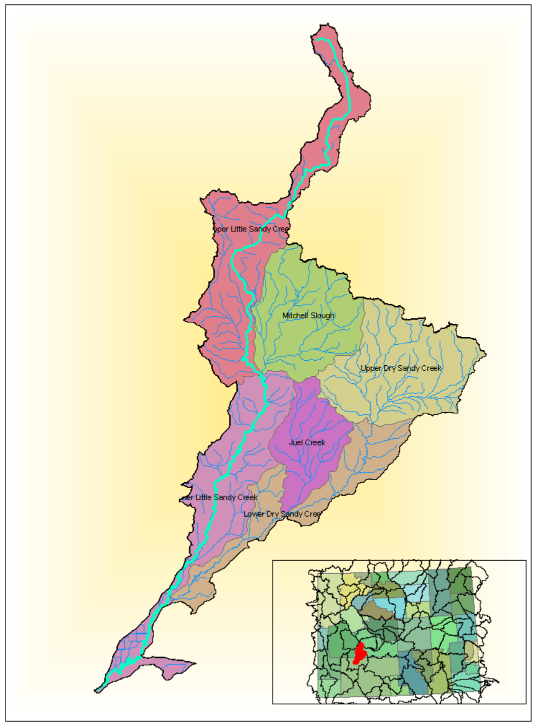
Little Sandy Watershed Plan



A comprehensive natural resource management plan
designed to address water quality issues
in the Little Sandy Watershed

Developed by:
Sublette County Conservation District
and
Little Sandy Watershed Steering Committee
Assistance Provided by:
USDA Natural Resources Conservation Service
Wyoming Association of Conservation Districts

Little Sandy Watershed Water Quality Management Plan
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- Wyoming Office of State Lands and Investments (OSLI)
- Wyoming Department of Environmental Quality (WDEQ)
- Wyoming Association of Conservation Districts (WACD)
- Sublette County Conservation District (SCCD)

1.B. Mission

The mission of the Little Sandy Watershed Steering Committee is to support voluntary land use and other practices within the land area, identify natural conditions, and address human influenced water quality issues related to non-point source pollution within the Little Sandy watershed. The history, custom, culture, and natural background influences within the watershed will be considered. The watershed plan will be developed to identify natural resource issues, and if needed, practices which will alleviate the need for regulatory agency enforcement actions.

1.C. Purpose

The purpose of the Little Sandy Watershed Plan is to:

- Define the possible causes and extent of the impairment on the Little Sandy, and an estimate of natural background loads and anthropogenic inputs and sources of sediment, for effective implementation of practices to address the impairment that are applicable to water quality standards.
- Estimate load reductions for significant sources needed to meet reduction targets and the Best Management Practices (BMPs) to address them.
- Estimate the total amount of Technical and Financial Assistance and other associated costs and the possible sources that will be relied on for implementation.
- Develop information and education to enhance the public understanding of the watershed and the BMP selection, design, and implementation process.
- Create an implementation schedule for planned BMPs.
- Establish Interim goals and milestones.
- Evaluate progress through development of criteria to establish changes in loading over time to determine if planning and implementation needs revision. Maintain a monitoring component to measure the effects of implementation against the criteria established for evaluating progress and milestones of the plan.

1.D. Clean Water Act

The Clean Water Act (CWA) was adopted by Congress for two primary purposes. That is to:

- Restore and maintain the chemical, physical, and biological integrity of the nation's waters; and
- Where attainable, to achieve water quality that promotes protection and propagation of fish, shellfish, and wildlife, and provide for recreation in and on the water. This goal is commonly expressed by the phrase "fishable/swimmable".

1.E. WDEQ Water Quality Standards

In order to ensure compliance with the CWA, the State of Wyoming is required to adopt water quality standards (laws or regulations) to enhance water quality and protect public health and welfare. Under Section 305(b) of the CWA, the State of Wyoming must also report on the condition of their water(s) to the U.S. Environmental Protection Agency (EPA) once every two years. This report, prepared by the Wyoming Department of Environmental Quality (WDEQ), is known as the 305(b) report. Under section 303(d) of the CWA, States must identify those waters within its boundaries that are not meeting the water quality standards ("impaired waters") applicable to that waterbody based on its designated use(s). A designated use is that use that a waterbody is capable of attaining although it may or may not be currently attained by that specific segment or body of water. States are required to address impaired waterbodies by establishing water quality standards and pollution control activities designed to achieve and maintain the designated uses.

1.F. WDEQ 303(d) List of Waters Requiring TMDLs

The Little Sandy River was placed on Wyoming's 1996 303(d) List as partially-supporting its aquatic life other than fish and cold water fisheries uses along a 26.9 mile segment below Elkhorn Junction. Causes of the impairment were identified as siltation, chloride, salinity and TDS and the sources of these pollutants were listed as livestock grazing and natural sources. The Little Sandy River was subsequently removed from the 1998 303(d) List because it was determined that quantitative or "credible data" were lacking to justify the listing. Subsequent monitoring by WDEQ on the Little Sandy River between 1998 and 2003 indicated that chloride, salinity and Total Dissolved Solids (TDS) were not a concern above Elkhorn Junction; however, areas of habitat degradation, stream bank instability and sedimentation were identified along several miles of Bureau of Land Management (BLM) lands, as well as, State and private lands below Elkhorn Junction. The BLM and grazing permit holders were already in the process of modifying the grazing management plan along the Little Sandy River within the Little Sandy Grazing Allotment to improve riparian and in-stream habitats; these changes included the installation of fencing and the rotation of stock within the allotment (BLM-GR, 2002). In 2004, WDEQ met with a stakeholder group including Sublette County Conservation District (SCCD), Sweetwater County Conservation District (SWCD), Bureau of Land Management (BLM) and the Little Sandy Grazing Association (LSGA) to discuss the study's findings and to conduct a watershed tour. In an effort to evaluate the effectiveness of BMPs on reducing sedimentation within the impacted reach, identify potential sources of sediment and determine designated use support, WDEQ committed to monitoring the reach of concern for a period of five years (2004-2008). The resulting study (WDEQ, 2012) found that a section of the Little Sandy River from the northern boundary of Section 33-Township 28 North-Range 104 West-downstream 17.7 miles to the Sublette/Sweetwater County line was not supporting its aquatic life other than fish and cold water fisheries uses, and this segment was added to the 2012 303(d) List. Accelerated bank erosion is the primary source of the excess sediment and the causes have been identified as livestock and wildlife grazing and historic habitat/channel modifications.

1.G. Wyoming Conservation District Authority for Watershed Planning

Following the enactment of the Clean Water Act (CWA), the U.S. EPA has delegated water quality assessment and regulatory responsibilities to the Wyoming Department of Environmental Quality (WDEQ) which is the regulatory agency responsible for enforcement of the CWA as it applies to Wyoming waters. Local Conservation Districts, by statutory authority, have assumed the responsibility of leading information and education programs and providing technical and financial assistance to their constituents to conserve Wyoming's natural resources, and to protect the quality of life of all Wyoming citizens. Conservation Districts serve as a liaison between WDEQ and local land mangers within the Little Sandy Watershed to address water quality concerns and to investigate historical, custom, cultural, and background conditions as they apply to environmental compliance with regard to water quality standards. The SCCD has endorsed the formation of the Little Sandy Watershed Plan Steering Committee to develop a locally-led, comprehensive watershed management plan to improve water quality while preserving the economic sustainability of activities and maintaining multiple uses within the Little Sandy Watershed.

Under Wyoming Statute, 11-16-103 Legislative declarations and policy, the conservation districts have the authority to "provide for the conservation of the soil and water resources of this state, and for the control and prevention of soil erosion and for flood prevention or the conservation, development, utilization, and disposal of water, and thereby to stabilize ranching and farming operations, to preserve natural resources, protect the tax base, control floods, prevent impairment of dams and reservoirs, preserve wildlife, protect public lands, and protect and promote the health, safety and general welfare of the people of this state."

Wyoming Statute 11-16-122 (b) authorizes the Conservation Districts to "conduct surveys, investigations and research and disseminate information relating to . . . the conservation, development, utilization and disposal of water. . . in cooperation with the government of this state or its agencies . . . (v)," to "develop comprehensive plans for . . . conservation of soil and water resources . . .[that] specify in detail the acts, procedures, performances, and avoidances necessary or desirable to carry out the plans (xvi)," and to "make public the plans and information and bring them to the attention of owners and occupiers of land within the district (xvii)."

In 1996 Wyoming Conservation Districts, the Natural Resources Conservation Service and the Wyoming Department of Agriculture saw an increasing need for Conservation Districts to represent local interests and take the lead in watershed planning efforts. As a result they developed the Watershed Strategic Plan to guide watershed planning efforts across the state. This document insists that "any Watershed effort led by a conservation District should be landowner driven. . .[and] any participation on behalf of any landowner is strictly voluntary." By taking an active role in the planning process, the Little Sandy Watershed landowners and the local Conservation District have adhered to this principle. The landowners have followed the steps for watershed planning as outlined in the Watershed Strategic Plan. They have identified and prioritized concerns, set goals and objectives, and developed a watershed management plan. Included in the Little Sandy Watershed Plan are elements to solicit funds, implement the plan, and evaluate the plan.

Public Participation

Following the release of data and findings by the Wyoming Department of Environmental Quality that indicated the need for action on the Little Sandy, the local land owners, in cooperation with the Sublette County Conservation District and in consultation with the Wyoming Association of

Conservation Districts held a series of public meetings in Farson, Wyoming to discuss options for addressing the concerns on the Little Sandy. These informational meetings, open to all created an opportunity for discussion among the different interested parties and the responsible local governments and agencies. The local stakeholders determined that it was in the best interest of the resource to begin developing a watershed level plan to maintain the progress that had been noted by WDEQ and to continue pursuing a path that would lead to a finding that the stream was meeting all of its designated uses.

The Sublette County Conservation District supported the development of an ad hoc steering committee, the Little Sandy watershed steering committee, in the summer of 2011. That steering committee, composed of local landowners, local resource professionals and other interested parties began working on a monthly basis to develop the Little Sandy Watershed plan EPA watershed based planning criteria for section 319 funding were used as the map for determining the items addressed in the plan. Significant assistance in facilitation and plan development was provided by the USDA NRCS, WACD, and WDEQ.

2. Watershed Description

2.A. Hydrology

The Little Sandy River is a perennial stream that originates in the southern Wind River Mountains in Sublette County and flows south/southwest to its confluence with the Big Sandy River near Farson, Wyoming (Figure 1). The stream courses through a mixture of land ownership, predominantly managed by the United States Bureau of Land Management. The Wyoming Department of Environmental Quality Water Quality Division categorizes the Little Sandy River as a Class 2AB water throughout its entire length. Class 2AB waters are protected for the following designated uses: cold-water fisheries, non-game fisheries, drinking water, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture and scenic value (Wyoming Department of Environmental Quality, 2013).

The Headwaters are located within the Bridger Wilderness in the Wind River Mountains, from here the stream moves through glacially carved landscapes until it drops into the prairie. Within the prairie, the stream cuts through soft Cretaceous and Tertiary sedimentary rocks until it joins the Big Sandy River, the Green River, the Colorado River, and ultimately drains into the Pacific Ocean.

Most streams in the Little Sandy River watershed are ephemeral or intermittent and typically respond to snowmelt/spring thaw and intense thunderstorm events. The Little Sandy River is perennial and fed by snowmelt and springs. Stream flow in the Little Sandy River, from approximately the Sublette/Sweetwater County line (the location of the Chambers Ditch Diversion Dam) downstream to its confluence is greatly influenced by surface water diversions and operation of Eden Reservoir. Though a few surface water diversions occur upstream of Chambers Ditch Diversion Dam, their influence on the natural surface water hydrology of the Little Sandy River is minimal relative to diversions in the lower watershed.

No active United States Geological Survey (USGS) gages occur on the Little Sandy River. However the USGS Little Sandy Creek Above Eden Gage (09214500) http://waterdata.usgs.gov/nwis/nwisman/?site_no=09214500) and the Little Sandy Creek Near Elkhorn Gage (09214000) http://waterdata.usgs.gov/nwis/nwisman/?site_no=09214000) are both historic within the watershed. The Wyoming SEO maintains a gaging station at the District surface water site, downstream of Elkhorn Crossing and private land.

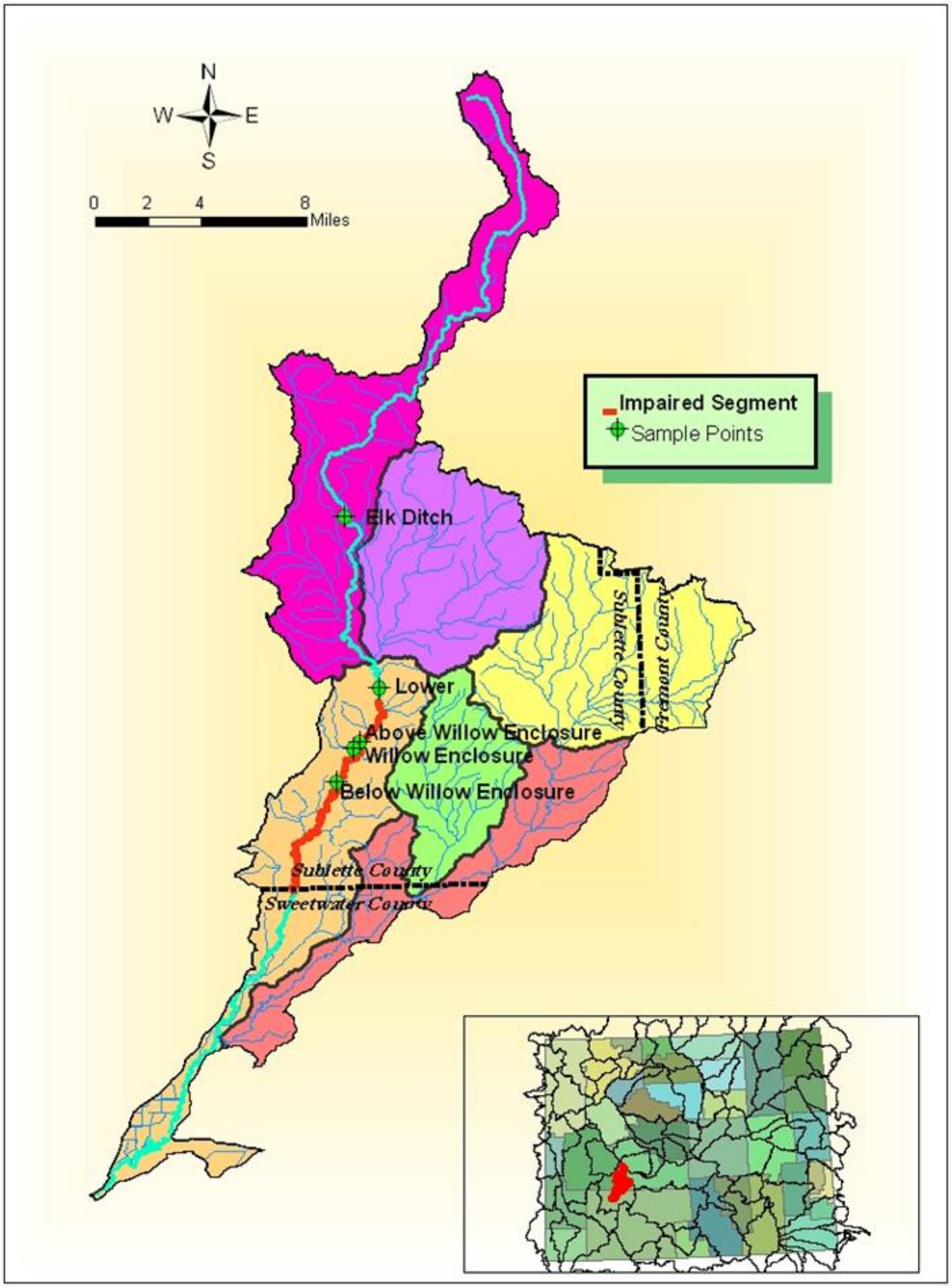


Figure 1 – Location of the impaired segment of the Little Sandy, Watershed Boundaries, Tributaries, and Initial Sample Sites.

2.B. Soils

The soils within the Little Sandy watershed have been mapped by the Natural Resource Conservation Service. Most of the soil mapping is at an approved for public use status, including the impaired segment in its entirety. The provisional mapping has also been provided further upstream for public use by the Pinedale Soil Survey Office. The soil types are important within the watershed for estimating rates of erosion.

Figure 2– Soils map showing soil types in the impaired segment.

The riparian corridor is primarily Soil map unit 9114, the Harshinger Occasionally Flooded and Harshinger Rarely Flooded Complex. The Harshinger series consists of very deep, somewhat poorly drained soils that formed in recent alluvium. These soils are on stream terraces, drainageways, and floodplain steps. Harshinger is a coarse-loamy over sandy or sandy-skeletal, mixed, superactive, calcareous, frigid Oxyaquic Torrifluvent. The slopes range from 0 to 2 percent. This complex is mapped on drainageways in intermontane basins. The parent material consists of alluvium derived from sedimentary rock. Depth to a strongly contrasting textural stratification is 20 to 39 inches. Somewhat poorly drained soil water movement in the most restrictive layers is high. Available water to a depth of 60 inches is low. These soils are occasionally flooded, however, no ponding occurs. A seasonal zone of water saturation is at 22 inches during April, May, June, July, August, September, October and November. The components are in the R034AY174WY Subirrigated (Green River – Great Divide Basins) ecological site and the R034AY130WY Overflow (Green River – Great Divide Basins) ecological site. The soil has a slightly sodic horizon within 30 inches of the soil surface.

The upland areas along the riparian are varied, but are dominated by a few major soil types and map units. Map unit 5332, the Juel-Sandbranch-Ravenhole complex is common. Juel makes up 50 percent of the map unit, Sandbranch makes up 25 percent of the map unit, and the Ravenhole makes up 15 percent of the map unit. Slopes are 1 to 8 percent. The parent material consists of slope alluvium over residuum weathered from sandstone and shale. Depth to a root restrictive layer, bedrock, paralithic, is 39 to 59 inches. The natural drainage class is well drained. The components are in the R034AY144WY Saline Upland (Green River - Great Divide Basins) ecological site, R034AY104WY Clayey (Green River - Great Divide Basins) ecological site, and the R034AY150WY Sandy (Green River - Great Divide Basins) ecological sites respectively. These soils do not meet hydric criteria. The soils have slightly saline horizon within 30 inches of the soil surface and a slightly sodic horizon within 30 inches of the soil surface.

Map Unit 5333, the Ravenhole-Jonah-Buckloaf complex, is also common. The Ravenhole component makes up 35 percent of the map unit, the Jonah component makes up 35 percent of the map unit, and the Buckloaf component makes up 20 percent of the map unit. Slopes are 1 to 6 percent. The parent material consists of eolian deposits over residuum weathered from sandstone and shale and slope alluvium over residuum weathered from sandstone and shale. Depth to a root restrictive layer, bedrock, paralithic, ranges from 20 to 59 inches. The components are in the R034AY150WY Sandy (Green River - Great Divide Basins) ecological site and the R034AY122WY Loamy (Green River - Great Divide Basins) ecological site. These soils have a slight to moderate sodic horizon within 30 inches of the soil surface.

The final map unit shown here as a critical example, is the Forelle-Bluerim-Worfman complex, unit 5504. It is steeper than some of the other examples, with slopes ranging from 2 to 35 percent. The Forelle component makes up 40 percent of the map unit, the Bluerim component makes up 25 percent of the map unit, and the Worfman component makes up 15 percent of the map unit. These components are on hillslope landforms residing on footslopes, shoulders, and backslopes respectively. The parent material consists of slope alluvium derived from sandstone and shale. Depth to a root restrictive layer varies from deep, greater than 60 inches, to shallow, 12 inches, depending on which soil is encountered and the location on the landform. The components are in the R034AY122WY Loamy (Green River - Great Divide Basins) ecological site, R034AY104WY Clayey (Green River - Great Divide Basins) ecological site, and the R034AY162WY Shallow Loamy (Green River - Great Divide Basins) ecological site. These soils have a slightly sodic horizon within 30 inches of the soil surface.

2.C. Vegetation

As you move from higher to lower elevations in the watershed, the landcover changes significantly. Rocky mountain subalpine dry-mesic spruce fir forest is the first major landcover type encountered. As the elevation in the forest decreases, the major landcover is Rocky Mountain lodgepole pine forest. Once out of the pine forest, alluvial fans and transitions are encountered and covered with Inter-mountain basins montane sagebrush steppe, then inter-mountain basins big sagebrush steppe. Wyoming Dwarf Sage Brush Shrubland and inter-mountain basin big sagebrush shrubland make up the majority of the landcover in the lower sections of the watershed (2010, Gap)
The riparian corridor is best represented by the Subirrigated (Sb) 7-9" Green River Great Divide Basins Ecological Site Description (R034A174WY). The interpretive plant community for this site is the Historic Climax Plant Community and has evolved with grazing by large herbivores and is suited for grazing by domestic livestock. Potential vegetation is estimated at 70% grasses or grass-like plants, 15% forbs and 15% woody plants.

The major grasses and grass-like plants include basin wildrye, tufted hairgrass, Nebraska sedge, inland sedge, slender wheatgrass and rhizomatous wheatgrasses. Other grasses and grass-like species that may occur on this site include Baltic rush, Canby bluegrass, Mat muhly, Northern reedgrass, and American and Tall mannagrass. Woody plants are mainly willows and Shrubby cinquefoil, but may also include Chokecherry, Wild rose, and Rubber rabbitbrush.

A typical plant composition for this state consists of Basin wildrye 15-35%, Tufted hairgrass 15-30%, Nebraska sedge 5-10%, Inland sedge 1-10%, Slender wheatgrass 1-10%, Rhizomatous wheatgrass 1-10%, other grasses and grass-like plants 10-20%, perennial forbs 5-15%, willows 5-10%, Shrubby cinquefoil 5-10%, and 5-10% other woody plants. Ground cover, by ocular estimate, varies from 85-100%.

The total annual production (air-dry weight) of this state is about 3000 pounds per acre, but it can range from about 2300 lbs./acre in unfavorable years to about 3500 lbs./acre in above average years.

2.D. Climate & Topography

The average annual precipitation for the Little Sandy watershed is 13 inches, with an 8 inch minimum and 30 Maximum (SuiteWater, 2017).

The impaired reach of the Little Sandy received an average annual precipitation of 9 inches with a minimum of 7 inches and maximum of 11 inches.

The Natural Resources Conservation Service has maintained monitoring for snowfall and other weather data within the general area. Specific data can be found on the Big Sandy Snotel Site https://wcc.sc.egov.usda.gov/nwcc/site?sitenum=342 with details on the amount and timing of precipitation in the Wind River Mountains near the watershed headwaters.

Climate data has been collected near the watershed as part of the standard practices of other entities. The nearest data that can be correlated to is that of Farson, Wyoming. http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?wy3170. The United States Geological Survey has maintained stream flow gages at several points within the watershed over time, as mentioned on page 8.

The range of elevation in the watershed is from 12,808 feet in the mountains, to 6,552 feet at the outlet of the watershed. The mean elevation is 7,376.59 feet.

Wyoming Water Development Cloud Seeding Project

The Wyoming Water Development Commission has worked on the development of a cloud seeding program within the Wind River Mountain Range, and a large part of that program affects the watershed. The steering committee will stay informed on any development of Cloud Seeding efforts that could affect hydrology within the watershed.

2.E. Land Management and Land Use

The Little Sandy Watershed has a 10 digit Hydrologic Unit Code (1404010404), with sub-watersheds located therein: Juel Creek, Lower Dry Sandy Creek, Lower Little Sandy Creek, Mitchell Slough, Upper Dry Sandy Creek, Upper Little Sandy Creek. The watershed itself is a sub-watershed of the larger Big Sandy watershed, lying primarily within Sublette County, Wyoming. The Little Sandy watershed has a total of 181,941 acres. Land management in the watershed is mixed as shown in Figure 3. The United State Bureau of Land Management is responsible for 77.81 percent of the surface, private land owners 7.12 percent, the State of Wyoming 6.65 percent, United States Forest Service 6.38 percent, and the United States Bureau of Reclamation 2.01 percent. The State of Wyoming managed lands are used primarily for grazing. Though most of the state lands in the watershed are in the "uplands", some of the area managed by the state lies along the riparian corridor, with a small portion falling directly within the impaired segment.

Administration and Political Boundaries

The watershed is managed under a series of governmental units that are important to the functions of water quality, quantity and distribution of water: Within the watershed the following units of management and government exists:

- The State Engineers office District 6 Division 4
- Wyoming Office of State Lands and Investments
- Eden Valley Irrigation District
- Wyoming High Dessert BLM District
- BLM Rock Springs Field Office
- Sublette County Conservation District
- Sweetwater County Conservation District
- Bridger-Teton National Forest Pinedale Ranger District
- Wyoming Game and Fish

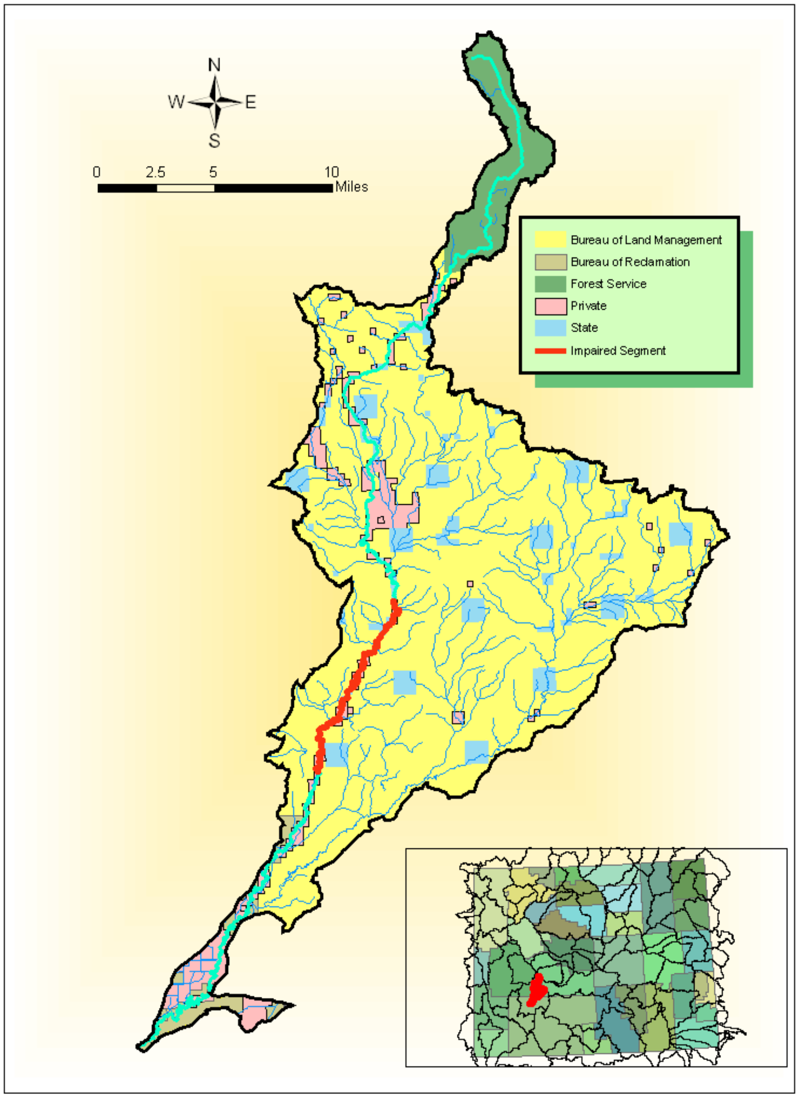


Figure 3 – Land management within the Little Sandy Watershed

Anthropomorphic Influence

Based on estimates from the 2010 census, the population with the watershed is around 140 individuals.

There are 3,368 irrigated acres within the watershed, primarily in the lower Little Sandy.

Agricultural statistics are unavailable for the watershed itself, but they are available for the county. Based on the 2012 Ag Census by the United States Department of Agriculture National Agricultural Statistics Service (NASS) within Sublette County, agriculture is a significantly important industry in the county, and within the watershed (NASS, 2012). The number of agricultural operations has increased within the county by 9%. The current private grazing land Animal Unit Month (AUM) value is $21.00 based on 2016 Wyoming Ag Stats Bulletin.

Most private agricultural land within the county is dedicated to hay production, with roughly 77% of agricultural lands being used as such. Cropland made up almost 20% of the remaining agricultural uses. The lower portion of the watershed, below the impairment, is within the Eden valley Irrigation District. The primary agricultural product produced within the county in terms of units is forage, with over 93,000 tons produced in 2015 (SuiteWater, 2017). 4,500 tons of that was alfalfa hay, with the remainder being forage; much of which is harvested and utilized on site for livestock. Livestock within the county in 2012 was comprised of primarily cattle, roughly 69,588 including calves (NASS, 2012). Sheep were not accounted for in the 2012 census, however about 11,500 sheep including lambs were recorded in the 2009 census (NASS, 2009). There are roughly 3,376 horses in the county, and 629 layers (NASS, 2012). The vast majority of the livestock producers are cow/calf and lambing operations who grow and ship livestock to other areas. These numbers, although not specific to the watershed alone, illustrate the general agricultural operations in the area.

Watershed Land Use History

As with many areas of the arid west, historic land use in the watershed is tied to production agriculture in general and livestock production in particular. Prior to the late 1960's, the vast majority of livestock grazing within the Little Sandy watershed was centered on the sheep industry. A few cattle from the Boulder area were permitted on the upper stretches below the forest boundary in conjunction with the sheep use. In addition, Bar X Sheep Company also ran some cattle on their portion of the watershed starting in the early 1960's. The area of the Little Sandy watershed under USFS management was permitted to the White Acorn Sheep Company, who ran sheep there until the early 1970's. Grazing within the forest occurred primarily in the summer, between July 10 and September 10 each year.

The Bar X Sheep Company (Leonard Hay) acquired the majority of the Little Sandy from the forest boundary past the Megeath Place just upstream 2 ½ miles from the impaired segment, at an early date, somewhere in the late 1930's or early 1940's. The two exceptions were in an area adjacent to Prospect Mountain, still held by Midland Land & Livestock (Pete Arambel), and an area of state land just below Elkhorn, held by Blair & Hay (John Hay) that has been fenced in recent years. Bar X held one permit on the Forest in the upper Little Sandy drainage. The majority of Bar X use was for lambing their late lambing ewes. Historically, sheep would be brought in around May 25th for range lambing and remain lower on the watershed until going to the Forest in early July. Some areas of fenced pasture on the river served as a ram pasture throughout the summer and early fall. Fall use with herds in the watershed was minimal.

Blair and Hay held rights to state land sections in the watershed and used those lands primarily as a resting place while trailing herds to and from the Pacific Creek Allotment to the Forest. At the point where the Sublette County Road (from Boulder to the Sweetwater County line) crosses the Little Sandy River, several herds of sheep trailed across each summer going to and from the Forest at the Big Sandy Opening.

A tributary of the Little Sandy called Mitchell Slough (with the exception of its last mile used by Leonard Hay) was used by another sheep operation, Lander Creek Land & Livestock (Paul Juel) until it was acquired by Magagna Bros. in 1952. Mitchell Slough is primarily an ephemeral drainage that is supplemented in part by a water right from Magagna Bros. out of the Little Sandy. In the 1968 BLM adjudication it was proposed to put this area into the Little Sandy Allotment. However, by agreement of all parties it was left within the Little Prospect Allotment and the Little Sandy Grazing Association was permitted use in the allotment. Sheep use on this drainage still occurs from May 15th to July 10th.

The portion of Little Sandy from the Megeath place to the Eden Project was a part of the Spicer sheep operation until 1965. It was used as a lambing area from approximately May 5th until sheep began trailing to the forest in early July. Again, the only regular summer use on the Little Sandy would have been for rams. Spicer again used this area in the fall, approximately September 10 to October 30 (Jim Magagna, 2011). Ownership and management of the land changed significantly in 1965. Producers began converting sheep permits to cattle permits and the Little Sandy Grazing Association purchased private land and grazing rights from Leonard Hay and the Spicer's. The Association then improved the newly acquired grazing land by installing boundary fences and nine off-stream water sources.

In the mid-seventies grazing permits in the area were adjudicated and allotments were assigned. Little Sandy Grazing permits were divided between the Little Sandy and the Little Prospect allotments. Some boundary fences divided the allotments. The Little Prospect Allotment is in common use with sheep. Grazing plans were written for both allotments. They were both deferred systems utilizing private, state, and federal lands. Cross fences were built to aid in pasture management.

In 1990, the Little Sandy Grazing Association, White Acorn Ranch and Magagna Brothers were recognized for their leadership in riparian management by the BLM. Their accomplishments were used in a BLM training video utilized at the agencies National Training Center in Phoenix, Arizona.

Some of the more recent activities within the watershed have included adjustments in grazing management to further improve riparian habitat. A deferred grazing system was put in place in the Little Sandy allotment in which cattle grazed one side of Little Sandy River in the spring and the alternate side in the fall. The following year this procedure was reversed. Under this grazing system cattle have access to the riparian area both spring and fall. Thus, in order to help control grazing on the riparian area, seven miles of riparian management fence was built in 2003.

In addition to the Little Sandy Grazing Association, other current permittees in the Little Sandy allotment are: Blair and Hay, Ruth Chesnovar, G&E Livestock, Midland Dunton Sheep Company, Magagna Brothers, and White Acorn Sheep Company. In 2002 Blair and Hay, Magagna Bros., Midland Dunton, White Acorn, and G&E Livestock all took non-use. In the Little Prospect grazing allotment, in addition to the Little Sandy Grazing Association, are: Blair and Hay, G&E Land and Livestock, Magagna Brothers, Mark And Jeanna Renae Jones, and Hellyer Limited Partnership. Non-use in 2002 and 2003 was taken by Hellyers, G&E, and Blair and Hay.

Range Resources

The major use of the Little Sandy Watershed at this time is related to range utilization by wildlife and livestock. The United States Forest Service (USFS), Blucher Creek Allotment sits at the top of the watershed. From the forest boundary, the area is dominated by public land allotments managed by the BLM. The BLM Rock Springs Field office is responsible for managing the allotments.

As one follows the Little Sandy watershed and decreases in elevation, the following BLM grazing allotments are encountered:

The Prospect Mountain grazing allotment, 13004, sits higher in the watershed. There are multiple permit holders in the allotment, and 3,642 Animal Unit Months (AUM) are made available for livestock grazing on 48,738 acres, 8,094 acres (17%) lies within the Little Sandy watershed. FLPMA [Sec. 4100.0-5] defines an AUM as "the amount of forage necessary for the sustenance of one cow or its equivalent for a period of 1 month." The allotment is broken in pastures identified as A, B, C, D, E, and F.

The Little Prospect, 13002, grazing allotment is the next encountered in the watershed, and it also has multiple users. The BLM has allocated 7,236 AUMs within this allotment on 84,346 acres for the use of livestock grazing, of which 69,669 acres (83%) lies within the Little Sandy watershed. The allotment is broken into the Lander Creek, Middle and South pastures. The BLM has implemented an Allotment Management Plan to improve the range resources within the unit.

The Little Sandy grazing allotment, 13003, is another allotment within the watershed. The BLM has allocated 7,725 total AUMs on 114,683 total acres in the allotment for grazing livestock. Of these allotment acres, 65,947 (57%) lie within the Little Sandy watershed. The allotment is broken into the Reservoir, Mountain, Dry Sandy, and Elkhorn pastures. Multiple permits are issued to users and an Allotment Management Plan (AMP) has been implemented. The AMP, certified December 13, 1982 (RSBLM, 1982), provides detailed information on the grazing system and treatments. The system uses a horseshoe pattern starting lower in the allotment, moving up, and then returning later in the year. In addition to grazing by livestock, the AMP states that the allotment contains crucial winter habitats for moose, elk, mule deer, and pronghorn antelope. Pronghorn migration corridors also exist along with important Greater sage-grouse habitats, in which the area is now considered part of the Sage-grouse Core Area (State of Wyoming Executive Order 2015-4 http://psc.state.wy.us/pscdocs/dwnload/SageGrouseExecOrder2015-7.pdf). The AMP indicates 3700 AUMs per year are needed to support the wildlife (RSBLM, 1982).

The final allotment in the watershed is the Eden Project, 03028, having 3,131 total AUMs available for livestock on 29,034 acres, of which 7681 acres (26%) lies within the Little Sandy watershed. These numbers were taken from individual Allotment reports, and are summarized in the Table below.

Allotment Name	Allotment Number	Total Acres	Total AUM's	Acres in Little Sandy watershed	% of total allotment acres
Prospect Mountain	13004	48,739	3,642	8,094	17
Little Prospect	13002	84,346	7,236	69,669	83
Little Sandy	13003	114,683	7,725	65,947	57
Eden Project	03028	29,034	3,131	7,681	26
				151,391 Little Sandy Acres	

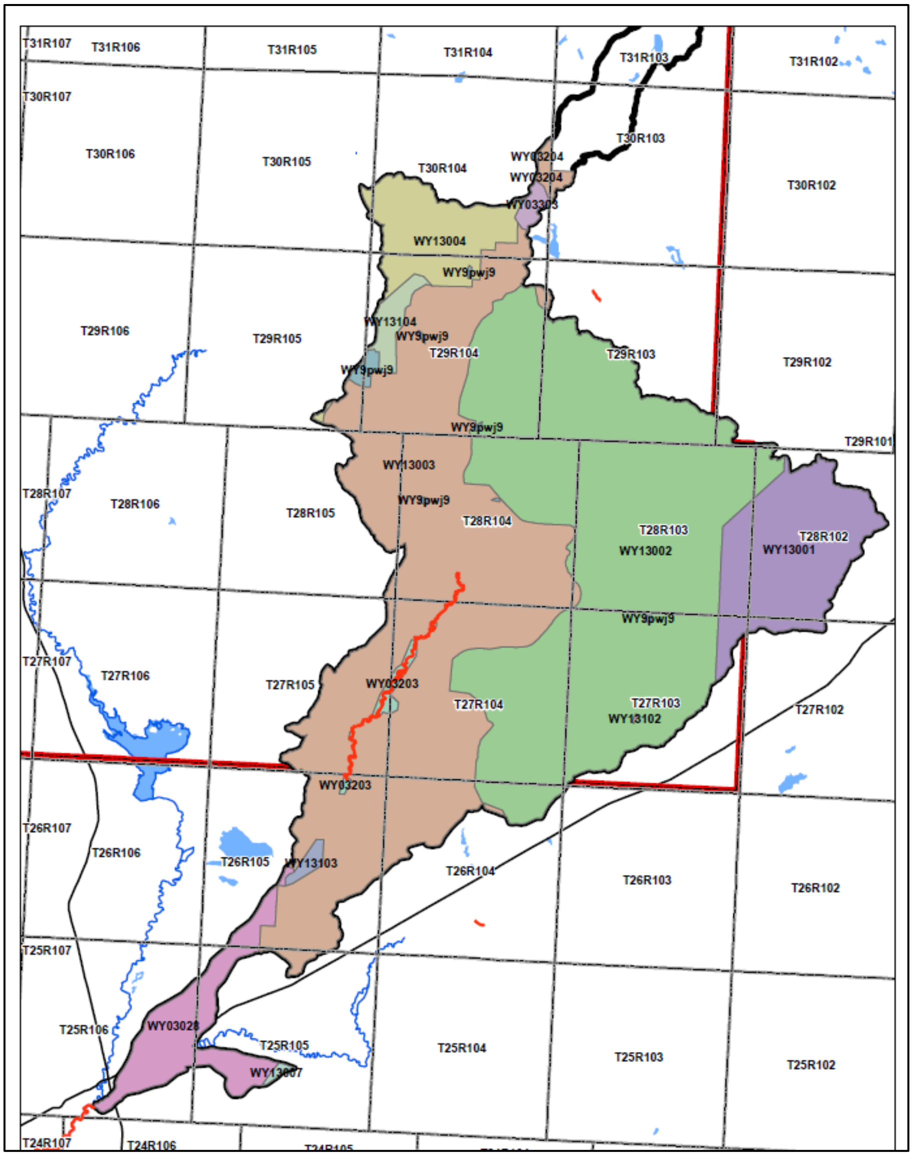


Figure 4 – BLM Allotments within the Little Sandy Watershed

The BLM has monitored the Little Sandy watershed extensively in the past. Utilization has been measured using the Landscape Appearance method during years 2001, 2002, 2003, 2009, 2010, 2016. Utilization transects were conducted near the Little Sandy River. Photos were taken in these areas as part of the documentation. A series of photographs exist south of the Little Sandy Grazing Association Headquarters from 2001, showing that the creek had totally dried up. Proper Functioning Condition (PFC) assessments have also been completed on multiple reaches within the watershed in years 1995, 1998, 2006, 2010 and 2016 (BLM, 2016).

Wildlife

The Little Sandy watershed is an important winter range area for big game in Sublette County. The Wyoming Game and Fish Department (WGFD) identify crucial elk (*Cervus canadensis*) winter range located around the Prospect Mountains and winter range designated near Highway 191 north of Big Sandy Reservoir. Land users have noted use by elk, expressing estimated numbers in the 300 to 400 range; WGFD estimates the numbers of elk using the area in the winter to be 500 to 700 head.

Much of the area is designated as mule deer crucial winter range, encompassing a big chunk of the area south of Buckskin Crossing, along the west and south slopes of Little Prospect, and south all the way along the Little Sandy River and east of Elk Mountain. Mule deer (*Odocoileus hemiounus*) using the area are estimated to be 6,000 to 10,000 animals. Pronghorn antelope (*Antilocarpa americana*) crucial winter range is located in all directions around the Big Sandy Reservoir and the population there is estimated in the 4,000 to 6,000 range.

Using conservative numbers, the grazing by the amount of deer and elk identified by Game and Fish during the winter is then estimated at 4395 AUMs, based on 5,000 deer and 500 elk during a 5 month period. When compared to the Little Sandy Grazing Allotments number of AUMs allotted by BLM of 7725 AUM's for livestock, it is clear that wildlife can have a significant impact within the watershed.

WGFD has also monitored grazing impacts on woody browse species in the Little Sandy watershed. WGFD surveyed the Tabernacle Butte winter range using sagebrush transects in 2009. The data for hedging indicated 64% of plants were severely hedged, 34% moderately hedged and 4% were lightly hedged. This takes into account historic pressure and structure of the plant due to browsing patterns over time. The 2009 age class diversity data indicated 0% of the stand is young, 62% is mature, 36% is decadent and 2% is dead. The data shows a lack of recruitment, and supports the observations of generally poor vigor. The result of less recruitment and poor vigor is less than desirable annual leader production on these Wyoming big sagebrush plants according to the WGFD in 2009.

A large portion of the stream's riparian area, from just off the forest boundary along the Big Sandy River, Little Sandy River, Lander Creek and the Sweetwater River is designated as crucial winter range for moose. Wyoming Game and Fish has estimated approximately 30 to 50 moose use these areas. The Little Sandy drainage was estimated to have lower populations of moose less than 10. These estimates by the Wyoming Game and Fish are based on flights since 2008. Additionally, the Sublette County Conservation District (SCCD) noted evidence of use via sign (i.e. pellets or animals) by moose and deer during their site visit in May of 2011. Numerous dead deer in the area were documented by SCCD counting upward of 25 deer carcasses. Presumably these were winter kill due to the harsh winter of 2010/2011. The winter of 2016 also had a large effect on the deer population. Typical of big game wintering areas, some willows and shrubs showed evidence of moderate to heavy browsing. More complete data on wildlife use is not currently available, and both the SCCD and WGFD expressed a need to develop a better data set to accurately determine browse.

This area in general is considered important Greater sage-grouse habitat. The vast majority of the watershed lies within the Greater South Pass Sage Grouse Core Area. The BLM also recognizes this area as a Sagebrush focal area. The area contains all of the year round habitats needed for the bird to survive. There are several active leks located in the vicinity, as well as potential winter use and winter concentration areas.

In 2015, Governor Mead signed Executive Order 2015-4 for Greater Sage-Grouse Core Area Protection. This executive order establishes that state agencies will work collaboratively with local governments and private landowners to maintain and enhance Greater Sage-Grouse habitats and populations in a manner consistent with the Executive Order. Should funding be awarded from state or federal agencies to implement portions of this watershed plan that involve land-disturbing activities in core areas, coordination with the funding agency and/or Wyoming Game and Fish

Department may be required to ensure consistency with the Executive order and minimize impacts to Greater Sage-Grouse populations and habitat. If any such consistency reviews are needed to implement action items of this watershed plan, all involved parties will work together to ensure the necessary review and analysis are completed.

The Little Sandy shows evidence of past and present beaver (*Castor canadensis*) activity. Historically, there was likely a larger beaver population that could have effectively widened the riparian area. Beaver are both a source of stability and sediment in these stream systems. Beaver dams slow water, collecting sediment contributing, and contribute to water filtration and purification; however when the dams wash out, the stored sediment and energy is released downstream. When this occurs the river must compensate and find a new dynamic equilibrium. The most important factor to maintaining a beaver population would be the presence of sufficient woody materials for the beaver, as well as protection of willows from the same animals until woody vegetation can be well established.

Other important species have also made historical use of the watershed and continue to do so. The watershed provides habitat to multiple species identified by the United States Fish and Wildlife Service (USFWS). In addition to Greater sage-grouse and pygmy rabbits, portions of the watershed are listed as habitat for Canada lynx (*Lynx canadensis*), American bittern (*Botaurus lentiginosus*), Bald eagle (*Haliaeetus leucocephalus*), Brewer's sparrow (*Spizella breweri*) Burrowing owl (*Athene cunicularia*), Ferruginous hawk (*Buteo regalis*), Mountain plover (*Charadrius montanus*) , Sage sparrow (*Artemisiospiza nevadensis*), Swainson's hawk (*Buteo swainsoni*), white-tailed prairie dog (*Cynomys leucurus*), bluehead sucker (*Catostomus discobolus*) , and the flannelmouth sucker (*Catostomus latipinnis*; (USFWS, GIS). SCCD also noted use by pygmy rabbits with the presence of burrows and pellets found along many of the sagebrush terraces with loamy and sandy soils, as well as raptors perching on top of ridges and in crevices of the soil outcrops.

Fisheries

In the Little Sandy watershed the following species are prevalent. Three Wyoming native fish species, bluehead sucker, flannelmouth sucker, and roundtail chub *Gila robusta*, commonly referred to as "the three species", are present and are facing serious threats to their populations. The three species have declined dramatically throughout their native range in Wyoming, causing concern over the sustainability of their populations (Wheeler 1997, Bezzerides and Bestgen 2002, Gelwicks et al. 2009). Habitat degradation, including altered flow regimes and interactions with non-native fishes such as white sucker *Catostomus commersoni*, , lake chub *Couesius plumbeus* and Utah chub *Gila atraria*), have facilitated these declines (Wheeler 1997, Bezzerides and Bestgen 2002, Bower 2005, Gelwicks et al. 2009).

Native bluehead and flannelmouth suckers face risks of hybridization with non-native suckers. Introduced white sucker hybridize with native bluehead and flannelmouth suckers (Baxter and Stone 1995, Douglas and Douglas 2007) to produce viable offspring (Douglas and Douglas 2007, McDonald et al. 2008). This poses a serious threat to the genetic integrity of their populations (Gelwicks et al. 2009). Hybridization will continue to threaten native sucker populations until non-native fish are extirpated from their habitats (Douglas and Douglas 2007, McDonald et al. 2008, Gelwicks et al. 2009).

The Wyoming Game and Fish Department has identified four priority drainages: the Big Sandy River, Bitter Creek, Little Sandy Creek, and Muddy Creek within the upper Green River and Little

Snake River watersheds in southern Wyoming as important habitat for the enhancement of populations of bluehead sucker, flannelmouth sucker and roundtail chub populations in Wyoming. Wyoming Game and Fish has worked cooperatively with other agencies and landowners within the Little Sandy River watershed. Electrofishing surveys, to identify the relative abundance and distribution of native non-game fish species within the drainage were conducted during the summer of 2003. Non-native fish removal was conducted in 2009, 2010, and 2011 to benefit native bluehead suckers and flannelmouth suckers. The focus of this project was to conserve native fish populations by removing as many non-native fish as possible in priority drainages prior to future native fish salvage and chemical restoration. Single pass electrofishing and picket weirs were used to mechanically remove non-native fishes and sample native fish populations. In the Little Sandy River a total of 25,413 fish were captured during removal efforts in 2009-2011. Of those, 16,912 non-native fish were removed from the Little Sandy River. White suckers were the most abundant species in each year. Bluehead and flannelmouth suckers increased from 28% of the 2009 catch to 32% of the 2011 catch even though the total number decreased from 2010 to 2011 and were captured in downstream reaches more frequently. Declines in the relative abundance of non-native fish were observed following mechanical removal efforts. Fewer adult white suckers were captured after each year of removal.

A total of 3,193 fish were captured during removal efforts from 2009 to 2011 on Long Draw and 3,160 non-native fish were removed. White suckers represented 99% (*n*=3,146) of the non-native fish removed; fish < 6 in dominated the sample of white suckers. Three bluehead suckers and six flannelmouth suckers were captured in 2009 (all 4-7 in), but none were found in 2010 or 2011.

While this work has not completely eliminated the threats posed by non-native fish, it alleviated the pressures (hybridization, competition and predation) placed on native fish populations by introduced fish. For example, population structures suggested that recruitment occurred in native fish populations in the Big Sandy River and Little Sandy and Muddy Creeks. Recruitment of native suckers in the Big Sandy River had not been observed in several years prior to the removal efforts. Future management of native non-game fish in the Little Sandy River watershed will focus on the salvage and holding of native fish and chemical treatments to eliminate non-native fish populations. Additional details on the Little Sandy Creek removal efforts can be found by inquiring with the Wyoming Game and Fish Department.

The Wyoming Game and Fish Department installed a sheet piling fish migration barrier on Long Draw 2012. The barrier was installed in preparation for upcoming chemical treatments to eliminate non-native fish. The barrier is intended to keep non-native fish in the Little Sandy River from reinvading Long Draw. The Wyoming Game and Fish Department chemically treated Long Draw with liquid rotenone in 2015 and again in 2016. Both treatments were considered successful. Only a small number of Lake Chub were killed by rotenone during the 2016 treatment. The chemical treatments eliminated a large population of white suckers that was impacting the native suckers in the Little Sandy River.

As part of their 2009 Strategic Habitat Plan, the WGFD has recommended that the Little Sandy River drainage (which includes the delineated reach) should receive high management priority given its unique populations of two native sucker species (i.e., flannelmouth sucker and bluehead sucker) and the ability to manage non-native fishes in this drainage. Both of these suckers are endemic to the Colorado River Basin and have been experiencing range-wide declines in distribution and abundance. The WGFD has recommended solutions to management of this crucial habitat in no particular order that includes restoration and habitat enhancement for native suckers; reductions in sediment yield to aquatic habitats from grazing and timber practices; restoration of aspen, willow and other woody riparian vegetation; encourage expansion of beaver colonies; advocate habitat protection and minimize future energy development impacts in the area.

Habitat requirements of native suckers

Bluehead suckers are widely distributed in the Colorado River Basin and occur in main-stem rivers and tributary streams from the mouth of the Grand Canyon upstream to headwater reaches of the Green and Colorado rivers (Bezzerides and Bestgen 2002, Baxter and Stone 1995). They are more frequently found in headwaters than flannelmouth suckers (Baxter and Stone 1995). Large adults are associated with deep pools, undercut banks, moderate to fast current velocities, and rocky substrates (Sigler and Miller 1963). Sublette et al. (1990) noted spawning to occur on gravel beds in shallow water. Maddux and Kepner (1988) observed egg deposition in shallow redds excavated in stream gravel.

Flannelmouth suckers typically inhabit pools and deeper runs in the Colorado River Basin, but they are also found in small streams and occasionally in lakes (Sigler and Miller 1963, Baxter and Stone 1995). Juveniles select for slower current velocity habitats, such as backwaters, eddies, side channels, and shallow riffles (Bezzerides and Bestgen 2002). Substrate preferences vary from mud and silt to cobble and gravel (Sigler and Miller 1963, McAda et al. 1980), but adults are often more abundant over hard substrates, rather than sand and silt (Holden and Stalnaker 1975a). Flannelmouth spawning aggregations have been observed in tributaries of the Lower Colorado River in glides or slow riffles, over medium –course gravel substrate (Weiss 1993, Otis 1994).

Recreation

The Little Sandy Watershed continues to be a world class location for wildlife and natural resource based recreational activities. The Bridger-Teton National Forest sits at the headwaters of the watershed, with a small section of the Bridger Wilderness at the very top. This area provides recreation to visitors and sportsman every year that use the area for hiking, camping, fishing, hunting, and many other recreational pursuits.

Outdoor enthusiasts utilize the Forest Service and BLM lands for dispersed camping throughout the year, although the USFS has not developed or designated a campground in the watershed. Recreational use of dirt roads and trails is permitted and encouraged by the land management agencies in the watershed, and maps are made available to the public at local offices and area retailers to inform the general public of the roads and trails available for automobiles, four wheel drive vehicles, four wheelers, motorcycles, snowmobiles, and any other motorized transportation. Trails within the wilderness are not open to any motorized transportation, and are also closed to bicycles.

Hunting opportunities are abundant in the watershed, and big game hunting access is prevalent due to the large amount of public land present, although most of the riparian acreage is primarily private with some state lands. The Wyoming game and fish department has identified large sections of the watershed, including the impaired segment, as critical habitat for big game species. According to Wyoming Game and Fish statistics, 184 Elk were harvested in Elk Area 99 in 2010, which encompasses the Little Sandy Watershed. In addition, 1398 Mule Deer were taken in the same period, that being within the entire herd unit (Wyoming Game and Fish, 2010). These animals also use the watershed continuously from December to April. These numbers are representative of the annual harvests and wintering that can be expected in the area. In addition, antelope, moose, and numerous other small and big game species are annually present in the watershed in significant numbers.

Industry

Although this watershed has not been subject to high amounts of pressure from the extractive energy industry, it lies close to areas that have been developed and utilized. Gas production has been prevalent in much of the Green River Basin and within Sublette County, but there are only three permitted gas wells within the watershed, two are listed as abandoned, and one is idle at this time. Traffic has increased with potential for further increase in the near future. The upper section of the watershed was identified as a possible Wind Energy Development Zone, though no developments have yet occurred in that area (SuiteWater, 2017).

3. Watershed Assessment and Condition

3.A. Water Quality Summary

Sublette County Conservation District

The Sublette County Conservation District (SCCD) has been monitoring surface water in Sublette County since 2000. In 2008, SCCD began monitoring the Big and Little Sandy Rivers. Two surface water sites were established on each of the rivers for a total of four sites. BS1 upper site and BS2 lower site on the Big Sandy River, and LS1 upper site and LS2 lower site on the Little Sandy River.

Chemical samples and field data are collected five times per year (before high water, during high water, after high water, early fall and late fall) at all four sites. Chemical analysis includes alkalinity, bicarbonate, carbonate, calcium, chloride, magnesium, nitrogen (Nitrate as Nitrite+N), phosphorus, potassium, sulfate and sodium. Field parameters include: dissolved oxygen (mg/L and %), pH, conductivity, total dissolved solids and turbidity. Flows are measured when staff is safely able to do so.

Macroinvertebrates (aquatic insects) are collected at two sites BS1 and LS1 using Surber Samplers and floating bug traps are used at BS2 and LS2 to collect aquatic insects. The macroinvertebrate samples collected by SCCD staff are sent to an aquatic ecologist for identification and analysis. Following the fifth year of data collection a report will be prepared using the macroinvertebrate data collected at each of the four sites (Marshall, B. A. 2015 Baseline Biological Condition of the Big Sandy River and the Little Sandy River in Sublette County, WY).

Grants from WDA/WACD and monies from Sublette County have paid for the surface water monitoring program on the Big and Little Sandy Rivers.

USGS

In 1982 the United States Geological Survey (USGS) produced a document titled " Sediment transport and source areas of sediment and runoff, Big Sandy River Basin, Wyoming." (Kircher, J. 1981) This report detailed some aspects that are still pertinent on Little Sandy River today, such as geology, physiography, soils, climate, geomorphology, vegetation and land use, stream flow, channel shape and size, sediment sources and transport, suspended loads, bed loads, total transport rate, source areas of sediment and runoff, factors affecting sediment, yield, and discussion of these issues.

The report notes specifics of the Little Sandy. Specific notes and calculations were made of related channel shape and size. USGS notes that channel shape and size is complex, resulting from the interaction of multiple factors such as the lithology, amount, and depositional forms of the sediment load, as well as the hydraulic factors related to water flow. The USGS notes a trans-basin diversion of water from the Little Sandy to the Sweetwater River for irrigation and notes that this may affect natural flow.

The USGS found that Geology was composed of Tertiary and Cretaceous mudstone, siltstone, sandstone, and shale, all of which were easily eroded. They determined that the geology of the region was a major factor in contributing to the large sediment production. The eroding and weathering of bedrock was noticeable in the watershed and its tributaries, so that sediment rates could at least partially be explained by geology.

There is a downstream increase in sediment transport rate once the streams leave the glacial deposits and mountains and flow across the semi-arid plains. The stream carries almost no sediment in its upper reaches, very few point bars existed and there was large stream capacity to carry more than the supplied sediment. Many locations exhibited mass wasting along the banks. The stream leaves the glaciated terrain and flows through a more erodible region, and the pattern changes to meandering. As the stream flows it has a large capacity for sediment, but little is supplied by its tributaries, therefore, the banks and bed become the main sediment source for the stream.

In summary, the USGS report concluded that there was a large increase in sediment load within the Big Sandy below the confluence with the Little Sandy, and that the sediment came primarily from the load in Pacific Creek. Furthermore, it indicates that sedimentation was caused by the erodible basin material and the semiarid climate.

WDEQ Monitoring Activities

In 2004, WDEQ began intensive monitoring of the Little Sandy to insure that it fully supported designated uses as defined by the law. As previously noted the Monitoring and Assessment Program of the Wyoming Department of Environmental Quality-Water Quality Division (WDEQ/WQD) assesses the water quality and makes designated use-support recommendations for streams, rivers, lakes, reservoirs and wetlands in Wyoming. The Little Sandy River is categorized as a Class 2AB water throughout its entire length, it is protected for cold-water fisheries, non-game fisheries, drinking water, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture and scenic value.

The Little Sandy River was originally placed on Wyoming's 1996 303(d) List for partial-support of coldwater fisheries and other aquatic life uses for an undetermined distance upstream and downstream of Elkhorn Junction. This listing was based on information provided by the Wyoming Game and Fish Department (WGFD) and the Natural Resources Conservation Service (NRCS). Suspected causes of the impairment were siltation (sedimentation) and elevated salinity, total dissolved solids (TDS) and/or chlorides that possibly originated from rangeland and natural sources. The Little Sandy River was ultimately removed from the 1996 303(d) List due to an absence of credible data to substantiate the impairment and subsequently placed on Table E of Wyoming's 1998 305(b) report. Streams on the 1998 Table E list including Little Sandy River, required the collection of credible data (biological, chemical and physical data) to determine the validity of impairments described on Wyoming's 1996 303(d) List.

The required monitoring was conducted by WDEQ/WQD in 1998 and 2003 indicated all designated uses were supported in the Little Sandy River upstream of Elkhorn Junction and that elevated salinity, TDS and chlorides were not a concern in the Little Sandy River. However, the Little Sandy River's ability to support fisheries and other aquatic life designated uses downstream of Elkhorn Junction for several stream miles (i.e., reach of concern), appeared to be compromised due to channel aggradation caused by excess sediment contributions from accelerated stream bank erosion.

The 1998 and 2003 assessments were conveyed to the United States BLM in March of 2004. The BLM, in return, contributed a plan that the BLM in cooperation with the Little Sandy Grazing Association had worked to modify grazing practices within the Little Sandy grazing allotment. This plan encompassed the reach of concern and includes BLM, Wyoming State Lands and private holdings. Grazing practices were modified through additional fencing and rotational grazing, to improve riparian habitat and bank/channel conditions and ultimately allow the BLM to comply with their standards for healthy rangelands. WDEQ/WQD determined that a multi-year monitoring of the reach of concern was warranted to evaluate trends in physical, biological and chemical conditions of the stream following the initiation of the modified grazing management plan.

In July 2004, the WDEQ/WQD hosted a field tour of the Little Sandy River reach of concern, to convey findings from the agency's 2003 assessment, to further understand the watershed and the existing and proposed modifications to the grazing management plan and discuss plans for a multi-year monitoring design. The tour was attended by representatives from the WDEQ/WQD, USBLM, Sublette and Sweetwater County Conservation Districts and the Little Sandy Grazing Association. With input from the aforementioned entities, the WDEQ/WQD committed to monitor the Little Sandy River reach of concern over a five-year period beginning in August/September of 2004. This modified grazing plan was implemented in the spring of 2005. The monitoring objectives were to 1) gather information to document trends in the physical and biological condition of the stream as a result of modified grazing management, 2) identify potential source(s) of physical instability/sediment and with results of the monitoring 3) evaluate chemical, physical and biological conditions of the Little Sandy River with respect to Wyoming water quality standards to determine designated use support.

Information from the 2004-2008 monitoring indicated the Little Sandy River from a point approximately 11 stream miles below Elkhorn Junction near the landmark Squaw Teat, downstream 18 stream miles to near the Sublette/Sweetwater County line, is partially/non-supportive of its designated fisheries and other aquatic life uses (i.e. impacted reach). The weight-of-evidence showed a departure in the biological condition of this impacted reach of the Little Sandy River from the expected regional reference condition. In addition, there was an appreciable decline in biological condition with distance downstream within the upper four stream miles of the impacted reach. Within the lower 14 stream miles there was a slight increase in biological condition. Biological condition within the impacted reach fluctuated considerably from 2004 to 2008 with no consistent positive or negative trend during the study period.

3.B. Actual Bank Erosion Measurements and Results

There are several lines of physical evidence that when combined and weighted, indicate an alteration to the sediment regime of the Little Sandy River. Information from the sediment competence, sediment capacity, stream bank erosion, channel bed materials, channel profile and channel fill and scour analyses provide the strongest evidence that channel aggradation is occurring in the Little Sandy River at all three multi-year monitoring sites, though this is particularly pronounced from the BLM exclosure downstream.

Based on the most recent 2008 stream bank erosion rates, approximately 1,564 tons (or 59% of the estimated total excess sediment load for the impacted reach) of excess sediment is contributed annually by accelerated stream bank erosion within the upper four stream miles of the impacted reach. Likewise, accelerated stream bank erosion contributes 1,088 tons/yr (41% of the total excess estimated total load) within the remaining 14 stream miles of the impacted reach.

Measurements of stream bank erosion rates among all three multi-year monitoring sites using bank profiles are presented in the Water Quality Condition and Designated-Use Support Determination for the Little Sandy River, Green River Basin, 2004-2008 (WDEQ 2010; see Figure 5 and Appendix 13). Corresponding Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) ratings varied among years, though were generally higher at 'Above Willow Exclosure' relative to the other two sites. In several instances where annual BEHI and NBS ratings were both low, stream bank erosion was not evident, particularly at 'Willow Exclosure' and 'Below Willow Exclosure'. For more information refer to WDEQ 2010 *Water Quality Condition and Designated Use- Support Determination for the Little Sandy River, Green River Basin, 2004 -2008* report.

Based on BEHI/NBS ratings at bank profiles and reach-wide, predicted annual stream bank erosion rates at each site using Rosgen's (2006) BANCS model for the Colorado River Basin were close to measured values on the Little Sandy River, though the Colorado curve generally over-predicted annual stream bank erosion rates (Appendices 10-12 in WDEQ 2010). To provide the most accurate estimation of annual stream bank erosion rates, a BANCS model was developed specifically for the Little Sandy River based on measured stream bank erosion rates at bank profiles with associated BEHI/NBS ratings (Appendix D).

The Little Sandy River BANCS model provided a lower, more accurate estimation of annual stream bank erosion on the Little Sandy River relative to the Colorado Basin BANCS model (Appendices 10-12). Based on the BANCS model developed for the Little Sandy River the mean stream bank erosion rate over the study period was significantly different between sites with 'Above Willow Exclosure' having the highest mean rate of 0.0678 tons/yr/ft, 'Below Willow Exclosure' the lowest mean rate of 0.0369 tons/yr/ft and 'Willow Exclosure' falling between at 0.0517 tons/yr/ft (Appendices 4 and 10-12 in WDEQ 2010).

There was also a significant difference in mean stream bank erosion rate for all sites combined between years with the greatest amount of erosion occurring in 2005, followed by 2004, 2007 and 2008 (Table 2 and Appendix 4 in WDEQ 2010). From 2004 to 2008, annual stream bank erosion rates declined at all sites with the greatest decline of 65% at 'Below Willow Exclosure', the smallest decline of 13% at 'Above Willow Exclosure' and 'Willow Exclosure' with a 49% decline (Table 2, Figure 6 in WDEQ 2010). Though an overall 13% decline in annual stream bank erosion rate was observed at 'Above Willow Exclosure', there was a 50% decrease from 2005 to 2007 followed by a 70% increase from 2007 to 2008 (Figure 6 in WDEQ 2010).

An evaluation of annual stream bank erosion rates per segment, associated BEHI/NBS values, and segment location over time indicate that the majority of bank erosion (and consequently annual stream bank erosion rate reductions) among all three sites primarily occurs along outside meander bends and secondarily along straight sections (Appendices 14-16 in WDEQ 2010). Annual stream bank erosion rates along outside meander bends are greatest at 'Above Willow Exclosure' (Appendix 14 in WDEQ 2010). BEHI values among all years and sites indicate that segments of channel where stream bank erosion rates were greatest were characterized by steep bank angles; minimal surface protection, root depth and density from riparian vegetation; and high bank-height ratios as shown in Figure 5. High bank-height ratios indicate more bank surface is exposed above the bankfull elevation and thus the bank is at greater risk for surface erosion, freeze/thaw, bank slumping and failure and other mass erosion processes (Rosgen 2006). Furthermore, reaches of the channel where stream bank erosion was greatest were characterized by greater densities of invasive species and upland vegetation; along with limited willow; hoof impact; hummocks in the riparian zone and/or compacted soils (Figure 7 in WDEQ 2010). The combination of these indicators suggests that grazing pressure is high in these areas (Skinner et al. 2000). Associated NBS values of 'Moderate' to 'High' also characterized segments of eroding bank where stream bank erosion rates were greatest.

3.C. Causes of Impairment

Non-attainment for fisheries and other aquatic life designated uses in the impacted reach is primarily due to channel aggradation from excess sediment contributions that become more pronounced with distance downstream. The primary source of the excess sediment originates from accelerated stream bank erosion within the Little Sandy River of which the cause is identified as grazing. Areas where accelerated stream bank erosion occurs is characterized by absent or limited diversity and density of riparian vegetation, extensive stands of invasive upland vegetation, limited dead and tunneled willow, hoof impact, hummocks in the riparian zone, and compacted soils. All of these indicators are suggestive of high grazing pressure. The weight-of-evidence shows that within the impacted reach, the upper four miles is a geomorphic degraded section that is the primary source of the excess stream bank sediment. The lower 14 stream miles of the impacted reach, though still experiencing appreciable channel aggradation, exhibited slightly greater in-stream aquatic habitat and reduced bank erosion relative to the upper four stream miles. It appears this marginal difference in physical condition is responsible for the slight increase in biological condition within the lower 14 stream miles of the impacted reach. Temporary additions of sediment to the already excess sediment load in the stream may occur as a result of beaver dam failures. As with accelerated stream bank erosion, these beaver dam failures are primarily attributed to the absence or limited cover and diversity of riparian vegetation along the stream banks. Legacy effects from historical channel adjustments do not appear to contribute significantly to the channel degradation and aggradation that currently exists in the Little Sandy River. Combined, this information translates to non-attainment of narrative criteria Sections 15 (Settleable Solids) and 21 (Protection of Aquatic Life) in WDEQ/WQD's Chapter 1 Water Quality Rules and Regulations within the impacted reach. No applicable numeric criteria were exceeded during the study period.

Monitoring of Impaired Segments

The Little Sandy River at the three multi-year monitoring sites is, at a minimum, competent or has the stream energy necessary to transport the largest existing (coarse sand to fine gravel) and predicted (medium gravel) size of particle. However, 'Above Willow Exclosure' is at risk for potential channel degradation such as channel incision and/or stream bank erosion (relative to the other two sites) due to excess competency from a combination of greater than predicted mean bankfull riffle depths and channel gradients. During the initial study period, average net gains in bankfull cross- sectional area (4.88 ft2) and net losses in channel bed elevation (-0.17 ft), were greatest at 'Above Willow Exclosure' relative to 'Willow Exclosure' (0.37 ft2 , -0.01 ft) and 'Below Willow Exclosure' (0.00 ft2, 0.00 ft).

The 2004-2008 survey data also suggest that the channel at all three sites, though particularly at 'Willow Exclosure' and 'Below Willow Exclosure', is aggrading with sand and fine gravel because the largest existing particle moved at bankfull flows is less than what was predicted. Average net losses in bankfull cross-sectional area and gains in channel bed elevation were noted at 'Above Willow Exclosure' (-7.26 ft2, 0.28 ft), 'Willow Exclosure' (-4.74 ft2, 0.15 ft) and 'Below Willow Exclosure' (-7.55 ft2, 0.24 ft).

It should be noted that the average net loss in bankfull cross-sectional area and gain in channel elevation at 'Above Willow Exclosure' only occurred at cross-section 1+73. Overall, 'Above Willow Exclosure' is primarily experiencing channel degradation rather than aggradation. Investigating where these gains and losses occurred revealed that most degradation occurred at riffle and to some degree run habitats whereas aggradation was more prominent at pool and to some degree glide habitats. Indeed, decreases in mean bankfull pool cross-sectional area, mean bankfull pool depth and the mean ratios of maximum pool depth to mean riffle depth at all three sites, particularly 'Willow Exclosure' and 'Below Willow Exclosure' indicate pool aggradation. This information combined with analyses of channel profiles and channel materials further supports the conclusion that channel aggradation is most prominent at 'Willow Exclosure' and 'Below Willow Exclosure'.
As a result of the data collected in their studies, the WDEQ found that a section of the Little Sandy River from the northern boundary of Section 33-Township 28 North-Range 104 West downstream 17.7 miles to the Sublette/Sweetwater County line was not supporting its cold water fishery and aquatic life other than fish uses and this segment was added to the 303(d) list of impaired waterbodies in 2012.

The reasons for the determination are: excess sediment contributions causing channel aggradation that are linked to contributions from accelerated stream bank erosion in reaches of the Little Sandy River experiencing channel degradation. These physical alterations have caused a decline in biological condition with distance downstream from the 'Lower' site and a departure from the expected regional biological condition. Accelerated stream bank erosion is most pronounced from the northern boundary of the USBLM Willow Exclosure upstream to the northern extent of the identified impacted reach. Excess sediment deposition or channel aggradation is most pronounced from the northern boundary of the USBLM Willow Exclosure downstream to the Sublette/Sweetwater County line. (WDEQ, 2011)

Past Resource Management Changes

Implementation of the modified grazing management plan may have reduced excess sediment contributions from accelerated stream bank erosion within the impacted reach. From 2004 to 2008, annual stream bank erosion rates declined between 49% and 65% within the lower 14 stream miles of the impacted reach, with only a marginal reduction of 13% in the upper four miles of the impacted reach where accelerated stream bank erosion is greatest. Associated with these reductions was an overall improvement in the percentage of stream banks covered by riparian vegetation, particularly within the upper four miles of the impacted reach. Below normal peak flows in 2007 are likely responsible for an exacerbation of channel aggradation during that year. However, accounting for the low flows of 2007, there has been no significant change in channel aggradation or degradation (other than a reduction in stream bank erosion) within the impacted reach during the study period.

WDEQ determined that "although the excess sediment from accelerated stream bank erosion has reduced marginally over time, it has not been sufficient to result in appreciable improvements in overall channel aggradation/degradation nor biological condition of the impacted reach. It is speculated that the rate of improvement in stream bank erosion within the upper four miles of the impacted reach may be slower relative to the remainder of the impacted reach in part, because of the magnitude and extent of riparian disturbance. Consequently, noticeable improvements in channel aggradation and associated aquatic life use support in the impacted reach will not be realized until the upper four miles stabilizes appreciably and comes to equilibrium with its natural sediment regime. A stabilized channel with well vegetated stream banks should also help to reduce the frequency of future beaver dam failures. This may take considerably longer than the five years since the modified grazing management plan was implemented".

3.D. Background Sediment Sources in Little Sandy

The Little Sandy River, in the area of concern, has many contributing sources of sediment; some of which are caused by natural processes, as well as other factors that may have triggered erosion at accelerated rates in the past. Background or natural sediment sources include contributions from upland sites as well as from the stream banks and bed itself. Due to the geology and topographic features of the area, there is potential for a large amount of natural sediment to be transported through this system. Accelerated bank erosion is perceived as the major source of excess sediment contribution, which is the reason for the listing of the stream.

Sediment is a natural component of a stream where the main sources include erosion of uplands, lateral movement of channels into stream banks and down-cutting of channel beds (Waters 1995). However, most natural sediment inputs are relatively small, occur gradually and can be incorporated by stream processes into nondestructive forms and quantities thereby maintaining a stream that is physically stable or in dynamic equilibrium (Waters 1995). Physically stable is defined as a stream's ability in the present climate to transport the stream flows and sediment of its watershed, over time, in such a manner that the channel maintains its dimension, pattern and profile without either aggrading or degrading (Rosgen 1996).

Streams are dynamic systems that go through a natural evolution over time. In their geomorphic lifespan, changes in stream power related to precipitation, bed loads, vegetation, base level, and climate can have significant impacts on the nature of the stream. Stream sediment load moved through a system is a product of complex interaction of energy, geology, climate, bed load, etc. Some deposited sediment if associated with vegetation can lead to better width to depth ratios over time, resulting in a system that is competent to move the average annual loads within them (Skinner, 2000). However, streams that were in an equilibrium condition and that then see an increase in sediment input may show bank failure as a result of in-stream deposition that leads to stream widening. The condition persists until the additional sediment load is moved through the system.

In the Little Sandy, there are two different parent materials with two separate erosion rates. The steeper stream reaches in mountainous areas of the Little Sandy tend to resist erosion due to the water running over minimally-erosive bedrock. Bed load materials, especially fine material, are more easily moved here. In the mid and lower sections of the Little Sandy watershed channels widen and become shallower. Vegetated banks here are keys to maintaining the continuity of these systems (Skinner, 2000).

Moving away from the streambed itself other natural sources of sediment are found. The geology of the mid and lower portion of the watershed is dominated by sedimentary bed rock including sandstones, siltstones and limestone. All are prone to weathering. These parent materials have produced sandy and sandy loam soils in the uplands that are susceptible to erosion if plant cover is not maintained. Areas of poor soil are naturally void of vegetation on a consistent basis. The uplands that are relatively flat, with moderately deep to deep soils, have plant communities that can be characterized as healthy sagebrush/bunchgrass communities; which promote infiltration and slow run-off. Little sediment directly enters the stream from sheet or rill erosion in the uplands. However, there are bluffs and knolls with exposed bedrock and shallow soils (< 10 in) that have naturally low vegetation cover. Intense rain events and spring run-off events can cause accelerated erosion and produce excess sediment loads in these areas. There are also numerous gullies that drain the watershed and that have the potential to contribute significant amounts of sediment during spring snow melt or intense rainstorms. In the arid soils of the watershed some sediment loads from stable upland communities of this type would be considered normal, and part of the natural/background load. Although this has not yet been quantified through field study, this could be a large source of sediment contribution.

Anthropogenic Sources of Sediment

Anthropogenic disturbance such as riparian vegetation removal or over-utilization can result in excess available sediment contributions, erosion, and eventual channel aggradations downstream. Excess sediment can occur when riparian areas and stream banks are vegetation-limited or lacking in well-developed root structures. In this condition they cannot retain soil and stable stream banks. This can result is accelerated stream bank erosion at high flows. The increased supply of sediment moves with the high flows as suspended sediment, or is pushed along the channel bed creating scour. As flows recede, the excess sediments are deposited, changing the substrate composition, filling the interstitial spaces within gravels and cobles; covering larger substrate and aquatic macrophyte habitat. Information obtained from the 2004-2008 survey indicates that stretches of the Little Sandy River with inadequate stream bank vegetation and accelerated bank erosion are likely responsible for channel aggradation in the stream (WDEQ, 2011).

Other Sources of Sediment

Other sources of sediment originate directly at or in the stream. There are numerous alluvial fans and upper terraces that the stream contacts as it meanders through the valley. These areas have high banks that are incapable of supporting stabilizing riparian vegetation due to the height above the water table. These banks are susceptible to erosion and caving and contribute large amounts of sediment especially during high water. This natural contribution has also not been quantified.

The excess sediment identified by WYDEQ is presumably coming from banks that should be stable, but are not and are eroding at an accelerated rate. Some historical events (some identified such as the extreme drought of the early 20th century, as well as other unknown events), have caused the stream to severely down-cut, resulting in an incised channel. Consequently, the drop in the water table has resulted in the stream loosing regular access to its flood plain, further accelerating erosion and channel incising. Not having an accessible flood plain results in water flow exerting more force on the banks during frequent flood events.

The lowering of the water table has impacted what vegetation can survive on the banks, changing it into a more mesic plant community on the banks and old flood plain. Upland plants have less dense root systems than riparian vegetation and are less capable of stabilizing the banks, resulting in increased bank failure and increased sediment load. Down-cutting of the stream will also have affected the drainages and gullies coming in from the surrounding uplands, which would have to cut down to meet the base level of the stream, creating head cuts which travel into the uplands; causing an additional increase in sediment.

3.E. Sediment Sources to the Little Sandy River

Reasonably accurate estimations of sediment contributions from known sources, under both existing and physically stable target conditions, are critical to understanding the sediment reductions needed in the Little Sandy River. Understanding necessary sediment reductions is important to develop and implement appropriate best management practices.

Known sediment contributions in the Little Sandy River study area can be broadly categorized into four sources: bank erosion, uplands, roads and in-channel sediment storage. Using several years of data collected by the WDEQ, SCCD, USGS and others, sediment contributions from these sources, for both existing and target conditions, were predicted using five models - FLOWSED, POWERSED, BANCS and RII (part of the Watershed Assessment of River Stability and Sediment Supply (WARSSS) methodology (Rosgen 2006)) as well as the USDA Revised Universal Soil Loss Equation (RUSLE). Combined, these sediment quantifications were used to develop a total annual sediment budget and associated source allocations for both existing and target conditions. Brief descriptions of each model, input data and sediment predictions can be found in the following sections; detailed information can be found in WDEQ/WQD Technical Addendum found in Appendix D (2014)

<u>Total Annual Sediment Load</u>

Total annual sediment load (bedload and suspended) for both existing and target conditions were estimated using FLOWSED at the lowermost extent of the impaired segment (endpoint). Stream flow data collected at USGS gage 09213500 (Big Sandy River near Farson, WY) combined with field-derived estimates of bankfull discharge within the Little Sandy River were used to develop a localized flow-duration curve for the ungaged Little Sandy River endpoint. Representative bankfull bed transport rate and suspended sediment concentration for stable conditions at the endpoint were derived from sediment data collected at gage 09213500. The measured bankfull flow of 334 cfs at the endpoint equated to a predicted stable bed transport rate of 1.07 kg/s and a suspended sediment concentration of 387.3 mg/L. Using these data in combination with the localized flow duration and sediment rating curves developed for the endpoint, FLOWSED predicted 2,203 tons of bedload and 7,151 tons of suspended sediment, for a total annual sediment load of 9,354 tons/yr. Using the unstable sediment rating curve that represents existing conditions at the endpoint, FLOWSED predicted 4,914 tons of bedload and 8,019 tons of suspended sediment for a total annual existing sediment load of 12,933 tons/yr.

<u>Contributions from Stream Banks</u>

Bank erosion rates and associated sediment loads were estimated with the Bank Assessment for Non-point source Consequences of Sediment (BANCS) model developed specifically for the Little Sandy River (WDEQ, 2010). The BANCS model estimates annual bank erosion rates based on integration of data obtained using two tools: Bank Erosion Hazard Index (BEHI) and Near-Bank Stress (NBS). BEHI and NBS measurements were collected along erodible banks at six monitoring sites in 2012 and 2013. Data obtained from these six monitoring sites in addition to bank erosion rates obtained from stream types similar to the Little Sandy River, represented best attainable or impacted bank erosion conditions among the six channel/valley type segments within the study area.

In order to validate estimates of bank erosion from the BANCS model, bank profile surveys were conducted at two representative cross-sections along erodible banks at each monitoring site. Measured annual bank erosion rates along with paired BEHI/NBS results obtained at bank profiles generally corresponded to predicted annual stream bank erosion rates from the BANCS model. For channel/valley type segments with both best attainable and impacted bank erosion conditions, estimated annual stream bank erosion rates representative of impacted conditions were 1.3 to 1.7 times greater than best attainable bank conditions. Existing annual sediment load from bank erosion was calculated by multiplying the predicted annual stream bank erosion rate by the corresponding length of each stream bank condition within each channel/valley type segment and then summed for a total of 9,735 tons/yr. Results from this procedure indicated that contributions from accelerated stream bank erosion were greatest within the *Little Sandy Upper "Critical" Area* (identified later in this document). The target annual bank sediment load was calculated following the same procedure, though only annual bank erosion rates representing the best attainable condition for each channel/valley type segment were used, for a total of 7,911 tons/yr.

<u>Contributions from Roads</u>

Contributions of road sediment to the study area from stream encroachment, crossings, exposed cut banks, road fill, surfaces and inadequate drainage were estimated using the Road Impact Index (RII) (Rosgen, 2006). This process involved delineating the study area into 58 sub-watersheds and using GIS to obtain the following information within each sub-watershed: acres of sub-watershed, acres of roads, number of stream crossings,valley slope position of roads, proximity of roads to streams, road age and road surfacing. This information was then used to determine an overall risk rating of potential sediment delivery from roads in each sub-watershed. Using the final RII values and road sediment delivery equations developed by Rosgen (2006), road sediment yield was calculated for each sub-watershed. The RII estimated the total existing sediment load from approximately 221 miles of gravel and dirt roads in the study area to be approximately 129 tons/yr. Assuming all roads in the study area can achieve an optimal annual sediment yield of 2.9318 tons/yr/acre (value derived from road sediment delivery equations) under best management practices, the target annual road contribution would be 78.4 tons/yr.

<u>Contributions from Uplands</u>

Target upland contributions of sediment in the form of surface, rill and gully erosion at the endpoint were deductively determined as the difference of the natural bank erosion contribution (7,911 tons/yr.) and target road contributions (78 tons/yr.) from the total annual target sediment load (9,354 tons/yr.), for an upland contribution estimate of 1,365 tons/yr. It is assumed that under target conditions, the channel would be able to effectively transport flow and sediment with minimal to no aggradation; therefore, in-channel storage of sediment would be negligible. As there have been no documented significant anthropogenic disturbances to the uplands of the study area (less roads), the target upland contribution of 1,365 tons/yr. is also used to represent upland contributions under existing conditions.

<u>Contributions from In-Channel Storage</u>

Using the predicted FLOWSED sediment rating curves along with geomorphic data obtained from cross-sections representative of stable (best attainable) and unstable channel conditions, POWERSED was used to predict sediment transport capacity and any resultant channel degradation or aggradation, which can then be used to infer whether in-channel storage of sediment is a source of excess sediment at endpoint. Existing geomorphic data (WDEQ, 2010) were used to obtain representative best attainable and unstable cross-sections for the endpoint. Using these data, POWERSED developed discharge/unit stream power relationships at the endpoint, that in combination with the corresponding FLOWSED predicted sediment rating curves, produced relationships to calculate sediment transport capacity at each representative cross-section. The total annual sediment transport capacity at the stable cross-section is then compared to that of the unstable cross-section to evaluate channel stability (aggradation, degradation or stable). POWERSED predicted that with an incoming total annual existing sediment load of 12,933 tons/yr., the channel at the endpoint is only able to effectively transport 7,981 tons/yr., indicating aggradation or in-channel storage. Because the representative best attainable cross-sections used in the POWERSED run were quasi-stable at best and that in-channel storage can vary spatially, the difference between the total annual existing sediment load and the current channel transport capacity cannot be used as a reasonably accurate quantification of in-channel storage. Rather, the quantity of in-channel storage was deduced as the difference between the sum of the existing upland, stream bank and road contributions from the existing total annual sediment load; the result is an in-channel storage estimate of 1,704 tons/yr.

Sediment Targets for the Little Sandy River

The following table summarizes the total annual sediment load under both existing and target conditions in addition to associated sediment allocations. In summary, for the Little Sandy River study area to achieve a total annual sediment load under target conditions, 3,579 tons/yr. of sediment would need to be addressed. The reduction of 1,824 tons/yr. from accelerated stream bank erosion along with passive or active adjustment of the channel to the stable form, will consequently contribute to the reduction of 1,704 tons/yr. of in-channel storage.

	Existing Conditions (Unstable)				**Target Conditions (Stable)**				**Reductions**	
	Bedload (tons/yr)	Suspended (tons/yr)	Total (tons/yr)	% of Total	Bedload (tons/yr)	Suspended (tons/yr)	Total (tons/yr)	% of Total	Difference (tons/yr)	% of Total
Stream Bank Erosion			9,735	75.3			7,911	84.6	-1,824	51.0
Road Contributions			129	1.0			78	0.8	-51	1.4
Upland Contributions			1,365	10.6			1,365	14.6	0	0.0
In-Channel Storage			1,704	13.2			0	0.0	-1,704	47.6
Total Sediment Load	4,914	8,019	**12,933**		2,203	7,151	**9,354**		**-3,579**	

3.F. Water Quality Target for the Little Sandy

Water quality in the Little Sandy must be improved by reducing the total eroded sediment and associated deposition within the watershed in order for the Little Sandy to meet all of its designated uses. The Water Quality Target is a numeric standard used to establish achievement of these water goals. Each target is unique to its waterbody, and represents the achievement of water quality standards for each waterbody to meet the requirements for all relevant beneficial uses. For pollutants with a narrative standard, such is the case with the Little Sandy, narrative standard must be translated into a measurable value. Since a numeric target is being established in this case to address the narrative standard, the methodologies used to determine the numeric criterion, target, and the links with the pollutant of concern have been described in detail above.

Initial WDEQ studies indicated that 1564 tons of erosion due to bank failure was present within the impaired segment on an annual basis. The total in the system is equal to the this excess sediment, plus the natural input from bank erosion, plus the sheet and rill erosion reaching the stream, plus the sediment present from gully erosion.

3.G. Critical Areas

The WDEQ decision to list the Little Sandy as impaired was based on a weight of evidence approach, as well as centered on the effects of sediment deposition and aggradation in the section of the Little Sandy below a point identified as the "Above Willow Exclosure". It also included the effects of incision and erosion above that point between "Above Willow Exclosure" and the "Lower" Sample point.

As noted in the WDEQ study, the primary effects of sedimentation and deposition are clearly in the impaired reach. The primary contributions of sediment are from a combination of accelerated erosion within the upper section of the impairment in addition to the natural sources of sediment that exist in the uplands and hillsides surrounding the Little Sandy.

As noted previously in this document, land ownership is mixed within the watershed between federal, state, and private holdings. Because of the mixed ownership, a suite of approaches that can be used to for implementation will be best planned on a case by case basis in cooperation with the land owners, leases, and managers of the various holdings. The Critical implementation areas within the watershed will likewise need to be separated and re-evaluated in time to ensure that practical and effective Best Management Practices are being thoughtfully selected to meet the needs of each area and land type, and that there actual implementation is possible. For the purposes of this initial plan, it is effective to think of the impaired segment in terms of three "critical areas.

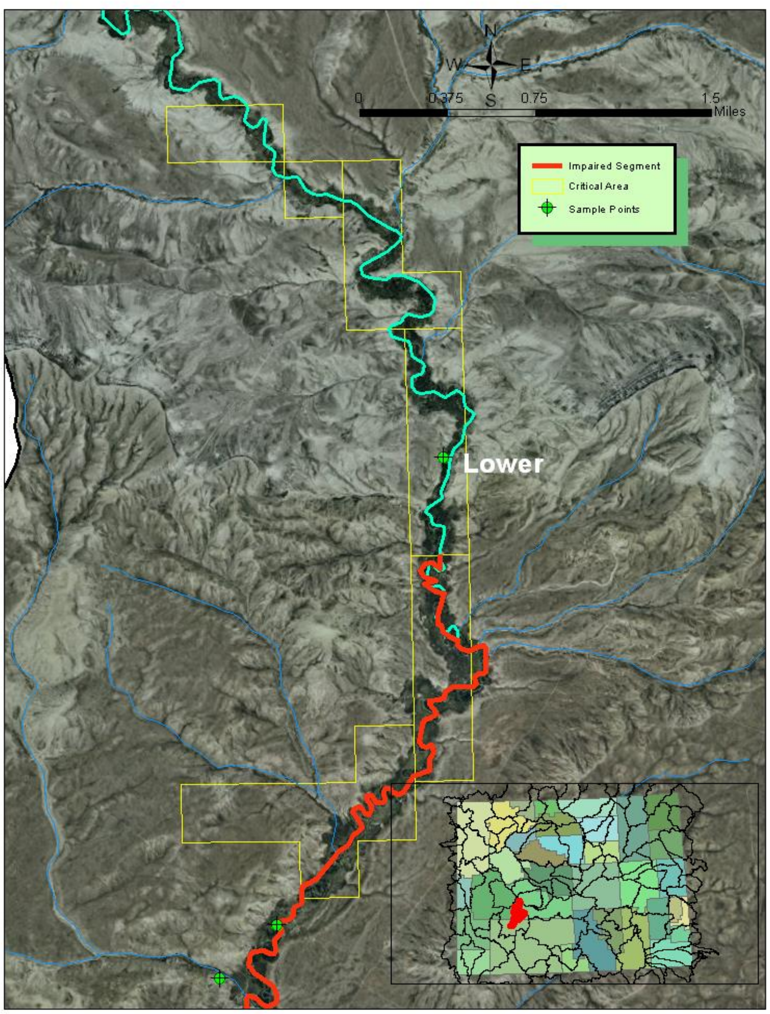


Figure 5– Upper "Critical" Section of the Little Sandy

<u>*Little Sandy Upper "Critical" Area*</u>

The first critical area is the segment of the Little Sandy is the section of stream (approximately 7,000 meters) from the point "Above Willow Exclosure" including the "Lower" sample point. This section is critical for a variety of reason. The first is that this section includes the initial section of the impairment, and it has been identified as a major excess sediment contributing area to the zones of aggradation further down. The incision that is going on within this stretch is directly related to the "historic event" identified in the listing document that

contributed to the acceleration of incision and sediment transport. When incision begins, it moves from upward through the system. The "nick-point" for the incising has already moved past the lower impaired areas. Which means controlling further down-cutting that moves upstream will require aggressive implementation of practices within this first critical zone. The implementation practices employed here will likely require a combination of in-stream engineering practices, associated vegetation management, and continued grazing management in support of the engineered and vegetative controls.
It is advantageous that this section of the stream is primarily made up of private lands and state leases. The selection and implementation of BMPs can in some situations be more quickly/easily completed in these areas. A large part of that is due to the capacity of the private land owners to select and apply BMPs rapidly as well as the availability of technical and financial assistance above and beyond that which might not be available to a federal agency like the BLM. A large part of this "critical" area is outside of the impairment, but selection and application of BMPs within this area could have a substantial positive benefit to those impaired areas downstream.

Lower "Critical" Area
The second critical area where implementation of BMPs could most effectively address the impairment on the Little Sandy lies downstream on a large area close to the point known as "Below Willow Exclosure". This area is considered critical for several reasons. Unlike the upper section of the impairment and its contributing area, incision is already complete in this section of the watershed and the stream is working to widen itself and create a new lower stable pattern and profile. Within this section aggradation is prominent in the channel. Stream banks here are slumping and eroding, but rather than cutting down, there is movement from side to side as tall banks erode and fall inwards. Flood plain detachment is complete here, and the stream will continue to erode and widen until it creates a new geometry at its new base level. In order to return the stream to a condition where it is meeting all of its beneficial uses it will likely be necessary to reattach the system to its previous floodplain, or to accelerate the process of developing newer stable geometry at this lower base level.

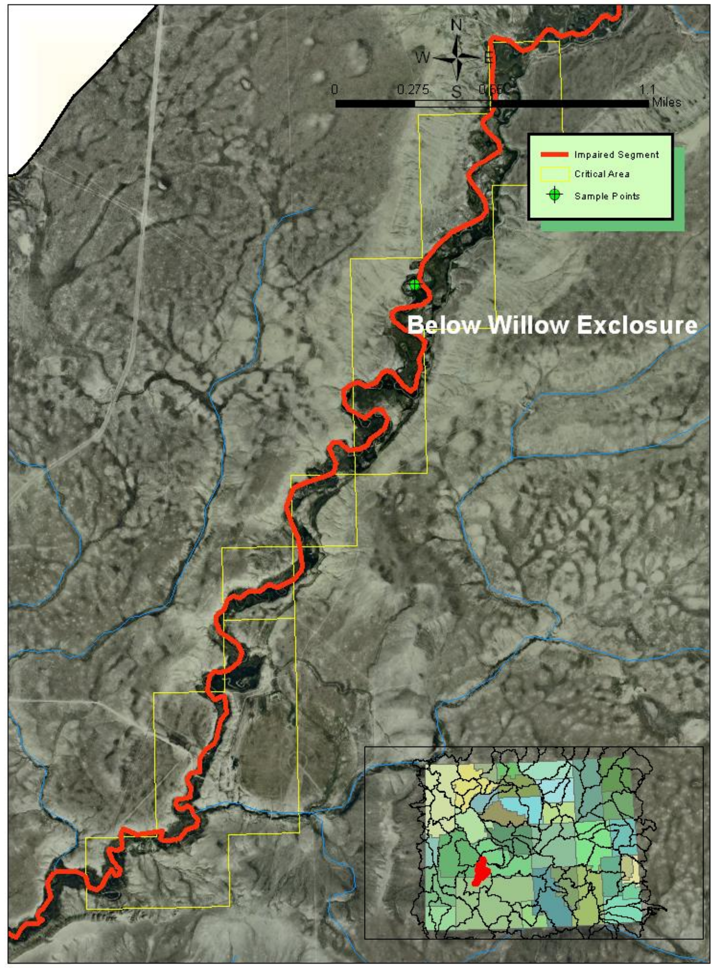


Figure 6 – Lower "Critical" section of the Little Sandy

Like the first "critical area", the second is also important as it also consists of primarily private and state land. The management and implementation efforts on these lands are likely to be more efficient and effective due to the ownership. As with the first critical area example above, EPA 319 programs, USDA NRCS costs share programs, state financial assistance programs, local government, and private resources are much more easily brought to bear for implementation efforts on these lands. It is for these reasons, not just location, that these are seen as "critical" in developing and implementation strategy to address the impairment.

<u>*Contributing Watershed Critical" Area*</u>

The third, "Critical" area is best identified as the entire watershed area that contributes to the impaired segments of the Little Sandy, but in areas where stream work is not possible, or where off stream or non-structural practices can most effectively be used to reduce impacts on riparian areas. This critical zone is related to the first two, and may even overlaps, but in general the management of these areas is necessary regardless of any stream restoration options that are pursued. As noted previously in this document, the management on this zone has been considered and revised over time, and is currently considered to be positive by the federal and state management agencies and the WDEQ. Range conditions and riparian trends are positive in the watershed. The WDEQ and NRCS state water quality professionals noted the positive trends in the watershed, and viewed continued management of the resources in this positive manner as important. SCCD consultation with Dr. Dave Rosgen verified that the current management practices had little negative effect on the current impaired segment of Little Sandy (Rosgen, 2011). Further discussion with Dr. Rosgen by the SCCD indicated that over extended time periods under current management paradigms (estimated from 50 to 100 years) the Little Sandy would likely develop a new stable condition where it would most probably meet its designated uses. However, if it is deemed necessary to return the stream to a stable condition rapidly, more activities would be necessary. A conceptual restoration plan developed by professional environmental consultants took place in the fall of 2016. (Appendix C),

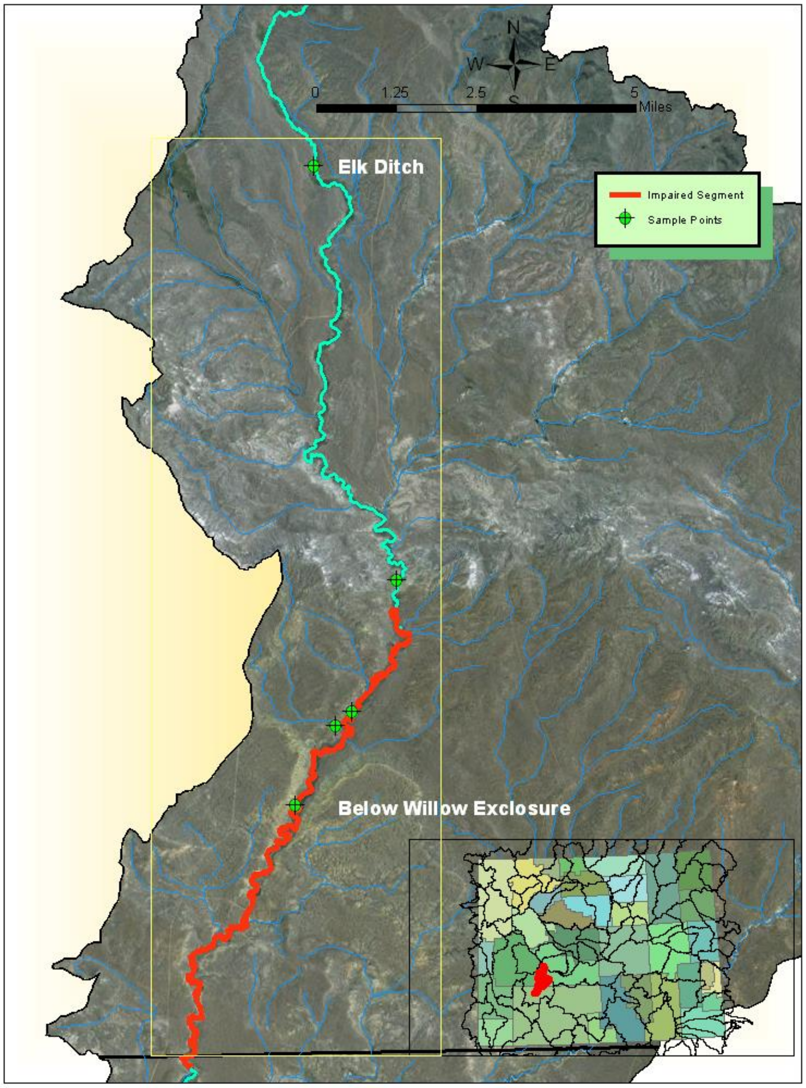


Figure 7 – Contributing Watershed "Critical" area, a primarily non-structural BMP implementation zone.

This final critical area would best be served by addressing land management with different suites of BMPs than those that might be more effective in the first two. In this area practices that reduce riparian pressure and increase wildlife and livestock distribution are likely to be most beneficial and cost effective. As with other critical areas, these practices should be selected by the local land owners/managers based on their needs in consultation with resource professionals. It is recognized that there is no "one size fits all" solution in these cases, but BMPs such as off-site water, access controls, and grazing strategies are likely to be most effective in terms of both cost and results.

3.H. Prioritization of Sources

Fully prioritizing the different implementation alternatives on the whole of the Little Sandy will require awaiting the results of any survey and engineering work that is performed as part of detailed implementation planning on the little Sandy. However, based on the discussion above, as well as the issues and concerns that are outlined below this section, generalizations can be made on the hypothetical direction of implementation with the understanding that as financial resources technical resources fluctuate, implementation strategies may change as well.

The primary source of excess sediment is the stream action itself, down-cutting, incising, and seeking a stable geometry as a result of some historic channel disturbing event or events. The prioritization should then start with correcting these issues, then move to a management paradigm that maintains a stable condition.

Primary activities in this section would include stabilization of the stream banks.
The second area of prioritization should be stabilization of channels banks and channels within the impaired section.

Following the physical stabilization or reconstruction of critical stream segments, riparian area vegetation and management will become critical components of a management strategy.

The final level of prioritization should go to increasing the capacity to manage uplands for better utilization and animal distribution. These upland areas contribute little in the way of sediment to the impairment. However, increasing water availability in the uplands, as well the distribution of livestock and wildlife as a result, decreases the pressure on riparian zones and water sources.

4. Issues and Concerns

4.A. Accurate Watershed Characterization

One of the greatest concerns facing the watershed steering group and those landowners who are working on resource conservation in the area is the dissimilarity of the watershed to those areas commonly used as references for determining the state of the resource. In many cases, watersheds can be compared against another in paired studies. This cannot be done on the Little Sandy River due to the unique nature of its geography, geology, and the limited amount of data on the stream's erosion over long periods of time. Determining "acceptable" rates of erosion and more importantly, understanding the dynamics of the system in order to understand the landscape level result of such erosion is therefore difficult.

In order to compensate for the lack of a comparable analog, WDEQ set up studies on the river using a nested watershed method, monitoring the changes that occurred in upper sections and lower sections of the stream relative to one another. The steering committee recognizes the limitations of this approach, and that it still leaves questions related to how the stream should "naturally" be functioning. Geology, climate, topography, vegetation, land use, and time all play significant roles in the shaping of the stream, and therefore the committee recognizes that there are limitations to what the stream can be. Limitations due to these factors, as well as financial constraints that make it economically impractical to implement some engineering and management activities will ultimately shape the planning and implementation on this stream.

4.B. Benthic Sampling Obstacles

Most benthic sampling for macroinvertabrates in Wyoming is based in areas with stream substrates that vary significantly from that found on the Little Sandy. In most benthic sampling, rocks and gravel in the stream are "scrubbed" and the associated macroinvertabrate community harvested and quantified. The resulting numbers can then be interpreted using a matrix developed from a "reference stream". In order to make a determination on the Little Sandy, the WDEQ used streams as reference that do not mimic the "natural" analog for the Little Sandy. As previously noted, no suitable reference has been identified for this stream. In addition, the sandy substrate makes the stream a poor location for the collection of data in the manner described above. Other methods exist for the study of a system such as this one; however, those methods have not yet been incorporated into WDEQ methodologies.

4.C. Cold Water and Warm Water Fisheries Transition

The Little Sandy is currently classified as a 2AB fishery, indicating that one of its beneficial uses is the protection of cold water fish, such as salmonids. However, the Wyoming Game and Fish, as previously noted in the WDEQ study, have expressed a desire to maintain and protect the habitat of the stream for certain cool/warm water species. It is important to recognize that the cool/warm water species in question can in fact inhabit colder waters, but cannot complete their life history in the colder waters of the transition zone. It may be appropriate to take a look at the designation of the stream and reevaluate as to what the appropriate classification may be.

Changing the classification of the Little Sandy to a "warm water" fishery would be significant in several chemical respects. The difference specifically would be the criteria for temperature, dissolved oxygen, and acute ammonia. These changes would not affect the current listing of the stream as impaired or not impaired, but might have significance on future data collection and management decisions on the stream.

4.D. Wildlife & Fisheries

Wildlife habitat and management have been important aspects over time within the watershed, and land owners as well as federal managers have recognized the difficultly in controlling these components of the ecosystem. The effective and timely management of wildlife will have a significant impact on the overall watershed. The steering committee and local conservation district recognize that good management decisions are based on accurate local knowledge.

Beaver Impacts

One of the key species affecting the hydrology of the watershed is the Beaver. Beavers have been present in and around the watershed throughout recorded history. The presence and/or absence of beaver dams as well as the number of dams in a system can have profound effects on hydrology.

Beaver dams increase the water table in areas near where they are built and can have positive effects on the capture of sediment and widening riparian zones near them. Beavers can also have some negative effects by destroying woody vegetation needed to stabilize stream banks, or in areas where dam blowouts can cause increased erosion or aggradation downstream. Beaver are present within the impaired segment.

Big Game

The numbers of big game animals in the watershed are significant in many ways. As noted previously in this document, grazing associated with big game has an impact on the overall vegetation in the watershed, as well as on the riparian areas specifically. Because the watershed serves as an area where big game such as elk, deer, moose, and antelope winter; there is significant pressure on vegetation other than grasses. Plants most affected by winter browsing in riparian areas include willows (*Salix spp.*), rose (*Rosa spp.*), and other small woody vegetation critical to the stability of stream banks. Uplands perform a critical function in providing alternative browse and the health of upland shrubs and communities are therefore important components in determining riparian pressures and watershed health as well. In watersheds like the Little Sandy, riparian plants are likely to be preferentially browsed in most conditions. Wildlife grazing occurs on any plants not covered by snow. This is particularly of concern because unlike livestock, these pressures cannot be changed through changes in grazing management, rotation, etc. Changes in upland grazing and livestock management will have little effect on stream sediment in cases such as this if riparian woody vegetation cannot be established to aid in bank stability. SCCD staff has observed some browsing patterns, noting heavy browsing on shrubby cinquefoil (*Dasiphora fruticosa*) and rose and light to moderate utilization on willow species, which can often be species dependent (SCCD, 2011). It is important to note that these use patterns can change significantly based on the severity of winter conditions. In addition to providing a preferential food source, these areas also serve as shelter for both hiding cover and thermal cover. Accurate wildlife counts and appropriate changes in herd management will be of key importance in developing a strategy for the increase of woody plants for stabilization of stream banks over time.

Loss of Unique "Sand Dominated System"

The Little Sandy is a system that differs greatly from many streams in the mountain west. The sand dominated system has unique habitat features that are important for species. High banks, for example, make up an important habitat feature for animals such as cavity nesting songbirds, pygmy rabbits, etc. Likewise, certain fish species depend on the sandy substrates and unique habitat that the stream provides. The steering committee feels strongly that it is important that any changes and implementation maintain the integrity of the watershed as a unique sand dominant system.

Potential Endangered Species Concerns

The WDEQ/WGFD has noted the presence of two species of native suckers, identified as species of greatest conservation need in the State Wildlife Action Plan, within the Little Sandy. Flannelmouth suckers and bluehead suckers have evolved to occupy the mainstem and tributaries of large rivers in the Colorado River drainage. Historically flannelmouth suckers and bluehead suckers would have been common throughout the Green River drainage, including the Little Sandy drainage downstream of the cold water habitats that supports trout. Streams that support these native suckers are becoming less prevalent, as a result of competition with non-native fish species, hybridization with non-native suckers and the effects of water development and reservoir construction exacerbated by drought have cut off this species' migratory corridors, degraded its habitat, and encouraged the spread of non-natives. The potential for a listing on any of these types of native fishes as endangered is a concern. The steering committee feels that one of the primary focuses of planning and implementation should be maintaining this as a fishery to support these native suckers.

In studies of the Little Sandy, concerns were expressed by WDEQ and WGFD that aggradation of sediments might lead to covering of riffles considered spawning habitat for these native fishes. Natural resource professionals and landowners on the stream have expressed concern on the relevance of that question. Little is known about the potential of the stream to support gravel beds, due primarily to a general lack of gravels in the system. In addition, the system itself might not provide ideal habitat due to the transitional nature of the temperature (cold water/warm water) coupled with a capacity to build gravel beds that simply might not be possible. The system undergoes a significant change from the upper to lower sections; where the substrates and temperatures transition across a continuum of variability. The ability of this segment of the Little Sandy River to support fisheries will continue to be evaluated as restoration is pursued and more is understood about the ability of the system to support gravel beds.

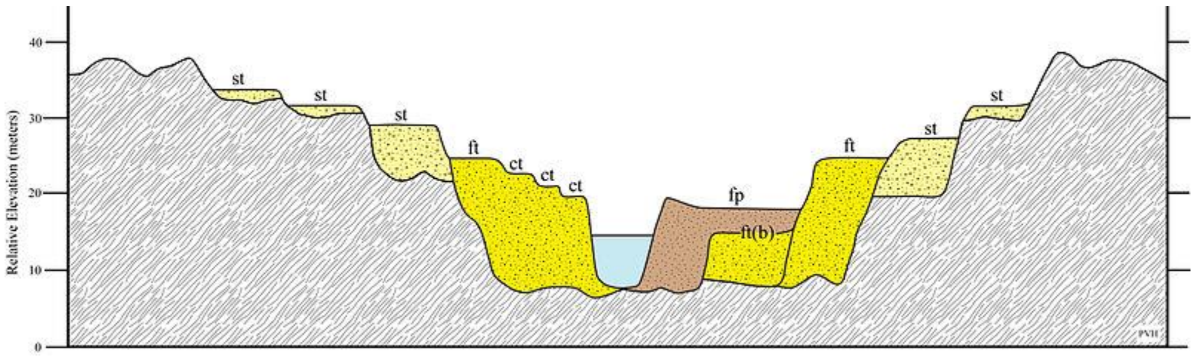
4.E. Livestock Grazing & Management

Livestock grazing in the Little Sandy watershed is arguably the most studied and managed of any of the land use activities present in the system. Over time, a great deal of study and effort has gone into studying the interaction of livestock and the other resources in the watershed. Over time the effects of grazing on uplands, riparian areas, and stream banks has been qualitatively and quantitatively monitored and changed to implement the proper degree of use, and the time and intensity of livestock grazing. As time has progressed, management objectives have changed, and more has become known about the science of natural resource management. The grazing systems have likewise evolved in order to maintain the quality of the watershed and its productivity.

Based on the 2004-2008 WDEQ assessment, grazing and historic habitat/channel modifications were identified as contributing factors to stream bank instability. However, this assessment also indicated variable reductions in sediment contributions from accelerated stream bank erosion during the period of assessment took place. The WDEQ concluded that the current grazing system might be promoting the Little Sandy towards stability (i.e. reducing sediment loads). Based on the available information at the time, the WDEQ in 2010 proposed a conditional alternative approach to postpone a 303(d) impairment listing decision for two cycles that was dependent on the BLM and Grazing Association demonstrating that in fact the current grazing management was continuing to reduce bank erosion. If continuing reductions in bank erosion were demonstrated, then the Little Sandy River would be put into Category 4B in the 305(b)/303(d) Integrated Report. Category 4B indicates that a management plan is in place to address a surface water impairment, but does not indicate that all designated uses are supported. If continued reductions in stream bank erosion were not demonstrated, then the impaired segment of the Little Sandy River would be put into Category 5 (303(d) list).

Several years following the WDEQ assessment, Dr. Rosgen concluded during his 2011 field visit that the stream could stabilize within several decades assuming that the current grazing management was maintained; however, grazing management alone would not accelerate channel stability recovery within a shorter time frame. He indicated that the Little Sandy River was likely more unstable than it was during the WDEQ assessment years. This was not a negative reflection on the current grazing practices, but rather emphasized that the stream was continuing to adjust from historical legacy impacts. This may have been exacerbated by the record high flows that occurred in 2010/2011.

Based on these conclusions from a nationally recognized professional hydrologist, the WDEQ felt that the conditional alternative approach originally proposed was no longer defensible. While grazing management was still an important component to overall watershed stability, in-stream channel erosion due to the stream adjusting from historical legacy impacts had taken the dominant role in the conditions of the channel. Thus, the Little Sandy River was placed on the 303(d) list in 2012.



Hypothetical valley cross-section illustrating a complex sequence of aggradational (fill) and degradational (cut and strath) terraces. Note ct = cut terrace, ft = fill terrace, ft(b) = buried fill terrace, fp = active floodplain, and st = strath terrace - Paul V. Heinrich

Continued proper grazing management will play an important role in restoring the waterbody to meeting all of its designated uses. However, livestock grazing is clearly the most easily controlled land use in the watershed, which often leads to it being identified as the sole surrogate for other problems that may be unrelated.

<u>Wildlife and Stock Water Availability</u>

In the Little Sandy watershed, as elsewhere in the arid west, the presence or absence of water ultimately determines the level of use by wildlife, livestock, and to an extent, humans. One of the critical positive effects that ranching has had on the watershed is the development of water resources. These resources in the form of springs, diversions, wells, reservoirs, tanks, etc., have allowed for the dispersion of wildlife, livestock, and other uses. As animals move to other watering locations, riparian zones and streams like the Little Sandy receive less pressure. Forage can be accessed by animals that no longer need to return to the stream for water. Reducing trailing and energy consumption, reduced erosion, and increased utilization of previously unavailable forage are positive aspects to both livestock and wildlife. Although there are limited water developments, off site water availability could be greatly expanded in the watershed. Much of the development opportunity lies on federal lands, requiring the coordination of federal partners in order to make these environmental improvements.

<u>Fencing</u>

Fencing is a management tool with both positive and negative impacts. Fencing allows managers to more closely monitor and control the movement, access, and timing of certain grazing events in the watershed. When developed correctly, these tools can have minimal negative impacts that are certainly outweighed by the positive attributes that they provide. Although fencing can be useful, it is also a tool with limitations. In the watershed, concerns about the Oregon Trail and its' viewshed have made it difficult to consider implementing fencing alternatives in some locations where it might be beneficial and effective to do so. In other areas, especially those that are not maintained by a private individual, fencing maintenance and effectiveness can be compromised by poor design or lack of upkeep.

4.F. Private Lands

As with a large part of the west, this watershed has a significant component of federal ownership. This factor can have a negative effect on the capacity of a concerned group or local government to effect meaningful change. The management of federal lands can be hampered due to a lack of resources, either human or capital, that enable the agencies address permittee interests in a timely manner. Federal guidance and policy on land management can be daunting. There is also the inherent complexity of decision making for federal managers who may have limited local knowledge in comparison to landowners who have lived and worked in an area for a greater amount of time. In every case, it has been demonstrated that decision making by individuals at a local level with increased knowledge lends itself to better long term management of the resources. It is not surprising then that the vast majority of conservation activities are carried out either on private lands, or by private individuals with some type of lease on public lands.

Management prescriptions on most impaired waters target private landowners. These individuals are typically more flexible and motivated to implement positive change. The general public and members of the regulatory community can lose sight of the fact that participation required to implement change is largely voluntarily. In most cases of conservation implementation the public goods, better air, land and water quality, are largely paid for by the private individuals who own and manage land. Public land users then benefit from these activities when downstream water quality is improved.

The landownership on the Little Sandy is likewise similar to other arid areas of the western United States. The Homestead Act of 1862 was passed by the U.S. Congress. It provided for the transfer of 160 acres of unoccupied public land to each homesteader on payment of a nominal fee after five years of residence; land could also be acquired after six months of residence at $1.25 an acre. The act required that the land be put to beneficial use. The amount of land that could actually be claimed varied based on a few parameters, but in general, land that could be put to a beneficial agricultural use was homesteaded and became private property. One of the primary limiting factors was the availability of water. Because of this fact, most of the lands in the west that have significant running water were at some point homesteaded and still remain private property today. Those lands that did not have attributes that would make them useful to settlers remained the property of the federal government and eventually came under the control of the BLM. For this reason the majority of the riparian lands on the Little Sandy and other watersheds in the west remain private holdings.

One of the difficulties in developing planning to address conservation is the proper allocation of economic resources to improve the natural resource. Gains in water quality for example, can be relatively insignificant, or even impossible to quantify at the level of practical monitoring employed. A question must be asked as to whether this given activity is a valid way to spend private dollars or taxpayer funding. Ultimately, the decision on the prioritization of implementing any given conservation practice should be made by the individual landowner. As decision makers become more removed from the ground level, they typically have less understanding of the issues and concerns and less capacity to accurately detail all of the variables that go into these decisions that are inherently geographic in nature.

4.G. Federal Policy and Decision Making

Within the past, the BLM and Forest Service have dedicated significant resources on developing partnerships and planning within the watershed. Examples of cooperative historical projects such as fencing and water development are prevalent throughout federal lands, and examples are found in the Little Sandy watershed. The fiscal and human resources applied to the development of projects to improve the resources on federal lands have benefited multiple uses. . The BLM and Forest Service have statutory requirements related to Federal Environmental Policy Acts that must be met by the agencies. The compliance with the requirements of these acts can be time consuming. Where technical resources are scarce or unavailable for the completion of the necessary assessments land management activities may be difficult to implement or maintain. Examples of these positive practices include springs development, small reservoirs, other water enhancements, necessary fencing, etc.

The lack of familiarity with Federal policies can be a serious impediment to local land owners who would otherwise work with the agencies on projects. It can be difficult for the agencies to maintain local knowledge as personnel move. Federal agencies also face challenges in moving at a pace that is compatible with the needs and business decisions of their private partners. However, the biggest impediment for the agencies is a lack of dedicated resources for implementation within the agencies.

Because of the difficulties faced by federal agencies, development of beneficial conservation practices, as well as expense and maintenance, often falls to private individuals such as grazing permittees. More often than not, these activities are developed on private lands at the land owner's expense with the benefits "carrying over" to the federal lands.

4.H. Private Water Rights and Effects on Flow

By design, Wyoming water law maintains a separation of water quality and water quantity regulation in different divisions of the state government. Although separated by statute, water quality and quantity can have significant links in practical applications. Upstream water rights can have an effect on the amount and timeliness of flow in a stream, which is the case on the Little Sandy. Irrigation diversions exist upstream of the impaired stream segment. In such diversions, water can be removed from the system for use elsewhere, and in some cases, added to the system for transport. Decreases in flow invariably reduce the stream energy present in the system. The net result is a loss of capacity for a stream to carry a sediment load through the system, thus leading to aggradation. Increased flows can be equally dynamic, causing marked increases in erosion and scouring.

The effects of water quantity issues can have a significant impact on the system. As mentioned in other areas of this document, the ability of the stream to move sediment and to establish a "stable" condition is highly dependent on a number of factors. The actual flow is certainly one of these. In development of this plan, the steering committee recognizes that water quantity issues are not under the jurisdiction of the WDEQ and that the rights of water users should not be affected by any of the developments in this plan.

4.I. Stream Geomorphology

Streams are inherently dynamic, changing over time. The ultimate goal of stream work is to manage that change in a way that minimizes what one might consider a negative impact, and maximizes the ability of the system to quickly correct itself and maintain its' gradient and general sinuosity over time. The balance of the system is actually always in flux based on the climatic conditions, sediment and suspended load of the stream, and surrounding terrestrial environmental conditions. The conceptual restoration plan has been completed; final construction designs would need to be completed before implementing stream structures. As identified in this plan, a large cost estimate has been associated with stream restoration for the impaired segment. The steering committee will need to evaluate feasibility based on possible funding resources.

4.J. Effects of Large Scale Precipitation Events and General Climate Change

The Little Sandy River and the surrounding watersheds are greatly affected by shifts in climate and precipitation. In arid environments like this one, vegetation can be relatively sparse. This vegetation, in conjunction with the soils that develop around it, are largely responsible for absorbing excess precipitation and distributing it over time through subsurface flow to the streams. Therefore, in arid environments flashy precipitation events are more quickly transmitted to the stream and carried out of the watershed. The higher flows result in increased power to erode, and the banks and soils are more prone to erosion due to the lack of vegetation.

Recently within the watershed, snowpack has been at extremely high levels, and the result has been an increase in the amount of water, and therefore the erosive power of that water on the streambed and stream banks. This comes in the aftermath of several years of drought that ultimately left the watershed with less vegetative cover and less prepared to offset the effects of extremely wet years. In the future it remains to be seen as to whether the recent patterns of drought and high flows will become the norm and if the watershed will move to a state that will accommodate that variability.

The variability of the flows has a significant effect on the flooding within the Little Sandy watershed, and therefore the dynamics of the stream system. On wet years the floodplain is inundated as was observed in 2011. In other dry years, the stream fails to run at all. This variability makes it very difficult to accurately describe the dynamics of the stream system with data that is limited to a small number of years.

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Publication date: 200406
Data type: vector digital data
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Originators: USDA Natural Resource Conservation Service (NRCS)
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Site IDs: R034AY130WY, R034AY174WY, R034AY122WY, R034AY162WY, R034AY144WY, R034AY104WY, R034AY150WY
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