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BUFFALO CREEK WATERSHED STUDY

LEVEL I

ACE Project: WYWDC31

Prepared For:

Wyoming Water Development Commission
6920 Yellowtail Road
Cheyenne, WY 82002

Prepared By:

Anderson Consulting Engineers, Inc.
375 E. Horsetooth Rd. Bldg. 5
Fort Collins, CO 80525

ANDERSON CONSULTING ENGINEERS, INC.
Civil • Water Resources • Environmental

March 9, 2012

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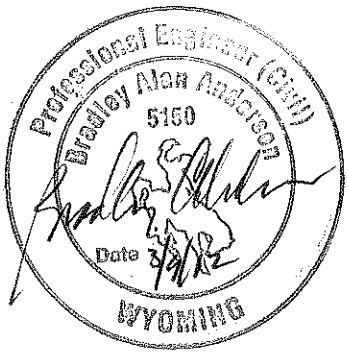

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I. INTRODUCTION

On June 30, 2010 Anderson Consulting Engineers, Inc. (ACE) entered into a contract with the Wyoming Water Development Commission (WWDC) to provide professional services for the Buffalo Creek Watershed Level I Study. ACE was retained to evaluate and describe the study area and specifically develop a watershed management plan. Opportunities and issues within the watershed are to be identified and practical economic solutions proposed. This report documents the results of all tasks associated with this effort

1.1 Project Overview

The term "watershed" may have been best defined by John Wesley Powell, scientist geographer, when he said that a watershed is:

> *"that area of land, a bounded hydrologic system, within which all living things are inextricably linked by their common water course and where, as humans settled, simple logic demanded that they become part of a community."*

The State of Wyoming recognizes the benefits of basin planning efforts on the basis of watershed areas which do not necessarily adhere to political boundaries such as counties or states. The WWDC describes the watershed planning process as follows:

> *"Today, conservation by watershed is an old concept with new horizons. Watersheds have long been recognized in the western United States for their significant natural resources and the interrelationships found contained in land areas connected by stream systems. These relationships were recognized by John Wesley Powell from his early expeditions of the west and resulted in proposed conservation, low density open grazing, irrigation systems and state boundaries based on watershed areas.*
>
> *The conservation concept developed over time to coalesce in the early 1930's with the formation of special districts whose boundaries were often based on watersheds. At that time the relationship between stream systems and landscape function was recognized. This relationship was broadened to embrace watershed condition and quality and its response to human influences. This further provided some understanding of the historic land use effect on watershed condition and how management and restoration needs to be based on local landscape characteristics.*
>
> *Today, these relationships are embraced by the Wyoming Water Development Commission and Office through a watershed study program. On behalf of a local community sponsor, a watershed study can provide a comprehensive evaluation, analysis and description of the resources associated with a watershed and the*

watershed's water development opportunities. It is best stated that information related to the physical sciences is incorporated into a biological system.

There are three prominent issues that are important considerations in a watershed information review and study. The first is surface water storage. Surface water storage is often of significant interest to a watershed community in order to address seasonal and/or annual shortages of water supply, augment late season stream flow to benefit riparian habitat, fisheries and wildlife, address flood impacts, enhance recreation opportunities, improve water quality and steam channel stability.

Second is the evaluation of irrigation infrastructure and development of information necessary to guide its rehabilitation and conservation. Of interest to local water users are ways to improve water delivery and on-farm irrigation efficiencies often timed to address annual or seasonal shortages of water supply or irrigation water delivery issues.

Third is the enhancement of upland water resources and distribution for livestock and wildlife that allows grazing management adjustments for range resource improvement. Benefits to the watershed, through plant community invigoration, reduction of erosion and stream channel stabilization, can be achieved from water development projects being strategically implemented over the watershed. Other issues and opportunities such as making beneficial use of produced water and removal of high water demand invasive species can also be important.

A watershed study, providing management and rehabilitation plans for water storage, irrigation systems and upland water development, can help empower a community to proactively enhance their watershed. Conservation by watershed can be an effective holistic approach to embracing the natural resource challenges and opportunities facing a community. A watershed study can provide the information to meet those challenges."

The Buffalo Creek Watershed Study is one of several watershed planning studies completed on behalf of the WWDC and the Wyoming Water Development Office (WWDO). Watershed investigations either completed or in the process of being completed include the following:

Prairie Dog Creek Watershed Study
Popo Agie River Watershed Study
Cottonwood Creek / Grass Creek Watershed Study
Sweetwater River Watershed Study
Thunder Basin Watershed Study
Clear Creek Watershed Study
Kirby Creek Watershed Study
Shell Valley Watershed Study
Little Snake River Watershed Study
Nowood River Watershed Study

As a direct result of these efforts, numerous additional studies have been initiated and multiple projects have been constructed.

1.2 Background

The Buffalo Creek watershed is located in the Big Horn River basin near the town of Thermopolis in Hot Springs County, Wyoming (Figure 1.1). The project study area includes the Buffalo Creek watershed plus the adjacent Warm Springs Creek and Black Willow Draw watersheds (Figure 1.1). For simplicity, the study area will be referred to as the "Buffalo Creek watershed" throughout this report. The total area encompassed by these watersheds is approximately 175 square miles. With the exception of a small region at the mouth of Warm Springs Creek, there are no incorporated areas within the watershed and it is only sparsely populated. Elevations range from less than 4,350 feet above mean sea level at its mouth to over 8,300 feet on Copper Mountain, resulting in overall relief of over 3,950 feet. Annual precipitation typically averages 13 to 15 inches throughout most of the watershed with much of the precipitation derived from summer thunderstorms.

The majority of the basin (approximately 62.4 percent) is privately owned. The remainder of the study area is either federally owned lands managed by the Bureau of Land Management (25.1 percent), State of Wyoming (10.1 percent) or the Wind River Tribes (2.4 percent). The privately owned portion of the study area, including Buffalo Creek, Warm Springs Creek, and Black Willow Draw watersheds, consists of approximately 45 individual land owners.

1.2.1 Water Quantity, Location and Timing

Bedrock geology plays a key and unique role in determining availability of streamflow within the Buffalo Creek watershed. Limestone bedrock underlies the majority of the upper reaches of Buffalo Creek watershed. Streams classified as perennial upstream of the limestone outcrops are depleted entirely as they flow across reaches underlain by limestone. Water is lost to sinks and infiltration. Consequently, the downstream reaches are classified as ephemeral and flow only when surface runoff exceeds the rate of loss. Local ranchers have resorted to construction of pipeline systems which divert flows in the upper reaches and pipe it downslope to the lower reaches of the watershed where it is used for irrigation and livestock watering purposes.

1.2.2 Utilization of Grazing Allotments and Range Management

Grazing of livestock is one of the primary land uses within the study area; the livestock industry has played an important role in the economy and character of the area. In general, water available for livestock and wildlife consumption within the watershed is limited to riparian corridors in the upper portions of the watershed. In the lower portions of the watershed, water opportunities are limited to scattered stock reservoirs and pipeline/stock tank projects.

Several pipeline / stock tank projects have been completed within the watershed. Inventory of this infrastructure and evaluation of potential upland water supply needs and opportunities will highlight

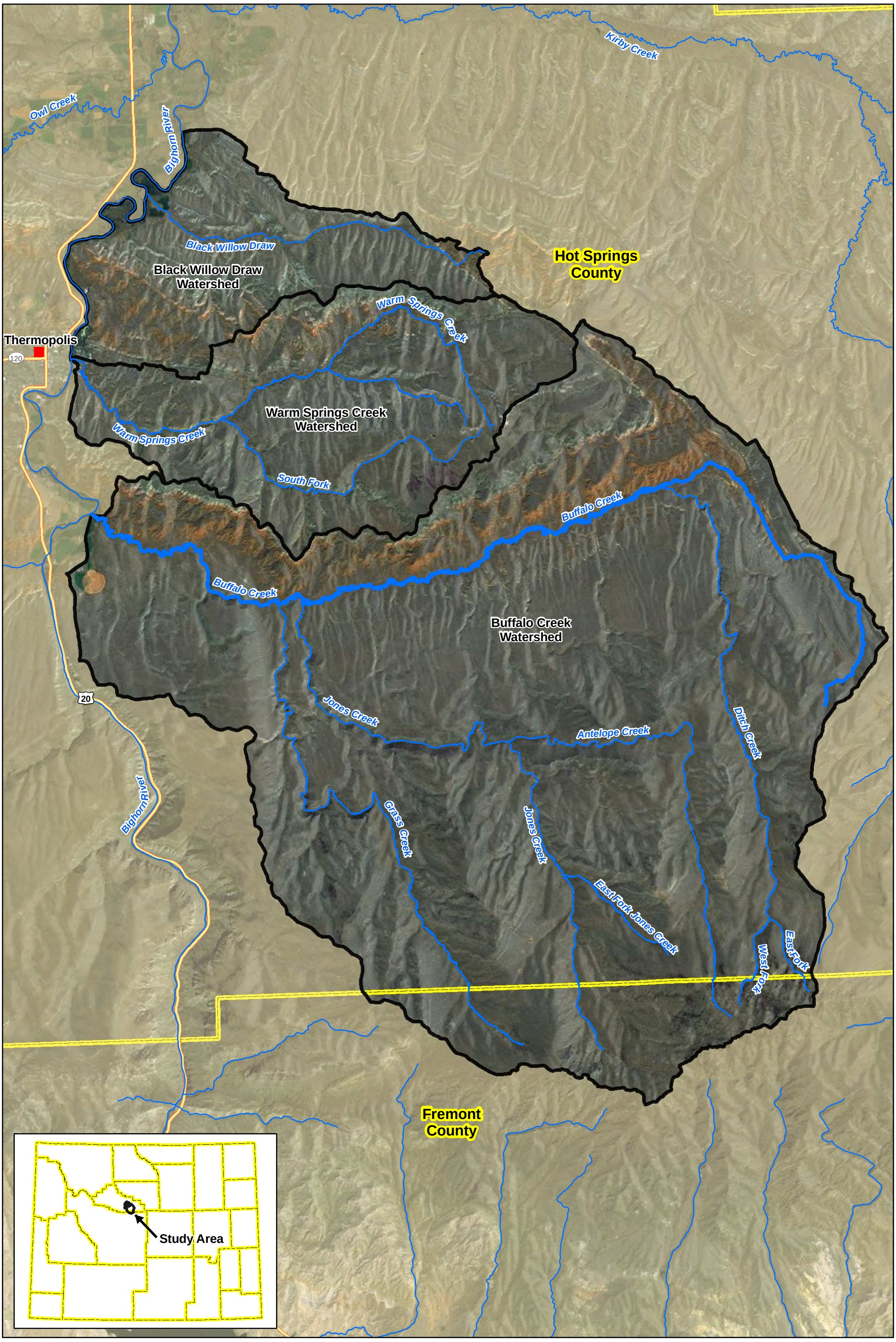


Figure 1.1 Buffalo Creek Watershed: Location Map

areas which may be deprived of adequate water supplies to optimize usage of upland resources. Many of the existing stock reservoirs have become filled with sediment and/or breached rendering them incapable of meeting their intended purpose

The Bureau of Land Management administers grazing allotments in the watershed through its Worland District office. Based upon data provided by the BLM, there are 31 individual allotments spanning the study area. Consequently, grazing can have a significant impact upon the condition and character of the watershed.

1.3 Purpose and Scope

The primary purposes of the Buffalo Creek Watershed, Level I Study are to:

- Inventory all conditions in the watershed relevant to identification and characterization of issues and opportunities related to water resource.
- Develop a watershed management and rehabilitation plan describing potential alternative projects and management strategies to address water resource related issues and potential water development opportunities identified in the watershed inventory.
- Assess the potential environmental issues or constraints that may affect the projects/strategies identified in the watershed management and rehabilitation plan, and identify and characterize the permits/clearances and any associated environmental studies and/or mitigation that may be required.
- Develop conceptual-level estimates of the costs of the potential projects identified in the watershed management and rehabilitation plan.
- Perform preliminary economic analyses of major project alternatives (i.e., dams and reservoirs), including assessment of project benefits and sponsor ability to pay, and identify and describe potential funding sources for all potential project types identified in the watershed management and rehabilitation plan.
- Compile and collate all of the spatial data available into a comprehensive Geographic Information System (GIS) to facilitate the completion of this project and also to be available as a resource for future studies.

II. PROJECT MEETINGS

2.1 Introduction

An integral part of the Buffalo Creek Watershed Study was the public outreach and involvement effort. This effort was initiated by the WWDO prior to Anderson Consulting Engineers, Inc. (ACE) being awarded the contract in June 2010.

Meetings were orchestrated by Anderson Consulting Engineers (ACE) and typically included informal presentations conducted by ACE staff and the Wyoming Water Development Office (WWDO). The objectives of the meetings were to:

- Obtain direction from landowners pertaining to the project;
- Obtain information and opinions of the public regarding their perspective on the watershed planning process;
- Provide guidance to landowners with respect to setting of goals; and
- Keep landowners informed of initial results and project progress.

Seven project meetings were held and included the following:

- Steering Committee Meeting 30-Jun-10
- Project Update Meeting 15-Sep-10
- Project Update Meeting 4-Nov-10
- Project Update Meeting 12-Dec-10
- Project Open House / Workshop 4-Apr-11
- Project Open House / Workshop 16-May-11
- Project Open House / Workshop 15-Nov-11

At each of the meetings, ACE representatives typically made presentations summarizing the status of the project and the next steps to be accomplished. The project GIS was demonstrated when appropriate to keep landowners up to date on the information which would ultimately be incorporated within it. Following each meeting, discussions and question and answer sessions were held.

In the later stages of the project as the watershed plan began to take shape, the meeting format changed to informal open houses/workshops where landowners were invited to drop in and discuss their proposed projects one on one with the project team.

2.2 Field Trips and "Tailgate Talks"

Field investigation efforts generally were held in coordination with scheduled meetings for efficiency. Specific field efforts targeted irrigation inventory, upland livestock/wildlife water opportunities, stream

channel conditions, hydrologic investigations (including establishment of temporary stream gages), and storage site investigations.

“Tailgate Talks” were informal discussions held whenever the opportunity arose. It is apparent that regardless of our familiarity with the area, local ranchers, irrigators, and residents generally have the best knowledge of the watershed. Through the interviewing process, the project team incorporated this knowledge and experience directly into the study. These informal interviews, often held spontaneously while in the field, have become dubbed "tailgate talks" and provide valuable insight into the overall assessment of the watershed.

III. WATERSHED DESCRIPTION AND INVENTORY

3.1 Introduction and Purpose

A considerable amount of information exists pertaining to the Buffalo Creek Study Area and its resources. The data spans a wide variety of disciplines and includes basin hydrology, water quality, land use and ownership, geology and soils, and agricultural practices as typical examples. The primary objective of the watershed inventory phase of this project was to accomplish the following objectives:

1. collect, review, and compile pertinent information regarding the study area;
2. collate the data in a single database; and
3. assess the data to characterize the watershed and facilitate identification of existing issues and development of improvements to the watershed.

3.2 Data Collection and Management

3.2.1 Collection of Existing Information

A significant amount of information and pertinent data were available from existing sources at the time this project was initiated. In an effort to collect and incorporate as much of this information as possible, the following sources were either contacted directly or information and documents procured via websites, libraries, or personal contacts:

- U.S. Bureau of Land Management (BLM)
- U.S. Geological Survey (USGS)
- U.S. Department of Agriculture/Natural Resources Conservation Service (NRCS)
- U.S. Department of Agriculture/Farm Service Agency (FSA)
- U.S. Environmental Protection Agency (EPA)
- U.S. Fish and Wildlife Service (FWS)
- Wyoming Water Development Commission (WWDC)
- Wyoming Department of Environmental Quality (WDEQ)
- Wyoming Game and Fish Department (WGFD)
- Wyoming State Engineer's Office (WSEO)
- Wyoming Oil and Gas Conservation Commission (WOGCC)
- Wyoming State Geological Survey (WSGS)
- Wyoming Board of Land Commissioners/State Lands and Investments Board (WBLC/SLIB)
- Wyoming Wildlife and Natural Resources Trust (WWNRT)
- Wyoming Geographic Information Science Center (WyGISC)
- Hot Springs County Assessor's Office
- Hot Spring Conservation District
- Hot Springs County Weed and Pest District

3.2.2 Geographic Information System

The results of the data collection efforts were incorporated into a comprehensive Geographic Information System (GIS). A GIS can be thought of as a powerful three- dimensional mapping tool that can be used to evaluate and compare spatial data pertaining to a wide range of topics. Numerous maps can be "stacked" to overlay information; each map, or "theme", incorporates data, or "attributes" pertaining to the theme. For instance, a theme showing location of irrigation ditches could also include numerical data pertaining to each ditch's irrigated acreage, improvements, problems, etc.

The Buffalo Creek watershed GIS was developed with the "clearinghouse" approach in mind. The GIS is intended to incorporate not only the spatial data pertaining to the watershed, but also analytical spreadsheets and documents. Figure 3.1 displays this approach graphically. The user can evaluate spatial data with the conventional GIS tools as well as linking to photographs, spreadsheets containing analytical tools and graphical representation of the various data, and the various documents prepared or collected in the course of this investigation.

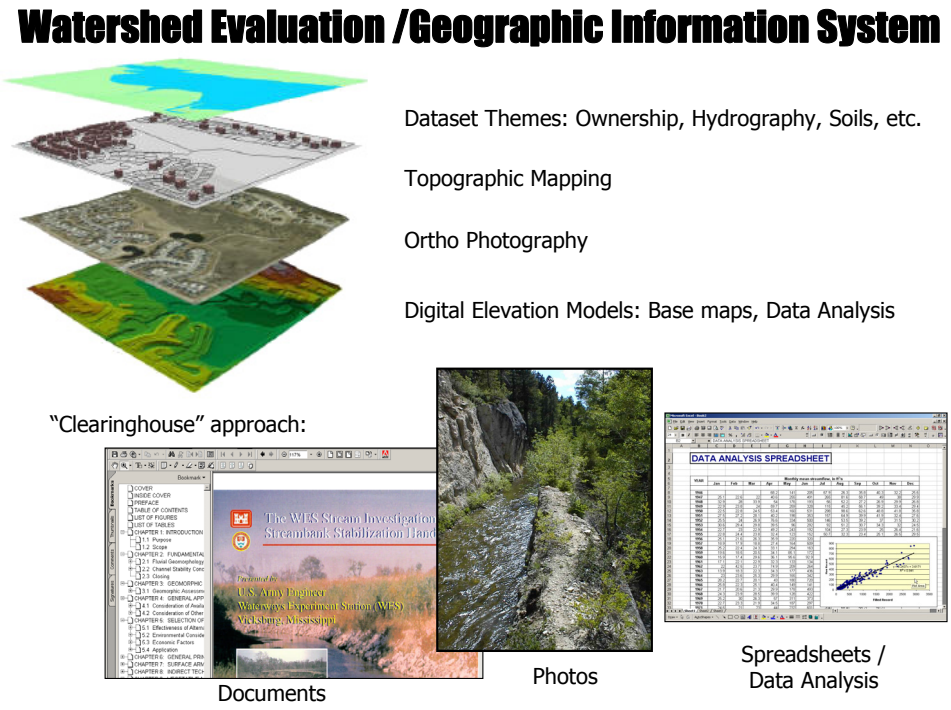


Figure 3.1 Example of the Buffalo Creek Watershed Study GIS Structure and "Clearinghouse" Capabilities.

Spatial data pertaining to the Buffalo Creek study area was collected from a wide range of sources. Agencies providing information included the State of Wyoming, USDI Bureau of Land Management, Wyoming Game and Fish Department, Hot Springs County, the USDA Natural Resources Conservation Service, and others. A significant amount of the information was also specifically developed during the

course of this investigation. Table 3.1 presents a list of the individual themes, maps, and aerial photographs which have been incorporated into the project GIS.

Table 3.1 Generalized GIS Contents.

Hydrology	**Irrigation**
Streams - Statewide	2007 Point of Diversion (POD)
Streams for Sinuosity - study area	Irrigated Land 2005 - Statewide
NPDES_Permits	Irrigated Lands ACE Generated
Watershed Boundary	**Land Management**
Subwatersheds Boundary	Land Management - BLM Surface Mangement - Statewide
SEO Wells 2009	BLM Allotments 2009 intersected to watershed area
National Wetlands Inventory (NWI) - Statewide	WY BLM Field Office Boundary- Statewide
Ace Fieldwork	Wilderness Study Areas - Statewide
Field Investigations - points	Mine Permit Boundaries - Statewide
Field Investigations - tracks	**Ownership**
Temporary Stream Gage Locations- tracks	Private Ownership-Hot Springs County
Temporary Stream Gage Locations- points	**Fish and Wildlife**
Political	Aquatic Habitat Priorities 2009 - Statewide
Cities - Statewide	Terrestrial Habitat Priorities 2009 - Statewide
County Boundaries - Statewide	Combined Habitat Priorities 2009 - Statewide
Public Land Survey System (PLSS)	Migration Barrier - Statewide (Antelope, Elk, Moose, Mule Deer, White Tail Deer)
UTM Zones	Crucial Range - Statewide (Antelope, Elk, Moose, Mule Deer, White Tail Deer)
BLM Data	Migration Routes - Statewide (Antelope, Elk, Moose, Mule Deer, White Tail Deer)
Miscellaneous regional data layers: leases, seeding, visual mgt. areas, etc.	Seasonal Range - Statewide (Antelope, Elk, Moose, Mule Deer, White Tail Deer)
Fences	Hunt Area Herd Unit Boundaries - Statewide (Antelope, Elk, Moose, Mule Deer, White Tail Deer)
Springs	Parturition Area - Statewide (Antelope, Elk, Moose, Mule Deer, White Tail Deer)
Proper Functioning Condition Data (PFC)	Bison Hunt Area Herd Unit Boundaries - Statewide
Oil and Gas	Black Bear Hunt and Management Areas - Statewide
Oil and Gas Wells-Wyoming Oil and Gas Conservation Commission (WOGCC)	Mountain Lion Hunt and Management Areas - Statewide
Gas Fields - ACE Generated	Sage Grouse Leks - Statewide
Infrastructure	Sage Grouse Core Areas - Statewide
Antenna - Countrywide	Sage Grouse Connectivity - Statewide
Cellular Tower - Countrywide	**Geology and soils**
Microwave Tower - Countrywide	Surficial Geology - Statewide
Roads	Bedrock Geology - Statewide
Transmission Lines -Statewide	Landslide Data WSGS - Statewide
Cultural	Dikes - Statewide
Cultural Sites Wyoming State Historic Preservation Office (SHPO)	Faults - Statewide
Landcover	250,000 Scale Soils - Statewide
Landfire -Existing Vegetation Type	Geologic Hazards
Landfire -Existing Vegetation Cover	**Watershed Management Plan**
Wyoming GAP Analysis - Statewide	Existing Upland Water Supply
Backgrounds	Proposed Upland Water Supply Project Points
Countywide Topographic Map mosaic	Existing Pipeline Systems
2009 NAIP Color Infra-red Imagery	Proposed Upland Water Supply Project Pipelines
2009 NAIP True Color Imagery	**Linked Data Resources**
USGS 10M DEM - Study Area	Photo points
Climate	Proposed Project Cost Estimates Spreadsheets
Western Regional Climate Center (WRCC) Cooperative Observer Program Sites	Temporary Stream Gage Data Spreadsheets
Rain Gauges (BLM)	Thermopolis Climatic Data Spreadsheet
Community Collaborative Rain, Hail & Snow Network Sites (CoCoRaHS)	
Average Annual Precipitation - Statewide	

The project GIS was used in the generation of a majority of the figures included in this report. It will be available as a resource for future investigations and a tool for watershed stakeholders to use during pursuit of permits, environmental analyses, mapping projects, etc. GIS software (ArcView 9.x) is required to view and utilize the data to the maximum of its potential. However, free 'shareware' data viewers (ArcExplorer) are available which enable the user limited capabilities to view the data. It must be kept in mind when using the shareware versions of the GIS software that certain data layers symbology will vary from what is presented in this report. Also, the shareware software may not be capable of simultaneously presenting data layers which were generated in different coordinate systems. Consequently, it may not be possible to view certain layers in the same field of view.

It is also important to note that data presented in the project GIS and within this report are subject to change with time as the agencies creating them continually update their databases. The user is

encouraged to obtain the most current data available to meet the needs of future endeavors utilizing the project GIS.

3.2.3 Digital Library

The Digital Library is a collection of documents, plats, maps, figures, spreadsheets, etc., pertaining to the project. Documents reviewed during the completion of this project were scanned and included in the Digital Library to the extent possible. Copyright protected documents were not included in the Library; however documents published by public agencies were included where feasible. The Digital Library consists of a spreadsheet listing the available documents and links to each; it can be searched or sorted depending upon the user's needs. Individual document files can be accessed via the Digital Library or directly by "browsing". Documents included in the Digital Library were obtained from the agencies listed in Table 3.2.

Table 3.2 Sources of Information Included in the Digital Library.

USDI Bureau of Land Management
USDA Natural Resource Conservation Service
United States Environmental Protection Agency
USDI United States Geologic Survey
Hot Springs Conservation District
Wyoming Department of Environmental Quality
Wyoming Department of Game and Fish
Wyoming Natural Diversity Database
Wyoming State Engineers Office
Wyoming Water Development Office
Miscellaneous

3.3 Land Uses and Activities

3.3.1 Land Ownership

The total land area within the project study area is over 111,839 acres (174.8 square miles). Figure 3.2 presents a map indicating the various land ownership categories within the watershed. The study area lies primarily within Hot Springs County (164.2 square miles or 94.0 percent) with a small portion within Fremont County 10.7 square miles or 6.0 percent) as indicated in Figure 3.3.

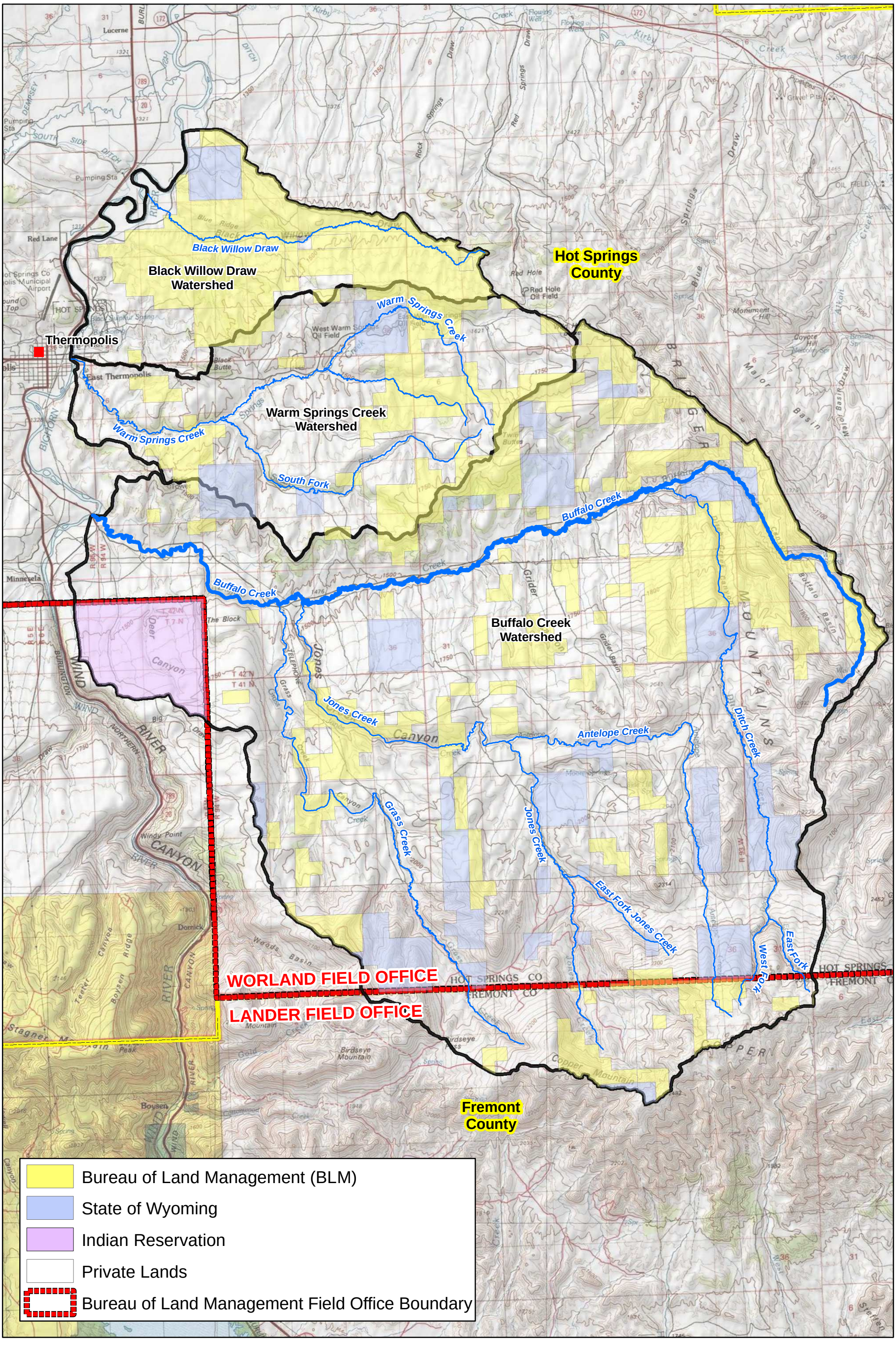


Figure 3.2 Buffalo Creek Watershed: Land Ownership

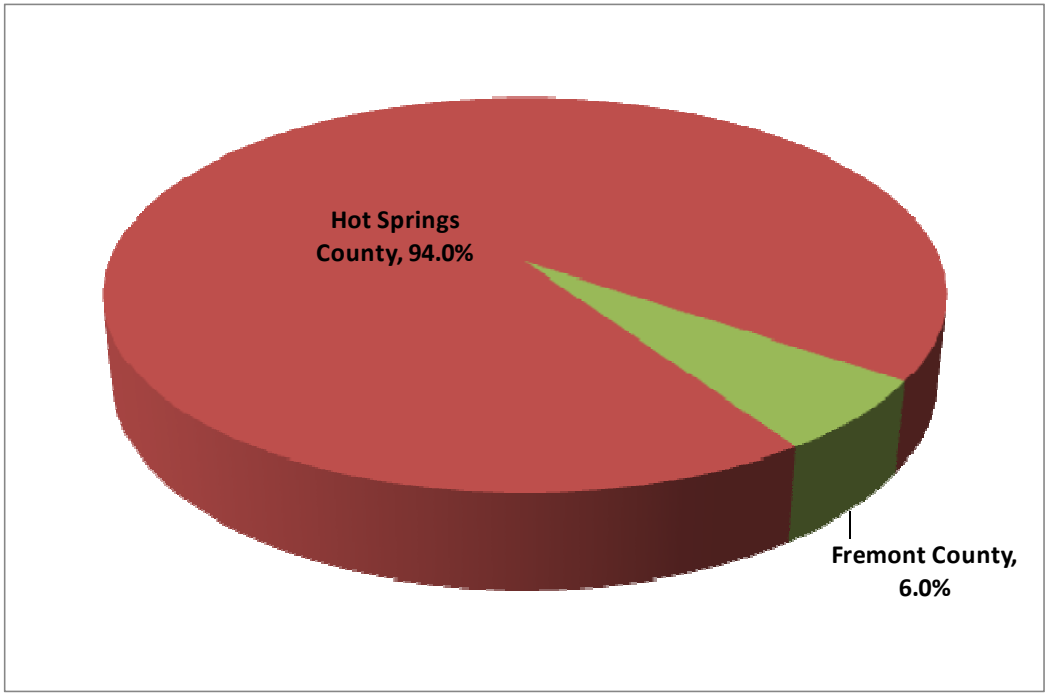


Figure 3.3 Distribution of Study Area among Counties.

Land ownership information was obtained from the Hot Springs County and Fremont County Assessors' offices and incorporated into the project GIS. The largest portion of these lands is deeded property held by relatively small number of landowners. According the assessor's office data, approximately 109.1 square miles (62.4 percent) of the study area are privately owned. The second largest land owner is the federal government with approximately 43.9 square miles (25.1 percent) managed by the Bureau of Land Management. The State of Wyoming (17.5 square miles or 10.0 percent) and the Bureau of Indian Affairs (4.2 square miles or 2.4 percent) round out the surface ownership within the study area. A pie chart displaying the relative percentage of land ownership within the watershed is presented as Figure 3.4

3.3.2 Transportation, Energy and Communications Infrastructure

Transportation corridors within the study area are extremely limited. The only improved roads are Buffalo Creek road which connects State Highway 20 to Kirby Creek Road and Warm Springs Road which connects Thermopolis with the Warm Springs Oil Field. There are no improved roads within the Black Hollow Draw watershed. All remaining roads are unimproved and of varying quality. Access is difficult throughout most of the study area during winter or wet conditions.

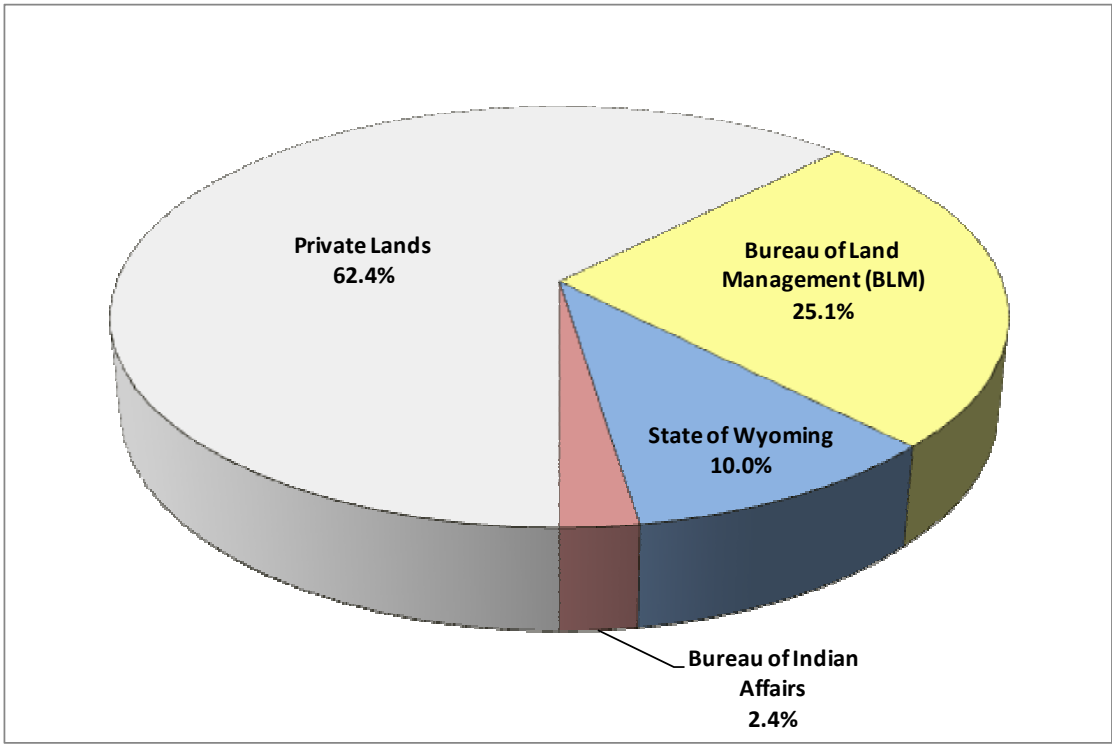


Figure 3.4 Distribution of Land Ownership within the Buffalo Creek Study Area.

Several electric transmission lines cross the area. Mapping of the lines provided by WyGISC is coarse in nature with poor accuracy; presumably for security reasons. Consequently, the lines indicated on Figure 3.5 are approximations of alignment only.

3.3.3 Irrigation

Irrigation activities are extremely limited in the study area. Based upon information provided by the WSEO water rights tabulation, there are approximately 922.55 acres within the study area with irrigation rights. Table 3.3 tabulates the water rights within the project study area. The majority of these lie within the Buffalo Creek drainage (865.55 acres) with the remainder in the Warm Springs Creek drainage (57.0 acres). There were no water rights with irrigation as a permitted use within the Black Willow Draw basin. Figure 3.6 displays the mapping of irrigated acres in the vicinity of the project areas as delineated by the Wind/Bighorn Basin Planning Study. As indicated in this figure, there were very few acres (approximately 400) delineated during that effort within the project area. Those that were delineated appear to be associated with the Bighorn River and not tributaries in the Buffalo Creek watershed study area.

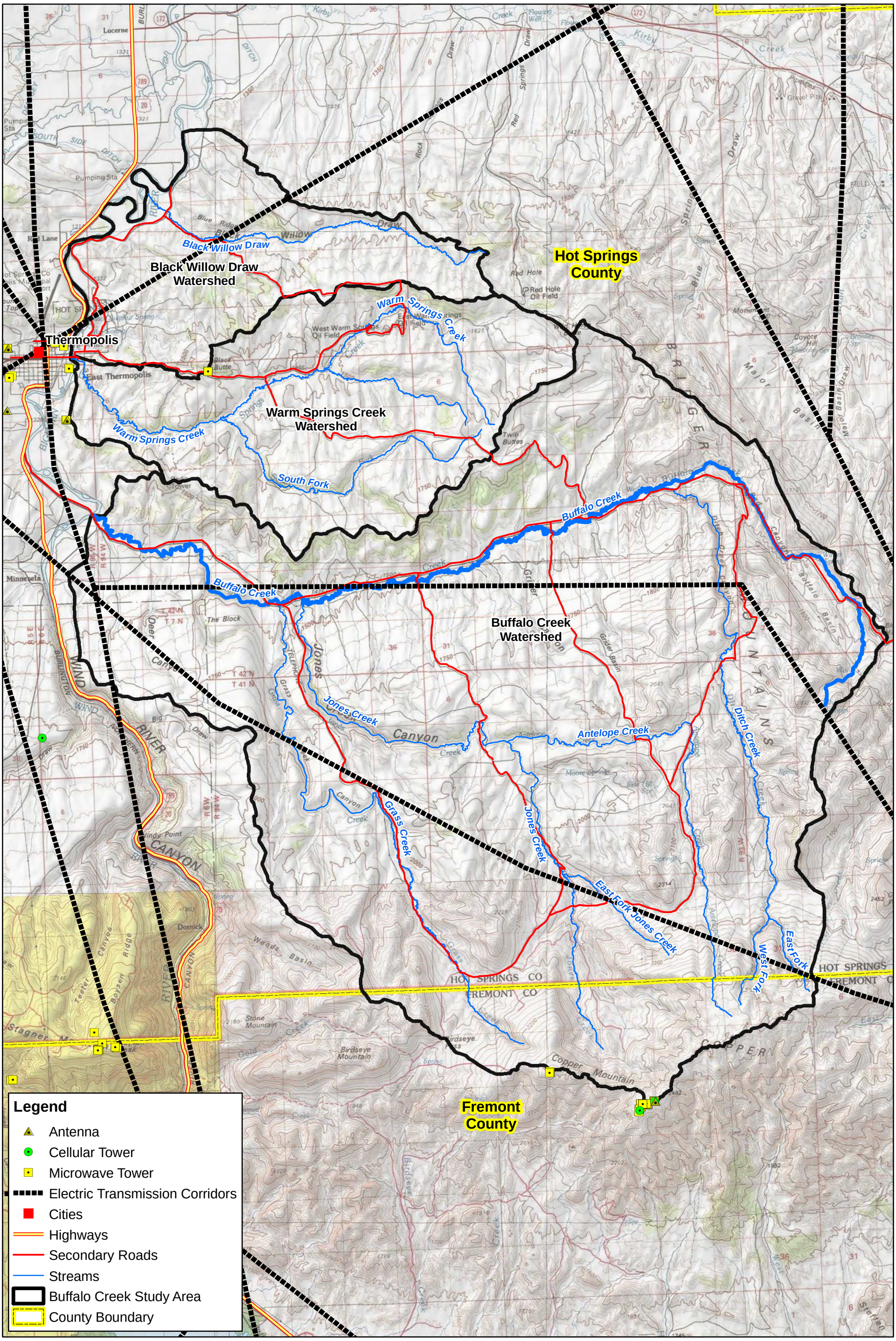


Figure 3.5 Buffalo Creek Watershed: Communications and Transportation

Table 3.3 Tabulation of Surface Water Rights within the Buffalo Creek Watershed Study Area

Basin	Stream Name	Permit No.	Ditch Name	Priority Date	Permitted Use	Allocation		Headgate Location
						CFS	Acres	(Sec, Twn, Rng)
Buffalo Creek Drainage	Buffalo Creek	3034	red Cliff	2/14/1901	I	0.36	25	13-42-093
		3690	Harrison	1/31/1902	I	0.31	22	30-42-093
		16756	Arneson	4/17/1923	D,I,S	0.57	39.8	21-42-093
	Spring (21-42-94)	13858	Haynes	10/27/1915	I	0.06	4	21-42-094
	Grass Creek	3686	Cross No. 2	1/28/1902	I	0.31	22	24-42-094
		3689	Cross	1/31/1902	I	1.6	112	31-41-093
		3702	Sherman	2/3/1902	I	0.21	15	31-41-093
		11924	E.J.R. No. 1	7/12/1913	D,I,S	0.42	29.75	1-40-094
	Spring (27-41-94)	14893	Baker	7/9/1917	I	0.05	3.5	27-41-094
	Jones Creek	2689	Saint John	7/3/1900	I	1.07	75	27-41-093
		11184	Brenner No. 1	2/26/1912	I	0.78	55	4-40-093
		11185	Brenner No. 2	2/26/1912	I	0.07	5	4-40-093
		11455	Asbiorn	8/15/1912	D,I,S	0.16	11	10-40-093
	Antelope Creek	8606	Kitchings	8/14/1908	I	1.26	88.5	11-41-093
		12850	Hale	11/21/1914	I	0.64	45	11-41-093
	East Fork Jones Creek	8337	Osborne no. 1	4/1/1908	I	0.43	30	9-40-093
	West Fork Jones Creek	8338	Osborne No. 2	4/1/1908	I	0.64	45	9-40-093
	Ditch Creek	2025	Maine	1/14/1889	I	1	70	12-41-093
		2028	Hank	1/23/1899	I	0.21	15	12-41-093
		2028	Hank	1/23/1899	I	0.54	38	12-41-093
		3110	T.4	4/4/1901	I	1.3	97	14-42-093
		3110	T.4	4/4/1901	I	0.26	18	14-42-093
Warm Springs Drainage	Warm Springs	6826	Scott	6/22/1905	I	0.08	6	31-43-093
		10637	Chase	4/26/1911	D,I,S	0.2	14.3	8-42-094
		10637	Chase	4/26/1911	I	0.09	6.5	8-42-094
		3656E	Enl. Chase	7/6/1916	D,I,S	0.14	10.2	8-42-094
	Spring	8216	Maret	10/25/1907	I	0.29	20	3-42-094
						Total	**922.55**	

The discrepancy between permitted acreage and mapped acreage appears to be an artifact of the location and type of irrigation. Within the project study area, only one landowner appears to be irrigated cultivated crops or cutting hay. Review of aerial photography with respect to the permitted headgate locations indicates that the majority of irrigated acres consist of narrow strips of irrigated pasture within riparian corridors. Consequently, mapping efforts may have excluded these areas. In addition, some headgates on Buffalo Creek appear to have been rendered unusable due to incision of Buffalo Creek. Figure 3.7 displays a headgate located on Buffalo Creek which is no longer capable of diverting flows. The length of time the headgate has been unusable isn't known, however, based upon age of vegetation in the existing streambed it has been many years. Consequently, irrigated acres associated with this headgate,

Figure 3.7 Inoperable Irrigation Headgate on Buffalo Creek.

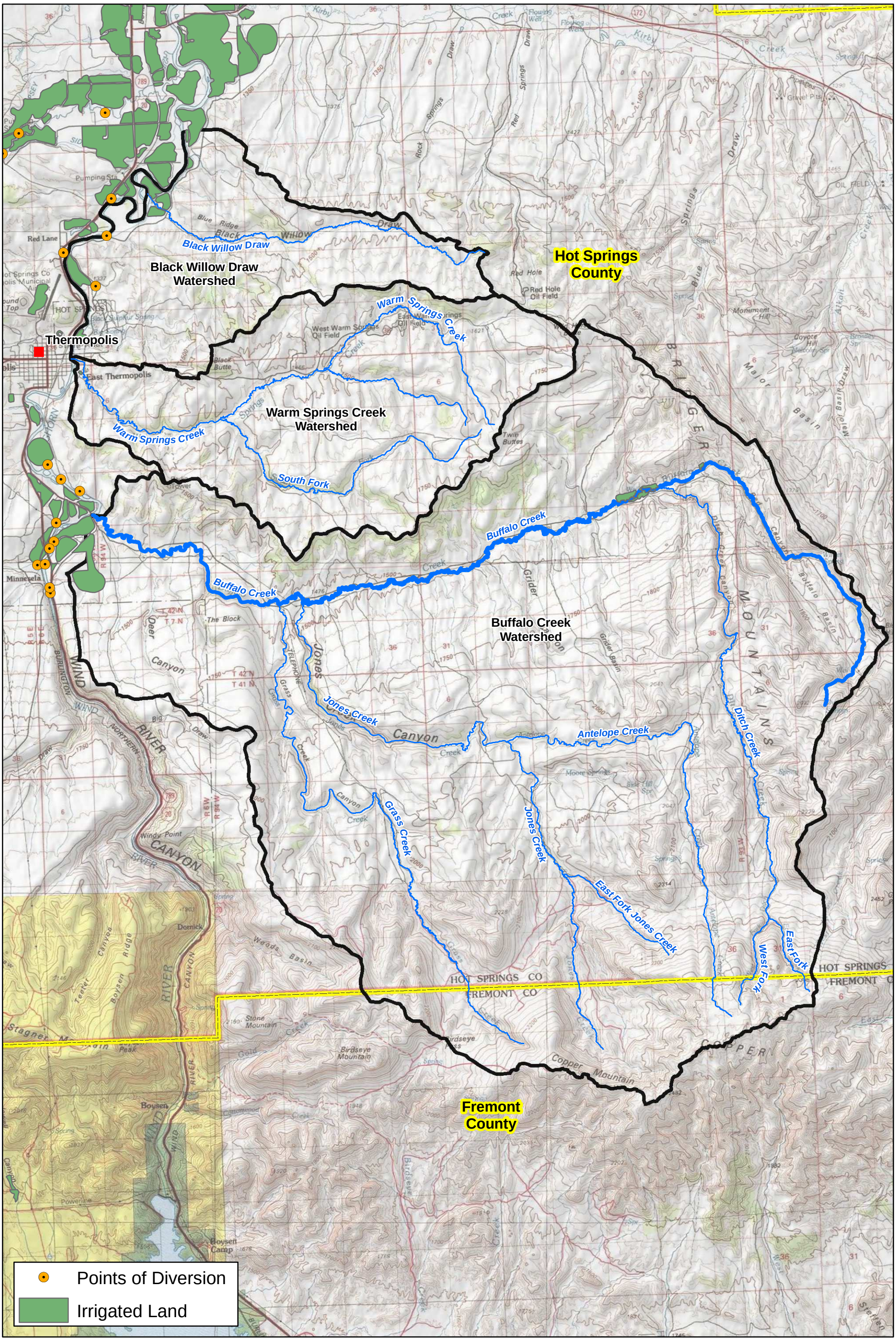


Figure 3.6 Buffalo Creek Watershed: Irrigated Acres

and others, have not been irrigated in many years and may have also been excluded from irrigated lands mapping. The headgate invert lies approximately three feet above the current bed elevation of Buffalo Creek.

3.3.4 Range Conditions/Grazing Practices

3.3.4.1 Grazing Allotments Administration

Grazing on federal lands within the study area watershed is administered by the Bureau of Land Management. The BLM-administered allotments typically include intermingled private, state, and federally-administered lands used for grazing. Figure 3.8 displays the grazing allotments found within the study area. Based upon information collected from the BLM, there are 28 individual allotments within the study area. Note that some of these allotments may be located primarily in adjacent watersheds and "spill" over the watershed divide. Table 3.4 lists the allotments and pertinent data associated with them. It is important to note that the BLM allotments represent a management area and do not imply ownerhip.

Under the umbrella of the Washakie Resource Management Plan, management of grazing allotments are prioritized based on the classification of the allotments into one of three management categories; Improve (I), Maintain (M), and Custodial (C). These categories broadly define management objectives of the BLM-administered public lands in the allotment (BLM, 2008).

Table 3.4 Buffalo Creek Watershed: BLM Grazing Allotments.

Allotment Number	Allotment Name	Acres
135	AXTELL DITCH CREEK	1,274
518	HOME PLACE	1,737
547	RED FARM	1,528
565	RED HOLE	1,347
592	WILD HORSE BUTTE	4,346
602	ROCK SPRINGS DRAW	6,717
624	BLACK WILLOW DRAW	7,429
631	DITCH CREEK	3,488
649	MARET	1,142
658	RED SPRINS	2,289
659	BLACK WILLOW	2,020
1347	LFO, JONES CREEK BASIN	7,610
1373	LFO, COPPER MOUNTAIN	2,719
2018	WARM SPRINGS	6,244
2019	HAZAEN DRAW	1,306
2503	GRIDER BASIN	14,713
2506	DYE	6,138
2515	EAST FORK JONES CREEK	3,109
2516	WOOD'S BASIN	2,133
2525	JONES CREEK MTN	5,485
2529	JONES CREEK	1,932
2530	NEILSON	2,181
2536	BLUE HILL	3,914
2538	JONES CREEK BASIN	14,465
2541	M.F. WARM SPRINGS	399
2546	MAJOR BASIN	6,207
2552	TWIN BUTTES	10,345
2554	REED CREEK	4,610

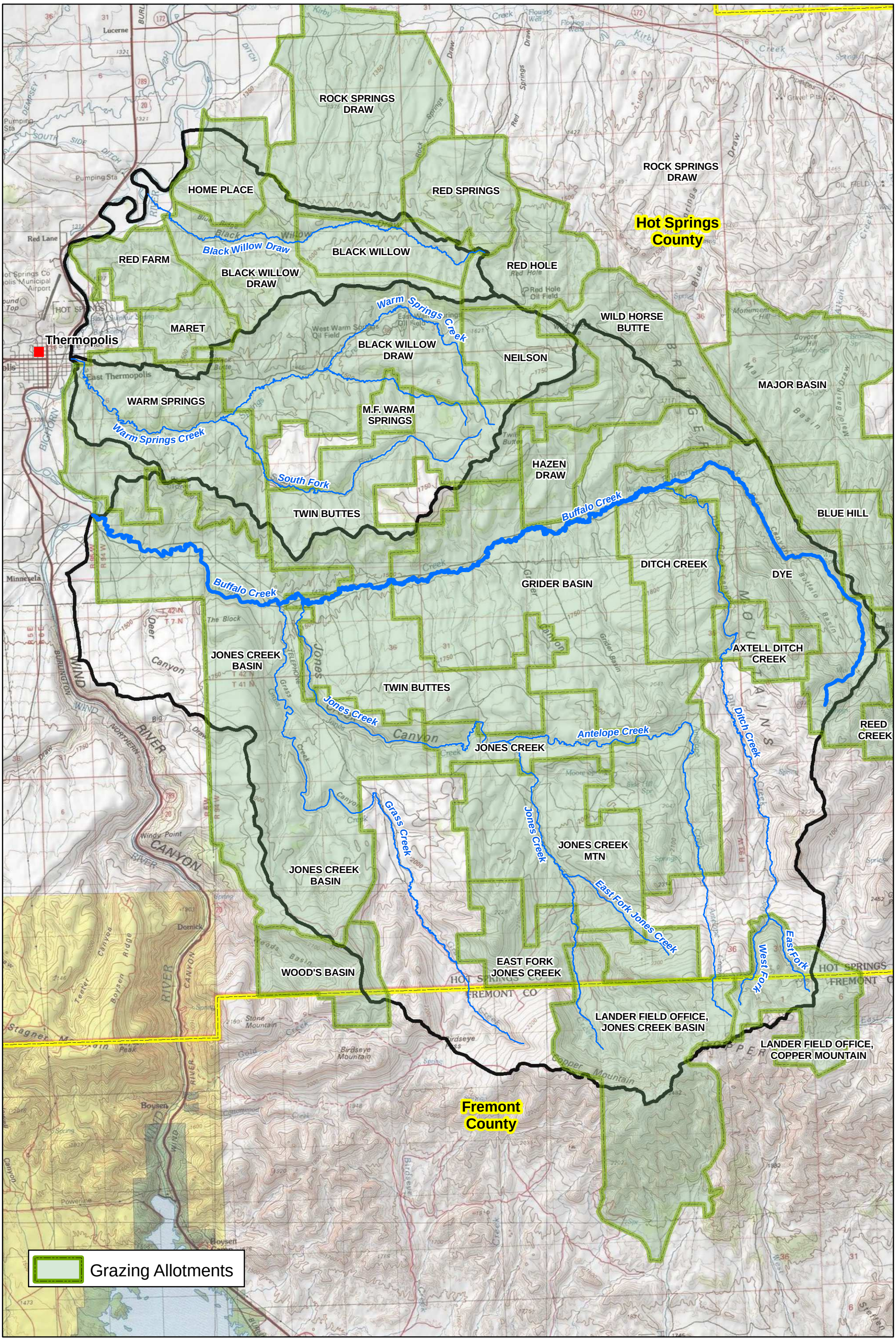


Figure 3.8 Buffalo Creek Watershed: Grazing Allotments

Livestock grazing is managed in accordance with the principles of multiple use and sustained yield embodied in the Federal Land Policy and Management Act (1976) and the Taylor Grazing Act (1934). BLM's specific objectives and procedures for managing livestock grazing are contained in the agency's grazing regulations. BLM's grazing regulations were revised in 1995 to ensure that livestock grazing is conducted in a manner that will sustain or improve the fundamental ecological health of public rangelands.

Grazing on BLM lands to meet these requirements is managed under the Standards for Healthy Rangelands and Guidelines for Livestock Grazing Management for the Public Lands Administered by the BLM in the State of Wyoming (BLM, 2007). Among the full suite of grazing management guidelines, those most applicable to this watershed study are summarized as follows:

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

A set of six standards have been established to meet the above guidelines (BLM, 2007). Each standard sets a specific objective, explains the function and importance of the objective, and provides indicators to assess the attainment of the objective. Implementation of appropriate range management practices and/or improvements is carried out under an activity or implementation plan, including allotment management plans (AMPs).

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

Grazing on Private Lands. Grazing practices on private lands are established by the landowner, often with technical assistance from the local NRCS staff and/or a range consultant. Range improvement projects implemented under NRCS program (e.g., EQIP or PL566) follow the guidelines established in

the plan of operations developed for the property and/or applicable NRCS technical guidelines as adapted for local conditions.

3.3.4.2 Existing Water Supply

Numerous upland water supply sources currently exist within the study area. Within the Buffalo Creek watershed, several range improvement projects have been completed which utilize the perennial stream reaches on Copper Mountain and pipe it to drier areas lacking adequate water supplies. Typical projects include livestock/wildlife water tanks and/or livestock/wildlife reservoirs. Water supply sources include not only the perennial streams but also several springs have been developed as water sources as well. The Warm Springs Creek and Black Willow Draw basins are drier and consequently, water sources are more limited. In this portion of the study area, perennial sources are limited and upland water supply relies to a greater extent upon development of springs and upon groundwater wells.

Mapping of existing sources was completed to provide valuable information for completion of the watershed management plan. Mapping of stock reservoirs, springs, and guzzlers was initially obtained from the Worland Field Office of the BLM. Due to the relatively limited extent of federal ownership in the study area, the mapping provided by the BLM provided limited information. Interviews with landowners were conducted during project workshops, in the field, and at their homes. During these interviews, locations of existing sources were documented and the information incorporated into the project GIS. Not all landowners participated in the project; consequently, the mapping is not expected to be an exhaustive accounting of all available sources. However, the information provides a starting point upon which to evaluate the watershed. In addition, aerial photography was reviewed within the GIS environment to document visible features (i.e. stock reservoirs).

This mapping indicated the presence of 107 stock reservoirs. Mapping of springs was augmented with digitized locations from USGS topographic mapping. Field inspection of the sites was beyond the scope and budget of this project, however, a reasonable estimate of the viability of the reservoirs was needed. Based upon those reservoirs which were encountered in the field and interviews with landowners, it is obvious that many of the reservoirs have either failed or have filled with sediment and are no longer viable sources of livestock and wildlife water.

Using the project GIS, mapping of the reservoirs sites was overlain on recent high resolution aerial photography. Each reservoir was examined in the GIS to determine its status at the time of the photography (2009). Those containing water were determined to be viable sources. Physical breaches were visible on many of the reservoirs resulting in a classification of “non-viable”. Likewise, many were visibly filled with sediment and also classified as “non-viable”. Others were simply empty and firm conclusions could not be drawn. These sites could have been dry at the time of the photography but remain viable sources following precipitation events. Figure 3.9 displays an example of this process.

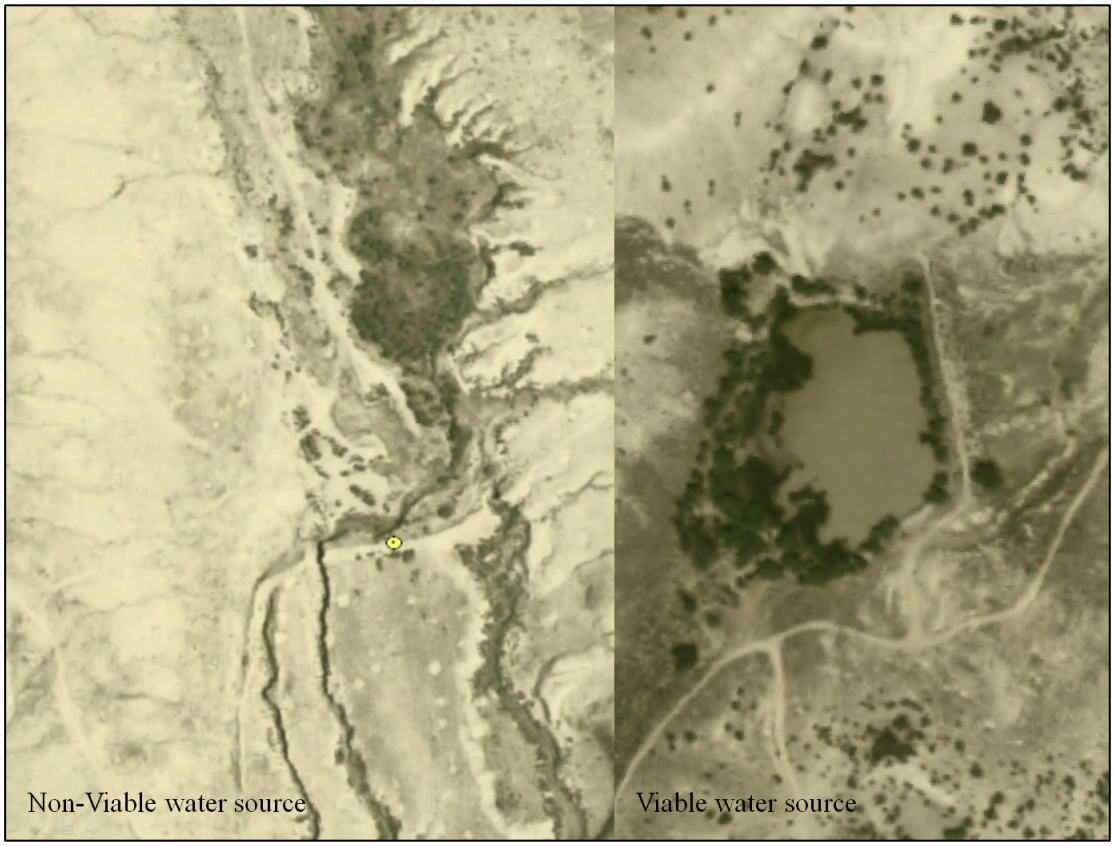


Figure 3.9 Evaluation of Stock Ponds in the Project GIS Environment

Figure 3.10 displays a map of the watershed showing the results of this classification. Based upon this analysis, it appears that a minimum of 72 remain viable water sources. This analysis also indicates that 35 are either breached, sediment filled, or in need of site visits to determine their status.

3.3.4.3 Ecological Site Descriptions

The concept of "Ecological Sites" is described by the NRCS as follows:

> "A *distinctive kind of land with specific soil and physical 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 Site Descriptions (ESDs) are reports available from the NRCS that describe the following for each Ecological Site:

- **Site Characteristics:** Identifies the site and describes the physiographic, climate, soil, and water features associated with the site.

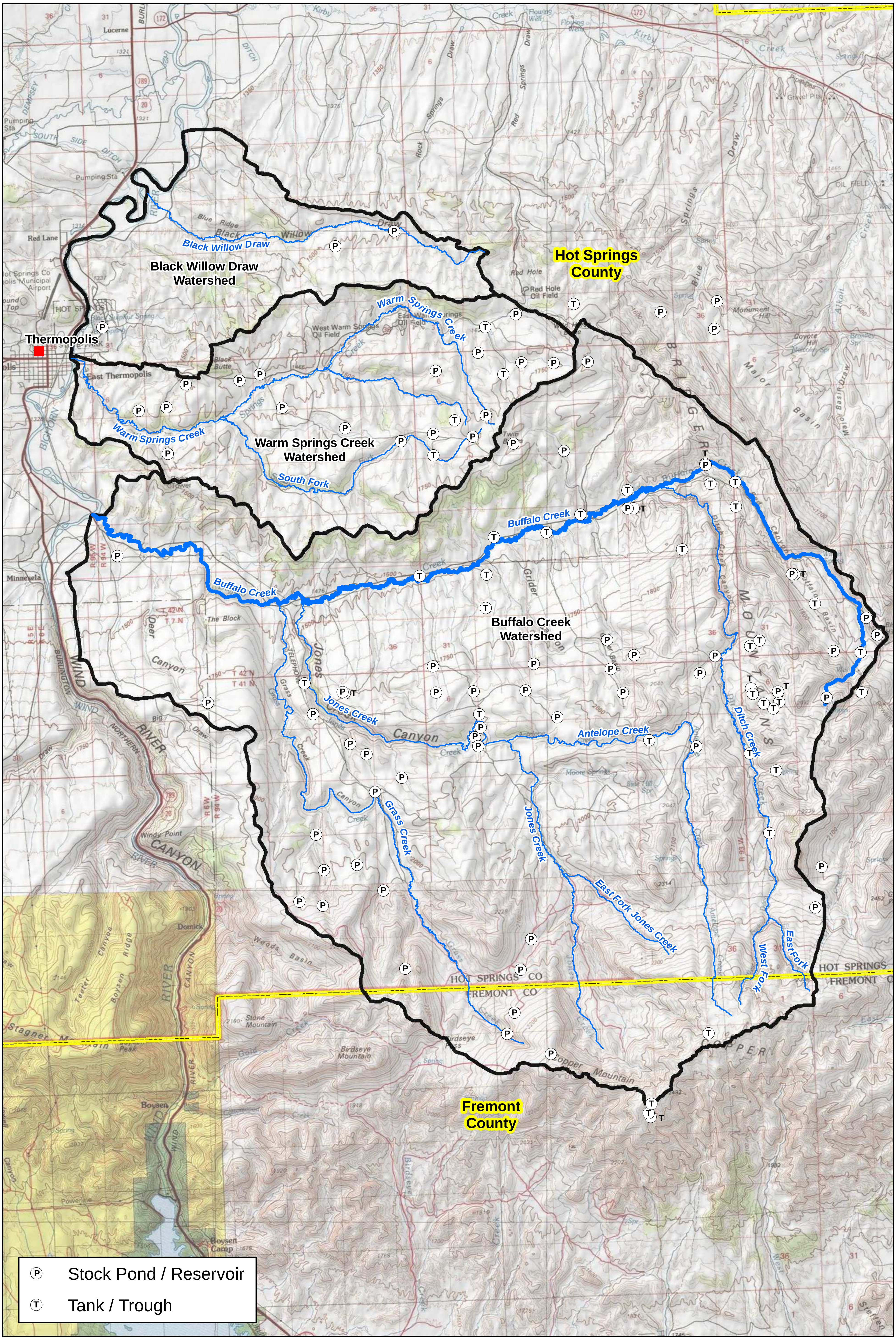


Figure 3.10 Buffalo Creek Watershed: Existing Upland Water Sources

- **Plant Communities**: Describes the ecological dynamics and the common plant communities comprising the various vegetation states of the site. The disturbances that cause a shift from one state to another are also described.
- **Site Interpretations:** Interpretive information pertinent to the use and management of the site and its related resources.
- **Supporting Information**: Provides information on sources of information and data utilized in developing the site description and the relationship of the site to other ecological sites (NRCS, 2009).

More information regarding ESDs and their application is available at: http://esis.sc.egov.usda.gov/ESIS/About.aspx.

The ESDs can be used to compare what is growing on the rangeland with what each site is capable of growing. By comparing the present vegetative composition to the potential compositions, the relative health of the range resource can be evaluated. Production of each site is closely related to the ecological condition of the site. Ecological Sites are defined based upon their location within defined Ecological Precipitation Zones and soil characteristics. Figure 3.11 displays the ecological precipitation zones found in the Study Area.

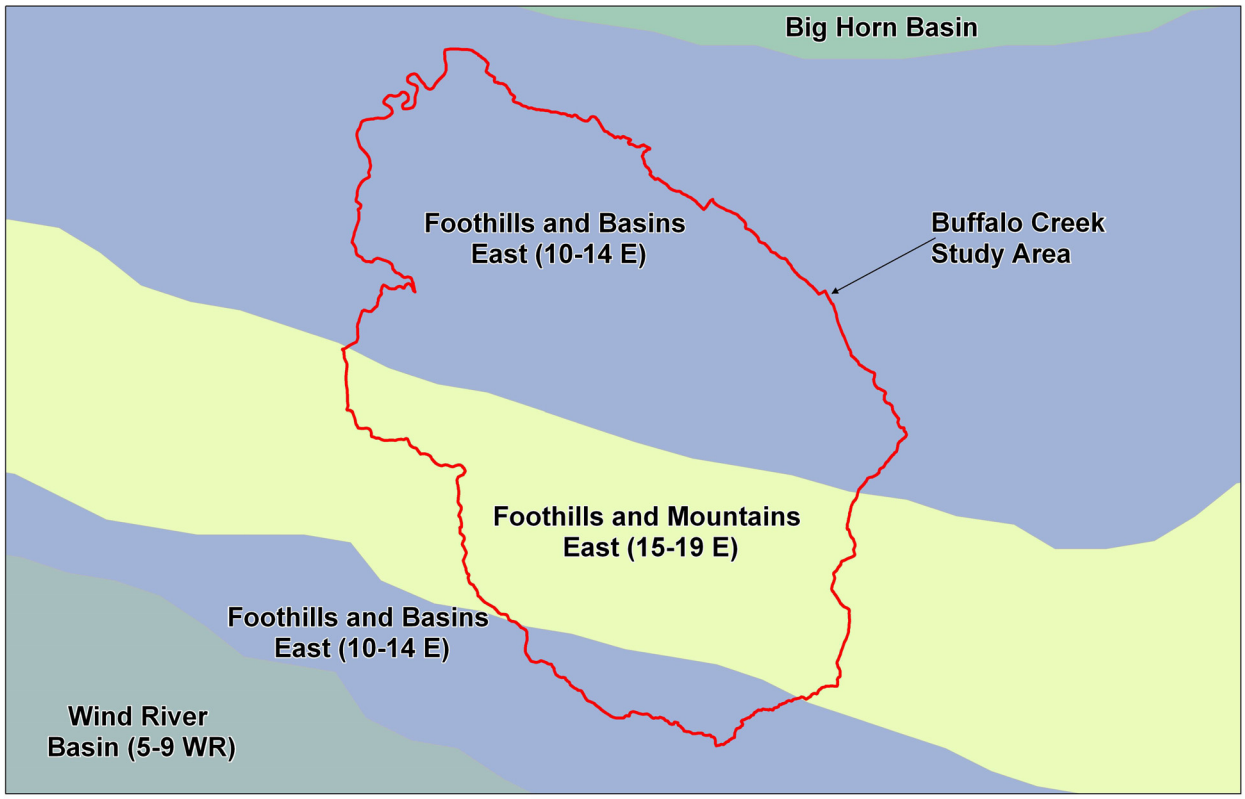


Figure 3.11 Ecological Precipitation Zones.

Using database tools provided by the NRCS, the available soils mapping was evaluated and Ecological Sites defined within the study area. Unfortunately, detailed soils mapping was not available within the study area. The NRCS assigns its detailed soils mapping (1:24,000 scale) pertinent attributes, including the ESD. In this case, the 1:24,000 scale mapping was available only for Fremont County which comprises only 6 percent of the study area. Consequently, the broader scale general soils mapping (1:250,000) was attributed with anticipated ESDs based upon soils encountered.

Ecological Sites are defined based upon their location within defined Ecological Precipitation Zones and soil characteristics. Using database tools provided by the NRCS, the available soils mapping was evaluated and Ecological Sites defined within the study area. Figure 3.12 displays their generalized location within the study area.

Table 3.5 lists the various Ecological Sites which are found within each of the two precipitation zones found in the study area. Due to the lack of detailed soils mapping, delineation of these ecological sites is not feasible at this time. However, based upon field observations and information provided by the Hot Springs Conservation District, there are several which are understood to be predominant. These ecological sites would be:

- Loamy 10-14 inch precipitation zone, East
- Sandy 10-14 inch precipitation zone, East
- Loamy 15-19 inch Foothills and Mountains East
- Shallow loamy 15-19 inch Foothills and Mountains East

The following descriptions of the Historic Climax Plant Communities (HCPC) associated with these ESDs are extracted from the NRCS descriptions (NRCS, 2008).

Loamy 10-14 inch Precipitation Zone East

Potential vegetation on this site is dominated by mid cool-season perennial grasses. Other significant vegetation includes winterfat, big sagebrush, and a variety of forbs. The expected potential composition for this site is about 75% grasses, 10% forbs and 15% woody plants. The composition and production will vary naturally due to historical use, fluctuating precipitation and fire frequency.

As this site deteriorates species such as blue grama, Sandberg bluegrass, and big sagebrush will increase. Plains pricklypear and weedy annuals will invade. Cool-season grasses such as Griffiths and bluebunch wheatgrass, rhizomatous wheatgrasses, needleandthread, and Indian ricegrass will decrease in frequency and production.

Big sagebrush may become dominant on areas with an absence of fire and sufficient amount of precipitation. Wildfires are actively controlled in recent times and as a resulted old decadent stands of big sagebrush persist. Chemical control using herbicides has replaced the historic role of fire on this site. Recently, prescribed burning has regained some popularity.

Foothills and Basins East (10-14 inch)	
Identifier	**Predominant Site**
R032XY322WY	Loamy (Ly) 10-14" East Precipitation Zone
R032XY350WY	Sandy (Sy) 10-14" East Precipitation Zone
R032XY362WY	Shallow Loamy (SwLy) 10-14" East Precipitation Zone
R032XY376WY	Very Shallow (VS) 10-14" East Precipitation Zone

Hot Springs County

Black Willow Draw

Black Willow Draw Watershed

Thermopolis

Warm Springs Creek

Foothills and Basins East (10-14 E)

Warm Springs Creek Watershed

Warm Springs Creek

South Fork

Buffalo Creek

Buffalo Creek

Buffalo Creek Watershed

Foothills and Mountains East (15-19 inch)	
Identifier	**Predominant Site**
R043BY322WY	Loamy (Ly) 15-19” Foothills and Mountains East Precipitation Zone
R043BY350WY	Sandy (Sy) 15-19” Foothills and Mountains East Precipitation Zone
R043BY362WY	Shallow Loamy (SwLy) 15-19” Foothills and Mountains East Precipitation Zone
R043BY366WY	Shallow Sandy (SwSy) 15-19” Foothills and Mountains East Precipitation Zone
R043BY376WY	Very Shallow (VS) 15-19” Foothills and Mountains East Precipitation Zone

Antelope Creek

Ditch Creek

Jones Creek

East Fork Jones Creek

Foothills and Mountains East (15-19 E)

Foothills and Basins East (10-14 E)

Fremont County

Foothills and Basins East (10-14 inch)	
Identifier	**Predominant Site**
R032XY322WY	Loamy (Ly) 10-14" East Precipitation Zone
R032XY350WY	Sandy (Sy) 10-14" East Precipitation Zone
R032XY362WY	Shallow Loamy (SwLy) 10-14" East Precipitation Zone
R032XY376WY	Very Shallow (VS) 10-14" East Precipitation Zone

N W E S

0 8,500 17,000

Feet

Legend

- Cities
- Streams
- Buffalo Creek Study Area
- County Boundary

Figure 3.12 Buffalo Creek Watershed: Predominant Ecological Sites of Management Relevance

Table 3.5 Ecological Sites Potentially Encountered within the Buffalo Creek Watershed Study Area.

Identifier	Type	MLRA	Site Name
Foothills and Basins East (10-14 inch)			
R032XY304WY	Range	032X	Clayey (Cy) 10-14" East Precipitation Zone
R032XY306WY	Range	032X	Clayey Overflow (CyO) 10-14" East Precipitation Zone
R032XY308WY	Range	032X	Coarse Upland (CU) 10-14" East Precipitation Zone
R032XY312WY	Range	032X	Gravelly (Gr) 10-14" East Precipitation Zone
R032XY322WY	Range	032X	Loamy (Ly) 10-14" East Precipitation Zone
R032XY328WY	Range	032X	Lowland (LL) 10-14" East Precipitation Zone
R032XY330WY	Range	032X	Overflow (Ov) 10-14" East Precipitation Zone
R032XY338WY	Range	032X	Saline Lowland (SL) 10-14" East Precipitation Zone
R032XY340WY	Range	032X	Saline Lowland, drained (SLdr) 10-14" East Precipitation Zone
R032XY342WY	Range	032X	Saline Subirrigated (SS) 10-14" East Precipitation Zone
R032XY344WY	Range	032X	Saline Upland (SU) 10-14" East Precipitation Zone
R032XY350WY	Range	032X	Sandy (Sy) 10-14" East Precipitation Zone
R032XY354WY	Range	032X	Shale (Sh) 10-14" East Precipitation Zone
R032XY358WY	Range	032X	Shallow Clayey (SwCy) 10-14" East Precipitation Zone
R032XY362WY	Range	032X	Shallow Loamy (SwLy) 10-14" East Precipitation Zone
R032XY366WY	Range	032X	Shallow Sandy (SwSy) 10-14" East Precipitation Zone
R032XY374WY	Range	032X	Subirrigated (Sb) 10-14" East Precipitation Zone
R032XY376WY	Range	032X	Very Shallow (VS) 10-14" East Precipitation Zone
R032XY378WY	Range	032X	Wetland (WL) 10-14" East Precipitation Zone
Foothills and Mountains East (15-19 inch)			
R043BY304WY	Range	043B	Clayey (Cy) 15-19" Foothills and Mountains East Precipitation Zone
R043BY308WY	Range	043B	Coarse Upland (CU) 15-19" Foothills and Mountains East Precipitation Zone
R043BY316WY	Range	043B	Igneous (Ig) 15-19" Foothills and Mountains East Precipitation Zone
R043BY322WY	Range	043B	Loamy (Ly) 15-19" Foothills and Mountains East Precipitation Zone
R043BY330WY	Range	043B	Overflow (Ov) 15-19" Foothills and Mountains East Precipitation Zone
R043BY350WY	Range	043B	Sandy (Sy) 15-19" Foothills and Mountains East Precipitation Zone
R043BY358WY	Range	043B	Shallow Clayey (SwCy) 15-19" Foothills and Mountains East Precipitation Zone,
R043BY360WY	Range	043B	Shallow Igneous (Swlg) 15-19" Foothills and Mountains East Precipitation Zone
R043BY362WY	Range	043B	Shallow Loamy (SwLy) 15-19" Foothills and Mountains East Precipitation Zone
R043BY366WY	Range	043B	Shallow Sandy (SwSy) 15-19" Foothills and Mountains East Precipitation Zone
R043BY374WY	Range	043B	Subirrigated (Sb) 15-19" Foothills and Mountains East Precipitation Zone
R043BY376WY	Range	043B	Very Shallow (VS) 15-19" Foothills and Mountains East Precipitation Zone
R043BY378WY	Range	043B	Wetland (WL) 15-19" Foothills and Mountains East Precipitation Zone

Due to the amount and pattern of the precipitation, the big sagebrush component may not be resilient once it has been removed or severely reduced if a vigorous stand of grass exists and is maintained. On these areas, blue grama may become dominant if the area is subjected to a combination of frequent and severe grazing especially yearlong grazing. As a result, a dense sod cover of blue grama will become established.

The HCPC for this site is the Bluebunch Wheatgrass/Rhizomatous Wheatgrass Community. This state evolved with grazing by large herbivores and periodic fires. The cyclical natural of the fire regime in this community prevented big sagebrush from being the dominant landscape. 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% grasses or grass-like plants, 10% forbs, and 15% woody plants. This state is dominated by cool season mid-grasses.

The major grasses include Griffiths and bluebunch wheatgrasses, rhizomatous wheatgrasses, needleandthread, and Indian ricegrass. Other grasses occurring in this state include bottlebrush squirreltail, prairie junegrass, and Sandberg bluegrass. Big sagebrush is a conspicuous element of this state, occurs in a mosaic pattern, and makes up 5 to 15% of the annual production. Winterfat is a common component found on this site. A variety of forbs also occurs in this state and plant diversity is high.

The total annual production (air-dry weight) of this state is about 800 lbs./acre, but it can range from about 500 lbs./acre in unfavorable years to about 1100 lbs./acre in above average years.

This plant community is extremely stable and well adapted to the Northern Intermountain Desertic Basins 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).

Sandy 10-14 inch Precipitation Zone, East

Potential vegetation on this site is dominated by mid cool-season perennial grasses. Other significant vegetation includes winterfat, big sagebrush, and a variety of forbs. The expected potential composition for this site is about 75% grasses, 15% forbs and 10% woody plants. The composition and production will vary naturally due to historical use, fluctuating precipitation and fire frequency.

As this site deteriorates, species such as threadleaf sedge, blue grama, and big sagebrush will increase. Plains pricklypear and weedy annuals will invade. Cool season grasses such as needleandthread, bluebunch and Griffith's wheatgrasses, Indian ricegrass, and rhizomatous wheatgrasses will decrease in frequency and production.

Big sagebrush may become dominant on areas with an absence of fire and sufficient amount of precipitation. Wildfires are actively controlled in recent times and as a resulted old decadent stands of big sagebrush persist. Chemical control using herbicides has replaced the historic role of fire on this site. Recently, prescribed burning has regained some popularity

Due to the amount and pattern of the precipitation, the big sagebrush component may not be resilient once it has been removed or severely reduced if a vigorous stand of grass exists and is maintained. On these areas, threadleaf sedge and blue grama may become dominant if the area is subjected to a combination of frequent and severe grazing especially yearlong grazing. As a result, a dense sod cover of threadleaf sedge and blue grama will become established.
The Historic Climax Plant Community has been determined by study of rangeland relic areas, or areas protected from excessive disturbance. Trends in plant communities going from heavily grazed areas to lightly grazed areas, seasonal use pastures, and historical accounts have also been used.

The HCPC for this site is the Needleandthread/ Indian Ricegrass community. This state evolved with grazing by large herbivores and periodic fires. The cyclical natural of the fire regime in this community

prevented big sagebrush from being the dominant landscape. 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 state is comprised of mostly cool season mid-grasses and a variety of forbs and woody species. Potential vegetation is about 75% grasses or grass-like plants, 15% forbs, and 10% woody plants.

The major grasses include needleandthread, Indian ricegrass, bluebunch and/or Griffith's wheatgrasses, and rhizomatous wheatgrasses. Other grasses occurring in the state include prairie junegrass, Sandberg bluegrass, blue grama, threadleaf sedge, and bottlebrush squirreltail. Spikefescue occurs on sites in the higher precipitation ranges of this zone. Big sagebrush and winterfat are conspicuous components of this state.

*When compared to the **Historic Climax Plant** Community, bluebunch and Griffith's wheatgrasses, Indian ricegrass, and winterfat have decreased. Indian ricegrass and bluebunch and Griffith's wheatgrasses may occur in only trace amounts under the sagebrush canopy or within the patches of pricklypear. Threadleaf sedge, blue grama, Sandberg bluegrass, and big sagebrush have increased. Plains pricklypear cactus will also have invaded, but occurs only in small patches.*

The total annual production (air-dry weight) of this state is about 650 pounds per acre, but it can range from about 400 lbs./acre in unfavorable years to about 950 lbs./acre in above average years.

This plant community is resistant to change. The herbaceous species present are well adapted to grazing; however, species composition can be altered through long-term overgrazing. The herbaceous component is mostly intact and plant vigor and replacement capabilities are sufficient. Water flow patterns and litter movement may be occurring but only on steeper slopes. Incidence of pedestalling is minimal. Soils are mostly stable and the surface shows minimum soil loss. The watershed is functioning and the biotic community is intact.

Loamy 15-19 inch Foothills and Mountains East

Potential vegetation on this site is dominated by mid cool-season perennial grasses. Other significant vegetation includes big sagebrush, rubber rabbitbrush, and a variety of forbs. The expected potential composition for this site is about 75% grasses, 15% forbs and 10% woody plants. The composition and production will vary naturally due to historical use, fluctuating precipitation and fire frequency.

As this site deteriorates species such as big sagebrush, rubber rabbitbrush, and bluegrasses will increase. Cool season grasses such as Columbia needlegrass, spikefescue, and Idaho fescue will decrease in frequency and production. As conditions deteriorate further, annuals such as cheatgrass will invade.

Big sagebrush may become dominant on areas with an absence of fire and a sufficient amount of precipitation. Wildfires are actively controlled in recent times and as a result old decadent stands of big

sagebrush persist. Chemical and mechanical controls have replaced the historic role of fire on this site. Recently, prescribed burning has regained some popularity.

The big sagebrush component may not be as resilient once it has been removed or severely reduced, if a vigorous stand of grass exists and is maintained. The exception to this is where the herbaceous component is severely degraded at the time of treatment; growing conditions are unfavorable after treatment, and/or recovery of herbaceous species are inadequate due to poor grazing management. Regeneration of big sagebrush may also be suppressed if three-tip sagebrush and rubber rabbitbrush are established. This situation is more likely to develop in areas where fires have occurred in a relatively short cycle. Three-tip sagebrush and rubber rabbitbrush are strong resprouters and will out compete other shrubs where a site is disturbed. Any thinning project should be designed in a way to maintain the viability of the stand and to consider wildlife requirements.

The HCPC for this site is the Columbia Needlegrass/Spikefescue Plant Community. This state evolved with grazing by large herbivores and periodic fires. Potential vegetation is about 75% grasses or grass-like plants, 15% forbs, and 10% woody plants. This plant community can be found on areas that are properly managed with grazing and/or prescribed burning, and on areas receiving periods of rest. The cyclical nature of the fire regime in this community prevents big sagebrush from being the dominant landscape.

Cool season midgrasses dominate the site. The major grasses include Columbia needlegrass,Spikefescue, Idaho fescue, and bluebunch wheatgrass. Big sagebrush is a conspicuous element of this site, occurs in a mosaic pattern, and makes up 5 to 10% of the annual production. Natural fire occurred in this community and prevented sagebrush from being the dominant landscape. A variety of forbs also occurs in this state and plant diversity is high.

Annual production on this site ranges from 1100 to 1600 pounds depending on climatic conditions.

This plant community is extremely stable and well adapted to the Central Rocky Mountains 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).

Shallow loamy 15-19 inch Foothills and Mountains East

Potential vegetation on this site is dominated by mid cool-season perennial grasses. Other significant vegetation includes black and big sagebrush, antelope bitterbrush and a variety of forbs. On areas along the west slopes of the Big Horn Mountains, mountain mahogany is the significant shrub. The expected potential composition for this site is about 75% grasses, 10% forbs and 15% woody plants. The composition and production will vary naturally due to historical use, fluctuating precipitation and fire frequency.

As this site deteriorates, species such as bluegrasses, rhizomatous wheatgrasses and black and big sagebrush will increase. Cool season grasses such as Columbia needlegrass, spikefescue, bluebunch

wheatgrass, and Idaho fescue will decrease in frequency and production. As conditions continue to deteriorate annuals such as cheatgrass will invade.

Big sagebrush may become dominant on areas with an absence of fire. Wildfires are actively controlled in recent times and as a result old decadent stands of big sagebrush persist. Chemical and mechanical controls have replaced the historic role of fire on this site. Recently, prescribed burning has regained some popularity.

The big sagebrush component may not be as resilient once it has been removed or severely reduced, if a vigorous stand of grass exists and is maintained. The exception to this is where the herbaceous component is severely degraded at the time of treatment; growing conditions are unfavorable after treatment, and/or recovery of herbaceous species are inadequate due to poor grazing management. Regeneration of big sagebrush may also be suppressed if three-tip sagebrush and rubber rabbitbrush is established. This situation is more likely to develop in areas where fires have occurred in a relatively short cycle. Three-tip and rubber rabbitbrush are strong resprouters and will out compete other shrubs where a site is disturbed. Any thinning project should be designed in a way to maintain the viability of the stand and to consider wildlife requirements.

The HCPC for this site is the Columbia Needlegrass/Spikefescue Plant Community. This state evolved with grazing by large herbivores and periodic fires. Potential vegetation is about 75% grasses or grass-like plants, 10% forbs, and 15% woody plants. The cyclical nature of the fire regime in this community prevents big sagebrush from being the dominant landscape. This plant community can be found on areas that are properly managed with grazing and/or prescribed burning, and on areas receiving periods of rest.

Cool season midgrasses dominate the state. The major grasses include Columbia needlegrass, spikefescue, Idaho fescue, and bluebunch wheatgrass. Big and black sagebrush are conspicuous element of this state, occurring in a mosaic pattern, and makes up 5 to 10% of the annual production. On areas along the west slope of the Big Horn Mountains, mountain mahogany is the dominant shrub. A variety of forbs also occurs in this state and plant diversity is high.

Annual production on this state ranges from 500 to 1000 pounds depending on climatic conditions.

This plant community is extremely stable and well adapted to the Central Rocky Mountains 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).

3.3.4.4 Range Conditions and Needs

The Buffalo Creek study area has been grazed by domestic livestock (both cattle and sheep) since the late 1800's. Detailed assessment of range conditions within the study area was beyond the scope of this project. However, based upon observations made during field investigations and interviews with landowners and agency representatives, it is apparent that there is a great variety of conditions. The following observations describe the general condition of the study area:

- Riparian areas in many portions of the study area continue to be heavily relied upon for their wildlife and livestock water, feed values, and cover.
- The majority of the study area appeared to be in high-fair to good ecological condition.
- Portions of the study area near higher ridges appeared to be in high-good ecological condition. Offsite water development can reduce grazing impacts on riparian areas
- Better distribution of grazing on upland areas would be beneficial to watershed values by moving grazing impacts from historically heavily utilized areas to under-utilized areas.
- Livestock water development is generally needed before constructing fences and implementing improved grazing systems.

An important factor needed to facilitate improved grazing management and thereby achieve the associated benefits to the watershed is well-distributed, reliable water. Despite the relatively ample water supplies within much of the watershed, good grazing systems control both the time (amount of time spent in an area), and the timing (the time of the year) that the livestock spend in a pasture. Grasses and other plants need to recover from the last grazing event before being grazed again because food reserves in the roots must be utilized for new plant growth. If root reserves are not restored, the plants are weakened and may eventually die. Less desirable plants eventually take over and plant densities decrease. In the absence of well-distributed livestock water, areas near water (frequently riparian areas) are grazed heavily while many other areas are under-utilized. Livestock water must also be reliable so that each pasture can be used as needed in a grazing rotation. Otherwise, the same pastures with reliable water get grazed repeatedly at the same crucial time of the year.

Due to the fact that plants grow rapidly during the growing season, re-growth is frequently grazed multiple times during each grazing period, resulting in depleted root reserves. Because of this, it is often desirable to combine herds so livestock can spend shorter time periods in one pasture. This requires adequate quantities of water to accommodate larger herds.

In addition to restoration of more healthy conditions, continuing adjustments in overall range management will contribute to the maintenance, recovery or improvement of a variety of interrelated aspects of watershed function, including but not necessarily limited to:

- Improved infiltration of snowmelt and rainfall;
- Retention of soil moisture;

- Groundwater recharge;
- Sustained release of soil moisture and groundwater as seeps/springs; and
- Stabilization of soils against erosion into streams.

In general, most range improvement practices which improve watershed and livestock values also improve wildlife habitat values. With important and sensitive species found within the watershed, such as sage grouse, care must be taken to ensure that practices are beneficial rather than detrimental to their habitat values. Examples of this include the need for mixed age stands of sagebrush, adequate vegetative residues, wildlife escape ramps from livestock tanks, and provisions for wildlife water.

Alternatives to address the need for additional wildlife/livestock watering sites are presented in Section 4.6. Potential management practices and improvements to address other rangeland/grazing related issues are included in Section 4.7. It is important to consider that to be cost-effective any range improvement practices/facilities that may be implemented must be followed up with a good grazing system. Otherwise, any short term gains will be lost, and often made worse. The key to any good grazing system is often a good, reliable livestock water system; this usually is the most cost-effective practice to initiate the process. The best value for the investment of resources frequently occurs on the more productive land. Land that is too steep or shallow can only show limited returns on investments.

3.3.5 Oil and Gas Production and Resources

The locations of all active and permanently abandoned oil and gas wells were obtained from the Wyoming Oil and Gas Conservation Commission (WOGCC) website: http://wogccms.state.wy.us/. Active wells and permanently abandoned wells within the study area are shown on Figure 3.13. Annual oil and gas production for 2011 for the well fields encountered is summarized in Table 3.6 (It must be kept in mind that the well fields may extend beyond the boundaries of the current study area). Total oil production was approximately 28,598 barrels. Natural gas production was negligible. In addition, approximately 1.47 million barrels of water were produced (approximately 189 acre feet). Historically, this water was typically discharged to receiving surface waters. However, due to restrictions imposed by the WYDEQ pertaining to water quality, a greater number of producers currently re-inject produced water.

Table 3.6 Tabulation of 2010 Oil, Gas, and Water Production

Field	Oil	Gas	Water
	(Bbls)	(Mcf)	(bbls)
Centennial	4,135	58	52,559
Red Springs	0	0	0
Warm Springs	24,009	0	1,415,976
WC	454	0	2,515
Total	**28,598**	**58**	**1,471,050**

Centennial Field

Black Willow Draw Watershed

Hot Springs County

Thermopolis

Warms Springs Field

Warm Springs Creek Watershed

Buffalo Creek Watershed

Fremont County

Producing Oil/Gas Well within Study Area

Producing Oil/Gas Wells outside Study Area

Permanently Abandoned Well

Oil/Gas Fields determined by grouping like named field names from WOGCC Database. Colors vary by field.

Bentonite Mine Permit Boundary

Sand & Gravel Mine Permit Boundary

N W E S

0 8,500 17,000

Feet

Legend

Cities

Streams

Buffalo Creek Study Area

County Boundary

Figure 3.13 Buffalo Creek Watershed: Oil and Gas Fields with Mine Permit Boundaries

3.3.6 Mining and Mineral Resources

At the time of this reporting, there was only one mine permit on record with the WDEQ which could potentially affect the study area. Wyo-Ben Inc. operates bentonite mining operations north of the study area within the Kirby Creek drainage basin. A portion of their permitted lands laps over the watershed divide into Black Willow Draw. However, there is currently no bentonite extraction occurring within the Black Willow Draw watershed. The permit boundary is displayed graphically in Figure 3.13.

3.3.7 Wildlife

Much of the watershed has been mapped by the Wyoming Game and Fish Department (WGFD) as crucial habitat for several big game species. Specifically, approximately 63,900 acres (approximately 57 percent of the study area) have been determined to be crucial habitat for one or more of elk, antelope, or mule deer. The WGFD maps the seasonal ranges by herd unit for each big game species and makes special note of areas listed as crucial habitat and parturition (birthing areas). Crucial habitat or range is defined as those seasonal ranges or habitats (mostly winter range) that have been documented as the determining factor in a population's ability to maintain itself at a certain level over a long period of time.

Figures 3.14 through 3.18 display the seasonal range, crucial range, parturition range, and migration corridors for antelope, elk, moose, mule deer and white tailed deer within the study area. Examination of these figures clearly shows that big game are found throughout the entire watershed and that extensive portions of the study area have been classified as crucial habitat, especially for elk, antelope, and mule deer.

The Wyoming Natural Diversity Database (WYNDD) lists numerous non-game species of concern within the watershed, including amphibians, birds, fish, mammals, mollusks, and reptiles. Table 3.7 presents the results of a database query conducted by the WYNDD for the watershed. Included in this list are all species of concern or species of potential concern which have been documented in the study area. Review of the list shows that the only endangered species known to have been observed within the study area is the black-footed ferret (*Mustela nigripes*) and the only threatened species is the grey wolf (*Canis lupus*).

The potential exists for some of these species to occur within appropriate habitats within the watershed. For example, areas of known greater sage grouse (*Centrocercus urophasianus*) leks are displayed in Figure 3.19. The sage grouse does not receive federal or state protection at this time; however, it is recognized as a sensitive species / species of concern by the BLM and a species of concern by WGFD. In August 2008, Executive Order 2008-2 was signed by the Governor which stresses additional management consideration to sage grouse and sage grouse habitat statewide. The Order includes requirements of state agencies to encourage development outside of the Core areas and to focus management to the greatest extent possible on the maintenance and enhancements of habitat

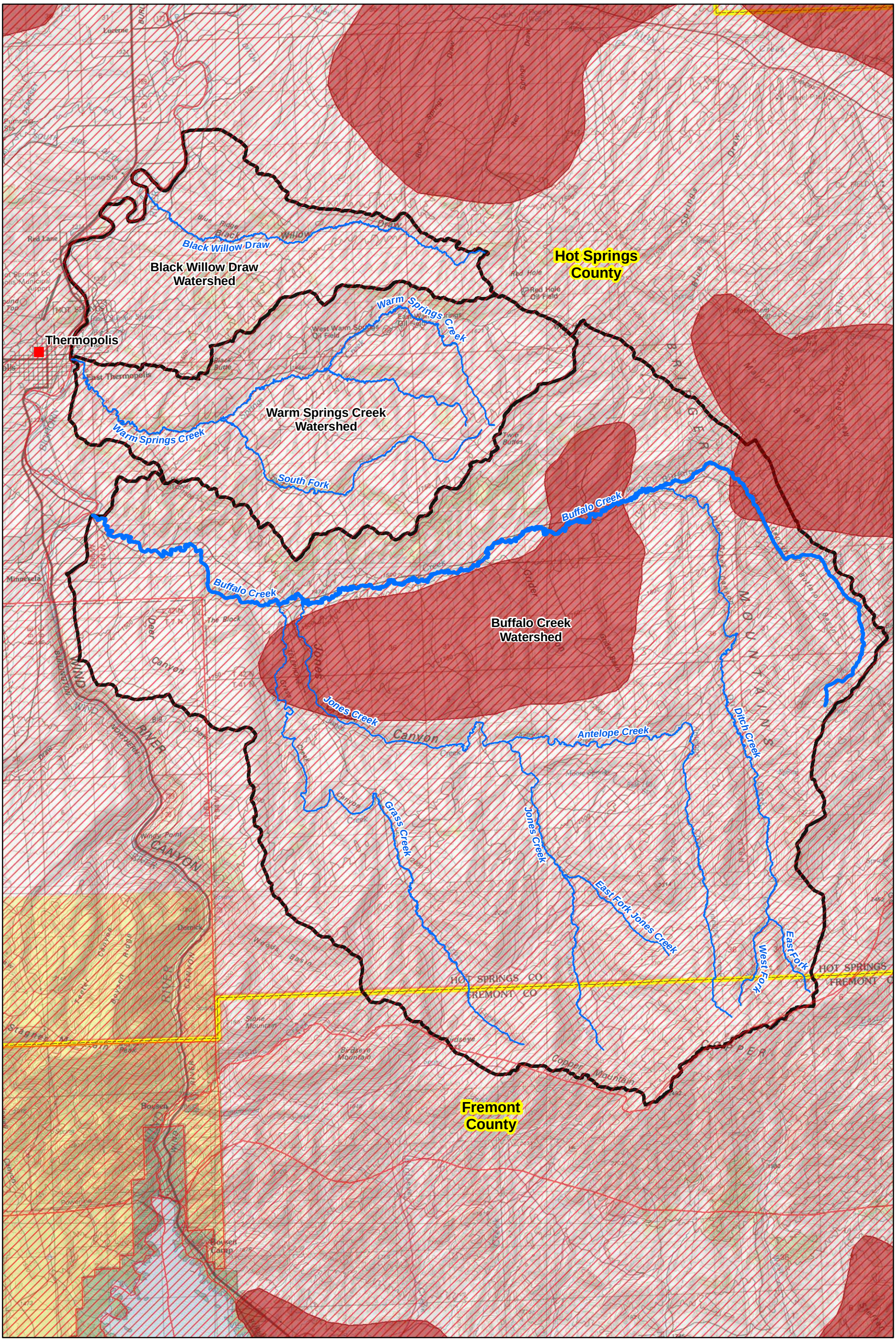


Figure 3.14 Buffalo Creek Watershed: Antelope Habitat

Black Willow Draw Watershed

Warm Springs Creek Watershed

Buffalo Creek Watershed

Hot Springs County

Fremont County

Thermopolis

Black Willow Draw

Warm Springs Creek

South Fork

Buffalo Creek

Jones Creek

Antelope Creek

Ditch Creek

Grass Creek

East Fork Jones Creek

East Fork

West Fork

Legend

Migration Routes

Crucial Range

Seasonal Range

Cities

Streams

Buffalo Creek Study Area

County Boundary

0 8,500 17,000

Feet

Figure 3.15 Buffalo Creek Watershed: Elk Habitat

Black Willow Draw Watershed

Warm Springs Creek Watershed

Buffalo Creek Watershed

Hot Springs County

Fremont County

Thermopolis

Black Willow Draw

Warm Springs Creek

South Fork

Buffalo Creek

Jones Creek

Canyon Creek

Grass Creek

Antelope Creek

Ditch Creek

East Fork Jones Creek

East Fork

West Fork

Legend

Seasonal Range

Cities

Streams

Buffalo Creek Study Area

County Boundary

N

W E

S

0 8,500 17,000

Feet

Figure 3.16 Buffalo Creek Watershed: Moose Habitat

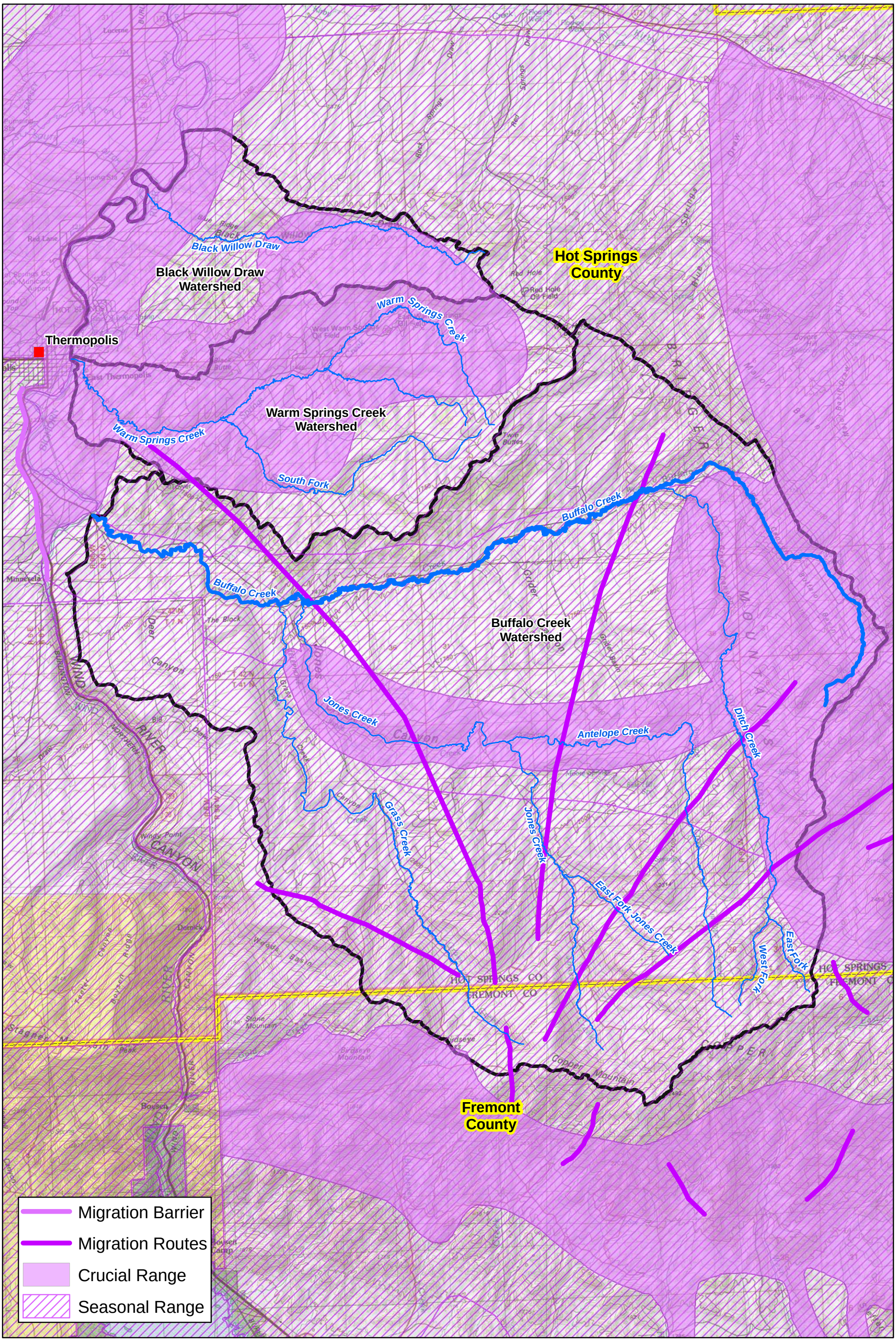


Figure 3.17 Buffalo Creek Watershed: Mule Deer Habitat

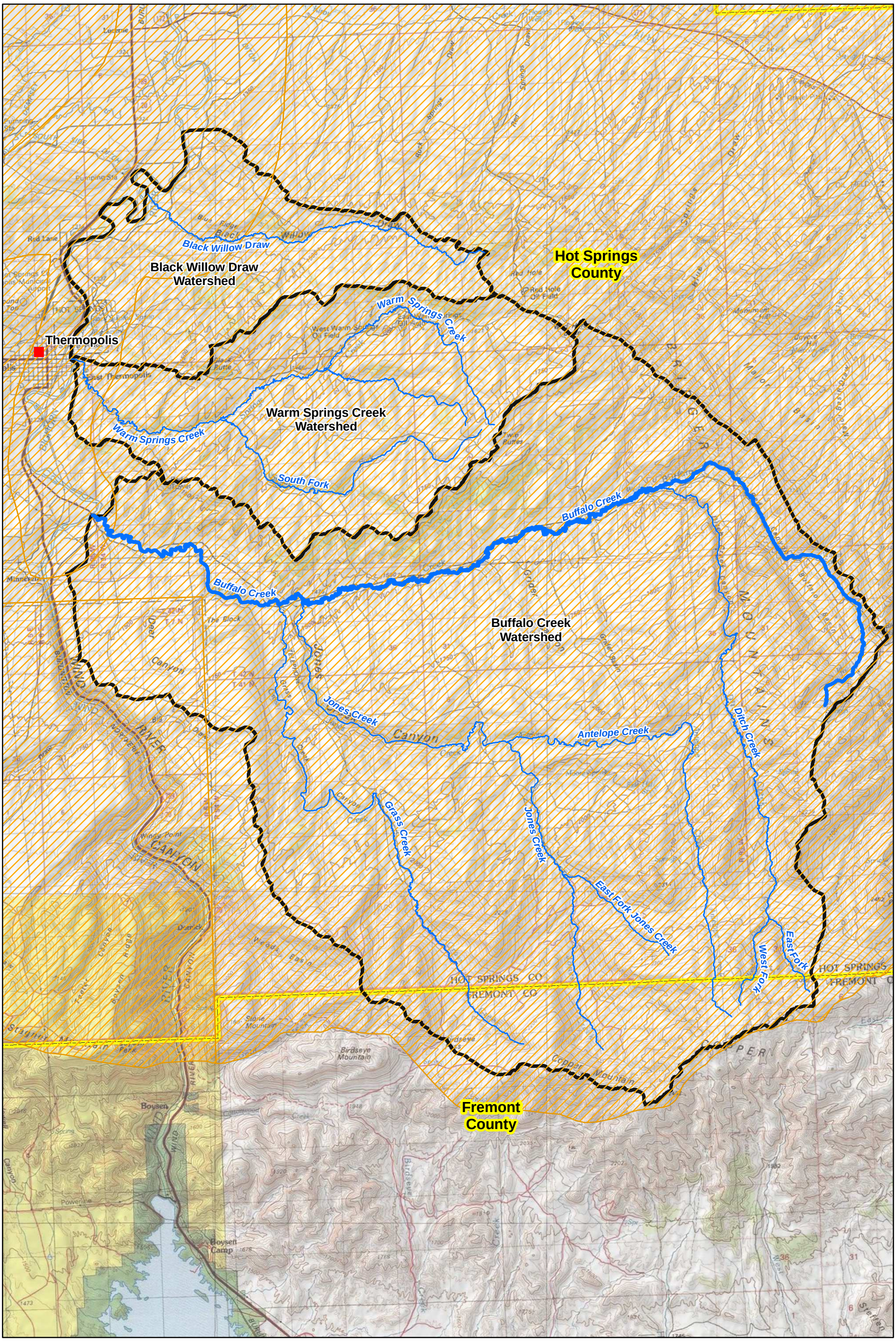


Figure 3.18 Buffalo Creek Watershed: Whitetail Deer Habitat

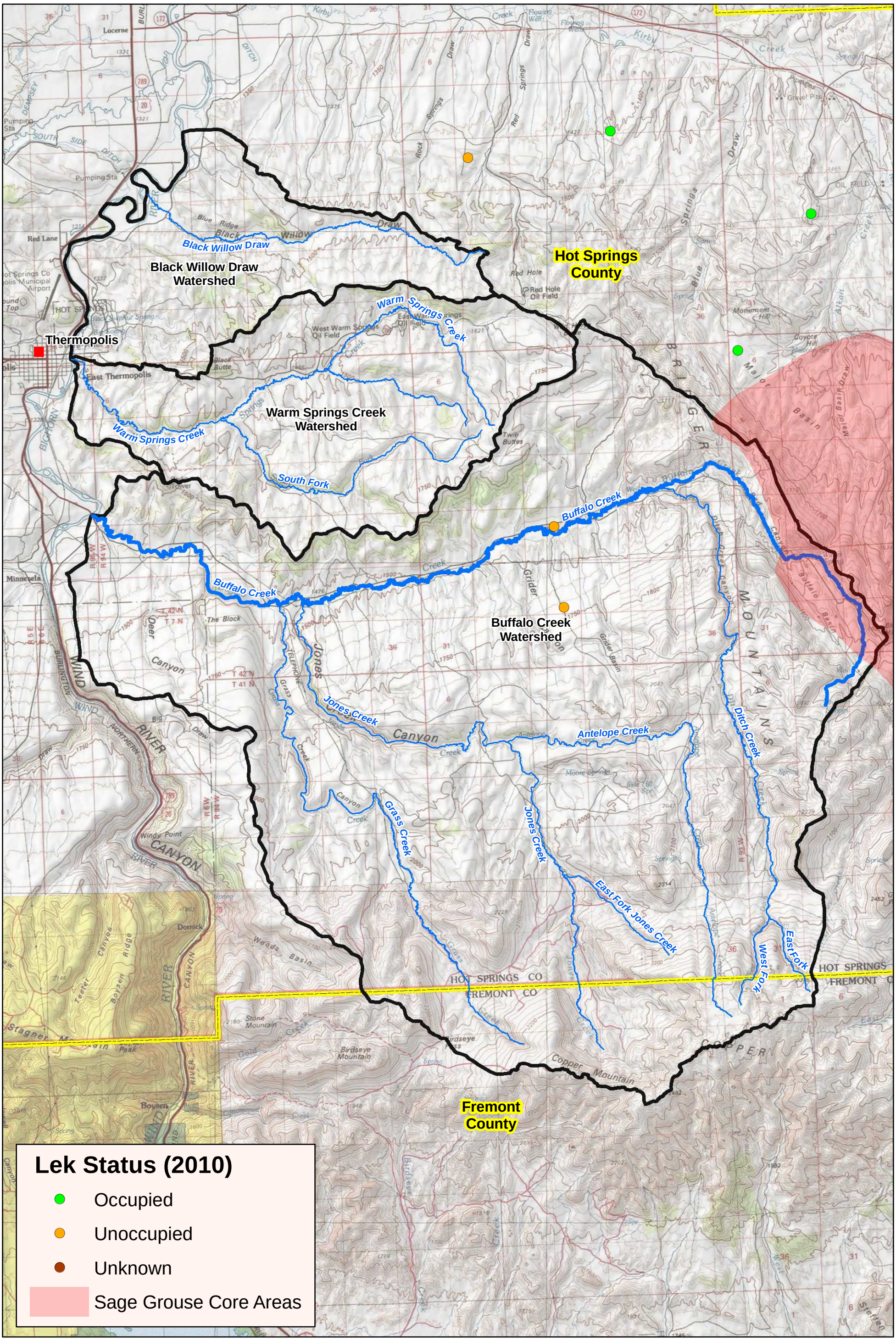


Figure 3.19 Buffalo Creek Watershed: Sage Grouse Leks and Core Areas

within them. The Core Sage Grouse Population Areas within the study area are delineated in Figure 3.19. As is evident in this figure, the current delineation of the sage grouse core areas do not significantly affect the project study area.

Table 3.7 Wyoming Natural Diversity Database: Wildlife Species in the Buffalo Creek Watershed.

Scientific Name	Common Name	Listing Status	Tracked / Watched	Date Observed
Amphibians				
Ambystoma mavortium	Tiger Salamander	Not Listed	Watched	7/12/1951
Birds				
Cinclus mexicanus	American Dipper	Not Listed	Watched	5/22/2001
Aquila chrysaetos	Golden Eagle	Not Listed	Watched	6/23/1978
Pandion haliaetus	Osprey	Not Listed	Watched	4/30/1983
Aythya collaris	Ring-necked Duck	Not Listed	Watched	9/22/1994
Grus canadensis	Sandhill Crane	Not Listed	Watched	10/25/1997
Dendroica townsendi	Townsend's Warbler	Not Listed	Watched	8/17/1940
Cygnus columbianus	Tundra Swan	Not Listed	Watched	11/25/1982
Pelecanus erythrorhynchos	American White Pelican (Breeding Colonies)	Not Listed	Tracked	5/28/2006
Haliaeetus leucocephalus	Bald Eagle	Not Listed	Tracked	12/23/1982
Sterna caspia	Caspian Tern	Not Listed	Tracked	6/7/2001
Aechmophorus clarkii	Clark's Grebe	Not Listed	Tracked	5/23/2001
Gavia immer	Common Loon	Not Listed	Tracked	5/16/1988
Buteo regalis	Ferruginous Hawk	Not Listed	Tracked	6/25/1981
Centrocercus urophasianus	Greater Sage Grouse	Candidate	Tracked	7/3/1980
Accipiter gentilis	Northern Goshawk	Not Listed	Tracked	11/21/1978
Asio flammeus	Short-eared Owl	Not Listed	Tracked	11/15/1997
Cygnus buccinator	Trumpeter Swan	Not Listed	Tracked	11/12/1985
Plegadis chihi	White-faced Ibis	Not Listed	Tracked	5/7/1986
Mammals				
Ovis canadensis	Bighorn Sheep	Not Listed	Watched	6/18/2001
Sylvilagus floridanus	Eastern Cottontail	Not Listed	Watched	6/11/2005
Lasiurus cinereus	Hoary Bat	Not Listed	Watched	9/21/1983
Myotis evotis	Long-eared Myotis	Not Listed	Watched	6/16/1994
Myotis volans	Long-legged Myotis	Not Listed	Watched	9/20/1994
Myotis ciliolabrum	Western Small-footed Myotis	Not Listed	Watched	6/16/1994
Spermophilus elegans	Wyoming Ground Squirrel	Not Listed	Watched	8/14/1990
Spermophilus tridecemlineatus alleni	Allen's Thirteen-lined Ground Squirrel	Not Listed	Tracked	9/15/1893
Mustela nigripes	Black-footed Ferret	Endangered	Tracked	8/1972
Canis lupus	Gray Wolf	Threatened	Tracked	2003
Lutra canadensis	River Otter	Not Listed	Tracked	8/22/1993
Corynorhinus townsendii	Townsend's Big-eared Bat	Not Listed	Tracked	
Cynomys leucurus	White-tailed Prairie Dog	Not Listed	Tracked	9/14/1893
Molluscs				
Gyraulus parvus	Ash Gyro	Not Listed	Tracked	7/18/2009
Lampsilis siliquoidea	Fatmucket	Not Listed	Tracked	2/15/2004
Reptiles				
Coluber constrictor flaviventris	Eastern Yellow-bellied Racer	Not Listed	Watched	7/2/1950
Charina bottae	Northern Rubber Boa	Not Listed	Tracked	8/4/2004

The BLM definition of a sensitive species is as follows: species that could easily become endangered or extinct in the state, including: (a) species under status review by the FWS/National Marine and Fisheries Service; (b) species whose numbers are declining so rapidly that Federal listing may become necessary;

(c) species with typically small or fragmented populations; and (d) species inhabiting specialized refuge or other unique habitats.

WGFD lists the greater sage grouse as: species that are widely distributed, with population status or trends unknown but suspected to be stable; habitat restricted or vulnerable but no recent or on-going significant loss; species likely sensitive to human disturbance. *The sage grouse are not listed as a Threatened or Endangered species and does not receive any protections from the Endangered Species Act; however, BLM and WGFD have developed restrictions/recommendations to help protect the sage grouse.*

As part of the WGFD Strategic Habitat Plan (2009), areas within the State which have been determined to be Crucial Priority Areas or Enhancement Priority Areas for both riparian and terrestrial terrain were delineated (Figure 3.20). As defined by WGFD at: http://gf.state.wy.us/habitat/portal/index.asp,

*"**Crucial Priority Areas** are based on significant biological or ecological values. These are areas that need to be protected or managed to maintain viable healthy populations of terrestrial and aquatic wildlife for the present and future. They represent habitat values and identify where those values occur on the landscape. Examples of values include crucial winter range, sage grouse core area seasonal habitats, Species of Greatest Conservation Need (SGCN) diversity and uniqueness, quality and condition of vegetative communities, movement corridors, quality of watershed hydrologic function, etc. The Department will concentrate habitat protection and management activities in these areas."*

***Enhancement Habitat Priority Areas** represent those with a realistic potential to address wildlife habitat issues and to improve, enhance, or restore wildlife habitats. These areas offer potential for improving habitat and focusing Department habitat efforts. They may overlap crucial areas or be distinct from them. Enhancement areas are based on habitat issues. Like crucial areas where values are key, issues were identified by regional personnel and used to select enhancement habitat areas. Examples of issues include loss of aspen communities, habitat fragmentation, development, loss of connectivity, water quality effects, water quantity limitations, beetle killed conifer, lack of fish passage, loss of fish to diversions, degraded habitat, etc." (http://gf.state.wy.us/habitat/portal/index.asp).*

3.3.8 Cultural Resources

The Wyoming State Historic Preservation Office (SHPO) maintains an in-progress database of inventoried historic sites within the state. A determination of each site's eligibility for inclusion in the National Register of Historic Places (Register) is included in the database. The WYGISC website has available a spatial data file from SHPO which generalizes cultural resource inventory to the section level. This "location fuzzing" of the archaeological data is to protect the sites from unauthorized disturbance. The attributes recorded for each section include: site count, inventory acres, report numbers, and eligible site number. Figure 3.21 displays the results of the database retrieval in a graphical format.

Thermopolis

Black Willow Draw Watershed

Warm Springs Creek Watershed

Buffalo Creek Watershed

Hot Springs County

Fremont County

Black Willow Draw

Warm Springs Creek

South Fork

Buffalo Creek

Jones Creek

Antelope Creek

Ditch Creek

Grass Creek

East Fork Jones Creek

West Fork

East Fork

Combined Crucial Priority Area

Aquatic Crucial Priority Area

Aquatic Enhancement Priority Area

Terrestrial Crucial Priority Area

Terrestrial Enhancement Priority Area

N

W E

S

0 8,500 17,000

Feet

Legend

Cities

Streams

Buffalo Creek Study Area

County Boundary

Figure 3.20 Buffalo Creek Watershed: Habitat Priority Areas

Black Willow Draw Watershed

Warm Springs Creek Watershed

Buffalo Creek Watershed

Hot Springs County

Fremont County

Thermopolis

Black Willow Draw

Warm Springs Creek

South Fork

Buffalo Creek

Jones Creek

Grass Creek

Antelope Creek

Ditch Creek

East Fork Jones Creek

East Fork

West Fork

Number of Cultural Sites Eligible for Inclusion on the National Register of Historic Places (Per PLSS Section)

1 2 3 4 5 6 8

N W E S

0 8,500 17,000

Feet

Legend

- Cities
- Streams
- Buffalo Creek Study Area
- County Boundary

Figure 3.21 Buffalo Creek Watershed: Cultural Sites

Each section within the study area has been color coded based upon the number of sites within it determined to be eligible for inclusion on the Register.

3.4 Natural Environment

3.4.1 Climate

The Buffalo Creek study area contains topography ranging in elevation from 4,300 msl feet at the mouth of Black Willow Draw to over 8,300 msl feet on Copper Mountain, the highest point in the basin. Consequently, even within this relatively limited geographical area, climate varies considerably. The Thermopolis weather station was used to characterize the climatic condition of the study area. Data recorded at this station were obtained from the Western Regional Climate Center (http://www.wrcc.dri.edu/). Table 3.8 presents a summary of the monthly average values for temperature and precipitation for the period 1980 through 2010.

Table 3.8 Summary of Monthly Climatic Data: Thermopolis, WY.

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Average Max. Temperature (F)	37.8	43.3	53.7	62.2	72.1	82.1	91.2	89.6	79.5	64.7	47.3	37.9	63.6
Average Min. Temperature (F)	11.5	16.6	25.2	33.6	42.5	50.3	56.5	54.8	45.5	33.6	21.3	12.6	33.8
Average Total Precipitation (in.)	0.42	0.43	0.92	1.64	2.27	1.58	0.93	0.68	1.14	1.25	0.68	0.42	12.35

To a large degree, the climate patterns in Thermopolis are controlled by the surrounding mountains. The Absaroka Mountains tend to block easterly moving Pacific air masses and moisture creating a semi-arid climate in their lee. Figure 3.22 displays the annual precipitation for the 1990 through 2011 study period. As indicated in this figure, at the time of this investigation (2010 and 2011) precipitation patterns were somewhat typical of the long term average with total precipitation approaching the long-term average of 12.35 inches.

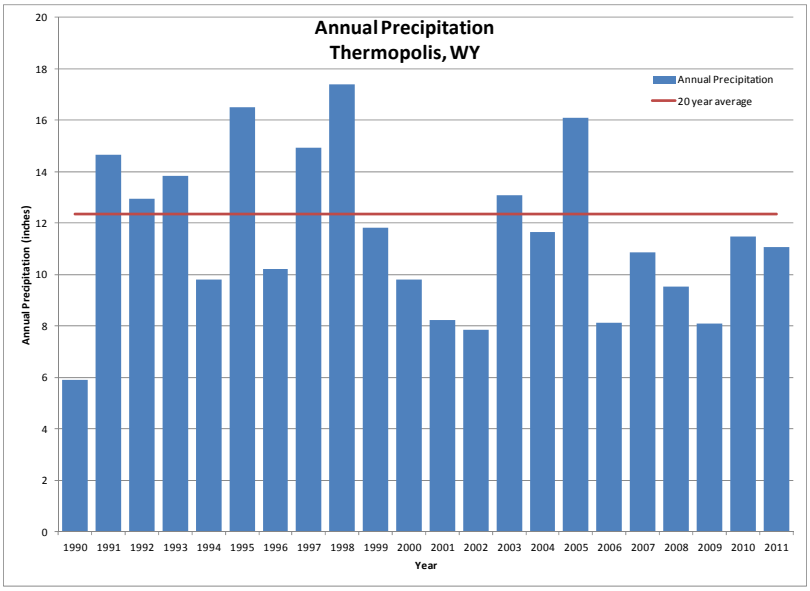


Figure 3.22 Annual Precipitation at Thermopolis, WY 1990 to 2011.

Figure 3.23 shows the distribution of the annual precipitation on a monthly basis. This figure and Table 3.8 show that the wettest months are typically May and June when about one third of the annual precipitation arrives. Figure 3.23 also shows the mean monthly high and low temperatures for Thermopolis. Mean highs range from the mid-80's in July to the low 30's in December and January. Mean lows range from single digits in December and January to the mid-50's by July.

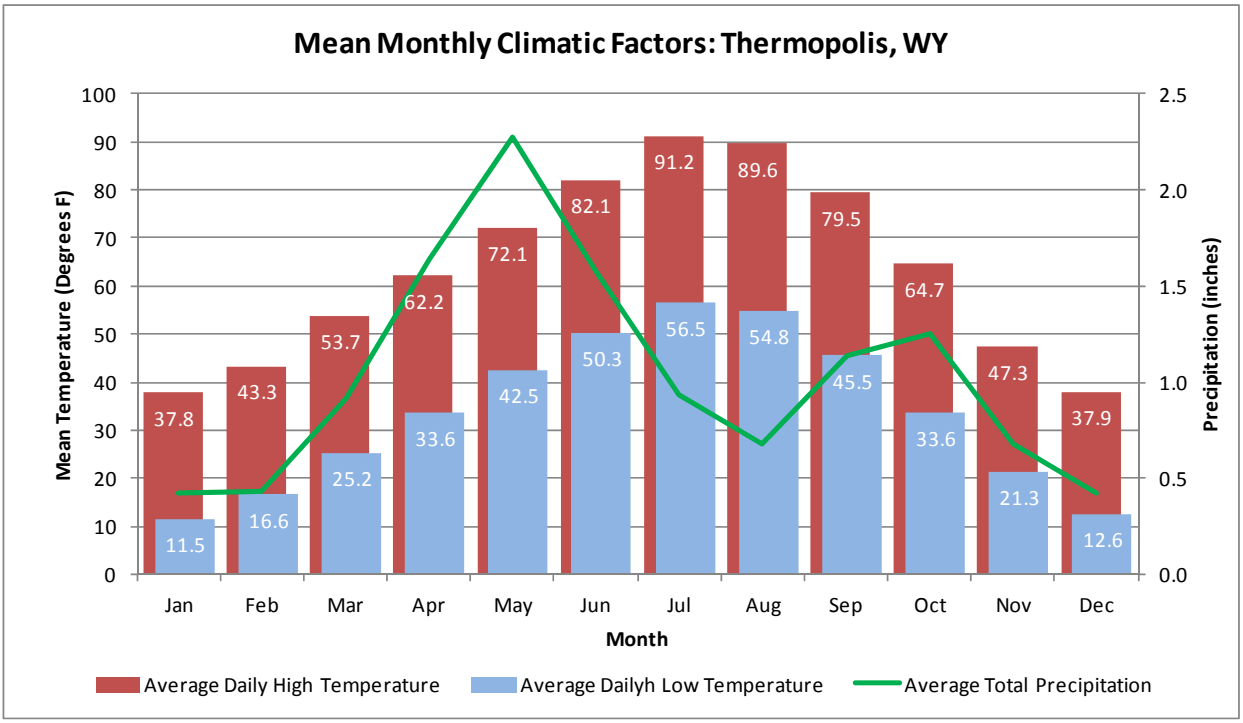


Figure 3.23 Mean Monthly Climatic Factors for Thermopolis, Wyoming 1981 – 2010.

Figure 3.24 displays the isohyetals (lines of equal precipitation) within the study area. This figure clearly shows the relationship between elevation and precipitation amounts. The data used to generate this figure were obtained from the Wyoming Geographic Information Center (WyGISC). These data represent the results of PRISM spatial climate data generated at the Oregon Climate Center, Oregon State University. As indicated in this figure, the mean annual precipitation varies from a minimum of about 13 inches at the lower elevations to over 17 inches at higher elevations.

3.4.2 Vegetation and Land Cover

3.4.2.1 Overview

Vegetative cover within the watershed was evaluated using data obtained through the LANDFIRE project (www.landfire.gov). LANDFIRE (Landscape Fire and Resource Management Planning Tools Project) is an interagency vegetation, fire, and fuel characteristics mapping project. It is a shared project between the Department of Interior (DOI) and Forest Service wildland fire management programs. The primary

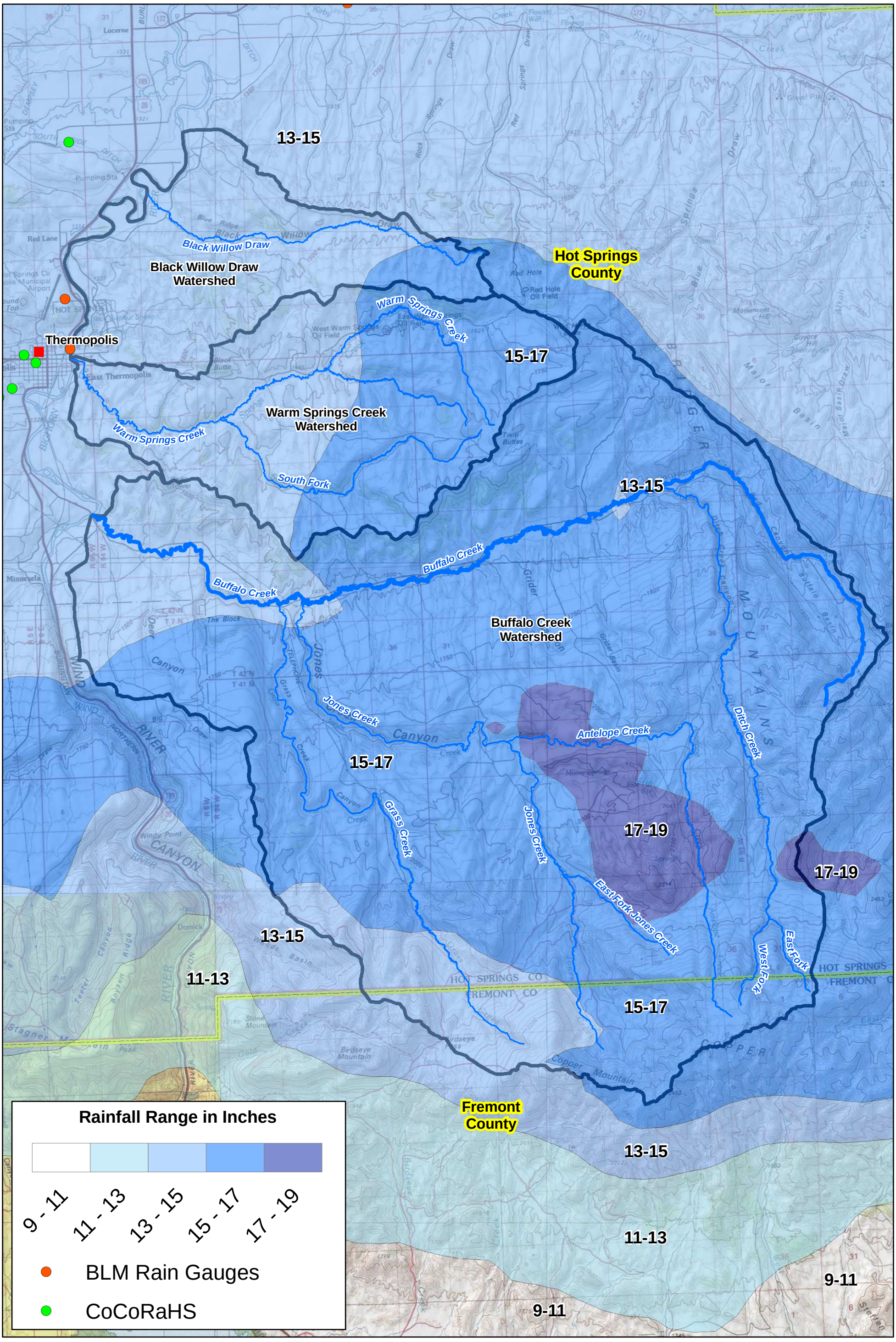


Figure 3.24 Buffalo Creek Watershed: Meteorological Stations and Precipitation Isohyetals

purpose of the LANDFIRE project is to collect the data necessary to develop wildland fire models. The data are generated using remote sensing techniques with on-the-ground truthing. Data products accessed for this project included 30-meter spatial resolution raster data sets describing vegetation type and cover. LANDFIRE vegetation map units are derived from NatureServe's Ecological Systems classification (Comer and others, 2003).

The LANDFIRE data describes numerous attributes pertinent to this study, including:

- Environmental Site
- Potential Biophysical Settings
- Existing Vegetation Type
- Existing Vegetation Height
- Existing Vegetation Cover

The LANDFIRE "existing vegetation type" (EVT) data were analyzed and summarized in Table 3.9. The LANDFIRE existing vegetation data indicate 45 different vegetation classes within the watershed. As is clearly indicated in this table, the major sagebrush community (Inter-Mountain Basins Big Sagebrush Shrubland) dominates coverage of the study area with a total of over 46% of the watershed acreage. While the fact that the majority of the study area is covered in sagebrush comes as no surprise, the table presents valuable information pertaining to the vegetation types present to a much lesser extent. For instance, the LANDFIRE data indicates that approximately 10.3 percent (11,534 acres) exist as Rocky Mountain Foothill Limber Pine-Juniper Woodland. In addition, the LANDFIRE data indicate that approximately 2.2 percent (2,447 acres) exist as some form of riparian vegetation (Rocky Mountain Subalpine/Upper Montane Riparian Systems, Rocky Mountain Montane Riparian Systems, plus Western Great Plains Depressional Wetland Systems).

While the LANDFIRE data provides valuable insight into watershed conditions, its display is difficult because of the fact the data are represented by a grid with 30 meter spacing. For graphical purposes, data obtained through the Wyoming Gap Analysis program are shown on Figure 3.25 (http://www.wygisc.uwyo.edu/wbn/gap.html). However, this data set is included within the project GIS and available for use in subsequent projects and associated efforts.

The GAP dataset was produced "with an intended application at the state or ecoregion level - geographic areas from several hundred thousand to millions of hectares in size. The data provide a coarse-filter approach to analyses, meaning that not every occurrence of habitat is mapped; only large, generalized distributions are mapped, based on the USGS 1:100,000 mapping scale in both detail and precision. Therefore, this dataset can be used appropriately for coarse-scale (> 1:100,000) applications, or to provide context for finer-level maps or applications" (University of Wyoming, Spatial Data Visualization Center, 1996).

Table 3.9 Summary of LANDFIRE Existing Vegetation Type Data Analysis.

Existing Vegetation Type	Acres	Percent of Watershed	Cummulative Percent
Inter-Mountain Basins Big Sagebrush Shrubland	51,826.00	46.29%	46.29%
Rocky Mountain Foothill Limber Pine-Juniper Woodland	11,534.06	10.30%	56.59%
Rocky Mountain Lower Montane-Foothill Shrubland	9,603.90	8.58%	65.17%
Artemisia tridentata ssp. vaseyana Shrubland Alliance	6,321.13	5.65%	70.82%
Inter-Mountain Basins Big Sagebrush Steppe	5,526.51	4.94%	75.75%
Inter-Mountain Basins Montane Sagebrush Steppe	4,515.50	4.03%	79.78%
Introduced Riparian Vegetation	4,398.75	3.93%	83.71%
Western Great Plains Floodplain Systems	4,230.39	3.78%	87.49%
Inter-Mountain Basins Curl-leaf Mountain Mahogany Woodland and Shrubland	3,644.83	3.26%	90.75%
Introduced Upland Vegetation-Annual Grassland	1,525.85	1.36%	92.11%
Inter-Mountain Basins Semi-Desert Grassland	1,520.74	1.36%	93.47%
Rocky Mountain Montane Riparian Systems	1,489.16	1.33%	94.80%
Wyoming Basins Dwarf Sagebrush Shrubland and Steppe	922.94	0.82%	95.62%
Rocky Mountain Subalpine/Upper Montane Riparian Systems	914.71	0.82%	96.44%
Inter-Mountain Basins Greasewood Flat	671.63	0.60%	97.04%
Rocky Mountain Aspen Forest and Woodland	507.73	0.45%	97.49%
Agriculture-Pasture and Hay	507.51	0.45%	97.95%
Northern Rocky Mountain Lower Montane-Foothill-Valley Grassland	371.84	0.33%	98.28%
Inter-Mountain Basins Mat Saltbush Shrubland	241.30	0.22%	98.49%
Middle Rocky Mountain Montane Douglas-fir Forest and Woodland	232.18	0.21%	98.70%
Southern Rocky Mountain Ponderosa Pine Woodland	192.37	0.17%	98.87%
Colorado Plateau Pinyon-Juniper Woodland	186.59	0.17%	99.04%
Introduced Upland Vegetation-Annual and Biennial Forbland	165.91	0.15%	99.19%
Developed-Open Space	143.22	0.13%	99.32%
Open Water	137.00	0.12%	99.44%
Northern Rocky Mountain Subalpine Woodland and Parkland	84.07	0.08%	99.51%
Inter-Mountain Basins Juniper Savanna	82.51	0.07%	99.59%
Developed-Low Intensity	70.28	0.06%	99.65%
Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland	70.28	0.06%	99.71%
Western Great Plains Shortgrass Prairie	66.50	0.06%	99.77%
Inter-Mountain Basins Semi-Desert Shrub-Steppe	57.38	0.05%	99.82%
Western Great Plains Depressional Wetland Systems	43.81	0.04%	99.86%
Inter-Mountain Basins Mixed Salt Desert Scrub	41.14	0.04%	99.90%
Developed-Medium Intensity	29.36	0.03%	99.93%
Barren	24.91	0.02%	99.95%
Agriculture-Cultivated Crops and Irrigated Agriculture	21.13	0.02%	99.97%
Rocky Mountain Subalpine-Montane Mesic Meadow	20.46	0.02%	99.99%
Rocky Mountain Gambel Oak-Mixed Montane Shrubland	5.78	0.01%	99.99%
Northwestern Great Plains Mixedgrass Prairie	4.89	0.004%	99.99%
Developed-High Intensity	2.00	0.002%	100.00%
Introduced Upland Vegetation-Perennial Grassland and Forbland	1.56	0.001%	100.00%
Inter-Mountain Basins Sparsely Vegetated Systems	1.33	0.001%	100.00%
Southern Rocky Mountain Montane-Subalpine Grassland	0.67	0.001%	100.00%
Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	0.22	0.0002%	100.00%
Northern Rocky Mountain Subalpine-Upper Montane Grassland	0.22	0.0002%	100.00%
Total	**111,960.24**		

The WYNDD has two known sensitive plant species of concern located in the study area (Table 3.10). The potential exists for some of these species to occur within appropriate habitats within the watershed. However, none of these species receive federal or state protection.

Table 3.10 Wyoming Natural Diversity Database: Vegetation Species in the Buffalo Creek Watershed.

Scientific Name	Common Name	Listing Status	Tracked/ Watched	Date Observed
Flowering Plants				
Sullivantia hapemanii var. hapemanii	Hapeman's sullivantia	Not Listed	Watched	
Artemisia porteri	Porter's sagebrush	Not Listed	Tracked	6/21/1979

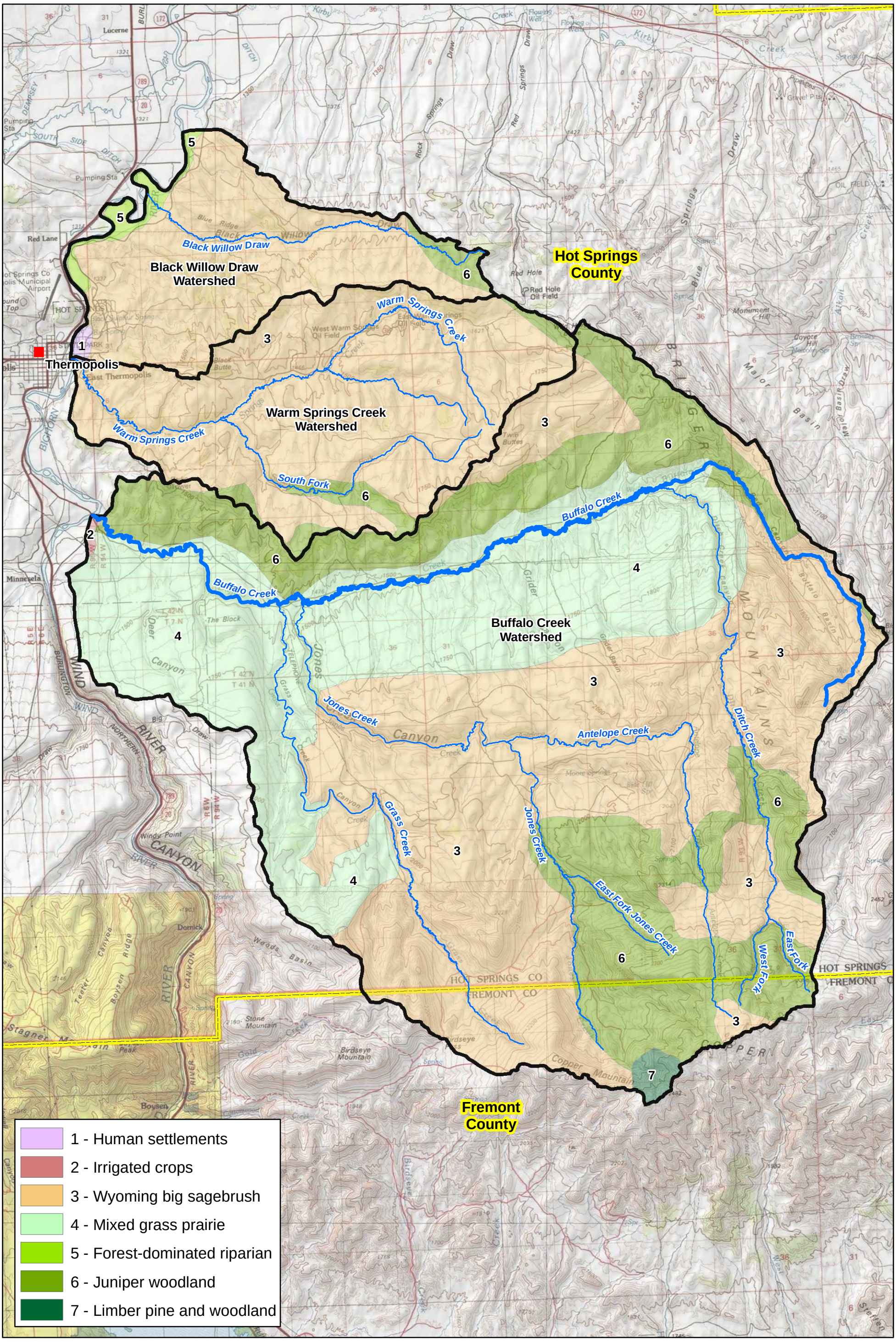


Figure 3.25 Buffalo Creek Watershed: Land Cover - Wyoming GAP Analysis

3.4.2.2 Targeted Vegetation

Vegetation of particular importance with respect to land use and habitat that were identified by Hot Springs County Weed and Pest District, Hot Springs Conservation District, and local landowners include:

- Juniper (Juniperus sp.),
- Scotch thistle (Onopordum acanthium L.),
- Musk thistle (Carduus nutans L.),
- white-top (Cardaria draba), and
- Cheatgrass (Bromus tectorum L), among others.

The Hot Springs County Weed and Pest District actively conducts control measures to reduce the spread and reproduction of weed species.

It should be kept in mind that proper and appropriate grazing management should follow any vegetative control efforts to maximize benefits and improve competitive benefits of desirable vegetation. Proper grazing management practices can also reduce the incidences of future undesirable plant reestablishment.

Although native to Wyoming, juniper encroachment has resulted in a loss of habitat and rangeland. Historically juniper expansion was kept in check by naturally occurring range fires. However, fire suppression and grazing practices have contributed to juniper expansion into areas where it was not previously a factor. Juniper has expanded its area into more productive range sites and has greatly increased its density in its normal habitat. This has resulted in decreased forage production for livestock and wildlife. Decreased water infiltration has also had negative effects on watershed values

Juniper control has been successful in many areas of the Big Horn Basin of restoring sagebrush grassland, aspen, and riparian communities:

- Prescribed burning has been the major tool, and has proven to be effective and economically feasible.
- Chemical control has been tried, but has generally been expensive. The herbicides used generally need to be used at high enough rates to slow recovery of understory grasses. Spike (tebuthiuron) has been used with some success.
- Mechanical treatment methods include chainsaws, dozing, or more recently, use of larger chippers.

The threat of introduced weeds is one of the most important considerations when applying control practices in juniper woodlands. For example, prevalence of cheatgrass has become a problem on rangeland in the Big Horn Basin. In many cases, cheatgrass infestations on burn projects have caused

significant problems. Cheatgrass infestation and other problem weeds need to be considered on any soil or vegetation disturbing project.

A large variety of wildlife species use early transitional states of woodlands that still contain an understory of shrubs, grasses and forbs. However, once juniper dominates an area and shrubs and understory species decline or are crowded out, wildlife abundance and diversity decline substantially (Miller et al. 2005). According to the NRCS, encroachment of juniper can also negatively affect sage grouse habitat by providing perching opportunities for raptors and ravens that may result in higher rates of mortality and nest predation (NRCS, 2012).

In an effort to assist the Hot Springs Conservation District and the area landowners, the project team evaluated the extent of juniper within the GIS environment. Using the previously described LANDFIRE dataset for the study area, those areas categorized as juniper woodland were extracted. The LANDFIRE dataset also contains attributes describing the slope of each discrete cell within the coverage. Since terrain with lower slopes will develop deeper and more productive soils, the cells with slopes less than ten percent were also extracted. By overlaying the two resulting datasets, Figure 3.26 was prepared. While ground truthing of the results would be necessary, the data used to generate this figure could be used to initiate planning efforts associated with juniper removal.

3.4.2.3 Wetlands

Existing mapping of wetlands within the study area consisted of the National Wetlands Inventory (NWI) created by the US Fish and Wildlife Service (USFWS). The NWI mapping was completed using aerial photographs within the GIS environment and digitizing by analysts, however due to the relatively limited extent of mapped wetlands in relation to the size of the watershed, the data does not lend itself to presentation at this scale. Based upon the NWI mapping, approximately 230 acres of wetlands exist within the watershed. These wetlands are located primarily along perennial streams in the lower portions of the watershed, and also throughout the Big Horn National Forest. It is generally understood by users of the NWI mapping that the data are suitable for broad scale planning efforts such as this Level I investigation; however, before design and completion of any project potentially affecting wetlands, detailed onsite delineation should be conducted.

In addition to the NWI mapping, the LANDFIRE data includes limited determination of wetlands as well. Based upon the LANDFIRE data analysis, there are Rocky Mountain Subalpine/Upper Montane Riparian Systems (1,489 acres) and Rocky Mountain Montane Riparian Systems (914.7 acres). In addition, the LANDFIRE data indicate the presence of approximately 43.8 acres of Western Great Plains Depressional Wetlands with the watershed (Figure 3.27).

Hot Springs County

Black Willow Draw

Black Willow Draw Watershed

Warm Springs Creek

Thermopolis

Warm Springs Creek Watershed

Warm Springs Creek

South Fork

Buffalo Creek

Buffalo Creek

Buffalo Creek Watershed

Jones Creek

Antelope Creek

Ditch Creek

Grass Creek

Jones Creek

East Fork Jones Creek

West Fork

East Fork

Fremont County

0 - 3.5% Slopes with Juniper Cover

3.5 - 8.7% Slopes with Juniper Cover

N

W E

S

0 8,500 17,000

Feet

Legend

Cities

Streams

Buffalo Creek Study Area

County Boundary

Figure 3.26 Buffalo Creek Watershed: Noted Dense Juniper Areas

Hot Springs County

Black Willow Draw

Black Willow Draw Watershed

Warm Springs Creek

Thermopolis

Warm Springs Creek Watershed

Warm Springs Creek

South Fork

Buffalo Creek

Buffalo Creek

Buffalo Creek Watershed

Jones Creek

Antelope Creek

Ditch Creek

Grass Creek

Jones Creek

East Fork Jones Creek

West Fork

East Fork

Fremont County

Introduced Riparian Vegetation

Rocky Mountain Montane Riparian Systems

Rocky Mountain Subalpine/Upper Montane Riparian Systems

Western Great Plains Depressional Wetland Systems

Western Great Plains Floodplain Systems

N

W E

S

0 8,500 17,000

Feet

Legend

Cities

Streams

Buffalo Creek Study Area

County Boundary

Figure 3.27 Buffalo Creek Watershed: LANDFIRE Wetland Classes

The US Army Corps of Engineers has adopted a 'watershed approach' to wetland classification which includes consideration of the 'hydrogeomorphic character' of the various wetland types. According to the USACE manual (USACE, 1995):

> *"The hydrogeomorphic classification is based on three fundamental factors that influence how wetlands function, including geomorphic setting, water source, and hydrodynamics. Geomorphic setting refers to the landform of a wetland, its geologic evolution, and its topographic position in the landscape. For example, a wetland may occur in a depressional landform or a valley landform and may occur at the top, middle, or bottom of a watershed."*

Seven wetland types have been defined using the classification system adopted by the USACE: Riverine, Slope, Lacustrine Fringe, Depressional, Estuarine, Mineral Soil Flats, and Organic Soil Flats. Within the study area, the following three types are likely to be encountered: slope wetlands, depressional wetlands, and riverine wetlands. In the paragraphs that follow, extracts from the USACE are presented which describe the nature and function of each.

"Slope Wetlands

Slope wetlands normally are found where there is a discharge of groundwater to the land surface. They normally occur on sloping land; elevation gradients may range from steep hillsides to slight slopes. Slope wetlands are usually incapable of depressional storage because they lack the necessary closed contours. Principal water sources are usually groundwater return flow and interflow from surrounding uplands as well as precipitation. Hydrodynamics are dominated by downslope unidirectional water flow. Slope wetlands can occur in nearly flat landscapes if groundwater discharge is a dominant source to the wetland surface. Slope wetlands lose water primarily by saturation subsurface and surface flows and by evapotranspiration. Slope wetlands may develop channels, but the channels serve only to convey water away from the slope wetland. Fens are a common example of slope wetlands.

Depressional Wetlands

Depressional wetlands occur in topographic depressions with a closed elevation contour that allows accumulation of surface water. Dominant sources of water are precipitation, groundwater discharge, and interflow from adjacent uplands. The direction of water movement is normally from the surrounding uplands toward the center of the depression. Depressional wetlands may have any combination of inlets and outlets or lack them completely. Depressional wetlands may lose water through intermittent or perennial drainage from an outlet, by evapotranspiration, and, if they are not receiving groundwater discharge, may slowly contribute to groundwater. Dominant hydrodynamics are vertical fluctuations, primarily seasonal. Peat deposits may develop in depressional wetlands. Prairie potholes are a common example of depressional wetlands.

Riverine Wetlands

Riverine wetlands occur in floodplains and riparian corridors in association with stream channels. Dominant water sources are overbank flow from the channel or subsurface hydraulic connections between the stream channel and wetlands. Additional water sources may be interflow and return flow from adjacent uplands, occasional overland flow from adjacent uplands, tributary inflow, and precipitation. When overbank flow occurs, surface flows down the floodplain may dominate hydrodynamics. At their headwater most extension, riverine wetlands often intergrade with slope or depressional wetlands as the channel (bed) and bank disappear, or they may intergrade with poorly drained flats or uplands. Perennial flow is not required. Riverine wetlands lose surface water via the return of floodwater to the channel after flooding and through saturation surface flow to the channel during rainfall events. They lose subsurface water by discharge to the channel, movement to deeper groundwater (for losing streams), and evapotranspiration. Peat may accumulate in off-channel depressions (oxbows) that have become isolated from riverine processes and subjected to long periods of saturation from ground-water sources. Bottomland hardwood floodplains are a common example of riverine wetlands."

The classification system discussed by the USACE also incorporates consideration of the various 'functions' of the wetland types:

"Wetland functions are defined as the normal or characteristic activities that take place in wetland ecosystems or simply the things that wetlands do. Wetlands perform a wide variety of functions in a hierarchy from simple to complex as a result of their physical, chemical, and biological attributes. For example, the reduction of nitrate to gaseous nitrogen is a relatively simple function performed by wetlands when aerobic and anaerobic conditions exist in the presence of denitrifying bacteria. Nitrogen cycling and nutrient cycling represent increasingly more complex wetland functions that involve a greater number of structural components and processes. At the highest level of this hierarchy is the maintenance of ecological integrity, the function that encompasses all of the structural components and processes in a wetland ecosystem."

Figure 3.28 provides a figure extracted from the USACE manual depicting the hierarchy of wetland functions associated with the example cited above regarding the nitrogen cycle. Additional information regarding the wetlands classification scheme is contained in the USACE document available at: http://el.erdc.usace.army.mil/wetlands/pdfs/wrpde9.pdf.

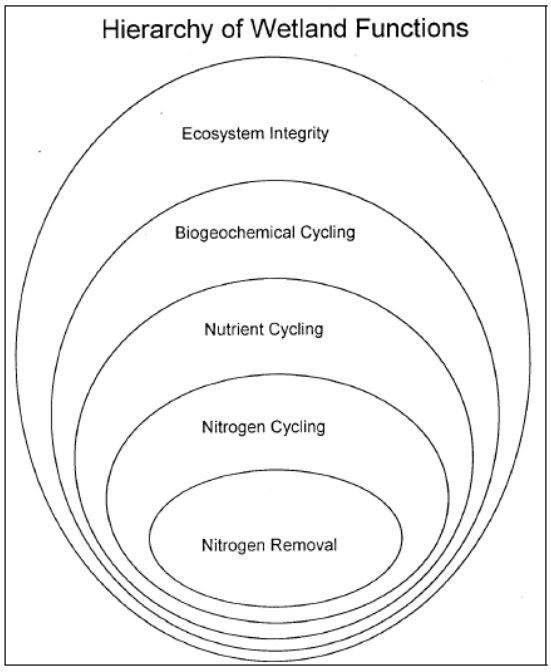


Figure 3.28 Hierarchy of Wetland Functions (USACE, 1995).

Delineation of wetlands and classification by function was beyond the scope of this study. However, based upon the project team's familiarity of the basin and the hydrologic regime of the watershed, it can be assumed that the majority of the wetlands in the study area consist primarily of riverine wetlands found along the water courses. To a lesser extent, slope wetlands are found in association with springs outside of the riparian zones.

3.4.3 Geology

3.4.3.1 Surficial Geology

The surficial deposits found within the Buffalo Creek watershed are presented on Figure 3.29. Most of the study area is covered with undifferentiated "slope wash and colluvium" and "residuum", i.e., simply the erosional debris created by weathering of the underlying bedrock. At scattered locations, the accumulation of eroded material has been sufficient to merit mapping as "alluvial fan" deposits. Material deposited more energetically is indicated by the rare occurrence of mapped "landslide" deposits.

Each of these deposits will produce soils and vegetation as a function of its physical and chemical composition, slope, slope aspect, local precipitation and other climatic factors, age, etc. which vary widely across the study area.

3.4.3.2 Bedrock Units

Geologically, as well as topographically, the study area is located in the southeast portion of the Bighorn Basin, a broad structural basin bounded by Laramide (faulted anticline) mountain uplifts on the north, east, and south, and by the volcanic pile of the Absaroka Mountains on the west. The study area is located on the northern dip-slope of the Owl Creek Mountains, where, from south to north, successively younger sedimentary strata outcrop and dip northward into the basin. Figure 3.30 provides a generalized geologic map of the study area extracted from the 1:500,000-scale geologic map compilation by Love and Christiansen (1985). Figure 3.31 provides a schematic north-south cross section and indicates the deeply dipping attitude of the strata. This figure also shows more detailed segregation into individual formations.

Table 3.11 provides a geologic column for the study area, modified from the Plafcan and Ogle (1994) report on the water resources of Hot Springs County. Included on the table is a summary description of the water-bearing characteristics of the various formations. For the geologic bedrock formations present in the study area, all of Cretaceous age or older, there are no systematic differences between the study area and the rest of Hot Springs County, i.e. the Plafcan and Ogle (1994) descriptions are appropriate. (Only those units present in the study area are included. There are substantial thicknesses of younger strata elsewhere in Hot Springs County and in the Bighorn Basin.)

Hot Springs County

Fremont County

Black Willow Draw Watershed

Warm Springs Creek Watershed

Buffalo Creek Watershed

Black Willow Draw

Warm Springs Creek

South Fork

Buffalo Creek

Jones Creek

Grass Creek

Antelope Creek

Ditch Creek

East Fork Jones Creek

West Fork

Ri - Bedrock

ai - Alluvium

fi - Alluvial fan

li - Landslide mixed

ri - Residuum

sci - Slopewash and colluvium

tdi - Dissected terrace

ti - Terrace deposits

N

W E

S

0 8,500 17,000

Feet

Legend

Cities

Streams

Buffalo Creek Study Area

County Boundary

Figure 3.29 Buffalo Creek Watershed: Surficial Geology

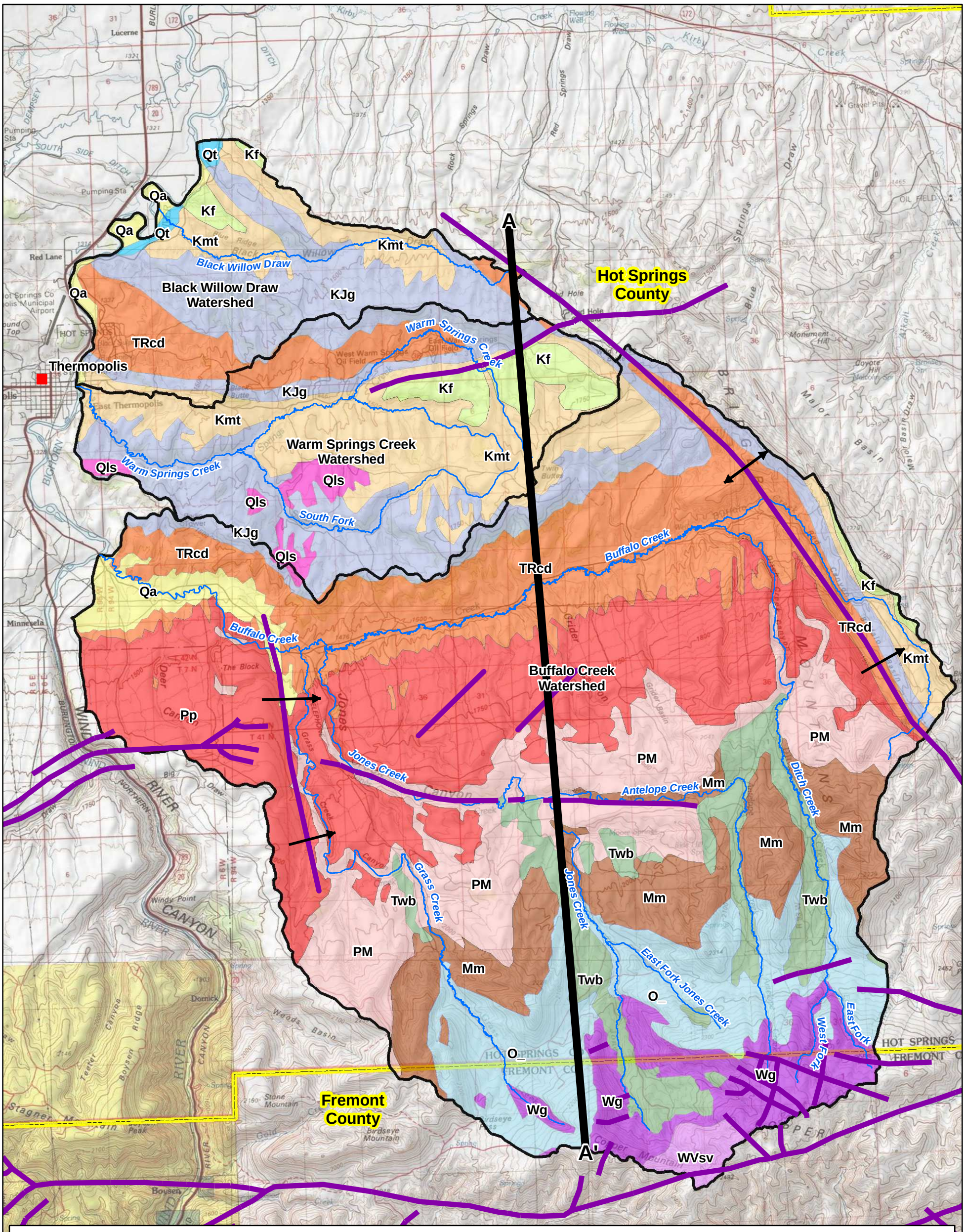


Figure 3.30 Buffalo Creek Watershed: Bedrock Geology

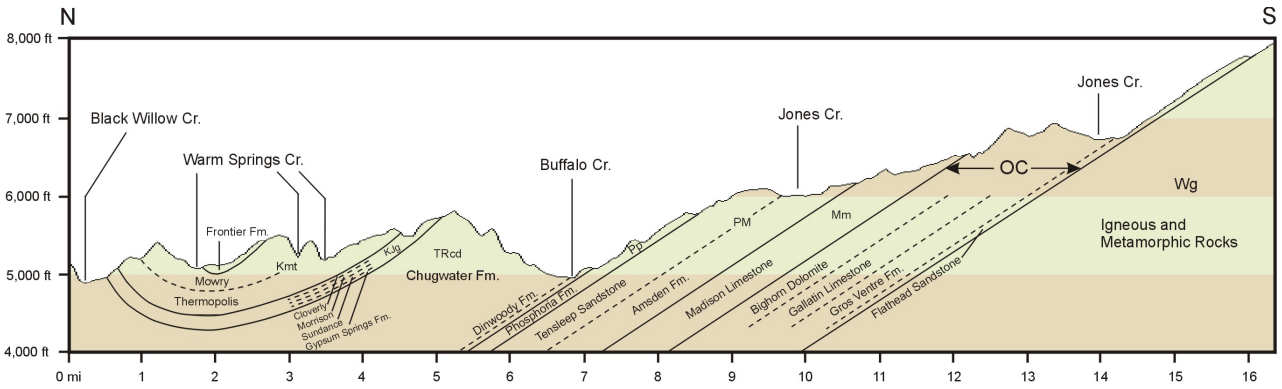


Figure 3.31 Geologic Cross Section A - A'

The oldest rocks in the study area are exposed at the surface along the crest of the Owl Creek Mountains, in the southernmost, most upstream portions of the Buffalo Creek study area. These granites and gneisses contain limited mineral deposits, although little of commercial significance has been developed.

Overlying the "basement" rocks of the Owl Creeks is a series of sedimentary strata. The older (Paleozoic-age) formations are dominated by limestones and dolomites, which provide prolific aquifers under favorable geologic conditions. The younger (Mesozoic-age) formations are dominated by shales, and typically provide less productive aquifers, present locally as interbedded sandstone units.

The youngest geologic materials in the study area are the sand, silts, and gravels associated with streams – collectively called "alluvium" – and the veneer of surface materials discussed below. Alluvial deposits are generally relatively flat, a function of their deposition on flood plains, so often provide fertile soils amenable to flood irrigation. In the Buffalo Creek study area, limited alluvial deposits are likely present along most streams, but are generally thin and of limited areal extent, only sufficient to have been mapped (at 1:500,000 scale) in the lowest reaches of the Buffalo Creek and, of course, along the Bighorn River.

3.4.3.3 Structure

The basic structure of the study area is a series of northward-dipping layers beveled off by erosion to create the roughly east-west "stripes" visible in Figure 3.30. The folds and faults seen in cross-section (Figure 3.31) show how the relatively simple geometry of these strata is complicated at the scale of the study area. (Faults are indicated by the dark lines without arrows). Along these lines, the strata have been broken and shifted relative to one another. For the faults in this area, the shift (called "fault displacement") is relatively small, as indicated by how rarely the displacement is enough to bring a different formation to the surface on opposite side of a fault. Earthquakes commonly accompany the displacement along faults, but, as discussed further below, the faults in the Buffalo Creek study area are all long-since inactive.

Table 3.11 Geologic Column of the Buffalo Creek Watershed Study Area.

System	Geologic Unit	Approx. Thickness (ft)	Lithology	Water-Yielding Characteristics	Range of Most Common Water	Map Symbol
CENOZOIC ERA						
Quaternary	allumium and colluvium	0 - 100	Unconsolidated clay, silt, sand,andgravel in floodplains, fans, and terraces. Deposits associated with mountain streams are generaly coarser	Might yield large quantities (>200 gal/min) of water to wells (Libraand others, 1981, p. 41); permeability dependent upon sorting and size of grains and clasts	<50	Qa, Qt
	landslide deposits		Aggregate of poorly sorted parent material (Lowry and others, 1976).	Composed of material of low perme-ability and not favorable sites for wells (Lowry and others, 1976)		Qls
Tertiary	Wagon Bed Formation		Green and gray tuffaceous claystone,sandstone, and conglomerate. Some marlstone and bentonitic claystone. Local oil shale (Love and Christiansen,1985).	Water-bearing properties vary greatly due to diverse lithologies (Lowry andothers, 1976).		Twb
MESOZOIC ERA						
Cretaceous	Cody Shale	2,100-3,000	Lower part dominantly consists ofdark gray marine shale, glauconitic sandstone, and thin bentonite beds; whereas, the upper part is interbeddedgray, sandy shale and sandstone (Libra and others, 1981, p. 42).	Artesian conditions exist in the area along Kirby Creek. Yields as large as 38 gal/min were observed from spring 41-090-04baa01.		Kc
	Frontier Formation	450-700	Lenticular fine- to medium-grained sandstone and conglomeratic sand-stone beds alternating with shale and lesser amounts of bentonite (Libra andothers, 1981, p. 42).	Brittle shales and thin sandstones might yield very limited quantities ofwater to wells where fractured. Yields as large as 5 gal/min were observed from well 42-092-34bab01.	2-10	Kf
	Mowry Shale	300	Siliceous brittle shale with thin beds; sandstone and bentonite beds in the upper part (Libra and others, 1981,p. 42).	Yields of 5 gal/min were observed from well 41-092-11abd01 and spring 41-092-11adb01. Wells developed in the Muddy Sandstone Member wereobserved to yield up to 8 gal/min (well 43-091-36bca01).		Kmt
	Thermopolis Shale	300	Soft shale with bentonite beds and sandy and silty zones. The Muddy Sandstone Member, which is about40 ft thick, occurs about 200 ft above the base (Libra and others, 1981,p. 42).	Sandstones might yield enough water for domestic or stock use. Yields as large as 21 gal/min were observed from well 43-094-13add01.		Kmt
	Cloverly Formation	100	Composed of three units; an upper sandstone, a middle shale, and a lower lenticular conglomeratic sandstone(Libra and others, 1981, p. 42).	Sandstones might yield enough water for domestic or stock use.		KJg
Jurassic	Morrison Formation	150	Variegated sandy shale and mudstone with lenses of fine-grained sandstone,conglomerate, and limestone.	Sandstones might yield enough water for domestic or stock use.		KJg
	Sundance Formation	260	Greenish-gray glauconitic sandstone and shale, underlain by red and gray nonglauconitic sandstone and shale (Love and Christiansen, 1985).	Solution zones in gypsum beds yield small amounts of water (Libra andothers, 1981, p. 43). Yields as large as28 gal/min were observed from spring41-091-23ddd01.		KJg
	Gypsum Spring Formation	80	Red siltstone and shale with gray to brown limestone beds and massive gypsum beds (Libra and others, 1981,p. 43).	Yields as large as 50 gal/min were observed from spring 41-091-27dbc01.		KJg
Triassic	Chugwater Formation	900	Red very fine-grained sandstone, silt- stone, shale, and one thin limestone (Alcova Limestone Member) in the southern part of the Bighorn Basin(Lowry and others, 1976).	Yields as large as 50 gal/min were observed from spring 41-091-27dbc01.	2-10	TRcd
	Dinwoody Formation	70	Yellowish siltstone interbedded with gypsum and shales (Lowry and others,1976).	Unknown.		
PALEOZOIC ERA						
Permian	Phosphoria Formation and Related Rocks	250	Brown sandstone and dolomite, cherty phosphatic and glauconitic dolomite, phosphatic sandstone and dolomite,greenish-gray to black shale (Loveand Christiansen, 1985).	Yields as large as 1,000 gal/min were observed from spring 42-095-25bca01.		Pp
Pennsylvanian	Tensleep Sandstone	300	Tan to white massive, cross beddedsandstone. Lower part more dolomite with interbedded carbonate beds(Libra and others, 1981, p. 44).	Flowing wells yield large and depend-able supplies of potable water inadjacent counties. Development ofsecondary permeability in addition toprimary permeability increases the water-yielding ability (Lowry andothers, 1976). Yields as large as25 gal/min were observed from spring41-094-21cda01.	50-200	PM
Pennsylvanian / Mississippian	Amsden Formation	360	Red shale and dolomte with chert andoccasional gypsum. Darwin Sand-stone Member at base ranges in thick-ness from 0 to 90 ft (Libra and others,1981, p. 44).	Darwin Sandstone Member yields water under pressure (Libra and others,1981, p. 44).		PM
Mississippian	Madison Limestone	500	Massive crystalline limestone and dolomite with siltstone and shalezones, cherty in places (Libra andothers, 1981, p. 44).	Secondary porosity due to solution along joints and fractures. Yields as large as 3,000 gal/min, but usually less(Libra and others, 1981, p. 44). In hydrologic connection with the under-lying Bighorn Dolomite forming the Madison-Bighorn aquifer. One well(46-098-28bcc01) had a water yield of284 gal/min.		Mm
Ordovician	Bighorn Dolomite	150	Massive to thin-bedded dolomite anddolomite limestone. Fine-grained massive sandstone at base. Contains cavernous zones near outcrop areas(Libra and others, 1981, p. 44).	In combination with the Darby Forma-tion and the Madison Limestone,forms the Madison-Bighorn aquifer,which produces large and dependable supplies of potable water in adjacentcounties. Porosity primarily due to fracturing and solution (Libra andothers, 1981, p. 44). Yields as large as323 gal/min were observed from well46-098-18cbb01.		OC
Cambrian	Gallatin Limestone	450	Gray-green calcareous shale and flat-pebble conglomerate (Lowry andothers, 1976).	In combination with the underlying Gros Ventre Formation, forms a confining layer for the Flathead Sand-stone.		OC
	Gros Ventre Formation	400	Greenish-gray thin-bedded limestone and limestone-pebble conglomerate(Lowry and others, 1976).	Thin sandstone beds indicate potential for small yields. However, one well(43-093-28ccd01) yielded 110 gal/min.		OC
	Flathead Sandstone	200	Arkosic and quartzitic sandstone with interbedded shale in upper part (Libraand others, 1981, p. 45).	Libra and others (1981, p. 45) reported water yields over 2,000 gal/min.Yields as large as 15 gal/min were observed from spring 41-092-33daa01and spring 41-093-31dcd01.		OC
PRECAMBRIAN ERA						
	Igneous and Metamorphic Rocks		Metasedimentary and metavolcanic rocks, and granitic rocks of 2,600-Ma age group (Love and Christiansen,1985).	Dominantly not an aquifer, but in the mountains intensively weathered orfractured rocks within 100 feet of the surface might yield enough water fordomestic or stock use.		Wg, WVsv

NOTES: Copied from Plafcan and Ogle, 1994 (Table. 5), with thicknesses modified after Haughan (1972a & b), and Thaden, 1980. Generalized map symbols from Love andChristiansen (1985).

The geologic significance of faults in this area lies in the fracturing of strata subjected to displacement. Such fractures may greatly increase permeability, creating attractive targets for groundwater development. Where displacement is large, faulting may juxtapose a relatively permeable, oil- or gas-bearing formation against a relatively impermeable formation, creating a "trap" that may yield exploitable accumulations of hydrocarbons.

More pronounced structural elements in the study area are the folds indicated by the dark lines (with arrows) on Figure 3.30. The arrows indicate the direction in which the strata are dipping down, away from the fold axis. Along much of the east side of the area, for example, is the Wildhorse Butte Anticline. Throughout the Bighorn Basin, folds like these are the most important traps for the accumulation of oil in commercial quantities. The Wild Horse Butte oil field (production from the Phosphoria Formation) occupies the north end of the Wild Horse Butte Anticline. Smaller folds provide the Warm Springs oil field just east of Thermopolis, and the Red Springs oil field at the far north end of the area.

3.4.3.4 Geologic Hazards

Conventional "geologic hazards" are minor in the Buffalo Creek study area (Figure 3.32).

The formations in the southern half of the area – Bighorn and Gallatin ("OC"), Madison ("Mm"), and Phosphoria ("Pp") Formations are largely composed of the carbonate minerals, limestone and dolomite. These minerals are slightly soluble in water and can create karst features such as sinkholes and other solution collapse features. Solution features may also be present in the Gypsum Springs formation (base of the "KJg" group) due to the presence of gypsum.

A karst landscape can be hazardous for construction and travel due to the obvious interruption of the land surface and collapse risk. However, these formations are largely confined to the open-range north slopes of the Owl Creek Mountains, where substantial development is unlikely.

Landslide deposits are included with the mapping of general surficial geology. Specific landslide mapping supplied by WRDS (2007) is also shown on the figure. As with the alluvium mapping discrepancies noted above, the different coverages generated by different mapping perspectives are also evident with respect to landslides. Landslide activity in the Buffalo Creek study area is relatively minor in any case, marking local occurrences where slope, permeability, pore pressure, and formation strength have combined to create slope failure. Not surprisingly, landslides have been largely confined to the weak shales of Cretaceous age ("KJg"). Future landslides are most likely to occur in association with areas of historical slope failure. Thus, while this potential hazard is not restricted to the areas mapped, those areas merit heightened concern.

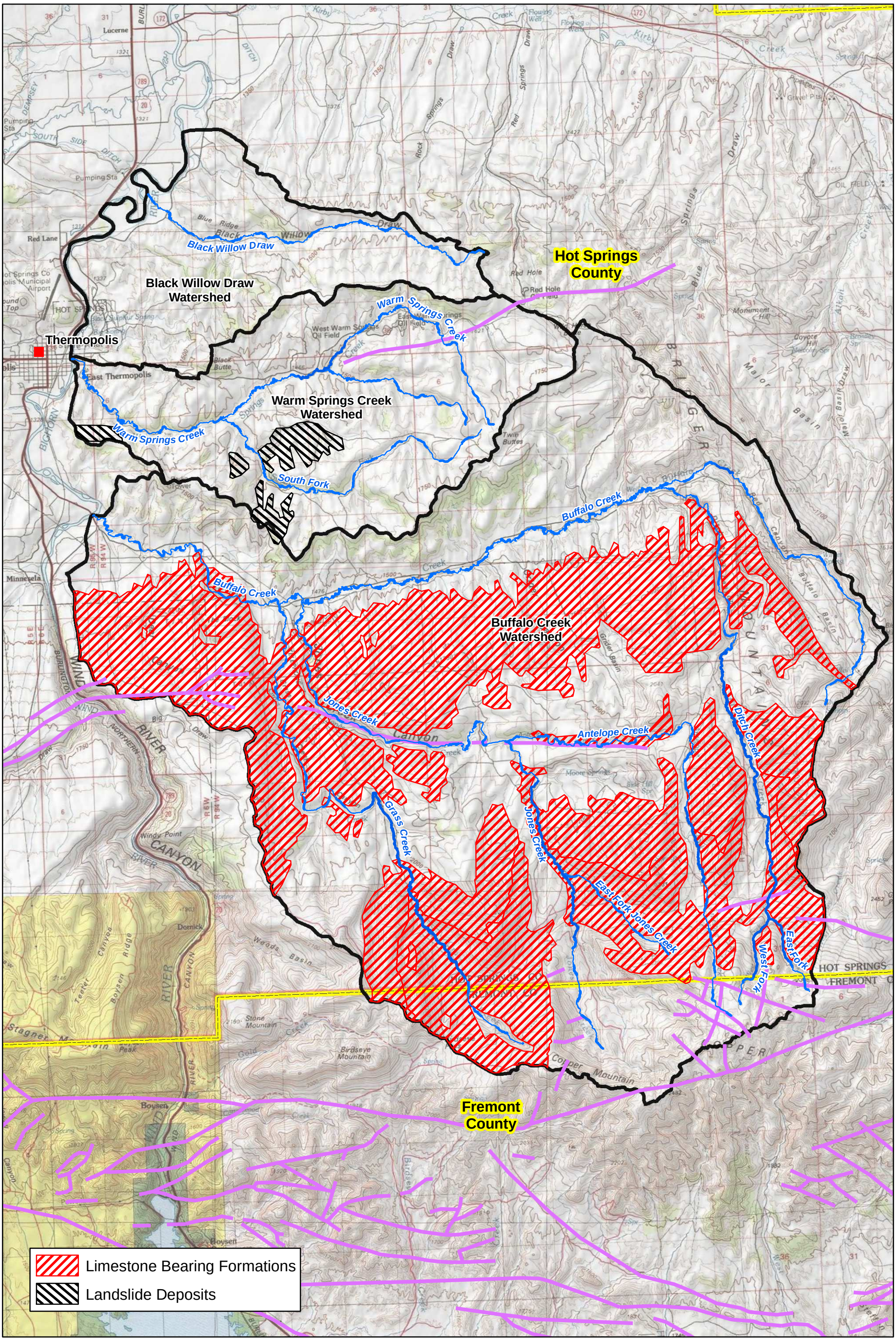


Figure 3.32 Buffalo Creek Watershed: Geologic Hazards

Data compiled on U.S. earthquakes of magnitude 2.5 or greater over the period 1897 - 2001 show no such occurrences within the Buffalo Creek study area. The nearest has been a magnitude 4 event in 1978, approximately 6 miles to the west, along Kirby Creek. (A magnitude 4 earthquake is perceptible by people in motion, but is not destructive.)

There have been eight magnitude 3.0 or greater earthquakes recorded in the larger Thermopolis area over the last 110 years, although none in the Buffalo Creek study area specifically (WyGISC, 2002). Although of sufficient magnitude to be felt by residents, none resulted in significant damage. (see Case et. al. 2002 for descriptions.) On as scale of zero to 4 (4 being the riskiest), the study area falls in zone 2 according to seismic risk mapping by the Uniform Building Code Seismic Zone Map. Similarly, mapping of seismic hazard by the U.S. Geological Survey indicate relatively low risk in the study area, e.g. a 10% probability of exceeding a ground acceleration of 6% of the acceleration of gravity in 50 years, compared with 40-60% of the acceleration of gravity for certain locations in Teton County (Case et. al. 2002).

3.4.4 Soils

Many of the physical and chemical properties of the soils in the study area are strongly influenced by the nature of the parent materials. Very young soils are influenced more by parent material than by vegetation. The soils in the watershed area formed from limestone and sandstone on mountainsides and from interbedded sandstone. Soils within the study area vary greatly as would be anticipated given the areal extent of the basin and the variety of parent materials, precipitation, and other soil forming factors. Figure 3.33 displays a general soils map of the study area prepared using data mapped at the 1:250,000 level of detail and obtained from the NRCS. This level of detail is valuable for regional planning efforts such as this investigation; however, more detailed mapping is required for site-specific investigations and evaluation of specific projects.

Within the study area, detailed soils mapping was not available for the majority of the area. The NRCS assigns its detailed soils mapping (1:24,000 scale) pertinent attributes, including the ESD. The 1:24,000 scale mapping was available only for Fremont which spans approximately 6 percent of the study area.

3.5 Watershed Hydrology

3.5.1 Groundwater

Groundwater is simply the underground component of the hydrologic cycle. Water enters the subsurface as rainfall, snowmelt, streamflow, irrigation water, etc. infiltrates, in a process called “recharge”. Groundwater moves beneath the surface in response to groundwater gradients, much as surface water flows “downhill”. And groundwater leaves the subsurface as “discharge” via springs, wells, baseflow into streams, uptake by deep-rooted vegetation, and evaporation from the ground surface.

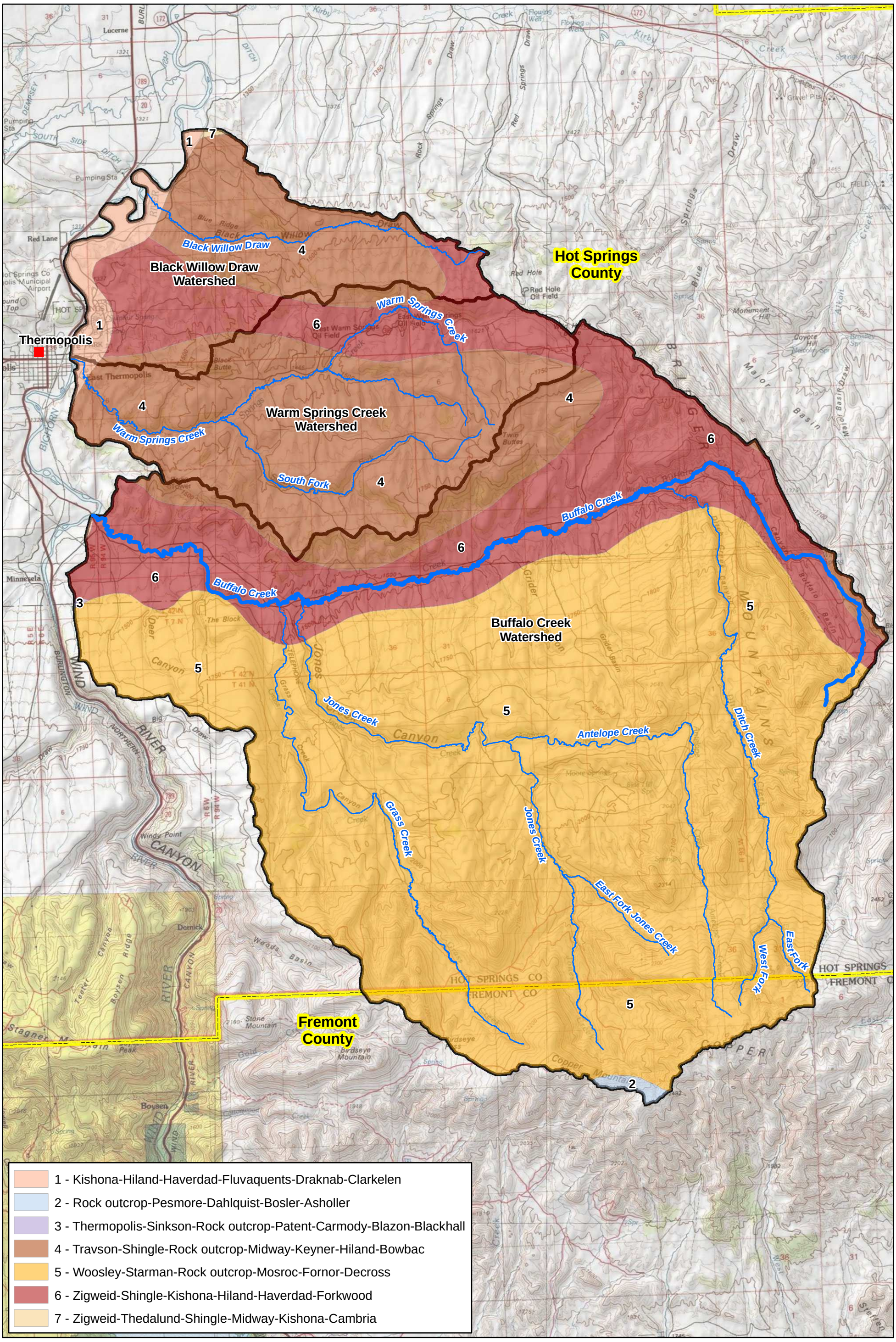


Figure 3.33 Buffalo Creek Watershed: Soils Mapping at 1:250,000

3.5.1.1 Springs

Groundwater is naturally discharged by springs and seeps, by evapotranspiration, and by discharge to streams and other aquifers. Springs and seeps occur when the water table intersects the land surface. This commonly is the result of changes in lithology, faults and fractures, and topography. For example, where a sufficiently permeable geologic unit (e.g., uncemented sandstone or conglomerate) crops out in a swale or on a hillside at an elevation below the ambient groundwater table in the bedrock unit at that location, a spring may develop. Similarly, a permeable geologic structure (e.g., an open joint, fracture or fault zone) may intersect the ground surface and serve as a conduit for the discharge of groundwater. Spring flows vary widely due to the nature of the aquifer/structure discharging, the amount of seasonal recharge from snowmelt and rainfall, depletion of storage during periods of drought, and even evaporation and evapotranspiration at the site of the spring. The flows can be concentrated or diffuse, again depending on the nature of the geologic conditions causing the spring (Susong, et al., 1993).

Numerous small springs and a few large springs exist in the area. Figure 3.34 displays the location of springs mapped by the USGS and the BLM.

3.5.1.2 Bedrock Aquifers

In the Buffalo Creek area, groundwater recharge is most significant in the upland areas (the southern portion of the study area), where there is more precipitation and snowmelt, but likely occurs seasonally across much of the study area. Generalized estimates of recharge generated as part of a statewide aquifer vulnerability project by the University of Wyoming (WyGISC, 1998) vary from 10-15 inches per year at the highest elevations of the study area to 0 - 0.5 inches in at the lowest elevations.

Recharge is also a function of the character of the underlying geologic materials. The highest elevations in the study area are underlain by the relatively impermeable rocks forming the core of Copper Mountain, from which water runs off rather than infiltrating. Next lower in elevation, proceeding northward, are the outcrops of the major aquifers of the Bighorn, Madison, Tensleep, and Park City Formations. At a regional level, these formations are commonly grouped together as the "Paleozoic Aquifer" (e.g. Spencer, 1986). At the study area level, the former two are somewhat separated from the latter two by the intervening low-permeability beds of the Horseshoe Shale Member of the Amsden Formation. Figure 3.35 replicates geologic section A – A' shown on Figure 3.30; however, in this figure, the approximate water table is indicated.

Groundwater flows "downhill", between points of recharge and points of discharge, in response to local groundwater gradients defined by the water table (or the distribution of artesian pressure in confined aquifers). For the major aquifers of the Buffalo Creek study area, permeability is sufficient to allow groundwater to "drain" away beneath areas of recharge, leaving substantial depths to water at most locations.

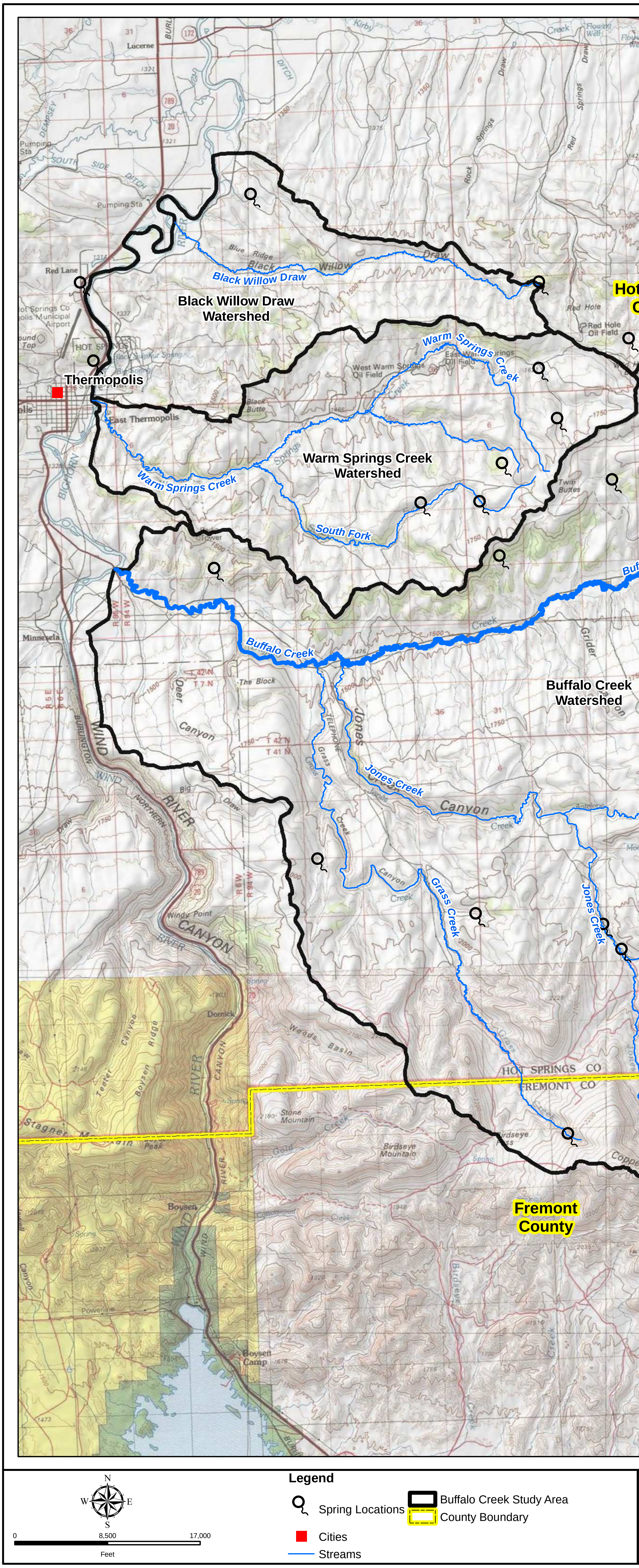


Figure 3.34 Buffalo Creek Watershed: Springs

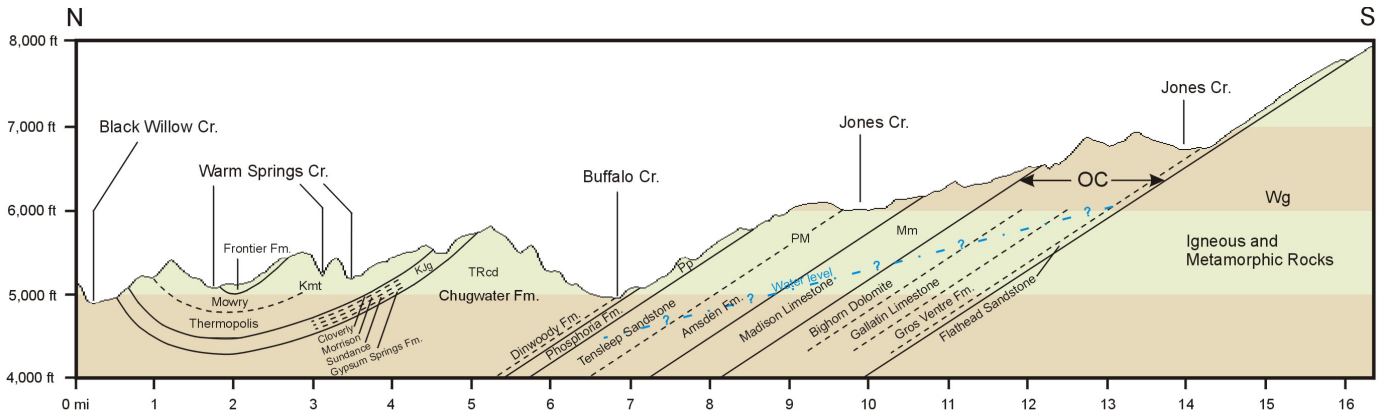


Figure 3.35 Geologic Section A-A' with approximate ground water table.

Wells permitted with the Wyoming State Engineers Office (WSEO) are shown in Figure 3.36. Table 3.12 tabulates pertinent information on the wells and serves as a key to accompany the map displayed n Figure 3.36. In the WWDC "Hot Springs Well No. 1" (aka "T & V #1") at the east edge of the study area, the depth to groundwater in the Madison Fm. was 950 ft. (i.e. at elevation 4445 ft.). In the WWDC "Buffalo Creek No. 2" well near the west edge of the study area, the depth to groundwater in the Madison Fm. was 176 ft . (elev. 4394 ft.). A domestic well a mile downstream appears to have been completed in the Tensleep Fm. (Weston, 2011), where a depth to water of 100 ft. (elev. 4380 ft.) was encountered. Finally, a well identified by the US Geological Survey as producing from the Tensleep Fm. (Plafcan and Ogle, 1994) east of the Buffalo Creek No. 2 Well (well "V") reports a depth to groundwater of 289 ft. (elev. 4561 ft.). Figure 3.37 presents a west-east topographic profile and schematic cross section drawn along the Buffalo Creek road, from the Bighorn River to the Hot Springs Well No. 1. Depth-to-water in the Madison or Tensleep Formation and formation depths are presented on the cross section. The indicated groundwater level shows the considerable depth of regional groundwater in the western portion of the study area, and the westward convergence of the land surface and the deep-aquifer water levels as the surface elevation drops going downstream along Buffalo Creek.

There are not sufficient data to map out the water table in these formations in detail, and the Tensleep/Park City aquifer water levels may be somewhat different from those in the Madison/Bighorn section, but there appears to be a general westward component to the regional groundwater gradient marked by these few wells. This is consistent with generalized maps of the water levels in these formations and the directions of flow at a regional scale (e.g. Bredehoeft and Bennet, 1971; Spencer, 1986), which show regional convergence of flow on the lowest point on the landscape, i.e. the Bighorn River (elevation 4380 ft. at the mouth of the Wind River Canyon) from both east and west.

The groundwater level data from the major aquifers show little or no opportunity for intersection of the regional water table and the land surface to create springs or streamflow gains from these formations over any but the lowest-elevation portions of the Buffalo Creek basin. Nonetheless, Figure 3.34 includes a scattering of springs across the central and northern portion of the study area.

Black Willow Draw Watershed

Warm Springs Creek Watershed

Buffalo Creek Watershed

Hot Springs County

Fremont County

Thermopolis

Note: Refer to Table 3.12 for pertinent well data

Wells Buffalo Creek Study Area

Wells Surrounding Area

N W E S

0 8,500 17,000

Feet

Legend

Cities

Streams

Buffalo Creek Study Area

County Boundary

Figure 3.36 Buffalo Creek Watershed: Wells Permitted with the Wyoming State Engineer

Table 3.12 Tabulation of Permitted Groundwater Wells.

Map ID	Permit	Priority	Status	Applicant	Facility Name	Permitted Uses	Reported Yield	Depth	Static Depth	Well Log	Chemical Analysis	Decade
1	P92352W	7/2/1993	GST	DEBBIE A. AXTELL	AXTELL #1 SPRING	DOM,STO	15	2	-4	No	No	1990
2	39/4/86W	6/8/2006	UNA	JACK & ELLEN BAIRD	DEVILSLIDE #1	STO				No		2000
3	P90777W	2/5/1993	GST	JAMES V. WILSON	WEST FORK DITCH CREEK#1 SPRING	STO	4	2	-4	No	No	1990
4	39/3/86W	6/8/2006	UNA	JACK & ELLEN BAIRD	DEVILSLIDE #2	STO				No		2000
5	P5498W	5/12/1970	ADJ	DON & RUTH BUCHANAN	BUCHANAN #3	STO	8	180	145	Yes		1970
6	P88907W	7/27/1992	GST	PATRICK K. AND LEONA F. KELLY	LEONA SPRINGS	DOM,STO	14	3	-4	No	No	1990
7	P88906W	7/27/1992	UNA	PATRICK K. AND LEONA F. KELLY	KEVIN SPRINGS	DOM,STO	3	14	-4	No	No	1990
8	P89183W	7/31/1992	GST	JERRY B. WALSH	WALSH HILLSIDE SPRING	STO	5	2	0	No	No	1990
9	P36856W	10/8/1976	ADJ	DENNIS W. & CAROLINE R. JONES	MELLIGAN #1	STO	10	120	50	Yes	No	1970
10	P126302W	6/12/2000	GST	WYOMING DEQ-WQD	MW-4093-1	MON	0	15	9.6	Yes	No	2000
11	P126303W	6/12/2000	GST	WYOMING DEQ-WQD	MW-4093-2	MON	0	16.5	12	Yes	No	2000
12	P126304W	6/12/2000	GST	WYOMING DEQ-WQD	MW-4093-3	MON	0	15	11	Yes	No	2000
13	P82163W	4/12/1990	GST	DEBBIE A. AXTELL	AXTELL #1	DOM,STO	1	220	85	Yes	No	1990
14	P164886W	12/28/2004	GSI	WYOMING WATER DEVELOPMENT COMMISSION	BUFFALO CREEK #2 TEST	TST				No		2000
15	40/3/334W	9/6/2007	UNA	Wyoming Water Development Commission	BUFFALO CREEK NO 2 MONITOR	MON				No		2000
16	P61314W	6/23/1982	ADJ	FRANK L. AND SHEILA A. LUTZ	MOUNTAIN VIEW #7	DOM	25	220	125	Yes	No	1980
17	P61315W	6/23/1982	ADJ	J & W INC.	MOUNTAIN VIEW #8	DOM	6	220	125	Yes	No	1980
18	P91413W	4/14/1993	GST	GREGORY E. BERNING	BERNING #2	DOM	15	240	138	Yes	No	1990
19	P61312W	6/23/1982	ADJ	CHARLES R. & SHARON M. STENDER	MOUNTAIN VIEW #5	DOM	22	220	120	Yes	No	1980
20	P149512W	2/26/2003	GSE	WYOMING WATER DEVELOPMENT COMMISSION	BUFFALO CREEK NO. 1 (SITE A)	TST				No		2000
21	P111498W	8/19/1998	GSI	AXTELL RANCHES, LLC	Buffalo Creek Well #5	DOM	0	0	0	No		1990
22	P50222W	10/3/1979	ADJ	DENNIS W. & CAROLINE R. JONES	JONES HORSE PASTURE #1	DOM,STO	10	55	23	Yes	No	1970
23	P104542W	11/21/1996	GST	DENNIS W JONES	HOMESTEAD #1	DOM,STO	23	885	100	Yes	No	1990
24	P48811W	6/26/1979	ADJ	DENNIS W. & CAROLINE R. JONES	JONES CALVING #1	DOM,STO	12	63	38	No	No	1970
25	P103272W	7/29/1996	GST	JOHN L & VIRGINIA A BAIRD	JOHN BAIRD #2	DOM,STO	25	120	65	No	No	1990
26	P141075W	12/3/2001	GST	JOHN L / VIRGINIA A BAIRD	JOHN BAIRD # 4	DOM,STO	12	160	100	Yes	No	2000
27	P51198W	2/12/1980	ADJ	DENNIS W. & CAROLINE R. JONES	JONES BULL PASTURE #1	DOM,STO	2	1	-4	No	No	1980
28	P149942W	3/14/2003	GST	WY STATE BOARD OF LAND COMMISSIONERS	T & V # 1	DOM,STO	25	1703	960	Yes	No	2000
29	P80964W	10/5/1989	GST	WYO BOARD OF LAND COMMISSIONERS**TAD	JOHNSON SPRING #1	STO	10	2	-4	No	No	1980
30	P153416W	8/20/2003	GST	TAD HENTHORNE	JP CAMP 1	DOM,STO	0	161	113.6	Yes	No	2000
31	P25651P	12/31/1963	ADJ	INC. BLACK BUTTE LIVESTOCK CO.	CARTER #5	STO	1	30	-6	No	No	1960
32	P25654P	12/31/1963	ADJ	INC. BLACK BUTTE LIVESTOCK CO.	CARTER #1	STO	1	30	25	No	No	1960
33	P110886W	7/13/1998	GST	BUCKHARD POHL (WARM SPRINGS RANCH)	Carter #3	DOM,STO	14	60	20	Yes	No	1990
34	P25655P	12/31/1963	ADJ	INC. BLACK BUTTE LIVESTOCK CO.	LOWER CORRALS #2	STO	3	100	90	No	No	1960
35	P25684W	1/26/1974	ADJ	BLACK BUTTE LIVESTOCK	READY #1	STO	10	60	20	Yes	No	1970
36	P93960W	4/17/1926	ADJ	USDI, BLM	NIELSEN LESTER SPRING	STO	1	-1	-1	No	No	1920
37	P93962W	4/17/1926	ADJ	USDI, BLM	MARET SPRING	STO	3	-1	-1	No	No	1920
38	39/5/44W	5/16/2006	UNA	CONNIE & JOSHUA KRUEGER	KRUEGER 1	DOM				No		2000
39	P41748W	1/31/1978	ADJ	MONA MCGARY	MCGARY #1	DOM	10	26	12	Yes	No	1970
40	P49424W	8/14/1979	ADJ	LOUIS T. EINER	EINER #3	DOM	21	28	11	No	No	1970
41	P49509W	8/17/1979	ADJ	LILLIAN MCQUEEN	MCQUEEN #1	DOM	25	24	10	Yes	No	1970
42	P49510W	8/17/1979	ADJ	LILLIAN MCQUEEN	MCQUEEN #2	DOM	25	25	9	Yes	No	1970
43	P49514W	8/20/1979	ADJ	EDNA DOCKERY	EDNA #2	DOM	25	27	12	Yes	No	1970
44	P50831W	11/5/1979	ADJ	WILFORD H. JOHNSON**RODNEY R. ST. CL	WHJ #1	DOM	25	33	10	Yes	No	1970
45	P52081W	5/8/1980	ADJ	ETHEL L. COVER	COVER #1	DOM	25	27.5	11	Yes	No	1980
46	P56908W	3/5/1981	ADJ	CHARLES H. DICKESON	DICKESON WELL #1	DOM	25	30	19	No	No	1980
47	P115968W	5/3/1999	GST	JOHN S VIETTI	VIETTI #1	DOM,STO	20	54	36	Yes	No	1990
48	P150267W	2/6/2003	GST	CORRIE L. LOVERCHECK & MICHAEL KELLE	LOVERCHECK # 1	DOM	15	35	11.7	No	No	2000
49	P151370W	4/24/2003	GST	SMITH BROTHERS INVESTMENTS	SMITH BROS. WELL NO. 1	DOM	6	37	12.1	Yes	No	2000
50	P17210W	12/12/1972	ADJ	INC. BLACK BUTTE LIVESTOCK CO.	BLACK BUTTE #1	STO	4	368	50	Yes	No	1970
51	P25652P	12/31/1963	ADJ	INC. BLACK BUTTE LIVESTOCK CO.	FRISBY #4	STO	5	65	35	No	No	1960
52	P72762W	6/12/1986		DUANE R. HARVEY	HARVEY #1	MIS	25	30	14	Yes	No	1980
53	P74983W	6/8/1987		DUANE R. HARVEY	ENL HARVEY #1	MIS	20	30	14	Yes	No	1980
54	P113239W	12/1/1998	GSI	DUANE R. HARVEY	HARVEY #2	DOM	0	0	0	No		1990
55	P132604W	1/19/2001	GST	DUANE R. HARVEY	HARVEY # 2	DOM	25	30	10	Yes	No	2000
56	P39348W	8/4/1977	ADJ	GILBERT RAYMOND NORING	NORING #1	DOM	1	45	18	No	Yes	1970
57	P132605W	1/19/2001	GST	DUANE R. HARVEY	HARVEY # 3	DOM	18	32	10	Yes	No	2000
58	P36800P	3/25/1977	ADJ	HEINZE INC.	HEINZE #12	DOM,STO	25	55	40	No	No	1970
59	P99081W	4/26/1995	UNA	CHRISTOPHER D. & SUE A. STEWART	MALLARD MARSH 02	MIS	20	27	5	Yes	No	1990
60	P63309W	2/18/1983		USDI, BLM** TRIGG OIL & MINING CORPO	WEST WARM SPRINGS BATTERY	IND,MIS	7	-1	-1	No	No	1980
61	P138111W	8/16/2001	GST	JOHN L & VIRGINIA A BAIRD	JOHN BAIRD # 3	STO	7	110	45.5	Yes	No	2000
62	P26187W	1/31/1974		CORK PETROLEUM INC.	FREUDENTHAL WELL #28	IND,DRI	14	1719	750	No	Yes	1970
63	P13201W	1/17/1972	ADJ	DON W. MARET	DON MARET #1	STO	5	500	20	Yes	No	1970
64	P87547W	4/3/1992	GST	RONALD JUROVICH	JUROVICH #1	STO	25	30	6	Yes	No	1990
65	P63307W	2/4/1983		USDI, BLM** TRIGG OIL & MINING	TRIGG W S-2	IND,MIS	20	1265	930	Yes	No	1980
66	P68340W	9/2/1983		WY BOARD OF LAND COMMISSIONERS**INC.	EAST WARM SPRINGS INJECTION	IND	150	1823	-1	Yes	No	1980
67	P3805W	9/8/1961	ADJ	TOWN OF THERMOPOLIS**HOT SPRINGS COU	LEGION WELL #1	IRR,MUN	400	14	8	No	No	1960
68	P4160W	2/1/1969	ADJ	CHARLOTTE MCCARTHY**GLADYS I. MILEK	RED FARM #2	STO	12	-1	-1	No	No	1960
69	P78475W	2/11/1988	UNA	LEGION TOWN & COUNTRY CLUB	ENL LEGION #1	RES,MIS	0	13.5	8	No	No	1980
70	40/6/442W	11/20/2007	UNA	TAYLOR FAMILY PARTNERSHIP	ENLARGED RED FARM #1 WELL	MIS				No		2000
71	P4159W	2/1/1969	ADJ	CHARLOTTE MCCARTHY**GLADYS I. MILEK	RED FARM #1	IRR	725	-1	-1	No	No	1960
72	P94010W	4/17/1926	ADJ	USDI, BLM	BLACK BUTTE #1 SPRING	STO	5	-1	-1	No	No	1920
73	P93961W	4/17/1926	ADJ	USDI, BLM	MARET SPRING	STO	4	-1	-1	No	No	1920
74	P36333W	2/19/1977	ADJ	WOLFGANG & CHRISTINE LUEHNE	STAR #1	DOM,STO	7	204	88	Yes	No	1970
75	39/2/183W	7/25/2006	UNA	CARL & ROLAND LEYBA	LEYBA #1	DOM				No		2000
76	39/3/183W	7/25/2006	UNA	CARL & ROLAND LEYBA	LEYBA #2	DOM				No		2000
77	P93959W	4/17/1926	ADJ	USDI, BLM	DON MARET SPRING	STO	4	-1	-1	No	No	1920
78	P93956W	4/17/1926	ADJ	USDI, BLM	PWR #107(185)	STO	2	-1	-1	No	No	1920
79	P74143W	10/4/1971	ADJ	TOMMIE J. & MARY A. BERRY,(BUYERS)**	SACAJAWEA	MIS	520	900	-6	No	Yes	1970
80	P93955W	4/17/1926	ADJ	USDI, BLM	DT SPRING PWR #75(184)	STO	8	-1	-1	No	No	1920
81	P79903W	5/22/1989	GST	JERRY AND ZOLA VAN NORMAN	VAN NORMAN #4	DOM	10	40	11	Yes	No	1980
82	P150334W	4/9/2003	GST	JOHN & BILLIE MCCLELLAND	MAC # 1	DOM,STO	10	42	19.6	Yes	No	2000
83	P150335W	4/9/2003	GSE	JOHN & BILLIE MCCLELLAND	MAC # 2	DOM,STO				No		2000
84	P93957W	10/27/1920	ADJ	USDI, BLM	PWR #75 SPRING(186)	STO	3	-1	-1	No	No	1920
85	P27145W	6/26/1974	EXP	USDI, BLM	BRATEN #4587	WIL	0	0	0	No		1970
86	P90244W	11/1/1982	ADJ	USDI, BLM	BRUTEN WELL	STO	15	-1	-1	No	No	1980
87	P113365W	12/14/1998	GST	MICHAWL J/JACKEY WRIGHT	WRIGHT #2	DOM,STO	15	25	4	Yes	No	1990
88	P45004W	9/11/1978	ADJ	JOHN T. & PHYLLIS K. HENLEY	BLACK WILLOW #2	DOM	24	35	10	Yes	No	1970
89	P45005W	9/11/1978	ADJ	RANDY D. & JEAN OWSLEY	BLACK WILLOW #3	DOM	24	40	18	Yes	No	1970
90	P113364W	12/14/1998	GSE	MICHAWL J/JACKEY WRIGHT	WRIGHT #1	DOM,STO	0	0	0	No		1990
91	P41808W	2/10/1978	ADJ	RAYMOND L. & PATRICIA L. GRAHAM	BLACK WILLOW #1	DOM	24	38	12	Yes	Yes	1970
92	P45711W	10/20/1978	ADJ	JIM A. & SARAH M. MILLER MILLER	MILLER #1	DOM	25	397	2	Yes	No	1970
93	P46468W	1/26/1979	ADJ	DON & KATHI LUNDVALL	LUNDVALL #1	DOM	12	200	40	Yes	No	1970
94	P46736W	2/27/1979	ADJ	CLAYTON E. & FRANCES A. HARMES	BLACK WILLOW #4	DOM	24	40	11	Yes	No	1970
95	P49628W	8/28/1979	ADJ	PATRICK D/DEBRA L LAW	MILLER #2 (DEPENED)	DOM	5	200	30	Yes	No	1970
96	P67668W	6/15/1984	ADJ	GERALD AND SANDRA CLOUSE	CLOUSE #1	DOM	5	121	28.5	Yes	No	1980
97	P67832W	7/2/1984	ADJ	MICHAEL E. NELSON	M.E. NELSON #1	DOM	7	80	20	No	No	1980
98	P25653P	12/31/1968	ADJ	INC. BLACK BUTTE LIVESTOCK CO.	JAMES #3	STO	2	186	170	No	No	1960
99	P91124W	4/2/1993	GST	BLACK BUTTE LIVESTOCK CO., INC.	RJ #1	STO	5	400	25	Yes	No	1990
100	P110690W	6/22/1998	GST	MICHAEL W/NANCY LEIGH READY	READY #3	DOM,STO	15	49	32	Yes	No	1990
101	P163675W	11/12/2004	GSI	COLLEEN ANDRETTI & HOWARD WILKS	HOJAM-SHIRE 216	DOM,STO				No		2000
102	P111390W	8/5/1998	GST	MARTIN/PATRICIA STEGMAN	Stegman #2	DOM	9	55	33	Yes	Yes	1990

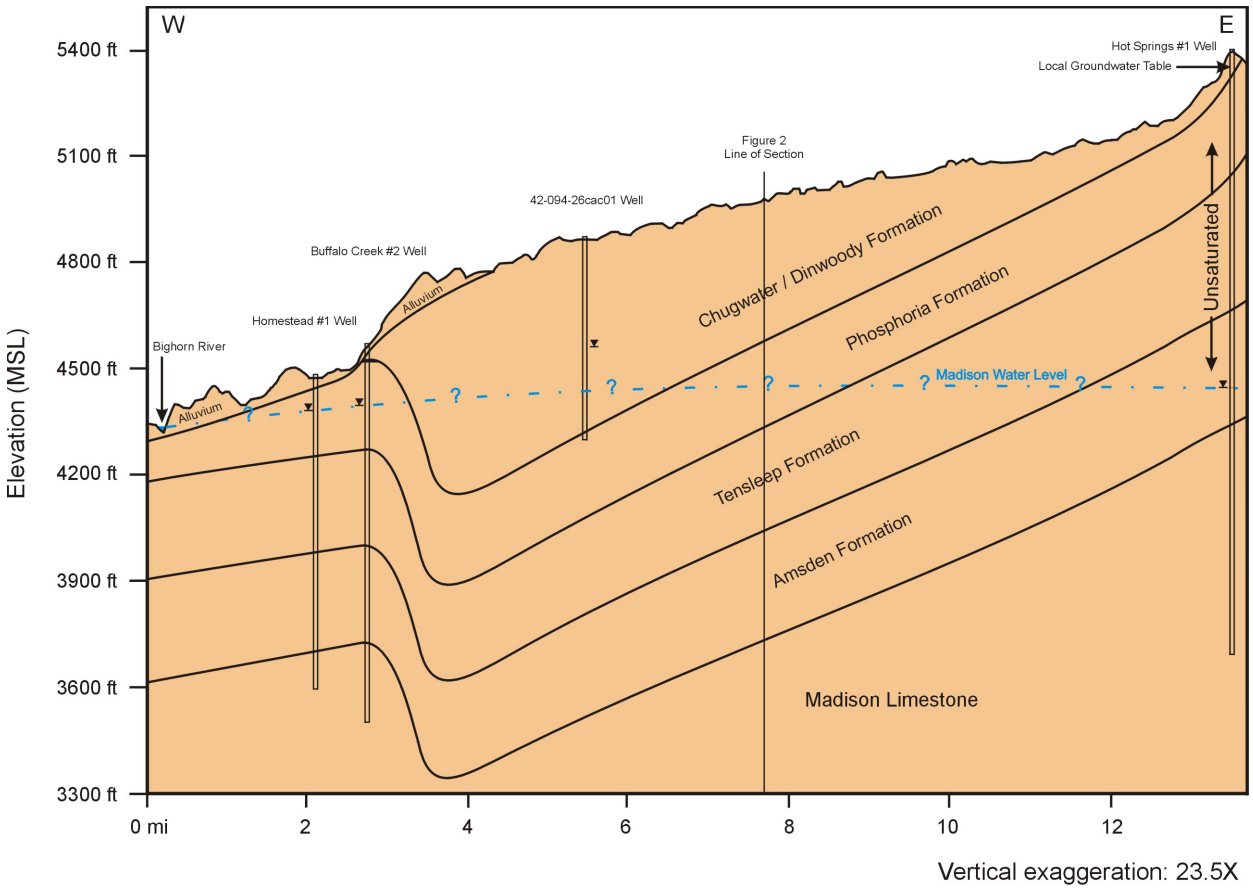


Figure 3.37 Buffalo Creek Road Topographic Profile and Thematic Geologic Cross Section.

There are also a number of low-production water wells with relatively small (<100 ft.) depths-to-water. ***The conclusion of the preceding paragraphs is significant in this regard, in that it says that the groundwater produced from these springs and shallow wells is not derived from the deep, productive aquifers that are recharged by abundant infiltration across the upland areas to the south. Rather these springs and wells appear to reflect local, shallower groundwater systems, largely disconnected from the regional groundwater flow of the deeper aquifers.***

The vicinity of the Hot Springs Well No. 1 provides an example. "Both the Park City Formation [i.e. Phosphoria] and the Tensleep Sandstone were unsaturated at this location." However, "water was first encountered at a depth of roughly 40 feet in the Dinwoody Formation. Approximately 25-35 gallons per minute (gpm) were air lifted from this section." (Lidstone, 2002). The shallow groundwater encountered in this well (ground water level elevation 5355 ft.) is interpreted as being recharged by local precipitation and snowmelt, rather than by the abundant, deep-aquifer recharge system present across much of the mountain slopes to the southwest. At "25-35 gallons per minute", this is a relative productive aquifer for the geologic formations above the Phosphoria Formation. The nearby "Johnson Spring No. 1" is permitted for 10 gpm and may be a reflection of this, or a similar, local groundwater system.

The bedrock along and north of Buffalo Creek is dominated by shale formations of relatively low permeability. Sandstone units within this section serve to transmit local infiltration (precipitation,

snowmelt, intermittent streamflow) to local springs and provide groundwater development targets for wells of modest yield. These formations also tend to contain higher concentrations of soluble minerals, imparting lower quality to the groundwater moving through them. (Groundwater quality is discussed further below.)

Although this report focuses on the watershed of Buffalo Creek, the study area also includes Hot Springs State Park on the east bank of the Bighorn River in Thermopolis. The large mineral hot springs which the park was created to protect are an extraordinary example of the same basic hydrogeologic principles discussed above. The largest spring - Big Spring - flows approximately 3,000 gpm of 133^{o}F water. There are several smaller springs flowing from the same geothermal system, as well as several flowing hot-water wells within two miles downstream (Breckenridge and Hinckley, 1978).

The springs flow from the surface in the Chugwater Formation, but are sourced in the underlying Tensleep Sandstone, rising up along faulting at the core of the Thermopolis Anticline. Exploratory drilling and geothermal modeling have identified the groundwater flow path for these springs to consist of recharge in outcrop areas far to the west (not to the south on the slopes of the Owl Creek Mountains, as previously believed), circulation and heating through the depths of the intervening syncline, and discharge to the surface where the overlying strata are broken by faulting. Temperature, potentiometric, and permeability data indicate that little of the water supplying the springs arrives from the east, i.e. from beneath the Buffalo Creek study area (Hinckley et a., 1982). Thus, no significant geothermal development potential has been identified within the study area (exclusive of the immediate area of the State Park).

Water Quality

Table 3.13 provides the limited groundwater quality information available for the study area. Figure 3.38 includes these sampling points, distinguished as “USGS” wells and springs. These points are plotted based on published latitude/longitude information, so should correctly reflect actual locations.

In general, these samples paint a picture similar to that for most of the region. Groundwater quality, like groundwater productivity, is best in the older, Paleozoic-age formations. That is why these formations have been the target of choice for groundwater development throughout the state. Note, however, that the quality of groundwater in these formations becomes widely variable away from the mountain-flank recharge areas, as residence times in the formations are longer, groundwater becomes involved with oil and gas accumulations, and circulation systems are interrupted by faulting. These groundwaters tend to have calcium and bicarbonate as the dominant cation and anion, respectively, indicative of the carbonate rocks that dominate this part of the geologic column.

The younger, Mesozoic-age formations tend to produce poorer quality groundwater, commonly of a calcium sulphate type. Although generally within primary (i.e. health based) drinking water standards, the total dissolved solids (TDS) and sulphate concentrations in groundwater from these rocks commonly exceed the secondary (aesthetics based) drinking water standards.

Table 3.13 USGS Sampling Points and Buffalo Creek Groundwater Quality (analytical results in milligrams per liter [mg/l] except as indicated)

ID	Local number	Type of site	Depth of Well (ft)	Year drilled	Primary Use	Elevation (ft)	Static water level (ft above (+) or below land surface)	Static water level Date	Discharge (gpm)	Discharge Date	Sample Date	Specific Conductance (µS/cm)	pH	Water Temperature (°C)	Hardness ($CaCO_3$)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Sodium adsorption ratio	Potassium (K)	Bicarbonate (HCO_3)	Alkalinity, total (as $CaCO_3$)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Silica (SiO_2)	Total Dissolved Solids	Nitrogen, NO_2+NO_3
Geologic unit unknown																												
A	42-094-27cab01	Well	190		Stock	4,880	146.6	7/27/1989	2.0	7/27/1989																		
Mowry Shale																												
B	42-092-29abc01	Spring			Stock	5,575																						
C	42-093-07cdc01	Spring			Stock	5,430			<.1	7/25/1989	7/25/1989	815	7.6	27.0	160	39	16	110	4	3.3		180	240	5.1	0.7	12	**537**	1.20
D	42-094-12cdc01	Spring			Stock	5,335			<.1	7/25/1989																		
Cloverly Formation																												
E	42-094-07bac01	Well	75	1955	Stock	4,670					6/25/1970	2,960	7.8	10.5	1,700	490	130	140	1	4.9	120		**1,900**	8.6	2.0	20	**2,750**	
Gypsum Spring Formation																												
F (7)	42-092-18caa01	Spring			Stock	5,450			8.0	9/15/1989	9/15/1989	2,000	8.0	10.5	940	270	64	84	1	4.8		120	**970**	3.1	0.8	19	**1,490**	0.58
G	42-094-15dad01	Spring			Stock	5,010			4.0	9/12/1989	9/12/1989	2,900	7.3	14.0	1,800	540	110	100	1	5.4		130	**1,800**	2.6	0.7	16	**2,650**	0.80
Chugwater Formation																												
H	41-092-04bcb01	Well	210		Stock	6,150	169.0	9/15/1989	6.0	9/15/1989	9/15/1989	1,300	7.5	10.0	450	84	59	20	0.4	7.0		210	240	9.6	0.9	11	**569**	2.5
I	42-093-14ccb01	Well	127		Stock	5,108	111.5	7/26/1989	10	7/26/1989	7/26/1989	1,790	7.2	14.0	1,000	320	53	30	0.4	3.0		240	**870**	2.5	0.3	15	**1,450**	3.4
J	42-093-20caa01	Well	127		Stock	5,015	100.5	7/26/1989	1.0	7/26/1989																		
K	42-093-21acc01	Well	183		Stock	5,043	165.0	7/26/1989	10	7/26/1989	7/26/1989	2,680	7.1	14.0	1,700	570	71	24	0.3	4.4		180	**1,500**	2.8	0.5	11	**2,320**	7.1
L	42-093-22bbc01	Well	287		Stock	5,082	163.1	7/26/1989																				
M (21)	42-094-17ddc01	Spring			Domestic	4,635			1.0	7/26/1989	7/26/1989	2,880	7.3	21.0	1,500	430	95	170	2	5.5		130	**1,800**	3.3	0.6	16	**2,600**	0.63
N (22)	42-094-19adc01	Well	54		Stock	4,400	30.30	7/27/1989																				
O	42-094-25aad01	Well	112		Stock	4,910	91.20	7/26/1989																				
P	42-094-25bdb01	Well	260		Stock	4,970	128.7	7/25/1989	5.0	7/25/1989	7/25/1989	3,120	7.1	14.0	1,900	530	130	110	1	6.9		140	**1,900**	6.5	0.4	11	**2,790**	2.5
Phosphoria Formation																												
Q	42-093-29bdb01	Well	627		Stock	5,041			0.5	7/26/1989	7/26/1989	1,080	7.3	17.0	580	130	62	16	0.3	3.7		180	450	4.4	1.5	9.7	**787**	0.49
Tensleep Sandstone																												
R	41-093-08bbc01	Well	600		Unused	5,970	498.5	8/8/1989																				
S	41-093-08cba01	Well	230	1962	Unused	6,028	199.1	7/26/1989																				
T	41-094-21cda01	Spring			Stock	6,180			25	8/8/1989	8/8/1989	370	7.8	9.0	160	36	16	1.9	0.1	0.6		150	8	0.7	0.1	13	171	0.73
U	41-094-27aaa01	Spring			Stock	6,480			5.0	8/8/1989	8/8/1989	390	8.0	11.0	190	42	21	2.0	0.1	0.6		190	9	0.6	0.1	13	204	0.97
V	42-094-26cac01	Well	550		Domestic	4,850	289.1	7/25/1989	2.0	7/25/1989	10/12/1970	730	8.2		400	92	41	10	0.2	1.6	300		170	3.1	2.2	12	478	
Madison Limestone																												
W (24)	42-94-21cc	Well	1,068	2004		4,572	176.25	2/9/2006	700	2/9/2006	4/25/2004	952	7.30		376	89	37	16		4.6	291	239	136	9.4	1.1	12	449	<0.1
											2006																440	
X (8)	42-92-18cc	Well	1,703	2001							11/14/2001	657	8.30		311	70.5	33.0	12.6		3.4	245	201	144	8.2	0.60	11.2	441	<0.1
Bighorn Dolomite																												
Y (4)	41-093-21bcd01	Spring			Stock	6,270			5.0	8/8/1989																		
Z (5)	41-093-21dcb01	Spring			Stock	6,310			22	8/8/1989	8/8/1989	450	7.4	10.0	200	49	19	3.9	0.1	2.2		200	18	1.2	0.2	9.8	223	0.570
AA	41-093-23aad01	Spring			Stock	6,720			1.0	7/26/1989	7/26/1989	440	7.4	12.0	240	41	34	2.1	0.1	1.9		230	16	1.1	0.2	8.8	247	0.620
Gros Ventre Formation																												
BB	41-093-32aab01	Spring			Stock	6,670			3.0	8/9/1989																		
Flathead Sandstone																												
CC	41-093-25cac01	Spring			Stock	7,050			7.5	9/14/1989	9/14/1989	70	7.8	8.0	35	9.7	2	2.5	0.2	0.7		20	5	3.7	0.1	11	58	1.90
DD (1)	41-093-31dcd01	Spring			Stock	6,685			15	8/9/1989	8/9/1989	150	6.7	12.0	61	18	4	2.6	0.1	0.5		60	6	0.9	0.1	15	85	0.88
EPA Drinking Water Standards			Primary																						4.0			10
			Secondary										6.5-8.5										250	250	2.0		500	

Table 3.13 USGS Sampling Points and Buffalo Creek Groundwater Quality (continued)
(analytical results in milligrams per liter [mg/l] except as indicated)

ID	Local number	Type of site	Phos-phorous, total	Aluminum	Arsenic	Barium	Boron	Cadmium	Chromium	Copper	Iron	Lead	Man-ganese	Mercury	Nickel	Selenium	Silver	Zinc	Nitrogen, Nitrite	Iron Bacteria	Sulfate Bacteria	Hydrogen Sulfide	Odor	Total Suspended Solids	Oil & Grease	Gross Alpha	Radium 226	Radium ss8	Uranium	Total Coliform Bacteria	E-Coli Coliform Bacteria
			(P)	(A1)	(As)	(Ba)	(B)	(Cd)	(Cr)	(Cu)	(Fe)	(Pb)	(Mn)	(Hg)	(Ni)	(Se)	(Ag)	(Zn)	as N	CFU/ml	CFU/ml		T.O.N.			pCi/l	pCi/l	pCi/l	(U)		
Geologic unit unknown																															
A	42-094-27cab01	Well																													
Mowry Shale																															
B	42-092-29abc01	Spring																													
C	42-093-07cdc01	Spring	0.02				0.14				0.11		0.004			0.004															
D	42-094-12cdc01	Spring																													
Cloverly Formation																															
E	42-094-07bac01	Well					0.5																								
Gypsum Spring Formation																															
F (7)	42-092-18caa01	Spring	<.01				0.21				0.02		0.002			0.003															
G	42-094-15dad01	Spring	<.01				0.05				0.04		0.01			0.004															
Chugwater Formation																															
H	41-092-04bcb01	Well	<.01				0.1				0.01		0.009			0.005															
I	42-093-14ccb01	Well	<.01				0.11				0.01		0.002																		
J	42-093-20caa01	Well																													
K	42-093-21acc01	Well	0.02				0.22				0.07		0.02																		
L	42-093-22bbc01	Well																													
M (21)	42-094-17ddc01	Spring	<.01				0.54				0.008		0.002																		
N (22)	42-094-19adc01	Well																													
O	42-094-25aad01	Well																													
P	42-094-25bdb01	Well	<.01				0.55				0.14		0.02																		
Phosphoria Formation																															
Q	42-093-29bdb01	Well	0.02				0.06				**1.1**		0.018																		
Tensleep Sandstone																															
R	41-093-08bbc01	Well																													
S	41-093-08cba01	Well																													
T	41-094-21cda01	Spring	0.01				<0.010				0.01		<0.001			<0.001															
U	41-094-27aaa01	Spring	0.04				<0.010				0.01		0.002																		
V	42-094-26cac01	Well					0																								
Madison Limestone																															
W (24)	42-94-21cc	Well		<0.1	<0.005	<0.1	<0.0001	<0.0005	<0.05	<0.01	**0.32**	0.014	0.01	<0.0005	<0.02	0.016	<0.01	0.15	<0.10	100	NA	<1.0	NOO	<1.0	NA	6.9	1.4	<1.0	0.004	Present	Absent
											0.05	ND								2300	<1	ND	H_2S by smell	<1.0	6.9						
X (8)	42-92-18cc	Well		0.032	0.013	0.027	<0.0001	<0.001	0.004	0.009	**4.46**	0.006	**0.095**	<0.001	0.007	0.001		0.005	<0.1							1.9	2.5	<1.0	0.0024		
Bighorn Dolomite																															
Y (4)	41-093-21bcd01	Spring																													
Z (5)	41-093-21dcb01	Spring	0.01				0.02				0.01		<0.001																		
AA	41-093-23aad01	Spring	<.01				0.02				0.04		0.002																		
Gros Ventre Formation																															
BB	41-093-32aab01	Spring																													
Flathead Sandstone																															
CC	41-093-25cac01	Spring	<.01				<0.010				0.03		<0.001			<0.001															
DD (1)	41-093-31dcd01	Spring	0.02				0.03				0.02		0.001																		
EPA Drinking Water Standards					0.01	2		0.005	0.1	1.3		0.015		0.002		0.05			1							15		5	0.03		
				0.05-0.2						1.0	0.3		0.05				0.10	5					3								
s in milligrams per liter (mg/l) exc																															

Note: Refer to Table 3.13 for associated water quality data at indicated wells and springs

Hot Springs County

Black Willow Draw Watershed

Warm Springs Creek Watershed

Buffalo Creek Watershed

Fremont County

Thermopolis

Red Lane

East Thermopolis

Lucerne

Minnesela

Boysen

Red Hole Oil Field

West Warm Springs Oil Field

East Warm Springs Oil Field

Black Willow Draw

Warm Springs Creek

South Fork

Buffalo Creek

Jones Creek

Grass Creek

Antelope Creek

Ditch Creek

East Fork Jones Creek

West Fork

T&V #1 (HotSpring Well #1)

Buffalo Creek No. 2 Monitor

Wells with Water Quality Data

Springs with Water Quality Data

Legend

Cities

Streams

Buffalo Creek Study Area

County Boundary

0 8,500 17,000 Feet

Figure 3.38 Buffalo Creek Watershed: Groundwater Quality Sampling Points

3.5.2 Surface Water

Streams within Study Area are subbasins of the Bighorn River system. As previously discussed, the project study area is defined as the Buffalo Creek, Warm Springs Creek, and Black Willow Draw watersheds as specified by the hydrologic units defined in Table 3.14. Note that only that portion of the Black Willow Draw basin (HUC 10080070106) lying east of the Bighorn River was incorporated in the project study area.

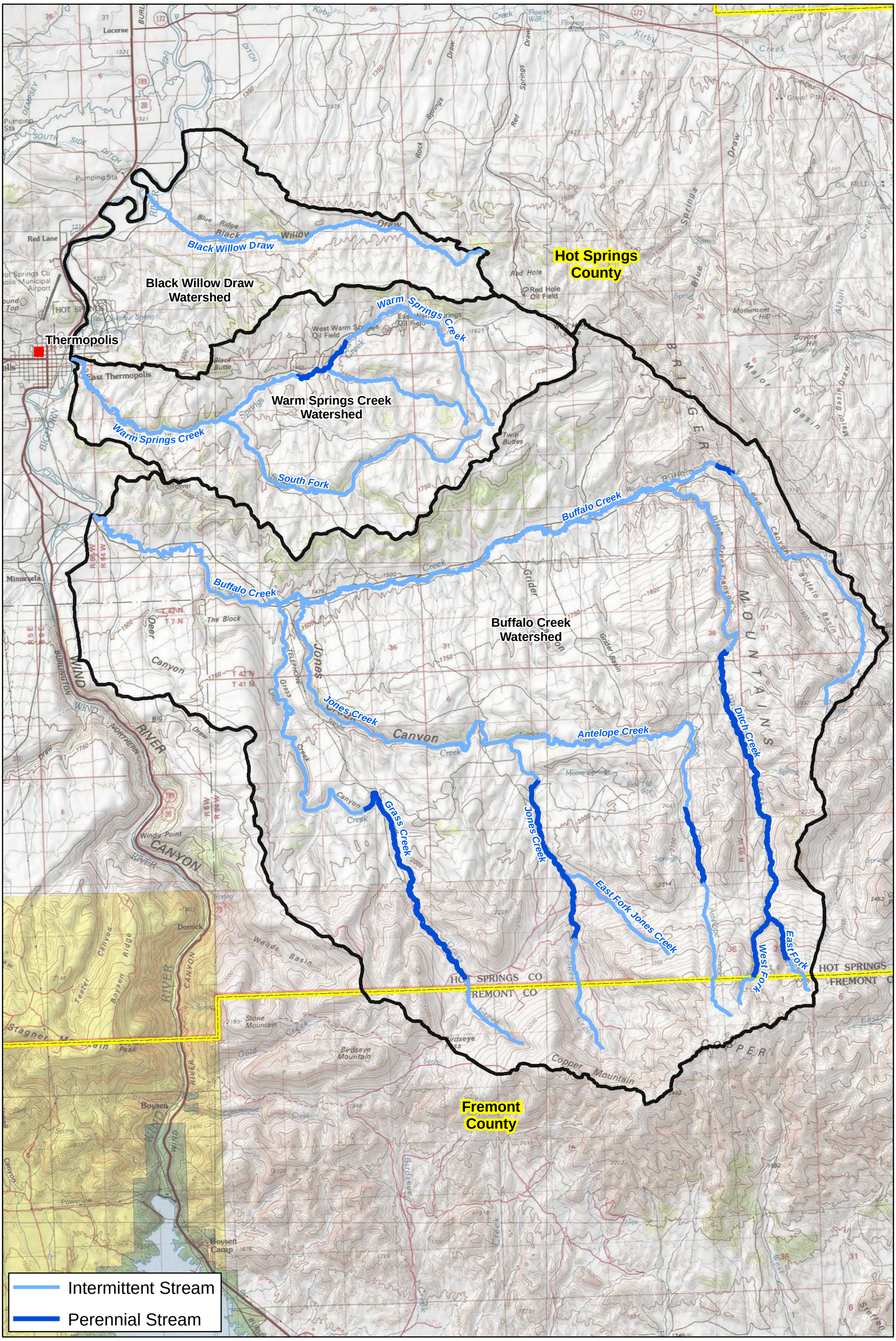
Table 3.14 Buffalo Creek Watershed Study: Hydrologic Units

Permittee	Facilitiy Name	Outfalls	Receiving Waters
Continental Operating Company	East Warm Springs Unit	1	Bighorn River via Warm Springs Creek
Cork Petroleum, Inc.	Freudenthal Lease, Battery #1	1	Bighorn River via Warm Springs Creek
Cork Petroleum, Inc.	Freudenthal Lease, Battery #3	1	Bighorn River via Warm Springs Creek

These subbasins represent the HUC 12 (hydrologic unit code) watersheds. The HUCs were delineated by the USGS using digital elevation models. As the HUC value increases, the level of detail increases as well. In other words, HUC 12 watersheds are subbasins of HUC 10 watersheds which are subbasins of HUC 8 watersheds, and so forth.

The stream reaches and tributaries in the Black Willow Draw and Warm Springs Creek basins typically range from intermittent to ephemeral. Ephemeral streams are defined as those streams/reaches that flow only in response to direct precipitation events, and where any groundwater inflows are insufficient to sustain streamflow due to losses from evaporation, transpiration, and seepage. The hydrologic behavior of intermittent streams/reaches is transitional between perennial and ephemeral stream hydrology. Ephemeral streams tend to be extremely 'flashy', displaying very rapid rise to peak followed by a rapid recession in streamflow. Annual runoff is typically low.

Streams within the Buffalo Creek watershed consist of a mix of perennial and intermittent streams highly influenced by local geology. As previously discussed, streams originating on Copper Mountain (i.e., Jones Creek, Grass Creek, Antelope Creek, and Ditch Creek) are perennial upstream of outcrops of limestone bearing formations (i.e., primarily the Madison and Phosphoria formations). As the streams cross these formations, surface flow is lost to groundwater recharge. Although not witnessed during the course of this study, landowners state that they have observed sinks capturing all surface flow like a 'toilet bowl'. During much of the year, the sinks can capture most or all of the surface water. During periods of higher discharge, flows do pass over the limestone although flows are often visibly diminished. Figure 3.39 displays the approximate extent of intermittent and perennial stream reaches.



N
W E
S

0 8,500 17,000
Feet

Legend

- Cities
- Buffalo Creek Study Area
- County Boundary

Figure 3.39 Buffalo Creek Watershed: Approximate Extent of Intermittent and Perennial Stream Reaches

3.5.2.1 Temporary WWDC Gaging Stations

There are currently no active stream gaging stations within the watershed nor have there been stations established historically. In an effort to gather additional streamflow data on the ungaged stream network, four temporary stream gages were installed in conjunction with this study:

- Grass Creek
- Jones Creek
- Antelope Creek
- Ditch Creek

Figure 3.40 Temporary Stream Gage Installed in Antelope Creek.

The gages consist of pressure transducers and data loggers protected in a PVC housing fabricated onsite (Figure 3.40). The data loggers were programmed to collect depth of water data at fifteen minute intervals throughout the investigation period.

The gages were initially installed on April 20, 2010 by WWDC staff prior to the initiation of the project by ACE. Following the 2010 field season, the instruments were retrieved by ACE staff and reinstalled in spring of 2011. The objective of the effort was to provide a minimal amount of hydrologic data in a watershed lacking any historic gages. The information collected by the gages will help to reduce uncertainty associated with the existing hydrologic regime. Figure 3.41 displays their locations. The objective with respect to gage locations was to measure streamflow upstream of known 'sinks' in perennial reaches. There, gage locations were found upstream of the limestone bearing formation outcrops (Amsden/Big Horn Dolomite and Madison Limestone). The Ditch Creek gage is the lone exception to this objective. This gage was sited downstream of the formations, however, the site still maintains perennial streamflow.

Initial rating curves were developed for each gage by completing hydraulic modeling flow conditions at each gage. Stream stage / discharge relationships were used to convert the depth data to stream discharge. Cross section surveys, channel slope, and observations of bed and overbank conditions were made for model input. Stream gaging data measured at each site also provided information with respect to flow depth and velocities for model calibration. The initial rating curve provided a basis upon which to evaluate the depth data recorded by the pressure transducers. During the completion of the study, stream measurements were completed at each gage as they were serviced (battery replacement, data download, etc). These "real data" were then compared to the results of the hydraulic models and adjustment made as necessary.

Hot Springs County

Black Willow Draw Watershed

Warm Springs Creek Watershed

Buffalo Creek Watershed

Fremont County

Thermopolis

Black Willow Draw

Warm Springs Creek

South Fork

Buffalo Creek

Jones Creek

Grass Creek

Antelope Creek

Ditch Creek

East Fork Jones Creek

East Fork

West Fork

N
W E
S

0 8,500 17,000
Feet

Legend

- Temporary Stream Gage
- Cities
- Buffalo Creek Study Area
- County Boundary

Figure 3.41 Buffalo Creek Watershed: Temporary Stream Gages

As discussed in Section 3.4.1, the two years of the study (2010 and 2011) were essentially 'average' years with respect to annual precipitation. Consequently, the data collected during this effort, though limited in quantity to only two seasons, will provide valuable information regarding mean runoff for future planning efforts without extrapolation to wet or dry conditions. Table 3.15 tabulates the results of the two year temporary stream gaging effort.

Table 3.15 Summary of Temporary Stream Gage Hydrology.

Stream Gage	Grass Creek	Jones Creek	Antelope Creek	Ditch Creek
2010				
Basin Area (sq. mi.)	5.7	12.5	3.0	9.7
Average (cfs)	3.6	15.9	5.1	4.3
Peak (cfs)	11.6	45.9	17.4	34.6
Date of Peak	23-May	19-May	19-May	19-May
Yield (ac-ft)	1,334	3,617	1,048	1,591
Minimum (cfs)	1.1	4.0	1.1	0.5
2011				
Average (cfs)	2.6	11.2	4.2	9.6
Peak (cfs)	12.8	47.1	16.0	40.5
Date of Peak	23-May	23-May	23-May	23-May
Yield (ac-ft)	916	4,019	1,031	2,016
Minimum (cfs)	0.1	5.8	0.4	1.3

Grass Creek

The gage is located in a perennial streamflow reach upstream of the Madison Limestone outcrop and therefore characterizes streamflows unaffected by losses associated with the limestone. As indicated in Figure 3.42, the runoff associated with the two years of study was very similar. Streamfiow peaked in May during the snowmelt period and gradually drops to baseflow conditions throughout the rest of the summer. Peak streamflows were approximately 11 to 12 cubic feet per second in both years. By August, flows are consistently less than one cubic feet per second. Total runoff for the study periods was approximately 1,334 acre-feet in 2010 and 916 acre feet in 2011.

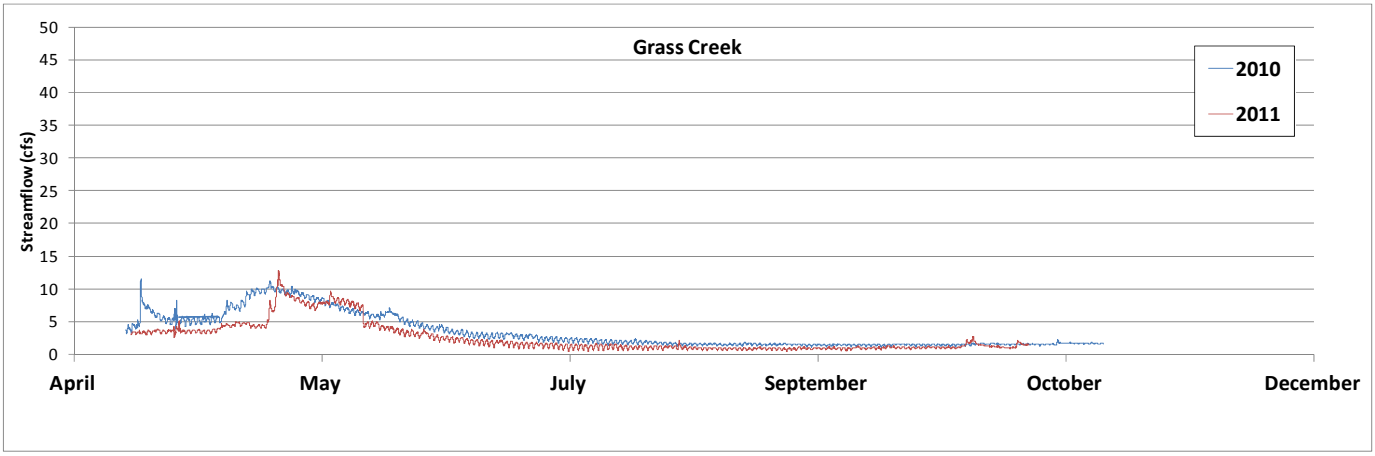


Figure 3.42 Temporary Stream Gage: Grass Creek Hydrograph.

Jones Creek

The Jones Creek gage is located in a perennial streamflow reach upstream of the Madison Limestone outcrop and therefore characterizes streamflows unaffected by losses associated with the limestone. As indicated in Figure 3.43, the runoff associated with the two years of study was very similar. The bulk of the runoff occurs between the onset of the snowmelt period in early May and its completion by mid-June. Peak runoff on Jones Creek was the highest of all gages and crested at a level consistent between the two years (45.9 cfs in 2010 and 47.1 cfs in 2011). Flows gradually recede to baseflow conditions throughout the summer and remain relatively consistent between four and five cubic feet per second throughout the summer and fall. Occasional 'blips' occurring in result to precipitation events are evident in the hydrographs. Total annual runoff for the study period was 1,048 acre-feet in 2010 and 1,031 acre-feet 2011.

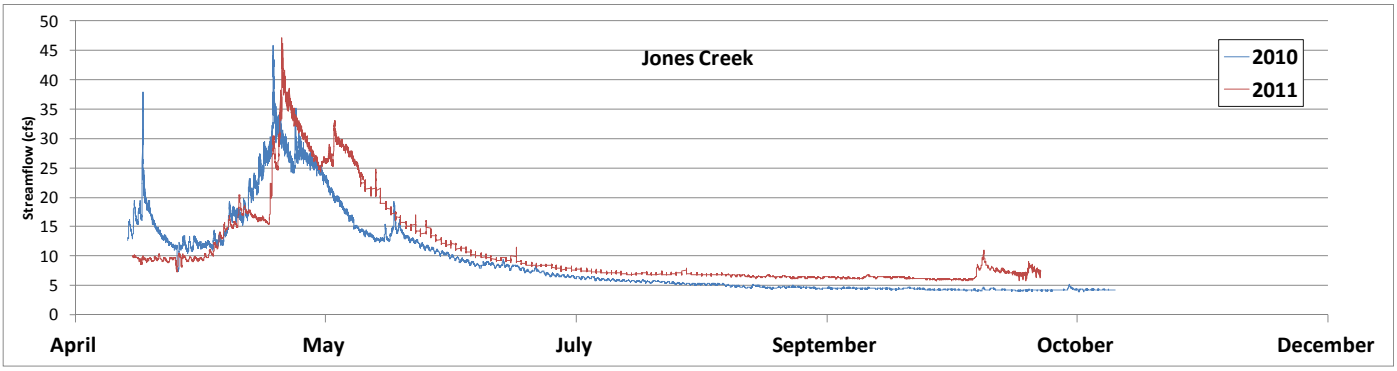


Figure 3.43 Temporary Stream Gage: Jones Creek Hydrograph.

Antelope Creek

Antelope Creek is tributary to Jones Creek. The gage is located in a perennial streamflow reach upstream of the Madison Limestone outcrop and therefore characterizes streamfiows unaffected by losses associated with the limestone. As indicated in Figure 3.44, the runoff associated with the two years of study was very similar. The general runoff pattern is consistent with the other streams in the study area with the bulk of the runoff occurring between the onset of the snowmelt period in early May and its completion by mid-June. Peak runoff on Antelope Creek crested at a level consistent between the two years (17.4 cfs in 2010 and 16.0 cfs in 2011). Flows gradually recede to baseflow conditions throughout the summer and remain relatively consistent at one cubic foot per second or less. Occasional `blips' occurring in result to precipitation events are evident in the hydrographs. Total annual runoff for the study period was 3,617 acre-feet in 2010 and 4,019 acre-feet 2011. During the summer of 2010, the exposed cable between the data logger and the pressure transducer was destroyed (apparently it was chewed through by a small animal on August 2). Consequently, streamflow was not recorded during the late summer months.

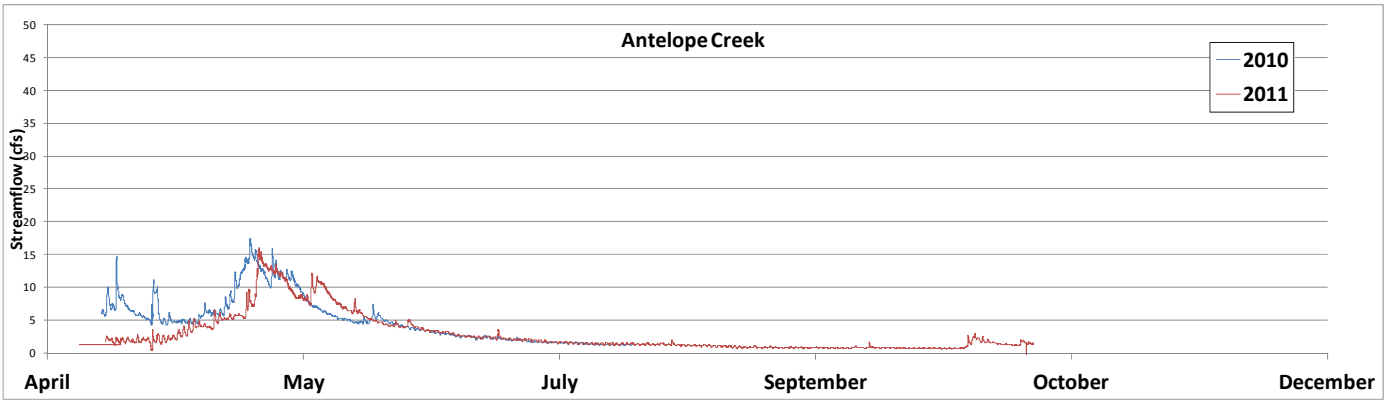


Figure 3.44 Temporary Stream Gage: Antelope Creek Hydrograph.

Ditch Creek

The Ditch Creek gage was inadvertently sited downstream of the limestone bearing formations and therefore characterizes streamflow as affected by potential losses associated with them. However, streamflow is still perennial at this site. As indicated in Figure 3.45, the runoff associated with the two years of study was similar, yet the 2011 experienced slightly higher runoff in the period prior to early July. As indicated in the hydrograph, Ditch Creek showed a slightly higher and longer snowmelt period which consequently resulted in higher total runoff (3,617 and 4,019 acre feet for the 2010 and 2011 seasons respectively).

The general runoff pattern is consistent with the other streams in the study area with the bulk of the runoff occurring between the onset of the snowmelt period in early May and its completion by mid-July. Peak runoff on Ditch Creek crested at a level consistent between the two years (30.6 cfs in 2010 and 40.5 cfs in 2011). Flows gradually recede to baseflow conditions throughout the summer and remain relatively consistent at approximately 1.5 cubic feet per second or less. Occasional 'blips' occurring in result to precipitation events are evident in the hydrographs.

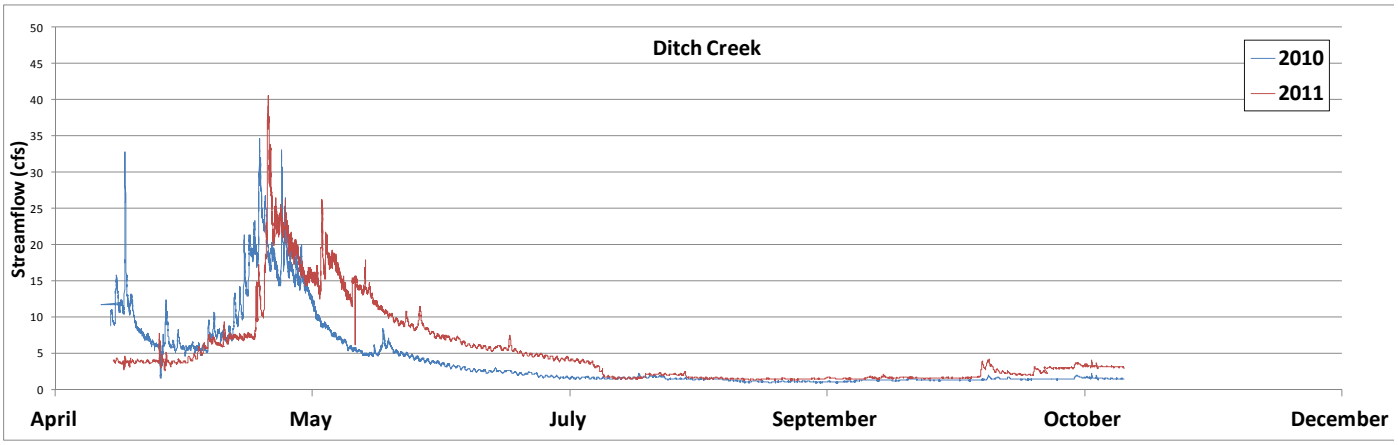


Figure 3.45 Temporary Stream Gage: Ditch Creek Hydrograph.

3.5.2.2 Stream Loss Measurement

Figure 3.46 "Sinks" on Jones Creek.

Loss of surface runoff to deep aquifers associated with the limestone bearing bedrock encountered in the study area is evident in the observation of "sinks" areas along the courses of Grass, Jones, Antelope, and Ditch Creeks. Figure 3.46 displays a photo of the sink on Jones Creek where water effectively 'disappears' at a specific location during low-flow periods. During times of higher streamflow, flows exceed the infiltration capacity of the outcrop and can continue on downslope; eventually joining Buffalo Creek. The point at which standard USGS 7-1/2 minute topographic quadrangle mapping indicates the change from perennial flow (upstream) to intermittent flow (downstream) were previously displayed on Figure 3.39. These delineations generally coincide with the location of the outcrops.

In an effort to quantify the magnitude of these losses, a stream gaging exercise was completed on June 6 and 7, 2011. Streams were gaged at locations upstream and downstream of the limestone bearing formations and stream losses measured as the difference between measurements. In addition, each stream was gaged again at its confluence with Buffalo Creek. Table 3.16 summarizes the results of the study and Figure 3.47 displays them in relation to their locations.

Table 3.16 Results of Stream Loss Gaging Effort.

Stream	Site No.	Location	Geologic Location	Streamflow (cfs)	Reach Losses		notes
					(cfs)	(percent)	
Grass Creek	1	Upper	Bottom (upstream) of Bighorn Fm.	8.7	--	--	At Temporary Stream Gage
	2	Middle	mid-Amsden Fm.	7.3	1.4	16.1%	
	3	Lower	Lower Chugwater Fm.	6.0	1.3	17.8%	At Buffalo Creek
Jones Creek	4	Upper	Lower Bighorn Fm.	22.5	--	--	At Temporary Stream Gage
	5	Middle	Upper Madison Fm.	14.8	7.7	34.2%	
	6	Lower	Lower Chugwater Fm.	9.2	5.6	37.8%	At Buffalo Creek
Antelope Creek	7	Upper	Lower Bighorn Fm.	6.6	--	--	At Temporary Stream Gage
	8	Middle	Mid-Madison Fm.	0	6.6	100.0%	End of flow (6/6/11)
Ditch Creek	9	Upper	Lower Bighorn Fm.	19.1	--	--	
	10	Middle	Mid-Amsden Fm.	15.5	3.6	18.8%	At Temporary Stream Gage
	11	Lower	Lower Chugwater Fm.	10.9	4.6	29.7%	At Buffalo Creek

The gaging occurred following several weeks of snowmelt and rain. Without losses to the underlying aquifers, streams would generally be gaining flow from shallow infiltration ("interflow") under these conditions. For example, Buffalo Creek was dry above its confluence with Ditch Creek on June 7, yet

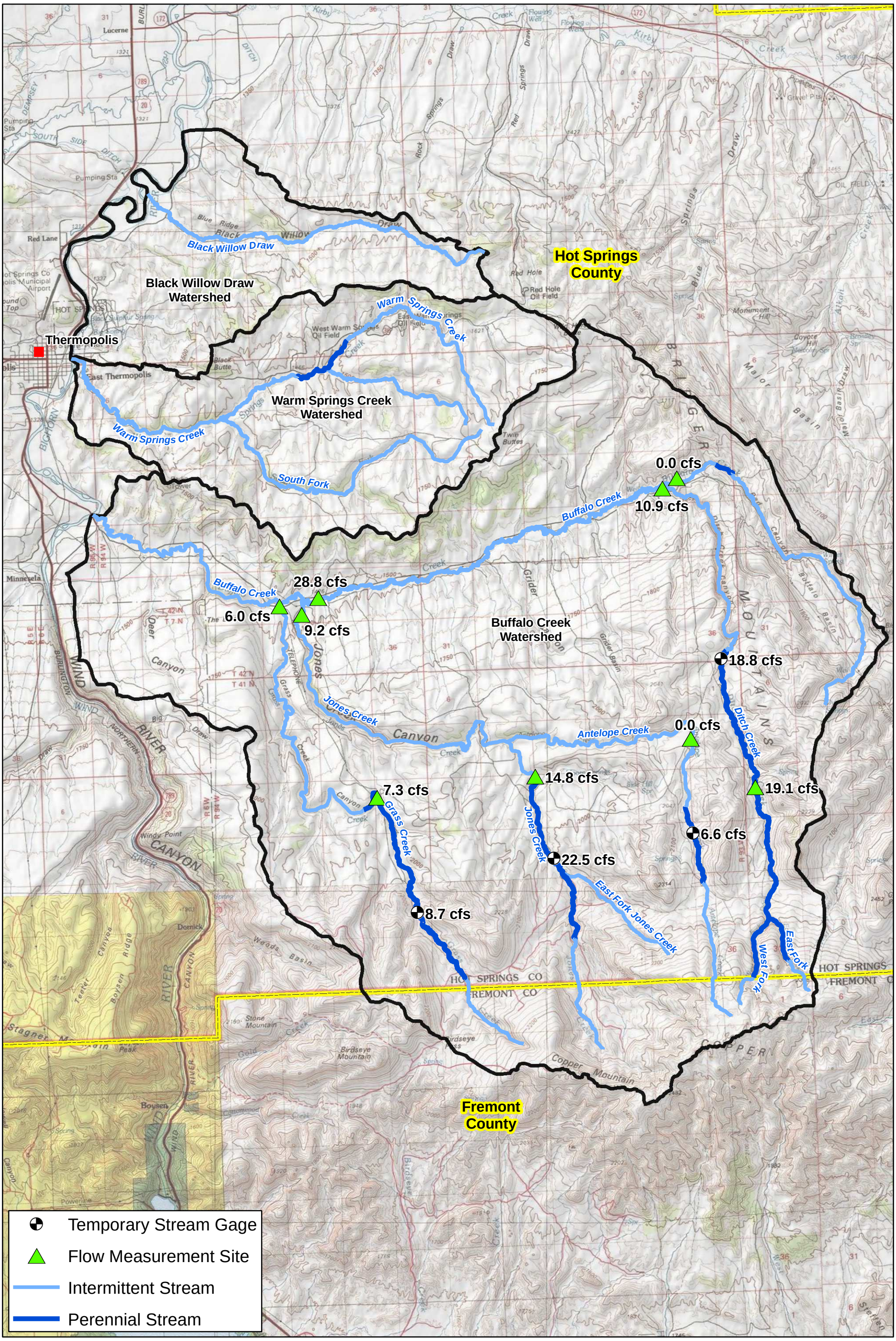


Figure 3.47 Buffalo Creek Watershed: Stream Measurement

gained 3.7 cfs (in addition to the inflow from Ditch Creek) between there and its confluence with Jones Creek. There were no surface inflows through this reach; the underlying bedrock is the low-permeability Chugwater Formation. The gaged gain is attributed to shallow groundwater inflow. Thus, the losses indicated likely under-estimate the full recharge to groundwater.

These flow measurements presented were intended to bracket the upper and lower aquifers of the Paleozoic section. On each of the four creeks, substantial flow was lost to both the Bighorn/Madison and Tensleep/Park City sections. Although infiltration certainly varies along these creeks in response to local conditions (e.g. soil development, fractures, faulting) qualitative observations indicated flow losses were distributed through each reach, rather than being concentrated at specific points. Antelope Creek was most conspicuous in this regard, as the measured flow of 7.3 cfs gradually declined to a trickle, then to nothing over the 1.2 miles below the gaging point.

3.6 Stream Geomorphology

3.6.1 General

The field of fluvial geomorphology is the study of how land is formed under processes associated with running water. The balance between processes such as erosion, deposition, and sediment transport determines the character and condition of a stream. The objective of the geomorphic evaluation of the study area is to determine the nature of this balance, and where the balance has been upset.

The condition of a stream can be assessed with respect to its basic form (width, depth, slope, etc.), as well as its state of equilibrium, or geomorphic stability (Thorne, et al, 1996; Johnson, et al., 1999). Stable, or equilibrium, channels are generally defined as those that have achieved a balance between flow energy and sediment delivery, such that sediment is transported at the rate at which it is delivered, and the form and pattern of the channel is maintained (Thorne, et al., 1996). Dynamically stable channels are adjustable in nature, and “stability” does not preclude lateral migration and associated dynamics such as bank erosion and sediment deposition.

In geomorphically stable conditions, minor changes in either sediment supply or transport energy result in gradual adjustment of channel form to accommodate those changes (Lane, 1955). Channels destabilize when changes in those factors are extreme enough that rapid and dramatic alterations in pattern or form occur. Common indicators of channel instability include active downcutting and accelerated bank erosion, major changes in channel width/depth ratios, and increased flooding due to sediment deposition. Geomorphic function is achieved when a channel is in equilibrium, while undergoing processes such as lateral migration, sediment reworking, and occasional overbank flooding that effectively create and sustain quality habitat elements, such as bars, pool/riffles, step/pools, and healthy, regenerating riparian corridors.

Impairments to geomorphic function reflect a significant loss of the functional potential of the green channel segment. These impairments are typically described in general, qualitative terms, and any

rehabilitation of impaired channel segments requires a more thorough, site-specific assessment of impacts, impairments, and feasible remedies.

3.6.2 Rosgen Classification System

The literature presents descriptions of numerous systems for classifying and evaluating stream systems. Of these, perhaps the most widely used today is the Rosgen classification system (Rosgen, 1996). This system, based upon the stream's existing channel morphology, was utilized in this study. Parameters such as the sinuosity, slope, width/depth ratio, and size of channel materials are evaluated and used to classify the stream into one of the various "types" included in the system.

There are four levels of classification in the Rosgen system, each being more detailed than the previous level. Figure 3.48 displays the hierarchy of the assessment levels and the general nature of effort associated with each. Much of the Level I geomorphic characterization is qualitative and utilizes aerial photography and topographic maps. Streams are divided into eight (8) broad types on the basis of their channel and floodplain geometry. Rosgen's classification system stream types can be thought of in their relative location within the watershed, from their headwaters through lowlands. The major stream types reflect their location in the watershed. For example, "A" type streams are located in headwaters; "C" & "E" stream types are located in meandering lowlands, etc. provides a more detailed description of the stream using measurements at selected locations. Stream types are further subdivided into 94 subtypes based upon degree of entrenchment, width-to-depth ratio, water surface slope, streambed materials, and sinuosity (Figure 3.49). Consequently, the Level II characterization is more quantitative than the Level I effort. Levels III and IV require more extensive data collection and quantification of stream characteristics. ***The Buffalo Creek Watershed Study included Level I evaluation of the mainstem streams and their principal tributaries.***

3.6.2.1 Level I Methods

The purpose of the Level I geomorphic classification is to provide an inventory of the Buffalo Creek watershed study area's overall stream morphology, character, and condition. It is intended to serve as an initial assessment for use in more detailed assessments and to determine the location and approximate percentage of stream types within the basin. The results of the Level I classification can be integrated directly into the project Geographic Information System (GIS) providing a graphical "snapshot" of the basin. Based upon this initial effort, potential stream reference reaches can be identified for further study in Level II classification efforts. The end product of the Level I classification is the determination of the major stream types, A through G.

Figure 3.50 with the Rosgen Classification System shows the relative locations of these stream types within a typical watershed. Brief descriptions of the various stream types encountered in the watershed are presented in the following paragraphs.

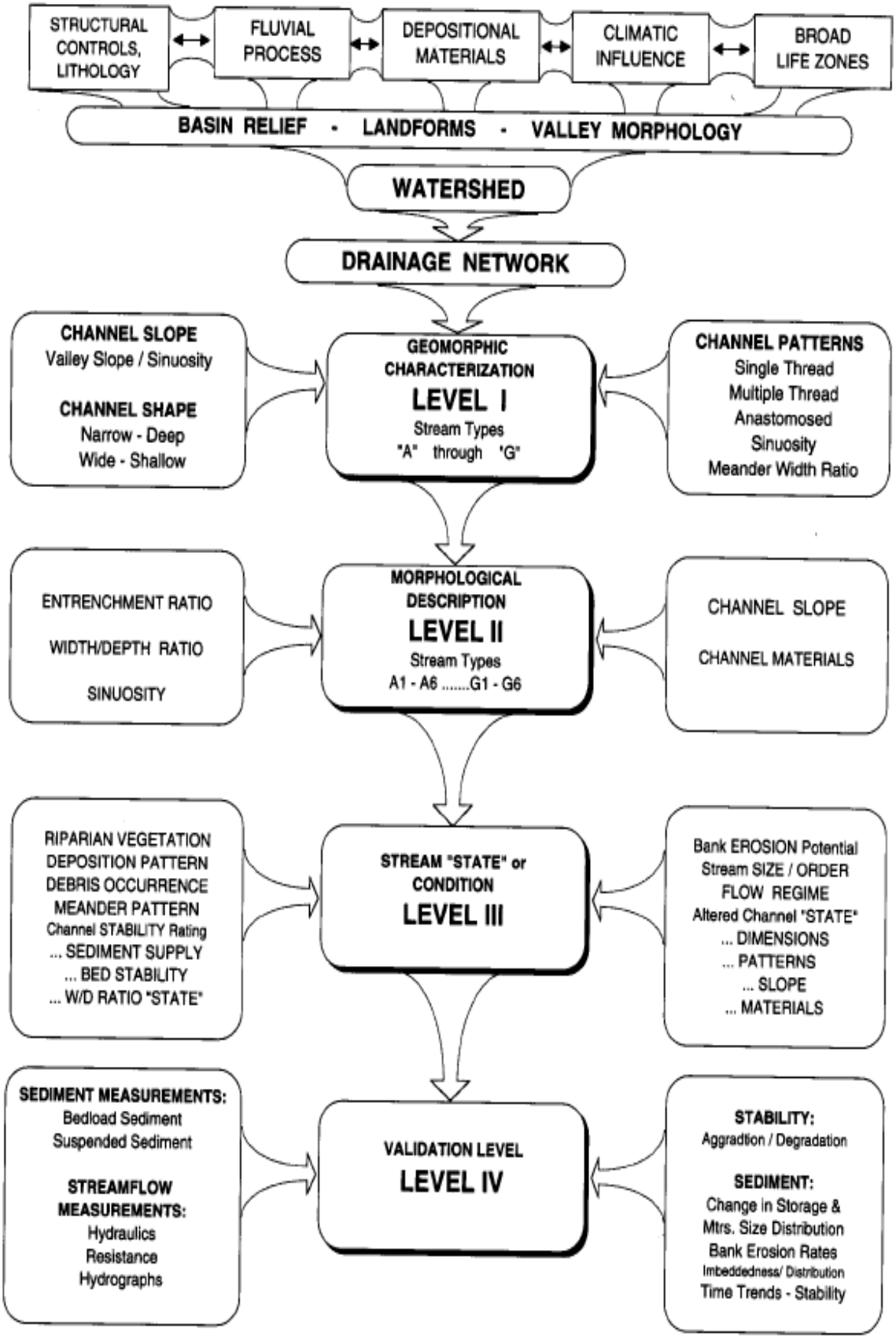


Figure 3.48 Hierarchy of the Rosgen Stream Classification System.

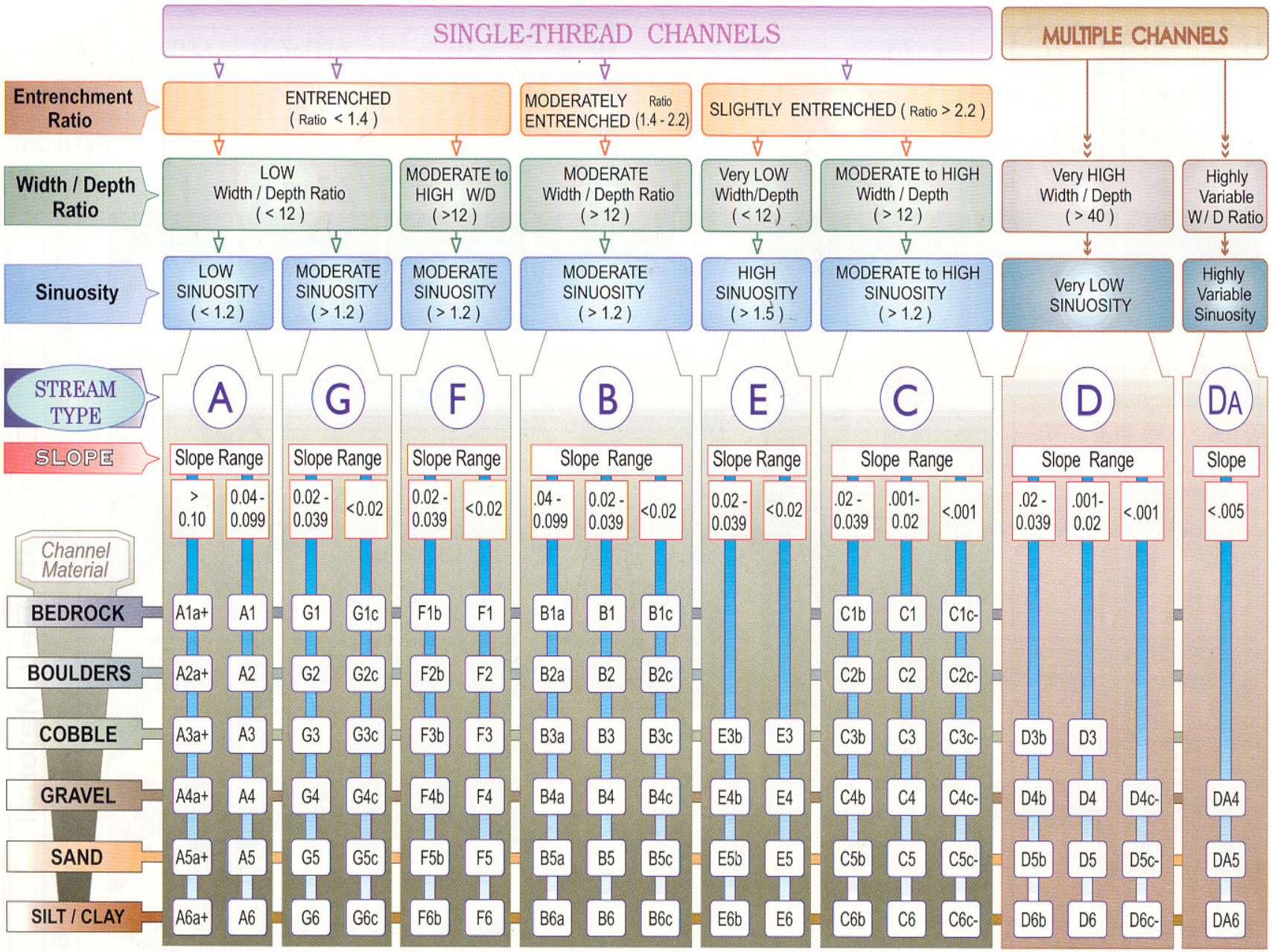


Figure 3.49 Rosgen Classification Matrix (Rosgen, 1996).

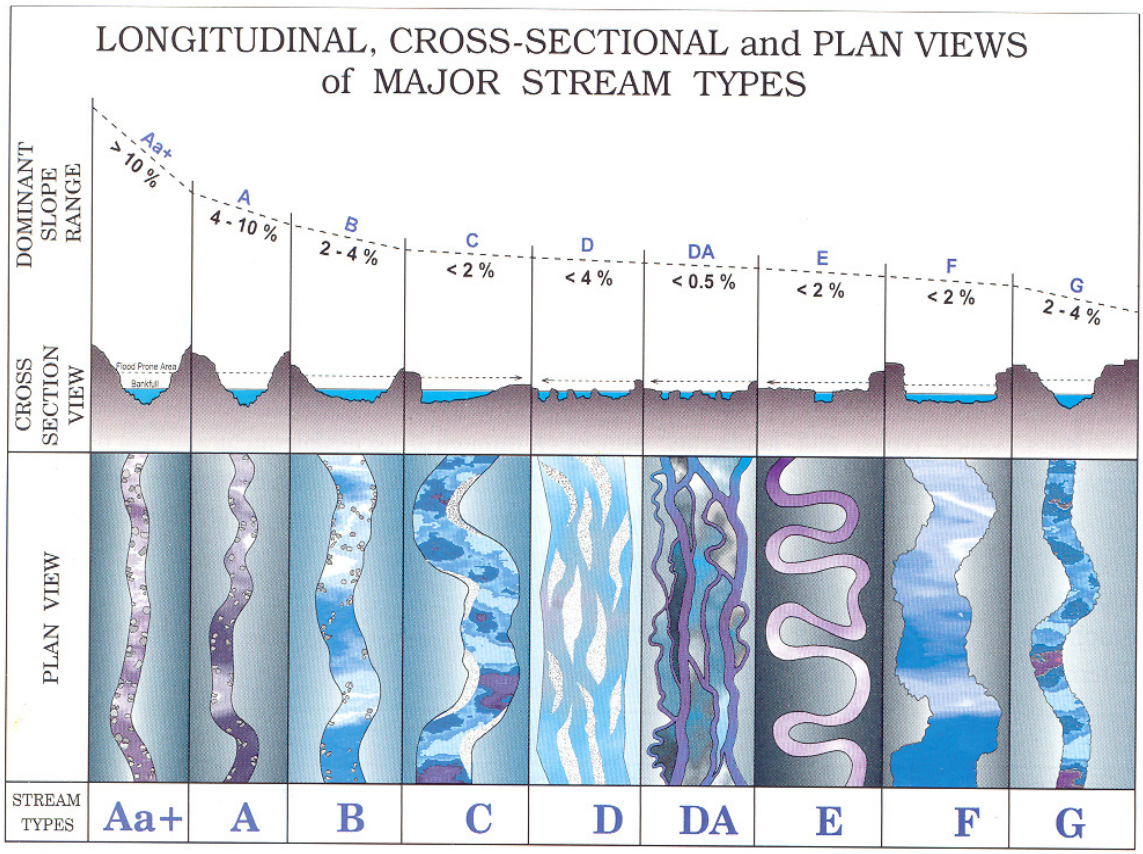


Figure 3.50 Major Stream Types within the Rosgen Classification System (Rosgen, 1996).

A-Type Channels are relatively steep channels that form in headwater areas as well as within bedrock canyons (Figure 3.51). These channels are entrenched and confined by steep valley margins such that little to no floodplain area borders them. As the boundaries of A-type channels are typically highly resistant to erosion, these stream types are generally quite resilient with respect to human impacts. The most common cause of geomorphic change within A-type channels is due to large-scale sediment transport events, (landslides, debris flows, debris jam failure) that may result in blockage or deflection of channel flow.

Figure 3.51 Example Type A Channel: Unnamed Tributary to Buffalo Creek.

Figure 3.52 Example Type B Channel: Antelope Creek above the "Sinks".

B-Type Channels tend to form downstream of headwater channels, in areas of moderate slope where the watershed transitions from headwater environments to valley bottoms (Figure 3.52). B-Type channels are characterized by moderate slopes, moderate entrenchment, and stable channel boundaries. Due to the relatively steep channel slopes and stable channel boundaries, B-channels are moderately resistant to human impacts, although, their reduced slopes relative to headwater areas can make them prone to

sediment deposition and subsequent adjustment following a large sediment transport event such as an upstream landslide, debris flow, or flood.

C-Type Channels are typically characterized by relatively low slopes, meandering planforms (i.e., the shape one would see if viewing from above, as on a map or aerial photo), and pool/riffle sequences (Figure 3.53). The channels tend to occur in broad alluvial valleys, and they are typically associated with broad floodplain areas; they are not entrenched and still have 'access' to their floodplains. C-channels tend to be relatively sinuous, as they follow a meandering course within a single channel thread. In stream systems in which the boundaries of C-type channels are composed of alluvial sediments, channels tend to be dynamic in nature, and susceptible to rapid adjustment in response to disturbance.

Figure 3.53 Example Type C Channel: Buffalo Creek.

E-Type Channels are somewhat similar to C channels, as they form as single threads with defined, accessible floodplain areas (Figure 3.54). However, E channels are different in that they tend to have fine-grained channel margins, which provide cohesion and support dense bankline vegetation. The fine-grained, vegetation-reinforced banklines allow for the development of steep banks, very sinuous planforms, and relatively deep, U-shaped channel cross sections. E-type channels commonly form in low gradient areas with fine-grained source areas, mountain meadows, and in beaver-dominated environments. E-channels tend to have very stable planforms, and efficient sediment transport capacities due to low width/depth ratios.

Figure 3.54 Example Type E Channel: Mid Reaches of Grass Creek.

F-Type Channels typically have relatively low slopes (<2%), similar to C and E channel types. The primary difference between C/E channels and F channels is with respect to entrenchment. F channels are entrenched, which means that the floodplain is quite narrow relative to the channel width. The entrenchment of alluvial F-type channels typically is an indicator of an historic downcutting event. F-type channels may form in resistant boundary materials (e.g., U-shaped bedrock canyons), and relatively erodible alluvial materials (e.g., arroyos). When the boundary materials are erodible, the steep valley walls are prone to instability, and channel widening commonly occurs within the entrenched channel cross section (Figure 3.55).

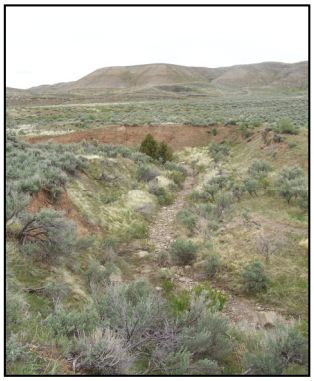


Figure 3.55 Example Type F Channel: Black Willow Draw.

G-Type Channels are narrow, steep entrenched gullies. G-Type channels typically have high bank erosion rates and a high sediment supply. Channel degradation and sideslope rejuvenation processes are typical. The Level I classification effort was conducted primarily using existing information incorporated into the project GIS. Several analytical tools were developed and integrated into the GIS which allowed the evaluation of various geomorphic parameters (sinuosity, slope, stream station determination). The data collated and incorporated in the Project GIS include digital aerial photography, USGS topographic maps, Landsat color infrared imagery, a digital elevation model (DEM), and digitized hydrography information. The most current data available were used in the geomorphic evaluation. Because the DEM was limited to a 30-meter grid, elevations and subsequent slope calculations are approximate. Stream alignments were digitized using 2006 aerial photography and represent the best available estimate of current channel alignment.

The streams evaluated were divided into reaches based upon definable geographic factors (e.g. confluences with tributaries, major road crossings, etc) or where their geomorphic character displayed changes. Each reach was evaluated in light of the characteristics required at the Level I classification. These parameters, as indicated in Figure 3.48, were channel slope, channel shape, channel patterns, and valley morphology. Note that in the Level I classification, these parameters are not typically quantified and the relative magnitude (i.e., "moderate", "slightly", etc.) is utilized to classify the stream.

3.6.2.2 Level I Classification Results

Results of the Level I classification effort are presented in Table 3.17 and graphically in Figure 3.56. This figure displays a map of the study are depicting the various stream types as well as the reach designations used in the classification effort.

The primary tributaries to Buffalo Creek originate on the steep Copper Mountain. High on the mountain, the channels are steep and bounded by very coarse, resistant materials that include hillslope colluvium, and bedrock. As a result, the channels are laterally stable, and geomorphically resilient with respect to human impacts. Channel change in these upper subreaches typically results from punctuated hillslope processes rather than gradual channel migration. The channels are A-type or B-type channels which reflects their steep slope and stable boundaries. Examples include Upper Ditch Creek, Antelope Creek, Grass Creek and Jones Creek. Likewise, headwater reaches of Warm Springs Creek are also classified as A-type and B-type channels.

Historic incision of Buffalo Creek has resulted in an entrenched condition which results in the F-Type classification. Portions of the channel appear less entrenched and could conceivably be classified as C-Type; however, given the relative extent of the entrenchment in relation to the non-entrenched reaches, the entire stream segment is classified as F-Type. Incision of Buffalo Creek appears to have occurred historically and there were no indicators of active incision observed. Given the age of vegetation observed in the bed of the stream channel, it appears that the channel has become stabilized. However, due to its incision, at least two irrigation headgates have been rendered inoperative because they are no longer capable of diverting flows. In other words, they've been left "high and dry".

Table 3.17 Summary of Rosgen Level I Classification Results

Stream	Reach Number	Station (Distance from Mouth)		Reach Length(Ft)	Sinuosity	Slope	Rosgen
		Station Start(ft)	Station End(ft)				
Antelope Creek	1	0	32,204	32,204	1.25	0.017	B
	2	32,204	61,689	29,485	1.14	0.050	A
Black Willow Draw	1	0	25,780	25,780	1.20	0.017	F
	2	25,780	47,119	21,339	1.25	0.034	F
Buffalo Creek	1	0	21,009	21,009	1.52	0.006	B
	2	21,009	37,478	16,469	1.24	0.019	B
	3	37,478	126,086	88,608	2.17	0.004	F
	4	126,086	149,043	22,957	1.18	0.017	B
	5	149,043	171,868	22,825	1.08	0.047	A
Ditch Creek	1	0	27,633	27,633	1.18	0.041	B
	2	27,633	66,469	38,836	1.43	0.021	B
East Fork	1	0	9,822	9,822	1.10	0.089	A
East Fork Jones Creek	1	0	14,715	14,715	1.07	0.076	A
Grass Creek	1	0	20081	20081	1.17	0.032	B
	2	20081	48793	28712	1.14	0.030	B
	3	48793	69601	20808	1.71	0.013	E
	4	69601	82269	12668	1.14	0.068	A
Jones Creek	1	0	41418	41418	1.16	0.030	B
	2	41418	60520	19102	1.21	0.015	B
	3	60520	84623	24103	1.26	0.030	B
Middle Fork Warm Springs Creek	1	0	10033	10033	1.34	0.020	B
	2	10033	21129	11096	1.12	0.069	A
South Fork	1	0	23278	23278	1.20	0.022	B
	2	23278	40472	17194	1.06	0.036	A
Warm Springs Creek	1	0	26005	26005	1.30	0.012	B
	2	26005	42675	16670	1.39	0.012	B
	3	42675	64273	21598	1.35	0.015	B
	4	64273	75929	11656	1.07	0.060	A

A minimal number of first-order tributaries in the basin can be classified as G-Type channels, or gullies. These channels are highly erosive, generate high sediment volumes, and can result in the loss of productive lands and destabilize upland conditions. However, the extent of these channels is apparently minimal within the study area. An example of a G-Type channel is the degraded overflow channel associated with the breached reservoir embankment on Buffalo Creek.

3.6.3 Proper Functioning Condition

Only a small portion of the study area lies within the jurisdiction of the BLM, consequently, stream channel assessments conducted by BLM staff are similarly limited. However, the condition of approximately 7.9 miles of stream channel on federal lands has been evaluated by BLM staff and the results incorporated herein.

The BLM utilizes a procedure for assessing the health of a stream called Proper Functioning Condition assessment or PFC. PFC is described by the BLM as:

Black Willow Draw Watershed

Warm Springs Creek Watershed

Buffalo Creek Watershed

Hot Springs County

Fremont County

Thermopolis

Red Lane

Lucerne

Minnesela

Boysen

Dornick

Black Willow Draw

Warm Springs Creek

South Fork

Buffalo Creek

Jones Creek

Grass Creek

Antelope Creek

Ditch Creek

East Fork Jones Creek

West Fork

East Fork

Rosgen Classification

- A
- B
- E
- F

Legend

- Cities
- Buffalo Creek Study Area
- County Boundary

N W E S

0 8,500 17,000

Feet

Figure 3.56 Buffalo Creek Watershed: Rosgen Level I Classification

"A qualitative method for assessing the condition of riparian-wetland areas. The term PFC is used to describe both the assessment process, and a defined, on the-ground condition of a riparian-wetland area. The PFC assessment refers to a consistent approach for considering hydrology, vegetation, and erosion/deposition (soils) attributes and processes to assess the condition of riparian-wetland areas. A checklist is used for the PFC assessment, which synthesizes information that is foundational to determining the overall health of a riparian-wetland system" (BLM, 1998).

The PFC assessment terminates with the definition of one of three classes for a given stream segment as described below.

Proper Functioning Condition: A stream is said to be functioning properly when adequate vegetation, landform, or debris is present to:

- dissipate energies associated with wind action, wave action, and overland flow from adjacent sites, thereby reducing erosion and improving water quality;
- filter sediment and aid floodplain development;
- improve flood water retention and groundwater recharge;
- develop root masses that stabilize islands and shoreline features against cutting action;
- restrict water percolation;
- develop diverse ponding characteristics to provide the habitat and water depth, duration, and temperature necessary for fish production, water bird breeding, and other uses; and
- support greater biodiversity.

Functional At Risk: Riparian/wetland areas are classified as *functioning-at-risk* when they are in functioning condition but an existing soil, water, or vegetation attribute makes them susceptible to degradation. These areas are further distinguished based on whether or not they demonstrate an *upward*, *not apparent*, or *downward* trend.

Nonfunctioning: Riparian/wetland areas are classified as *nonfunctioning* when they clearly are not providing adequate riparian vegetation, physical structure, or large woody debris to dissipate stream energy associated with high flows.

Within the project study area, the BLM has conducted PFC assessments on selected stream segments intermittently since 1999. Results of the BLM PFC assessment are shown on Figure 3.57. As evidenced in this figure, the PFC assessment results in evaluation of specific and frequently isolated stream reaches.

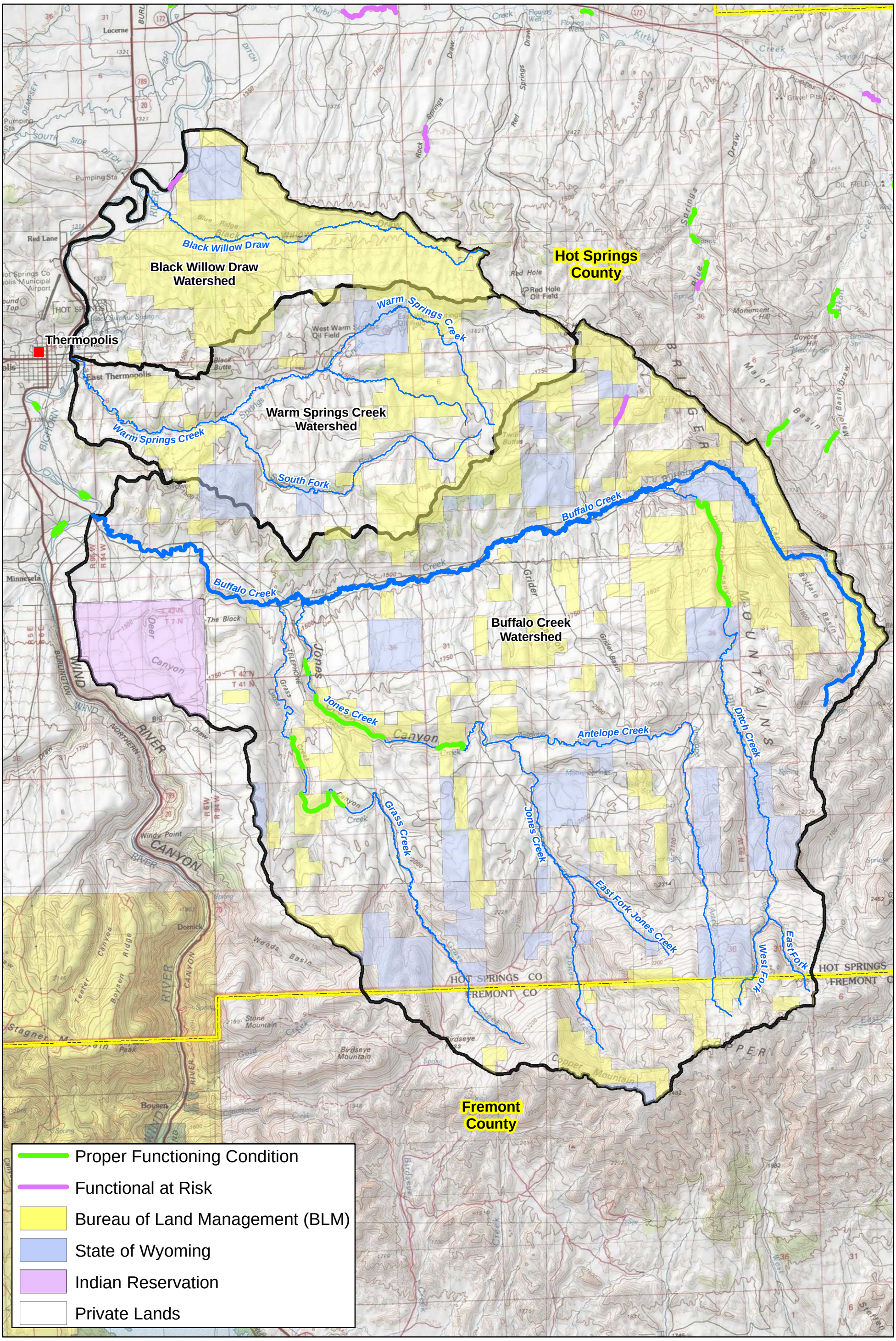


Figure 3.57 Buffalo Creek Watershed: BLM Proper Functioning Condition (PFC) Assessments

3.6.4 Impairments

Impairments to stream channels within the study area appear to fall into two broad and interrelated categories:

- Riparian Vegetation Degradation: Impaired riparian condition and habitat, and
- Riparian Degradation: Generally bank erosion and physical disturbance of stream banks.

Based upon field observations and information provided by landowners, Buffalo Creek has experienced a limited amount of incision and minor lateral migration. This is evidenced by locations where bare vertical banks are present. Stream bank erosion on the perennial tributary reaches of Jones, Ditch, Grass, and Antelope Creeks appears to be localized and not indicative of systemic erosional events. Figure 3.58 displays an example of localized bank erosion on Antelope Creek.

Figure 3.58 Localized streambank erosion on Antelope Creek.

Black Willow Draw is incised throughout much of its extent as evidenced by its entrenched condition (Figure 3.59). Incision appears to have stopped and the system has reached an equilibrium state. Perennial streams (i.e., upper reaches of Jones Creek, Antelope Creek, Grass Creek, and Ditch Creeks) all appear to have experienced degradation of riparian condition and habitat as is evidenced by the lack of diverse riparian vegetation.

Multiple approaches to restoration can be applied to incised river channels (Rotar and Boyd, 1999). Common objectives in such restoration efforts are to promote channel stability, as well as to connect the channel to its historic floodplain. The reconnection of the channel to its historic floodplain requires raising the channel bed, which can be achieved through grade controls and channel infilling, or even reconstruction of a new channel. These approaches can have difficult and costly challenges, however, such as tying in the project end points to the incised channel grade, or preventing post-project channel relocation (avulsion).

Figure 3.59 Incised channel on lower Black Willow Draw.

Another approach to incised channel stabilization is to completely armor the channel banks and add grade control structures. This process will reduce sediment inputs, but will not provide a dynamic, functional channel configuration. Perhaps the most geomorphically beneficial approach to incised channel restoration is to promote the natural recovery process of channel widening and incised floodplain development. This can be achieved by encouraging the development of a new floodplain surface adjacent to the channel to provide an area for flood energy dissipation and new riparian corridor establishment.

Any work in incised channel restoration requires an assessment of the status of the current channel stability, so that the potential for further downcutting is known and accommodated for in the channel restoration design.

3.7 Water Quality

3.7.1 Stream Classifications

All streams named on the U.S. Geological Survey 1:500,000 scale hydrologic map of Wyoming and other selected streams have been classified for protection of one or more designated uses by the Water Quality Division of the WDEQ. The stream classifications applicable to the study area as noted in the latest Wyoming Surface Water Classification List (WDEQ, 2001) are indicated below. This list is included in the project Digital Library for reference. The definitions of the stream classes applicable to the watershed are quoted from the Water Quality Rules and Regulations, Chapter 1, Wyoming Surface Water Quality Standards (WDEQ, 2007) as follows:

Class 2AB: Perennial Headwaters Streams (Jones Creek, Antelope Creek, Ditch Creek, and Grass)

WYDEQ defines class 2AB waters as follows:

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

Class 3B: Mainstem reaches ()Buffalo Creek, Warm Springs Creek, and Black Willow Draw: 3B)

WYDEQ defines class 3B waters as follows:

> *Class 3B waters are tributary waters including adjacent wetlands that are not known to support fish populations or drinking water supplies and where those uses are not attainable. Class 3B waters are intermittent and ephemeral streams with sufficient hydrology to normally support and sustain communities of aquatic life including invertebrates, amphibians, or other flora and fauna which inhabit waters of the state at some stage of their life cycles. In general, 3B waters are characterized by frequent linear wetland occurrences or impoundments within or adjacent to the stream channel over its entire length. Such characteristics will be a primary indicator used in identifying Class 3B waters."*

3.7.2 WYPDES Permitted Discharges

A database of permitted discharges under the National Pollution Discharge Elimination System (NPDES) was obtained from the Wyoming Department of Environmental Quality. A total of four active (WYPDES) permitted discharges are present within the study area. Table 3.18 summarizes pertinent information regarding the permits. The locations of these discharges are shown on Figure 3.60.

Table 3.18 Summary of NPDES Permitted Discharge Locations.

Permit	Outfalls	Permittee	Facility Name	Receiving Water
WY0025798	1	Continental Operating Company	East Warm Springs Unit	Big Horn River via Warm Springs Creek
WY0028070	1	Cork Petroleum, Inc.	Freudenthal Lease, Battery #1	Big Horn River via Warm Springs Creek
WY0030996	1	Cork Petroleum, Inc.	Freudenthal Lease, Battery #3	Big Horn River via Warm Springs Creek
WY0032565	1	Cork Petroleum, Inc.	Freudenthal Lease, Battery #2	Big Horn River via Warm Springs Creek

3.7.3 Waters Requiring TMDLs

A Total Maximum Daily Load (TMDL) is the amount of pollutant which a stream can accept and still meet its designated uses. TMDLs must be established for each pollutant which is a source of stream impairment. They must be measurable and must consider both point and nonpoint source pollutant loads, natural background conditions, and a margin of safety.

Section 303(d) of the Clean Water Act requires States to:

1) Identify all waters of the state which are impaired--i.e. they contain pollutants which adversely affect the designated use of the water.
2) Prioritize all impaired waterbodies for development of TMDLs. Prioritization is to take into consideration public health and environmental risk. Therefore, point source discharges generally are a higher priority than nonpoint sources of clean sediment.

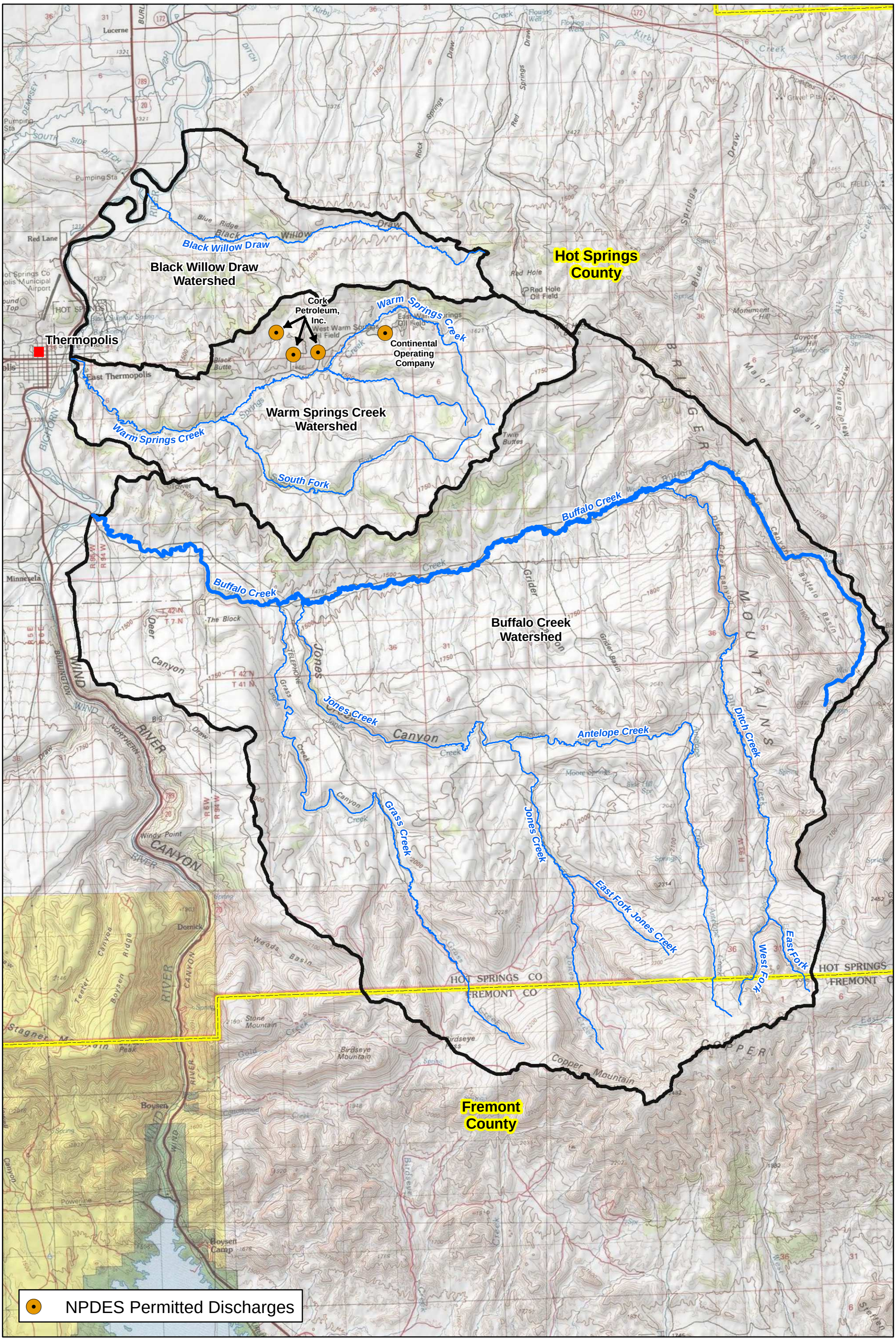


Figure 3.60 Buffalo Creek Watershed: Location of NPDES Permitted Discharges

3) Establish and adopt TMDLs for all impaired waterbodies or for waterbodies which would be impaired if a TMDL was not established.

If a state does not comply with Section 303(d), the Environmental Protection Agency is required to perform these activities.

At this time, none of the water bodies within the project study area have been included in the 303(d) lists nor are the indications they will be in the foreseeable future.

IV. WATERSHED MANAGEMENT AND REHABILITATION PLAN

4.1 Overview

As stated previously, the objective of this study is to generate a watershed management and irrigation rehabilitation plan that is not only technically sound, but also one that is practical and economically feasible. In conjunction with the development of a database for the watershed, the investigative phase of this study focused on an assessment of the watershed and the identification and evaluation of improvements to address those issues described in Chapter 3. Potential improvements were developed and categorized into the following:

- **Irrigation System Conservation and Rehabilitation.** The inventory and evaluation 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 upon an evaluation of existing water sources and the condition of upland grazing resources, potential upland water source development projects were identified.

- **Stream Channel Condition and Stability**. Stream channels within the watershed were characterized with respect to their condition and stability. Impaired channels were identified for further evaluation and alternative improvements developed.

- **Grazing Management Opportunities**. Based upon a review of the pertinent Ecological Site Descriptions (ESDs) and the ambient vegetation and soil conditions, grazing management strategies are presented.

- **Other Upland Management Opportunities**. Additional watershed management alternatives were identified.

It is important to note that development of reservoir storage opportunities in the Buffalo Creek watershed was not evaluated beyond the need for small wildlife / livestock water supplies for the following reasons:

- The geologic character of the watershed (see Chapter 3.4.3) does not lend itself to construction of reservoirs due to the location and types of limestone bearing formations.

- Previous investigations within the Bighorn Basin have concluded that there is not a significant demand for additional reservoir storage (ACE, 2005).

- Given the limited irrigation use benefit perceived from the Buffalo Creek surface storage opportunity which was preliminarily evaluated during this study and the projected cost of that facility in excess of $1M, this option was not further evaluated.

Rehabilitation plans have been developed for each category, and are presented in the following portions of this chapter. These plans have been prepared to provide an overview of potential improvements that can partially or fully address the key issue identified within the watershed.

In the remainder of this chapter, the individual plans developed within each watershed component are described and evaluated with respect to providing benefits to improving the existing water supply through conservation. The results of the geomorphic assessment are further refined to identify those impaired reaches that merit more immediate attention.

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
- Project Components "L/W": Livestock / wildlife upland watering opportunities
- Project Components "G": Grazing management opportunities
- Project Components "C": Stream channel stability components
- Project Components "O": Other management opportunities

In summary, this chapter provides a plan that can be used to guide future efforts to enhance the water resources within the Buffalo Creek Watershed Study Area.

4.2 Irrigation System Conservation and Rehabilitation

At this time, there is only a limited amount of irrigation infrastructure within the study area. None of those individuals currently irrigating requested the project team to inventory their existing infrastructure. Consequently, there are no specific irrigation system rehabilitation components in the watershed management plan.

During the completion of this project, however, headgates were observed on Buffalo Creek which were no longer operable due to the lowering of Buffalo Creek due to channel incision. The ownership status of these headgates is uncertain as is the desire of the owner to potentially reestablish irrigation of lands served by them. Restoration of Buffalo Creek's original grade level is feasible with construction of relatively small check dams in the affected reaches. These alternatives are presented in Section 4.5 Stream Channel Stability Components of the watershed management plan.

4.3 Upland Wildlife/Livestock Watering Sources

4.3.1 Alternative New Watering Opportunities

Based upon the premise that existing water sources are capable of providing water to livestock within a one mile radius, buffers were drawn around existing water sources discussed in Chapter 3 (Figure 4.1). Note that this figure does not show buffers about perennial / intermittent streams, nor springs. A general objective of this effort was to provide means of providing reliable sources of livestock / wildlife drinking water as alternative water supplies to riparian corridors. As indicated in this figure, much of the study area appears to be adequately supplied with water sources. However, it is important to note that many of these sources are stock reservoirs located on intermittent / ephemeral channels and are consequently reliant upon uncertain runoff. Long-term or season-long utility is not always certain. Based upon this analysis, much of the study area may benefit by the development of upland water sources. In addition, land owners indicated locations where existing sources could benefit from enhanced or improved infrastructure.

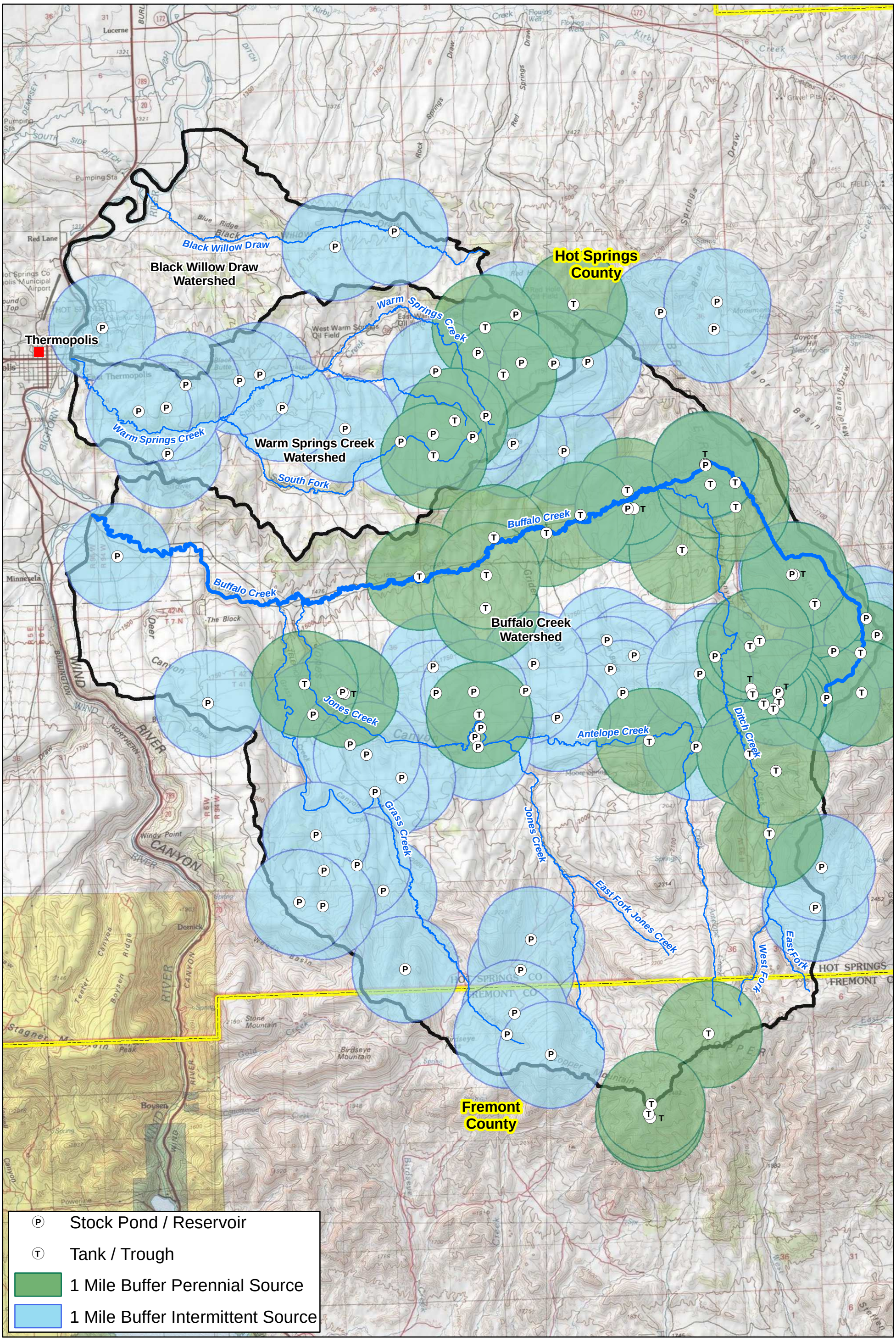


Figure 4.1 Buffalo Creek Watershed: Existing Wildlife / Livestock Water Sources with 1 Mile Buffers

As presented in Chapter 3, there are numerous springs scattered throughout the study area. Many of these could conceivably be developed as upland water sources for wildlife and livestock. Prior to the design of any project, site-specific evaluation of the water source would be required to ensure adequate water yield and to develop environmental safeguards. Final design of any upland water projects would consequently require consideration of the yield of the water source and the number of animals the project is anticipated to serve. Sizing of water facilities cannot be determined at this time due to the uncertainties associated with the grazing management plan proposed by the BLM. For the purposes of this project, watering facilities were assumed to consist of rubber tire stock tanks providing approximately 1,200 gallons of storage. This volume would facilitate the water needs of approximately 80 cattle per day assuming a water requirement of 15 gallons per day. A water source capable of providing 1 gallon per minute would be required to supply these facilities. By incorporating closed storage tanks in a project design, greater use of existing water sources could be realized.

With respect to development of groundwater as a source for proposed projects, existing groundwater development in the study area primarily consists of relatively shallow, low-yield wells constructed for stock and domestic use and the similar, limited development of small springs. With the exception of deep wells associated with oil field production (e.g. waterflood operations), all study area wells have water right permits for less than 30 gpm; the average permit yield is 11 gpm.

Across most of the study area north of the Buffalo Creek valley, the aquifers available at depths that could be economical for low-production uses (e.g. stock watering, domestic use) are of poor - moderate yield and of poor-moderate groundwater quality. Additional wells less than 500 feet deep and yielding on the order of 10 gpm or less could likely be constructed at geologically favorable locations in the sandstone beds of the Chugwater, Cloverly, and Frontier Formations, although power to run pumps is problematic across much of the area. The advent of solar-powered, low-yield pumps creates additional opportunities in remote areas. Well depths and depths-to-water and the availability of groundwater at all, are likely to be highly variable across the study area, dependent on localized conditions of recharge and permeability.

By the same token, groundwater-development interference in these areas is likely to be localized, e.g. a nearby well reducing the flow of a spring, rather than extending over large distances.

High-production groundwater-supply opportunities are largely confined to the Paleozoic-age aquifers that outcrop south of the Buffalo Creek valley. Particularly where fractured along geologic structures, the permeability of these brittle formations is likely to have been enhanced, creating attractive development potential.

The depth and water quality of these aquifers pose severe limitations on development across the northern portions of the study area. This is why previous evaluations (e.g. BRS,2004; EA, 2006; Jarvis, 1986; Spencer, 1986; Weston, 2011) have focused on the mountain-flank groundwater development opportunities, e.g. in this study area, locations along Buffalo Creek. This area was investigated as a potential target for municipal water supply, not only to supply the City of Thermopolis, but to serve as

the southern anchor of the extensive Bighorn Regional Joint Powers Board municipal-rural water system. The most recent work (Weston, 2011b) recommends bringing the Buffalo Creek No. 2 well into that system, with an initial yield of 700- 800 gpm and opportunity for expansion to 1200 gpm.

These productive aquifers could also be successfully developed in the upland areas to the south, where well depths could be considerably less, although on-site power supplies would likely be necessary. Small-yield supplies could likely be developed based at locations of need, as sufficient permeability is likely pervasive. Such wells should be sufficiently deep to provide protection against seasonal water-level changes. Projection of that depth, i.e. the difference between the ground surface and the elevation of the water table, is difficult due to an absence of depth-to-water measurements.

Water level elevations along Buffalo Creek have been discussed previously. The reports of total well depths of 230 and 600 ft. near the intersection of Jones and Antelope Creeks (Plafcan and Ogle, 1994; Tensleep Fm. wells) suggest reliable water supplies were not encountered much shallower. Figure 3.35 included a schematic representation of the groundwater level elevations south of Buffalo Creek, but these elevations are not well constrained by measured values. Weston (2011; Fig. 1-7) suggest a similar geometry of the water table for a 4-mile cross section just west of the mouth of Jones Creek, i.e. depths to groundwater on the order of 500 ft. across the upland area.

As noted in the discussion of water levels, development of these major aquifers in unlikely to have an impact on the relatively shallow wells and local springs present along and north of Buffalo Creek.

Finally, is has been suggested that the water currently serving to recharge the aquifers south of Buffalo Creek via the losing reaches of Grass, Jones, Antelope, and Ditch Creeks might be intercepted before it becomes groundwater and thereby made available for use. Were recharge concentrated in short reaches of these creeks, some sort of lining or piping might be feasible to significantly reduce infiltration. However, as discussed in Section 3.5.2.2 (Stream Loss Measurement) geologic considerations indicate streamflow loss over substantial reaches where these creeks flow across the Madison/Bighorn and Tensleep/Park City Formations. Interception of recharge in the higher reaches of these creeks might be feasible, but would require facilities to conduct the water entirely across the Paleozoic outcrop areas (e.g. down into the Buffalo Creek valley). *In other words, water development alternatives considering <u>bypassing</u> the infiltration areas (i.e, 'sinks') should not be considered because losses occur throughout extensive portions of the channels as opposed to isolated and discernable locations.*

The aquifers are not currently heavily developed, existing use is minimal. Consequently, even if substantial interception of recharge were to occur, impacts to existing users would not be discernable.

It must be kept in mind that designs presented in this report are conceptual only. The indicated alignments of pipelines and placement of livestock / wildlife watering facilities are general and intended to represent the concept behind the alternatives if implemented, detailed design would be required.

Also, the reader should note that the names associated with the following components of the watershed plan were organized by the project team to assist in their identification. They are generally based upon a project's location or named water source where appropriate.

4.3.2 Upland Wildlife/Livestock Water Development Projects

A list of interested land owners and allotment permittees was generated based upon input obtained at project meetings. Individual meetings were scheduled and completed to gain their input on the water needs of their respective geographical areas of interest. Based upon the results of these interviews and the information presented above pertaining to existing water supplies and areas in need of upland water development, several conceptual water development projects were identified. The general objective of this effort was to create a means of providing reliable sources of livestock / wildlife drinking water in water-short portions of the watershed as well as alternative water supplies to riparian corridors. In the following paragraphs, several alternatives are presented at the conceptual level. For each project, a conceptual design is also presented. It must be kept in mind that these designs are conceptual only and if implemented, detailed design would be required. The projects and their respective component identifiers in the watershed management plan are summarized in Table 4.1. Figure 4.2 displays the general location of all livestock/wildlife water opportunity projects.

Federal lands are not significant in extent within the project area. However, pipeline projects have the potential to require cooperation among multiple landowners. Several of the upland water development projects could involve coordination with the BLM in order for construction to occur. Written agreements would be required which define the maintenance responsibility and ownership liability associated with each project. In addition, environmental evaluations would be required for the impacts identified with each project. BLM typically conducts these evaluations; however, the NRCS or other agencies may provide input, particularly on archaeological or cultural resources issues. Consequently, implementation would be partially contingent upon BLM scheduling and manpower for their completion of the requisite evaluation and documentation. It is our understanding that the permitting process is simplified for those projects which do not involve placement of above ground facilities pipeline alignment only and thus requiring granting of easement for buried pipelines.

4.3.2.1 Pipeline Extension Project (Plan Component L/W- 01)

This project consists of extension of an existing pipeline system to provide a source of water for winter use on deeded property in Section 32, Township 42 North, Range 93 West. The existing pipeline originates on Antelope Creek and runs westerly towards the location of this project. The pipeline is primarily located on deeded property; only a limited extent of the existing pipeline crosses federal lands managed by the BLM. The proposed project would entail tapping an extension into the existing pipeline to supply a stock tank located downslope (Figure 4.3). A small stock reservoir would be constructed downslope of the stock tank.

Table 4.1 Summary of Wildlife/Livestock Water Development Components of the Watershed Management Plan

Watershed Plan Component	Project Description	Stakeholder/ Originator
L/W-1	Extension of existing pipeline system/new tank/new stock pond	Axtell-1
L/W-2	Extension of existing pipeline system/new tank/new stock pond	Axtell-2
L/W-3	Antelope Creek diversion to pipeline system	Axtell-3
L/W-4	Develop Existing Spring / install stock tank	Axtell-4
L/W-5	Clean Existing Stock Reservoir	Axtell-5
L/W-6	Develop Existing Spring / install stock tank / Pipeline	Axtell-6
L/W-7	Extend Existing Pipeline Project	Axtell-7
L/W-8	Rehabilitate / Clean Existing Stock Reservoirs	Axtell-8
L/W-9	Rehabilitate / Clean Existing Stock Reservoir	Axtell-9
L/W-10	Develop Existing Spring / install stock tank / Pipeline	Axtell-10
L/W-11	Rehabilitate / Clean Existing Stock Reservoirs	Axtell-11
L/W-12	Rehabilitate / Clean Existing Stock Reservoirs	Axtell-12
L/W-13	Extend Existing Pipeline / Provide alternative source to existing well	Axtell-13
L/W-14	Develop Existing Spring / install stock tank / Pipeline	Axtell-14
L/W-15	Develop Existing Spring / install stock tank / Pipeline	Axtell-15
L/W-16	Redevelop Existing Spring	Jones-1
L/W-17	Redevelop Existing Spring	Jones-2
L/W-18	Develop Existing Spring	Thoren-1
L/W-19	Develop Existing Spring	Thoren-2
L/W-20	Develop Existing Spring	Thoren-3
L/W-21	Develop Existing Spring	Thoren-4
L/W-22	Enhance Existing Well	Belden-1
L/W-23	Enhance Existing Well	Belden-2
L/W-24	Enhance Existing Well	Belden-3
L/W-25	New Diversion / Pipeline	Baird-1
L/W-26	Develop Existing Spring	Henthorne-1
L/W-27	Buchanon Pipeline Project Phase I	Jennigis - 1
L/W-28	Buchanon Pipeline Project Phase II	Jennigis - 2
L/W-29	New Diversion / Pipeline	Baird, John-1
L/W-30	New Diversion / Pipeline	ACE-1
L/W-31	New Diversion / Pipeline	ACE-2

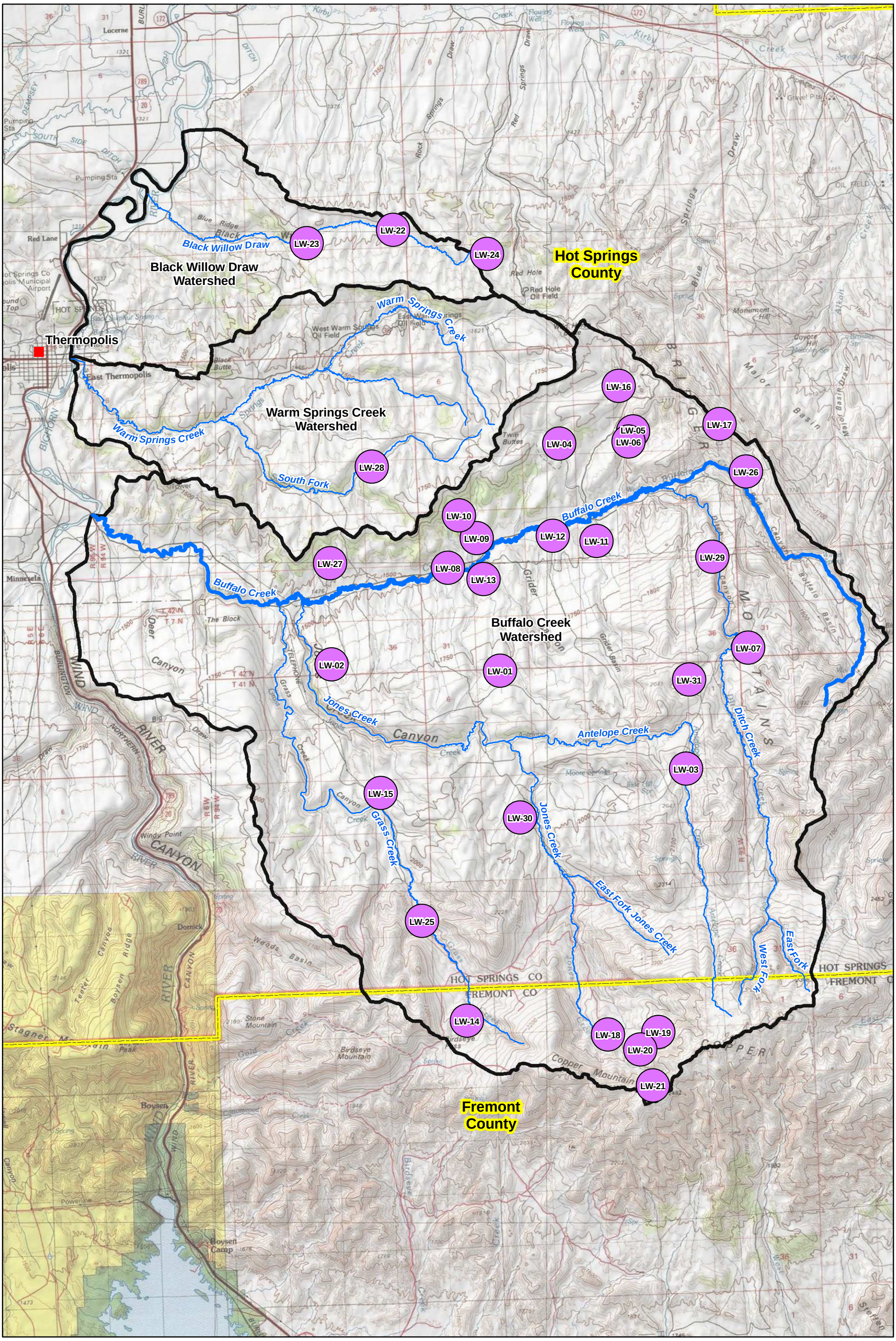


Figure 4.2 Buffalo Creek Watershed: Locations of Proposed Wildlife and Livestock Water Supply Projects

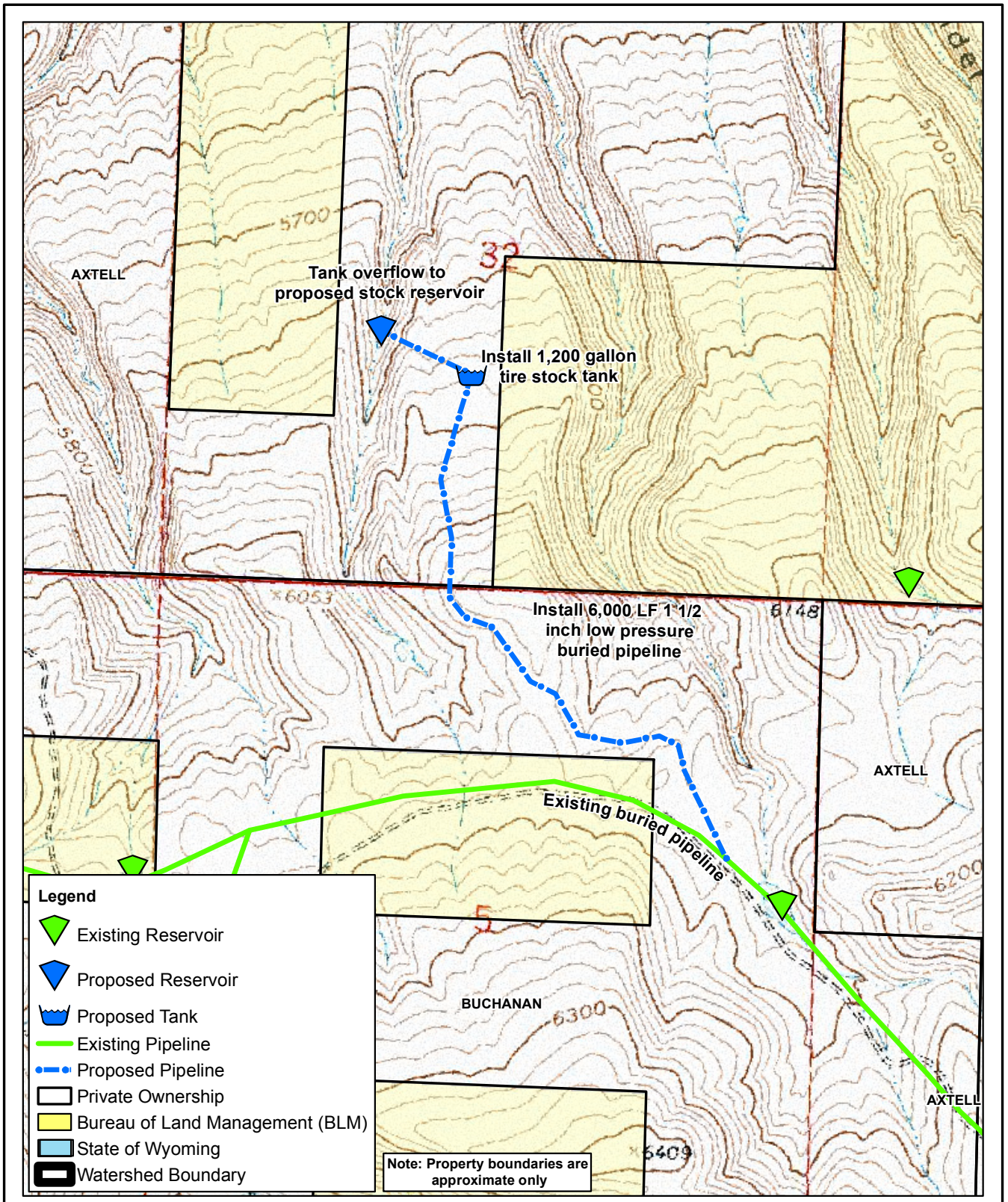


Figure 4.3 Conceptual Design: Watershed Management Plan Component LW-01 (Axtell-1)

Completion of this project would require modification of the system management strategies to avoid exceeding the capacity of the pipeline. By timing delivery of water to different locations of the system, the extension would not place undue demands upon it. A booster pump placed at the pipeline diversion on Antelope Creek would enhance the system's capacity.

Under this alternative, the following components would be employed:

- A solar powered booster pump would be installed at the pipeline diversion on Antelope Creek. (Not shown on figure due to scale considerations)
- The existing pipeline would be located and appropriate valves and fittings installed to facilitate the addition of an extension to the system and control of flows within it.
- Approximately 6,000 linear feet of 1½ inch HDPE pipeline would be installed.
- A 1,200 gallon rubber tire stock tank would be installed.
- Wildlife egress ramps would be installed in the proposed stock tank.
- An overflow pipeline would be installed to convey water from the stock tank to a small proposed stock reservoir.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.

Note that the proposed project as delineated would only involve privately owned lands. A shorter pipeline could be installed crossing BLM lands. However, this alignment would require coordination with BLM and procurement of an easement to cross federal lands with a pipeline.

4.3.2.2 Pipeline Extension Project (Plan Component L/W-02)

This project consists of extension of an existing pipeline system to provide a source of water for winter use on deeded property in Section 35, Township 42 North, Range 94 West. The existing pipeline originates on Antelope Creek and runs westerly towards the location of this project. The pipeline is primarily located on deeded property; only a limited extent of the existing pipeline crosses federal lands managed by the BLM. The proposed project would entail tapping an extension into the existing pipeline to supply a stock tank located downslope (Figure 4.4). A small stock reservoir would be constructed downslope of the stock tank.

Completion of this project would require modification of the system management strategies to avoid exceeding the capacity of the pipeline. By timing delivery of water to different locations of the system, the extension would not place undue demands upon it. A booster pump placed at the pipeline diversion on Antelope Creek would enhance the system's capacity.

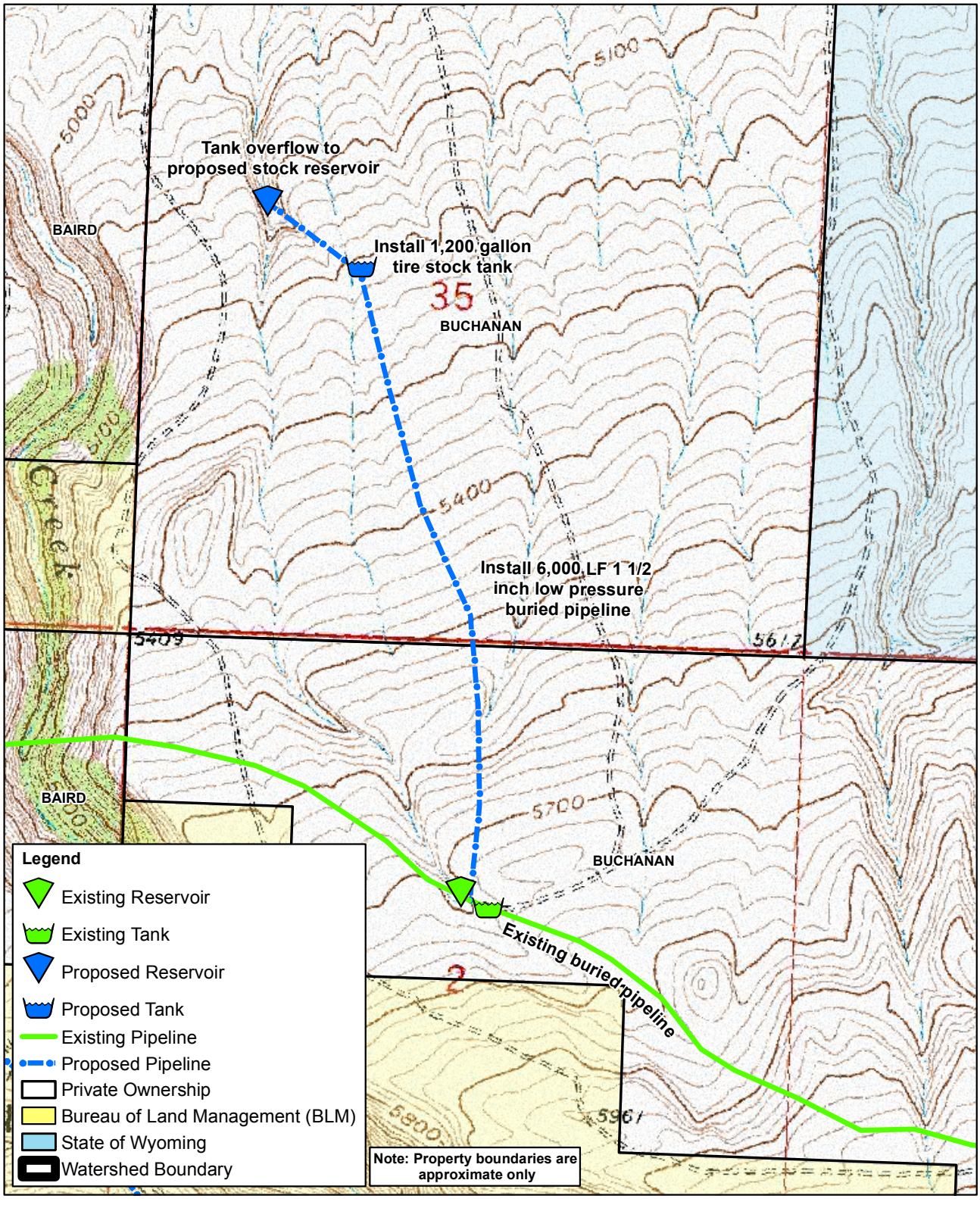


Figure 4.4 Conceptual Design: Watershed Management Plan Component LW-02 (Axtell-2)

Under this alternative, the following components would be employed:

- A solar powered booster pump would be installed at the pipeline diversion on Antelope Creek. (Not shown on figure due to scale considerations)
- The existing pipeline would be located and appropriate valves and fittings installed to facilitate the addition of an extension to the system and control of flows within it.
- Approximately 6,000 linear feet of 1½ inch HDPE low pressure pipeline would be installed. Pressure reduction valves (PRVs) would be required to maintain pipe pressures below 160 psi.
- A 1,200 gallon rubber tire stock tank would be installed.
- Wildlife egress ramps would be installed in the proposed stock tank.
- An overflow pipeline would be installed to convey water from the stock tank to a small proposed stock reservoir.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.

Note that the proposed project as delineated would only involve privately owned lands.

4.3.2.3 Antelope Creek Stock Reservoir Enhancement (Plan Component L/W-03)

This project consists of construction of a pipeline paralleling Antelope Creek and improvements to an existing stock reservoir well located in Section 12, Township 41North, Range 93 West. The viability of the existing stock reservoir would be enhanced by the addition of a pipeline diverting water from Antelope Creek to a stock tank with overflow to the reservoir. The reservoir is located in the vicinity of limestone sinks which capture all of the Antelope Creek streamflow during normal flow conditions. From the reservoir, the pipeline would continue downslope approximately two miles along Antelope Creek to supply water to two additional livestock/wildlife tanks. Figure 4.5 displays the conceptual design of the project.

Construction of this project would provide a viable water supply to the stock reservoir and proposed stock tanks by diverting water from Antelope Creek upstream of the sinks.

Under this alternative, the following components would be employed:

- A diversion structure would be constructed in Antelope Creek upstream of the limestone sinks. The diversion would consist of a buried gravel infiltration gallery and perforated pipe. A valve would be included for management of pipeline flows.
- Approximately 5,200 linear feet of 1½ inch buried HDPE low pressure pipeline would be installed between the diversion and the proposed stock reservoir. The pipeline would follow the alignment of an abandoned irrigation ditch.
- From the reservoir, approximately 15,800 feet of 1½ inch HDPE low pressure pipeline would extend downstream and generally follow the alignment of Antelope Creek. This portion of the project would likely be unburied as trenching appears to be problematic.

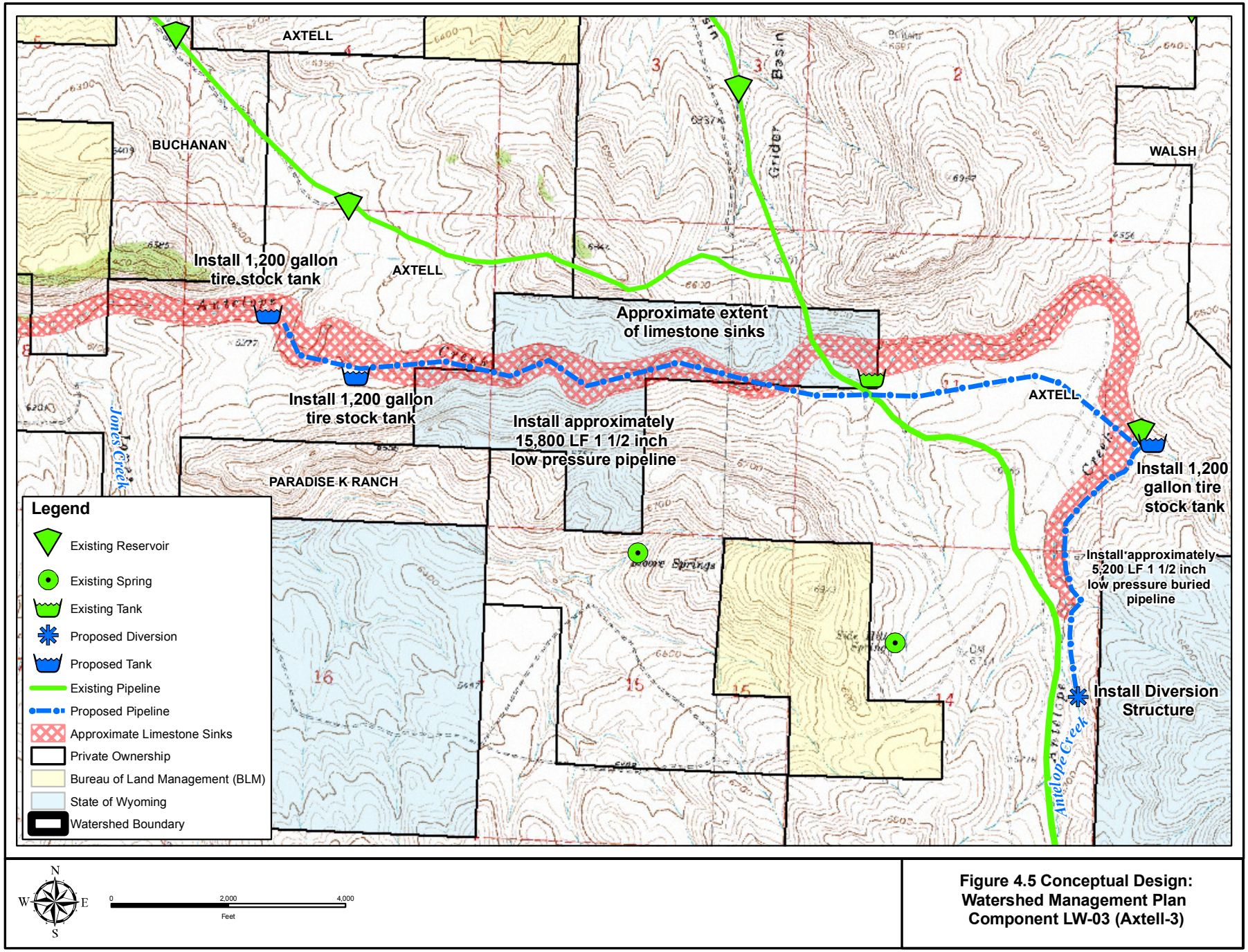


Figure 4.5 Conceptual Design: Watershed Management Plan Component LW-03 (Axtell-3)

- Three (3) 1,200 gallon capacity stock tanks would be installed.
- Wildlife egress ramps would be installed in the proposed stock tanks.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels. Pressure reduction valves (PRVs) would be required to maintain pipeline pressures below 160 psi.

Note that the proposed project as delineated would involve state and privately owned lands.

4.3.2.4 Unnamed Spring Development / Reservoir Enhancement (Plan Component L/W-04)

This project consists of development of an existing spring and conveyance of spring flows to an existing stock reservoir. Development of the spring would provide an alternative source of upland water for wildlife and livestock in an area where the riparian zones are heavily utilized. The spring is located in Section 9, Township 42 North, Range 93 West. Currently, water to the reservoir is limited and it provides limited value as a source of water for wildlife and livestock. Figure 4.6 displays the conceptual design of the proposed project.

Under this alternative, the following components would be employed:

- A new spring development would be completed in the vicinity of the existing spring. The spring development would facilitate diversion of flows to a gravity pipeline. See the attached NRCS designs for typical spring development plans.
- The spring vicinity would be fenced to prevent the spring development damage from livestock and wildlife.
- A 1,200 gallon capacity stock tank would be installed near the spring.
- Wildlife egress ramps would be installed in the proposed stock tank.
- Approximately 1,800 linear feet of buried HDPE low pressure pipeline (1½ inch diameter) would be installed to convey overflow from the stock tank to the stock reservoir located downstream.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.
- Fence installed as indicated in Figure 4.6 would facilitate management of livestock in a manner which would protect recovering willows and riparian vegetation.

Note that the proposed project as delineated would only involve privately owned lands.

4.3.2.5 Stock Reservoir Rehabilitation (L/W-05)

This project consists of the rehabilitation of an existing stock reservoir located in Section 11, Township 42 North, Range 93 West. Water is supplied to the reservoir by an undeveloped spring located upstream. The reservoir is currently filled with sediment and provides only limited water retention capability. Review of aerial photography indicates the reservoir may be breached due to the

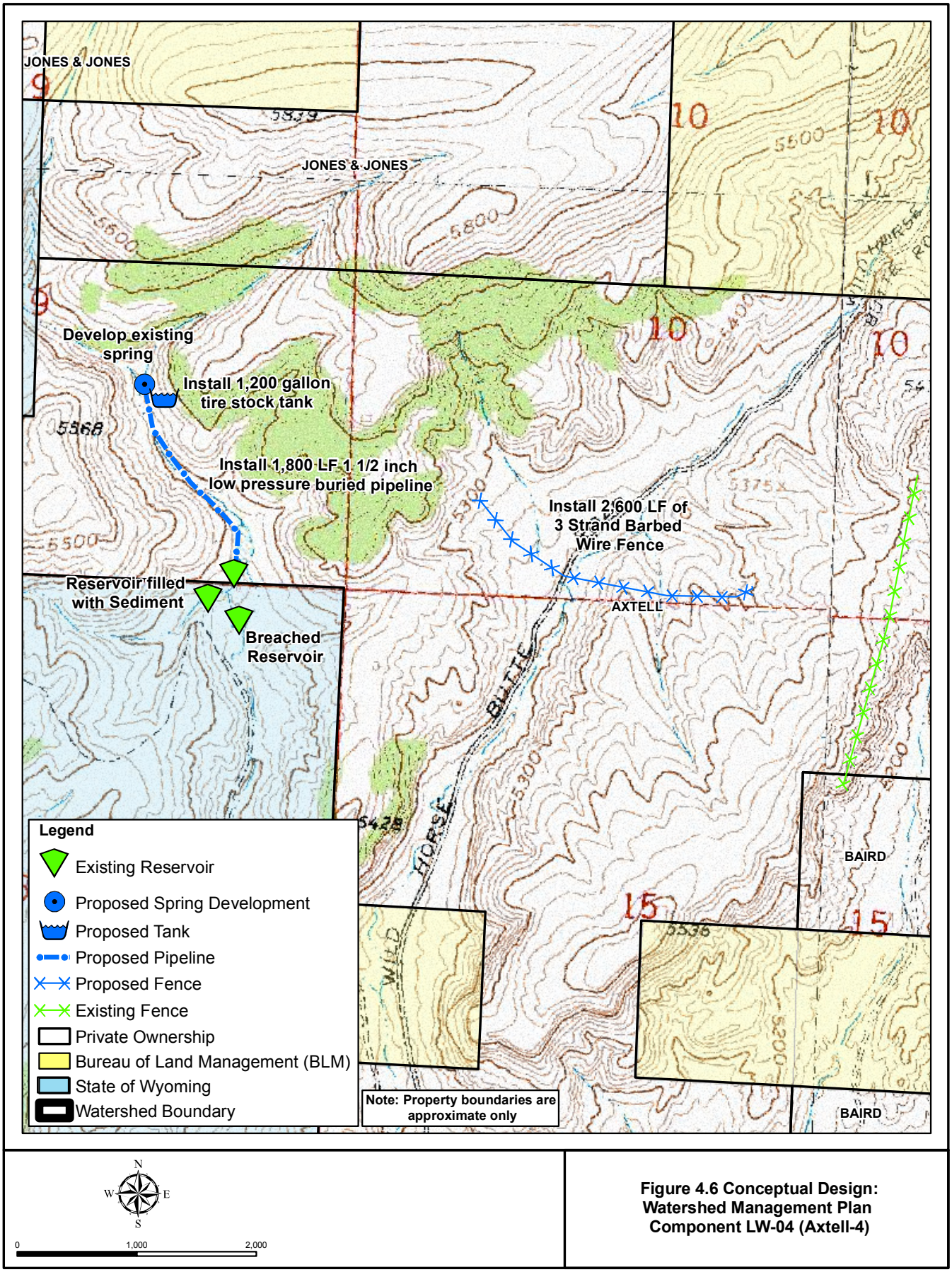


Figure 4.6 Conceptual Design: Watershed Management Plan Component LW-04 (Axtell-4)

sedimentation. Figure 4.7 displays the general location of the reservoir. Completion of this proposed project would logically be completed with project L/W-06 which includes the reservoir in a pipeline project. However, it is included individually because restoration of the reservoir would be valuable with or without completion of the pipeline project.

Under this alternative, the following components would be employed:

- The reservoir embankment would be inspected and necessary repairs made as appropriate.
- The reservoir pool area would be cleared of sediment.

Note that the proposed project as delineated would only involve privately owned lands.

4.3.2.6 Spring Development and Pipeline System (Plan Component L/W-06)

This project consists of improvements to an existing spring located in Section 11, Township 42 North, Range 93 West. Under this proposed project, the spring would be developed and collected flows conveyed downstream to a rehabilitated stock reservoir (See project L/W-05 above). Flow from the stock reservoir would be conveyed to a pipeline supplying water to two additional stock tanks downstream. Figure 4.7 displays the conceptual configuration of this project.

Under this alternative, the following components would be employed:

- A new spring development would be completed in the vicinity of the existing spring. The spring development would facilitate diversion of flows to a gravity pipeline. See the attached NRCS designs for typical spring development plans.
- The spring vicinity would be fenced to prevent the spring development damage from livestock and wildlife.
- Approximately 3,475 linear feet of buried HDPE low pressure pipeline (1½ inch diameter) would be installed.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.
- Two (2) 1,200 gallon capacity stock tanks would be installed.
- Wildlife egress ramps would be installed in the proposed stock tanks.

Note that the proposed project as delineated would involve primarily privately owned lands. A limited extent of pipeline would cross Federal lands managed by the BLM.

4.3.2.7 Existing Pipeline Enhancement (Plan Component L/W-07)

This project consists of constructing a short extension to an existing pipeline system originating in Section 36, Township 42 North, Range 93 West within the Ditch Creek drainage. The existing system

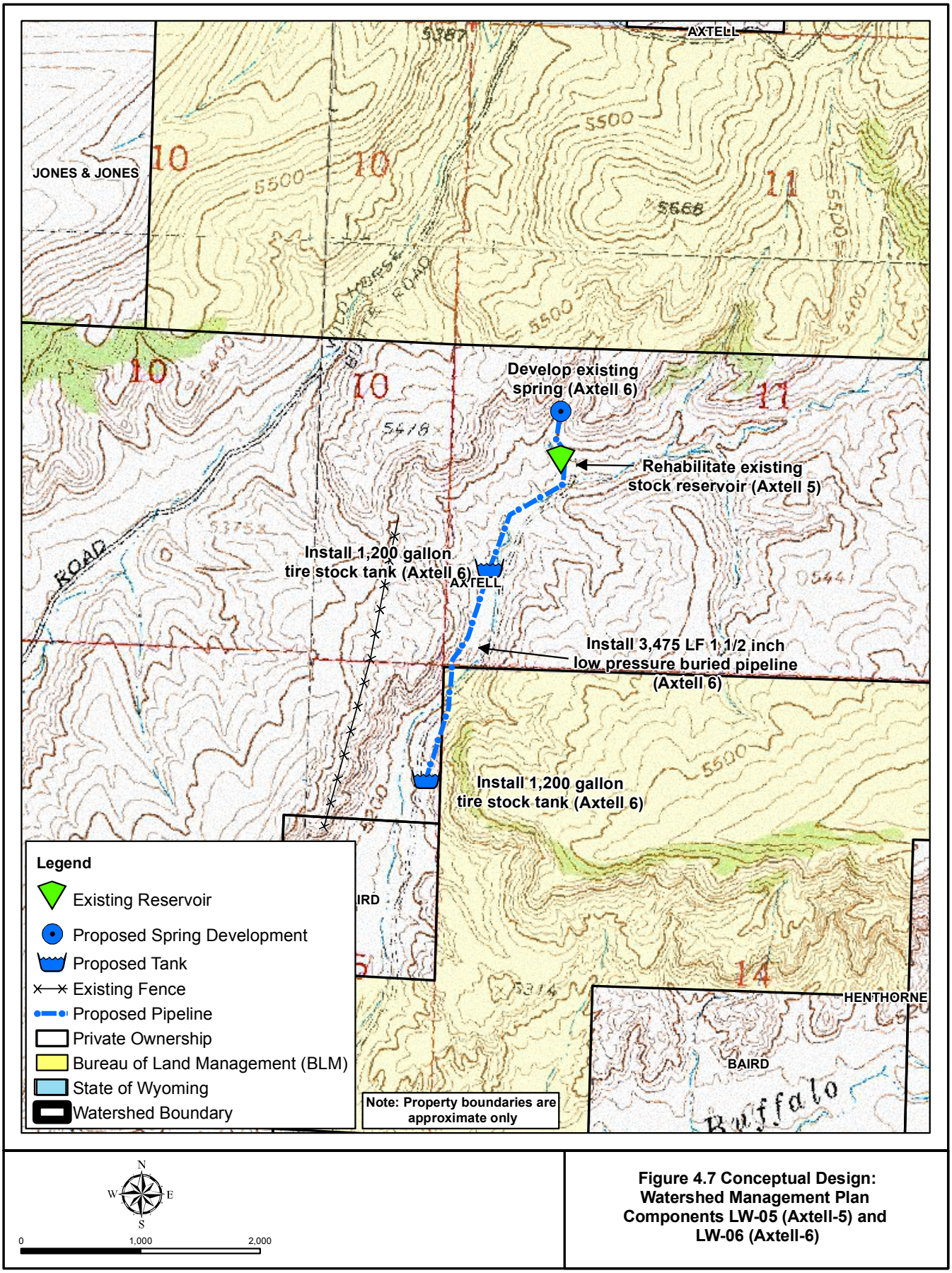


Figure 4.7 Conceptual Design: Watershed Management Plan Components LW-05 (Axtell-5) and LW-06 (Axtell-6)

consists of buried pipeline (approximately 4,000 linear feet) and two stock tanks. The proposed project would entail the construction of a small stock reservoir downstream of the second stock tank to collect and store system overflows (Figure 4.8).

Under this alternative, the following components would be employed:

- The existing gasoline fueled pump which pumps water from Ditch Creek into the pipeline system would be replaced with a solar pump.
- Approximately 1,100 linear feet of buried HDPE low pressure buried pipe (1½-inch diameter) would be installed to extend the system to the proposed stock reservoir.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.
- As configured under this alternative, a small stock reservoir would be constructed within the unnamed drainage downstream of the pipeline system.

Note that the proposed project as delineated would involve state and privately owned lands.

4.3.2.8 Stock Pond Rehabilitation Projects (Plan Component L/W-08)

This project involves the rehabilitation of three small stock reservoirs in Section 30, Township 42 North, Range 93 West. According to the landowner, both ponds have been filled with sediment and leakage prevents them from holding water for a desirable time period. This project would entail inspection of their embankments, making necessary repairs if needed, removing sediment and installing impermeable liners (Figure 4.9).

Under this alternative, the following components would be employed:

- Existing sediment would be excavated from the existing ponds.
- Each pond would be sealed with agricultural grade bentonite at a rate of 4 pounds per square foot based upon NRCS guidelines.

As delineated, the projects involve privately-owned lands only.

Note: Several options exist to reduce seepage in small stock reservoirs, including Geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Options involving liners were deemed cost-prohibitive; costs associate with lining a stock reservoir using commercial lining products would range from approximately $2 to $4 per square foot depending upon the type of material. Typical lining projects would therefore be approximately $10,000 to $20,000 per site for a small stock reservoir. Bentonite fabrics (Bentomat) can sometimes be obtained free or at very low cost from distributors when there are over-runs or excess available. However, the reliability is not certain.

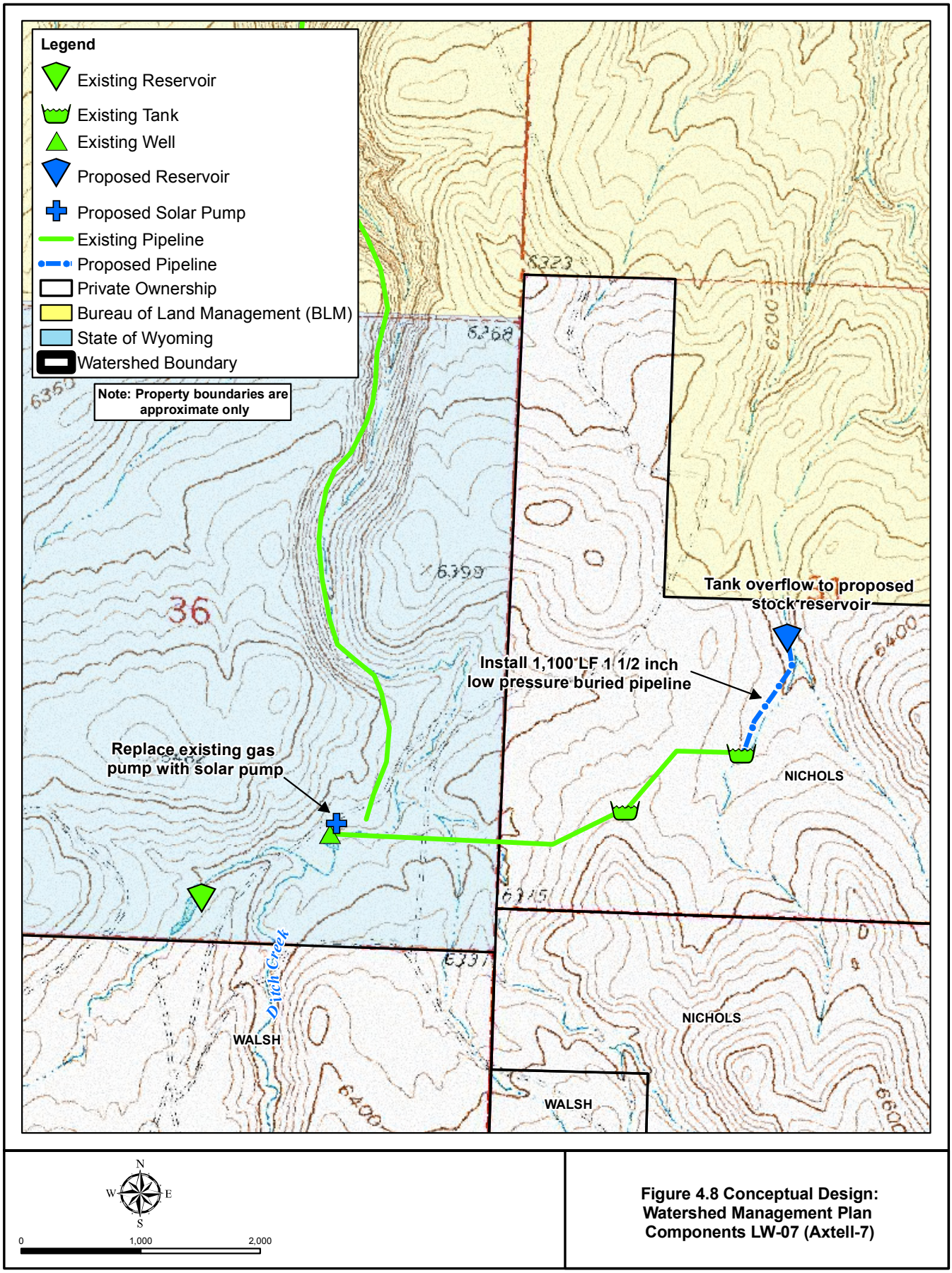


Figure 4.8 Conceptual Design: Watershed Management Plan Components LW-07 (Axtell-7)

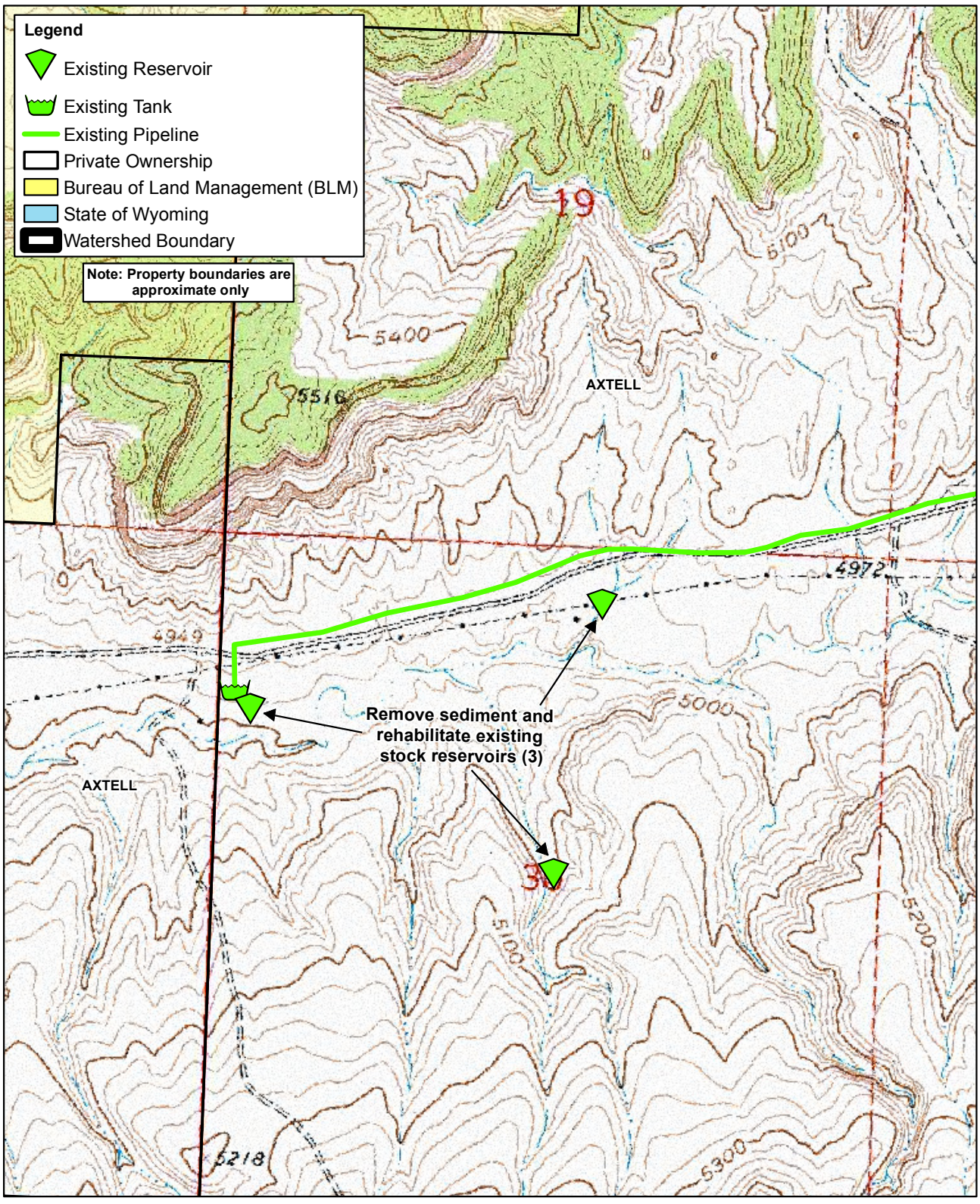


Figure 4.9 Conceptual Design: Watershed Management Plan Component LW-08 (Axtell-8)

Wyo-Ben in Thermopolis quoted a cost of approximately $50 per bulk ton at their site or $86 per ton in 3,000 lb bags. For the purposes of this project, it was assumed that the 3,000 lb bags would be used and picked up and delivered to the site by the project proponent.

4.3.2.9 Stock Pond Rehabilitation Project (Plan Component L/W-09)

This project involves the rehabilitation of a small stock reservoir in Section 20, Township 42 North, Range 93 West. According to the landowner, both ponds have been filled with sediment and leakage prevents them from holding water for a desirable time period. This project would entail inspection of the embankments, making necessary repairs if needed, removing sediment and installing impermeable liner.

Completion of this proposed project would logically be completed with project L/W-10 which includes the reservoir in a pipeline project. However, it is included individually because restoration of the reservoir would be valuable with or without completion of the pipeline project (Figure 4.10).

Under this alternative, the following components would be employed:

- Existing sediment would be excavated from the existing pond.
- The pond would be sealed with agricultural grade bentonite at a rate of 4 pounds per square foot based upon NRCS guidelines.

As delineated, the projects involve privately-owned lands only.

Note: Several options exist to reduce seepage in small stock reservoirs, including Geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Options involving liners were deemed cost-prohibitive; costs associate with lining a stock reservoir using commercial lining products would range from approximately $2 to $4 per square foot depending upon the type of material. Typical lining projects would therefore be approximately $10,000 to $20,000 per site for a small stock reservoir. Bentonite fabrics (Bentomat) can sometimes be obtained free or at very low cost from distributors when there are over-runs or excess available. However, the reliability is not certain.

Wyo-Ben in Thermopolis quoted a cost of approximately $50 per bulk ton at their site or $86 per ton in 3,000 lb bags. For the purposes of this project, it was assumed that the 3,000 lb bags would be used and picked up and delivered to the site by the project proponent.

4.3.2.10 Spring Development Project(Plan Component L/W-10)

This project consists of improvements to an existing spring located on State lands in Section 18, Township 42 North, Range 93 West. Under this proposed project, the spring would be developed and collected flows conveyed downstream to a rehabilitated stock reservoir (See project L/W-09 above).

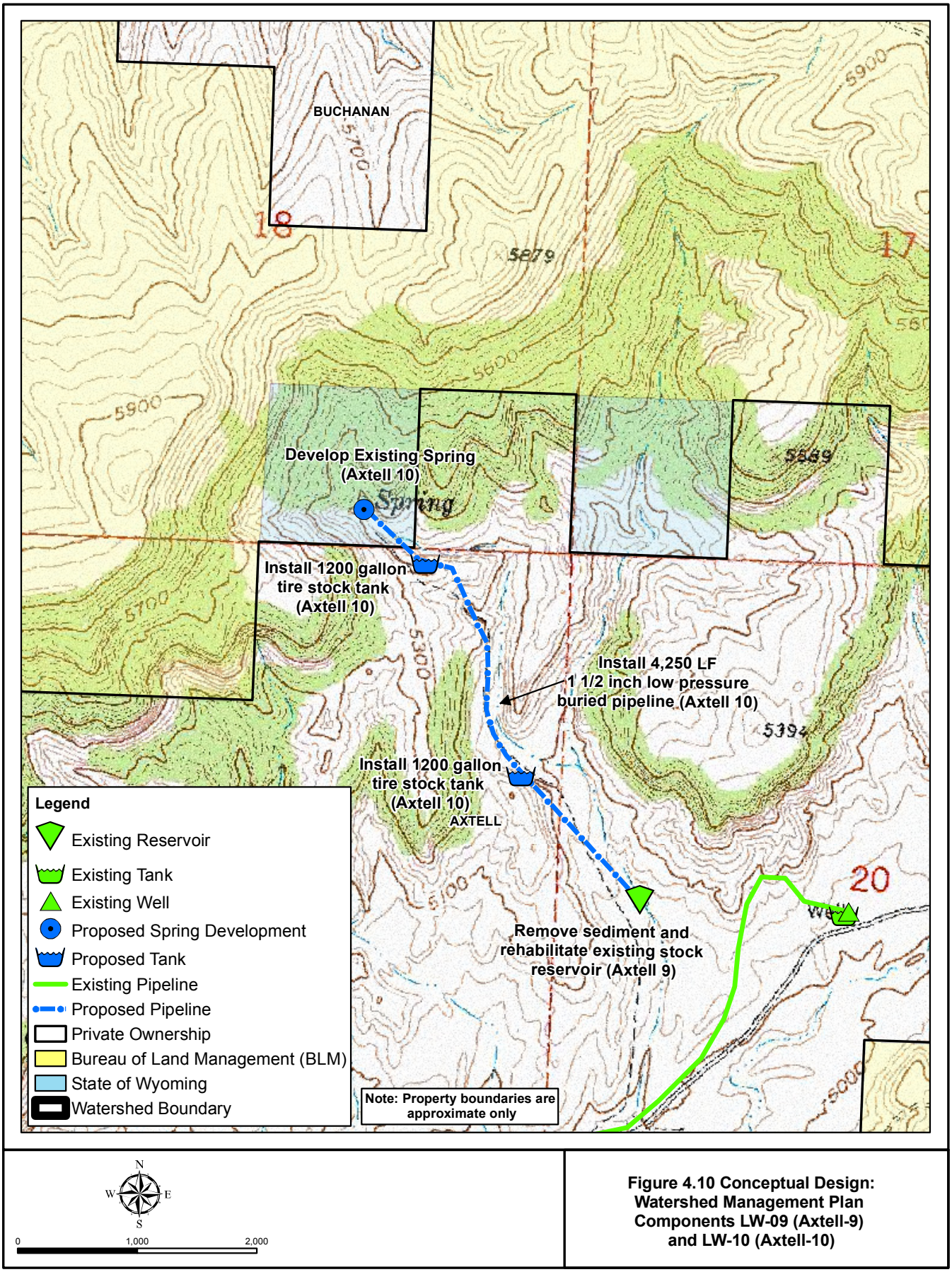


Figure 4.10 Conceptual Design: Watershed Management Plan Components LW-09 (Axtell-9) and LW-10 (Axtell-10)

Flow from the stock reservoir would be conveyed to a pipeline supplying water to two additional stock tanks downstream. Figure 4.10 displays the conceptual configuration of this project.

Under this alternative, the following components would be employed:

- A new spring development would be completed in the vicinity of the existing spring. The spring development would facilitate diversion of flows to a gravity pipeline. See the attached NRCS designs for typical spring development plans.
- The spring vicinity would be fenced to prevent the spring development damage from livestock and wildlife.
- Approximately 4,250 linear feet of buried HDPE low pressure pipeline (1½ inch diameter) would be installed.
- Two (2) 1,200 gallon capacity stock tanks would be installed.
- Wildlife egress ramps would be installed in the proposed stock tanks.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.

As delineated, this project would involve state and privately owned lands.

4.3.2.11 Stock Pond Rehabilitation Project (Plan Component L/W-11)

This project involves the rehabilitation of two small stock reservoirs in Section 22, Township 42 North, Range 93 West. According to the landowner, both ponds have been filled with sediment and leakage prevents them from holding water for a desirable time period. This project would entail inspection of their embankments, making necessary repairs if needed, removing sediment and installing impermeable liners (Figure 4.11).

Under this alternative, the following components would be employed:

- Existing sediment would be excavated from the existing ponds
- Each pond would be sealed with agricultural grade bentonite at a rate of 4 pounds per square foot based upon NRCS guidelines.

As delineated, the projects involve privately-owned lands only.

Note: Several options exist to reduce seepage in small stock reservoirs, including Geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Options involving liners were deemed cost-prohibitive; costs associate with lining a stock reservoir using commercial lining products would range from approximately $2 to $4 per square foot depending upon the type of material. Typical lining projects would therefore be approximately $10,000 to $20,000 per site for a small stock reservoir. Bentonite fabrics (Bentomat) can sometimes be obtained free or at very low cost from distributors when there are over-runs or excess available. However, the reliability is not certain.

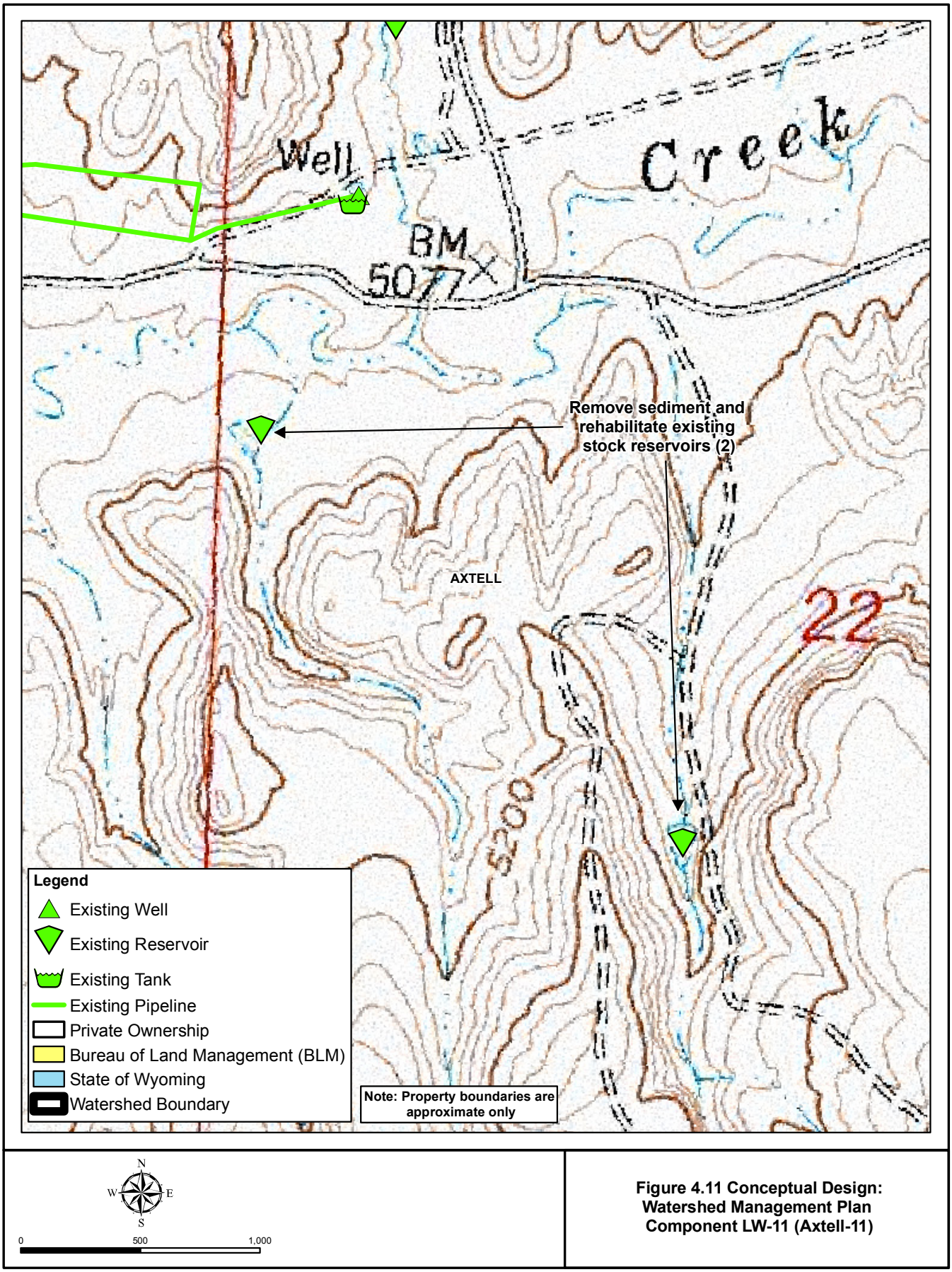


Figure 4.11 Conceptual Design: Watershed Management Plan Component LW-11 (Axtell-11)

Wyo-Ben in Thermopolis quoted a cost of approximately $50 per bulk ton at their site or $86 per ton in 3,000 lb bags. For the purposes of this project, it was assumed that the 3,000 lb bags would be used and picked up and delivered to the site by the project proponent.

4.3.2.12 Stock Pond Rehabilitation Project (Plan Component L/W-12)

This project involves the rehabilitation of two small stock reservoirs in Section 21, Township 42 North, Range 93. According to the landowner, both ponds have been filled with sediment and leakage prevents them from holding water for a desirable time period. This project would entail inspection of their embankments, making necessary repairs if needed, removing sediment and installing impermeable liners (Figure 4.12).

Under this alternative, the following components would be employed:

- Existing sediment would be excavated from the existing ponds.
- Each pond would be sealed with agricultural grade bentonite at a rate of 4 pounds per square foot based upon NRCS guidelines.

As delineated, the projects involve privately-owned lands only.

Note: Several options exist to reduce seepage in small stock reservoirs, including Geotextile liners, bentonite mat liners, or placement of agricultural grade bentonite. Options involving liners were deemed cost-prohibitive; costs associate with lining a stock reservoir using commercial lining products would range from approximately $2 to $4 per square foot depending upon the type of material. Typical lining projects would therefore be approximately $10,000 to $20,000 per site for a small stock reservoir. Bentonite fabrics (Bentomat) can sometimes be obtained free or at very low cost from distributors when there are over-runs or excess available. However, the reliability is not certain.

Wyo-Ben in Thermopolis quoted a cost of approximately $50 per bulk ton at their site or $86 per ton in 3,000 lb bags. For the purposes of this project, it was assumed that the 3,000 lb bags would be used and picked up and delivered to the site by the project proponent.

4.3.2.13 Pipeline Extension Project (Plan Component L/W-13)

The purpose of this project is to provide a more viable source of water to an existing stock tank than it currently is provided with. A stock tank located in Section 29, Township 42 North, Range 93 West currently is supplied by a groundwater well with unreliable yield. This project would provide an alternate source of water to the stock tank at its present location by tapping an existing pipeline and constructing a connecting pipeline (Figure 4.13).

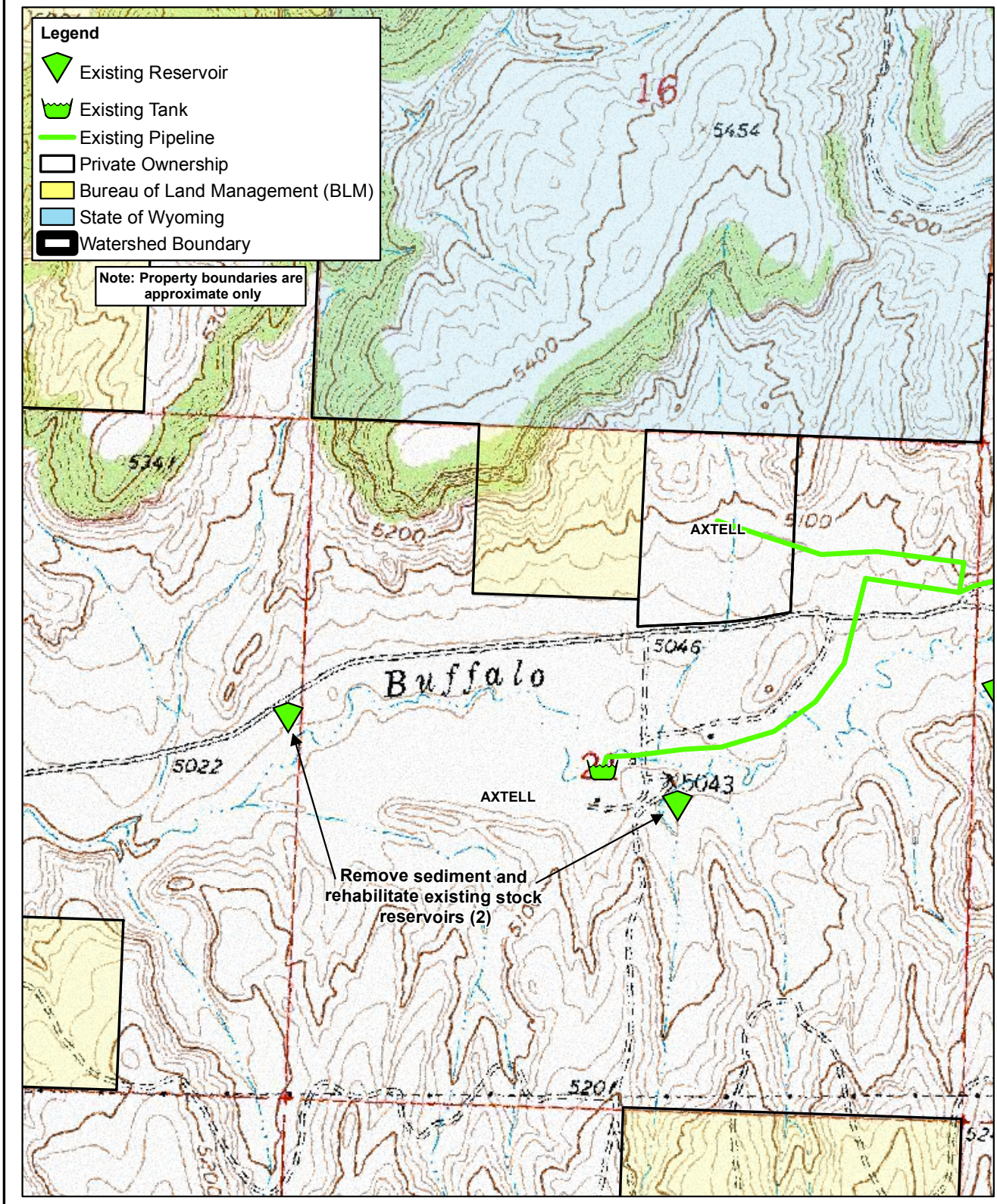


Figure 4.12 Conceptual Design: Watershed Management Plan Component LW-12 (Axtell-12)

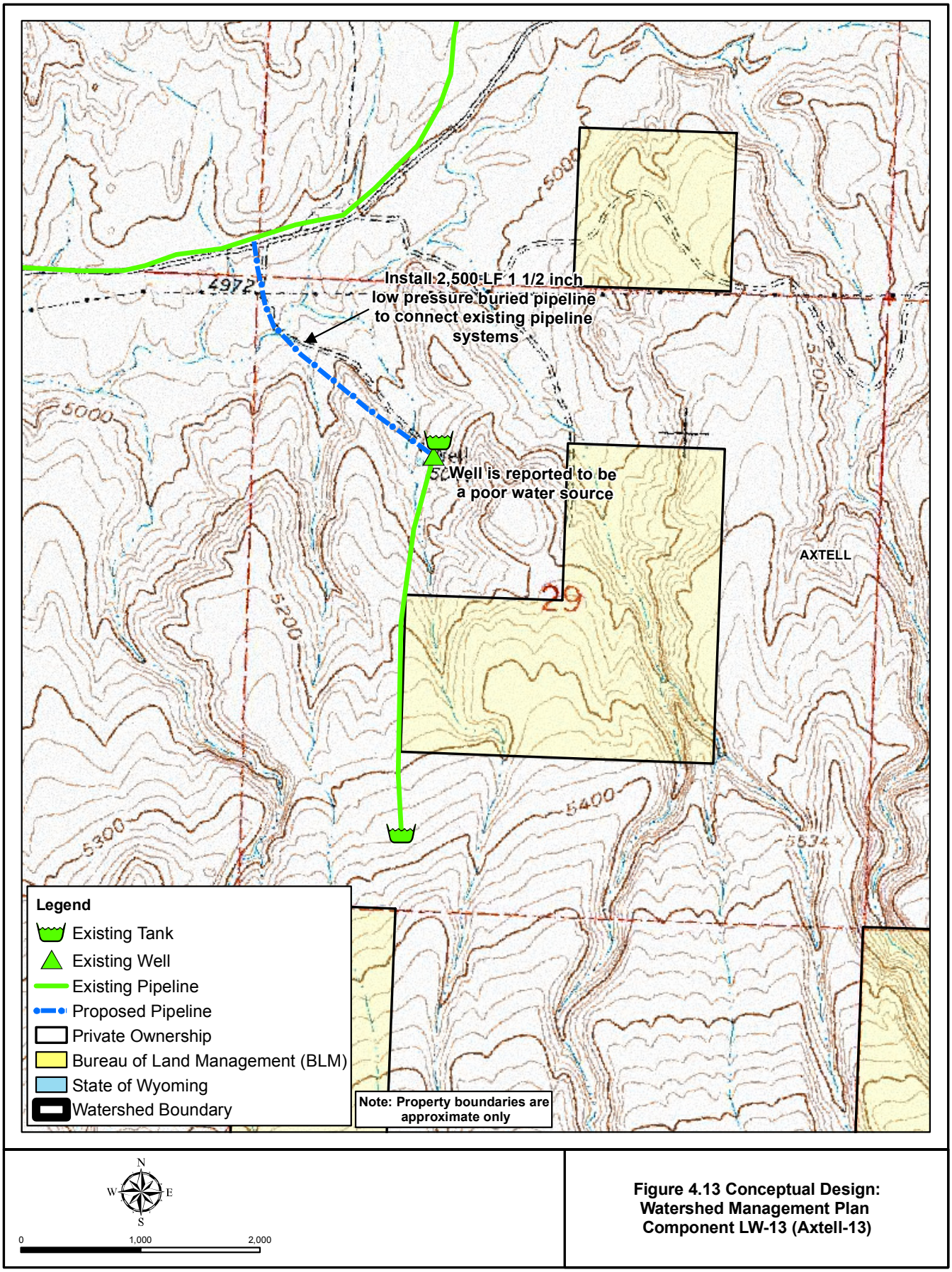


Figure 4.13 Conceptual Design: Watershed Management Plan Component LW-13 (Axtell-13)

Under this alternative, the following components would be employed:

- The existing pipeline would be located and appropriate valves and fittings installed to facilitate the addition of an extension to the system and control of flows within it.
- Approximately 2,500 linear feet of 1 ½ inch HDPE low pressure buried pipeline would be installed.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.
- Wildlife egress ramps would be installed in the existing stock tank.

Note that the proposed project as delineated would only involve privately owned lands.

4.3.2.14 Upper Grass Creek Pipeline Project (Plan Component L/W-14)

This alternative would involve the development of an existing spring in the Upper Grass Creek watershed. The alternative would supply water to a portion of the watershed lacking adequate alternative livestock and wildlife upland water sources. Figure 4.14 displays the conceptual design of the project.

Under this alternative, the following components would be employed:

- A spring development would be completed in the upper Grass Creek stream channel. The facility would conceivably be installed in Section 7, Township 40 North, Range 93 West. A valve would be included for management of pipeline flows. See the attached NRCS designs for typical spring development plans.
- The spring vicinity would be fenced to prevent the spring development damage from livestock and wildlife.
- The buried 1 ½ inch HDPE low pressure pipeline (a total of approx. 11,400 feet) would be routed northwesterly and away from the Grass Creek channel to stock tanks located away from the riparian corridor.
- As configured under this alternative, three (3) stock tanks (1,200 gallon capacity each) would be placed at sites determined during final design.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels. Pressure reduction valves (PRVs) would be required to maintain pipeline pressures below 160 psi.
- Wildlife egress ramps would be installed in the proposed stock tanks.

Note that the proposed project as delineated would only involve privately owned lands.

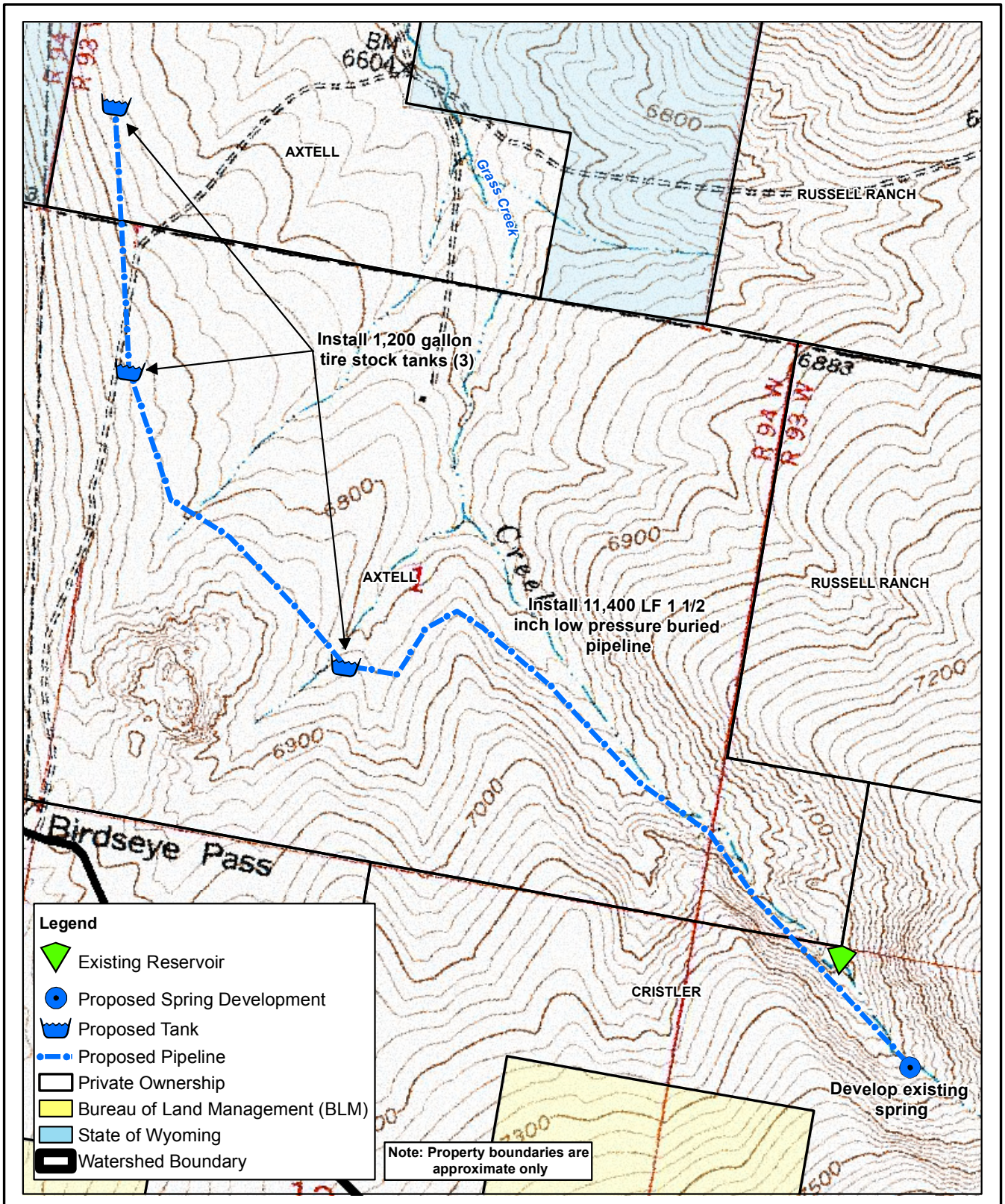


Figure 4.14 Conceptual Design: Watershed Management Plan Component LW-14 (Axtell-14)

4.3.2.15 Grass Creek Spring Development and Pipeline Project (Plan Component L/W-15)

This alternative would utilize springs located along the Grass Creek drainage and convey captured flows to three small stock reservoirs. Grass Creek in this portion of the study area is dry most of the year due to losses associated with underlying limestone and "sinks" within it. By piping upstream water, the stock reservoirs would provide more viable sources of livestock and wildlife water (Figure 4.15).

Under this alternative, the following components would be employed:

- A spring development would be completed in the upper Grass Creek drainage in Section 19, Township 41 North, Range 93 West. See the attached NRCS designs for typical spring development plans.
- The spring vicinity would be fenced to prevent the spring development damage from livestock and wildlife.
- The buried HDPE low pressure pipeline (a total of approx. 11,500 feet) would be routed northwesterly along Grass Creek.
- Three small stock water reservoirs would be served by the pipeline.
- As configured under this alternative, three (3) stock tanks (1,200 gallon capacity each) would be placed at sites determined during final design; stock tank overflow would be captured within the existing stock reservoirs.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels. Pressure reduction valves (PRVs) may be required to maintain pipeline pressures below 160 psi.
- Wildlife egress ramps would be installed in the proposed stock tanks.

Note that the proposed project as delineated would only involve privately owned lands.

4.3.2.16 Wild Horse Butte Spring Development (Plan Component L/W-16)

This project consists of improvements to an existing spring located in Section 3, Township 42 North, Range 93 West. Under this proposed project, the spring would be redeveloped and collected flows conveyed downstream to a stock tank which would be installed as part of the project. Figure 4.16 displays the conceptual configuration of this project.

Under this alternative, the following components would be employed:

- A new spring development would be completed in the vicinity of the existing spring. The spring development would facilitate diversion of flows to a gravity pipeline. See the attached NRCS designs for typical spring development plans.
- The spring vicinity would be fenced to prevent the spring development damage from livestock and wildlife.

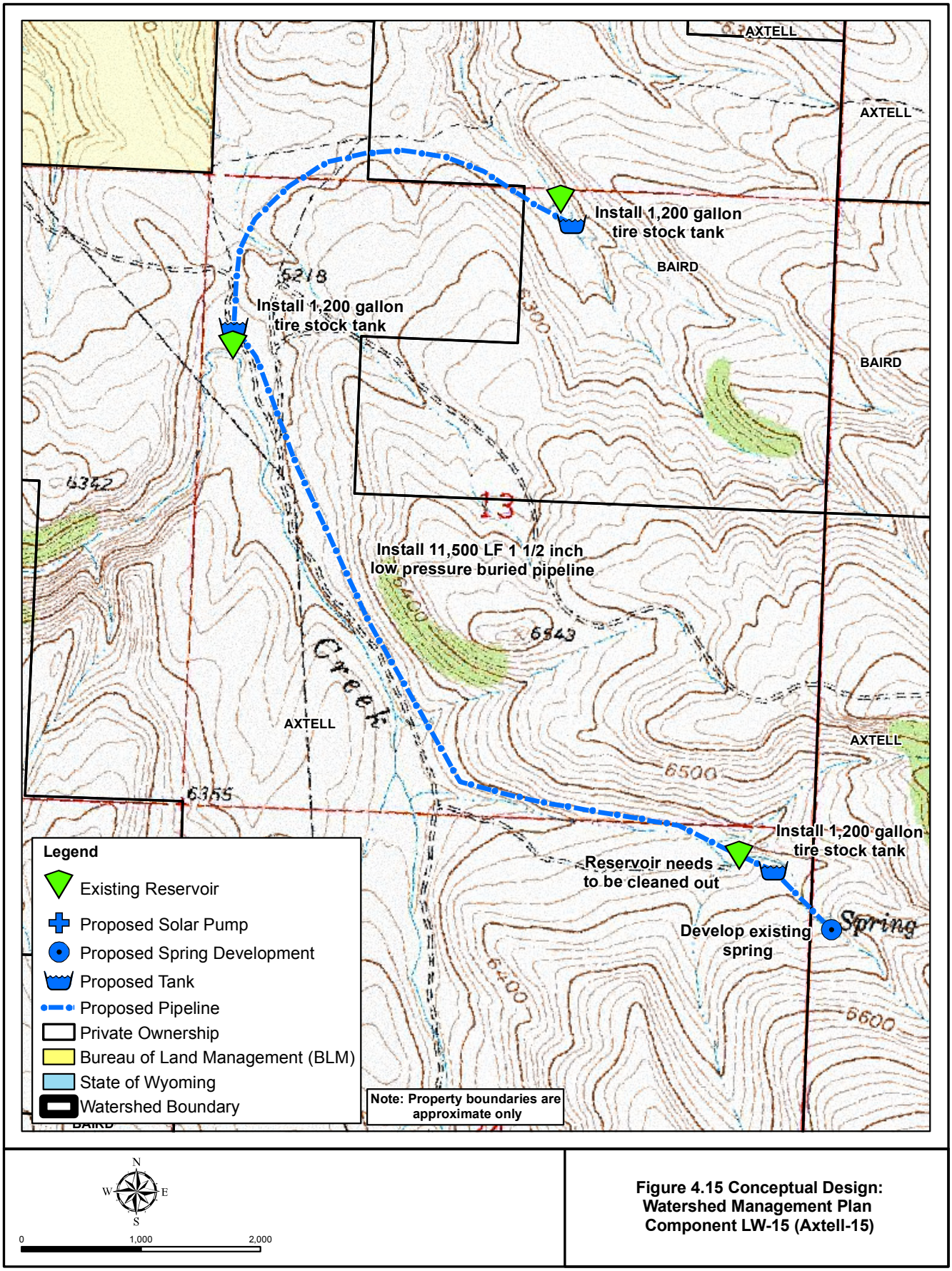


Figure 4.15 Conceptual Design: Watershed Management Plan Component LW-15 (Axtell-15)

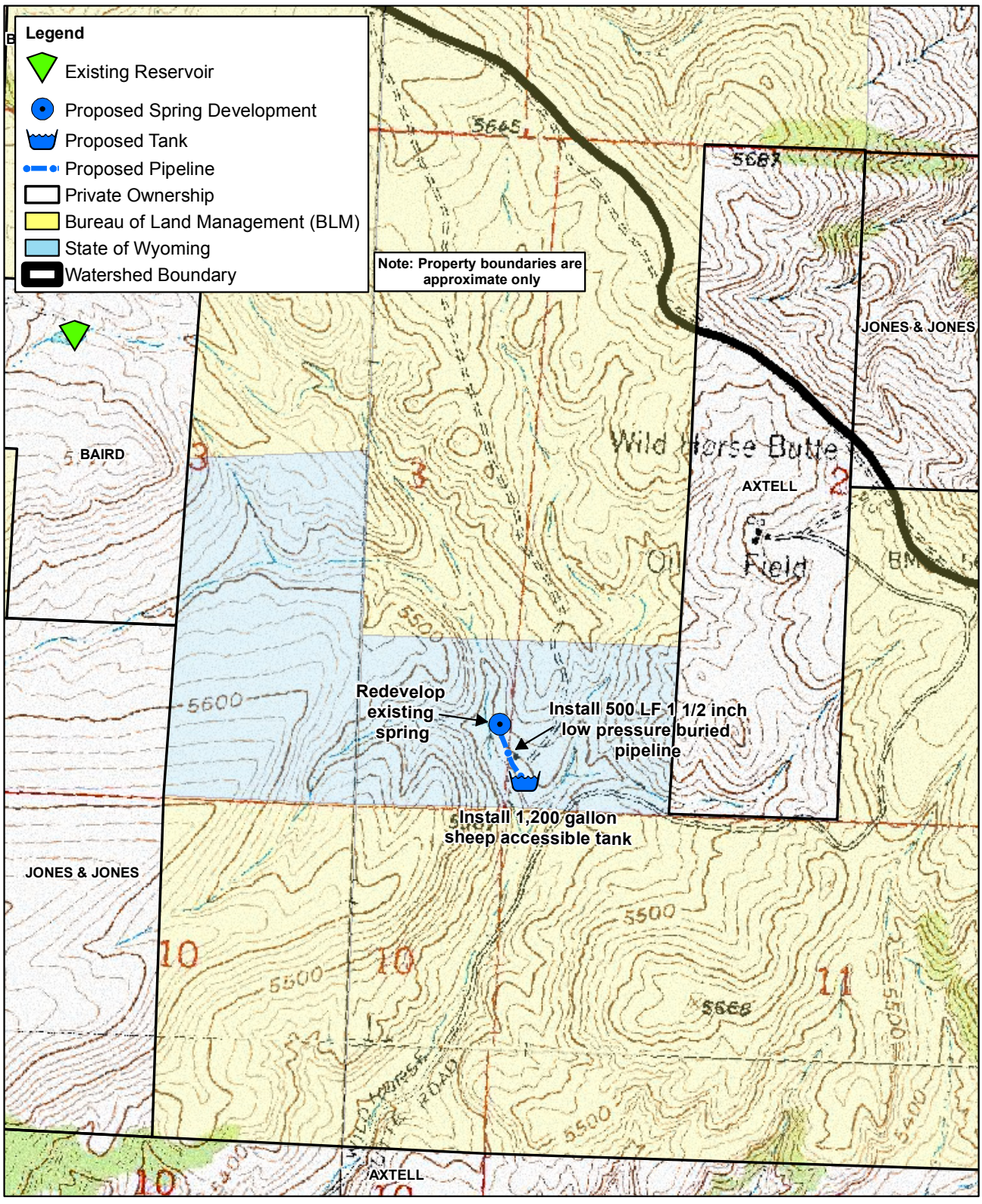


Figure 4.16 Conceptual Design: Watershed Management Plan Component LW-16 (Jones-1)

- Approximately 500 linear feet of buried HDPE low pressure pipeline (1½ inch diameter) would be installed.
- One (1) 1,200 gallon capacity stock tank would be installed.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.
- Wildlife egress ramps would be installed in the proposed stock tank.

4.3.2.17 Blue Springs Draw Pipeline Project (Plan Component L/W-17)

This project consists of development of an existing spring located in Section 18, Township 42 North, Range 92 West. Under this proposed project, a pipeline would be installed from the spring to a lower storage tank. A solar pump would be installed to pump water up to a second (upper) storage tank, located at the divide between Buffalo Creek and Blue Springs Draw. At the divide, the upper storage tank would then provide gravity flow conditions to stock tanks located on both sides of the divide. Under the conceptual design displayed in Figure 4.17, two stock tanks would be installed.

Under this alternative, the following components would be employed:

- A new spring development would be completed in the vicinity of the existing spring. The spring development would facilitate diversion of flows to a gravity pipeline. See the attached NRCS designs for typical spring development plans.
- The spring vicinity would be fenced to prevent the spring development damage from livestock and wildlife.
- Two (2) storage tanks (15,000 gallon capacity each) would be incorporated into the design. One would be sited near the spring to store water collected from the spring development. The second would be sited at the high point of the system to provide storage for gravity flow to the distribution system.
- A solar pump would be installed at the lower storage tank.
- Approximately 6,100 linear feet of buried HDPE high-pressure pipeline (1½ inch diameter) would be installed on an alignment to be determined during the design phase.
- Approximately 12,000 linear feet of buried HDPE low-pressure pipeline (1½ inch diameter) would be installed on an alignment to be determined during the design phase.
- Two (2) 1,200 gallon capacity stock tanks would be installed.
- Wildlife egress ramps would be installed in the proposed stock tanks.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.

Note that completion of this project would take coordination of multiple landowners and development of agreements for use of the spring and alignment of the proposed pipeline. In addition, the proposed project would include federal lands administered by the BLM. Consequently, coordination with the BLM through the Worland Field Office and completion of an Environmental Assessment would be required.

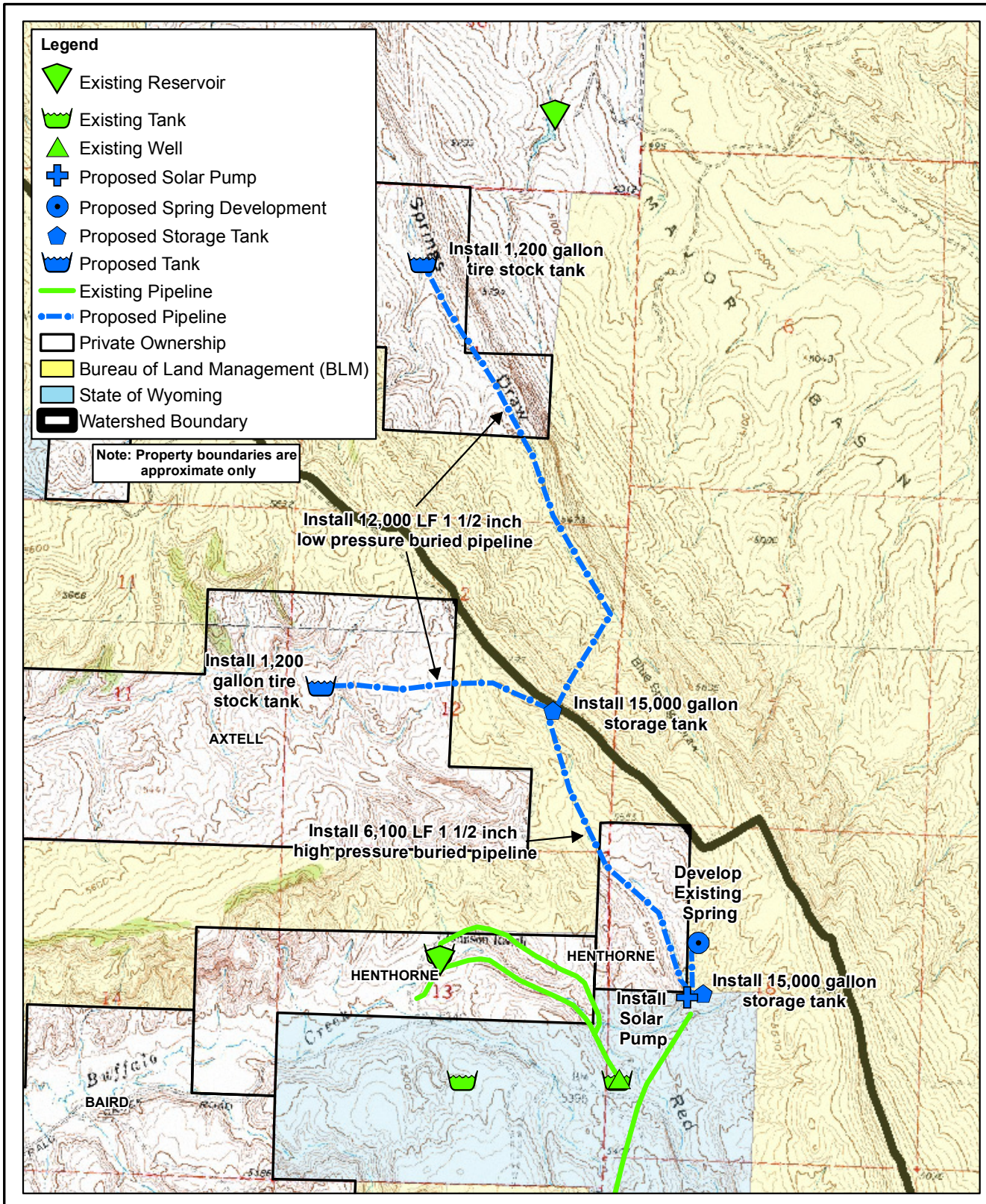


Figure 4.17 Conceptual Design: Watershed Management Plan Component LW-17 (Jones-2)

4.3.2.18 Copper Mountain Pipeline Project (Plan Component L/W-18)

This proposed project involves development of springs located in the upper reaches of the Jones Creek drainage near the drainage divide in Section 9, Township 40 North, Range 93 West. The springs have not yet been developed; therefore, the project would entail new spring development and fencing of the spring vicinity. Buried HDPE pipelines would serve three stock tanks as displayed in Figure 4.18 which shows the conceptual design.

Under this alternative, the following components would be employed:

- A new spring development would be completed in the vicinity of the existing spring. The spring development would facilitate diversion of flows to a gravity pipeline. See the attached NRCS designs for typical spring development plans.
- The spring vicinity would be fenced to prevent the spring development damage from livestock and wildlife.
- Approximately 6,600 linear feet of buried HDPE low pressure pipeline (1½ inch diameter) would be installed.
- Three (3) 1,100 gallon capacity galvanized stock tanks (10 ft diameter) would be installed.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.
- Wildlife egress ramps would be installed in the proposed stock tanks.

Note that the proposed project as delineated would only involve privately owned lands.

4.3.2.19 Copper Mountain Pipeline Extension Project (Plan Component L/W-19)

This project consists of extension of an existing pipeline system to provide an additional source of water wildlife and livestock use in Section 9, Township 40 North, Range 93 West. The existing pipeline originates at a spring in the upper Jones Creek drainage. The proposed project would entail tapping an extension into the existing pipeline to supply two stock tanks located downslope. Figure 4.19 displays the conceptual designs of the project.

Under this alternative, the following components would be employed:

- The existing pipeline would be located and appropriate valves and fittings installed to facilitate the addition of an extension to the system and control of flows within it.
- Approximately 1,100 linear feet of 1 ½ inch HDPE low pressure buried pipeline would be installed.
- A new spring development would be completed in the vicinity of the existing spring. The spring development would facilitate diversion of flows to a gravity pipeline. See the attached NRCS designs for typical spring development plans.

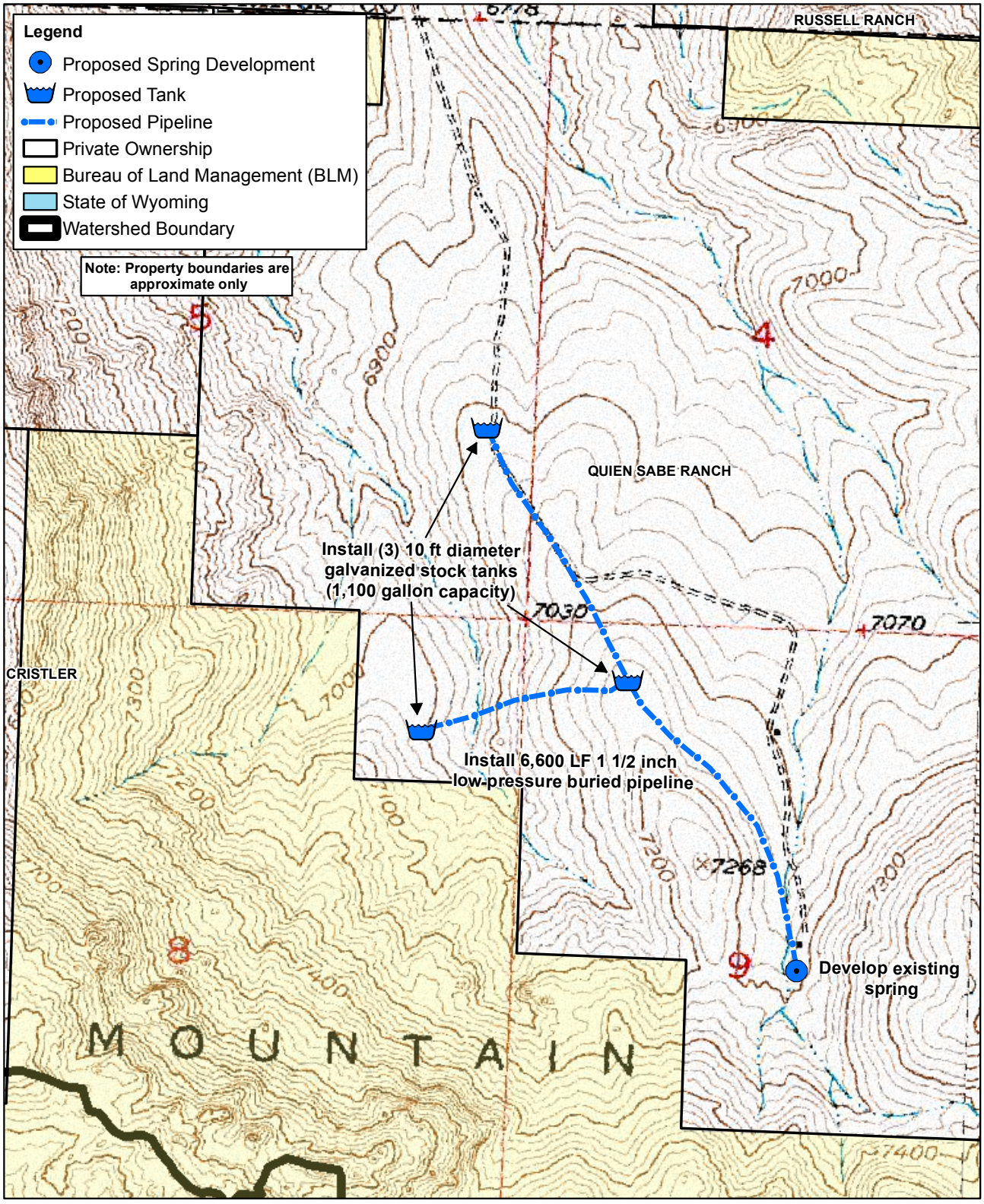


Figure 4.18 Conceptual Design: Watershed Management Plan Component LW-18 (Thoren-1)

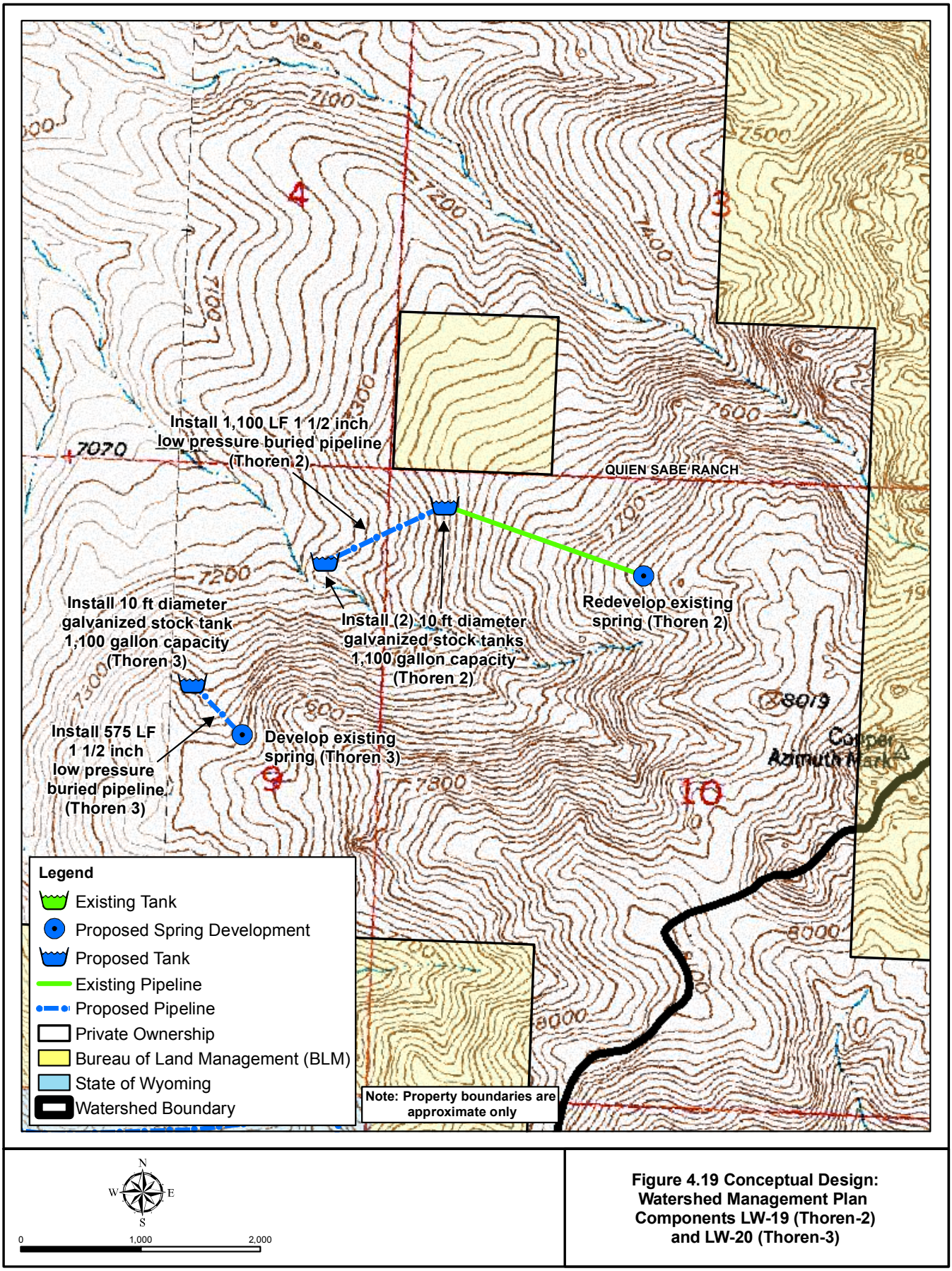


Figure 4.19 Conceptual Design: Watershed Management Plan Components LW-19 (Thoren-2) and LW-20 (Thoren-3)

- The spring vicinity would be fenced to prevent the spring development damage from livestock and wildlife.
- Two (2) 1,100 gallon galvanized stock tank (10 ft. diameter) would be installed.
- Wildlife egress ramps would be installed in the proposed stock tanks.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.

Note that the proposed project as delineated would only involve privately owned lands.

4.3.2.20 Spring Development Project (Plan Component L/W-20)

This project consists of development of existing spring located in Section 9, Township 40 North, Range 93 West. Under this proposed project, the spring would be developed and collected flows conveyed downstream to a stock tank which would be installed as part of the project. Figure 4.19 displays the conceptual configuration of this project.

Under this alternative, the following components would be employed:

- A new spring development would be completed in the vicinity of the existing spring. The spring development would facilitate diversion of flows to a gravity pipeline. See the attached NRCS designs for typical spring development plans.
- The spring vicinity would be fenced to prevent the spring development damage from livestock and wildlife.
- Approximately 575 linear feet of buried HDPE low pressure pipeline (1½ inch diameter) would be installed.
- One (1) 1,100 gallon capacity galvanized stock tank (10 ft. diameter) would be installed.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.
- Wildlife egress ramps would be installed in the proposed stock tank.

Note that the proposed project as delineated would only involve privately owned lands.

4.3.2.21 Spring Enhancement Project (Plan Component L/W-21)

This project consists of enhancement of a spring located on the south side of the watershed divide on State lands in Section 16, Township 40 North, Range 93 West. The spring has already been developed. The proposed project would entail construction of a pipeline system which would convey water north across the divide to two stock tanks Figure 4.20 displays the conceptual designs for the project.

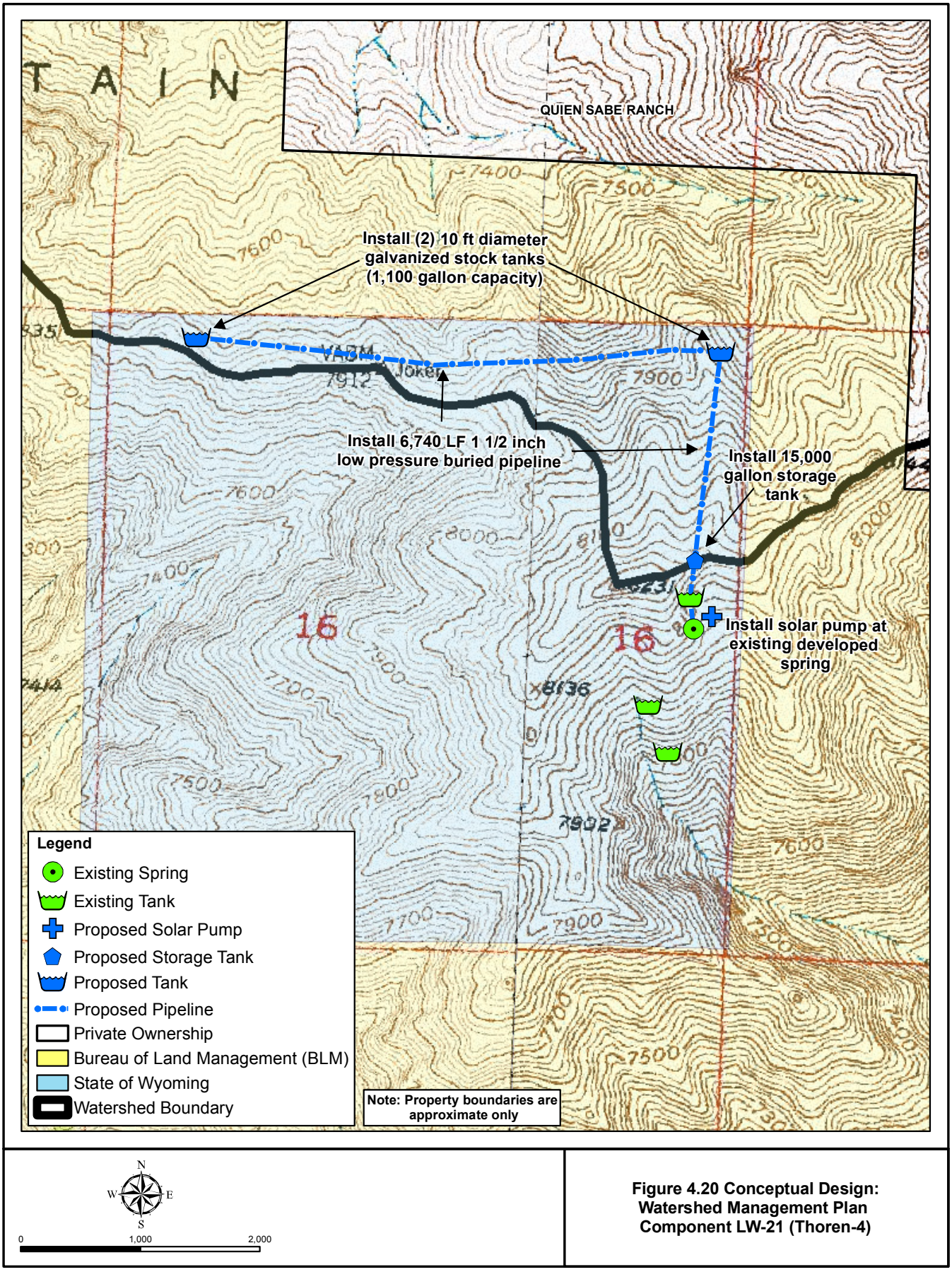


Figure 4.20 Conceptual Design: Watershed Management Plan Component LW-21 (Thoren-4)

Under this alternative, the following components would be employed:

- A solar powered pump would be installed at the pipeline origin.
- Approximately 6,740 linear feet of 1½ inch HDPE low pressure pipeline would be installed.
- A storage tank (15,000 gallon capacity) would be installed on the watershed divide.
- Two (2) 1,100 gallon galvanized stock tanks (10 ft. diameter) would be installed.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.
- Wildlife egress ramps would be installed in the proposed stock tanks.

Note that the proposed project as delineated would involve only lands owned and managed by the State of Wyoming.

4.3.2.22 Black Willow Draw Well Enhancement Project No. 1 (Plan Component L/W-22)

This project entails the placement of a solar powered pump within a well located in Section 24, Township 43 North, Range 94 West in Black Willow Draw. The well is permitted to the BLM (P90244W). Under this alternative the following components would be employed as indicated in Figure 4.21:

- One solar pump would be installed in the existing well
- One (1) 1,200 gallon capacity stock tank would be installed.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.
- Wildlife egress ramps would be installed in the proposed stock tank.

Completion of this alternative would require coordination with the BLM through the Worland Field office for permission to install the pump and stock tank.

4.3.2.23 Black Willow Draw Well Enhancement Project No. 2 (Plan Component L/W-23)

This alternative would involve enhancements to an existing well (P150334W) located in Section 23, Township 43 North, Range 94 West in Black Willow Draw. The alternative would supply water to a portion of the watershed lacking adequate alternative livestock and wildlife upland water sources. Figure 4.22 displays the general configuration of this alternative.

Under this alternative, the following components would be employed:

- The existing well would be equipped with a solar pump.
- The buried 1½ inch HDPE low pressure pipeline (a total of approx. 1,400 feet) would be routed northerly and southerly from the well to stock tanks placed away from the riparian corridor.
- As configured under this alternative, three (3) rubber tire stock tanks (1,200 gallon capacity each) would be placed at sites determined during final design.

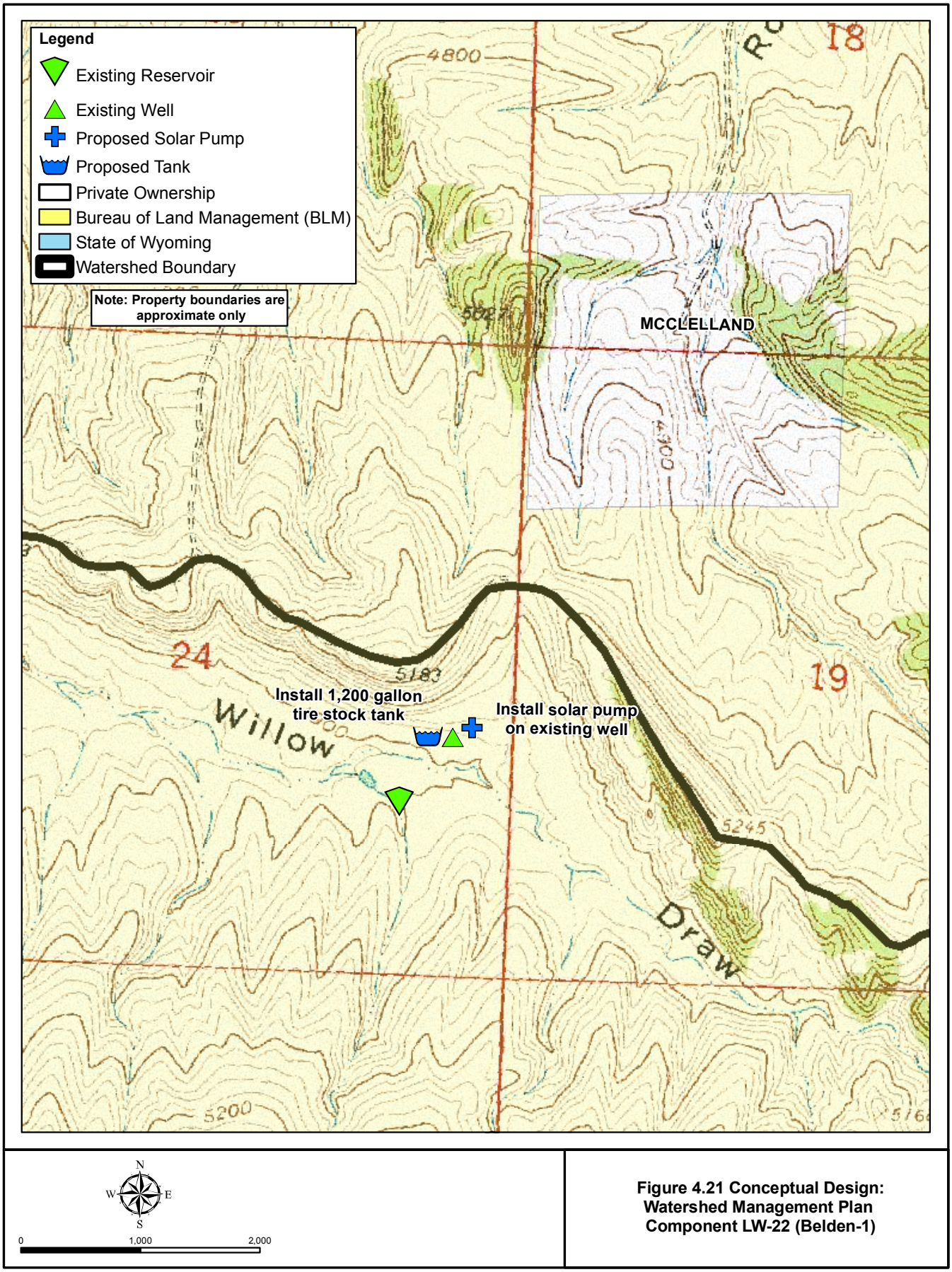


Figure 4.21 Conceptual Design: Watershed Management Plan Component LW-22 (Belden-1)

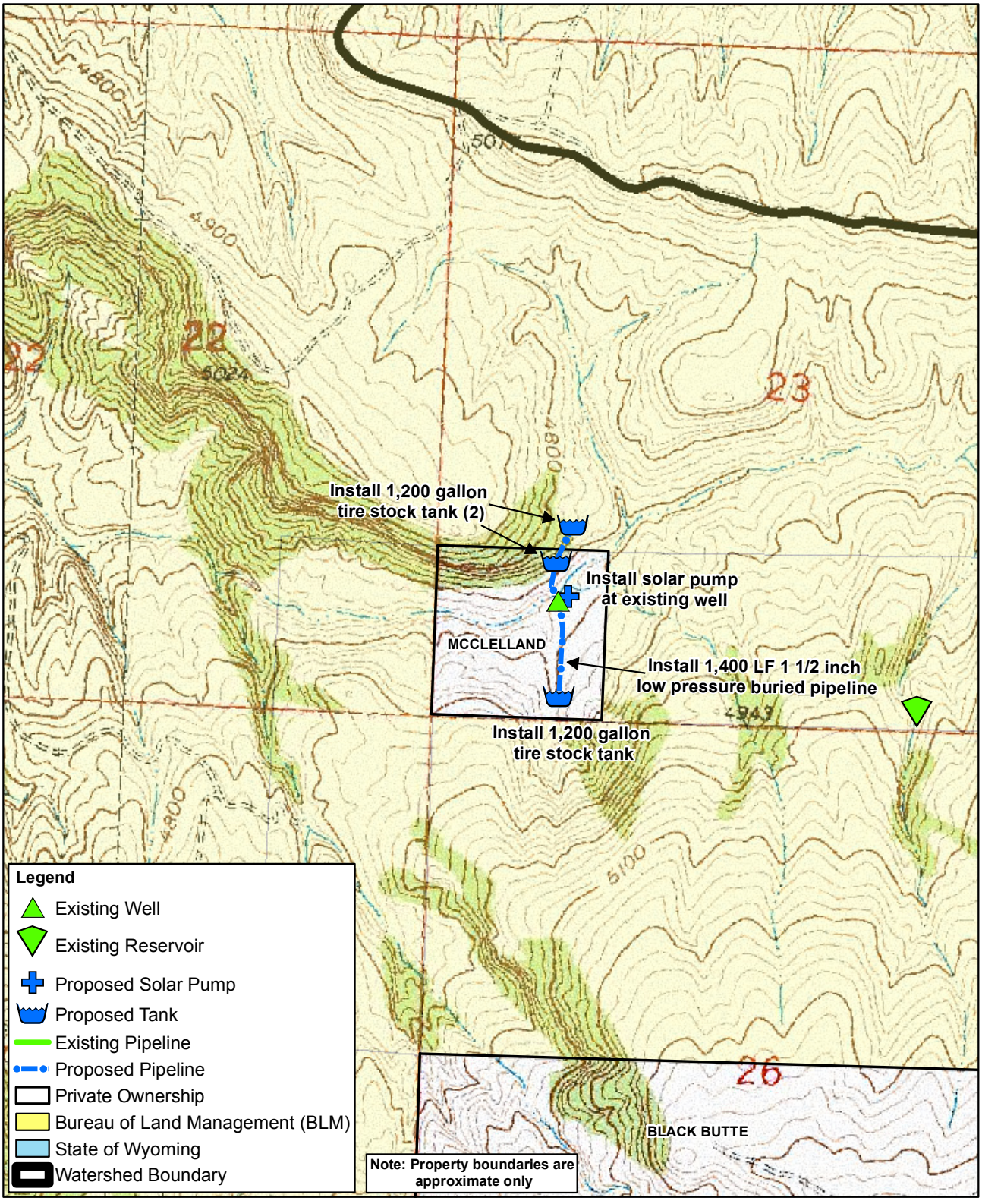


Figure 4.22 Conceptual Design: Watershed Management Plan Component LW-23 (Belden-2)

- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.
- Wildlife egress ramps would be installed in the proposed stock tanks.

4.3.2.24 Black Willow Draw Spring Enhancement Project (Plan Component L/W-24)

This project consists of development of existing spring located in Section 29, Township 43 North, Range 93 West. Under this proposed project, the spring would be developed and collected flows conveyed downstream to two stock tanks which would be installed as part of the project.

Under this alternative, the following components would be employed as indicated in Figure 4.23:

- A new spring development would be completed in the vicinity of the existing spring. The spring development would facilitate diversion of flows to a gravity pipeline. See the attached NRCS designs for typical spring development plans.
- The spring vicinity would be fenced to prevent the spring development damage from livestock and wildlife.
- Approximately 400 linear feet of buried HDPE low pressure pipeline (1½ inch diameter) would be installed.
- Two (2) 1,200 gallon capacity stock tanks would be installed.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.
- Wildlife egress ramps would be installed in the proposed stock tanks.

Completion of this alternative would require coordination with the BLM through the Worland Field office for permission to install the pipeline and stock tanks.

4.3.2.25 Grass Creek Pipeline (Plan Component L/W-25)

This project entails development of a pipeline system which would originate on Grass Creek within its perennial reaches above the limestone sinks. A diversion facility would convey stream water into a pipe system and feed multiple livestock/wildlife tanks located downslope. The project could be designed with numerous different alignments and stock tank locations.

The conceptual design presented in Figure 4.24 are presented as an example of the design strategy which could be employed.

The diversion would likely be placed in Section 25, Township 41 North, Range 94 West on private lands. This site is located above the limestone bedrock outcrops which capture a significant portion of Grass Creek streamflow. However, upon completion of more detailed site investigation associated with the design phase of the project, the diversion could conceivably be relocated farther downstream and thereby reduce the amount of pipeline needed and result in a commensurate reduction in project costs.

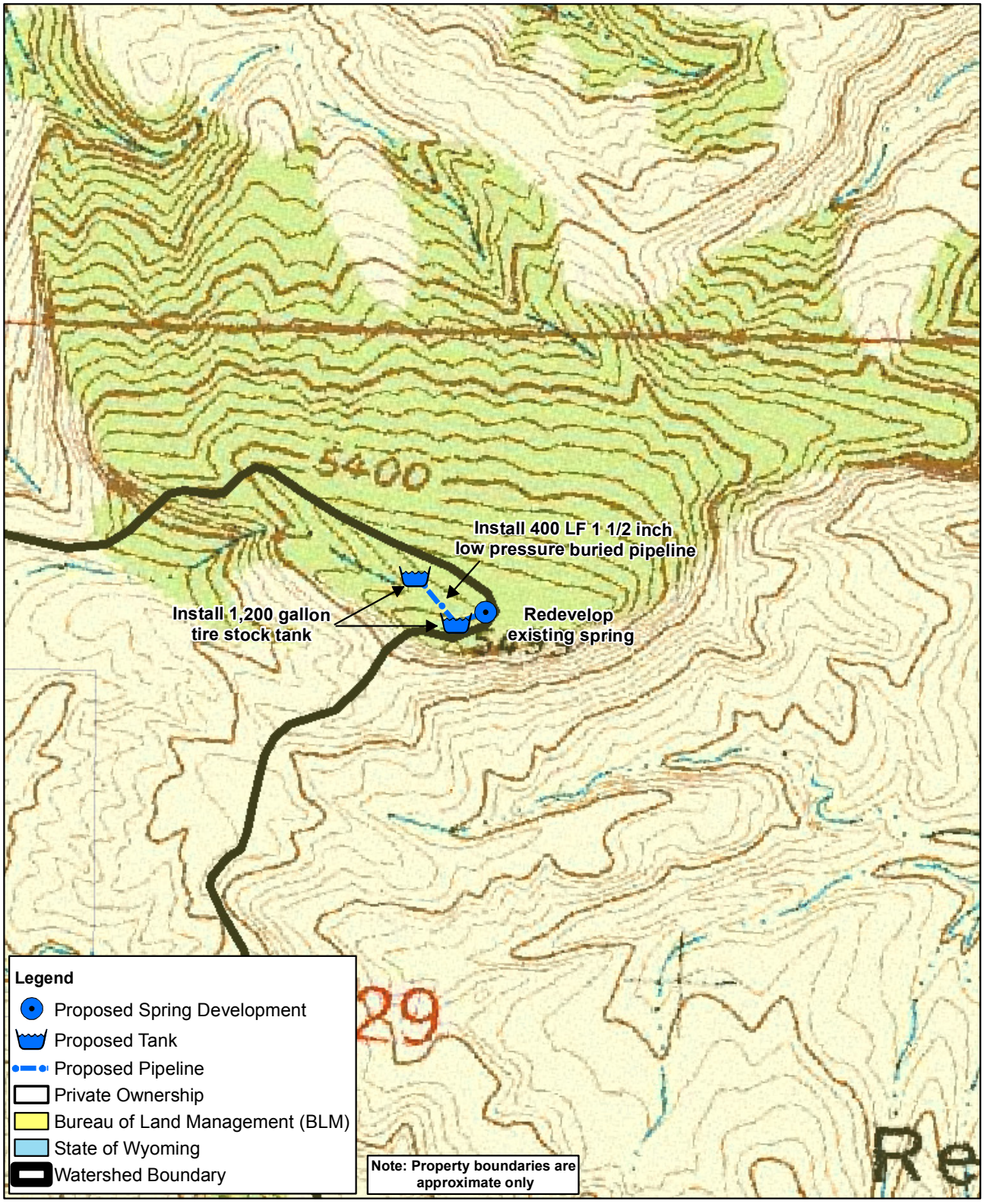


Figure 4.23 Conceptual Design: Watershed Management Plan Component LW-24 (Belden-3)

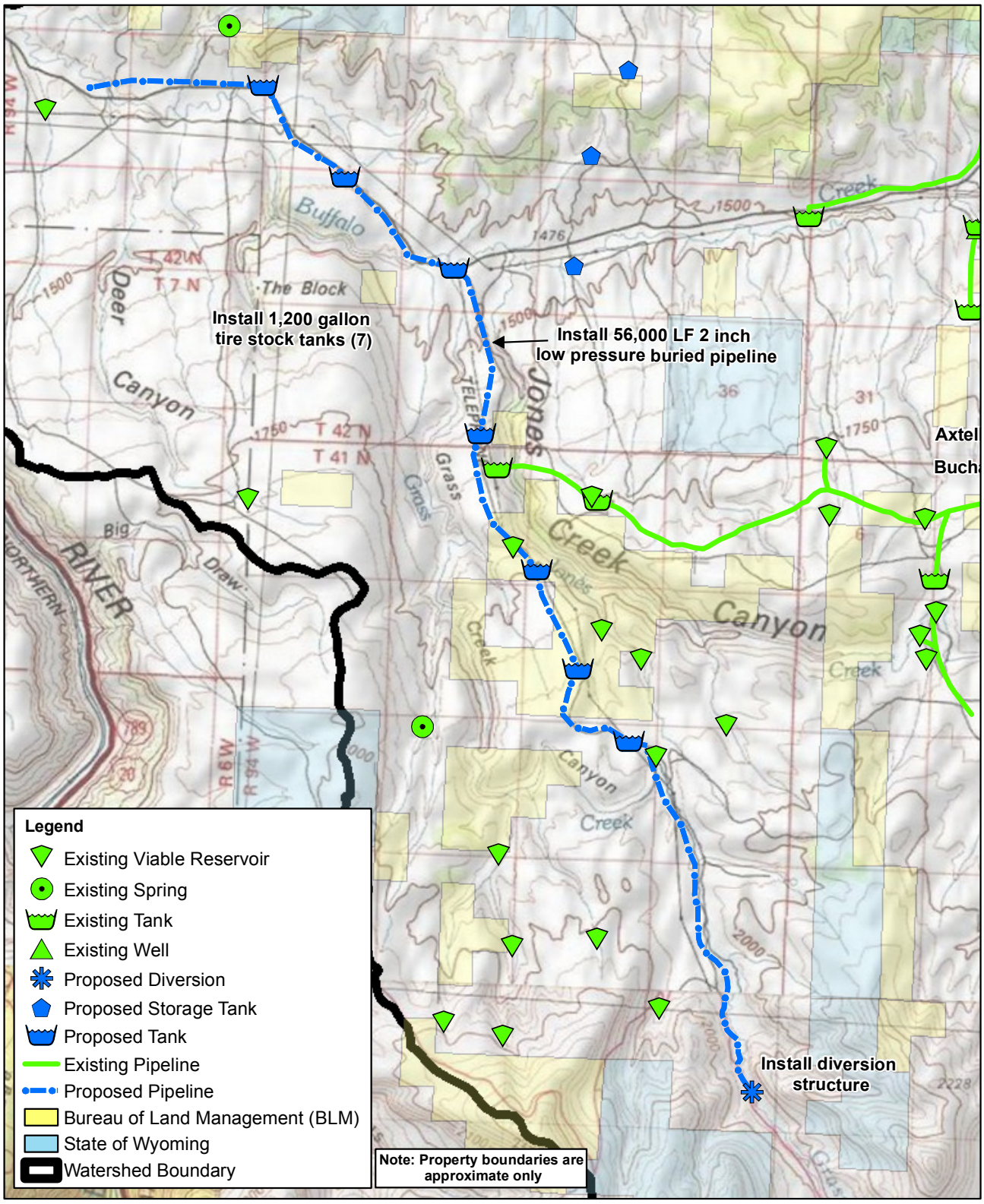


Figure 4.24 Conceptual Design: Watershed Management Plan Component LW-25 (Baird-1)

The pipeline would then flow northerly downslope under gravity flow conditions. The system could adequately supply numerous livestock/wildlife water tanks; under the design presented herein, seven are displayed. Water not used in the water tanks would be available for irrigation purposes downstream. Several sizes of pipe sizes were evaluated under this alternative in an effort to provide choices with respect to conveyance capacity and associated costs.

Under this alternative, the following components would be employed:

- A diversion structure would be constructed in Grass Creek upstream of the limestone sinks. The diversion would consist of a buried gravel infiltration gallery and perforated pipe. A valve would be included for management of pipeline flows.
- Approximately 56,000 linear feet of 2-inch low pressure pipeline would be installed.
- Approximately seven stock tanks (1,200 gallon capacity each) would be installed.
- Wildlife egress ramps would be installed in the proposed water tanks.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels. Pressure reducing valves (PRVs) would be installed at appropriate locations to maintain proper pressure for the pipeline.
- The 2-inch diameter pipe specified in the conceptual designs would provide over 50 gallons per minute. If 4-inch pipe were used, flows would be increased to approximately 300 gallons per minute.

Completion of this alternative would require coordination with the BLM through the Worland Field office for permission to install the pipeline and stock tanks.

4.3.2.26 Johnson Spring Rehabilitation (Plan Component L/W-26)

This project consists of development of existing spring located in Section 18, Township 42 North, Range 92 West. The spring is permitted through the Wyoming State Engineers Office under permit number P149942W and has a reported yield of approximately 20 gallons per minute. Field observations of the well confirm this value. The spring has been previously developed by the current land owner and it is used to supply water to a livestock/wildlife water system. However, the existing intake infrastructure should be replaced with an improved spring development in order to capture a greater amount of the available flow from the spring. Figure 4.25 displays the conceptual design of the project.

Under this proposed project, the spring would be redeveloped and collected flows conveyed downstream to the existing stock tank system. The land owner would have the option in the future of extending the existing pipeline or incorporating a new pipeline.

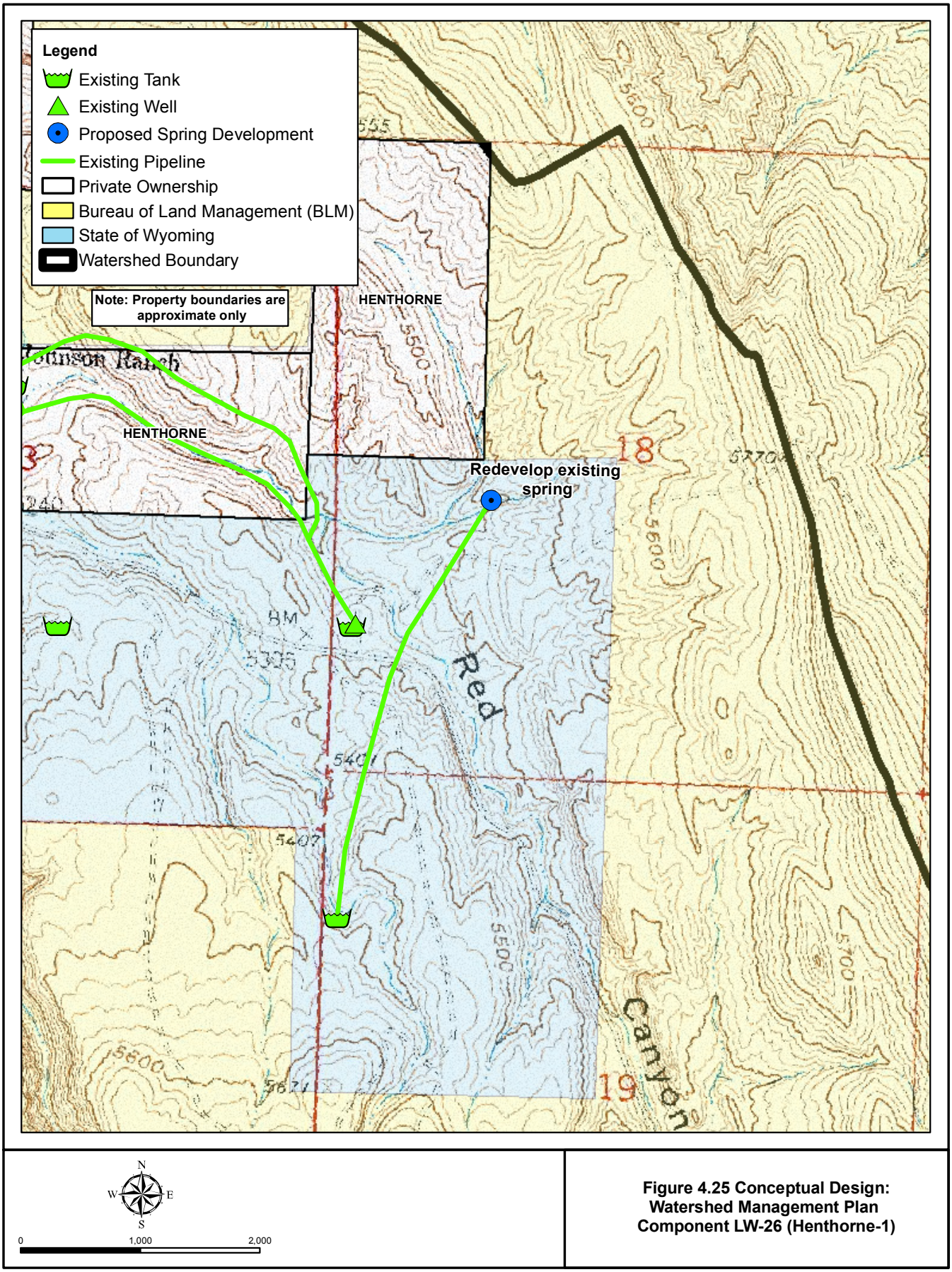


Figure 4.25 Conceptual Design: Watershed Management Plan Component LW-26 (Henthorne-1)

Under this alternative, the following components would be employed:

- A new spring development would be completed in the vicinity of the existing spring. The spring development would facilitate diversion of flows to a gravity pipeline. See the attached NRCS designs for typical spring development plans.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.
- The spring vicinity would be fenced to prevent the spring development damage from livestock and wildlife.

4.3.2.27 Buchanon Pipeline Project-Phase I (Plan Component L/W-27)

Initial designs for this project have been completed by the NRCS and have been incorporated into the conceptual designs. Completion of the project would provide reliable sources of water for wildlife and livestock in an area where water is generally limited to intermittent streamflow associated with Warm Springs Creek.

The Phase I of the proposed project entails a pipeline originating at an existing well located on deeded land in Section 26, Township 42 North, Range 94 West near Buffalo Creek. From the wellhead, the pipeline would run north 5,000 feet upslope to a storage tank. A solar booster pump at this storage tank would provide the lift necessary to pump the water 6,000 feet further upslope over the divide between Buffalo Creek and Warm Springs Creek, where a stock tank and storage tank (Phase 2) would be placed on private lands.

The proposed project would require two pumps: one electric pump at the well head and a second solar powered pump at the first storage tank. Figure 4.26 displays the conceptual design of the project.

Under this alternative, the following components would be employed:

- A storage tank (15,000 gallon capacity) would be installed at the well head to store water prior to being pumped upslope into the system.
- An electric pump would be installed at the well head.
- Water would be pumped from the storage tank to an additional storage tank located approximately 5,000 feet distant up the slope to the north. This pipeline would be high pressure 2 inch HDPE and would likely be buried above the frost line.
- At the second storage tank, a solar power booster pump would be installed to provide the additional lift necessary to pump water to the highest point of the Phase I system. Approximately 6,000 linear feet of 2 inch HDPE high pressure pipeline would be installed. This portion of the pipeline system would likely be unburied due to rocky conditions.
- One (1) livestock/wildlife water tank (1,200 gallon capacity each) would be installed.

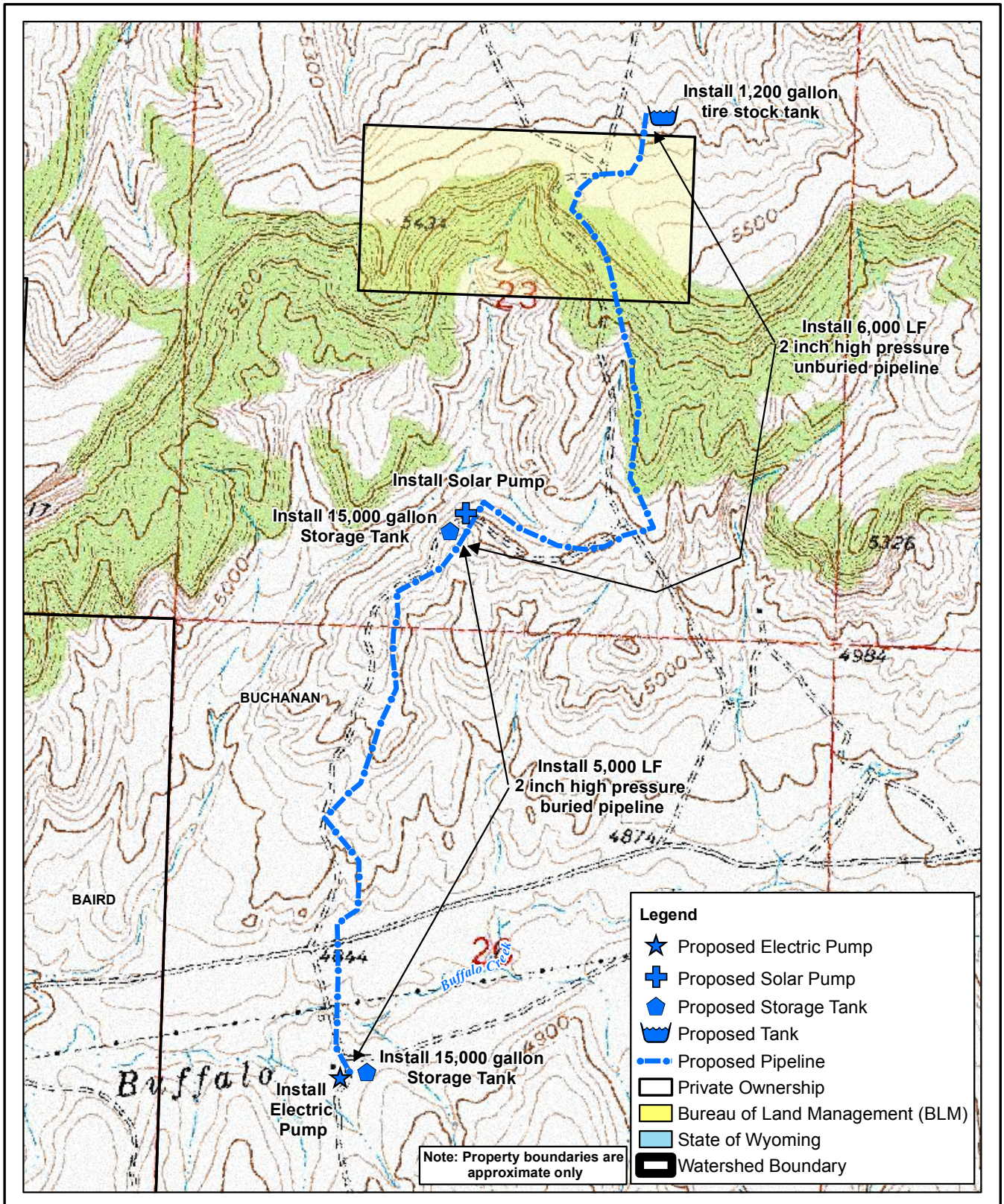


Figure 4.26 Conceptual Design: Watershed Management Plan Component LW-27 (Jennegis-1)

- Wildlife egress ramps would be installed in the proposed water tank.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.

As delineated, this alternative would require procurement of an easement from the BLM through coordination with their Worland office.

4.3.2.28 Buchanon Pipeline Project- Phase II (Plan Component L/W-28)

Construction of this project would be contingent upon the successful completion of Phase I of the project (Plan Component L/W-27) which was previously discussed.

Initial designs for this project have been completed by the NRCS and have been incorporated into the conceptual designs. Completion of the project would provide reliable sources of water for wildlife and livestock in an area where water is generally limited to intermittent streamflow associated with Warm Springs Creek.

The proposed Phase II project entails a pipeline originating at a storage tank which would be installed on the divide between Buffalo Creek and Warm Springs Creek within Section 23, Township 42 North, Range 94 West. From the storage tank, a low pressure pipeline would run north downslope to a series of four (4) livestock/wildlife tanks located within the Warms Springs Creek drainage.

Under this alternative, the following components would be employed as indicated in Figure 4.27:

- A 15,000 gallon storage tank would be installed at the high point of the Phase I project.
- Approximately 16,500 linear feet of 1 ½ inch HDPE low pressure pipeline would be installed.
- Four (4) livestock/wildlife water tanks (1,200 gallon capacity each) would be installed.
- Pressure Reduction Valves (PRVs) would be required at appropriate locations to maintain pressures below 160 psi.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.
- Wildlife egress ramps would be installed in the proposed water tanks.

As delineated, this alternative would require procurement of an easement from the BLM through coordination with their Worland office.

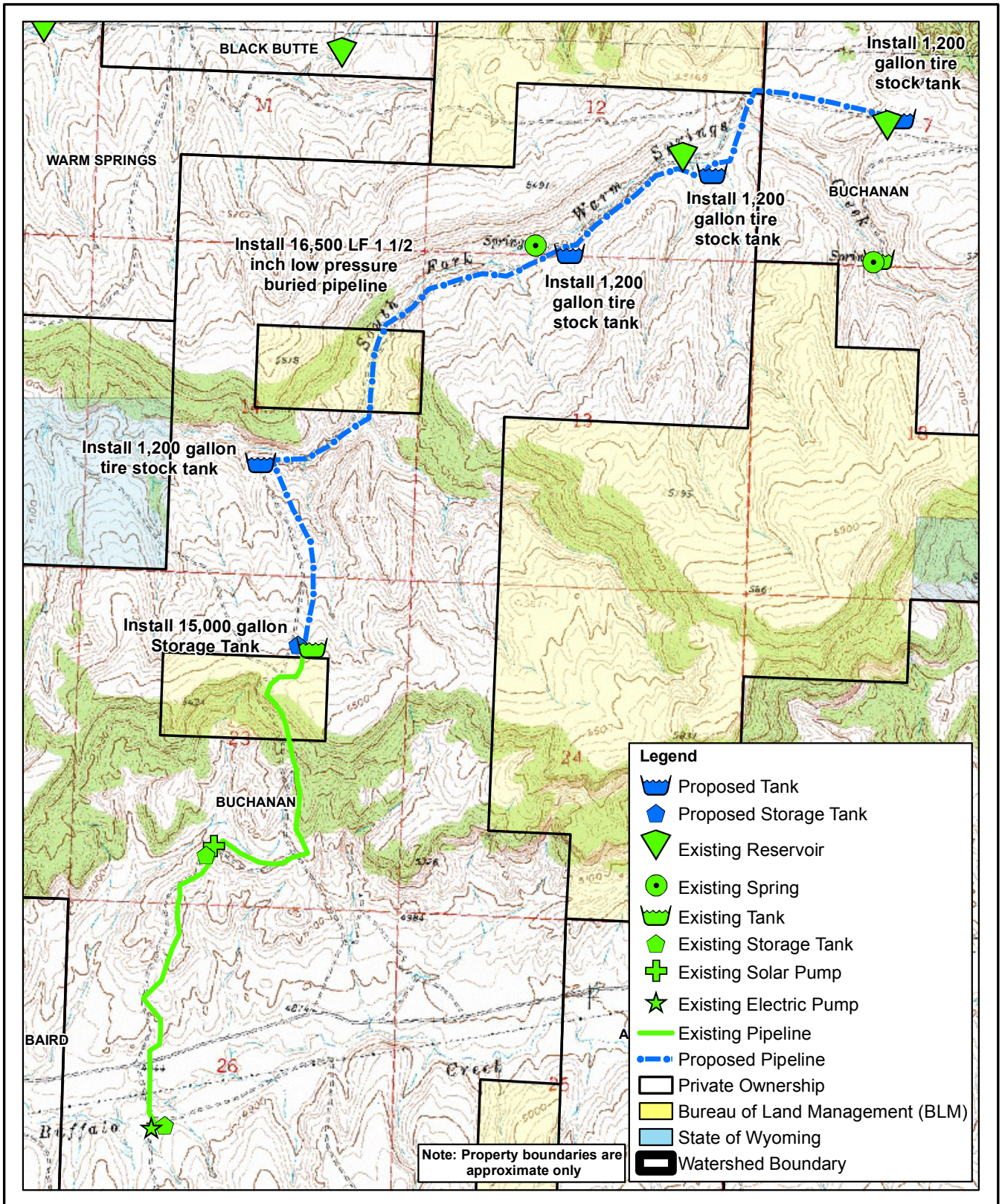


Figure 4.27 Conceptual Design: Watershed Management Plan Component LW-28 (Jennegis-2)

4.3.2.29 Ditch Creek Parallel Pipeline (Plan Component L/W-29)

The objective of this project is to provide an additional source of water for livestock and wildlife usage to the upper Buffalo Creek valley. Ditch Creek flows are entirely captured during the much of a typical year by "sinks" within limestone outcrops in Section 36, Township 42, Range 93. In an effort to provide water to livestock and wildlife downstream of the sinks, the landowner installed a 2-inch pipeline which conveys water past the sinks and delivers it to lands in the valley bottom.

The general alignment of the pipeline is shown on Figure 4.28.

Under this proposed alternative, a pipeline would be constructed that roughly parallels the existing system, however, by diverting from Antelope Creek. Alternative alignments were evaluated which could potentially avoid construction and maintenance problems associated with an exposed pipeline in the rugged canyon. However, alternative alignments would require power sources for pumps to provide the lift necessary to avoid the canyon. Solar pumps would likely not provide the energy necessary to provide the requisite pumps. Likewise, diesel powered pumps were deemed undesirable. Should the project proponent deem alternative alignments worthy of further examination and pumping alternatives, detailed review of the alternatives could be completed during the design phase. For the purposes of this Level I investigation, the project was assumed to utilize a similar alignment to the existing and functioning pipeline. Under gravity flow conditions, a 2-inch diameter pipeline would be expected to convey at least 50 gallons per minute. Likewise, 200 gallons per minute and 440 gallons per minute could be obtained in 4-inch and 6-inch pipelines, respectively.

Under this alternative, the following components would be employed:

- A diversion facility would be constructed in Ditch Creek. The facility would consist of a buried gravel infiltration gallery and perforated pipe. A valve would be included for management of pipeline flows.
- A combined buried / unburied high-pressure HDPE pipeline would be installed. Diameter of the pipeline would be selected during the final design process to meet the ultimate needs of those involved. Total length of the pipeline would be approximately 21,500 feet.
- Diameter of the pipeline would be selected during the final design process to meet the ultimate needs of those involved. Total length of the pipeline would be approximately 21,500.
- Pressure relief valves would be required to maintain appropriate pressures within the pipeline.
- Several livestock/wildlife water tanks could be installed. For the purposes of this project, it was assumed that four (4) would be installed.

As delineated, this project would involve Federal lands administered by the BLM. An agreement would be required of the BLM for an easement for the pipeline. Likewise, lands owned by the State of Wyoming and privately owned lands would be involved.

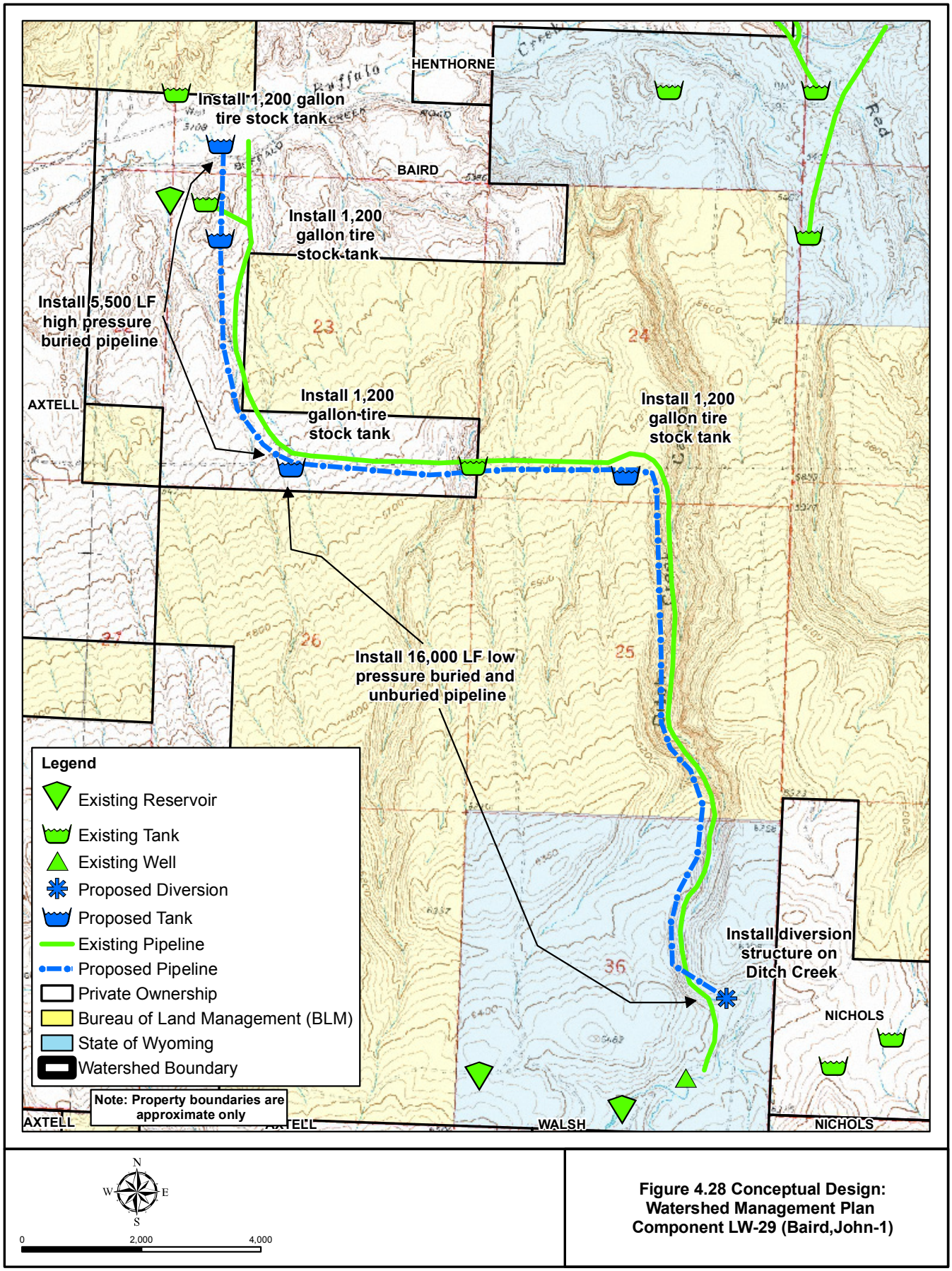


Figure 4.28 Conceptual Design: Watershed Management Plan Component LW-29 (Baird,John-1)

It should be noted that a number of potential alignments and configurations could be developed for this alternative. The alignment indicated follows the adjustment of the previously installed system. Burial of the pipeline is impractical through much of the system. However, this alignment can be built without the need for solar or diesel pumps; thereby, eliminating costs and maintenance issues associated with them.

In an effort to provide options to the project proponent, conceptual costs associate with larger pipelines were estimated. The attached table includes cost estimates associated with 2-inch, 4-inch, and 6-inch design alternatives.

Note: It must be kept in mind that the Wyoming State Engineers Office (WSEO) generally limits permits for livestock usage to 25 gallons per minute. Variations to this ruling have been known to have been granted. Should the project proponent decide to use the water for irrigation purposes, additional permits for its use would be required from the WSEO.

4.3.2.30 Jones Creek Pipeline System (Plan Component L/W-30)

The objective of this project is to provide a reliable source of livestock and wildlife water in a portion of the study area which is apparently lacking alternative sources to Jones Creek. Based upon interviews with landowners and the water source database developed, there are few water sources in the area covered by the proposed project. Consequently, the project team developed this project alternative as an example project which could be developed in such an area.

This project would involve construction of a diversion facility in Jones Creek, a buried pipeline, and stock tanks located outside of the riparian corridor. Figure 4.29 displays the general configuration of this alternative. Note that the alignment presented is conceptual to display the general intent of the proposed alternative. Final alignment of the pipeline and locations/numbers of stock tanks would be determined during final design.

Under this alternative, the following components would be employed:

- A diversion facility would be constructed in Jones Creek. The facility would consist of a buried gravel infiltration gallery and perforated pipe. A valve would be included for management of pipeline flows.
- A solar pump would be incorporated to pump diverted water via a buried HDPE pipeline (1½-inch diameter) to a storage tank (15,000 gallons) located north of the diversion.
- A buried HDPE low pressure pipeline (1½--inch diameter) would be routed from the storage tank downslope outside of the Jones Creek riparian corridor on an alignment selected to optimize range utilization and to facilitate gravity flow from the storage tank. The length of the pipeline, as delineated, would be approximately 17,000 linear feet under the configuration displayed.
- As delineated, five (5) stock/wildlife water tanks (1,200 gallon capacity each) would be installed.

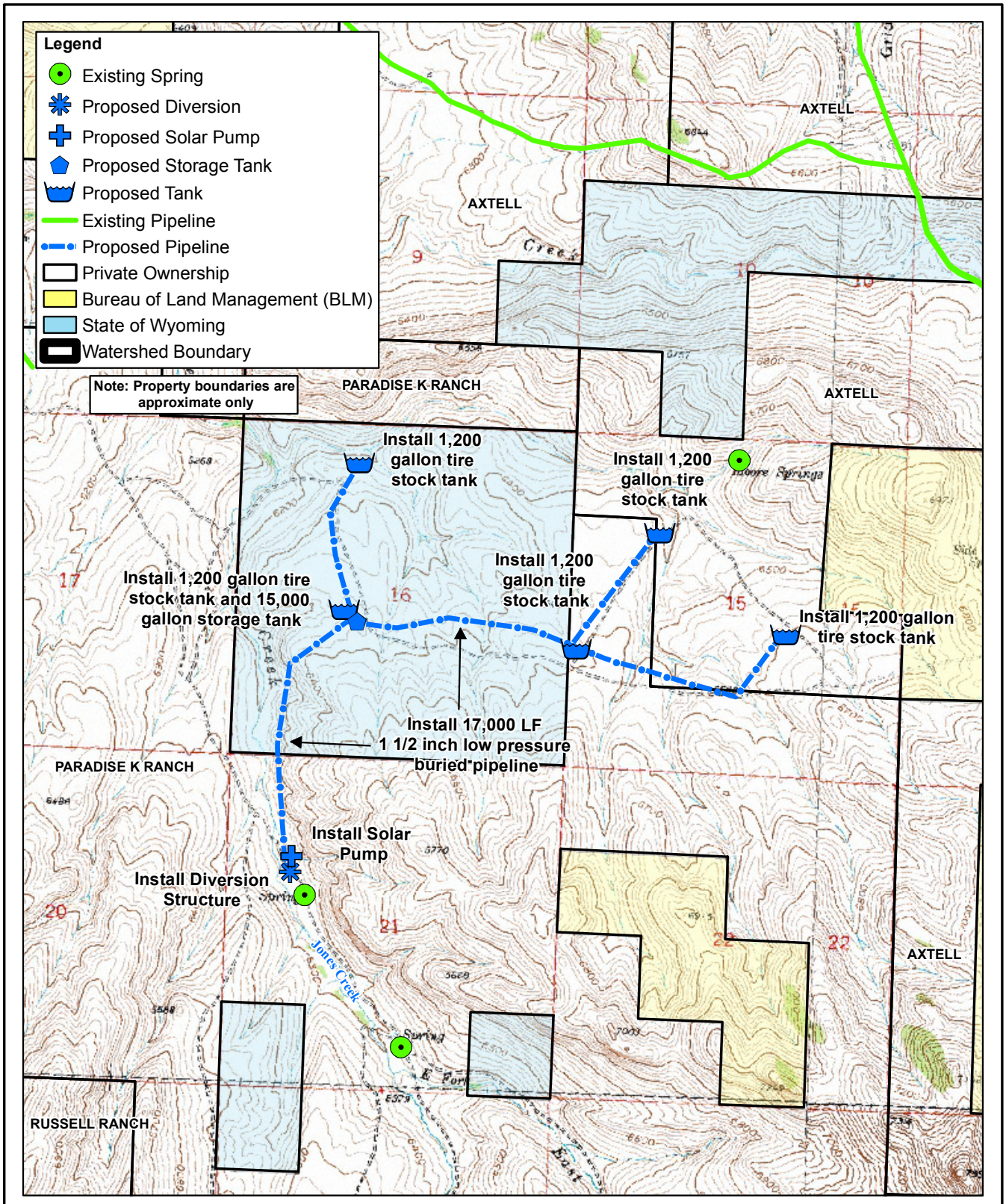


Figure 4.29 Conceptual Design: Watershed Management Plan Component LW-30 (ACE-1)

- Wildlife egress ramps would be installed in the proposed water tanks.
- Requisite valves and fittings would be incorporated to facilitate management of flows and water levels.

4.3.2.31 Antelope Creek Pipeline Project (Plan Component L/W-31)

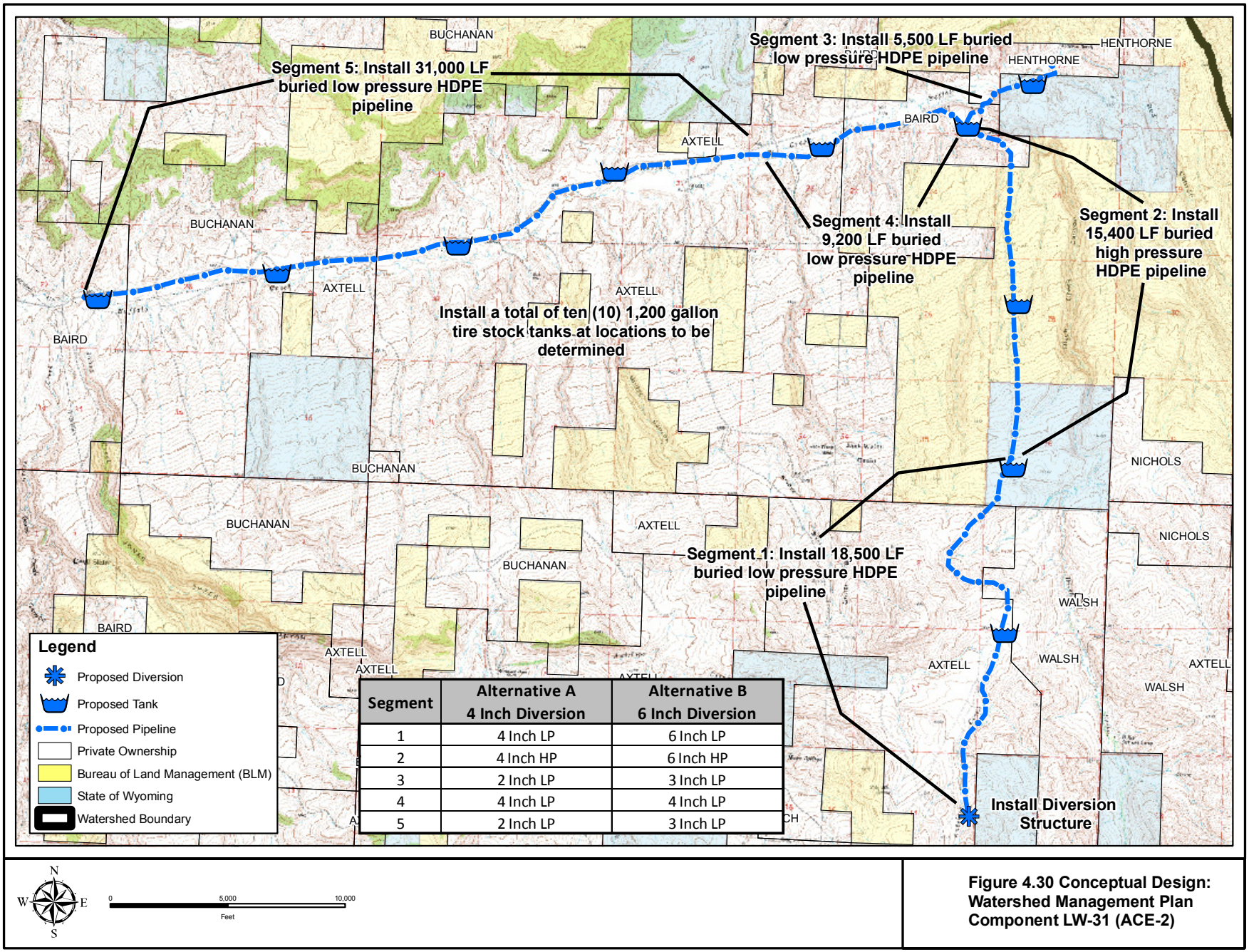
This project alternative was developed as a potential project which could serve multiple landowners in the Buffalo Creek watershed. The objective of the project is to provide an additional source of water for livestock and wildlife throughout the upper portions of the valley. Supply could be adequate for small scale irrigation as well, if water rights were obtained. The WSEO generally limits diversions for stock watering purposes to 25 gallons per minute. The proposed system could potentially supply approximately 200 to 400 gallons per minute depending upon the pipe size selected during the design process. Consequently, coordination with the WSEO would be required and water rights obtained prior to design and construction.

The proposed project would originate on Antelope Creek upstream of the limestone bearing bedrock where perennial conditions exist (Section 14, Township 41 North, Range 93 West). The general alignment of the pipeline is shown on Figure 4.30. Entirely via gravity flow, water could be diverted and conveyed via a buried pipeline parallel to Antelope Creek, pass over the divide between Ditch and Antelope Creek, then be aligned down slope to users in the Buffalo Creek valley bottom. While this alignment is longer than alternatives previously presented which originate on Ditch Creek (see Plan Component L/W-29), the alternative could be designed such that pumping would not be required, thereby eliminating the associated costs and maintenance associated with remote pumping facilities.

Size of the pipeline would vary depending upon the ultimate needs of the users. For the purposes of this Level I investigation two alternatives with identical alignments were evaluated. Alternative A is based upon a 4-inch diameter diversion pipeline (approx. 200 gpm) and Alternative B a 6-inch diameter pipeline (approx. 440 gpm).

Under this alternative, the following components would be employed:

- A diversion facility would be constructed in Antelope Creek. The facility would consist of a buried gravel infiltration gallery and perforated pipe. A valve would be included for management of pipeline flows.
- A combined buried / unburied high-pressure HDPE pipeline would be installed. Diameters of the pipeline segments would be selected during the final design process to meet the ultimate needs of those involved. Total length of the pipeline would be approximately 79,600 feet.
- Pressure relief valves would be required to maintain appropriate pressures within the pipeline.



Segment	Alternative A 4 Inch Diversion	Alternative B 6 Inch Diversion
1	4 Inch LP	6 Inch LP
2	4 Inch HP	6 Inch HP
3	2 Inch LP	3 Inch LP
4	4 Inch LP	4 Inch LP
5	2 Inch LP	3 Inch LP

Figure 4.30 Conceptual Design: Watershed Management Plan Component LW-31 (ACE-2)

- Several livestock/wildlife water tanks could be installed. For the purposes of this project, it was assumed that ten (10) would be installed. The ultimate number of water tanks and their locations would ultimately be determined during the design process. The sites indicated in this conceptual design are for general illustration purposes of options available.

Numerous variations of this design are potentially available depending upon the interest and commitment of landowners.

4.3.2.32 Additional Upland Management Opportunities

Guzzlers are artificial catchments providing sources of water in remote areas for wildlife. Larger systems could be employed for livestock watering purposes. They rely entirely upon direct precipitation; therefore, their reliability is only as good as can be expected in a water short region. Figure 4.31 displays a photo of a guzzler installed in the Cottonwood Creek watershed near Thermopolis, Wyoming. The option of installing a guzzler type water collection system with watering facilities may be considered in areas where wildlife water is needed, and alternative options are not available.

Figure 4.31 Wildlife Guzzler.

Guzzler watering systems utilize direct precipitation as a source of supply, with a storage tank of capacity suitable to the watering need. Wildlife guzzlers are typically designed to maximize use by wildlife and discourage use by livestock. A complete guzzler system is comprised of the following components:

- Catchment apron – typically made of textured HDPE; secured with rocks placed on a suitable grid spacing, and protected by suitable fencing from trampling by wildlife or livestock,
- Catchment outlet - pipe boot, clamps and well screen section,
- HDPE pipe – typically 1.5-2-inch, 160 psi, SDR 11,
- Catchment tank – HDPE tank sized to accommodate wildlife or livestock watering needs, with integral drinker (ideally with no float valve required), small animal escape ladder and overflow adapter, and
- Overflow pipe – with erosion protection at discharge.

These guzzlers would be installed at locations to be determined. The guzzler operates by intercepting direct rainfall or snowmelt on the catchment, routing the captured water via a pipe to the tank, and controlling the tank level via a simple overflow outlet pipe. Complete guzzler systems are commercially available.

4.4 Stream Channel Condition and Stability

4.4.1 Stream Channel Restoration Strategies

The general condition of the principal stream channels and primary tributaries were evaluated during the geomorphic investigation. Results of that study are presented in Chapter 3. During the evaluation of existing channel conditions, several impaired reaches were identified and two general classes of impairments noted. The general category of impairments were classified as indicated below:

- Channel degradation/incision; and
- Bank erosion associated with channel migration and/or widening.

Various approaches can be taken during channel restoration and stabilization efforts, including both "hard" engineering and "soft" approaches and combinations of the two. Examples of "hard" approaches would include construction of channel structures or reconstruction of channels themselves. The selection of the appropriate mitigation/restoration technique depends upon site-specific information and critical review of hydrologic and hydraulic data. Installation of an inappropriate type of structure or improper installation could exacerbate conditions.

For instance, methods of restoring incised channels may include construction of gradient restoration facilities (i.e., drop structures, check structures) within the incised channel. Figure 4.32 displays a diagram of a typical stream channel stabilization strategy for small channel experiencing where log check dams are placed in series within a problematic reach. Figure 4.33 shows an alternative form of stream stabilization: the rock filled gabion.

Figure 4.33 Stream Stabilization Structure.

Re-establishment of pre-incision channel elevations can be accomplished by means of check dams. Figure 4.34 displays a photo of a large-scale check dam on Muddy Creek within the Little Snake River Watershed. While this structure is considerably larger than would likely be required in the current study area, it serves as a good example of how gradient restoration strategies can be utilized to restore diversion capabilities at irrigation headgates rendered inoperable by changes in channel configuration.

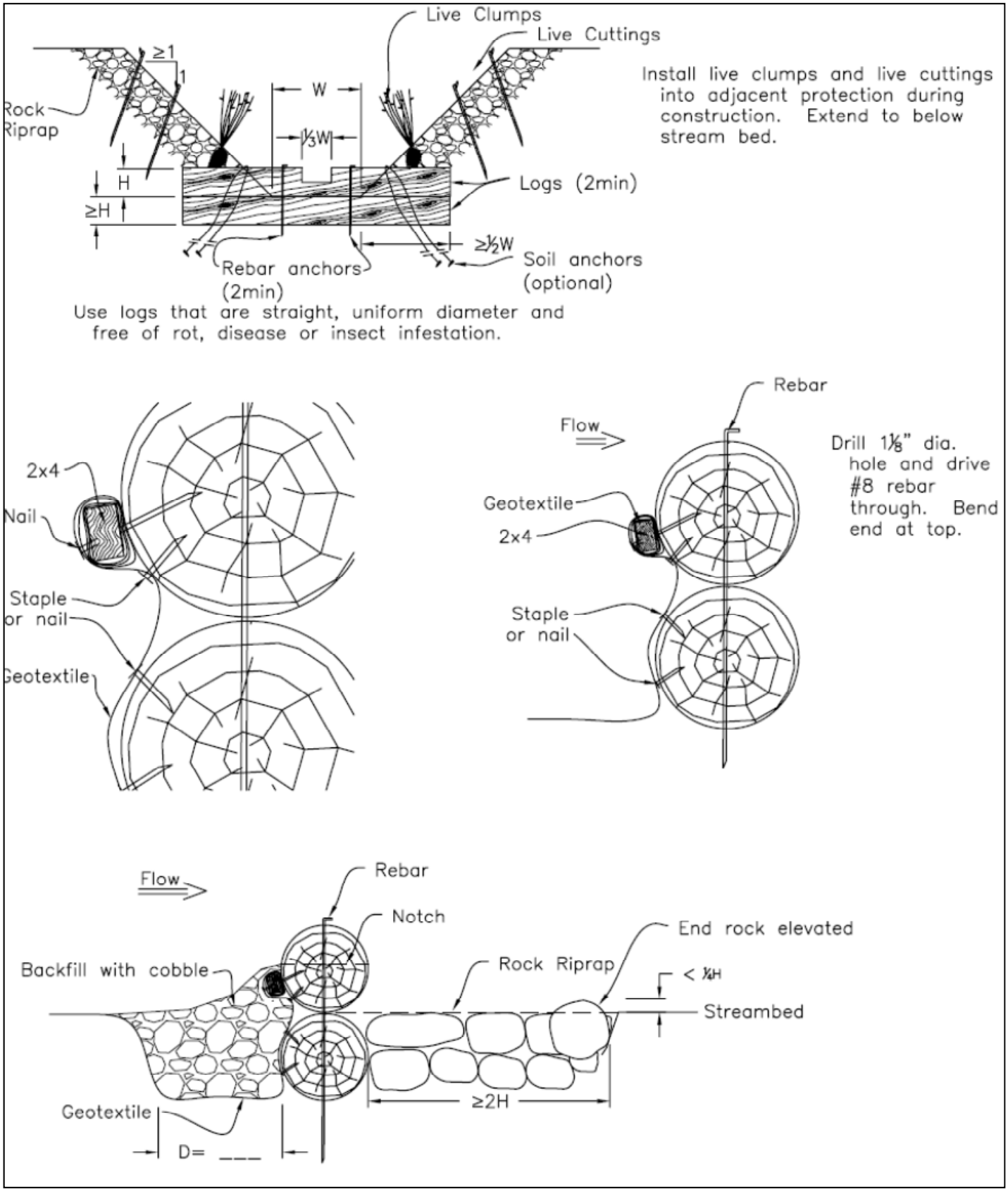


Figure 4.32 Conceptual Design: Log Check Dam.

Figure 4.34 Channel Gradient Restoration Feature on Muddy Creek near Baggs, WY. Photo on left is viewed downstream from the dam at incised channel. Photo on the right is viewed upstream at restored gradient.

Examples of "soft" approaches include a variety of Best Management Practices (BMPs). Examples of potentially applicable BMPs designed for channel restoration activities include those that result in reducing or, at least temporarily, excluding wildlife and livestock from accessing designated riparian zones, establishment of riparian buffers, etc. The proposed and potential wildlife/livestock water developments discussed previously (and others that may be identified in the future) can be considered elements of a range management BMP that will help restore over time those areas of channel impairment related to historic or current grazing practices that have resulted in overutilization of riparian areas or adjacent upland range. Figure 4.35 displays a photo of willow fascine installation. This strategy could be employed on many of the perennial channels or intermittent where sufficient flow exists to support the vegetation, in an effort to restore riparian habitat and stabilize streambanks.

Figure 4.35 Stream Stabilization Measure: Willow Fascine Installation.

These examples of "hard" and "soft" approaches represent both extremes of the continuum of channel restoration strategies that exist. In practice, it must be kept in mind that it is generally a combination of strategies, integrated into a cohesive plan that provides the most effective solution. Table 4.2 presents a summary of some of these channel restoration strategies which can be employed during future restoration efforts.

Table 4.2 Summary of Potential Stream Channel Stabilization/Restoration Techniques.

Flow-Redirection Techniques	**Biotechnical Techniques**
Vanes	Woody Plantings
Groins	Herbaceous Cover
Buried Groins	Soil Reinforcement
Barbs	Coir Logs
Engineered Log Jams	Bank Reshaping
Drop Structures	**Internal Bank-Drainage Techniques**
Porous Weirs	Subsurface Drainage Systems
Structural Techniques	**Avulsion-Prevention Techniques**
Anchor Points	Floodplain Roughness
Roughness Trees	Floodplain Grade Control
Riprap	Floodplain Flow Spreaders
Log Toes	**Other Techniques**
Roughened-Rock Toes	Channel Modifications
Log Cribwalls	Riparian-Buffer Management
Manufactured Retention Systems	Spawning-Habitat Restoration
	Fish Ladders/bypass structures
	Fish Screens/entrainment prevention

Development of more specific projects and BMPs was beyond the scope of this Level I study. Such projects can be identified and developed on the basis of more detailed geomorphic analysis of impaired stream reaches.

If further study of reservoir storage is planned within the watershed, the potential effects of such storage on stream stability/geomorphic conditions should be evaluated in appropriate detail as part of those studies. This may also result in identification of further opportunities not only to minimize impacts of any such new storage, but to improve stream conditions with proper reservoir operations management and implementation of appropriate “hard” and/or “soft” measures as described above.

4.4.2 Stream Channel Components of the Watershed Management Plan

Based on the information presented above, the following items are presented for inclusion in the Buffalo Creek watershed management plan:

Watershed Plan Component C-1: Installation of stream channel degradation/incision mitigation measures based upon site-specific evaluation of conditions. Appropriate mitigation measures could be ‘hard’ engineering, ‘soft’ approaches, or combinations of both.

Watershed Plan Component C-2: Installation of stream bank erosion mitigation measures based upon site-specific evaluation of conditions. Appropriate mitigation measures could be 'hard' engineering, 'soft' approaches, or combinations of both.

4.5 Grazing Management Opportunities

4.5.1 State and Transition Models

In Chapter 3, the ecological sites found within the watershed were presented and the concept of the ecological site description (ESD) was introduced. The ESD for a given ecological site contains a wealth of information pertaining to the site and its community. Within each ESD is a State and Transition model.

State and transition models describe the patterns, causes, and indicators of transitions between communities within an ecological site based upon the ecological site description (ESD). In a graphical form, they display information obtained from literature supplemented by the knowledge and experience of range scientists and managers. Basically, they display the response of a given ecological site to various range management practices or disturbances. They help to distinguish changes in vegetation and soils that are easily reversible versus changes that are subject to thresholds beyond which reversal is costly or unlikely. By being aware of the predicted response of a given ecological site to a treatment, the land manager can use this knowledge to best prescribe land management practices or treatments to direct the transition in a desirable direction. For instance, land management strategies can be prescribed which could result in restoration of the Historic Climax Plant Community (HCPC) under the right circumstances.

Based upon the assumptions presented in Chapter 3, the four dominant ecological sites found within the Buffalo Creek Watershed study area are likely to be the following:

- Loamy 10-14 inch precipitation zone, East
- Sandy 10-14 inch precipitation zone, East
- Loamy 15-19 inch Foothills and Mountains East
- Shallow loamy 15-19 inch Foothills and Mountains East

It is important to note that other ecological sites will be encountered and that the list above is provided as an initial point for prescription of grazing practices. Prior to prescription of a grazing management plan, local site-specific conditions must be considered and the appropriate ESD determined. Portions of the study area will certainly consist of additional ecological sites (eg., sandy 15-19 inch Foothills and Mountains East).

4.5.1.1 ESD: Loamy 10-14 inch precipitation zone, East

One of the most prevalent ecological sites within the lower portions of the study area is the loamy 10-14 inch precipitation zone, East site. Figure 4.36 displays the state and transition model for this site.

The following description of the ecological site's HCPC and transitions to and from it was extracted from the NRCS ESD for the site:

The HCPC for this site is the bluebunch wheatgrass/rhizomatous wheatgrass plant community. This state evolved with grazing by large herbivores and periodic fires. The cyclical natural of the fire regime in this community prevented big sagebrush from being the dominant landscape. 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% grasses or grass-like plants, 10% forbs, and 15% woody plants. This state is dominated by cool season mid-grasses.

The major grasses include Griffiths and bluebunch wheatgrasses, rhizomatous wheatgrasses, needleandthread, and Indian ricegrass. Other grasses occurring in this state include bottlebrush squirreltail, prairie junegrass, and Sandberg bluegrass. Big sagebrush is a conspicuous element of this state, occurs in a mosaic pattern, and makes up 5 to 15% of the annual production. Winterfat is a common component found on this site. A variety of forbs also occurs in this state and plant diversity is high (see Plant Composition Table).

The total annual production (air-dry weight) of this state is about 800 lbs./acre, but it can range from about 500 lbs./acre in unfavorable years to about 1100 lbs./acre in above average years.

This plant community is extremely stable and well adapted to the Northern Intermountain Desertic Basins 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:

- *Moderate, continuous season-long grazing will convert the plant community to the Perennial Grass/Big Sagebrush Plant Community. Prolonged drought will exacerbate this transition.*

4.5.1.2 ESD: Sandy 10-14 inch precipitation zone, East

A prevalent ecological sites within the lower portions of the study area is the sandy 10-14 inch precipitation zone, East site. Figure 4.37 displays the state and transition model for this site. The following description of the ecological site's HCPC and transitions to and from it was extracted from the NRCS ESD for the site:

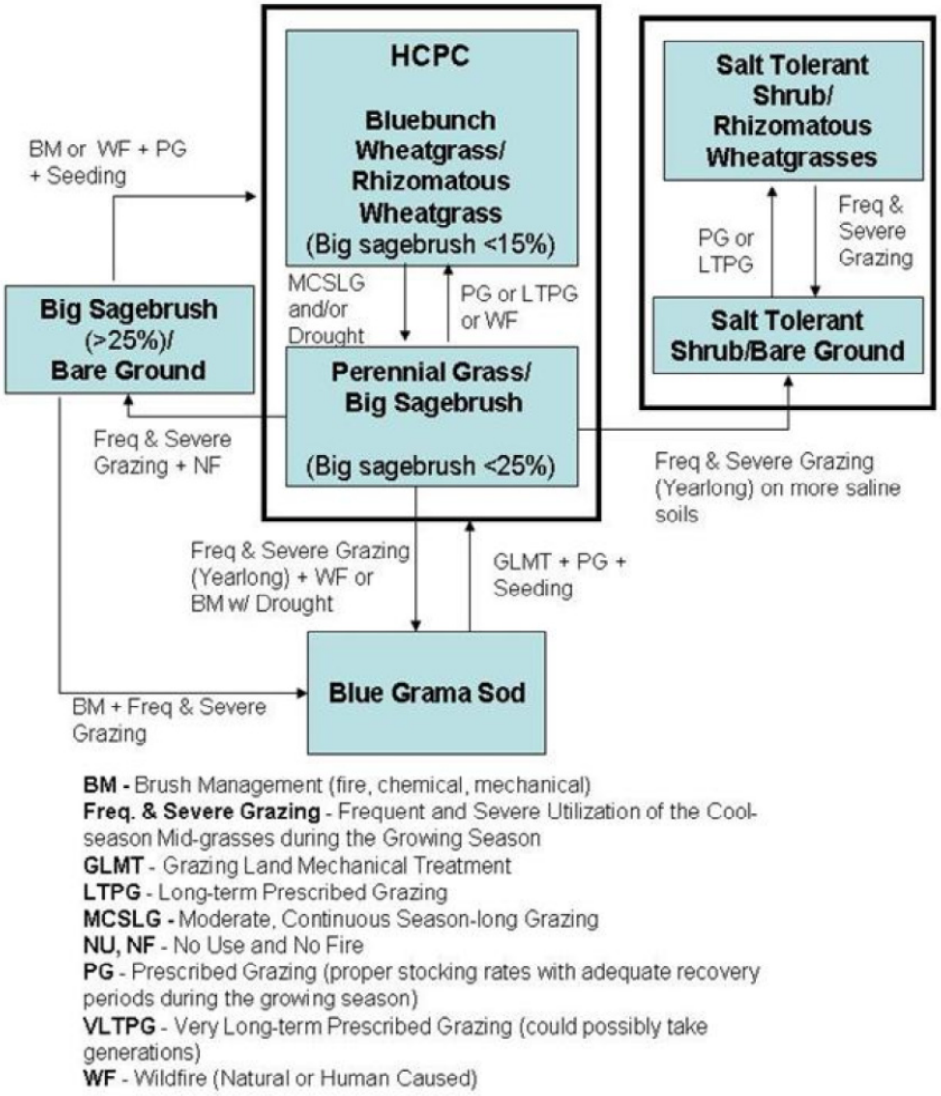


Figure 4.36 State and Transition Model Diagram: Loamy 10-14 inch precipitation zone East.

The HCPC for this site is the Needleandthread / Indian Ricegrass community. This state evolved with grazing by large herbivores and periodic fires. The cyclical natural of the fire regime in this community prevented big sagebrush from being the dominant landscape. 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 state is comprised of mostly cool season mid-grasses and a variety of forbs and woody species. Potential vegetation is about 75% grasses or grass-like plants, 15% forbs, and 10% woody plants.

The major grasses include needleandthread, Indian ricegrass, bluebunch and/or Griffith's wheatgrasses, and rhizomatous wheatgrasses. Other grasses occurring in the state include prairie junegrass, Sandberg bluegrass, blue grama, threadleaf sedge, and bottlebrush squirreltail. Spikefescue occurs on sites in the higher precipitation ranges of this zone. Big sagebrush and winterfat are conspicuous components of this state. A variety of forbs also occurs in this state and plant diversity is high (see Plant Composition Table).

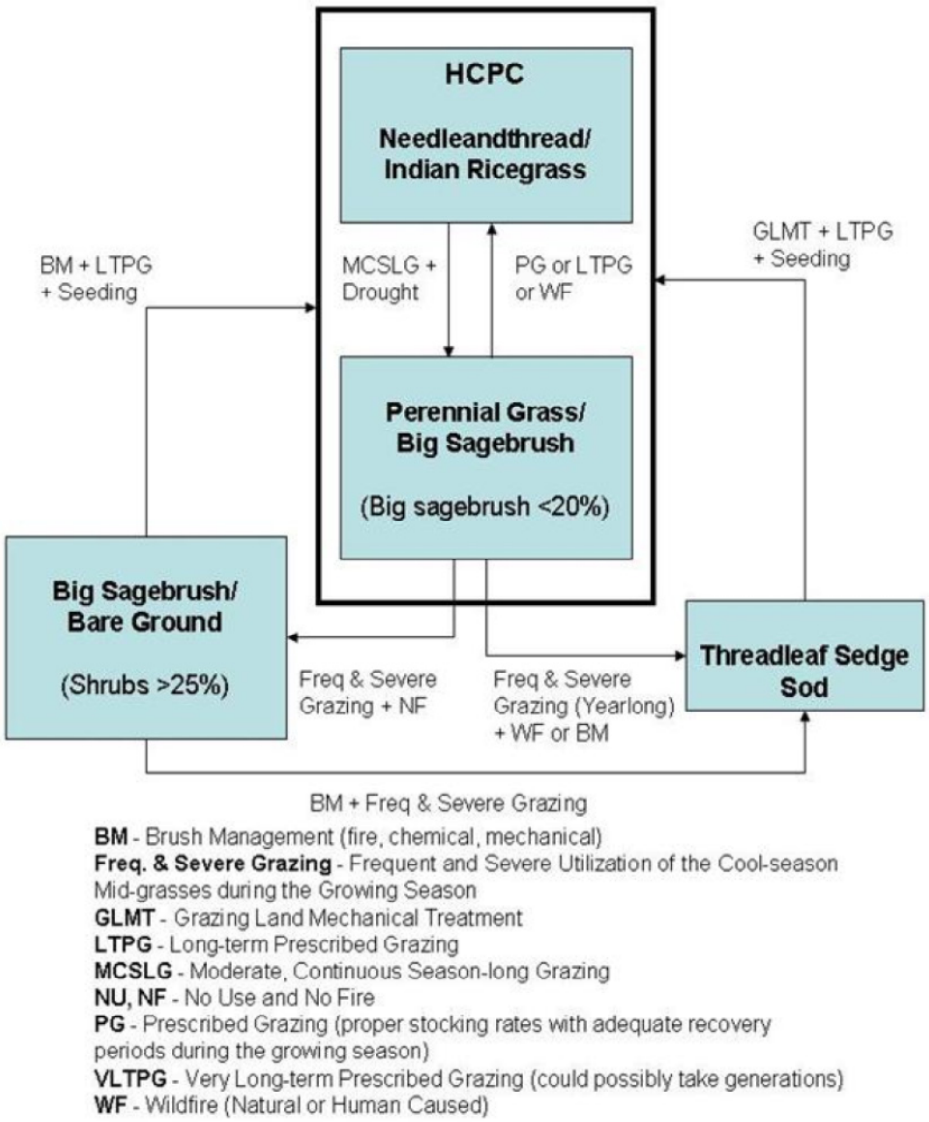


Figure 4.37 State and Transition Model Diagram: Sandy 10-14 inch precipitation zone East.

The total annual production (air-dry weight) of this state is about 800 lbs./acre, but it can range from about 500 lbs./acre in unfavorable years to about 1100 lbs./acre in above average years.

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

- *Moderate, Continuous Season-Long grazing will convert the plant community to the Perennial Grass/Big Sagebrush Plant Community. Prolonged drought will exacerbate this transition.*

4.5.1.3 ESD: Loamy 15-19 Inch Foothills and Mountains East

A third prevalent ecological site within the watershed is the loamy 15-19 inch precipitation zone Foothills and Mountains East site. Figure 4.38 displays the state and transition model for this site. The following description of the ecological site was extracted from the NRCS ESD for the site:

"The HCPS for this site is the Columbia Needlegrass/Spikefescue Plant Community. This state evolved with grazing by large herbivores and periodic fires. Potential vegetation is about 75% grasses or grass-like plants, 15% forbs, and 10% woody plants. This plant community can be found on areas that are properly managed with grazing and/or prescribed burning, and on areas receiving periods of rest. The cyclical nature of the fire regime in this community prevents big sagebrush from being the dominant landscape.

Cool season midgrasses dominate the site. The major grasses include Columbia needlegrass, spikefescue, Idaho fescue, and bluebunch wheatgrass. Big sagebrush is a conspicuous element of this site, occurs in a mosaic pattern, and makes up 5 to 10% of the annual production. Natural fire occurred in this community and prevented sagebrush from being the dominant landscape. A variety of forbs also occurs in this state and plant diversity is high (see Plant Composition Table).

Annual production on this site ranges from 1100 to 1600 pounds depending on climatic conditions. This plant community is extremely stable and well adapted to the Central Rocky Mountains 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).

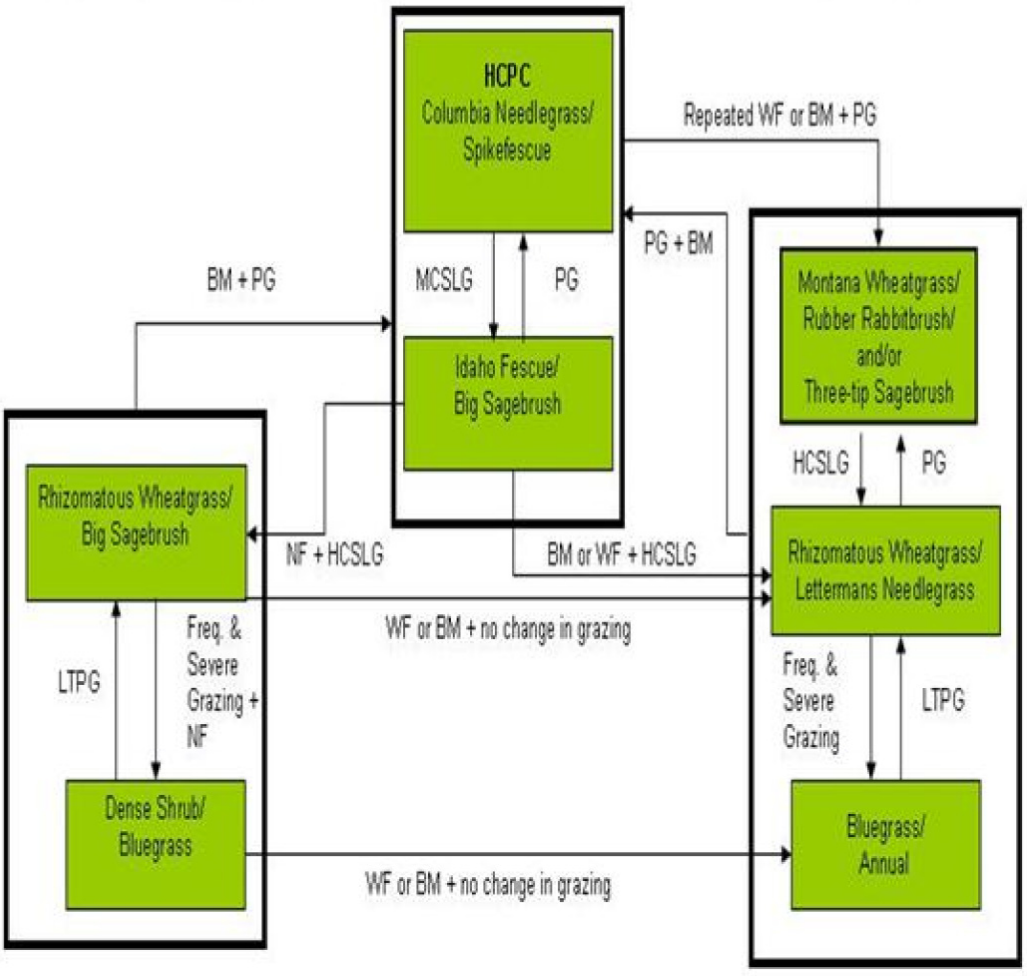
Transitions or pathways leading to other plant communities are as follows:

- *Moderate, continuous season-long grazing will convert the plant community to the Idaho Fescue/Big Sagebrush Plant Community.*
- *Repeated Wild Fire or Brush Management + Prescribed Grazing will convert the HCPC to the Montana Wheatgrass/Rubber Rabbitbrush and/or Three-tip Sagebrush Plant Community."*

4.5.1.4 ESD: Shallow loamy 15-19 inch Foothills and Mountains East

A fourth prevalent ecological site within the watershed is the shallow loamy 15-19 inch Foothills and Mountains East site.

Figure 4.39 displays the state and transition model for this site. The following description of the ecological site was extracted from the NRCS ESD for the site:



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-term Prescribed Grazing
MCSLG – Moderate, Continuous Season-long Grazing
HCSLG – Heavy, Continuous Season-long Grazing
NU, NF – No Use and No Fire
PG – Prescribed Grazing (proper stocking rates with adequate recovery periods during the growing season)
VLTPG – Very Long-term Prescribed Grazing (could possibly take generations)
Na – Moderate Sodium in Soil
WF – Wildfire

Figure 4.38 State and Transition Model: Loamy 15-19 Inch Foothills and Mountains East.

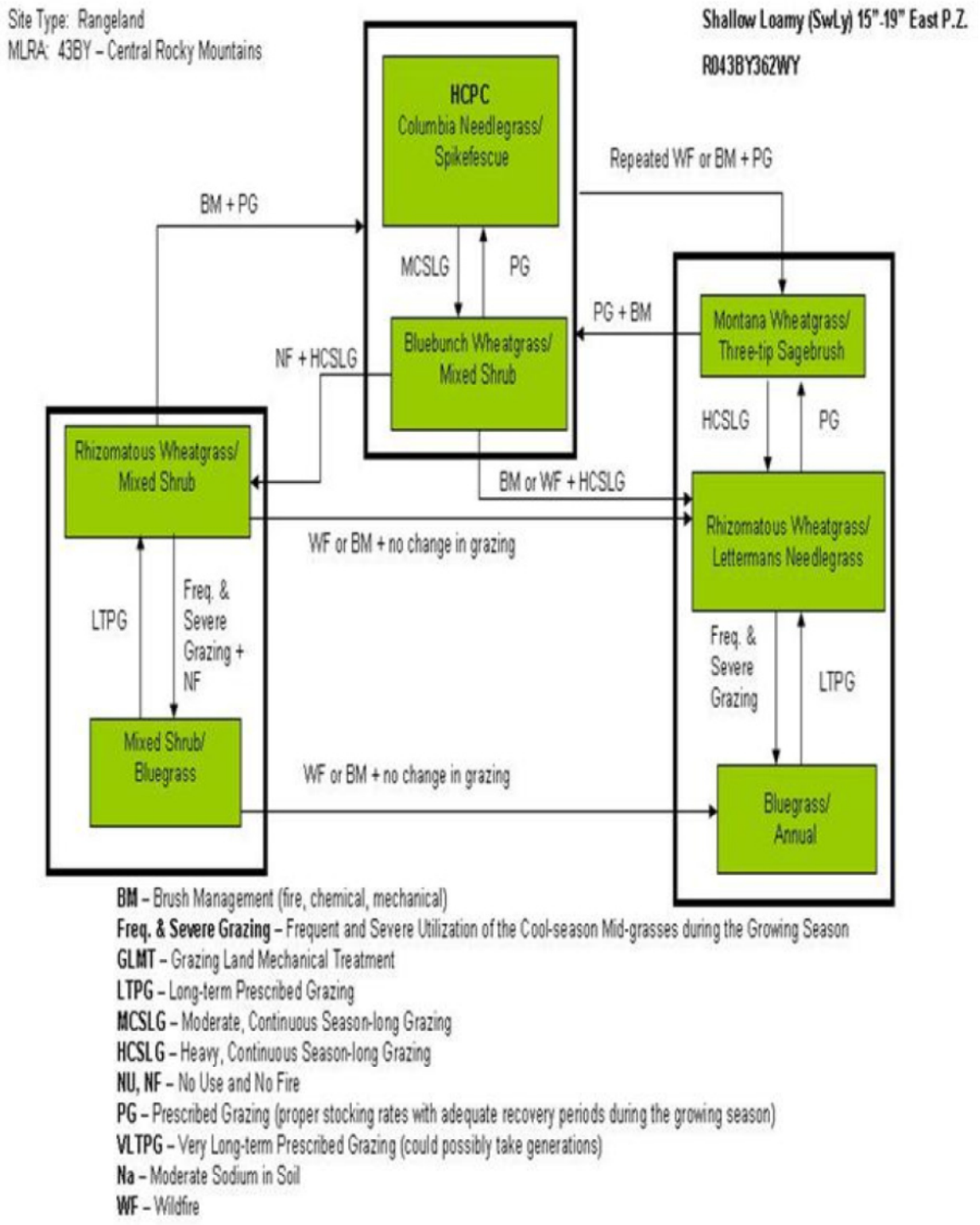


Figure 4.39 State and Transition Model: Shallow Loamy 15-19 Inch Foothills and Mountains East.

The HCPC for this site is the Columbia Needlegrass/Spikefescue Plant Community. This state evolved with grazing by large herbivores and periodic fires. Potential vegetation is about 75% grasses or grass-like plants, 10% forbs, and 15% woody plants. The cyclical nature of the fire regime in this community prevents big sagebrush from being the dominant landscape. This plant community can be found on areas that are properly managed with grazing and/or prescribed burning, and on areas receiving periods of rest.

Cool season midgrasses dominate the state. The major grasses include Columbia needlegrass, spikefescue, Idaho fescue, and bluebunch wheatgrass. Big and black sagebrush are conspicuous element of this state, occurring in a mosaic pattern, and makes up 5 to 10% of the annual production. On areas along the west slope of the Big Horn Mountains, mountain mahogany is the dominant shrub. A variety of forbs also occurs in this state and plant diversity is high (see Plant Composition Table).

Annual production on this state ranges from 500 to 1,000 pounds depending on climatic conditions.

This plant community is extremely stable and well adapted to the Central Rocky Mountains 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:

- *Moderate, continuous season-long grazing will convert the plant community to the Bluebunch Wheatgrass/Mixed Shrub Plant Community.*
- *Repeated Wild Fire or Brush Management + Prescribed Grazing will convert the HCPC to the Montana Wheatgrass/Three-tip Sagebrush/ Plant Community*

4.5.2 Range and Grazing Management Components of the Watershed Plan

Based on the information presented above, the following items are presented for inclusion in the watershed management plan:

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-5: Strategies recommended in the state and transition models associated with NRCS descriptions of the ecological sites found within the watershed should be adopted and employed to optimize range conditions through prescribed grazing management and best management practices.

Watershed Plan Component G-6: Prescribed fire may be utilized as a tool to assist in the restoration of range health areas benefitting by this treatment according to the state and transition models. Delineation of specific areas potentially benefitting from this practice was beyond the scope of this Level I project. However, based upon input from landowners and land managers and observations made during the completion of this investigation, it is evident that there are areas which would likely benefit from prescribed fires.

Watershed Plan Component G-7: Application of chemicals may be utilized as a tool to assist in the restoration of range health areas benefitting by this treatment according to the state and transition models. Delineation of specific areas potentially benefitting from this practice was beyond the scope of this Level I project. However, based upon input from landowners and land managers and observations made during the completion of this investigation, it is evident that there are areas which would likely benefit from chemical application for control of range (eg. Big Sagebrush).

These tools can be used to maintain and/or improve watershed function particularly when coupled with implementation of appropriate grazing management strategies.

4.6 Other Upland Management Opportunities

4.6.1 Noxious Weed and Undesirable Plant Control

The Hot Springs County Weed and Pest District implements aggressive, well planned, and cost-effective treatment and control measures for noxious and other weeds as available staffing and funding allow. The District has been successful in enlisting broadly based participation in various control programs, work days and workshops. The most effective overall strategy going forward would appear to be to assist the District in applying for additional grant funding, participate with in-kind efforts on work days and attend/support workshops and planning sessions.

4.6.2 Invasive Species Treatment

As previously discussed in Chapter 3, juniper encroachment has been identified as a management issue within the study area.

Juniper treatment and control can include a number of different methods and strategies, including but not necessarily limited to:

- Prescribed burning
- Manual/mechanical removal: bulldozing, hand pulling (seedling stage), mowing, chain sawing (followed by spot chemical treatment if needed)
- Chemical treatment: Chemicals as recommended by Wyoming Weed and Pest Control Council

The appropriate treatment strategy and method(s) depends on a large number of factors including especially: maturity stage of the infestation; density of the stand(s), access and costs.

4.6.3 Mechanical Removal

Mechanical control of junipers is being used in some areas of the Big Horn Basin. This method utilizes powerful machines that chop, grind, chip or otherwise remove the junipers. These machines have been used in the last few years to remove Russian Olive and Saltcedar in the Basin. Consequently, there are several types of machines available in the geographical area. Use of mechanical methods to remove juniper will likely result in a less significant infestation of Cheatgrass in comparison with prescribed burn alternatives.

Cost effectiveness of mechanical methods is questionable in heavily juniper infested areas. However, since issues associated with juniper infestation are more significant in more productive areas (deeper soils, flatter slope), mechanical removal may be cost effective if done while encroachment is scattered.

4.6.4 Prescribed Fire

Prescribed fire is often used to control juniper encroachment. However, as presented in Chapter 3, due to the relationship between fire and invasive annual grasses, use of prescribed fire in sagebrush restoration can be complicated (USGS 2002). Prescribed fires tend to raise levels of nitrogen for two to three months following a fire. Prescribed fires are also typically conducted in fall; timing which tends to increase the seed production of annual grasses such as cheatgrass (USGS 2002). Timing of actual burns is determined based upon the moisture content of the juniper; therefore fall is typically when the burns occur. However, windows of opportunity may present themselves in spring. When spring conditions are suitable, these may preferable as burns will have less impact on associated desirable fire-sensitive vegetation.

The Wyoming Partners in Flight, in coordination with the BLM, has summarized Best Management Practices for juniper woodlands to benefit wildlife in Wyoming. These recommendations were reviewed and incorporated herein, where appropriate, for consideration in the watershed management plan. The full document can be reviewed at: http://www.blm.gov/wildlife/plan/WY/menu.htm

The following BMP's pertaining to prescribed fire as a tool for controlling juniper encroachment or other habitat management were extracted from the document referenced above:

- *Use prescribed fire with great care or not at all in areas threatened by cheatgrass or medusahead invasion. Cheatgrass, an alien annual grass, has invaded many juniper woodlands, and when the tree and shrub overstory is removed by fire, this aggressive grass may dominate the site. If the native understory vegetation is depleted by competition from a dense tree overstory or by overgrazing, its ability to compete with cheatgrass and other noxious weeds is further hindered. In severe cases, fire suppression may be the only way to avoid continued cheatgrass invasion. In other cases, prescribed fire may be combined with artificial reseeding of native bunchgrass and forb species to curb the invasion of non-native annuals. A hot fire may destroy enough of the seed reserve of cheatgrass, which is mostly located in the litter or on the soil surface, to provide a brief time window for successful seeding of native species.* [NOTE, other desirable species may have merit for application on private lands (non-native and / or rhizomatous native species)]

- *Burns should be relatively small so a portion of the area contains nesting cover and mature stands at all times. Historically, small, patchy fires were probably the norm in most juniper woodlands. Burns to create openings in continuous or dense juniper should be on a small scale and designed to allow gradual reestablishment of juniper from adjacent stands. This will provide multiple ages of juniper cover across the landscape and over time*.

- *In areas known to support nesting birds, prescribed burns should not be conducted until fall to avoid loss of nesting cover. Burns should also be timed to consider the development and susceptibility of desired plants. Mid-summer burns can devastate native perennial grasses and forbs because they destroy plants before they have reached maturity. Mid-summer fires also favor cheatgrass, and can increase erosion when the soil is exposed to severe rainstorms.* [NOTE: Timing of actual burns is determined based upon the moisture content of the juniper; therefore fall is typically when the burns occur. However, windows of opportunity may present themselves in spring. When spring conditions are suitable, these may preferable as burns will have less impact on associated desirable fire-sensitive vegetation.]

- *Juniper stands are often difficult to ignite, and a reduced herbaceous ground cover may cause the fire to carry poorly. Burning has been most successful when the trees themselves were lit and managers did not depend on the understory to carry the fire into the canopy. Often the conditions necessary to get a fire to burn in juniper—hot, dry, windy weather—are too dangerous to allow burning. Temperatures above 70° F, relative humidity of less than about 25%, and winds of 10 to 30 mph provide the most favorable conditions for burning. A Haines index of 5 or 6, which indicates the lower atmosphere is dry and unstable, is helpful for large fire growth and successful burning. Cloud-free days are necessary for sustained fire spread, and ignition in drainage bottoms can help achieve crown fires.*

- *Natural fires less than 1,000 acres (400 ha) should not be suppressed except when significant stands are threatened or when fragmentation of old growth stands will become too severe. If a large increase in fire frequency and areas burned occurs then the policy should be reviewed by considering the amount of old growth left and its distribution over the landscape.*

- *Keep cattle off recovering sites for one to two growing seasons. Grazing after a burn can seriously damage soil and native perennials, delaying recovery.*

- *Develop a fire use plan before burning. It should include the following:*
    - *Burn Area – Clearly define the boundaries of the burn area.*
    - *Burn Objectives – Define the purpose of the prescribed burn, when it should be conducted, and the desired results.*
    - *Burn Prescription – Define the components of the burn that will accomplish your objectives. Time of year is a major burn prescription component for obtaining desired results.*
    - *Burn Plan – Clearly define how the prescribed burn will be carried out on the ground. Include components such as fuel treatments and fire lines to ensure the fire will carry into all areas to be burned, will not burn too hot or flare up, and will be contained within natural or constructed boundaries.*

4.6.5 Other Upland Components of the Watershed Management Plan

Based on the information presented above, the following items are presented for inclusion in the Buffalo Creek watershed management plan:

Watershed Plan Component O-1: Eradication efforts targeting noxious weeds and undesirable plants should continue. Landowners within the study area should continue to coordinate with the Hot Springs County Weed and Pest District in an effort to maximize use of available funds through specific programs such as District sponsored work days.

Watershed Plan Component 0-2: Juniper infestation mitigation efforts should be implemented. Prescribed burns should be planned and executed in coordination with the BLM where appropriate. Recommended guidelines should be incorporated into the site-specific burn plan in order to minimize associated impacts (noxious weeds, wildlife impacts, etc).

Watershed Plan Component O-3: Mechanical treatment of juniper infestation should be completed in areas where prescribed burns are not feasible or practical. Areas where there are insufficient fuels to sustain a burn or to generate the required fire movement should be evaluated with respect to mechanical removal of juniper.

4.7 The Buffalo Creek Watershed Management

The information presented in this chapter provides recommendations for improvements associated with:

- Irrigation System Rehabilitation,
- Upland Wildlife/Livestock Water Opportunities,
- Stream Channel Restoration Opportunities,
- Grazing Management Opportunities, and
- Other Management Opportunities.

These improvements focus on potential mitigation of several key issues that presently exist within the watershed. For the Buffalo Creek watershed, the watershed management plan consists of a compilation of the recommendations for each category. The plan is summarized in Table 4.3.

Table 4.3 Buffalo Creek Watershed Management Plan.

Plan Component	Project Name	Local Reference	Solar Pump	Spring Development	Stream Diversion	Pipeline	Stock Tank	Storage Tank	Stock Reservoir Rehabilitation	Stock Reservoir Construction
Watershed Plan Component: Irrigation System Components (I)										
Plan Component I	No Specific Irrigation Components were idenditified for inclusion in the Buffalo Creek Watershed Management Plan. Restoration of channel gradient at headgates rendered inoperable by channel incision could be accomplished with recommendations under Stream Channel Restoration Components (Plan Components C) below									
Watershed Plan Component: Livestock / Wildlife Water Supply Projects (L/W)										
Plan Component LW- 01	Pipeline Extension Project	Axtell-1	1	0	0	6,000	1	0	0	1
Plan Component LW- 02	Pipeline Extension Project	Axtell-2	0	0	0	6,000	1	0	0	1
Plan Component LW- 03	Antelope Creek Stock Reservoir Enhancement	Axtell-3	0	0	1	21,000	2	0	0	0
Plan Component LW- 04	Unnamed Spring Development / Reservoir Enhancement	Axtell-4	0	1	0	1,800	1	0	1	0
Plan Component LW- 05	Stock Reservoir Rehabilitation	Axtell-5	0	0	0	0	0	0	0	0
Plan Component LW 06	Spring Development and Pipeline System	Axtell-6	0	1	0	3,475	2	0	0	0
Plan Component LW 07	Existing Pipeline Enhancement	Axtell-7	1	0	0	1,100	0	0	3	1
Plan Component LW-08	Stock Pond Rehabilitation Projects	Axtell-8	0	0	0	0	0	0	1	0
Plan Component LW-09	Stock Pond Rehabilitation Project	Axtell-9	0	0	0	0	0	0	0	0
Plan Component LW-10	Spring Development Project	Axtell-10	0	1	0	4,250	2	0	2	0
Plan Component LW-11	Stock Pond Rehabilitation Project	Axtell-11	0	0	0	0	0	0	2	0
Plan Component LW 12	Stock Pond Rehabilitation Project	Axtell-12	0	0	0	0	0	0	0	0
Plan Component LW 13	Pipeline Extension Project	Axtell-13	1	0	0	2,500	0	0	0	0
Plan Component LW-14	Upper Grass Creek Pipeline Project	Axtell-14	0	1	0	11,400	3	0	0	0
Plan Component LW-15	Grass Creek Spring Development and Pipeline Project	Axtell-15	0	1	0	11,500	3	0	0	0
Plan Component LW-16	Wild Horse Butte Spring Development	Jones-1	0	1	0	500	1	0	0	0
Plan Component LW-17	Blue Springs Draw Pipeline Project	Jones-2	1	0	0	16,100	2	2	0	0
Plan Component LW-18	Copper Mountain Pipeline Project	Thoren-1	0	1	0	6,600	3	0	0	0
Plan Component LW-19	Copper Mountain Pipeline Extension Project	Thoren-2	0	1	0	1,100	2	0	0	0
Plan Component LW-20	Spring Development Project	Thoren-3	0	1	0	1,100	1	0	0	0
Plan Component LW-21	Spring Enhancement Project	Thoren-4	1	1	0	15,000	2	1	0	0
Plan Component LW-22	Black Willow Draw Well Enhancement Project No. 1	Belden-1	1	0	0	200	1	0	0	0
Plan Component LW-23	Black Willow Draw Well Enhancement Project No. 2	Belden-2	1	0	0	1,400	3	0	0	0
Plan Component LW-24	Black Willow Draw Spring Enhancement Project	Belden-3	0	1	0	400	2	0	0	0
Plan Component LW-25	Grass Creek Pipeline	Baird-1	0	0	1	56,000	7	0	0	0
Plan Component LW-26	Johnson Spring Rehabilitation	Henthorne-1	0	1	0	0	0	0	0	0
Plan Component LW-27	Buchanon Pipeline Project- Phase I	Jennigis - 1	1	0	0	11,000	1	2	0	0
Plan Component LW-28	Buchanon Pipeline Project- Phase II	Jennigis - 2	0	0	0	16,500	4	1	0	0
Plan Component LW-29	Ditch Creek Parallel Pipeline	Baird, John-1	0	0	1	16,500	4	0	0	0
Plan Component LW-30	Jones Creek Pipeline System	ACE-01	1	0	1	17,000	5	1	0	0
Plan Component LW-31	Antelope Creek Pipeline System LW-31	ACE-02	0	0	1	79,600	10	0	0	0
Plan Component LW-32	Guzzler Installation	ACE-03	0	0	0	0	0	0	0	0
			9	12	5	308025	63	7	9	3
Watershed Plan Component: Stream Channel Restoration Projects (C)										
Plan Component C-1	Installation of stream channel degradation/incision mitigation measures.									
Plan Component C-2	Installation of stream bank erosion mitigation measures									
Watershed Plan Component: Grazing Management Opportunities (G)										
Plan Component G-1	Expansion of grazing distribution / limited reliance on riparian areas.									
Plan Component G-2	Fencing to create pastures of similar ecological condition to enable a rest-rotation grazing system.									
Plan Component G-3	Strategic salting and herding are other tools that can be used to enhance grazing distribution.									
Plan Component G-4	Consideration of wildlife needs in upland water source development (escape ramps, wildlife watering facilities, etc).									
Plan Component G-5	Utilization of Ecological Site Description State and Transition Modeling to optimize range conditions.									
Plan Component G-6	Use of prescribed fire to assist in the restoration of range health areas benefitting by this treatment according to the state and transition models.									
Plan Component G-6	Application of chemicals may be utilized as a tool to assist in the restoration of range health areas benefitting by this treatment according to the state and tran									
Watershed Plan Component: Other Management Opportunities (O)										
Plan Component O-1	Continuaton of eradication efforts targeting noxious weeds and undesirable vegetation									
Plan Component O-2	Prescribed burns planned and executed in an effort to control juniper encroachment.									
Plan Component O-3	Mechanical treatment of juniper infestation should be completed in areas where prescribed burns are not feasible or practical.									

V. PERMITS

The following discussion presents the results of an early regulatory process analysis for the types of alternative projects that have been identified in Chapter 4 above. The purpose of this analysis is to characterize the known and likely environmental processes, permits and related requirements and conditions associated with the alternative projects, including identification of environmental documentation, permits, agency clearances and approvals, and agency coordination steps that would be required for implementation of the proposed actions and alternatives.

Many of the potential projects described in this plan will be subject to the National Environmental Policy Act (NEPA) and other federal environmental regulations administered by federal agencies such as the EPA, Bureau of Land Management (BLM), Army Corps of Engineers (COE), and/or the U.S. Fish and Wildlife Service (FWS). The Wyoming agencies which may have environmental, land use, and other regulatory approval requirements include, but are not necessarily limited to the Department of Environmental Quality (WDEQ), State Engineer's Office (WSEO), State Historic Preservation Officer (SHPO), Board of Land Commissioners through the State Lands and Investments Board (SLIB), and Game and Fish Department (WGFD).

Much of the following text was extracted from previous watershed investigations conducted on behalf of the Wyoming Water Development Commission (WWDC) in which Anderson Consulting Engineers (ACE) participated. Specifically, the Nowood River Storage and the Watershed Investigation (ACE, 2010) and the Clear Creek Watershed Management Plan, Level I (States West Water Resources Consultants, 2011) are referenced here as sources of permitting information. The previously prepared descriptions of the permitting process were revised to reflect conditions anticipated within the Nowood River watershed.

5.1 NEPA Compliance And Documentation

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

For this project, it is likely that BLM would be the lead federal agency for implementation of the NEPA process for projects on lands under their administration. The COE would presumably be the lead federal agency otherwise where wetlands may be impacted. It is also possible that these agencies may work out a shared lead under a Memorandum of Understanding (MOU) if there are significant issues best led by both agencies for a given project.

The applicability of NEPA to projects other than major (non-stock pond) reservoir storage must be determined on a case-by-case basis. For example, proposed new wildlife/livestock watering developments, including especially tank/pipeline systems that cross and/or serve federal or state rangeland will require that an appropriate NEPA process be followed. In this case, and for many of the lesser potential impact projects (e.g., a well, stock/wildlife pond, guzzler, etc.), it is possible if not likely that an EA process will be found appropriate rather than a full EIS (see related discussion in Section 5.1 above).

BLM. Under current practice, NEPA evaluations and processes for projects that may be proposed where BLM is the lead federal agency will be performed by BLM staff or qualified, independent third party experts responsible to BLM. These experts may include specialists from other federal and/or state agencies working under memoranda of understanding (MOU) or other appropriate arrangement(s). At the time of this reporting, compliance with NEPA will be guided in large part by the Record of Decision (ROD) and Approved Resource Management Plan for the Washakie Resource Management Plan (BLM, 1988) and any subsequent new or additional guidance and/or updates. The ROD and Plan were developed on the basis of a NEPA-compliant Environmental Impact Statement (EIS) (BLM, 1987). Currently, the BLM is in the process of completing the Bighorn Basin Resource Management Plan Revision and associated EIS. The project is a combined effort revising RMPs for both the BLM Cody and BLM Worland Field Offices. Public lands within the field offices are currently managed according to three RMPs: the Washakie RMP (1988) and Grass Creek RMP (1998) for the Worland Field Office; and the Cody RMP (1990). The field offices intend to produce a single RMP and EIS encompassing both field offices that will be called the Bighorn Basin RMP Project. Each field office will issue its own Record of Decision for its jurisdictional area.

Other State/Federal Agencies. Depending on the specific circumstances of a particular project, it is possible that another state or federal agency may lead the NEPA process. For example, a project proposed within the Bighorn National Forest would presumably be led by the U.S. Forest Service, most likely from the Cody District office. All of the relevant state and federal land management agencies have management plans developed from NEPA-compliant processes where appropriate. As discussed above for BLM, these plans will guide these agencies' NEPA process for any applicable proposed projects or improvements.

Watershed-Wide Environmental Analysis. Given the significant number of planned and potential wildlife/livestock water development projects and the opportunity for larger-scale, cooperative projects as discussed identified Chapter 4, it is recommended that serious consideration be given to the potential benefits of conducting a comprehensive "watershed-wide" environmental analysis for these and other potential water-resources related improvement projects. A key benefit of this approach would be developing a single baseline characterization and impacts assessment of the relevant environmental issues associated with these types of projects rather than repetitively for many similar individual projects. This should, in turn, substantially reduce the overall resources and time necessary to conduct the required environmental permitting (including especially NEPA compliance) for these projects. If

necessary, the overall environmental analysis could be supplemented on a case-by-case basis for a particular issue in a focused, time and resource efficient manner.

5.2 Permitting/Clearances/Approvals

Section 404 Permit. Projects involving work with the stream channels in the study area could require a Section 404 Dredge and Fill Permit from the COE, Omaha District. Water storage alternatives were not identified in this watershed management plan. These activities typically require extensive coordination and permitting efforts. Those projects identified herein will typically not require 404 permitting.

The 404 permit language states that activities associated with existing irrigation infrastructure and activities are exempt from permitting requirements. Consequently, stream channel gradient restoration efforts, when planned in conjunction with the inoperable diversion headgates discussed in Chapters 3 and 4, would likely not require Section 404 permits.

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

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

Laws and Regulations Addressing Cultural Resources. Because federal approvals are likely involved with any of the identified alternatives, a consideration of effects on cultural resources must be undertaken (Section 106 consultation), as required under the following laws and regulations: the National Historic Preservation Act (NHPA) of 1966 (16 U.S.C. § 470 et seq.); the National Environmental Policy Act (NEPA) of 1969 (42 U.S.C., § 4321); the Archaeological Resources Protection Act (ARPA) of 1979 (16 U.S.C. § 470aa et seq.); the National Park Services (NPS) procedures concerning the National Register of Historic Places (NR) (36 CFR Part 60); the Advisory Council on Historic Preservation's Procedures for the Protection of Cultural Properties (36 CFR Part 800); the Treatment of Archaeological Properties of 1980: Determination of Eligibility for Inclusion in the NR (36 CFR 63); the Secretary of Interior's Standards and Guidelines for Archaeological Historical Preservation of 1983; Reservoir Salvage Act of 1960; and the

1974 Amendment to the Reservoir Salvage Act of 1960. The State of Wyoming Historic Preservation Office (SHPO) coordinates with federal agencies in determining the significance of cultural resources potentially affected by ground disturbing activities.

In addition, consultation with relevant Native American groups concerning traditional cultural properties is required under the American Indian Religious Freedom Act of 1978 (AIRFA, P.L. 95-341.42 U.S.C. § 1996) and Section 4 of ARPA of 1979. Guidelines for evaluation of traditional cultural properties are contained in Bulletin 38 issued by the National Park Service.

Wyoming Board of Land Commissioners. The Wyoming Board of Land Commissioners through the State Lands and Investments Board (SLIB) is responsible for regulating all activities on state lands, including granting of rights-of-way. Any facility, utility, road, railroad, ditch or reservoir to be constructed on state or school lands must have a right-of-way, as required in the "Rules and Regulations Governing the Issuance of Rights Of Way" (W.S. 36-20 and W.S. 36-202).

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

Although no specific projects have been identified entailing construction of dams greater than 20 feet high, the following information is included as background for future planning.

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

Wyoming State Engineer's Office Ditch Enlargement Permit. In addition to the permits and clearances that will be required for reservoir construction, existing irrigation ditches may required to convey water to off-channel reservoirs. If so, this effort would require an enlargement filing with the Wyoming SEO. Even if physical enlargement of the existing ditch was found to not be required, the enlargement filing would be a legal formality as a water right requirement.

Wyoming Department of Environmental Quality – National Pollution Discharge Elimination System (NPDES) permit and Section 401 Certification. The federal Clean Water Act is administered in Wyoming by the Department of Environmental Quality (WDEQ), Water Quality Division (WQD) consistent with the

Wyoming Environmental Quality Act. The Section 401 Certification is the State's approval to ensure that the activities authorized under Section 404 meet state water quality standards and do not degrade water quality. Any discharge of pollutants into the broadly defined "waters of the state" requires application to and permit issuance by WQD in accord with WQD's Rules and Regulations. This body of regulations sets forth classification of surface and groundwater uses and establishes water quality standards (Wyoming Water Quality Standards). The WQD administers the NPDES permit system including storm water permits and construction-related, short-term discharge permits.

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

EPA has oversight responsibility for federal Clean Water Act programs delegated to and administered by the State Water Quality Division. EPA also may intervene to resolve interstate disputes where discharges of pollutants in an upstream state may affect water quality in a downstream state.

Mining Permit. A Wyoming mining permit is not required for development of an aggregate and/or borrow material source solely for use in construction of one of the various reservoir alternatives and whose product is not for commercial sale. Commercial sources of aggregate, rock, or other mined materials are responsible for obtaining and maintaining all required permits and clearances for their operations.

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

Other. In addition to the above, there may be other permits and clearances required for a given dam and reservoir project. These might include permits typically required to be provided by the construction contractor (e.g., air quality permit; trash/slash burning permit; etc.).

5.3 Environmental Considerations

Proposed, Threatened and Endangered Species. The following species have the potential to occur within the proposed project areas of the watershed:

Endangered: Black-footed Ferret (*Mustela nigripes)*
Threatened: Gray Wolf *Canis lupus*

(Wyoming Natural Diversity Database [WYNDD], 2012).

Other Animal Species of Concern. The Wyoming Natural Diversity Database (WYNDD) lists several other species of concern existing within the study area. This list was presented and discussed in Chapter 3 of this report and contained 1 amphibian, 2 reptiles, 0 fish, 18 birds, 13 mammals, and 2 mollusks.

The potential exists for some of these species to occur within appropriate habitats within the watershed. Although none of these species receive federal or state protection, sage grouse are identified as a sensitive species/species of concern and merit special attention as discussed in some detail in the following paragraphs.

The greater sage grouse (Centrocercus urophasianus) is a native species to the area and is almost totally dependent on open sagebrush plain. The males will gather in the early spring to lek (breeding ground) locations to start their elaborate courtship rituals (strutting). They are considered omnivores, eating insects, sagebrush and seeds; but are most reliant upon sagebrush for both cover from predators and for food.

The greater sage grouse is listed as a sensitive species by the BLM, and a species of concern by WGFD. The BLM definition of a sensitive species is as follows: species that could easily become endangered or extinct in the state, including: (a) species under status review by the FWS/National Marine and Fisheries Service; (b) species whose numbers are declining so rapidly that Federal listing may become necessary; (c) species with typically small or fragmented populations; and (d) species inhabiting specialized refugia or other unique habitats. WGFD lists the greater sage grouse as: species that are widely distributed, with population status or trends unknown but suspected to be stable; habitat restricted or vulnerable but no recent or on-going significant loss; species likely sensitive to human disturbance. The sage grouse are not listed as a Threatened or Endangered species and does not receive any protections from the Endangered Species Act; however, BLM and WGFD have developed restrictions/recommendations to help protect the sage grouse.

BLM has recommended that there be no surface occupancy within 0.25-mile radius of any known lek location or a 2-mile radius during the breeding season, on BLM land or lands adjacent to BLM lands. Recent studies have shown that the 2-mile radius is not sufficient, showing declines in the number of males returning to the leks with activities occurring beyond the 2-mile radius. Thus, the current recommendations may change over time.

It is recommended that coordination with BLM and WGFD occur regarding any proposed or alternative project that has the potential to impact sage grouse habitat. Note that providing water to areas where water is limited may create a beneficial impact for sage grouse and should be considered when evaluating the net potential impacts to this species.

As discussed in Chapter 3, the majority of the study area lies outside the currently delineated core areas. Consequently, permit constraints would not be anticipated. However, construction of projects involving BLM lands or certain funding opportunities could potentially involve consideration of sage grouse habitat and impacts.

Rare Plant Species of Concern. This section will be completed in the final report upon receipt of information from the WYNDD.

Big Game. The Buffalo Creek watershed study area contains portions of crucial big game habitat for antelope, mule deer, elk and moose managed by the Wyoming Game and Fish Department (WGFD) and big game (elk and moose) parturition (birthing) sites. The WGFD maps the seasonal ranges by herd unit for each big game species and makes special note of areas listed as crucial habitat. Crucial habitat or range is defined as those seasonal ranges or habitats (mostly winter range) that have been documented as the determining factor in a population's ability to maintain its self at a certain level over a long period of time.

Wetland Resources. Formal wetland delineation in accordance with the Corps of Engineers guidelines was beyond the scope of this Level I study and was not conducted. GIS digital mapping from the National Wetland Inventory (NWI) was acquired to preliminarily identify wetland habitats in the study area. Likewise, LANDFIRE data were obtained and evaluated as presented in Chapter 3. The various locations identified as potential alternative reservoir storage sites are all located on what are considered intermittent to perennial riverine systems. These systems are associated with streambeds and their associated wetland/riparian habitat. Riparian habitats are considered to be valuable habitat for both mammals and birds, along with assisting in reducing flooding. The creation of a reservoir on the drainage would inundate the basin bottoms changing the landscape/habitat.

Some of the areas identified on the NWI maps and within the LANDFIRE datasets as wetlands or other riparian system categories, may in fact not qualify as jurisdictional wetlands upon subsequent detailed examination in the field. This is due to inherent limitations in the aerial photography or satellite imagery-based methodologies used to prepare the NWI maps. In general, our previous experience

suggests that estimates of wetland acreage based on the NWI maps or within LANDFIRE datasets tend to be conservatively high and actual acreage of jurisdictional wetlands may be less.

Formal wetlands delineation would be necessary prior to construction at any proposed reservoir storage site, and in any other areas of proposed disturbance (e.g., at spring development sites and along associated pipeline alignments) to determine the level of impacts to wetlands located in the alternative project area and to identify and quantify any necessary mitigation of those impacts.

5.4 Land Ownership and Property Owners

Where applicable, permission should be negotiated for easement/right-of-access for all construction activities associated with the project.

VI. COST ESTIMATES

Conceptual-level costs have been developed for each of the alternative potential projects identified and described in Chapter 4. The bases for these costs are described in the following subsections for each of the overall project categories. Cost estimates presented represent 2010 dollars.

6.1 Irrigation System Components

No specific irrigation system components were identified for incorporation within the Buffalo Creek Watershed Management Plan.

6.2 Upland Wildlife/Livestock Water Components

The anticipated costs associated with these components of the watershed management plan were based upon previous experience completing similar projects in the Bighorn Basin, current NRCS EQIP cost tables, and current costs of various other system components obtained from reliable sources.

Table 6.1 presents the estimated costs associated with each of the upland wildlife / livestock water source components of the watershed management plan. The following components are common to most of the systems and are itemized below for general reference.

Spring Developments: Typical costs range from $1,000 to $5,000 depending on size and yield of the spring. For the purposes of this Level I investigation a cost of $3,000 was used because site-specific information was not available.

Pipelines: A cost of approximately $1.34 / lineal foot (installed) for 1.5-inch diameter HDPE pipe (low pressure) was used and is based upon recently completed projects in the Bighorn Basin. Costs associated with larger pipe were based upon information obtained from local suppliers: 2-inch diameter HDPE pipe

	Low Pressure	High Pressure
1.5 inch	$1.34	- -
2 inch	$1.70	$2.05
4 inch	$3.54	$4.75
6 inch	$5.5	$8.11

Length of pipe associated with each project was approximated within the GIS environment.

Water Tanks (Stock and Storage): Unless otherwise noted, a cost of $3,000 per stock tank was used for a typical 1,200 gallon rubber-tire type tank. Several projects involved use of galvanized stock tanks which could be hauled in sections and assembled on site; costs for these facilities were obtained from the manufacturers. Cost of storage tanks were assumed to be approximately $1 per gallon of storage.

Table 6.1 Conceptual Cost Estimates: Livestock / Wildlife Components

Project		Watershed Component L/W-1	Watershed Component L/W-2	Watershed Component L/W-3	Watershed Component L/W-4	Watershed Component L/W-5	Watershed Component L/W-6	Watershed Component L/W-7	Watershed Component L/W-8	Watershed Component L/W-9
Description		**Extension of existing pipeline system/new tank/new stock pond**	**Extension of existing pipeline system/new tank/new stock pond**	**Antelope Creek diversion to pipeline system**	**Develop Existing Spring / install stock tank**	**Clean Existing Stock Reservoir**	**Develop Existing Spring / install stock tank / Pipeline**	**Extend Existing Pipeline Project**	**Rehabilitate / Clean Existing Stock Reservoirs**	**Rehabilitate / Clean Existing Stock Reservoir**
Project Name		**Axtell-1**	**Axtell-2**	**Axtell-3**	**Axtell-4**	**Axtell-5**	**Axtell-6**	**Axtell-7**	**Axtell-8**	**Axtell-9**
Water Source:		Extension of existing pipeline	Extension of existing pipeline	Diversion Structure	Existing Spring	Existing Reservoir	Existing Spring	Existing Pipeline	Existing Stock Resevoirs	Existing Stock Resevoir
Well Construction / Spring Development	Mobilization	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
	Source:	Existing system	NA	NA	Existing Spring	NA	Existing Spring	Existing Diversion	Existing Stock Resevoirs	Existing Stock Resevoir
	Units (each)	NA			1		1	0	0	0
	Depth Each				NA		NA	NA	NA	NA
	Unit Cost ($/LF wells ror $/EA springs				$3,000		$3,000			
	Well Screen (LF each well)				NA					
	Well Screen ($/LF)				NA					
	Component Subtotal	$3,000	$3,000	$3,000	$6,000	$3,000	$6,000	$3,000	$3,000	$3,000
Stock Pond / Guzzler Construction / Rehabilitation	Units (each)	1	1	NA	NA	NA	NA	1		
	Pond/Guzzler Const. Unit Cost ($ EA)	$8,000	$8,000					$5,000		
	Number of Ponds to Seal	NA	NA					$0	3	1
	Bentonite Sealing (total square feet)								20,500	12,000
	Tons (4lbs/ft2)								41.00	24.00
	Bentonite Cost per Ton								$86	$86
	Bentonite Cost								$3,526	$2,064
	Transportation (15% of Bentonite)								$529	$310
	Pond Component Subtotal	$8,000	$8,000	$0	$0	$0	$0	$5,000	$4,055	$2,374
Pump	Units (EA)	1	Solar pump assumed to be installed with completion of Project L/W-1	NA	NA	NA	NA	1	NA	NA
	Type	Solar						Solar		
	Unit Cost (EA)	$8,640						$8,640		
	Component Subtotal	$8,640						$8,640		
Pipeline	**Low Pressure Pipe Diameter:**	1.5	1.5	1.5	1.5	NA	1.5	1.5	NA	NA
	Units (LF)	6,000	6,000	21,000	1,800		3,475	1,100		
	Unit Cost (EA)	$1.34	$1.34	$1.34	$1.34		$1.34	$1.34		
	Component Subtotal	$8,040	$8,040	$28,140	$2,412		$4,657	$1,474		
	High Pressure Pipe Diameter:	NA	NA	NA	NA		NA	NA		
	Units (LF)									
	Unit Cost (EA)									
	Component Subtotal									
Additional Storage Tanks	Units (EA)	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Size (gal)									
	Unit Cost ($/gal)									
	Component Subtotal									
Livestock / Wildlife Water Tanks	Units (EA)	1	1	2	1	NA	2	NA	NA	NA
	Size (gal)	1,200	1,200	1,200	1,200		1,200			
	Unit Cost	$3,000	$3,000	$3,000	$3,000		$3,000			
	Component	$3,000	$3,000	$6,000	$3,000		$6,000			
Miscellaneous	Item	NA	NA	Diversion Structure	Fencing	Clean Existing Stock Reservoir	Fencing	NA	Clean Existing Stock Reservoir	Clean Existing Stock Reservoir
	Units (Each)			1	3600	1	1000		3	1
	Unit Cost ($/ea)			$5,000	$2.50	$3,000	$2.50		$3,000	$3,000
	Component Subtotal			$5,000	$9,000.00	$3,000	$2,500.00		$9,000	$3,000
Construction Subtotal		$30,680	$22,040	$42,140	$20,412	$6,000	$19,157	$18,114	$16,055	$8,374
Engineering (10%)		$3,068	$2,204	$4,214	$2,041	$0	$1,916	$1,811	$0	$0
Constuction and Engineering Subtotal		$33,748	$24,244	$46,354	$22,453	$6,000	$21,072	$19,925	$16,055	$8,374
Contingency (15%)		$5,062	$3,637	$6,953	$3,368	$900	$3,161	$2,989	$2,408	$1,256
Total Construction Cost		$38,810	$27,881	$53,307	$25,821	$6,900	$24,233	$22,914	$18,463	$9,630
Final Plans and Specs		$500	$500	$2,000	$500	$500	$500	$2,000	$0	$0
Additional		$0	$0	$0	$0	$0	$0	$0	$0	$0
Permitting / Legal Fees / Access and Rights of Way		$0	$0	$1,000	$500	$0	$500	$1,000	$0	$0
Total Project Cost		**$39,310**	**$28,381**	**$56,307**	**$26,821**	**$7,400**	**$25,233**	**$25,914**	**$18,463**	**$9,630**

Table 6.1 Conceptual Cost Estimates: Livestock / Wildlife Components (continued)

Project		Watershed Component L/W-10	Watershed Component L/W-11	Watershed Component L/W-12	Watershed Component L/W-13	Watershed Component L/W-14	Watershed Component L/W-15	Watershed Component L/W-16	Watershed Component L/W-17	Watershed Component L/W-18
Description		**Develop Existing Spring / install stock tank / Pipeline**	**Rehabilitate / Clean Existing Stock Reservoirs**	**Rehabilitate / Clean Existing Stock Reservoirs**	**Extend Existing Pipeline / Provide alternative source to existing well**	**Develop Existing Spring / install stock tank / Pipeline**	**Develop Existing Spring / install stock tank / Pipeline**	**Redevelop Existing Spring**	**Develop Existing Spring**	**Develop Existing Spring**
Project Name		**Axtell-10**	**Axtell-11**	**Axtell-12**	**Axtell-13**	**Axtell-14**	**Axtell-15**	**Jones-1**	**Jones-2**	**Thoren-1**
Water Source:		Existing Spring	Existing Stock Resevoir	Existing Stock Resevoir	Existing Pipeline	Existing Spring	Existing Spring	**Existing Spring**	**Existing Spring**	**Existing Spring**
Well Construction / Spring Development	Mobilization	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
	Source:	Existing Spring	Existing Stock Resevoir	Existing Stock Resevoir	Existing Pipeline	Existing Spring	Existing Spring	Existing Spring	Existing Spring	Existing Spring
	Units (each)	1	0	0	0	1	1	1	1	1
	Depth Each	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Unit Cost ($/LF wells ror $/EA springs	$3,000				$3,000	$3,000	$3,000	$3,000	$3,000
	Well Screen (LF each well)									
	Well Screen ($/LF)									
	Component Subtotal	$6,000	$3,000	$3,000	$3,000	$6,000	$6,000	$6,000	$6,000	$6,000
Stock Pond / Guzzler Construction / Rehabilitation	Units (each)	NA			NA	NA	NA	NA	NA	NA
	Pond/Guzzler Const. Unit Cost ($ EA)									
	Number of Ponds to Seal		2	2						
	Bentonite Sealing (total square feet)		32,000	9,000						
	Tons (4lbs/ft2)		64.00	18.00						
	Bentonite Cost per Ton		$86	$86						
	Bentonite Cost		$5,504	$1,548						
	Transportation (15% of Bentonite)		$826	$232						
	Pond Component Subtotal	$0	$6,330	$1,548	$0	$0	$0	$0	$0	$0
Pump	Units (EA)	NA	NA	NA	NA	NA	NA	NA	1	NA
	Type								Solar	
	Unit Cost (EA)								$8,640	
	Component Subtotal								$8,640	
Pipeline		1.5	NA	NA	1.5	1.5	1.5	1.5	1.5	1.5
	Low Pressure Pipe Diameter:									
	Units (LF)	4,250			2,500	11,400	11,500	500	12,000	6,600
	Unit Cost (EA)	$1.34			$2.34	$1.34	$1.34	$1.34	$1.34	$1.34
	Component Subtotal	$5,695			$5,850	$15,276	$15,410	$670	$16,080	$8,844
	High Pressure Pipe Diameter:	NA			NA	NA	NA	NA	2.0	NA
	Units (LF)								6,100	
	Unit Cost (EA)								$2.34	
	Component Subtotal								$14,274	
Additional Storage Tanks	Units (EA)	NA	NA	NA	NA	NA	NA	NA	2	NA
	Size (gal)								15,000	
	Unit Cost ($/gal)								$1	
	Component Subtotal								$30,000	
Livestock / Wildlife Water Tanks	Units (EA)	2	NA	NA	NA	3	3	1	2	3
	Size (gal)	1,200				1,200	1,200	1,200	1,200	1,100
	Unit Cost	$3,000				$3,000	$3,000	$3,000	$3,000	$1,000
	Component	$6,000				$9,000	$9,000	$3,000	$6,000	$3,000
Miscellaneous	Item	Fencing	Clean Existing Stock Reservoirs	Clean Existing Stock Reservoirs	NA	Fencing	Fencing	Fencing	Fencing	Fencing
	Units (Each)	1000	2	2		1000	1000	1000	1000	1000
	Unit Cost ($/ea)	$2.50	$5,000	$5,000		$2.50	$2.50	$2.50	$2.50	$2.50
	Component Subtotal	$2,500.00	$10,000	$10,000		$2,500.00	$2,500.00	$2,500.00	$2,500.00	$2,500.00
Construction Subtotal		$20,195	$19,330	$14,548	$8,850	$32,776	$32,910	$12,170	$83,494	$20,344
Engineering (10%)		$2,020	$0	$0	$885	$3,278	$3,291	$1,217	$8,349	$2,034
Constuction and Engineering Subtotal		$22,215	$19,330	$14,548	$9,735	$36,054	$36,201	$13,387	$91,843	$22,378
Contingency (15%)		$3,332	$2,899	$2,182	$1,460	$5,408	$5,430	$2,008	$13,777	$3,357
Total Construction Cost		$25,547	$22,229	$16,730	$11,195	$41,462	$41,631	$15,395	$105,620	$25,735
Final Plans and Specs		$2,000	$0	$0	$500	$500	$500	$500	$1,000	$500
Additional		$0	$0	$0	$0	$0	$0	$0	$0	$0
Permitting / Legal Fees / Access and Rights of Way		$500	$0	$0	$500	$1,000	$1,000	$500	$1,000	$500
Total Project Cost		**$28,047**	**$22,229**	**$16,730**	**$12,195**	**$42,962**	**$43,131**	**$16,395**	**$107,620**	**$26,735**

Table 6.1 Conceptual Cost Estimates: Livestock / Wildlife Components (continued)

Project		Watershed Component L/W-19	Watershed Component L/W-20	Watershed Component L/W-21	Watershed Component L/W-22	Watershed Component L/W-23	Watershed Component L/W-24	Watershed Component L/W-25	Watershed Component L/W-26	Watershed Component L/W-27
Description		**Develop Existing Spring**	**Develop Existing Spring**	**Spring Enhancement**	**Utilize Existing Well**	**Utilize Existing Well**	**Redevelop Existing Spring**	**New Diversion / Pipeline**	**Redevelop Existing Spring**	**Buchanon Pipeline Project Phase I**
Project Name		**Thoren-2**	**Thoren-3**	**Thoren-4**	**Belden-1**	**Belden-2**	**Belden-3**	**Baird-1**	**Henthorne-1**	**Jennigis - 1**
Water Source:		**Existing Spring**	**Existing Spring**	**Existing Spring**	**Existing Well**	**Existing Well**	**Existing Spring**	**Grass Creek Diversion**	**Existing Spring**	**Existing Well**
Well Construction / Spring Development	Mobilization	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
	Source:	Existing Spring	Existing Spring	Existing Spring	Existing Well	Existing Well	Existing Spring	Existing Well	Existing Spring	Existing Well
	Units (each)	1	0	0	0	0	1	0	1	0
	Depth Each	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Unit Cost ($/LF wells ror $/EA springs	$3,000					$3,000		$3,000	
	Well Screen (LF each well)									
	Well Screen ($/LF)									
	Component Subtotal	$6,000	$3,000	$3,000	$3,000	$3,000	$6,000	$3,000	$6,000	$3,000
Stock Pond / Guzzler Construction / Rehabilitation	Units (each)	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Pond/Guzzler Const. Unit Cost ($ EA)									
	Number of Ponds to Seal									
	Bentonite Sealing (total square feet)									
	Tons (4lbs/ft2)									
	Bentonite Cost per Ton									
	Bentonite Cost									
	Transportation (15% of Bentonite)									
	Pond Component Subtotal	$0	$0	$0	$0	$0	$0	$0	$0	$0
Pump	Units (EA)	NA	NA	1	1	1	NA	NA	NA	2
	Type			Solar	Solar	Solar				Electric (1) and Solar (1)
	Unit Cost (EA)			$8,640	$8,640	$8,640				$8,640
	Component Subtotal			$8,640	$8,640	$8,640				$17,280
Pipeline		1.5	1.5	1.5	1.5	1.5	1.5	2.0	NA	NA
	Low Pressure Pipe Diameter:									
	Units (LF)	1,100	575	6,740	200	1,400	400	56,000		
	Unit Cost (EA)	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.70		
	Component Subtotal	$1,474	$771	$9,032	$268	$1,876	$536	$95,200		
	High Pressure Pipe Diameter:	NA	NA	NA	NA	NA	NA	NA	NA	2.0
	Units (LF)									11,000
	Unit Cost (EA)									$2.10
	Component Subtotal									$23,100
Additional Storage Tanks	Units (EA)	NA	NA	1	NA	NA	NA	NA	NA	2
	Size (gal)			15,000						15,000
	Unit Cost ($/gal)			$1						$1
	Component Subtotal			$15,000						$30,000
Livestock / Wildlife Water Tanks	Units (EA)	2	1	2	1	3	2	7	NA	1
	Size (gal)	1,100	1,100	1,100	1,200	1,200	1,200	1,200		1,200
	Unit Cost	$1,000	$1,000	$1,000	$3,000	$3,000	$3,000	$3,000		$3,000
	Component	$2,000	$1,000	$2,000	$3,000	$9,000	$6,000	$21,000		$3,000
Miscellaneous	Item	Fencing	Fencing	NA	NA	NA	Fencing	Diversion Structure	Fencing	NA
	Units (Each)	1000	1000				1000	1	1000	
	Unit Cost ($/ea)	$2.50	$2.50				$2.50	$5,000.00	$2.50	
	Component Subtotal	$2,500.00	$2,500.00				$2,500.00	$5,000.00	$2,500.00	
Construction Subtotal		$11,974	$7,271	$37,672	$14,908	$22,516	$15,036	$124,200	$8,500	$76,380
Engineering (10%)		$1,197	$727	$3,767	$1,491	$2,252	$1,504	$12,420	$850	$7,638
Constuction and Engineering Subtotal		$13,171	$7,998	$41,439	$16,399	$24,768	$16,540	$136,620	$9,350	$84,018
Contingency (15%)		$1,976	$1,200	$6,216	$2,460	$3,715	$2,481	$20,493	$1,403	$12,603
Total Construction Cost		$15,147	$9,197	$47,655	$18,859	$28,483	$19,021	$157,113	$10,753	$96,621
Final Plans and Specs		$500	$500	$500	$500	$500	$500	$2,000	$500	$1,000
Additional		$0	$0	$0	$0	$0	$0	$0	$0	$0
Permitting / Legal Fees / Access and Rights of Way		$500	$500	$1,000	$1,000	$500	$500	$2,000	$500	$500
Total Project Cost		**$16,147**	**$10,197**	**$49,155**	**$20,359**	**$29,483**	**$20,021**	**$161,113**	**$11,753**	**$98,121**

Table 6.1 Conceptual Cost Estimates: Livestock / Wildlife Components (continued)

Project		Watershed Component	Watershed Component			Watershed Component	Watershed Component									
		L/W-28	L/W-29			L/W-30	L/W-31									
Description		Buchanon Pipeline Project Phase II	New Diversion / Pipeline			New Diversion / Pipeline	New Diversion / Pipeline									
Project Name		Jennigis - 2	Baird, John-1			ACE-1	ACE-2 (Antelope Creek Pipeline Project)									
			Option A: 2-inch	Option A: 4-inch	Option A: 6-inch		Option A: 4-inch Diversion					Option A: 6-inch Diversion				
Water Source:		Existing Well / Extend Phase I Project	New Diversion / Pipeline			Jones Creek Diversion	New Diversion on Antelope Creek									
Well Construction / Spring Development	Mobilization	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000					$3,000				
	Source:		New Diversion / Pipeline	New Diversion / Pipeline	New Diversion / Pipeline	New Diversion / Pipeline	New Diversion / Pipeline					New Diversion / Pipeline				
	Units (each)		1	1	1	0	1					1				
	Depth Each		NA	NA	NA	NA	NA					NA				
	Unit Cost ($/LF wells ror $/EA springs		$3,000	$3,000	$3,000		$5,000					$5,000				
	Well Screen (LF each well)															
	Well Screen ($/LF)															
	Component Subtotal	$3,000	$6,000	$6,000	$6,000	$3,000	$8,000					$8,000				
Stock Pond / Guzzler Construction / Rehabilitation	Units (each)	NA	NA	NA	NA	NA	NA					NA				
	Pond/Guzzler Const. Unit Cost ($ EA)															
	Number of Ponds to Seal															
	Bentonite Sealing (total square feet)															
	Tons (4lbs/ft2)															
	Bentonite Cost per Ton															
	Bentonite Cost															
	Transportation (15% of Bentonite)															
	Pond Component Subtotal	$0	$0	$0	$0	$0	$0					$0				
Pump	Units (EA)	NA	NA	NA	NA	1	NA					NA				
	Type					Solar										
	Unit Cost (EA)					8,640										
	Component Subtotal					8,640										
		1.5	2.0	3.0	4.0	1.5	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5	Segment 1	Segment 2	Segment 3	Segment 4	Segment 5
Pipeline	Low Pressure Pipe Diameter:						4.0		2.0	4.0	2.0	6.0		3.0	4.0	3.0
	Units (LF)	16,500	16,000	16,000	16,000	17,000	18,500		5,500	9,200	31,000	18,500		5,500	9,200	31,000
	Unit Cost (EA)	$1.34	$1.70	$2.60	$3.54	$1.34	$3.54		$1.70	$3.54	$1.70	$5.50		$2.54	$3.54	$2.54
	Component Subtotal	$22,110	$27,200	$41,600	$56,640	$22,780	$65,490		$9,350	$32,568	$52,700	$101,750		$13,970	$32,568	$78,740
	High Pressure Pipe Diameter:	NA	2.0	3.0	4.0	NA		4.0					6.0			
	Units (LF)		5,500	5,500	5,500			15,400					15,400			
	Unit Cost (EA)		$2.05	$3.40	$4.75			$4.75					$8.11			
	Component Subtotal		$11,275	$18,700	$26,125			$73,150					$124,894			
							$233,258					$351,922				
Additional Storage Tanks	Units (EA)	1	0	0	0	1	NA					NA				
	Size (gal)	15,000	15,000	15,000	15,000	15,000										
	Unit Cost ($/gal)	$1	$1	$1	$1	1										
	Component Subtotal	$15,000	$0	$0	$0	15,000										
Livestock / Wildlife Water Tanks	Units (EA)	4	4	4	4	5	10					10				
	Size (gal)	1,200	1,200	1,200	1,200	1,200	1,200					1,200				
	Unit Cost	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000					$3,000				
	Component	$12,000	$12,000	$12,000	$12,000	$15,000	$30,000					$30,000				
Miscellaneous	Item	NA	NA	NA	NA	Diversion Structure	NA					NA				
	Units (Each)					1										
	Unit Cost ($/ea)					$5,000.00										
	Component Subtotal					$5,000.00										
Construction Subtotal		$52,110	$56,475	$78,300	$100,765	$69,420	$271,258					$389,922				
Engineering (10%)		$5,211	$5,648	$7,830	$10,077	$6,942	$27,126					$38,992				
Constuction and Engineering Subtotal		$57,321	$62,123	$86,130	$110,842	$76,362	$298,384					$428,914				
Contingency (15%)		$8,598	$9,318	$12,920	$16,626	$11,454	$44,758					$64,337				
Total Construction Cost		$65,919	$71,441	$99,050	$127,468	$87,816	$343,141					$493,251				
Final Plans and Specs		$1,000	$1,000	$1,000	$1,000	$1,000	$3,000					$3,000				
Additional		$0	$0	$0	$0	$0	$0					$0				
Permitting / Legal Fees / Access and Rights of Way		$500	$1,000	$1,000	$1,000	$500	$2,500					$2,500				
Total Project Cost		**$67,419**	**$73,441**	**$101,050**	**$129,468**	**$89,316**	**$348,641**					**$498,751**				

Guzzlers: A cost of $10,000 was used for a 2,250 square feet catchment area feeding a 1800 gallon, BOSS brand tank.

Solar Water Pump: A total cost of $8,640 was used for a typical system.

6.3 Other Management Practices and Improvements

The costs of other potential management practices and improvements such as:

- Stream channel restoration,
- Range/grazing management,
- Prescribed burning, and
- Removal/control of invasive plants and noxious weeds are very project and site dependent.

Normally, all but some of the range/grazing management practices or improvements would be implemented by the appropriate agency (NRCS, BLM, Weed and Pest Districts, etc.).

Local staff of those agencies should be consulted regarding the costs of these practices and improvements. The cost of range/grazing practices and improvements (other than wildlife/livestock watering addressed in Section 6.1 above) mostly involve the rancher's time for planning, herding, salting, noxious weed and plant control/removal (where not otherwise covered by cooperative efforts managed by the Weed and Pest Districts), and possibly installation of local fencing in critical areas.

VII. FUNDING OPPORTUNITIES

7.1 Overview

Project funding/financing is a critical aspect associated with the implementation of watershed improvement projects. Given the scope of the investigation and the perceived projects which may be pursued (storage reservoirs, irrigation infrastructure improvements, wildlife/stock watering, stream/riparian corridor rehabilitation, and "other" water-resource related project types), there may be a large variety of funding sources which may be available to provide funding for future watershed improvements.

Alternative sources of funding to watershed projects are discussed in the pages that follow. Potential sources include local, state, and federal entities. Much of the information contained in this report was obtained through the following sources which provide a wealth of information on grant, loan and in-kind support for watershed related projects:

- ***Water Management & Conservation Assistance Programs Directory, Fourth Edition*** (WWDC, May 2009) first compiled by the Wyoming State Engineer's Office and now maintained by the Wyoming Water Development Commission at the following website: http://wwdc.state.wy.us/wconsprog/WtrMgntConsDirectory.html.

- ***Catalog of Federal Funding Sources for Watershed Protection*** developed and maintained by the Environmental Protection Agency. This site is a searchable database of financial assistance sources (grants, loans, cost-sharing programs, etc.) available to fund a variety of watershed protection projects. The document is available at the following website: http://cfpub.epa.gov/fedfund/

- ***Habitat Extension Bulletin No. 50 – Fisheries and Wildlife Habitat Cost Share Programs and Grants*** published by the Wyoming Game and Fish Department provides a very comprehensive listing of potential funding sources for fisheries and wildlife habitat projects. The document is available at the following website: http://gf.state.wy.us/downloads/pdf/habitat/Ext%20Bulletin%20No.%2050.pdf .

In addition, discussions of several funding programs were extracted from previous watershed investigations completed on behalf of the Wyoming Water Development Commission. Specifically, the Nowood River Watershed Investigation (Anderson Consulting Engineers, 2010) and the Thunder Basin Watershed Investigation (Olsson, 2011) were reviewed and sections incorporated herein where appropriate.

It is important to understand that the potential sources identified herein are not necessarily exhaustive of the resources that may be available, that existing programs change and sometimes disappear over

time, new programs arise, funding levels vary year to year, and competition for many of the programs is significant. Also, contact information for various programs and key people can also change. Key local contacts for current information on funding sources relevant to watershed protection, restoration and conservation, wildlife/stock watering, and irrigation infrastructure improvements include, but are not limited to the following:

- Hot Springs Conservation District (307.864.3488)
- NRCS Worland Office (307.347.2456)
- Bureau of Land Management/Worland District Office (307.347.5100)

Key aspects and information about the primary funding programs identified are discussed in the following sections and summarized in a matrix format (Table 7.1).

7.2 Local Agencies

7.2.1 Worland Grazing District/Taylor Grazing Act Funds

The Hot Springs and Washakie County treasurers hold monies received from federal Taylor Grazing Act grazing fees on behalf of the Worland Grazing District (District). Hot Springs County receives 15.93 percent of the fees allocated to the Worland Grazing District. These fees are credited to a special Range Improvement Fund (Fund) for the District. The District is administered by the Wyoming State Grazing Board of the Worland District (Board) which is comprised of permittees who hold Taylor Act permits and graze livestock on public lands within the District. Meetings may be held by the Board at any time to conduct the business of the Board, but must be held at least twice each year.

Disbursements by the County treasurers from the Fund may be made at the request of the Board for the construction of range improvements or any other purpose beneficial to the District. Projects involving construction and maintenance of range improvements on public lands may only be undertaken by cooperative agreements between the Board and the applicable federal officials (in this case the BLM or USFS). Similarly, other projects not involving construction or maintenance but located on public lands also must be implemented under a cooperative agreement with the applicable governmental entity. The relevant state statutes for the District are available at: http://legisweb.state.wy.us/statutes/titles/Title9/T9CH4AR4.htm.

7.2.2 Hot Springs Conservation District

The Hot Springs Conservation District (HSCD) serves as the local liaisons between local landowners and resource users and state and federal government agencies. In addition to their many other roles and responsibilities, these districts can also provide funding assistance as follows:

Table 7.1 Potential Funding Sources.

Agency/Entity	Program Name	Project Type(s)	Internet Site	Telephone	Email
Local					
Hot Springs Conservation District	n/a	Liaison, in-kind administrative and technical assistance, program coordination/partnering	http://www.conservewy.com/hscd.html	307.864.3488	See Website
Worland Grazing District	Range Improvement Fund	Range and related improvements	NA	Na	wsgb@wyoming.com
Hot Springs County Weed and Pest District	n/a	Noxious weed and undesirable plant control	www.wyoweed.org	307.864.2278	hscwpcd@rtconnect.net
State					
Wyoming Department of Environmental Quality	Nonpoint Source Implementation Grants (319 Program)	Water quality BMPs	http://deq.state.wy.us/wqd/watershed/index.asp	307.777.7072	See WDEQ Website for contact directories
Wyoming Game and Fish Department	Riparian Habitat Improvement Grant	Stock water development; streambank stabilization; etc.	http://gf.state.wy.us	Scott Talbott Director 307.777.4565	See WGF Website for contact diretories
	Water Development/Maintenance Habitat Project Grant	Water developments (springs, windmills, guzzlers, pumps, etc.)			
	Upland Development Grant	Range management; prescribed burns			
	Fish Wyoming	Public fishing opportunities	http://slf-web.state.wy.us/admin/slib.aspx		
	Wyoming Sage Grouse Conservation Fund	Sage-grouse habitat protection or improvement			
Wyoming Office of State Lands and Investments	Regular Farm Loans	Projects involving most agricultural purposes	http://lands.state.wy.us/	307.777.7331	ryan.lance@wyo.gov
	Small Water Development Project Loans	Converson of dry land to irrigated land and/or water use efficiency improvements			
Wyoming Water Development Commission	Wyoming Water Development Program	Planning, design and construciton of new reservoir storage and rehabiliation of existing reservoir storage projects	http://wwdc.state.wy.us/opcrit/final_opcrit.pdf	307.777.7626	jon.wade@wyo.gov
	Small Water Project Program	Small reservoirs and stock ponds, wells, pipelines/conveyance, spring			ron.vore@wyo.gov
Wyoming Wildlife and Natural Resource Trust	n/a	Aquatic and wildlife habitat improvement, including water developments, prescribed burns, invasive plant control, etc.	http://wwnrt.state.wy.us	307.856.4665	NA
Federal					
Bureau of Land Management	Riparian Habitat Management Program	Projects to maintain, restore, improve, protect and expand riparian/wetland areas	http://www.blm.gov/wy/st/en.html	307.775.6092 (Rick Schuler)	Rick_Schuler@blm.gov
	Cooperative Agreement for Range Improvements	Reservoirs, pits, spring developments, wells, and associated distribution pipelines	http://www.blm.gov/wy/st/en/field_offices/Worland.html	307.347.5100 (Worland District Office)	worland_wymail@blm.gov
Bureau of Reclamation	Water 2025 Challenge Grant Program	Water conservation, efficiency and marketing	http://www.usbr.gov/newsroom/newsrelease/detail.cfm?RecordID=2541	307.261.5671	jlawson@gp.usbr.gov
Environmental Protection Agency	Targeted Watershed Grants Program	Riparian, wetland, aquatic and upland habitat protection and improvement	http://www.epa.gov/owow/funding/watershedfunding.html	202-566-1730	dtoledo@rivernetwork.org
Farm Service Agency	Conservation Reserve Program (CRP)	Removal of highly erobible lands from production	http://www.fsa.usda.gov/FSA/stateoffapp?mystate=wy&area=home&subject=landing&topic=landing	307.347.2456	Sherri.McMillan@wy.usda.gov
	Continuous Sign-Up for High Priority Conservation Practices	Riparian buffers, filter strips, grass waterways, salt tolerant vegetation, shallow water areas for wildlife, etc.			
	Emergency Conservation Program (ECO)	Emergency livestock watering conservation during severe drought			
Fish and Wildlife Service	Partners for Wildlife Habitat Restoration	Various fish and wildlife habitat restoration projects	http://ecos.fws.gov/partners/viewContent.do?viewPage=home	307.332.8719	mark_j_hogan@mail.fws.gov
	North American Wetlands Conservation Act Program	Various wetlands conservation projects	http://www.fws.gov/birdhabitat/Grants/NAWCA/index.shtm		
	Landowner Incentive Program (Non-Tribal)	Funding to WGFD to support above project types			
Natural Resources Conservation Service	Environmental Quality Incentives Program	Conservation planning, range management, irrigation rehabilitation, livestock watering, etc.	http://www.nrcs.usda.gov/PROGRAMS/EQIP	307.233.6750 (State Office) 307.864.3488 (Thermopolis Office)	jim.mischke@wy.usda.gov
	Watershed Protection and Flood Prevention Program	Water supply, water quality control, erosion and sediment control, wetland creation and restoration, fish and wildlife habitat enhancement, flood control, public recreation, etc.	http://www.nrcs.usda.gov/programs/watershed/index.html		
	Wildlife Habitat Incentives Program(WHIP)	See websites and/or local contacts for detailed information on these programs	http://www.nrcs.usda.gov/programs/whip/		
	Wetlands Reserve Program (WRP)		http://www.nrcs.usda.gov/programs/wrp/		
	Grassland Reserve Program (GRP)		http://www.nrcs.usda.gov/programs/GRP/		
	Conservation Security Program (CSP)		http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/alphabetical/csp		
	Farm and Ranchlands Protection Program (FRPP)		http://www.nrcs.usda.gov/programs/frpp/		
	Emergency Watershed Protection (ERP)		http://www.nrcs.usda.gov/programs/ewp/		
	Sage Grouse Restoration Project (SGRP)		http://sgrp.usu.edu/		
	Grazing Lands Conservation Initiative (GLCI) Grants		http://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/programs/technical/?cid=nrcs143_008456		
Private					
Ducks Unlimited	n/a	Waterfowl aquatic and upland habitat protection, restoration and enhancement	http://www.ducks.org/conservation/du-regional-offices	Great Plains Regional Office: 701.355.3550	
National Fish and Wildlife Foundation	Pulling Together Initiative	Long-term weed management projects	http://www.nfwf.org/AM/Template.cfm?Section=Grants	202.857.0166	info@nfwf.org
	Native Plant Conservation Initiative	Restoration of native plant communities			
	Bring Back the Natives Grant Program	Riverine habitat and aquatic species restoration projects			
	Five-Star Restoration Program	Wetland and riparian habitat restoration			
Trout Unlimited	Watershed Restoration	Erosion control, fish habitat structures, willow and other riparian plantings, etc.	http://www.tu.org/conservation/watershed-restoration-home-rivers-initiative	307.332.7700	syates@tu.org

- In-kind technical assistance as local resources, capacity and expertise allow.
- Administration of programs, projects and grants on behalf of recipients of state and federal natural resources program funding.
- Assistance in development of leveraged, partnered programs and projects.

7.2.3 Hot Springs County Weed and Pest Districts

Wyoming Weed and Pest Districts provide in-kind support to landowners and other agencies/entities including, but not necessarily limited to:

- Assistance in the identification of noxious weeds and other undesirable plants;
- Organization and/or participation in local meetings, seminars and field trips to educate local landowners and agencies on the problems and potential solutions for weed and other undesirable plant control;
- Facilitating work days attended by a broad base of stakeholders (e.g., Russian olive tree cutting); and
- Assistance in preparation of grant applications.

7.3 State Programs

7.3.1 Wyoming Department of Environmental Quality

The Wyoming Department of Environmental Quality (WDEQ) provides funding for implementation of best management practices (BMPs) to address non-point sources of pollution under Section 319 of the Clean Water Act. Section 319 grant funding requires a non-federal (i.e., local) match of 40 percent from the applicant. These matching funds may be provided by landowners, a conservation district, other quasigovernmental entities (e.g., watershed improvement district, irrigation district, etc.), and/or non-profit organizations (e.g., Trout Unlimited, Ducks Unlimited, and the Rocky Mountain Elk Foundation). Applications (proposals) conforming to a specified format are required. The proposal describes in some detail the issues to be addressed and the proposed methods/BMPs to be implemented, as well as providing all other information required to evaluate the proposed project and matching fund entity(ies). These proposals are normally due in August or September of each year.

7.3.2 Wyoming Game and Fish Department

The following summary of funding assistance available from the Wyoming Game and Fish Department (WGFD) is quoted from the Water Management & Conservation Assistance Program Directory (WWDC, 2009):

“The Wyoming Game and Fish Department offers a funding program to help landowners, conservation groups, institutions, land managers, government agencies, industry and non-profit organizations

develop and/or maintain water sources for fish and wildlife. This program also provides funding for the improvement and/or protection of riparian/wetland areas for fish and wildlife resources in Wyoming. Applications for projects are accepted any time with approval on January 1 and August 1 of each year."

- **Riparian Habitat Improvement Grant**. The purpose of this program is to improve or maintain riparian and wetland resources. Fencing, herding, stock water development, streambank stabilization, small damming projects and beaver transplanting are a few examples of efforts that qualify under this program. Permits, NEPA compliance, construction, maintenance, access and management planning are all grantee responsibilities. There is $10,000/project maximum available with 50% cash or in-kind required from grantee.
- **Water Development/Maintenance Habitat Project Grant.** The purpose of this program is to develop or maintain water for fish and wildlife. Spring development, windmills, guzzlers, water protection and pumping payments are examples of the extent of this program. Permits, NEPA compliance, maintenance, access and water rights are responsibilities of the grantee. There is a maximum of $7,500/project and 50% cash or in-kind contribution required from the grantee.
- **Upland Development Grant**. The purpose of this program is to develop upland wildlife habitat. Example project include management, grazing systems, prescribed burning, wildlife food plots such as oat, millet or corn plantings, range pitting and range seeding. Permits, NEPA compliance, maintenance, access and management planning are responsibilities of the grantee. There is a maximum of $10,000/project and 50% cash or in-kind contribution required from the grantee.
- **Fish Wyoming**. The purpose of this program is to develop public fishing opportunities. Examples of projects within this effort are boat ramps and fishing access. This program provides a 50% match of funding which is channeled through a private organization or municipality."
- **Wyoming Sage Grouse Conservation Fund**. WGFD also administers the Wyoming Sage-Grouse Conservation Fund (WSGCF); http://gf.state.wy.us). The WSGCF is a special fund established by the Wyoming State Legislature to support the efforts of Local Sage-Grouse Working Groups (LWGs). The WSGCF funding is intended to promote conservation of sage grouse populations and habitat (sagebrush ecosystems), including socio-economic and human use of the habitat. The BHLWG has recently completed the Sage-grouse Conservation Plan for the Big Horn Basin (BHLWG, 2007) to identify and guide implementation of these objectives.

Requests for WSGCF funding must be made on a Project Proposal Form available at: http://gf.state.wy.us/wildlife/wildlife_management/sagegrouse/BigHornBasin/BHB%20SgConservPlanFinal.pdf . Funding is normally considered for projects ranging between $5,000 and $50,000, with priority given to those with matching funds, established partnerships, multi-species benefits, management relevance and consistency with the local sage-grouse conservation plan, highest wildlife impact, appropriate budgets, landscape scale, and a lasting legacy of benefits. Evaluation criteria include: consistency with the local plan, likelihood of project success, project readiness, availability of matching funds, multiple species benefits, significance at local/state/regional level, duration of benefits, and adequacy of funding. Application may be made at any time, but should be made by February 1 to

receive first round consideration. Funds awarded must be expended between July 1 of the year received and September 30 of the second year after award. The funds are normally distributed as reimbursable grants (i.e., payments are made for expenses incurred and not "up-front"). Requests for funding of habitat improvement projects, including water developments, must include a livestock grazing management plan. A Project Close-out Report must also be submitted upon completion to allow tracking of expenditures and tracking of results.

7.3.3 Wyoming Office of State Lands and Investments

As the administrative advisory arm of the Board of Land Commissioners and State Loan and Investment Board, the Office of State Lands and Investments (OSLI) administers Regular Farm Loans and Small Water Development Project Loans that may be applicable to potential projects identified in Chapter 4.

- **Regular Farm Loans**. These loans are made for a wide range of agricultural purposes, including as most applicable to the potential projects identified in Chapter 3, purchasing, constructing or installing equipment and/or improvements necessary to maintain or improve the earning capacity of the farming operation. Eligible applicants include individuals whose primary residence is in Wyoming and legal entities with a majority of the ownership meeting the individual residency requirements. Single loans or combinations of loans cannot exceed an outstanding principal balance of $600,000. Loan rates are 8 percent for loans up to 50 percent of the appraised value of the security land and improvements and 9 percent for loans between 50 and 60 percent of the security. The term of a given loan is limited to 30 years.
- **Small Water Development Project Loans**. These loans are authorized for projects for development and use of water upon agricultural lands for agricultural purposes. These projects may convert dry land into irrigated land or lead to more efficient use of water and/or increased crop or forage production. Eligible recipients may include court approved water districts, agencies of state and local government, persons, corporations, associations, and other legal entities recognized under state law. Individual loans up to $150,000 may be made. Interest is currently set at 6 percent and the maximum term of loans is 40 years.

7.3.4 Wyoming Water Development Commission

The mission of the Wyoming Water Development Commission (WWDC) as defined in the enabling legislation is to: *"provide, through the commission, procedures and policies for the planning, selection, financing, construction, acquisition and operation of projects and facilities for the conservation, storage, distribution and use of water, necessary in the public interest to develop and preserve Wyoming's water and related land resources. The program shall encourage development of water facilities for irrigation...for abatement of pollution, for preservation and development of fish and wildlife resources…and shall help make available the waters of the state for all beneficial uses…"* (W.S. 41-2-112(a)).

Key aspects of the Wyoming Water Development Program and the Small Water Project Program administered by WWDC are described in the following subsections.

7.3.4.1 Wyoming Water Development Program

The main Wyoming Water Development Program encompasses new development, dams and reservoirs, rehabilitation, water resources planning and master planning. Of most relevance to the Buffalo Creek Study Area in terms of implementing alternative projects are the New Development -Rehabilitation Programs and Dams and Reservoirs Program described below. This information was abstracted from the Operating Criteria of the Wyoming Water Development Program available at: http://wwdc.state.wy.us/opcrit/final_opcrit.pdf and from a form titled Information for New Applicants available at the following website: http://wwdc.state.wy.us/projappl/New_Ap_Info.pdf .

It is very important to ensure that the most current information on funding is reviewed prior to making an application as WWDC's policies and procedures can and do change over time in response to legislative direction and/or Commission action. Review of information available at the above websites and contact with the staff of the WWDC (307.777.7626) is recommended prior to beginning the application process.

- New Development Program — The New Development Program develops presently unused and/or unappropriated waters of Wyoming.
- Rehabilitation Program — The Rehabilitation Program provides funding assistance for the improvement of water projects completed and in use for at least fifteen (15) years.
- Dam and Reservoir Program — Proposed new dams with storage capacity of 2,000 acre feet or more and proposed expansions of existing dams of 1,000 acre feet or more qualify for the Dam and Reservoir Program.
- Water Resource Planning — The Wyoming Water Development Commission serves as the water development planning agency for the State of Wyoming. In this capacity, the WWDC can provide the following assistance to project sponsors.
    - Basin Wide Plans — The program serves to develop basin wide plans for each of the state's major drainage basins.
    - Master Plans — The program provides a service to municipalities, districts and other entities to assist in the preparation of planning documents which serve as master plans for future water supply systems and improvements. The plans serve as a framework for the entities to establish project priorities and to perform the financial planning necessary to meet those priorities. These plans can assist entities in preparing the reports necessary to achieve federal funding assistance for water development and other water related projects.

- Groundwater Grant Program — The primary purpose of the program is to inventory the available groundwater resources in the state. The program also serves to assist communities in developing efficient water supplies. Municipalities and special districts that purvey drinking water are eligible to receive up to $400,000 in grant funds if 25% of the total project costs will be paid by local matching funds.

New Development Program. This program provides technical assistance and funding to develop waters of the state that are unused and/or unappropriated at present. It deals with a wide range of projects, including as most relevant to the Buffalo Creek Study Area are the following types of projects:

- Multiple Purpose (including among other uses two or more of the following: agriculture, recreation, environmental, and erosion control);
- New Storage (dams and reservoirs less than 2,000 acre-feet);
- New Supply (e.g., deep wells, alluvial wells, diversion dams);
- Watershed Improvement (for components whose primary function or benefit is water development); and
- Recreation.

These project types are listed above in the order of preference assigned by WWDC when determining what projects to pursue among all of the applications received for funding.

Rehabilitation Program. The Rehabilitation Program addresses the improvement of water projects completed and in use for at least fifteen years in order to assist in keeping existing water supplies effective and viable for the future. Relative to the Buffalo Creek Study Area, the Rehabilitation Program can improve existing agricultural storage facilities or conveyance systems to insure safety, decrease operation and maintenance (O&M) costs, and increase the efficiency of agricultural water use. The types of projects supported relevant to this watershed are essentially the same as listed above for the New Development Program.

Note that on-farm improvements (e.g., gated pipe, side rolls, center pivots and related facilities and/or equipment such as pumps, power lines) are excluded from WWDC funding under both the New Development and Rehabilitation Programs.

Dam and Reservoir Program. Proposed new dams with storage capacity of 2,000 acre feet or more and proposed expansions of existing dams of 1,000 acre feet or more qualify for the Dam and Reservoir Program. The source of revenue for the program is Water Development Account No. III [W.S. 41-2-124(a)(iii)], which has received Water Development Account No. I appropriations and budget reserve account appropriations on occasion, as approved by the legislature; the interest earnings that have accrued to the Water Development Account No. III; and a percentage (0.5%) of the revenues which

accrue to the state's severance tax distribution account. Legislative approval must be granted prior to allocating funds to a particular purpose or project.

Dams and reservoirs typically provide opportunities for many potential uses. While water supply shall be emphasized in the development of reservoir operating plans, recreation, environmental enhancement, flood control, erosion control and hydropower uses should be explored as secondary purposes.

Key Criteria and Procedures. An application for funding under either the New Development and Rehabilitation Programs must meet the following key criteria most applicable to potential projects as identified in Chapter 3 above:

- *"The project sponsor shall be a public entity that can legally receive state funds, incur debt, generate revenues to repay a state loan, hold title and grant a minimum of a parity position mortgage on the existing water system and improvements or provide other adequate security for the anticipated state construction loan."*
- *"The proposed project must serve…2,000 or more acres of irrigated cropland, or must rehabilitate watershed infrastructure, which will develop or preserve the beneficial use of water in a watershed. The watershed rehabilitation projects must possess an estimated minimum useful life span of twenty-five (25) years and demonstrate that sufficient public benefits will accrue to justify construction of the anticipated improvements..."*

Important procedures, deadlines and requirements for applications to the New Development and Rehabilitation Programs include but are not necessarily limited to the following:

- A fee of $1,000 must be submitted with initial project applications; the fee does not apply to projects advanced to the next level of study or to construction.
- A certified resolution passed by the governing body of the sponsoring entity must accompany an application for a Level II study or Level III construction. This requirement may be deferred if the applicant is in the process of forming a public entity.
- A public entity must be in place before a Level II study or Level III construction can commence, with certain exceptions discussed below.
- The due date for new project applications is August 15 of each year; the due date for applications for advancing to the next study level or construction funding is October 1 of each year.

Two important criteria that apply specifically to dam and reservoir projects are:

- *"For projects that enlarge existing storage projects by 1,000 acre-feet or greater or for proposed new dam and reservoirs with a capacity of 2,000 acre-feet or greater, expenses associated with final engineering design and required National Environmental Policy Act reviews, including but*

not limited to environmental assessments and environmental impact statements, are eligible components of a Water Development Program Level II, Phase III Study Project."

- *"For dam and reservoir projects, the Commission may waive sponsor eligibility requirements through Level II, Phase II. However. the eligible entity requirements shall be met prior to initiation of Level II, Phase III activities described herein."*

Financial Plan. The current standard terms of the Wyoming Water Development Program financial plan are summarized as follows:

- Sixty-seven (67) percent grant to thirty-three (33) percent loan mix.
- Minimum four (4) percent loan interest rate (current rate is 4 percent, but legislature may increase rate).
- Maximum 50-year term of loans; term shall not exceed economic life of project.
- Payment of loan interest and principal may be deferred up to 5 years after substantial completion at WWDC's discretion under special circumstances.

In the document titled Information for New Applicants the following additional relevant information is provided regarding financial terms:

- *"The best available project financial terms include a grant for Level I and Level II expenses, a grant of 75% of the Level III costs, a loan of 25% of the Level III costs with an interest rate of four percent (4%) and a term equal to the economic life of the project/improvements or fifty (50) years, whichever is less. Principal and interest payments may be deferred for five (5) years after project completion. However, these favorable terms will be granted when a project is essential and the project sponsor has a very limited ability to pay."*
- *"Those sponsors who feel more favorable terms are warranted due to a limited ability to pay must make a formal presentation to the Commission documenting their case. Sponsors electing to pursue this option should be aware that the Commission is reluctant to deviate from this standard and such requests will be denied unless they are clearly documented and justified."*

The Commission will evaluate whether or not a project will be funded for Level III construction following review of the results of Level II studies. If the Commission determines that the project should not advance due to high repayment costs (as determined by an analysis of the sponsor's ability-to-pay and after other funding sources have been considered), the sponsor has the option of making a formal presentation to WWDC relative to the sponsor's ability and willingness to pay. This presentation must address the need for the project, the direct and indirect benefits of the project, and any other information the sponsor feels is relevant to the Commission's final decision.

The project sponsor shall be a public entity that can legally receive state funds, incur debt, generate revenues to repay a state loan, hold title and grant a minimum of a parity position mortgage on the

existing water system and improvements appurtenant to the project or provide other adequate security for the anticipated state construction loan.

The WWDC may waive the requirement that the project sponsor be a public entity under the following exceptions:

1. The WWDC may accept applications for Level I studies from applicants that are not public entities. This will allow the applicant to know if there is a viable project prior to becoming a public entity. However, the applicant must be a public entity before applying for a Level II study. Under these circumstances, the Level I process will have a two-year duration with the study being completed the first year and the sponsor forming a public entity the second year.

2. The WWDC may accept applications related to the construction of dams and reservoirs from applicants that are not public entities. As the evaluations of the feasibility of new dams are complex, this will allow the applicant to know if the proposed reservoir is feasible prior to becoming a public entity. However, the applicant must be a public entity before applying for Level II, Phase III funding.

7.3.4.2 Small Water Project Program

The Small Water Project Program (SWPP) is intended to be compatible with the conventional WWDC program described above. Small water projects are defined as providing multiple benefits where the total estimated project costs (including construction, permitting, construction engineering, and land procurement) are less than $100,000 or where WWDC's maximum financial contribution is 50 percent of project costs or twenty-five thousand dollars ($25,000), whichever is less. SWPP funding is a "one-time" grant so that ongoing operation and maintenance costs are not included. Loans are not available under SWPP.

Eligibility. The kinds of projects eligible for SWPP funding include, but are not necessarily limited to:

- small reservoirs and stock watering ponds (up to 20 feet high and 20 acre-feet capacity);
- wells;
- pipelines and conveyance facilities;
- spring developments;
- windmills;
- wetland developments;
- solar platforms; and
- irrigation infrastructure.

These projects may address environmental concerns by providing water supplies to support plant and animal species, and serve as instruments to improve range land conditions.

Funding can only be provided to eligible public entities including but not necessarily limited to conservation districts, watershed improvement districts, water conservancy districts, and irrigation districts.

Application, Evaluation and Administration. Details of the application and evaluation process and program administrative procedures are provided in the Small Water Project Program Operating Criteria available online as noted previously. Some key aspects of the process and procedures applicable to the potential projects identified in Chapter 4 include the following:

1. Planning for small water projects will be generated by a WWDC watershed study or equivalent as determined by the WWDO. A watershed study will incorporate, at a minimum, available technical information describing conditions and assessments of the watershed including hydrology, geology, geomorphology, geography, soils, vegetation, water conveyance infrastructure, and stream system data. A plan outlining the site specific activities that may remediate existing impairments or address opportunities beneficial to the watershed shall also be included. A watershed study may identify one or more projects that may qualify for SWPP funding. A professional engineer and/or geologist, as appropriate, shall certify any analysis submitted unless generated by a federal agency.

2. Applications shall be received by January 1 of each calendar year. Applications meeting criteria requirements will be considered during the regularly scheduled WWDC meeting in March. Applications shall include a project application, sponsor project referral, project location map, project cost estimates and any letters of authorization or commitment of participation that may be available from other funding sources.

3. Projects that improve watershed condition and function, provide multiple benefits, and meet the funding criteria specified in W.S. 99-3-703(j)(vii) or W.S. 99-3-704(g)(vii), as described in B.4 herein, are eligible for consideration.

4. The sponsoring entity will be required to address the WWDC and provide testimony and other additional supporting evidence that justifies SWPP funding whenever the public benefit documentation, submitted with the application, is deemed to be insufficient by the WWDO.

7.3.5 Wyoming Wildlife and Natural Resource Trust

The Wyoming Wildlife and Natural Resource Trust (WWNRT) was formed by the state legislature in 2005 to preserve and enhance Wyoming's wildlife and natural resources. Projects funded by WWNRT must provide a public benefit such as continued agricultural production to maintain open space and healthy ecosystems, enhancements to water quality, and maintenance or enhancement of wildlife habitat.

Wildlife and Natural Resource Trust funding is available for a wide variety of projects throughout the state, including natural resource programs of other agencies. Some examples include the following:

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

Allowable projects under this program that are potentially relevant to this watershed management plan study include:

- Improvement and maintenance of existing aquatic habitat necessary to maintain optimum fish populations.
- Conservation, maintenance, protection and development of wildlife resources, the environment, and Wyoming's natural resource heritage.
- Participation in water enhancement projects to benefit aquatic habitat for fish populations and allow for other watershed enhancements that benefit wildlife.

Funding is by grant with no matching funds required. Non-profit and governmental organizations (including watershed improvement districts, conservation districts, etc.) are eligible for funding by WWNRT. Projects will be funded in July and January. Applications may be filed any time, but must be filed within 90 days of the next funding cycle to receive consideration in that cycle.

7.4 Federal Agencies

7.4.1 Bureau of Land Management

- **BLM's Riparian Habitat Management Program** offers the opportunity to coordinate with outside interests on riparian improvement projects. The goal of BLM's riparian-wetland management is to maintain, restore, improve, protect, and expand these areas so they are in

proper functioning condition for their productivity, biological diversity, and sustainability. The overall objective is to achieve an advanced ecological status, except where resource management objectives, including proper functioning condition, would require an earlier successional stage. The goal includes aggressive riparian-wetland information, inventory, training, and research programs as well as improving the partnerships and cooperative management processes.

Partnerships have been available for riparian improvement projects and for research into riparian issues. Funding is available on an annual basis subject to budget allocations from Congress. All submitted cooperative projects compete for the funds available in the riparian program. For information on the riparian habitat program within BLM, please contact Mark Gorges (307) 775-6100.

- **Range Improvement Planning and Development** is a cooperative effort not only with the livestock operator but also with other outside interests including the various environmental/conservation groups. Water development, whether it be for better livestock distribution or improved wetland habitats for wildlife, is key to healthy rangelands and biodiversity. Before actual range improvement development occurs, an approved management plan must be in place. These plans outline a management strategy for an area and identify the type of range improvements needed to accommodate that management. Examples of these plans are Coordinated Resource Plans, Allotment Management Plans, and Wildlife Habitat Management Plans.

  All rangeland improvement projects on lands administered by the Bureau of Land Management require the execution of a Permit. Although there are a couple of methods for authorizing range improvements on the public lands, Cooperative Agreement for Range Improvements form 4120-6 is the method most commonly used. This applies equally to range improvement projects involving water such as reservoirs, pits, springs, and wells including any associated pipelines for distribution. The major funding source for the Bureau of Land Management's share comes from the range improvement fund which is generated from the grazing fees collected. There, too, is a limited amount of funding from the general rangeland management appropriations. If the cooperator is a livestock operator, their contributions come generally in the form of labor. There are times they also provide some of the material costs as well. Contributions from the conservation/environmental interests is monetary and often come in the form of grants. They also contribute labor on occasion. For information on the range improvement program within BLM, please contact Jim Cagney (307) 775-6194.

- **BLM's Watershed and Water Quality Improvement** efforts are undertaken in a cooperative approach with the State of Wyoming, Conservation Districts, livestock operators and various conservation groups. Wyoming's BLM is partnering in the implementation of several Section 319 watershed plans state-wide.

It is anticipated that as the Wyoming Department of Environmental Quality (WDEQ) continues the inventory of waters of the State and the identification of Impaired and/or Threatened water bodies, BLM will be partnering with the WDEQ to improve water quality in water bodies on Public Lands. In the course of developing watershed plans or TMDL's for these watersheds, BLM will be routinely involved in watershed health assessments, planning, project implementation and Best Management Practice (BMP) monitoring.

Now, and in the future, the goals of cooperative watershed projects will typically be the restoration and maintenance of healthy watershed function. These goals will typically be accomplished through approved BMP's, e.g. prescribe burns, vegetation treatments, instream structures, too enhance vegetation cover, control accelerated soil erosion, increase water infiltration and enhance stream flows and water quality.

Currently, in response to the Clean Water and Watershed Restoration initiative and associated funding increases, BLM is expanding its efforts to address water quality and environmental concerns associated with abandoned mines. This work will also be accomplished, in cooperation with the State Abandoned Mine Lands Division, on a priority watershed basis and will employ appropriate BMP's to address identified acid mine drainage and runoff problems from mine tailings and waste rock piles.

7.4.2 Bureau of Reclamation

The Bureau of Reclamation (BOR) administers the Water 2025 Challenge Grant Program. This program provides funding on a competitive basis for projects focused on water conservation, efficiency and water marketing. Preference is given to projects that can be completed within 24 months that will help to prevent crises over water in areas identified as "hot spots" where potential for conflict is judged to be moderate to highly likely by 2025.

Because there are no existing projects within the Buffalo Creek watershed study area under jurisdiction of the BOR, funding through this program is unlikely.

7.4.3 Environmental Protection Agency

The Targeted Watershed Grants Program administered by the Environmental Protection Agency (EPA) "encourages watershed practitioners to examine local water related problems in the context of the larger watershed in which they exist, to develop solutions to those problems by creatively applying the full array of available tools, including general, state and local programs, to restore and preserve water resources through strategic planning and coordinated project management that draw in public and private sector partners..." as described in the following program website: http://www.epa.gov/twg/2006/2006faq.html#intro. Organizations eligible for funding include nonprofits, tribes, and local governments. The assistance provided consists of grants for up to 75 percent of the total project costs. A match of at least 25 percent is required. The typical median amount

awarded is $700,000 with a typical range of $300,000 to $900,000. It is important to note that application must be made by the governor, and that the competition for these grants is keen.

7.4.4 Farm Service Agency

The Farm Service Agency (FSA) administers three different programs that may be applicable to some of the alternative projects identified in Chapter 4. Technical assistance for the FSA programs is provided by NRCS. Each of these three programs is briefly discussed below.

- **Conservation Reserve Program (CRP).** This is a voluntary program under which eligible highly erodible cropland is removed from production in return for annual rental payments and cost share assistance by FSA over a 10-15 year period. The producer is required to establish long-term conservation practices on the erodible, environmentally sensitive lands taken out of production. Continuous Sign-Up for High Priority Conservation Practices. Under this program farmers and ranchers implement certain high-priority conservation practices on their eligible CRP lands. These practices may include: riparian buffers, filter strips, grass waterways, shelter belts, field windbreaks, living snow fences, contour grass strips, salt tolerant vegetation, and shallow water areas for wildlife.

  This cost share program offers rental rates for the CRP lands based on the average value of dryland cash rent with an additional financial incentive of up to 20 percent of the soil rental rate for selected practices. Establishing permanent cover merits up to a 50 percent cost share.

- **Emergency Conservation Program (ECP)**. This program provides emergency funding and technical assistance for implementing emergency livestock watering conservation measures during periods of severe drought and rehabilitating farmland damaged during natural disasters. Cost share assistance up to 75 percent of the cost to implement the emergency measure(s) is available.

- **Continuous Sign-Up for High Priority Conservation Practices:** Continuous sign-up provides management flexibility to farmers and ranchers to implement certain high-priority conservation practices on eligible land. Land must meet the requirements of CRP and be determined by the NRCS to be eligible and suitable for:

Riparian buffers	Living snow fences
Filter strips	Contour grass strips
Grass waterways	Salt tolerant vegetation
Shelter belts	Shallow water areas for wildlife Field windbreaks

  This is a cost share program that offers rental rates based on the average value of dryland cash rent with an additional financial incentive of up to 20% of the soil rental rate for field

windbreaks, grass waterways, filter strips and riparian buffers. An additional 10% may be added if the land is located in an EPA-designated wellhead protection area. There is also a provision for cost share of up to 50% of the cost of establishing permanent cover.

7.4.5 Fish and Wildlife Service

Technical and financial assistance are available to private landowners, profit or nonprofit entities, public agencies and public-private partnerships under several programs addressing the management, conservation, restoration or enhancement of wildlife and aquatic habitat (including riparian areas, streams, wetlands and grasslands). These programs include, but are not necessarily limited to:

- **Partners for Wildlife Habitat** This program provides technical and financial assistance directly to private landowners through voluntary cooperative agreements called Wildlife Extension Agreements (WEA). The program targets habitats that are in need of management, restoration or enhancement such as riparian areas, streams, wetlands and grasslands. Under these Wildlife Extension Agreements, private landowners agree to maintain the restoration projects as specified in the agreement but otherwise retain full control of the land. Depending on the number of partners, the cost share may vary somewhat but is typically 75% partners and 25% landowner.

- **North American Wetlands Conservation Act Grant Program** This grant program promotes long-term conservation of wetlands ecosystems and the waterfowl, migratory birds, fish and wildlife that depend upon such habitat. Conservation actions supported are acquisition, enhancement and restoration of wetlands and wetlands associated habitat. This program encourages voluntary , public-private partnerships. Public or private , profit or non-profit entities or individuals establishing public-private sector partnerships are eligible . Cost-share partners must at least match grant funds with non-federal monies.. *Small Grants are typically for $50,000.*

- **Wildlife Conservation and Appreciation Program .** This program provides grants to state fish and wildlife agencies to fund projects that bring together USFWW S, state agencies and private organizations and individuals. Projects include identification of significant problems that can adversely affect fish and wildlife and their habitats, actions to conserve species and their habitats, actions that will provide opportunities for the public to use and enjoy fish and wildlife through non-consumptive activities, monitoring of species and identification o f significant habitats.

- **Cooperative Endangered Species Conservation Fund.** This program is available to states that have a cooperative agreement with the Secretary of Interior. The intent is to provide Federal assistance too any state to assist in the development of programs for the conservation of endangered and threatened species. Potential programs include animal, plant and habitat surveys, research, planning, management, land acquisition, protection and public education. Single states may receive up to 75% of program costs

- **Landowner Incentive Program (Non-Tribal**). This program provides funding directly to the lead state wildlife service agency (WGFD in Wyoming) for programs addressing the issues noted previously.

7.4.6 Natural Resources Conservation Service

The Natural Resources Conservation Service (NRCS) administers a number of funding and technical assistance programs applicable to many of the alternative projects identified in Chapter 4. These programs are briefly described below and summarized in Table 7.1.

- **Environmental Quality Incentives Program.** The Environmental Quality Incentives Program (EQIP) is a voluntary program available to agricultural producers that provides technical assistance, cost sharing and incentive payments for projects and practices that improve water quality, enhance grazing lands, and/or increase water conservation. Current priorities used by NRCS in allocating EQIP funds that are applicable to the Buffalo Creek study area include reduction of nonpoint source pollution of surface waters, reduction in soil erosion and sedimentation from agricultural lands, and promotion of at-risk species habitat conservation.

  Non-federal landowners (including American Indian tribes) that engage in livestock operations or agricultural production are eligible for funding. Eligible land includes cropland, rangeland, pasture, forestland, and other farm and ranch lands. Eligibility also requires that the applicant develop an EQIP plan of operations that becomes the basis of the cost-sharing agreement between NRCS and the participant.

  EQIP provides payments up to 75 percent of the incurred costs and income foregone of certain conservation practices and activities. However certain historically underserved producers (Limited resource farmers/ranchers, beginning farmers/ranchers, socially disadvantaged producers) may be eligible for payments up to 90 percent of the estimated incurred costs and income foregone. Farmers and ranchers may elect to use a certified Technical Service Provider (TSP) for technical assistance needed for certain eligible activities and services. The new Farm Bill established a new payment limitation for individuals or legal entity participants who may not receive, directly or indirectly, payments that, in the aggregate, exceed $300,000 for all program contracts entered during any six year period. Projects determined as having special environmental significance may, with approval of the NRCS Chief, have the payment limitation raised to a maximum of $450,000.

  Detailed information about the EQIP program is available at the following website: http://www.nrcs.usda.gov/PROGRAMS/EQIP/.

- **Watershed Protection and Flood Prevention Program.** Also known as the "Small Watershed Program" or the "PL 566 Program," this program provides technical and financial assistance to address resource and related economic problems on a watershed basis. Projects related to

watershed protection, flood prevention, water supply, water quality, erosion and sediment control, wetland creation and restoration, fish and wildlife habitat enhancement, and public recreation are eligible for assistance. Technical and financial assistance is also available for planning and installation of works of improvement to protect, develop, and use land and water resources in small watersheds.

Applicants eligible for funding through this program that are potentially relevant to the Buffalo Creek study area include: local or state agencies, counties, conservation districts, or other subunits of state government (e.g., watershed improvement, water conservancy and irrigation districts) with the authority and capacity to carry out, operate, and maintain installed works of improvement. Projects are limited to watersheds containing less than 250,000 acres.

The assistance provided consists of technical assistance and cost sharing (amount varies) for implementation of NRCS-authorized watershed plans. Technical assistance is provided on watershed surveys and planning. Although projects vary significantly in scope and complexity, projects receiving $3.5 million to $5 million in federal financial assistance are not uncommon.

- **Other NRCS Programs.** Other programs administered through NRCS that may be relevant to certain of the alternative projects discussed in Chapter 4 include, but are not necessarily limited to the following:

    - **Wildlife Habitat Incentives Program (WHIP**) – Through WHIP, technical and financial assistance is provided to landowners and others to develop and improve wildlife habitat on private lands.
    - **Wetlands Reserve Program (WRP)** – Eligible landowners may receive technical and financial assistance through the WRP to address wetland, wildlife habitat, soil, water and related natural resource concerns on private lands.
    - **Grassland Reserve Program (GRP**) – This program emphasizes support for grazing operations, plant and animal biodiversity, and grassland and land containing shrubs and forbs under the greatest threat of conversion.
    - **Farm and Ranch Lands Protection Program (FRPP**) – FRPP is designed to help farmers and ranchers keep their land in agriculture. It provides matching funds to State, Tribal or local governments and non-governmental organizations with existing farm and ranch land protection programs to purchase conservation easements.
    - **Resource Conservation and Development (RC&D)** – Wyoming's five RC&D areas assist communities by promoting conservation, development and use of natural resources; improving the general level of economic activity; and enhancing the environment and standard of living for residents of those communities.
    - **Emergency Watershed Protection (ERP)**
    - **Small Watershed Rehabilitation Program**
    - **Sage Grouse Restoration Project (SGRP)**

- **Grazing Lands Conservation Initiative (GLCI) Grants**
- **Cooperative Conservation Partnership Initiative (CCPI)**

Information on all NRCS programs is available from the local contacts listed Table 7.1.

7.4.7 US Army Corps of Engineers

The Army Corps of Engineers has civil responsibilities for flood damage reduction, hydroelectric power generation and navigational improvement as well as other water and land resource problems and needs including environmental preservation and enhancement, ecosystem management and comprehensive flood plain management. The Corps is responsible for a worldwide military construction program, an extensive environmental program and a broad national civil works program.

The Corps of Engineers is authorized to provide technical assistance to local communities, States and federally recognized Indian Tribes in support of their efforts to alleviate flooding impacts, reduce erosion and otherwise plan for the wise and prudent use of the nation's water and related land resources. They also have authority to construct certain water resources related projects and respond to water resource needs.

- **Planning Assistance to States.** This program provides for assistance in preparation of plans for the development, utilization and conservation of water and related land resources. The Corps provide technical planning assistance in all areas related to water resources development such as bank stabilization, sedimentation, water conservation, ecosystem and watershed planning and water quality. Assistance is limited to $500,000 per state and studies are cost-shared on a 50-50 basis with a non-federal sponsor such as a state, public entity or an Indian Tribe.
- **Floodplain Management Services.** This program provides technical services and planning guidance for support and promotion of effective flood plain management. Flood and flood plain data are developed and interpreted with assistance and guidance provided in the form of "Special Studies" on all aspects of flood plain management planning. All services are provided free of charge to local, regional, state or non-federal public agencies. Federal agencies and private entities have to cover 100% of costs.
- **Flood Damage Reduction Projects.** This program provides structural and non-structural projects to reduce damages caused by flooding and focuses on solving local flood problems in urban areas, towns and villages. The Corps works with the project sponsor to define the flood problem, evaluate solutions, select a plan, develop the design and construct a project. A feasibility study is conducted to identify potential projects with the first $100,000 of the cost Federal. Any cost above this amount is cost-shared 50-50 with the sponsor in the form of cash and in-kind services. Construction lands, easements, rights-of-way, relocations and disposal and 5% of the projects costs are the sponsor's responsibility. Operation and maintenance and a maximum of 50% of total project cost are the sponsor's responsibility.

- **Project Modification For Improvement of Environment.** The purpose of this program is to modify structures or operation of previously constructed water resources projects to improve environmental quality, especially fish and wildlife values. A study, at federal expense, is initiated followed by a feasibility plan that is cost-shared 25% by the sponsor.
- **Aquatic Ecosystem Restoration.** This effort is for restoration of historic habitat conditions to benefit fish and wildlife resources. This is primarily to provide structural or operational changes to improve the environment such river channel reconnection, wetland creation or improving water quality. Conditions are similar to the Project Modification program with sponsor cost-share being 35%.
- **Water Resources Projects.** The purpose of this program is to construct larger projects for flood damage reduction and to provide technical assistance in resolving more complex water resource problems. It is used to evaluate projects costing more than $10 million that include purposes of flood control, water supplies, water quality, environmental protection and restoration, sedimentation or recreation. This would include reservoirs, diversions, levees, channels or flood plain parks as examples. The Corps works with a non-federal sponsor to define the flood or water resource related problem or opportunity, evaluate flood control or solutions, select a plan, develop a design and construct a project. This requires special authorization and funding from Congress with a reconnaissance study being federal cost. A feasibility study to establish solutions is cost-shared 50% by the non-federal sponsor with 35 to 50% of construction cost the responsibility of the sponsor.
- **Support For Others Program.** This program provides for environmental protection and restoration or facilities and infrastructure. This includes Environmental Planning and Compliance, Economic and Financial Analyses, Flood Plain Management, Cultural Resources and General Planning. All costs for these programs are provided by the customer agency.
- **Regulatory Authority/Responsibility.** The Corps of Engineers has regulatory authority under the Clean Water Act and the River and Harbor Act. The purpose of these laws is to restore and maintain the chemical, physical and biological integrity of waters of the United States. Section 404 of the Clean Water Act authorizes the Corps to regulate the discharge of dredged or fill material into waters. This would include dams and dikes, levees, riprap, bank stabilization and development fill. There are three kinds of permits issued by the Corps. They are Individual, Nationwide and Regional General permits.

7.4.8 Rural Utilities Service

The United States Department of Agriculture, Rural Development's utilities program is authorized to provide financial assistance for water and waste disposal facilities in rural areas and towns of up to 10,000 people. This program is intended for Non-profit corporations and public bodies such as municipalities, counties, and special purpose districts and authorities.

Funding may be obtained through Rural Development only when the applicant is unable to secure funding from other sources at reasonable rates and terms. The applicant must have legal capacity to borrow and repay loans, to pledge security for loans and to operate and maintain the facilities. The applicant must be financially sound and able to manage the facility effectively as well as have a financially sound facility based upon taxes, assessments, revenues, fees or other satisfactory sources of income to pay costs of operating, debt service and reserve. Grants are also available and are used to supplement loans to reduce debt service where necessary to achieve reasonable user rates. Assistance is also available on how to assemble information concerning engineering, financing and management of proposed improvements.

Loans and grants may be used to construct, repair, improve, expand or modify rural water supplies and distribution facilities such as reservoirs, pipelines, wells and pumping stations, waste collection, pumping, treatment or other disposal facilities. This assistance may also be used to acquire a water supply or water right or finance facilities in conjunction with funds from other agencies or those provided by the applicant. These funds can be used to pay legal and engineering fees connected with the development of a facility or pay other costs related to development including rights-of-way or easements and relocation of roads or utilities. Loan terms are a maximum of 40 years, State Statute, or the useful life, whichever is less with interest rates based on current market yields for municipal obligations.

USDA Rural Development also guarantees loans to eligible commercial lenders to improve, develop or finance water or waste disposal facilities in rural areas. This guarantee is a warrant to protect the lender and may cover up to 90% of the principal advanced. The guarantee fee is 1% of the loan amount multiplied by the percent of the guarantee. Interest rates will be negotiated between the lender and the borrower.

7.5 Non-Profit and Other Organizations

7.5.1 Ducks Unlimited

Ducks Unlimited, Inc. (DU) is a potential funding source for wetlands and waterfowl restoration projects. Although direct grant funding is limited (to the extent that there is generally about $20,000 to $30,000 available annually statewide), in-kind assistance may be available from the local chapter of DU. Additional information on DU's funding programs and opportunities is available in the Water Management & Conservation Assistance Program Directory referenced previously.

7.5.2 National Fish and Wildlife Foundation

The National Fish and Wildlife Foundation (NFWF) is a private, non-profit, tax exempt organization chartered by Congress in 1984 to sustain, restore and enhance the Nation's fish, wildlife, plants and habitats. NFWF provides grant funding on a competitive basis through their Keystone Initiative Grants

and Special Grant Program. Some of the grants/programs that may be applicable to potential projects in the Buffalo Creek Study Area include, but are not limited to the following:

- **Pulling Together Initiative** - provides support on a competitive basis for the formation of local Weed Management Area (WMA) partnerships that engage federal resource agencies, state and local governments, private landowners, and other interested parties in developing long-term weed management projects within the scope of an integrated pest management strategy; minimum 1:1 nonfederal match is required.
- **Native Plant Conservation Initiative** – funding preference for "on-the-ground" projects that involve local communities and citizen volunteers in the restoration of native plant communities.
- **Bring Back the Natives Grant Program** – funds to restore damaged or degraded riverine habitats and their native aquatic species provided by BLM, Bureau of Reclamation, FWS, Forest Service, and NFWF; minimum 2:1 nonfederal match required.
- **Five-Star Restoration Program** - provides modest financial assistance on a competitive basis to support community-based wetland, riparian, and coastal habitat restoration projects that build diverse partnerships and foster local natural resource stewardship through education, outreach and training activities; average grant is $13,000.

Information about all of these and other NFWF grants/programs is available at their website: http://nfwf.org/.

7.5.3 Trout Unlimited

The Wyoming Council of Trout Unlimited provides funding and volunteer labor for a variety of stream and watershed projects such as erosion control and fish habitat structures, willow and other riparian plantings and stream protection fencing. Embrace-A-Stream grants are available for up to $10,000 per project. Partnerships are encouraged and can include local conservation districts and state and federal agencies.

VIII. CONCLUSIONS AND RECOMMENDATIONS

A multidisciplinary inventory of the Buffalo Creek watershed was conducted in an effort to identify and evaluate key resource issues and concerns. A comprehensive Geographic Information System (GIS) was completed in conjunction with the inventory. The GIS incorporates the data collected and results generated during the study and collates it with information collected from a wide variety of sources. The GIS will be a valuable resource for the community and future studies which will likely be conducted in the watershed.

8.1 Conclusions

Upon completion of the watershed inventory phase of the project, the project team developed the watershed management plan. The plan was developed based upon findings of the inventory phase, a series of public meetings, questionnaires, and interaction with the project steering committee. In previous chapters, the key issues and problems were identified and ultimately, project goals and objectives were formulated to address them. Specifically, plans were developed to address issues associated with the following broad categories:

- *Irrigation System Conservation and Rehabilitation,*
- *Livestock/Wildlife Upland Watering Opportunities,*
- *Surface Water Storage Opportunities,*
- *Stream Channel Condition and Stability,*
- *Grazing Management Opportunities, and*
- *Other Upland Management Opportunities.*

In summary, the following conclusions are provided.

8.1.1 Irrigation System Components

1. No specific irrigation system components were identified for incorporation into the Buffalo Creek Watershed Management Plan.

2. Irrigation activities within the study area are limited, however, infrastructure does exist. Although no landowners requested evaluation of irrigation structures, headgates were observed on Buffalo Creek which are no longer operable due to channel degradation. Use of these facilities could be restored with completion of gradient restoration facilities recommended in the Stream Channel Restoration components of the watershed management plan.

3. Completion of the channel restoration projects in conjunction with an irrigation headgate would likely not require a 404 permit through the USACE due to the irrigation infrastructure exclusion. Coordination with the COE Omaha District's Wyoming Regulatory Office in Cheyenne would be necessary to verify permit requirements.

4. Funding assistance for irrigation system rehabilitation projects within the study area is available from a number of sources, especially the WWDC Small Water Project Program and various programs administered by the NRCS.

8.1.2 Livestock/Wildlife Upland Watering Opportunities

1. There appears to be numerous opportunities to improve range and riparian conditions by means of increasing the availability of upland water sources for wildlife and livestock use.

2. Pipeline/tank systems appear to offer the most efficient and cost-effective means to provide adequate watering to large areas of rangeland. Water sources for these systems will depend on the location of the rangeland to be served and the available alternative sources. The most likely sources are wells or spring developments.

3. A total of 32 potential wildlife/livestock water supply projects were identified based upon evaluation of available water sources and input from local land owners and allotment permittees. Conceptual plans and conceptual level cost estimates were prepared for each project. Projects ranged from installation of a guzzler to a regional upland water supply project servicing 10 individual wildlife / livestock water tanks and approximately 15 miles of pipeline.

4. Any such improvements and practices must be fully implemented and maintained by the landowner to gain the maximum overall benefits to the watershed.

8.1.3 Stream Channel Condition and Stability

1. Based on the geomorphic assessment, several impaired channel reaches were identified within the watershed. The categories of impairments identified include, but are not limited to degradation of riparian vegetation and degradation of riparian condition in the form of stream bank erosion and channel degradation.

2. Site-specific solutions should be developed to mitigate the channel impairment and ultimately included in the watershed management rehabilitation plan.

3. Locally-sponsored stream channel and habitat improvement projects could provide numerous benefits to the watershed. Potential projects would include efforts such as bank stabilization efforts using techniques such as willow plantings. In addition to providing direct benefits to the specific stream, ancillary benefits include education and community involvement.

8.1.4 Grazing Management Opportunities

1. Strategies, recommended in the state and transition models associated with NRCS descriptions of the ecological sites found within the watershed, should be adopted and employed to optimize range conditions through prescribed grazing management and best management practices.

2. Prescribed fire should be utilized as a tool to assist in the restoration of range health areas benefitting by this treatment according to the state and transition models. Delineation of specific areas potentially benefitting from this practice was beyond the scope of this Level I project. However, based upon input from landowners and land managers and observations made during the completion of this investigation, it is evident that there are areas which would likely benefit from prescribed fires.

8.1.5 Other Upland Management Opportunities

1. Eradication efforts targeting tamarisk and Russian Olive have been largely successful and continuation of these efforts is encouraged.

2. Noxious weed management programs currently being conducted by Hot Springs County Weed and Pest Control District should continue. Education opportunities for land owners and managers should continue to be made available.

8.2 Recommendations

Based upon the information presented throughout this report and the conclusions presented above, the recommendations listed below are presented for consideration:

Many of the livestock / wildlife upland watering alternatives fall within the constraints for funding eligibility of the WWDC's Small Water Project Program (SWPP). These projects should be reviewed and selected alternatives should be implemented as soon as is practical. Completion of one or more of these projects in the near future would serve to benefit those directly involved in the project and increase interest and awareness of the benefits associated with the watershed planning process**.**

Funding through the SWPP does not require formation of a district but does require an entity sponsor such as the local conservation district. Consequently, individuals can seek funding through this program. As discussed in Chapter 7, projects providing multiple benefits and for which total project cost are less than $100,000 are eligible for funding under this program. Grants are available for up to 50 percent of the total project cost or $25,000, whichever is less.

Creative strategies for funding/financing of projects should be more fully investigated following identification of projects worthy of additional evaluation and potential implementation. *By combining funding sources, the owner could conceivably obtain grants for most, if not all, of the project costs.*

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