.

2.1.2.2. *Precipitation Zones*

Precipitation patterns throughout the watershed study area vary significantly between available weather stations. Table 2.1.2-1 and Figure 2.1.2-1 show the average monthly precipitation for each weather station. While there is typically higher precipitation in the winter and spring and lower precipitation in the summer and fall, the same annual patterns are not evident at every weather station. The various locations of these weather stations within the study area is because they lie in different precipitation zones.

Map 5 Weather Stations and Precipitation, displays the current and historic weather stations along with the average annual precipitation within the study area for the years 1981–2010. The data used to generate this map was obtained from many of the weather stations on the map, the WyGISC, and USDA (USDA 2016a). These data represent the results of Parameter Elevation Regression on Independent Slopes Model (PRISM) spatial climate data generated at the Oregon Climate Center, Oregon State University. Mean annual precipitation in the study area varies from a minimum of about five inches to over 98 inches annually. Spatial distribution of precipitation varies greatly throughout the study area because of effects of the topography within the watershed. The map clearly illustrates the strong influence of topography on precipitation patterns.

Table 2.1.2-1 Summary of Monthly Climatic Data: Upper Snake River Watershed

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Darwin Rch, Wyoming 482375: 8/1/1974 to 6/7/2016													
Average Max. Temperature (F)	26.4	29.8	36.4	44.1	53.9	64.0	72.2	70.6	62.4	49.6	34.5	25.9	47.5
Average Min. Temperature (F)	-7.4	-5.0	4.4	15.3	25.0	31.0	35.1	33.3	26.5	18.2	5.0	-6.4	14.6
Average Total Precipitation (in.)	1.2	0.9	1.3	1.5	2.0	1.5	1.4	1.4	1.5	1.3	1.2	1.1	16.2
Jackson, Wyoming 484910: 1/3/1905 to 6/10/2016													
Average Max. Temperature (F)	27.0	31.8	40.3	51.7	62.6	71.9	81.8	80.3	71.1	58.3	39.8	28.6	53.8
Average Min. Temperature (F)	4.1	6.9	15.0	24.3	30.7	36.7	40.8	38.7	31.4	23.7	15.5	6.7	22.9
Average Total Precipitation (in.)	1.5	1.1	1.2	1.1	1.8	1.6	0.9	1.2	1.3	1.2	1.3	1.5	15.8
Moose, Wyoming 486428: 12/14/1958 to 6/10/2016													
Average Max. Temperature (F)	26.1	31.0	39.4	49.3	60.9	70.7	80.6	79.2	69.3	55.7	38.3	26.5	52.3
Average Min. Temperature (F)	0.9	3.2	12.1	22.3	30.8	37.3	41.6	39.7	32.1	23.2	13.6	1.8	21.6
Average Total Precipitation (in.)	2.6	1.9	1.6	1.5	2.0	1.7	1.2	1.3	1.4	1.4	2.1	2.6	21.3
Moran 5 WNW, Wyoming 486440: 3/1/1911 to 6/10/2016													
Average Max. Temperature (F)	25.5	31.3	38.6	47.8	58.1	67.9	77.6	76.1	66.6	53.9	37.1	27.0	50.6
Average Min. Temperature (F)	-1.5	0.7	8.0	19.6	29.0	35.7	39.9	38.1	31.0	23.6	13.2	2.4	20.0
Average Total Precipitation (in.)	2.9	2.3	2.1	1.9	2.0	1.7	1.1	1.3	1.5	1.6	2.4	2.6	23.5
Old Faithful, Wyoming 486845: 5/1/1904 to 6/10/2016													
Average Max. Temperature (F)	27.2	30.8	38.3	46.5	55.1	64.9	75.0	74.2	64.2	51.1	36.0	27.3	49.2
Average Min. Temperature (F)	0.9	1.9	10.3	19.0	27.7	34.2	39.5	37.1	29.4	22.2	10.5	1.0	19.5
Average Total Precipitation (in.)	2.4	1.7	2.4	2.0	2.3	2.2	1.5	1.4	1.4	1.6	2.0	2.3	23.3
Snake River, Wyoming 488315: 6/21/1905 to 6/10/2016													
Average Max. Temperature (F)	25.9	30.7	37.8	47.4	57.2	67.4	77.6	76.4	66.4	52.8	36.5	27.3	50.3
Average Min. Temperature (F)	0.1	1.5	8.6	18.7	27.0	33.5	37.8	35.5	28.0	21.0	10.3	2.0	18.7
Average Total Precipitation (in.)	4.0	3.0	3.0	2.3	2.4	2.4	1.5	1.5	1.6	2.0	3.1	3.9	30.3

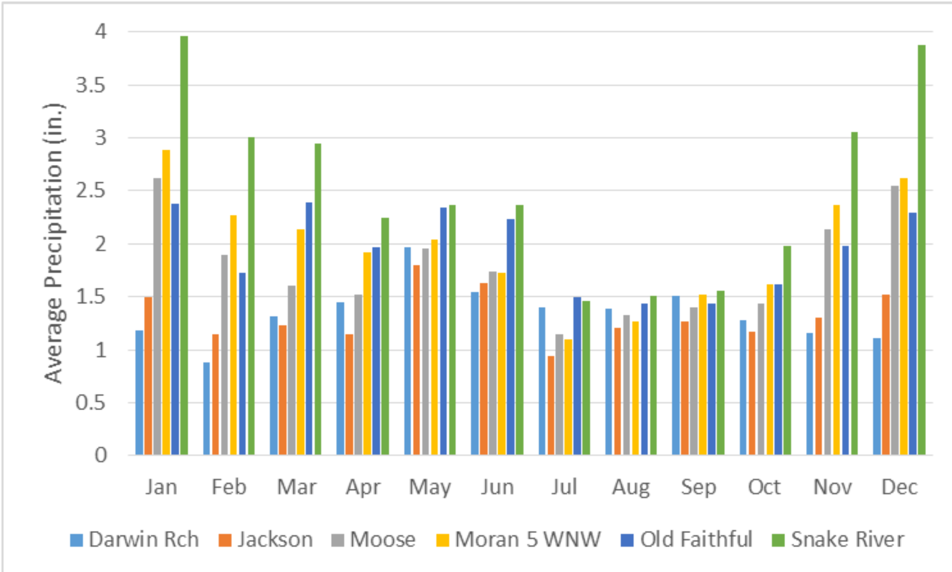


Figure 2.1.2-1 Average Monthly Precipitation

Areas of higher average annual precipitation coincide with areas of high elevation. Precipitation is enhanced by orographic lifting of prevailing westerly flow, which means that air is forced up and over the high elevation and mountain peaks, where it cools. The moisture in the air mass condenses, falling as precipitation. The highest annual precipitation in the study area falls on the west side of the Teton Range.

On the leeward side of major topography, the “rain shadow” effect is evident. After traveling over the higher elevation and losing moisture in the form of snow or rain, the air mass is dry. It warms as it descends to lower elevation, further inhibiting the formation of precipitation. Map 5 shows a dry region in the central portion of the study area that coincides with lower elevation just east of the Teton Range. Secondary maximums are seen in the eastern portion of the study area. These areas of enhanced annual precipitation coincide with the windward sides of higher topography found in the eastern portions of Teton County.

2.1.2.3. *Temperature Climate*

Annual temperature patterns are consistent across all six weather station locations. Figures 2.1.2-2 and 2.1.2-3 show monthly maximum and minimum temperatures for these six locations. As would be expected, the highest temperatures typically occur in mid-summer, and the coldest temperatures typically occur in mid-winter. For all stations, the highest monthly mean maximum temperature occurs in July. Mean high temperatures in July at these stations range from about 72° F to about 82° F. The lowest monthly mean minimum temperature for all stations occurs in January. Mean low temperatures in January at these stations range from -7° F to just above 4° F.

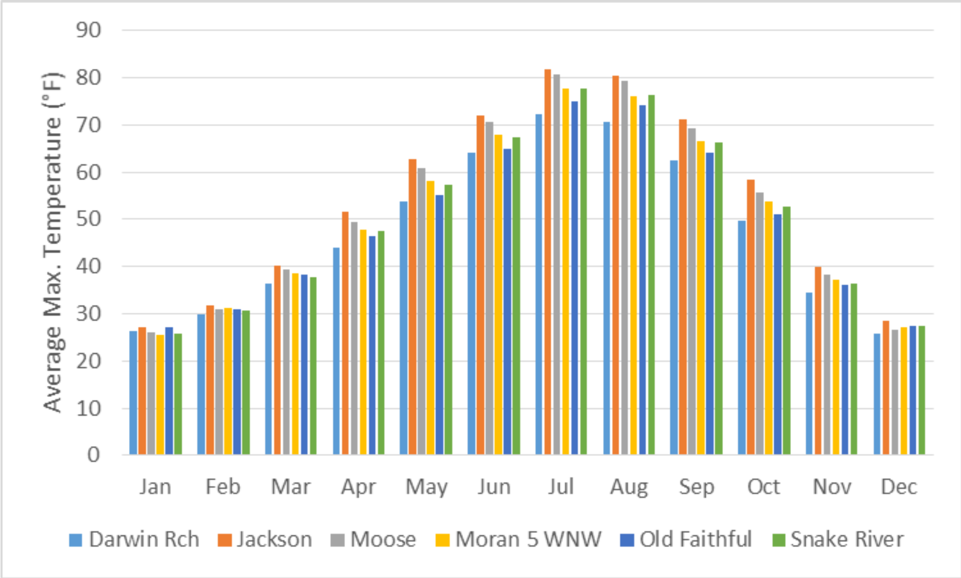


Figure 2.1.2-2 Average Maximum Temperature

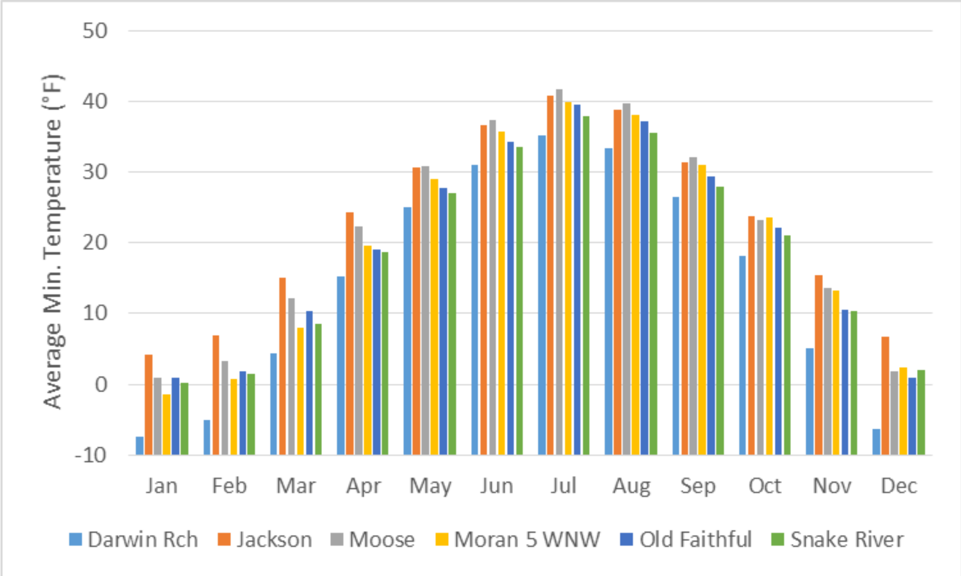


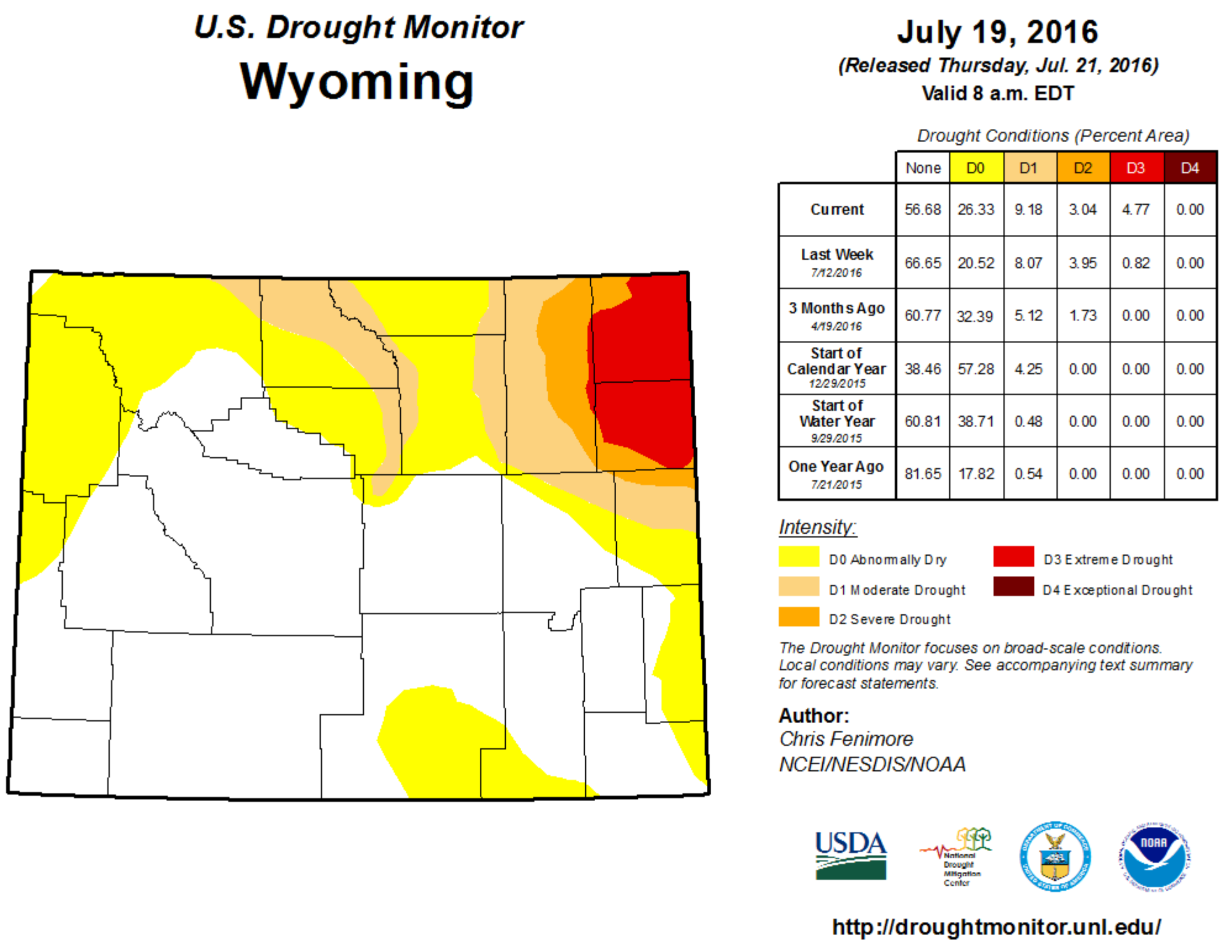
Figure 2.1.2-3 Average Minimum Temperature

2.1.2.4. *Drought Conditions in Wyoming*

The U.S. Drought Monitor is a weekly drought map that classifies regions across the country according to a drought intensity scale. The U.S. Drought Monitor scale is based on a combination of many drought indices and observations. It is important to note that the U.S. Drought Monitor represents only large-scale drought conditions. Local variations within the study area cannot be represented with this index.

Figure 2.1.2-4 shows the U.S. Drought Monitor for the state of Wyoming on July 19, 2016 (U.S. Drought Monitor 2016). This figure indicates that drought conditions in most of the study area were classified as a D0, or abnormally dry, under the U.S. Drought Monitor. A D0 intensity, according to the U.S. Drought

Monitor, is “used for areas showing dryness but not yet in drought, or for areas recovering from drought.” A small area in the extreme southeastern portion of the study area, in parts of Teton, Sublette, and Fremont counties, were classified as having non-drought conditions (U.S. Drought Monitor 2016).



	None	D0	D1	D2	D3	D4
Current	56.68	26.33	9.18	3.04	4.77	0.00
Last Week 7/12/2016	66.65	20.52	8.07	3.95	0.82	0.00
3 Months Ago 4/19/2016	60.77	32.39	5.12	1.73	0.00	0.00
Start of Calendar Year 12/29/2015	38.46	57.28	4.25	0.00	0.00	0.00
Start of Water Year 9/29/2015	60.81	38.71	0.48	0.00	0.00	0.00
One Year Ago 7/21/2015	81.65	17.82	0.54	0.00	0.00	0.00

The U.S. Drought Monitor is jointly produced by the National Drought Mitigation Center at the University of Nebraska-Lincoln, the USDA, and the NOAA. Map courtesy of NDMC-UNL.

Figure 2.1.2-4 U.S. Drought Monitor for the State of Wyoming – July 19, 2016

This historical climate analysis is based on approximately the last 50 to 100 years of recorded data. It should be noted that climate conditions in this study area are not static. Climate change is occurring and will continue to occur in the future. The nature and causes of these changes vary. According to Gray and Anderson (2009) climate change will have a significant impact on the climate and water supply of Wyoming:

> *There is a mounting evidence that the earth is experiencing a warming trend. Climate change has resulted in a 1° F increase in average global temperature in the past century, largely in the past 30 years (IPCC 2007). The concern now is that climate change may increase the impact of droughts, just as population growth and other factors have greatly increased the West’s vulnerability to water shortages. The impacts of these global changes on Wyoming’s weather and river systems include altered precipitation patterns and*

changes to the timing of snowmelt and river flows, which together will significantly alter Wyoming's water supply…On the whole, small increases in regional temperature changes as small as 1.5° F of additional warming — would have major consequences for Wyoming's water resources, even in the absence of major precipitation change.

For further information on how these changes might affect the watershed, an interesting study was just published identifying how the temperature of streams of the west may impact fisheries and aquatic habitats (Isaak et al. 2015). As reported in the Jackson Hole News and Guide, "New USFS research suggests that cutthroat trout will still have some suitable spawning grounds in the Jackson Hole area by 2080, when the climate change will have warmed water temperatures significantly (JHNG 2015). It is for this reason that the information on how to access and review the information from the Drought Monitor and other climate data from weather stations in the Upper Snake watershed are presented here for future planning purposes.

2.1.3. Vegetation and Land Cover

The Upper Snake River watershed is within the Utah-Wyoming Rocky Mountain terrestrial-based ecoregion. The complex geology coupled with microclimates presented by both topographical elevations and soil conditions creates varied growing conditions that support a large number of plants and plant communities. The most dominant land cover to be considered in watershed management is the Sagebrush Flats, existing from about 6,350 feet to 6,900 feet and covering large plains. The other most dominant land cover in the watershed area is riparian forests that are generally comprised of broadleaved deciduous cottonwoods and willows along the Snake River and its tributaries (Map 6, Land Cover). It is not unusual that plant species may intermingle between these two dominant communities, and also that they may include many coniferous species as well. In some areas, the sagebrush and grassland types may extend into the lower toe slopes of the surrounding mountains. Here the grasslands give way to more forb-dominated meadows (USGS 2005).

Photo 2 Fall Foliage along the Gros Ventre River

Generally, the dominant species in the Sagebrush Flats include low sagebrush (*Artemisia arbuscula*), mountain big sagebrush (*Artemisia tridentata*), and bitterbrush (*Purshia tridentata*). Areas with higher moisture may support shrubby cinquefoil (*Dasiphora floribunda*) and silver sage (*Artemisia cana*) or rabbitbrush (*Ericameria nauseosa*). Drier, well-drained hillsides often lack shrubs, and various bunchgrasses dominate instead. These include bluebunch wheatgrass (*Pseudoroegneria spicata*) and various needlegrasses (*Stipa* spp.).

The understory and herbaceous layers in riparian communities are often lush, containing Kentucky bluegrass (*Poa pratensis*), which is a naturalized but non-native species; various groundsels (*Senecio* spp.), and asters (USGS 2005). The bulk of upland vegetation is comprised of plant communities in which grasses are dominant, both biologically and visually. These grasslands are present mostly in the form of mid-grass prairie in the watershed. Shrub abundance varies both in response to substrates and climate but also in response to range condition. Stress resulting from drought or long-duration grazing can encourage the establishment of shrubs because grass competition is lessened. Based on state and transition model information presented in the NRCS Ecological Site Descriptions (ESDs), most ecological sites of the watershed can be expected to experience greater shrub cover as the effects of stress, such as over-grazing, compound (USGS 2005).

Major plant community segregates include the following:

- *Pseudoroegneria spicata*
- *Poa pratensis* / *Festuca idahoensis* (Idaho fescue)
- *Pseudoroegneria spicata* / *Cercocarpus montanus* (mountain mahogany)
- *Elymus macrourus* (tufted wheatgrass) / *Willow* sp. (willow)
- Managed noxious weed – cattail/bulrush – willow/sedge

Besides the species included in the above community names, grasses including western needlegrass (*Achnatherum occidentale*), western wheatgrass (*Pascopyrum smithii*), blue wildrye (*Elymus glaucus*), mountain brome (*Bromus marginatus*), kingspike fescue (*Leucopoa kingii*), bluejoint (*Calamagrostis canadensis*), basin wildrye (*Leymus cinereus*), tufted hairgrass (*Deschampsia caespitosa*), as well as grass-like Nebraska sedge (*Carex nebrascensis*), needleleaf sedge (*Carex duriuscula*), and threadleaf sedge (*Carex filifolia*) are present in the study area. Forbs present but not usually abundant include such species as common yarrow (*Achillea millefolium*), fireweed (*Chamerion angustifolium*), rose pussytoes (*Antennaria rosea*), elkweed (*Frasera speciosa*), and common sneezeweed (*Helenium autumnale*). Numerous annual plants are present, though Japanese brome (*Bromus japonicus*) and cheatgrass (*Bromus tectorum*) are winter annual plants that may significantly reduce the productivity of the native perennial species because they germinate in late summer and fall. This competitive advantage apparently is mediated by their early establishment and pre-emptive use of moisture and perhaps nutrient resources during the early growing season. Although palatable during early growing season, their presence in the plant community is regarded negatively because of limited later season palatability, added fire hazard, and displacement of perennial plants.

2.1.3.1. *Targeted Vegetation*

According to the BLM (2003), vegetational components that have particular importance with respect to water resources of the Upper Snake River include spotted knapweed (*Centaurea maculosa*), Dalmatian toadflax (*Linaria dalmatica*), houndstongue (*Cynoglossum officinale*), Canada thistle (*Cirsium arvense*), and musk thistle (*Carduus nutans*).

Spotted knapweed is a biennial or short-lived perennial that develops a large tap root and spreads primarily by seeds. This weed is known to be allelopathic, meaning it releases its own chemicals that can reduce the ability of native plants to compete with it or in some situations can kill desirable vegetation. Spotted knapweed has invaded several thousand acres in Teton County and often prefers dry, gravelly sites.

Dalmatian toadflax is a short-lived, herbaceous perennial plant that is capable of forming colonies through adventitious buds from creeping root systems. It can rapidly colonize disturbed or cultivated ground to outcompete desirable native plant species, and its presence decreases plant species diversity.

In addition, the distribution of cheatgrass and Japanese brome across the watershed is of concern. High prevalence of fine litter left by these plants can increase fire frequency and extent by providing combustible materials across large areas. Fires also tend to enhance the spread of annual bromes in many circumstances.

2.1.3.2. *Mountain Pine Beetle*

The infestation of whitebark pine by the mountain pine beetle (MPB; *Dendroctonus ponderosae*) in Wyoming and Colorado has been a persistent problem for many years (Bockino et al. 2013). Ponderosa pine (*Pinus ponderosa*), lodgepole pine (*Pinus contorta*), and limber pine (*Pinus flexilis*) are also affected by MPB infestations. In particular, the impacts of drought (which has weakened tree health) combined with overall warmer winters (which has enabled the MPB to flourish) have dramatically affected timber stands in the GTNP and the BTNF. In their report, "Whitebark Pine Monitoring in Grand Teton National Park 2007–2013," Bockino et al. note that tree damage from MPB is spatially variable but is greatest below elevations of 9,500 feet above mean sea level on south-facing slopes, with most severe impacts on trees that are also affected by white pine blister rust (*Cronartium ribicola*). While most tree mortality is caused by MPB infestation, the incidence of blister rust infection is widespread and increasing in severity.

Populations of MPB grew steadily with resulting tree death during the 1990s and through the early 2000s. Since 2011, areas affected by MPB have been decreasing. This effect is likely because of the reduced number of target trees available for beetles to infect rather than from climatic conditions that favor tree health and MPB control. (Target trees are typically those with a diameter at breast height greater than 7 inches, although beetle infestation has been found in trees with diameters as small as 5 inches.) Monitoring completed by the USFS indicates that while fewer acres of ponderosa pine, lodgepole pine, and limber pine forests are being affected in recent years, an additional 71,000 acres of these forests were affected in 2012 alone. While damages resulting from MPB have decreased, the incidence of infestation into new areas remains a concern. For the Final Report for the Upper North Platte River Watershed Study (Anderson Consulting Engineers 2015), the Medicine Bow-Routt National Forest: 5/10 Year Forest Plan Monitoring Review states that water runoff flow and distribution and drainage stability can be negatively affected, resulting from increased debris accumulation from dead trees. Debris dams may cause water backup, saturation and destabilization of banks, and increased erosion. These impacts could also adversely affect timber restoration and woodland ecology. The same is likely the case for the Upper Snake River watershed.

Periodic reductions in timber stands is not unusual, even in recent history. Substantial logging in the late 1800s and early 1900s resulted in regeneration of pine tree populations; however, much of the regeneration resulted in evenly aged stands of trees that led to an abundance of forest susceptible to the MPB infestation. Currently, the GTNP Division of Science and Resource Management is assessing opportunities for restoration of whitebark pine with emphasis in areas with low MPB infestation and white pine blister rust. In addition, it is anticipated that regeneration of forest will occur, and is – in fact – well underway in many places.

2.1.4. Soils

Soil surveys have been completed throughout the Upper Snake River watershed and are available online through the USDA NRCS (NRCS 2016). The distribution of the predominant soil types of the Upper Snake River watershed can be seen in Map 7, STATSGO (STATe Soil GeOgraphic) Soil Survey. Additionally, SSURGO (Soil SURvey GeOgraphic) Soil Survey data is available across portions of the watershed and the data was incorporated in the GIS dataset included electronically with this report. The SSURGO Soil Survey map is too detailed to show at the scale of the maps in this report.

As stated in the data description for the NRCS SSURGO Soil Survey map, the dataset is a digital soil survey and generally is the most geographically detailed level of soil data developed by the National Cooperative Soil Survey. The information was prepared by digitizing maps, by compiling information onto a planimetric-correct base and digitizing, or by revising digitized maps using remotely sensed and other information. The dataset consists of a detailed, field-verified inventory of soils and miscellaneous areas that normally occur in a repeatable pattern on the landscape and that can be cartographically shown at the scale mapped. The SSURGO Soil Survey map depicts information about the kinds and distribution of soils on the landscape. The soil map and data used in the SSURGO product were prepared by soil scientists as part of the National Cooperative Soil Survey.

Both the STATSGO and SSURGO Soil Survey interpretations predict soil behavior for specified soil uses and under specified soil management practices. For the purposes of this study, they assist the planning of broad categories of land use such as cropland, rangeland, and pastureland. Soil survey interpretations also help plan specific management practices that are applied to specific soils, such as equipment use or irrigation of cropland. Soil interpretations use soil properties and qualities that directly influence a specified use of the soil. These properties and qualities include: (1) site features, such as slope gradient; (2) individual horizon features, such as particle size; and (3) characteristics that pertain to soil as a whole, such as depth to a restrictive layer.

The majority of the watershed (39 percent) is overlain by the Tongue River – Hechtman – Buffork – Adel series (Young 1982). The Tongue River series can be described as deep, well-drained soils formed from the residuum of sandstone. Tongue River series is found on hillsides and mountainsides with slopes ranging from 3 to 40 percent (Young 1982). The Hechtman series consists of shallow, well-drained soil formed from the residuum of rhyolite. Hechtman series is found on mountainsides with slopes ranging from 6 to 60 percent (Young 1982). Similar to the Tongue River, the Buffork series is characterized by moderately deep, well-drained soils formed from the residuum of sandstone. It is also typically found on hillsides and mountainsides with slopes ranging from 3 to 60 percent (Young 1982). The descriptions of the remaining soil types found within the Upper Snake River watershed can be found in Table 2.1.4-1. Table 2.1.4-1 summarizes the extent of the STATSGO Soil deposits by square miles and percentage of the Upper Snake River watershed.

Table 2.1.4-1 Soil Deposits of the Upper Snake River Watershed

Unit Symbol	Soil Description	Area (acres)	Study Area (%)
s1905	Alluvium Winegar-Lagall till substratum-Huckridge-Bradco	1,755	0.1
s1924	Zeebar-Rhylow-Koffgo-Edgway	386	0.0
s8369	Water	42,239	2.4
s9059	Tongue River-Starman-Rubble land-Midfork-Greyback	227,642	12.8
s9065	Turnerville-Tongue River-Tetonia-Rock outcrop-Midfork-Buffork-Adel	127,583	7.2
s9076	Woosley-Starman-Rock outcrop-Mosroc-Fornor-Decross	17	0.0
s9112	Rock outcrop-Handran-Frisco	9,567	0.5
s9123	Rubble land-Rock outcrop-Cowood	58,833	3.3
s9124	Water-Shadow-Rubble land-Rock outcrop-Garlet -Cowood	154,808	8.7
s9125	Slocum-Lick-Garlet-Comad-Blaine	29,275	1.7
s9126	Taglake-Rock outcrop-Perceton-Hechtman-Bobtail	30,711	1.7
s9127	Rhylow-Oleo-Lasac-Koffgo-Dashiki	104,960	5.9
s9128	Tongue River-Hechtman-Buffork-Adel	690,117	38.9
s9129	Yodal-Koffgo-Jumpstart-Edgway	78,246	4.4
s9130	Tongue River-Teewinot-Perceton-Moran-Leighcan	28,854	1.6
s9131	Walcott-Taglake-Sebud	45,025	2.5
s9132	Tineman-Greyback-Bearmouth	73,648	4.2
s9133	Wilsonville-Tetonville-Riverwash-Cryaquolls	70,022	3.9

2.1.5. Geology

The Upper Snake River watershed has been described as one of the most geologically active areas on Earth. This is because of the supervolcano that lies beneath Yellowstone National Park. It is beyond the scope of this watershed study to describe the geology of the area in detail. However, before a description of the surficial and bedrock geology is presented, it is important to understand the overall geologic history of deposition, erosion, mountain building, and volcanism that have formed the foundation of the Upper Snake River watershed. Therefore, a brief geologic history of the Upper Snake River area, as described by the WSGS, is summarized as follows. The description was paraphrased for this watershed study, and the major events are described from oldest to youngest (WSGS 2014).

This geologic history of the Upper Snake River watershed begins with the deposition and erosion of marine sediments onto Precambrian basement rocks. The Paleozoic Era, or the period of time from approximately 540 million to 252 million years ago, was marked by the deposition of transgressive and regressive sediments of marine and terrestrial origin. These sediments consist predominately of sandstone, shale, limestone, conglomerate, with some dolomite. The Paleozoic Era was also marked by periods of erosion resulting in large-scale unconformities. Unconformities represent periods of geologic time that are missing because of either an interruption in deposition or erosion of the strata.

The Mesozoic Era, or age of the dinosaurs from approximately 252 to 66 million years ago, consisted of a shallow sea environment in which interbedded shale, sandstone, siltstone, carbonates, and evaporites were deposited. The Mesozoic was also marked by a transitional period from shallow marine into a terrestrial environment in which fluvial, eolian (windblown), and marshy sediments were deposited.

Although the exact time periods are still debated, during the early Cretaceous to Eocene Epoch, the Sevier and Laramide mountain-building events resulted in extensive folding and faulting in the area. The Sevier was characterized by shallow thrust faults, whereas the Laramide was characterized by large-scale thrust and reverse faults with asymmetric folds. Folding and faulting during the Laramide event resulted in the uplift of Precambrian basement rocks. The middle Eocene was marked by intense volcanism in which the volcanic sediments of the Absaroka Volcanic Supergroup, such as rhyolite and basalt, were deposited along the north, north-eastern boundary of the Upper Snake River area.

During the late Tertiary, additional volcanism occurred from the Yellowstone hotspot, resulting in the deposition of extensive volcanic deposits including porphyries, breccias, and andesite flows. Considerable geologic uplift occurred during the late Tertiary, resulting in faulting and erosion of the Tertiary sediments. This uplift and erosion shaped the present day landscape of the Upper Snake River area.

One of the thickest and most complete sequences of non-marine Cenozoic sedimentary rocks in North America is found in Wyoming (Love 1960). The Quaternary sediments, or the last 1.8 million years ago of geologic history in the Upper Snake River watershed, consist of unconsolidated river (alluvial), lake (lacustrine), runoff/landslide (colluvial), and glacial deposits. The most recent glacial advances and retreats took place during the Quaternary or about 15,000 years before present.

The following subsections provide information obtained from the USGS, WSGS, and WyGISC. The geologic maps and tables of geologic units are presented for use in evaluation of specific watershed improvement projects as described in the Watershed Management and Rehabilitation Plan (Section 4).

2.1.5.1. *Surficial Units*

Map 8 illustrates the surficial geology of the Upper Snake River watershed. The surficial geology units are subdivided into four categories, including (1) river valley deposits; (2) bedrock, residuum, and mined deposits; (3) upland deposits; and (4) other. The units categorized as “other” include landslide deposits, alluvial and gradational fan deposits, and glacial deposits. Table 2.1.5-1 summarizes the extent of the surficial geology deposits by acreage and percentage of the study area (acres indicated in Table 2.1.5-1 do not include acres of the watershed that are covered by surface water including lakes, rivers, and streams). The surficial geology units that dominate the watershed include bedrock/glaciated bedrock (39.2 percent), landslide deposits (24.3 percent), and glacial deposits (18.2 percent).

Table 2.1.5-1 Surficial Geologic Deposits of the Upper Snake River Watershed

Unit Symbol	Geologic Unit Name	Area (acres)	Study Area (%)
River Valley Deposits			
ai	Alluvium	89,879	5.2
ti	Terrace Deposits	32,355	1.9
tdi	Dissected Terrace Deposits	2,281	0.13
Bedrock/Residuum/Mined			
ri	Residuum	24,566	1.4
Ri	Bedrock/Glaciated Bedrock	679,615	39.2

Unit Symbol	Geologic Unit Name	Area (acres)	Study Area (%)
Upland Deposits			
ei	Eolian	674	0.04
sci	Slopewash and Colluvium	96,901	5.6
Other			
li	Landslide	420,576	24.3
fi	Alluvial Fan and Gradational Fan Deposits	22,689	1.3
gi	Glacial Deposits	315,245	18.2
oai	Glacial Outwash	47,009	2.7

2.1.5.2. *Bedrock Units*

Map 9, Bedrock Geology, illustrates the bedrock geology units of the Upper Snake River Watershed. Table 2.1.5-2 indicates the bedrock geology units organized by geologic age with subsequent coverage area and percentage of study area (again, acres indicated in Table 2.1.5-2 do not include acres of the watershed that are covered by surface water including lakes, rivers, and streams). Geologic units vary greatly across the Upper Snake River watershed in terms of lithology, distribution, and age. The distribution of the geologic units is indicative of multiple occurrences of deposition, uplift, folding, faulting, erosion, volcanism, and reworking of older units into younger units as described above in Section 2.1.5 from WSGS, 2014. Figure 2.1.5-1 illustrates a generalized cross-section from Love and Keefer (1975) of the area north of Jackson Lake. The significance of the structural basin that defines this area of northwest Wyoming cannot be overstated. The tectonic events of the Laramide Orogeny affected the outcrop patterns which thus influenced soil development; aquifer characteristics; groundwater flow patterns; oil, gas, and mineral deposits; and the topographic relief of the region.

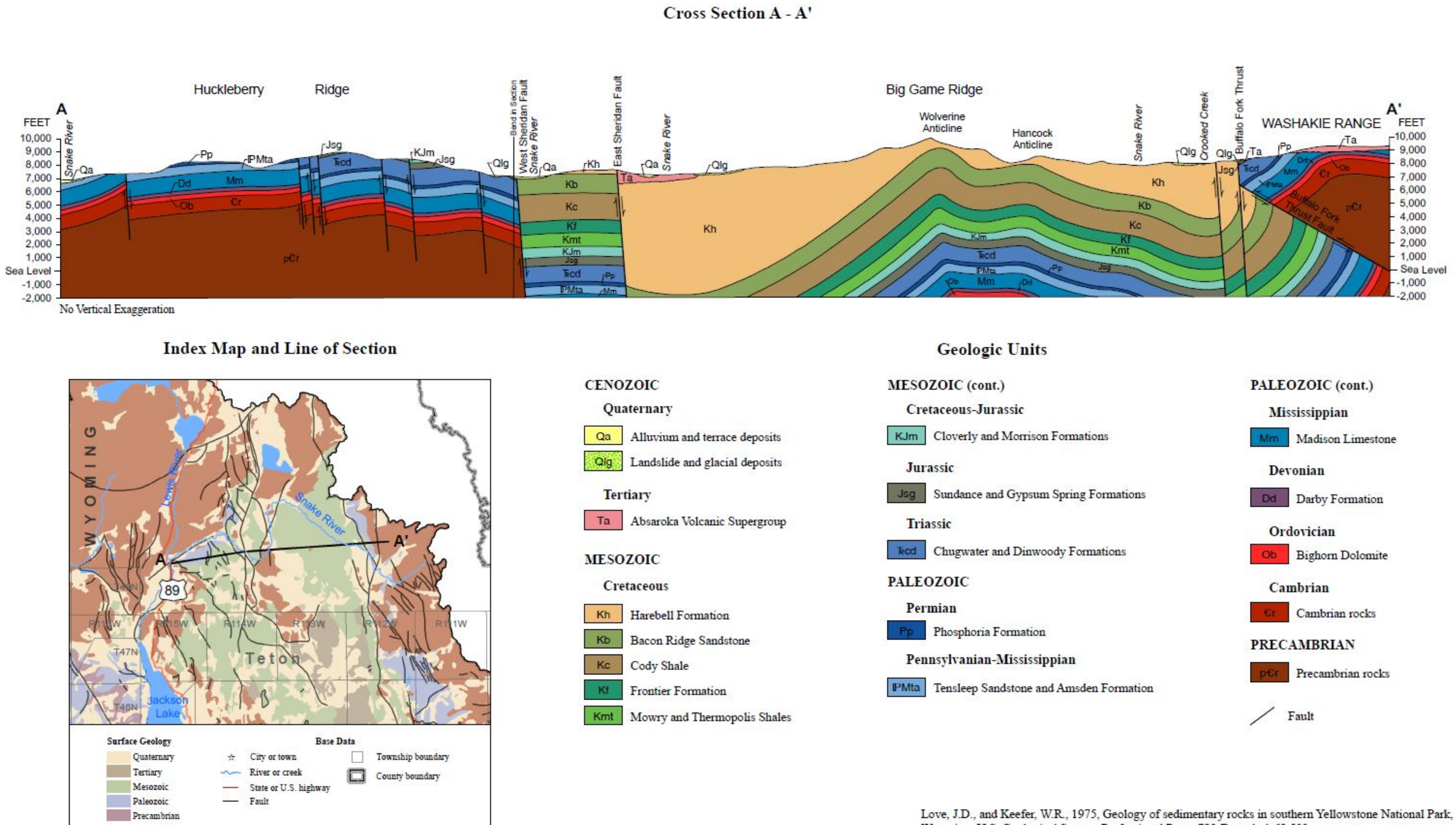
Table 2.1.5-2 Bedrock Geologic Units of the Upper Snake River Watershed

Unit Symbol	Geologic Unit Name	Area (acres)	Study Area (%)
Cenozoic			
Quaternary			
Qa	Alluvium and colluvium	172,781	9.98
Qt	Gravel, pediment, and fan deposits	84,297	4.87
Qg	Glacial deposits	215,154	12.43
Qls	Landslide deposits	177,392	10.25
Qu	Undivided surficial deposits	49,670	2.87
Qb	Basalt flows, tuff, and intrusive igneous rocks	1,168	0.07
Qr	Rhyolite flows, tuff, and intrusive igneous rocks	116,649	6.74
Quaternary – Tertiary			
QTc	Conglomerate	3,680	0.21
Tertiary			
Thr	Huckleberry Ridge Tuff of Yellowstone Group	36,142	2.09
Thl	Heart Lake Conglomerate	247	0.01

Unit Symbol	Geologic Unit Name	Area (acres)	Study Area (%)
Tsi	Shooting Iron Formation	429	0.02
Tii	Intrusive and extrusive igneous rocks	957	0.06
Tcc	Conant Creek tuff	112	0.01
Tte	Teewinot Formation	8,176	0.47
Tcd	Camp Davis Formation	2,515	0.15
Tc	Colter Formation	4,190	0.24
Ti	Intrusive igneous rocks	155	0.01
Twi	Absaroka Volcanic Supergroup: Thorofare Creek Group – Wiggins Formation	80,258	4.64
Ttl	Absaroka Volcanic Supergroup: Thorofare Creek Group – Two Ocean and Langford Formations; may include Trout Peak Trachyandesite of Sunlight Group	43,284	2.50
Ta	Absaroka Volcanic Supergroup: Thorofare Creek Group – Aycross Formation	18,188	1.05
Ttp	Absaroka Volcanic Supergroup: Sunlight Group: Sunlight Group – Trout Peak Trachyandesite	449	0.03
Thp	Absaroka Volcanic Supergroup: Hominy Peak Formation	3,163	0.18
Tv	Volcanic conglomerate	2,819	0.16
Twdr	Wind River Formation – at base locally includes equivalent of Indian Meadows Formation	18,140	1.05
Tcs	Conglomerate of Sublette Range	88	0.01
Th	Hoback Formation	1,853	0.11
Tdb	Devils Basin Formation	12,823	0.74
Tertiary – Cretaceous			
TKp	Pinyon Conglomerate	67,605	3.91
Mesozoic			
Cretaceous			
Kha	Harebell Formation	87,093	5.03
Km	Meeteetse Formation	384	0.02
Kso	Sohare Formation	28,035	1.62
Ksb	Sohare Formation and Bacon Ridge Sandstone	16,422	0.95
Kb	Bacon Ridge Sandstone	19,217	1.11
Kmv	Mesaverde Formation (N) or Mesaverde Group (S)	11,027	0.64
Kc	Cody Shale	23,873	1.38
Kf	Frontier Formation	21,428	1.24
Kft	Frontier Formation, and Mowry and Thermopolis shales	216	0.01
Ka	Aspen Shale	18,836	1.09
Kbr	Bear River Formation	6,133	0.35
Kmt	Mowry and Thermopolis Shales	13,749	0.79

Unit Symbol	Geologic Unit Name	Area (acres)	Study Area (%)
Cretaceous – Jurassic			
Kg	Gannett Group – Includes Smoot Formation, Draney Limestone, Bechler Conglomerate, Peterson Limestone, and Ephraim Conglomerate	3,215	0.19
KJ	Cloverly and Morrison Formations (N, S) or Cloverly Formation (Hartville uplift), or Inyan Kara Group (Black Hills), and Morrison Formation (NE)	3,412	0.20
KJg	Cloverly, Morrison, Sundance, and Gypsum Spring Formations	28,076	1.62
Jurassic – Triassic			
Jst	Stump formation, Preuss Sandstone or Redbeds, and Twin Creek Limestone	4,471	0.26
Jsg	Sundance and Gypsum Springs Formations	2,194	0.13
JЂn	Nugget Sandstone	363	0.02
JЂnd	Nugget Sandstone, Ankareh Formation, Thaynes Limestone, Woodside Shale, and Dinwoody Formation, or Nugget Sandstone, and Chugwater and Dinwoody Formations (N)	36,373	2.10
Ђcd	Chugwater and Dinwoody Formations	12,687	0.73
Paleozoic			
Permian – Mississippian			
Pp	Phosphoria Formation and related rocks	11,894	0.69
PIMa	Phosphoria, Wells, and Amsden Formations, Phosphoria Formation and related rocks, Quadrant Sandstone, and Amsden Formation, or Phosphoria Formation and related rocks, Tensleep Sandstone, and Amsden Formation (N)	21,783	1.26
PM	Tensleep Sandstone and Amsden Formation	19,304	1.12
Mississippian – Devonian			
MD	Madison Limestone and Darby Formation	100,059	5.78
Ordovician – Cambrian			
OЄ	Bighorn Dolomite, Gallatin Limestone, Gros Ventre Formation; Bighorn Dolomite, Snowy Range Formation, Pilgrim Limestone, Park Shale, Meagher Limestone, Wolsey Shale, and Flathead Sandstone; Bighorn Dolomite, Gallatin Limestone, Gros Ventre	42,492	2.46
Precambrian			
Wgn	Granite Gneiss	8,788	0.51
WVsv	Metasedimentary and metavolcanic rocks	36,743	2.12
Wmu	Metasedimentary and metavolcanic rocks – Metamorphosed mafic and ultramafic rocks	3,159	0.18
Wg	Granitic rocks of 2,600-Ma age group	22,293	1.29
Ugn	Oldest gneiss complex	4,405	0.25

Figure 2.1.5-1 Generalized Cross-Section



Love, J.D., and Keefer, W.R., 1975, Geology of sedimentary rocks in southern Yellowstone National Park, Wyoming: U.S. Geological Survey, Professional Paper 729-D, scale 1:62,500.

2.1.5.3. *Geologic Hazards*

On June 23, 1925, a mile-wide landslide occurred on the northern slope of Sheep Mountain near Kelly, Wyoming. In less than three minutes, over 50,000,000 cubic yards of rock and debris blocked the Gros Ventre River. What is now known as the Gros Ventre Slide altered the physiography of the area and formed a five-mile-long body of water known as the Lower Slide Lake (USDA 2016b). Factors that may have contributed to the landslide include (1) heavy rains and rapid snowmelt saturating the Tensleep Sandstone, (2) the Gros Ventre River cutting through sandstone, thus limiting support, (3) swampy pools on top of Sheep Mountain, and (4) earthquake tremors (USDA 2016b). On May 18, 1927, a portion of the natural dam backing up the water in the Lower Slide Lake failed, resulting in a massive flood. The flood destroyed the town of Kelly, Wyoming, and killed six people (USDA 2016b).

Landslides in the area still occur today. In April 2014, a slow landslide caused a hillside to crack and buckle in the center of Jackson, Wyoming, on the East Gros Ventre Butte. The landslide caused large quantities of dirt and rocks to cover a parking lot of the former Walgreens pharmacy on West Broadway Street. The movement along the slope caused a residential structure to split in half (Stanford 2014).

These two examples illustrate the active geologic hazards in the area in and around Yellowstone. Faulting occurs across the entire Upper Snake River watershed. Active faults, or faults that have evidence of movement within the last 10,000 years, are considered geologic hazards. Areas containing active faults are subject to additional earthquakes, tectonic deformation, liquefaction, landslides, and rock falls. Locations of faults in the Upper Snake River watershed are illustrated in Map 10, Hazardous Geological Features.

According to the WSGS, landslides (often called mass wasting) occur when a slope becomes unstable. Rock falls, debris flows, slumps, and creep are all types of landslides. Landslides can cause considerable damage; they can cover or destroy roads, carry houses downslope, and temporarily block rivers with unstable earthen dams, which cause flash-flooding downstream when compromised. The WSGS has mapped more than 30,000 landslides in Wyoming, and it maintains a database of these locations. Numerous landslides have been mapped in the Upper Snake River watershed and are also illustrated in Map 10.

2.1.6. Hydrogeology

Hydrogeology is the study of the movement of groundwater through geologic units, typically that water which can be accessed and used by people. Groundwater moves through the interconnected voids in host rocks. These voids consist of intergranular spaces, fractures, faults, vesicles, or some combination of these (WSGS 2014). Aquifers can be confined above or below by confining units consisting of clay or shale. These units act as barriers to groundwater flow. Alluvial aquifers and shallow bedrock aquifers are the primary sources of groundwater in the Upper Snake River watershed.

Alluvial aquifers are defined by the 2007 Wyoming Statewide Framework Water Plan as highly permeable, unconsolidated sand and gravel deposits that lie along active rivers and streams. Bedrock aquifers are described as consolidated formations that consist of coarse-grained lithologies such as sandstone, conglomerates, limestone, and dolomite (WWC Engineering et al. 2007). Groundwater flow through sandstone and conglomerate aquifers occurs mostly through the primary porosity. However, enhanced groundwater flow through limestone and dolomite aquifers takes place through enhanced secondary permeability such as solution-enlarged fractures caused by structural deformation (WSGS 2014). Recharge for these aquifers occurs primarily from rain and snowmelt (WSGS 2016a). The following subsections provide more information on the groundwater available in the two specific aquifer types and from the springs that discharge groundwater to the surface.

2.1.6.1. *Alluvial Aquifers*

The most widely used aquifer system in the Upper Snake River watershed is the Quaternary alluvial aquifer, which lies along the Snake River and its tributaries (WSGS 2014). Nearly all of the registered wells within the Upper Snake River watershed, including domestic, irrigation, stock watering, municipal, industrial, and miscellaneous, are located within the Quaternary alluvial river valley deposits. Groundwater flow typically follows the topography of the watershed, toward or parallel to the Snake River and its tributaries (WSGS 2014). As mentioned in Section 2.1.6, recharge to the alluvial aquifer primarily takes place through direct infiltration of precipitation, but it also occurs through discharge from bedrock aquifers, infiltration of streamflow from losing stream reaches, and recharge from irrigation. Groundwater discharges the alluvial aquifer through evapotranspiration, discharges into lower aquifer systems, and withdrawals from supply wells (WSGS 2014).

2.1.6.2. *Bedrock Aquifers*

Within the Upper Snake River watershed are two primary types of bedrock aquifers, including the Laramide structure aquifers and volcanic aquifers. Groundwater movement in the Laramide structures is highly influenced by large-displacement thrust faults, reverse-fault-cored anticlines, and associated fractures. These fractures developed during the compressional deformation of the Laramide Orogeny in Paleozoic and lower Mesozoic carbonate aquifers, which were uplifted in the Wyoming foreland basins (WSGS 2014). Volcanic aquifers are the most aerially extensive of the aquifers in the Upper Snake River watershed. Exposures of the volcanic aquifer system can be seen within Yellowstone National Park. The most vigorous groundwater movement in the volcanic aquifers takes place mostly along brecciated areas, fractures, and volcanic rocks with high permeabilities (WSGS 2014). Similarly, to the alluvial aquifer, recharge takes place through infiltration of precipitation, streamflow seepage, and inflows from neighboring aquifers. Discharges from the volcanic aquifers are gravity-driven and result in natural springs and seeps, or they flow directly into alluvial sediments (WSGS 2014).

2.1.6.3. *Springs*

Natural groundwater discharges occur through baseflow into lakes, rivers, and wetlands; leakage between geologic units; and springs (WSGS 2014). As of 2015, 243 springs have been mapped by the USGS within the Upper Snake River watershed (Map 11, Springs). It is important to note that many more occur within the watershed that currently remain unmapped.

Kelly Warm Springs is one of the more well-known springs located within the Upper Snake River watershed. Kelly Warm Springs is a geothermally fed pool, which has received attention in recent years because of the presence of goldfish and other exotic fish species in the pool. What started out as a seemingly innocent practice of discarding unwanted fish has since turned into an ecological concern. It was originally believed the non-native species were not adapted to the climate of western Wyoming and would survive only near the hot springs (JHNG 2014a). However, it has since been determined that the exotic fish pose a threat to downstream fish populations when the National Park Service (NPS) found goldfish in nearby Ditch Creek and within hundreds of yards of the Snake River (JHNG 2014a). The Upper Snake River and its tributaries between Jackson Lake and Palisades Reservoir are the only native habitat of the fine-spotted cutthroat trout. The exotic fish species could create competition for the cutthroat trout and cause their displacement (JHNG 2014). In order to protect the cutthroat trout and other native species, the NPS has begun restoration of Kelly Warm Springs.

2.1.7. Surface Water Hydrology

The Snake River originates west of the Yellowstone River and south of Yellowstone Lake within Yellowstone National Park. The Upper Snake River watershed covers approximately 1.7 million acres and the area from the east at the continental divide at Togwotee Pass on Highway 26 west to the top of the Grand Teton mountain range. The surface water that falls within this geographic area, be it rain or snow, will flow out of the study area at the southern tip of the watershed near Hoback Junction. Major tributaries to the Snake River within the study area include Pacific Creek, Buffalo Fork, Spread Creek, Flat Creek, Fish Creek, Spring Creek, Fall Creek, and the Gros Ventre River, as show in Map 2, Study Area.

2.1.7.1. Hydrologic Regions and Stream Types

The USGS uses a system of "hydrologic map units" to divide and subdivide the United States into successively smaller watersheds. The hydrologic map units are denoted by numeric hydrologic unit codes (HUC). The HUCs extend to 12 digits, which would be referred to as a twelfth-order HUC. The Upper Snake River watershed lies within the following hydrologic map units:

Region (Second-order HUC):	17	Pacific Northwest Region
Subregion (Fourth- order HUC):	1704	Upper Snake
Accounting Unit (Sixth-order HUC):	170401	Snake Headwaters
Cataloging Unit (Eighth-order HUC):	17040101	Snake Headwaters
	17040102	Gros Ventre
	17040103	Greys-Hobock
Subbasin (Tenth-order HUC):	See Data Summary 2.1.7-1	
Subbasin (Twelfth-order HUC):	See Data Summary 2.1.7-1	

Map 12, Watershed Hydrologic Features, shows a more detailed breakdown of watershed areas, along with their HUCs. A listing of the HUCs is included as Data Summary 2.1.7-1 in Appendix A.

Within the state of Wyoming, the majority of the watershed lies within the Rocky Mountains region, with a small portion downstream of the confluence with the Gros Ventre River identified to be in the Overthrust Belt region, as designated by Miller (2003). Most of the precipitation in the Rocky Mountains region occurs during the winter months in the form of snow from Pacific fronts. Late spring and early summer snowmelt generally causes the annual peak flows. Variability in the annual peak flows is low because of the low variability in the annual snow accumulations. The Overthrust Belt region generally has lower annual peak flows than the Rocky Mountains region and was identified as a separate region. Snowmelt generates the annual peak flows.

The U.S. Army Corps of Engineers (USACE 2000) defines different stream regimes as follows:

- A **perennial stream** has flowing water year-round during a typical year. The water table is located above the streambed for most of the year. Groundwater is the primary source of water for stream flow. Runoff from rainfall is a supplemental source of water for stream flow.
- An **intermittent stream** has flowing water during certain times of the year, when groundwater provides water for stream flow. During dry periods, intermittent streams may not have flowing water. Runoff from rainfall is a supplemental source of water for stream flow.
- An **ephemeral stream** has flowing water only during, and for a short duration after, precipitation events in a typical year. Ephemeral streambeds are located above the water table year-round.

Groundwater is not a source of water for the stream. Runoff from rainfall is the primary source of water for stream flow.

Based on the National Hydrography Dataset dated with most field entry dates of January 18, 2012, and February 19, 2012, most of the streams within the study area are considered to be perennial for the majority of the stream length (USGS 2016c). Some segments of the perennial streams are considered to be intermittent in their upper reaches. None of the streams were identified as ephemeral. Data Summary 2.1.7-2 in Appendix A shows the classifications for perennial and intermittent streams.

2.1.7.2. *Existing Lakes, Reservoirs and Wetlands*

There are no natural lakes of significant size in the Upper Snake River watershed. According to the National Inventory of Dams, seven dams are within the study area, with an eighth, Grassy Lake, immediately northwest of the study area. Map 13, National Inventory of Dams, shows the locations of the dams. The combined storage behind the identified dams is 890,840 acre-feet, with the majority of the storage occurring in Jackson Lake, which has 872,700 acre-feet of volume. Jackson Lake primarily serves as a flood control reservoir, with many secondary purposes. Irrigation, fish and wildlife, recreation, and debris control are the primary purposes of the other ponds. Dams that do not fall under the jurisdiction of the WSEO are not included in the database. Data Summary 2.1.7-3 in Appendix A lists the dams included in the database, along with select relevant information.

Photo 3 Jackson Lake Dam at Grand Teton National Park

The study area contains numerous small impoundments and stock watering ponds, which are shown in Map 14, Stock/Wildlife Ponds. The map shows 454 stock and wildlife ponds in the study area. These stock ponds represent permitted ponds with uses identified as stock and wildlife ponds.

Numerous important wetlands and wetland complexes occur in the watershed, as shown in Map 15, National Wetlands Inventory. The wetlands and their functional significances are described in detail in Section 3.4.6.

2.1.7.3. *Existing Levees*

In 1964, the Jackson Hole Flood Control Project levees were completed. They consist of 24.5 miles of levees along the Snake River in Teton County. The levees have protected against flooding but have had ecological impacts on the adjacent riparian areas. For example, cottonwood trees do not experience the seasonal flooding required to support healthy communities. Watershed stakeholders have been exploring alternatives to allow water to inundate behind the levees in some areas. In 1990, the USACE was authorized by the U.S. Congress to conduct the Jackson, Wyoming, Environmental Restoration Feasibility Study. The purpose of the study was to investigate the feasibility of restoring fish and wildlife habitat that had been lost as a result of the levee construction. In April 2000, the Jackson Hole, Wyoming, Environmental Restoration Draft Feasibility Study (Feasibility Study) was completed (USACE 2000). In April 2001, the U.S. Congress authorized $66.5 million in funding for the project. The USACE, Teton County, and TCD entered into a cost-share agreement in 2004. The project has moved forward only slightly. Issues such as real estate and the financial match of the local sponsors need to be addressed. The project is slated for re-scoping this year (2016). The local sponsors have the opportunity to determine priorities for the project and the desired path for implementation. The USACE is interested in moving the project forward, but it wants to collaborate with the TCD and Teton County to meet their needs.

The Fall Creek Associates contracted with Biota Research and Consulting Inc. to prepare an enhancement design at the 50 percent level to connect surface water from Morel Creek to access a relic flood channel of the Snake River that is on the landward side of the Snake River levees. The 50 percent design was completed in October 2014. Final design and construction have not been completed (Biota 2014).

2.1.7.4. *Gaging/Sampling Stations*

The study area contains 12 active USGS gages. These gages, along with an additional 20 historical gages that are no longer in use, are shown in Map 16, Gaging Stations. Water quality samples have been collected at 17 of the gage locations. The latest samples were collected at Gage 13018350, Flat Creek below Cache Creek near Jackson, Wyoming, on May 11, 2015, and at Gage 13016450, Fish Creek at Wilson, Wyoming, on May 16, 2016. Table 2.1.7-1 lists the gages that are still in operation and their periods of record. A complete listing of the 32 current and historical gages and the information available for each gage are listed in Data Summary 2.1.7-4 in Appendix A. Detailed information regarding these sites is available at http://waterdata.usgs.gov/wy/nwis/si (USGS 2016b).

Table 2.1.7-1 USGS Gaging Stations in Operation

Station Number	Station Name	Flow Measurement Period of Record, Water Years*
13010065	Snake River above Jackson Lake at Flagg Ranch, WY	10/1/1983 - present
13011000	Snake River near Moran, WY	10/1/1903 - present
13011500	Pacific Creek at Moran, WY	7/20/1917 - present
13011900	Buffalo Fork above Lava Creek near Moran, WY	9/22/1965 - present
13013650	Snake River at Moose, WY	4/6/1995 - present
13014500	Gros Ventre River at Kelly, WY	6/16/1918 - present
13015000	Gros Ventre River at Zenith, WY	7/13/1917 - present
13016305	Granite Creek above Granite Creek Supplemental near Moose, WY	6/2/1995 - present
13016450	Fish Creek at Wilson, WY	3/24/1994 - present
13018300	Cache Creek near Jackson, WY	7/1/1962 - present
13018350	Flat Creek below Cache Creek near Jackson, WY	4/1/1989 - present
13018750	Snake River below Flat Creek near Jackson, WY	11/12/1975 - present

* Daily flows are not available for the entire date range. They are available for at least portions of the date range.

2.1.7.5. *Stream Flow Characteristics*

Most of the streams within the study area are classified as perennial, having flowing water year-round during a typical year. The water table is located above the streambed for most of the year. Groundwater is the primary source of water for stream flow, with runoff from rainfall or snowmelt as a supplemental source of water. Most of the study area lies within the Rocky Mountains region of Wyoming, as designated by Miller (2003). Most of the precipitation in the Rocky Mountains region occurs during the winter months in the form of snow from Pacific fronts. Late spring and early summer melting of the snow generally causes the annual peak flows. Variability in the annual peak flows is low because of the low variability in the annual snow accumulations.

As seen in Figure 2.1.7-1, the majority of flow occurs between April and October. Peak-flow gage data for the Snake River at Moose, Wyoming, and the Snake River below Flat Creek near Jackson, Wyoming, show the earliest peak flow occurring on May 16 and the latest occurring on July 4, with the majority of peaks occurring in early June.

Intermittent winter flooding occurs along Flat Creek as it flows through Jackson, causing damage to homes along the creek. The exact causes of the flooding and why ice dams form in some years but not others are not well understood. The Flat Creek Water Improvement District (FCWID) was formed with the mission "to explore and implement ways to prevent damage to private property because of winter flooding of Flat Creek with a commitment to honor water rights, represent the best interests of the district's property owners and residents, while maintaining and improving water and habitat quality within the stream corridor." (FCWID 2016a). The FCWID is seeking solutions to the flooding problems in collaboration with the TCD and Town of Jackson.

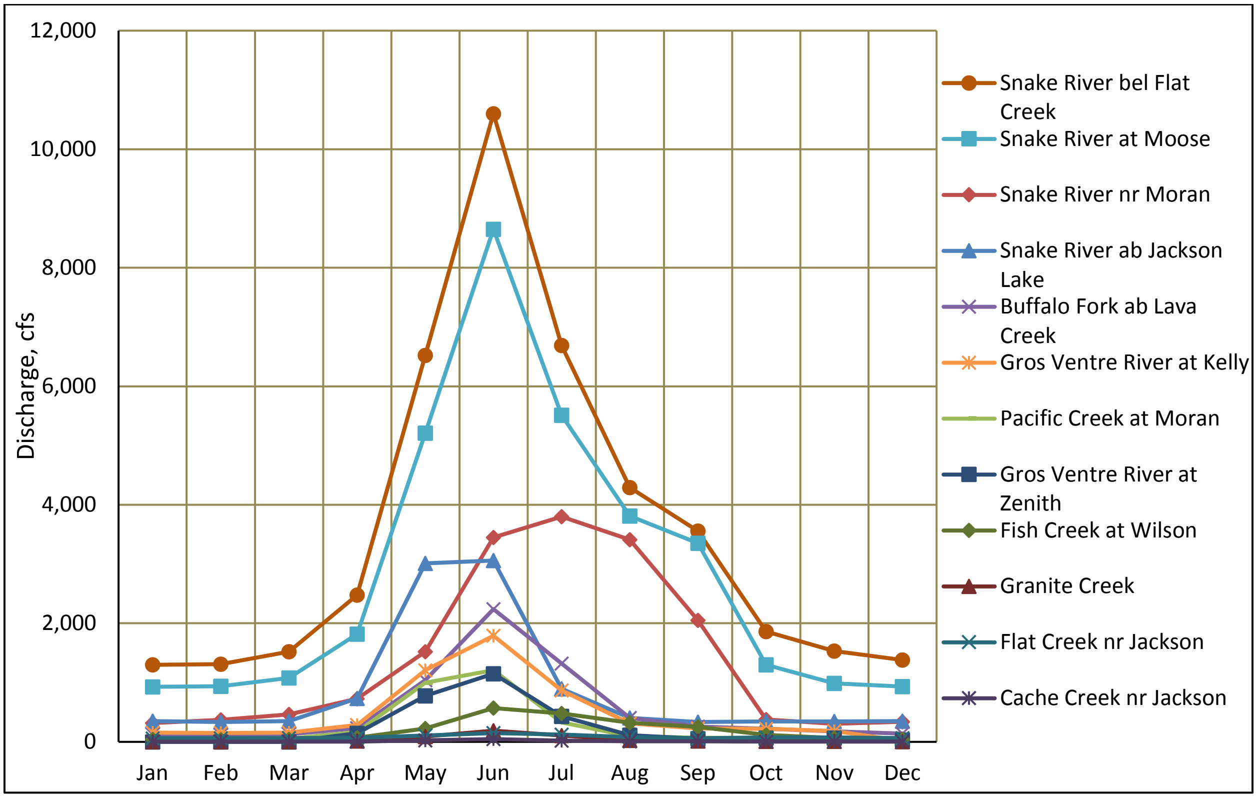


Figure 2.1.7-1. Mean Annual Discharge for Period of Record (Varies)

2.1.8. Stream Geomorphology

The following section provides information on the stream geomorphology of the Upper Snake River watershed. Stream or more precisely, fluvial geomorphology, is the study of how land is formed under the processes associated with running water. Over time, a natural stream channel at a given location establishes a cross-section and planiform that reflect the quantity of water and the quantity and characteristics of sediment delivered to it from the drainage basin, as well as the imposed topography and local geologic conditions. Neither the water supplied (discharge) nor the quantity and distribution of sizes of the sediment load are delivered to the channel at a constant rate. All are subject to the variations of weather and climate, which dictate the magnitude, timing, and frequency of the range of flows and sediment, delivered to a given channel reach. Thus, the channel experiences varying sequences of low and high flows, depending on runoff from the drainage basin. Largely because of the varying runoff, the sediment supplied from the landscape and from sediments stored in, and adjacent to, the channel, varies as well (Emmett et al. 1983).

Stream stability is morphologically defined as the ability of the stream to maintain, over time, its dimension, pattern, and profile, in such a manner that it is neither aggrading nor degrading and is able to transport without adverse consequence the flows and detritus of its watershed. Stable streams do, however, assume many combinations of dimension, pattern, profile, and materials within individual valley and geologic types. Due to the great diversity of these morphological features within rivers and streams, Rosgen (1994, 1996) developed a stream classification system by which to stratify and describe these various river types. The Rosgen Stream Classification System was utilized for this watershed study and is described in greater detail below.

2.1.8.1 Rosgen Classification System

The Rosgen Stream Classification System is a way of classifying and evaluating a stream system. The Rosgen system is widely accepted as the classification system of choice for watershed management activities. Each of the four levels is more detailed and site-specific than the one before it. Figure 2.1.8-1 shows the four inventory or assessment levels. Rosgen (2006) describes the following five objectives of this stream classification system:

- To predict a river's behavior from its appearance, based on documentation of similar response from similar types for imposed conditions
- To stratify empirical hydraulic and sediment relations by stream type by state (condition) to minimize variance
- To provide a mechanism to extrapolate site-specific morphological data
- To describe physical stream relations to complement biological inventory and assist in establishing potential and departure states
- To provide a consistent frame of reference for communicating stream morphology and condition among a variety of disciplines

As part of the Upper Snake River Level I watershed study a Level I Rosgen channel classification was completed. This basic level of stream classification is based on morphological characteristics that result from the integration of basin relief, landform, and valley morphology. This coarse-scale level uses dimension, pattern, and profile to make determinations. Level I criteria are typically determined from topographic maps, landform maps, and/or aerial topography. Table 2.1.8-1 shows the general stream type descriptions and delineative criteria for a Level I classification.

Disturbances to the channel, such as accelerated bank erosion or sediment supplies, can lead to channel changes and eventually stream type changes as well. For example, there were evolutionary channel changes observed where an E-typed channel originally was functioning at a higher base level that, over time, converted to a C, Gc, F, and now is a C-type channel at a lower base level (see Figure 2.1.8-1).

2.1.8.2 Level I Classification Methods

For the Upper Snake River Level I watershed study, a Level I Rosgen channel classification was completed for the entire watershed. This Level I classification is intended to provide a general summary of the channel types (A through G) present within the watershed. The classification was completed utilizing topographic maps and aerial photography (GoogleEarth) and limited field visits.

Level I stream classification is a general characterization of the stream within the watershed and is intended to be preliminary. This level of classification makes use of readily available published information and relies on the experience of the observer. The first four delineative criteria for classification levels I and II are the same, but the criteria vary greatly in the intensity of required data. Level II stream classification requires field measurements of the entrenchment ratio, width-to-depth ratio, slope, and sinuosity by establishment of a cross-section and longitudinal profile.

To complete the Level I classification, an initial assessment of the streams includes completing the following tasks:

- Map and identify the origin and character of landforms
- Overlay the drainage systems of interest
- Locate the terrace elevations to differentiate Pleistocene, Holocene, and Modern depositional features

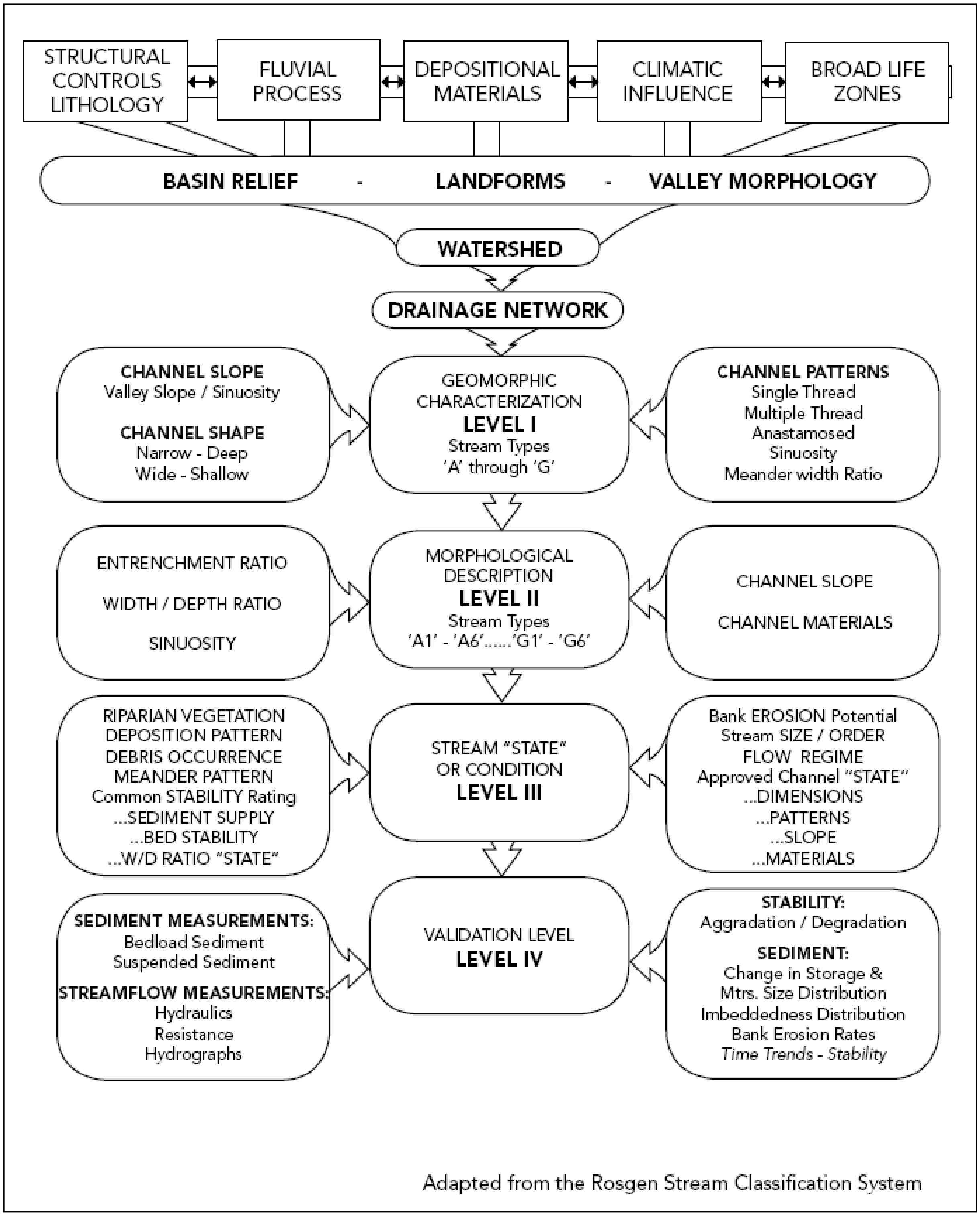


Figure 2.1.8-1 Rosgen's Four Inventory Assessment Levels

Table 2.1.8-1 General Stream Type Descriptions

Stream Type	General Description	Entrench-ment Ratio	Width to Depth Ratio	Sinuosity	Slope	Landform/Soils/Features
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.	<1.4	<12	1.0 to 1.1	>0.10	Very high relief. Erosional, bedrock or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with deep scour pools; waterfalls.
A	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.	<1.4	<12	1.0 to 1.2	0.04 to 0.10	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step/pool bed morphology.
B	Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 to 2.2	>12	>1.2	0.02 to 0.039	Moderate relief, colluvial deposition, and/or structural. Moderate entrenchment and W/D ratio. Narrow, gently sloping valleys. Rapids predominate w/scour pools.
C	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well defined floodplains.	>2.2	>12	>1.2	<0.02	Broad valleys w/terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channels. Riffle/pool bed morphology.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	n/a	>40	n/a	<0.04	Broad valleys with alluvium, steeper fans. Glacial debris and depositional features. Active lateral adjustment, w/abundance of sediment supply. Convergence/divergence bed features, aggradational processes, high bedload and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.	>2.2	Highly variable	Highly variable	<0.005	Broad, low-gradient valleys with fine alluviium and/or Lacustrine soils. Anastomosed (multiple channel) geologic control creating fine deposition w/well-vegetated bars that are laterally stable with broad wetland floodplains. Very low bedload, high wash load sediment.
E	Low gradient, meandering riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio.	>2.2	<12	>1.5	<0.02	Broad valley/meadows. Alluvial materials with floodplains. Highly sinuous with stable, well-vegetated banks, Riffle/pool morphology with very low width/depth ratios.
F	Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio.	<1.4	>12	>1.2	<0.02	Entrenched in highly weathered material. Gentle gradients, with a high width/depth ratio. Meandering laterally unstable with high bank erosion rates. Riffle/pool morphology.
G	Entrenched "gully" step/pool and low width/depth ratio on moderate gradients.	<1.4	<12	>1.2	0.02 to 0.039	Gullies, step/pool morphology w/moderate slopes and low width/depth ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials, i.e., fans or deltas. Unstable, with grade control problems and high bank erosion rates.

After the initial assessment is complete, the following sequence of analysis is used in the Level I stream channel classification:

1) Overlay the river system on the fluvial landscape to get the following:

   - General channel slope (steep/flat)
   - Channel bed features (step/pool or riffle/pool)
   - Estimate of channel shape (general width/depth ratios categories – less than 12; 12 to 40; and more than 40)
   - Pattern and profile to show floodplain extent
   - Plan view pattern (single or multiple channels)
   - Confinement (entrenchment slight, moderate, entrenched) or lateral containment (yes or no)

2) Delineate the valley types and landforms

   - Landforms (alluvial fans, glacial and/or fluvial terraces, floodplains, hanging valleys)
   - Valley Types I through X (see Rosgen 1996)

2.1.8.3. Level I Classification Results

The results of the Level I Rosgen stream classification are described and graphically displayed in the following text, figures and charts. Additionally, results are graphically displayed on Map 17, Rosgen Stream Classification and summarized in Data Summary 2.1.8-1 in Appendix A.

The Snake River, being the largest tributary of the Columbia River, is a major river of the greater Pacific Northwest in the United States. The division of rugged mountains by rolling plains characterize the physiographically diverse watershed of the Upper Snake River. In this area, the streams and rivers are driven by spring runoff from high elevation snow pack in the Teton mountain range. Runoff events occur typically from late April through October. Flows taper and may vary into the middle/end of June depending on spring rain storms and the flows decrease gradually through autumn.

The Upper Snake River watershed consists of seven drainages from which their tributaries were classified by stream reach. The following descriptions will point out the differences in stream type based on stream/landscape character and ultimately how they were classified utilizing the Rosgen Stream Classification System (Figure 2.1.8-1 Rosgen's Four Inventory Assessment Levels).

The seven drainages represented in Figures 2.1.8-1 and 2.1.8-2, typically maintain year-round flow from groundwater, springs and snow (in good years). Percentages and lengths of stream types within their drainages are depicted in Figures 2.1.8-2 and 2.1.8-3.

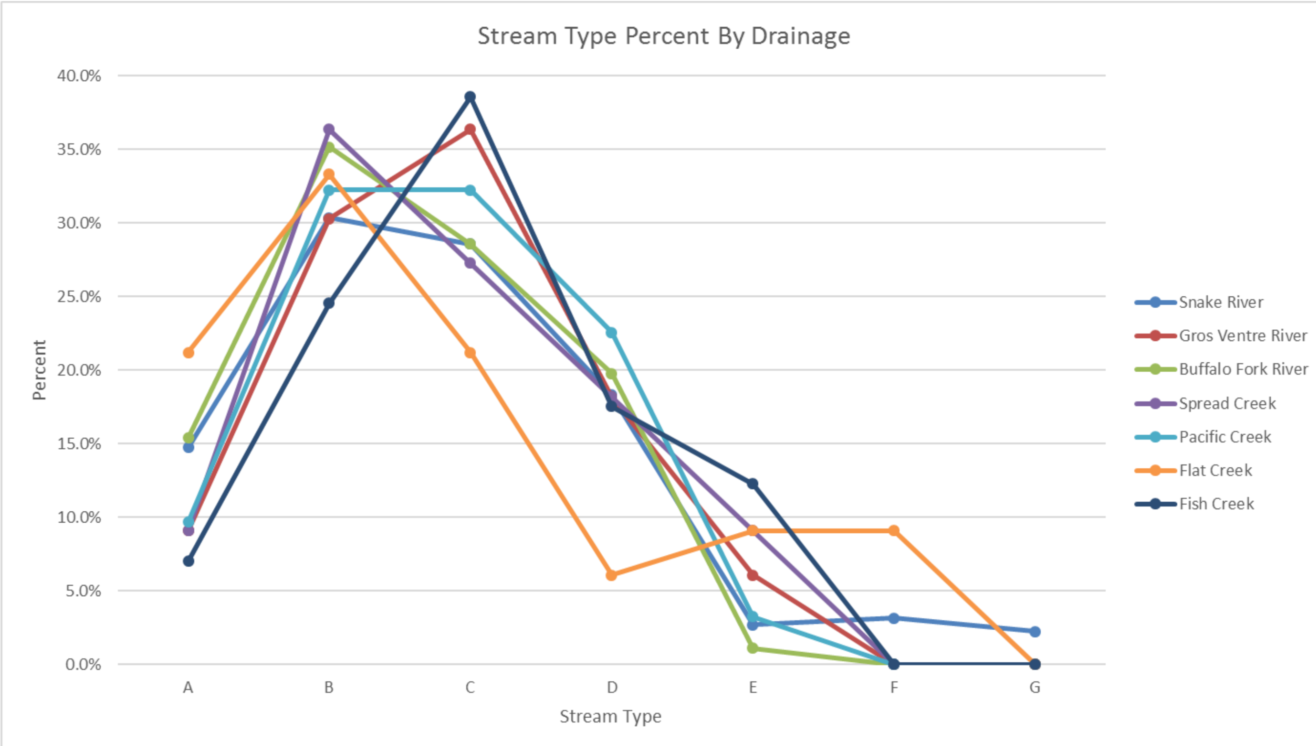


Figure 2.1.8-2 Drainage Average Percent per Stream Type

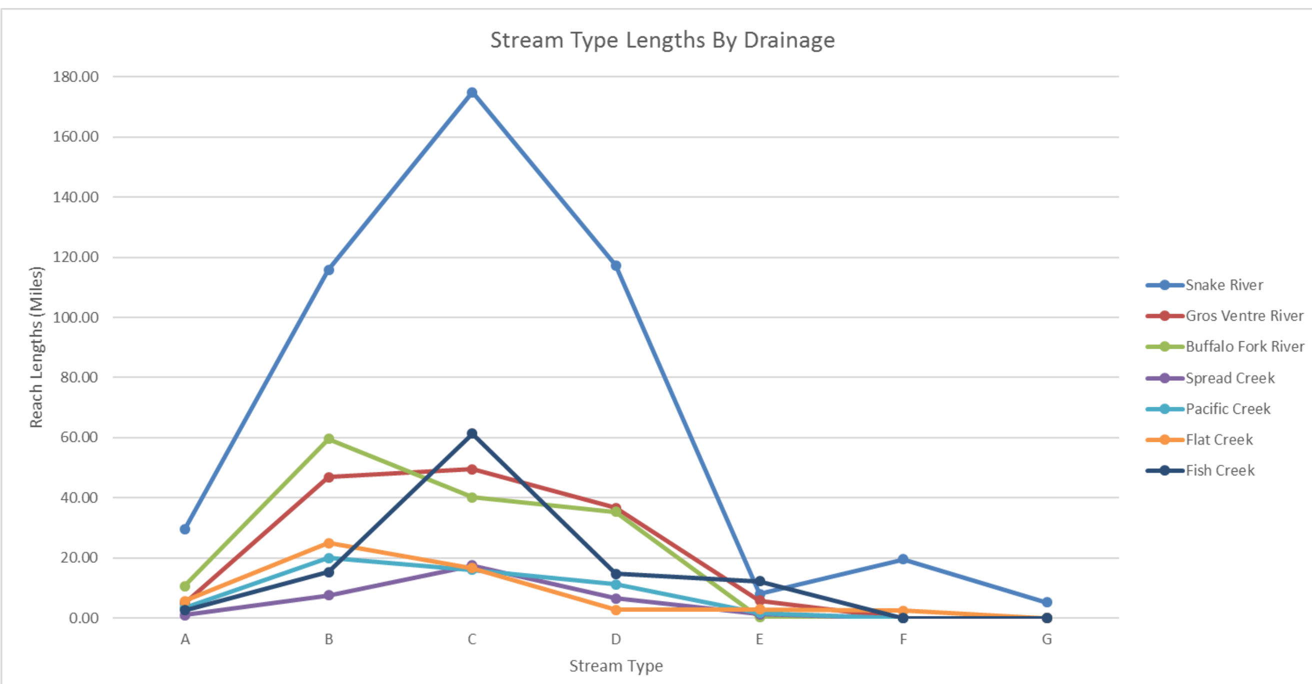


Figure 2.1 8-3 Stream Type Length (Miles) by Drainage

Snake River Drainage- Within the Upper Snake River watershed, 31 creeks were assessed and are listed below with a total of 224 reaches classified. Results showing the percentage and lengths of stream types for the Upper Snake River watershed are listed in Table 2.1.8-2.

- Arizona Creek
- Basin Creek
- Berry Creek
- Buffalo Fork
- Cascade Creek
- Cottonwood Creek
- Coulter Creek
- Crooked Creek
- De Lacy Creek
- Ditch Creek
- Fall Creek
- Fish Creek
- Forest Creek
- Heart River
- Horse Creek
- Lake Creek
- Leigh Lake
- Lewis River
- Lower Pacific Creek
- Moose Creek
- Moran Creek
- Mosquito Creek
- Pilgrim Creek
- Plateau Creek
- Polecat Creek
- Porcupine Creek
- Sheffield Creek
- Spring Creek
- Snake River
- Stewart Draw
- Wolverine Creek

Table 2.1.8-2 Upper Snake River Stream Type Percentage and Length

Snake River Drainage		
Stream Type	Percentage	Stream Length
A	15	29.4
B	30	115.9
C	29	175.0
D	18	117.3
E	3	8.0
F	3	19.6
G	2	5.2
Total	**100**	**470.4**

The northern portion of the Upper Snake River watershed consists of its truest headwaters that arise in the southern part of Yellowstone National Park. A majority of the tributaries enter the watershed from the north by feeding Jackson Lake. In the most northern portions of these tributaries the channels were observed as types A and B. As the reaches neared the lake in the flattened, less confined valleys, more Type C, D and F channels were documented. Photo 4 is where the Snake River was field-verified as a Type F stream.

The Level I stream classification is a very high-level and generalized classification. Various sites were field verified as possible to validate the Level I classification. Details that are not apparent from the aerial photos were observed in the field. Field verified sites were assessed by utilizing primary methods as described by the paper “Stream Channel Reference Sites: An Illustrated Guide to Field Technique” (Harrelson et al 1994).

As shown in Photo 5, Ditch Creek was field-verified as a Type B along this reach at the highway where there is a higher slope although it is classified as a Type C in the Level I classification.

Photo 4 The Snake River at Moose Looking Downstream from the Bridge Entering Moose

Photo 5 Ditch Creek Looking Upstream from Hwy 191

Steeper tributaries observed entering the watershed from the west along the prominent Teton mountain range were primarily Type A, B, and some C channels, which was expected. These more confined, steep reaches are typically associated with Type A and Type B channels. As the channels became less steep and the valleys widened, Type C stream reaches were more evident before dropping into the Snake River.

Pacific Creek Drainage- Within the Pacific Creek drainage five creeks were assessed and are listed below with a total of 31 reaches classified. Results showing the percent and length of stream types for the entire Pacific Creek drainage are listed in Table 2.1.8-3.

- Lower Pacific Creek
- Middle Pacific Creek
- Mink Creek
- Upper Pacific Creek
- Rodent Creek

Table 2.1.8-3 Pacific Creek Stream Type Percentage and Length

Pacific Creek Drainage		
Stream Type	Percentage	Stream Length
A	10	3.5
B	32	20.0
C	32	16.1
D	23	11.2
E	3	1.8
F	0	0.0
G	0	0.0
Total	**100**	**52.5**

In much of the northern portions of this watershed, the slopes are barren with fallen trees from the 1988 fires in the southern section of Yellowstone Park. These fallen trees could be reason for additional sediment/log debris observed and stream types alternating C and D. As seen in Photo 6, logs are still being transported at high flows and deposited from higher reaches to these lower portions. The sediment source from the unstable banks in these reaches is evidence of the distinct, dominant D-type stream in the lower reaches of the watershed. The C reaches are typically associated with widened valleys and flatter slopes where the Type D reaches, being multiple channels, are even wider and flatter. Photo 6 from the field verification shows the stream at this location was indeed a Type D stream.

Photo 6 Pacific Creek Looking Downstream from Hwy 191

Lower Pacific Creek had more consistent, thus flat valley slopes and multiple channels classifying them as Type D. In valleys like these, where Type D streams are dominant, additional bedload from upstream sections have deposited and widened the channel(s). Consequently, multiple channels form causing disequilibrium in the system as seen in this southern portion of the Pacific Creek watershed.

Flat Creek Drainage- Within the Flat Creek drainage seven creeks were assessed and are listed below with a total of 33 reaches classified. Results showing percentage and length of stream types for the entire Flat Creek drainage are listed in Table 2.1.8-4.

- Cache Creek
- Game Creek
- Lower Flat Creek
- Middle Flat Creek
- Nowlin Creek
- Upper Flat Creek
- Wilson Creek

Table 2.1.8-4 Flat Creek Stream Type Percentage and Length

Flat Creek Drainage		
Stream Type	Percentage	Stream Length
A	21	5.7
B	33	24.9
C	21	16.6
D	6	2.7
E	9	2.9
F	9	2.5
G	0	0.0
Total	**100**	**55.3**

This watershed begins with several springs in the Teton National Forest flowing north and west out of the mountains and on to the National Elk Refuge, which sits just north to the Town of Jackson. Once it reaches Jackson, Flat Creek flows south, through town, until eventually emptying into the Snake River.

On its eastern side, this watershed begins with typical Type A reaches in confined, steep valleys. It then flows from them into less steep valleys where they were classified as Type B. The Type B reaches eventually flatten as they exit the canyons and increase in sinuosity turning into Type C and in some areas types E and D. Type E streams are associated with very flat, narrow, deep and highly sinuous channels with broad floodplains. These reaches were classified near flat, agricultural land near the bottom end of the watershed. Type D channels observed were intermittent and dispersed throughout the Upper Flat Creek portion within the watershed. At points, the Type C reaches spread to disperse energy into multiple channels and slowed down forming the random Type D channels.

Gros Ventre River Drainage - Within the Gros Ventre Drainage 10 creeks were assessed and are listed below with a total of 66 reaches classified. Results showing percentage and lengths of stream types for the entire Gros Ventre River drainage are listed in Table 2.1.8-5.

- Gros Ventre River
- Bierer Creek
- Dry Cottonwood Creek
- Kinky Creek
- Lower Crystal Creek
- Lower South Fork Fish Creek
- North Fork Fish Creek
- Redmond Creek
- Slate Creek
- Upper Crystal Creek

Table 2.1.8-5 Gros Ventre Stream Type Percentage and Length

Gros Ventre Drainage		
Stream Type	Percentage	Stream Length
A	9	5.0
B	30	46.9
C	36	49.5
D	18	36.6
E	6	5.8
F	0	0.0
G	0	0.0
Total	**100**	**143.8**

The Gros Ventre River, a main tributary to the Snake River, has headwaters that originate in the Wind River range and meet to flow east, north, west and then finally southwest before joining the Snake River in the Jackson Hole Valley. The gigantic landslide of 1925 and the later lower landslide occurring in 1927 (caused by dam failure) have contributed massive amounts of sediment to the system, therefore, influencing the characteristics of the streams.

This watershed's drainages range within themselves from steep, confined Type A channels to flat, unconfined Type D and E channels. A majority of the south eastern portion of the headwater reaches are mountainous and portray this exactly, whereas the near-end segments were classified as Types C and D.

The more northwestern tributaries have a higher number of reaches meaning their stream classification types (associated with valley types) were changing more frequently.

Fish Creek Drainage- Within the Fish Creek drainage five creeks were assessed and are listed below with a total of 57 reaches classified. Results showing percentage and length of stream types for the entire Fish Creek Drainage are listed in Table 2.1.8-6.

- Cottonwood Creek
- Bacon Creek
- Fish Creek
- Middle South Fork Fish Creek
- Upper South Fork Fish Creek

Table 2.1.8-6 Fish Creek Stream Type Percentage and Length

Fish Creek Drainage		
Stream Type	Percentage	Stream Length
A	7	2.5
B	25	15.3
C	39	61.3
D	18	14.8
E	12	12.3
F	0	0.0
G	0	0.0
Total	**100**	**106.2**

The Fish Creek drainage area includes part of the southern extent of the Teton Range and the southwestern portion of the Snake River Valley. The geology of the Teton Range, which has a north-south trending fault-block, and Fish Creek which flows parallel to the southern extent of this Teton fault, presents this area with a unique landscape. However, because of this fault, investigations have been conducted throughout the area to try and explain seepage issues within the Fish Creek watershed (Wheeler and Eddy-Miller 2005).

The steeper tributaries, in the most western portion of the Fish Creek drainage, along the prominent Teton mountain range, were, upon observation (not classification), primarily Type A and B channels. Aside from Lake Creek having a few confined reaches classified as Type B, both Lake Creek and Fish Creek flow primarily over very flat and wide landscapes with reaches classified as Type C, D, E, and F. Photo 7 is an upstream picture of Lake Creek classified and field-verified at this location as a Type C stream. Mostly, the Type F channels flow through developed areas where the stream was wide and flat and had zero accessibility to its floodplain. In contrast, the Type E channels were narrower and deeper and appeared to have access to their floodplains.

Photo 7 Lake Creek Looking Upstream at the Bridge on Moose Wilson Road

Spread Creek Drainage- Within the Spread Creek drainage three creeks were assessed and are listed below with a total of 11 reaches classified. Results showing percentage and lengths of stream types for the entire Spread Creek drainage are listed in Table 2.1.8-7.

- North Fork Spread Creek
- Skull Creek
- South Fork Spread Creek

Table 2.1.8-7 Spread Creek Stream Type Percentage and Length

Spread Creek Drainage		
Stream Type	Percentage	Stream Length
A	9	1.0
B	36	7.6
C	27	17.4
D	18	6.5
E	9	1.2
F	0	0.0
G	0	0.0
Total	**100**	**33.8**

The Spread Creek drainage is located east of the Town of Jackson and flows into GTNP draining parts of Togwotee Pass and the Teton Range. Historically, a dam designed to divert water to the Elk Ranch Reservoir for pasture irrigation to graze cattle inside the national park was located on Spread Creek. A recent project by TU removed the dam for fish passage and consequently the stream is again seeking equilibrium.

Reaches classified in the north and south forks of the drainage began in confined, steep valleys primarily flowing from the east, which were classified as Type A and B. As the streams entered the lower, less confined valleys they flattened, allowing them more access to flood plains and were observed as Type C and Type D channels (larger single and multiple-threaded channels respectively). To the west, smaller Type E and B channels drained flat, high-plain areas of this portion of the Teton Range. In Photo 8, Spread Creek shows the abundance of sediment the watershed contributes to the system. At this location, the Type D stream was field-verified.

Photo 8 Spread Creek Looking Upstream from Right Bank on Highway 191 Bridge

Buffalo Fork Drainage - Within the Buffalo Fork drainage 10 creeks were assessed and are listed below with a total of 91 reaches classified. Results showing percentage and length of stream types for the entire Buffalo Fork drainage are listed in Table 2.1.8-8.

- Blackrock Creek
- Box Creek
- Cub Creek
- Lava Creek
- Lower Buffalo Fork
- Lower South Buffalo Fork
- North Buffalo Fork
- Soda Fork
- Upper Buffalo Fork
- Upper South Buffalo Fork

Table 2.1.8-8 Buffalo Fork Stream Type Percentage and Length

Buffalo Fork Drainage		
Stream Type	Percentage	Stream Length
A	15	10.6
B	35	59.6
C	29	40.1
D	20	35.4
E	1	0.2
F	0	0.0
G	0	0.0
Total	**100**	**145.9**

Beginning in the Teton wilderness in BTNF, the Buffalo Fork has the highest drainage in the Jackson Hole area and drains a majority of the land around Togwotee Pass. Its north and south branches both originate immediately west of the Continental Divide coming together to travel southwest into GTNP, emptying into the Snake River near Moran, Wyoming. Photo 9 of Lava Creek shows the tributary before it enters the Buffalo Fork.

Photo 9 Lava Creek Looking Downstream from the Bridge on Highway 191

Photo 10 Buffalo Fork Looking Downstream at the Highway 191 Bridge

The Buffalo Fork drainage is comprised of its many smaller watersheds, all containing headwaters in steep, confined valleys where the Type A and Type B channels were observed and documented. In each watershed, even the Blackrock Creek watershed (where the highway parallels Blackrock Creek), the valleys become less confined allowing for floodplain accessibility. In turn, the stream reaches were primarily observed as B and C channels with a few Type D's (multiple channels) dispersed throughout. Photo 10 is the Lower Buffalo Fork off Highway 191 where it was classified as a C type channel in the Level I classification and it was field-verified as such.

The following photos of Blackrock Creek give a good representation of the current state of the stream near the Blackrock Creek ranger station. As seen in Photo 11, lateral migration has increased near bank stress during high-flow periods. Decreasing the width-to-depth ratio of this bend and using an upstream headgate and ditch (to alleviate substantial flows against the dike to the right) would be a consideration to protect the ranger station. Photo 12 shows the existing headgate and left bank dike protecting high flows from reaching the ranger station.

Photo 11 Blackrock Creek above the Blackrock Creek Ranger Station

Photo 12 Blackrock Creek Headgate above Blackrock Creek Ranger Station

2.2. Land Uses and Activities

Land use throughout the Upper Snake River watershed is dependent upon many factors including elevation, precipitation, and land ownership (WSGS 2014). The Upper Snake River watershed consists of approximately 1,773,615 acres within the four counties of Fremont, Lincoln, Sublette, and Teton, Wyoming.

2.2.1. Land Ownership

As listed in Table 2.2.1-1, most of the watershed is either state or federal public land. Less than approximately 4 percent is privately owned. Map 18, Land Ownership, illustrates the extent of land ownership within the watershed including that which is privately or federally owned. Much of the privately owned land is used for agriculture. Grazing is typical in the foothills and rangelands (WSGS 2014).

Table 2.2.1-1 Study Area Land Ownership

Landowner	Acres	Estimated Percentage (%) of Total Acres
Federal		
Bureau of Land Management (BLM)	1,014	<1
National Park Service (NPS) National Park/ Monument	581,580	33
U.S. Forest Service (USFS) National Forest	1,093,401	62
U.S. Fish and Wildlife Service (USFWS) National Wildlife Refuge	24,852	1
State	7,257	<1
Private	63,862	4

The Upper Snake River watershed is also unique in the amount of land set aside for conservation easement. Conservation easements protect land for future generations while allowing owners to retain many private property rights and to live on and use their land, at the same time potentially providing them with tax benefits. In a conservation easement, a landowner voluntarily agrees to sell or donate certain rights associated with his or her property – often the right to subdivide or develop – and a private organization or public agency agrees to hold the right to enforce the landowner's promise not to exercise those rights. In essence, the rights are forfeited and no longer exist (The Nature Conservancy 2016). In Jackson Hole, the Jackson Hole Land Trust (JHLT), is a private, nonprofit organization that was established in 1980 to preserve open space and the critical wildlife habitat, magnificent scenic vistas, and historic ranching heritage of Jackson Hole. By working cooperatively with the owners of the area’s privately owned open lands, the JHLT has ensured the permanent protection of over 25,000 acres in and around Jackson Hole and the greater Yellowstone area. Map 19, Conservation Easements and Recreational Trails, illustrates the land set aside for conservation easement. Many of the corridors are also used for recreational trails and are also illustrated on the map.

2.2.2. Grazing Management and Range Conditions

2.2.2.1 Grazing Allotments/Leases

Federal Grazing Allotments

The BLM and BTNF grazing allotments encompass less than 1 percent (approximately 108,638 acres) of the land within the study area (Map 20, Active Grazing Allotments). The BLM and BTNF allotment numbers and names are provided in Tables 2.2.2-1 and 2.2.2-2. Among the full suite of grazing management guidelines, those most applicable to this watershed study are summarized as follows:

- Ensure that conditions after grazing use will support infiltration, maintain soil moisture storage, stabilize soils, release sufficient water to maintain overall system function, and maintain soil permeability rates and other appropriate processes.
- Restore, maintain, or improve riparian plant communities to sustain adequate residual plant cover for sediment capture and groundwater recharge.
- Implement riparian improvements (e.g., instream structures, water troughs, etc.) to maintain or enhance appropriate stream channel morphology; develop springs, seeps, reservoirs, wells, or other water development projects in a manner protective of watershed ecological and hydrological functions; and implement range improvements away from riparian areas to avoid conflicts in achieving or maintaining riparian function.
- Adopt management practices and implement range improvements that protect vegetative cover and thereby maintain, restore, or enhance water quality.

Table 2.2.2-1 Listing of BLM Grazing Allotments

Allotment Name	Allotment Number	Acres
Walton Ranch	12210	320
Porter Est SR No 2215	12215	72
Porter Est SR No 3	12214	61
Snake River Lease	12224	90
TOTAL		**543**

Table 2.2.2-2 Listing of BTNF Grazing Allotments

Allotment Name	Allotment Number	Acres
Big Cow Creek	40098	10,652
Granite Creek	4003	24,582
Leeks Canyon	4076	1,555
Lower Slide Lake	40102	39
Miners Creek	40092	9,763
Munger Mountain	4007	14,610
Porcupine/Squaw Creek	4008	3,241

Allotment Name	Allotment Number	Acres
Red Rock Ranch	40096	109
Redmond/Bierer Creek	40100	7,113
Robinson Ranch	40097	200
Spotted Horse	4074	957
Taylor	40101	89
Upper Gros Ventre	40095	35,183
TOTAL		**108,093**

An Environmental Impact Statement (EIS) was completed for areas within the Snake River Resource Management Plan (RMP; BLM 2003) to evaluate alternative land use plans for the public lands and resources administered by the BLM. The result will be used as the basis for an RMP that resolves the resource land use issues associated with current management and that provides direction for site-specific activity planning and implementation of management actions in the future. The EIS included the following items that directly relate to this watershed study:

- Rotate livestock season of use in riparian areas to increase rush, sedge, shrub, and tree canopy cover.
- If the desired condition of a specific riparian area includes increasing willow cover or cottonwood density, manage livestock to improve riparian woody species.
- Manage livestock use through control of time/timing and duration/frequency of use in riparian areas and wetlands to maintain or improve long-term stream health.
    - Exclude livestock from riparian areas and wetlands that are not meeting or moving toward desired condition objectives where monitoring information shows continued livestock grazing would prevent attainment of those objectives.
    - Decrease livestock congregation in riparian areas and adjust livestock grazing distribution in areas of concern through appropriate analyzed management options.
- Keep stock tanks, salt supplements, and similar features out of the water influence zone if practicable and out of riparian areas and wetlands always. Keep stock driveways out of the water influence zone except to cross at designated points. Armor water gaps and designated stock crossings where needed and practicable.

In addition to the federal grazing allotments on BLM and BTNF land, according to the NPS, there are five private ranches that have livestock grazing privileges at GTNP. The private ranches include Triangle X Dude Ranch, Moosehead Ranch, Pinto Ranch, Teton Valley Ranch and Taylor Ranch. The ranches share the natural resources with park wildlife including a herd of over 850 wild bison. The Pinto Ranch, a park in-holder with a grandfathered grazing allotment, recently shifted out of Pacific Creek onto the Elk Ranch due to grizzly bear activity (JHNG 2014b).

State Grazing Leases

Most of the state lands within the study area are leased to private landowners for grazing. These leases are typically issued by the Board of Land Commissioners and administered by the Office of State Lands and Investments. Grazing management, practices, and improvements on state lands are usually established and implemented by the lessee. Improvements are normally paid for and owned by the lessee with reimbursement by the new lessee upon transfer of the lease.

Grazing on Private Lands

Grazing practices on private lands are established by the landowner, often with technical assistance from the local NRCS staff and/or a range consultant. Range improvement projects implemented under an NRCS program follow the guidelines established in the plan of operations developed for the property and/or applicable NRCS technical guidelines as adapted for local conditions.

2.2.2.2 Ecological Site Descriptions

The potential capabilities of grazing resources are best understood when landscape units with homogenous growing conditions – such as precipitation, soils, slope, and geomorphic nature – are identified and separated from each other. These units (known as ecological sites) are included in the NRCS Electronic Field Office Technical Guides (eFOTGs) for Fremont, Lincoln, Sublette, and Teton counties. These eFOTGs are available online at the following website: http://www.nrcs.usda.gov/technical/efotg/. (USDA 2016c)

ESDs are grouped by precipitation zones and a total of seven ecological sites are applicable for the Upper Snake River watershed. As an example, a copy of the most prevalent ESD for this watershed is MLRA 43B, Site Type: Rangeland, Site Name: Subirrigated [Sb] 15 inches to 19 inches Central Rocky Mountains, 303 acres. It is included in Appendix B, Ecological Site Description. The ESD addresses the full range of physiographic and climatic features that influence water features, representative soil features, plant communities, wildlife interpretations, grazing interpretations, hydrology functions, recreational uses, and other factors relevant to the site type. NRCS staff can assist in identifying the applicable ESDs to a given area, and the ESDs can then be easily downloaded in PDF format from the previously cited website.

Only a portion of the Upper Snake River watershed has the detailed soil mapping needed to complete the associated ecological site assessments. Map 21, Ecological Sites, illustrates these areas, and Table 2.2.2-3 lists the five ecological sites occurring within the study area and are summarized by acreage. Since the ESD datasets are limited, evaluating potential grazing and forage production in locations other than areas near the Snake River and its confluence with Gros Ventre River is limited.

Table 2.2.2-3 Ecological Sites within the Study Area

Ecological Site Name	Approximate Acreage
Coarse Upland (15-19W) and (20+)	14,494
Gravelly (15-19W)	32,864
Loamy (15-19W)	73,510
Shallow Loamy (15-19W)	5,509
Steep Stony (15-19W)	5,321
Subirrigated (15-19W)	34,403
Wetland (15-19W) and (20+)	18,081
Ecological Classification Not Defined	1,589,506

Generally, the majority of acreage that has or can be mapped with ecological site assessments falls within the loamy and subirrigated ecological sites. In these areas, soils typically consist of deep loamy, poorly to well-drained soils with good percolation capability. The response of forage production in these areas is good during normal years, and it is typically enhanced with irrigation during dry years.

The Upper Snake River watershed includes two precipitation zones: 15 inches to 19 inches; and 20+ inches. These are shown in parentheses after the title of the ecological site in Table 2.2.2-3. Using the ESD to compare what is growing on rangeland sites with what each site is capable of supporting allows the relative health (ecological condition) of the range resource to be evaluated. Forage production of each site is closely related to the ecological condition of the site. Watershed values also are tied to the condition class. For example, areas with reduced ground cover have greater potential for limited infiltration and increased runoff; similarly, degraded sites may have soils with reduced organic content and consequently degraded soil structure, which likewise limits moisture infiltration and holding capacity.

2.2.2.3 Range Conditions

Good range management assures that adequate vegetative cover – that being the portions of stem and leaf matter above the ground – remains after authorized livestock grazing. Through good range management practices, the remaining vegetation will promote and support good infiltration of precipitation, maintaining soil moisture storage for release to ecological functions such as wetlands, stream flow, and plant production to maintain ecosystem function.

Photo 13 Allotment on Elk Ranch, Grand Teton National Park

Well-distributed livestock water sources are critical for effective grazing management control. Evaluations of range condition on a particular property can be used to identify areas that will benefit from a plan to adjust exposure to grazing, and therefore improve more nutritious and productive species. However, such plans inevitably require that an area be possessed of water in close proximity to encourage livestock to stay rather than leave for water.

As drainage ways are often the location of available water, livestock pressure in these areas is often disproportionately great. With dispersal of livestock watering sources to uplands, not only are riparian areas relieved of grazing and trampling pressure, but little-used forage on remote uplands may also be accessed by foraging animals.

Fundamentals of science-based range management revolve around the health of individual range plants. The degree to which the plants are allowed access to their basic needs determines their overall well-being and their ability to produce usable forage. That usable forage is at once the sought-after product and the means by which future plant production is enabled. The aboveground portions of range plants are the means by which carbohydrates are produced. Some amount of this production must be reserved to enable growth of new photosynthetic parts (leaves and stems) in future years. Defoliation – which removes the plant's capacity to produce these carbohydrates – has also been proven to diminish the capacity of range plants to renew growth in future seasons. The objective of range management is to balance grazing use (defoliation) with allowing growth of the range plants. This balance is not usually possible merely by adjusting the number of animals continuously present on a pasture. Rather, the balance is struck by limiting the exposure to defoliation and by leaving the plants and their photosynthetic parts at rest for planned periods. Length of rest from defoliation is important, but the timing of the harvest is also highly influential in encouraging (or discouraging) long-term plant health, depending on the plant species.

Ultimately, improved health of perennial range plants with greater ground cover and average overall height will tend to enhance snow-catch in winter and reduce surface water runoff during melt out and rain events. The latter tends to enhance soil moisture infiltration, which feeds back to improved plant growth and more firmly controlled competitive advantage by these desirable plants, with resulting improved resistance to weed invasion. Enhanced soil moisture infiltration also increases the likelihood that moisture will pass through the soil and into groundwater and may support more continuous moisture supply to riparian and swale sites.

Range management in recent times has also come to incorporate concern with wildlife habitat conditions. Rested rangeland vegetation mosaics may enhance availability of forb buds, flowers, and fruits and seeds highly sought after by many wildlife species. Greater plant height and cover in general offers improved habitat for native insect and arachnid populations that birds especially find necessary. The alternative water resources improvements presented in this report will achieve their highest and their most durable positive effects in conjunction with well-reasoned range management planning that directs and times livestock activities in accordance with range plant health.

2.2.3. Oil and Gas Production

Wyoming has large reserves of oil and natural gas that lie under fault-bounded Laramide basins. In fact, Wyoming ranks fifth nationwide in natural gas production and eighth in oil production (Lynds and Toner 2015). The oil and gas industry experiences pricing highs and lows which affect the production, employment, and statewide economy. In order to boost oil production, Wyoming continues to expand horizontal drilling and hydraulic fracturing in certain basins (Lynds and Toner, 2015). The Upper Snake River watershed differs dramatically from the rest of the state in that there is no active oil and gas production in the study area. One inactive gas well, known as Sohare, is located within the Upper Snake River watershed; it last produced gas in 1978 (Map 22, Oil/Gas, Coal Potential and Pipelines). Oil and gas production in the surrounding area is very limited as well. A gas well, Game Hill, is located just south of the watershed boundary, and the oil field near Dubois is located east of the watershed boundary. The Dubois oil field includes eight oil wells.

Table 2.2.3-1 lists the amount of oil, gas, and water produced during oil and gas production in Wyoming with the counties located within the basin (Fremont, Sublette, and Lincoln) highlighted for emphasis. Teton County, which makes up the majority of the basin, is not present in the table because the last time oil/gas was produced from this well was in 1978. Fremont, Sublette, and Lincoln counties alone account for less than 14 percent of the total crude oil production in Wyoming in 2014 but nearly 60 percent of the state's total natural gas production (WSGS 2016d). Although Fremont, Sublette, and Lincoln counties extend well beyond the boundaries of the watersheds, the data in Table 2.2.3-1 is useful for comparing orders of magnitude of oil, gas, and water production in the state.

Table 2.2.3-1 2014 Oil and Gas Production Summary

County	Producing Wells	Total Year Oil/BBLS*	% State Oil Total	Total Year Gas/MCF**	% State Gas Total	Total Year Water/BBLS	% State Water Total
Albany	33	66,904	0.1	5,208	0.0	7,277,725	0.4
Big Horn	463	1,584,555	2.1	2,046,618	0.1	178,203,484	8.9
Campbell	6,210	18,820,087	24.7	101,645,444	5.1	220,622,014	11.1
Carbon	1,942	1,351,842	1.8	103,318,425	5.2	97,936,472	4.9
Converse	1,199	12,832,853	16.9	36,304,729	1.8	11,850,867	0.6
Crook	520	1,354,076	1.8	30,949	0.0	32,303,166	1.6
Fremont	1,236	3,824,927	5.0	147,562,096	7.4	184,483,201	9.2
Goshen	6	2,997	0.0	17,576	0.0	832	0.0
Hot Springs	691	2,504,515	3.3	456,658	0.0	239,272,248	12.0
Johnson	3,924	1,735,954	2.3	169,179,233	8.5	111,191,815	5.6
Laramie	223	3,808,137	5.0	2,615,483	0.1	4,165,675	0.2
Lincoln	1,372	391,128	0.5	52,262,165	2.6	653,982	0.0
Natrona	1,577	5,638,223	7.4	12,179,979	0.6	166,787,453	8.4
Niobrara	278	1,068,977	1.4	750,847	0.0	14,510,476	0.7
Park	1,267	6,687,656	8.8	9,624,264	0.5	586,928,162	29.4
Platte	2	192	0.0	926	0.0	501	0.0
Sheridan	1,085	31,554	0.0	11,108,499	0.6	49,318,057	2.5
Sublette	5,948	6,269,097	8.2	997,813,906	49.9	25,745,482	1.3
Sweetwater	3,702	5,887,010	7.7	251,217,387	12.6	44,378,629	2.2
Uinta	437	784,545	1.0	96,930,531	4.9	1,692,605	0.1
Washakie	335	735,879	1.0	1,720,606	0.9	11,292,675	0.6
Weston	1,207	755,981	1.0	1,714,593	0.9	6,287,089	0.3
County Totals	33,657	76,137,089		1,998,506,122		1,994,902,610	
Source: Wyoming Oil and Gas Conservation Commission (www.wogcc.state.wy.us)							

*BBLS = barrels
**MCF = million cubic feet

2.2.4. Mining and Mineral Resources

Rock exposures throughout Wyoming make it an excellent place to collect minerals including gemstones, industrial minerals, and metals (WSGS 2016b). Wyoming is the most prolific coal-producing state in the union, supplying 40 percent of U.S. domestic supply of coal in 2014 (WSGS 2016b). In fact, Wyoming produces more coal than the next six coal-producing states combined, including West Virginia, Kentucky, Pennsylvania, Illinois, Texas, and Montana (WSGS 2015). Wyoming coal ranges were originally deposited as freshwater peat swamps along the western shoreline of the Cretaceous Interior Seaway (WSGS 2015). More detailed information on Wyoming coal production can be found online at http://www.wsgs.wyo.gov/energy/coal (WSGS 2016c). The nearest active coal mine to the study area is the Grass Creek, about 90 miles east of Jackson Lake in Park County. Although no active coal mines exist in the study area, data from the WSGS indicates that nearly 520,000 acres of land, stretching across Jackson Hole and the southwestern portion of the watershed, have potential for coal production (Map 22, Oil/Gas, Coal Potential and Pipelines). Also, two known coal outcrops are within the Upper Snake River watershed. These are located near the southeastern border of the watershed along the border of Teton and Fremont counties.

2.2.5. Other Minerals

No mineral mines are located within the Upper Snake River watershed. There is, however, the potential for mineral production. Map 23, Mineral Potential, delineates the locations of gypsum, bentonite, limestone, phosphorus, and oil and gas potential in the study area. A list of the minerals with subsequent acres and percentage of the watershed can be seen in Table 2.2.5-1.

Table 2.2.5-1 Upper Snake River Watershed Mineral Potential Summary

Mineral	Area (acres)	Study Area (%)
Gypsum	23,168	28.4
Bentonite	51,071	8.8
Limestone	102,876	3.8
Phosphorus	395,493	0.15
Oil and Gas Field	694,330	4.8

2.2.6. Transportation and Energy Infrastructure

The only major pipeline that runs through the Upper Snake River watershed is a natural gas pipeline (Map 22, Oil/Gas, Coal Potential and Pipelines). The pipeline is owned by Lower Valley Energy and runs along Highway 189 south of Jackson. There are no major electrical transmission lines and no active railroads.

3. WATERSHED INVENTORY

The second part of a Level I watershed study is to provide an inventory of water development. The following sections provide this inventory as gathered from the cited sources and accompanying maps. The features inventoried incorporate the priorities of the WWDC watershed planning process and have been subdivided into irrigation, groundwater, and surface water. Because of the importance of wetlands in this watershed, their distribution and function is highlighted in this section. Finally, water development is only effective if the water is of good quality and, therefore, the portion of this section addresses water quality in the Upper Snake River watershed.

It is not within the scope of a Level I watershed study to evaluate projected water use since projections of this type are completed as part of WWDC's river basin planning process. However, it is important to understand the future demand on water resources in this watershed planning document and for this reason, several of the major conclusions of the latest Snake/Salt River Basin Plan Update are provided here (WWDC 2014):

- The Snake/Salt River Basin population is predicted to grow over the 20-year planning period from 2012 to 2032. Growth is likely due to the strength of tourism and second home development and the associated growth in the service industries. Increases in groundwater use will accompany the growth in population, since municipal and rural domestic water uses are supplied from groundwater.
- Surface water use is estimated to decrease in the Snake River area since the number of irrigated acres would likely decrease as agricultural lands are converted to other uses, reducing surface water use.
- Industrial water use is projected to remain a minor use in the basin over the 30-year planning period.
- Environmental and recreational water uses are non-consumptive but are important uses because of the basin's dependence on environmental aesthetics for tourism, outdoor recreation and second home development. These uses will generally remain constant because of the protection afforded environmental and recreational water uses in much of the basin. However, some conflicts could develop if irrigated acres increase, if access to lands and stream segments decreases as parcels are developed, or as an increasing population drive greater demand for environmental and recreational water uses. This could change stream segments that currently have the status of complementary water uses to having competing water uses.

3.1. Irrigation Inventory

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way the soils respond to management. The criteria used in grouping the soils do not include major – and generally expensive – land forming that would change slope, depth, or other characteristics of the soils, nor do they include possibly but unlikely major reclamation projects. Capability classification is not a substitute for interpretations that show suitability and limitations of groups of soils for rangeland, for woodland, or for engineering purposes. Map 24, Irrigated Land Capability Classes, shows the suitability of the soils across the study area for field crops. Land capability data is not available for all of the watershed.

Agricultural water uses consume more water than any other use in the Snake/Salt basin (Sunrise Engineering 2003). Nearly two-thirds of the agricultural land in Teton County is pastureland, and 76 percent of agricultural sales are livestock sales. In 2012, the livestock inventory for the county was 2,860 cattle and calves, which means Teton County ranked 23rd out of 23 counties in the state for cattle inventory (USDA 2012).

Class I soils have few limitations that restrict their use. Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices. Class III soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both. Class IV soils have very severe limitations that reduce the choice of plants or that require very careful management, or both. Class V soils are subject to little or no erosion but have other limitations, are impractical to remove, or that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat. Class VI soils have severe limitations that make them generally unsuitable for cultivation and that restrict their use mainly to pasture, rangeland, forestland, or wildlife habitat. Class VII soils have very severe limitations that make them unsuitable for cultivation and that restrict their use mainly to grazing, forestland, or wildlife habitat. Class VIII soils and miscellaneous areas have limitations that preclude commercial plant production and that restrict their use to recreational purposes, wildlife habitat, watershed, or aesthetic purposes.

Table 3.1-1 shows that all of the soils that have been mapped in the watershed area are Class IV or higher, indicating that soils have limitations for use other than for pasture and rangeland and wildlife habitat. The percentages do not add up to 100 because there is not data for the entire watershed. Map 25, Irrigated Land, shows locations of land that is currently irrigated, with an estimated 24,626 irrigated acres in the watershed. Generally, pasture or range areas with native or adapted grasses and forbs will typically do well with normal precipitation. On a localized basis, irrigation requirements are very site-specific and depend on localized drainage, localized micro-climates, soil types, and more.

Table 3.1-1 Irrigation Class Distribution in the Study Area

Irrigation Capability	Acres	Percentage of Total Watershed
Class I	0	0
Class II	0	0
Class III	0	0
Class IV	101,448	6
Class V	16,488	1
Class VI	118,334	7
Class VII	41,305	2
Class VIII	11,147	1
Water	33,368	2

3.2. Groundwater Development Inventory

Based on the WSEO's March 2015 database, there are approximately 3,076 supply wells that are fully adjudicated and in good standing in the Upper Snake River watershed. The primary uses of the wells are listed in Table 3.2.1-1 and are illustrated in Map 26, Groundwater Registered Well Inventory. As listed in the table, domestic wells are the most numerous water wells in the watershed. Additionally, there are 642 monitoring and test wells in the watershed that are not illustrated in Map 26 since they are not water-production wells.

Map 27, Groundwater Registered Well Yield, and Map 28, Groundwater Registered Well Depth, illustrate the well yields and completion depths of the registered wells in the Upper Snake River watershed. This information is useful in reviewing additional opportunities to install wells. A more detailed geologic evaluation would be needed before a well construction project could be initiated, but information on well depth and yield can provide preliminary information on the productivity and installation costs of proposed new wells.

Table 3.2.1-1 Registered Well Use in Upper Snake River Watershed

Well use	Registered Wells	Percentage of Total
Domestic	2,120	69
Miscellaneous	799	26
Stock Watering	97	3
Irrigation	46	1
Municipal	8	<1
Industrial	6	<1
Total	3,076	100%

3.3. Water Storage Site Inventory

In many ways, the Upper Snake River Level I watershed study differs from Level I studies completed across the state of Wyoming. One of the main reasons for this difference is because development of additional surface water storage opportunities was not a key objective of this Level I study. Rather, the investigation of large water storage reservoirs was specifically identified as **not** being desirable. Developing fire suppression drafting sites and potential storage for southern Jackson and Snow King Mountain were identified by the sponsors as opportunities. To create additional storage, both storage needs and potentially available water must be evaluated. The volume of storage needed for potential projects is small relative to other types of projects such as reservoirs. The following sections discuss the potentially available water, existing reservoirs, and previous water storage investigations.

3.3.1. Snake River Compact

As described in the 2012 Snake/Salt River Basin Plan Update (WWDC 2014), the Snake River Compact, was negotiated by representatives of both Idaho and Wyoming with participation by a representative of the United States. It was signed on October 10, 1949 and ratified by the two states and by an act of Congress in 1950. The Compact divides the waters of the Snake and Salt River watersheds between the states of

Idaho and Wyoming. The compact recognizes, without restriction, all existing water rights in Wyoming and Idaho established prior to July 1, 1949. It permits Wyoming unlimited use of water for domestic and stock watering purposes, providing stock water reservoirs do not exceed 20 acre-feet in capacity. The Compact allocates to Wyoming, for all future uses, the right to divert or store four percent of the Wyoming-Idaho state line flow of the Snake River. Idaho is entitled to the remaining 96 percent of the flow. The use of water is limited to diversions or storage within the Snake River drainage basin unless both states agree otherwise. The Compact also provides preference for domestic, stock and irrigation water use over storage for the generation of power.

The historical perspective of this seemingly “un-equitable” division of water was the fact that the majority of the existing and potential future use of water was in Idaho. In 1949, the lack of arable land for irrigation and the high percentage of federal land (national parks, national forests and wildlife reserves) in the Wyoming portion of the Snake River Basin were factors in the negotiations.

One unique aspect of the Snake River Compact, compared to other compacts to which Wyoming is a party, is a requirement that calls for Wyoming to provide Idaho replacement storage for one-third of any usage after the first two percent is put to beneficial use. Early estimates of these replacement storage quantities, based upon the average state line flow, are 33,000 acre-feet (WWDC 2014).

3.3.2. Surface Water Availability and Shortages

Surface water availability was evaluated for the Snake/Salt River Basin Plan Final Report (Sunrise Engineering 2003). Three 12-month spreadsheet models were developed to represent dry, average, and wet year stream flows. The study period for the Snake River was 1971 through 2001. Annual physically available flow was determined for the three scenarios. Constraints of the Snake River Compact were then applied to reduce the physically available water to an estimate of physically and legally available water.

In 2012, the WWDC updated the Snake/Salt River Basin plan and issued the final report in November 2014 (WWDC 2014). The surface water availability models were updated to the study period of 1971 through 2010. The report and technical appendices that accompany the 2012 Snake/Salt River Basin Plan Update provide great detail on how the data was developed and how the modeling was done. The models themselves were updated to a Microsoft Office database model that involves macros and queries to calculate the dry, average, and wet year hydrologic data and surface water availability. The physically available water was adjusted for Jackson Lake operations, instream flow requirements, and compact limitations. Available flow at the Wyoming/Idaho state line in the entire Snake River watershed was determined to be as follows:

- Dry year: 75,949 acre-feet
- Average year: 114,885 acre-feet
- Wet year: 167,416 acre-feet

According to historic maps and data on the U.S. Drought Monitor website, Teton County experienced droughts of severe intensity in 2002, 2003, 2004, 2007, and 2010 (US Drought Monitor 2016). The updated models would have incorporated any impacts of these drought years. Since the update study period, portions of Teton County experienced moderate droughts in August 2012 through December 2012 and in August 2013 through February 2014. One of the main objectives of developing the hydrology and surface water availability is to be able to evaluate the feasibility of large reservoirs. Since large reservoirs will not be evaluated as part of this Level I study, and since the drought years were incorporated during the 2012 update, there would be little value in updating the surface water availability models for this study. For these reasons, the WWDC project manager was in agreement that the models did not require updating as part of this Level I study.

3.3.3. Existing Reservoirs

As discussed in Section 2.1.7.2, Map 13, National Inventory of Dams, shows the locations of the study area's seven dams in the National Inventory of Dams, with an eighth, Grassy Lake, immediately northwest of the study area. The combined storage behind the identified dams is 890,840 acre-feet, with the majority of the storage occurring in Jackson Lake, which has 872,700 acre-feet of volume. Grassy Lake and Jackson Lake are both owned by the U.S. Bureau of Reclamation. The primary purpose of Jackson Lake is to serve as a flood control reservoir, with many secondary purposes. Irrigation, fish and wildlife, recreation, and debris control are the primary purposes of the other reservoirs. Dams that do not fall under the jurisdiction of the WSEO were not included in the database. Data Summary 2.1.7-3 in Appendix A lists the dams included in the database, along with select relevant information. Map 14, Stock/Wildlife Ponds, shows the location of 454 stock ponds in the study area.

After construction of Jackson Lake Dam in 1911, flow of the Snake River was controlled below the lake. This control was generally exercised to the benefit of farmers located downstream in Idaho. Peak flows that would have spilled from the lake were held back for use later in the growing season. However, management of the flow for optimal use by farmers does not necessarily mean that the flow will be suited for fish and/or recreational use in the river. Drought in the 1980s compounded the concern of flows for fish populations and led to negotiations regarding storage, release, and operations at Palisades Reservoir and Jackson Lake to the benefit of both the state of Wyoming and the state of Idaho. ***As a result of the negotiations, the WSEO and the WGFD now have semi-annual meetings with the U.S. Bureau of Reclamation, called the Snake River Agency meetings, regarding operations of the reservoir facilities (WWDC 2014).***

3.3.4. Previous Storage Site Investigations

The 2003 Snake/Salt River Basin Plan identified only one storage site/reservoir project in the short list of future water use opportunities (Sunrise Engineering 2003). The project was construction of Cottonwood Creek Reservoir on the Gros Ventre River in southeastern Teton County in Section 35, Township 42 North, Range 112 West. No additional details were provided other than the purpose of the reservoir would be for irrigation. The 2012 Snake/Salt River Basin Plan Update did not include any additional storage or future water use opportunities (WWDC 2014).

3.4. Wetland Inventory and Function

Wetlands can provide many functions, including wildlife habitat, flood flow alteration, erosion control, sediment capture, nutrient transformation, groundwater recharge/discharge, habitat for rare species, and recreational opportunities. An individual wetland may provide some but not all of these functions, depending on variables such as size, hydrologic regime, location in the landscape, connectivity to other wetlands, and surrounding land use. Thus for the Upper Snake River watershed, it is only possible to generalize about wetlands and their functions and not discuss the functions of individual wetlands.

The locations of the Upper Snake River watershed wetlands were mapped as part of the National Wetlands Inventory (Map 15). The watershed primarily contains these general categories of wetlands:

- Snake River Valley wetland complex
- Riparian wetlands adjacent to stream channels
- Seep and spring wetlands in areas where groundwater reaches the surface
- Wetlands associated with lakes and ponds
- Geothermal wetlands
- Engineered wetlands

The functions most likely to be provided by each type of wetland are discussed in the following subsections.

3.4.1. Snake River Valley Wetland Complex (SRWC)

The Snake River Valley Wetland Complex (SRWC) complex is located in the Jackson area of Teton County and is one of nine priority wetland complexes identified in the Wyoming Wetlands Conservation Strategy (Wyoming Joint Ventures Steering Committee 2010; see Figure 3.4.1-1). This priority area was identified as a wetland complex with high potential for enhancement through acquisition of land and conservation easements. According to the strategy report, landowners within the Snake River drainage have expressed an interest in establishing conservation easements to protect important and scenic habitats that may ultimately be threatened by sale and subdivision. In addition, because of the large amount of public land in the vicinity, there would be opportunities to continue building wetlands projects and enhancing wetlands both on federal and private lands.

The SRWC was delineated in The Nature Conservancy's (TNC) Wetlands Assessment Study (Copeland et al. 2010). The TNC study used National Wetlands Inventory (NWI) map layers to identify wetland complexes based on polygons containing average wetland densities of at least one per square kilometer. This wetland complex provides just about every wetland function, including very diverse wildlife and fish habitat, habitat for several rare species (including nesting habitat for trumpeter swans), flood flow alteration, erosion control, sediment capture, nutrient transformation, aesthetic features, and groundwater recharge/discharge. In addition, parts of the wetland, in conjunction with the Snake River, provide recreational opportunities.

As delineated by TNC, the SWRC is 256 square miles and contains approximately 8,544 acres of palustrine wetland systems, which would be comprised of freshwater ponds, freshwater emergent wetlands, and freshwater forest or scrub-shrub wetlands. The SRWC also includes a 96-mile corridor of federally designated wild and scenic river extending from the headwaters in Yellowstone National Park to Palisades Reservoir in Alpine, Wyoming.

Part of the SWRC is located within the National Elk Refuge and GTNP. Much of the refuge consists of grassy wet and mesic meadows and marshes on the valley floor. The floodplain riparian forest along the Gros Ventre River contains blue spruce, narrowleaf cottonwood, red osier dogwood, and willow as major species. The main function of the refuge is habitat for a wide variety of wildlife, including elk, bison, trumpeter swan, bald eagle, and even gray wolf. GTNP also has abundant wetlands, fed by numerous mountain streams, springs, or seeps. These wetlands provide wildlife habitat functions and are very diverse. Vegetation such as pond lilies, willows, and cattails supply wildlife with food and shelter, including grazing habitat for moose. In addition, the natural and beaver-created wetlands in the park provide aesthetic features, nutrient transformation, sediment removal, erosion reduction, and flood flow alteration as well as recreational opportunities.

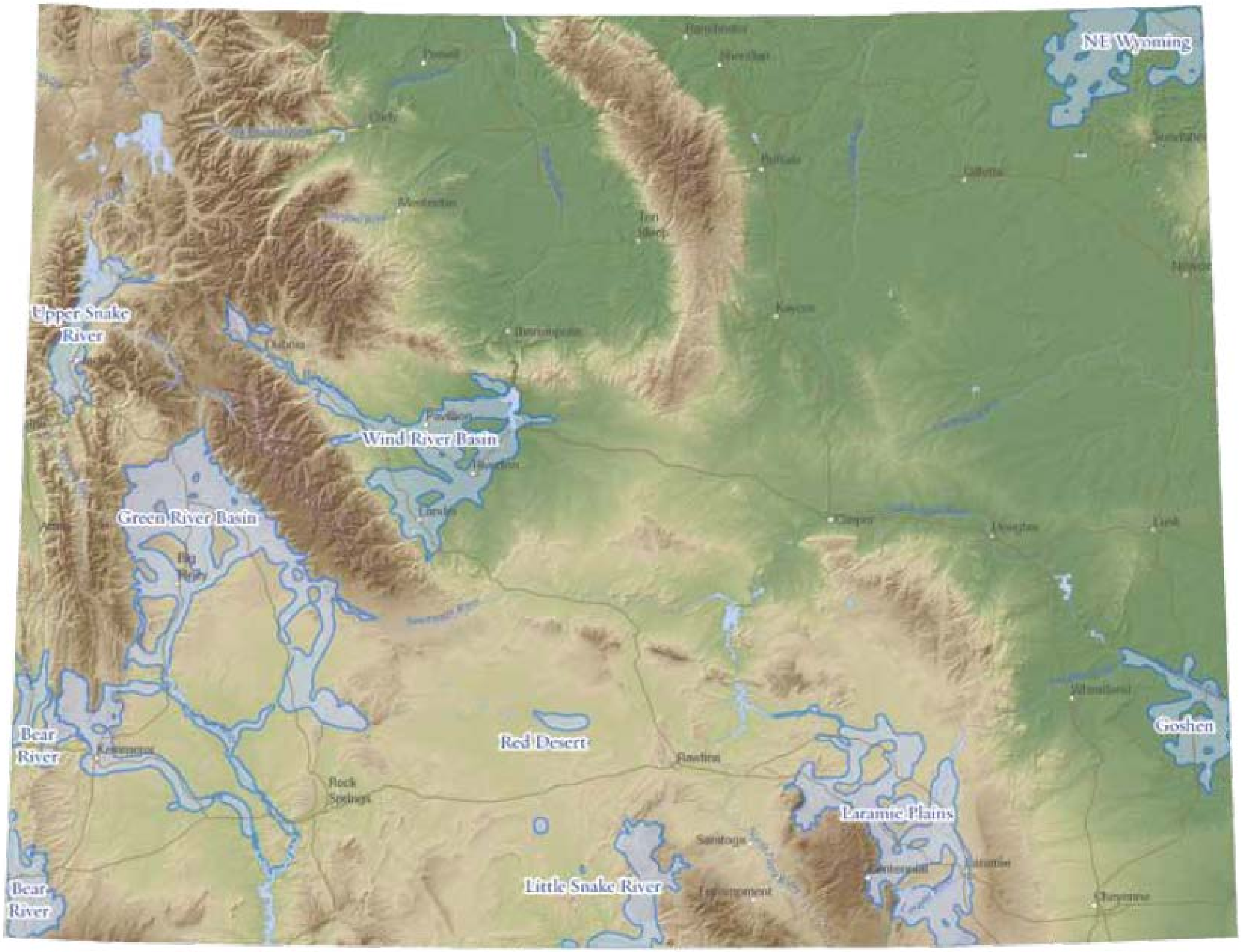


Figure 3.4.1-1 Nine Wyoming Priority Wetland Complexes. Source: Wyoming Wetlands Conservation Strategy (Source: Wyoming Joint Ventures Steering Committee 2010)

The WYGD, along with several other resource agencies and groups, has developed the Snake River Valley Wetland Complex Regional Wetlands Conservation Plan (WyGFD 2015), which describes the unique characteristics of this wetland complex and the fish, birds, and other wildlife that are found here. The wetland complex has a wide array of natural and restored wetland habitats, including riverine wetlands (associated with river or stream channels), lacustrine wetlands (associated with lakes and large ponds), and palustrine wetlands (other types of wetlands, usually smaller and not associated with flowing water or lakes). According to the plan, the National Wetlands Inventory has mapped well over 50,000 acres of riverine, lacustrine, and palustrine wetlands in the region. In addition, there are many acres of riparian habitat that are upland areas fringing the rivers, lakes, and wetland complexes. Altogether, the SRWC provides a wide range of ecological functions including water and carbon storage, water quality improvement, wildlife habitat, and habitat for rare and diverse species. Some wetlands have been restored and engineered to provide additional functions of water quality and habitat. In addition, the location of these wetlands in a relatively accessible location provides a unique opportunity for recreational and educational uses.

The Upper Snake River watershed is characterized by the extremely diverse wildlife that inhabit the area. The indigenous Snake River cutthroat trout is only found in the river and its tributaries, and a number of other species of native fish are found here. The area also provides habitat for native mussels, amphibians, and reptiles. Wetlands and reservoirs in the Snake River basin provide substantial nesting and breeding habitat for a resident population of trumpeter swans, several species of ducks and Canada geese, and the only nesting habitat in the state for the common loon. Migratory and resident birds designated as species of concern in Wyoming that are found in this river basin include common loon, trumpeter swan, white-faced ibis, bald eagle, peregrine falcon, greater sage-grouse, long-billed curlew, greater Sandhill crane, canvasback, lesser scaup, northern pintail, redhead, and willow flycatcher.

Typical species within the channel and ponded wetlands consist of aquatic and semiaquatic vegetation. In the flood channels and tributaries, watercress, white water crowfoot, and pondweed are most prevalent. Watercress is found primarily in the shoreline areas, white water crowfoot is associated with gravel-rocky bottom areas, and pondweed is associated with silt bottom areas. Other major species found in the aquatic zone are star duckweed, water milfoil, mare’s tail, monkey flower, and horsetail. Moss and algae are also in this zone.

The USGS National Gap Analysis Program (GAP) identifies the following wetland and transitional ecological systems as occurring within the Upper Snake River watershed, as well as within the SRWC (USGS GAP 2016):

North American Arid West Emergent Marsh. These are natural marshes that occur in depressions (ponds, kettle ponds), as fringes around lakes, and along slow-flowing streams and rivers (sloughs). They are frequently or continually flooded with water depths up to six feet deep, but they have rooted, mostly grass-like plants. They usually have peat or muck in the bottom, and this system occurs in dry environments, typically surrounded by savanna, shrub steppe, steppe, or desert vegetation. Common emergent and floating vegetation includes species of bulrush, cattail, rush, pondweed, knotweed, pond lily, and canary grass.

Rocky Mountain Alpine-Montane Wet Meadow. These are high-elevation communities found throughout the Rocky Mountains and the intermountain regions, dominated by herbaceous species found on wet sites with very low-gradient surface and subsurface flows. They range in elevation from montane to alpine (1,000–3,600 meters). They occur as large meadows in montane or subalpine valleys; as narrow strips bordering ponds, lakes, and streams; and along toeslope seeps. In alpine regions, sites typically are small depressions located below late-melting snow patches. Wet meadows are dominated by grasses, sedges, or wildflowers such as western bluejoint, white marsh-marigold, large mountain bittercress, small-head sedge, small-wing sedge, black alpine sedge, Holm's Rocky Mountain sedge, northwest territory sedge, native sedge, tufted hairgrass, few-flower spikerush, Drummond's rush, ice grass, yellowcress, arrowleaf ragwort, Parry's clover, and American globeflower.

Rocky Mountain Subalpine-Montane Mesic Meadow. Somewhat drier than the previous habitat type, these high-elevation meadows are found throughout the Rocky Mountains, often in a mosaic with conifer forests of spruce and fir just below the treeless alpine zone. Sometimes they are found at middle and lower elevations of the mountains, but they are mostly found on gentle to moderate slopes. These meadows are often moist but are wet only in the spring when snow is melting. In the late summer they dry out, and they are often good habitat for burrowing mammals such as ground squirrels or pocket gophers. Meadows such as these are very diverse in plant species, with a mix of herbs and grasses; often they appear as lush fields of wildflowers. Some of the common plants include fleabane, bluebells, beardtongue, bellflowers, lupines, goldenrod, licorice-root, western meadowrue, Sitka valerian, western coneflower, arrowleaf balsamroot, hairgrass, prairie junegrass, and perennial brome.

Rocky Mountain Subalpine Mesic Spruce-Fir Forest and Woodland. This is a high-elevation system of the Rocky Mountains, the dry eastern Cascade Mountains, and the eastern Olympic Mountains. These are the major subalpine forests of the northern Rockies, found on gentle to very steep mountain slopes, high-elevation ridgetops and upper slopes, plateau-like surfaces, basins, alluvial terraces, well-drained benches, and inactive stream terraces. In drier and warmer regions, such as in Colorado and New Mexico, they occur in cooler and moister landscape settings such as north-facing slopes, areas with late-lying snow, or toe slopes. They are dominated by Engelmann spruce and subalpine fir, and the shrubs, grasses, and wildflowers found with them are highly diverse. These forests burn very infrequently.

Besides providing exceptional wildlife habitat functions, the wetlands in the SRWC also provide the functions of riparian zone wetlands, discussed in more detail in the next section.

3.4.2. Riparian Wetlands

Riparian wetlands are located along drainages throughout the watershed. Depending on their size and whether the stream is ephemeral, intermittent, or perennial, these wetlands are most likely to provide the functions of wildlife habitat, flood flow alteration, and streambank erosion control. Some of these wetlands may occur in cut-off oxbows of streams. Wetlands adjacent to streams can serve as corridors for movement of terrestrial wildlife, and particularly if they are associated with permanent bodies of water and if they serve as cover and food sources for aquatic organisms. Thus, they may provide recreational opportunities for hunting and fishing. In addition, wetlands adjacent to streams provide storage for out-of-bank flood flows. In these areas, flood waters will be slowed, and the lower flood velocity combined with the vegetative cover are likely to reduce erosion in and adjacent to stream channels.

Riparian wetlands along perennial streams will have a more diverse plant community, and they may provide habitat for a large number of species, including rare species, depending on variables such as hydrologic regime, microclimate, and soil characteristics. The diversity is further increased by the large number of edges and strata in a comparatively small area that is typical of riparian zones.

For example, along the Upper Snake River, a number of riparian plant communities have developed within the river valley. Sandbars, gravel bars, and abandoned river channels provide substrate for different plant communities. Narrowleaf cottonwood usually develops on gravel, interior willow usually develops on sand, and blueberry willow usually develops on silt and flooded areas. Forested wetland also is a plant community found within the riparian zone. Along the Upper Snake River, this community is often dominated by blue spruce and narrowleaf cottonwood, but it also may include lodgepole pine, quaking aspen, russet buffaloberry, red osier dogwood, thinleaf alder, balsam poplar, and willow.

Two types of riparian plant communities are identified in the USGS GAP analysis, both of which occur within the Upper Snake River valley as well as elsewhere in the watershed:

Rocky Mountain Subalpine-Montane Riparian Woodland. These may be a mix of upland and wetland habitats and consist of woodlands and forests found along rivers and streams from mid elevations to the upper limit of tree line in the Rocky Mountains. Trees includes subalpine fir, Douglas fir, Engelmann spruce, aspen, cottonwood, and mountain alder, with diverse shrubs and wildflowers in the understory. This includes streamside forests and woodlands that occur in narrow stream borders in steep, V-shaped valleys and canyons, to broader floodplains in wide valley bottoms.

Rocky Mountain Subalpine-Montane Riparian Shrubland. These are tall to mid-sized shrublands found along rivers and streams from mid elevations to the upper limit of tree line in the Rocky Mountains. It includes deciduous shrublands, dominated by different willow species (which vary by area and elevation), mountain alder, western birch, with diverse low shrubs and forbs in the understory. This system includes stream-side shrublands ranging from narrow stream borders in steep, V-shaped valleys and canyons, to broader floodplains in wide valley bottoms. It also includes headwaters basins in the alpine to subalpine transition where willow shrublands can form dense thickets on the slopes, with small rivulets running through them as winter snow melts.

3.4.3. Spring and Seep Wetlands

Seep and spring wetlands develop in places where groundwater intersects with the land surface for at least part of the year. The wetlands in these areas may have a hydrologic regime that is temporary or relatively permanent. Depending on the season of the year, these wetlands may provide the functions of recharging or discharging groundwater, or both. Recharging groundwater may be important for maintaining the water table and thus supplying wells, while discharging groundwater may be important for maintaining the headwaters of streams, particularly perennial streams. Wetlands maintained by groundwater are often quite diverse because of their relative hydrologic stability compared to wetlands maintained exclusively by surface runoff, and thus also may provide habitat for rare species.

3.4.4. Lake and Pond Wetlands

A number of lakes and ponds, some naturally occurring and some created artificially by impoundments, are found in the watershed. These range in size from large lakes such as Jackson Lake to small ponds, such as those created for cattle. Some of the large naturally occurring lakes such as Jackson have been enlarged by building dams; others, such as Shoshone, Lewis, and Heart lakes in Yellowstone National Park, are completely natural. In the case of small impoundments, these ponds may be on-line (in other words, impoundments of a channel) or off-line, in which case the water may be maintained by pumping water. Depending on the size of the lake or pond, the depth of the water, and the source of the water, the wetland may be a fringe around the margins or may be more extensive. In either case, the natural or impounded basin allows for water to be detained for longer periods of time than is the case for most riparian or seep wetlands. Thus, these wetlands can provide the function of improving water quality by trapping sediment and removing and transforming nutrients, which can be particularly important if the lakes are used as water supply. In general, lakes and ponds provide a water source for wildlife during times when surface water is otherwise scarce. Lakes and larger ponds can provide a permanent aquatic environment, and fringe wetlands provide excellent breeding and cover habitat for a large variety of fish species. Even a small pond with a fringe wetland may provide the function of resting habitat for migrating waterfowl. Because of the fish and wildlife functions provided by fringe wetlands, these areas provide excellent recreational functions for activities such as birding, hunting, and fishing. Impacts to these wetland systems can limit plant diversity or suitable habitat for rare species.

3.4.5. Geothermal Wetlands

Geothermal wetlands that are located around and in the vicinity of geothermal waters have certain unique characteristics and functions because of their relatively small temperature range, which is unusual in this part of the U.S. They serve the functions of groundwater discharge, erosion control, and habitat for a wide array of wildlife and fish, and they provide homes for some of the rarest plants in Wyoming. In addition, they are a recreational destination and provide scenic diversity and aesthetic functions.

Yellowstone National Park. Yellowstone National Park has a large number of different types of wetlands scattered throughout it, including numerous playas, flooded meadows, beaver ponds, and man-made and natural lakes (Elliott and Hektner 2000). The complex of habitats and the protected nature of the park make these wetlands particularly highly valuable for wildlife. One of the unique features of the park is its large area of geothermal activity. Within the park, the three large natural lakes that are located within the headwaters of the Snake River, Shoshone Lake, Lewis Lake, and Heart Lake, are all associated with geothermal features. The heat generated in thermal areas has allowed some plant species that are rare in Wyoming to survive far north of their typical distributions, while others evolved to survive only in these unusual habitats. For example, Cronquist yellow spikerush (*Eleocharis flavescens* var. *thermalis*) grows primarily as floating mats on warm thermal water, vanishing if the water temperature becomes too hot or too cold. Tweedy's rush (*Juncus tweedyi*) also occurs only in Teton County in Wyoming. This wetland plant is often associated with thermal areas and sometimes is the dominant plant species in thermal areas.

Grand Teton National Park. Kelly Warm Springs within this park is a spring-fed pond surrounded by wetlands, and it provides recreational functions. Habitat functions are limited, however, since the 1940s, this spring has been a popular illegal disposal site for unwanted aquarium fish. A number of tropical and warm water aquatic species that are harmful to native fish and capable of surviving a wide range of temperatures, persist in both the spring and its outflow areas of Savage Ditch and Ditch Creek, which drains to the Snake River. Park managers are planning to restore this area by removing the non-native species.

3.4.6. Engineered and Restored Wetlands

A number of wetland restoration or creation projects have been completed in the vicinity of Jackson, Wyoming. Some of the projects include the restoration of gravel pits to reestablish historic wetland habitat south of Jackson and improvement of existing water control structures to restore habitat that is critical for many native wildlife species. Other restoration projects have taken advantage of the wetland creation and maintenance abilities of beavers; for example, beavers have been trapped from areas where they are a nuisance and relocated to other areas, such as parts of the Gros Ventre River and adjacent drainages, to restore, create, and maintain wetland habitat. Other wetlands have been created or restored as mitigation for impacts to wetlands from a variety of projects. For example, road work within the watershed often affects wetlands, and so Wyoming Department of Transportation (WyDOT) has been required to provide compensatory mitigation for wetland impacts. Functions of the engineered/restored wetlands vary depending on the location and the reason for construction, but they generally include enhancing habitat for wildlife, improving water quality through sediment retention and nutrient transformation, and creating recreational opportunities.

Two sites in the watershed are examples of different engineered/restored wetlands that provide substantial wetland functions.

WyDOT Buffalo Fork Wetland Mitigation Site. The wetland site is near an aggregate pit associated with the reconstruction of the road between Moran Junction and Dubois (Wyoming Highway 26/287) and is located at the USFS Blackrock ranger station work compound (Blackrock) on the south side of the Buffalo Fork River in Teton County, Wyoming. The site was designed to provide woody riparian scrub-shrub wetland as mitigation for area lost in the same watershed because of road construction. The wetland mitigation site was constructed in 2007 and vegetated in 2008. According to Muths (2012), the site provides wildlife habitat functions, including habitat for several species of amphibians. The Blackrock area had an oxbow pond separated from the Buffalo Fork River by levees, where boreal toad (*Anaxyrus boreas*), Columbia spotted frog (*Rana luteivensis*), chorus frog (*Pseudacris maculata*), and tiger salamander (*Ambystoma tigrinum*) were breeding. Two of these species, boreal toad and Columbia spotted frog, are considered species of greatest conservation need in Wyoming, and the boreal toad is considered a Tier 1 species, of highest priority. Heavy, late-spring runoff in 2011 and 2012 breached the levees between the oxbow and the river, thus potentially eliminating the oxbow as a breeding location. It appears that the mitigation site may prove a function that is very important to rare species, as it was known that at least two of the four species, including the boreal toad, were breeding there (Muths 2012).

Karns Meadow Wetland Stormwater Treatment Site. The Town of Jackson, TCD, Teton County-Jackson Parks and Recreation Department, JHLT, and many partners constructed a wetland-based stormwater treatment system that benefits aquatic resources in Flat Creek, wildlife habitat in Karns Meadow, and the people of the Town of Jackson, Teton County, and the state of Wyoming. The wetland is intended to provide the functions of improving the chemical and physical quality of urban runoff entering Flat Creek at the Karns Meadow property by trapping sediment and transforming nutrients; enhancing habitat quality on the adjacent Karns Meadow property east of Flat Creek; and developing a naturalistic, aesthetically attractive design for passive recreational use (Nichols 2012). This wetland is discussed in relation to its impact on water quality in the next section.

3.5. Water Quality

3.5.1. Stream Classifications

Many of the streams in the Upper Snake River watershed have been classified for protection of one or more uses by the WDEQ. Streams within the study area have been classified as Class 1 or Class 2AB (WDEQ 2013). The WDEQ (2013) Water Quality Rules and Regulations, Chapter 1, Wyoming Surface Water Quality Standards defines these three classifications as follows:

“Class 1, Outstanding Waters. Class 1 waters are those surface waters in which no further water quality degradation by point source discharges other than from dams will be allowed. Nonpoint sources of pollution shall be controlled through implementation of appropriate best management practices. Pursuant to Section 7 of these regulations, the water quality and physical and biological integrity which existed on the water at the time of designation will be maintained and protected. In designating Class 1 waters, the Environmental Quality Council (council) shall consider water quality, aesthetic, scenic, recreational, ecological, agricultural, botanical, zoological, municipal, industrial, historical, geological, cultural, archaeological, fish and wildlife, the presence of significant quantities of developable water and other values of present and future benefit to the people.

Class 2, Fisheries and Drinking Water. Class 2 waters are waters, other than those designated as Class 1, that are known to support fish and/or drinking water supplies or where those uses are attainable. Class 2 waters may be perennial, intermittent or ephemeral and are protected for the uses indicated in each subcategory listed below. There are five subcategories of Class 2 waters.

"Class 2AB waters are those known to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where a game fishery and drinking water use is otherwise attainable. Class 2AB waters include all permanent and seasonal game fisheries and can be either "cold water" or "warm water" depending upon the predominance of cold water or warm water species present. All Class 2AB waters are designated as cold water game fisheries unless identified as a warm water game fishery by a "ww" notation in the "Wyoming Surface Water Classification List". Unless it is shown otherwise, these waters are presumed to have sufficient water quality and quantity to support drinking water supplies and are protected for that use. Class 2AB waters are also protected for non-game fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture and scenic value uses."

Table 3.5.1-1 defines the uses that are protected for all of the WDEQ surface water classifications. Table 3.5.1-2 lists the streams in the Upper Snake River study area and their classifications, and Map 29, WDEQ Stream Classification provides a map of their distribution.

Table 3.5.1-1 WDEQ Surface Water Classes and Use Designations

	Drinking water	Game Fish	Non-Game Fish	Fish Consump-tion	Other Aquatic Life	Recrea-tion	Wild-life	Agri-culture	Industry	Scenic Value
1*	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2AB	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2A	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
2B	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2C	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3A	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3B	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3C	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
4A	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4B	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4C	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes

* Class 1 waters are not protected for all uses in all circumstances. For example, all waters in the national parks and wilderness are Class 1; however, all do not support fisheries or other aquatic life uses (e.g., hot springs, ephemeral waters, wet meadows, etc.). For stormwater permitting, 401 Certification, and water quality assessment purposes, the actual uses on each particular water must be determined independently.

Photo 14 Pacific Creek at GTNP, a Class 2AB Perennial Stream

Table 3.5.1-2 Upper Snake River Basin Stream Classifications

Stream Name	WDEQ Classification
Snake River (upstream of Hwy 22)	1
Snake River (downstream of Hwy 22)	2AB
Spring Creek	2AB
Fall Creek	2AB
Coburn Creek	2AB
Horse Creek	2AB
Flat Creek	2AB
Cache Creek	2AB
Sheep Creek	2AB
Mosquito Creek	2AB
Fish Creek	1
Gros Ventre River	2AB
Crystal Creek	2AB
Slate Creek	2AB
Cottonwood Creek	2AB
Bacon Creek	2AB
Clear Creek	1
Ditch Creek	2AB

Stream Name	WDEQ Classification
Cascade Creek	1
Spread Creek	2AB
Buffalo Fork	2AB
Lava Creek	2AB
Blackrock Creek	2AB
Soda Fork	1
Cub Creek	1
Pacific Creek	2AB
Pilgrim Creek	1
Moran Canyon Creek	1
Arizona Creek	1
Moose Creek	1
Owl Creek	1
Berry Creek	1
Lewis River	1
Wolverine Creek	1
Coulter Creek	1
Polecat Creek	1
Tanager Creek	1

Source: Wyoming Surface Water Classification List, Water Quality Division Surface Water Standards, 2013

Many of the stream reaches within the Upper Snake River study area have received designation as wild and scenic rivers. They are shown in Map 30, Wild and Scenic Rivers. According to Rivers.org, “the National Wild and Scenic Rivers System was created by Congress in 1968…to preserve certain rivers with outstanding natural, cultural, and recreational values in a free-flowing condition for the enjoyment of present and future generations. The Act is notable for safeguarding the special character of these rivers, while also recognizing the potential for their appropriate use and development. It encourages river management that crosses political boundaries and promotes public participation in developing goals for river protection.” Three classifications of rivers exist and are defined as follows (Rivers 2016):

- **Wild River Areas:** Those rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and waters unpolluted. These represent vestiges of primitive America.
- **Scenic River Areas:** Those rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped, but accessible in places by roads.

- **Recreational River Areas:** Those rivers or sections of rivers that are readily accessible by road or railroad, that may have some development along their shorelines, and that may have undergone some impoundment or diversion in the past.

As seen in Map 30, the river segments within the study area are classified as “wild” and “scenic.” A short segment of Hoback Creek is shown to be “potentially eligible.” As discussed in more detail in Section 6 (Permits), proposed projects that might affect these classified stream segments or their shorelines must be coordinated with at least one of the four agencies on the Interagency Wild & Scenic Rivers Coordinating Council. The four agencies are the USFWS, the USFS, the NPS, and the BLM.

3.5.2. Water Quality Assessment

As discussed in Section 3.5.1, Stream Classifications, the streams in the study area are Class 1 and 2AB, the best, highest classification. Water quality is of critical importance in the watershed. Water quality testing and monitoring has been done in the watershed by multiple agencies as part of different efforts. One of the main water quality concerns is habitat for aquatic species and ensuring that streams can provide for their designated uses. The USGS has collected water quality samples, for which the results are available on their website at http://waterdata.usgs.gov/wy/nwis/rt (USGS 2016d). The gages, along with the number and date range of samples, are shown in Data Summary 2.1.7-4 in Appendix A. Flat Creek, in particular, has been studied by several entities for different purposes. The following documents are included with the electronic library and provide information on water quality and habitat quality.

- *Wyoming’s 2014 Integrated 305(b) and 303(d) Report* by the WDEQ, dated February 25, 2016. Report discusses the status of impaired and threatened streams in Wyoming. See Section 3.4.3.
- *Flat Creek Watershed Management Plan*, dated November 2006 and prepared by Intermountain Aquatics Inc. for the Flat Creek Watershed Committee. Table 4 in the document lists existing water quality and habitat quality assessments and data for Flat Creek that was collected between 1965 and 2006.
- *Feasibility Study – Trout Unlimited Flat Creek Project, Teton County, Wyoming*, dated December 9, 1996, and prepared by Biota Research and Consulting Inc.
- *Water Quality Summary for the Snake River and Alpine Lakes in Grand Teton National Park and the John D. Rockefeller Jr. Memorial Parkway: Preliminary Analysis of 2014 Data*, dated September 2015 published by the National Park Service.
- *2012 Snake/Salt River Basin Plan Update* by the WWDC and dated November 2014. The report presents a summary of water quality in the major subbasins, while Technical Memorandum, Tab XIV: Surface Water Quality, presents the information and results from monitoring programs that were implemented after the 2003 Snake/Salt River Basin Plan.

Additionally, numerous measures have been taken in the study area to improve water quality, and the TCD has been involved in several of them. The following describes some of the ways that the TCD is addressing the issues of water quality in the watershed.

The TCD (2014) developed a Stormwater Pollution Prevention Plan guide for Teton County in a cooperative effort with many agencies. The objective was to provide information on construction best management practices that would help protect surface waters of the state of Wyoming during and after construction projects. Another example is the construction of the Karns Meadow Stormwater Treatment Wetlands, a project completed by a partnership that included the TCD, Town of Jackson, WDEQ, Jackson Hole OneFly, National Fish and Wildlife Foundation (NFWF), Jackson Hole TU, Jackson Hole Ducks Unlimited, Intermountain Aquatics Inc., and Alder Environmental (Photo 15). The purpose of the wetlands was to significantly improve the physical and chemical quality of urban runoff entering Flat Creek. Sediment and wetland basins were constructed to remove pollutants from the stormwater prior to it entering Flat Creek. The project treats stormwater from three sources next to the site that collect runoff from 27 percent of the Town of Jackson. This includes areas that contribute disproportionate amounts of sediment and associated road-derived salt, metals, and hydrocarbons, and in particular, storage of snow removed from streets and alleys.

Photo 15 Karns Meadow Stormwater Treatment Wetlands in Jackson

An additional water quality project initiated by the TCD was to enhance treatment of wastewater from single-family homes that rely on septic systems for their wastewater disposal. The TCD and Intermountain Aquatics Inc. tested the use of a small artificial wetland to enhance treatment of wastewater from a single-family home in Wilson, Wyoming. The recirculating vertical flow (RVF) wetland was installed between the existing septic tank and leach field. It was constructed in the fall of 2009 and planted, instrumented for data collection, and put into service in the spring of 2010. Performance was monitored from June 2010 to June 2011, and further work on the project is ongoing.

The TCD, in conjunction with the USGS Wyoming Water Science Center, Jackson Hole Onefly, and NFWF, are conducting a multiphase study along Fish Creek to better understand the hydrologic system and the possible relation to aquatic life in the stream.

3.5.3. Waters Requiring TMDLs

A Total Maximum Daily Load (TMDL) is a “pollution budget and includes a calculation of the maximum amount of a pollution that can occur in a waterbody and allocates the necessary reductions to one or more pollutant sources” (EPA website 2016). A TMDL is a planning tool that takes into consideration restoration and protection activities with the goal of maintaining water quality standards. For each pollutant source of impairment, a TMDL must be established.

Under the Clean Water Act (CWA), the EPA requires all states to prepare and submit a "303(d) list," which is a term for the list of impaired and threatened waters (stream/river segments and lakes) in the state. States are required to submit the list for approval every two years during even-numbered years.

Wyoming's 2014 Integrated 305(b) and 303(d) Report (WDEQ 2016) currently shows only one stream reach as threatened. A reach of Flat Creek (HUC 170401030205_01) from the confluence with the Snake River upstream to the confluence with Cache Creek was added to the 303(d) list in 2000 as threatened. Municipal stormwater from the Town of Jackson was identified as the source of the pollutant. Since then, the Flat Creek Restoration Project was initiated in 2004 by the Town of Jackson, TCD, TU, and WGFD; a Watershed Management Plan for Flat Creek was completed in 2006 for the Flat Creek Watershed Committee, which consisted of several entities and the public; the Town of Jackson has adopted a commercial stormwater code and other measures; and the Karns Meadow Stormwater Treatment Wetland Section 319 Project was constructed. In 2013, WDEQ began collecting biological, chemical, and physical data to reevaluate the aquatic life (WDEQ 2016).

The North Fork Spread Creek watershed (HUC 170401010503_01) upstream of the confluence with South Fork Spread Creek was added to the 303(d) list in 1993. The North Spread Creek Riparian Demonstration Section 319 Project was completed in 1999. Because of the success of the project, the watershed was removed from the 303(d) list in 2008 (WDEQ 2016).

3.5.4. WYPDES Permitted Discharges

A database obtained from the WDEQ shows 10 Wyoming Pollutant Discharge Elimination System (WYPDES) permitted discharges in the study area. They are all oil treatment permits. The locations of the outfalls are shown in Map 31, WYPDES Permitted Discharges. The permitted outfalls are listed in Table 3.5.4-1.

Table 3.5.4-1 Wyoming Permitted Outfalls in the Upper Snake River Watershed

Permit Number	Permittee	Facility Name	Permit Type	Permit Status
WY0000019	USFWS	Jackson Fish Hatchery	Fish Hatchery	In Effect
WY0021458	Jackson, Town of	Jackson Wastewater Lagoon	Sanitary Wastewater	In Effect
WY0049484	Jackson, Town of	Jackson Thaw Well Project	Industrial	In Effect
WY0049484	Jackson, Town of	Jackson Thaw Well Project	Industrial	In Effect
WY0049484	Jackson, Town of	Jackson Thaw Well Project	Industrial	In Effect
WY0052094	3 Creek Ranch	3 Creek Ranch	Unknown	In Effect
WY0052094	3 Creek Ranch	3 Creek Ranch	Unknown	In Effect
WY0052094	3 Creek Ranch	3 Creek Ranch	Unknown	In Effect
WY0053546	Grand Teton Park LLC	Grand Teton Park LLC	Sanitary Wastewater	In Process
WY0095320	SSDA LLC	SRMHP MBR	Sanitary Wastewater	In Effect

4. WATERSHED MANAGEMENT AND REHABILITATION PLAN

The purpose of this Level I watershed study is to describe Upper Snake River watershed in its current condition, to suggest resolutions for any water-related issues, and to provide insight into opportunities for improvements. At this point in the study report, the current condition of the watershed has been described. The following subsections provide details on the proposed watershed improvement projects that constitute the watershed management and rehabilitation plan.

As described briefly in Section 1.2 Key Issues in the Watershed, in order to identify the water issues and improvement opportunities in the district, public meetings were held in Jackson and Moran. The meetings were intended to introduce the public and private landowners, managers, and stewards of the Upper Snake River watershed to the Level I watershed study and request information on potential water improvement projects. The project meetings were announced through publication in the local newspapers such as the Jackson Hole Daily and the Jackson Hole News & Guide, through advertising on Facebook, and through publishing meeting announcements on the TCD website. Additionally, letters introducing the project and postcard invitations to the project meetings were sent out to residents and agencies in the Upper Snake River watershed. Table 4.0-1 lists the meeting dates, topics, and locations.

Table 4.0-1 Project Meeting Dates, Topics, and Locations

Date	Topic/Description	Location
9/23/2015	Project Introduction and Public Input Requests	Teton County Library, Jackson
11/09/2015	Project Status and Irrigation Evaluations	Teton County Library, Jackson
01/28/2016	Project Status and Water Quality Evaluations	Teton County Library, Jackson
4/28/2016	Project Status and Geomorphological Evaluations	Teton County Library, Jackson
7/28/2016	Project Status and Water Improvements Identified	Teton Fire Station #4, Moran
9/20/2016	Watershed Study Results and Recommendations	Antler Inn Meeting Rm, Jackson
9/22/2016	Watershed Study Results and Recommendations	Teton Fire Station #4, Moran

Additionally, to collaborate with the numerous agencies working in the watershed, a representative from the Olsson Associates project team and/or the WWDC attended each of the Snake River agency meetings that occurred during the project. The meetings were held every six months in Jackson at the WGFD office and included representatives from the following agencies involved in water and conservation efforts in the watershed:

- U.S. Bureau of Reclamation
- USFS
- USACE
- WGFD
- WSEO
- TCD
- Idaho Power
- GTNP
- WWDC
- NPS

The agency meetings are held to hear about the U.S. Bureau of Reclamation's operational plans for the reservoirs, projected Snake River flows, and status reports on research occurring in the watershed. At the meetings, the scope and goals of this watershed study were introduced to the agencies. At the initial meetings, the agencies provided input on the types of projects they are currently working on and how the Level I watershed study may dovetail with many of their initiatives. As the project progressed, updates on the project's status were provided to the agencies. At a meeting on September 20, 2016, the results and recommendations of the study were presented to the agencies.

The public and agency interactions developed into evaluations of over 40 potential watershed improvement projects. For nearly every project described, a site visit was organized and the appropriate team members visited the sites. For example, for projects that involved irrigation improvements, a professional engineer on the project team examined the proposed improvements and developed conceptual designs and cost estimates. Additionally, since the intent is to provide a holistic approach to watershed management, additional team members such as stream geomorphologists and geologists were included in the project review team to ensure that any conceptual design was developed in recognition of the need to ensure that all proposed projects in the watershed study are evaluated holistically.

Each of the proposed projects are described in more detail in the following subsections. To provide a systematic approach to project improvements consistent with the objectives of the WWDC Level I project scope, projects were subdivided into irrigation improvements, wildlife/livestock watering opportunities, surface water flood and water supply/storage improvements, grazing management improvements, and other management practice improvements. In Appendix C, a description of the benefits to these types of projects is listed for use in preparing the applications for funding through the WWDC Small Water Program and other funding sources.

4.1. Irrigation Systems Improvements

At the project meetings held in Jackson and Moran, landowners, land managers, and area residents repeatedly identified irrigation system improvements as an area of significant need. The proposed irrigation improvements included a wide range of complexity and scale. For example, some irrigation improvements involved suggestions with minimal effort such as minor realignments to existing irrigation ditches. On the other end of the spectrum, irrigation improvements included a conceptual design for a new diversion structure off the main stem of the Snake River. Furthermore, several landowners east of Wilson brought to light one project that may be best suited for evaluation under a WWDC Level II study because of the number of entities that would be involved and because of the size of the project. The improvements proposed in this watershed management plan provide the landowners and land managers with an assessment of the conditions and conceptual project plans that can be used as a starting point as the projects move through the process of engineering design and funding applications. The alternatives proposed can be used by the WWDC, NRCS, or other cooperating conservation programs or funding agencies as described in more detail in Section 7, Project Financing.

Table 4.1-1 provides a list of the project names and the types of proposed improvements identified for each site. Map 32, Proposed Irrigation System Improvement Locations, provides an index map of the proposed project locations.

Table 4.1-1 Irrigation System Improvement Projects

Project Number	Ranch / Site Name	Water Source	Diversion / Headgate	Ditch Improvements	Piping / Sprinkler	Other
ISI-1	Pinto Ranch	Lava Creek	Yes		Yes	
ISI-2	Hatchet Ranch	Blackrock Creek		Yes		
ISI-3	Blackrock Ranger Station	Blackrock Creek				Yes
ISI-4	Elk Ranch	Spread Creek	Yes	Yes	Yes	
ISI-5	Antler Ditch	Spread Creek		Yes	Yes	
ISI-6	Upper Snake River Ranch	Granite Creek Supplemental Ditch Headgate	Yes	Yes		
ISI-7	Upper Snake River Ranch	Millstream Ditch				Yes
ISI-8	Upper Snake River Ranch	Lake Creek and Granite Creek Supplemental Ditch	Yes			
ISI-9	Upper Snake River Ranch	Wyoming School Section 36 (T42N R117W) Hazel Ditch	Yes			
ISI-10	Upper Snake River Ranch and others	Jensen Creek	Yes			
ISI-11	R Lazy S	West Field Ditch		Yes	Yes	
ISI-12	Huidekoper Ranch	Trail Creek	Yes			
ISI-13	Jackson Hole Land Trust	Prosperity Ditch at Highway 22	Yes			
ISI-14	Jackson Hole Land Trust	Pioneer Ditch to Hardemon Field		Yes		
ISI-15	Jackson Hole Land Trust	Prosperity Ditch at Highway 390		Yes		
ISI-16	Lockhart Ranch	Flat Creek	Yes			
ISI-17	Lockhart Ranch	Wiley Ditch	Yes	Yes		
ISI-18	Lower Snake River Ranch	Alaska Ditch	Yes	Yes		
ISI-19	Game Creek	Carter Ditch	Yes		Yes	Yes
ISI-20	Fall Creek Ranch	Fall Creek	Yes			

4.1.1. Pinto Ranch (ISI-1)

Pinto Ranch is a cattle ranch along the Buffalo Fork and Lava Creek in Teton County, Wyoming. Their diversion off Lava Creek supplies several irrigation ditches that are used for hay production throughout the summer. The historic ranch was incorporated in 1938, although operations began well before that in the late 1800s. Over the years, several diversion structures have been upgraded and others are scheduled for reconstruction to optimize irrigation operations. There is a persistent problem of wet hay field west of the ranch headquarters during certain times of the year. The hay field is surrounded on three sides with irrigation ditches. Currently, there are no irrigation control structures along the ditches to allow for the field to be drained in the late summer. The problem leads to mosquito infestation and difficulties accessing the field because of wet conditions. Installation of a drainage pipe from a low area in the field east, under the supply ditch and into a nearby creek, would provide a means of drainage.

As illustrated in Map ISI-1, the conceptual project description for Pinto Ranch irrigation improvement includes the following activities:

- Survey the area for use in design analysis
- Install 600 linear feet (LF) of buried drain pipe
- Install one extra small-sized diversion structure on the drain pipe

4.1.2. Hatchet Ranch (ISI-2)

Between the owners and operation managers of Hatchet Ranch and Hatchet Meadow, agricultural production is maintained on 1,200 acres west of Hatchet Resort on Highway 287. The irrigated hay fields are fed by a diversion off Blackrock Creek (described in more detail in Section 4.1.3). The irrigation ditch runs west along the south side of a hay field and currently the field is too wet late in the season to hay. The field historically would dry out when the irrigation ditch was no longer running; however, because of changes in irrigation by the downstream appropriator, it is necessary to keep the irrigation ditch running later in the season. The problem leads to mosquito infestation and difficulties accessing the field because of persistent wet conditions.

As illustrated in Map ISI-2, the conceptual project description for Hatchet Ranch irrigation improvement includes:

- Survey the area for use in irrigation design analysis
- Clean and re-grade 2,400 LF of small irrigation ditch
- Option 1:
    - Install 2,400 LF of irrigation pipeline to minimize seepage and optimize water delivery
- Option 2:
    - Install 2,670 square yards (SY) (2,400 LF x 10 feet wide) of concrete ditch liner to minimize seepage and optimize water delivery
- Option 3:
    - Install 2,670 SY (2400 LF x 10 feet wide) of flexible ditch liner to minimize seepage and optimize water delivery

4.1.3. Blackrock Ranger Station (ISI-3)

The integrity of the Blackrock Creek levee has recently been compromised in two locations downstream of a permitted irrigation diversion. The levee, located approximately 550 feet east of the Blackrock ranger station, serves to protect the ranger station from flood damage from Blackrock Creek (Photo 16). The levee also serves to protect a permitted irrigation structure. The BTNF proposes to repair the degraded sections of the levee and to potentially install two or three instream barbs upstream from the irrigation ditch diversion. As identified during the Rosgen stream classification and presented in Section 2.1.8, decreasing the width-to-depth ratio of this bend and using an existing headgate and ditch (to alleviate substantial flows against the dike to the right) would be a consideration to protect the ranger station.

Any actions considered would need to be compatible with Blackrock Creek's status as a scenic river under the national Wild and Scenic Rivers Act. A Section 7 analysis would be required to evaluate potential impacts to wild and scenic rivers' values before activities could be undertaken. Activities would also require coordination with the operators of the irrigation ditch. Currently, the diversion and irrigation structures are working adequately as stated by one downstream irrigator.

Engineering designs of the levee repair have not been completed for this project and, therefore, only USFS-proposed conceptual design concepts are included in this proposed project for budgeting purposes. According to the USFS, plans are for the repaired and enlarged levee sections to blend in with the rest of the existing levee. Angular rock would be used to best interlock with adjacent rock. Concerns about wildlife passage would be addressed during levee repair design.

Existing vegetation would be retained and additional riparian vegetation may be planted along (or near) the waterline using a "stinger" or via clump plantings to provide cover for aquatic organisms. To avoid causing problems with the irrigation diversion, vegetation would not be planted upstream from the irrigation diversion. The levee repair and stream geomorphology will require engineering and geomorphologic evaluation and designs.

Photo 16 Blackrock Creek and Levee

Additionally, Swan Lake and the WyDOT Buffalo Fork Wetland Mitigation Site, is located approximately a half mile north of the ranger station. The lake is supplied by an open ditch, with a diversion upstream of Blackrock Creek levee. At the time of the initial site visit in the fall of 2015, the open ditch was in need of maintenance, as flow into Swan Lake was not adequate to maintain proper lake levels. In 2016, the ditch was cleaned out by the operations manager at Pinto Ranch. Currently, the ditch is functioning properly and the lake is full once again. The diversion structures for the open ditch to Swan Lake and on the south end of the Blackrock Creek levee should be maintained to ensure that diversions during flood events can be managed to help reduce flood potential at the ranger station.

As illustrated in Map ISI-3, the conceptual project description for Blackrock Creek Levee Repair includes:

- Surveying the area for use in flood and design analysis
- Re-enforcing approximately 360 LF of levee by adding two feet of fill to the top of the existing levee (approximately 500 cubic yards of rock rip rap)

4.1.4. Elk Ranch (ISI-4)

Elk Ranch comprises approximately 2,425 acres in the northern section of GTNP, just south of Moran and the junction of highways 191 and 287 (Map ISI-4). Highway 191 bisects the property, dividing it into the nonirrigated sagebrush bench lands to the west and the irrigated bench lands to the east. The irrigated pastures to the east of Highway 191 are fenced for cattle and have a complex system of irrigation ditches. The bench lands extend unobstructed to the south, where the southern boundary of the Elk Ranch property is defined by Wolff Ridge (Humstone 2011).

Representatives from the GTNP led a site tour across the ranch to illustrate the current state of disrepair of the irrigation ditch system. The pasture at Elk Ranch is currently irrigated with an open ditch flood irrigation network. Across most of the nearly 1,000 acres currently irrigated, boards and tarps are used to control water distribution through over 140,000 feet of the supply ditches and field ditches. After nearly 100 years of operation on the ranch, the open ditch irrigation system has deteriorated. Numerous diversion structures are in disrepair; failing to adequately control water distribution. In addition, many open ditches have either silted in, or blown out. The primitive quality of the existing infrastructure and the size of the Elk Ranch make the current water delivery system labor intensive and inefficient in its water usage (Photo 17).

Photo 17 Elk Ranch Flood Irrigation Ditch and Diversions

The NPS is currently replacing diversion structures throughout the irrigation system as they fail; however, there is no systematic approach to the replacement of diversion structures. The NPS personnel requested that several alternatives be evaluated as part of this watershed study to improve the irrigation system currently used on the Elk Ranch. The alternatives the NPS personnel requested for evaluation included continuing with the current system of headgate replacement as failures occur, replacing the flood irrigation system with a modern irrigation system similar to the one that is used on the National Elk Refuge north of Jackson, and other alternatives suggested by the project team.

It is important to note that during summer 2010, the University of Wyoming American Studies Program conducted an intensive cultural landscape survey and historical analysis of the Elk Ranch in GTNP. The team determined that the property is eligible for the National Register of Historic Places, with significance in agriculture and conservation (Humstone 2011). Because of the historic nature of this site, the alternatives evaluated for this project are different from those that would be assessed on a cattle ranch where historic preservation is not a consideration.

> *"The specific features that contribute to the significance of the Elk Ranch are the location and setting of the ranch itself, which have changed little since the property was homesteaded in 1909; the intricate system of irrigation ditches created by*

homesteaders and early 20th century cattle ranchers which still functions today in much the same way it did 100 years ago; and the building complex, which remains much the same as it was in the 1940s, when it achieved prominence as the premier cattle ranching property of the Snake River Land Company/Jackson Hole Preserve. Because of the buildings, irrigation ditches, pastures and other landscape features, the site retains the feeling and association of an early 20th century cattle and hay ranch" (Humstone 2011).

For example, although pivot irrigation may provide efficiency in operation and water usage, it was not considered as an alternative for this site. The visual impact of such a modern irrigation system on the historic landscape would not be appropriate. A less obtrusive, traveling gun system was identified; however, the aesthetics of such as system may not be appropriate for this site.

Therefore, the first conceptual plan, Option 1, includes a systematic approach including engineering designs for diversion structure replacement beginning at the head of the system to the east and moving down through the distribution system to the west. Diversion structures should be replaced in conjunction with the rehabilitation of corresponding supply ditches and field ditches.

Photo 18 USFWS Photo of the Pod Irrigation System at the National Elk Refuge.

Option 1a, is supplemental to Option 1. Option 1a includes a traveling gun sprinkler system that could be moved across the ranch throughout the summer months to provide irrigation for the pasture while the headgate replacements are underway. The traveling gun would require a pump and pump pit. The pump pit could be excavated near any existing irrigation ditch. The pump would likely be gasoline powered. Adding a traveling gun sprinkler system to irrigation operations while headgate replacements are being completed would add cost and maintenance to the irrigation system, with the benefit of increased water accessibility and efficiency.

The second alternative, Option 2, includes replacement of the flood irrigation system with a pod sprinkler system (Photo 18). This would eliminate the need to repair the flood irrigation system and provide a more efficient water delivery system across the ranch. This option requires a significant upfront cost.

In addition to the options stated above, we recommend a forage assessment be performed to adequately evaluate the irrigation needs of the ranch. As described in the NRCS Range and Pasture Handbook (USDA 2003), the goal is to, "Identify stable and sustainable ecological states for rangeland that provide identified and desired benefits, and describe appropriate management inputs to achieve them." By incorporating an intensive grazing management system through temporary fencing and water facilities, reduction of invasive species may be achieved via livestock grazing with limited chemical applications.

4.1.5. Antler Ditch (ISI-5)

Antler Ditch is located in the BTNF on the south side of Spread Creek. The ditch provides water to USFS concessionaires. Spread Creek is a very dynamic stream with high flow and rocky stream bed. Nearly every spring, the USFS has to repair the berm that separates Spread Creek from Antler Ditch. Additionally, because of the highly porous nature of the rock and gravel substrate in the ditch, seepage is significant. To ensure efficient delivery of water to the permittees and to minimize ditch maintenance, the conceptual plan for this project is to extend a pipeline from the diversion structure approximately one mile, where the ditch flows parallel to Spread Creek (Photo 19). Approximately one mile from the diversion structure, the ditch flows to the southeast away from Spread Creek.

Photo 19 Terminus of Pipeline for Antler Ditch

As illustrated in Map ISI-5, the conceptual project description for the Antler Ditch pipeline includes:

- Surveying the area for use in pipeline design analysis
- Installing approximately 5,000 LF of high-density polyethylene (HDPE) pipeline along Antler Ditch to reduce seepage and minimize annual ditch maintenance

4.1.6. Upper Snake River Ranch

The Snake River Ranch is a family owned cattle ranch that began operations in 1929. The Upper Snake River Ranch is located adjacent to the southern border of GTNP. The ranch's agricultural operations support and maintain wildlife habitat and migration routes across the scenic foreground of GTNP and the greater Yellowstone ecosystem.

4.1.6.1. *Granite Creek Supplemental Ditch Headgate (ISI-6)*

The Granite Creek Supplemental Ditch Headgate is located on the west bank of the Snake River approximately 3.7 miles northeast of Teton Village (Photo 20). It was constructed around 1960 and consists of three 48-inch corrugated metal pipe culverts, 34 feet long, with a slope of 0.5 percent. The culverts are attached to headwalls on the upstream and downstream sides of the structure. The upstream side has steel screw gates mounted to the headwall at each culvert. There is an adjudicated water right of 390 cubic feet per second (CFS). Typical flows range from 200–350 CFS. The current size and elevation of the gates require approximately a foot of head above the culverts to divert the full 390 CFS. The Upper Snake River Ranch identified the need to lower/replace the headgate to efficiently deliver irrigation water. The alternative evaluated for this site is to lower the headgate and build a more natural channel into the gate. The new structure could be built to improve two-way fish passage, remove dangerous high-velocity culverts from popular floating areas, reduce annual operational costs, and reduce the need to conduct excavation within the channel of the Snake River.

Photo 20 Granite Creek Supplement Headgate

Granite Creek Supplemental Ditch runs for 4,200 feet before reaching the Lake Creek diversion structure. Based on survey data obtained from the ranch, there are approximately 10.5 feet of fall in this section of ditch, resulting in an average slope of 0.26 percent. In order to install the new headgate at a lower elevation, the slope of the ditch needs to be flattened. Reducing the slope from 0.26 to 0.15 percent along 3,000 linear feet downstream from the new headgate, will allow the new headgate to be installed 3.3 feet lower than the existing headgate. Due to site constraints and proximity to the GTNP, the proposed new headgate would ideally be built immediately north of the existing headgate. The new headgate would be installed with larger culverts/gates; reducing the velocity of the flow through the headgate.

As illustrated in Map ISI-6, the conceptual project description for Granite Creek Supplemental Ditch Headgate includes:

- Survey the area for use in design analysis
- Constructing new large diversion structure on the Snake River
- Regrading 3,000 LF of the Granite Creek Supplemental Ditch

4.1.6.2. *Millstream Ditch (ISI-7)*

The Millstream Ditch Headgate is located on the west bank of the Snake River, near Snake River Ranch. The existing headgate, built in 1944, is on the National Historic Register. It is a concrete structure with a slide gate attached (Photo 21). This structure diverts 50 CFS when sufficient source water is present.

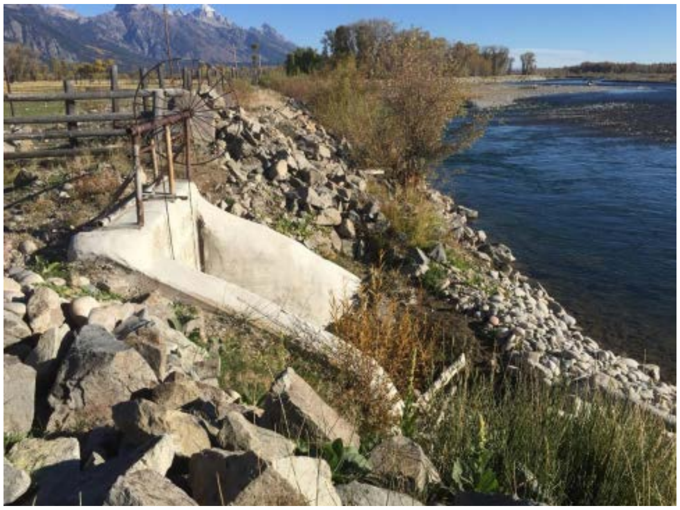


Photo 21 Historic Millstream Headgate off the Snake River.

The river has cut down in front of the headgate. This has led to decreased flow into the headgate.

As illustrated in Map ISI-7, the conceptual project description for Millstream Ditch Headgate includes:

- Survey the area for use in design analysis

- Construction of a new diversion channel in the Snake River (approximately 600 cubic yards of rip rap, and 4,000 cubic feet of embankment)

This project provides opportunities to provide for fish passage restoration. It is recommended that concurrent with project design, considerations for fish passage and protection be examined. This can be accomplished through collaboration with WGFD and local non-profit groups focused on fisheries and habitat restoration.

4.1.6.3. *Lake Creek and Granite Creek Supplemental Headgate (ISI-8)*

Granite Creek Supplemental Ditch crosses Lake Creek approximately 3 miles northeast of Teton Village (Photo 22). The Lake Creek crossing is a two-way headgate that is functioning adequately. The existing Granite Creek (west) diversion structure is functioning as intended; however, operation of the structure is difficult and often dangerous. A proposed new diversion structure would utilize shorter stop log sections, increasing operational efficiency, safety, and fish passage for spawning runs.

Photo 22 Granite Creek Supplemental Ditch Crossing at Lake Creek.

As illustrated in Map ISI-8, the conceptual project description for Lake Creek Crossing, Granite Creek Supplemental Ditch includes:

- Survey the area for use in design analysis
- Removal of existing diversion structure on the Granite Creek Supplemental Ditch
- Constructing new large diversion headgate on the Granite Creek Supplemental Ditch

This project provides opportunities to provide for fish passage restoration. It is recommended that concurrent with project design, considerations for fish passage and protection be examined. This can be accomplished through collaboration with WGFD and local non-profit groups focused on fisheries and habitat restoration.

4.1.6.4. *Wyoming School Section 36 (T42N R117W) Hazel Ditch (ISI-9)*

Wyoming School Section 36 is a pasture located approximately 1.5 miles south of Teton Village, west of Highway 390 in Section 36 of Township 42 North Range 117 West (T42N R117W). It is currently flood-irrigated with open ditches. The ditches are fed off a main supply ditch running along the east side of the property. Flow into the field ditches is controlled with culverts extending into the supply ditch. The culverts are then boarded as necessary to direct flow. The boards don't fully stop the water supply into the culverts, which leads to over-irrigation in areas of the property. This inefficient application of water, combined with the current system operations, lead to excess sedimentation through the field ditches and downstream into Fish Creek.

As illustrated in Map ISI-9, the conceptual project description for Wyoming School Section 36 (T42N R117W) Hazel Ditch includes:

- Construction of seven new extra small diversions in the field ditches

4.1.6.5. *Jensen Creek (ISI-10)*

Jensen Canyon Headgate was located 2.5 miles southwest of Teton Village in Jensen Canyon. Jensen Canyon has experienced three major debris flows since 1915. The existing headgate was destroyed in 2007 by a large-debris flow (Photo 23). A replacement headgate is needed to divert flow into the irrigation ditches that supply water to several private landowners and irrigators.

As illustrated in Map ISI-10, the conceptual project description for the Jensen Canyon includes:

- Survey the area for use in design analysis
- Constructing a new medium headgate

Photo 23 Jensen Creek Diversion Structure Crushed by a Boulder During a Debris Flow.

4.1.7. R Lazy S Ranch (ISI-11)

The R Lazy S Ranch is located approximately 1.5 miles northeast of Teton Village. The field west of the ranch headquarters is approximately 25 acres, half of which are currently under-irrigated. The field is flood-irrigated with open ditches. The main supply ditch runs along the north side of the field, with field ditches running south from the main supply. The field ditches are spaced too far apart, resulting in under-irrigated areas.

As illustrated in Map ISI-11, the conceptual project description for the West Field Irrigation includes:

- Installing piping and a traveling gun sprinkler system,
- Installing a pump and pump pit for the surface water pump

4.1.8. Huidekoper Ranch (ISI-12)

Lockwood headgate is a control structure located on Trail Creek that provides water to Huidekoper and two other private ranches. The existing headgate is in a state of disrepair and needs to be replaced. The project is located on public land and is being coordinated through the NRCS. The proposed plan is to replace the existing diversion structure with a new headgate structure that utilizes stop-logs for flow control, as requested by the landowners who operate the ditch.

As illustrated in Map ISI-12, the conceptual project description for Lockwood Headgate includes:

- Survey the area for use in design analysis
- Removing the existing headgate structure
- Constructing a new medium headgate structure
- Install one measurement flume

4.1.9. Jackson Hole Land Trust (JHLT)

The JHLT is a private, nonprofit organization that was established in 1980 to preserve open space and the critical wildlife habitat, scenic vistas, and historic ranching heritage of Jackson Hole. The JHLT owns several properties along Prosperity Ditch and Pioneer Ditch east of Wilson, Wyoming. The following projects were proposed by the staff at JHLT to facilitate irrigation of the properties.

4.1.9.1. *Prosperity Ditch at Highway 22 (ISI-13)*

Prosperity Ditch flows into a three-way diversion structure located just north of Highway 22 (Photo 24). The JHLT requested a method to measure flow through the diversion to better manage water distribution to the JHLT property and other private water users downstream of this juncture. Two methods of measuring flow were proposed. The two options differ in price and accuracy. The first option includes installing three staff gages at the diversion. The staff gages are used to measure the water depth and once a rating curve is developed, the discharge can be estimated. The second option includes installing three measuring flume structures. A measuring flume structure is a calibrated flume that can be used to accurately measure flow through each of the ditches. Additionally, for either Option 1 or 2, a remote water level monitoring system could be installed at this location for approximately $30,000 to allow for continuous discharge monitoring.

Photo 24 Three-way Headgate, Prosperity Ditch at Highway 22

As illustrated in Map ISI-13, the conceptual project description for the Three-way diversion included two options:

Option 1: Install staff gage on downstream side of each gate (three total)

Option 2: Install measurement flume on downstream side of each gate (three total)

4.1.9.2. *Prosperity Ditch at Highway 390 (ISI-14)*

The JHLT has noted that the flow in Prosperity Ditch is impeded downstream of a culvert under Highway 390 (Map ISI-14). The water backs up in the ditch on the east side of Highway 390 and it is likely the result of insufficiently buried utilities downstream of the culvert on the west side of the highway. The JHLT has retained a local engineering firm that has suggested installation of a pipe along a segment of the ditch to facilitate delivery of water. No further detail regarding pipe size or length was provided at the time of this report preparation and therefore the specific improvements are not outlined here. The potential project is raised in this report because the issue of low flow in Prosperity Ditch was brought up by other landowners in the area as well as at one of the project meetings. Installing a pipe to facilitate flow at Highway 390 may only address a part of the problem. The bigger issue may be the location of the Prosperity Ditch headgate on the Snake River. The issue of low and impeded flow along Prosperity Ditch should be evaluated through additional study. The potential for a Level II study was proposed to the JHLT and other landowners at one of the public meetings. There are potentially additional benefits to the area should the flow be increased including aquifer recharge and return flow to Fish Creek. As stated at the project meeting, a Level II study can be pursued with assistance by the WWDC.

4.1.9.3. *Pioneer Ditch to Hardemon Field (ISI-15)*

Pioneer Ditch provides irrigation water to approximately 25 acres of pasture (Hardemon north) located adjacent to the north side of Highway 22 and 0.5 mile west of Highway 390. Pioneer Ditch supplies approximately seven small irrigation ditches across the field. JHLT has requested that the Pioneer Ditch be realigned to facilitate flow to the small irrigation ditches.

As illustrated in Map ISI-15, the conceptual project description for Pioneer Ditch includes:

- Realigning 600 LF of Pioneer Ditch

4.1.10. Lockhart Ranch

The Lockhart Cattle Company was founded in 1914 and continues to function as a family run Hereford cattle operation in the Jackson Hole area. The irrigation diversions that provide water to ranch operations include diversions off Flat Creek in Jackson and a diversion off the Snake River south of the Wilson bridge.

4.1.10.1. *Flat Creek Leeks Diversion (ISI-16)*

The Flat Creek Leeks Diversion crosses Flat Creek downstream of Russ Garaman Park on Flat Creek in Jackson (Map ISI-16). The diversion provides irrigation water to pasture and hay fields south of town. In the summer, this section of Flat Creek is extremely popular for tubing and the Leeks Diversion from Flat Creek has been identified as a potential safety hazard for adults and children tubing on the creek (Photo 25). It is not within the scope of this watershed study to evaluate the safety of a diversion structure. However, the irrigation diversion structure is dated and replacement may allow for enhancements such as fish passage and operations optimization.

Photo 25 Leeks Diversion on Flat Creek in Jackson

As illustrated in Map ISI-16, the conceptual project description for Leeks Diversion on Flat Creek includes:

- Survey the area for use in design analysis
- Removal of existing headgate
- Constructing a new large diversion headgate across Flat Creek

4.1.10.2. *Snake River at Wiley Ditch (ISI-17)*

Wiley Ditch is an irrigation ditch off the Snake River 3.5 miles downstream of the Wilson bridge (Map ISI-17). The headgate structure that controls water flow into the irrigation ditch has several deficiencies. Late summer flows in the Snake River are at times too low to reach the headgate structure. Significant modification to river flow is often required to redirect adequate flow to the Wiley Ditch. Additionally, the gates for the headgate are on the downstream side of the structure, which leads to clogging and maintenance issues. The headgate structure penetrates the Snake River levee system and – because of project time constraints – contact with the USACE for headgate redesign requirements were not completed. Therefore, the conceptual plans for this proposed project are similar to those proposed for the Granite Creek Supplemental project off the Snake River (ISI-6). Modification to the conceptual plans may be needed after coordination with the USACE.

As illustrated in Map ISI-17, the conceptual project description for Wiley Ditch headgate includes:

- Survey the area for use in design analysis
- Removal of existing headgate
- Constructing a new large headgate structure on the Snake River
- Regrading Wiley Ditch

This project provides opportunities to provide for fish passage restoration. It is recommended that concurrent with project design, considerations for fish passage and protection be examined. This can be accomplished through collaboration with WGFD and local non-profit groups focused on fisheries and habitat restoration.

4.1.11. Lower Snake River Ranch (ISI-18)

Alaska Ditch is an irrigation ditch off the Snake River that provides irrigation water to the Lower Snake River Ranch. The headgate structure that controls water flow into the irrigation ditch has several deficiencies. Similar to the headgate at Wiley Ditch, late summer flows in the Snake River are at times too low to reach the headgate structure. The Antler Ditch structure was not visited during the watershed project and therefore, no site-specific map illustrating the plans was prepared. The conceptual plans for this proposed project are similar to those proposed for the Granite Creek Supplemental project off the Snake River (ISI-6) with one exception. The exception is that the existing Alaska Ditch headgate is not located directly on

Photo 26 Game Creek Diversion

the Snake River; thus, removal of the existing headgate is unnecessary. A new headgate is proposed for construction upstream of the existing headgate on the levee of the Snake River.

The conceptual project description for Alaska Ditch headgate includes:

- Survey the area for use in design analysis
- Constructing new large headgate on the Snake River
- Regrading 1,000 linear feet of Alaska Ditch

This project provides opportunities to provide for fish passage restoration. It is recommended that concurrent with project design, considerations for fish passage and protection be examined. This can be accomplished through collaboration with WGFD and local non-profit groups focused on fisheries and habitat restoration.

4.1.12. Game Creek (ISI-19)

Game Creek is a second-order tributary to the Snake River. The creek joins Flat Creek approximately 0.6 mile upstream from its confluence with the Snake River, downstream of the South Park Bridge, approximately 5.5 miles south of the Town of Jackson. Abundant habitat for all life stages of cutthroat trout is provided throughout the South Park Wildlife Habitat Management Area, which is located adjacent to the Game Creek / Flat Creek confluence. Game Creek has historically been disconnected from Flat Creek because of porous geology resulting in natural losing reaches, and more recently, the routing of Game Creek through a long, steep culvert to allow for the reconstruction of Highway 89. Game Creek is now perennial and WyDOT, in conjunction with many project partners and stakeholders, are in the process of reconstructing the highway to improve transportation needs and provide fish and wildlife passage. Opening Game Creek up to Snake River cutthroat trout movement has inspired several habitat and water delivery improvement projects on WGFD commission lands located immediately upstream (east) of the Highway 89 crossing (Photo 26).

As illustrated on Map ISI-19, all project components share a common goal, which is to make Game Creek accessible to in- and out-migrating cutthroat trout. The improvements include:

- Survey the area for use in design analysis
- Converting from flood irrigation to gated pipe irrigation to improve irrigation efficiency on six-acre pasture (approximately 1,000 feet of pipe)
- Removal of existing headgate
- Constructing a small headgate structure enabling regulation of irrigation water, sediment transport, and fish passage
- Installing a 500-gallon stock tank for off-channel livestock watering
- Restoring approximately 100 feet of stream to restore width-to-depth ratios (to be completed by WGFD)

It should be noted that sub-irrigated pastureland west of Highway 89, should be monitored after the conversion from flood irrigation to gated pipe irrigation east of Highway 89 is complete. Hydrologic conditions in the pasture may change.

4.1.13. Fall Creek (ISI-20)

Fall Creek is a tributary to the Snake River with a headgate structure that provides water to an irrigation ditch that runs through Fall Creek Ranch. According to the USFS, the headgate structure is not adequate and, therefore, the USFS requested an upgrade to facilitate operations. Representatives from the BTNF specifically requested that a gated structure be proposed to allow for regulation of the flow out of Fish Creek (Photo 27). Since the request was initiated through USFS to maximize flows in Fish Creek for fish habitat maintenance, there was no information provided by the irrigators on their operational requirements. Further discussion with Fall Creek Ranch and others will be required to ensure the upgrade meets the operation requirements of the USFS and irrigators.

Photo 27 Fall Creek Diversion Structure

The goal of the project is to ensure adequate flow is maintained in Fish Creek for fish habitat. The improvements include:

- Survey the area for use in design analysis
- Removal of existing headgate
- Constructing a small headgate structure to enable regulation of irrigation water, sediment transport, and fish passage

This project provides opportunities to provide for fish passage restoration. It is recommended that concurrent with project design, considerations for fish passage and protection be examined. This can be accomplished through collaboration with WGFD and local non-profit groups focused on fisheries and habitat restoration.

4.2. Livestock/Wildlife Watering Improvements

Because of the network of perennial streams in the Upper Snake River watershed, the distance between sources of water is not as significant an issue for livestock and wildlife as in other parts of the state (see Sections 2 and 3, Watershed Description and Watershed Inventory). For this reason, the number of requests for livestock/wildlife watering improvements were small relative to other watershed management studies prepared for the WWDC. Table 4.2-1 provides a list of projects identified, the water source, and the types of proposed improvements identified for each site. Other project areas in need of watering improvements with similar parameters still exist throughout the watershed. The sites listed below provide a basis for evaluation upon which other sites could be assessed. Some benefits of the watering improvements discussed with the ranch owners included:

- Healthy livestock with additional watering sites that minimize distance traveled per day to a clean water source
- Reduced soil erosion because of reduced distance livestock travel to water per day, resulting in reduced sediment loading on streams

- Reduced impacts to sensitive riparian habitats
- Enhanced stream stability through stable vegetative cover
- Reduced expansion and establishment of non-native plants

Map 33, Proposed Livestock/Wildlife Watering Improvement Locations, provides an index map of the proposed project locations.

Table 4.2-1 Livestock/Wildlife Watering Improvement Projects

Project Number	Ranch or Site Name	Water Well/Spring Development	Stock Pond	Pipeline Length (feet)	Fencing (feet)	Solar Pump	Stock Tank
LWW – 1	Taylor Ranch Spring Development	1	0	100	100	0	1
LWW – 2	Wyoming School Section 36 (T40N R117W) Stock Pond	0	1	0	0	0	0
LWW – 3	Kelly Warm Springs Wells	2	0	200	0	2	0
LWW – 4	Lower Snake River Ranch Ridge Spring	1	0	4,500	100	0	4

4.2.1. Upland Watering Opportunities

4.2.1.1. Taylor Ranch Spring Development (LWW-1)

Taylor Ranch on Bierer Creek is a full-service outfitter for hunting, wildlife viewing, and horseback riding. The watershed improvement requested for Taylor Ranch involves rehabilitating an existing spring in order to provide adequate water supply for livestock and wildlife in an area with inadequate water sources. Spring improvement will facilitate rotational grazing practices and provide for a stable water supply for wildlife in the area. The allotment where the improvement is proposed is within the Gros Ventre wilderness area and near the Gros Ventre Slide National Geological Site.

According to the USFS, the Gros Ventre wilderness provides critical habitat for many species of wildlife, hosts the headwaters of multiple wild and scenic rivers, and offers miles of trails to access via horseback or on foot. In addition, the Gros Ventre wilderness is unique for its geological features and for the Gros Ventre Slide National Geological Site. Because of the sensitive habitats and unique geologic features in the wilderness area, the improvement request will be coordinated with the USFS and the conceptual project plans will be implemented following the guidelines for improvements within designated wilderness areas.

As illustrated in Map LWW-1, the conceptual project description for Taylor Ranch includes:

- Site preparation
- Spring rehabilitation using a buried HDPE pipe, partially perforated
- Fencing

- Piping
- Stock tank installation

4.2.1.2. *Wyoming School Section 36 (T40N R117W) Stock Pond (LWW-2)*

The Lower Snake River Ranch is a family owned cattle ranch that began operations in 1929. The ranch's agricultural operations support and maintain wildlife habitat and migration routes across the scenic foreground of GTNP and the greater Yellowstone ecosystem. On and around Munger Mountain, there are four hillside pastures with steep terrain and limited water. The pastures range in size from 340 acres to 1,200 acres. One of the pastures is on Wyoming State School Section 36 (T40N R117W) with a limited late season water supply. There is a small seep that is intermittently productive in a draw. The project is intended to provide a stable water supply for grazing in the school section.

The proposed conceptual plan is to build a small stock pond. The pond volume would be obtained by a combination of excavation to take advantage of groundwater as a water source and an embankment to add volume. An excavation depth of an average of six feet was assumed, so that the pond would be deep enough to discourage vegetation growth. The embankment was assumed to be four feet high with 3:1 slopes on the upstream side and 6:1 slopes on the downstream side. The excavated material would be used in the embankment assuming it is suitable. A foot of freeboard would be provided in the pond and installation of an outlet structure was included.

The conceptual project description for the Lower Snake River Stock Pond as illustrated in Map LWW-2 includes:

- Site preparation
- Small stock pond construction
- Outlet structure installation

4.2.1.3. *Kelly Warm Springs Well Development (LWW-3)*

The Kelly Warm Springs is a geothermally fed pond that maintains tropical water temperatures year-round. The spring is located northeast of Kelly, Wyoming, within GTNP. According to the NPS, Kelly Warm Springs has had a long history of illegal aquarium dumping (NPS, 2016d). Residents of Jackson and the surrounding area, take their pet fish to the warm spring for release. Records of guppies in the warm spring date back to the 1940s. In recent years, goldfish, madtoms, and bullfrog tadpoles originating from the warm spring have been found in Ditch Creek within approximately 30 feet of the Snake River. While no exotic species have been found in the Snake River at the date of the news release, according to the NPS, it is likely they are present. The aquarium fish are a detriment to native fish—including Snake River cutthroat trout, bluehead suckers, Utah suckers, Utah chubs, redside shiners, longnose and speckled dace—because the aquarium fish prey on native fish's eggs and juveniles, deplete the food sources used by native fish, and spread disease (NPS 2015d). The NPS is reviewing several options to protect native aquatic communities. The following proposed conceptual plan is one component of the preservation plan.

Currently, Savage Ditch, an irrigation diversion off the Gros Ventre River, flows on the south end of Kelly Warm Springs where the spring discharge flows into the irrigation ditch. Savage Ditch crosses Ditch Creek as it flows toward Antelope Flats Road. The ditch provides irrigation water supply for private residences along the road.

In order to minimize the need to run water down Savage Ditch and therefore reduce the threat that non-native species enter the Snake River, two irrigation water supply wells are proposed to supply the needed irrigation water for the residential properties. A location map was not prepared for the wells since the exact location has not been identified.

The conceptual project description for the Kelly Warm Springs Well Development includes:

- Two new solar powered wells drilled to supply water for irrigation
- Well solar panel installations to include solar panels, solar-powered pumps, and all necessary regulators, connections, and appurtenances
- Pipeline installation from the well to the existing irrigation distribution systems including approximately 200 LF of 1.5-inch pipe and all valves, fittings, and appurtenances to regulate flow, pressure, and water level in the tanks

4.2.1.4. *Lower Snake River Ranch Ridge Spring Development and Don's Draw Pipeline (LWW-4)*

As described in the Lower Snake River Ranch stock pond project, (LWW-2), on and around Munger Mountain, there are four hillside pastures with steep terrain and limited water. The pastures range in size from 340 acres to 1,200 acres. There are a number of small springs that provide water in the early part of the summer, but they are unreliable later in the season. The proposed improvement for Ridge Spring includes both development of an existing spring and diversion of water from Don's Draw to supply several new stock tanks. The existing spring will be developed with standard spring development practices as site conditions warrant. Spring water will be piped approximately 100 feet to a new stock tank. Surface water from Don's Draw will be diverted via pipeline approximately 4,000 feet to supply three new stock tanks along the hillside.

The conceptual project description for the Lower Snake River Ranch Ridge Spring Development and Don's Draw Pipeline as illustrated in Map LWW-4 includes:

- Site preparation at Ridge Spring and Don's Draw
- Spring development
- Fencing around spring (approximately 100 LF)
- Stock tank on hillside
- Pipeline from Don's Draw to three stock tanks (approximately 4,400 LF)
- Three stock tanks along lower hillside pasture
- Wildlife escape ramp installation in the stock tanks (as needed depending on tank size)

4.3. Surface Water Flood and Water Supply/Storage Improvements

As stated previously in this report, from the outset of this watershed study, the project sponsors and WWDC stated that there is no desire to evaluate large water storage improvements for the Upper Snake River watershed. Potential water storage sites that were previously identified in other studies, primarily the Snake/Salt River Basin Plan (Sunrise Engineering 2003). Instead, the issues that were identified included flood control and small water supply improvements. Table 4.3-1 provides a list of projects identified and the types of proposed improvements identified for each site. Map 34, Proposed Surface Water Flood and Storage Improvement Locations, provides an index map of the proposed project locations.

Table 4.3-1 Surface Water Flood and Water Supply/Storage Improvement Projects

Project Number	Ranch or Site Name	Water Source	Project Description		
SWF-1	Jackson Hole	Flat Creek	Implement proposed recommendations from the study being conducted for the FCWID and funded by the TCD.		
SWF-2	Snake River	Snake River	Implement proposed recommendations from USACE Jackson Hole, Wyoming Environmental Restoration Draft Feasibility Study		
Drafting Sites for Fire Trucks					
Project Number	**Ranch or Site Name**	**Water Source**	**Tank and pipes**	**Access Road Improvements (square feet)**	**Other**
SWF - 3	Wilderness Ranches	Buffalo Fork	1 tank; 35 LF of pipe and fittings	900	NA
SWF - 4	Buffalo Valley Estates	Buffalo Fork	1 tank; 35 LF of pipe and fittings	900	NA
SWF - 5	Heart Six Ranch	Buffalo Fork	1 tank; 35 LF of pipe and fittings	2,180	NA
SWF - 6	USFS dispersed camping	Buffalo Fork	1 tank; 35 LF of pipe and fittings	4,900	NA
SWF - 7	Buffalo Fork Ranch Subdivision	Buffalo Fork	1 tank; 35 LF of pipe and fittings	900	NA
SWF - 8	Buffalo Fork	Buffalo Fork	1 tank; 35 LF of pipe and fittings	1,300	NA
SWF - 9	Turpin Meadows	Buffalo Fork	5 LF of pipe and fittings	NA	Repairs to existing drafting site with welding

4.3.1. Flood Control

4.3.1.1. *Flat Creek Winter Flooding (SWF-1)*

Intermittent winter flooding occurs along Flat Creek as it flows through Jackson, causing damage to homes along the creek. The exact causes of the flooding and why ice dams form in some years but not others are not well understood. The FCWID was formed with the mission “to explore and implement ways to prevent damage to private property because of winter flooding of Flat Creek with a commitment to honor water rights, represent the best interests of the district’s property owners and residents, while maintaining and improving water and habitat quality within the stream corridor” (FCWID 2016a). The FCWID is seeking solutions to the flooding problems in collaboration with the TCD and Town of Jackson. The FCWID instigated a study that was funded by the TCD and conducted by Alder Environmental to collect data and document where and how ice forms. The data collection took place over winter 2015 (FCWID 2016b). The study – or a subsequent, future phase of the study – may present recommendations for improvements that will prevent or mitigate for future flooding. Design and construction of proposed recommendations would be completed as recommended by the FCWID. The study/project area is shown in Map SWF-1.

4.3.1.2. *USACE Snake River Levee Mitigation Project (SWF-2)*

In 1964, the Jackson Hole Flood Control Project levees were completed. They consist of 24.5 miles of levees along the Snake River in Teton County. In 1990, the USACE was authorized by the U.S. Congress to conduct the Jackson Hole, Wyoming, Environmental Restoration Feasibility Study (USACE 2000). The purpose of the study was to investigate the feasibility of restoring fish and wildlife habitat that had been lost as a result of the levee construction. In April 2000, the Jackson Hole, Wyoming Environmental Restoration Draft Feasibility Study (Feasibility Study) was completed (USACE 2000). In April 2001, the U.S. Congress authorized $66.5 million in funding for the project. The USACE, Teton County, and TCD entered into a cost-share agreement in 2004. The amount of money allocated to the project is unclear. The project has moved forward only slightly. Issues such as real estate and the financial match of the local sponsors need to be addressed. The project is slated for re-scoping this year (2016). The local sponsors have the opportunity to determine priorities for the project and the desired path for implementation. The USACE is interested in moving the project forward, but it wants to collaborate with the TCD and Teton County to meet their needs.

The Feasibility Study objectives were to restore channel stability, protect remaining diverse habitats, restore diversity and sustainability to degraded habitats, and restore degraded habitats for threatened and endangered species. Twelve initial sites were identified for restoration and were reduced to four sites that were studied in depth. Two restoration plans were developed, an Initially Proposed National Ecosystem Restoration Plan that involved implementation of improvements at the four sites, and a Progressive Plan that recommended a phased approach to restore the entire 22-mile study reach. The Progressive Plan was the recommended plan, at an estimated cost of $52.3 million in 2000 dollars (USACE 2000). Map SWF-2 shows the study reach and the four priority areas.

During completion of this watershed study, the TCD continued to meet with the USACE. When the project priorities are updated, further studies, design, and construction of proposed recommendations will be completed as agreed to by the USACE and TCD.

4.3.2. Water Supply/Storage

The ability to adequately respond to and fight fires is an important issue in areas of the watershed. Watershed stakeholders identified needs in the watershed, including access to water to fill trucks for fire-fighting purposes (known as drafting sites) and existing system improvements. Drafting sites can consist of several different types and methods, including, but not limited to, suction drafting from a static water source such as a creek or pond, portable or permanent tanks from which water can be suctioned, and underground storage tanks. Existing system improvements and potential drafting sites have been identified, are included as projects SWF-3 through SW-9, and are shown on Maps SWF-3-5 and SWF-6-9.

4.3.2.1. *Wilderness Ranches Drafting Site (SWF-3)*

The SWF-3 drafting site would be located adjacent to the U.S. Highway 26 bridge over the Buffalo Fork. The site would be available during snow-free periods and would serve the Wilderness Ranches area. It would consist of an underground 3,000-gallon plastic or fiberglass tank. A 4 ½-inch connection is required. The connection point should be at least 4 feet above the ground. The tank should be buried below frost line, approximately 4 feet down to the top of the tank. The pipe must be able to be accessed by a truck backing into it. An ideal location could be right off Buffalo Valley Road; however, it is private property. Locating the tank at a location easy to access of the Highway but not as close to Buffalo Fork would reduce the limits of a necessary access road. Water would be pumped from the Buffalo Fork into the tank with portable equipment. The property is privately owned on the west side of the bridge. Access from the east side would cross both private and BTNF land. The Buffalo Fork is designated as a Wild and Scenic River. The location is shown on Map SWF-3-5.

4.3.2.2. Buffalo Valley Estates and Evergreen Estates Subdivisions Drafting Site (SWF-4)

The proposed drafting site would be an underground tank that would consist of a 3,000-gallon plastic or fiberglass tank. A 4 ½-inch connection is required. The connection point should be at least 4 feet above the ground. The tank should be buried below frost line, approximately 4 feet down to the top of the tank. The pipe must be able to be accessed by a truck backing into it. If the site were close to the road, it could provide year-round access. The land on both sides of Buffalo Valley Road is privately owned. The general location of the proposed drafting site is shown on Map SWF-3-5. If preferable, the site can be moved approximately 500 feet to the east to be located on USFS property.

An existing water system serves the Buffalo Valley Estates and Evergreen Estates subdivisions, which have an active homeowners' association. The water system is owned and managed by the Buffalo Valley Water District. The fire department has not done any recent flow tests on the two hydrants in the system, though the Buffalo Valley Water District noted that the pressure in the system is high. The potential for developing the water source to supplement the Buffalo Valley Estates water system can be evaluated, as a new well will be needed at some point in the future. The existing well is on USFS property.

4.3.2.3. Heart Six Drafting Site (SWF-5)

Location SWF-5 is currently a popular, unofficial USFS trailhead, boat launch, and dispersed camping area. The proposed draft site could be directly in the Buffalo Fork channel similar to a boat ramp or an underground tank that would consist of a 3,000-gallon plastic or fiberglass tank. A 4 ½-inch connection is required. The connection point should be at least 4 feet above the ground. The tank should be buried below frost line, approximately 4 feet down to the top of the tank. The pipe must be able to be accessed by a truck backing into it. The location would be available during snow-free periods and would serve the Heart 6 Ranch and nearby areas. Access to the site is a two-track road down to the river just east of the Heart 6 Ranch gate. The road would benefit from improvement for department access. A 30-foot by 30-foot area to back up to the connection and turn around would also be desirable. If the USFS Blackrock Ranger District wanted to make improvements in the area to facilitate boat access, a joint project could be undertaken. The proposed site is located on USFS property. The Buffalo Fork is designated as a Wild and Scenic River. The location of the proposed drafting site is shown on Map SWF-3-5.

4.3.2.4. Dispersed Camping Drafting Site (SWF-6)

Location SWF-6 is at a dispersed campground owned by the USFS. The site has river access. The proposed drafting site could be developed into a direct draft or an underground storage tank that would consist of a 3,000-gallon plastic or fiberglass tank. A 4 ½-inch connection is required. The connection point should be at least 4 feet above the ground. The tank should be buried below frost line, approximately 4 feet down to the top of the tank. The pipe must be able to be accessed by a truck backing into it. Road improvement and a 30-foot by 30-foot area to back up to the connection and turn around would be needed for fire department access. The site would be available during snow free periods. The property is owned by USFS. The Buffalo Fork is designated as a Wild and Scenic River. The location of the proposed drafting site is shown on Map SWF-6-8.

4.3.2.5. Buffalo Fork Ranch Drafting Site (SWF-7)

The Buffalo Fork Ranch subdivision has an existing hydrant system with a fire pump from the ponds located south of the system. Although the system has not been tested by the fire department, it is thought that the flow is low pressure. It could, however, be helpful for wildland fire response. Improvements to assist with fire suppression would entail overall water system improvements. An evaluation of the current system should be made to determine ways to improve the system. The site is located on private property. The proposed drafting site would be an underground storage tank that would consist of a 3,000-gallon plastic or fiberglass tank. A 4 ½-inch connection is required. The connection point should be at least 4 feet above the ground. The tank should be buried below frost line, approximately 4 feet down to the top of the tank. The pipe must be able to be accessed by a truck backing into it. A 30-foot by 30-foot area to back up to the connection and turn around would be needed off the side of the road for fire department access. The location of the proposed drafting site is shown on Map SWF-6-8.

4.3.2.6. Buffalo Fork Drafting Site (SWF-8)

The proposed drafting site would be either a direct draft or an underground tank that would consist of a 3,000-gallon plastic or fiberglass tank. A 4 ½-inch connection is required. The connection point should be at least 4 feet above the ground. The tank should be buried below frost line, approximately 4 feet down to the top of the tank. The pipe must be able to be accessed by a truck backing into it. The proposed location would be on USFS property, but access would be through private property, through which permission would be required. The area is accessed unofficially and through powerline right-of-way, but legal access would be needed. An access road through the USFS property and a 30-foot by 30-foot area to back up to the connection and turn around would be needed for fire department access. The USFS would need to be involved because of the Buffalo Fork River's Wild and Scenic designation. The site would be available during snow-free periods. The location of the proposed drafting site is shown on Map SWF-6-8.

4.3.2.7. Turpin Meadows Drafting Site Maintenance (SWF-9)

Located at the Turpin Meadows Bridge over the Buffalo Fork River, site SWF-9 is a developed culvert stand pipe at the water table and has been used for training by the Jackson Hole Fire/Emergency Medical Services (JHFEMS) Station 4 apparatus during the winter and summer. The existing equipment needs maintenance and repairs in the form of welding to reduce current safety hazards of the improvement. A longer pipe that stands approximately 4 feet high would also be beneficial. Although the installation does not meet current standards, the USFS researched it and essentially approved or "grandfathered" the improvement. The site would serve the Turpin Meadow Summer Homes and the Turpin Meadow Guest Ranch. The property is owned by the USFS. The Buffalo Fork is designated as a Wild and Scenic River. The location of the proposed drafting site is shown on Map SWF-9.

Photo 28 Drafting Site at Turpin Meadows on the Buffalo Fork

4.4. Stream Channel Condition Improvements

Stream channels within the watershed were characterized using the Rosgen classification system. Impaired channels were identified through the classification and through input from residents and landowners. Table 4.4-1 lists the areas that require further evaluation and proposed improvements. Map 35, Proposed Stream Channel Condition, Stability Improvement, and Other Watershed Management Opportunity Locations, provides an index map of the proposed project locations.

Table 4.4-1 Stream Channel Condition and Stability Improvement Projects

Project Number	Ranch or Site Name	Stream or Ditch	Description
SCC - 1	Upper Snake River Ranch	Last Chance Ditch	Improve erosion issues and irrigation efficiency
SCC - 2	Upper Snake River Ranch	Lake Creek	Minimize bank erosion on Lake Creek
SCC - 3	Lower Snake River Ranch	Morel Creek	Restore stream and improve habitat
SCC - 4	Jackson Area	Fish Creek	Minimize sediment loads on Fish Creek

4.4.1. Erosion of Last Chance Ditch (SCC-1)

On the Upper Snake River Ranch there were discussions involving the Last Chance Ditch and erosion occurring along its banks (Map SCC-1). It was requested that conceptual design options be assessed to reduce the erosion along Last Chance Ditch and associated ditches. Because of the extent of the ditches and the need for efficiency of irrigation water movement, there are limited options to reduce erosion. Potential concept designs to assist erosion reduction are as follows:

- Maintain a buffer of deep-rooted vegetation along the banks of the ditches by regulating livestock uses and utilizing best management practices within the pastures where the ditches are located. A two- to three-foot buffer of vegetation along the ditch would help maintain its width and depth during the irrigation season. This option is the most cost-effective in that no structural change or adjustment to the ditches is required.
- Along isolated sections, where the ditches curve, there may be opportunities to reshape the ditch to a natural stream channel with a pool feature on the outside of the meander and a point bar along the inside to reduce erosion to some extent. This concept, in conjunction with a vegetative buffer, could aid in minimizing sediment inputs downstream from ditch erosion.
- Utilizing structures such as check dams is not a viable option because the dams would increase width and associated bank erosion in locations where they would be placed. There may be locations where the ditch width is sufficient to build small V-shaped weirs to decrease bank erosion and bring the water toward the center of the ditch to disperse energy. Additionally, because of the nature of irrigation ditches running basically straight and along contours to maintain elevation, the idea of increasing sinuosity and length to slow velocity and decrease erosive power is also not a viable alternative.

4.4.2. Bank Stabilization on Lake Creek (SCC-2)

There were reaches along Lake Creek where bank erosion was evident during the site visits. In addition to the active erosion, a reach was observed where the meander was stabilized using a wood toe-type structure along the outside bend (Map SCC-2). This type of toe wood structure is recommended for overwide and actively eroding reaches of Lake Creek. The meander can be stabilized by creation of a low “bankfull” bench being constructed along the meander. A footer log is placed below the water surface, at or below the maximum pool depth, and then additional trees with root wads are placed facing upstream into the flow on the footer log. The entire structure is covered with bed material and then deep-rooted sod mats are transplanted on top of the wood. The final elevation of the sod is at “bankfull’ elevation essentially at the elevation where the creek begins to access the floodplain. The toe wood feature is completely under water so the logs will not decay. Proper channel dimensions of width, depth, and cross-sectional area need to be incorporated into the final design of such structures.

4.4.3. Morel Creek and Snake River Tributaries Restoration (SCC-3)

The Morel Creek project is an effort to enable surface water to access riparian zones and relic flood channels on the landward side of the Snake River levees to restore fluvial processes currently precluded by the Snake River levee system. Proposed activities include grading activities along Morel Creek (Map SCC-3, Morel Creek), a relic Snake River flood channel, to establish a groundwater-supported Spring Creek and use of the Alaska Ditch irrigation water conveyance network to augment flows through the creek to simulate natural seasonal floodplain inundation (Biota 2014). According to the 30 percent design documents, the specific improvements identified for Morel Creek include excavation within the existing relic Snake River flood channel to enable natural groundwater discharges to provide hydrologic support for a low-gradient, meandering Spring Creek system, referred to as Morel Creek. Proposed treatments include establishment of floodplain benches along the creek and seasonal delivery of surface water to the upstream end of the reach to augment groundwater-supported hydrology and achieve overbank flooding during the natural spring runoff period. Specific treatments identified for Morel Creek include:

- Cut and fill to establish floodplain benches
- Cutthroat trout enhancement pool creation
- Cutthroat trout spawn bed creation
- Rock cross-vane construction
- Culvert installation
- Fine grading
- Seeding and reclamation
- Active weed control
- Post-construction monitoring

Similarly, several other creeks and tributaries of the Snake River watershed including, for example Fish, Flat, Spring, Blue Crane and Cody creeks, provide vital spawning habitat and are integral to sustaining wild populations of native Snake River cutthroat trout. Levees installed as flood protection and some irrigation practices have changed the structure and function of the river and these streams. Maintenance of lateral habitats for juvenile and adult spawning cutthroat trout are therefore dependent upon continued instream enhancement activities that reestablish the channel pattern and form necessary to maintain or increase suitable habitat for multiple life stages of Snake River cutthroat trout.

At issue is the fact that the levee system along the Snake River has disconnected the creeks and tributaries from the sediment-flushing flows of spring runoff. Sediment now deposits on the streambed, instead of the floodplain, making streams and particularly riffles, shallow and wide. Wide, shallow areas require an even more powerful or higher volume of water to scour and flush accumulated sediment and reinvigorate spawning gravels. Without the influence of spring spates, aggradation continues to occur, and a positive feedback loop of habitat degradation is established.

Specific improvements and or best management practices that will contribute to the fish habitat enhancements in the creeks and tributaries of the Snake River include:

- Retrofitting irrigation infrastructure to reduce bank instability, channel degradation, fish passage concerns, and maintenance needs
- Decreasing average stream width-to-depth ratio
- Developing instream habitat feature sequences (pool-riffle-run) that are maintained by the creek's geometry through multiple runoff seasons
- Providing a mix of spawning (riffles), holding (pools), and rearing (shallow, low velocity, high-cover) habitats
- Supplementing existing riffles with 0.25-inch to 2-inch, washed gravels
- Where possible, using existing infrastructure to simulate spring flooding in side channels and oxbows located outside of the Snake River levees
- Coordinating with adjacent landowners and managers to sequentially conduct instream habitat work in an up to downstream fashion to avoid inundating downstream projects with fine sediment liberated during upstream excavation

4.4.4. Sediment Loads and Flows in Fish Creek (SCC-4)

Fish Creek – a tributary to the Snake River – is nearly 16 miles long with a watershed drainage of 71 square miles (45,440 acres; Map SCC-4). It is located in Teton County and flows through the town of Wilson, Wyoming. As a valuable water resource for irrigation, fishing, and recreation, Fish Creek is important to the scenic Jackson Hole Valley. However, nuisance growths of aquatic plants in Fish Creek have increased local public concerns of the watershed's health since the early 2000s.

An issue of excess nutrients within Fish Creek is causing damage to the stream quality, fish habitat, drinking water, and the environment. If the unnatural algal and vegetative growth continue and no action is taken, degradation will continue. More importantly, the current conditions in Fish Creek could consequently cause the stream to be added to the WDEQ's list of impaired streams, which would result in additional state and federal regulation and use restrictions.

Local residents became aware of the excess nutrients and in response, to address these concerns, a nonprofit organization known as Friends of Fish Creek was incorporated in May 2014 (receiving 501[c]3 status in May 2015) with a mission to "protect the Upper Snake River watershed by improving and restoring water quality in Fish Creek and the Westbank aquifer through science-based research, engagements of community stakeholders, and collaborative problem solving." Several long-term initiatives, listed below, were established to begin a journey toward a healthier watershed. As seen on the Friends of Fish Creek website, http://fishcreekfriends.org/, the first two initiatives include (1) organizing a nonprofit; and (2) establishing restoration goals. These are complete and are not listed below. The organization's current courses of action include:

- Groundwater Study - Identify current and future sources of nutrient loading by developing a nutrient loading model (to be complete summer 2016).

  - A draft proposal (June 14, 2016) titled "Estimation of Nutrient Inputs into Fish Creek Watershed, 2015" has been prepared for the TCD by Cheryl A. Eddy-Miller and Roy Sando, of the USGS and the Wyoming-Montana Water Science Center. Submission is to occur in 2016 following the Fish Creek stakeholder meeting.
- Implement stakeholder engagement with collaborative solutions to complex environmental, political, and natural resource challenges (in progress through 2017).
  - The now established stakeholder group (reference: http://fishcreekfriends.org/about/stakeholders/) includes all individuals and organizations that can help restore the Fish Creek watershed.
  - This group initiated the source nutrient study.
- Develop, implement, and monitor best management practices through education and outreach programs (in progress through 2019).
  - Methods are being established for preventing and/or reducing pollution in Fish Creek through engagement with community stakeholders and industry professionals (reference: http://fishcreekfriends.org/approach/programs/).
  - Best management practices for nutrient reduction include landscaping, wastewater management, and commonly used chemicals.
- Develop a long -term watershed protection plan (program) working with Teton County and the TCD (in progress through 2019).

Since the establishment of Friends of Fish Creek, various publications ("Fish Creek: A Situation Assessment", "Report to Crescent H Stream and Trail Committee: Assessments of Fish Creek, Teton County Wyoming and their implication for management and restoration efforts" and "Characterization of Water Quality and Biological Communities, Fish Creek, Teton County, Wyoming, 2007–2011," etc.) are now resources of current stream conditions and can be obtained on the website, http://fishcreekfriends.org/resources/. As a compilation, these research documents have stated public responses to their concerns through creation of a nonprofit, listed the issues to determine problems within the biological/ecological environment and following assessments of Fish Creek, and identified other communities with similar issues to use as guidance in organizing a plausible solution.

As the organization and stakeholder group move forward, understanding the problems that confront today's Fish Creek watershed are vital in restoring and protecting this valuable resource. For instance, in the Estimation of Nutrient Inputs proposal mentioned above, the potential source will be identified, estimated, documented, and summarized. By continuing this type of science-based research along with education, best management practices, and collaborative solutions, the Fish Creek watershed can and will be restored and preserved.

4.5. Other Management Practice Improvements

Numerous other management practices and improvements are in various stages of implementation across the watershed. The following specific improvements and/or best management practices are listed in Table 4.5-1, Other Management Practice Improvements and are presented as recommendations to either continue or begin to implement. Map 35, Proposed Stream Channel Condition, and Stability Improvements and Other Management Opportunity Locations, provides an index map of the proposed project locations.

Table 4.5-1 Other Management Practice Improvement Projects

Project Number	Ranch or Site Name	Stream or Ditch	Description
OMP - 1	Rafter J Ranch	East Side Ditch	Mitigation for high water table
OMP - 2	Jackson Hole	Flat Creek	Karns Meadow Stormwater Treatment Wetlands Operations and Maintenance (O&M) Plan. Assess the current condition of the wetlands and develop an O&M plan.
OMP - 3	Single-family Homes	Fish Creek	Recirculating Vertical Flow (RVF) wetlands
OMP - 4	Watershed-wide	NA	Noxious Weed and Undesirable Plant Control
OMP - 5	Watershed-wide	NA	Trumpeter Swan Habitat Enhancement Opportunities
OMP - 6	Jackson Hole	Flat Creek	Fishery Habitat Improvements

4.5.1. Rafter J Ranch High Water Table Mitigation Improvements (OMP-1)

The residents of Rafter J Ranch, a subdivision south of Jackson in the floodplain of the Snake River, have experienced high water table conditions that were especially persistent in the spring and summer of 2015. In early 2016, the Homeowners Association (HOA) initiated a survey to assess the extent of the problem. Additionally, they held two meetings to discuss the concerns, possible causes, and potential solutions. The concerns they identified are that the high water table causes damage to wood floors, causes insulation to mold, and causes damage to equipment and items in crawl spaces. The possible causes identified by the homeowners include seepage from the East Side Irrigation Ditch, water pipe leaks, excessive lawn irrigation, and potentially poor maintenance in the East Side Irrigation Ditch (See Map OMP-1). Some of the potential solutions discussed included lining the irrigation ditch; enhancing maintenance by removing vegetation; investigating the ditch for areas of high seepage; and changing operations to minimize flow in the ditch yet still maintain enough flow for downstream water users.

On June 1, 2016, the HOA submitted a request that an evaluation of this issue be incorporated into the Upper Snake River watershed study. The HOA's board of directors clarified that they have authority to manage the subdivision's open space and that the landowners within the subdivision have adjudicated water rights to the East Side Irrigation Ditch. The water right was verified through the WSEO, and the following assessments were made.

The high water table conditions are inherent to developments in the floodplains; however, the conditions may be aggravated by operations of the irrigation ditch, lawn watering, and/or maintenance of the ditch. It is not in the scope of this study to identify the source or sources of the problem; however, suggestions can be made for further study to help identify the likely causes and cost-effective solutions.

Specific studies and/or best management practices that may help assess the causes and identify solutions for the high water table issues are as follows:

- Install a network of groundwater monitoring wells to document the water table conditions in the subdivision.
- Install continuous monitoring devices in the wells and irrigation ditch to document the water table fluctuations and ditch operational conditions.

- Initiate lawn watering schedules to establish best management practices for lawn irrigation.
- Consider a tiered water rate structure to discourage excess lawn water use.

Once the most likely cause of the high water table conditions is identified, a cost-benefit analysis of potential mitigation measures such as irrigation ditch lining should be completed. Additional measures, such as excavation of existing field ditches to provide a drain for the system, could also be evaluated. The costs should be compared to best management practices such as lawn watering scheduling and ditch maintenance so that the best solution for the residents of Rafter J Ranch and downstream water users can be selected for implementation.

4.5.2. Karns Meadow Stormwater Treatment Wetlands O&M (OMP-2)

The Karns Meadow Stormwater Treatment Wetlands were discussed in Section 3.5.2, Water Quality Assessment, and are shown on Map OMP-2. Development of an operations and maintenance (O&M) plan would be beneficial to determine the current level of operation and an anticipated schedule for maintenance and sediment removal. Typical O&M plans also describe the intent of the project and design information, such as the storage volume. Development of the O&M plan should be coordinated with the Town of Jackson.

4.5.3. Recirculating Vertical Flow (RVF) Wetlands for Enhanced Wastewater Treatment (OMP-3)

In 2015, The TCD tested the use of a small artificial wetland to enhance treatment of wastewater from a single-family home in Wilson, Wyoming. The RVF wetland was installed between the existing septic tank and leach field. As described by Intermountain Aquatics (2011), the wetland was constructed in the fall of 2009 and planted, instrumented for data collection, and put into service in the spring of 2010; performance was monitored from June 2010 to June 2011. Data from the first year of operation showed that the wetland significantly improved water quality. Compared to septic tank effluent that would otherwise be discharged to the leach field, water treated by the wetland had:

- Approximately 97 percent lower Biological Oxygen Demand (BOD5), Total Suspended Solids (TSS), and turbidity
- Nearly 90 percent reduction in ammonia N and Total Kjeldahl N (TKN) and 62 percent total nitrogen (TKN plus nitrate)
- Approximately 38 percent less phosphorous
- Removal of roughly 58 pounds of BOD5, 36 pounds of TSS, 18 pounds of nitrogen, and 1.3 pounds of phosphorus over a year

The Intermountain Aquatics completion report (2011) also provided an in-depth review of similar research and management projects to compare performance and cost of the RVF wetland to other types of onsite wastewater treatment systems and to provide information on key O&M issues. RVF is not the only option for single-family home wetland treatment systems, and the local setting of each proposed site should be considered in any wetland enhancement installations.

4.5.4. Noxious Weed and Undesirable Plant Control (OMP-4)

Noxious weeds and other undesirable vegetation on public lands in the study area will be controlled in accordance with the Jackson Hole weed management guidance and applicable BLM regulations and policies. Noxious weed treatments will avoid bird nesting seasons and other times when loss of cover or disturbance by equipment would be detrimental to wildlife. Control of noxious weeds and other invasive species may include manual, mechanical, biological, or chemical methods.

Good range condition tends to provide sufficient competitive pressure to limit the presence of annual bromes; however, there has been a trend in Wyoming for the plants to have a progressively higher average presence, even on sites that would be considered in good range condition. Chemical treatment of annual bromes with Matrix® and/or Plateau® can be effective (JHWMA 2007).

4.5.5. Trumpeter Swan Habitat Enhancement Opportunities (OMP-5)

According to the research by Dave Lockman, Dan Stevenson, and Susan Patla of the WGFD, trumpeter swans require shallow-water wetlands that produce extensive, luxuriant, and diverse stands of submerged aquatic vegetation (WGFD 2004). These kinds of wetlands, with some recognized physical and biological characteristics, fulfill functions important for swans of all age classes. The following information was developed based on data and publications from past investigations and presented in "Considerations and Prescriptions for the Design, Construction, and Management of Shallow Water Wetlands for Spring through Fall Use by Trumpeter Swans (*Cygnus buccinator*) In Western Wyoming" (WGFD 2004):

- Wetland Size and Water Depths – Provide at least 5 acres of shallow wetland water with depth ranges of 6 to 42 inches. Open water areas of 8 to 15 surface acres in size as one water body or in an inter-connected complex are preferred.
- Shoreline Configuration and Characteristics – Provide irregular-shaped shorelines with peninsulas and bays. The larger the open water wetland area, the more irregularity can be designed into the shoreline. All slopes should be designed and constructed with gradual slopes of at least 5:1. Islands and impoundment structures that may be influenced by wave action and erosion should be protected by cobble rock riprap or by sod removed during excavation.
- Desired Substrates (Bottom Soils) and Associated Submergent Aquatic Plants – Soft substrates with 6 inches or greater depth are preferred. Cobble or gravel bottoms are not conducive to aquatic plant growth, and if present, they should be covered with at least 6 inches of soil. Before inundation, disturb sod-bound soils and soils with excessive litter accumulation by disking or rototilling to provide a bare soil site more conducive for occupancy by rooted, submerged aquatic vegetation. In colder water environments with an over-water covering, it takes a considerably long time for sods and coarse plant materials to decompose and provide a substrate conducive to submerged aquatic plant growth. Sago pondweed, muskgrass, and Elodea are preferred submerged aquatic food species for trumpeter swans and are also found throughout Wyoming.
- Water Level Management and Wetland Vegetation – Flow-through systems with some degree of water level control are preferred. Sufficient water should be available throughout the ice-free period to maintain relatively stable water levels and prevent summer stagnation. Natural over winter partial draw-downs in water level of a foot or less are acceptable, and in some cases complete over-winter draw-downs may be necessary.

- Nesting and Loafing Islands – Construct at least two low-profile island sites with gradual contours of at least 5:1 slope, and a 100-square- foot surface area two feet above the highest water line. Each island should be located farther than 50 feet from any land mass.
- Flight Corridor Safety – Do not locate wetlands for swans and other water birds beneath overhead power lines or in wetlands crossed by fence lines. Power lines and fence lines located in or adjacent to probable flight corridors should be relocated if possible or made visible with markers.

Specific locations for trumpeter swan habitat enhancements were not identified in this report, however, the improvements are presented here for use in future project planning and development.

4.5.6. Fishery Habitat Improvements on Flat Creek in Jackson Hole (OMP-6)

Flat Creek, south of the National Elk Refuge, is listed on the CWA's 305(d) list of "threatened" streams for its inability to support cold-water fisheries and aquatic life. This finding was because surveys revealed Total Suspended Solids and turbidity to be in excess of WDEQ standards. Increased sediment loading is attributed to municipal stormwater runoff, and, to a lesser degree, to the operation of the Gros Ventre diversion and South Park Ditch. Stormwater runoff and sediment inputs, loss of riparian habitat, and altered or degraded fish habitat were identified as priority watershed issues (WDEQ 2013).

Specific observations of stream degradation within the 305(d) "threatened" reach include (1) degradation to riparian vegetation and streambanks from development, cattle ranching, and elk feed grounds; (2) sediment loading that has altered streambed structure, aquatic invertebrate assemblages, and available trout spawning habitat; (3) channel morphology that has been altered by development and by ranching, which has created long sections of wide, shallow riffles; and (4) fish habitat that is lacking pools, large woody debris, and spawning gravels. The Town of Jackson, the TCD, and the WGFD are working to address water quality, icing, and/or habitat concerns within and downstream of town limits. In so doing, the potential exists to restore processes to balance sediment transport. Additionally, according to the agencies working on this issue, a reduction in anchor ice formation and ice dams that scour banks could occur. This could affect erosion in addition to flooding, improve water quality through incorporation of wetlands, and benefit the native Snake River cutthroat trout fishery by significantly improving habitat quality for all life stages of cutthroat trout.

The availability of Snake River cutthroat trout spawning habitat in the lower portions of Flat Creek is extremely limited. Minor disturbances can contribute to a significant proportion of egg mortality. Thus, any improvements to adult spawning habitat will greatly benefit the fishery.

Specific improvements and/or best management practices that will contribute to the fish habitat enhancements on Flat Creek south of the National Elk Refuge and prior to the confluence with the Snake River south of Jackson include:

- Retrofit irrigation infrastructure to reduce bank instability, channel degradation, fish passage concerns, and maintenance needs.
- Decrease average stream width-to-depth ratio.
- Improve floodplain connectivity as measured by riffle incision ratios near "1" and entrenchment ratios near reference channel conditions.
- Restore a meander pattern and sinuosity appropriate for the stream type.

- Establish a functional riparian area with multiple-age classes of woody vegetation.
- Establish native riparian vegetation of a species composition, width, and longitudinal extent appropriate for a spring stream at this elevation.
- Increase channel complexity and diversity evidenced by deeper pools and having pool-pool distances appropriate for the channel type.
- Develop habitat feature sequences (pool-riffle-run) that are maintained by the creek's geometry through multiple runoff seasons.
- Improve lateral channel stability with bank erosion rates throughout the reach at stable levels of less than 0.02 feet per year.
- Increase woody debris to a level commensurate with reference reach conditions.

4.5.7. Collaborative Fish Passage Restoration (OMP-7)

In 2015, Governor Mead released the Wyoming Water Strategy to protect, manage, plan and utilize water in Wyoming (Mead 2015). Strategy #10 calls for collaboration when replacing and rehabilitating irrigation infrastructure to include considerations for fish passage and protection. This strategy speaks directly to the project opportunities outlined in this Level I watershed study, and by incorporating fish passage into several of the projects, significant positive outcomes can be realized for coldwater fisheries in the Upper Snake River watershed.

As stated previously, the Upper Snake River watershed study area is home to a unique mix of native Snake River fine-spotted and Yellowstone cutthroat trout. According to the WGFD these two subspecies are considered "Species of Greatest Conservation Need." Furthermore, the Upper Snake River Watershed represents some of the finest native, naturally reproducing fish populations in the United States. Although the watershed has many protections afforded it because of the high percentage of public land ownership as well as Wild and Scenic and wilderness designations, habitat fragmentation and degradation nevertheless pose threats to the health and resiliency of the fishery and watershed, especially in areas of the valley that have been developed.

*As stated in Governor Mead's Wyoming Water Strategy (2015), "**Repairs and replacement of infrastructure create natural opportunities for improvement.** One improvement is fish passage and protection….This initiative [Collaborative Fish Passage Restoration] will result in collaborative agreements among state agencies for "fish friendly structures" when updating water infrastructure. It will identify funding mechanisms available to share the costs of improvements for fisheries in conjunction with traditional water development work on a project.*

The native trout populations have been shown to use a wide variety of habitat types, making them susceptible to fish passage barriers like irrigation diversions, culverts, dewatered stream reaches, and entrainment in irrigation systems during their migrations. To ensure their long-term persistence, the fish must be able to migrate to preferred habitat for various life stages and environmental conditions, and away from floods, fires, drought and other disturbances. Fish passage projects seek to remove or retrofit dams and diversions, fix perched or broken culverts, improve and increase flows, and install fish screens on irrigation ditches, to allow for fish passage and protect migratory adults and out-migrating juvenile fish from being entrained. As described in Section 4.1, many of the irrigation projects described represent opportunities for landowners and water users to simultaneously improve irrigation and road crossing infrastructure and efficiencies (and vice versa). It is important to note that these collaborative fish passage projects may be eligible for additional sources of project financing, because of the conservation benefit they provide to fish. Nonprofit and local, state, and federal partners focused on native trout conservation can provide technical, financial, and coordination assistance to identify and implement collaborative fish passage projects. More information on funding opportunities for these and other projects is provided in Section 7.0, Project Financing.

Photo 29 Example of Fish Passage Before and After at Fontenelle Creek, Green River Watershed. Photos courtesy of Trout Unlimited

5. COST ESTIMATES

In this section, conceptual cost estimates are presented for many of the proposed watershed improvement projects described in Section 4. To be consistent with the objectives of the watershed study and with other watershed reports prepared for WWDC across Wyoming, the projects are grouped into the following categories:

- Irrigation System Improvements
- Livestock/Wildlife Upland Watering Improvements
- Surface Water Flood and Storage Improvements
- Stream Channel Condition and Stability Improvements
- Other Watershed Management Opportunities

Cost estimates are based on the NRCS Environmental Quality Incentives Program (EQIP) costs, as presented in the Fiscal Year 2015 Practice Payment Rates (NRCS 2014). The values in the rate table represent the amount of money typically paid to the applicant for the EQIP project and not the actual cost of the project. To better represent actual construction costs, the EQIP payment rates for livestock projects were inflated by 25 percent; irrigation projects were inflated by 33 percent. This cost-estimating protocol, using inflated EQIP rate table pricing, is consistent with other WWDC watershed reports and is used here so that projects costs are comparable.

5.1. Irrigation System Cost Estimates

Component costs were estimated by taking the NRCS payment rate, multiplied by 1.33. Diversion structure costs were derived from final costs of recent projects similar in size and scope to the projects in this report. The project contingencies have been added to the costs to reflect project unknowns at this level of study. For projects constructed after 2016, an increase in the total construction cost can be anticipated. General assumptions for the components listed in Table 5.1-1 include the following:

- Diversion / headgates: all structures include a concrete headwall and gate. Pricing for the diversion / headgate structures was estimated from final construction costs from recent similar projects in the Jackson Hole area, and recent Olsson Associates projects.
  - Extra Small – Structure consists of concrete headwall w/ sheet metal slide gate attached to end of corrugated metal pipe, capacity up to 5 CFS
  - Small – Approximate structure size up to 15 feet long, 3 feet tall, capacity up to 20 CFS
  - Medium – Approximate structure size up to 30 feet long, 6 feet tall, capacity up to 100 CFS
  - Large – Approximate structure size up to 40 feet long, 14 feet tall, capacity up to 500 CFS, with headwalls upstream and downstream
  - Existing Structure Removal is priced for a large structure size.
- Ditch Improvements: Work consists of cleaning, shaping, and/or slope grading of existing ditch systems.
  - Ditch Grading Small – capacity up to 20 CFS
  - Ditch Grading Large – capacity up to 400 CFS
  - Ditch Lining – Liner to be constructed with 4” Portland cement concrete, assumes site can be accessed by concrete truck.
- Piping / Sprinkler:
  - Pod system pricing based on the K-Line Irrigation System installed at the Elk Refuge, near Jackson, WY.

  - Traveling Gun System costs obtained from NRCS data; include gun, base, approximately 400 LF of flexible hose, diesel pump, and pump pit.
  - 24” HDPE Pipe pricing is based on ADS PIPE N-12, or equal piping
  - 12” HDPE Drain Pipe pricing is based on ADS PIPE N-12, or equal piping
- Other Components:
  - Measuring Flume pricing is for a ramp flume, Global Water RF series, or equal.
- Engineering – Engineering costs include project design, with detailed plans and specifications.
- Contingency – a 15% contingency is applied to all irrigation projects.

5.2. Livestock/Wildlife Watering Cost Estimates

Cost estimates for the livestock/wildlife watering projects are provided in Table 5.2-1. As stated above, to better represent actual construction costs for the four livestock/wildlife watering projects, the EQIP payments rates were inflated by 25 percent.

5.3. Surface Water Flood and Water Supply/Storage Cost Estimates

Cost estimates for the surface water flood and water supply/storage projects are provided in Table 5.3-1. Note that for project SWF-1, Flat Creek Winter Flooding, the FCWID has undertaken a study funded by the TCD to investigate causes of winter flooding along Flat Creek. Projects that may be recommended as part of the study have not yet been developed, and cost estimates are, therefore, not available. Similarly, SWF-2, proposed recommendations for the Snake River Jackson Hole Wyoming Environmental Restoration, have not been developed and, therefore, are not available for inclusion in this study.

5.4. Stream Channel Condition and Stability Cost Estimates

For Last Chance Ditch (project SCC-1) and similar projects, cost estimates for maintaining deep-rooted vegetation along the banks of ditches is estimated at zero because this would be completed as part of the ongoing livestock management program for the ranch. The cost estimate for reshaping the ditch is estimated at $1,600 per day, completing 200 feet per day, or approximately $8 per LF. There is no estimate of the total length of ditch to be reshaped.For Bank Stabilization on Lake Creek (project SCC-2) and similar projects, cost estimates for construction of toe-wood along eroding banks of Lake Creek is estimated at approximately $126 per LF. As with most types of bank stabilization, the linear costs associated with construction will decrease as the length increases. Stabilization of more than one meander at a time is essentially more cost effective. This cost estimate is for actual instream construction only and does not include costs for design and permitting. A permit from the USACE is required before any work is undertaken in waters of the U.S.A cost estimate for Morel Creek and Snake River Tributaries Restoration (SCC-3) and the various proposals for Sediment Loads and Flows in Fish Creek (SCC-4) were not available at the time this report was prepared.

5.5. Other Management Practice Improvements Cost Estimates

Because the cost estimates for most of the other management practice improvements (OMP-1. OMP-2, OMP-3, OMP-5, and OMP-6) are very site specific and the locations for the improvements have not yet been identified, only one general cost estimate is provided for use in future project estimating. For Noxious Weed Control, project OMP-4, costs of chemical herbicide application are variable depending on scale of infestation, distances to be traveled, and fuel costs. The NRCS Wyoming practice payment rate for ground application of chemical to control noxious or invasive herbaceous vegetation is $48 per acre (NRCS 2016).

Table 5.1-1 Irrigation System Improvement Cost Estimates

Project Number				ISI-1	ISI-2			ISI-3	ISI-4			ISI-5	ISI-6	ISI-7	ISI-8	ISI-9
Ranch or Site Name				Pinto Ranch	Hatchet Ranch			Blackrock Ranger Station	Elk Ranch			Antler Ditch	Upper Snake River Ranch GCSD Headgate	Upper Snake River Ranch Millstream	Upper Snake River Ranch Lake Creek / GCSD	Wyoming School Section 36 (T42N R117W) Hazel Ditch
		Unit Cost	Unit		Option 1	Option 2	Option 3		Option 1	Option 1a	Option 3					
Mobilization		$1,000	EA	2.0	10.0	15.0	10.0	4.0	70.0	20.0	150.0	20.0	18.0	7.0	17.0	1.0
Diversion / Headgate	Extra Small (>5 CFS)	$2,000	EA	1					90							7
	Small (>20 CFS)	$40,000	EA						5							
	Medium (>100 CFS)	$75,000	EA						2							
	Large (>500 CFS)	$150,000	EA										1		1	
	Remove Existing Structure	$10,000	EA												1	
Ditch Improve-ments	Ditch Grading small (>20CFS)	$4	LF		2400	2400	2400		50000							
	Ditch Grading large(>400CFS)	$12	LF										3000			
	Ditch Lining (concrete)	$50	SY			5400										
	Ditch Lining (flexable)	$10	SY				5400									
Piping / Sprinkler	Pod System	$1,500	Acre								1000					
	Traveling Gun System	$20,000	EA							10						
	24" HDPE Pipe	$40	LF		2400							5000				
	12" HDPE Drain Pipe	$30	LF	600												
	6" Aluminum Gated Pipe	$6.40	LF													
Other Compo-nents	Rock Rip Rap	$70	CY					500						600		
	On Site Embankment	$5	CY											4000		
	Site Survey	$2,000	Acre	2	2	2	2	3	10		10	4	4	2	2	
	Staff Gage	$300	EA													
	Measuring Flume	$7,500	EA													
	Water Tank	$1,000	EA													
Construction Subtotal				$26,000	$119,600	$298,600	$77,600	$45,000	$820,000	$220,000	$1,670,000	$228,000	$212,000	$73,000	$181,000	$15,000
Engineering / Design				$20,000	$1,000	$10,000	$4,000	$5,500	$30,000	$2,000	$75,000	$15,000	$10,000	$10,000	$10,000	$2,000
Construction and Engineering Subtotal				$46,000	$120,600	$308,600	$81,600	$50,500	$850,000	$222,000	$1,745,000	$243,000	$222,000	$83,000	$191,000	$17,000
Contingency (15%)				$6,900	$18,090	$46,290	$12,240	$7,575	$127,500	$33,300	$261,750	$36,450	$33,300	$12,450	$28,650	$2,550
Total Construction Cost				$52,900	$138,690	$354,890	$93,840	$58,075	$977,500	$255,300	$2,006,750	$279,450	$255,300	$95,450	$219,650	$19,550
Permitting/Legal Fees/Access				$2,000	$2,000	$2,000	$2,000	$10,000	$20,000	$20,000	$20,000	$5,000	$10,000	$10,000	$10,000	$500
Total Project Cost Estimate				**$54,900**	**$140,690**	**$356,890**	**$95,840**	**$68,075**	**$997,500**	**$275,300**	**$2,026,750**	**$284,450**	**$265,300**	**$105,450**	**$229,650**	**$20,050**

Notes:

CFS = Cubic Feet per Second
EA = Each
GCSD = Granite Creek Supplemental Ditch
CY = Cubic Yards
SY = Square Yards
LF = Linear Feet

Table 5.1-1 Irrigation System Improvement Cost Estimates (continued)

Project Number				ISI-10	ISI-11	ISI-12	ISI-13		ISI-15	ISI-16	ISI-17	ISI-18	ISI-19	ISI-20
Ranch or Site Name				Upper Snake River Ranch and Others (Jenson Creek)	R Lazy S	Huidekoper Ranch (Trail Creek)	JHLT Prosperity Ditch at Hwy 22		JHLT Pioneer Ditch	Lockhart (Flat Creek)	Lockhart (Wiley Ditch)	Lower Snake River Ranch Alaska Ditch	Game Creek	Fall Creek Ranch
		Unit Cost	Unit				Option 1	Option 2						
Mobilization		$1,000	EA	8.0	2.0	5.0	0.1	0.1	1.0	16.0	16.0	18.0	5.0	5.0
Diversion / Headgate	Extra Small (>5 CFS)	$2,000	EA											
	Small (>20 CFS)	$40,000	EA			1							1	1
	Medium (>100 CFS)	$75,000	EA	1										
	Large (>500 CFS)	$150,000	EA							1	1	1		
	Remove Existing Structure	$10,000	EA			0.3				1	1	1	0.05	1
Ditch Improvements	Ditch Grading small (>20CFS)	$4	LF						600				500	
	Ditch Grading large(>400CFS)	$12	LF									1000		
	Ditch Lining (concrete)	$50	SY											
Piping / Sprinkler	Pod System	$1,500	Acre											
	Traveling Gun System	$20,000	EA		1									
	24" HDPE Pipe	$40	LF											
	12" HDPE Drain Pipe	$30	LF											
	6" Aluminum Gated Pipe	$6.40	LF										1000	
Other Components	Rock Rip Rap	$70	CY											
	On Site Embankment	$5	CY											
	Site Survey	$2,000	Acre	2		0.8		0.5		2	2	2	3	2
	Staff Gage	$300	EA				3							
	Measuring Flume	$7,500	EA			1		3						
	Water Tank	$1,000	EA										1	
Construction Subtotal				$87,000	$22,000	$57,100	$1,000	$23,600	$3,400	$180,000	$180,000	$194,000	$60,900	$59,000
Engineering / Design				$10,000	$5,000	$10,000	$0	$2,400	$2,000	$15,000	$15,000	$17,500	$7,000	$10,000
Construction and Engineering Subtotal				$97,000	$27,000	$67,100	$1,000	$26,000	$5,400	$195,000	$195,000	$211,500	$67,900	$69,000
Contingency (15%)				$14,550	$4,050	$10,065	$150	$3,900	$810	$29,250	$29,250	$31,725	$10,185	$10,350
Total Construction Cost				$111,550	$31,050	$77,165	$1,150	$29,900	$6,210	$224,250	$224,250	$243,225	$78,085	$79,350
Permitting/Legal Fees/Access				$10,000	$500	$5,000	$0	$0	$2,000	$10,000	$10,000	$10,000	$10,000	$2,000
Total Project Cost Estimate				**$121,550**	**$31,550**	**$82,165**	**$1,150**	**$29,900**	**$8,210**	**$234,250**	**$234,250**	**$253,225**	**$88,085**	**$81,350**

Notes:

CFS = Cubic Feet per Second
EA = Each
LF = Linear Feet

CY = Cubic Yards
SY = Square Yards

Table 5.2-1 Livestock/Wildlife Watering Improvement Cost Estimates

Project Number		LWW-1	LWW-2	LWW-3	LWW-4
Ranch or Site Name		Taylor Ranch Spring Development	Wyoming School Section 36 (T40N R117W) Stock Pond	Kelly Warm Spring Wells	Lower Snake River Ranch Ridge Spring
Water Source		Existing Spring	Proposed Pond	New Wells	Existing Spring
Mobilization		$1,000	$3,000	$3,000	$3,000
Well Construction/ Spring Development	Units (each)	1	NA	2	1
	Depth (feet)	NA		100	NA
	Unit Cost ($/LF well or $/EA spring)	$3,145		$46	$3,145
	Component Subtotal	$3,145		$9,240	$3,145
Solar Pump	Units (each)	NA	NA	2	NA
	Unit Cost (each)			$10,734	
	Component Subtotal			$21,467	
Pipeline	Low Pressure Pipe Diameter (inches)	1.5	NA	1.5	1.5
	Units (linear feet)	100		100	4500
	Unit Cost (each)	$5.89		$5.89	$5.89
	Component Subtotal	$589		$589	$26,494
Stock Pond Construction	Units (each)	NA	1	NA	NA
	Earthwork (cubic yards)		3730		
	Unit cost earthwork		$4.30		
	Agri-Drain Installation		$4,800		
	Component Subtotal		$20,832		
Livestock / Wildlife Water Tanks	Units (each)	1	NA	NA	4
	Size (gallon)	1,000			1,000
	Unit Cost	$2.43			$2.43
	Component Subtotal	$2,425			$9,700
Other Components	Item	Fencing (linear feet)	NA	Fencing (linear feet)	Fencing (linear feet)
	Units (each)	100		100	100
	Unit Cost ($/ea)	$4.59		$4.59	$4.59
	Component Subtotal	$459		$459	$459
Construction Subtotal		$7,617	$23,832	$25,515	$42,797
Engineering (10%)		$762	$2,383	$2,551	$4,280
Construction and Engineering Subtotal		$8,379	$26,215	$28,066	$47,077
Contingency (15%)		$1,257	$3,932	$4,210	$7,062
Total Construction Cost		$9,636	$30,147	$32,276	$54,139
Final Plans and Specs		$1,000	$1,000	$1,000	$1,000
Permitting/Legal Fees/Access		$2,000	$1,000	$2,000	$500
Total Project Cost Estimate		**$12,636**	**$32,147**	**$35,276**	**$55,639**
Notes:	*All estimates based on EQIP Practice payment rate Guidande Document FY2015 inflated by 25%.*				

Table 5.3-1 Surface Water Flood and Water Supply/Storage Cost Estimates

Project Number		SWF-3	SWF-4	SWF-5	SWF- 6	SWF-7	SWF-8	SWF-9
Ranch or Site Name		**Wilderness Ranches**	**Buffalo Run Subdivision**	**Heart 6 Ranch**	**USFS dispersed camping**	**Buffalo Fork Ranch Subdivision**	**Buffalo Fork**	**Turpin Meadows**
Mobilization		$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$500
Drafting Site Components	Steel pipeline, unit cost, $/LF	$15	$15	$15	$15	$15	$15	$15
	Steel pipeline, LF	35	35	35	35	35	35	5
	Underground storage tank, 3,000 (min) gallons	$8,430	$8,430	$8,430	$8,430	$8,430	$8,430	NA
Access Road	New access road, unit cost, $/SF	$0.95	NA	$0.95	$0.95	$0.95	$0.95	NA
	Access road grading, sf	900		900	4900	900	900	
	Rehabilitate existing access road, unit cost, $/LF	NA		$2.62	NA	NA	$2.62	
	Access road rehabilitation, LF			1280			400	
Maintenance	Welding	NA	NA	NA	NA	NA	NA	$2,000
Construction Subtotal		$12,810	$11,955	$16,161	$16,610	$12,810	$13,857	$2,575
Engineering (10%)		$1,281	$1,196	$1,616	$1,661	$1,281	$1,386	$0
Construction and Engineering Subtotal		$14,091	$13,151	$17,777	$18,271	$14,091	$15,243	$2,575
Contingency (15%)		$2,114	$1,973	$2,667	$2,741	$2,114	$2,286	$386
Total Construction Cost		$16,205	$15,123	$20,444	$21,012	$16,205	$17,529	$2,961
Final Plans and Specs		$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	NA
Additional								
Permitting/Legal Fees/Access		$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$500
Total Project Cost Estimate		**$20,205**	**$19,123**	**$24,444**	**$25,012**	**$20,205**	**$21,529**	**$3,461**

6. PERMITS

The following discussion presents the regulatory issues for the types of projects that have been identified in this report. The purpose of this analysis is to characterize the potential environmental permitting issues. This includes the identification of environmental documentation, permits, agency clearances and approvals, and agency requirements necessary for implementation of the proposed actions and alternatives. The WWDC has requested that there be a semblance of consistency between the different watershed studies. This section, therefore, will be structured similar to the report prepared for the WWDC in the last five years.

__Before we begin this discussion on permitting, it is important to note the significance of this watershed to the surrounding area__. As a central part of the greater Yellowstone ecosystem, the Upper Snake River watershed is the home to the largest concentration of wildlife in the lower 48 states. The migration patterns across the watershed have been the subject of numerous studies that are summarized in "Great Migrations: Keeping Yellowstone's Life-blood Flowing" (National Geographic 2016). Several maps were developed as part of this watershed study to illustrate the distribution and habitat of important mammals in the Upper Snake River. Maps 36-44 are included in Volume II as a reference for evaluation during project development and permitting.

The National Environmental Policy Act (NEPA) applies to any federal action, and compliance is the responsibility of the lead federal agency. Other federal environmental regulations are regulated by the following federal agencies: EPA, BLM, USFS, USACE, and/or the USFWS and may apply to the potential projects described in this plan. The state of Wyoming agencies that may have approval requirements include, but are not limited to, the WDEQ, WSEO, State Historic Preservation Officer, and the Board of Land Commissioners through the Office of State Lands and Investments.

The following discussions are based upon various assumptions about the potential actions within the study area. These assumptions may change as project planning progresses from this Level I study. Ultimately, the applicability of the individual federal and state permits, clearances, and approvals will depend upon sites selected and the potential implications at each of those sites.

Before this discussion about permitting begins, it is important to note the significance of this watershed to the surrounding area. As a central part of the greater Yellowstone ecosystem, and the lower part of Yellowstone National Park, the Upper Snake River watershed is the home to the largest concentration of wildlife in the lower 48 states. The migration patterns through the corridors in and around the ecosystem and across the watershed have been the subject of numerous studies that are summarized in "Great Migrations: Keeping Yellowstone's Life-blood Flowing" (National Geographic 2016). Several maps were developed as part of this watershed study to illustrate the distribution of important mammals in the Upper Snake River. The maps are included in Volume II as a reference for evaluating potential permitting and other issues.

6.1. NEPA Compliance and Documentation

NEPA requires federal agencies to assess the possible environmental consequences of projects they propose to undertake, fund, or approve. NEPA applies to any of the proposed actions for which the project site is located on federal land, federal funds may be used, and/or when formal federal agency actions are necessary for the project to move forward. One of the primary intentions of the NEPA process is to avoid, minimize, and mitigate adverse environmental consequences of federal actions. NEPA requires analysis and documentation of potential adverse and beneficial effects of a proposed action and alternatives and mandates an open public involvement process.

The vast majority of land in the Upper Snake River watershed is owned by the federal government. For this project, it is likely that NPS, USFS, USFWS, and/or BLM would be the lead federal agency(s) charged with ensuring compliance with NEPA and related environmental statutes, depending on the major location of the project. Each agency would be the lead federal agency for those projects occurring primarily on lands under its administration. Map 18 illustrates land ownership across the study area. The USACE would likely be the lead federal agency on private lands where wetlands may be affected. These agencies also may work out a shared lead under a Memorandum of Understanding, if there are significant issues best led by both (or several) agencies for a given project.

The level of NEPA documentation needed for projects would be determined on a project-specific basis. For example, proposed new wildlife/livestock watering developments, including tank/pipeline systems that cross and/or serve federal or state rangeland, will require that an appropriate NEPA process be followed.

6.1.1. National Park Service

Any projects that are proposed for NPS lands, that have NPS funding, or that otherwise need NPS approval would require NEPA documentation that follows the NEPA guidelines developed and detailed in Director's Order 12 (NPS 2011) and the NPS NEPA Handbook (NPS 2015b). In general, for simple NPS-sponsored projects, documents may be completed in house, but more complex ones proposed by other project sponsors will require qualified, independent third-party experts who are responsible to NPS for review and approval of documents. The NPS manages three areas within the Upper Snake River Basin: Yellowstone National Park, GTNP, and the John D. Rockefeller Jr. Memorial Parkway.

Yellowstone National Park. Each park has existing guidance and management plans that projects within the park will need to comply with, including foundation documents that spell out decision-making procedures. For example, the Yellowstone National Park Foundation Document (NPS 2014a) discusses the features of the park, in particular unique features in need of particular management considerations. The NPS Superintendent's Compendium (2016) lists restricted uses. For this watershed, the reaches of the Snake and Lewis rivers that are listed as wild and scenic rivers are of particular management interest to NPS. The next section on permits and approvals discusses wild and scenic rivers and their management strategies in greater detail.

Another major water-related concern in Yellowstone National Park is the management of native fish species and control of introduced species. The NPS is concerned about management to reduce the long-term extinction risk of three species whose populations had declined in the past within the park: fluvial Arctic grayling, westslope cutthroat trout, and Yellowstone cutthroat trout. The NPS developed the Native Fish Conservation Plan and Environmental Assessment (2010), which detailed management strategies, including restoration and maintenance of the important ecological role of native fishes and creation of sustainable native fish angling and viewing opportunities for the public.

Grand Teton National Park and John D. Rockefeller Jr. Memorial Parkway. GTNP has recently developed several NEPA documents for projects within the Upper Snake River watershed. The Moose-Wilson corridor surrounds Wyoming Highway 390 near the eastern border of the park. NPS's document, The Moose-Wilson Corridor Draft Comprehensive Management Plan / Environmental Impact Statement (2015a), is intended to develop a vision and comprehensive management strategy for the more than 10,000 acres in this transportation corridor. The Jenny Lake Renewal Plan Environmental Assessment (NPS 2014b) spells out several proposed projects to enhance and improve visitor experience. Older documents include a 1997 Snake River Management Plan / Environmental Assessment (NPS 1997), which evaluated alternatives for recreational river management.

Photo 30 The Grand Tetons at GTNP

GTNP also manages the federally owned John D. Rockefeller Jr. Memorial Parkway. This is the major highway connecting Grand Teton to Yellowstone, and the highway and 24,000 acres of land surrounding it and the Snake River are managed with the goal of maintaining a continuous scenic corridor between the two parks. The 2015 Superintendent's Compendium (NPS 2015c) is a management document that spells out use rules and restrictions for both GTNP and the John D. Rockefeller Jr. Memorial Parkway. Earlier management documents include a 2005 strategic plan (NPS 2005) for both of these properties.

6.1.2. United States Forest Service

As is the case for other federal agencies, the USFS has guidelines for completing NEPA documents. Also as is the case for other federal agencies, simple projects may have NEPA documents completed by USFS staff; other more complex projects may be done by qualified third-party experts, which would be reviewed and approved by USFS staff. The USFS updated its NEPA guidelines in 2012 and has documented these updates in the manual that spells out methods and procedures for different levels of NEPA documentation.

Projects located on the BTNF would have the USFS as a lead federal agency. Compliance with the BTNF Land and Resource Management Plan (USFS 2015a) would be an important consideration. This management plan was first developed in 1990 and has been updated at intervals, the latest in 2015. The management plan describes policies to solve or prevent serious problems associated with existing natural resources and people's continuing use of them, including human access to, and commercial or recreational use of, the BTNF; the needs of threatened, endangered, and sensitive plant and animal species; and the need to mitigate the impacts of human use and access to natural resources. The study area includes the Jackson and Blackrock ranger districts, and coordination with staff would be important for projects located within these districts.

6.1.3. United States Fish and Wildlife Service

To support and fulfill the mission of the refuge system, the National Wildlife Refuge Improvement Act of 1997 required that the USFWS develop a 15-year comprehensive conservation plan for each national wildlife refuge in the refuge system. These plans need to be updated regularly and also require documentation to comply with NEPA. The USFWS NEPA Reference Handbook (1994) establishes policy and provides uniform guidance to USFWS personnel on responsibilities for implementing the National Environmental Policy Act of 1969, as amended, and related authorities (550 FW 1.4) in planning and implementing actions and in preparing NEPA documents. Projects conducted on national wildlife refuges should be consistent with the comprehensive conservation plans.

The USFWS National Elk Refuge consists of 24,700 acres of intermountain valley in the Jackson Hole area of northwestern Wyoming. The refuge is bounded on the south by the Town of Jackson, on the east by BTNF, and on the north by GTNP. To meet the requirements of regulations covering refuges, the most recent draft comprehensive conservation plan and accompanying environmental assessment (EA) that describes management alternatives and their effects on the environment was prepared in 2014 and approved in 2015 (USFWS 2014). The USFWS preferred management alternative would strike a balance between allowing natural processes and conducting planned management actions. The plan would keep some areas undeveloped, return some areas to a natural state, and increase development in other areas to enhance visitor services. This alternative included some aquatic projects, for example enhancing Flat Creek by restoring channel form and function over three stream miles through removal of inappropriate instream structures and construction of stable channel morphology. In addition, the project would remove reed canary grass infestations along the creek and revegetate with native woody and sod plants. The project would reduce sediment inputs to the watershed, improve stream processes, and increase habitat for all age classes of Snake River cutthroat trout.

The Jackson National Fish Hatchery is also located on the National Elk Refuge. Jackson National Fish Hatchery was originally established in 1950 as part of the Palisades Dam Act to improve fish populations along the headwaters of the Snake River. The hatchery's primary emphasis is producing eggs and fish to mitigate for fish losses from federal water development projects and to provide the same for states, tribes, and research facilities. The hatchery rears trout for a distribution area that covers close to 18,000 square miles.

6.1.4. Bureau of Land Management

Under current practice, NEPA evaluations and processes for projects that may be proposed where BLM is the lead federal agency will be performed by BLM staff or qualified, independent third-party experts responsible to BLM. These experts may include specialists from other federal and/or state agencies working under Memorandums of Understanding, or other appropriate arrangements. All BLM-led NEPA-related processes and studies are administered by the lead BLM district staff (Pinedale Field Office), with assistance, as necessary and appropriate, from BLM state office staff.

Compliance with NEPA will be guided in large part by the Snake River RMP/EIS and Record of Decision (ROD; BLM 2004). The Snake River corridor and adjacent areas in Teton County, Wyoming, comprise the Snake River RMP area. BLM-administered public lands addressed in the RMP include approximately 1,345 acres of public land surface and federal mineral estate; 740 acres of public land surface overlying state or privately owned mineral estate; and 12,000 acres of federal mineral estate (mostly outside of the river corridor), which underlies lands owned or administered by private individuals, the state of Wyoming or local governments. This management plan may be updated or amended as changes occur. For example, concerns about greater-sage grouse management resulted in an EIS, ROD, and revised Approved RMP for BLM lands in the Rocky Mountain region (BLM 2015).

6.1.5. Other State/Federal Agencies

Depending on the specific circumstances of a particular project, it is possible that another state or federal agency may lead the NEPA process. All of the relevant state and federal land management agencies have management plans developed from NEPA-compliant processes where appropriate. As discussed above for NPS, BLM, USFWS, and USFS, these plans will guide these agencies' NEPA processes for any applicable proposed projects or improvements.

NEPA compliance would also consider compatibility with local land use plans, including the Jackson/Teton County Comprehensive Plan (Town of Jackson and Teton County 2012), the Town of Jackson and Teton County Land Development Regulations (Town of Jackson 2016 and Teton County 2016), the TCD Long-Range Plan: 2016-2021 (TCD 2015a), and the TCD Strategic Planning Document (TCD 2015b), as well as any subsequent new or additional guidance or updates. In addition, state of Wyoming lands are located within the watershed, including wildlife habitat management areas, which may have certain restrictions and regulations concerning use. The Jackson regional office of WGFD would be involved in coordinating projects potentially affecting state lands or species of concern.

6.1.6. Watershed-Wide Environmental Analysis

Given the large number of planned and potential water development and habitat restoration projects, it is recommended that serious consideration be given to the potential benefits of conducting a comprehensive "watershed-wide" environmental analysis for these and other potential water resources-related improvement projects. A key benefit of this approach would be to develop a single baseline characterization and impacts assessment of the relevant environmental issues associated with these types of projects. That approach is preferable to repeating the same assessments for many similar individual projects. A watershed-wide environmental analysis should substantially reduce the overall resources and time necessary to conduct the required environmental permitting (especially NEPA compliance) for individual projects. If necessary, the overall environmental analysis could be supplemented on a case-by-case basis for specific projects with particular issues.

6.2. Permitting/Clearances/Approvals

Environmental resources are protected by a variety of state and federal regulations such as the CWA and the Endangered Species Act (ESA). Potential permits and/or agency contacts are explained in more detail below.

6.2.1. Wild and Scenic Rivers Act and Craig Thomas Snake Headwaters Legacy Act

For the Upper Snake River watershed, key management documents include two Snake River Headwaters comprehensive management plans (discussed below), which were prepared to be in compliance with the March 30, 2009, passage of the Craig Thomas Snake Headwaters Legacy Act. This act added all or segments of 13 rivers and streams in the Snake River Headwaters to the National Wild and Scenic Rivers System. The purpose of this designation is to protect the free-flowing condition, water quality, and "outstandingly remarkable" ecologic, geologic, fisheries, scenic, recreation, and cultural values of the headwaters for the benefit and enjoyment of present and future generations.

One of these documents is the Snake River Headwaters Comprehensive River Management Plan and Environmental Assessment (CRMP/EA), which was jointly prepared by Grand Teton and Yellowstone National Parks, John D. Rockefeller Jr. Memorial Parkway, and the National Elk Refuge, to comply with NEPA, the Wild and Scenic Rivers Act, and the Craig Thomas Snake Headwaters Legacy Act. The 2014 Finding of No Significant Impacts decision document for the EA identified the agencies' preferred alternative (Alternative C) as presented in the CRMP/EA as the selected action, and it summarized the management strategy as follows:

> "Under this action, visitor connections with the natural world would be emphasized through interpretive opportunities and more primitive, resource–related recreational activities in undeveloped natural settings. Recreational activities will be consistent with the protection and enhancement of river values. In general, visitor uses will adapt to changing natural conditions such as rebraiding river channels, fluctuating water levels, seasons, or protections for sensitive habitats and nesting areas. In general, use levels will be similar to or lower than current conditions under this alternative. Park administrative activities will focus on protecting natural and cultural resources and river-based recreational values in a manner consistent with the Wild and Scenic Rivers Act and the Craig Thomas Snake Headwaters Legacy Act of 2008.
>
> "Environmental education and awareness will be promoted by focusing on sustainable recreational and operational practices. Native species will receive management emphasis. Preservation of cultural resources will be accomplished using techniques to avoid adverse effects.

> "In general, infrastructure within the river corridor, including key river access nodes, will be consolidated by removing, relocating, and/or redesigning poorly sited and/or less sustainable facilities and infrastructure. New developments and facilities will only be considered in order to benefit resources" (NPS and USFWS 2013).

The wild and scenic river designation included 13 rivers and 25 separate reaches totaling 414 miles, with 315 miles within the BTNF. Because of the size of this wild and scenic river designation within the national forest, the BTNF developed a separate, concurrent management plan for river segments within the USFS administrative boundaries. The USFS Snake River Headwaters Comprehensive River Management Plan (2014) was intended to closely coordinate with the NPS's CRMP goals, to guide federal actions in the wild and scenic river corridors. The USFS CRMP indicated that all designated river segments will be managed to protect and enhance their outstandingly remarkable values, free-flowing condition, and water quality for future generations. The RMP stated that management will:

- Promote the rivers' natural hydrological processes, channel form and function, and ability to shape the landscape, reduce impediments to free flow, ensure sufficient flows to protect and enhance outstandingly remarkable values, and ensure the maintenance of water quality.
- Protect and enhance the natural biodiversity, complexity, and resiliency of riparian areas, wetlands, floodplains and adjacent uplands.
- Protect and enhance cultural resources as important links to the human history of the river corridors, including historical and archaeological sites, cultural landscapes, and ethnographic resources.
- Provide a diversity of settings and opportunities for visitors of varying abilities to experience, learn about, and have a direct connection with the rivers and their special values. Such opportunities must be consistent with the values that caused the rivers to be designated.
- Allow for legal and permitted multiple uses and associated developments, consistent with each river segment's classification while supporting the protection and enhancement of river values.

Any projects located on federal land and within these river corridors will require compliance with the management strategies of the appropriate federal agency.

6.2.2. Wilderness Act of 1964

Wilderness, as defined in the Wilderness Act of 1964, is land protected and managed so as to preserve its natural conditions and which generally appears to have been affected primary by the forces of nature, with the imprint of man's work substantially unnoticeable.

Designated wilderness is wilderness designated by Congress and signed by the president. In addition to designated wilderness, Congress directed federal agencies to evaluate lands for suitability as wilderness. For NPS compliance with the Wilderness Act, NPS Director's Order 41 (NPS 2013) stated, "The NPS will apply the guidance contained in [Director's Order 41] to all of its wilderness stewardship activities. For the purpose of applying guidance, unless specifically noted, the term 'wilderness' includes the categories of eligible, proposed, recommended, and designated. Potential wilderness may be identified within the proposed, recommended, or designated categories…For every designated wilderness, a Wilderness Stewardship Plan will guide management actions to preserve wilderness character…Parks with lands determined eligible, proposed, or recommended should also develop plans to preserve wilderness character... Preservation of wilderness character will be incorporated into appropriate sections of park planning and management documents."

Lands evaluated and categorized as "designated," "recommended," "proposed," "suitable," or "study area" in the Wilderness Preservation System must be managed in such a way as to (1) not diminish their suitability as wilderness; and to (2) apply the concepts of "minimum requirements" to all management decisions affecting those lands, regardless of the wilderness category. Designated wilderness areas in general have the most restrictive uses. The Wilderness Act generally prohibits installation of structures or the use of motor vehicles in wilderness, but the law contains special provisions for motor vehicle use when required in emergencies or as necessary for the administration of the area. Motor vehicles may also be permitted for special uses such as access to a private inholding, to support grazing, or to exercise valid existing rights.

The only congressionally designated wilderness areas in the Upper Snake River watershed are within BTNF, which has two designated wilderness areas: Teton wilderness and Gros Ventre wilderness. Map 2, Study Area, shows the location of these wilderness areas. The Teton wilderness borders the south end of Yellowstone National Park and provides important habitat to many wildlife species. It also has 450 miles of trails, which allow access to a large variety of hunting and fishing opportunities. As the Teton wilderness is both partly within the Upper Snake River watershed and also extends outside of it, it contains the unique Two Ocean Creek, which splits along the Continental Divide and flows to both the Atlantic and Pacific oceans. The Gros Ventre wilderness also provides important habitat for many species of wildlife and headwaters of multiple wild and scenic rivers. It includes miles of horseback or foot trails, and it also has a wide array of geological features, including alpine peaks, rocky slopes, the Gros Ventre Slide National Geological Site, and the more recently formed Crystal Slide.

Yellowstone National Park has no congressionally designated wilderness. However, approximately 90 percent of the park's acreage has been proposed as wilderness. The only areas not so proposed are along existing road corridors. Although Congress has not yet acted on the proposal, NPS policy is that proposed wilderness be managed the same as designated wilderness. Therefore, projects located in potential wilderness areas may have certain construction, maintenance, and management restrictions placed upon them.

As is the case for Yellowstone, GTNP has no congressionally designated wilderness. Grand Teton does have land that has been recommended for wilderness protection and has been added to the National Wilderness Preservation System. The park also has areas of potential wilderness, while land in the John D. Rockefeller Jr. Memorial Parkway is eligible for wilderness protection. By NPS policy, recommended, potential, and eligible wilderness areas are managed the same as designated wilderness. Figure 6.2.2-1 shows managed wilderness areas within these two NPS properties. Projects located in recommended, potential, and eligible wilderness areas may have certain construction, maintenance, and management restrictions placed upon them.

6.2.3. USACE Section 404 Permit

The USACE, through requirements contained in Section 404 of the CWA, regulates activities involving the discharge of dredged or fill material into waters of the United States. As such, any project that has the potential to affect wetlands or waters in the Upper Snake River watershed will need to address Section 404 permitting issues. Many small projects with minor impacts will qualify for general permits (Nationwide Permits or Regional General Permits) that are relatively easy to obtain. Larger projects with greater impacts may not qualify for general permits, and thus may need individual permits. Individual permits require much more documentation, including a sequencing report showing efforts to avoid, minimize, and mitigate impacts, in that order. Among other things, the proposed project must demonstrate that the least environmentally damaging practicable alternative was selected to achieve the project's purpose. This is the alternative most likely to receive a permit. Almost all permits, whether Nationwide or Individual, will require a formal wetland delineation in order to identify and quantify impacts to wetlands and other waters of the U.S.

In addition to the CWA, Executive Order 11990, Protection of Wetlands, requires federal agencies to avoid to the extent possible the long- and short-term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative. This would apply for projects on BLM, USFWS, USFS, and NPS lands in the watershed.

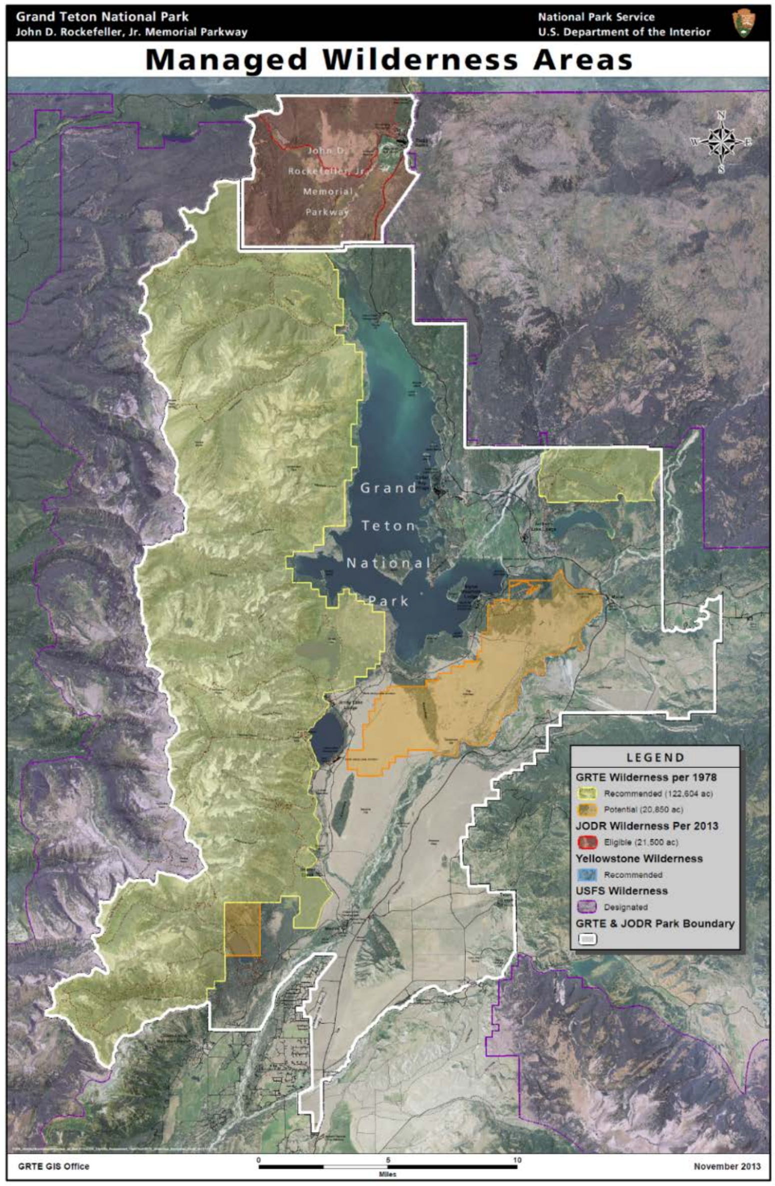


Figure 6.2.2-1 Grand Teton National Park Managed Wilderness Areas

6.2.4. Endangered Species Act

For compliance with the ESA, a Section 7 Consultation is often required. The lead federal agency would prepare a biological assessment to determine project effects on threatened and endangered plant and animal species listed or proposed for listing (candidate species) under the ESA (16 U.S.C. § 1531 et seq.). The USFWS would then issue an opinion on whether federal actions are likely to jeopardize the continued existence of a threatened or endangered species or whether it would destroy or adversely modify critical habitat. In order to render its decision, the USFWS must approve the preparation of a biological assessment so it complies with the ESA. If USFWS determines that the preferred alternative would jeopardize the continued existence of a species, it may offer a reasonable and prudent alternative that would preclude jeopardy.

6.2.4.1 Threatened and Endangered Species

The following federally proposed, threatened, or endangered species have the potential to occur within the Upper Snake River watershed study area (USFWS 2016):

Table 6.2.4-1 Federally Proposed, Threatened, or Endangered Species

Common Name	Scientific Name	Status
Yellow-Billed Cuckoo	*Coccyzus americanus*	Threatened
Whitebark Pine	*Pinus albicaulis*	Candidate
Bonytail Chub	*Gila elegans*	Endangered
Colorado Pikeminnow (=squawfish)	*Ptychocheilus lucius*	Endangered
Humpback Chub	*Gila cypha*	Endangered
Kendall Warm Springs Dace	*Rhinichthys osculus thermalis*	Endangered
Razorback Sucker	*Xyrauchen texanus*	Endangered
Black-footed Ferret	*Mustela nigripes*	Experimental Population, Non-Essential*
Canada Lynx	*Lynx canadensis*	Threatened
Gray Wolf	*Canis lupus*	Experimental Population, Non-Essential
Grizzly Bear	*Ursus arctos horribilis*	Threatened
North American Wolverine	*Gulo gulo luscus*	Proposed Threatened

* THIS SPECIES NEEDS TO BE CONSIDERED ONLY IF THE FOLLOWING CONDITION APPLIES:
Experimental, non-essential population of black-footed ferrets established pursuant to Section 10(j) of the ESA. Section 7 consultation not required except on lands administered by the USFWS or the NPS.

In addition to the potential presence of species, the study area also includes part of the designated critical habitat for Canada lynx. Lynx habitat can generally be described as moist boreal forests that have cold, snowy winters and a high-density prey base of snowshoe hare. The predominant vegetation of boreal forest is conifer trees, primarily species of spruce and fir. Lynx may also use other habitat types, particularly those that connect patches of boreal forest. Figure 6.2.4-2 shows the mapped critical habitat area for this species within Wyoming.

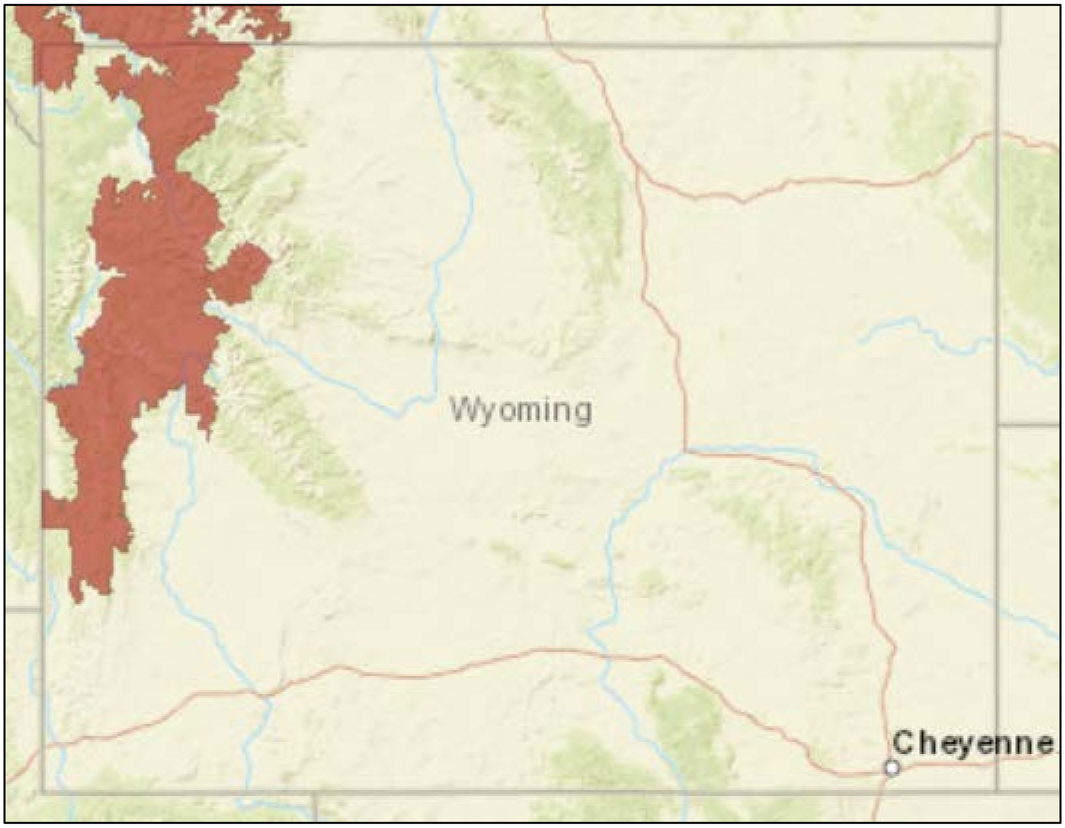


Figure 6.2.4-2 Canada lynx Designated Critical Habitat in Wyoming

6.2.4.2 Federal Agency Species of Concern

In addition to the ESA, federal land management agencies such as BLM or USFS may have developed a list of species of concern specific to each federally owned site. Although these species generally are not listed on the ESA, evaluation of impacts will also need to be done for projects that are located on federal land. For example, the greater sage-grouse is not a federally listed endangered or threatened species; instead, the USFWS identified it as "warranted but precluded" from listing. In order to address the specific threats to this species, the USFS developed conservation measures for the greater sage-grouse within several national forests, including BTNF, in an EIS and a ROD (USFS 2015b). The ROD was the culmination of an extensive planning effort in cooperation with the BLM to conserve greater sage-grouse habitat on national forest system lands and BLM-administered lands. The USFS, as a cooperating agency with the BLM, developed a targeted, multitier, collaborative landscape-level conservation strategy to provide a high level of protection for greater sage-grouse in the most important habitat areas. Projects in greater sage-grouse habitat areas within USFS land would need to comply with the conservation strategies developed by this agency. Several types of habitat were identified, with different levels of conservation management measures:

- **Priority habitat management areas** — National forest system lands identified as having the highest habitat value for maintaining sustainable greater sage-grouse populations. Two types were identified:
    - **Priority-core habitat management areas** – Priority habitat management areas that are the most important breeding and nesting habitat.

  - **Priority-connectivity habitat management areas** –Priority habitat management areas that are known migration corridors that connect populations or population segments.
- **General habitat management areas** — National forest system lands that are occupied seasonally or year-round habitat outside of priority habitat management areas where some special management would apply to sustain greater sage-grouse populations.

Map 44 shows the Greater Sage Grouse Focal Areas within the Upper Snake River watershed.

6.2.4.3 Wyoming State Species of Concern

The Wyoming Natural Diversity Database develops and maintains lists of plant and animal species in Wyoming that are rare, endemic, disjunct, threatened, or otherwise biologically sensitive. Plants and animals are considered for inclusion on the Species of Concern List if they are vulnerable to extirpation at the global or state level (WYNDD 2016).

The WGFD has also developed management strategies to identify and maintain populations of wildlife species at risk for listing under the ESA. Wyoming's State Wildlife Action Plan is a comprehensive strategy to maintain the health and diversity of wildlife within the state, including reducing the need for future listings under the ESA. Special emphasis is given to addressing wildlife species that have received less attention in the past, including those that are not hunted or fished. Wyoming's State Wildlife Action Plan addresses a variety of wildlife and habitat management challenges; the terrestrial habitat types and aquatic basins that cover a majority of the state; and Wyoming's species of greatest conservation need, which are species whose conservation status warrants increased management attention, funding, and consideration in conservation, land use, and development planning. The plan (WGFD 2010) is in the process of being updated to include more recent information on species status. The identification of species of greatest conservation need is part of this plan, and this list has been updated. The list is included in Data Summary 6.2.4-1 included in Appendix A.

The state of Wyoming, along with federal agencies and other stakeholders, developed a statewide conservation strategy for the Greater Sage-grouse, which has now been incorporated into Executive Orders issued by two Wyoming Governors and resulted in the creation of a standing Sage-grouse Implementation Team. The overall approach of this strategy is to focus on directing development outside of Core Areas, which have been identified as having the highest conservation value to maintaining sustainable populations. In addition, the Core Area Strategy has provisions for incorporating additional data and adjusting management. By establishing this regulatory framework, the state of Wyoming has created more certainty about conservation and management; and, to date, results indicate that the approach is succeeding.

6.2.5. Other Federal and State Permits

Fish and Wildlife Coordination Act. The Fish and Wildlife Coordination Act requires federal agencies involved in actions that will result in the control or structural modification of any natural stream or body of water for any purpose to take action to protect the fish and wildlife resources that may be affected by the action. It requires federal agencies or applicants to first consult with state and federal wildlife agencies to prevent, mitigate, and compensate for project-caused losses of wildlife resources and to enhance those resources.

Migratory Bird Treaty Act. The Migratory Bird Treaty Act (MBTA) recommends avoiding construction activities in grassland, wetland, stream, and woodland habitats and bridges that may result in the "taking" of migratory birds, eggs, young, and/or active nests. In Wyoming, most migratory bird activity occurs during the period of April 1 to July 15. Taking in the MBTA is defined as pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to pursue, hunt, shoot, wound, kill, trap, capture, or collect.

The USFWS has indicated that if the proposed construction period is planned to occur during the primary nesting season, or at any other time that may result in taking the nests of migratory birds, a survey should be performed. The USFWS recommends that a qualified biologist conduct a field survey of the affected habitats and structures to evaluate the presence of nesting migratory birds during nesting season. The survey results should be maintained with the project files and made available to USFWS personnel upon request. The USFWS should be contacted immediately if active nests that cannot be avoided are identified within the construction area.

If construction of roadways falls within the primary nesting season, a survey of nesting birds will be conducted. As requested by the USFWS, a biologist will perform a field survey before construction activities to inspect the project construction corridor for nesting birds. The USFWS will be contacted if active nests that cannot be avoided are identified within the construction area and within a half-mile line of sight east and west from the construction area. The results of the field survey for nesting birds, along with the information regarding the qualifications of person or persons performing the survey, will be documented and maintained on file for potential review.

Bald and Golden Eagle Protection Act. Although the bald eagle has been de-listed under the ESA, bald eagles are still federally protected under the Bald and Golden Eagle Protection Act (BGEPA) of 1940. The BGEPA prohibits anyone, without a permit issued by the U.S. Secretary of the Interior, from the taking, possession, or commerce of bald and/or golden eagles, including their parts, eggs, or active or inactive nests. The definition of "take" in the BGEPA includes to pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest, or disturb. Compliance with the BGEPA is part of the NEPA documentation.

Map 43, Raptor Buffer Areas, shows several known nesting occurrences for both bald and golden eagles in the Upper Snake River area. As with the MBTA, if construction falls within the primary eagle nesting season, a survey of eagle nesting sites should be conducted following guidelines set by the USFWS.

Fish and Wildlife Coordination Act. The Fish and Wildlife Coordination Act requires federal agencies involved in actions that will result in the control or structural modification of any natural stream or body of water for any purpose to take action to protect the fish and wildlife resources that may be affected by the action. It requires federal agencies or applicants to first consult with state and federal wildlife agencies to prevent, mitigate, and compensate for project-caused losses of wildlife resources and to enhance those resources.

Birds of Conservation Concern. The 1988 amendment to the Fish and Wildlife Conservation Act mandates that the USFWS identify species, subspecies, and populations of all migratory nongame birds that, without additional conservation actions, are likely to become candidates for listing under the ESA of 1973. At the moment, no regulatory framework exists to protect these species other than the MBTA or BGEPA, but the species could become listed under the ESA. Table 6.2.5-1 lists the birds of conservation concern that may be found in the project area during certain seasons of the year, according to the USFWS IPaC Trust Resources Report (generated October 19, 2016).

Table 6.2.5-1 Birds of Conservation Concern

Common Name	Scientific Name	Season of Occurrence
American Bittern	*Botaurus lentiginosus*	Season: Breeding
Bald Eagle	*Haliaeetus leucocephalus*	Season: Year-round
Black Rosy-finch	*Leucosticte atrata*	Season: Year-round
Brewer's Sparrow	*Spizella breweri*	Season: Breeding
Burrowing Owl	*Athene cunicularia*	Season: Breeding
Calliope Hummingbird	*Stellula calliope*	Season: Breeding
Cassin's Finch	*Carpodacus cassinii*	Season: Year-round
Ferruginous Hawk	*Buteo regalis*	Season: Breeding
Flammulated Owl	*Otus flammeolus*	Season: Breeding
Fox Sparrow	*Passerella iliaca*	Season: Breeding
Golden Eagle	*Aquila chrysaetos*	Season: Year-round
Greater Sage-grouse	*Centrocercus urophasianus*	Season: Year-round
Lewis's Woodpecker	*Melanerpes lewis*	Season: Breeding
Loggerhead Shrike	*Lanius ludovicianus*	Season: Breeding
Long-billed Curlew	*Numenius americanus*	Season: Breeding
Olive-sided Flycatcher	*Contopus cooperi*	Season: Breeding
Peregrine Falcon	*Falco peregrinus*	Season: Breeding
Pinyon Jay	*Gymnorhinus cyanocephalus*	Season: Year-round
Red-headed Woodpecker	*Melanerpes erythrocephalus*	Season: Breeding
Rufous Hummingbird	*Selasphorus rufus*	Season: Breeding
Sage Thrasher	*Oreoscoptes montanus*	Season: Breeding
Short-eared Owl	*Asio flammeus*	Season: Year-round
Swainson's Hawk	*Buteo swainsoni*	Season: Breeding
Western Grebe	*Aechmophorus occidentalis*	Season: Breeding
Williamson's Sapsucker	*Sphyrapicus thyroideus*	Season: Breeding
Willow Flycatcher	*Empidonax traillii*	Season: Breeding

Source: USFWS IPaC Trust Resources Report, Oct. 19, 2016.

Laws Addressing Cultural Resources. Because federal approvals may be involved with the potential projects, a consideration of the impact on cultural resources must be undertaken (Section 106 consultation), as required under the National Historic Preservation Act of 1966. Federal agencies will request a determination from Wyoming's State Historic Preservation Office regarding the significance of cultural resources potentially affected by ground-disturbing activities.

In addition, consultation with relevant Native American groups concerning traditional cultural properties is required. Guidelines for evaluation of traditional cultural properties are contained in Bulletin 38 (Parker and King 1998) issued by the NPS. Furthermore, the Native American Graves and Repatriation Act protects burial sites; additional coordination would be needed if any burial sites were found in the vicinity of a project.

Wyoming Board of Land Commissioners. The Wyoming Board of Land Commissioners, consisting of the five statewide elected officials, is responsible for regulating all activities on state lands, including granting of ROWs. This is accomplished through the Office of State Lands and Investments. Any project to be constructed on state or school lands must have a ROW, as required in the "Rules and Regulations Governing the Issuance of Rights of Way" (W.S. 36-20 and W.S. 36-202).

Wyoming State Engineer's Office Surface Water Storage Permit. The WSEO administers the water rights system of appropriation within the state. The applicant must obtain the necessary water rights permits from the state of Wyoming for the diversion and storage of the state's surface water.

Wyoming State Engineer's Office Permit to Construct/Dam Safety Review. The Wyoming Dam Safety Law (W.S. 41-3) requires that any persons, public company, government entity, or private company who proposes to construct a dam that is greater than 20 feet high or that will impound more than 50 acre-feet of water, or a diversion system that will carry more than 50 CFS of water, must obtain approval for construction of the dam or ditch from the WSEO. The approval by the WSEO of a dam's construction is contingent upon the office's review and approval of all dam plans and specifications, which must be prepared by a registered professional engineer licensed in Wyoming. Design, construction, and operation of jurisdictional dams must also comply with dam safety regulations promulgated pursuant to the Dam Safety Act. At present, these regulations are in final draft form; formal issuance is anticipated soon.

Wyoming State Engineer's Office Ditch Enlargement Permit. In addition to the permits and clearances that will be required for reservoir construction, if an enlargement to an existing ditch or storage facilities is needed, an enlargement filing with the WSEO is required. Even if physical enlargement of an existing ditch is found not be to required, the enlargement filing would be required as a legal formality of a water right requirement.

Wyoming Department of Environmental Quality – National Pollutant Discharge Elimination System (NPDES) Permit and Section 401 Certification. The federal CWA is administered in Wyoming by the WDEQ's Water Quality Division (WQD) and is consistent with the Wyoming Environmental Quality Act. The Section 401 certification is the state's approval to ensure that the activities authorized under Section 404 meet state water quality standards and do not degrade water quality. Any discharge of pollutants into the broadly defined "waters of the state" requires application to and permit issuance by WQD in accord with WQD's rules and regulations. This body of regulations sets forth classification of surface and groundwater uses and establishes water quality standards (Wyoming water quality standards). The WQD administers the NPDES permit system including stormwater permits and construction-related, short-term discharge permits.

Implementation of any of the action alternatives would require application for and compliance with the provisions of the statewide general NPDES's Construction Stormwater Discharge Permit number WYR10-000. Construction activities associated with dam construction or enlargement often result in the requirement to temporarily discharge pumped water. These discharges are provided for in a general permit. Upon acceptance of the application by WQD, the temporary discharge must comply with the terms of the general permit and any stipulations applied as a result of the application's review.

EPA has oversight responsibility for the federal CWA delegated to and administered by the state WQD. EPA also may intervene to resolve interstate disputes where discharges of pollutants in an upstream state may affect water quality in a downstream state.

Many of the streams and lakes in this watershed, including the main stem of Snake River and all the streams and lakes in Yellowstone National Park, GTNP, and Bridger-Teton Wilderness, are designated as Class 1, Outstanding Natural Resource Waters, by the state of Wyoming under the CWA. This means that long-term degradation of surface waters is prohibited, and existing water quality must be maintained. All activities involving a discharge of fill to a Class 1 water or adjacent wetland will require an individual 401 water quality certification from WQD, regardless of the type of Section 404 permit used to authorize the activity. A public notice and comment period (14 days) is also required.

Mining Permit. A Wyoming mining permit is not required for development of an aggregate and/or borrow material source solely for use in construction, and whose product is not for commercial sale.

Special Use Permits/Rights-of-Way/Easements. Special use permits, ROWs, or easements will be required wherever access across the lands of others (private, state, or federal) is needed for construction and/or operation of the project facilities. These may be temporary (e.g., access to a temporary borrow area or quarry site to be closed and reclaimed; construction of a new haul road; etc.) or permanent (e.g., construction of a wildlife/livestock pipeline alignment). Usually privately owned lands that will be rendered permanently unavailable (such as the dam and reservoir footprint of a storage project) would be purchased unless the owner desires – and the sponsoring entity concurs – a permanent easement instead. Permanent use of BLM lands likely would be administered under a grant with an appropriate term issued under the BLMs ROW process; the USFS would use their equivalent special use process. An easement or ROW from the WyDOT, and/or from Teton County also may be required. The specific requirements for ROW, special use permits, and easements vary widely and should be determined as part of the early stages of planning for a specific proposed project. This will help to avoid the potential for project delay, higher costs, or required changes in location/alignment or design during project development and implementation

6.3. Environmental Considerations

6.3.1. Wetland Resources

A formal wetland delineation in accordance with the USACE's guidelines has not been conducted across the Upper Snake River watershed. GIS digital mapping from the NWI does exist and was acquired to preliminarily identify wetland habitats in the study area. The wetland habitats inferred to be present within the study area, based on NWI mapping, are shown on Map 15, National Wetlands Inventory.

Some areas identified as wetlands on the NWI map may, in fact, not qualify as jurisdictional wetlands upon field investigation. This is because of limitations in the methodology used to prepare the NWI maps and the nature of wetlands to change over time based on natural events. As discussed previously, a formal delineation should be conducted once potential sites are selected to determine the level of impacts to wetlands located in the future project area.

Rare Species Resources. The Upper Snake River is one of the most diverse and undeveloped watersheds in the United States, and thus a large number of species threatened, endangered, and species of concern are found in this area. As discussed in the permits and approvals section above, coordination and, potentially, consultation will be needed with resource agencies including USFWS, WGFD, and federal land management agencies for projects that could potentially affect protected species.

6.3.2. Fish and Wildlife Resources

Hunting and fishing are very popular recreational activities within this watershed, and there are numerous opportunities to do so for a variety of fish and wildlife species. WGFD and federal agencies regulate the timing and location of permitted hunting and fishing. No hunting is permitted on Yellowstone National Park.

Elk that summer within GTNP migrate between the park and the National Elk Refuge, located southeast of the park. These elk are managed as a part of the Jackson elk herd, the largest elk herd in North America, and management includes an annual elk reduction program. Hunters with valid licenses and permits can harvest elk within parts of National Elk Refuge and GTNP during the hunting season of October to December. In contrast, the hunting area designated for the Jackson herd of wild bison excludes GTNP but is allowed with a valid bison permit on National Elk Refuge.

Some lands are considered sensitive habitat for species at different times of year and cannot be accessed then. For example, starting December 1, BTNF lands begin closing to protect wildlife and habitat. South of the Gros Ventre River and east of the National Elk Refuge, much of the forest is closed to human presence. BTNF lands north of the Gros Ventre River remain open to vehicular traffic through December 15. Thereafter, travel restrictions are in place, with some allowances for motorized travel on designated routes. Projects located in areas that are seasonally closed for wildlife may need to be scheduled for accessible seasons.

Seven varieties of game fish are found in Yellowstone National Park: grayling and mountain whitefish and cutthroat, rainbow, brown, brook, and lake trout; however, only cutthroats, grayling, and mountain whitefish are native to the park. Fishing is allowed in Yellowstone with appropriate permits including a park permit and a Wyoming fishing license. To reduce competition, predation, and hybridization stress on native fishes, Yellowstone has increased harvest limits of rainbow and brown trout in waters where they coexist with cutthroat trout and fluvial arctic grayling. Regulations are complex and include seasonal closures and two areas with differing fishing rules: The Native Trout Conservation Area and the Wild Trout Enhancement Area. Fishing is also allowed with appropriate licenses and permits in GTNP and BTNF. Fishing seasons and regulations vary from one location to another, depending on the need to protect fish species during spawning season and other sensitive times of year, such as during low water levels. Projects located in sensitive fisheries locations, or during sensitive times of year, may need additional levels of coordination with the appropriate federal agencies.

6.4. Cultural and Paleontological Resources

Cultural resources include prehistoric and historic cultural resources, including prehistoric and historic archaeological sites and standing structures. The cultural resources of Teton County have been mapped and are available online at:

https://en.wikipedia.org/wiki/National_Register_of_Historic_Places_listings_in_Teton_County,_Wyoming

Although a Class 1 cultural resources survey was not included in the scope of this study, it is likely that there are other cultural resources within the watershed, potentially at future project sites, since this area was known to be used by various Native American tribes as well as for historic ranching activities. Cultural resources may be protected by the National Historic Preservation Act, if a federal action such as federal funding or permitting is part of a project. In addition, the Native American Graves Protection and Repatriation Act protects some archaeological sites such as Native American burial sites.

Paleontological resources including fossil specimens are found throughout the watershed where fossiliferous sedimentary bedrock is exposed at the surface. Collection of fossils on public lands is not allowed unless special permits are obtained. Collection of fossils on private land is not prohibited; however, some spectacular fossils have been found in the watershed. Any such fossils should only be collected and preserved by a trained paleontologist.

6.5. Mitigation

Mitigation may be required for impacts to resources, including wetland and riparian vegetation, stream channel habitat, cultural resources, fish and game resources, and possibly threatened or endangered species. A variety of mitigation measures are presented in Appendix 3 of the Wyoming BLM Guidelines for Surface-Disturbing and Disruptive Activities (BLM 1998). As noted previously, it is preferred to avoid the need for mitigation of a potentially significant impact by relocation and/or “self-mitigating” design if technically and economically feasible. If mitigation is required for wetland impacts, a detailed mitigation plan would need to be prepared and approved by USACE prior to obtaining a Section 404 permit for any project that requires mitigation for wetlands.

Mitigation of potential raptor, migratory bird, and big game impacts would generally involve avoidance or minimization of impacts, for example by controlling certain construction activities during sensitive time periods and avoiding direct disturbance of the subject species. One common example is to schedule tree clearing during non-nesting periods to be in compliance with the MBTA. If any threatened and endangered species have the potential to occur at a given site, special studies would be required to determine whether appropriate conservation measures could be implemented. Developing and implementing these measures can be time consuming and expensive; therefore, in general, any such impacts should be avoided to the greatest extent possible.

Although no dams or reservoirs are proposed in this watershed study, it should be noted that additional cultural resources fieldwork would need to be completed to identify and document any such resources that would be inundated or otherwise affected as a result of constructing any dams or reservoirs. This would include, in turn, a Class I (literature search) survey, a Class II (reconnaissance inventory) survey, and if needed, a Class III (intensive inventory) survey. Ultimately, a mitigation plan for cultural resources would be developed, which would culminate in a Memorandum of Understanding between the Wyoming State Historic Preservation Office and the lead federal agency, with concurrence by the project sponsor(s), and possibly affected Native American tribes.

7. PROJECT FINANCING

A variety of funding sources may be available to offer funding for various portions of the project. The general criteria and applicability of each of the funding sources are discussed in this section and categorized by project type. A summary of the funding sources can be found in Appendix A, Data Summaries. Funding sources presented here are not necessarily inclusive of all funding options available. Information presented here is also subject to change, since funding sources may change their terms and criteria. The contacts listed for the various funding sources may also change in time.

The primary local resources for the project are the local conservation districts, the NRCS, the BLM and the Teton County Board of Commissioners. These entities offer local expertise relative to the area as well as intimate knowledge of potential funding programs that may apply to the projects outlined in this report. These key local resources include, but are not limited to:

A multitude of funding opportunities are available to help with conservation project development and implementation. *There are many local, state, and federal programs that are designed to provide both technical and funding assistance. In addition, many local and regional organizations offer assistance in getting conservation on the ground. Matching these sources of assistance can be a challenge as they have different application requirements, design and construction protocols, as well as varying trigger or batching dates. The local conservation district is a great local resource for help in getting through the hurdles associated with applications, permitting, reporting, and administration of conservation projects. The staff is committed to assisting local partnerships in conservation.*

Local Conservation Districts:

- Teton Conservation District (phone: 307.733.2110)
- Star Valley Conservation District (phone: 307.885.7823)
- Sublette County Conservation District (phone: 307.367.2257)
- Dubois – Crowheart Conservation District (phone: 307.455.3688)

Bureau of Land Management:

- Pinedale Field Office - Pinedale, Wyoming (phone: 307.367.5300)

Natural Resources Conservation Service Offices:

- Fremont County – Dubois, Wyoming (phone: 307.455.3098)

Teton County Board of Commissioners

- Teton County phone: (phone: 307.733.8094)

Additionally, two online resources outline a variety of funding sources for grant, loan, and in-kind support for watershed related projects. These two resources were used extensively for researching available funding sources for this project. The first is the Water Management & Conservation Assistance Programs Directory, which was last updated in 2014 and is available from the WWDC. The directory is available online: http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf

The second site, developed and maintained by the EPA, is an online Catalog of Federal Funding Sources for Watershed Protection and can be accessed online: https://www.cfda.gov/downloads/CFDA_2015.pdf.

The WGFD has published "Habitat Extension Bulletin No. 50 – Fisheries and Wildlife Habitat Cost-Share Programs and Grants." This bulletin provides a listing of potential funding sources for fisheries and wildlife habitat projects and may be viewed online:

https://wgfd.wyo.gov/WGFD/media/content/PDF/Habitat/Extension%20Bulletins/B50-Fisheries-and-Wildlife-Habitat-Cost-Sharing-Programs-and-Grants.pdf

7.1. Local Agencies

7.1.1. Teton Conservation District

Conservation districts are locally elected and lead government entities. Conservation districts act to promote best management practices and conservation of the natural resources of the county. Conservation districts provide funding assistance through cost-share programs and in-kind contributions. A complete list of TCD cost-share programs is available at http://www.tetonconservation.org/programs/.

One of the primary cost-share programs that would be applicable to projects described in this watershed study is the TCD Technical Assistance Cost-Share Grants (TAC), which funds projects in one or more of the following categories: Agriculture, Mapping Resources and GIS, Restoration and Sustainability, Teton County Planning and Development Regulations, Water Resources, and Wildlife. The TAC grant funds are open to all applicants and require a 50 percent match from the applicant, which may include direct dollars and/or in-kind contribution. Applications are accepted twice a year.

7.1.2. Other Local Agencies

The Upper Snake River watershed also extends across small portions of the Star Valley Conservation District, Sublette County Conservation District, and Dubois-Crowheart Conservation District. Additional programs may be available to the portions of the Upper Snake River watershed that fall within these districts.

7.2. State Agencies

7.2.1. Wyoming Department of Environmental Quality

The WDEQ provides financial assistance for best management practices to address non-point sources of pollution under Section 319 of the CWA. Grant funding requires a 40 percent match from the applicant. The match may come from the local landowner, a conservation or irrigation district, or a nonprofit organization. A Request for Proposals is typically issued in spring or early summer of each year. Additional information about the program and the application process can be obtained from the program's website: http://deq.wyoming.gov/wqd/non-point- source./

7.2.2. Wyoming Game and Fish Department

The WGFD offers a variety of funding options and is best summarized from the Water Management & Conservation Assistance Program Directory (http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf):

The WGFD may offer technical and funding assistance to help landowners, conservation groups, institutions, land managers, government agencies, industry, and nonprofit organizations develop or maintain water sources for fish and wildlife. Assistance may also be provided for protecting or improving riparian areas/wetlands, restoring streams, and upgrading irrigation infrastructure in a manner that provides improved fish passage or diversion screening.

Habitat Trust Fund: Funds can be used for acquisition, maintenance, or improvement of wildlife habitat or for the promotion of human understanding and enjoyment of the fish and wildlife resource (habitat or information and education projects). Funds can be used for interval projects or paid as grants to an outside entity. All proposals must have a WGFD sponsor and be entered into a department proposal database by early January or early August annually. Project proposals will be prioritized for funding by WGFD staff during January through March; the preliminary approval for WGFD grants is March, and final approval in July for funds available in July. No cost-share is required, but it is strongly recommended. Projects should occur in priority habitats or wetlands. Approximately $600,000 to $1,200,000 is allocated annually to projects across Wyoming.

Fish Passage Grants: Funds can be used for creating or improving upstream or downstream passage of all life stages of fish in Wyoming waterways and for screening diversions. Examples include developing fishways or fish ladders, assisting with the replacement of traditional push-up diversion dams with more fish-friendly options, and installing various screening technologies to keep fish from becoming entrained into irrigation ditches. All proposals must have a WGFD sponsor and be entered into a department proposal database by early January annually. Project proposals will be prioritized for funding by WGFD staff during January through March; the preliminary approval for WGFD grants is March, and final approval is in July for funds available in July. No cost-share is required, but it is strongly recommended. Projects should occur in priority habitats or watersheds. Approximately $25,000 to $90,000 is allocated annually to projects across Wyoming.

7.2.3. Wyoming Office of State Lands and Investments

The Wyoming Office of State Lands and Investments offers a variety of funding options and is best summarized from the Water Management & Conservation Assistance Program Directory available online at: (http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf).

The Office of State Lands and Investments is the administrative arm of the Board of Land Commissioners and the State Loan and Investment Board. It is the statutory responsibility of the Office of State Lands and Investments to carry out the policy directives and decisions of these two boards.

The organizational structure of Office of State Lands and Investments consists of the Office of the Director and five divisions: Financial Programs and Management Services, Real Estate Management and Farm Loans, Mineral Leasing and Royalty Compliance, Wyoming State Forestry, and Information Technology. Collectively, these divisions serve the trust's beneficiaries: Wyoming's school children and state institutions; numerous clients in agriculture, mineral, timber, transportation, communication, public utility, recreation, tourism, and other Wyoming industries; local government entities; state and federal agencies; and the resident and non-resident general public.

The Farm Loan Program, which was established in 1921, provides long-term real estate loans to Wyoming's agricultural operators. The use of this program has been expanded over the years to also include loans for the purchase of livestock and to assist beginning agricultural producers.

The Irrigation Loans Program, which was established in 1955, is designed to support small and large agricultural water development projects. The Wyoming Legislature has allocated a total of $275 million for loans under the Farm Loan Program and $20 million for the Irrigation Loans Program. Both programs are funded from the Wyoming Permanent Mineral Trust Fund.

Joint Powers Act Loan Program was established in 1974. The Wyoming Legislature authorized the Joint Powers Act Loan Program to benefit local communities for infrastructure needs. These loans are approved from funds within the Wyoming Permanent Mineral Trust Fund. These programs aid cities, counties, and special districts by providing needed government services and public facilities.

7.2.4. Wyoming Water Development Programs

The WWDC provides grant and loan funding for water supply reconnaissance and feasibility studies and construction projects. Funding for studies and construction projects comes from mineral taxes. All planning studies and construction projects must be approved for funding by the Wyoming Legislature. Applicants must be public entities such as municipalities, irrigation districts, service and improvement districts, or joint powers boards. Projects must address water supply, transmission, or storage.

Project Planning: The WWDC funds and manages both Level I reconnaissance studies and Level II feasibility studies. Level I studies carry out necessary reconnaissance work, while Level II studies determine a projects' feasibility. Levels I and II are 100 percent grant-funded. Project construction is covered in Level III. Project applications originate with sponsoring entities. New applications must be received by the WWDC by September 15 of each year. The Wyoming Legislature must authorize each project and approve funding before a project is initiated and before it advances to the next level.

Construction: Once a project receives a Level III authorization, the staff of the WWDC's Construction Division works with project sponsors to establish the legal documentation making state funds available and ensuring that the project constructed complies with the description, intent, and budget as specified in the enabling legislation. One of the professional staff is assigned to each construction project from design through construction and warranty acceptance. The Construction Division assists the sponsor with design engineer selection, plan and specification review, and award of the construction contract, and then it reviews and approves all project payments. WWDC policy allows for grants of 67 percent of the eligible portions of new development and rehabilitation projects. The remainder of funding for eligible portions can be loaned at a 4 percent interest rate for new development and rehabilitation projects. Sponsors may choose to fund the loan portion from other sources.

River Basin Planning: The purpose of river basin planning is to gather and make available accurate, contemporary water information. This would include such information as hydrology for the average wet, dry, and average years, GIS format coverage maps of irrigated land masses, well locations, headgate locations, estimates of consumptive water use, and projection of future water demands. WWDC's River Basin Planning division will assist Commission, the Legislature, and the governor in developing effective state water policies to protect Wyoming's water and promote responsible development. It will also quantify Wyoming's water resource allocations available under the state's compacts and decrees and will give Wyoming citizens access to the water information they need to deal with water issues at the grassroots level. The completion of each river basin plan is achieved with the help of the public, private consultants, and state and federal agencies.

Groundwater Grant Program: The 1981 and 1984 Wyoming Legislatures addressed W.S. 41- 2-119, which authorized the WWDC to grant up to $4 million to incorporated cities and towns for exploration programs to evaluate the potential use of underground water for municipal purposes. During the 2002 session, the Legislature appropriated an additional $1,500,000 for the groundwater grant program and included water and sewer districts and improvement and service districts in addition to cities and towns, which were already eligible to receive groundwater grants, as eligible grant recipients. Authorized entities are eligible to receive up to $400,000 in grant funds and are required to provide 25 percent of the total project costs in local matching funds. The primary purpose of the program is to inventory the available groundwater resources in the state where data on aquifer resources are scarce. The program also serves to assist communities in the development of efficient water supplies. The program is not a well rehabilitation program that, for instance, replaces failed wells or repairs deficient wells. Unlike other projects within the water development program, funding for projects that meet the criteria of the Groundwater Grant Program can be allocated directly by the WWDC without legislative action.

Small Water Project Program: The Small Water Project Program (SWPP) is intended to be compatible with the WWDC conventional program and criteria and to parallel and partner with other local, state, and federal programs that perform water resource planning and water development in Wyoming. Small water projects are defined as those projects that provide multiple benefits and where estimated construction costs, permit procurement, construction engineering, and project land procurement are $135,000 or less, or where the maximum financial contribution from the commission is 50 percent of project costs or $35,000, whichever is less. SWPP funding is a "one-time" grant so that ongoing O&M costs are not included. Loans are not available under SWPP. The kinds of projects eligible for SWPP funding include, but are not necessarily limited to:

- Environmental projects (stream bank stability, water quality improvements, or erosion protection)
- Irrigation infrastructure
- Pipelines
- Small reservoirs
- Spring developments
- Solar platforms
- Tanks
- Wells
- Wetland development
- Windmills

*As stated in Governor Mead's Wyoming Water Strategy, 2015, "**Aging infrastructure for irrigation and diversion can negatively affect stream systems.** Rebuilding old infrastructure provides opportunities to use new technologies and improve efficiencies in water and in time spent on management. Irrigation practices can be more efficient and precise that ever imagined in earlier generations."*

These projects may address environmental concerns by providing water supplies to support plant and animal species, and they serve as instruments to improve rangeland conditions. Funding can only be provided to eligible public entities including, but not necessarily limited to, conservation districts, watershed improvement districts, water conservancy districts, and irrigation districts.

7.2.5. Wyoming Department of Agriculture

Rangeland Health Assessment Program

The Wyoming Department of Agriculture has developed the Rangeland Health and Assessment Program and the TCD has partnered with the Wyoming Department of Agriculture on several of the Rangeland Health and Assessment Program grants in the Upper Snake River watershed. The purpose of the grant program is to assure the development and use of credible data in the assessment of Wyoming rangelands by providing a structured approach that fosters and assists in collaborative efforts to monitor rangelands involving, as applicable, landowners, lessees, permittees, and federal and state land agencies.

The Wyoming Department of Agriculture has several goals for the program. The short-term goal of the program is to sustain viable levels of federal grazing land by providing credible data to assist federal land agencies in completing required permit NEPA analysis and to enable agencies and permittees to defend against challenges to grazing permit renewals and management plans.

The long-term goal of the program is to assess trends in the health of all rangelands and assure the use of credible data in making adjustments in their management where indicated. Monitoring will help maintain or improve the economic viability of the livestock grazing industry and its contribution to the Wyoming economy.

The Rangeland Health and Assessment Program grants, valued from $16,000 to $20,000, provided for professional contractors and equipment to monitor vegetation and soils on grazing allotments. These allotments are located on the northern half of the BTNF. Data collection included locating historic transects and collecting data using the same method as was used during the previous data collection event. This allows for trend determination. Plants were identified to the species level, involving keying out many plants. Soil pits were also dug to determine chemistry, structure, texture, and layers. The USFS will incorporate data into allotment files and will utilize them in future management decisions, such as permit renewal processes.

Wyoming Department of Agriculture's Rangeland Health and Assessment Program information is located on their website at http://wyagric.state.wy.us/divisions/nrp/rangeland-health. Additionally, further information can also be provided through the TCD office.

7.2.6. Wyoming Wildlife and Natural Resources Trust

The Wyoming Wildlife and Natural Resources Trust offers a variety of funding options and is best summarized from the Water Management & Conservation Assistance Program Directory available online at: (http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf).

The Wyoming Wildlife and Natural Resources Trust was created in 2005 and is funded by interest earned on a permanent account, and by donations and legislative appropriations. The purpose of the program is to enhance and conserve wildlife habitat and natural resources values throughout the state. Any project designed to improve wildlife habitat or natural resources values is eligible for funding.

Wyoming Wildlife and Natural Resources Trust funding is available for a wide variety of projects throughout the state, including the natural resources programs of other agencies. Examples of projects eligible for funding include, but are not limited to:

- Projects that improve or maintain existing terrestrial habitat necessary to maintain optimum wildlife populations and may include grassland restoration, changes in management, prescribed fire, or treatment of invasive plants
- Preservation of open space by purchase or acquisition of development rights, contractual obligations, or other means of maintaining open space
- Improvements and maintenance of aquatic habitats, including wetland creation or enhancement, stream restoration, water management, or other methods
- Acquisition of terrestrial or aquatic habitat when existing habitat is determined crucial/critical or is present in minimal amounts and when acquisition presents the necessary factors in attaining or preserving desired wildlife or fish population levels
- Mitigation of impacts detrimental to wildlife habitat, the environment, and the multiple use of renewable natural resources, or mitigation of conflicts and reduction of potential disease transmission between domestic wildlife and domestic livestock

7.3. Federal Agencies

7.3.1. Bureau of Land Management

The BLM offers three distinct programs for funding, which are best summarized in the Water Management & Conservation Assistance Program Directory available online at:
http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf

Riparian Habitat Management Program. The program offers the opportunity to coordinate with outside interests in riparian improvement projects. The goal of BLM's riparian-wetland management is to maintain, restore, improve, protect, and expand these areas so they are in proper functioning condition for their productivity, biological diversity, and sustainability. The overall objective is to achieve an advanced ecological status, except where resource management objectives, including proper functioning condition, would require an earlier successional stage. The goal includes aggressive riparian-wetland information inventorying, training, and research programs as well as improving the partnerships and cooperative management processes. Funding is available on an annual basis subject to budget allocations from Congress. All submitted cooperative projects compete for the funds available in the riparian program.

Range Improvement Planning and Development. The program is a cooperative effort not only with the livestock operator but also with other outside interests including the various environmental/conservation groups. Water development – whether it be for better livestock distribution or improved wetland habitats for wildlife – is key to healthy rangelands and biodiversity. Before actual range improvement development occurs, an approved management plan must be in place. All rangeland improvement projects on lands administered by the BLM require the execution of a permit. Although there are a couple of methods for authorizing range improvements on public lands, Cooperative Agreement for Range Improvements form 4120-6 is the method most commonly used. This applies equally to range improvement projects involving water such as reservoirs, pits, springs, and wells including any associated pipelines for distribution. The major funding source for the BLM's share comes from the range improvement fund, which is generated from grazing fees collected. There is also a limited amount of funding from general rangeland management appropriations. Contributions come either in the form of labor or may provide some material costs as well and are typically in the form of a grant.

Watershed and Water Quality Improvement. Efforts are undertaken in a cooperative approach with the state of Wyoming, conservation districts, livestock operators, and various conservation groups. Wyoming's BLM is partnering in the implementation of several Section 319 watershed plans statewide. This program is a cooperative effort between the BLM and the WDEQ. Goals of the program for watershed projects will typically be the restoration and maintenance of healthy watershed function and are typically accomplished through best management practices, prescribed burns, vegetation treatment, and instream structures to enhance vegetation cover, control accelerated soil erosion, increase water infiltration, and enhance stream flows and water quality.

7.3.2. Bureau of Reclamation

The Bureau of Reclamation offers two programs for funding, which are best summarized in the Water Management & Conservation Assistance Program Directory online at:
http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf

The Bureau of Reclamation's mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public. The Bureau of Reclamation has a major responsibility, in partnership with states, water users, and other interested parties, to help improve water resources and the efficiency of water use in the western United States. After more than 100 years, the bureau's primary role has evolved from one of water resource development to one of water resource management. More efficient water use is a key component of the bureau's water resource management strategy.

WaterSMART (Sustain and Manage America's Resources for Tomorrow). This program established a framework to provide federal leadership and assistance on the efficient use of water, integrating water and energy policies to support the sustainable use of all natural resources, and coordinating the water conservation activities of various Bureau of Reclamation bureaus and offices. Through the WaterSMART program, the Bureau is working to achieve a sustainable water management strategy to meet the nation's water needs through projects that conserve and use water more efficiently, increase the use of renewable energy and improve energy efficiency, protect endangered and threatened species, facilitate water markets, or carry out other activities to address climate-related impacts on water or prevent any water-related crisis or conflict. A major component of WaterSMART is the Water and Energy Efficiency Grant Program, through which the bureau provides funding in two funding groups. In Funding Group I, up to $300,000 in federal funding is available per project, for smaller on-the-ground projects that can be completed within two years. In Funding Group II, up to $1 million in funding is available for larger, phased, on-the-ground projects that may take up to three years to complete. Water and Energy Efficiency Grants are awarded through a west-wide competitive process that requires a minimum 50 percent cost share by the recipient. More information can be found online here: http://www.usbr.gov/WaterSMART.

Water Conservation Field Services Program (WCFSP). Provides smaller amounts of funding ($100,000 per project maximum) through local competitions within a region or area. The projects funded are generally smaller in scope than Water and Energy Efficiency Grant projects, and they are focused on fundamental conservation improvements as identified in water conservation plans developed by water users. Financial assistance provided through the program also requires a minimum 50 percent cost share by the recipient. More information can be found online here: http://www.usbr.gov/waterconservation.

7.3.3. Environmental Protection Agency

The EPA administers the Targeted Watersheds Grant Program. Established in 2003, the Targeted Watersheds Grant Program is designed to encourage successful community-based approaches and management techniques to protect and restore the nation's watersheds. The Targeted Watersheds Grant Program is competitive and based on the fundamental principles of environmental improvement: collaboration, new technologies, market incentives, and results-oriented strategies. The Targeted Watersheds Grant Program focuses on multifaceted plans for protecting and restoring water resources that are developed using partnership efforts of diverse stakeholders. The program's implementation grants are focused on individual watershed organizations. Successful watershed organizations are chosen because they best demonstrated the ability to achieve on-the-ground, measurable environmental results relatively quickly, having already completed the necessary watershed assessments and developed a technically sound watershed plan. Each of the watershed organizations exhibits strong partnerships with a wide variety of support; creative, socio-economic approaches to water restoration and protection; and explicit monitoring and environmentally based performance measures. Proposals must be nominated by either a governor or a by tribal leader from the state in which the project resides. More information can be found here: https://www3.epa.gov/region9/water/watershed/grants.html.

7.3.4. Farm Service Agency

The FSA is a member agency of the USDA. Programs administered through the FSA are offered through local county committees. Technical assistance needed for implementation of FSA programs is provided through the NRCS. The FSA programs available include the following:

Conservation Reserve Program. This program offers agricultural producers annual rental payments to remove highly erodible cropland from production. Farmers and ranchers establish long-term conservation practices on erodible and environmentally sensitive land. In exchange, they receive 10 to 15 years of annual rental payments and cost-share assistance. This is a voluntary program specifically for highly erodible lands currently in active production planted two of the five most recent crop years. Land offered for the program is ranked according to environmental benefit for wildlife habitat, erosion control, water quality, and air quality.

Continuous Sign-Up for High Priority Conservation Practices. Continuous sign-up provides management flexibility to farmers and ranchers to implement certain high-priority conservation practices on eligible land. Land must meet the requirements of the Conservation Reserve Program and be determined by NRCS to be eligible and suitable for riparian buffers, filter strips, grass waterways, shelter belts, field windbreaks, living snow fences, contour grass strips, salt-tolerant vegetation, and shallow water areas for wildlife. This is a cost-share program that offers rental rates based on the average value of dryland cash rent with an additional financial incentive of up to 20 percent of the soil rental rate for field windbreaks, grass waterways, filter strips, and riparian buffers. An additional 10 percent may be added if the land is located in an EPA-designated wellhead protection area. There is also a provision for cost share of up to 50 percent of the cost of establishing permanent cover.

Emergency Conservation Program. The program provides emergency funding and technical assistance for farmers and ranchers to rehabilitate farmland damaged by natural disasters and for carrying out emergency water conservation measures for livestock during periods of severe drought. Participants receive cost-share assistance of up to 75 percent of the cost to implement approved emergency conservation practices as determined by county FSA committees. Some conservation practices are removing debris, restoring fences and conservation structures, and providing water for livestock in drought situations.

More information for each of the programs can be found online at: http://www.fsa.usda.gov/FSA/webapp?area=home&subject=landing&topic=landing.

7.3.5. U.S. Fish and Wildlife Service

The USFWS offers technical and financial assistance to a variety of entities. They offer six programs addressing the management, conservation, restoration, or enhancement of wildlife and aquatic habitat. These six programs are best summarized in the Water Management & Conservation Assistance Program Directory available online at: http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf

Partners for Fish and Wildlife Program. The Partners for Fish and Wildlife Program serves as the primary tool for conservation delivery on privately owned land for the USFWS. The program provides technical and financial assistance to private landowners and tribes on a voluntary basis to help meet the habitat needs of federal trust species and conservation partner-designated species of interest. The program targets habitats that are in need of restoration or enhancement such as riparian areas, streams, wetlands, and grasslands. Field biologists work one-on-one with landowners and partners to plan and implement a variety of projects including grazing lands management, sage steppe enhancement, stream habitat improvement and fish passage, invasive species removal, and wetland establishment.

Wildlife and Sport Fish Restoration. The USFWS's Wildlife and Sport Fish Restoration Program works with states, insular areas, and the District of Columbia to conserve, protect, and enhance fish, wildlife, their habitats, and the hunting, sport fishing, and recreational boating opportunities they provide. The program provides oversight and /or administrative support for the following grant programs: Wildlife Restoration Grant Program, Sport Fish Restoration Grant Program, Boating Infrastructure Grant Program, State Wildlife Grant Program, Tribal Wildlife Grant Program, and Tribal Landowner Incentive Grant Program.

Conservation Planning and Assistance Program. The Conservation Planning Assistance program works directly with other federal agencies and programs, as well as the American public, on infrastructure development projects to protect the environment and preserve our nation's biological, terrestrial, and aquatic natural resources. Field biologists in all 50 states assist project proponents, planners, and agency personnel in developing plans that conserve, restore, or enhance fish and wildlife while at the same time accomplishing the objectives of proposed development. This program provides grants to state fish and wildlife agencies to fund projects that bring together USFWS, state agencies, and private organizations and individuals. Projects include identification of significant problems that can adversely affect fish and wildlife and their habitats, actions to conserve species and their habitats, actions that will provide opportunities for the public to use and enjoy fish and wildlife through non-consumptive activities, monitoring of species, and identification of significant habitats.

Cooperative Endangered Species Conservation Fund/Section 6 Grants. The Cooperative Endangered Species Conservation Fund (section 6 of the ESA) provides grants to states and territories to participate in a wide array of voluntary conservation projects for candidate, proposed, and listed species. The program provides funding to states and territories for species and habitat conservation actions on non-federal lands.

States and territories must contribute a minimum non-federal match of 25 percent of the estimated program costs of approved projects, or 10 percent when two or more states or territories implement a joint project.

North American Wetlands Conservation Act Grant Program. This grant program promotes long-term conservation of wetlands ecosystems and the waterfowl, migratory birds, fish, and wildlife that depend upon such habitat. Conservation sections supported are acquisition, enhancement, and restoration of wetlands and wetlands-associated habitat. This program encourages voluntary, public, and private partnerships. Public or private, profit or nonprofit entities or individuals establishing public/private sector partnerships are eligible. Cost-share partners must at least match grant funds with non-federal monies.

National Wildlife Refuge Challenge Cost-Share Program. The USFWS Challenge Cost-Share Program started in 1988 as a way to enhance partnerships with state and local governments, individuals, and public and private groups. The program enables the USFWS to manage cooperatively its natural and cultural resources and fulfill stewardship responsibilities to fish and wildlife management. Under this program, projects must occur on a refuge or directly benefit a refuge. The program encourages refuge managers to form partnerships and leverage allocated funds to complete the projects. Appropriated funds may be used to pay no more than 50 percent of the cost of a project. Non-federal sources, including state/local governments, private individuals/organizations, business enterprises, and philanthropic and charitable groups provide the matching 50 percent cost share. The cooperator share may be a non-monetary contribution. Cooperative agreements are signed with the cost-share partners.

7.3.6. Natural Resource Conservation Service

The NRCS provides leadership in a partnership effort to help people voluntarily conserve, improve, and sustain natural resources on private lands. The purpose and mission of the agency is to help landowners treat every acre of their private property according to its needs and within its capability. The treatment includes a balance between the land use for economic return and protecting its ability to be productive from generation to generation. Technical and cost-share assistance is available through NRCS. The NRCS administers the following Farm Bill programs, which are best summarized in the Water Management & Conservation Assistance Program Directory available online at:
http://wwdc.state.wy.us/wconsprog/2014-WMCAP-Directory.pdf.

Environmental Quality Incentives Program (EQIP). Through EQIP, technical assistance, cost-share, and incentive payments are available to agricultural producers to implement conservation practices that improve water quality, enhance grazing lands, and/or increase water conservation.

The Sage-grouse Working Lands for Wildlife Initiative is offered under the EQIP with the purpose of providing assistance to agricultural producers to implement practices that will alleviate or reduce threats to sage-grouse habitat.

Conservation Stewardship Program (CSP). This program encourages land stewards to improve their conservation performance by installing and adopting additional activities, and improving, maintaining, and managing existing activities on agricultural land and nonindustrial private forest land.

The Regional Conservation Partnership Program. This program promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. NRCS provides assistance to producers through partnership agreements and through program contracts or easement agreements. Assistance is delivered in accordance with the rules of EQIP, CSP, and the Agricultural

Conservation Easement Program (ACEP), and in certain areas, the Watershed Operations and Flood Prevention Program.

The Agricultural Management Assistance Program. This program provides financial assistance to agricultural producers to address resource issues such as water management, water quality, invasive species control, and erosion control by incorporating conservation into their farming or ranching operations. The purpose of the program is to assist producers in reducing risk to their operations.

Conservation Innovation Grants. This program is intended to stimulate the development and adoption of innovative conservation approaches and technologies while leveraging federal investment in environmental enhancement and protection, in conjunction with agricultural production. Under this grant program, EQIP funds are used to award competitive grants to non-federal governmental or nongovernmental organizations, tribes, or individuals.

The Agricultural Conservation Easement Program (ACEP). This program provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. Under the Agricultural Land Easements component, NRCS helps Indian tribes, state and local governments, and non-governmental organizations protect working agricultural lands and limit non-agricultural uses of the land. Under the Wetlands Reserve Easements component, NRCS helps to restore, protect, and enhance enrolled wetlands.

7.4. Nonprofit and Other Organizations

In this section, several national nonprofit organizations that promote conservation and fund restoration projects are described. Additionally, there are numerous nonprofits based in Jackson that promote conservation and the environment. An online directory is maintained by the Community Foundation of Jackson Hole available online at: http://www.cfjacksonhole.org/nonprofits/nonprofit-directory/

7.4.1. Ducks Unlimited

Ducks Unlimited Inc. is a funding source for wetlands and waterfowl restoration. Ducks Unlimited conducts program development through a “partner” agency in providing short-term project funding assistance. Money availability is limited to what is within the organizational system. Generally, $20,000 to $30,000 is available annually statewide with additional funding support from project-specific donations. The local Ducks Unlimited of Jackson Hole has a $50,000 budget. Their mission is to develop, preserve, restore, and maintain waterfowl habitat for migration, nesting, and brooding and to educate the public concerning waterfowl and wetlands management.

Ducks Unlimited offers a waterfowl habitat development and protection program called MARSH, which stands for Matching Aid to Restore State Habitat. This is a reimbursement program that provides matching funds for restoration, protection, or enhancement of wetlands. The financial extent of this program is dependent on Ducks Unlimited’s income within the state. Projects receiving funding support must demonstrate at least 30 years of beneficial life at a minimum.

7.4.2. National Fish and Wildlife Foundation

The NFWF provides a number of charter grant programs for regions across the nation. The most applicable programs for this project include the following:

Five-Star Restoration Program. Provides modest financial assistance on a competitive basis to support community-based wetland, riparian, and coastal habitat restoration projects that build diverse partnerships and foster local natural resources stewardship through education, outreach, and training activities.

Bring Back the Natives. The NFWF, in cooperation with the USFWS, BLM, USDA, USFS, and TU, is requests pre-proposals from nonprofit organizations; universities; Native American tribes; and local, state, and federal agencies interested in restoring, protecting, and enhancing native populations of sensitive or listed aquatic species, especially on lands on or adjacent to federal agency lands. Funding for the program is administered through NFWF from federal agencies cooperating to support this program. This funding requires a $2 non-federal match for each federal dollar requested by applicants. Since 1991, this program has supported 279 projects and has benefited over 120 species, 29 of which are federally listed as threatened or endangered.

Native Plant Conservation Initiative. The NFWF solicits proposals for the Native Plant Conservation Initiative grants cycle. This grant program is conducted in cooperation with the Plant Conservation Alliance (PCA), a partnership between the NFWF, 10 federal agencies, and more than 270 non-governmental organizations. The Plant Conservation Alliance provides a framework and strategy for linking resources and expertise in developing a coordinated national approach to the conservation of native plants. Since 1995, the Native Plant Conservation Initiative grant program has funded multiple-stakeholder projects that focus on the conservation of native plants and pollinators under any of the following six focal areas: conservation, education, restoration, research, sustainability, and data linkages.

Pulling Together Initiative. The Pulling Together Initiative seeks proposals that will help control invasive plant species, mostly through the work of public/private partnerships such as Cooperative Weed Management Areas. Applications are accepted from private nonprofit (501) (c) organizations; federally recognized tribal governments; local, county, and state government agencies; and from field staff of federal government agencies. Individuals and for-profit businesses are not eligible to receive these grant funds, but they are encouraged to work with eligible applicants to develop and submit applications to the initiative. Applicants must provide a 1:1 non-federal match for their grant request.

More information for each of these funding options and others can be found at NFWF’s website here: http://www.nfwf.org.

7.4.3. Trout Unlimited

TU was founded in 1959 with a mission to conserve, protect, and restore North America’s trout and salmon fisheries and their watersheds. TU works to achieve this mission on a local, state, and national levels through an extensive volunteer network and dedicated staff. The primary TU program relevant to this watershed study is the new Snake River Headwaters Home Rivers Initiative. Through this initiative, TU is able to provide partnership, technical, administrative, and financial assistance to landowners for collaborative fish passage projects and channel and stream restoration projects.

Since 2007, TU’s Wyoming Water and Habitat Program has developed innovative and pragmatic partnerships with landowners, ranchers, and agencies in an effort to conserve our cold-water fisheries. To date, TU has raised over $10 million to reconnect and restore over 1,000 miles of streams for wild and native trout through the implementation of over 100 projects with numerous partners in Wyoming. Landowners and agencies who partner with TU have enjoyed the benefits of maintenance-free irrigation diversion structures, irrigation efficiency upgrades, riparian fencing, river channel restoration, stream habitat enhancements, and new road crossing infrastructure while at the same time benefiting fisheries.

Snake River Headwaters Home Rivers Initiative. In April 2016, TU launched a new initiative to restore and protect the headwaters of the Snake River. The Snake River Headwaters program area, which includes the main stem of the Snake River and its tributaries ranging from Yellowstone National Park in the north to Star Valley in the south, is home to a unique mix of native Snake River fine-spotted and Yellowstone cutthroat trout, both of which are WGFD species of greatest conservation need.

Snake River Headwaters Home Rivers Initiative goals and strategies include the following:

- Reconnect native trout spawning and rearing habitat.
- Restore water quality, trout habitat, and healthy stream conditions.
- Educate students about the watershed through the Adopt-A-Trout Program.
- Develop a conservation strategy for the Upper Snake River with partners and stakeholders.

TU welcomes the opportunity to work with landowner and agency partners on collaborative fish passage projects and channel and stream restoration projects identified in this Upper Snake River Basin Level I Watershed Study, as well as other projects not yet identified, that provide a benefit to cold-water fisheries as described in the sections above. For more information, contact Leslie Steen, Snake River Headwaters Project Manager, Trout Unlimited, 185 Center Street, Suite. B, Jackson, WY 83001, 307.699.1022, lsteen@tu.org.

7.5. Funding for Sage-Grouse Conservation Efforts

Sage-grouse conservation in the Upper Snake River watershed will provide a number of benefits relative to the construction and funding of projects proposed. There are a great number of funding sources whose mission is to benefit the habitat and success of the sage-grouse. There are also a number of organizations who will have special requirements for any construction or modification to the local habitat. The WGFD has compiled a list of funding opportunities for Wyoming sage-grouse conservation efforts. The funding opportunities are best summarized in the WGFD's web site:
https://wgfd.wyo.gov/WGFD/media/content/PDF/Habitat/Sage%20Grouse/SGC_FUNDINGOPPS_REVISED0414.pdf

7.5.1. State of Wyoming Sources for Sage-Grouse Conservation Efforts

Wyoming Wildlife and Natural Resource Trust Account. Created by legislative action in 2005 for the purposes of preserving and enhancing Wyoming's wildlife and natural resources. Income from the trust account funds a wide variety of conservation programs (http://wwnrt.state.wy.us).

Wyoming Game and Fish Department (WGFD) Trust Fund. Matching grants program for riparian or upland habitat improvement, water development, and industrial water projects (http://wgfd.wyo.gov).

WGFD/Wyoming State General Fund – Wyoming Sage-Grouse Conservation Fund. Funding approved by the Legislature via the governor's budget request and designed to implement projects identified in local sage-grouse conservation plans (http://wgfd.wyo.gov).

Wyoming Animal Damage Management Board. Provides funding for the purposes of mitigating damage caused to livestock, wildlife, and crops by predatory animals, predacious birds, and depredating animals or for the protection of human health and safety (http://www.wyadmb.com).

7.5.2. Federal Sources for Sage-Grouse Conservation Efforts

U.S. Department of the Interior, U.S. Fish and Wildlife Service (USFWS) (http://www.fws.gov)

- **Partners for Fish and Wildlife Program**. Provides assistance to private landowners who want to restore or improve habitat on their property. The landowner is reimbursed after project completion, based on the cost-sharing formula in the agreement.
- **Private Stewardship Program**. Provides grants or other assistance to individuals and groups engaged in private conservation efforts that benefit species listed or proposed as endangered or threatened under the ESA, candidate species, or other at-risk species on private lands. Maximum federal share is 90 percent.
- **Cooperative Conservation Initiative**. Supports efforts to restore natural resources and establish or expand wildlife habitat. Maximum federal share is 50 percent.
- **Multistate Conservation Grant Program**. Supports sport fish and wildlife restoration projects identified by the International Association of Fish and Wildlife Agencies. Maximum federal share is 100 percent.
- **Tribal Landowner Incentive Program**. For actions and activities that protect and restore habitats that benefit federally listed, proposed, or candidate species, or other at-risk species on tribal lands. Maximum federal share is 75 percent.
- **Tribal Wildlife Grants**. Provides for development and implementation of programs for the benefit of tribal wildlife and their habitat. Maximum federal share is 100 percent.
- **Conservation Grants**. Provides financial assistance to states to implement wildlife conservation projects such as habitat restoration, species status surveys, public education and outreach, captive propagation and reintroduction, nesting surveys, genetic studies, and development of management plans. Maximum federal share is 75 percent for a single state or 90 percent for two or more states implementing a joint project.

USDA Farm Service Agency (FSA) (http://www.fsa.usda.gov/pas/)

- **Conservation Reserve Program.** A voluntary program for agricultural landowners. Through this program, an individual can receive annual rental payments and cost-share assistance to establish long-term, resource-conserving covers and to enhance wildlife habitat on eligible agricultural land.

USDA Natural Resource Conservation Service (NRCS) (http://www.wy.nrcs.usda.gov)

- **Conservation Technical Assistance.** Provides voluntary conservation technical assistance to land users, communities, units of state and local government, and other federal agencies in planning and implementing conservation systems. This assistance is for planning and implementing conservation practices that address natural resources issues.
- **Environmental Quality Incentives Program (EQIP).** Provides a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental

quality as compatible goals. EQIP offers financial and technical help to assist eligible participants install or implement a broad variety of structural and management practices on eligible agricultural land.

- **Conservation Innovation Grants.** A voluntary program that enables the NRCS to work with public and private entities to accelerate the development and adoption of innovative conservation approaches and technologies in conjunction with agricultural production.
- **Working Lands for Wildlife.** A partnership between NRCS and the USFWS to combat the decline of seven specific wildlife species whose decline could be reversed and could benefit other species with similar habitat needs. The greater sage-grouse is one of the seven.
- **Conservation Stewardship Program.** Helps agricultural producers maintain and improve their existing conservation systems and adopt additional conservation activities to address priority resources concerns. Participants earn CSP payments for conservation performance – the higher the performance, the higher the payment.
- **Agricultural Conservation Easement Program (ACEP).** Provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. Under the Agricultural Land Easements component, NRCS helps Indian tribes, state and local governments, and non-governmental organizations protect working agricultural lands and limit non-agricultural uses of the land through conservation easements. Under the Wetlands Reserve Easements component, NRCS helps to restore, protect, and enhance enrolled wetlands. ACEP is a new program that consolidates three former programs – the Wetlands Reserve Program, Grasslands Reserve Program, and Farm and Ranch Land Protection Program.
- **Regional Conservation Partnership Program.** Promotes coordination between NRCS and its partners to deliver conservation assistance to producers and landowners. NRCS provides assistance to producers through partnership agreements and through program contracts or easement agreements. This program combines the authorities of four former conservation programs – the Agricultural Water Enhancement Program, the Chesapeake Bay Watershed Program, the Cooperative Conservation Partnership Initiative, and the Great Lakes Basin Program – and delivers assistance through covered programs, including EQIP, CSP, ACEP, Healthy Forest Reserve Program, and Watershed and Flood Prevention Operations in Critical Conservation Areas.

U.S. Department of Interior, Bureau of Land Management (BLM) (http://www.blm.gov)

- **Challenge Cost Share**. This program is designed to leverage funds with partners to monitor and inventory resources; implement habitat improvement projects; develop recovery plans; protect or document cultural resources; provide enhanced recreational experiences; and to better manage wild horse and burro populations. Matching funds, goods or services are required.

USDA U.S. Forest Service (USFS) (http://www.fs.fed.us)

- **Cooperative project funding.** Contact local USFS staff for information about opportunities to develop partnerships in projects involving national forests or national grasslands.
- **Partnership Resource Center**. The Partnership Resource Center of the National Forest Foundation and the UFSF provides partnering organizations and USFS staff with the

information to enhance working relationships. Partnerships expand opportunities for obtaining grants. Many funding sources prefer or require them because projects involving partnerships have an increased potential for success (http://www.partnershipresourcecenter.org).

7.5.3. Other Potential Sources for Sage-Grouse Conservation Efforts

Wyoming Wildlife – The Foundation. This foundation (now a component fund of the Wyoming Community Foundation) is a charitable, non-advocacy organization dedicated to conservation education and the funding and management of projects that benefit Wyoming wildlife (http://www.wyomingwildlifefoundation.org).

Wyoming Governor's Big Game License Coalition. Funding generated from the sale of governor's licenses are placed in five accounts: bighorn sheep, moose, elk, mule deer, and general wildlife. Funds administered by the Wyoming Wildlife – The Foundation.
(http://www.wyomingwildlifefoundation.org/index.aspx)

National Fish and Wildlife Foundation (NFWF) – Conservation Partners Program. Grants funded through this program provide staff and technical assistance to private landowners in regions where some of the nation's most crucial conservation issues can be addressed through Farm Bill programs (http://www.nfwf.org/conservationpartners/Pages/home.aspx).

National Fish and Wildlife Foundation (NFWF) - Pulling Together Initiative. Provides support for the formation of local Weed Management Area partnerships. These partnerships engage federal resource agencies, state and local governments, private landowners, and others in developing weed management projects within an integrated pest management strategy. Non-federal matching funds, goods, or services are required (http://www.nfwf.org/pti/Pages/home.aspx).

Intermountain West Joint Venture - Capacity Grants Program. Habitats within the program area support nearly 100 percent of the range of all high-priority sagebrush steppe landbird species, such as sage sparrow, sage thrasher, sage-grouse, and Brewer's sparrow. This grants program is designed to build capacity and catalyze partnerships that measurably contribute to the protection, restoration, or enhancement of priority bird habitats to support sustainable populations of birds in the Intermountain West. Successful capacity grants are meant to join conservation partners together—around priority areas, habitats, or bird species—to improve conservation program effectiveness) http://iwjv.org/funding-opportunity/iwjv-capacity-grantsprogram).

The Nature Conservancy (TNC). Works with conservation supporters and partner organizations to create funding for conservation worldwide using a variety of creative methods (http://nature.org).

Rocky Mountain Elk Foundation. This wildlife conservation organization has an emphasis on elk. It advocates sustainable, ethical use of resources and seeks common ground among stakeholders. It funds habitat restoration and improvement projects and acquires land or conservation easements (http://www.rmef.org).

Mule Deer Foundation. This foundation's goals center on restoring, improving, and protecting mule deer habitat. The Mule Deer Foundation achieves its goals through partnering with state and federal wildlife agencies, conservation groups, businesses, and individuals to fund and implement habitat enhancement projects on both public and private lands (http://www.muledeer.org).

Muley Fanatic Foundation. The mission of this organization is to ensure the conservation of mule deer and their habitat and to provide such supporting services to further the sport of hunting and sound wildlife management (http://www.muleyfanatic.com).

One Shot Antelope Foundation-Water for Wildlife. Water for Wildlife is a conservation program designed to benefit wildlife and the environment in arid regions of the western United States. Emphasis focuses on the development of supplemental water resources in areas where both the habitat and wildlife are being impaired by lack of this vital resource (http://www.waterforwildlife.com).

North American Grouse Partnership. Promotes the conservation of prairie grouse and the habitats necessary for their survival and reproduction (http://www.grousepartners.org).

Pheasants Forever. Some sage-grouse populations in Wyoming occur within areas that have a local Pheasants Forever chapter. Local chapters determine how their funds are spent. Projects that benefit game birds other than pheasants may be eligible for funding (http://www.pheasantsforever.org/chapters/).

Bow Hunters of Wyoming. Assists with wildlife studies, habitat improvement, water guzzlers, and other conservation efforts.

8. CONCLUSIONS AND RECOMMENDATIONS

This section provides the conclusions and recommendations of this Level I watershed study. The conclusions and recommendations pertain to the watershed improvements presented in the Watershed Management Plan (Section 4) and incorporate interpretations from the cost estimates, permitting and project financing (Sections 5, 6, and 7).

8.1. Conclusions

This watershed study provides a holistic evaluation of the Upper Snake River watershed, an area of over 1.7 million acres. This Level I watershed study evaluated the current condition of the Upper Snake River watershed and looked at opportunities for water improvement projects to restore, maintain, and enhance healthy watershed function. The current condition of the watershed was evaluated and summarized in the description and inventory of the watershed, Sections 2 and 3 of this report. The datasets and reports evaluated for the inventory and description were incorporated into a GIS dataset and digital library provided electronically to the TCD and WWDC. The datasets and digital library will provide the TCD, WWDC, and cooperating agencies information for planning and implementation of the watershed improvements outlined in this report.

At the beginning of the process, the TCD identified several reasons why this study was needed; additionally, agencies that manage public lands – together with the local residents who live in the watershed – attended project meetings to voice their concerns about what they viewed as watershed issues and opportunities. Table 8.1-1 provides a summary of these issues and opportunities identified and a summary of the resolution identified for each item.

Table 8.1-1 Issues, Opportunities, and Resolutions

Item Identified by	Issue or Opportunity	Resolution
Agency	A comprehensive GIS dataset needs to be developed and accessible by all groups working in the area.	Completed
Agency	A geomorphic classification of the streams in the Upper Snake River watershed is important to complete as a foundation to watershed improvement projects.	Completed
Agency	Some of the engineered wetlands designed as mitigation for projects in the watershed need to be addressed.	Swan Lake wetland issues were resolved by agency and landowner cooperation. Future opportunities exist elsewhere.
Agency	There is a need to evaluate fish entrainment and fish passage along irrigation ditches to protect and enhance the habitat of native species.	Projects improvements identified in this study will be evaluated by TU, TCD, and WGFD.
Agency	Winter flooding along Flat Creek continues to be a problem for the residents of Jackson.	This issue is currently being addressed by FCWID.

Item Identified by	Issue or Opportunity	Resolution
Agency	Additional water supply is needed for fire suppression and possibly for some subdistricts, the southern part of Jackson, and potentially the ski resort in Jackson (Snow King Mountain).	Proposed improvements were identified in Buffalo Valley with the assistance from Teton County Fire Department. No specific need was identified for Jackson or for Snow King at the time of this report.
Agency	Habitat enhancements for specific species of interest and/or threatened and endangered species is needed.	Proposed improvements were described for trumpeter swan and for fish habitat.
Agency	Irrigation system improvements are needed for leases and allotments on public land.	Numerous proposed improvements were identified that will benefit allotments on federal and state lands.
Agency	Flood protection that is needed may be accomplished through levee improvements.	Proposed improvements were identified for Blackrock Creek levee.
Landowner	There are water quality issues in Fish Creek related to septic systems.	Proposed that TCD continue their support for Friends of Fish Creek initiatives and RVF wetlands for residents near Fish Creek.
Landowner	Historic control structures that feed irrigation ditches from the main stem of the Snake River are no longer functioning adequately because of changes in river dynamics over time.	Several improvements were proposed for large headgates along the Snake River. An additional Level II study was proposed at project meetings.
Landowner	Control structures along irrigation ditches need to be modified to allow for safer operations, enhancements to fish habitat, and better operations for irrigated fields.	Several improvements were proposed for medium-sized diversion structures.
Landowner	Certain areas of Jackson are experiencing high water-table issues.	Monitoring and potential mitigation measures were suggested for a subdivision south of Jackson.
Landowner	Control structure replacements were suggested for where damage has occurred.	Several improvements were proposed for medium-sized diversion structures on Jensen and Trail creek.
Landowner	Irrigation management optimization is needed.	Several options were identified for irrigation system optimization on both private and publicly owned land.
Landowner	Stream stabilization may be needed in specific areas.	Several options were identified for stabilization measures for Lake Creek.

Item Identified by	Issue or Opportunity	Resolution
Landowner	There are concerns of the cumulative impacts of small ponds on hydrology of the area.	This issue was not resolved with this study. WSEO is conducting a mapping inventory.
Landowner	Irrigation improvements are needed to minimize sedimentation to streams and enhance water quality.	Identified structures to help control flow across pastures.

Many of the specific recommendations are presented below; however, it is important to note that not every possible project was identified during project development. Public outreach was completed and those who expressed interest in participating in the study were contacted. Individuals will inevitably come forward after this project is complete with issues that require resolution. The TCD and WWDC will be available to work with these individuals to let them know that projects **are still eligible** for funding through the SWPP if they are within the Upper Snake River watershed.

8.2. Recommendations

A Level I watershed study looks for projects, programs, or activities that support sustainable, beneficial water use for current and future watershed residents – human, animal, or plant. The following recommendations are made to help foster this goal.

8.2.1. Irrigation System Improvements

- Irrigation improvements are proposed as requested by ranchers/landowners/agencies in the Upper Snake River watershed. The irrigation improvements focus on rehabilitation/replacement of existing structures, enhanced delivery of water, reduction in annual O&M costs, improvement in ditch management and efficiency, and economic practicality and physical feasibility.
- The specific recommendations include regrading ditches, replacing open ditches with piping and/or lining, replacing headgates, creating new diversion structures, and several options for upgrading irrigation systems. The cost estimates for the projects range from just over $1,000 to install a low-cost discharge measuring device for a diversion structure near Wilson to an option presented for a new irrigation system at the Elk Ranch at GTNP that, if selected, would cost over $2 million.
- Recommended improvements include projects at 20 locations across the watershed. More than half of the projects may apply to the WWDC SWPP, NRCS programs, and/or TAC through the TCD for funding. The projects that were estimated to cost over $135,000 have other options including programs administered by the WWDC, Wyoming Wildlife and Natural Resources Trust, and others as described in Section 7 of this report.
- Additional improvements could be made across the watershed using the plans and cost estimates provided in this report as a guide for conceptual design, cost, and financing opportunities.

8.2.2. Livestock/Wildlife Watering Opportunities

- One of the best options to enhance rangeland and riparian habitat is to ensure adequate watering opportunities in the uplands and away from riparian zones. With dispersal of livestock watering sources to uplands, not only are riparian areas relieved of grazing and trampling pressure, but little used forage on remote uplands may also be accessed by foraging animals. For these reasons, livestock/wildlife watering development projects in underserved areas are recommended.
- The proposed livestock/wildlife projects include the combinations of the following elements: development of existing springs; construction of a small stock pond on an existing seep; and installation of groundwater wells, solar powered pumps, stock tanks, piping, and fencing to maximize water distribution for livestock and wildlife.
- The projects were all estimated to cost less than $135,000 and may be eligible for the WWDC SWPP.
- Additional livestock/wildlife water development improvements could be made, as needed, using the plans and cost estimates provided in this report as a guide for conceptual design, cost, and financing opportunities.

8.2.3. Surface Water Flood and Storage Improvements

- The Upper Snake River watershed is unique for watershed studies because there have been no requests for large surface-storage improvements. In contrast, the issues that were repeatedly identified for communities in the watershed include surface water flood control along Flat Creek in Jackson because of winter ice dams and environmental enhancements related to the USACE flood control levees. These two issues are currently being evaluated and addressed through the FCWID and USACE. Continued involvement and support by the TCD is encouraged to ensure that the projects identified by these initiatives are implemented.
- In contrast, the issue of source water for fire protection was a significant concern for the watershed. In late August 2016, when this report was being completed, the Berry Fire at the north end of Jackson Lake in the GTNP, the Lava Mountain fire near Dubois, and the Cliff Creek fire near Bondurant were all actively burning causing evacuations, road closures, and property destruction.
- The proposed source water for fire protection projects include suction drafting from static water sources such as creeks or ponds, portable or permanent tanks, and underground storage tanks.
- The projects were all estimated to cost less than $135,000 and may be eligible for the WWDC SWPP. These projects can be described as source water development projects since their primary purpose is to provide additional sources of water for watershed fire protection. Not only do source water development projects rank as the highest priority projects in the SWPP operating criteria (WWDC 2015), but at the June 2016 Western Governors' annual meeting in Jackson, one of the seven resolutions passed by the governors was about wildfires – "Wildfire Fire Management and Resilient Landscapes" (Western Governors' Association 2016). The governors' resolution identified the need "to take advantage of current authorities to expedite projects that would improve western ecosystems and reduce extreme wildfire danger." The modest projects proposed in this watershed report are examples of the types of projects that could be implemented to address this important issue.

- The surface water flood and storage improvement projects could be made in other parts of the watershed, as needed, using the plans and cost estimates provided in this report as a guide for conceptual design, cost, and financing opportunities.

8.2.4. Stream Channel Condition and Stability

- Stream channels within the watershed were characterized using the Rosgen classification system. Impaired channels were identified through the classification and through input from residents and landowners. The improvement projects focus on stream restoration to minimize channel erosion, reduce sedimentation, and best management practices that contribute to fish habitat enhancements in the creeks and tributaries of the Snake River.
- The project cost estimates varied greatly depending on the length and extent of the proposed stream channel enhancement. The projects that were estimated to cost less than $135,000 may be eligible for the WWDC SWPP as environmental stream stability improvements. Additional funding from the USACE Environmental Restoration program may be available for projects like the one proposed for Morel Creek. For the Fish Creek projects that will be identified by the Friends of Fish Creek, funding may be available through local nonprofits in the Jackson area along with the WWDC and through the TCD technical assistance cost-share grants called TAC.
- The stream channel condition and stability improvement projects could be made in other parts of the watershed, as needed, using the plans and cost estimates provided in this report as a guide for conceptual design, cost, and financing opportunities.

8.2.5. Other Management Opportunities

- Numerous other management practices and improvements are in various stages of implementation across the watershed. The specific improvements and/or best management practices recommended in this report include additional engineered wetland improvements, habitat enhancements for specific threatened or endangered species, monitoring and mitigation for high water-table conditions, and noxious weed control.
- Because the cost estimates for most of the other management practice improvements are very site-specific and the locations for the improvements have not yet been identified, cost estimates for the improvements at specific sites were not provided.
- As described above, the other management practice projects that cost less than $135,000 may be eligible for the WWDC SWPP as environmental improvements.

As stated in Governor Mead's Wyoming Water Strategy (2015), "Vibrant Wyoming watersheds are essential to the health and sustainability of farms and ranches, kayak rental businesses and fly stores, municipal water systems, and family fishing vacations. ***In short, ensuring the health of Wyoming's watersheds is essential to ensuring the health of our state."***

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10. ACRONYMS AND ABBREVIATIONS

ACEP.............................Agricultural Conservation Easement Program
BAG...............................Basin Advisory Group
BGEPA..........................Bald and Golden Eagle Protection Act
BLM ....Bureau of Land Management
BTNF.............................Bridger-Teton National Forest
CRMP............................Comprehensive River Management Plan
CSP ....Conservation Stewardship Program
CWA..............................Clean Water Act
EA.................................Environmental Assessment
eFOTGs.........................Electronic Field Office Technical Guides
EIS................................Environmental Impact Statement
EPA ....U.S Environmental Protection Agency
ESA ....Endangered Species Act
ESD ....Ecological Site Description
EQIP..............................Environmental Quality Incentives Program
FCWID...........................Flat Creek Water Improvement District
FSA ....Farm Service Agency
GAP...............................Gap Analysis Program
GIS ....Geographic Information System
GTNP ....Grand Teton National Park
HDPE ....high-density polyethylene
HOA...............................Homeowners Association
HUC...............................Hydrologic Unit Code
JHLT..............................Jackson Hole Land Trust
JHNG.............................Jackson Hole News & Guide
MBTA ....Migratory Bird Treaty Act
MPB...............................mountain pine beetle
NEPA.............................National Environmental Policy Act
NFWF............................National Fish and Wildlife Foundation
NOAA……………………National Oceanic and Atmospheric Administration
NPS ....National Park Service
NRCS ............................U.S. Natural Resources Conservation Service
NWI ....National Wetlands Inventory
O&M ....Operations and Maintenance
PRISM...........................Parameter Elevation Regression on Independent Slopes Model
ROD ....Record of Decision
RMP ....Range Management Plan
ROW..............................right-of-way
RVF ....recirculating vertical flow
SRWC ....Snake River Valley Wetland Complex
SWPP............................Small Water Project Program
TAC ....Technical Assistance Cost-Share Grants

TCD .... Teton Conservation District
TMDL............................. Total Maximum Daily Load
TNC .... The Nature Conservancy
TU.................................. Trout Unlimited
USACE .... U.S. Army Corps of Engineers
USDA…………………… U.S. Department of Agriculture
USFS............................. U.S. Forest Service
USFWS .... U.S. Fish and Wildlife Service
USGS .... U.S. Geological Survey
UTM............................... Universal Transverse Mercator System
WDEQ .... Wyoming Department of Environmental Quality
WGFD .... Wyoming Game and Fish Department
WQD.............................. Water Quality Division
WSEO .... Wyoming State Engineer’s Office
WSGS .... Wyoming State Geological Survey
WWDC .... Wyoming Water Development Commission
WyDOT.......................... Wyoming Department of Transportation
WyGISC .... Wyoming Geographic Information Science Center
WYPDES....................... Wyoming Pollutant Discharge Elimination System

<u>Units of Measure</u>

CFS .... cubic feet per second
CY .... cubic yards
LF .... linear foot or linear feet
SY.................................. square yards

Appendix A

Data Summaries

Data Summary 1.2-1 GIS Layer Information
Data Summary 2.1.7-1 HUC12IDs
Data Summary 2.1.7-2 NHD Hydrographic Categories
Data Summary 2.1.7-3 NID database dams
Data Summary 2.1.7-4 USGS Gaging Stations
Data Summary 2.1.8-1 Rosgen Classifications
Data Summary 6.2.4-1 2016 Species of Greatest Conservation Need
Data Summary 7.5-1 Funding Sources

Data Summary 1.2-1 GIS Layer Information

Data Name in Map	Date of Development (YYYY-MM-DD)	Geodatabase	Filename in Geodatabase
Bureau of Land Management (BLM)			
Active BLM Grazing Allotments	2013-01-01	Administrative	Grazing_Allotment
BLM Recreational Trails (2001)	2001-09-07	Administrative	Recreational_Trails
Raptor Buffers	2013-01-01	Animals	Raptor_Buffers
Jackson Hole Land Trust (JHLT)			
Jackson Hole Land Trust (2015)	2015-07-23	Administrative	Jackson_Hole_Land_Trust
Teton County Scenic Preserve Trust (TCSPT)			
Teton County Scenic Preserve Trust (2015)	2015-07-23	Administrative	Teton_Scenic_Preserve_Trust
ESRI			
Town	2006-10-01	Administrative	Town_Point
Counties	2006-10-01	Administrative	Counties
State Boundary	2001-03-07	Administrative	State
Federal Lands	2015-01-29	Administrative	Federal_Lands
Gros Ventre Slide Geological Area	1998-01-01	Administrative	Gros_Ventre_Slide_Geological_Area
World Terrain Base	2015-11-19	Administrative	World_Terrain_Base
World Imagery	2016-09-15	Administrative	World_Imagery
U.S. Army Corps of Engineers (USACE)			
National Inventory of Dams	2015-08-06	Hydrology	Dams
U.S. Bureau of Mines (USBM)			
Mineral Potential	2001-01-01	Geology	Mineral_Potential
U.S. Census Bureau (USCB)			
Major Roads	2014-01-01	Infrastructure	Major_Roads
Major Roads	2014-01-01	Infrastructure	Northern_Roads
Highways	2014-01-01	Infrastructure	Major_Roads
U.S. Department of Agriculture (USDA)			
STATSGO Soils	2006-07-06	Geology	STATSGOSoils
Irrigated Land Capability Classes	2014-09-07	Geology	Irrigated_Lands
Ecological Sites	2014-09-07	Ecology	Ecological_Sites
BTNF Recreation Trails (2015)	2015-07-31	Recreational	BTNF_Trails_2015
Active BTNF Grazing Allotments	2015-01-01	Administrative	BTNF_Grazing_Allotments
NRCS SNOTEL Weather Station	2002-12-18	Weather	SNOTEL_Weather_Station
Snow Course Weather Station	2002-12-18	Weather	Snow_Course_Weather_Station
U.S. Fish & Wildlife Service (USFWS)			
NWI Wetland	2014-10-01	Hydrology	NWI_Wetlands
Greater Sage Grouse Focal Areas	2016-04-22	Animals	Greater_Sage_Grouse_Focal_Areas

Data Name in Map	Date of Development (YYYY-MM-DD)	Geodatabase	Filename in Geodatabase
U.S. Geological Survey (USGS)			
Surrounding Watershed Basin Boundaries	2015-05-13	Hydrology	HUC_6_Basin_Boundary
Major River	2015-05-13	Hydrology	Major_River
Major River	2015-05-13	Hydrology	Northern_Streams
Major Waterbody	2015-05-13	Hydrology	Major_Waterbody
Major Waterbody	2015-05-13	Hydrology	Minor_Lakes
Spring	2015-05-13	Hydrology	Spring
USGS Stream Gage	2006-06-13	Hydrology	Stream_Gage
Stream/Ditch Flow Line	2015-05-13	Hydrology	Flowlines
Regions for Peak-Flow Characteristics	2003-01-01	Administrative	Regions
Land Ownership	2016-05-05	Administrative	Land_Ownership
State	2016-05-05	Administrative	Land_Ownership
Annual Average Precipitation (1981 - 2010)	2010-01-01	Weather	Precipitation
National Elevation Data Hillshade	2015-12-28	Administrative	NED_Hillshade
Ground Elevation (feet)	2015-12-28	Administrative	NED_Elevation
GAP Analysis Land Cover	2013-06-01	Administrative	Land_Cover
National Agriculture Imagery Program (NAIP)			
Teton County Imagery	2015-01-01	Administrative	Teton_County_Imagery
Wyoming Department of Environmental Quality (WDEQ)			
WYPDES Permitted Discharge	2015-07-21	Environment	Permitted_Discharge
WDEQ Stream Classification	2013-07-26	Environment	Stream_Classification
Wyoming Game and Fish Department (WGFD)			
Antelope Seasonal Range	2012-06-01	Animals	Antelope_Range
Migration Corridor	2008-04-01	Animals	Antelope_Migration
Elk Seasonal Range	2014-01-01	Animals	Elk_Range
Migration Corridor	2008-04-30	Animals	Elk_Migration
Parturition Area	2014-01-01	Animals	Elk_Parturition
Moose Seasonal Range	2012-06-01	Animals	Moose_Range
Migration Corridor	2006-04-28	Animals	Moose_Migration
Mule Deer Seasonal Range	2012-06-01	Animals	Mule_Deer_Range
Migration Corridor	2008-04-30	Animals	Mule_Deer_Migration
Bighorn Sheep Seasonal Range	2012-09-01	Animals	Bighorn_Sheep_Range
Migration Corridor	2008-04-25	Animals	Bighorn_Sheep_Migration
Parturition Area	2012-05-01	Animals	Bighorn_Sheep_Parturition
Rocky Mountain Goat Seasonal Range	2012-06-01	Animals	Rocky_Mountain_Goat_Range
Trumpeter Swan Sites	2015-03-16	Animals	Trumpeter_Swan_Sites

Data Name in Map	Date of Development (YYYY-MM-DD)	Geodatabase	Filename in Geodatabase
Wyoming State Engineers Office (WSEO)			
Registered Well Inventory	2015-03-10	Hydrology	Registered_Wells
Registered Well Yield	2015-03-10	Hydrology	Registered_Wells
Registered Well Depth	2015-03-10	Hydrology	Registered_Wells
Stock/Wildlife Pond	2015-09-16	Hydrology	Stock_Wildlife_Pond
Wyoming State Geological Survey (WSGS)			
Bedrock Geology	2013-01-01	Geology	Bedrock
Surficial Geology	1998-01-01	Geology	Surficial
Landslides	2004-01-01	Geology	Landslides
Faults	1994-01-01	Geology	Fault_Lines
Gas Well	2012-01-01	Infrastructure	Gas_Well
Oil Field	2012-01-01	Infrastructure	Oil_Field
Coal Field	2014-01-01	Infrastructure	Coal_Field
Coal Outcrop	2014-01-01	Infrastructure	Coal_Outcrop
Major Pipeline (Operator)	2007-01-01	Infrastructure	Natural Gas
Wyoming Water Development Commission (WWDC)			
Irrigated Lands	2005-01-01	Hydrology	Irrigated_Land
Irrigation Points of Diversion	2005-01-01	Hydrology	Points_of_Diversion
Western Regional Climate Center (WRCC)			
NOAA Weather Station	2015-07-21	Weather	Stations
Wyoming Gegraphic Information Science Center (WyGISC)			
Conservation Easements (2012)	2012-21-12	Administrative	Conservation_Easement
Public Land Survey System	2006-08-30	Administrative	PLSS
Teton County GIS (TCGIS)			
Private	2013-01-01	Administrative	Private_Lands
National Wild and Scenic Rivers System (NWSRS)			
Wild and Scenic Rivers	2009-10-20	Hydrology	Wild_and_Scenic_Rivers
National Parks Service (NPS)			
Potentially Eligible	2010-04-29	Hydrology	Wild_Scenic_Eligible_Reaches
Primary Irrigation Ditch	2016-08-19	ISI4	Elk_Ranch_Irrigation_Ditches
Secondary Irrigation Ditch	2016-08-19	ISI4	Elk_Ranch_Irrigation_Ditches
Headgates Replaced in 2015	2016-08-19	ISI4	Elk_Ranch_2015_Headgate
Headgates Replaced in 2016	2016-08-16	ISI4	Elk_Ranch_2016_Headgate
Existing Headgate	2016-08-19	ISI4	Elk_Ranch_Existing_Headgate
Developed for Project (Olsson)			
Upper Snake River Boundary	2016-11-01	Administrative	Project_Boundary

Data Name in Map	Date of Development (YYYY-MM-DD)	Geodatabase	Filename in Geodatabase
Rosgen Level 1 Stream Classification	2016-11-01	Hydrology	Rosgen_Classification
Irrigation System Improvement Project Locations	2016-11-01	Hydrology	Irrigation_Improvement
Livestock/Wildlife Watering Improvement Projects	2016-11-01	Hydrology	Livestock_Wildlife_Improvement
Proposed Surface Water Flood and Storage Improvement Locations	2016-11-01	Hydrology	Flood_Storage_Improvement
Proposed Channel Condition and Stability Improvement Locations	2016-11-01	Hydrology	Channel_Improvement
Other Watershed Management Opportunity Locations	2016-11-01	Hydrology	Watershed_Opportunity
Diversion	2016-11-01	ISI1	Pinto_Ranch_Diversion
Pinto Ranch Headquarters	2016-11-01	ISI1	Pinto_Ranch_Headquarters
Drain Line	2016-11-01	ISI1	Pinto_Ranch_Drainage
Hatchet Ranch	2016-11-01	ISI2	Hatchet_Ranch
Hatchet Ranch Irrigation Ditch	2016-11-01	ISI2	Hatchet_Ranch_Irrigation_Ditch
Existing 24" Culvert	2016-11-01	ISI3	Blackrock_Creek_Culvert_Ditch
Irrigation Ditch	2016-11-01	ISI3	Blackrock_Creek_Culvert_Ditch
Reinforce 360 LF of Existing Levee	2016-11-01	ISI3	Blackrock_Creek_Culvert_Ditch
Swan Lake Supply Ditch	2016-11-01	ISI3	Blackrock_Creek_Culvert_Ditch
Blackrock Ranger Station	2016-11-01	ISI3	Blackrock_Ranger Station
Existing Headgate	2016-11-01	ISI3	Blackrock_Existing_Headgate
Historic Elk Ranch Headquarters	2016-11-01	ISI4	Elk_Ranch_Headquarters
Irrigation Improvement Area	2016-11-01	ISI4	Elk_Ranch_Irrigatioin_Improvement_Area
Existing Headgate	2016-11-01	ISI5	Antler_Ditch_Existing_Headgate
Antler Ditch Pipeline	2016-11-01	ISI5	Antler_Ditch_Pipeline
Existing Diversion Structure	2016-11-01	ISI6	Granite_Creek_Existing_Diversion
Proposed New Diversion Structure	2016-11-01	ISI6	Granite_Creek_New_Diversion
Granite Creek Supplemental Ditch	2016-11-01	ISI6	Granite_Creek_Supplemental_Ditch
Existing Millstream Ditch Headgate	2016-11-01	ISI7	Millstream_Headgate
Approximate Location of Proposed Millstream Ditch Diversion Channel	2016-11-01	ISI7	Millstream_Ditch
Existing Lake Creek Headgate	2016-11-01	ISI8	Lake_Creek_Existing_Headgate
Granite Creek Headgate	2016-11-01	ISI8	Granite_Creek_Headgate
Diversion	2016-11-01	ISI9	Wy_School_Diversion
Field Boundary	2016-11-01	ISI9	Wy_School_Field_Boundary
Headgate	2016-11-01	ISI10	Jensen_Creek_Headgate

Data Name in Map	Date of Development (YYYY-MM-DD)	Geodatabase	Filename in Geodatabase
Approximate Location of Irrigation Ditch	2016-11-01	ISI10	Jensen_Creek_Irrigation_Ditch
Field Boundary	2016-11-01	ISI11	RLazyS_Ranch_Field_Boundary
Pump Pit	2016-11-01	ISI11	RLazyS_Ranch_Project_Specifics
Sprinkler	2016-11-01	ISI11	RLazyS_Ranch_Project_Specifics
Unknown Ditch	2016-11-01	ISI11	RLazyS_Ranch_Project_Specifics
Sprinkler Supply Ditch	2016-11-01	ISI11	RLazyS_Ranch_Project_Specifics
Lockwood Headgate	2016-11-01	ISI12	Huidekoper_Ranch_Lockwood_Headgate
Irrigation Ditch	2016-11-01	ISI12	Huidekoper_Ranch_Irrigation_Ditch
Existing Diversion	2016-11-01	ISI13	Prosperity_Ditch_22_Diversion
Ditch	2016-11-01	ISI13	Prosperity_Ditch_22_Diversion
Prosperity Ditch	2016-11-01	ISI14	Prosperity_Ditch_390
Existing Headgate	2016-11-01	ISI14	Prosperity_Ditch_390_Existing Headgate
Pioneer Ditch Headgate	2016-11-01	ISI15	Pioneer_Ditch_Headgate
Irrigated Land	2016-11-01	ISI15	Pioneer_Ditch_Project_Specifics
Pioneer Ditch Headgate	2016-11-01	ISI15	Pioneer_Ditch_Project_Specifics
Ditch Realignment	2016-11-01	ISI15	Pioneer_Ditch_Project_Specifics
New Heagate	2016-11-01	ISI16	Flat_Creek_New_Headgate
Russ Garaman Park	2016-11-01	ISI16	Russ_Garaman_Park
New Headgate	2016-11-01	ISI17	Wiley_Ditch_New_Headgate
Wiley Ditch	2016-11-01	ISI17	Wiley_Ditch
Proposed Stock Tank	2016-11-01	ISI19	Game_Creek_Proposed_Stock_Tank
Upgrade Headgate	2016-11-01	ISI19	Game_Creek_Upgrade_Headgate
Irrigated Land	2016-11-01	ISI19	Game_Creek_Irrigated_Land
Propsoed Gated Pipe	2016-11-01	ISI19	Game_Creek_Proposed_Gated_Pipe
Re-grade Irrigation Ditch	2016-11-01	ISI19	Game_Creek_Regrade_Irrigation_Ditch
Propsoed Stock Tank	2016-11-01	LWW1	Taylor_Ranch_Proposed_Stock_Tank
Proposed Bierer Creek Spring Development and Fence	2016-11-01	LWW1	Taylor_Ranch_Spring_Development
Proposed Pipeline	2016-11-01	LWW1	Taylor_Ranch_Proposed_Pipeline
Existing Seep	2016-11-01	LWW2	WY_School_Existing_Seep
Potential Gate School Stock Pond Site	2016-11-01	LWW2	WY_School_Stock_Pond
Crossing	2016-11-01	LWW4	Dons_Draw_Project_Specifics
Diversion	2016-11-01	LWW4	Dons_Draw_Project_Specifics
Proposed Tank	2016-11-01	LWW4	Dons_Draw_Project_Specifics
Existing Salt Trough	2016-11-01	LWW4	Dons_Draw_Project_Specifics
Proposed Spring Development and Fence	2016-11-01	LWW4	Dons_Draw_Project_Specifics

Data Name in Map	Date of Development (YYYY-MM-DD)	Geodatabase	Filename in Geodatabase
Don's Draw Pipeline	2016-11-01	LWW4	Dons_Draw_Pipeline
Flat Creek Watershed Improvement District	2016-11-01	SWF1	Flat_Creek_Watershed_Improvement_District
Priority Area	2016-11-01	SWF2	Jackson_Hole_Priority_Area
Feasibility Study Area	2016-11-01	SWF2	Jackson_Hole_Feasibility_Study_Area
Project Locations	2016-11-01	SWF3_5	SWF_3_5_Project_Locations
Project Locations	2016-11-01	SWF6_9	SWF_6_9_Project_Locations
Existing Headgate	2016-11-01	SCC1	Last_Chance_Ditch_Existing_Headgate
Approximate Location of Last Chance Ditch	2016-11-01	SCC1	Last_Chance_Ditch_Existing_Headgate
Section with Erosion Problems	2016-11-01	SCC1	Last_Chance_Ditch_Erosion_Section
Morel Creek Project Area	2016-11-01	SCC3	Morel_Creek_Project_Area
Fish Creek Improvement Project	2016-11-01	SCC4	Fish_Creek_Improvement_Project
Project Location	2016-11-01	OMP1	RafterJ_Project_Location
East Side Ditch	2016-11-01	OMP1	RafterJ_East_Side_Ditch
Karns Meadow	2016-11-01	OMP2	Karns_Meadow

Data Summary 2.1.7-1 Watershed Hydrologic Features Index	
HUC ID Number	Watershed Name
17040101	**Snake Headwaters**
1704010101	**Lewis River**
170401010101	De Lacy Creek
170401010102	Shoshone Lake
170401010103	Upper Lewis River
170401010104	Lower Lewis River
1704010102	**Coulter Creek-Snake River**
170401010201	Plateau Creek-Snake River
170401010202	Heart River
170401010203	Crooked Creek-Snake River
170401010204	Wolverine Creek
170401010205	Coulter Creek
170401010206	Basin Creek-Snake River
170401010207	Forest Creek-Snake River
1704010103	**Pacific Creek**
170401010301	Mink Creek
170401010302	Upper Pacific Creek
170401010303	Middle Pacific Creek
170401010304	Lower Pacific Creek
1704010104	**Moose Creek-Snake River**
170401010401	Polecat Creek
170401010402	Sheffield Creek-Snake River
170401010403	Berry Creek
170401010404	Moose Creek
170401010405	Arizona Creek
170401010406	Upper Jackson Lake
170401010407	Moran Creek
170401010408	Pilgrim Creek
170401010409	Lower Jackson Lake
1704010105	**Buffalo Fork**
170401010501	Lake Creek
170401010502	Upper South Buffalo Fork
170401010503	Cub Creek
170401010504	Soda Fork
170401010505	North Buffalo Fork
170401010506	Lower South Buffalo Fork
170401010507	Blackrock Creek
170401010508	Upper Buffalo Fork
170401010509	Lava Creek
170401010510	Lower Buffalo Fork
1704010106	**Spread Creek-Snake River**
170401010601	North Fork Spread Creek
170401010602	South Fork Spread Creek
170401010603	Rock Creek-Snake River
170401010604	Elk Ranch Reservoir-Snake River
170401010605	Leigh Lake
170401010606	Jenny Lake
170401010607	Cottonwood Creek
170401010608	Ditch Creek
170401010609	Blacktail Ponds-Snake River
170401010610	Stewart Draw-Snake River
17040102	**Gros Ventre**
1704010201	**Fish Creek**
170401020101	Upper South Fork Fish Creek
170401020102	Middle South Fork Fish Creek
170401020103	North Fork Fish Creek
170401020104	Lower South Fork Fish Creek
170401020105	Bacon Creek-Fish Creek
1704010202	**Upper Gros Ventre River**
170401020201	Clear Creek-Gros Ventre River
170401020202	Cottonwood Creek
170401020203	Kinky Creek-Gros Ventre River
170401020204	Dry Cottonwood Creek-Gros Ventre River
1704010203	**Lower Gros Ventre River**
170401020301	Slate Creek
170401020302	Upper Crystal Creek
170401020303	Lower Crystal Creek
170401020304	Redmond Creek-Gros Ventre River
170401020305	Bierer Creek-Gros Ventre River
17040103	**Greys-Hobock**
1704010301	**Flat Creek**
170401030101	Upper Flat Creek
170401030102	Nowlin Creek
170401030103	Cache Creek
170401030104	Middle Flat Creek
170401030105	Lower Flat Creek
1704010305	**Snake River-Fall Creek**
170401030501	Lake Creek
170401030502	Fish Creek
170401030503	Mosquito Creek
170401030504	Spring Creek-Snake River
170401030505	Horse Creek
170401030506	Fall Creek
170401030507	Porcupine Creek-Snake River

Data Summary 2.1.7-2 Perennial and Non-Perennial Intermittent Streams

Alkali Creek	Game Creek	Packsaddle Creek
Arizona Creek	Game Warden Creek	Papoose Creek
Aspen Creek	Glade Creek	Park Creek
Aster Creek	Goosewing Creek	Pass Creek
Atherton Creek	Granite Creek	Pelton Creek
Bacon Creek	Gravel Creek	Pilgrim Creek
Bailey Creek	Grizzly Creek	Pilgrim Creek
Bang Creek	Gros Ventre River	Pill Creek
Bar B Creek	Grouse Creek	Pink Creek
Basin Creek	Hackamore Creek	Plateau Creek
Basin Creek	Hardscrabble Creek	Poison Creek
Bear Cabin Creek	Harebell Creek	Polecat Creek
Bear Paw Fork	Haystack Fork	Pond Creek
Beauty Park Creek	Heart River	Porcupine Creek
Beaver Creek	Hechtman Creek	Purdy Creek
Bell Creek	Heifer Creek	Quaker Creek
Berry Creek	Hereford Creek	Quarter Creek
Bierer Creek	Herron Creek	Raspberry Creek
Big Cow Creek	Holmes Cave Creek	Rat Creek
Blackman Creek	Horse Creek	Red Creek
Box Creek	Horsetail Creek	Redmond Creek
Breakneck Creek	I W W Creek	Rock Creek
Bridge Creek	Jagg Creek	Rodent Creek
Buck Creek	Jones Creek	Second Creek
Bull Creek	Joy Creek	Sheep Creek
Bullmoose Creek	Kettle Creek	Sheffield Creek
Burnt Creek	Kinky Creek	Sheffield Creek
Burnt Fork	Lafferty Creek	Shorty Creek
Butler Creek	Lake Creek	Shoshone Creek
Cache Creek	Larkspur Creek	Sickle Creek
Calf Creek	Lava Creek	Skull Creek
Carmichael Fork	Leeds Creek	Slate Creek
Cascade Creek	Leidy Creek	Snake River
Cavy Creek	Leigh Creek	Soda Creek
Christian Creek	Lewis River	Soda Fork
Clear Creek	Lightning Creek	Sohare Creek
Coal Creek	Little Bear Paw Fork	South Buffalo Fork
Coburn Creek	Little Cow Creek	South Fork Ditch Creek
Cold Mountain Creek	Little Devils Basin Creek	South Fork Fall Creek
Cottonwood Creek	Little Horse Creek	South Fork Fish Creek
Coulter Creek	Little Sohare Creek	South Fork Granite Creek
County Line Creek	Lizard Creek	South Fork Moran Creek
Crane Creek	Lloyd Creek	South Fork Spread Creek
Crawfish Creek	Lost Creek	South Twin Creek
Crooked Creek	Maverick Creek	Spirea Creek
Crows Nest Creek	Middle Fork Ditch Creek	Split Rock Creek
Crystal Creek	Middle Fork Granite Creek	Spread Creek
Cub Creek	Mill Creek	Spring Creek
Dallas Creek	Mink Creek	Spruce Creek
Dallas Fork	Moccasin Creek	Squaw Creek
De Lacy Creek	Moose Creek	Starvation Creek
Dead Horse Creek	Moran Creek	Steep Creek
Deer Creek	Mosquito Creek	Strawberry Creek
Devils Basin Creek	Mountain Creek	Summit Creek
Devils Dip Creek	Mud Creek	Surprise Creek
Ditch Creek	Nation Creek	Taggart Creek
Dog Creek	Negro Creek	Taylor Creek
Dogshead Creek	Negrohead Fork	Tent Creek
Dry Cottonwood Creek	Nickel Creek	Tepee Creek
Dry Creek	North Buffalo Fork	Third Creek
Dry Dallas Creek	North Fork Ditch Creek	Trail Creek
Dry Fork Clear Creek	North Fork Fall Creek	Tripod Creek
Dry Lake Creek	North Fork Fish Creek	Trunk Creek
Dude Creek	North Fork Granite Creek	Turner Fork
East Fork Pilgrim Creek	North Fork Horse Creek	Turpin Creek
East Miner Creek	North Fork Moran Creek	Two Water Creek
East Whetstone Creek	North Fork Mosquito Creek	Weasel Creek
Elkhorn Creek	North Fork Rodent Creek	West Fork Crystal Creek
Enos Creek	North Fork Spread Creek	West Fork Horsetail Creek
Ermine Creek	North Fork Trail Creek	West Goosewing Creek
Fall Creek	North Moran Creek	West Miner Creek
Falls Creek	North Twin Creek	West Whetstone Creek
Fish Creek	Nowlin Creek	Whetstone Creek
Flagstaff Creek	Open Fork	Witch Creek
Flat Creek	Outlet Creek	Wolverine Creek
Forest Creek	Owl Creek	Yellowjacket Creek
Fox Creek	Pacific Creek	

Note: Intermittent streams are highlighted. The remainder are perennial. It should be noted that some portions of the perennial creeks are intermittent.

Data Summary 2.1.7-3. Dams within the Study Area Included in the National Inventory of Dams

NID ID	Dam Name	River	Height (feet)	Storage (acre-ft)	Owner	Primary Purpose	Secondary Purpose(s)	County	Longitude	Latitude
WY01737	LEIDY LAKE	LEIDY CREEK	8	65	WYOMING GAME AND FISH DEPARTMENT	Fish and Wildlife Pond	Fish and Wildlife Pond	TETON	-110.3725	43.7202
WY01256	TRACY LAKE	RANDOLPH CREEK	20	646	PETER S. FINCH	Recreation	Recreation	TETON	-110.3667	43.8483
WY01712	JACKSON WASTEWATER TREATMENT PLANT	SNAKE RIVER OFFSTREAM	23	260	TOWN OF JACKSON	Debris Control	Debris Control, Other	TETON	-110.7814	43.4013
WY01652	FLAT CREEK RANCH	FLAT CREEK	11	151	JACKSON HOLE LAND TRUST	Fish and Wildlife Pond	Fish and Wildlife Pond	TETON	-110.5408	43.5247
WY01385	JACKSON LAKE	NORTH FORK SNAKE RIVER	68	872,700	DOI BR	Flood Control	Irrigation, Flood Control, Recreation, Fish and Wildlife Pond	TETON	-110.5897	43.8575
WY01270	PORTER	WALLACE CREEK	17	52	PORTER TRUST	Irrigation	Irrigation, Fire Protection, Stock, Or Small Fish Pond	TETON	-110.3875	43.8002
WY01287	UHL DAM AT ELK RANCH	SPREAD CREEK	24	756	DOI NPS	Fish and Wildlife Pond	Irrigation, Fish and Wildlife Pond, Other	TETON	-110.4667	43.8000
WY01384	GRASSY LAKE	GRASSY CREEK	118	16,210	DOI BR	Irrigation	Irrigation	TETON	-110.8185	44.1304

Data Summary 2.1.7-4. USGS Streamflow Stations and Water Quality Sites in the Upper Snake River Watershed

Station Number	Station Name	Flow Measurement Period of Record, Water Years[a]	Daily/ Monthly Flow Data	Annual Peak Flows	Water Quality Data Period of Record	Water Quality Data Samples
13010000	SNAKE RIVER AT S BOUNDARY OF YELLOWSTONE NATL PARK	6/1/1913 - 7/31/1925	Yes	11	---	---
13010065	SNAKE RIVER AB JACKSON LAKE AT FLAGG RANCH WY	10/1/1983 - present	Yes	32	10/1/1985 - 9/22/2004	260
13010450	PILGRIM CR 70 FT ABV HWY 287 BRIDGE NR MORAN WY	5/9/1997 - 9/30/1997	Yes	1	5/5/1997 - 11/5/2002	103
13010500	JACKSON LAKE NR MORAN WY	10/1/1917 - 9/30/2000[b]	Yes	---	2/6/1997 - 2/6/1997	1
13011000	SNAKE RIVER NR MORAN WY	10/1/1903 - present	Yes	112	10/8/1985 - 10/21-1998	101
13011500	PACIFIC CREEK AT MORAN WY	7/20/1917 - present	Yes	70	10/8/1985 - 10/20/1998	155
13011900	BUFFALO FORK AB LAVA CREEK NR MORAN WY	9/22/1965 - present	Yes	50	10/8/1985 - 10/20/1998	105
13012000	BUFFALO FORK NR MORAN WY	7/9/1917 - 9/4/1960	Yes	17	6/12/2002 - 11/6/2002	4
13012490	SPREAD CREEK AT DIVERSION DAM, NEAR MORAN, WY	5/1/1994 - 7/2/1996	Yes	3	6/13/2002 - 11/6/2002	4
13012500	SPREAD CREEK NR MORAN WY	7/1/1917 - 7/8/1993	Yes	1	6/5/1971 - 11/6/2002	25
13013000	COTTONWOOD CREEK NR TETON WY	7/16/1917 - 9/30/1918	Yes	1	---	---
13013500	SPRING CREEK NR TETON WY	7/16/1917 - 9/30/1918	Yes	---	---	---
13013650	SNAKE RIVER AT MOOSE, WY	4/6/1995 - present	Yes	21	10/14/1971 - 5/6/2006	92
13014000	SPRING CREEK NR ZENITH WY	7/24/1917 - 9/30/1919	Yes	---	---	---
13014500	GROS VENTRE RIVER AT KELLY WY	6/16/1918 - present	Yes	23	---	---
13015000	GROS VENTRE RIVER AT ZENITH WY	7/13/1917 - present	Yes	29	10/21/1987 - 10/20/1998	77
13015500	SPRING CREEK AT ZENITH WY	7/24/1917 - 9/30/1918	Yes	---	---	---
13016000	SPRING CREEK AT W GROS VENTRE BUTTE WY	6/1/1918 - 9/30/1918	Yes	---	---	---
13016100	SNAKE RIVER NR WILSON WY	10/1/1972 - 9/30/1975	Yes	---	---	---
13016240	LAKE CR BEL GRANITE CR SUPPLEMENTAL, NR MOOSE, WY	6/29/1995 - 10/18/2010	Yes	8	---	---
13016305	GRANITE C AB GRANITE C SUPPLEMENTAL, NR MOOSE, WY	6/2/1995 - present	Yes	21	6/13/2006 - 10/3/2006	4
13016450	FISH CREEK AT WILSON, WY	3/24/1994 - present	Yes	22	10/24/1973 - 5/16/2016	50
13016500	FISH CREEK NR WILSON WY	7/1/1917 - 9/30/1919	Yes	2	---	---
13017000	MOSQUITO CREEK NR WILSON WY	7/1/1917 - 9/30/1918	Yes	1	---	---
13017500	BIG SPRING CREEK NR CHENEY WY	6/1/1918 - 9/30/1918	Yes	---	---	---
13018000	FLAT CREEK NEAR JACKSON, WY	6/23/1933 - 9/30/1993	Yes	14	10/31/1966 - 10/2/1973	2
13018300	CACHE CREEK NEAR JACKSON, WY	7/1/1962 - present	Yes	71	7/20/1965 - 8/23/2011	408
13018350	FLAT CREEK BEL CACHE CREEK, NEAR JACKSON, WY	4/1/1989 - present	Yes	24	10/2/1973 - 5/11/2015	2
13018500	FLAT CREEK NEAR CHENEY, WY	7/1/1917 - 9/30/1993	Yes	6	---	---
13018750	SNAKE RIVER BL FLAT CREEK NR JACKSON WY	11/12/1975 - present	Yes	40	10/7/1985 - 10/19/1998	108
13019000	HORSE CREEK NR CHENEY WY	7/1/1917 - 9/30/1918	Yes	1	---	---
13020000	FALL CREEK NEAR JACKSON, WY	7/1/1917 - 6/30/1918	Yes	12	---	---

Appendix A Data Summary 2.1.8-1 Rosgen Classifications

Watershed	Reach ID - Formulas	Reach Length	Landform	Valley Type	Terrace Features	Channel Slope	Bed Features	Channel Shape	Floodplain	Pattern	Confinement	Lateral Containment	Channel Type	Notes
Buffalo Fork River	B-Bla-0-A	2.33	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Fluvial dissected
Buffalo Fork River	B-Bla-1-B	1.91	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases; valley narrows
Buffalo Fork River	B-Bla-2-C	1.32	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Pools and points bars evident; sinuosity increases slightly
Buffalo Fork River	B-Bla-3-D	1.94	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Multiple channels; decrease in sinuosity
Buffalo Fork River	B-Bla-4-C	3.06	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Point bars and pools; increase in sinuosity
Buffalo Fork River	B-Bla-5-B	8.38	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrows; sinuosity decreases; long reach
Buffalo Fork River	B-Bla-6-D	2.68	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Multiple channels; decrease in sinuosity
Buffalo Fork River	B-Bla-7-C	0.32	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Point bars and pools; increase in sinuosity
Buffalo Fork River	B-Box-0-A	0.07	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Fluvial dissected
Buffalo Fork River	B-Box-1-B	0.09	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases slightly; very short reach
Buffalo Fork River	B-Box-2-C	0.76	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Point bars and small pools; increase in sinuosity
Buffalo Fork River	B-Box-3-B	0.95	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity decreases; valley narrows
Buffalo Fork River	B-Box-4-C	1.27	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases slightly; a few point bars
Buffalo Fork River	B-Box-5-B	2.93	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrows; sinuosity decreases
Buffalo Fork River	B-Box-6-C	0.65	glacial/fluvial terrace	IX	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C	Valley widen slightly; point bars present
Buffalo Fork River	B-Box-7-D	0.75	glacial/fluvial terrace	III	none	flat	riffle/pool	12-40 w:d	none apparent	multiple	slight	no	D	Alluvial fan; multiple channels
Buffalo Fork River	B-Buf-0-B	5.21	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Steep channel; low sinuosity
Buffalo Fork River	B-Buf-1-D	6.65	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; Valley widens
Buffalo Fork River	B-Buf-2-C	0.87	glacial/fluvial terrace	V	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; Valley narrows
Buffalo Fork River	B-Cub-0-A	0.54	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Cascades from North and South; Fluvial dissected
Buffalo Fork River	B-Cub-1-B	0.97	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity increases slightly
Buffalo Fork River	B-Cub-2-C	0.62	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	A few, small points bars and small pools; increase in sinuosity
Buffalo Fork River	B-Cub-3-B	0.79	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity increases slightly
Buffalo Fork River	B-Cub-4-D	0.79	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; short section with multiple channels
Buffalo Fork River	B-Cub-5-C	1.72	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Point bars and small pools; increase in sinuosity
Buffalo Fork River	B-Cub-6-B	0.59	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity increases slightly
Buffalo Fork River	B-Cub-7-C	1.25	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Point bars and small pools; increase in sinuosity
Buffalo Fork River	B-Cub-8-B	2.44	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	North Side slopes steep; sinuosity increases slightly
Buffalo Fork River	B-Cub-9-C	1.69	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Point bars and small pools; increase in sinuosity; some abandoned channels
Buffalo Fork River	B-Cub-10-B	0.90	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity decreases slightly
Buffalo Fork River	B-Cub-11-A	0.35	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Very narrow, steep valley
Buffalo Fork River	B-Cub-12-D	0.26	glacial/fluvial terrace	V	none	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Very short reach where water spread; valley still narrow
Buffalo Fork River	B-Cub-13-B	0.61	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity increases slightly
Buffalo Fork River	B-Cub-14-A	0.49	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Very narrow, steep valley
Buffalo Fork River	B-Cub-15-B	0.27	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity increases slightly
Buffalo Fork River	B-Cub-16-C	0.37	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Point bars and small pools; increase in sinuosity
Buffalo Fork River	B-Lak-0-A	1.07	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	V-notched valleys; channels hidden by snow
Buffalo Fork River	B-Lak-1-B	2.35	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Some portions still covered with snow; Sinuosity increases
Buffalo Fork River	B-Lak-2-D	0.75	glacial/fluvial terrace	V	none	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	yes	D	Odd reach; Valley narrow but multiple channels evident; laterally confined
Buffalo Fork River	B-Lak-3-B	0.09	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrows slightly; sinuosity increases
Buffalo Fork River	B-Lak-4-A	0.52	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Very steep; Waterfalls; sinuosity decreases
Buffalo Fork River	B-Lak-5-B	0.28	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrows slightly; sinuosity increases
Buffalo Fork River	B-Lak-6-C	0.69	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; Valley widens
Buffalo Fork River	B-Lak-7-D	0.66	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Valley widens; short reach with multiple channels; Sinuosity decreases
Buffalo Fork River	B-Lav-0-A	0.10	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Fluvial dissected; steep face
Buffalo Fork River	B-Lav-1-B	0.99	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity increases slightly
Buffalo Fork River	B-Lav-2-C	2.55	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Valley widens significantly; sinuosity increases
Buffalo Fork River	B-Lav-3-D	1.31	glacial/fluvial terrace	IX	none	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Multiple channels; decrease in sinuosity
Buffalo Fork River	B-Lav-4-C	9.48	glacial/fluvial terrace	VIII	none	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Point bars and pools; sinuosity increases; valley widens
Buffalo Fork River	B-Lav-5-D	1.31	glacial/fluvial terrace	IX	none	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Multiple channels; decrease in sinuosity
Buffalo Fork River	B-Nor-0-A	1.18	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	V-notched Valley; very steep side slopes; cascades from north and south throughout reaches
Buffalo Fork River	B-Nor-1-B	0.54	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Valley side slopes steep; slight sinuosity increase
Buffalo Fork River	B-Nor-2-C	0.68	glacial/fluvial terrace	V	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Slight increase in sinuosity; valley bottom widens

Appendix A Data Summary 2.1.8-1 Rosgen Classifications

Watershed	Reach ID - Formulas	Reach Length	Landform	Valley Type	Terrace Features	Channel Slope	Bed Features	Channel Shape	Floodplain	Pattern	Confinement	Lateral Containment	Channel Type	Notes
Buffalo Fork River	B-Nor-3-D	1.05	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; multiple channels; multiple cascades from south west
Buffalo Fork River	B-Nor-4-B	0.20	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley side slopes steep; slight sinuosity increase
Buffalo Fork River	B-Nor-5-A	0.30	glacial/fluvial terrace	I	none	steep	step/pool	12-40 w:d	none apparent	single	entrenched	yes	A	Very steep side slopes; Sinuosity decreases
Buffalo Fork River	B-Nor-6-B	0.69	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley side slopes steep; slight sinuosity increase
Buffalo Fork River	B-Nor-7-C	1.39	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Slight increase in sinuosity; valley bottom widens
Buffalo Fork River	B-Nor-8-B	2.00	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley side slopes steep; slight sinuosity increase
Buffalo Fork River	B-Nor-9-D	1.20	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; multiple channels; tributary entering from south
Buffalo Fork River	B-Nor-10-B	5.43	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley side slopes steep; slight sinuosity increase
Buffalo Fork River	B-Nor-11-C	0.40	glacial/fluvial terrace	V	none	flat	riffle/pool	>40 w:d	active apparent	single	slight	yes	C	Slight increase in sinuosity; valley bottom widens
Buffalo Fork River	B-Nor-12-D	3.13	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; multiple channels
Buffalo Fork River	B-Nor-13-C	1.02	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Short reach; Slight increase in sinuosity; valley bottom widens
Buffalo Fork River	B-Nor-14-B	0.52	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley side slopes steep; slight sinuosity increase
Buffalo Fork River	B-Nor-15-A	0.77	glacial/fluvial terrace	I	none	steep	step/pool	12-40 w:d	none apparent	single	entrenched	yes	A	V-notched Valley; very steep side slopes
Buffalo Fork River	B-Nor-16-B	0.90	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley side slopes steep; slight sinuosity increase
Buffalo Fork River	B-Nor-17-D	0.69	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; multiple channels
Buffalo Fork River	B-Nor-18-C	5.35	glacial/fluvial terrace	VIII	none	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Slight increase in sinuosity; valley bottom wide in sections
Buffalo Fork River	B-Sod-0-A	0.05	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	V-notched valley; cascades on surrounding sides slopes throughout all reaches
Buffalo Fork River	B-Sod-1-B	0.08	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases slightly
Buffalo Fork River	B-Sod-2-E	0.19	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Sinuosity increases; Valley widens
Buffalo Fork River	B-Sod-3-B	2.00	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrows; sinuosity decreases
Buffalo Fork River	B-Sod-4-C	1.01	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; Valley widens
Buffalo Fork River	B-Sod-5-B	0.56	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrows; sinuosity decreases
Buffalo Fork River	B-Sod-6-C	0.46	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; Valley widens
Buffalo Fork River	B-Sod-7-B	4.32	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrows; sinuosity decreases
Buffalo Fork River	B-Sod-8-C	0.52	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; Valley widens
Buffalo Fork River	B-Sod-9-D	2.83	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; Valley widens; multiple channels
Buffalo Fork River	B-Sou-0-C	0.44	floodplain	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C	Laterally contained in this short section
Buffalo Fork River	B-Sou-1-D	1.38	floodplain	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Multiple channels; Sinuosity decreases
Buffalo Fork River	B-Sou-2-C	1.57	floodplain	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C	Valley narrowing; a few sections are B-type; Sinuosity increases
Buffalo Fork River	B-Sou-3-B	2.45	glacial/fluvial terrace	VI	multiple	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Some Bedrock influence; Sinuosity decreases
Buffalo Fork River	B-Sou-4-D	4.53	floodplain	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Valley widens; Sinuosity decreases
Buffalo Fork River	B-Sou-5-C	0.66	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C	Very short reach; Sinuosity increases
Buffalo Fork River	B-Sou-6-A	0.66	glacial/fluvial terrace	VI	none	steep	step/pool	12-40 w:d	none apparent	single	entrenched	yes	A	Some Bedrock influence; Sinuosity decreases
Buffalo Fork River	B-Sou-7-B	3.28	glacial/fluvial terrace	VI	none	steep	step/pool	>40 w:d	none apparent	single	moderate	yes	B	Some Bedrock influence; Sinuosity increases
Buffalo Fork River	B-Upp-0-A	2.13	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Channel staight, steep and partially under snow
Buffalo Fork River	B-Upp-1-B	5.04	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Slight increase in Sinuosity; side slopes steep
Buffalo Fork River	B-Upp-2-D	3.44	glacial/fluvial terrace	X	none	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Valley very wide near end of reach; multiple channels
Buffalo Fork River	B-Upp-3-B	1.87	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Slope steepens; Valley narrow with steep slopes
Fish Creek	F-Bac-0-A	0.66	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Side slopes steep;fluvial dissected
Fish Creek	F-Bac-1-B	0.84	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases slightly
Fish Creek	F-Bac-2-E	1.82	glacial/fluvial terrace	X	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Sinuosity increases; Valley widens
Fish Creek	F-Bac-3-B	1.03	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases slightly
Fish Creek	F-Bac-4-D	1.18	glacial/fluvial terrace	V	none	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; multiple channels
Fish Creek	F-Bac-5-C	2.69	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Channel narrow; pools and some point bars; sinuosity slightly increases
Fish Creek	F-Bac-6-E	0.24	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Sinuosity increases; Valley widens
Fish Creek	F-Bac-7-C	0.31	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Channel narrow; pools and some point bars; sinuosity slightly increases
Fish Creek	F-Bac-8-E	0.09	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Sinuosity increases; Valley narrows
Fish Creek	F-Bac-9-C	1.40	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Channel narrow; pools and some point bars; sinuosity slightly increases
Fish Creek	F-Bac-10-B	0.34	glacial/fluvial terrace	VIII	multiple	steep	step/pool	12-40 w:d	none apparent	single	moderate	no	B	Sinuosity increases slightly
Fish Creek	F-Bac-11-C	3.43	glacial/fluvial terrace	X	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Channel narrow; sinuosity increases; pools and some point bars
Fish Creek	F-Bac-12-E	0.68	glacial/fluvial terrace	X	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	E	Sinuosity increases; Valley wide and flat
Fish Creek	F-Bac-13-C	1.06	glacial/fluvial terrace	X	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Channel narrow; sinuosity increases; pools and some point bars
Fish Creek	F-Bac-14-E	3.41	glacial/fluvial terrace	X	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	E	Sinuosity increases; Valley wide and flat

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Watershed	Reach ID - Formulas	Reach Length	Landform	Valley Type	Terrace Features	Channel Slope	Bed Features	Channel Shape	Floodplain	Pattern	Confinement	Lateral Containment	Channel Type	Notes
Fish Creek	F-Bac-15-D	0.09	glacial/fluvial terrace	X	none	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Short reach before confluence; channel spreads into more than one channel
Fish Creek	F-Cot-0-A	0.27	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Side slopes steep;fluvial dissected
Fish Creek	F-Cot-1-B	0.57	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases slightly
Fish Creek	F-Cot-2-E	0.33	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Sinuosity increases; Valley widens
Fish Creek	F-Cot-3-C	0.33	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Channel narrow; sinuosity increases; pools and some point bars
Fish Creek	F-Cot-4-D	0.41	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; multiple channels
Fish Creek	F-Cot-5-C	0.61	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Channel narrow; pools and some point bars; sinuosity slightly increases
Fish Creek	F-Cot-6-B	0.81	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases slightly
Fish Creek	F-Cot-7-C	8.46	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Channel narrow; sinuosity slightly increases
Fish Creek	F-Cot-8-D	0.42	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; multiple channels
Fish Creek	F-Cot-9-C	6.13	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Channel narrow; sinuosity slightly increases
Fish Creek	F-Cot-10-D	3.69	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; multiple channels
Fish Creek	F-Mid-0-C	3.79	floodplain	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Valley wide; accessable floodplain
Fish Creek	F-Mid-1-B	3.68	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases
Fish Creek	F-Mid-2-C	0.59	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; pools and point bars
Fish Creek	F-Mid-3-B	0.70	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases; valley narrows
Fish Creek	F-Mid-4-C	0.19	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; pools and point bars
Fish Creek	F-Nor-0-A	1.00	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Fluvial dissected; steep face
Fish Creek	F-Nor-1-E	5.72	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	<12 w:d	active apparent	single	entrenched	no	E	Sinuosity high; Valley widens
Fish Creek	F-Nor-2-C	0.52	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Decrease in Sinuosity; Valley narrows
Fish Creek	F-Nor-3-B	1.57	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Decrease in Sinuosity; Valley narrows
Fish Creek	F-Nor-4-C	16.37	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Wide, flat valley; sinuosity increases
Fish Creek	F-Sou-0-B	0.53	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Moderate valley width and side slopes
Fish Creek	F-Sou-1-C	0.64	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Slight increase in sinuosity; valley widens
Fish Creek	F-Sou-2-D	0.56	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Multiple channels for short reach
Fish Creek	F-Sou-3-C	5.47	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Slight increase in sinuosity; on verge of having multiple channels
Fish Creek	F-Sou-4-D	0.65	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Multiple channels for short reach
Fish Creek	F-Sou-5-C	0.96	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Slight increase in sinuosity; portions may have multiple channels
Fish Creek	F-Sou-6-D	4.64	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Multiple channels; long reach
Fish Creek	F-USF-0-A	0.61	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Cascades; V-notched Valley
Fish Creek	F-USF-1-B	0.90	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley widens; Slight increase in sinuosity
Fish Creek	F-USF-2-C	0.82	floodplain	V	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	C	Valley widens; Slight increase in sinuosity
Fish Creek	F-USF-3-B	2.21	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrow; decrease in sinuosity
Fish Creek	F-USF-4-C	0.45	floodplain	V	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Short area with split channel; valley wide with slight increase in sinuosity
Fish Creek	F-USF-5-B	1.04	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Slope increases; Sinuosity slightly decreases
Fish Creek	F-USF-6-C	0.74	floodplain	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	moderate	no	C	Point bars evident; Increase in Sinuosity
Fish Creek	F-USF-7-B	0.44	glacial/fluvial terrace	VIII	multiple	steep	step/pool	<12 w:d	none apparent	single	moderate	no	B	Valley narrow; decrease in sinuosity
Fish Creek	F-USF-8-D	1.45	floodplain	V	none	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Multiple channels in varioius locations along reach; decrease in sinuosity
Fish Creek	F-USF-9-B	0.65	glacial/fluvial terrace	VIII	multiple	steep	step/pool	12-40 w:d	active apparent	single	moderate	no	B	Slope increases; Sinuosity slightly decreases
Fish Creek	F-USF-10-D	1.68	floodplain	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Multiple channels in varioius locations along reach; decrease in sinuosity
Fish Creek	F-USF-11-C	0.61	floodplain	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Point bars evident; Increase in Sinuosity
Fish Creek	F-1Fi-0-C	5.72	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	
Flat Creek	F-Cac-0-A	1.64	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	V-notched, Steep side slopes
Flat Creek	F-Cac-1-B	5.77	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases slightly; side slopes steep
Flat Creek	F-Cac-2-C	0.28	floodplain	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C	Sinuosity increases slightly; valley opens
Flat Creek	F-Cac-3-F	0.57	floodplain	V	none	flat	riffle/pool	<12 w:d	none apparent	single	entrenched	yes	F	U-shaped Valley; channel entrenched; loss of point bars;no defined channel downstream of this reach
Flat Creek	F-Gam-0-A	0.04	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Cascades to North; Steep valley slopes
Flat Creek	F-Gam-1-B	0.36	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Valley still narrow; Sinuosity increases slightly
Flat Creek	F-Gam-2-E	1.16	floodplain	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	E	Slope decreases; Sinuosity increases slightly
Flat Creek	F-Gam-3-B	2.65	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Valley slopes steepen; Valley narrows
Flat Creek	F-Gam-4-F	1.13	floodplain	V	none	flat	riffle/pool	<12 w:d	active apparent	single	entrenched	no	F	Valley widens; channel becomes more entrenched
Flat Creek	F-Now-0-E	1.21	floodplain	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Shallow bowl area; sinuosity high
Flat Creek	F-Now-1-C	1.94	floodplain	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Pools and points bars

Appendix A Data Summary 2.1.8-1 Rosgen Classifications

Watershed	Reach ID - Formulas	Reach Length	Landform	Valley Type	Terrace Features	Channel Slope	Bed Features	Channel Shape	Floodplain	Pattern	Confinement	Lateral Containment	Channel Type	Notes
Flat Creek	F-Upp-0-A	1.12	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Cascades coming from West Slopes; Steep Valley
Flat Creek	F-Upp-1-B	1.41	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Couple short stretches of C's
Flat Creek	F-Upp-2-C	0.48	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C	Slope decreased and Sinuosity increased; Valley slopes steep
Flat Creek	F-Upp-3-B	0.72	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrows slightly
Flat Creek	F-Upp-4-C	1.12	floodplain	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Valley bottom widens slightly
Flat Creek	F-Upp-5-A	0.30	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Valley constricts
Flat Creek	F-Upp-6-B	0.96	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases slightly; Valley slopes steep
Flat Creek	F-Upp-7-D	0.44	floodplain	V	none	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Valley bottom open and flat; steep valley slopes
Flat Creek	F-Upp-8-C	0.30	floodplain	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Valley bottom still open and flat; channels begin converging
Flat Creek	F-Upp-9-B	6.45	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrows slightly; Steep Valle walls
Flat Creek	F-Upp-10-A	1.06	glacial/fluvial terrace	I	none	steep	step/pool	12-40 w:d	none apparent	single	entrenched	yes	A	Sinuosity decreases through constricted valley
Flat Creek	F-Upp-11-F	0.78	glacial/fluvial terrace	IV	none	flat	step/pool	12-40 w:d	none apparent	single	entrenched	yes	F	Gorge with steep valley walls; meandering entrenched channel
Flat Creek	F-Upp-12-B	4.95	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Slope steepen slightly; small sections of C's apparent
Flat Creek	F-Upp-13-D	2.30	floodplain	III	none	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Inactive Alluvial Fan
Flat Creek	F-Upp-14-C	0.51	floodplain	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Slope decreases and bottom of Alluvial Fan
Flat Creek	F-Wil-0-A	0.85	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Steep A's from North; slight indication of channels
Flat Creek	F-Wil-1-B	0.41	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Valley widens; sinuosity increases slightly
Flat Creek	F-Wil-2-E	0.56	floodplain	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Modrately steep side slopes
Flat Creek	F-Wil-3-B	0.56	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Side slope increase slightly; Sinuosity decreases slightly
Flat Creek	F-Wil-4-A	0.67	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Steep and Constricted Valley; Channel difficult to define
Flat Creek	F-Wil-5-B	0.64	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Valley widens; sinuosity increases slightly; no defined channel downstream of this point
Flat Creek	F-1Fl-0-C	12.00	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	
Gros Ventre River	G-Bie-0-A	2.49	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	A	Steep Valley slopes; Channel difficult to identify
Gros Ventre River	G-Bie-1-B	1.08	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Valley slope decrease; Channel difficult to Identify
Gros Ventre River	G-Dry-0-A	0.51	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Fluvial dissected; side slopes steep
Gros Ventre River	G-Dry-1-B	3.59	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases; Side slopes steep
Gros Ventre River	G-Dry-2-C	0.34	glacial/fluvial terrace	IX	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Short reach; sinuosity increases
Gros Ventre River	G-Dry-3-D	2.40	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Multiple channels; sinuosity decreases
Gros Ventre River	G-Dry-4-C	1.74	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; Side slopes steep
Gros Ventre River	G-Fla-0-C	8.08	floodplain	X	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	C	Point bars; increase in sinuosity
Gros Ventre River	G-Fla-1-D	2.20	floodplain	X	none	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Multiple channels; decrease in sinuosity
Gros Ventre River	G-Fla-2-C	0.49	floodplain	X	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Slight increase in sinuosity
Gros Ventre River	G-Gro-0-A	0.82	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Very Steep slopes; small cascades from North and South
Gros Ventre River	G-Gro-1-B	2.38	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases; Side slopes steep
Gros Ventre River	G-Gro-2-C	0.95	glacial/fluvial terrace	V	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Increase in sinuosity; Side slopes still fairly steep
Gros Ventre River	G-Gro-3-B	0.58	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity decreases; Side slopes steep; Valley narrows
Gros Ventre River	G-Gro-4-C	4.08	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Increase in sinuosity; Side slopes still fairly steep
Gros Ventre River	G-Gro-5-A	0.19	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Waterfalls; very short reach
Gros Ventre River	G-Gro-6-C	0.90	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Increase in sinuosity; Side slopes still fairly steep
Gros Ventre River	G-Gro-7-D	1.11	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; Valley bottom wide
Gros Ventre River	G-Gro-8-C	1.02	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Increase in sinuosity; Side slopes still fairly steep
Gros Ventre River	G-Gro-9-B	0.71	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrows; Sinuosity decreases
Gros Ventre River	G-Gro-10-C	4.55	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Increase in sinuosity; Valley widens
Gros Ventre River	G-Gro-11-B	3.35	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Decrease in sinuosity; Valley narrows
Gros Ventre River	G-Gro-12-D	3.40	glacial/fluvial terrace	V	none	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Decrease in sinuosity; Flood plain access; Valley widens
Gros Ventre River	G-Gro-13-C	11.73	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Increase in Sinuosity
Gros Ventre River	G-Gro-14-D	5.54	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Decrease in Sinuosity
Gros Ventre River	G-Gro-15-B	21.53	glacial/fluvial terrace	V	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Increase in sinuosity
Gros Ventre River	G-Gro-16-D	12.19	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Decrease in Sinuosity
Gros Ventre River	G-Kin-0-E	3.25	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Shallow bowl area; sinuosity high
Gros Ventre River	G-Kin-1-C	0.52	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity decreases slightly; small terraces evident
Gros Ventre River	G-Kin-2-E	0.17	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	E	Sinuosity increases; Valley narrows
Gros Ventre River	G-Kin-3-B	1.08	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity decreases slightly; channel difficult to see through riparian brush

Watershed	Reach ID - Formulas	Reach Length	Landform	Valley Type	Terrace Features	Channel Slope	Bed Features	Channel Shape	Floodplain	Pattern	Confinement	Lateral Containment	Channel Type	Notes
Gros Ventre River	G-Kin-4-C	0.37	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity decreases slightly; small terraces evident
Gros Ventre River	G-Low-0-B	2.01	glacial/fluvial terrace	VIII	multiple	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley bottom fairly
Gros Ventre River	G-Low-1-C	1.24	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases
Gros Ventre River	G-Low-2-D	0.99	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Multiple channels; decrease in sinuosity
Gros Ventre River	G-Low-3-B	0.94	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrows
Gros Ventre River	G-Low-4-D	1.49	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Multiple channels; decrease in sinuosity
Gros Ventre River	G-Low-5-C	0.78	floodplain	VIII	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Sinuosity increases; valley widens
Gros Ventre River	G-Low-6-D	0.71	floodplain	IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Multiple channels; decrease in sinuosity
Gros Ventre River	G-Low-7-C	1.38	floodplain	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; valley widens
Gros Ventre River	G-Red-0-A	0.10	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Steep slopes; Channel difficult to identify (location)
Gros Ventre River	G-Red-1-B	0.09	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	active apparent	single	moderate	no	B	Sinuosity increases; valley widens
Gros Ventre River	G-Red-2-E	2.09	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Sinuosity increases; channel difficult to see through trees
Gros Ventre River	G-Red-3-B	2.16	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity decreases
Gros Ventre River	G-Sla-0-B	0.38	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Channel narrow and difficult to identify due to riparian cover
Gros Ventre River	G-Sla-1-E	0.25	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Sinuosity increases; Channel difficult to see due riparian vegetation
Gros Ventre River	G-Sla-2-C	4.01	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity decreases; point bars and pools evident in sections of reach
Gros Ventre River	G-Sla-3-D	0.68	glacial/fluvial terrace	V	none	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Multiple channels; sinuosity decreases
Gros Ventre River	G-Sla-4-C	2.70	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases
Gros Ventre River	G-Sla-5-B	0.22	glacial/fluvial terrace	VIII	multiple	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity decreases; Valley narrows slightly
Gros Ventre River	G-Sla-6-C	0.50	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases
Gros Ventre River	G-Sla-7-B	0.69	glacial/fluvial terrace	VIII	multiple	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity decreases
Gros Ventre River	G-Sla-8-C	1.81	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases
Gros Ventre River	G-Upp-0-A	0.88	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Fluvial dissected
Gros Ventre River	G-Upp-1-B	0.10	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases; valley narrows
Gros Ventre River	G-Upp-2-C	0.31	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; small point bars
Gros Ventre River	G-Upp-3-B	0.97	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Side slopes steep; Sinuosity decreases
Gros Ventre River	G-Upp-4-C	0.33	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; small point bars
Gros Ventre River	G-Upp-5-D	1.06	glacial/fluvial terrace	V	none	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; multiple channels
Gros Ventre River	G-Upp-6-C	0.32	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; small point bars
Gros Ventre River	G-Upp-7-B	1.08	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrows; Sinuosity decreases
Gros Ventre River	G-Upp-8-C	0.69	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; small point bars
Gros Ventre River	G-Upp-9-B	2.79	glacial/fluvial terrace	II	multiple	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity decreases; Valley narrows slightly
Gros Ventre River	G-Upp-10-C	0.70	glacial/fluvial terrace	V	multiple	flat	step/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; small point bars; land slide at end of this reach
Gros Ventre River	G-Upp-11-B	1.20	glacial/fluvial terrace	VIII	multiple	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity decreases; Valley narrows slightly; land slide at beginning of this reach
Gros Ventre River	G-1GV-0-D	4.82	glacial/fluvial terrace	IX	none	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	
Pacific Creek	P-Mid-0-A	2.34	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Fluvial dissected
Pacific Creek	P-Mid-1-B	0.90	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases
Pacific Creek	P-Mid-2-C	1.45	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Terraces very evident; sinuosity increases
Pacific Creek	P-Mid-3-B	0.94	glacial/fluvial terrace	VIII	multiple	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity decreases; Valley narrows
Pacific Creek	P-Mid-4-D	0.23	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; valley bottom widens; short reach
Pacific Creek	P-Mid-5-C	1.26	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; point bars and pools
Pacific Creek	P-Mid-6-D	0.73	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases
Pacific Creek	P-Mid-7-C	0.81	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; point bars and pools
Pacific Creek	P-Mid-8-D	2.00	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Valley widens; glacial outwash very evident; Sinuosity decreases
Pacific Creek	P-Min-0-A	0.22	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Fluvial dissected; side slopes steep
Pacific Creek	P-Min-1-B	1.16	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases; Side slopes steep
Pacific Creek	P-Min-2-D	0.88	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Multiple channels; sinuosity decreases
Pacific Creek	P-Min-3-C	0.22	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; Side slopes steep; Short reach
Pacific Creek	P-Min-4-B	4.20	glacial/fluvial terrace	VIII	multiple	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity decreases; Side slopes steep
Pacific Creek	P-Min-5-C	1.62	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; Side slopes steep; Short reach
Pacific Creek	P-Min-6-B	3.65	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity decreases; Side slopes steep
Pacific Creek	P-Pac-0-E	1.76	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Shallow bowl area; sinuosity high
Pacific Creek	P-Pac-1-B	1.88	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Glacial U-shaped trough; Sinuosity increases slightly

Watershed	Reach ID - Formulas	Reach Length	Landform	Valley Type	Terrace Features	Channel Slope	Bed Features	Channel Shape	Floodplain	Pattern	Confinement	Lateral Containment	Channel Type	Notes
Pacific Creek	P-Pac-2-D	1.10	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Sinousity decreases; multiple channels
Pacific Creek	P-Pac-3-C	1.18	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Point bars and pools; sinuosity increases
Pacific Creek	P-Pac-4-D	0.50	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Sinousity decreases; multiple channels
Pacific Creek	P-Pac-5-C	2.12	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Point bars and pools; sinuosity increases
Pacific Creek	P-Pac-6-B	1.17	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Glacial U-shaped trough; Sinuosity increases slightly
Pacific Creek	P-Pac-7-C	0.61	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Point bars and pools; sinuosity increases
Pacific Creek	P-Rod-0-A	0.95	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Steep, V-notched valleys with cascades
Pacific Creek	P-Rod-1-B	1.03	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Valley widens slightly; Sinuosity increases slightly
Pacific Creek	P-Rod-2-C	0.73	floodplain	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Point bars forming; Valley widens
Pacific Creek	P-Rod-3-B	0.45	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Valley constricts; sinuosity decreases
Pacific Creek	P-Rod-4-C	6.06	floodplain	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Point Bars more prominent; couple very small B sections
Pacific Creek	P-1Pa-0-B	4.62	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	
Pacific Creek	P-1Pa-1-D	5.72	glacial/fluvial terrace	IX	none	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	
Snake River	S- Up-0-C	1.16	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C	Lateral containment toward mid and end of reach
Snake River	S- Up-1-D	0.47	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Valley widens slightly; sinuosity decreases
Snake River	S- Up-2-C	1.29	glacial/fluvial terrace	IV	none	flat	riffle/pool	12-40 w:d	none apparent	single	slight	yes	C	Valley side slopes steepen; Bkf Width increases as entering delta to Lake
Snake River	S-1Mo-0-A	4.65	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Steep V-notched valleys with cascades
Snake River	S-1Mo-1-B	0.79	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Valley widens; Slight increase in sinuosity
Snake River	S-1Mo-2-C	7.57	floodplain	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Terrace features and point bars forming; Sinuosity increases slightly
Snake River	S-Ari-0-A	0.82	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Side slopes steep; cascades to north; fluvial dissected
Snake River	S-Ari-1-B	4.18	glacial/fluvial terrace	V	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Glacial U-shaped trough; Sinuosity increases slightly
Snake River	S-Ari-2-C	8.30	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C	Few point bars; Sinuosity increases
Snake River	S-Bas-0-A	0.85	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Side slopes steep; cascades to north/ northwest
Snake River	S-Bas-1-B	0.59	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity increases slightly
Snake River	S-Bas-2-C	0.16	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C	A few Pools and points bars; very short reach
Snake River	S-Bas-3-B	2.19	alluvial fan	III	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Lower portion is a small alluvial fan; upper end valley type more VIII
Snake River	S-Bas-4-C	5.08	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C	
Snake River	S-Ber-0-A	0.91	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Many tiny cascades; Side slopes steep
Snake River	S-Ber-1-B	3.22	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases; valley widens slightly
Snake River	S-Ber-2-C	0.19	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Short reach; more flood plain access
Snake River	S-Ber-3-D	0.53	floodplain	IX	none	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	many little channels, ephemeral; Wide Valley
Snake River	S-Ber-4-C	1.36	floodplain	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Single thread channel with Prominent point bars
Snake River	S-Ber-5-D	0.43	floodplain	IX	none	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Wide valley bottom; multiple threads
Snake River	S-Ber-6-C	2.66	floodplain	VIII	none	steep	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Wide valley bottom; single thread, sinuosity slightly increases
Snake River	S-Ber-7-B	1.70	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrows; side slopes steep
Snake River	S-Ber-8-C	1.16	floodplain	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Prominent point bars; increase in sinuosity
Snake River	S-Ber-9-B	2.82	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrow with steep side slopes; Sinuosity decreases slightly
Snake River	S-Ber-10-C	0.55	floodplain	VIII	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Valley wide; sinuosity increases near delta into lake
Snake River	S-Buf-3-C	1.80	floodplain	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Short section of C in D-dominated valley
Snake River	S-Buf-4-D	4.19	floodplain	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Multiple channels; decrease in sinuosity
Snake River	S-Buf-5-C	5.38	floodplain	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Point bars; increase in sinuosity
Snake River	S-Buf-6-D	3.09	floodplain	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Multiple channels; decrease in sinuosity
Snake River	S-Cas-0-A	1.04	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Steep V-notched valley with cascades from North and South
Snake River	S-Cas-1-B	1.18	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases slightly; Side slopes steep
Snake River	S-Cas-2-A	0.38	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Steep V-notched valley with cascades from North
Snake River	S-Cas-3-B	0.27	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases slightly; Side slopes steep
Snake River	S-Cas-4-C	0.64	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Some point bars; sinuosity increases slightly
Snake River	S-Cas-5-B	0.26	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases slightly; Valley narrows
Snake River	S-Cas-6-D	0.27	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; very short section with multiple channels
Snake River	S-Cas-7-C	0.67	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Some point bars; sinuosity increases slightly
Snake River	S-Cas-8-B	0.24	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases slightly; Valley narrows
Snake River	S-Cas-9-D	0.44	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; very short section with multiple channels
Snake River	S-Cas-10-C	0.63	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Some point bars; sinuosity increases slightly

Watershed	Reach ID - Formulas	Reach Length	Landform	Valley Type	Terrace Features	Channel Slope	Bed Features	Channel Shape	Floodplain	Pattern	Confinement	Lateral Containment	Channel Type	Notes
Snake River	S-Cas-11-B	0.62	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases slightly; Valley narrows
Snake River	S-Cas-12-A	0.56	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Series of waterfalls
Snake River	S-Cas-13-B	0.14	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Channel entrance into Lake of steep bank
Snake River	S-Col-0-A	1.57	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Steep cascades coming from side slopes; V-notched valley
Snake River	S-Col-1-B	2.51	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Side slopes steep with many cascades entering from north and south througout reach
Snake River	S-Col-2-D	0.19	glacial/fluvial terrace	V	none	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Very short reach; entrance into lake somewhat steep
Snake River	S-Cot-0-C	0.64	floodplain	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Short Section of C before multiple channels begin to form; Flat
Snake River	S-Cot-1-D	3.04	floodplain	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Multiple channels; decrease in sinuosity
Snake River	S-Cot-2-C	0.51	floodplain	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Short section of C in a D-dominated valley
Snake River	S-Cot-3-D	3.16	floodplain	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Multiple channels; decrease in sinuosity
Snake River	S-Cro-0-E	1.56	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Channels cery small with high sinuosity
Snake River	S-Cro-1-B	1.53	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases; Valley narrows
Snake River	S-Cro-2-D	0.28	glacial/fluvial terrace	V	none	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Short area of Multiple channels
Snake River	S-Cro-3-B	0.19	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases; Valley narrows
Snake River	S-Cro-4-D	0.32	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Short area of Multiple channels
Snake River	S-Cro-5-B	1.69	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases; Valley narrows
Snake River	S-Cro-6-D	2.23	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Short area of Multiple channels; Valley bottom open and broad
Snake River	S-Cro-7-C	1.02	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; Valley narrows
Snake River	S-Cro-8-B	0.42	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley steep slopes and narrow
Snake River	S-Cro-9-C	0.26	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; Valley narrows
Snake River	S-De -0-A	0.45	glacial/fluvial terrace	I	none	steep	step/pool	12-40 w:d	none apparent	single	entrenched	yes	A	Side slopes steep
Snake River	S-De -1-B	0.81	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Increase in Sinuosity
Snake River	S-De -2-C	3.72	glacial/fluvial terrace	V	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Increase in sinuosity; Valley widens
Snake River	S-De -3-E	3.10	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Sinuosity increases; channel narrow
Snake River	S-De -4-D	0.72	glacial/fluvial terrace	X	none	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; Valley widens
Snake River	S-Dit-0-A	0.10	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Side slopes steep;fluvial dissected
Snake River	S-Dit-1-B	0.21	glacial/fluvial terrace	V	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Glacial U-shaped trough; Sinuosity increases slightly
Snake River	S-Dit-2-C	0.61	glacial/fluvial terrace	V	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	C	Channel narrow with pools and points bars
Snake River	S-Dit-3-B	0.11	glacial/fluvial terrace	V	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Glacial U-shaped trough; Sinuosity increases slightly
Snake River	S-Dit-4-C	1.25	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Channel narrow with pools and points bars
Snake River	S-Dit-5-B	0.33	glacial/fluvial terrace	V	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Short reach; sinuosity decreases
Snake River	S-Dit-6-C	0.58	floodplain	X	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Channel narrow with pools and points bars
Snake River	S-Dit-7-B	0.48	glacial/fluvial terrace	V	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Glacial U-shaped trough; Sinuosity increases slightly
Snake River	S-Dit-8-C	1.25	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Channel narrow with pools and points bars
Snake River	S-Dit-9-B	1.29	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	12-40 w:d	none apparent	single	moderate	no	B	Sinuosity decreases; North east cliffs
Snake River	S-Dit-10-C	3.50	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Pools and points bars; sinuosity increases
Snake River	S-Dit-11-D	0.54	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; short reach with multiple channels
Snake River	S-Dit-12-C	3.88	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Pools and points bars; sinuosity increases
Snake River	S-Dit-13-D	1.14	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; short reach with multiple channels
Snake River	S-Dit-14-C	6.78	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Pools and points bars; sinuosity increases
Snake River	S-Fal-0-A	0.85	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	V-notched valley; cascades enter from South west
Snake River	S-Fal-1-C	2.82	glacial/fluvial terrace	V	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; some of reach difficult to see through trees
Snake River	S-Fal-2-B	0.43	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases; valley widens
Snake River	S-Fal-3-C	1.28	glacial/fluvial terrace	V	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; valley widens
Snake River	S-Fal-4-B	0.66	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrows; sinuosity decreases
Snake River	S-Fal-5-C	11.81	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Sinuosity increases; valley widens
Snake River	S-Fal-6-A	0.52	glacial/fluvial terrace	I	none	steep	step/pool	12-40 w:d	none apparent	single	entrenched	yes	A	Valley narrows; sinuosity decreases
Snake River	S-Fal-7-B	0.74	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley widens; Sinuosity increases
Snake River	S-Fis-0-F	1.24	floodplain	X	none	flat	riffle/pool	<12 w:d	active apparent	single	entrenched	yes	F	Channelized; straightened
Snake River	S-Fis-1-E	1.96	floodplain	X	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	yes	E	Sinuosity increases; only slightly entrenched
Snake River	S-Fis-2-D	3.09	floodplain	X	none	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Multiple threads; Very broad, gentle valley
Snake River	S-Fis-3-F	3.02	floodplain	X	none	flat	riffle/pool	>40 w:d	active apparent	single	entrenched	yes	F	Very large F; potential of C; no point bars
Snake River	S-For-0-A	1.72	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Canyon; steep side slopes

Watershed	Reach ID - Formulas	Reach Length	Landform	Valley Type	Terrace Features	Channel Slope	Bed Features	Channel Shape	Floodplain	Pattern	Confinement	Lateral Containment	Channel Type	Notes
Snake River	S-For-1-B	1.52	glacial/fluvial terrace II	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	B	Still Canyon: steep side slopes
Snake River	S-For-2-A	0.53	glacial/fluvial terrace I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Increased sinuosity somewhat due to tree debris
Snake River	S-For-3-B	0.65	glacial/fluvial terrace II	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	B	Side slopes steepening
Snake River	S-For-4-G	1.93	glacial/fluvial terrace VII	none	steep	step/pool	12-40 w:d	none apparent	single	entrenched	yes	G	Side slopes steepening; valley slightly widening
Snake River	S-For-5-G	1.25	glacial/fluvial terrace VII	none	steep	step/pool	12-40 w:d	none apparent	single	entrenched	yes	G	Increased sinuosity; Side slopes slightly flattening
Snake River	S-For-6-B	1.83	glacial/fluvial terrace V	none	steep	step/pool	12-40 w:d	none apparent	single	entrenched	yes	B	Very steep side slopes; sinuosity decreasing
Snake River	S-For-7-G	0.77	glacial/fluvial terrace I	none	steep	step/pool	12-40 w:d	none apparent	single	entrenched	yes	G	Very steep side slopes; moderate sinuosity
Snake River	S-Hea-0-C	0.81	glacial/fluvial terrace V	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Channel begins where water exits Heart Lake; pools on bends; short reach
Snake River	S-Hea-1-B	1.09	glacial/fluvial terrace VIII	multiple	steep	step/pool	>40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases; Side slopes steep; valley narrows
Snake River	S-Hea-2-C	1.07	glacial/fluvial terrace V	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Icrease in sinuosity; Side slopes still fairly steep
Snake River	S-Hea-3-D	1.90	glacial/fluvial terrace IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Multiple channels; sinuosity decreases
Snake River	S-Hor-0-A	0.71	glacial/fluvial terrace I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Side slopes steep; cascades to northeast
Snake River	S-Hor-1-B	4.23	glacial/fluvial terrace II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity increases slightly
Snake River	S-Hor-2-C	0.35	glacial/fluvial terrace V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Points bars; sinuosity increases; short reach
Snake River	S-Hor-3-B	2.98	glacial/fluvial terrace II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity increases slightly
Snake River	S-Hor-4-C	1.10	glacial/fluvial terrace VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Points bars; sinuosity increases
Snake River	S-Hor-5-D	1.80	glacial/fluvial terrace IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; multiple channels
Snake River	S-Hor-6-B	0.70	glacial/fluvial terrace VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity increases slightly
Snake River	S-Lak-0-B	1.23	glacial/fluvial terrace VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Fairly Steep reach exiting Lake
Snake River	S-Lak-1-C	0.42	glacial/fluvial terrace VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Increase in sinuosity; Valley widens
Snake River	S-Lak-2-D	0.21	glacial/fluvial terrace IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Very short reach; multiple channels
Snake River	S-Lak-3-B	0.41	glacial/fluvial terrace VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases
Snake River	S-Lak-4-C	10.62	glacial/fluvial terrace IX	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Increase in sinuosity; Valley widens
Snake River	S-Lei-0-A	0.28	glacial/fluvial terrace I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Very Steep slopes; small cascades from North and South
Snake River	S-Lei-1-B	0.79	glacial/fluvial terrace II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases; Side slopes steep; Valley narrows
Snake River	S-Lei-2-C	0.38	glacial/fluvial terrace IX	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Increase in sinuosity; Side slopes still fairly steep
Snake River	S-Lei-3-B	0.79	glacial/fluvial terrace IX	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity decreases
Snake River	S-Lei-4-C	0.52	glacial/fluvial terrace IX	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Increase in sinuosity; Side slopes still fairly steep
Snake River	S-Lei-5-B	2.42	glacial/fluvial terrace VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity decreases; Side slopes steep; Valley narrows
Snake River	S-Lei-6-A	0.19	glacial/fluvial terrace I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Waterfalls; steep channels
Snake River	S-Lei-7-D	0.16	glacial/fluvial terrace V	none	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Channels entering Lake; Sinuosity decreases
Snake River	S-Lew-0-C	2.01	glacial/fluvial terrace V	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	yes	C	Couple spots with two channels; pools and point bars
Snake River	S-Lew-1-F	1.78	glacial/fluvial terrace IV	none	flat	step/pool	12-40 w:d	none apparent	single	entrenched	yes	F	Gorge within gentle sloped valley; entrenched
Snake River	S-Lew-2-D	0.77	glacial/fluvial terrace V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinousity decreases; multiple channels
Snake River	S-Lew-3-C	0.93	glacial/fluvial terrace V	none	flat	riffle/pool	>40 w:d	active apparent	single	slight	yes	C	Valley narrows; pools and point bars
Snake River	S-Lew-4-F	1.26	glacial/fluvial terrace IV	none	flat	riffle/pool	12-40 w:d	none apparent	single	entrenched	yes	F	Gorge within gentle sloped valley; entrenched
Snake River	S-Lew-5-D	0.61	glacial/fluvial terrace V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Sinousity decreases; multiple channels
Snake River	S-Lew-6-C	1.69	glacial/fluvial terrace V	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C	Valley narrows; pools and point bars
Snake River	S-Lew-7-D	1.48	glacial/fluvial terrace V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Sinousity decreases; multiple channels periodically
Snake River	S-Low-0-D	1.60	glacial/fluvial terrace IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity low; multiple channels
Snake River	S-Low-1-C	0.95	glacial/fluvial terrace IX	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	yes	C	Sinuosity increases slightly; valley narrows
Snake River	S-Low-2-D	11.43	glacial/fluvial terrace IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity low; multiple channels
Snake River	S-Moo-0-A	1.02	glacial/fluvial terrace VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Side slopes steep; rocky cascades to south/ southwest
Snake River	S-Moo-1-B	1.76	glacial/fluvial terrace VII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Glacial U-shaped trough; Sinuosity increases slightly
Snake River	S-Moo-2-C	0.59	glacial/fluvial terrace V	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Few point bars; Sinuosity increases
Snake River	S-Moo-3-D	0.61	glacial/fluvial terrace V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Short reach with multiple channels
Snake River	S-Moo-4-C	1.29	glacial/fluvial terrace V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C	Few point bars; Sinuosity increases
Snake River	S-Moo-5-D	1.56	glacial/fluvial terrace V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Reach encompasses a couple D-type portions; sinuosity decreases
Snake River	S-Moo-6-C	0.63	glacial/fluvial terrace V	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C	Few point bars; Sinuosity increases
Snake River	S-Moo-7-B	1.73	glacial/fluvial terrace II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Glacial U-shaped trough; Sinuosity increases slightly
Snake River	S-Moo-8-D	2.00	glacial/fluvial terrace V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinousity decreases; multiple channels
Snake River	S-Mor-0-A	0.50	glacial/fluvial terrace I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Cascades on Side slopes to south and west
Snake River	S-Mor-1-B	3.16	glacial/fluvial terrace II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases slightly

Appendix A Data Summary 2.1.8-1 Rosgen Classifications

Watershed	Reach ID - Formulas	Reach Length	Landform	Valley Type	Terrace Features	Channel Slope	Bed Features	Channel Shape	Floodplain	Pattern	Confinement	Lateral Containment	Channel Type	Notes
Snake River	S-Mor-2-C	0.23	glacial/fluvial terrace	IV	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C	Very short Section with a few forming point bars
Snake River	S-Mor-3-D	0.81	floodplain	X	none	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Valley widens and flattens; multiple channels forming through trees
Snake River	S-Mor-4-C	0.73	floodplain	X	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Open Valley; Slight increase in Sinuosity; Short section
Snake River	S-Mor-5-B	2.39	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Valley narrows; Sinuosity decreases; Side slopes steep
Snake River	S-Mos-0-A	0.82	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Steep; fluvial dissected; Side slopes not V-notched
Snake River	S-Mos-1-B	2.45	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity increases slightly
Snake River	S-Mos-2-C	2.94	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Points bars; sinuosity increases
Snake River	S-Mos-3-B	2.52	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity increases slightly
Snake River	S-Mos-4-C	0.55	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Points bars; sinuosity increases; short reach
Snake River	S-Mos-5-B	2.55	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity increases
Snake River	S-Pil-0-A	0.86	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Side slopes steep; cascades to north; fluvial dissected
Snake River	S-Pil-1-B	2.13	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Steep side slopes; sinuosity increases
Snake River	S-Pil-2-C	0.75	glacial/fluvial terrace	V	none	flat	riffle/pool	12-40 w:d	none apparent	single	moderate	no	C	Point bars and pools; sinuosity increases
Snake River	S-Pil-3-D	0.78	glacial/fluvial terrace	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinousity decreases; multiple channels
Snake River	S-Pil-4-C	7.47	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	yes	C	Point bars and pools; sinuosity increases
Snake River	S-Pil-5-D	6.73	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinousity decreases; multiple channels
Snake River	S-Pla-0-A	0.74	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Side slopes steep;fluvial dissected
Snake River	S-Pla-1-B	0.46	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases slightly
Snake River	S-Pla-2-E	0.22	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Sinuosity increases; Valley widens
Snake River	S-Pla-3-B	1.96	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Side slopes not very steep; sinuosity increases slightly
Snake River	S-Pla-4-C	0.71	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Channel narrow; sinuosity slightly increases; multiple channels in a couple spots
Snake River	S-Pla-5-B	2.35	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity decreases; valley narrows
Snake River	S-Pla-6-C	0.37	glacial/fluvial terrace	X	none	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Sinuosity increases; Valley widens
Snake River	S-Pla-7-D	0.70	glacial/fluvial terrace	IX	none	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; multiple channels
Snake River	S-Pol-0-A	0.79	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Steep V-notched canyon
Snake River	S-Pol-1-B	1.62	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Side slopes less Steep
Snake River	S-Pol-2-E	0.75	floodplain	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Canyon opens into wide flooplain area
Snake River	S-Pol-3-G	0.49	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	G	Canyon narrows slightly again
Snake River	S-Pol-4-B	2.13	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	active apparent	single	moderate	no	B	Some floodplain access
Snake River	S-Pol-5-G	0.79	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	G	Valley narrow
Snake River	S-Pol-6-B	0.55	glacial/fluvial terrace	II	multiple	steep	step/pool	12-40 w:d	active apparent	single	moderate	no	B	Valley widening
Snake River	S-Pol-7-E	0.38	floodplain	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Valley open with access to floodplain
Snake River	S-Pol-8-B	1.41	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	active apparent	single	moderate	yes	B	Valley narrows slightly
Snake River	S-Pol-9-A	0.01	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Water fall
Snake River	S-Pol-10-B	2.54	floodplain	II	multiple	steep	step/pool	12-40 w:d	active apparent	single	moderate	no	B	Terrace apparent along East
Snake River	S-Pol-11-C	1.89	floodplain	IV	none	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Terrace non-apparent, open and flat
Snake River	S-Por-0-A	0.03	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Fluvial dissected
Snake River	S-Por-1-B	3.85	glacial/fluvial terrace	VIII	multiple	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Sinuosity increases; valley widens
Snake River	S-She-0-A	1.54	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	A	Steep V-notched valley
Snake River	S-She-1-B	0.91	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Valley side slopes less steep
Snake River	S-She-2-A	0.78	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Back to a Steep V-notched valley
Snake River	S-She-3-B	1.67	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	active apparent	single	moderate	no	B	Some Floodplain evident
Snake River	S-Sna-0-C	0.93	floodplain	VIII	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Channel coming out of South East end of Jackson Lake; very short section
Snake River	S-Sna-1-D	1.71	floodplain	V	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Sinuosity decreases; multiple channels
Snake River	S-Sna-2-C	2.09	floodplain	VIII	multiple	flat	riffle/pool	>40 w:d	active apparent	single	slight	no	C	Channel wide; valley wide
Snake River	S-Sna-4-F	1.13	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	none apparent	single	entrenched	yes	F	Short single thread section through Moose
Snake River	S-Sna-5-D	28.11	floodplain	IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	yes	D	Lateral confinement due to dikes along both banks
Snake River	S-Sna-6-F	5.22	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	none apparent	single	entrenched	yes	F	Slight increase in Sinuosity
Snake River	S-Sna-3-D	21.09	floodplain	IX	multiple	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	D to Moose
Snake River	S-Sou-0-A	0.26	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Fluvial dissected; side slopes steep
Snake River	S-Sou-1-B	0.33	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Sinuosity increases; Side slopes steep; Valley narrows
Snake River	S-Sou-2-C	2.53	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Increase in sinuosity; Side slopes still fairly steep
Snake River	S-Sou-3-D	0.50	glacial/fluvial terrace	V	none	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Multiple channels; sinuosity decreases

Watershed	Reach ID - Formulas	Reach Length	Landform	Valley Type	Terrace Features	Channel Slope	Bed Features	Channel Shape	Floodplain	Pattern	Confinement	Lateral Containment	Channel Type	Notes
Snake River	S-Sou-4-C	12.18	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Slight increase in sinuosity; short portions may have multiple channels
Snake River	S-Spr-0-B	1.03	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Very straight channel; not steep enough to be an A
Snake River	S-Spr-1-F	5.92	glacial/fluvial terrace	X	none	flat	riffle/pool	<12 w:d	none apparent	single	entrenched	yes	F	Channelized for irrigation; sinuosity increases slightly
Snake River	S-Spr-2-C	8.50	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Channel and valley widened; Sinuosity increases
Snake River	S-Spr-3-D	1.84	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Decrease in sinuosity; Valley wide
Snake River	S-Ste-0-A	0.99	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Fluvial dissected; cascades from all directions
Snake River	S-Ste-1-B	0.66	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity increases slightly
Snake River	S-Ste-2-A	1.37	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Steep face; sinuosity decreases
Snake River	S-Ste-3-B	1.65	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Side slopes steep; sinuosity increases slightly
Snake River	S-Ste-4-C	0.40	glacial/fluvial terrace	VIII	multiple	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	A few point bars and small pools; increase in sinuosity
Snake River	S-Ste-5-D	0.26	glacial/fluvial terrace	IX	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Short reach where channle enters the Snake River
Snake River	S-Wol-0-A	1.21	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Steep, V-notched canyons
Snake River	S-Wol-1-B	1.04	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Side slopes still steep; Slight increase in sinuosity
Snake River	S-Wol-2-A	0.72	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Steep, V-notched canyons
Snake River	S-Wol-3-B	2.75	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Side slopes still steep; Slight increase in sinuosity
Snake River	S-Wol-4-D	2.74	glacial/fluvial terrace	v	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Multiple channels apparent; Valley bottom widens; sinuosity decreases
Snake River	S-Wol-5-B	0.77	glacial/fluvial terrace	II	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Side slopes still steep; Slight increase in sinuosity
Snake River	S-Wol-6-D	3.77	glacial/fluvial terrace	V	multiple	flat	riffle/pool	12-40 w:d	active apparent	multiple	slight	no	D	Multiple channels apparent; Valley bottom widens; sinuosity decreases
Snake River	S-1Sn-0-A	1.68	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	
Snake River	S-1Sn-1-B	6.09	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	
Snake River	S-1Sn-2-C	1.52	glacial/fluvial terrace	VII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	
Snake River	S-1Sn-3-B	11.73	glacial/fluvial terrace	I	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	
Snake River	S-1Sn-4-C	7.56	glacial/fluvial terrace	II	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	
Snake River	S-1Sn-5-B	3.48	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	
Snake River	S-1Sn-6-C	21.77	glacial/fluvial terrace	II	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	
Spread Creek	S-Nor-0-A	0.96	glacial/fluvial terrace	VII	none	steep	step/pool	<12 w:d	none apparent	single	entrenched	yes	A	Fluvial dissected
Spread Creek	S-Nor-1-B	0.26	glacial/fluvial terrace	VIII	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Valley narrows; sinuosity increases
Spread Creek	S-Nor-2-C	5.86	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Valley bottom widens; Sinuosity increases slightly
Spread Creek	S-Nor-3-D	1.47	glacial/fluvial terrace	IX	none	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	Multiple channels; sinuosity decreases
Spread Creek	S-Nor-4-C	2.62	glacial/fluvial terrace	VIII	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	Point bars and pools present; Sinuosity increases
Spread Creek	S-Nor-5-B	2.54	glacial/fluvial terrace	VIII	none	steep	step/pool	12-40 w:d	none apparent	single	moderate	yes	B	Decrease in sinuostiy; Valley narrows
Spread Creek	S-Sku-0-E	1.24	glacial/fluvial terrace	VIII	none	flat	riffle/pool	<12 w:d	active apparent	single	slight	no	E	Water captured in Basin with no evident A channels to feed
Spread Creek	S-Sku-1-B	1.71	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	Channel steepens; Side slopes steepen; Valley narrows
Spread Creek	S-1Sp-0-B	3.11	glacial/fluvial terrace	II	none	steep	step/pool	<12 w:d	none apparent	single	moderate	yes	B	
Spread Creek	S-1Sp-1-C	8.96	glacial/fluvial terrace	II	none	flat	riffle/pool	12-40 w:d	active apparent	single	slight	no	C	
Spread Creek	S-1Sp-2-D	5.06	alluvial fan	IX	none	flat	riffle/pool	>40 w:d	active apparent	multiple	slight	no	D	

Data Summary 6.2.4-1
2016 Species of Greatest Conservation Need
Final January 2016

(blue)	New Species
(green)	Includes Multiple Species

Common Name	Scientific Name	Tier
Birds		
Common Loon	*Gavia immer*	I
Burrowing Owl	*Athene cunicularia*	I
Mountain Plover	*Charadrius montanus*	I
Northern Goshawk	*Accipiter gentilis*	I
Trumpeter Swan	*Cygnus buccinator*	II
American Bittern	*Botaurus lentiginosus*	II
Ash-throated Flycatcher	*Myiarchus cinerascens*	II
Bald Eagle	*Haliaeetus leucocephalus*	II
Black Tern	*Chlidonias niger*	II
Black-crowned Night-Heron	*Nycticorax nycticorax*	II
Boreal Owl	*Aegolius funereus*	II
Bushtit	*Psaltriparus minimus*	II
Caspian Tern	*Hydroprogne caspia*	II
Cattle Egret	*Bubulcus ibis*	II
Forster’s Tern	*Sterna forsteri*	II
Harlequin Duck	*Histrionicus histrionicus*	II
Juniper Titmouse	*Baeolophus ridgwayi*	II
Long-billed Curlew	*Numenius americanus*	II
Peregrine Falcon	*Falco peregrinus*	II
Pygmy Nuthatch	*Sitta pygmaea*	II
Snowy Egret	*Egretta thula*	II
Western Scrub-Jay	*Aphelocoma californica*	II
White-faced Ibis	*Plegadis chihi*	II
Williamson’s Sapsucker	*Sphyrapicus thyroideus*	II
American White Pelican	*Pelecanus erythrorhynchos*	II
Baird’s Sparrow	*Ammodramus bairdii*	II
Black-billed Cuckoo	*Coccyzus erythropthalmus*	II
Black-throated Gray Warbler	*Setophaga nigrescens*	II
Bobolink	*Dolichonyx oryzivorus*	II
Brewer’s Sparrow	*Spizella breweri*	II
Calliope Hummingbird	*Selasphorus calliope*	II
Chestnut-collared Longspur	*Calcarius ornatus*	II
Clark’s Nutcracker	*Nucifraga columbiana*	II
Columbian Sharp-tailed Grouse	*Tympanuchus phasianellus columbianus*	II
Ferruginous Hawk	*Buteo regalis*	II
Golden Eagle	*Aquila chrysaetos*	II

Common Name	Scientific Name	Tier
Grasshopper Sparrow	*Ammodramus savannarum*	II
Great Blue Heron	*Ardea herodias*	II
Greater Sage-Grouse	*Centrocercus urophasianus*	II
Loggerhead Shrike	*Lanius ludovicianus*	II
MacGillivray's Warbler	*Geothlypis tolmiei*	II
McCown's Longspur	*Rhynchophanes mccownii*	II
Red Crossbill	*Loxia curvirostra*	II
Red-eyed Vireo	*Vireo olivaceus*	II
Red-headed Woodpecker	*Melanerpes erythrocephalus*	II
Rufous Hummingbird	*Selasphorus rufus*	II
Sage Thrasher	*Oreoscoptes montanus*	II
Sagebrush Sparrow	*Artemisiospiza nevadensis*	II
Short-eared Owl	*Asio flammeus*	II
Black Rosy-Finch	*Leucosticte atrata*	II
Black-backed Woodpecker	*Picoides arcticus*	II
Black-chinned Hummingbird	*Archilochus alexandri*	II
Brown-capped Rosy-Finch	*Leucosticte australis*	II
Clark's Grebe	*Aechmophorus clarkii*	II
Dickcissel	*Spiza americana*	II
Franklin's Gull	*Leucophaeus pipixcan*	II
Gray Vireo	*Vireo vicinior*	II
Great Gray Owl	*Strix nebulosa*	II
Lewis's Woodpecker	*Melanerpes lewis*	II
Northern Pygmy-Owl	*Glaucidium gnoma*	II
Scott's Oriole	*Icterus parisorum*	II
Swainson's Hawk	*Buteo swainsoni*	II
Upland Sandpiper	*Bartramia longicauda*	II
Virginia's Warbler	*Oreothlypis virginiae*	II
Western Grebe	*Aechmophorus occidentalis*	II
Yellow-billed Cuckoo	*Coccyzus americanus*	II
Willow Flycatcher	*Empidonax traillii*	III
American Kestrel	*Falco sparverius*	III
American Pipit	*Anthus rubescens*	III
Bewick's Wren	*Thryomanes bewickii*	III
Blue Grosbeak	*Passerina caerulea*	III
Blue-gray Gnatcatcher	*Polioptila caerulea*	III
Canyon Wren	*Catherpes mexicanus*	III
Common Nighthawk	*Chordeiles minor*	III
Common Yellowthroat	*Geothlypis trichas*	III
Flammulated Owl	*Psiloscops flammeolus*	III
Merlin	*Falco columbarius*	III
Purple Martin	*Progne subis*	III
Snowy Plover	*Charadrius nivosus*	III

Common Name	Scientific Name	Tier
Virginia Rail	*Rallus limicola*	III
Mammals		
Black-footed Ferret	*Mustela nigripes*	I
Canada Lynx	*Lynx canadensis*	I
Wyoming Pocket Gopher	*Thomomys clusius*	I
American Pika	*Ochotona princeps*	II
Northern Long-eared Myotis	*Myotis septentrionalis*	II
Canyon Deermouse	*Peromyscus crinitus*	II
Cliff Chipmunk	*Tamias dorsalis*	II
Dwarf Shrew	*Sorex nanus*	II
Eastern Spotted Skunk	*Spilogale putorius*	II
Fringed Myotis	*Myotis thysanodes*	II
Idaho Pocket Gopher	*Thomomys idahoensis*	II
Little Brown Myotis	*Myotis lucifugus*	II
Northern River Otter	*Lontra canadensis*	II
Pallid Bat	*Antrozous pallidus*	II
Piñon Deermouse	*Peromyscus truei*	II
Plains Harvest Mouse	*Reithrodontomys montanus*	II
Preble's Meadow Jumping Mouse	*Zapus hudsonius preblei*	II
Pygmy Rabbit	*Brachylagus idahoensis*	II
Sand Hills Pocket Gopher	*Geomys lutescens*	II
Townsend's Big-eared Bat	*Corynorhinus townsendii*	II
Water Vole	*Microtus richardsoni*	II
Wolverine	*Gulo gulo*	II
Bighorn Sheep	*Ovis canadensis*	II
Black-tailed Prairie Dog	*Cynomys ludovicianus*	II
Moose	*Alces americanus*	II
Northern Flying Squirrel	*Glaucomys sabrinus*	II
Sagebrush Vole	*Lemmiscus curtatus*	II
Swift Fox	*Vulpes velox*	II
Western Small-footed Myotis	*Myotis ciliolabrum*	II
White-tailed Prairie Dog	*Cynomys leucurus*	II
Abert's Squirrel	*Sciurus aberti*	III
Eastern Red Bat	*Lasiurus borealis*	III
Long-eared Myotis	*Myotis evotis*	III
Long-legged Myotis	*Myotis volans*	III
Meadow Jumping Mouse	*Zapus hudsonius*	III
Olive-backed Pocket Mouse	*Perognathus fasciatus*	III
Spotted Bat	*Euderma maculatum*	III
Spotted Ground Squirrel	*Xerospermophilus spilosoma*	III
Uinta Chipmunk	*Tamias umbrinus*	III
Yellow-pine Chipmunk	*Tamias amoenus*	III
Yuma Myotis	*Myotis yumanensis*	III

Common Name	Scientific Name	Tier
American Pygmy Shrew	*Sorex hoyi*	III
Great Basin Pocket Mouse	*Perognathus mollipilosus*	III
Hayden's Shrew	*Sorex haydeni*	III
Hispid Pocket Mouse	*Chaetodipus hispidus*	III
Least Weasel	*Mustela nivalis*	III
Plains Pocket Mouse	*Perognathus flavescens*	III
Preble's Shrew	*Sorex preblei*	III
Ringtail	*Bassariscus astutus*	III
Silky Pocket Mouse	*Perognathus flavus*	III
Western Spotted Skunk	*Spilogale gracilis*	III
Fish		
Bluehead Sucker	*Catostomus discobolus*	I
Flannelmouth Sucker	*Catostomus latipinnis*	I
Hornyhead Chub	*Nocomis biguttatus*	I
Kendall Warm Springs Dace	*Rhinichthys osculus thermalis*	I
Roundtail Chub	*Gila robusta*	I
Colorado River Cutthroat Trout	*Oncorhynchus clarkii pleuriticus*	II
Finescale Dace	*Chrosomus neogaeus*	II
Northern Pearl Dace	*Margariscus nachtriebi*	II
Sturgeon Chub	*Macrhybopsis gelida*	II
Suckermouth Minnow	*Phenacobius mirabilis*	II
Western Silvery Minnow	*Hybognathus argyritis*	II
Bonneville Cutthroat Trout	*Oncorhynchus clarkii utah*	II
Burbot	*Lota lota*	II
Goldeye	*Hiodon alosoides*	II
Iowa Darter	*Etheostoma exile*	II
Northern Leatherside Chub	*Lepidomeda copei*	II
Northern Plains Killifish	*Fundulus kansae*	II
Orangethroat Darter	*Etheostoma spectabile*	II
Plains Minnow	*Hybognathus placitus*	II
Plains Topminnow	*Fundulus sciadicus*	II
Sauger	*Sander canadensis*	II
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*	II
Snake River Cutthroat Trout	*Oncorhynchus clarkii spp.*	II
Yellowstone Cutthroat Trout	*Oncorhynchus clarkii bouvieri*	II
Bigmouth Shiner	*Notropis dorsalis*	III
Brassy Minnow	*Hybognathus hankinsoni*	III
Common Shiner	*Luxilus cornutus*	III
Flathead Chub	*Platygobio gracilis*	III
Amphibians		
Western Toad	*Anaxyrus boreas*	I
Wyoming Toad	*Anaxyrus baxteri*	I
Wood Frog	*Lithobates sylvaticus*	II

Common Name	Scientific Name	Tier
Columbia Spotted Frog	*Rana luteiventris*	II
Great Basin Spadefoot	*Spea intermontana*	II
Northern Leopard Frog	*Lithobates pipiens*	II
Plains Spadefoot	*Spea bombifrons*	II
Great Plains Toad	*Anaxyrus cognatus*	II
Western Tiger Salamander	*Ambystoma mavortium*	III
Reptiles		
Midget Faded Rattlesnake	*Crotalus oreganus concolor*	I
Northern Tree Lizard	*Urosaurus ornatus wrighti*	II
Eastern Spiny Softshell	*Apalone spinifera spinifera*	II
Great Basin Gophersnake	*Pituophis catenifer deserticola*	II
Northern Rubber Boa	*Charina bottae*	II
Pale Milksnake	*Lampropeltis triangulum multistriata*	II
Smooth Greensnake	*Opheodrys vernalis*	II
Greater Short-horned Lizard	*Phrynosoma hernandesi*	II
Black Hills Red-bellied Snake	*Storeria occipitomaculata pahasapae*	II
Desert Striped Whipsnake	*Coluber taeniatus taeniatus*	II
Northern Many-lined Skink	*Plestiodon multivirgatus multivirgatus*	II
Plains Hog-nosed Snake	*Heterodon nasicus*	II
Prairie Lizard	*Sceloporus consobrinus*	II
Prairie Racerunner	*Aspidoscelis sexlineata viridis*	II
Plateau Fence Lizard	*Sceloporus tristichus*	III
Prairie Rattlesnake	*Crotalus viridis*	III
Western Painted Turtle	*Chrysemys picta bellii*	III
Great Basin Skink	*Plestiodon skiltonianus utahensis*	III
Great Plains Earless Lizard	*Holbrookia maculata maculata*	III
Plains Box Turtle	*Terrapene ornata ornata*	III
Plains Black-headed Snake	*Tantilla nigriceps*	III
Plains Gartersnake	*Thamnophis radix*	III
Red-sided Gartersnake	*Thamnophis sirtalis parietalis*	III
Valley Gartersnake	*Thamnophis sirtalis fitchi*	III
Crustaceans		
Pilose Crayfish	*Pacifastacus gambelii*	II
Ringed Crayfish	*Orconectes neglectus*	II
Constricted Fairy Shrimp	*Branchinecta constricta*	II
Mackin Fairy Shrimp	*Streptocephalus mackini*	II
Calico/Papershell Crayfish	*Orconectes immunis*	III
Devil Crayfish	*Cambarus diogenes*	III
Beavertail Fairy Shrimp	*Thamnocephalus platyurus*	III
Fairy, Tadpole, and Clam Shrimp (many species)		III
Mollusks		
Plain Pocketbook	*Lampsilis cardium*	I
Green River Pebblesnail	*Fluminicola coloradoensis*	I

Common Name	Scientific Name	Tier
Mountainsnails (many species)		I
California Floater	*Anodonta californiensis*	II
Cylindrical Papershell	*Anodontoides ferussacianus*	II
Jackson Lake Springsnail	*Pyrgulopsis robusta*	II
Cave Physa	*Physa spelunca*	II
Cooper's Rocky Mountain Mountainsnail	*Oreohelix strigosa cooperi*	II
Aquatic Snails (many species)		II
Land Snails (many species)		II
Pygmy Mountainsnail	*Oreohelix pygmaea*	II
Yavapai Mountainsnail	*Oreohelix yavapai*	II
Ash Gyro	*Gyraulus parvus*	III
Creeping Ancylid	*Ferrissia rivularis*	III
Dusky Fossaria	*Fossaria dalli*	III
Forest Disc	*Discus whitneyi*	III
Giant Floater	*Pyganodon grandis*	III
Marsh Rams-horn	*Planorbella trivolvis*	III
Multirib Vallonia	*Vallonia gracilicosta*	III
Pewter Physa	*Physa acuta*	III
Pill or Fingernail Clams (many species)		III
Prairie Fossaria	*Fossaria bulimoides*	III
Quick Gloss	*Zonitoides arboreus*	III
Rocky Mountain Mountainsnail	*Oreohelix strigosa*	III
Stagnicola Pond Snails (many species)		III
Subalpine Mountainsnail	*Oreohelix subrudis*	III
Tadpole Physa	*Physa gyrina*	III
Umbilicate Sprite	*Promenetus umbilicatellus*	III
Western Glass-snail	*Vitrina pellucida*	III

Data Summary 7.5-1
Primary Potential Funding Sources

Agency/Entity	Program Name	Project Type(s)	Internet URL	Telephone
Local				
Teton Conservation District	N/A	Liaison, In-Kind administrative and technical assistance, program coordination/partnering	http://www.tetonconservation.org/programs/	(307) 733-2110
Dubois-Crowheart Conservation District	N/A	Liaison, In-Kind administrative and technical assistance, program coordination/partnering	http://duboiscrowheart.org	(307) 455-3688
Sublette County Conservation District	N/A	Liaison, In-Kind administrative and technical assistance, program coordination/partnering	http://www.sublettecd.com	(307) 367-2257
Star Valley Conservation District	N/A	Liaison, In-Kind administrative and technical assistance, program coordination/partnering	http://www.starvalleycd.org/	(307) 885-7823
State				
Wyoming Department of Environmental Quality	Nonpoint Source Implementation Grants (Section 319 Program)	Water Quality Best Management Practices	http://deq.wyoming.gov/	307-777-7937
Wyoming Game and Fish Department	Habitat Trust Fund	Promotes Water Quality	https://wgfd.wyo.gov/web2011/home.aspx	307-777-4600
	Fish Passage Grants	Fish passage ladders or fish screens		
Wyoming Office of State Lands and Investments	Farm Loan Program	Agricultural and Livestock Assistance	http://lands.wyo.gov/	307-777-7331
	The Irrigation Loans Program	Small and large Agricultural Water Development Projects		
	Joint Powers Act Loan Program	Government Services and Public Facilities		
Wyoming Water Development Commission	New Development Program	Water Supply Development	http://wwdc.state.wy.us/	307-777-7626
	Rehabilitation Program	Improvements of Existing Water Projects		
	Dam and Reservoir Program	New Dams and Dam expansion		
	Small Water Projects Program	Construction/Rehabilitation of Small Reservoirs, Wells, Pipelines, Springs, Solar Platforms, Irrigation Works, Windmills, and Wetland Development		
Wyoming Department of Agriculture	Rangeland Health Assessment Program	Monitoring of rangeland	http://wyagric.state.wy.us/	(307) 777-7321
Wyoming Wildlife and Natural Resource Trust	N/A	Wildlife Habitat Improvements and Natural Resource Improvements/Preservation	http://wwnrt.state.wy.us/	307-777-8024
Federal				
Bureau of Land Management	Riparian Habitat Management Program	Improve/Restore/Protect Riparian Areas	http://www.blm.gov/wy/st/en.html	307-775-6256
	Range Improvement Planning and Development	Water Development for Livestock, Livestock BMP,		
	Watershed and Water Quality Improvement	Restoration and Maintenance of Watershed Function		
Bureau of Reclamation	WaterSMART	Promotes Water Management	http://www.usbr.gov/gp/wyao/	307-261-5671
	Water Conservation Field Services Program	Conservation Improvements		
Environmental Protection Agency	Targeted Watersheds Grants Program	Riparian, Wetland, Aquatic and Upland Habit Protection and Improvement	https://www.epa.gov/wy	303-312-6692
Farm Service Agency	Conservation Reserve Program	Removal of Highly Erodible Cropland from Production	http://www.fsa.usda.gov/state-offices/Wyoming/index	307-261-5231
	Continuous Sign-Up for High Priority Conservation Practices	Riparian Buffers, Filter Strips, Grass Waterways, Shelter Belts, Field Windbreak, Living Snow Fences, Contour Grass Strips, Salt Tolerant Vegetation, and Shallow Water Areas		
	Emergency Conservation Program	Farmland Rehabilitation Damaged by Natural Disasters or Emergency Water Conservation for Livestock		

Agency/Entity	Program Name	Project Type(s)	Internet URL	Telephone
Fish and Wildlife Service	Partners for Fish and Wildlife Program (PFW)	Grazing lands management, sage steppe enhancement, stream habitat improvement and fish passage, invasive species removal, and wetland establishment	http://www.fws.gov/	307-332-7607
	Wildlife and Sport Fish Restoration (WSFR)	Multiple grant programs to conserve, protect, and enhance fish, wildlife and their habitats.		
	Conservation Planning and Assistance Program	Infrastructure development projects to protect the environment and preserve our nation's biological, terrestrial, and aquatic natural resources.		
	Cooperative Endangered Species Conservation Fund	Conservation projects for candidate, proposed, and listed species		
	North American Wetlands Conservation Act Grant Program	Conservation program supports acquisition, enhancement, and restoration of wetlands and wetlands-associated habitat		
	National Wildlife Refuge Challenge Cost Share Program	For USFWS refuges to manage cooperatively the natural and cultural resources and fulfill stewardship responsibilities to fish and wildlife management		
Natural Resource Conservation Service	Environmental Quality Incentives Program (EQIP)	Improve Water Quality, Enhance Grazing Lands, and Increase Water Conservation	http://www.wy.nrcs.usda.gov/	307-233-6750
	Conservation Stewardship Program (CSP)	The program encourages land stewards to improve their conservation performance		
	The Regional Conservation Partnership Program (RCPP)	Deliver conservation assistance to producers and landowners		
	The Agricultural Management Assistance (AMA)	Financial assistance to address water management, water quality, invasive species control, and erosion control issues		
	Conservation Innovation Grants (CIG)	Stimulates the development and adoption of innovative conservation approaches		
	The Agricultural Conservation Easement Program (ACEP)	Protects working agricultural lands and limits non-agricultural uses of the land		
Non-Profit and Other Organizations				
Ducks Unlimited	Matching Aid to Restore States Habitat	Wetlands and Waterfowl Restoration	http://www.ducks.org/wyoming	(307) 733-3567
National Fish and Wildlife Foundation	Five-Star Restoration Matching Grants Program	Wetland, Riparian, and Coastal Habitat Restoration	http://www.nfwf.org/	202-857-0166
	Bring Back the Natives	Preserve/Enhance Native Aquatic Species		
	Native Plant Conservation Initiative	Conservation of Native Plantlife		
	Pulling Together Initiative	Invasive Plant Species Control		
Trout Unlimited	Snake River Headwaters Home Rivers Initiative	Partnership and grant coordination, reconnecting and restoring trout habitat. Irrigation diversion and efficiency upgrades, culvert replacements, fish screens and ladders, channel and stream restoration	http://wyomingtu.org/	307-699-1022
Sage Grouse Initiatives (multiple)	Multiple	Habitat Improvements to Benefit Sage Grouse	Varies, See Section 7.5	

Appendix B

Ecological Site Description

Site Name: Subirrigated (Sb) 15-19: Northern Plains Precipitation Zone
Site ID: 043BY474WY

United States Department of Agriculture
Natural Resources Conservation Service

Ecological Site Description

Site Type: Rangeland

Site Name: Subirrigated (Sb) 15-19" Northern Plains Precipitation Zone,

Site ID: 043BY474WY

Major Land Resource Area: 43B – Central Rocky Mountains

Physiographic Features
This site normally occurs on nearly level bottomlands and adjacent to perennial streams, springs and ponds.

Landform: Hill sides, alluvial fans, ridges & stream terraces **Aspect:** N/A

	Minimum	Maximum
Elevation (feet):	3700	7500
Slope (percent):	0	6
Water Table Depth (inches):	12	40
Flooding:		
Frequency:	rare	occasional
Duration:	brief	very brief
Ponding:		
Depth (inches):	0	0
Frequency:	None	None
Duration:	None	None
Runoff Class:	negligible	low

Climatic features
Annual precipitation ranges from 15" to 19" per year. May is generally the wettest month. July, August and September are somewhat drier with daily amounts rarely exceeding one inch. Snowfall is quite heavy in the mountainous area. Annual snowfall averages close to 70 inches.

Sunshine is abundant in the latter part of the summer, the greatest amount being in July and August. Sunshine possibility during these two months averages 70 to 75% possibility with only a 65% possibility for June and September. Winter averages about 40% sunshine.

Because of the varied topography, the wind will vary considerably for different parts of the area. The wind is usually much lighter at the lower elevations and in the valleys as compared with the higher terrain. The average winter wind velocity is 8.5 mph, while the summer wind velocity averages 7.5 mph. Winds during storms and on ridges may exceed 45 mph.

Temperatures show a wide range between summer and winter, and between daily maximums and minimums. Summer nights are cool and temperatures drop into the forties at most places before sunrise. Summer daytime temperatures are usually in the seventies and occasionally reach eighty, but rarely reach the mid nineties. Winters are cold with daily lows below freezing most of the time. January has the coldest temperatures with a range of near 10 deg. F at night to the mid thirties in the afternoon. Temperatures of well below zero to –30 deg. F are not uncommon in the winter months.

The growing season for the cool season plants will generally start about April 15 to May 1 and continue to about October 10.

The following information is from the "Sheridan Airport" climate station:
Frost-free period (32 °F): 95-156 days; (5 yrs. out of 10, these days will occur between May 21 – September 19)
Freeze-free period 28 °F): 116-187 days; (5 yrs. out of 10, these days will occur between May 4 – September 29)
Mean annual precipitation: 14.7 inches
Mean annual air temperature: 45.0 °F (31.2 °F Avg. Min. – 58.8 °F Avg. Max.)

For detailed information visit the Natural Resources Conservation Service National Water and Climate Center at http://www.wcc.nrcs.usda.gov/ website. Other climate station(s) representative of this precipitation zone include: "Parkman 5 WNW"

Influencing Water Features

Wetland Description:	**System**	**Subsystem**	**Class**	**Sub-class**
None	None	None	None	None

Stream Type: C (Rosgen)

Representative Soil Features

These are subirrigated soils of various depths and textures where nonsaline and/or nonalkaline water tables are within reach of the herbaceous species (usually less than three feet) through most of the growing season.

Parent Material Kind: alluvium
Parent Material Origin: sandstone, shale
Surface Texture: loam, clay loam, silt loam, fine sandy loam, sandy loam, clay, loamy sand
Surface Texture Modifier: none
Subsurface Texture Group: clay loam
Surface Fragments ≤ 3" (% Cover): 0
Surface Fragments > 3" (%Cover): 0
Subsurface Fragments ≤ 3" (% Volume): 0
Subsurface Fragments > 3" (% Volume): 0

	Minimum	**Maximum**
Drainage Class:	poorly drained	moderately well drained
Permeability Class:	moderately slow	moderately rapid
Depth (inches):	20	>60
Electrical Conductivity (mmhos/cm) ≤20":	0	8
Sodium Absorption Ratio ≤20":	0	10
Soil Reaction (1:1 Water) ≤20":	6.6	9.0
Soil Reaction (0.1M CaCl2) ≤20":	NA	NA
Available Water Capacity (inches) ≤30":	2.8	6.2
Calcium Carbonate Equivalent (percent) ≤20":	0	10

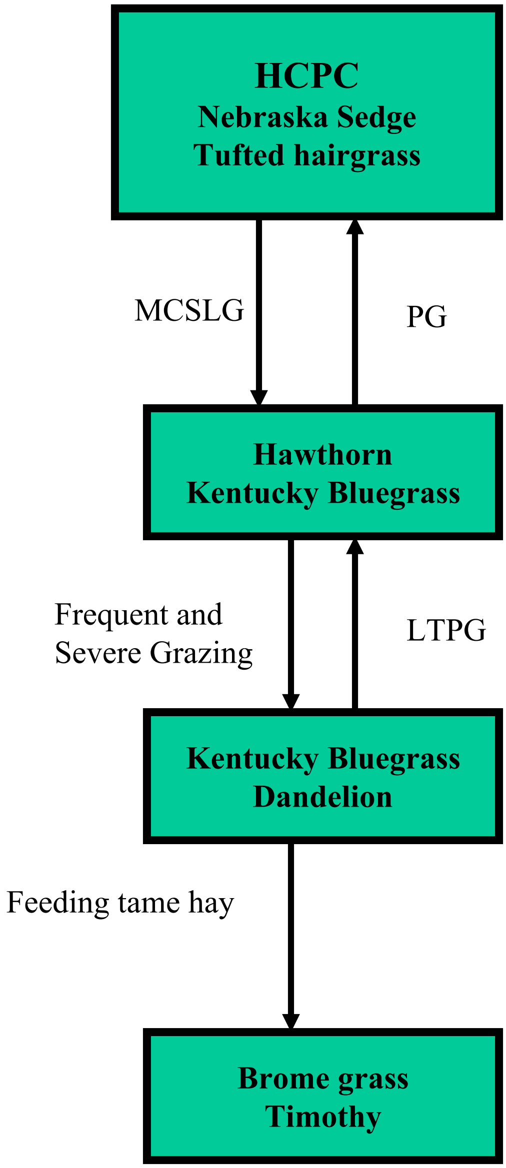
Plant Communities

Ecological Dynamics of the Site:

As this site deteriorates from improper grazing management, species such as spike sedge and Baltic rush increase. Species such as Kentucky bluegrass invade. Grasses such as tufted hairgrass, Nebraska sedge and northern and blue-joint reedgrass will decrease in frequency and production.

The Historic Climax Plant Community (description follows the plant community diagram) has been determined by study of rangeland relic areas, or areas protected from excessive disturbance. Trends in plant communities going from heavily grazed areas to lightly grazed areas, seasonal use pastures, and historical accounts have also been used.

The following is a State and Transition Model Diagram that illustrates the common plant communities (states) that can occur on the site and the transitions between these communities. The ecological processes will be discussed in more detail in the plant community narratives following the diagram.



BM - Brush Management (fire, chemical, mechanical)
Freq. & Severe Grazing - Frequent and Severe Utilization of the Cool-season Mid-grasses during the Growing Season
GLMT - Grazing Land Mechanical Treatment
LTPG - Long-tem Prescribed Grazing
MCSLG - Moderate, Continuous Season-long Grazing
NU, NF - No Use and No Fire
PG - Prescribed Grazing (proper stocking rates with adequate recovery periods during the growing season)
VLTPG - Very Long-term Prescribed Grazing (could possibly take generations)
Na - Moderate Sodium in Soil

Plant Community Composition and Group Annual Production

Reference Plant Community (HCPC)

COMMON NAME/GROUP NAME	SCIENTIFIC NAME	SYMBOL	Annual Production (Normal Year) Total: 5000		
			Group	lbs./acre	% Comp.
GRASSES AND GRASS-LIKES					
GRASSES/GRASSLIKES					
Nebraska sedge	Carex nebrascensis	CANE2	1	500 - 1250	10 - 25
Reedgrasses	Calamagrostis spp.	CALAM	2	500 - 1250	10 - 25
Tufted hairgrass	Deschampsia caespitosa	DECA18	3	500 - 1000	10 - 20
Spike sedge	Carex nardina	CANA2	4	500 - 1000	10 - 20
MISC. GRASSES/GRASSLIKES			**5**	**500 - 1000**	**10 - 20**
Alpine timothy	Phleum alpinum	PHAL2	5	0 - 250	0 - 5
Baltic rush	Juncus balticus	JUBA	5	0 - 250	0 - 5
Basin wildrye	Leymus cinereus	LECI4	5	0 - 250	0 - 5
Bearded wheatgrass	Elymus caninus	ELCA11	5	0 - 250	0 - 5
Bluejoint Reedgrass	Calamagrostis canadensis	CACAM	5	0 - 250	0 - 5
Canada wildrye	Elymus canadensis	ELCA4	5	0 - 250	0 - 5
Fowl bluegrass	Poa palustris	POPA2	5	0 - 250	0 - 5
Idaho fescue	Festuca idahoensis	FEID	5	0 - 250	0 - 5
Northern Reedgrass	Calamagrostis stricta	CAST13	5	0 - 250	0 - 5
Prairie cordgrass	Spartina pectinata	SPPE	5	0 - 250	0 - 5
Pumpelly bromegrass	Bromus inermis ssp. pumpellianus	BRINP5	5	0 - 250	0 - 5
Western wheatgrass	Pascopyrum smithii	PASM	5	0 - 250	0 - 5
other perennial grasses (native)		2GP	5	0 - 250	0 - 5
FORBS			**6**	**250 - 750**	**5 - 15**
American licorice	Glycyrrhiza lepidota	GLLE3	6	0 - 250	0 - 5
Blue-eyed grass	Sisyrinchium spp.	SISYR	6	0 - 250	0 - 5
cinquefoils	Potentilla spp.	POTEN	6	0 - 250	0 - 5
Mint	Mentha spp.	MENTH	6	0 - 250	0 - 5
Prairie coneflower	Ratibida columnifera	RACO3	6	0 - 250	0 - 5
Sticky geranium	Geranium viscosissimum	GEVI2	6	0 - 250	0 - 5
Western virginsbower	Clematis lequsticifolia	CLLI2	6	0 - 250	0 - 5
yarrows	Achillea spp.	ACHIL	6	0 - 250	0 - 5
other perennial forbs (native)		2FP	6	0 - 250	0 - 5
TREES/SHRUBS					
MISC. SHRUBS			**7**	250 - 500	**5 - 10**
American plum	Prunus americana	PRAM	7	0 - 250	0 - 5
Boxelder	Acer negundo ssp. interius	ACNE12	7	0 - 250	0 - 5
Chokecherry	Prunus virginiana	PRVIV	7	0 - 250	0 - 5
Hawthorn	Crataegus spp.	CRATA	7	0 - 250	0 - 5
Snowberry	Symphoricarpus occidentalis	SYOC	7	0 - 250	0 - 5
Wild Rose	Rosa woodsii var. woodsii	ROWOW	7	0 - 250	0 - 5
Willows	Salix spp.	SALIX	7	0 - 250	0 - 5
other shrubs & half shrubs (native)		2SHRUB	7	0 - 250	0 - 5

This list of plants and their relative proportions are based on near normal years. Fluctuations in species composition and relative production may change from year to year dependent upon precipitation or other climatic factors.

Plant Community Narratives

Following are the narratives for each of the described plant communities. These plant communities may not represent every possibility, but they probably are the most prevalent and repeatable plant communities. The plant composition tables shown above have been developed from the best available knowledge at the time of this revision. As more data is collected, some of these plant communities may be revised or removed, and new ones may be added. None of these plant communities should necessarily be thought of as "Desired Plant Communities". According to the USDA NRCS National Range and Pasture Handbook, Desired Plant Communities (DPC's) will be determined by the decision-makers and will meet minimum quality criteria established by the NRCS. The main purpose for including any description of a plant community here is to capture the current knowledge and experience at the time of this revision.

Nebraska Sedge, Tufted Hairgrass Plant Community

The interpretive plant community for this site is the Historic Climax Plant Community. This site evolved with grazing by large herbivores and is well suited for grazing by domestic livestock. Potential vegetation is about 75% grasses or grass-like plants, 15% forbs and 10% woody plants. The major grasses include Nebraska sedge, tufted hairgrass and spike sedge. Grasses of lesser importance are western wheatgrass, bearded wheatgrass, Canada wildrye, basin wildrye, prairie cordgrass, bluejoint reedgrass and northern reedgrass. Woody plants are mainly snowberry, chokecherry, hawthorn, boxelder, American plum, wild rose and willows.

This state produces between 3500 and 6000 pounds annually, depending on the growing conditions.

The following is the growth curve of this plant community expected during a normal year:
Growth curve number:
Growth curve name:
Growth curve description:

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	10	30	35	10	5	5	5	0	0

(Monthly percentages of total annual growth)

The state is extremely resilient and well adapted to the Northern Great Plains climatic conditions. The diversity in plant species allow for high drought resistance. This is a healthy and sustainable plant community (site/soil stability, watershed function, and biologic integrity).

Transitions or pathways leading to other plant communities are as follows:

- Moderate, continuous season-long grazing will convert this plant community to the *Hawthorn/Kentucky bluegrass Vegetation State.*

- Heavy, continuous, improper grazing will convert this plant community to *Kentucky bluegrass/Dandelion Vegetation State.*

- Feeding tame hay on this state will convert this site to *Brome/Timothy Vegetation state.*

Hawthorn/Kentucky Bluegrass Plant Community

This plant community is the result of moderate season long grazing by domestic livestock. Dominant grasses include rhizomatous wheatgrasses, Kentucky bluegrass, spike sedge and Baltic rush Forbs, commonly found in this plant community, include Louisiana sagewort (cudweed), cinquefoil, and scarlet globemallow. Hawthorn, snowberry, wild rose, boxelder, American plum and willows are common in the overstory.

This state produces between 1800 and 3500 pounds annually, depending on the growing conditions.

When compared to the Historical Climax Plant Community, tufted hairgrass, Nebraska sedge and northern and bluejoint reedgrass have decreased. Spike sedge and cinquefoil have increased. Kentucky bluegrass and curlycup gumweed have invaded, The abundant production and proximity to water make this state important for livestock and wildlife such as birds, mule deer and antelope.

The state is stable and protected from excessive erosion. The biotic integrity of this plant community is usually intact. The watershed is usually functioning.

The following is the growth curve of this plant community expected during a normal year:
Growth curve number:
Growth curve name:
Growth curve description:

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	10	30	35	10	5	5	5	0	0

(Monthly percentages of total annual growth)

Transitions or pathways leading to other plant communities are as follows:

- Prescribed grazing over the long-term will result in a plant community very similar to the *Historic Climax Plant Community.*

- Heavy, continuous, improper grazing will convert this plant community to *the Kentucky bluegrass/Dandelion Vegetation State.*

Kentucky Bluegrass/Dandelion Plant Community
This plant community is the result of long-term improper grazing use. This state is dominated by Kentucky bluegrass, dandelion, curlycup gumweed, hawthorn and cheatgrass. The site has been invaded by American licorice and Russian olive. Leafy spurge may invade this state. Willows are reduced.

Production ranges from 900 to 1500 pounds.

Bare ground has increased. The soil of this state is not well protected. Degraded stream banks may erode. The watershed is functioning but may produce excessive runoff. The biotic community is at risk due to invasive plants.

The following is the growth curve of the plant community expected during a normal year:
Growth curve number:
Growth curve name:
Growth curve description:

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	10	30	35	10	5	5	5	0	0

(Monthly percentages of total annual growth)

Transitions or pathways leading to other plant communities are as follows:

- Proper grazing use over the long-term will return this state to near *historic climax plant community plant community.*
- Feeding tame hay on this state will convert the site to *Brome/Timothy vegetation state.*

Brome/Timothy Plant Community
This state has been changed to a site dominated by tame grasses. The main species are smooth brome, timothy, Kentucky bluegrass and cheatgrass. Production for domestic animal grazing is

comparable to Climax conditions. The state is often invaded by noxious weeds such as leafy spurge and Canada thistle.

Production ranges from 1200 to 5000 pounds, depending on climatic conditions.

Bare ground has increased. The soil of this state is not well protected. Degraded stream banks may erode. The watershed is functioning but may produce excessive runoff. The biotic community is at risk due to invasive plants.
The following is the growth curve of the plant community expected during a normal year:
Growth curve number:
Growth curve name:
Growth curve description:

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	10	30	35	10	5	5	5	0	0

(Monthly percentages of total annual growth)

Transitions or pathways leading to other plant communities are as follows:

- Changing this state to the *Historical Climax Plant Community* may be difficult due to the dominance of tame species.

Ecological Site Interpretations

Animal Community – Wildlife Interpretations

Nebraska Sedge, Tufted Hairgrass Plant Community (HCPC): The predominance of grasses in this plant community favors grazers and mixed-feeders, such as bison, elk, and antelope. Woody vegetation provides thermal cover and habitat for migratory birds when found adjacent to sagebrush dominated states, this plant community may provide brood rearing/foraging areas for sage grouse, as well as lek sites. Other birds that would frequent this plant community include western meadowlarks, horned larks, migratory song birds, and golden eagles. Many grassland obligate small mammals would occur here.

Hawthorn/Kentucky Bluegrass Plant Community:
This plant community may be useful for the same large grazers that would use the Historic Climax Plant Community. Hawthorn trees will provide habitat for migratory song birds. However, the plant community composition is less diverse, and thus, less apt to meet the seasonal needs of grazing animals. It may provide some foraging opportunities for sage grouse when it occurs proximal to woody cover. Good grasshopper habitat equals good foraging for birds.

Kentucky Bluegrass/Dandelion Plant Community:
This plant community may be useful for the same large grazers that would use the Historic Climax Plant Community. However, the plant community composition is less diverse, and thus, less apt to meet the seasonal needs of these animals. It may provide some foraging opportunities for sage grouse when it occurs proximal to woody cover. Good grasshopper habitat equals good foraging for birds.
Brome/Timothy Plant Community: This plant community may be useful for the same large grazers that would use the Historic Climax Plant Community. However, the plant community composition is less diverse, and thus, less apt to meet the seasonal needs of these animals. It may provide some foraging opportunities for sage grouse when it occurs proximal to woody cover. Good grasshopper habitat equals good foraging for birds.

Animal Preferences (Quarterly - 1,2,3,4) for commonly occuring plants in MLRA 43B, 15-19 inch Northern Plains

COMMON NAME/	SCIENTIFIC NAME	SCI. SYMBOL	*Cattle*	*Sheep*	*Horses*	*Mule Deer*	*Antelope*
GRASSES AND GRASS-LIKES							
Alpine timothy	Phelum alpinum	PHAL2	PPPP	PPPP	PPPP	DDDD	UUUU
Baltic rush	Juncus balticus	JUBA	DDDD	UUUU	DDDD	UUUU	UUUU
Basin wildrye	Leymus cinereus	LECI4	PPPP	PPPP	PPPP	DDDD	DDDD
Bearded wheatgrass	Elymus caninus	ELCA	PPPP	DDDD	PPPP	DDDD	DDDD
Big bluegrass	Poa ampla (syn. to Poa secunda)	POAM (POSE)	PPPP	PPPP	PPPP	DDDD	DDDD
Blue grama	Bouteloua gracilis	BOGR2	DDDD	DDDD	DDDD	DDDD	DDDD
Blue wildrye	Elymus glaucus	ELGL	PPPP	DDDD	DDDD	DDDD	DDDD
Bluebunch wheatgrass	Pseudoroegneria spicata	PSSP6	PPPP	PPPP	PPPP	DDDD	DDDD
Bluejoint Reedgrass	Calamagrostis canadensis	CACA4	PPPP	DDDD	PPPP	UUUU	UUUU
Bottlebrush squirreltail	Elymus elymoides	ELELE	DDDD	DDDD	DDDD	UUUU	UUUU
Canada wildrye	Elymus canadensis	ELCA4	PPPP	PPPP	PPPP	DDDD	DDDD
Canby bluegrass	Poa canbyi (syn. to Poa secunda)	POCA (POSE)	PPPP	PPPP	PPPP	PPPP	PPPP
Columbia needlegrass	Achnatherum nelsonii	ACNE3	PPPP	PPPP	DDDD	DDDD	DDDD
Cusic bluegrass	Ribes spp.	RIBES	DDDD	DDDD	DDDD	PPPP	DDDD
Dunehead sedge	Carex phaeocephala	CAPH2	UUUU	UUUU	UUUU	UUUU	UUUU
Fowl bluegrass	Poa palustris	POPA2	DDDD	DDDD	DDDD	UUUU	UUUU
Green needlegrass	Nassella viridula	NAVI4	PPPP	PPPP	PPPP	PPPP	PPPP
Idaho fescue	Festuca idahoensis	FEID	PPPP	PPPP	PPPP	PPPP	PPPP
Indian ricegrass	Achnatherum hymenoides	ACHY	PPPP	PPPP	PPPP	PPPP	PPPP
Letterman needlegrass	Achnatherum lettermanii	ACLE9	PPPP	PPPP	DDDD	DDDD	DDDD
Little bluestem	Schizachyrium scoparium	SCSC	PPPP	PPPP	PPPP	DDDD	DDDD
Montana wheatgrass	Elymus albicans	ELAL7	DDDD	DDDD	DDDD	DDDD	DDDD
Mountain bromegrass	Bromus marginatus	BRMA4	PPPP	PPPP	DDDD	DDDD	UUUU
Mountain muhly	Muhlenbergia montana	MUMO	DDDD	DDDD	DDDD	DDDD	UUUU
Nebraska sedge	Carex nebraskensis	CANE2	PPPP	PPPP	PPPP	DDDD	DDDD
Needleandthread	Hesperostipa comata ssp. comata	HECOC8	DPDD	UPDU	DPDD	UDUU	UDUU
Needleleaf sedge	Carex duriuscula	CADU6	UUUU	UUUU	UUUU	UUUU	UUUU
Nodding bromegrass	Bromus anomalus (syn. B. porteri)	BRAN13 (BRPO	PPPP	PPPP	DDDD	DDDD	UUUU
Northern Reedgrass	Calamagrostis stricta ssp. inexpansa	CASTI3	UPDU	UDUU	UPDU	UDUU	UDUU
Onespike oatgrass	Danthonia unispicata	DAUN	DDDD	PPPP	DDDD	PPPP	DDDD
Plains muhly	Muhlenbergia cuspidata	MUCU3	DDDD	DDDD	DDDD	UUUU	UUUU
Plains reedgrass	Calamagrostis montanensis	CAMO	DDDD	DDDD	DDDD	DDDD	DDDD
Prairie cordgrass	Spartina pectinata	SPPE	PPPP	DDDD	PPPP	UUUU	UUUU
Prairie junegrass	Koeleria macrantha	KOMA	DDDD	DDDD	DDDD	DDDD	DDDD
Pumpelly bromegrass	Bromus inermis spp. Pumpellianus	BRINP5	PPPP	PPPP	DDDD	DDDD	UUUU
Red threeawn	Aristida purpurea	ARPUL	UUUU	UUUU	UUUU	UUUU	UUUU
Reedgrasses	Calamagrostis spp.	CALAM	DDDD	UUUU	DDDD	UUUU	UUUU
Rhizomatous wheatgrasses	Pascopyrum smithii	PASM	DDDD	DDDD	DDDD	DDDD	DDDD
Richardson needlegrass	Achnatherum richardsonii	ACRI8	PPPP	PPPP	DDDD	DDDD	DDDD
Sand bluestem	Andropogon halli	ANHA	PPPP	DDDD	PPPP	UUUU	UUUU
Sand dropseed	Sporobolus cryptandrus	SPCR	DDDD	DDDD	DDDD	UUUU	UUUU
Sandberg bluegrass	Poa secunda	POSE	DDDD	DDDD	DDDD	DDDD	DDDD
Sideoats grama	Bouteloua curtipendula	BOCU	PPPP	PPPP	PPPP	DDDD	UUUU
Slender wheatgrass	Elymus trachycaulus ssp. trachycaulus	ELTRT	DPDD	UPDD	DPDD	UDUU	UDUU
Slough sedge	Carex atherodes	CAAT2	DDDD	DDDD	DDDD	DDDD	DDDD
Spike fescue	Leucopoa kingii	LEKI2	PPPP	DDDD	PPPP	PPPP	DDDD
Spike sedge	Carex nardina	CANA2	DDDD	DDDD	DDDD	UUUU	UUUU
Spike trisetum	Trisetum spicatum	TRSP2	PPPP	DDDD	PPPP	PPPP	DDDD
Tall mannagrass	Glyceria elata (syn. G. striata)	GLEL (GLST)	DDDD	UUUU	DDDD	UUUU	UUUU
Thickspike wheatgrass	Elymus lanceolatus	ELLAL	DDDD	DDDD	DDDD	DDDD	DDDD
Threadleaf sedge	Carex filifolia	CAFI	DDDD	DDDD	DDDD	DDDD	PPPP
Tufted hairgrass	Deschampsia caespitosa	DECA18	PPPP	PPPP	PPPP	DDDD	DDDD
Water sedge	Carex aquatilis	CAAQ	DDDD	UUUU	DDDD	UUUU	UUUU
Western wheatgrass	Pascopyrum smithii	PASM	DDDD	DDDD	DDDD	DDDD	DDDD
FORBS							
American bistort	Polygonum bistortoides	POBI6	DDDD	DDDD	DDDD	DDDD	DDDD
American vetch	Vicia americana	VIAM	PPPP	PPPP	PPPP	PPPP	PPPP
Arrowgrass	Triglochin spp.	TRIGL	TTTT	TTTT	TTTT	TTTT	TTTT
Arrowleaf balsamroot	Triglochin spp.	TRIGL	TTTT	TTTT	TTTT	TTTT	TTTT
Aster	Asters	ASTER	UUUU	UUUU	UUUU	UUUU	UUUU
Balsamroot	Balsamorhiza spp.	BALSA	PPPP	PPPP	PPPP	PPPP	PPPP
Biscuitroot	Lomatium spp.	LOMAT	UDUU	UDDU	UDUU	UDDU	UDDU
Bluebells	Mertensia	MERTE	DDDD	PPPP	DDDD	DDDD	DDDD
Blue-eyed grass	Sisyrinchium spp.	SISYR	DDDD	PPPP	DDDD	DDDD	DDDD
Buckwheat	Eriogonum spp.	ERIOG	UUUU	UUUU	UUUU	UUUU	UUUU
Common commandra	Comandra spp.	COMAN	UUUU	UUUU	UUUU	UUUU	UUUU
Cudweed sagewort	Artemisia ludoviciana	ARLU	UUUU	UUUU	UUUU	UUUU	UUUU

Deathcamas	Zigadenus venenosus	ZIVE	TTTT	TTTT	TTTT	TTTT	TTTT
Dock	Rumex spp.	RUMEX	UUUU	UUUU	UUUU	UUUU	UUUU
Dotted gayfeather	Liatris punctata	LIPU	UPPU	UPPU	UPPU	UPPU	UPPU
Field chickweed	Cerastium arvense	CEAR4	UUUU	UUUU	UUUU	UUUU	UUUU
Flax	Linum spp.	LINUM	UUUU	UUUU	UUUU	UUUU	UUUU
Fleabane	Erigeron spp.	ERIGE2	UUUU	UUUU	UUUU	UUUU	UUUU
Fringed sagewort	Artemisia frigida	ARFR4	UUUU	UUUU	UUUU	UUUU	UUUU
Goldenrod	Solidago spp.	SOLID	NUNN	NUNN	NNNN	NUNN	NUNN
Green sagewort	Artemisia campestris	ARCA12	NNNN	NUUN	NNNN	NUUN	NUUN
Gromwell	Buglossoides spp.	BUGLO	UUUU	UUUU	UUUU	UUUU	UUUU
Groundsel	Senecio spp.	SENEC	NNNN	NNNN	NNNN	NNNN	NNNN
Hairy goldenaster	Heterotheca villosa	HEVI4	UUUU	UUUU	UUUU	UUUU	UUUU
Hawksbeard	Crepis acuminata	CRAC2	UUUU	PPPP	UUUU	DDDD	DDDD
Horsetails	Equisetum spp.	EQUIS	UUUU	UUUU	UUUU	UUUU	UUUU
Iris	Iris spp.	IRIS	UUUU	UUUU	UUUU	UUUU	UUUU
Larkspur	Delphinium spp.	DELPH	TTTT	TTTT	TTTT	TTTT	TTTT
Locoweeds	Oxytropis spp.	OXYTR	TTTT	TTTT	TTTT	TTTT	TTTT
Lupine	Lupinus spp.	LUPIN	DDDD	DDDD	DDDD	DDDD	DDDD
Mint	Menthan spp.	MENTH	UUUU	UUUU	UUUU	UUUU	UUUU
Mountain thermopsis	Thermopsis montana	THMOM3	UUUU	UUUU	UUUU	UUUU	UUUU
Nailwort	Paronychia spp.	PARON	NNNN	NNNN	NNNN	NNNN	NNNN
Pale agoseris	Agoseris glauca	AGGL	DDDD	PPPP	DDDD	DDDD	DDDD
Penstemons	Penstemon spp.	PENST	UPPU	UPPU	UPPU	UPPU	UPPU
Phlox	Phlox spp.	PHLOX	NNNN	NNNN	NNNN	NNNN	NNNN
Prairie clovers	Dalea spp.	DALEA	UPPU	UPPU	UPPU	UPPU	UPPU
Prairie coneflower	Ratibida columnifera	RACO3	DDDD	PPPP	DDDD	PPPP	PPPP
Flax	Linum spp.	LINUM	UUUU	UUUU	UUUU	UUUU	UUUU
Pussytoes	Antennaria spp.	ANTEN	NNNN	NNNN	NNNN	NNNN	NNNN
Sandwort	Arenaria spp.	ARENA	NNNN	NNNN	NNNN	NNNN	NNNN
Silverleaf scurfpea	Pediomelum argophyllum	PEAR6	UUUU	UUUU	UUUU	UUUU	UUUU
Stemless mock goldenweed	Stenotus acaulis	STAC	UUUU	UUUU	UUUU	UUUU	UUUU
Sticky geranium	Geranium viscosissimum	GEVI2	PPPP	PPPP	DDDD	PPPP	DDDD
Stonecrop	Sedum spp.	SEDUM	UUUU	UUUU	UUUU	UUUU	UUUU
Toadflax	Comandra umbellata	COUMP	UUUU	UUUU	UUUU	UUUU	UUUU
Violets	Viola spp.	VIOLA	DDDD	DDDD	DDDD	DDDD	DDDD
Water hemlock	Cicuta spp.	CICUT	TTTT	TTTT	TTTT	TTTT	TTTT
Waterleaf	Hydrophyllum	HYDRO4	DDDD	PPPP	DDDD	PPPP	DDDD
Western virginsbower	Clematis lequsticifolia	CLLI2	UUUU	DDDD	UUUU	DDDD	DDDD
Western wallflower	Erysimum capitatum	ERCAC	DDDD	DDDD	DDDD	DDDD	DDDD
Western yarrow	Achillea millefolium	ACMI2	NUUN	NUUN	NNNN	NUUN	NUUN
TREES/SHRUBS							
American plum	Prunus americana	PRAM	DDDD	DDDD	DDDD	DDDD	UUUU
Big sagebrush	Artemisia tridentata	ARTR2	UUUU	DDDD	UUUU	DDDD	DDDD
Black sagebrush	Artemisia nova	ARNO4	UUUU	PPPP	UUUU	PPPP	PPPP
Boxelder	Acer negundo	ACNE2	UUUU	UUUU	UUUU	UUUU	UUUU
Chokecherry	Prunus virginiana	PRVI	DDDD	DDDD	DDDD	PPPP	DDDD
Common Juniper	Juniperus communis	JUSCO6	UUUU	UUUU	UUUU	UUUU	UUUU
Cottonwoods	Tanacetum vulgare	TAVU	UUUU	UUUU	UUUU	UUUU	UUUU
Green ash	Fraxinus pennsylvanica	FRPE	UUUU	UUUU	UUUU	UDDU	UDDU
Hawthorn	Crataegus spp.	CRATA	UUUU	UUUU	UUUU	UUUU	UUUU
Juniper	Juniperus scopulorum	JUSC2	UUUU	UUUU	UUUU	DDDD	UUUU
Mountain mahogany	Cercocarpus spp.	CERCO	DDDD	PPPP	UUUU	PPPP	UUUU
Ponderosa pine	Pinus ponderosa	PIPO	UTTU	UNNU	UNNU	UNNU	UNNU
Rocky-Mountain juniper	Juniperus scopulorum	JUSC2	UNNU	UNNU	UNNU	UNNU	DUUD
Rubber rabbitbrush	Ericameria nauseosa	ERNA10	UUUU	DDDD	UUUU	DDDD	DDDD
Silver sagebrush	Artemisia cana	ARCAC5	DDDD	DDDD	DDDD	PPPP	PPPP
Skunkbush sumac	Rhus trilobata	RHTR	DDDD	DDDD	DDDD	DDDD	DDDD
Snowberry	Symphoricarpus occidentalis	SYOC	UUUU	UUUU	UUUU	DDDD	UUUU
Threetip sagebrush	Artemisia tripartita	ARTR4	UUUU	DDDD	UUUU	UUUU	DDDD
Wild rose	Rosa woodsii var. woodsii	ROWOW	DDDD	DDDD	UUUU	DDDD	DDDD
Willows	Salix L.	SALIX	PPPP	PPPP	DDDD	PPPP	UUUU
Winterfat	Krascheninnikovia lanata	KRLA2	PPPP	PPPP	PPPP	PPPP	PPPP
Yucca	Yucca glauca	YUGL	DDDD	DDDD	DDDD	DDDD	DDDD

Animal Community – Grazing Interpretations

The following table lists suggested stocking rates for cattle under continuous season-long grazing under normal growing conditions. These are conservative estimates that should be used only as guidelines in the initial stages of the conservation planning process. Often, the current plant composition does not entirely match any particular plant community (as described in this ecological site description). Because of this, a field visit is recommended, in all cases, to document plant composition and production. More precise carrying capacity estimates should eventually be calculated using this information along with animal preference data, particularly when grazers other than cattle are involved. Under more intensive grazing management, improved harvest efficiencies can result in an increased carrying capacity. If distribution problems occur, stocking rates must be reduced to maintain plant health and vigor.

Plant Community	**Production (Lb./ac)**	**Carrying Capacity* (AUM/ac)**
Nebraska sedge, Tufted hairgrass	3500-6000	2.0
Hawthorne/Kentucky bluegrass	1800-3500	1.5
Kentucky bluegrass/Dandelion	900-1500	1.0
Brome/Timothy	1200-5000	2.0

* - Continuous, season-long grazing by cattle under average growing conditions.

Grazing by domestic livestock is one of the major income-producing industries in the area. Rangeland in this area may provide yearlong forage for cattle, sheep, or horses. During the dormant period, the forage for livestock use needs to be supplemented with protein because the quality does not meet minimum livestock requirements.

Hydrology Functions

Climate is the principal factor limiting forage production on this site. This site is dominated by soils in hydrologic group B and C, with localized areas in hydrologic group D. Infiltration ranges from moderately slow to moderately rapid. Runoff potential for this site varies from moderate to high depending on soil hydrologic group and ground cover. In many cases, areas with greater than 75% ground cover have the greatest potential for high infiltration and lower runoff. An example of an exception would be where short-grasses form a strong sod and dominate the site. Areas where ground cover is less than 50% have the greatest potential to have reduced infiltration and higher runoff (refer to Part 630, NRCS National Engineering Handbook for detailed hydrology information).

Rills and gullies should not typically be present. Water flow patterns should be barely distinguishable if at all present. Pedestals are only slightly present in association with bunchgrasses. Litter typically falls in place, and signs of movement are not common. Chemical and physical crusts are rare to non-existent. Cryptogamic crusts are present, but only cover 1-2% of the soil surface.

Recreational Uses

This site provides hunting opportunities for upland game species. The wide variety of plants which bloom from spring until fall have an esthetic value that appeals to visitors.

Wood Products

No appreciable wood products are present on the site.

Other Products
None noted.

Supporting Information

Associated Sites

Wetland	043BY478WY
Lowland	043BY404WY
Overflow	043BY428WY

Similar Sites
() – Subirrigated 10-14" Northern Plains P.Z., 058BY174WY has lower production.

Inventory Data References (narrative)
Information presented here has been derived from NRCS clipping data and other inventory data. Field observations from range trained personnel was also used. Other sources used as references include USDA NRCS Water and Climate Center, USDA NRCS National Range and Pasture Handbook, and USDA NRCS Soil Surveys from various counties.

Inventory Data References

Data Source	Number of Records	Sample Period	State	County
SCS-RANGE-417		1971-1994	WY	
Ocular estimates		1990-1999	WY	

Site Correlation
.

Type Locality

Field Offices
Buffalo, Sheridan

Relationship to Other Established Classifications

Other References

Site Description Approval

State Range Management Specialist
Date

Ecological Reference Worksheet

Author(s)/participant(s):____

Contact for lead author: _____________________________________ **Reference site used? Yes/No**

Date: __4/05_ ___ **MLRA:** _ __43B__ **Ecological Site:** R043BY474WY Subirrigated (Sb) 15-19"NP

This *must* be verified based on soils and climate (see Ecological Site Description). Current plant community *cannot* be used to identify the ecological site.

Indicators. For each indicator, describe the potential for the site. Where possible, (1) use numbers, (2) include expected range of values for above- and below-average years for **each** community within the reference state, when appropriate & (3) cite data. Continue descriptions on separate sheet.
1. Number and extent of rills: Rills should not be present
2. Presence of water flow patterns: Barely observable
3. Number and height of erosional pedestals or terracettes: Essentially non-existent
4. Bare ground from Ecological Site Description or other studies (rock, litter, lichen, moss, plant canopy are *not* bare ground): Bare ground is less than 5%
5. Number of gullies and erosion associated with gullies: Active gullies should not be present
6. Extent of wind scoured, blowouts and/or depositional areas: None
7. Amount of litter movement (describe size and distance expected to travel): Little to no plant litter movement. Plant litter remains in place and is not moved by erosional forces.
8. Soil surface (top few mm) resistance to erosion (stability values are averages – most sites will show a range of values for both plant canopy and interspaces, if different): Plant cover and litter is at 95% or greater of soil surface and maintains soil surface integrity. Soil Stability class is anticipated to be 5 or greater.
9. Soil surface structure and SOM content (include type and strength of structure, and A-horizon color and thickness for both plant canopy and interspaces, if different): Use Soil Series description for depth and color of A-horizon
10. Effect of plant community composition (relative proportion of different functional groups) & spatial distribution on infiltration & runoff: Grass canopy and basal cover should reduce raindrop impact and slow overland flow providing increased time for infiltration to occur. Healthy deep rooted native grasses enhance infiltration and reduce runoff. Infiltration is moderately slow to moderately rapid.
11. Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site): No compaction layer or soil surface crusting should be present.
12. Functional/Structural Groups (list in order of descending dominance by above-ground weight using symbols: >>, >, = to indicate much greater than, greater than, and equal to): Tall and Mid stature Grasses/grasslikes > Forbs > Shrubs > Short stature Grasses/Grasslikes
13. Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence): Very Low
14. Average percent litter cover and depth : Average litter cover is 50-55% with depths of 0.75 to 1.5 inches
15. Expected annual production (this is all above-ground production, not just forage production): 5000 lbs/ac
16. Potential invasive (including noxious) species (native and non-native). List species which characterize degraded states and which, after a threshold is crossed, "can, and often do, continue to increase regardless of the management of the site and may eventually dominate the site": Kentucky Bluegrass, Spike sedge, Baltic rush, Dandelion, Hawthorn, and Species found on Noxious Weed List
17. Perennial plant reproductive capability: All species are capable of reproducing

Appendix C

Benefits of Watershed Improvement Practices

NRCS Conservation Practice Effects – Network Diagrams included for reference:

- Irrigation Canal or Lateral, number 320
- Irrigation Ditch Lining, number 428
- Irrigation Field Ditch, number 388
- Irrigation Pipeline, number 430
- Livestock Pipeline, number 516
- Pond, number 378
- Restoration and Management of Rare or Declining Habitats, number 643
- Shallow Water Development and Management, number 646
- Spring Development, number 574
- Sprinkler System, number 442
- Stream Habitat Improvement and Management, number 395
- Streambank Shoreline Protection, number 580
- Structure for Water Control, number 587
- Subsurface Drain, number 606
- Watering Facility, number 614
- Wetland Enhancement, number 659
- Wetland Restoration, number 657

Appendix C - Benefits of Watershed Improvement Practices

One of the goals of the watershed study is to identify specific watershed projects and practices that will improve the health and function of the Upper Snake River watershed. How does one identify the benefits to the watershed that the specific projects may provide? This question has been thoroughly researched and documented through U.S. Department of Agriculture (USDA) guidance documents compiled in the National Conservation Practices Standards (NRCS 2016[1]). Several tools and reference standards (available online at www.nrcs.usda.gov) were developed for use in planning conservation practices and to evaluate the net effect of specific practices. For planning purposes:

> *"The Conservation Practices Physical Effects (CPPE) matrix, and associated planning tools, describe how NRCS's conservation practices effect the Natural Resource and Human-Economic Environments. The Excel spreadsheets…can be used to describe the environmental and economic effects of each conservation practice. A qualitative statement describes the conservation practice's impact on Soil, Water, Air, Plants, Animals, Energy and Land, Labor, Capital and Risk. The tools also give define the conservation practice, practice units, typical land use and a relative cost estimate" (NRCS 2016).*

Additionally, the NRCS prepares Conservation Practice Effects – Network Diagrams to help identify the effects of specific practices. As stated on the NRCS website:

> *"NRCS prepares network diagrams of featured practices, or related sets of practices which act together to achieve desired purposes. Network diagrams are flow charts of direct, indirect and cumulative effects resulting from installation of the practices. Completed network diagrams are an overview of expert consensus on the direct, indirect and cumulative effects of installing proposed practice installation. They show the potential positive and negative outcomes of practice installation, and are useful as a reference point for next steps, and as a communication tool with partners and the public" (NRCS 2016).*

These network diagrams have been used in previous watershed studies to point out specific project effects and benefits. To maintain consistency with previous Level I studies, the same is true with the Upper Snake River watershed study. Table A-1 lists the NRCS Conservation Practice Effects – Network Diagrams included in this appendix along with an example of the potentially applicable projects as describe in Section 4 of this report.

Table A-1 List of NRCS Network Effect Diagrams Included in this Appendix

Best Management Practice Description or Title	NRCS Number	Publication Date	Example of Potentially Applicable Projects
Irrigation Canal or Lateral	320	2014	ISI-1
Irrigation Ditch Lining	428	2014	ISI-2
Irrigation Field Ditch	388	2014	ISI-14
Irrigation Pipeline	430	2014	ISI-5
Livestock Pipeline	516	2014	LWW-4
Pond	378	2015	LWW-2
Restoration and Management of Rare or Declining Habitats	643	2014	OMP-5

[1] NRCS, 2016, National Conservation Practice Standards accessed online on August 23, 2016 at http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/cp/ncps/?cid=nrcs143_026849

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Best Management Practice Description or Title	NRCS Number	Publication Date	Example of Potentially Applicable Projects
Shallow Water Development and Management	646	2014	LWW-4
Spring Development	574	2014	LWW-4
Sprinkler System	442	2015	ISI-11
Stream Habitat Improvement and Management	395	2014	SCC-3
Streambank Shoreline Protection	580	2014	SCC-2
Structure for Water Control	587	2014	ISI-6
Subsurface Drain	606	2014	ISI-1
Watering Facility	614	2014	LWW-4
Wetland Enhancement	659	2014	OMP-2
Wetland Restoration	657	2014	OMP-5

To illustrate how the network diagrams can be used to identify the direct and indirect benefits of specific projects, we have developed a summary of the potential effects/benefits for each of the types of projects. By reviewing the specific conceptual project components and the appropriate network diagrams, similar lists of effects/benefits can be developed for the projects proposed in this watershed study. Examples of a potentially applicable project are listed above; however, the list is not all inclusive because several projects have more than one conservation practice that could apply.

Irrigation System Improvement Projects

As described in NRCS Conservation Practice Effects – Network Diagram, Irrigation Pipeline (430), the effects and benefits of rehabilitating and improving water conveyance for irrigation systems include:

- Increased water availability for irrigation
  - Increased plant growth and productivity
- Decreased infiltration and evaporation losses
  - Increased plant growth and productivity
  - Decreased leaching of nutrients
- Decreased erosion associated with practice
  - Decreased sediment delivery to surface waters

The cumulative effects of this management practice include:

- Positive income stability to individuals and communities
- Positive impacts to aquatic health for humans and for domestic and wild animals
- Improved environmental quality and stream fauna

Livestock/Wildlife Watering Improvement Projects

As described in NRCS Conservation Practice Effects – Network Diagram, Spring Development (574), the effects and benefits of improving a natural spring to provide water for livestock and wildlife include:

- Increased water quality and quantity for livestock and wildlife
  - Decreased livestock concentration in sensitive areas
  - Increased livestock condition and productivity
  - Increased upland wildlife habitat
  - Increased water quality

The cumulative effects of this management practice include:

- Positive income stability to individuals and communities
- Positive impacts to health for humans, habitats, and domestic and wild animals
- Potential for improved environmental quality and stream fauna

- Potential for increased recreational opportunities

Surface Water Flood and Water Supply/Storage Improvement Projects

As described in NRCS Conservation Practice Effects – Network Diagram, Pond (378), the effects and benefits of constructing a pond where water is needed for livestock, fish, wildlife, recreation, fire control, and/or irrigation include:

- Increased water quality, quantity, and distribution for livestock and wildlife
    - Increased plant growth and productivity
    - Increased livestock condition and productivity
    - Potential for increased upland wildlife habitat

The cumulative effects of this management practice include:

- Positive income stability to individuals and communities
- Positive impacts to health for humans and for domestic and wild animals

Stream Channel Condition and Stability Improvement Projects

As described in NRCS Conservation Practice Effects – Network Diagram, Streambank and Shoreline Protection (580), the effects and benefits of enhancements of natural streambanks that are susceptible to erosion include:

- Decreased streambank erosion
    - Decreased sedimentation
    - Decreased turbidity and suspended solids
    - Increased riparian condition
- Increased flow capacity of streams and channels
    - Potential for increased water quantity
- Increased streambank vegetation and root matrix where vegetative treatment is used

The cumulative effects of this management practice include:

- Positive income stability to individuals and communities
- Positive impacts to aquatic and terrestrial habitat
- Increased water and air quality
- Potential positive impacts to aquatic and terrestrial populations and biodiversity

Other Management Practice Improvement Projects

As described in NRCS Conservation Practice Effects – Network Diagram, Wetland Enhancement (659), the effects and benefits of enhancements to small freshwater wetlands include:

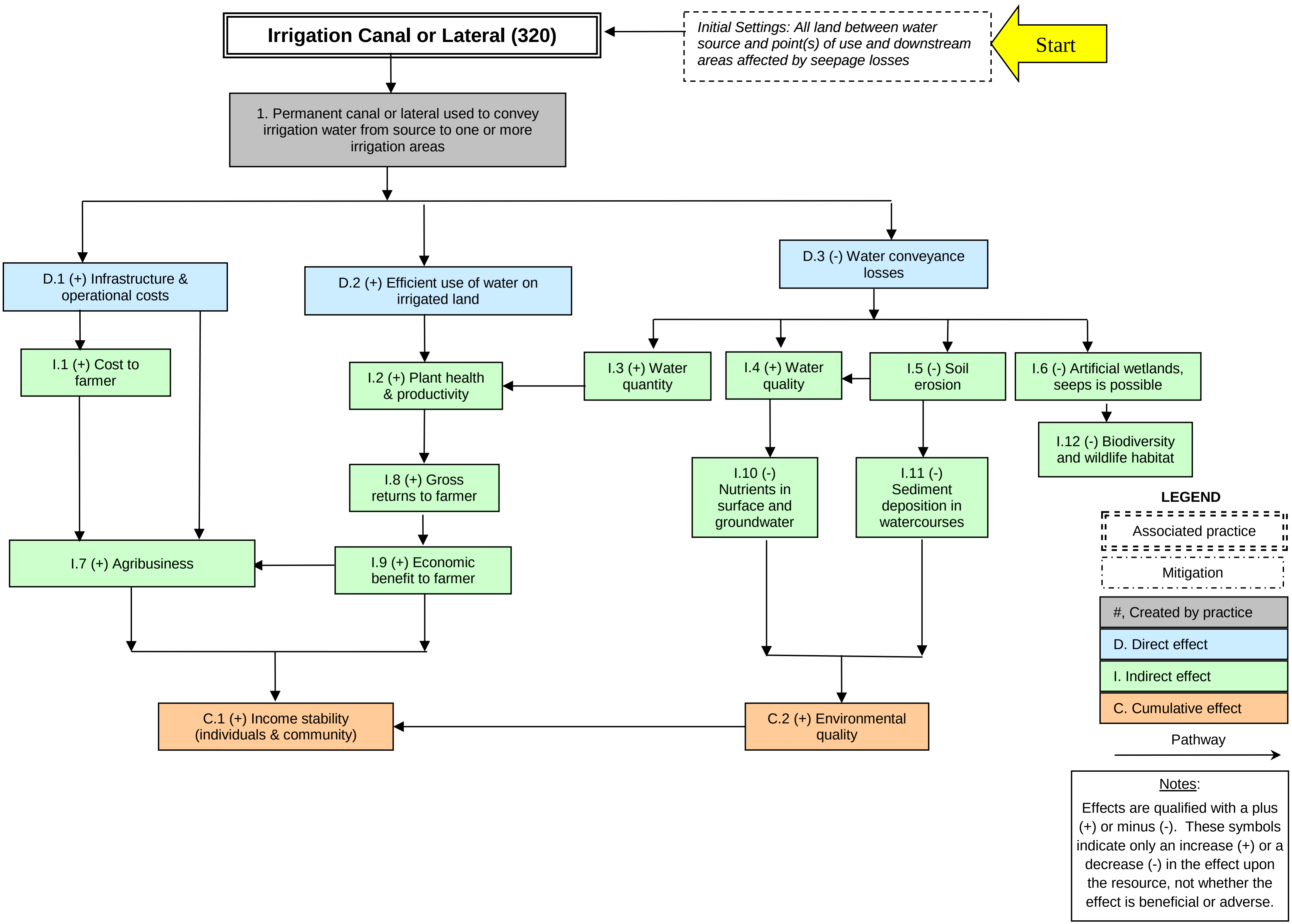
- Increased groundwater recharge
- Increased habitat quality for wildlife
    - Potential for increased wildlife use

The cumulative effects of this management practice include:

- Potential positive income stability to individuals and communities
- Positive impacts to aquatic and terrestrial habitat
- Potential for increased water and air quality
- Potential positive impacts to biodiversity

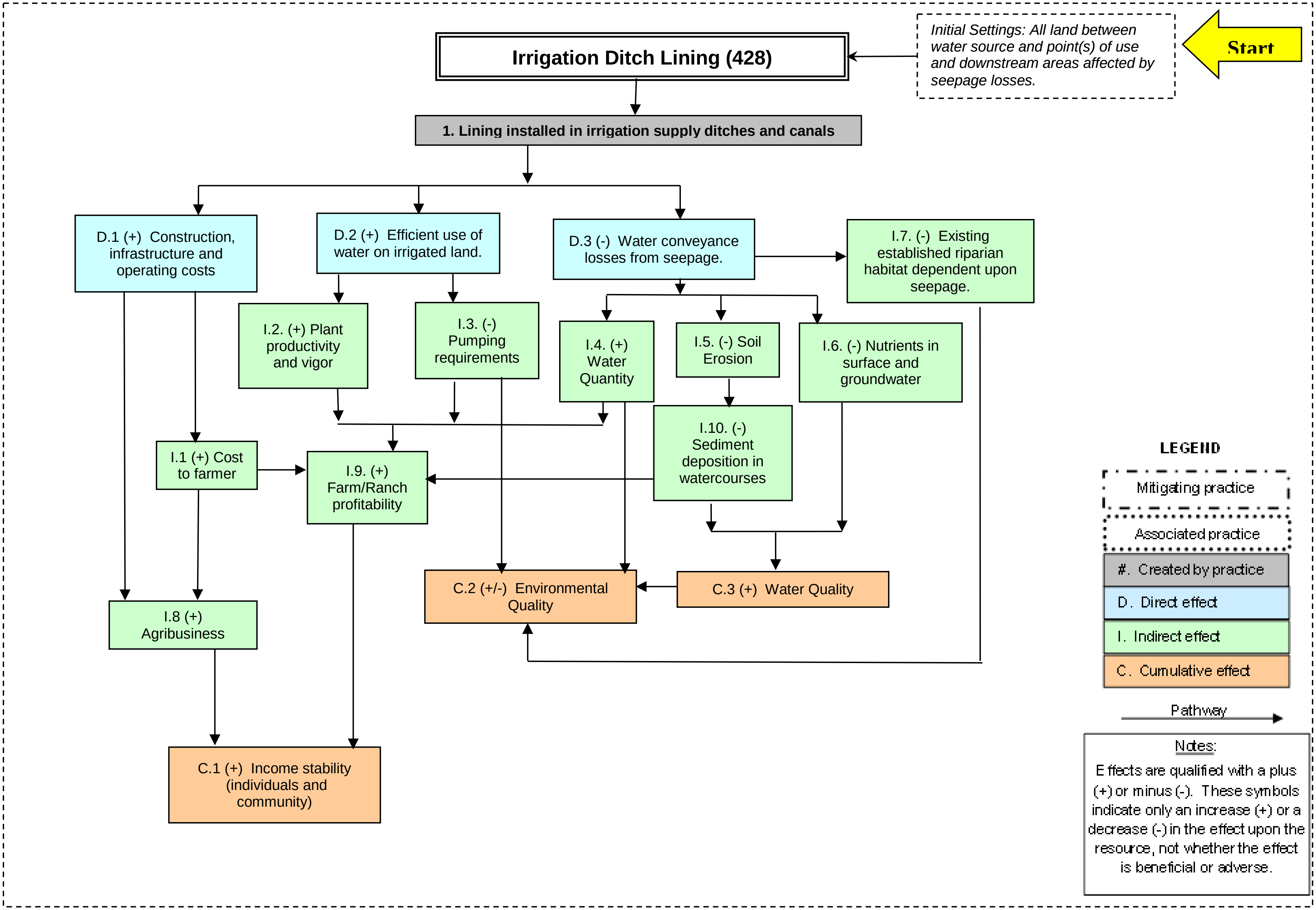
NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

March 2014



NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

March 2014



NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

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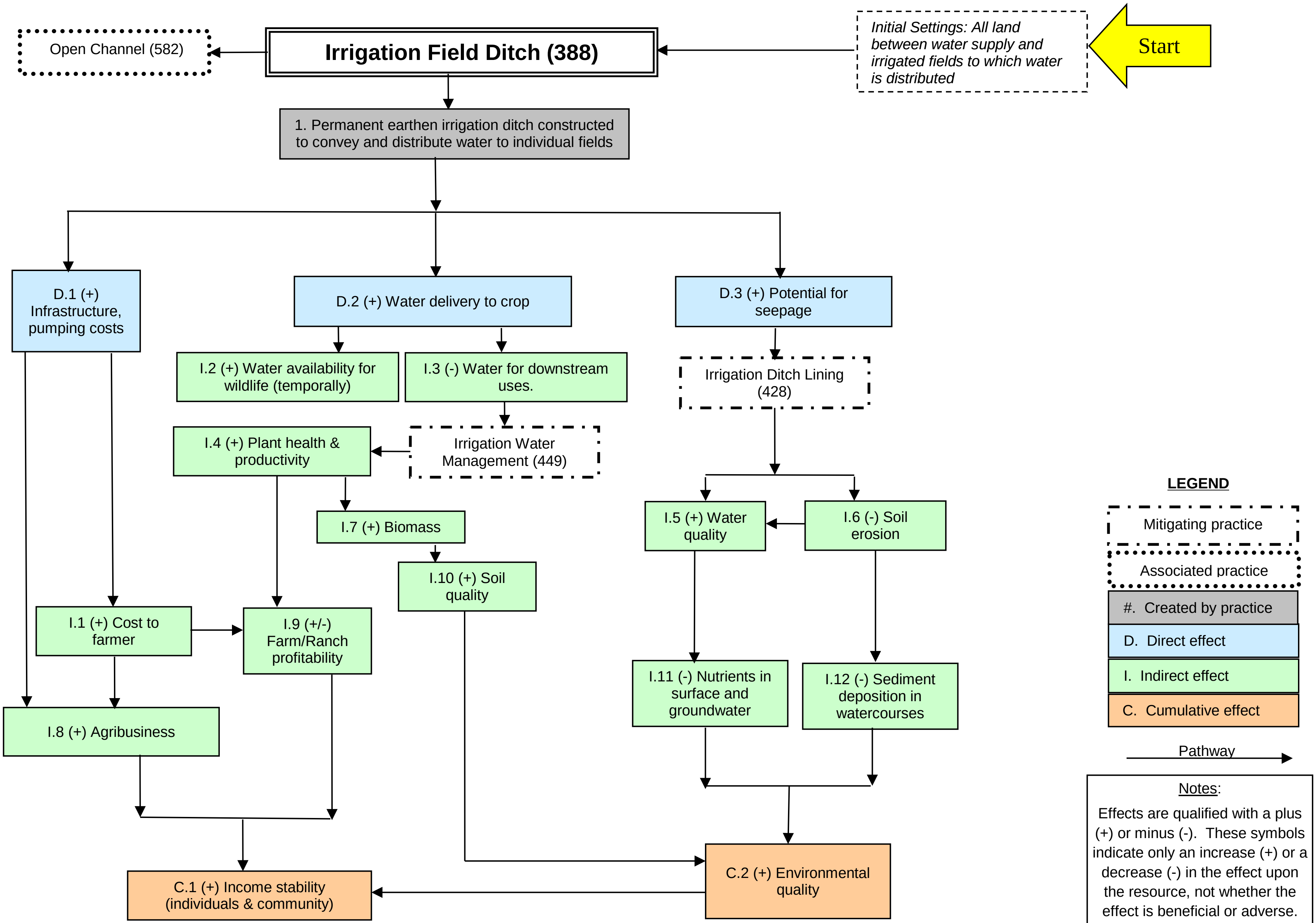
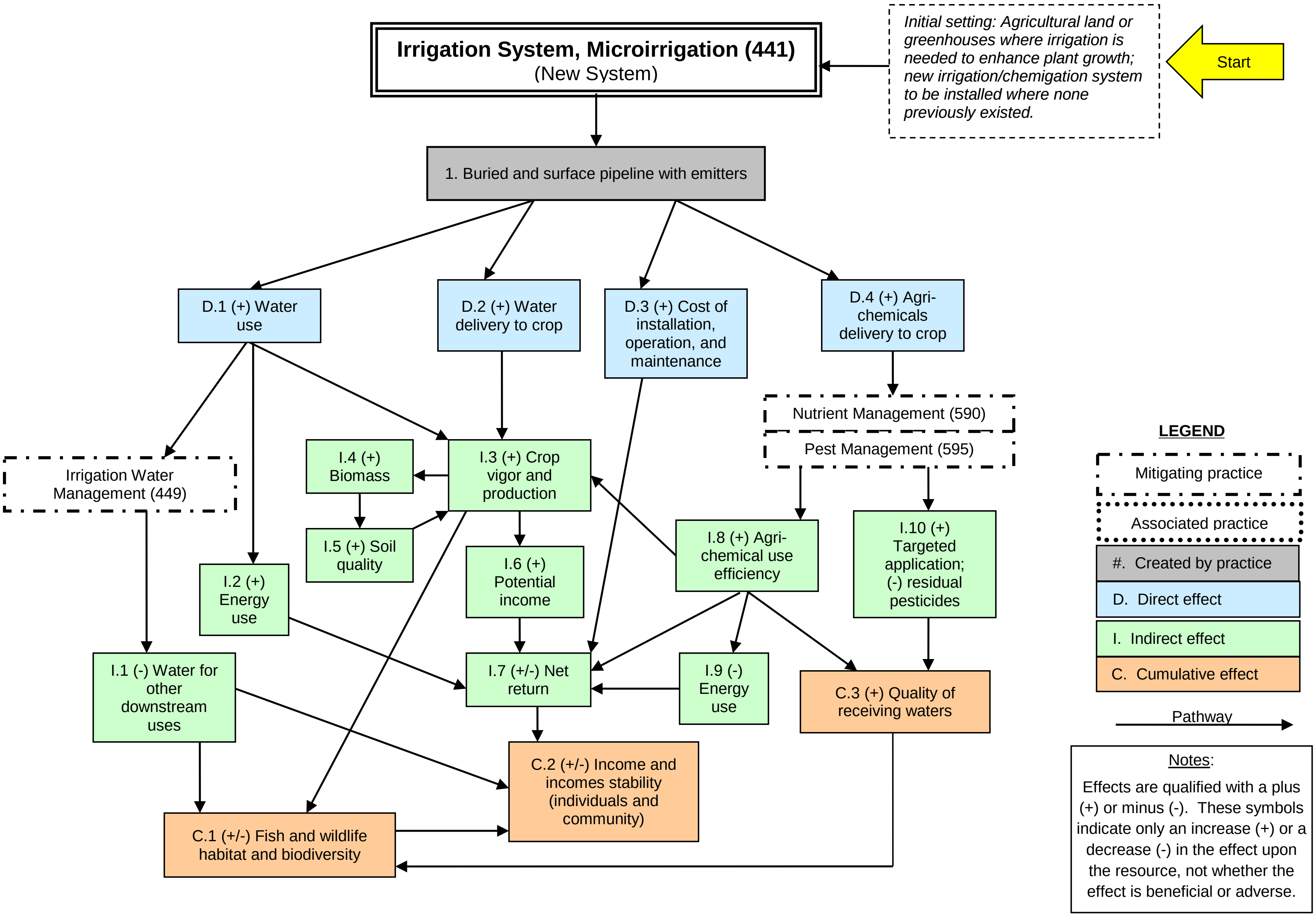


NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

September 2015



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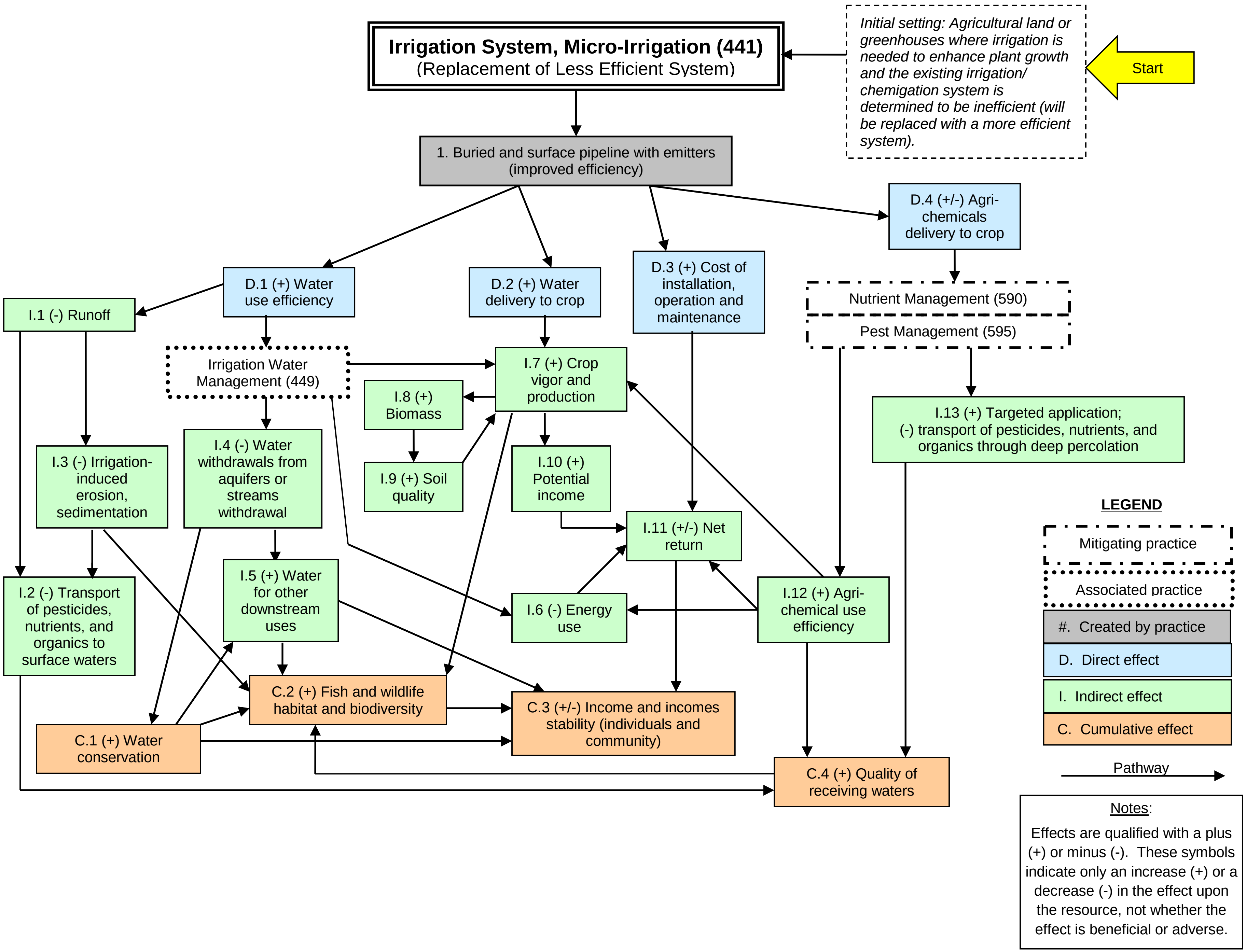

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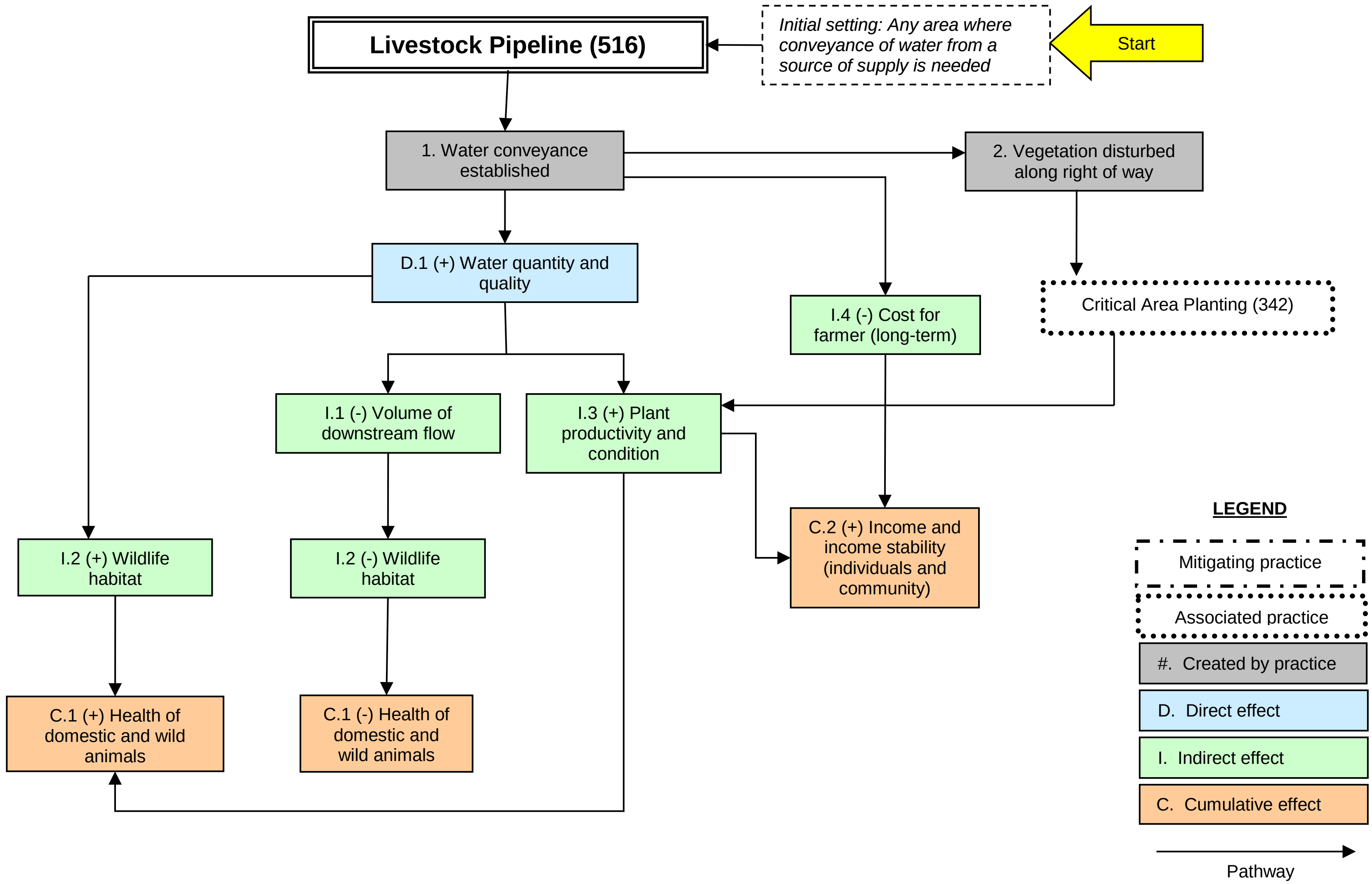
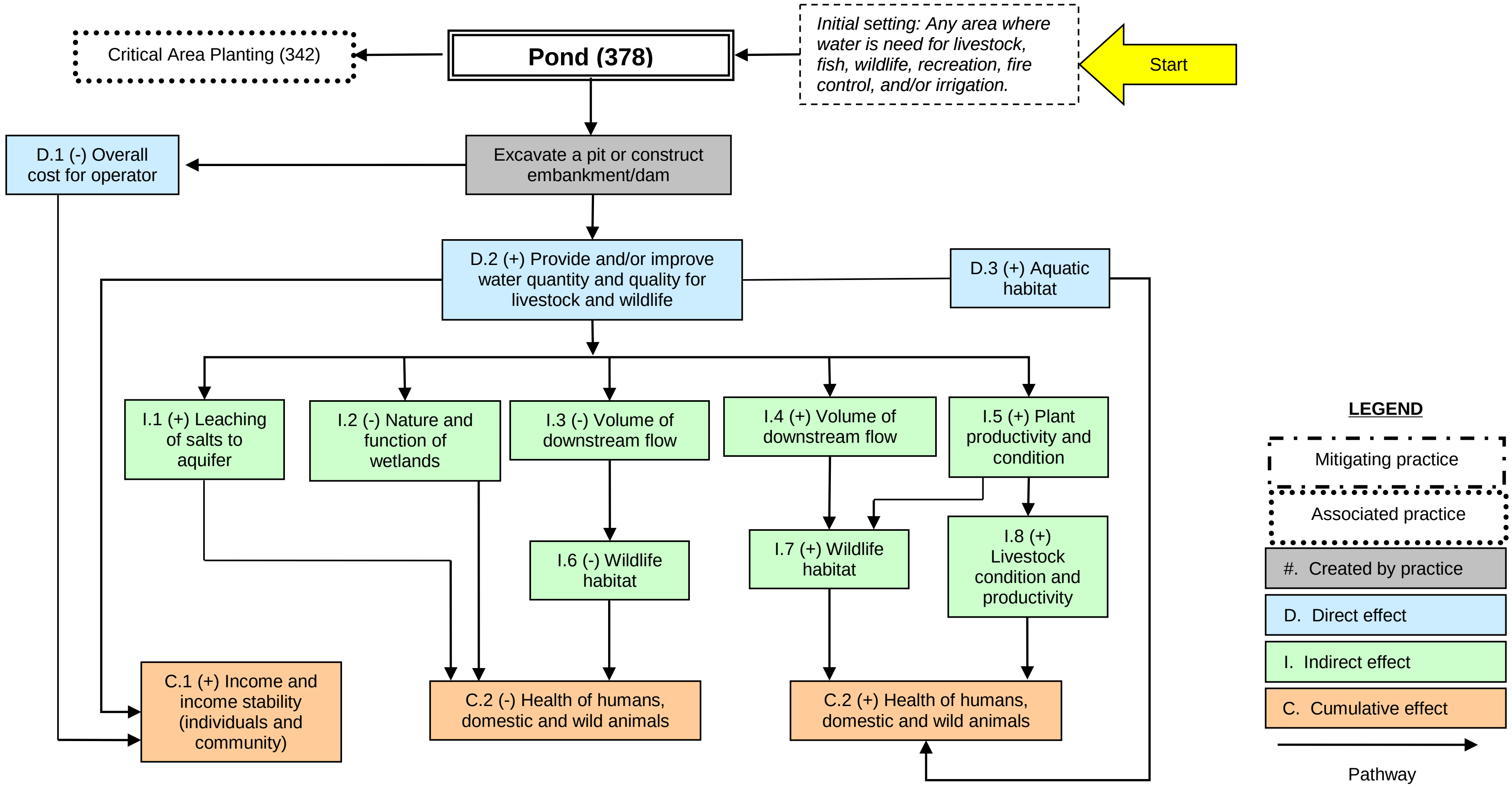


Notes:
Effects are qualified with a plus (+) or minus (-). These symbols indicate only an increase (+) or a decrease (-) in the effect upon the resource, not whether the effect is beneficial or adverse.

NRCS CONSERVATION PRACTICE EFFECTS- NETWORK DIAGRAM

September 2015



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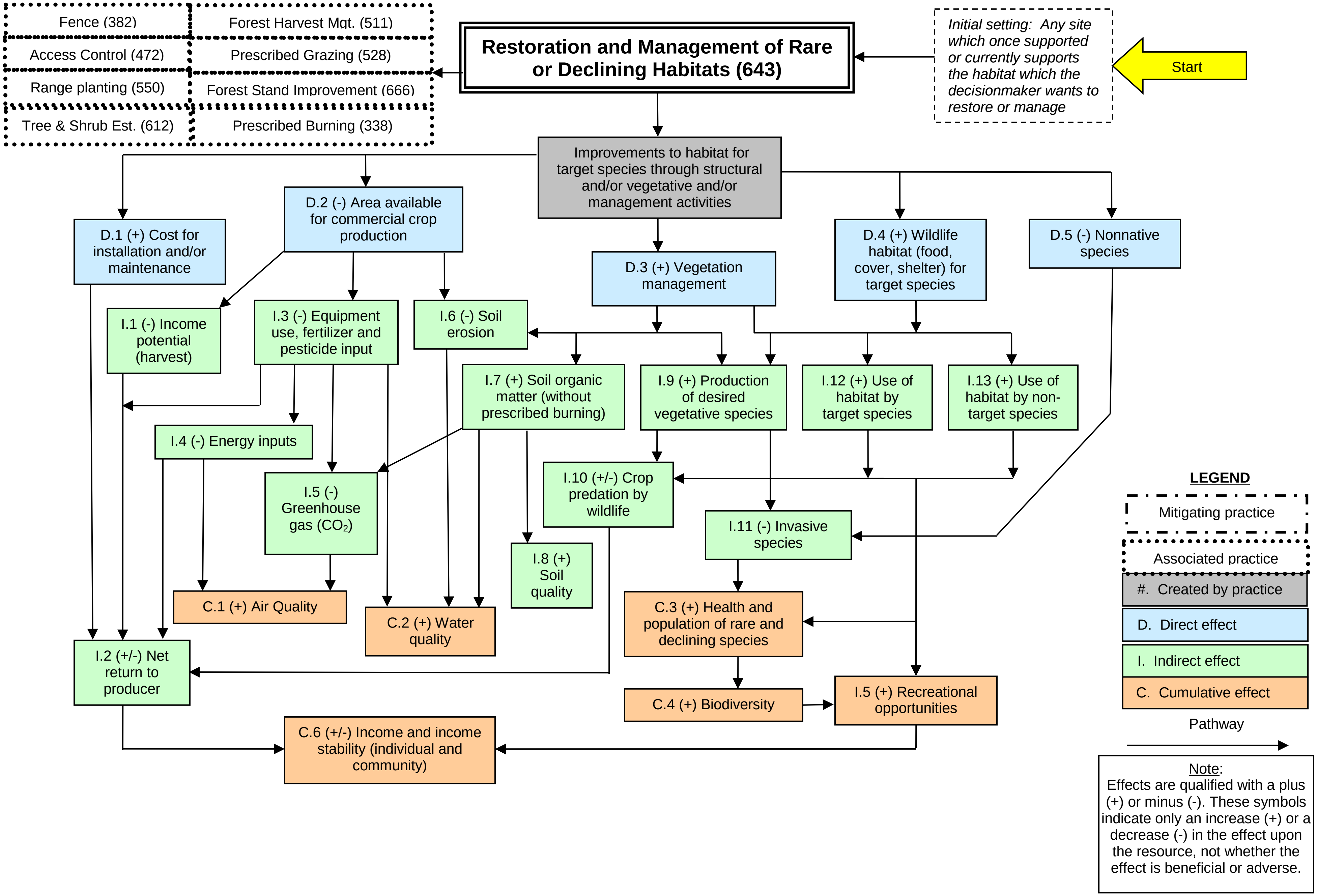

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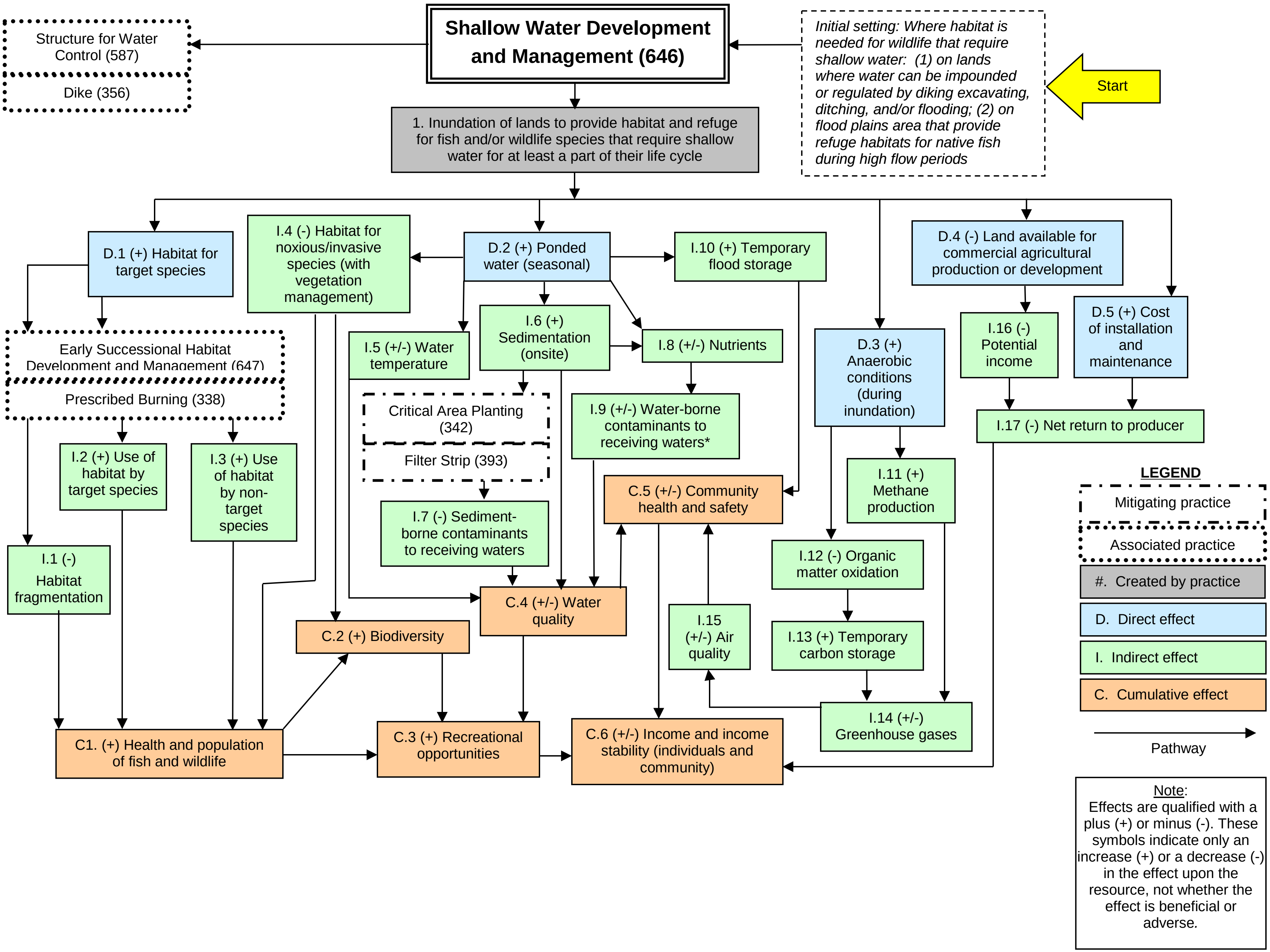

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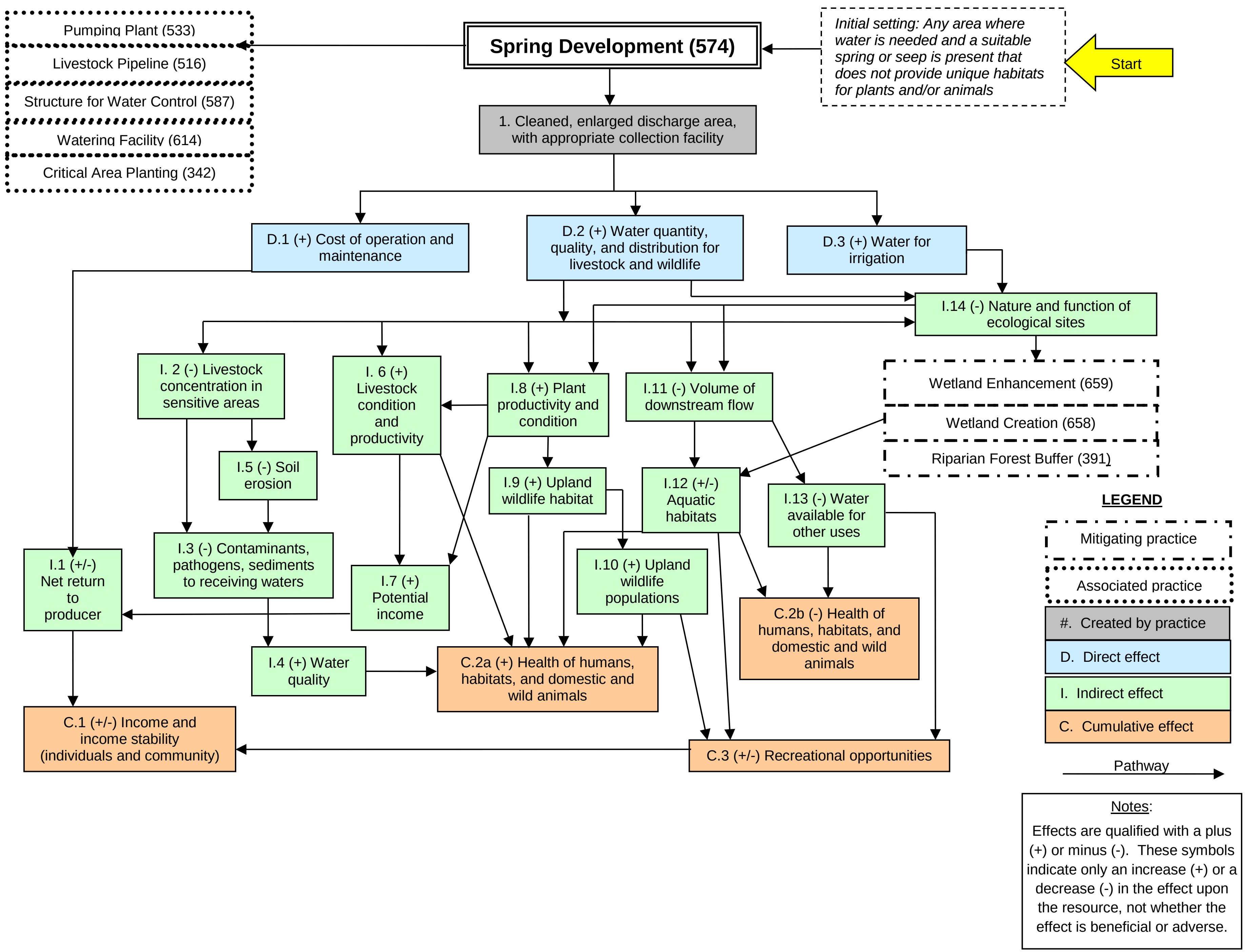

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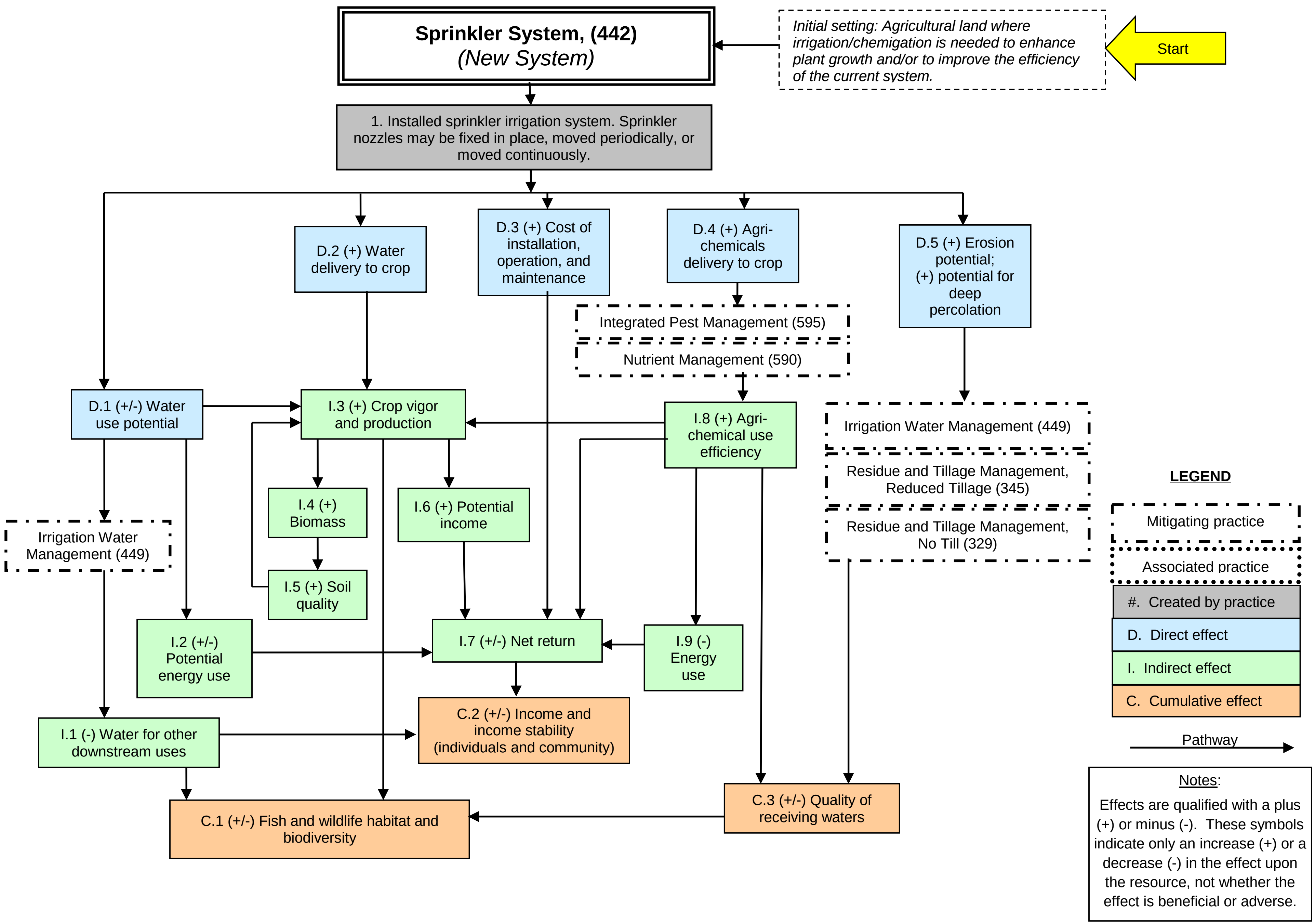

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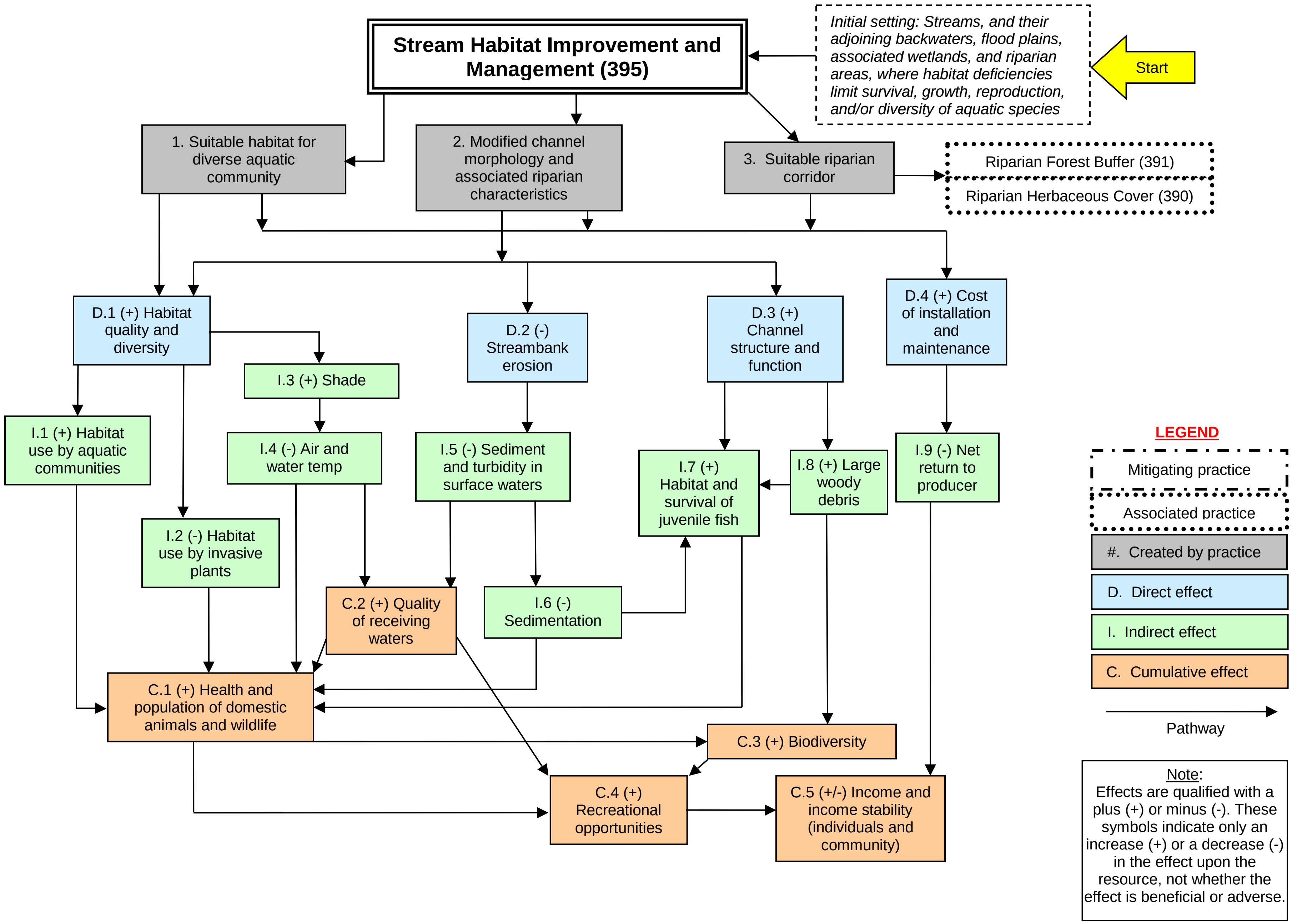

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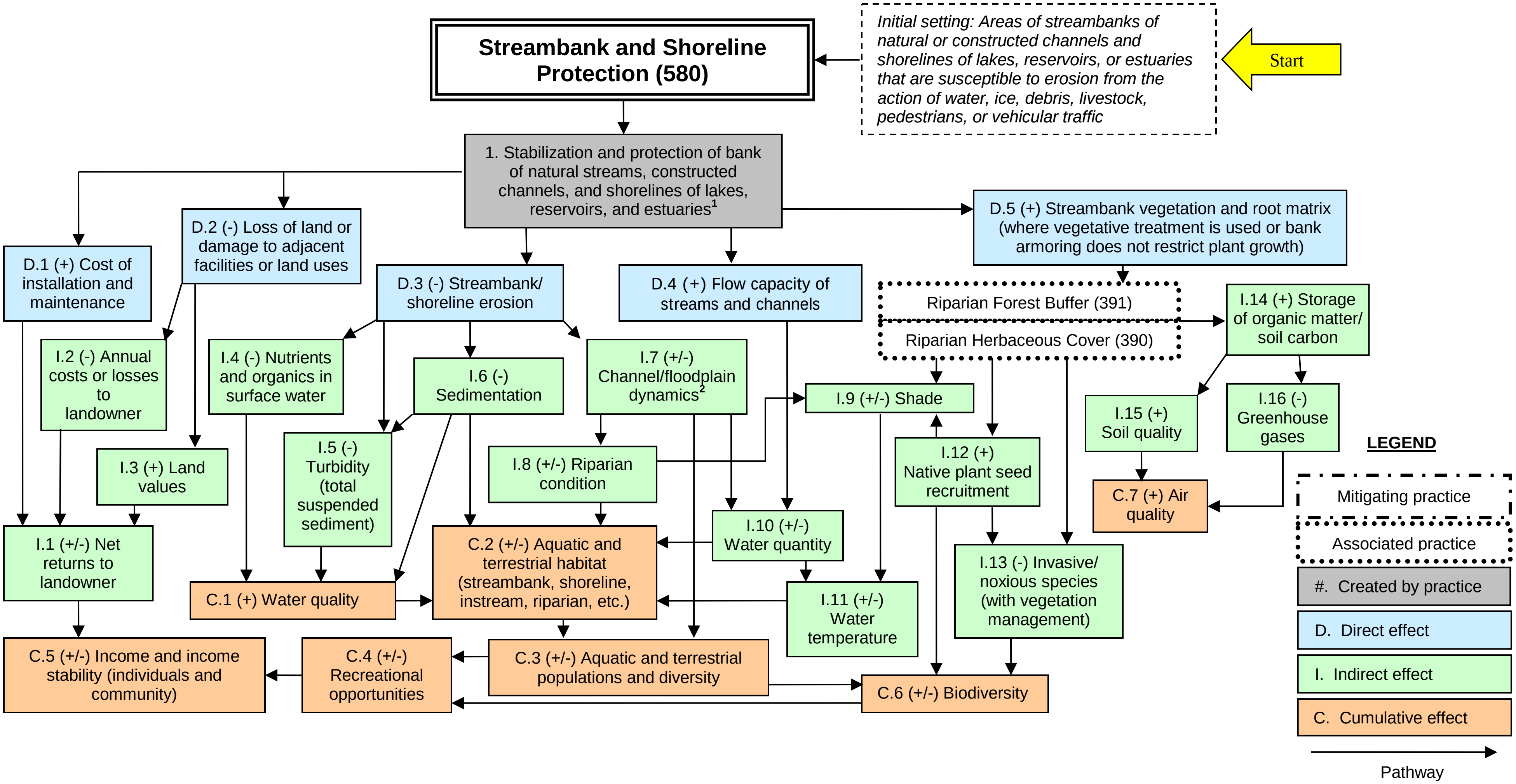

Notes:

Effects are qualified with a plus (+) or minus (-). These symbols indicate only an increase (+) or a decrease (-) in the effect upon the resource, not whether the effect is beneficial or adverse.

Projects involving long lengths of bank or shoreline, structural controls, substantial earth moving and/or fill, or sensitive waters may need to be evaluated in a site-specific EA or EIS.

[1] Additional information about potential protection measures and their impacts is available in the EIS for the Emergency Watershed Protection (EWP) Program.

[2] Conventional bank armoring (e.g., rip rap, gabions) may result in decreased (-) channel/flood plain dynamics, and associated impacts, while other less intrusive methods (e.g., stream barbs, stone toes with sloped, vegetated banks) may result in increased (+) channel/flood plain dynamics.

NRCS CONSERVATION PRACTICE EFFECTS - NETWORK DIAGRAM

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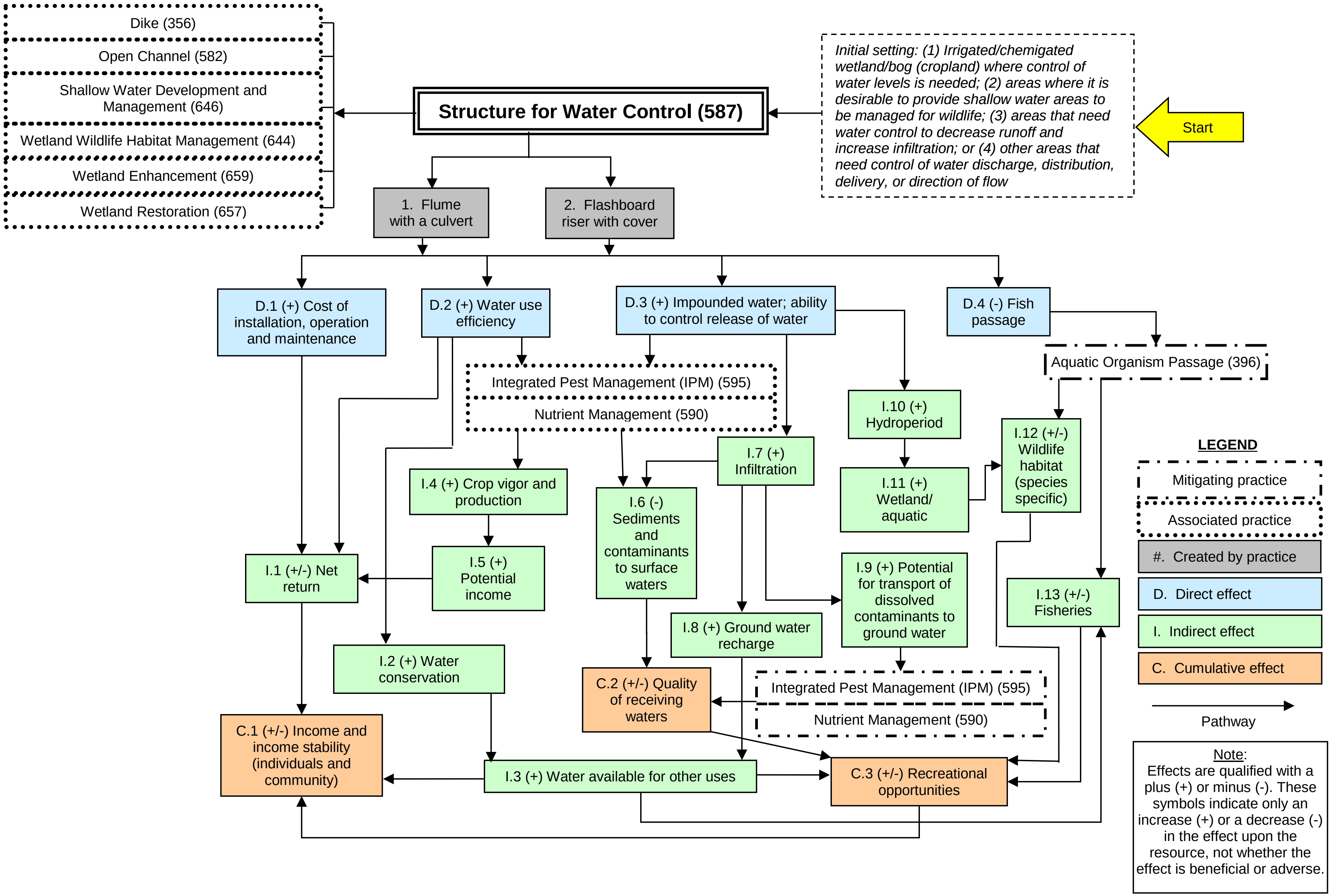

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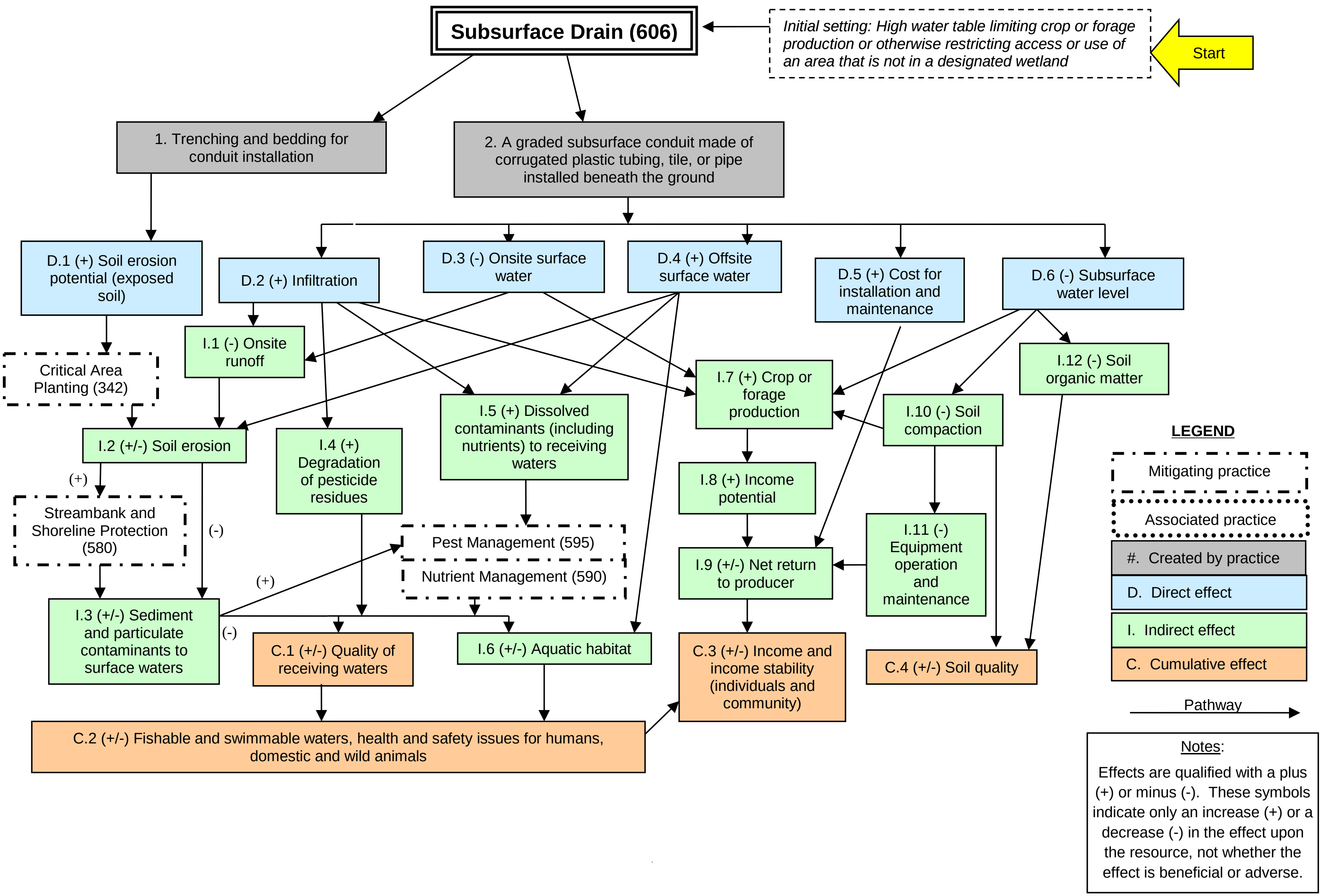

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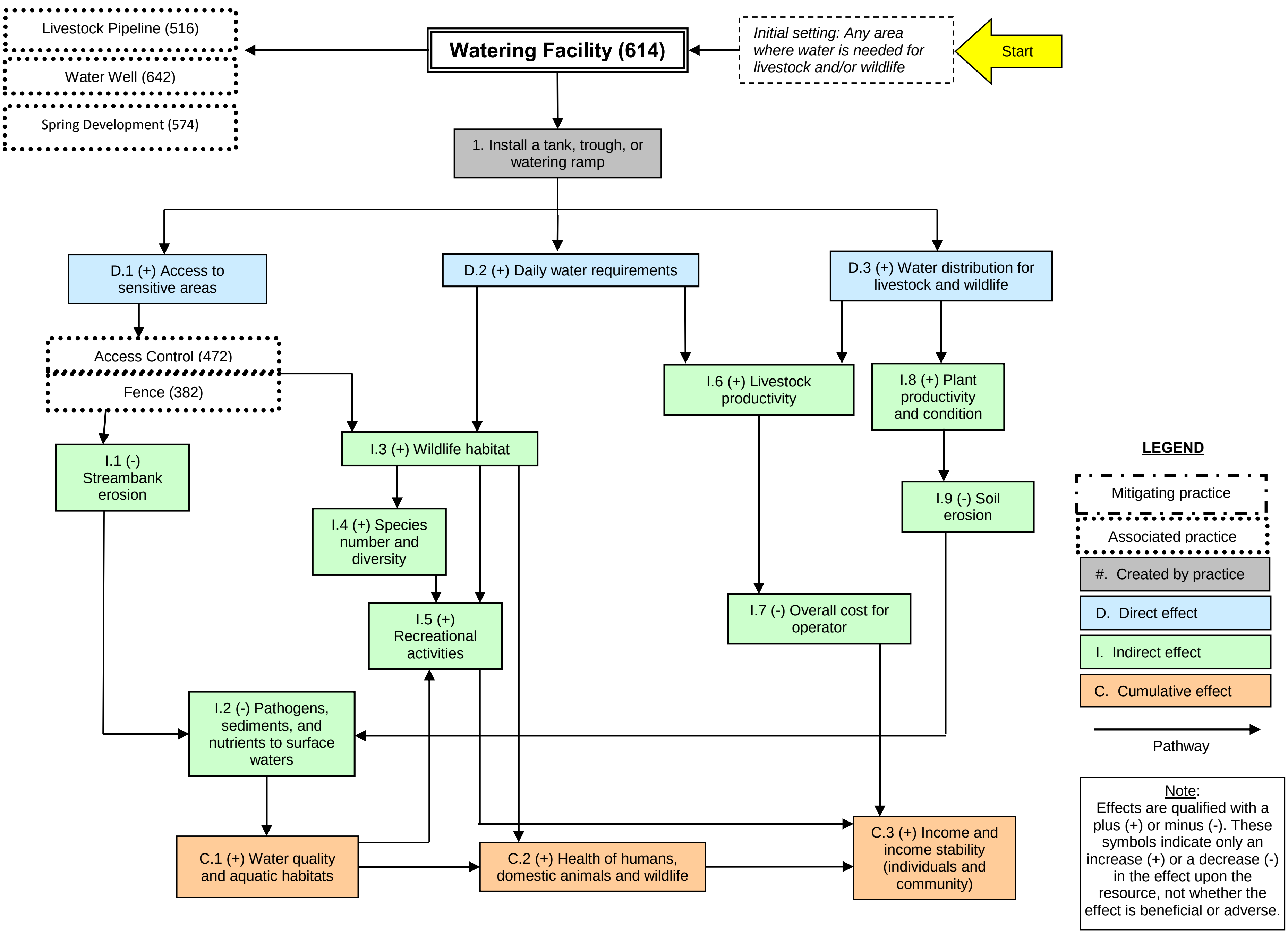

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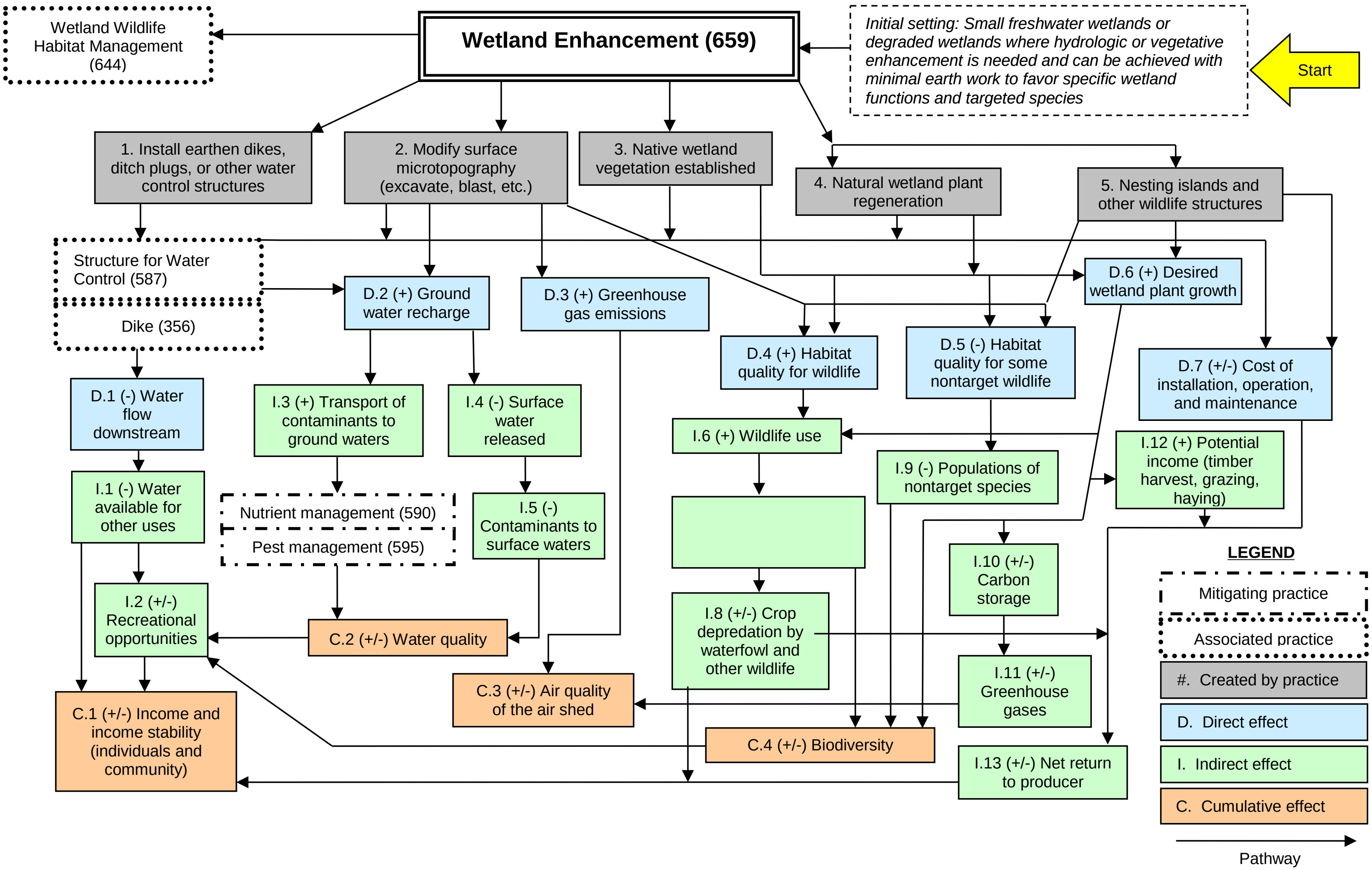

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