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Funding for WRDS and the creation of this electronic document was provided by the Wyoming Water Development Commission (http://wwdc.state.wy.us)

FINAL REPORT

BELLE FOURCHE RIVER WATERSHED STUDY

REDWATER SUBBASIN

WATERSHED MANAGEMENT PLAN

Topical Report RSI-2514

prepared for

Wyoming Water Development Commission
6920 Yellowtail Road
Cheyenne, Wyoming 82002

March 2015

RESPEC

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REDWATER SUBBASIN

WATERSHED MANAGEMENT PLAN

Topical Report RSI-2514

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March 2015

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1.0 INTRODUCTION

1.1 OVERVIEW

In 2012, the Crook County Natural Resources District (CCNRD), Campbell County Conservation District (CCCD), and Crook County Irrigation District (CCID) requested that the Wyoming Water Development Commission (WWDC) conduct a comprehensive study of the Belle Fourche River Watershed and its water resources. The local sponsors requested the Level I watershed study to evaluate watershed function, assess wetland and riparian conditions, develop geomorphic classifications, and identify resource concerns and water development opportunities on irrigated lands, rangelands, wetlands, and streams. The WWDC approved funding for the watershed study and then contracted with RESPEC and Anderson Consulting Engineers, Inc. (ACE), to provide technical or professional services for the watershed study.

The Belle Fourche River Watershed Study, Level I is a comprehensive evaluation and an initial inventory of the water and land resources within the study area. This Level I watershed study provides important information that the CCNRD, CCCD, and CCID—the study's local sponsors, and the WWDC—the study's sponsor, could use in developing water resources and implementing conservation practices that address water and land resource concerns within the study area. This study includes descriptions about needed water development projects that could provide economic, ecological, and social benefits to the state of Wyoming and its citizens.

Because of the size and variability of the study area for the Belle Fourche River Watershed, as shown in Figure 1.1, the final reports for the watershed were separated into this basin wide summary report and a final report was completed for each of the three subareas or subbasins. The terms "watershed" and "study area" are used interchangeably throughout this study and associated reports. The "subarea" and "subbasin" terms are also used interchangeably in these reports. This basin wide summary report was completed for the study area and includes data and information regarding the overall study area along with inclusion of all three of the subbasin reports and watershed management plan and rehabilitation components. Throughout these reports, mention will be made where more specific information can be found within the subbasin reports or the basin wide summary report where appropriate.

This "Redwater Subbasin Report" was completed for the Redwater Creek portion of the study area. This report includes data and information regarding the overall study area along with inclusion of all three of the subbasin reports and watershed plan components. The intent of these reports, accompanied by the "digital library" and Geographic Information System (GIS) geodatabase, is to provide the results of the Belle Fourche River Watershed Study, Level I. The subbasins were identified based on the U.S. Geological Survey (USGS) 10th order "hydrologic units" classification which has an assigned Hydrologic Unit Code (HUC). Three watersheds (HUC-10) are located within the Redwater Subbasin and are listed in Table 1.1 and shown in Figure 1.1.

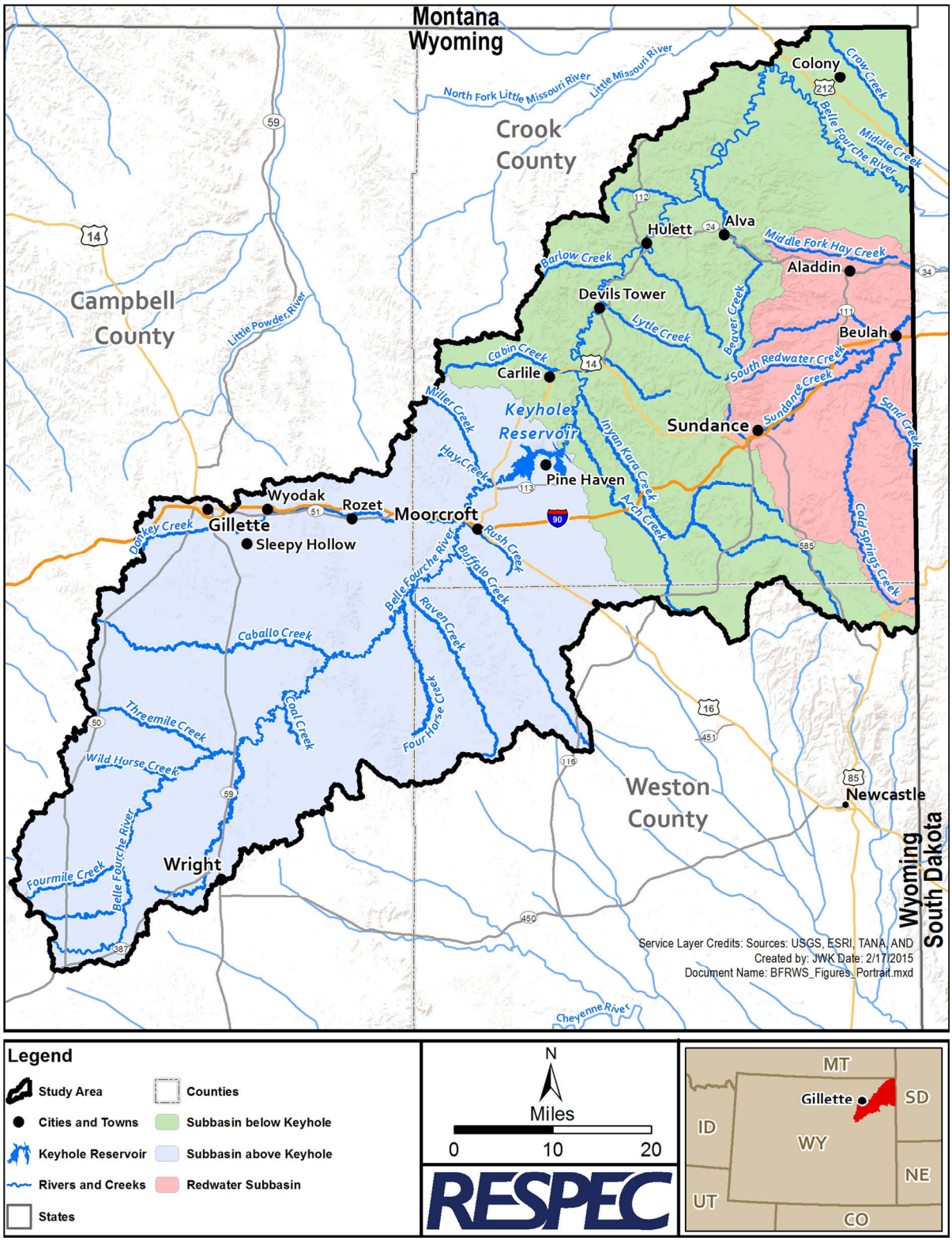


Figure 1.1. Belle Fourche River Watershed and Distinct Subbasins Within the Study Area.

Table 1.1. Watersheds (10th Order Hydrologic Unit Codes) Redwater Subbasin

Hydrologic Unit Code	Watershed (HUC-10) Name	Study Subbasin	Acres	Square Miles
1012020301	Upper Redwater Creek	Redwater	124,050	194
1012020304	Lower Redwater Creek	Redwater	53,790	84
1012020302	Sand Creek	Redwater	160,180	250
Subtotal			**338,020**	**528**
Total			**2,485,020**	**3,883**

1.2 REDWATER SUBBASIN

The Belle Fourche River Watershed – Redwater Subbasin encompasses the Wyoming portion of the drainage area for Redwater Creek, including Cold Springs Creek, Sand Creek, and Sundance Creek. Also included in the Redwater Subbasin are the streams that drain portions of Wyoming, but do not converge with Redwater Creek within Wyoming. The Redwater Subbasin includes all of the land draining to Redwater Creek and tributaries covering approximately 528 square miles or 338,020 acres in northeast Wyoming. The Redwater Subbasin is the smallest of the three subbasins, encompassing less than 14 percent of the study area. The subbasin is mainly situated in Crook County with a small portion in Weston County, and includes the cities, towns, and communities of Aladdin, Beulah, and Sundance, Wyoming.

1.3 STUDY ISSUES AND UNDERSTANDING

This Level I study provides a comprehensive evaluation of the Belle Fourche River Watershed and concludes with the Watershed Management and Rehabilitation Plan, which is included in Chapter 4.0 of the basin wide summary report. This report includes the proposed alternatives that address water and land resource issues identified by landowners within the Redwater Subbasin. During this study, the consultant worked with the local sponsors and WWDO and several study participants to address the following key issues within the subbasin including: surface water availability and storage; irrigation system assessment and improvements; rangeland and grazing assessment and improvements; wetland and riparian area restoration and channel stability; and invasive and noxious weed management.

1.4 PURPOSE AND SCOPE

The primary purpose of this Level I study was to combine all of the available and relevant data and information with the study-generated inventory data into a GIS geodatabase and digital library. And to develop a comprehensive Watershed Management and Rehabilitation Plan outlining proposed and potential water development opportunities and watershed improvement alternatives. To accomplish this effort, several objectives were completed and are discussed in detail throughout the basin wide summary report.

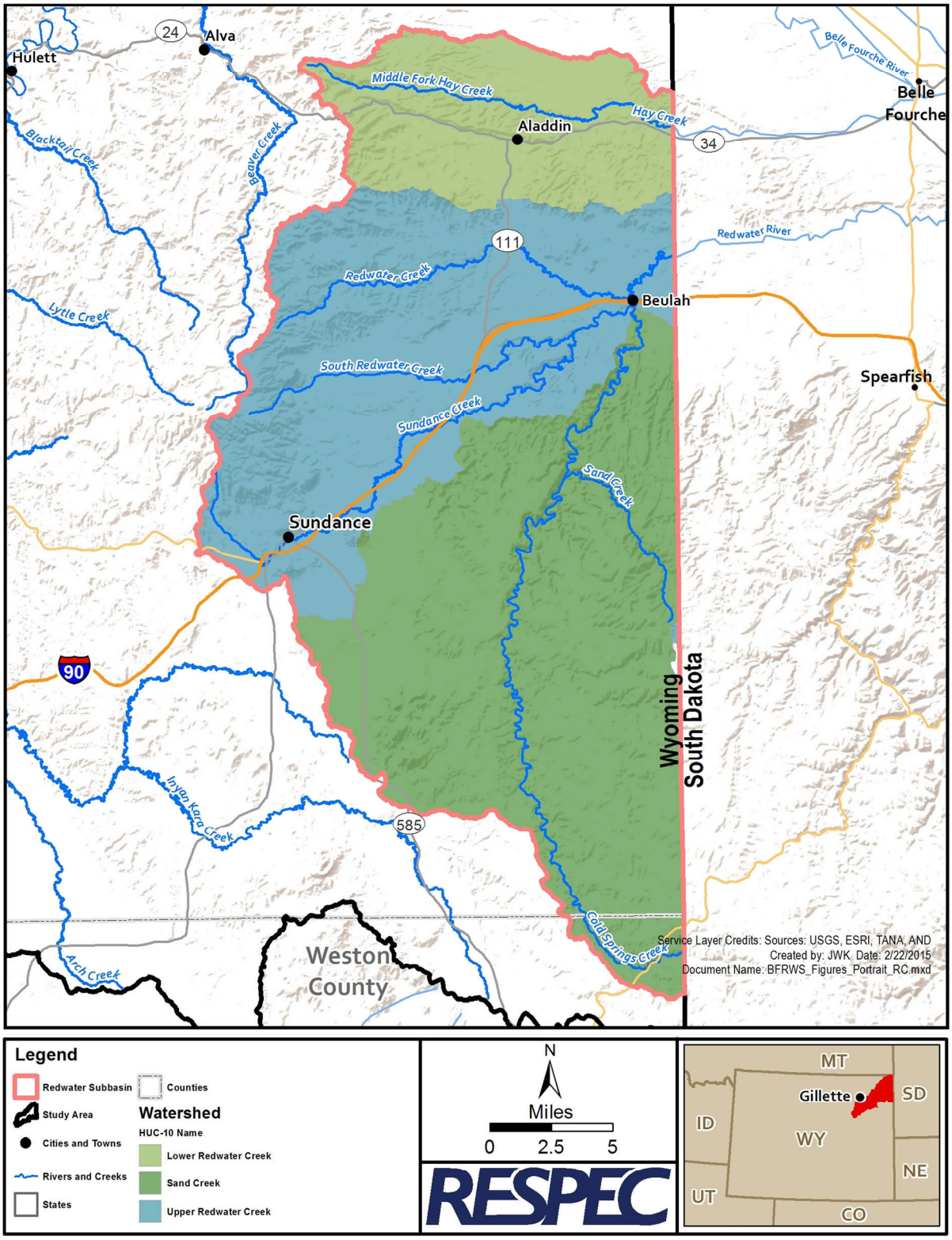


Figure 1.2. Watersheds (HUC-10) Within the Redwater Subbasin.

2.0 PROJECT MEETINGS

2.1 SCOPING MEETINGS, OPEN HOUSES, AND LANDOWNER MEETINGS

Public involvement and landowner participation were an important element of the Belle Fourche River Watershed Study effort because of the amount and complexity of the water and land issues and concerns within the study area. Therefore, considerable emphasis and time was placed on this aspect of the study. Scoping meetings, open houses, landowner meetings, and on-site field visits were conducted by RESPEC and ACE staff in cooperation with CCNRD, CCCD, CCID, WWDO, and Natural Resources Conservation Service (NRCS). Scoping meetings, open houses, landowner meetings, and field visits were coordinated by RESPEC with assistance from the CCNRD, CCCD, CCID, WWDO, and NRCS. A detailed description of the scoping meetings, open houses, and project meetings is included in the basin wide summary report.

Within the subbasin, a scoping meeting was held in Sundance, Wyoming on September 19th, 2013, where RESPEC representatives made presentations, summarized work, and outlined tasks. Draft maps generated with available GIS data were presented to inform attendees. Questions were answered during the meetings but most discussions occurred between the attendees, local sponsors, and consultants after the scoping meeting. Landowner open houses were held in Sundance on February 28, 2014, and October 16, 2014. During open houses, landowners discussed their concerns and potential projects with the consultant and representatives from CCNRD, CCCD, CCID, WWDO, or NRCS. Table 2.1 lists the meetings conducted within the Redwater Subbasin during the study.

2.2 LANDOWNER MEETINGS AND FIELD VISITS

Following the scoping meetings and open houses, landowners interested in the study contacted the consultant, CCNRD, CCCD, or NRCS staff. Meetings with landowners were then scheduled at their properties where discussions focused on land and water resource concerns and issues specific to the landowner. Usually, the landowner gave a tour of the property to the consultant, often accompanied by a representative from the CCNRD, CCCD, or NRCS. During these visits, conceptual projects were discussed for potential water development projects.

Field inventory efforts were often conducted in coordination with planned scoping meetings, landowner open houses, CCNRD and CCCD board meetings, and landowner visits. Field activities focused on irrigation, upland livestock/wildlife water opportunities, riparian and stream channel conditions, dam and reservoir assessment, and hydrologic investigations. Ranchers, irrigators, and residents who visited with the study team to discuss issues and concerns demonstrated extensive knowledge and valuable insight about the watershed.

Table 2.1. Scoping, Landowner, and Coordination Meetings in the Redwater Subbasin

Number	Date	Type	Location
1	07/02/13	Local Sponsor Meeting	CCNRD Sundance Office
5	09/09/13	Coordination Meeting	CCNRD Sundance Office
10	09/19/13	Scoping Meeting	Sundance State Bank
13	01/23/14	Landowner Meeting	Ellsbury Ranch
14	02/11/14	Landowner Meeting	CCNRD Sundance Office
15	02/28/14	Landowner Open House	Sundance State Bank
16	03/03/14	Project Update/Status	CCNRD Sundance Office
17	03/04/14	Landowner Meeting	RESPEC Spearfish Office
24	04/21/14	Landowner Meeting	Turgeon Ranch
30	04/23/14	Landowner Meeting	Habeck Ranch
32	04/25/14	Coordination Meeting	CCNRD Sundance Office
34	04/25/14	Coordination Meeting	City of Sundance Office
36	05/20/14	Coordination Meeting	CCNRD Sundance Office
40	07/10/14	Landowner Meeting	Ellsbury Ranch
42	07/24/14	Coordination Meeting	CCNRD Sundance Office
44	08/22/14	Landowner Meeting	Six T Nine Ranch
47	09/03/14	Landowner Meeting	Six T Nine Ranch
48	09/05/14	Landowner Meeting	Ellsbury Ranch
50	09/19/14	Landowner Meeting	CCCD Gillette Office
52	09/22/14	Coordination Meeting	U.W. Forest Service (USFS) Bear Lodge Ranger District Office
54	10/03/14	Landowner Meeting	Ellsbury Ranch
55	10/03/14	Coordination Meeting	CCNRD Sundance Office
60	10/16/14	Landowner Open House	CCNRD Sundance Office

3.0 WATERSHED DESCRIPTION AND INVENTORY

3.1 LAND USES AND ACTIVITIES

3.1.1 Land Ownership

The area of the Redwater Subbasin within the Belle Fourche River Watershed Study covers approximately 528 square miles or 338,020 acres. Land ownership within the subbasin consists of 65.6 percent of parcels or approximately 221,720 acres under private ownership, 30.1 percent of parcels or 101,800 acres managed by federal agencies, and 4.3 percent of parcels or 14,500 acres owned by the state of Wyoming. Almost 98 percent of the subbasin is within Crook County with the remaining 2 percent located in Weston County. Table 3.1 lists the generalized categories of land ownership within the subbasin and Figure 3.1 displays the land ownership.

Table 3.1. Land Ownership Within the Subbasin

Ownership	Area (acres)	Area (square miles)	Area (%)
Private	221,720	346	65.6
Federal	101,800	159	30.1
Wyoming State Lands	14,500	23	4.3
Total	**338,020**	**528**	**100.0**

3.1.2 Irrigated Lands

Irrigation within the subbasin is primarily for agricultural use. Based upon data provided by the WWDO, approximately 2,390 acres of irrigated land comprise 0.7 percent of the subbasin as listed by watershed (HUC-10) in Table 3.2 and shown in Figure 3.2. Thirty-one points of diversion are associated with these irrigated acres, and individual ditches convey water to these irrigated acres. The crop grown on irrigated lands within the subbasin is primarily alfalfa with some hay and small grains such as oats and barley.

3.1.3 Murray Ditch

One of the major diversions in the study area is the Murray Ditch, which conveys water from Redwater Creek in Sections 20 and 29 of Township 53 North, Range 60 West in Crook County north of Beulah. The Murray Ditch is also known as the Jan Moeller or Redwater Ditch and is incorrectly labeled Miller Ditch on the National Hydrography Dataset (NHD). The Murray Ditch headgate diverts from the main stem of Redwater Creek, approximately 1.2 miles from the South Dakota border; however the headgate is approximately 2.3 miles from the South Dakota border along the Murray Ditch [HKM Engineering Inc. et al., 2002]. The Murray Ditch is an open ditch with direct-flow water rights adjudicated in Wyoming as listed in Table 3.3.

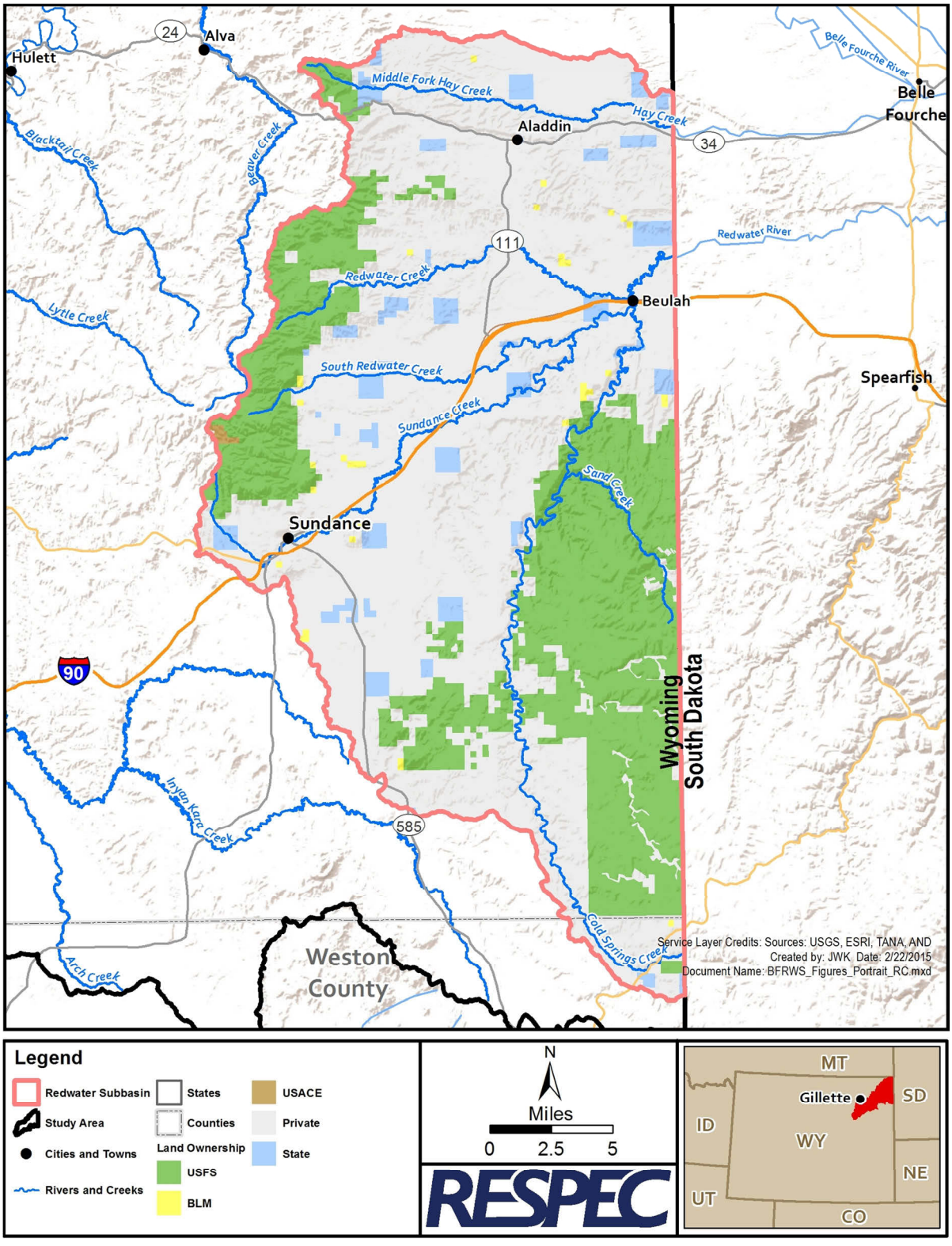


Figure 3.1. Categories of Land Ownership Within the Subbasin.

Table 3.2. Irrigated Lands by Subwatershed (HUC10) Within the Subbasin

Watershed (HUC10)	Estimated Area (acres)	Percent of Subbasin (%)
Lower Redwater Creek	159	0.05
Sand Creek	483	0.14
Upper Redwater Creek	1,748	0.52
Total Estimated Acres	**2,390**	**0.71**

3.1.4 Grazing

3.1.4.1 Range and Forest Lands

Approximately 331,162 acres of rangeland and forest lands occur within the subbasin and cover more than 98 percent of the subbasin, and approximately 170,857 acres of rangelands are within the subbasin (covering approximately 50.5 percent of the subbasin). Private land encompasses approximately 151,615 acres (88.7 percent) of the rangelands in the subbasin. The state of Wyoming manages 6.5 percent or 11,173 acres, the USFS manages approximately 4.2 percent or 7,132 acres and the Bureau of Land Management (BLM) manages approximately 937 acres (0.6 percent) of the rangelands within the subbasin as shown in Table 3.4.

In addition to the rangelands, forest lands cover approximately 47.4 percent of the subbasin or 160,305 acres within the subbasin. The USFS manages approximately 92,766 acres (57.9 percent) and private land encompasses approximately 63,844 acres (39.8 percent) of the forest lands within the subbasin. The state of Wyoming manages 2.0 percent or 3,174 acres and the BLM manages approximately 521 acres (0.3 percent) of the remaining forest lands within the subbasin as shown in Table 3.5.

3.1.4.2 Federal Grazing Allotments

Grazing on an estimated 99,898 acres of federal rangelands and forest lands within the subbasin is administered by the USFS. The USFS administers 20 grazing allotments encompassing approximately 133,218 range and forest acres consisting of private, state, and federal lands within the subbasin. The USFS Bearlodge Ranger District administers the majority of these grazing allotments as shown in Figure 3.3 and summarized in Table 3.6. In addition to the USFS allotments, 14 BLM grazing allotments encompass approximately 1,593 acres including some portions of private and state lands. The BLM Newcastle field office administers these allotments as shown in Figure 3.3 and in Table 3.6.

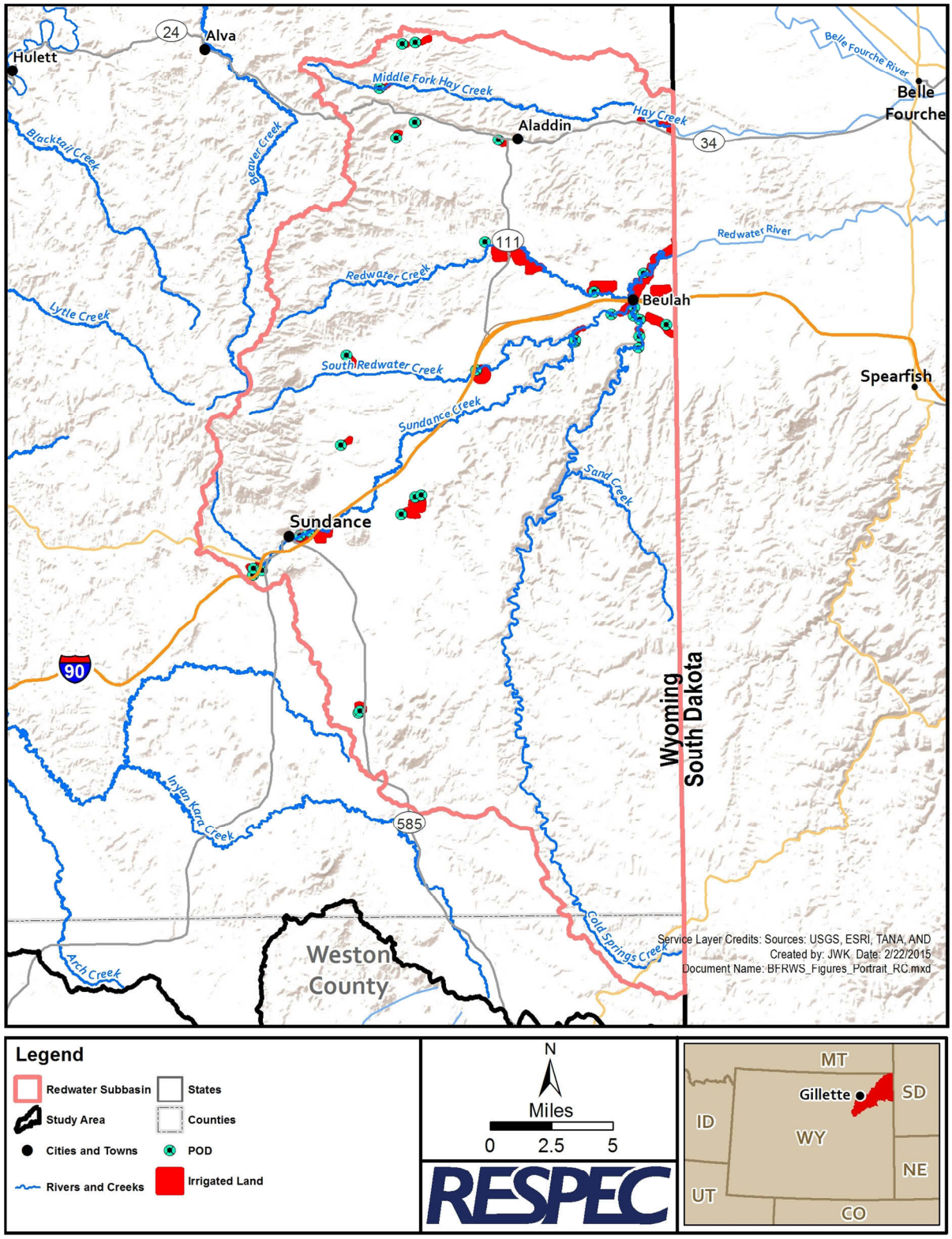


Figure 3.2. Irrigated Lands and Points of Diversions Within the Subbasin.

Table 3.3. Direct-Flow Water Rights Adjudicated in Wyoming in the Murray Ditch [HKM Engineering Inc. et al., 2002]

Permit	Priority Date	Permitted Use	Area (acres)	Flow (cfs)	Cumulative Flow (cfs)
Territorial	11/01/1881	D, I	95.47	1.36	1.36
Territorial	10/01/1882	I	88.89	1.27	2.63
306E	01/21/1898	I	40.00	0.57	3.20
5520E	11/20/1950	I	64.62	0.92	4.12

Table 3.4. Rangelands by Ownership/Management Within the Subbasin

Land Ownership or Management	Rangeland Acres	Percent of Total Rangeland Acres
Private	151,615	88.7
State of Wyoming	11,173	6.5
USFS	7,132	4.2
BLM	937	0.6
Total	**170,857**	**100.0**

Table 3.5. Forest Lands by Ownership/Management Within the Subbasin

Land Ownership or Management	Forest Land Acres	Percent of Total Forest Land Acres
Private	63,844	57.9
USFS	92,766	39.8
State of Wyoming	3,174	2.0
BLM	521	0.3
Total	**160,305**	**100.0**

Table 3.6. U.S. Forest Service and Bureau of Land Management Allotments Within the Subbasin

Ranger District or Field Office	Allotment Number	Allotment Name	Area (acres)
Bearlodge Ranger District	126	Cole	357
	117	Divide	3,367
	104	Farrall	12,372
	122	Grand Canyon	11,929
	124	Idol	10,445
	115	Lost Canyon	7,576
	102	North Bearlodge	8,404
	108	Ogden	8,397
	105	Redwater	5,996
	125	Sandcreek	17,480
	113	Silver Creek	11,915
	101	Stoney Point	9,085
	106	Togus	5,519
	119	Warren Peak	8,059
	112	Willow Springs	11,812
Hell Canyon Ranger District	403	Cold Creek	2
	416	Soldier Creek	2,926
	417	Stovehole	6
Northern Hills Ranger District	710	Bear Ridge	1
	711	Cement Ridge	3,345
Newcastle BLM Field Office	694	Brakes	81
	4055	South Redwater Creek	150
	4059	The Brakes	39
	4141	Cold Springs Creek	53
	4147	Dry Creek I	80
	4206	Sugarloaf Mountain	39
	4298	Rocky Ford Creek	248
	4299	Lime Buttes	412
	4310	Duling	80
	4322	Quail Spring	44
	4326	Hospital Gulch	162
	4343	Vore Draw	123
	4350	Green Mountain II	41
	4393	Green Mountain I	41

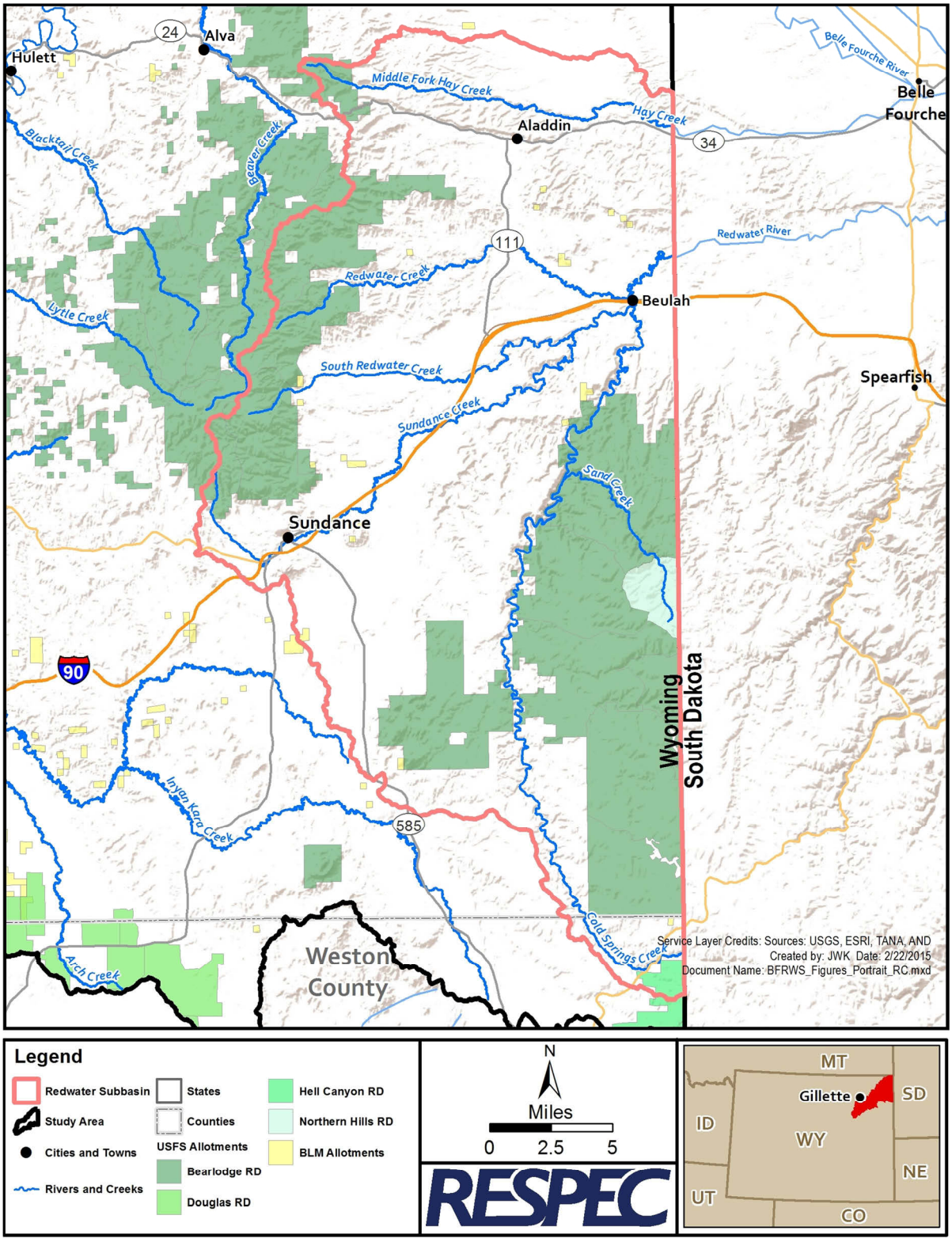


Figure 3.3. Federal Grazing Allotments Within the Subbasin and Study Area.

3.1.4.3 Range Conditions and Needs

Range conditions depend on a number of factors including, but not limited to, climate and precipitation, soil and water, plants and animals, topography and geology, and natural disturbances. Range condition goals, objectives, and actions for USFS or BLM managed allotments within the subbasin are detailed in the and the USFS Forest Plan and amendments and associated environmental impact statement (EIS) documents for the USFS Bearlodge Ranger District and in BLM's proposed and approved resource management plans (RMPs) and associated EIS documents for the BLM Newcastle field office.

Grazing permits or leases for a particular allotment, however, are not included within the RMP, Forest Plan, or EIS. Grazing leases and permits frequently include an allotment management plan (AMP), coordinated resource management plan (CRMP), or similar agreement that outlines a grazing plan and is prepared in cooperation with the permittees or operators. These plans often include goals and objectives, management indicators, use patterns, desired conditions, and monitoring techniques to measure progress.

Public land management policies directly affect the management of the private rangelands because public grazing leases and federal grazing allotments are integral components of a typical private grazing operation within the subbasin. Whether grazing occurs on private or public lands, a system of well-distributed, reliable water sources is a vital component to maintain or improve range conditions. The ecological site description, which helps landowners and managers evaluate the condition of a range or forest site by comparing the current growth to what the site is capable of growing, can also be a valuable tool for landowners to use in their decision making.

3.1.4.4 Existing Water Supply

A dependable water supply is the foundation for grazing management; it is necessary to provide sufficient amounts of suitable-quality water to animals over private and public rangelands. Numerous upland water sources are currently within the subbasin. Many rangeland improvements and grazing management projects have developed existing water sources such as springs, wells, and perennial streams. These projects often included storage tanks, ponds, reservoirs, pumping plants, and spring developments with pipelines carrying livestock and wildlife water to remote stock tanks.

Existing water sources on properties of participating landowners and managers were mapped within the watershed study. Mapping was not completed for the majority of private lands in the subbasin because many landowners or managers did not participate in the study. The mapping is not a complete account of all viable water sources but serves as a baseline for estimating livestock and wildlife water needs within the subbasin. Mapping viable water sources within the subbasin included the following items:

- Maps of springs were obtained from the BLM Newcastle Field Offices and the Black Hills National Forest (BHNF) Bearlodge Ranger District.
- Maps of stock wells were created by using data obtained from the Wyoming State Engineer's Office (SEO) and WWDO.
- Interviews with landowners were conducted during study meetings and field visits.
- Maps were developed and existing stock ponds and reservoirs were inventoried during landowner field visits and assessed using aerial imagery, infrared imagery, topographic maps, and hydrography datasets.

This mapping effort indicated the existence of ten stock reservoirs, ponds, lakes, and reservoirs. Digitized locations of springs were included using BLM, USFS, and USGS data. Although a detailed field verification of these sites was beyond the scope of this study, an initial review of the existing sources was completed. Recent high-resolution aerial imagery was examined using the GIS data to determine the status and viability of the water features.

Existing structures containing water and showing no breaches of the dam or spillway were determined to be likely water sources. Some structures showed visible evidence of dam and spillway breaches or filled with sediment and were determined to be nonfunctional. Other structures were dry and designated as potential water sources. An example of the mapping process is shown in Figure 3.4.

The results of this mapping effort are presented in Figure 3.5. Several livestock/wildlife water development projects, which typically include wells, spring developments, pipelines, and stock tanks, have been completed within the subbasin. A one-mile buffer was delineated around the existing viable water source locations within the subbasin and is presented in Figure 3.6. This figure of mapping results does not include surface water sources such as perennial and intermittent streams, undeveloped springs, or breached or nonfunctional ponds and reservoirs.

3.1.4.5 Ecological Site Descriptions

Rangelands are classified as ecological sites based on soils, topography, and climate that create each site's unique characteristics. An ecological site is a conceptual division of the landscape defined by the BLM, USFS, and NRCS [Caudle et al., 2013] as the following:

> *A distinctive kind of land based on recurring soil, landform, geological, and climate characteristics that differs from other kinds of land in its ability to produce distinctive kinds and amounts of vegetation and in its ability to respond similarly to management actions and natural disturbances.*

Ecological sites incorporate environmental factors such as climate, soils, landform, hydrology, vegetation, and natural disturbance regimes that together define the site and its relationships between these factors and how they influence plant community composition

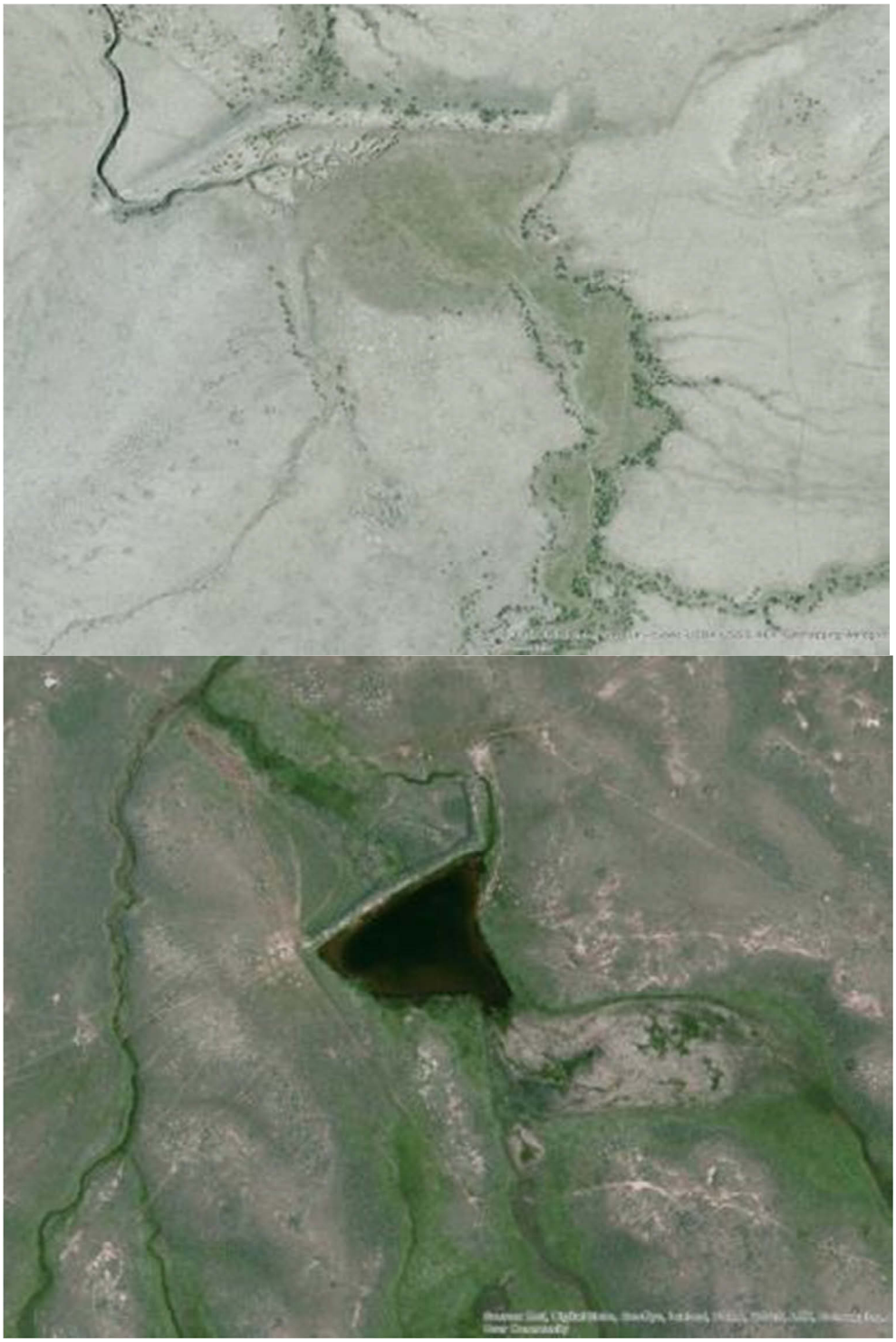


Figure 3.4. Geographic Information System Evaluation of Stock Ponds and Reservoirs Within the Subbasin.

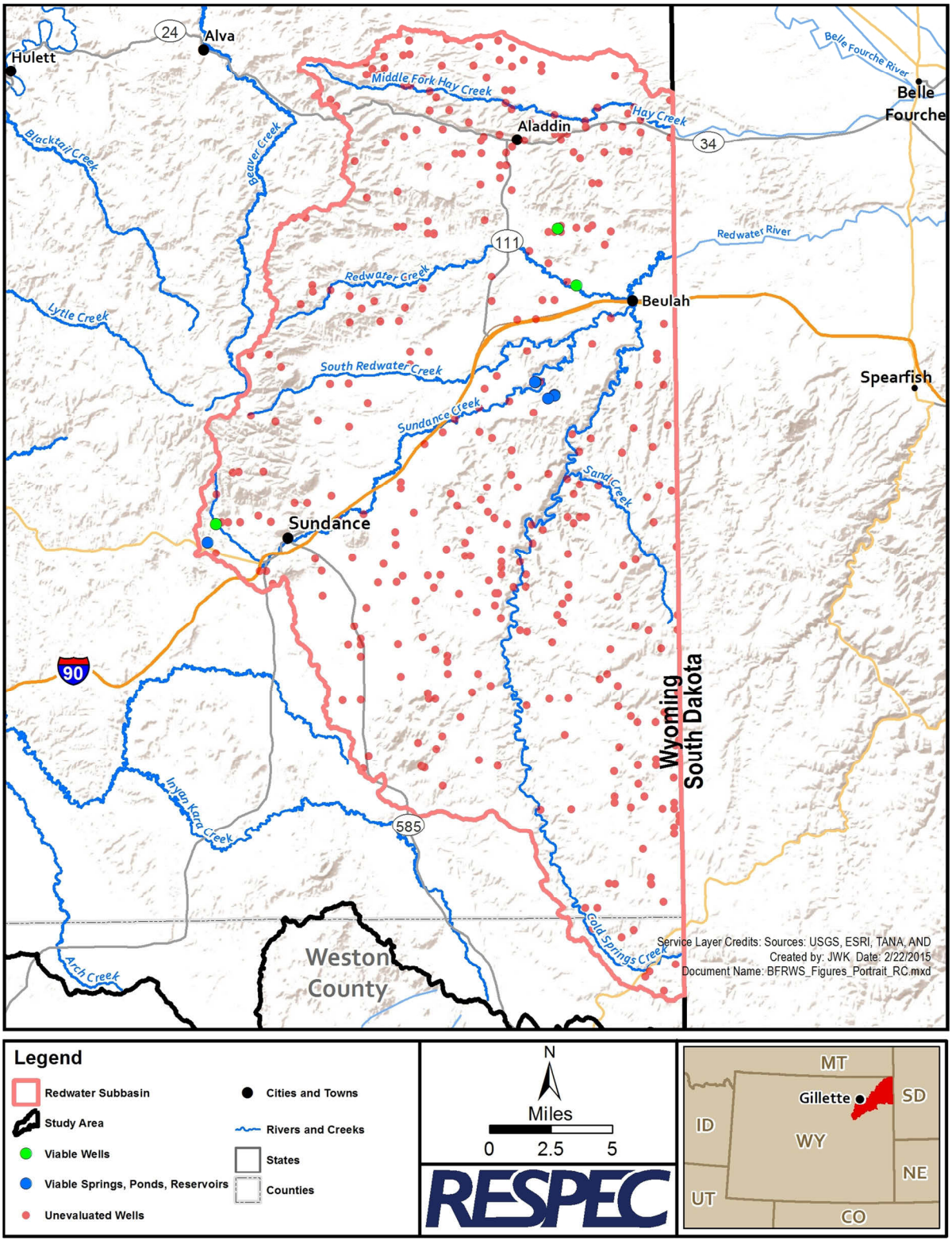


Figure 3.5. Viable Water Sources Within the Subbasin.

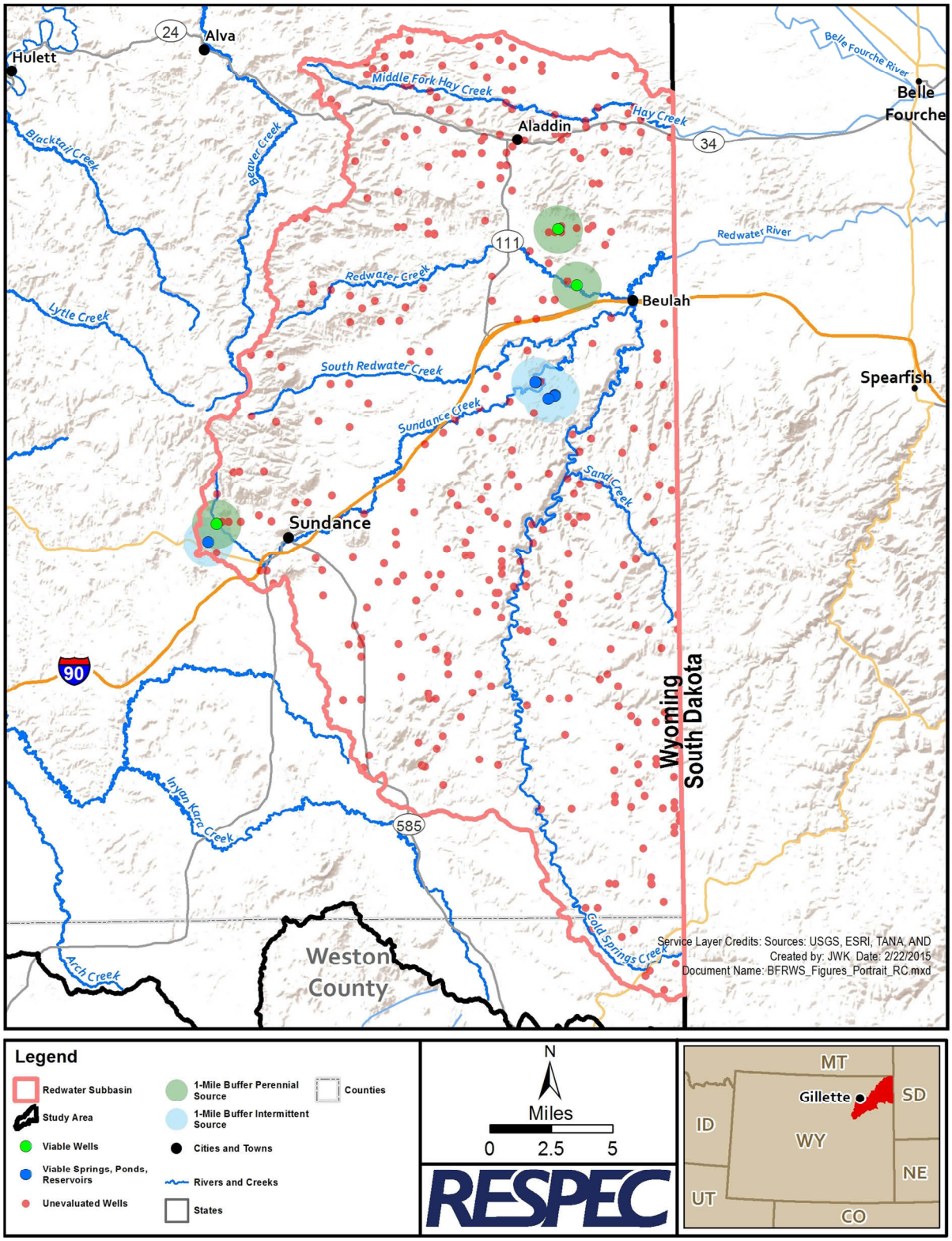


Figure 3.6. Viable Water Sources With a 1-Mile Buffer Within the Subbasin.

[Caudle et al., 2013]. The characteristics differentiating ecological sites and their features are documented as an ecological site description (ESD), which includes the following:

- Data used to define the distinctive properties and characteristics of the sites
- Biotic and abiotic characteristics that differentiate the site (i.e., climate, physiographic, soil characteristics, plant communities)
- Ecological dynamics including how changes in climate, disturbance processes, and management can affect the site.

An ESD includes interpretations about the land uses that a specific ecological site can support along with alternatives for achieving objectives. ESDs are valuable tools that can be used to help landowners and managers make decisions through evaluating the condition or health of a range or forest site and comparing the current vegetation composition to the type of plants the site is capable of growing. The ecological sites and associated descriptions were developed over many years of data collection and range site monitoring and are dependent on the location of a site within defined precipitation zones and existing soil characteristics. ESDs available from the NRCS (*https://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type=ESD*) describe the following for each ecological site:

- **Site characteristics**—physiographic, climate, soil, and water features
- **Plant communities**—plant species, vegetation states, and ecological dynamics
- **Site interpretations**—management alternatives for the site and its related resources
- **Supporting information**—relevant literature, information, and data sources.

The ESDs and NRCS soil map units are available and have been compiled for approximately 89 percent of the subbasin. Figure 3.7 shows the locations of the ecological sites within the subbasin. Five predominant ESDs cover approximately 59 percent of the subbasin as listed in Table 3.7.

The most predominant ecological site, Ponderosa pine-Idaho fescue (GFL_PIPO_FEID), covers approximately 62,228 acres (18.4 percent) of the subbasin. This is an ecological site on forest land and includes forest site index plot data, including mean, range, and standard deviation by soil series, tree species and curve numbers but report information and site interpretations are very limited.

Another predominant site is actually a forage suitability group description (FSGD), Not suited (G062XY0000SD), which occurs on approximately 43,959 acres within the subbasin. Report information and site interpretations for this FSGD is also very limited. Forest ecological site data and FSGDs could be used as a basic interpretive tool but caution should be exercised when using these for specific pastures, grazing allotments, or management units.

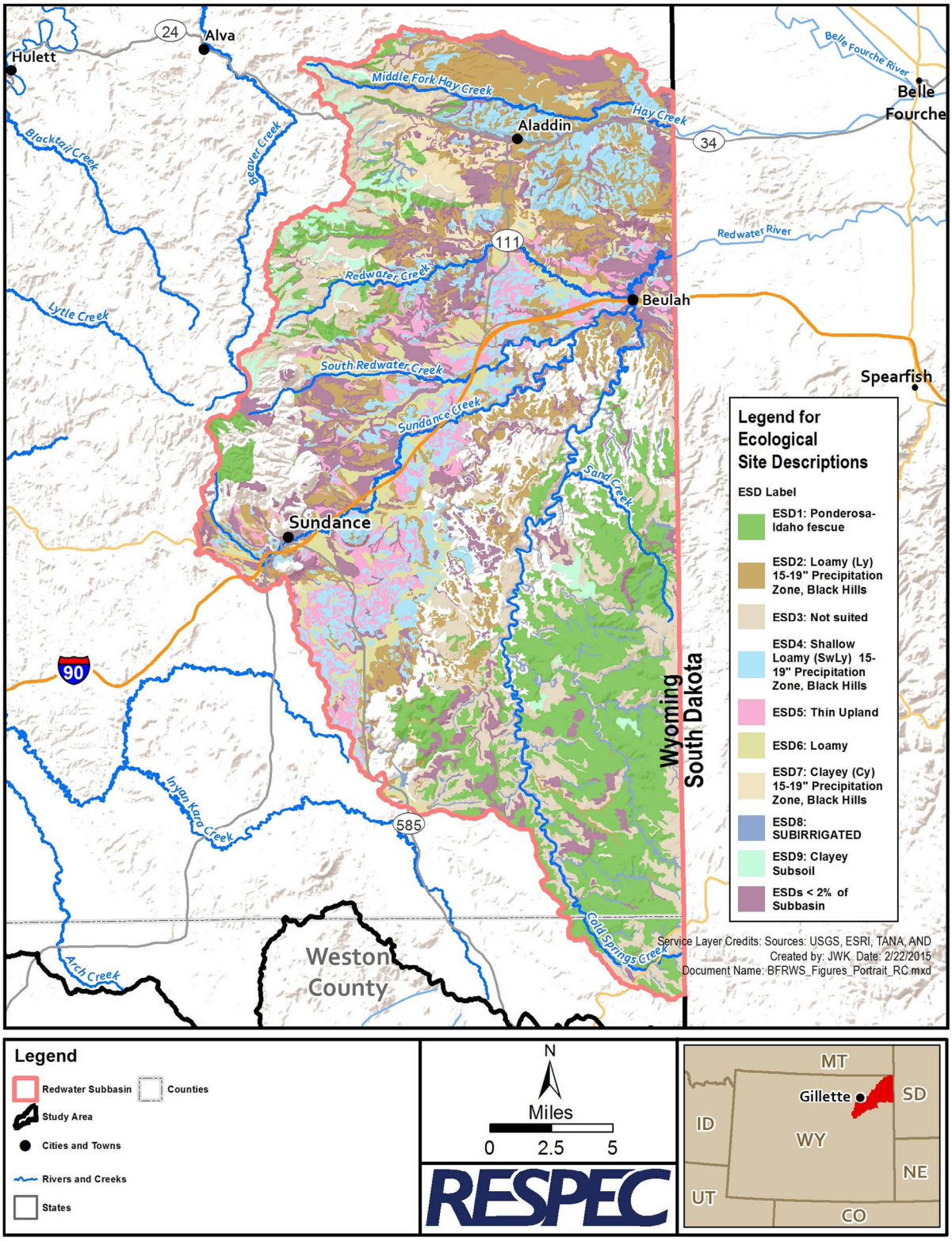


Figure 3.7. Ecological Site Descriptions Within the Subbasin.

Table 3.7. Ecological Sites, Descriptions, and Areas for Subbasin

Identifier	Ecological Site I.D.	Description	Area (acres)	Percent of Subbasin
1	GFL_PIPO_FEID	Ponderosa-Idaho fescue	62,228	18.4
2	R061XY122WY	Loamy (Ly) 15–19-inch Black Hills PZ	43,959	13.0
3	G062XY000SD	Not suited	42,322	12.5
4	R061XY162WY	Shallow Loamy (SwLy) 15–19-inch Black Hills PZ	32,665	9.7
5	R061XN010SD	Loamy	18,620	5.5
6	R061XY168WY	Thin Upland	17,618	5.2
7	R061XY104WY	Clayey (Cy) 15–19-inch Black Hills PZ	9,510	2.8
8	R062XY003SD	SUBIRRIGATED	7,431	2.2
9	G062XY210SD	Clayey Subsoil	6,877	2
10	R061XY016SD	Very Shallow	6,591	1.9
11	R061XN012SD	Thin Upland	5,696	1.7
12	GFL_PIPO_SCSC	Ponderosa Pine–little bluestem	4,196	1.2
13	R061XY158WY	Shallow Clayey (SwCy) 15–19-inch Black Hills PZ	4,156	1.2
14	R061XY022SD	Loamy Terrace	3,805	1.1
15	R061XY150WY	Sandy (Sy) 15–19-inch Black Hills PZ	3,511	1.0
16	R061XY166WY	Shallow Sandy (SwSy) 15–19-inch Black Hills PZ	3,484	1.0
17	R061XN024SD	Shallow Loamy	3,240	1.0
18	R061XY128WY	Lowland (LL) 15–19-inch Black Hills PZ	2,861	0.8
19	R061XY003SD	Subirrigated	2,103	0.6
20	G062XY300SD	Sand	2,083	0.6
21	R062XY012SD	THIN UPLAND	1,939	0.6
22-41	Various ESDs	ESDs covering less than 0.5 percent of the subbasin	6,613	1.9
Total			291,508	85.9

In addition to the Ponderosa pine-Idaho fescue forest ecological site and the Not suited FSGD, the rangelands within the subbasin contain numerous ESDs. More than one plant community can occur within an ESD given the site characteristics discussed above. Each range ecological site has a specific plant community that has developed because of these factors and is referred to as reference or Historic Climax Plant Community (HCPC). The HCPC describes the potential plant community and potential productivity of each individual range site.

Plant communities have distinct forage production potential; the HCPC usually has the greatest potential. The HCPC can be used to compare the current vegetation growing on a site to the plant community that could be grown on the site. This comparison using the HCPC can be an indicator of potential site productivity. The following descriptions of the HCPC associated with the predominant ESDs within the subbasin were obtained directly from the NRCS *ESD System for Rangeland and Forestland Data* website that can be accessed online (*https://esis.sc.egov.usda.gov/Welcome/pgReportLocation.aspx?type=ESD*). Four rangeland ESDs and associated HCPCs cover approximately 112,862 acres (33.4 percent) of the subbasin. These ESDs are also listed in Table 3.7 and described in Chapter 4.0.

3.1.5 Mining and Mineral Resources

The subbasin contains nine operating non-coal mines. Information about the mines was obtained from Wyoming Department of Environmental Quality (WDEQ) and summarized in Table 3.8 and Figure 3.8. Sand/gravel and limestone mines constitute the majority of permitted mine operations within the project area with one gypsum mine also located in the subbasin. The largest operation within the subbasin is the Rogers limestone mine operated by Croell Redi-Mix Inc. on a permitted acreage of approximately 600 acres. No active coal mines are located within the Redwater Subbasin.

Table 3.8. Current Mineral Resource Mines Within the Subbasin

Permit I.D.	Permitted Mine	Permittee	Commodity	Mine Area (acres)
ET0192	Croell	Croell Redi-Mix Inc.	Sand	8.4
ET1030	Goodson	Croell Redi-Mix Inc.	Sand and Gravel	4.5
PT0567	Sundance/Vondrisk	Lien, Pete & Sons Inc.	Limestone	208.7
PT0675	Mcinerney	Quality Agg & Construction Inc.	Sand and Gravel	198.2
PT0727	Sundance	Monolith Minerals LLC	Gypsum	720.0
PT0729	Cole Pit	Basic Energy Service LP	Sand and Gravel	54.3
PT0744	Hunter Quarry	Lien, Pete & Sons Inc.	Limestone	522.1
PT0772	Rogers	Croell Redi-Mix Inc.	Limestone	600.1
PT0793	State Line	Fisher Sand & Gravel Co.	Limestone	133.9

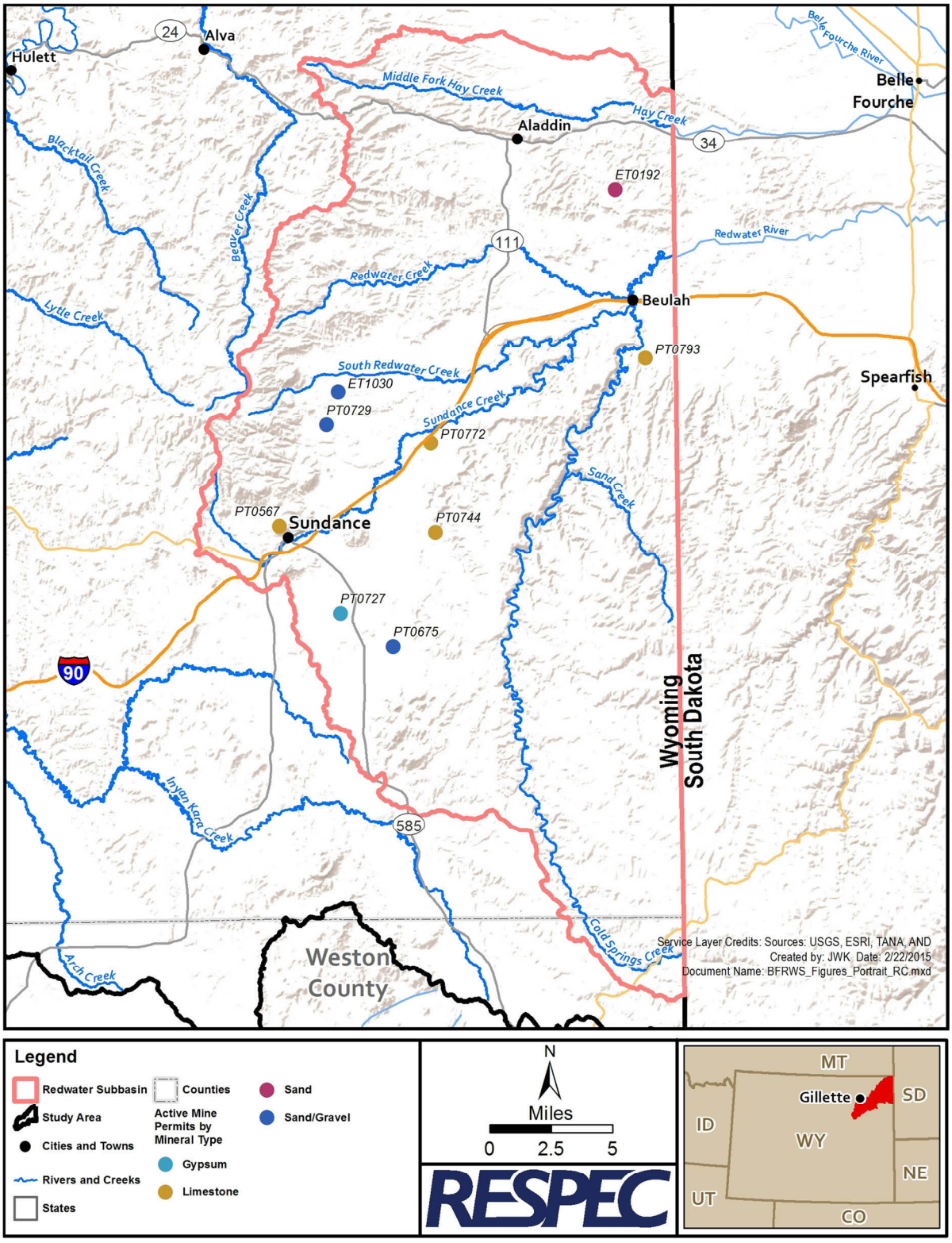


Figure 3.8. Permitted Mines Within the Subbasin.

3.1.6 Oil and Gas Production and Resources

Information regarding the active and abandoned oil and gas wells within the subbasin was obtained from the Wyoming Oil and Gas Conservation Commission (WOGCC) by accessing their website (*http://wogccms.state.wy.us/)* and by communicating with WOGCC staff. No active-producing gas or oil wells currently exist, but 30 permanently abandoned wells are located within the subbasin.

3.1.7 Wildlife and Habitat

3.1.7.1 Big Game

The Wyoming Game and Fish Department (WGFD) has recorded, mapped, and analyzed data for big game and developed geodata showing hunt areas, herd units, seasonal range, crucial range, parturition area, and migration routes and barriers for antelope, bighorn sheep, bison, elk, mule deer, moose, Rocky Mountain goat, and white-tailed deer. No areas within the subbasin are considered as parturition area for any big game species. The subbasin contains critical range for elk, mule deer, and white-tailed deer. Figures 3.9 through 3.12 display the herd units, seasonal range, and critical range for antelope, elk, mule deer, and white-tailed deer. These figures show that the entire subbasin is seasonal range for antelope, elk, mule deer, and white-tailed deer.

3.1.7.2 Species of Concern

The Wyoming Natural Diversity Database (WYNDD) records and maintains a list of species in Wyoming that are thought to be rare or sensitive. Table 3.9 lists the tracked or watched species of amphibians, birds, crustaceans, fern and fern ally, fish, insects, mammals, mollusks, and reptiles found within the subbasin [Wyoming Natural Diversity Database, 2014]. The list shows that there is one endangered species: the black-footed ferret (*Mustela nigripes*) and one threatened species, grizzly bear (*Ursus arctos arctos*), known to have occurred in the subbasin.

Table 3.9 shows that the sage-grouse is listed as “candidate species; warranted but precluded” because existing information supports a proposal to list the sage-grouse as endangered or threatened, but developing a proposed listing is precluded by higher priority listing activities. In 2011, the Governor of Wyoming issued an executive order to protect and enhance sage-grouse populations and habitat within and outside the core areas. The order requires state agencies to focus management to the greatest extent possible to prevent the sage-grouse from being listed on the endangered species list. Core areas for sage-grouse do not exist within the Redwater Subbasin as shown in Figure 3.13.

3.2 SETTING AND ENVIRONMENT

3.2.1 Land Cover

Table 3.10 is a summary of land cover using the National Land Cover Dataset (NLCD). The NLCD is a 16-category land cover classification method that is applied across the United States.

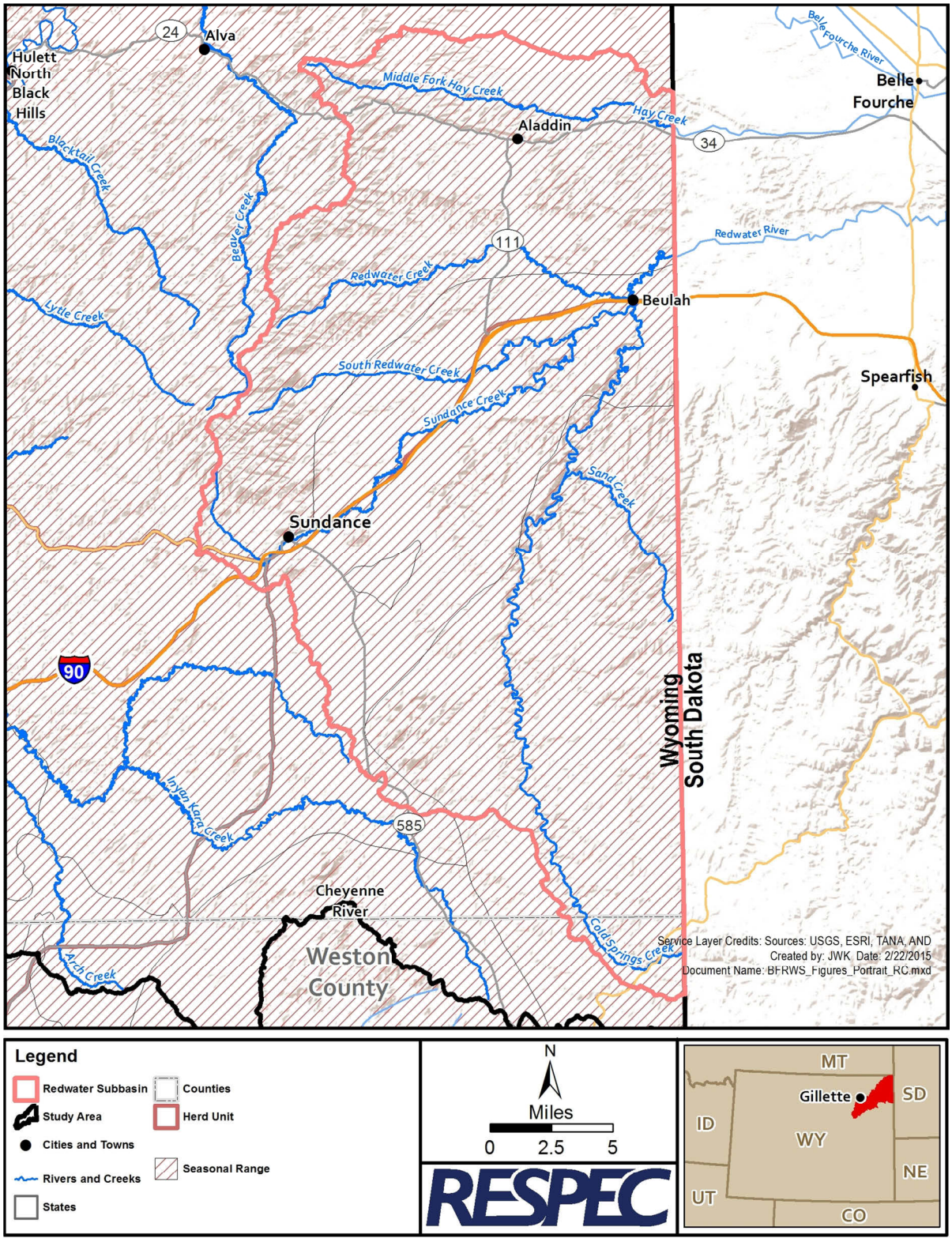


Figure 3.9. Antelope Habitat Within the Subbasin and Surrounding Area.

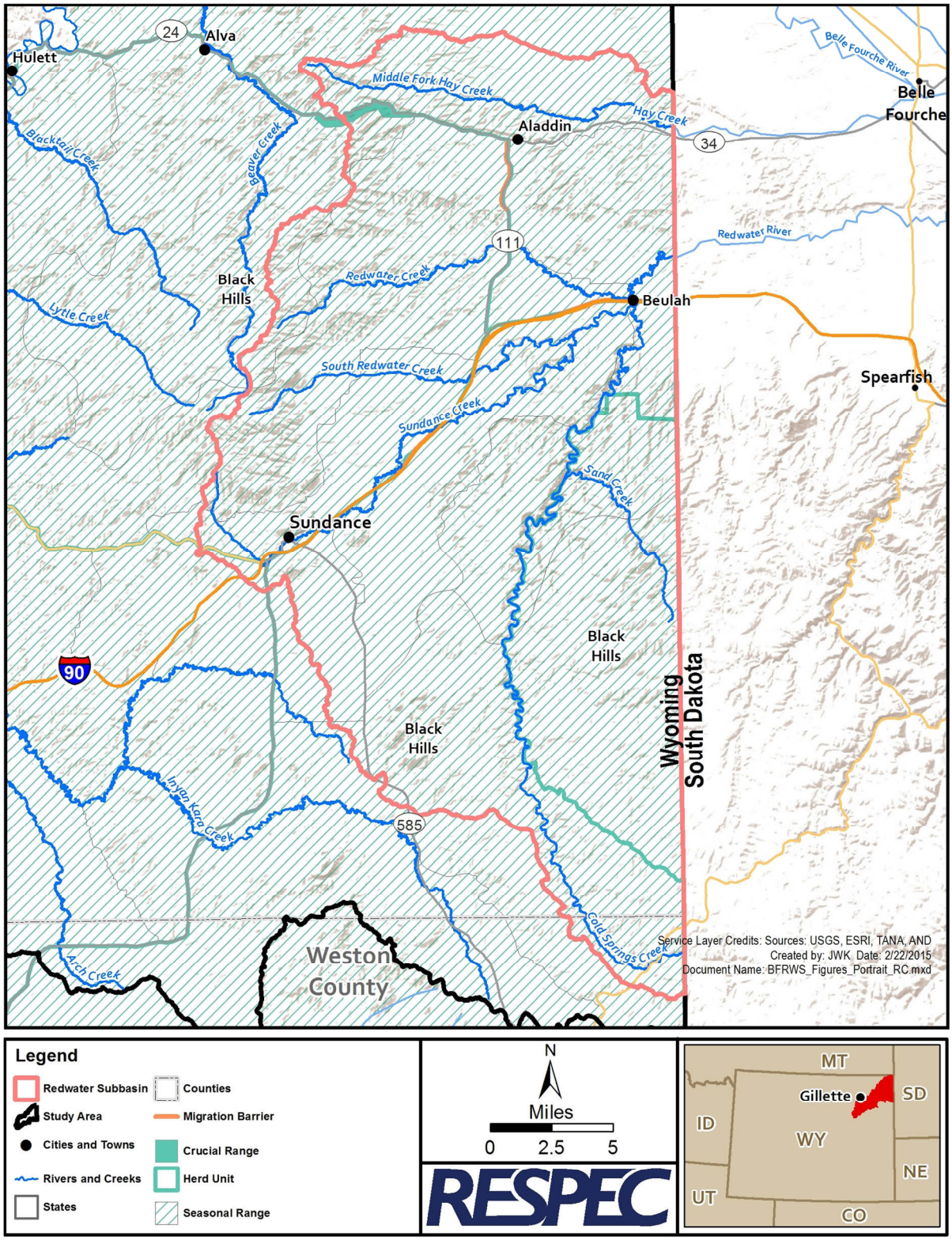


Figure 3.10. Elk Habitat Within the Subbasin and Surrounding Area.

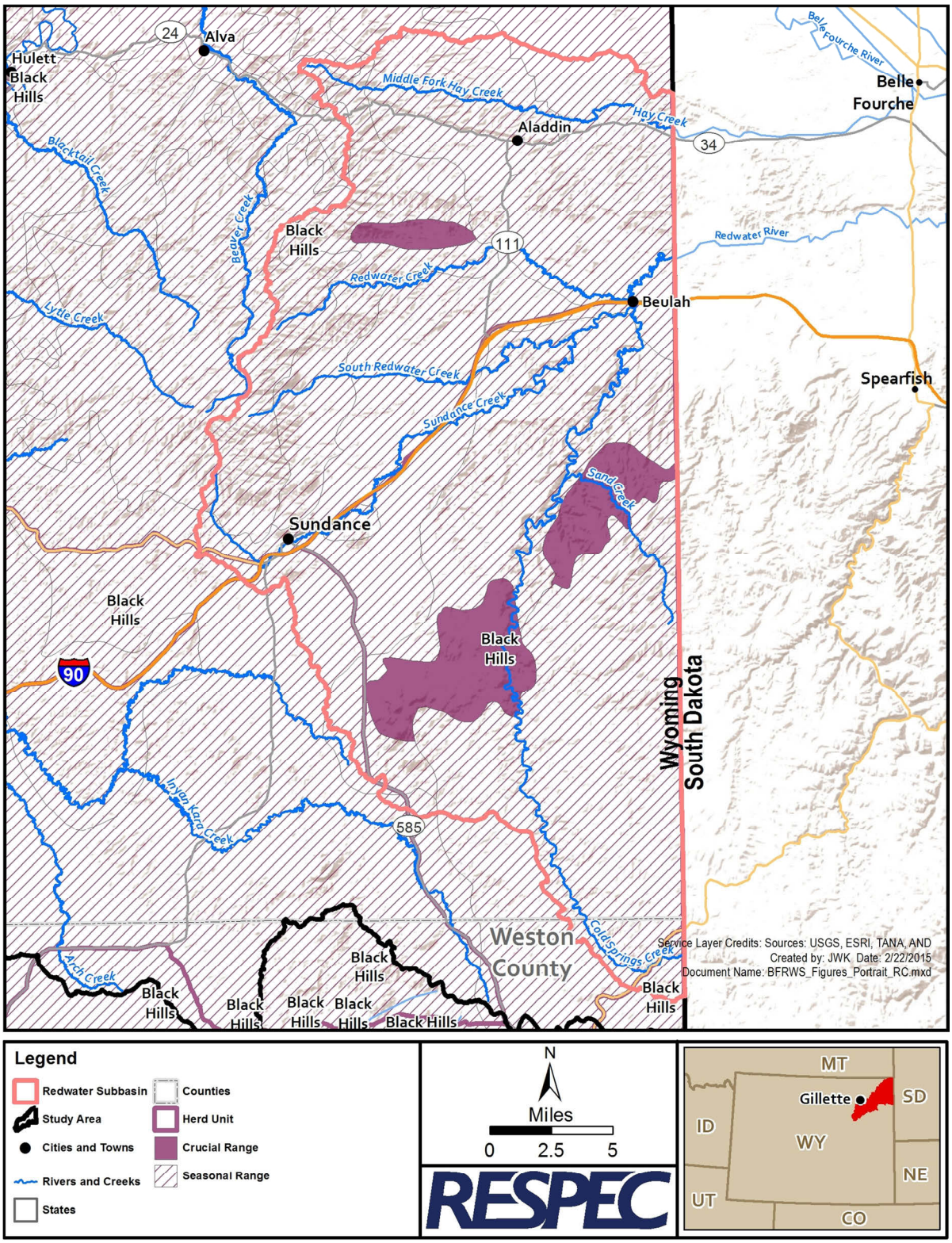


Figure 3.11. Mule Deer Habitat Within the Subbasin and Surrounding Area.

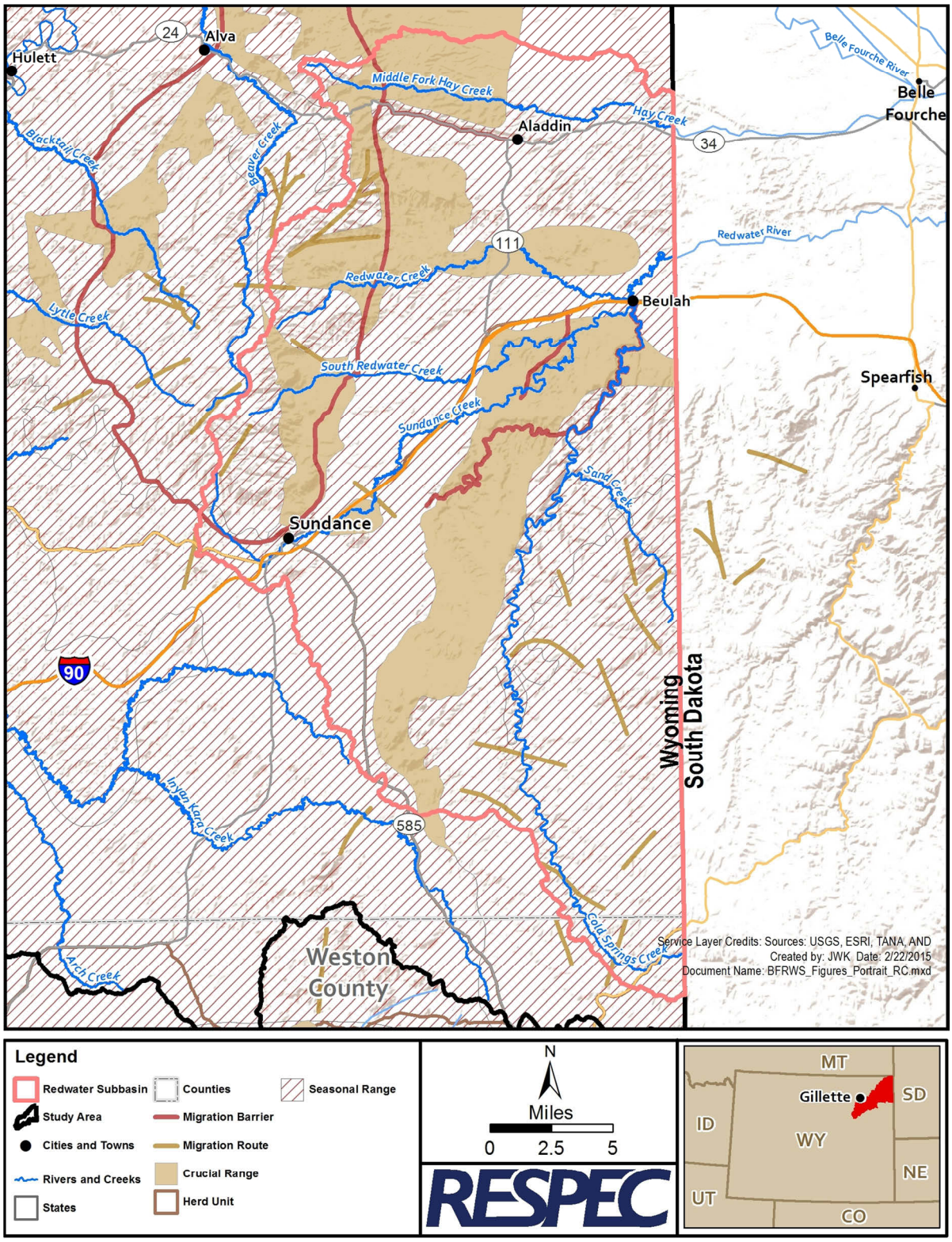


Figure 3.12. White-Tailed Deer Habitat Within the Subbasin and Surrounding Area.

Table 3.9. Wyoming Natural Diversity Database: Wildlife Species in the Subbasin (Page 1 of 3)

Scientific Name	Common Name	Listing Status	Tracking Status
Amphibian			
Ambystoma mavortium	Tiger Salamander		Watched
Lithobates pipiens	Northern Leopard Frog	Not Warranted for Listing	Tracked
Bird			
Accipiter gentilis	Northern Goshawk	Not Warranted for Listing	Tracked
Ammodramus savannarum	Grasshopper Sparrow		Watched
Aquila chrysaetos	Golden Eagle		Watched
Asio flammeus	Short-eared Owl		Tracked
Athene cunicularia	Burrowing Owl		Tracked
Bucephala clangula	Common Goldeneye		Watched
Buteo regalis	Ferruginous Hawk		Tracked
Catherpes mexicanus	Canyon Wren		Watched
Centrocercus urophasianus	Greater Sage-Grouse	Warranted but Precluded	Tracked
Charadrius montanus	Mountain Plover	Not Warranted for Listing	Tracked
Coccyzus americanus	Yellow-billed Cuckoo		Tracked
Coccyzus erythropthalmus	Black-billed Cuckoo		Tracked
Cygnus buccinator	Trumpeter Swan	Not Warranted for Listing	Tracked
Dolichonyx oryzivorus	Bobolink		Tracked
Empidonax hammondii	Hammond's Flycatcher		Watched
Falco columbarius	Merlin		Watched
Gavia immer	Common Loon		Tracked
Grus canadensis	Sandhill Crane		Watched
Haliaeetus leucocephalus	Bald Eagle	Delisted, formally monitored	Tracked
Junco hyemalis	Dark-eyed Junco		Tracked
Junco hyemalis aikeni	White-winged Junco		Watched
Lanius ludovicianus	Loggerhead Shrike		Tracked
Larus californicus	California Gull		Watched
Larus delawarensis	Ring-billed Gull		Watched
Loxia leucoptera	White-winged Crossbill		Watched
Melanerpes lewis	Lewis's Woodpecker		Tracked
Numenius americanus	Long-billed Curlew		Tracked
Pandion haliaetus	Osprey		Watched
Passerina caerulea	Blue Grosbeak		Watched
Passerina cyanea	Indigo Bunting		Watched

Table 3.9. Wyoming Natural Diversity Database: Wildlife Species in the Subbasin (Page 2 of 3)

Scientific Name	Common Name	Listing Status	Tracking Status
Bird			
Pelecanus erythrorhynchos	American White Pelican		Tracked
Picoides arcticus - Black Hills	Black Hills Black-backed Woodpecker	Petition Under Review	Tracked
Rallus limicola	Virginia Rail		Watched
Regulus satrapa	Golden-crowned Kinglet		Watched
Sialia sialis	Eastern Bluebird		Watched
Sitta pygmaea	Pygmy Nuthatch		Tracked
Spiza americana	Dickcissel		Watched
Spizella breweri	Brewer's Sparrow		Watched
Spizella pallida	Clay-colored Sparrow		Watched
Vireo olivaceus	Red-eyed Vireo		Watched
Fish			
Chrosomus neogaeus	Finescale Dace		Tracked
Insect			
Dichagyris (Mesembagrotis) reliqua	A Noctuid Moth		Tracked
Hesperia ottoe	Ottoe Skipper		Tracked
Phyciodes batesii	Tawny Crescent		Tracked
Speyeria idalia	Regal Fritillary		Tracked
Mammal			
Bos bison bison	Plains Bison	Not Warranted for Listing	Tracked
Canis lupus	Gray Wolf	Proposed for Delisting	Tracked
Corynorhinus townsendii	Townsend's Big-eared Bat		Tracked
Glaucomys sabrinus - Black Hills	Black Hills Flying Squirrel		Tracked
Lasionycteris noctivagans	Silver-haired Bat		Watched
Lasiurus cinereus	Hoary Bat		Watched
Mustela nigripes	Black-footed Ferret	Listed Endangered	Tracked
Myotis ciliolabrum	Western Small-footed Myotis		Watched
Myotis evotis	Long-eared Myotis		Watched
Myotis lucifugus	Little Brown Myotis	Petition Under Review	Watched
Myotis septentrionalis	Northern Myotis	Proposed Endangered	Tracked
Myotis thysanodes	Fringed Myotis		Tracked
Myotis volans	Long-legged Myotis		Watched
Perognathus fasciatus	Olive-backed Pocket Mouse		Watched

Table 3.9. Wyoming Natural Diversity Database: Wildlife Species in the Subbasin (Page 3 of 3)

Scientific Name	Common Name	Listing Status	Tracking Status
Mammal			
Peromyscus leucopus	White-footed Deermouse		Watched
Sorex haydeni	Hayden's Shrew		Tracked
Sylvilagus floridanus	Eastern Cottontail		Watched
Tamiasciurus hudsonicus dakotensis	Black Hills Red Squirrel		Tracked
Urocyon cinereoargenteus ocythous	Prairie Gray Fox	Petition Under Review	Watched
Ursus arctos arctos	Grizzly Bear	Listed Threatened	Tracked
Vulpes velox	Swift Fox	Not Warranted for Listing	Tracked
Zapus hudsonius campestris	Bear Lodge Meadow Jumping Mouse		Tracked
Mollusk			
Catinella stretchiana	Sierra Ambersnail		Tracked
Discus shimekii	Striate Disc		Tracked
Lasmigona complanata	White Heelsplitter		Tracked
Oreohelix strigosa cooperi	Cooper's Rocky Mountain Mountainsnail	Not Warranted for Listing	Tracked
Oreohelix strigosa ssp. 1	Bear Lodge Mountainsnail		Tracked
Oreohelix subrudis	A Mountainsnail		Tracked
Vertigo arthuri	Callused Vertigo Snail		Tracked
Oreohelix strigosa cooperi	Cooper's Rocky Mountain Mountainsnail	Not Warranted for Listing	Tracked
Oreohelix strigosa ssp. 1	Bear Lodge Mountainsnail		Tracked
Oreohelix subrudis	A Mountainsnail		Tracked
Vertigo arthuri	Callused Vertigo Snail		Tracked
Reptile			
Apalone spinifera spinifera	Eastern Spiny Softshell		Watched
Coluber constrictor flaviventris	Eastern Yellow-bellied Racer		Watched
Opheodrys vernalis	Smooth Greensnake		Tracked
Storeria occipitomaculata pahasapae	Black Hills Red-bellied Snake		Tracked
Thamnophis radix	Plains Gartersnake		Watched
Thamnophis sirtalis parietalis	Red-sided Gartersnake		Watched

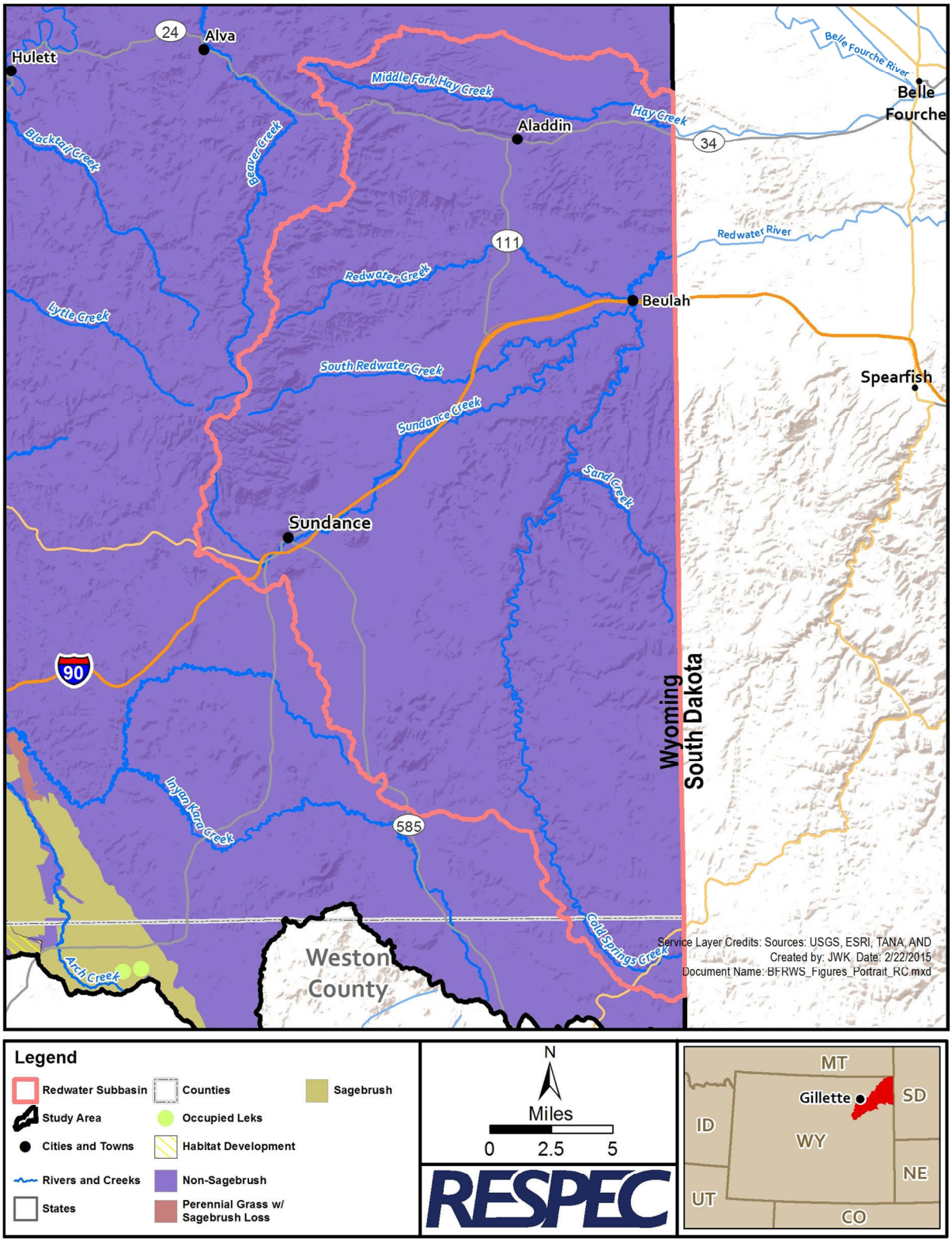


Figure 3.13. Sage-Grouse Distribution and Core Areas Within the Subbasin and Study Area.

The NLCD uses data derived from Landsat imagery and ancillary data. Approximately 47 percent or 157,840 acres of land cover within the subbasin is comprised of evergreen forest vegetative cover. Approximately 28 percent (94,880 acres) of the subbasin is classified as grassland/herbaceous and approximately 22 percent (75,940 acres) of the subbasin is classified as shrub/scrub land. The remaining areas consist of decidious forest, developed, open space, and other cover classes. An estimated 48 acres of water exists within the subbasin.

Table 3.10. National Land Cover Dataset Classifications Within the Subbasin

Classification	Description	Area (acres)	Percent of Subbasin
Evergreen Forest	Trees greater than 16 feet tall, and greater than 20 percent of total vegetation cover. More than 75 percent of the tree species maintain their leaves all year. Canopy is never without green foliage.	157,841	46.7
Grassland and Herbaceous	Gramanoid or herbaceous vegetation, generally greater than 80 percent of total vegetation. These areas are not subject to tilling, but are used for grazing.	94,882	28.1
Shrub and Scrub	Shrubs less than 16 feet tall with canopy typically greater than 20 percent of total vegetation. This class includes shrubs and trees in early successional stages or stunted from environmental conditions.	75,944	22.5
Deciduous Forest	Trees greater than 16 feet tall, and greater than 20 percent of vegetation cover. More than 75 percent of the tree species shed foliage in response to a seasonal change.	1,983	0.6
Developed, Open Space	A mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20 percent of cover. These areas commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developments for recreation, erosion control, or aesthetics.	1,451	0.4
Pasture and Hay	Grasses, legumes, or mixtures planted for livestock grazing or the production of seed or hay crops on a perennial cycle. Pasture/hay vegetation accounts for greater than 20 percent of total vegetation.	1,279	0.4
Emergent Herbaceous Wetlands	Perennial herbaceous vegetation accounts for greater than 80 percent of vegetative cover and the soil or substrate is periodically covered with water.	1,088	0.3
Developed, Low Intensity	A mixture of constructed materials and vegetation. Impervious surfaces account for 20 to 49 percent of total cover. These areas commonly include single-family housing units.	991	0.3
Woody Wetlands	Forests or shrublands accounts for greater than 20 percent and the soil is periodically covered with water.	822	0.2
Mixed Forest	Dominated by trees generally greater than 5 meters tall, and greater than 20 percent of total vegetation cover. Neither deciduous nor evergreen species are greater than 75 percent of total tree cover.	702	0.2
Cultivated Crops	Production of annual crops and also perennial woody crops. Crops accounts for greater than 20 percent of total vegetation. This class also includes land being tilled.	576	0.2
Other	Areas with less than 0.1 percent of the subbasin.	461	0.1
Total		**338,020**	**100.0**

3.2.2 Vegetation

The Wyoming Gap Analysis Program (GAP) data was obtained to evaluate existing vegetation in the subbasin, which are listed in Table 3.11 and shown in Figure 3.14. Additionally Table 3.12 lists the plant species of concern within the subbasin as supplied by WYNDD. The subbasin is mostly included in the Northwestern Forested Mountains Ecoregion. Plant communities include pine forests and woodlands, areas of deciduous forest, with an understory consisting of grasses, sedges, and shrubs. In general, the desirable grass species in the subbasin include rhizomatous wheatgrass, needleandthread, green needlegrass, prairie sandreed, big bluestem, and blue grama. Twenty-five designated and prohibited noxious weeds are on the state of Wyoming Weed and Pest Control Act Designated List and detailed in the basin wide summary report.

Table 3.11. Wyoming Gap Analysis Program: Existing Vegetation Type Within the Subbasin

Existing Vegetation Type	Area (acres)	Percent of Subbasin
Northwestern Great Plains - Black Hills Ponderosa Pine Woodland and Savanna	150,777	44.6
Northwestern Great Plains Mixedgrass Prairie	74,819	22.1
Close Grown Crop	65,611	19.4
Western Great Plains Sand Prairie	9,817	2.9
Inter-Mountain Basins Big Sagebrush Steppe	5,363	1.6
Rocky Mountain Aspen Forest and Woodland	5,320	1.6
Northwestern Great Plains Shrubland	3,591	1.1
All other classes, less than 1 percent each	22,722	6.7
Total	**338,020**	**100.0**

3.2.3 Wetlands

Approximately 411 acres of National Wetlands Inventory (NWI) are mapped wetland types, which cover approximately 0.122 percent of the subbasin. The predominant wetland type is a freshwater pond, which occurs on approximately 144 acres within the subbasin. The NWI wetlands within the subbasin are listed in Table 3.13. The NWI wetland areas are shown in Figure 3.15. However, because the NWI wetland areas are very small in size relative to the subbasin and are scarcely visible when presented at this scale, the mapped wetland polygons were outlined with a thicker border to increase their visibility; NWI wetlands do not actually cover the amount of area indicated in the map figure. Site-specific wetland delineation and inventories were not part of the scope of this study and it is recommended that wetland delineation and inventories should be completed before planning future wetland projects.

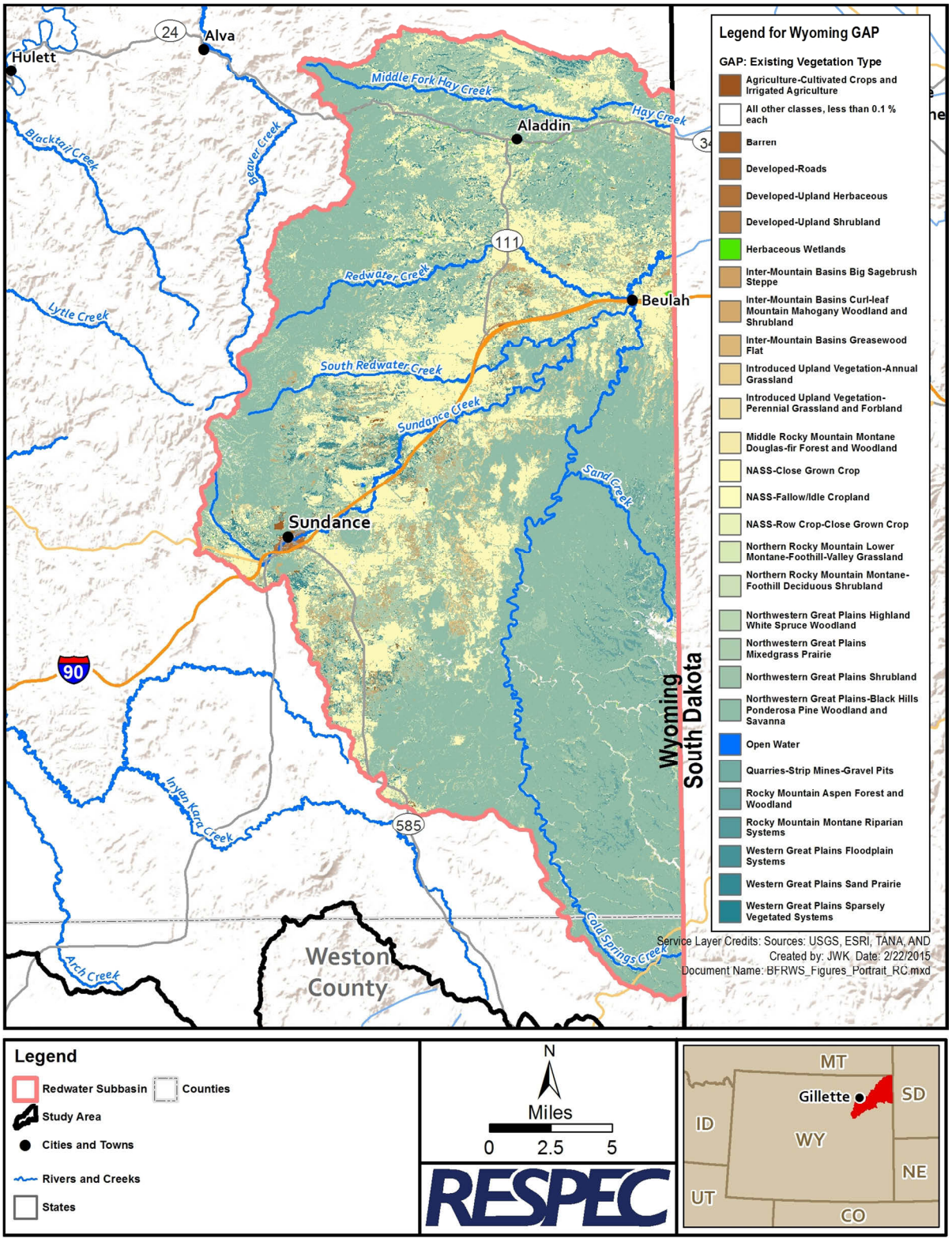


Figure 3.14. Wyoming Gap Analysis Program: Existing Vegetation Type Within the Subbasin.

Table 3.12. Wyoming Natural Diversity Database: Plants Within the Subbasin (Page 1 of 2)

Scientific Name	Common Name	Status
Adoxa moschatellina	Moschatel	Tracked
Amphicarpaea bracteata	Groundnut	Tracked
Aquilegia brevistyla	Small-flower columbine	Tracked
Bacopa rotundifolia	Roundleaf water-hyssop	Tracked
Calochortus apiculatus	Pointedtip mariposa-lily	Tracked
Campanula aparinoides	Marsh bellflower	Tracked
Carex alopecoidea	Foxtail sedge	Tracked
Carex concinna	Beautiful sedge	Tracked
Carex eburnea	Ebony sedge	Tracked
Carex foenea	Bronze sedge	Tracked
Carex granularis var. haleana	Meadow sedge	Tracked
Carex intumescens	Great bladder sedge	Tracked
Carex richardsonii	Richardson's sedge	Tracked
Carex rosea	Rosy sedge	Tracked
Carex scoparia	Broom sedge	Tracked
Ceanothus herbaceus	Prairie redroot	Tracked
Centunculus minimus	Chaffweed	Tracked
Circaea lutetiana var. canadensis	Canadian enchanter's nightshade	Tracked
Cypripedium parviflorum var. pubescens	Large yellow lady's-slipper	Tracked
Dalea enneandra	Nine-anther prairie-clover	Tracked
Dichanthelium linearifolium	Slim-leaf witchgrass	Tracked
Eleocharis ovata	Ovate spikerush	Tracked
Eleocharis tenuis var. borealis	Boreal spikerush	Tracked
Elymus villosus	Hairy wildrye	Tracked
Helianthemum bicknellii	Plains frostweed	Tracked
Hymenopappus tenuifolius	Chalk-hill woollywhite	Tracked
Machaeranthera bigelovii var. bigelovii	Bigelow's spiny aster	Tracked
Muhlenbergia glomerata	Marsh muhly	Tracked

Table 3.12. Wyoming Natural Diversity Database: Plants Within the Subbasin (Page 2 of 2)

Scientific Name	Common Name	Status
Myosotis verna	*Spring forget-me-not*	*Tracked*
Oenothera laciniata	Cut-leaved Evening-primrose	Tracked
Phryma leptostachya	Lopseed	Tracked
Physalis virginiana	Virginia ground-cherry	Tracked
Platanthera orbiculata	Large roundleaf orchid	Tracked
Polygala verticillata	Whorled milkwort	Tracked
Polygonatum biflorum	Common solomon's-seal	Tracked
Potamogeton diversifolius	Water-thread pondweed	Tracked
Prosartes hookeri	Hooker's Fairy Bell	Tracked
Viburnum opulus var. americanum	Highbush cranberry	Tracked
Viola pedatifida	Prairie violet	Tracked
Viola renifolia var. brainerdii	Kidney-leaf white violet	Tracked

Table 3.13. Summary of Wetland Types Within the Subbasin

Wetland Type	Area (Acres)	Percent of Subbasin
Freshwater Pond	178	0.053
Freshwater Emergent Wetland	144	0.043
Other	61	0.018
Freshwater Forested/Shrub Wetland	16	0.005
Riverine	11	0.003
Total	**410**	**0.12**

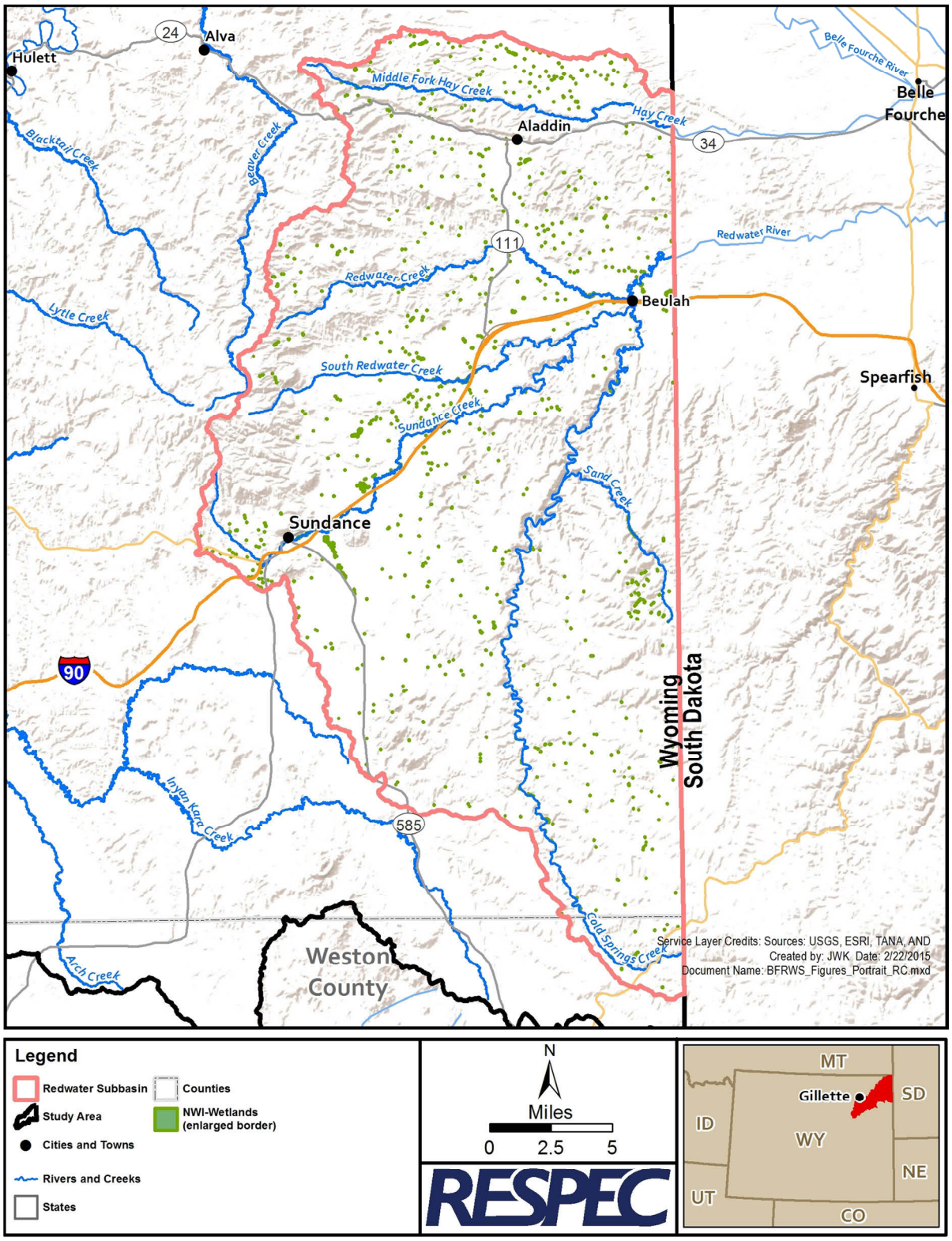


Figure 3.15. National Wetlands Inventory Wetlands Located Within the Subbasin.

3.2.4 Geology

Geologic mapping information and data for the subbasin were obtained from the USGS and the WSGS. A variety of geological features and rocks from Precambrian metamorphics are exposed in the uplifts to Quaternary alluvium along creeks within the subbasin. The subbasin includes parts of the Black Hills Uplift. The surficial geologic units within the subbasin consist of slopewash and colluvium and residuum mixed covering approximately 78 percent of the subbasin as shown in Figure 3.16. The remaining prominent units include alluvium, alluvial fan, bedrock, landslide mixed, and karst mixed. These geologic units influence the subbasin by providing the parent material and morphology for the soil formations and plant communities.

The bedrock geologic units that underlie the subbasin predominantly consist of the Minnelusa Formation, Spearfish Formation, Cloverly and Morrison Formations and Minnekahta Limestone and Opeche Shale covering approximately 80 percent of the subbasin as shown in Figure 3.17 and listed in Table 3.14. The remaining prominent bedrock features include Sundance and Gypsum Spring Formations, intrusive and extrusive igneous rocks , and alluvium and colluvium. Figure 3.18 displays the faults and landslides within the subbasin. Landslide deposits are present and indicate that landslide activity has occurred mainly in the Bear Lodge Mountains and surrounding foothills and in a smaller area southwest of Sundance.

3.2.5 Soils

Soils are diverse within the subbasin because of the variable characteristics of the subbasin's underlying geology, topography and elevation, climate and precipitation, and vegetation. Soils in the subbasin vary considerably but 52 percent of the soils contain slightly and moderately decomposed plant material. Also, approximately 40 percent of the subbasin soils are loamy with channery, cobbly, gravelly, sandy, and stony loam surface textures.

Soils information was obtained from the NRCS and compiled for the portions of the subbasin within Crook and Weston counties. Two digitized soil surveys cover approximately 94 percent of the subbasin. NRCS published the soil surveys in the Crook and Weston counties in 1983, and 1990, respectively. Detailed soils information, ratings, data, and maps can be accessed at the NRCS Web Soil Survey website (*http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm*).

Over 170 soil map units are within the subbasin. The rock outcrop-Vanocker complex is the largest single map unit and covers 33,700 acres (10.0 percent) of the subbasin. Other major soil units include the Citadel-McCaffery complex, Lakoa-Butche complex, Larkson-Lakoa loams, and Vanocker-Citadel complex. Figure 3.19 displays a general soils map of the subbasin. Hydric soil map units were mapped to identify areas where soils were formed under saturated, flooded, or ponded conditions during the growing season creating anaerobic conditions in the soil. Table 3.15 lists the four soil map units rated as hydric by NRCS within the subbasin. A detailed description of hydric soils is included in the basin wide summary report.

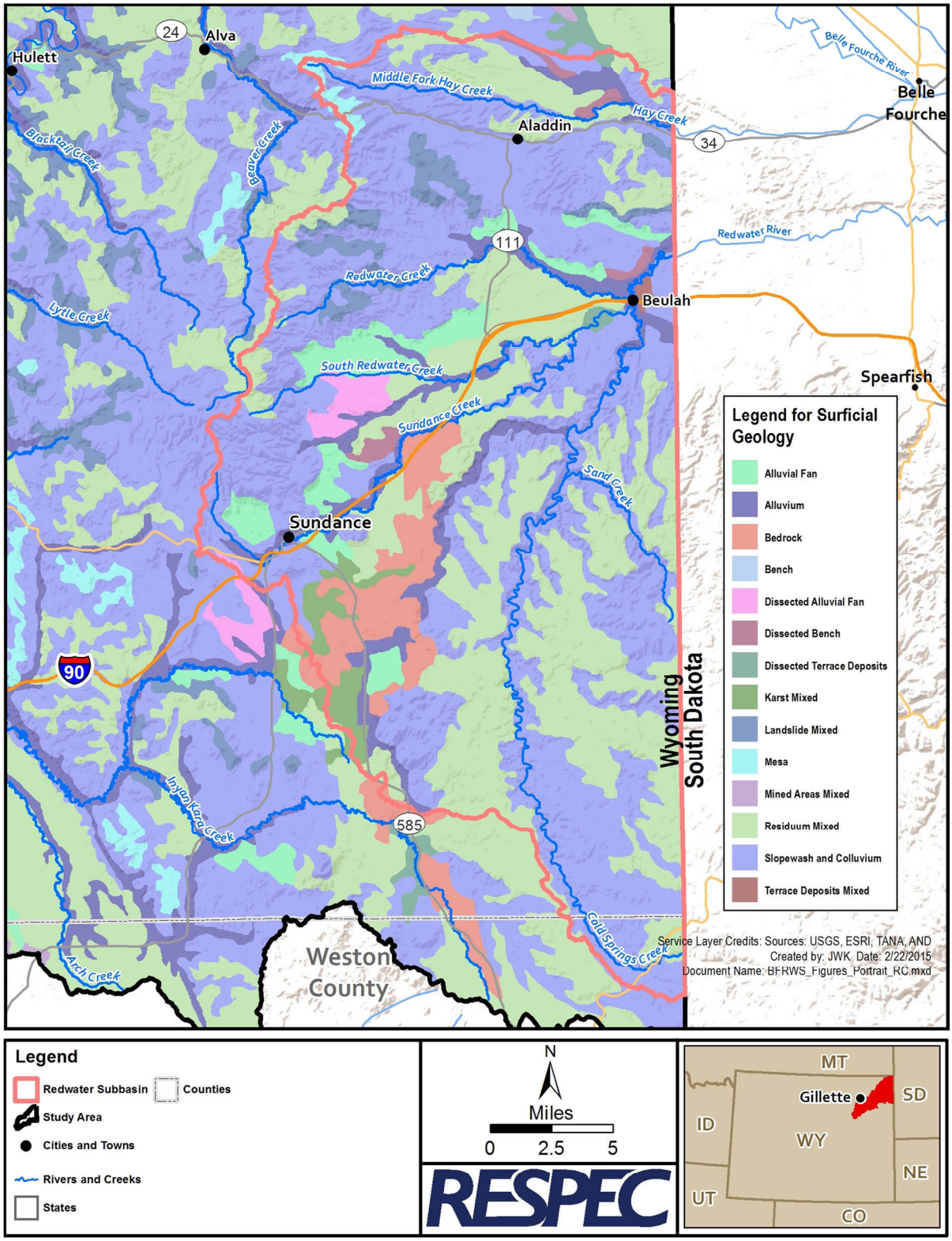


Figure 3.16. Surficial Geology of the Subbasin and Study Area.

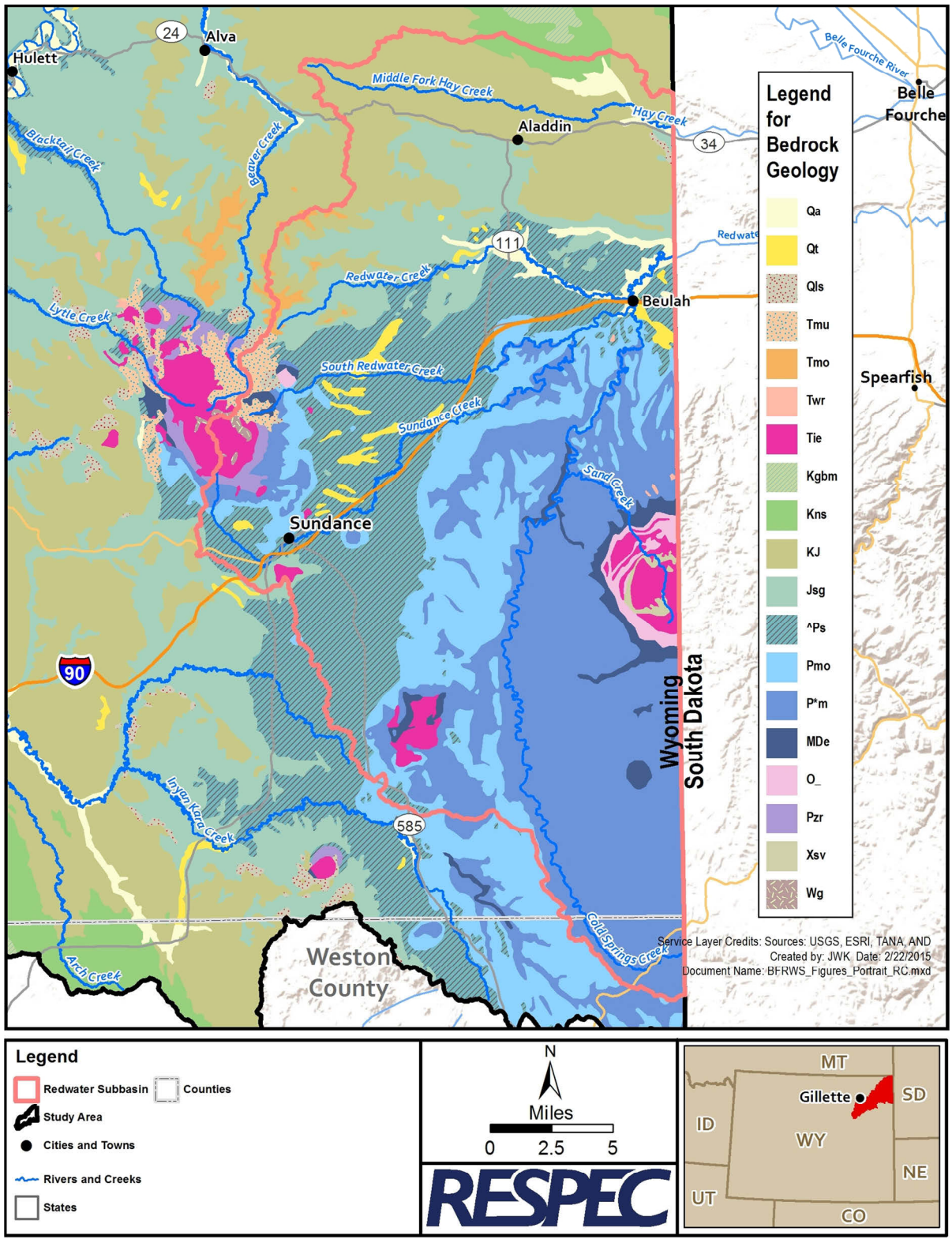


Figure 3.17. Bedrock Geology of the Subbasin and Study Area.

Table 3.14. Bedrock Geologic Units Within the Subbasin

Unit Symbol	Geologic Unit Name	Area (acres)	Percent of Subbasin
P&m	Minnelusa Formation	102,430	30.3
@Ps	Spearfish Formation	71,320	21.1
KJ	Cloverly and Morrison Formations	50,030	14.8
Pmo	Minnekahta Limestone and Opeche Shale	45,630	13.5
Jsg	Sundance and Gypsum Spring Formations	29,750	8.8
Tie	Intrusive and extrusive igneous rocks	8,790	2.6
Qa	Alluvium and colluvium	6,760	2.0
MDe	Pahasapa and Englewood Limestones	6,420	1.9
Qt	Gravel, pediment, and fan deposits	4,390	1.3
O_	Bighorn Dolomite, Gallatin Limestone, and Gros Ventre Formation	3,040	0.9
Kns	Newcastle Sandstone and Skull Creek Shale	2,700	0.8
Tmu	Upper Miocene rocks	2,370	0.7
Tmo	Lower Miocene and Upper Oligocene rocks, or rocks equivalent to Upper and Lower Miocene rocks and White River Formation	1,350	0.4
Pzr	Madison Limestone, Darby Formation, Bighorn Dolomite, Gallatin Limestone, Gros Ventre Formation, Flathead Sandstone	1,350	0.4
Xsv	Metasedimentary and Metavolcanic Rocks	1,010	0.3
Qls	Landslide deposits	680	0.2
Total		**338,020**	**100.0**

3.3 HYDROLOGY

3.3.1 Groundwater

Groundwater availability within the subbasin is variable because of the diverse aquifer characteristics and hydrogeological properties. Depending on the specific area, groundwater can occurs at various depths; areas near streams and along alluvial valleys have shallower groundwater with depths of 25 feet or less. Other locations in the subbasin have deep groundwater aquifers with depths of more than 1,000 feet below the ground surface. Groundwater information and water well databases were obtained from the SEO. Groundwater

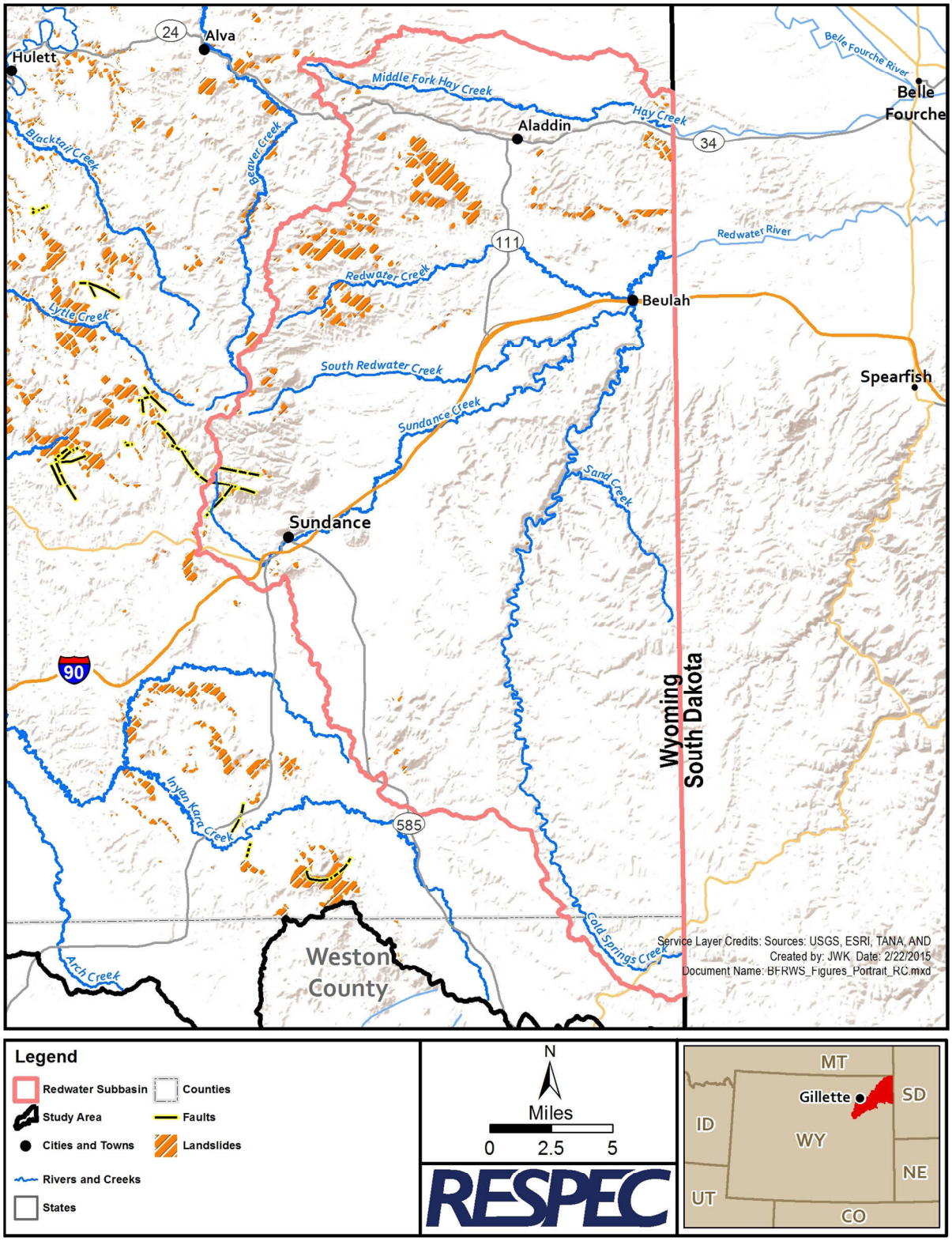


Figure 3.18. Hazardous Geologic Features Within the Subbasin and Surrounding Area.

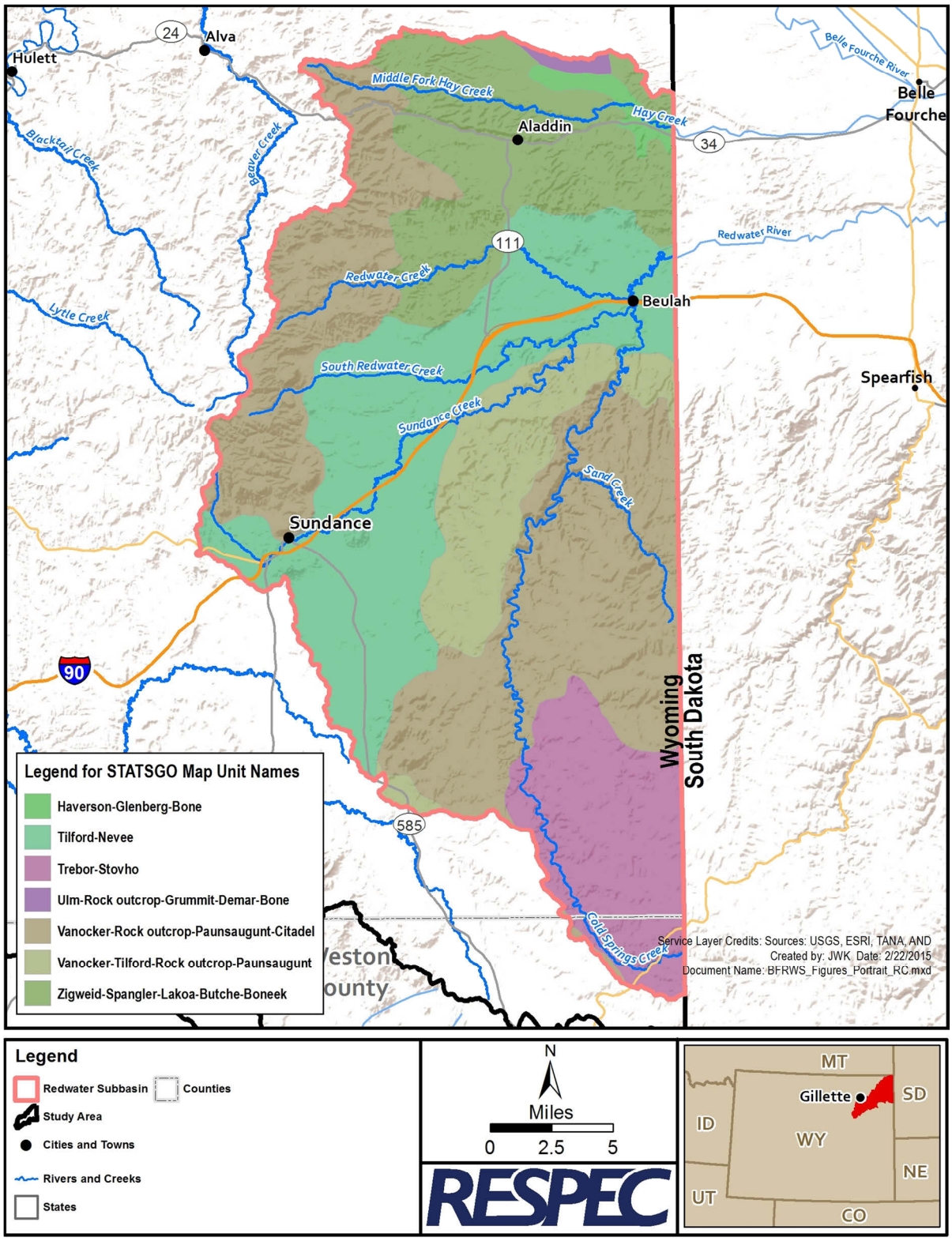


Figure 3.19. 1:250,000 Scale Soils Map of the Subbasin.

is locally important for livestock/wildlife water, private domestic wells, and municipal water. Approximately 957 wells are on file with the SEO within the subbasin including 572 stock wells, 253 domestic wells, 10 irrigation wells, and 4 municipal water wells. Figure 3.20 shows the SEO water wells within the subbasin. Many small springs and seeps exist in the subbasin and location data of springs from mapped by USGS and BLM are displayed in Figure 3.21.

Table 3.15. Summary of Hydric Soil Map Units Within the Subbasin

Map Unit Name	Area (acres)	Percent of Subbasin
Higgins silt loam, 0 to 3 percent slopes	1,514	0.44
Cordeston silt loam, cool, 0 to 6 percent slopes	886	0.26
Higgins, poorly drained-Higgins silt loams, 0 to 3 percent slopes	96	0.03
Colombo loam, occasionally flooded, 0 to 3 percent slopes	55	0.02
Total	**2,551**	**0.75**

3.3.2 Surface Water

The subbasin encompasses the Wyoming portion of the Redwater Creek drainage and includes streams that drain portions of Wyoming but do not converge with Redwater Creek within Wyoming as shown in Figure 3.21. The subbasin covers approximately 528 square miles or 338,020 acres. Redwater Creek and its tributaries, Cold Springs Creek, Hoe Creek, Sand Creek, and Sundance Creek occur in the subbasin. Hay Creek also in within the subbasin but drains into the Belle Fourche River in South Dakota. This subbasin includes the Wyoming portion of the eighth order HUC 10120203. Table 3.16 lists the 3 watersheds (HUC-10) and the 13 subwatersheds (HUC-12) within the subbasin.

Five USGS gaging stations are located in the subbasin and are listed in Table 3.17 and shown in Figure 3.22. Four active USGS gages are located in the subbasin and their discharge data are listed in Table 3.18. In addition to the USGS gages, a temporary gage was installed to obtain streamflow on Redwater Creek and is listed in Table 3.19 and also shown in Figure 3.22. A discussion of the temporary gages can be found in the basin wide summary report. Table 3.20 lists the discharge statistics and yield estimates for the temporary gage on Redwater Creek.

The Redwater Creek gage was installed on April 19, 2013. Three high flow spikes occurred in May and June with the highest peak of 135.7 cfs occurring on June 1. Average flow for the period was 4.8 cfs. The 2014 hydrograph reflects more effects from spring snowmelt and precipitation runoff than the site did in 2013 although the 2014 peak flow was lower at 84.6 cfs occurring on June 25. The average flow in 2014 was 7.9 cfs. Hydrographs from the 2013 and 2014 monitoring periods are displayed in Figure 3.23. The Redwater Creek gaging station has the second largest drainage area at 55 square miles. The gage showed watershed yields of 2,372 acre-feet in 2013 and 3,229 acre-feet in 2014. This resulted in respective mean yields of 42.9 ac-ft/mi^2 and 58.4 ac-ft/mi^2.

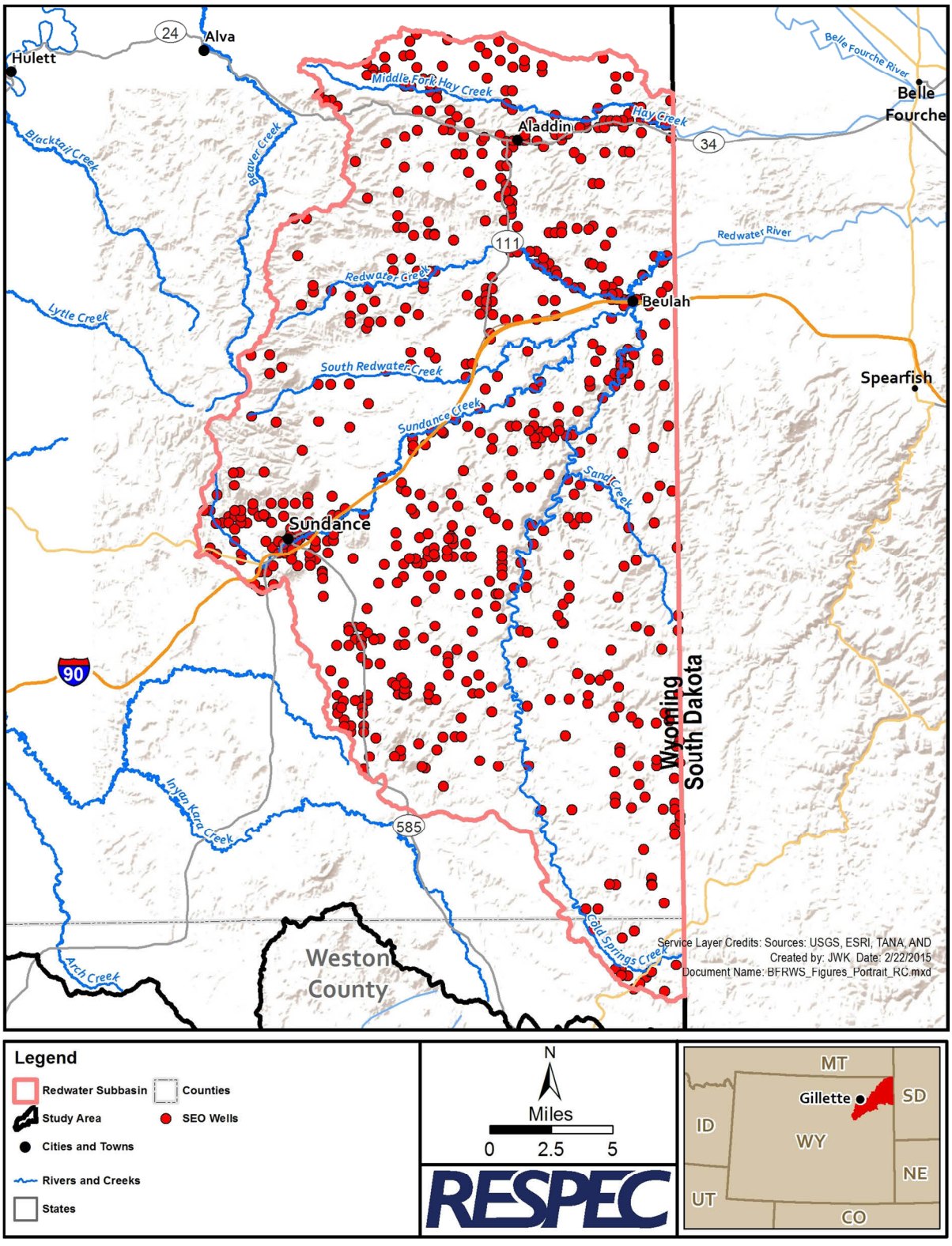


Figure 3.20. Permitted Water Wells Located Within the Subbasin.

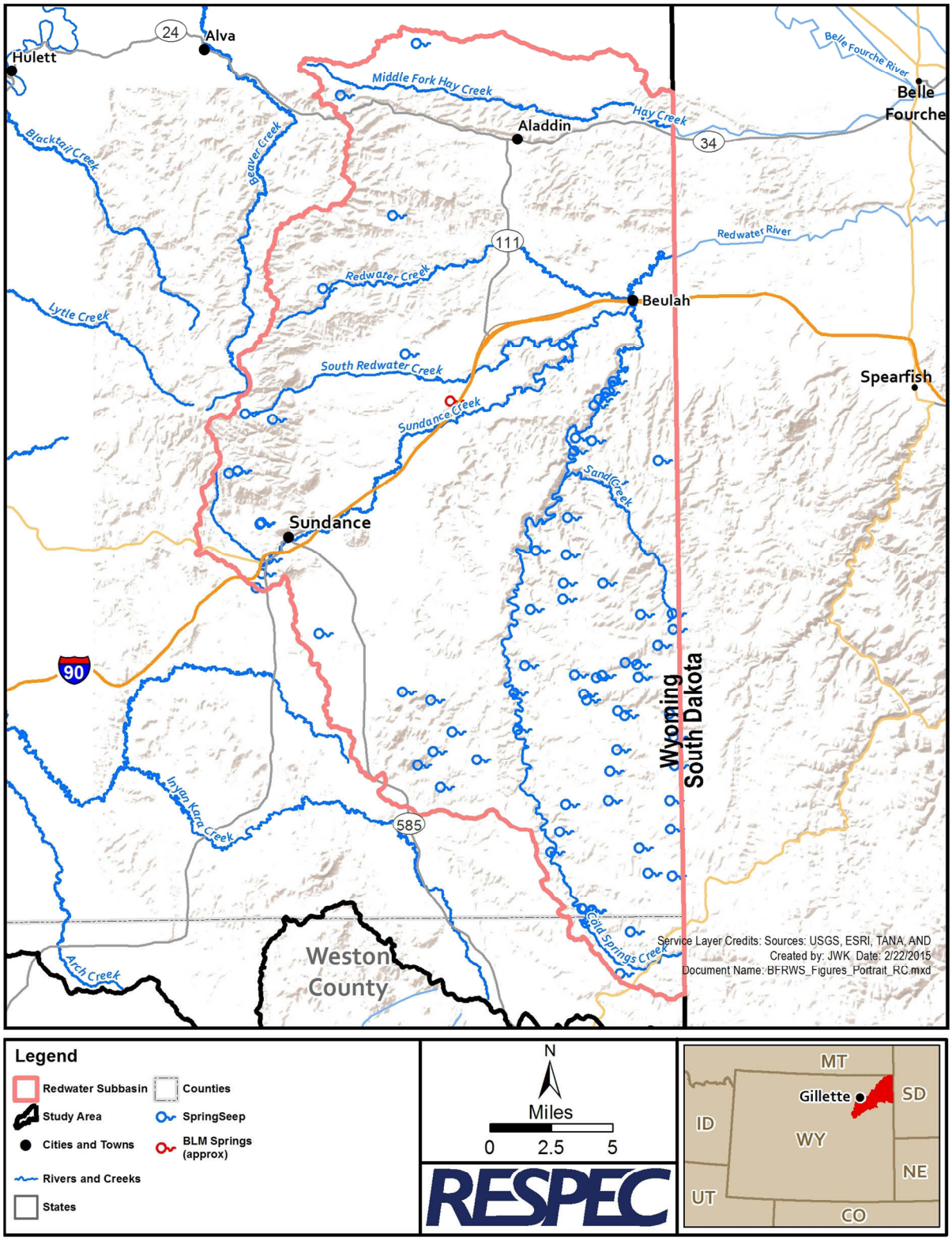


Figure 3.21. Springs Located Within the Subbasin.

Table 3.16. Hydrologic Unit Codes Within the Redwater Subbasin

HUC 2	HUC 4	HUC 6	HUC 8	HUC 10		HUC 12		Area (sq. mi.)
				Number	Name	Number	Name	
Region 10: Missouri	Subregion 1012: Cheyenne	Accounting Unit 101202: Belle Fourche	Cataloging Unit 10120203: Redwater	1012020301	Upper Redwater Creek	101202030101	North Redwater Creek-Redwater Creek	58.3
						101202030102	South Redwater Creek	65.8
						101202030103	Sundance Creek	49.6
						101202030104	Lower Redwater Creek	49.0
						101202030105	Crow Creek-Redwater Creek	40.8
				1012020302	Sand Creek	101202030201	Cold Springs Creek	70.3
						101202030202	Grand Canyon	51.8
						101202030203	Sand Creek	70.0
						101202030204	Red Canyon Creek	83.0
						101202030205	Bear Gulch	25.0
				1012020304	Lower Redwater Creek	101202030405	North Fork Hay Creek	38.7
						101202030406	South Fork Hay Creek	30.8
						101202030407	Hay Creek	53.7

Table 3.17. Summary of U.S. Geological Survey Gaging Stations Within the Redwater Subbasin

USGS Station Number	Station Name	Period of Record	Drainage Area (sq. mi.)	Latitude	Longitude	Gage Elevation (ft, NGVD29)
06429500	Cold Springs Creek At Buckhorn, WY	10/01/1974–Current	22	44°09'14"	104°04'39"	6,090
06429905	Sand Creek Near Ranch A, Near Beulah, WY	08/16/1976–Current	275	44°31'13"	104°05'00"	3,570
06429997	Murray Ditch Ab Headgate At WY-SD State Line	04/23/1987–Current	NA	44°34'35"	104°03'20"	3,440
06430000	Murray Ditch At WY-SD State Line	06/01/1954–04/22/1987	NA	44°34'49"	104°03'13"	3,452
06430500	Redwater Cr At WY-SD State Line	05/01/1929–Current	481	44°34'19"	104°03'11"	3,410

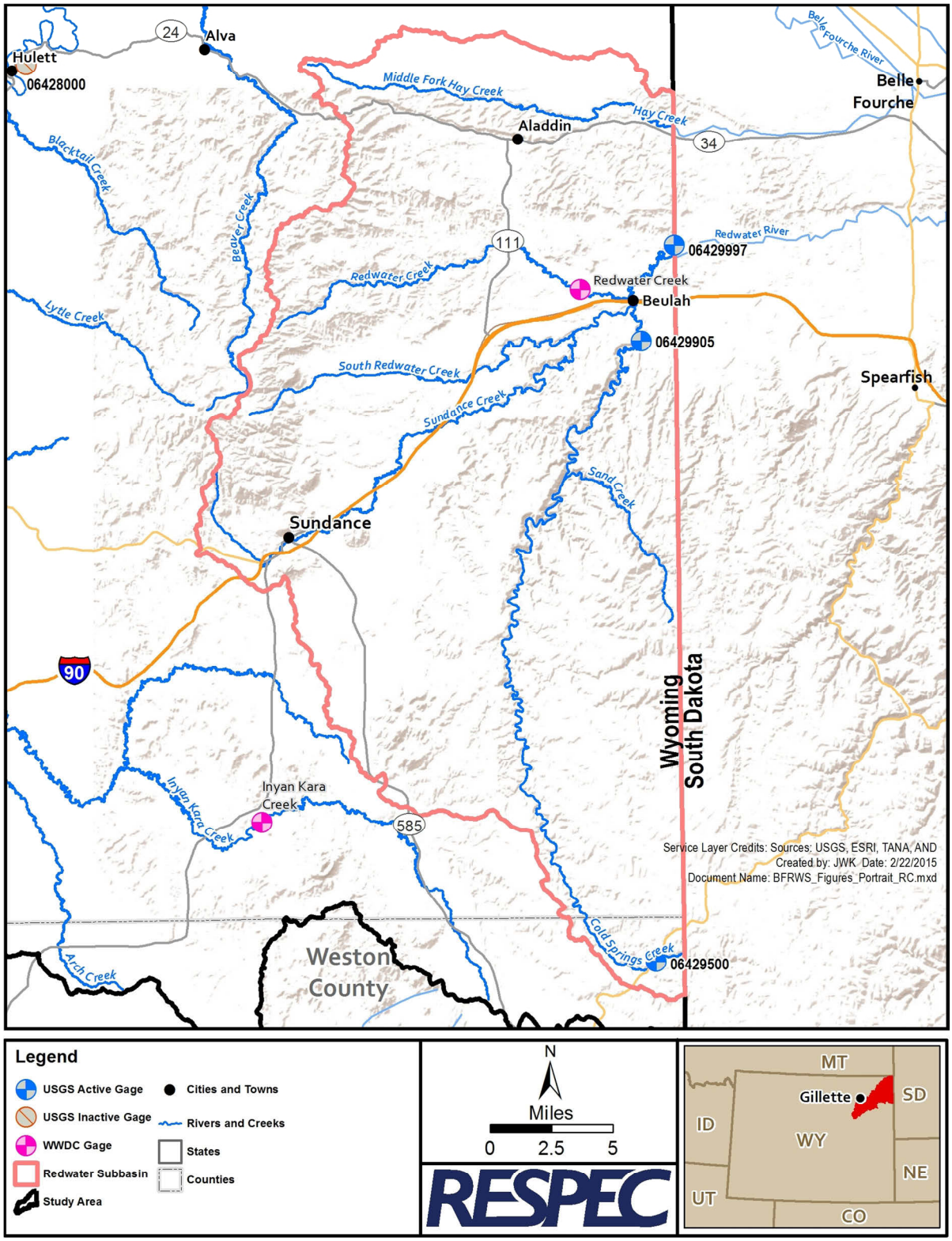


Figure 3.22. U.S. Geological Survey Gages and Wyoming Water Development Commission Temporary Gage Stations Within the Subbasin and Study Area.

Table 3.18. Historical Monthly Mean Discharge Rates for U.S. Geological Survey Gaging Stations Within the Subbasin

USGS Station Number	Period of Record	Historical Monthly Mean Discharge (cfs)											
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
06429500	Cold Springs Creek at Buckhorn, WY	4.2	4.3	4.6	4.9	4.7	4.8	4.6	4.7	4.6	4.4	4.3	4.2
06429905	Sand Creek Near Ranch A, Near Beulah, WY	20.3	19.8	20.4	21.6	30.2	29.4	25.8	23.6	22.3	21.9	22.0	21.3
06429997	Murray Ditch Above Headgate at WY-SD State Line	0.0	0.0	0.0	0.7	2.4	5.0	10.4	8.9	7.5	5.4	0.4	0.0
06430000	Murray Ditch at WY-SD State Line	0.0	0.0	0.0	0.2	2.0	4.0	10.3	11.0	7.7	5.1	1.2	0.0
06430500	Redwater Creek at WY-SD State Line	33.4	34.4	36.2	39.6	56.3	50.2	26.6	25.1	27.5	30.8	34.8	34.3

Table 3.19. Wyoming Water Development Commission Temporary Stream Gage Within the Subbasin

Gage Name and Identifier	General Location	Drainage Area (acres)	Latitude/ Longitude	Elevation (ft)
Redwater Creek (RC)	Located approximately 0.5 mile south off of Crook County Road 115, roughly 2.5 miles along County Road 115 northwest of the junction of Old Highway 14 and County Road 115.	35,390	44.550809 –104.133888	3,582

Table 3.20. Summary of Temporary Stream Gage Hydrology

Stream Gage	Redwater Creek
Drainage Area (mi^2)	55
2013	
Start Date	04/19/13
End Date	12/22/13
Average Flow (cfs)	4.8
Median Flow (cfs)	2.7
Total Yield (ac-ft)	2,372
Mean Yield (ac-ft/ mi^2)	42.9
Peak Flow (cfs)	135.7
Date of Peak	06/01/13
Minimum Flow (cfs)	0.0
2014	
Start Date	04/18/14
End Date	11/9/14
Average Flow (cfs)	7.9
Median Flow (cfs)	4.8
Total Yield (ac-ft)	3,229
Mean Yield (ac-ft/ mi^2)	58.4
Peak Flow (cfs)	84.6
Date of Peak	06/25/14
Min. Flow (cfs)	2.7

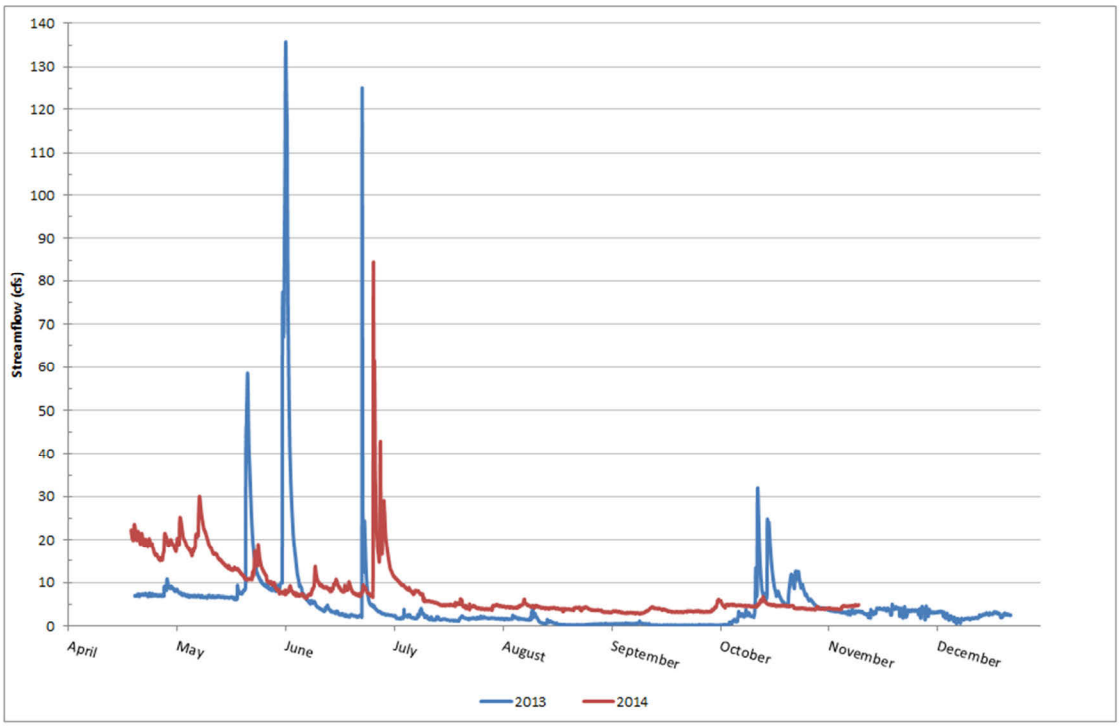


Figure 3.23. Hydrographs at Redwater Creek for the 2013 and 2014 Gaging Periods.

3.4 STREAM GEOMORPHOLOGY

3.4.1 Rosgen Level I Classification

In the basin wide summary report, an extensive discussion regarding the stream geomorphology within the subbasin and the subbasin is included to explain the Level I geomorphic classification methods, applicable classification systems, and Level II field stream assessments performed for this study. Within the subbasin, a Level I evaluation of Redwater Creek and its major tributaries and a limited Level II characterization were conducted on a selected reach of Redwater Creek. Based upon the GIS effort followed by field verification, it was concluded that the some of the channels in the subbasin are entrenched to some degree.

Entrenchment occurs for a variety of reasons including presence of erosive soils coupled with land use practices including road construction, energy development, grazing, etc. Observations of channel conditions revealed entrenchment ranging from slight to severe. In the case of many streams in the subbasin, channels appear to have stabilized or be in the process of stabilizing following episodes of incision. Figure 3.24 displays an entrenched reach of Redwater Creek. Results of the Level I classification effort are presented in Table 3.21 and graphically in Figure 3.25. This figure displays the subbasin's stream types resulting from the classification effort.

Figure 3.24. Entrenched Reach of Redwater Creek.

Table 3.21. Summary of Rosgen Level I Classification Results in the Subbasin

Name	Reach Number	Station (Distance From Mouth)		Reach Length (ft)	Sinuosity	Slope	Rosgen Type
		Station Start (ft)	Station End (ft)				
Cold Springs Creek	1	0	112,733	112,733	1.67	0.01	C
	2	112,733	196,189	83,456	1.31	0.01	B
Redwater Creek	1	0	89,880	89,880	2.04	0.003	C/F
	2	89,880	170,335	80,455	1.41	0.021	C/F
Sand Creek	1	0	88,840	88,840	1.81	0.008	B
	2	88,840	142,025	53,185	1.19	0.038	A

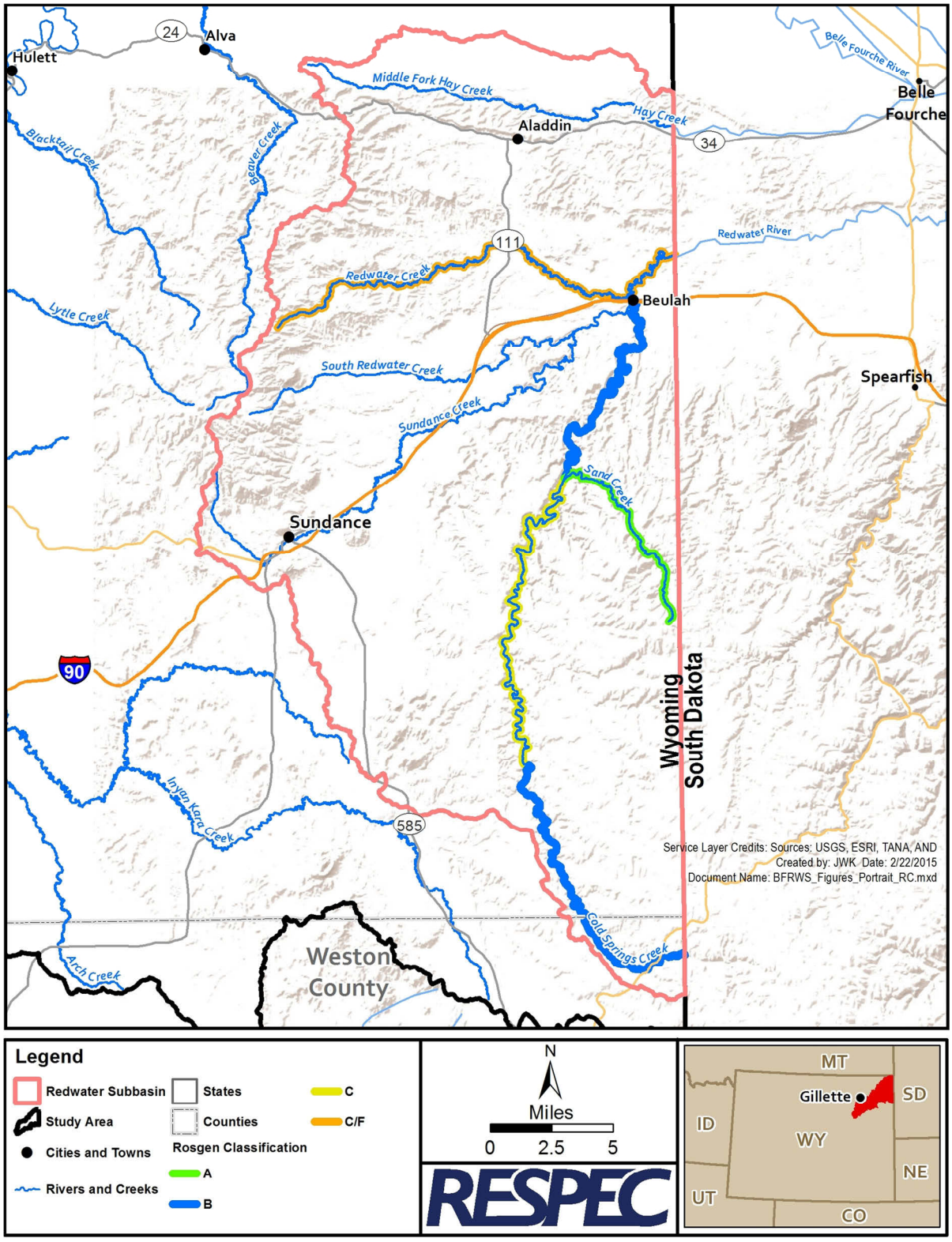


Figure 3.25. Rosgen Classification Stream Types Within the Subbasin.

3.4.2 Field Stream Assessment

A field stream channel assessment was conducted at a site selected on a reach of Redwater Creek within the subbasin located in Section 26, Township 53 North, Range 61 West, Crook County. The purpose of the field assessment was to obtain more detailed morphological description of the system by obtaining field data pertaining to channel entrenchment, dimensions, patterns, profile, and boundary materials. A detailed explanation about the Level II field stream assessments are included in the basin wide summary report. Field assessment data, Rosgen Level II parameters and stream types, and the Channel Evolution Model (CEM) channel types are summarized in Table 3.22 for cross sections located along the reach at the selected site on Redwater Creek.

Table 3.22. Geomorphic Parameters at a Selected Site on Redwater Creek

Parameter	Redwater Creek		
Cross Section	1	2	3
Bankfull Depth (ft)	3.10	3.26	3.17
Bankfull Width (ft)	8.0	6.0	9.7
Width/Depth Ratio	2.58	1.84	3.06
Floodprone Depth (ft)	6.20	6.50	6.30
Floodprone Width (ft)	31.0	23.0	15.0
Entrenchment Ratio	12.0	3.8	1.6
Slope	0.0007	0.0250	0.0038
Sinuosity	2.40	1.96	2.24
Rosgen Stream Type	C5c/F	E5b/F	C5c/F
Schumm CEM Type	IV to V	IV to V	IV to V

Redwater Creek (RC)

The selected reach on Redwater Creek shows conditions that the channel is obviously entrenched; there is currently little, if any, connection between the channel and the floodplain. Few indicators of active channel degradation were noted, however, indicating that the incision may have ceased and the channel is currently “healing”. Entrenched floodplains were noted in several locations indicating the channel is recovering from historic incision by forming stable geomorphic features within its current entrenched cross section.

The presence of mature boxelder trees on these features indicates that the current conditions have been vertically stable for a number of years as shown in Figure 3.26. For the most part, banks are well vegetated and appear stable with some localized bank erosion evident indicating that banks exceed critical bank height and are failing as the channel adjusts to historic incision by widening. Figure 3.27 displays a location on Redwater Creek where this process is evident.

RSI-2264-14-063

Figure 3.26. Mature Boxelder Trees Established on Entrenched Floodplain of Redwater Creek.

RSI-2264-14-063

Figure 3.27. Evidence of Channel Widening of Redwater Creek.

Three cross sections were surveyed and channel conditions evaluated to categorize the stream within the Rosgen classification. Cross section locations were selected to characterize the typical conditions encountered during the field evaluation. Based strictly upon the values in Table 3.22, Redwater Creek would likely be classified as a C5c or E5b-type channel.

As discussed within the basin wide summary report, E-type channels possess low width/depth ratios, are highly sinuous and are only slightly entrenched. C-type channels possess higher width/depth ratios and are 'connected' to their floodplains. Based on field observations, Redwater Creek is also clearly entrenched and isolated from its floodplain. The low entrenchment ratios measured at the surveyed cross sections are artifacts of the presence of an entrenched floodplain forming as the channel stabilizes following historic incision.

Based on observations of geomorphic processes occurring within the study reach; the classification has been amended with an F-type. Figure 3.28 is a photograph of the channel which clearly indicates the channel is considerably entrenched within its historic floodplain. Comparison of Redwater Creek and the ambient and the geomorphic processes observed for the CEM types, it appears that the channel is likely in the Type IV to V stages where active incision and degradation have subsided and channel widening has been initiated. Formation of an entrenched and vegetated floodplain indicates vertically stable conditions. Evidence of channel widening (bank erosion) exists as would be expected in the CEM Type IV channel.

RSI-2264-14-063

Figure 3.28. Entrenched Conditions of Redwater Creek.

3.5 WATER QUALITY

The Water Quality Division of the WDEQ has classified waterbodies in the state of Wyoming and these classifications are included in the basin wide summary report. No Wyoming Pollution Discharge Elimination System (WYPDES) point source discharge permits or permitted Municipal Separate Storm Sewer Systems (MS4s) are found within the subbasin. Additionally, no waterbodies are listed as impaired in the state of Wyoming's 2012 Integrated Report within the subbasin and no Total Maximum Daily Load (TMDL) assessments are required for waterbodies in the subbasin [Wyoming Department of Environmental Quality, 2012].

3.6 WATER STORAGE

Water storage development within the watershed has been impacted by the Belle Fourche River Compact of 1943, which divides the water in northeast Wyoming between Wyoming and South Dakota. The compact recognizes all rights in Wyoming existing as of the date of the compact, and permits Wyoming unlimited use for stock water reservoirs not exceeding 20 acre-feet in capacity. Wyoming is allowed to use 10 percent of the available flow of the Belle Fourche River in excess of the amount that is needed to supply the water rights in existence at the date of the contract. No reservoir constructed subsequent to the date of the compact solely to use the water allocated to Wyoming shall have a capacity greater than 1,000 acre-feet.

Water storage within the subbasin has been the subject of past studies and are summarized in Section 3.9.3 of the basin wide summary report. Because of the constraints related to the compact, the investigation of water storage focused on existing stock ponds and potential sites with less than 20 acre-feet. Additional storage reservoirs or enlargements to existing reservoirs may be limited by constraints identified above, however, improvements to fully realize and sustain the capacity of the existing reservoirs are not limited by these constraints. Although, no large potential sites were identified by landowners within the subbasin, problems with existing reservoirs that limited storage capacity were identified and initial field reviews were conducted to determine necessary improvements, which are included in the Chapter 4.0.

3.6.1 Major and Minor Reservoirs

The Wyoming SEO developed a list of major reservoirs within the Northeast Wyoming Basin. To qualify, a reservoir must have storage capabilities of 1,000 acre-feet or more and also serve multiple users. Two major reservoirs, Keyhole Reservoir and Gillette Lake, are located within the study area but neither are located within the subbasin and are discussed in the basin wide summary report.

Over 90 stock pond and reservoir permits within the subbasin have been filed with the SEO. Permit age ranges from the year 1906 to 1998. The permitted minor reservoirs within the

subbasin have a combined potential storage of 655 acre-feet. The majority of the ponds are small with only four having storage volumes greater than 20 acre-feet with the largest holding 210 acre-feet. Figure 3.29 shows the locations of the permitted ponds and reservoirs in the subbasin.

Although it is understood that additional large water storage reservoirs or enlargements to the existing storage reservoirs may be limited by the institutional constraints laid out in the Belle Fourche River Compact, improvements to fully realize and sustain the capacity of the existing reservoirs are not limited by these constraints.

3.6.2 Previously Proposed Water Storage Development

Several previous studies on potential reservoir development have been completed throughout the years within the study area. The WWDC has compiled a list of proposed reservoirs from these studies, which is included in the basin wide summary report. The only reservoir and dam project previously studied within the subbasin is the Redwater Creek Site – Alternative 5, which was reported in the *Crook County Reservoirs and Water Management Level I Study* [Short Elliott Hendrickson Inc., 2006]. Table 3.23 includes information about that proposed site on Redwater Creek and is shown in Figure 3.30.

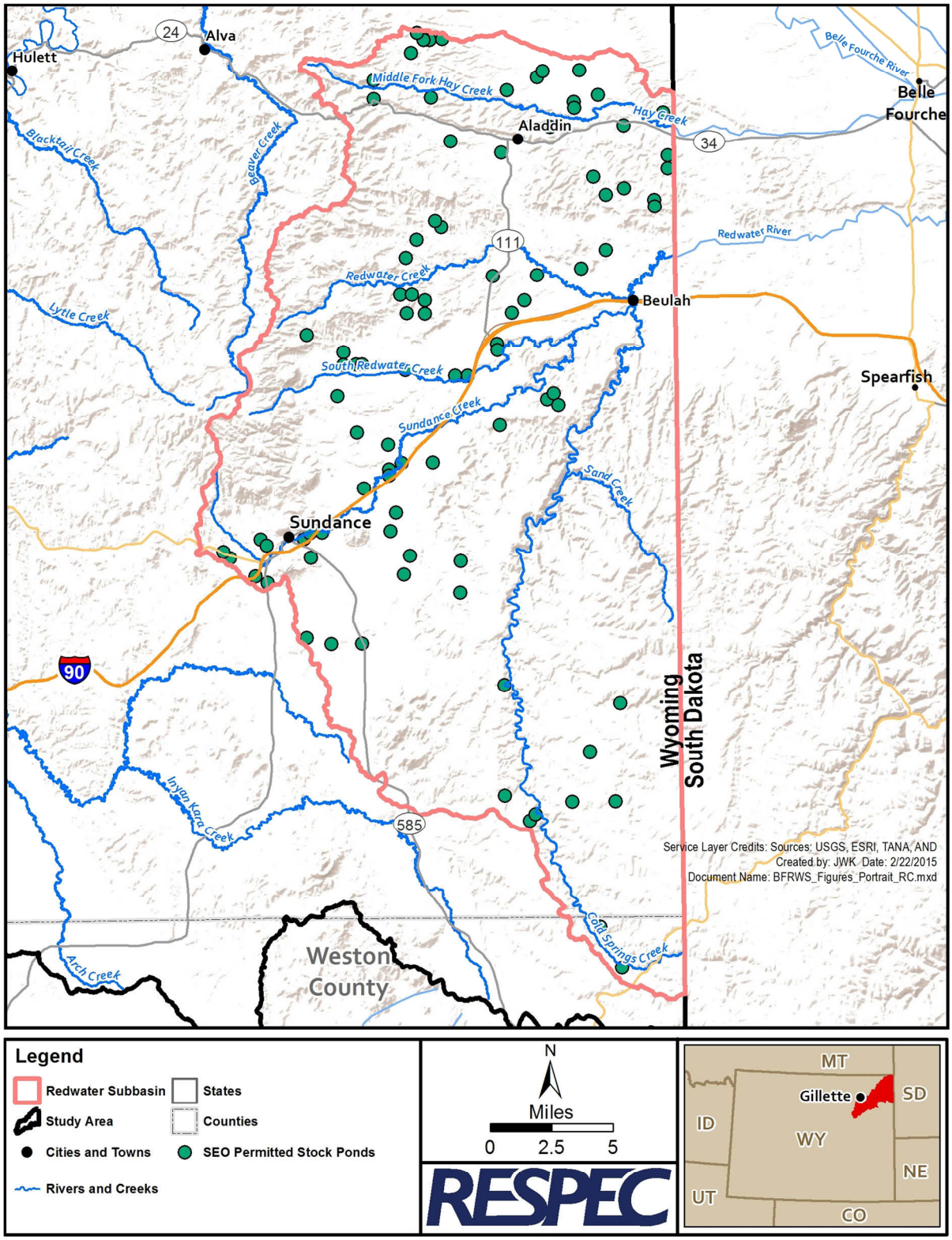


Figure 3.29. Wyoming State Engineer's Office Permitted Stock Ponds and Reservoirs Within the Subbasin.

Table 3.23. Previously Proposed Reservoirs Within the Subbasin

Project Name/Water Source	Approximate Location	Estimated Storage (ac-ft)	Water Use	Estimated Cost ($)
Crook County Reservoirs and Water Management Study Level 1, **[Short Elliot Hendrickson, Inc., 2006] prepared for the Wyoming Water Development Commission, located at the Wyoming Water District Office and State Library**				
Redwater Creek Alternative 5	Sec 21, T53N, R60W, Crook County	16,800	A,R	31,800,000

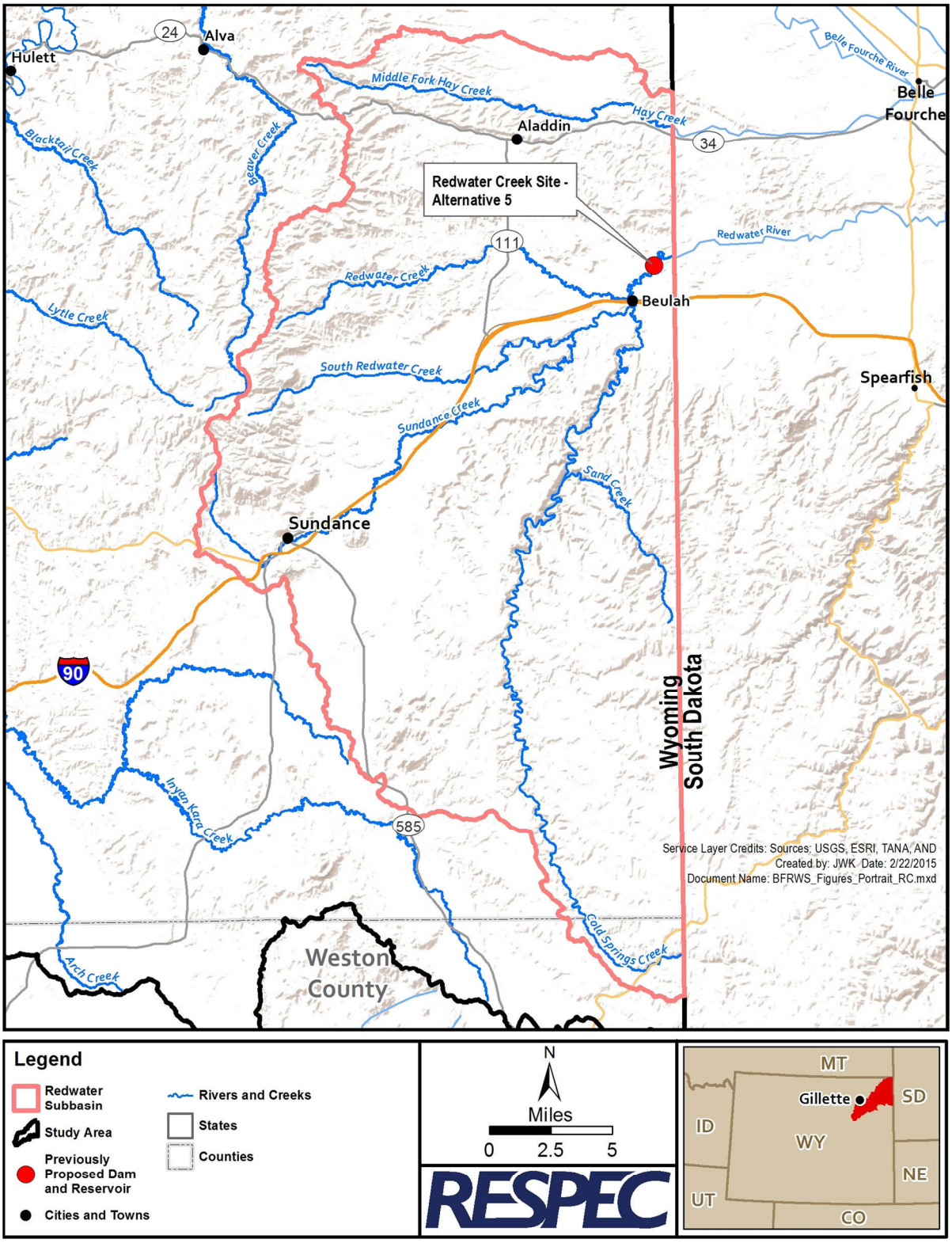


Figure 3.30. Previously Proposed Reservoir and Dam Project Locations Within the Subbasin.

4.0 REDWATER SUBBASIN WATERSHED MANAGEMENT AND REHABILITATION PLAN

4.1 OVERVIEW

The objective of this Level I study is to generate a Watershed Management and Rehabilitation Plan that is technically sound, practical in nature, and economically feasible This chapter includes the individual proposed projects within the Redwater Subbasin Watershed Management and Rehabilitation Plan. These potential improvements were developed to address those issues described in Chapter 3.0 and are categorized into the following:

- **Irrigation System Conservation and Rehabilitation.** The inventory of the existing infrastructure was completed and improvements identified for the rehabilitation of existing structures and the potential conservation of existing irrigation diversions.
- **Livestock/Wildlife Upland Watering Opportunities.** Based on an evaluation of existing water sources and the condition of upland grazing resources, potential upland water source development projects were identified.
- **Grazing Management Opportunities.** Based on a review of the pertinent ESDs and the vegetation and soil conditions, grazing management strategies are presented.
- **Surface Water Storage Opportunities.** Results of previous investigations pertaining to development of water storage opportunities within the watershed are incorporated.

Individual conceptual plans developed for each project component to improve the existing water supply through conservation are included in this chapter. For the purposes of tracking individual components of the watershed management plan, each component was designated a unique project or "improvement" number. The prefixes used for each improvement describe the category of the watershed management plan it falls under. The prefixes are as follows:

- Project Components "I": Irrigation system rehabilitation components (Section 4.4)
- Project Components "LW": Livestock/wildlife upland watering opportunities (Section 4.5)
- Project Components "G": Grazing management opportunities (Section 4.6)
- Project Components "S": Surface water storage opportunities (Section 4.7)

The proposed projects and components in this chapter are commonly referred to as best management practices (BMPs) or conservation practices, which include stock ponds, water wells, buried water delivery pipelines, stock tanks, spring developments, solar platforms and pumps, wetland enhancement and restoration, windmills, and irrigation diversion and conveyance improvements. There can be one or more benefits and effects related to the implementation of these BMPs and conservation practices and are discussed in detail within the basin wide summary report.

4.2 IRRIGATION SYSTEM RECOMMENDATIONS

This plan and its alternatives provide the irrigators and landowners with an assessment of conditions associated with the irrigation delivery infrastructure and associated hydraulic structures. The landowner or manager could use the alternatives in this plan as a starting point from which they could select projects for further design and for potential funding assistance from the WWDC Small Water Project Program (SWPP), the NRCS Environmental Quality Incentives Program (EQIP), or other participating conservation or watershed programs.

Irrigation system inventory efforts associated with this project consisted of evaluating structures, ditch conditions, and water storage structures at the request of interested landowners and stakeholders. At the request of those individuals who requested to participate in the study, irrigation system components were inventoried. In an effort to assist the irrigator and the CCNRD in prioritizing potential improvements, priorities were defined as follows:

- **Priority 1:** Install, replace, or rehabilitate aging infrastructure critical to the diversion and delivery of water.
- **Priority 2:** Install, replace, or rehabilitate aging infrastructure critical to the operation, measurement, and management of the irrigation diversions.
- **Priority 3:** Install, replace, or rehabilitate aging infrastructure to provide improvements in efficiency and conservation on farms.

The information in this plan provides the landowners with an assessment of the conditions associated with the structures that were inventoried during the fieldwork. The following improvements were identified after the field investigation and assessment of the data collection efforts. In Sections 4.2.1 through 4.2.3, the individual structures inventoried and assessed are discussed. Each irrigation system improvement was assigned a unique identifier within the watershed plan. The structures inventoried and their respective component identifiers in the watershed management plan are summarized in Table 4.1. This information has been incorporated in the study's GIS. Figure 4.1 through Figure 4.4 illustrate the typical conditions of the inventoried irrigation diversion and headgate structures within the subbasin.

4.2.1 Irrigation Component I-01: North Redwater Irrigation Pipeline Project

Rehabilitation of the diversion structure and headgate is needed on the North Redwater Creek. This project involves the following components:

- **Item No. I-01.1:** Rehabilitate diversion structure/headgate on North Redwater Creek
- **Item No. I-01.2:** Install irrigation regulating reservoir
- **Item No. I-01.3:** Install 3,520 feet of 12-inch plastic irrigation pipe (PIP) pipeline
- **Item No. I-01.4:** Install approximately 2,090 feet of 12-inch PIP pipeline.

Table 4.1. Summary of Recommended Irrigation System Improvements

Item Number	Description	Priority
I-01	• Rehabilitate diversion structure and headgate on North Redwater Creek • Install irrigation regulating reservoir. • Rehabilitate approximately 5,610 feet of 12-inch PIP pipeline and flume.	1
I-02	• Rehabilitate diversion structure and headgate. • Rehabilitate approximately 2,620 feet of 12-inch PIP pipeline and flume.	1
I-04A I-04	• Rehabilitate irrigation reservoir and dam • Install diversion structure and headgate • Install approximately 5,890 feet of 12-inch PIP pipeline • Install irrigation regulating reservoir • Install diversion structure and headgate • Install approximately 6,740 feet of 12-inch PIP pipeline	3

4.2.2 Irrigation Component I-02: South Redwater Irrigation Pipeline Project

Rehabilitation of the diversion structure/headgate is needed on South Redwater Creek to supply water to Irrigation Component I-01. This project involves the following components:

- **Item No. I-02.1:** Rehabilitate structure/headgate on South Redwater Creek
- **Item No. I-02.2**: Install approximately 2,620 feet of 12-inch PIP pipeline.

4.2.3 Irrigation Component I-04 and I-04A: Helmer Reservoir Irrigation Pipeline Project

Installation or rehabilitation of a diversion structure is needed. This project involves the following components:

- **Item No. I-04.1:** Install diversion structure and headgate
- **Item No. I-04.2:** Install irrigation regulating reservoir
- **Item No. I-04.3:** Install approximately 6,740 feet of 12-inch PIP pipeline
- **Item No. I-04A.1:** Install diversion structure and headgate
- **Item No. I-04A.2:** Rehabilitate irrigation reservoir and dam
- **Item No. I-04A.3:** Install 5,890 feet of 12-inch PIP pipeline.

RSI-2264-14-063

Figure 4.1. Diversion/Headgate Structure on North Redwater Creek.

RSI-2264-14-063

Figure 4.2. Diversion/Headgate Structure on South Redwater Creek.

RSI-2264-14-063

Figure 4.3. Diversion Outlet Pipe on Sunset Reservoir (Hemler Dam).

RSI-2264-14-063

Figure 4.4. Diversion Control Diversion Structure on Sunset Reservoir (Hemler Dam).

4.3 LIVESTOCK AND WILDLIFE UPLAND WATERING SOURCES

Participating landowners identified places where existing water sources could be improved and conceptual wildlife and livestock water components and associated facilities were developed and located on parcels, allotments, and pastures. A more detailed discussion about the livestock/wildlife sources and current availability within the study area is included in the basin wide summary report. The following proposed projects are conceptual only and are described in general for this report.

Before installation, it is recommended to determine the actual locations, specifications, alignments, volumes, and lengths of pipelines, tanks, wells, and pumps. It is also recommended to install wildlife ramps in the proposed water tanks, and incorporating all valves, fittings, and appurtenances to manage flows and water levels. Participation in the study was voluntary and a list of interested participants was created after the scoping meetings were held. On-site, field visits were scheduled and conducted with landowners and managers where the study team listened to concerns about water needs of the participants and visited potential project sites.

Participants identified areas that needed water development then conceptual water development projects were mapped and are summarized in Section 4.3.1 through Section 4.3.10. These project designs are conceptual only and, if initiated, would require additional design work before installation. The proposed projects and components in the watershed management plan are summarized in Table 4.2. The general locations of all of the proposed livestock/wildlife water projects are included in Chapter 4.0 of the basin wide summary report.

Because federal and state lands cover approximately 34 percent of the subbasin and are intermingled with private lands, some of the water development projects could involve coordination with the BLM, USFS, and Wyoming Office of State Lands and Investments (OSLI) before initiating construction. Additionally, some projects could involve multiple landowners because of the locations of wells and routes for pipelines. For these projects spanning multiple owners, written agreements would be necessary to outline the responsibilities and liabilities of the parties involved with each individual project. Moreover, environmental evaluations would be required for any potential effects identified for a specific project or project component, especially on federal and state lands. Therefore, coordination is necessary with BLM and USFS before implementing any project on federal land and coordination with OSLI is required before constructing any improvements on state land.

Ten upland livestock/wildlife water development plan components are described in Section 4.3.1 through Section 4.3.10 summarizing well construction, stock pond rehabilitation, and pipeline installation components. Future upland livestock/wildlife water projects are eligible for application funding through the WWDC's SWPP because of their geographic location within the study area and subbasin. However, these projects would need additional information and coordination with interested landowners before applications are submitted to the WWDO by any local sponsors.

Table 4.2. Summary of Livestock/Wildlife Upland Water Development Components

Item Number	Plan Component	Priority	Project Name	Description	Solar Pump	Well Construct	Spring Development	Pipeline	Stock Tank	Storage Tank	Stock Pond Rehab-Construct	Fence
6	LW-06	1	Spring/East Bluff	Pipeline and Tank				5,100	2			
7	LW-07	2	Strips/West Bluff	Pipeline and Tank				1,400	1			
8	LW-08	2	East Dry Creek	Well, Pipeline, and Tank		1		400	1			
9	LW-09	3	Vore Draw	Pipeline and Tank				2,700	1			
12	LW-11	1	Eagle Ridge 1	Spring Development, Pipeline, and Tank	1		1	900	2			
13	LW-12	2	Eagle Ridge 2	Spring Development and Tank	1		1	400	1			
14	LW-12A	2	Marr	Stock Reservoir							1	
15	LW-13	3	Porcupine	Stock Reservoir							1	
62	LW-52	3	Upper Sundance	Well, Pipeline, and Tank	1	1		400	1			
63	LW-53	2	East Rupe	Spring Development, Pipeline, Tank			1	800	1		1	

4.3.1 LW-06: Spring/East Bluff Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from an existing well, pump, and storage tank (> 1,800-gallon capacity) to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components would be installed:

- From the existing tank, pipeline, well, pump, and storage tank (> 1,800-gallon capacity), a buried high-density polyethlyene (HDPE) low-pressure pipeline would be installed southeasterly to supply two stock tanks (1,200-gallon capacity each). This pipeline would require installing 5,100 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate management of flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

4.3.2 LW-07: Strips/West Bluff Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from an existing well and pump to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components would be installed:

- From the existing pipeline, well, and pump, a buried HDPE low-pressure pipeline would be installed northerly to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 1,400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate management of flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

4.3.3 LW-08: East Dry Creek Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from an existing well and pump to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components would be installed:

- From the existing pipeline, well, and pump, a buried HDPE low-pressure pipeline would be installed northerly to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate management of flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

4.3.4 LW-09: Vore Draw Pipeline and Tank Project

This alternative would involve extending an existing pipeline supplied from an existing well and pump to supply water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components would be installed:

- From the existing pipeline, well, and pump, a buried HDPE low-pressure pipeline would be installed northwesterly to supply a stock tank (1,200-gallon capacity). This pipeline would require installing 2,700 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate management of flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

4.3.5 LW-11: Eagle Ridge 1 Spring Development and Tank Project

This alternative would involve rehabilitating an existing spring development and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components would be installed:

- The existing spring would be rehabilitated and equipped with collection pipe, spring box, and appurtenances would be installed.
- From the rehabilitated spring, a solar platform consisting of solar panel; solar-powered pump; batteries; and regulators, connections, and appurtenances would be installed to supply water via a buried HDPE low-pressure pipeline to two stock tanks (1,200-gallon capacity each). This pipeline would be aligned northerly and require installing 900 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate management of flow, pressure, and water level.
- Wildlife escape ramps would be installed in all of the proposed stock tanks.

4.3.6 LW-12: Eagle Ridge 2 Spring Development and Tank Project

This alternative would involve rehabilitating an existing spring development and stock pond supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components would be installed:

- The existing spring would be rehabilitated and equipped with collection pipe, spring box, and appurtenances would be installed.
- From the rehabilitated spring, a solar platform consisting of solar panel; solar-powered pump; batteries; and regulators, connections, and appurtenances would be installed to supply water via a buried HDPE low-pressure pipeline to a stock tank (1,200-gallon

capacity). This pipeline would be aligned northerly and require installing 400 linear feet of 2-inch pipeline.

- Required valves, fittings, and appurtenances would be incorporated to facilitate management of flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

4.3.7 LW-12A: Marr Stock Reservoir Rehabilitation Project

In addition to the development of livestock/wildlife water sources described in the *LW-12: Eagle Ridge 2 Spring Development and Tank Project*, this alternative would provide for the rehabilitation of a stock reservoir and associated wetlands. The existing stock reservoir is located on Smith Draw, an intermittent tributary to Sundance Creek, within Section 15 of Township 52 North, Range 61 West in Crook County. Currently, the stock reservoir experiences seepage loss of the impounded water behind the embankment.

This project would include the rehabilitation of the Marr Stock Reservoir (Permit No. P425S). The reservoir has a permitted total capacity of 1.74 acre-feet. This stock reservoir could be rehabilitated to provide an additional source of livestock/wildlife water along with restoring function of the associated wetland and riparian areas. This alternative includes the following features:

- Inspection of the embankment and rehabilitation of problem areas as needed. The embankment is approximately 150 feet long and less than 15 feet high at its highest point. The top-width of the embankment is approximately 10 feet wide.
- Investigation of site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- Installation of an inlet and outlet control mechanism would be used to control reservoir water levels. The installed structures would be stabilized with rock riprap.
- Excavation of the spillway to adequately convey overflow volumes along with stabilization with rock riprap for protection.
- Potential construction options for reducing seepage in small stock ponds and reservoirs include the installation of geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Potential options are detailed in the NRCS Construction Specifications for Pond Sealing or Lining (NRCS WY-521A, WY-521C, or WY-521D).
- Contingent on determination of adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- As proposed, the project involves private lands only.

4.3.8 LW-13: Porcupine Stock Reservoir Rehabilitation Project

This alternative would provide for the rehabilitation of a stock reservoir and associated wetlands. The existing stock reservoir is located on Porcupine Draw, an intermittent tributary to Sundance Creek, within Section 22 of Township 52 North, Range 61 West in Crook County. Currently, the stock reservoir experiences seepage loss of the impounded water behind the embankment. In addition, the structure is at risk of being breached because of the downstream channel headcutting.

This project would include the rehabilitation of the Porcupine Stock Reservoir (Permit No. P3587S). The reservoir has a permitted total capacity of 1.9 acre-feet. This stock reservoir could be rehabilitated to provide an additional source of livestock/wildlife water along with restoring function of the associated wetland and riparian areas. This alternative would include the following features:

- Inspection of the embankment and rehabilitation of problem areas as needed. The embankment is approximately 120 feet long and less than 10 feet high at its highest point. The top-width of the embankment is approximately 8 feet wide.
- Investigation of site-specific soil and geologic conditions to define the extent necessary to excavate existing sediment and to determine if alternatives to bentonite liner treatment should be considered because of karstic bedrock or other conditions of the underlying bedrock formation.
- Installation of an inlet and outlet control mechanism would be used to control reservoir water levels. The installed structures would be stabilized with rock riprap.
- Excavation of the spillway to adequately convey overflow volumes along with stabilization with rock riprap for protection.
- Potential construction options for reducing seepage in small stock ponds and reservoirs include the installation of geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Potential options are detailed in the NRCS Construction Specifications for Pond Sealing or Lining (NRCS WY-521A, WY-521C, or WY-521D).
- Contingent upon determination of adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- As proposed, the project involves private lands only.

4.3.9 LW-52: Upper Sundance Creek Well and Tank Project

This alternative would involve drilling a new well and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components would be installed:

- A new well would be drilled to supply water. The well would be equipped with a solar platform consisting of solar panels; solar-powered pump; batteries; and all regulators, connections, and appurtenances.
- From the well and pump, a buried HDPE low-pressure pipeline would be installed.
- The pipeline would be supply a stock tank (1,200-gallon capacity). This pipeline would require installing 400 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate management of flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

4.3.10 LW-53: East Rupe Spring Development and Tank Project

This alternative would involve rehabilitating an existing spring and supplying water to a portion of the watershed lacking adequate livestock/wildlife water sources. Under this alternative, the following components would be installed:

- The existing spring would be rehabilitated and equipped with collection pipe, spring box, and appurtenances would be installed.
- From the rehabilitated spring, a buried HDPE low-pressure pipeline to a stock tank (1,200-gallon capacity) would be installed to provide livestock/wildlife water. This pipeline would be aligned westerly and require installing 800 linear feet of 2-inch pipeline.
- Required valves, fittings, and appurtenances would be incorporated to facilitate management of flow, pressure, and water level.
- Wildlife escape ramps would be installed in the proposed stock tank.

In addition to the installation of a spring development, pipeline, and stock tank, this alternative would also provide for the rehabilitation of a spring-fed stock pond to provide an additional source of livestock/wildlife water along with providing associated wetland areas. This alternative would include the following features:

- Inspection of the embankment and rehabilitation of problem areas as needed.
- Investigation of site-specific conditions to define the extent necessary of removing obstructions, excavating sediments, rock, slope-wash materials, and vegetation.
- Installation of an inlet and outlet control mechanism would be used to control pond water levels. The installed structures would be stabilized with rock riprap.
- Contingent upon determination of adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.
- As delineated, the project involves privately owned lands only.

4.4 GRAZING MANAGEMENT OPPORTUNITIES

In Section 3.1.4.5 of Chapter 3.0 and within the basin wide summary report, the ecological sites within the subbasin were presented and the concept of the ESD was discussed. Within each ESD, there is a State and Transition Model (STM), which describes the patterns, causes, and indicators that cause vegetation to change from one plant community to a different group of plant species, and the management actions needed to restore to a desirable plant community.

The ESDs and their associated STMs for the four predominant ESDs that are available within the subbasin were obtained directly from the NRCS and are detailed in the following Sections 4.4.1 through 4.4.4. The four rangeland ESDs and associated HCPCs and STMs cover approximately 112,862 acres (33.4 percent) of the subbasin. The four predominant rangeland ESDs within the mapped area of the subbasin are likely to be one of the following:

- *R061XY122WY Loamy (Ly) 15–19-inch Precipitation Zone, Black Hills*
- *R061XY162WY Shallow Loamy (SwLy) 15–19-inch Precipitation Zone, Black Hills*
- *R061XY168WY Thin Upland*
- *R061XN010SD Loamy.*

In addition to the ESDs and the associated STMs, other tools are available to maintain and/or improve watershed function particularly when coupled with implementation of appropriate grazing management strategies. Other components are explained in detail in the Watershed Management and Rehabilitation Plan found in the basin wide summary report. Some of those grazing management components and supporting conservation practices include but are certainly not limited to the following:

- **Watershed Plan Component G-1:** Water developments can be used to expand grazing distribution to areas that do not currently have reliable water. Riparian area plant community condition can be enhanced by development of water into upland areas.
- **Watershed Plan Component G-2:** Fencing can be used to enhance grazing management options and to facilitate the planned grazing system.
- **Watershed Plan Component G-3:** Strategic salting and herding are other tools that can be used to enhance grazing distribution.
- **Watershed Plan Component G-4:** Most range improvement practices which improve watershed condition, may also improve wildlife habitat. Wildlife needs should be considered when installing practices such as wildlife friendly fences, wildlife escape ramps from tanks, and wildlife watering facilities.
- **Watershed Plan Component G-7:** Application of chemicals may be used as a tool to assist in the restoration of range health areas benefitting by this treatment according to the STMs. Delineation of specific areas potentially benefitting from this practice was beyond the scope of this Level I project.

4.4.1 Loamy (Ly) 15–19-Inch Black Hills Precipitation Zone

The most predominant rangeland ecological site in the subbasin is the Loamy (Ly) 15–19-inch Precipitation Zone, Black Hills (R061XY122WY) covering approximately 43,959 acres (18.4 percent) of the subbasin. The STM for the Loamy (Ly) 15–19-inch Precipitation Zone, Black Hills ESD is shown Figure 4.5.

Rhizomatous Wheatgrasses/Needleandthread/Big Bluestem Plant Community

This plant community is the interpretive plant community for this site and is considered to be the HCPC. This plant community evolved with grazing by large herbivores and is well suited for grazing by domestic livestock. This plant community can be found on areas that are properly managed with grazing and/or prescribed burning, and on areas receiving occasional short periods of rest. The potential vegetation is about 75 percent grasses or grass-like plants, 15 percent forbs, and 10 percent woody plants. A mix of warm- and cool-season mid-grasses dominates the state.

The major grasses include western wheatgrass, needleandthread, big bluestem, little bluestem, and green needlegrass. Other grasses occurring on the state include threadleaf sedge, Sandberg bluegrass, bluebunch wheatgrass, blue grama, and sideoats grama. A variety of forbs and half-shrubs also occur, as shown in the preceding table. Big sagebrush is a conspicuous element of this state, occurs in a mosaic pattern, and makes up 5 to 10 percent of the annual production. Plant diversity is high.

The total annual production (air-dry weight) of this state is about 2,200 pounds per acre, but it can range from about 1,500 pounds per acre in unfavorable years to about 3,000 pounds per acre in above average years.

This plant community is extremely stable and well adapted to the Black Hills Foot Slopes climatic conditions. The diversity in plant species allows for high drought tolerance. This is a sustainable plant community (site/soil stability, watershed function, and biologic integrity).

Transitions or pathways leading to other plant communities are as follows:

- No use and no fire for 20 years or more will convert this plant community to the Heavy Sagebrush Plant Community
- Moderate, continuous season-long grazing will convert the plant community to the Mixed Sagebrush/Grass Plant Community
- When cropped annually and then abandoned without reseeding, the state is converted to the Go-back Land Plant Community.

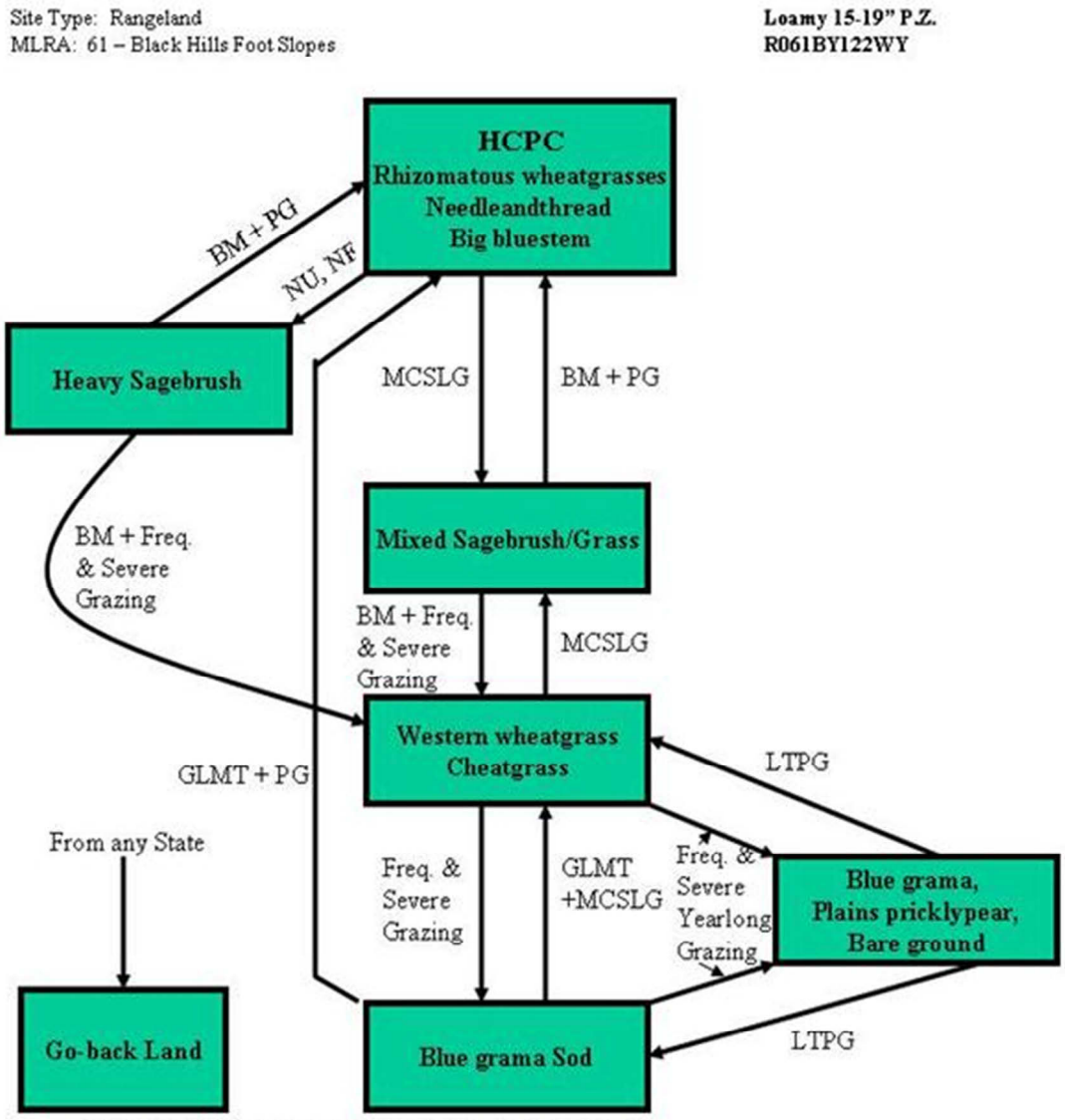


Figure 4.5. State and Transition Model: Loamy (Ly) 15–19-Inch Black Hills Precipitation Zone.

4.4.2 Shallow Loamy (SwLy) 15–19-Inch Black Hills Precipitation Zone

The second most predominant rangeland ecological site in the subbasin is the Shallow Loamy (SwLy) 15–19-inch Black Hills PZ (R061XY162WY) covering approximately 32,665 acres (9.7 percent) of the subbasin. The STM for the Shallow Loamy (SwLy) 15–19-inch Black Hills PZ ESD is shown Figure 4.6.

Rhizomatous Wheatgrasses/Needleandthread/Blue Grama Plant Community

The interpretive plant community for this site is the HCPC. This state evolved with grazing by large herbivores and is well suited for grazing by domestic livestock. Potential vegetation is about 80 percent grasses or grass-like plants, 10 percent forbs, and 10 percent woody plants. The state is dominated by cool-season midgrasses.

The major grasses include little bluestem, bluebunch wheatgrass, needleandthread, sideoats grama, and western wheatgrass. Other grasses occurring on the state include Sandberg bluegrass, blue grama, plains muhly, spikefescue and prairie junegrass. Big sagebrush is a conspicuous element of this state and occurs in a mosaic pattern. Big sagebrush may become dominant on some areas with absence of fire. Natural fire occurred frequently in this community and prevented big sagebrush from being the dominant landscape. Wildfires are actively controlled in recent times so chemical control using herbicides has replaced the historic role of fire on this state. Recently controlled burning has regained some popularity.

The total annual production (air-dry weight) of this state is about 1,400 pounds per acre, but it can range from about 900 pounds per acre in unfavorable years to about 1,800 pounds per acre in above average years.

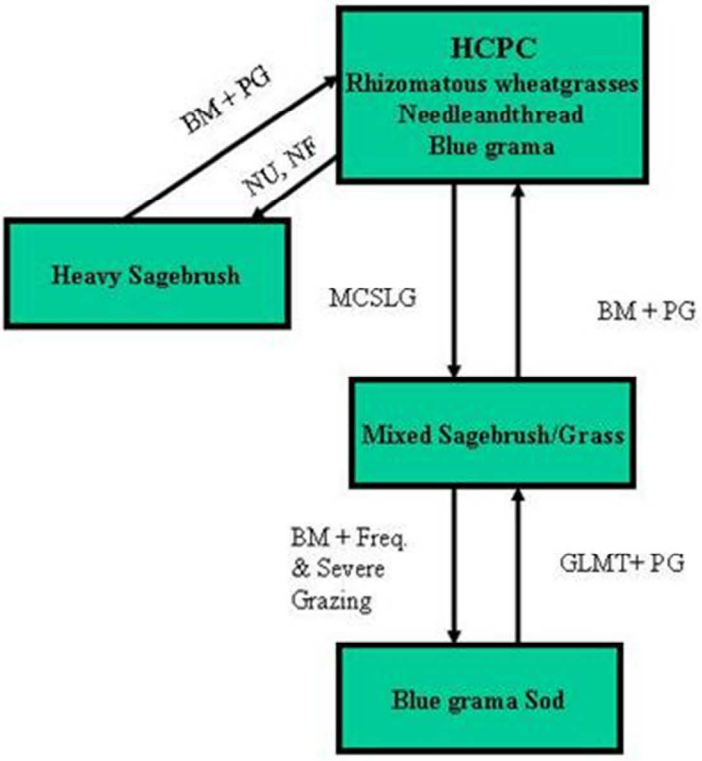
The state is extremely stable and well adapted to the Black Hills Foot Slopes climatic conditions. The diversity in plant species allows for high drought resistance. This is a sustainable plant community (site/soil stability, watershed function, and biologic integrity).

Transitions or pathways leading to other plant communities are as follows:

- Protection from grazing and fire will convert this plant community to the Heavy Sagebrush Plant Community
- Moderate, continuous season-long grazing will convert the plant community to the Mixed Sagebrush/Grass Plant Community
- Frequent and severe grazing and brush management will convert the plant community to the Blue Grama Plant Community.

Site Type: Rangeland
MLRA: 61 – Black Hills Foot Slopes

Shallow Loamy 15-19" P.Z
R061XY162WY



BM - Brush Management (fire, chemical, mechanical)
Freq. & Severe Grazing - Frequent and Severe Utilization of the Cool-season Mid-grasses during the Growing Season
GLMT - Grazing Land Mechanical Treatment
LTPG - Long-tem Prescribed Grazing
MCSLG - Moderate, Continuous Season-long Grazing
NU, NF - No Use and No Fire
PG - Prescribed Grazing (proper stocking rates with adequate recovery periods during the growing season)
VLTPG - Very Long-term Prescribed Grazing (could possibly take generations)
Na - found adjacent to a saline site

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Figure 4.6. State and Transition Model: Shallow Loamy (SwLy) 15–19-Inch Black Hills Precipitation Zone.

4.4.3 Loamy

The third predominant rangeland ecological site is the loam (R061XN010SD), which covers approximately 18,620 or 5.5 percent of the subbasin. The STM for the Loamy ESD (R061XN012SD) is shown in Figure 4.7.

Community Phase 1.1: Bluestem/Wheatgrass/Needlegrass

Interpretations are based on the Bluestem/Wheatgrass/Needlegrass Plant Community Phase (this is also considered to be climax). The potential vegetation was about 75 percent grasses or grass-like plants, 15 percent forbs, and 10 percent shrubs. The community was co-dominated by cool- and warm-season grasses, including big bluestem, western wheatgrass, needleandthread, green needlegrass, and sideoats grama. Other grasses included little bluestem, slender wheatgrass, Indiangrass, switchgrass, Idaho fescue, plains muhly, prairie dropseed, and threadleaf sedge. This community was resilient and well adapted to the Northern Great Plains climate. The diversity in species allowed for high drought tolerance. This was a sustainable community in regards to site/soil stability, watershed function, and biologic integrity.

Transition T1

Encroachment of non-native grasses such as Kentucky bluegrass and smooth bromegrass, and disruption of natural disturbance regimes (typically as a result of fire suppression following settlement led this state over a threshold to the Native/Introduced State (State 2).

4.4.4 Thin Upland

The fourth predominant rangeland ecological site is the Thin Upland (R061XY168WY), which covers approximately 17,618 or 5.2 percent of the subbasin. The HCPC and STM are unavailable, so a similar ESD, Thin Upland (R061XN012SD), is shown in Figure 4.8.

Community Phase 1.1: Little Bluestem/Needlegrass/Sideoats

Interpretations are based on the Little Bluestem/Needlegrass/Sideoats Grama Plant Community (this is also considered to be climax). The potential vegetation is about 80 percent grasses or grass-like plants, 10 percent forbs, and 10 percent shrubs. The community is dominated by warm-season grasses, with cool-season grasses being subdominant. Major grasses include little bluestem, needleandthread, sideoats grama, porcupine grass, and big bluestem. Other grasses include western wheatgrass, plains muhly, slender wheatgrass, green needlegrass, prairie dropseed, Indiangrass, prairie sandreed, and blue grama. This community is resilient and well adapted to the Northern Great Plains climate. The diversity in plant species allows for high drought tolerance. This is a sustainable plant community in regards to site/soil stability, watershed function, and biologic integrity.

Community Phase Pathway 1.1a

Heavy continuous grazing (stocking levels well above carrying capacity for extended portions of the growing season) or a combination of disturbances for extended periods of time will lead to the 1.2 Little Bluestem/Needleandthread/Western Wheatgrass Plant Community Phase.

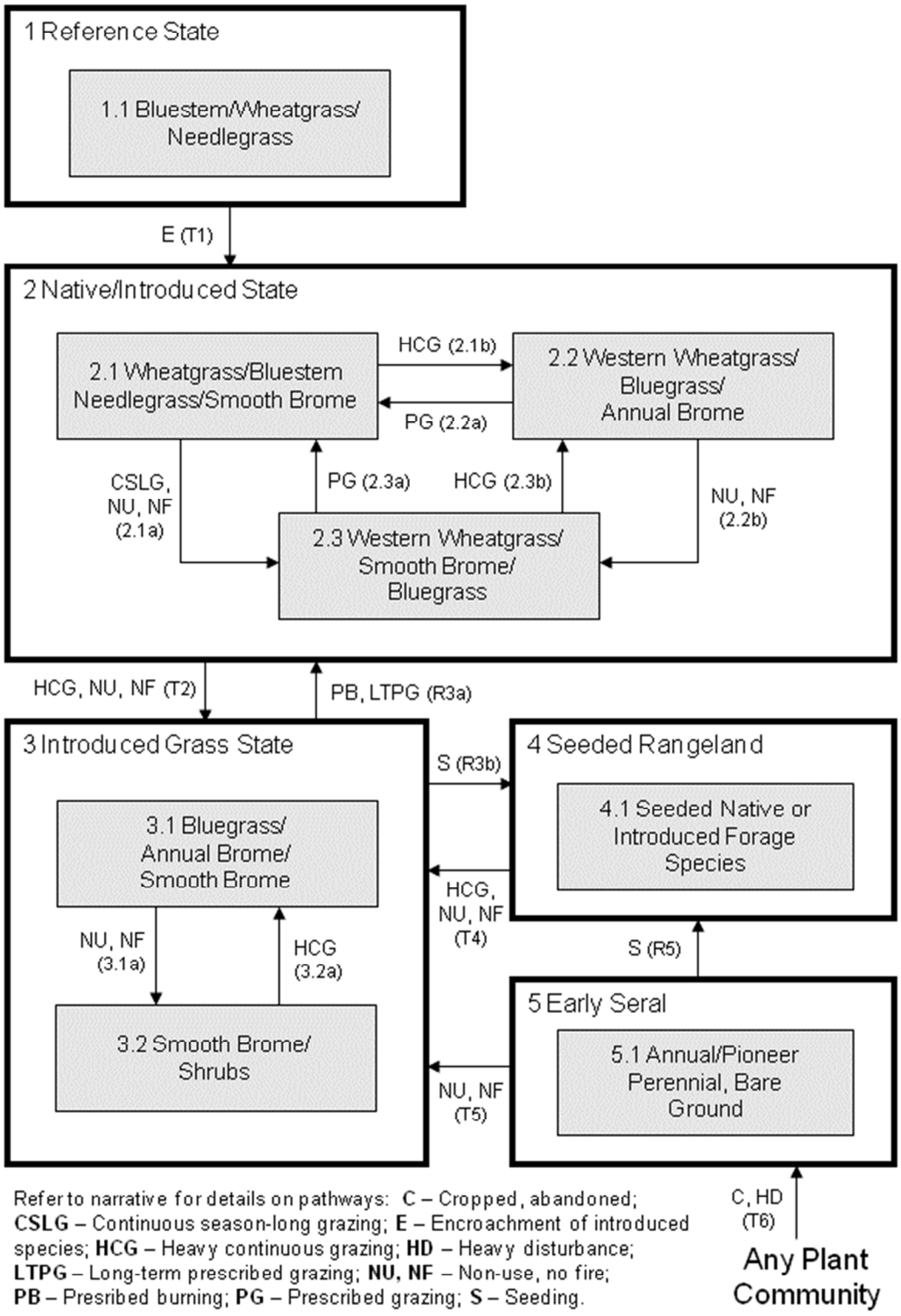

Figure 4.7. State and Transition Model: Loamy.

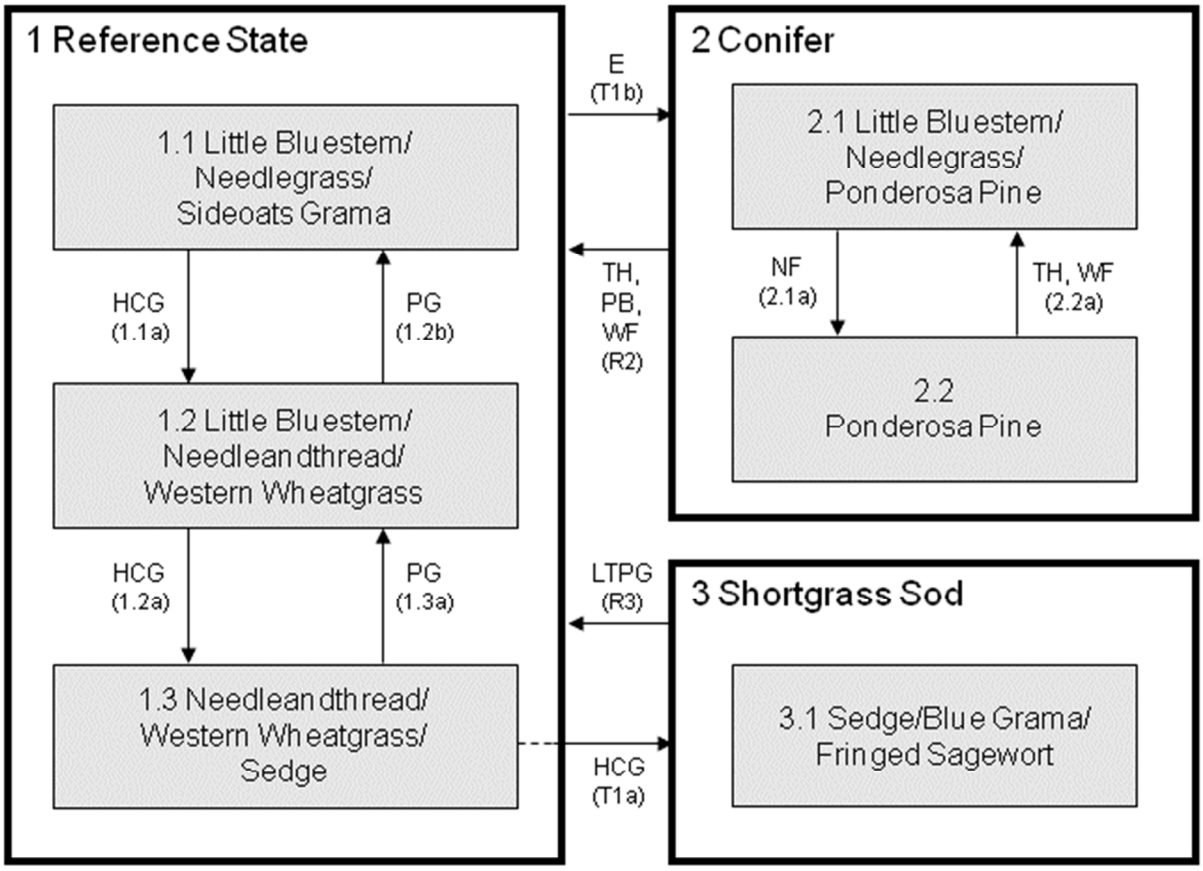

Figure 4.8. State and Transition Model: Thin Upland.

4.5 SURFACE WATER STORAGE OPPORTUNITIES

Investigations to identify large water storage reservoirs within the watershed have been the subject of several past studies and are summarized in the basin wide summary report. Landowners and water users identified problems with several existing reservoirs and associated facilities that limited the potential to store water in these facilities. Additionally, participants identified potential sites and possible opportunities for water storage facilities within the subbasin. Accordingly, site visits and initial reviews were conducted on some of the stock ponds, stock reservoirs, storage reservoirs, and previously proposed sites identified by participants.

A “long list” of ten potential surface water storage sites were identified within the study area and included in the basin wide summary report. Three sites from the “long list” are located within the subbasin and are listed in Table 4.3. These alternatives involve rehabilitation and/or

enlargement of existing facilities and construction of a new facility and are described in Section 4.5.1 through 4.5.3.

Table 4.3. Potential Storage Project Sites Identified Within the Subbasin

Item Number	Potential Storage Project Site	Potential and Project Alternative Type
S-01	S-01: Dry Creek	New
S-03	S-03: Washington Memorial Reservoir (Sundance Pond)	Rehabilitation and Enlargement
S-10	S-10: Sunset Reservoir (Hemler Dam)	Rehabilitation

However, only one site, S-01: Dry Creek, was included in the "short list" of potential sites that could provide substantial storage opportunities separate from those sites with minimal volumes, rehabilitation needs, or solely provide livestock/wildlife water. The short list of potential sites is discussed in more detail within the basin wide summary report along with the initial screening of these alternatives. Relevant information was collected about the potential sites to provide an initial screening of these alternatives based on environmental, hydrologic, geologic, potential benefits, costs, and other data. The information was organized in the Reservoir Evaluation Matrix presented in the basin wide summary report.

4.5.1 S-01: Dry Creek

This potential site is located on Dry Creek, a tributary to Redwater Creek, and is within the Belle Fourche River Watershed – Redwater Subbasin. The potential site is located in Section 17 of Township 53 North, Range 60 West in Crook County. A view of the site from the county road is shown in Figure 4.9. The potential site is located approximately 2.5 miles north of Beulah, Wyoming, on a 960-acre parcel owned by the state of Wyoming, as illustrated in Figure 4.10.

This potential site would involve construction of a new reservoir at this location. Consequently, a detailed investigation of geologic structure should be completed along with identification of the permitting requirements. This work can be accomplished through an evaluation of potential alternatives completed during a WWDC Level II-Phase I study.

This site alternative is limited to storage provided by Dry Creek and possibly diversions from Redwater Creek. Additional coordination with the SEO should be conducted before proceeding with any future work because of the constraints regarding the Belle Fourche River Compact and permitting through the U.S. Army Corps of Engineers (USACE). Lastly, although this potential site's reservoir embankment and storage pool are almost entirely contained within lands owned by the state of Wyoming; as mapped in Figure 4.10, a small portion of the storage pool would inundate privately owned lands which must be considered in any future studies related to this potential storage site.

Figure 4.9. A View of the Potential Site on Dry Creek Storage Site.

4.5.2 S-03: Washington Memorial Reservoir (Sundance Pond)

Washington Memorial Reservoir, known locally as Sundance Pond, is located on Sundance Creek in Washington Park within the City of Sundance, Wyoming. The reservoir and dam are located on Sundance Creek, a tributary to Redwater Creek, and is within the Redwater Subbasin. The Washington Memorial Reservoir is located in Section 13 of Township 51 North, Range 63 West in Crook County. The reservoir was permitted in 1933 (Permit No. P4565S) with a capacity of 22.78 acre-feet and then enlarged to a permitted capacity of 31.41 acre-feet in 1987 (Permit No. P9215R).

In 2012, the *Washington Memorial Reservoir (P9215R) 2012 Inundation Map Project* was completed by States West Water Resources Corporation [2012] for the Wyoming SEO to compute the inundation areas resulting from a clear weather breach of Washington Memorial Reservoir Dam. A dam breach analysis of Washington Memorial Reservoir was also conducted to determine the resulting outflow hydrograph using U.S. Army Corp of Engineers HEC-HMS 3.5 [States West Water Resources Corporation, 2012].

This alternative would provide for the rehabilitation of the reservoir, embankment, outlet facilities, and associated wetland and riparian areas. The reservoir's inlet and spillway structures are shown in Figure 4.11 and Figure 4.12. The alternative would involve installation of an inlet and outlet pipe control structure in the reservoir embankment and stabilizing the

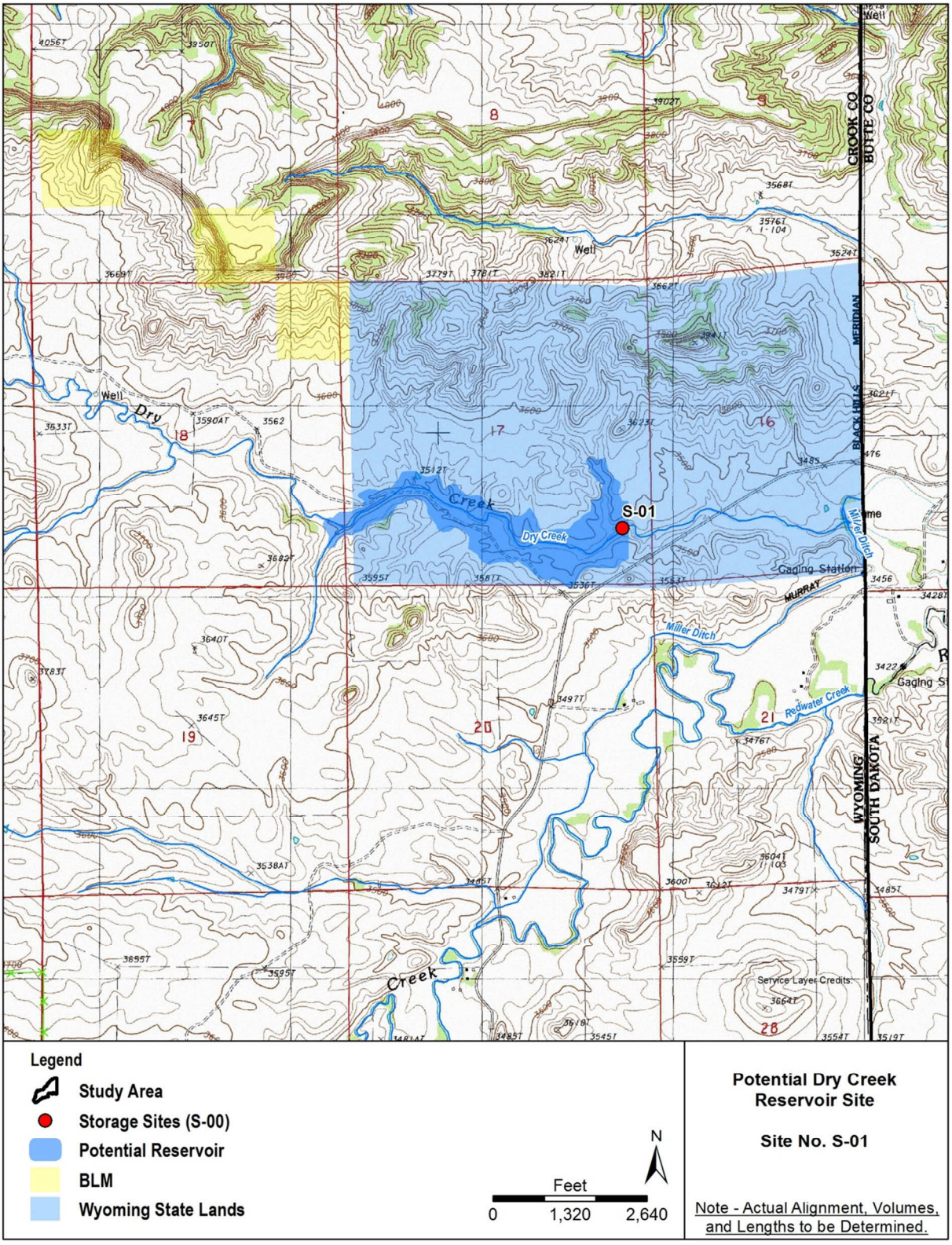

Figure 4.10. Map of the S-01: Dry Creek Storage Site.

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Figure 4.11. A View of Washington Memorial Reservoir's Inlet Structure and Emergency Spillway.

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Figure 4.12. A view of Washington Memorial Reservoir's Emergency Spillway.

installed structures and spillway with rock riprap. This reservoir could be rehabilitated to provide an additional source of wildlife and fisheries water along with restoring function of the associated wetland and riparian areas. The reservoir's embankment and storage pool involves city, county, and privately owned lands as shown in Figure 4.13. This alternative would include the following features:

- Inspection of the embankment and rehabilitation of problem areas as needed. The embankment is approximately 500 feet long and less than 25 feet high at its highest point. The top-width of the embankment is approximately 20 feet wide.
- Investigation of the reservoir's inlet and outlet facilities along with soil and bedrock geologic conditions to define the extent necessary for excavating sediment, restoring wetland and riparian vegetation, and rehabilitating the reservoir's function.
- Installation of an inlet/outlet control mechanism to control reservoir water levels.
- Excavation of the eroded spillway to adequately convey necessary water volumes along with stabilization with rock riprap for spillway protection.
- Contingent upon determination of adequate sources of borrow material and rock riprap for dam embankment repairs and spillway stabilization.

4.5.3 S-10: Sunset Reservoir (Hemler Dam)

Sunset Reservoir, known locally as Hemler Dam, is located on Redwater Creek a tributary to the Redwater River, and is within the Redwater Subbasin. The Sunset Reservoir is located in Section 1 of Township 52 North, Range 63 West in Crook County. The reservoir was permitted in 1951 (Permit No. P5870R) with a capacity of 8.0 acre-feet and then enlarged to a permitted capacity of an additional 7.25 acre-feet in 1958 (Permit No. P6810.0R). A view looking across the dam embankment from the left abutment is shown in Figure 4.14. The site is located approximately 8.3 miles north of Sundance, Wyoming, within the Black Hills National Forest on National Forest lands, as illustrated in Figure 4.15.

The alternative is limited in storage opportunities and only involves rehabilitating the existing reservoir facilities for proper operation and maintenance of the existing storage and outlet facilities. Specific rehabilitation needs regarding irrigation water conveyance are discussed in Section 4.2.3. The reservoir's embankment is approximately 350 feet long and 24 feet high at its highest point with an embankment volume of approximately 13,330 cubic yards. The existing reservoir is located entirely on National Forest land within the Black Hills National Forest as shown in Figure 4.15.

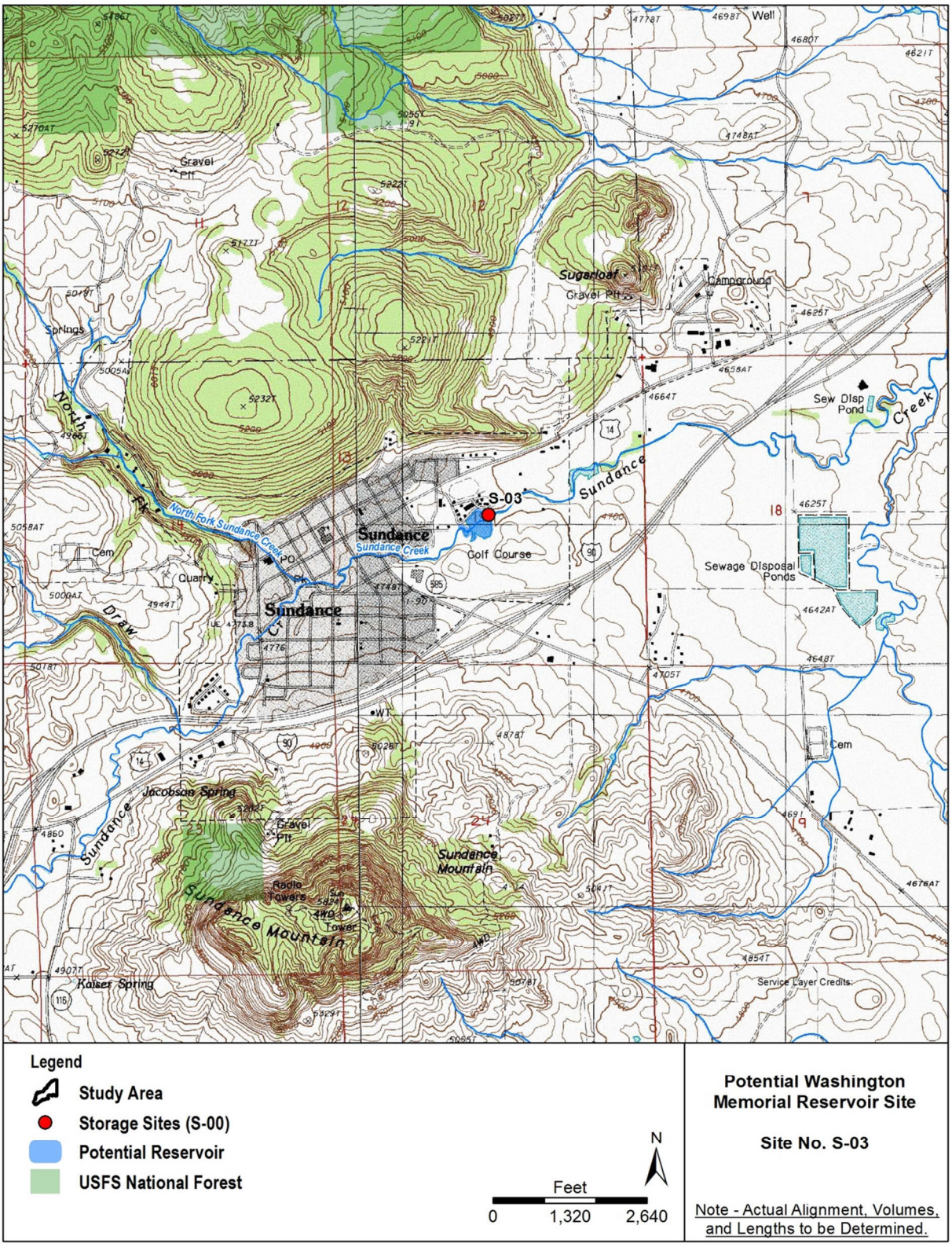

Figure 4.13. Map of the S-3: Washington Memorial Reservoir Storage Site.

Figure 4.14. A view of Hemler Dam on Sunset Reservoir on April 23, 2014.

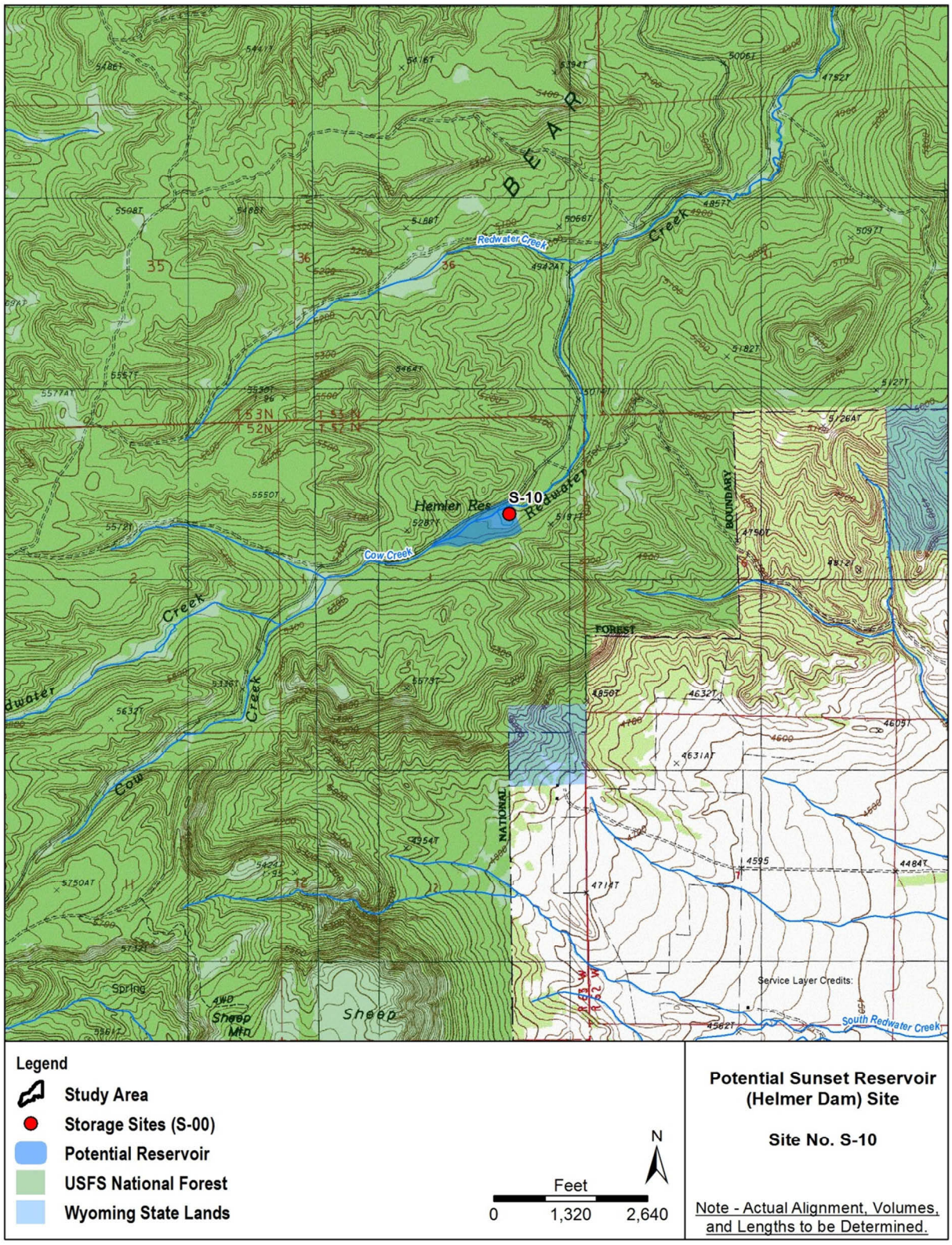

Figure 4.15. Map of the S-10: Sunset Reservoir (Hemler Dam) Storage Site.

5.0 PERMITS

5.1 PERMITS, CLEARANCES, AND APPROVALS

Information regarding the initial permitting and regulatory process for the proposed projects outlined in Chapter 4.0 of this report are contained within the basin wide summary report. Some of the proposed projects and future potential projects described in this study involving federal lands, funding, and programs are subject to the National Environmental Policy Act (NEPA) and other federal regulations, which requires coordination with the possibly several federal agencies. Coordination with state agencies may also be required depending on project locations and activities. Local ordinances and permits may be needed depending on the specific town, city, and/or county where the project is located. Right-of-way access is also required from WYDOT, utility entities, and energy companies when projects involve those properties. And finally, the state of Wyoming's "Wyoming Underground Facilities Notification Act" requires that before any excavation begins, the excavator is required to provide advance notice to the One-Call of Wyoming Notification Center at 811 (or if calling from out-of-state, 1.800.849.2476) [Wyoming State Legislature, 2013].

5.2 PROPOSED, THREATENED, AND ENDANGERED SPECIES

Two species have the potential to occur on proposed project areas within the subbasin: Endangered: Black-footed ferret (*Mustela nigripes*) and Threatened: Grizzly Bear (*Ursus arctos arctos*) [Wyoming Natural Diversity Database, 2014].

5.3 OTHER SPECIES OF CONCERN

The WYNDD records and maintains a list of animal and plant species in Wyoming that are thought to be rare or sensitive and included in Section 3.1.7.2 and Section 3.1.2 of this report. The sage-grouse is listed as a "candidate species; warranted but precluded" because existing information supports a proposal to list them as endangered or threatened; however, developing a proposed listing is precluded by higher priority listing activities. In 2011, the Governor of Wyoming issued an executive order that requires state agencies to focus management to the greatest extent possible to prevent the sage-grouse from being listed as a threatened or endangered species. No core areas for sage-grouse are located within the Redwater Subbasin as shown in Figure 3.13.

5.4 LAND OWNERSHIP AND PROPERTY OWNERS

Permission should be negotiated for easements, right-of-way access for all construction activities associated with a project. **Note that the WWDC has stated that lands will NOT be "taken" or condemned to construct projects recommended within the watershed**

management plan. WWDC representatives stated that the state is not interested in condemning lands for the purpose of constructing a reservoir built with an objective of benefitting those whose lands would be used. Participation must be voluntary.

6.0 COST ESTIMATES

Costs were estimated for each of the conceptual proposed projects and alternatives described in Chapter 4.0. The estimated costs shown in Tables 6.1 and 6.2, representing 2014 dollars, are explained in the basin wide summary report for each of the proposed project categories. However, cost estimates for surface water storage sites and alternatives were not adjusted for this study and represent values reported in the final reports. For each storage site, a conceptual layout of the reservoir pool was prepared in the study's GIS from previous study reports and using USGS topographic mapping. The reservoir layouts were primarily used to determine areas of attributes affected at the site and were used in the initial screening of the potential sites. Costs were estimated and extrapolated using the values previously stated for these alternatives and reported in the *Final Report Crook County Reservoir Project Level I* [ESA Consultants Inc., 1999] and the *Crook County Reservoirs and Water Management Study – Level I* [Short Elliot Hendrickson Inc., 2006]. The previous reported estimated costs represent 2006 dollars and were not adjusted for the purpose of this study.

Table 6.1. Irrigation Cost Estimates

Rehabilitation Item Number	Priority	Pipeline less than or equal to 12" diameter	Pipeline greater than 12" diameter	Structure for Water Control Medium	Structure for Water Control Large	Regulating Reservoir	Pumping Plant	Calculated Costs	Construction Costs	Engineering Costs (10%)	Construction & Engineering Subtotal	Contingency (15%)	Total Construction Costs	Final Plans and Specs	Permits, Fees, Access	Total Project Costs
I-01	1	5,610		1	1	1		$128,955	$128,955	$12,896	$141,851	$21,278	$163,128	$2,000	$2,000	$167,128
I-02	1	2,620		1				$44,476	$44,476	$4,448	$48,924	$7,339	$56,262	$3,500	$3,500	$63,262
I-04	3	6,740			1	1		$130,604	$130,604	$13,060	$143,664	$21,550	$165,214	$2,000	$2,000	$169,214
I-04A	3	5,890			1			$91,274	$91,274	$9,127	$100,401	$15,060	$115,462	$2,000	$2,000	$119,462

Table 6.2. Estimated Costs Associated With Each of the Upland Livestock/ Wildlife Water Source/Supply Proposed Projects and Components of the Watershed Management Plan

Item Number	Plan Component	Description	Priority	Construction Costs ($)	Engineering Costs (10%) ($)	Construction and Engineering Subtotal ($)	Contingency (15%) ($)	Total Construction Costs ($)	Final Plans and Specs ($)	Permits, Fees, Access ($)	Total Project Costs ($)
6	LW-06	Spring/East Bluff Pipeline and Tank	1	$29,150	$2,915	$32,065	$4,810	$36,875	$2,000	$2,000	$40,875
7	LW-07	Strips/West Bluff Pipeline and Tank	2	$12,500	$1,250	$13,750	$2,063	$15,813	$2,000	$2,000	$19,813
8	LW-08	East Dry Creek Well, Pipeline, and Tank	2	$32,400	$3,240	$35,640	$5,346	$40,986	$2,000	$2,000	$44,986
9	LW-09	Vore Draw Pipeline and Tank	3	$15,250	$1,525	$16,775	$2,516	$19,291	$3,500	$3,500	$26,291
12	LW-11	Eagle Ridge 1 Spring Development, Pipeline, and Tank	1	$24,130	$2,413	$26,543	$3,981	$30,524	$2,000	$2,000	$34,524
13	LW-12	Eagle Ridge 2 Spring Development and Tank	2	$17,400	$1,740	$19,140	$2,871	$22,011	$2,000	$2,000	$26,011
14	LW-12A	Marr Stock Reservoir	2	$25,000	$2,500	$27,500	$4,125	$31,625	$2,000	$2,000	$35,625
15	LW-13	Porcupine Stock Reservoir	3	$25,000	$2,500	$27,500	$4,125	$31,625	$3,500	$3,500	$38,625
62	LW-52	Upper Sundance Well, Pipeline, and Tank	3	$41,200	$4,120	$45,320	$6,798	$52,118	$2,000	$2,000	$56,118
63	LW-53	East Rupe Spring Development, Pipeline, Tank	2	$35,400	$3,540	$38,940	$5,841	$44,781	$3,500	$3,500	$51,781

7.0 FUNDING OPPORTUNITIES

Sources of funding and financing for proposed projects within the subbasin and the associated technical support and assistance are available from various local, private, state, and federal entities. Local coordination is crucial in developing viable financing approaches that could be used in implementing proposed projects and realizing benefits. Voluntary cooperation between landowners, managers, irrigators, residents, organizations, and agencies is essential in addressing the identified land and water resource concerns within the subbasin.

Local, state, and federal agencies, along with private organizations, provide technical assistance for watershed and conservation projects with a smaller amount of these entities also providing financial assistance. Private contributions, such as in-kind provisions, are vital in developing and accomplishing a successful watershed or conservation project. Agencies and organizations with technical and financial assistance programs, which could potentially assist with proposed projects and alternatives, are provided within the basin wide summary report. Funding and program information for potential conservation and watershed project and program assistance was obtained primarily from the following sources:

- **Water Management and Conservation Assistance Programs Directory**, is an overview of local, state, and federal programs with associated contact information, (*http://wwdc.state.wy.us/wconsprog/2014WtrMgntConsDirectory.html*)
- **Catalog of Federal Funding Sources for Watershed Protection** is a searchable database of financial assistance sources (grants, loans, and cost-sharing) available to fund a variety of watershed projects (*http://www.epa.gov/watershedfunding*)

Important local contact information within the subbasin for local conservation and civic organizations include, but are certainly not limited to, the following contacts:

- Crook County Natural Resource District (307.283.2870)
- Weston County Natural Resource District (307.746.3264)
- NRCS Newcastle Field Office (307.746.3264)
- NRCS Sundance Field Office (307.283.2870)
- BLM Newcastle Field Office (307.746.6600)
- USFS Bearlodge Ranger District (307.283.1361)
- WGFD Casper Regional Office (307.473.3400).

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 CONCLUSIONS

Resource issues and concerns within the subbasin were identified and evaluated to outline proposed improvements and alternatives associated with the following study areas:

- Irrigation System Conservation and Rehabilitation
- Livestock/Wildlife Upland Watering Opportunities
- Grazing Management Opportunities
- Surface Water Storage Opportunities.

8.1.1 Irrigation System Components

- Proposed projects and associated components for issues identified during field inventories for irrigation system infrastructure were completed for four irrigation systems.
- Recommended improvements to existing irrigation systems mainly involve replacement and/or rehabilitation of existing but weakened diversion structures, headgates, and pumps along with replacement of ditches with pipelines to reduce conveyance losses.
- Irrigation system improvements could be implemented individually or entirely at once depending on the goals of the landowner or manager.

8.1.2 Livestock/Wildlife Upland Watering Opportunities

- Opportunities to improve range and riparian conditions require the installation and operation of well-distributed, reliable upland water sources and watering facilities for wildlife and livestock. Installing pipelines and stock tanks is the foundation of effective grazing management and can be an economical way to improve rangeland conditions.
- There are 20 USFS grazing allotments encompassing 133,218 acres of rangeland and forest lands and another 14 BLM grazing allotments encompassing 1,593 acres of rangeland and forest lands consisting of private, state, and federal lands in the subbasin.
- Coordination with the USFS and the BLM regarding grazing allotment management is necessary and requires more involvement in developing proposed livestock/wildlife water supply projects beyond the conceptual level projects included within the study.
- Ten potential livestock/wildlife water projects were identified for development resulting from an effort that evaluated available water sources in coordination with participating landowners and allotment permittees.

- Conceptual project plans and component designs along with associated cost estimates were calculated for each of the proposed projects. The primary components included water wells, solar pumps, buried pipelines, and stock tanks, which would require additional final planning, design, and permitting completed before construction.
- The proposed projects and components would need to be installed, operated, and maintained by the landowner or manager in accordance with current standards and specifications realize the expected benefits to the project area and watershed.

8.1.3 Surface Water Storage Opportunities

- Water storage development within the watershed has been impacted by the Belle Fourche River Compact of 1943 which divides the water in Northeast Wyoming between Wyoming and South Dakota.
- Landowners and study participants identified problems with several existing reservoirs that limited the ability to store water and also identified potential opportunities for water storage within the study area.
- One site, S-01: Dry Creek was included on the "short list" of potential sites selected from the long list that may provide substantial storage opportunities and was screened based on environmental, hydrologic, geologic, potential benefits, costs, and other data.

8.1.4 Grazing Management Opportunities

- Construction and operation of reliable water supply projects must be developed and implemented in areas with inadequate water sources before adjustments or alternatives in grazing management could be made on a particular area or allotment.
- Development of reliable water sources and associated watering facilities can aid in distribution, timing, and frequency of grazing animals. However, additional measures such as cross-fencing, low-stress herding, mineral/salting, and grazing density should be evaluated as part of the site-specific, grazing management inventory and plan.
- Available tools such as the ESD and the STM can be used by landowners and managers to become aware of the growth potential of desirable vegetation and predicted responses on a particular range site.
- These tools could be used in developing appropriate rangeland treatments and grazing practices to begin the transition from an undesirable to a desirable plant community.

8.2 RECOMMENDATIONS

Several proposed conceptual projects, identified opportunities, suggested alternatives, and initial conclusions have been presented and discussed within this report and watershed management plan. Summary recommendations listed below are included for consideration:

- Several irrigation system rehabilitation projects and livestock/wildlife upland water projects could be eligible to apply for funding through the WWDC SWPP.
- Surface water opportunities exist within the watershed but would require a partnership of local organizations including but certainly not limited to the CCID and the Crook County Natural Resource District in order to pursue additional investigations, feasibility studies, along with financing to implement potential projects.
- Priority projects should be reviewed, selected, and components implemented once the necessary technical and financial requirements are determined.
- Landowners or managers seeking to participate in the SWPP should consult and coordinate with their local conservation districts, which are eligible sponsors of SWPP applications and project agreements.
- The study's GIS and digital library should be used as a tool in planning and developing projects and should be updated as necessary from available information sources.
- Potential funding opportunities exist for proposed and future improvement projects within the watershed including ranch and farm improvements, irrigation system rehabilitation, riparian/wetland enhancements, river corridor and stream channel restoration, and surface water storage projects.
- Innovative strategies for coordinated project funding and financing involving private, local, state, and federal sources will need to be pursued since many of the opportunities are unique in this watershed and do not conform to traditional programs and guidelines.
- It is essential that this approach be based on local, collaborative endeavors that integrate more than one watershed issue that could result in achievement of multiple benefits.

9.0 REFERENCES

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