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Nowood River
Storage / Watershed Study

Final Report
March 9, 2010

FINAL REPORT

NOWOOD RIVER STORAGE / WATERSHED STUDY

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March 9, 2010

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I. INTRODUCTION

On June 5, 2008 Anderson Consulting Engineers, Inc. (ACE) entered into a contract with the Wyoming Water Development Commission (WWDC) to provide professional services for the Nowood River Storage / Watershed Level I Study. ACE was retained to evaluate and describe the Nowood River watershed 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 Nowood River Storage / 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

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

In 2007, a group of interested landowners joined together to approach the WWDC in request of funding for a watershed investigation involving the Nowood River watershed. That group, now referring to itself as the Proponents of Nowood Drainage Storage, or PONDS, was successful in its application and funding was awarded to the project following the 2008 legislative session.

1.2 Background

The Nowood River watershed is generally located on the western slope of the Big Horn Mountains in Big Horn and Washakie Counties, Wyoming (Figure 1.1), covering approximately 2,020 square miles. The Nowood River is tributary to the Big Horn River and joins it at the Town of Manderson. The watershed encompasses the Towns of Hyattville and Tensleep. Elevations range from less than 4,000 feet above mean sea level at its mouth to over 13,000 feet in the Big Horn Mountains, resulting in overall relief of over 9,000 feet. Figure 1.2 shows the Nowood River watershed in relation to the Big Horn Mountains and the Big Horn Basin. This figure clearly shows the topographic variability in the study area. The eastern portion of the watershed consists of the west slope of the Big Horn Mountains. Precipitation ranges with elevation from 15 to 22 inches per year on the east side of the basin compared to 11 to 13 inches per year on the drier and lower west side of the basin.

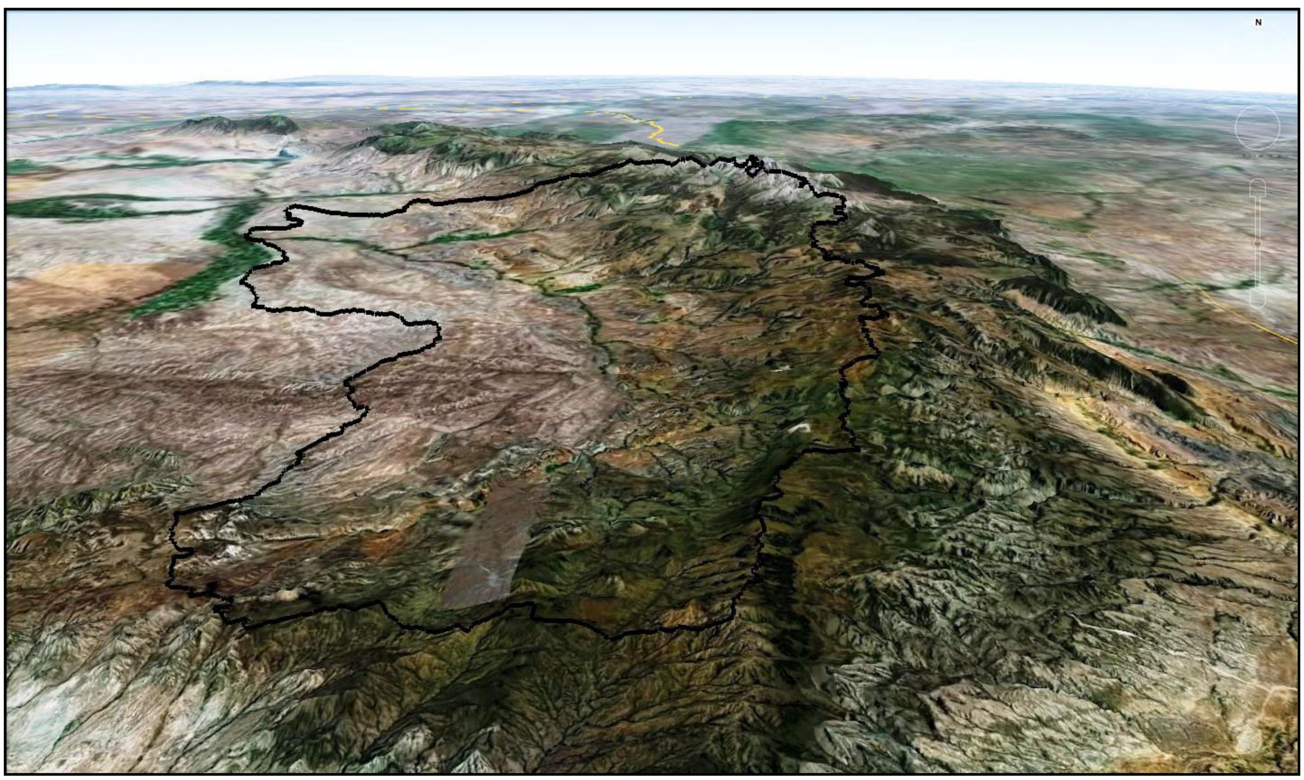

Figure 1.2 Overview of the Nowood River Watershed

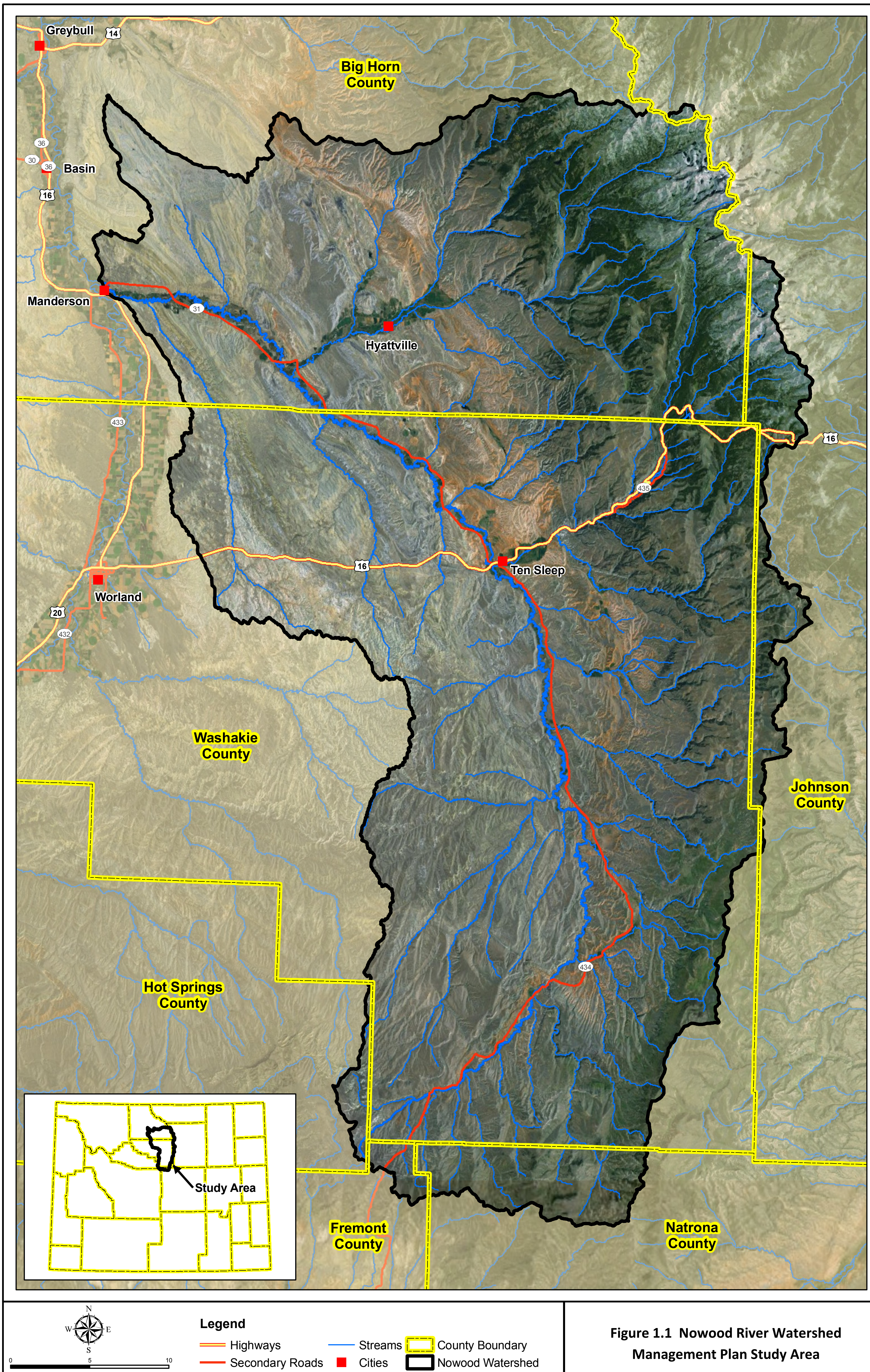

Figure 1.1 Nowood River Watershed Management Plan Study Area

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The majority of the basin is federally managed public land. The largest portion of these lands is managed by the Bureau of Land Management (approximately 49.18%), followed by United States Forest Service (National Forest plus Wilderness Area are approximately 16.16%). The remainder of the basin is primarily either privately owned (26.56 %), owned by the State of Wyoming (6.73 %). The Nature Conservancy (private) owns an additional 0.78% and 0.60% is administered by the Wyoming Department of Game and Fish.

Land owners and stakeholders within the study area face several key issues related to water within the basin and utilization of resources:

Runoff Quantity and Timing Issues

- The Nowood River generates a significant amount of runoff. Consequently, the problem with streamflow is not one of quantity but of timing. Shortages occur during late season low flow periods but spring runoff sees large amounts of water running out of the watershed.
- Flooding, while not a frequent problem, has caused damages historically.
- The problems presently experienced by limited flows in the summer months and occasional spring flooding may be mitigated by storage reservoirs within the watershed. Currently, there are no reservoirs located on the Nowood River and a limited number within the watershed.

Grazing Issues

- 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. Consequently, livestock and wildlife tend to focus on those areas where water is available for consumption. Those areas where water is available for livestock/wildlife consumption also support riparian vegetation.
- The Bureau of Land Management administers grazing allotments in the Nowood watershed through its Worland District office. Based upon data provided by the BLM, there are approximately 195 individual allotments totaling over 872,000 acres. The allotments encompass primarily BLM lands but also include portions of deeded property or State of Wyoming lands.

Channel Stability Issues

- Channel stability issues are evident in certain locations of the watershed.

Figure 1.3 Nowood River Exhibiting Lateral Channel Migration and Bank Erosion

Magnitude of degradation problems vary, but include bed and bank degradation, channel incision, degradation of riparian vegetation, etc.

- There are numerous causes of channel degradation instability and degradation, including encroachment by land use activities (agriculture, grazing), alteration of channel alignment (i.e., straightening), loss of riparian vegetation, etc.
- Erodible conditions in portions of the watershed has likely contributed to erosion and sedimentation in the lower portion of the Nowood River.

Irrigation Issues

- Total irrigated acreage is estimated to be on the order of 20,000 acres based upon available mapping. The ditches typically range in size from those servicing individual land owners with less than 20 acres to several ditches conveying water to irrigate several hundred acres of land (Figure 1.4).
- Irrigation ditches in the watershed are commonly in need of improvement in some form. Typical structures in need of rehabilitation include drop structures, siphons and headgates.
- Late season irrigation is frequently curtailed with the shortage of water in the streams. During recent drought conditions, irrigators had to frequently choose which field to let 'burn' (i.e., not irrigate).

Figure 1.4 Typical Irrigation Ditch in Nowood River Watershed: Anita Ditch

- Reservoir storage coupled with improvements to the irrigation conveyance facilities or on-farm irrigation methods may conserve water and create opportunities that would benefit irrigators and other water users within the watershed.

1.3 Purpose and Scope

The primary purposes of the Nowood River Storage and 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 Nowood River Storage and 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 2008. WWDO's involvement within the watershed was sparked in 2006 by local landowner interest in sustainable stream flows and storage, and request for more information regarding the WWDC's programs. A landowner meeting was held in early 2007 to inform the community of the Wyoming Water Development program and discuss the process of building storage within the basin. Following the meeting, the community organized and submitted a formal request asking for assistance in determining the best and most beneficial water storage system for the Nowood River Watershed area. The request culminated in a recommendation by the WWDO to conduct a Level I watershed study to provide a solid foundation on which to consider storage potential and other basin opportunities. Additional landowner and local agency meetings were held in early 2008 to discuss the watershed study process and objectives and to garner information from the public regarding their interests and concerns. Based on the positive response, the decision was made to proceed forward with the Nowood River Storage/Watershed Level I Study.

A Steering Committee was formed during the January 2008 landowner meetings. The committee consists of volunteer stakeholders from across the watershed and have provided invaluable guidance and coordination throughout the study. In addition, the Steering Committee was involved in the review of the project scope, evaluation of proposals, and the selection of the contracted consultant.

The pre-contract meetings included the following:

Landowner Meeting	28-Feb-07	Ten Sleep, WY
Washakie County Conservation District Meeting	17-Dec-07	Ten Sleep, WY
South Big Horn County Conservation District Meeting	8-Jan-08	Greybull, WY
Landowner Meeting	30-Jan-08	Ten Sleep, WY
Landowner Meeting	31-Jan-08	Hyattville, WY
Pre-Proposal Tour	18-Mar-08	Nowood River Watershed
Steering Committee Meeting (Scoping Comments)	15-Apr-08	O'Donnell Residence
Consultant Interviews/Selection w/ Steering Committee	7-May-08	Cheyenne, WY

The post-contract meetings were orchestrated by Anderson Consulting Engineers (ACE) with the assistance of members of the Steering Committee 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 the Steering Committee pertaining to the project;

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

The Project Update meetings were well attended, indicating a high level of interest by the public in the process. Representatives of key agencies were generally present, including representatives from the Bureau of Land Management, Wyoming State Engineers Office, Wyoming Game and Fish, Washakie County Conservation District, South Big Horn Conservation District, and others. The Northern Wyoming Daily News covered the process with several newspaper articles.

ACE advertised the meetings in the Northern Wyoming Daily News, via specific phone invitations, and by word of mouth. In general, the meetings were considered a success and were characterized by a high degree of interaction between participants.

Seven project meetings were held and included the following:

• Steering Committee Meeting	16-Jun-08	O'Donnell Residence
• Scoping Meeting	4-Aug-08	Hyattville Cafe
• Scoping Meeting	5-Aug-08	Tensleep Senior Center
• Project Update Meeting	11-Dec-08	Tensleep Senior Center
• Steering Committee Meeting	12-Mar-09	Hyattville Community Center
• Project Update Meeting	12-Mar-09	Hyattville Community Center
• Steering Committee Meeting	26-Aug-09	Tensleep Senior Center
• Project Update Meeting	17-Sep-09	Tensleep Senior Center
• Steering Committee Meeting (Draft Report Comments)	11-Feb-10	Tensleep Senior Center
• Final Report Presentation	11-Mar 2010	Tensleep Senior Center

At each of the meetings, ACE representatives made presentations summarizing the status of the project and the next steps to be accomplished. Attendee feedback on presented information was encouraged to ground truth gathered data and scrutinize proposed watershed projects…. The project GIS was demonstrated throughout the process to keep the public and the Steering Committee up to date on the information which would ultimately be incorporated within it. Following each meeting, discussions and question and answer sessions were held.

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 Nowood River watershed 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. Forest Service (USFS),
- 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)
- Big Horn County Assessor's Office
- South Big Horn Conservation District

- Big Horn County Weed and Pest District
- Washakie County Assessor's Office
- Washakie County Conservation District
- Washakie County Weed and Pest District
- TCT West Communications
- The Nature Conservancy
- National Fish and Wildlife Foundation

3.2.2 Project Questionnaire

In an effort to solicit information directly from landowners and stakeholders within the study area, a questionnaire was prepared and mailed to 140 basin landowners. The mailing list was generated with the assistance of the Washakie County Conservation District, the South Big Horn County Conservation District, and the project Steering Committee. The purpose of the questionnaire was to collect valuable first hand information regarding the watershed's resources. Specifically, questions targeted the landowner's concerns regarding irrigation, water supply, range, upland water sources and stream channel conditions. In addition, the questionnaire solicited participation in several phases of the project, including irrigation inventory, stream channel assessment, range management, and upland water supply development concerns.

Response from the mailing effort was less than desirable. Of the 140 sent, 20 were returned. Those responders who requested to be contacted were and interviewed during the pertinent phases of the project. Appendix A contains a copy of questionnaire. It should be noted that communication with landowners/stakeholders is a long, slow process. As the project proceeded, the landowners/stakeholders became more involved and informed through attendance at the project meetings and through conversations with neighbors.

3.2.3 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 Nowood River 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.

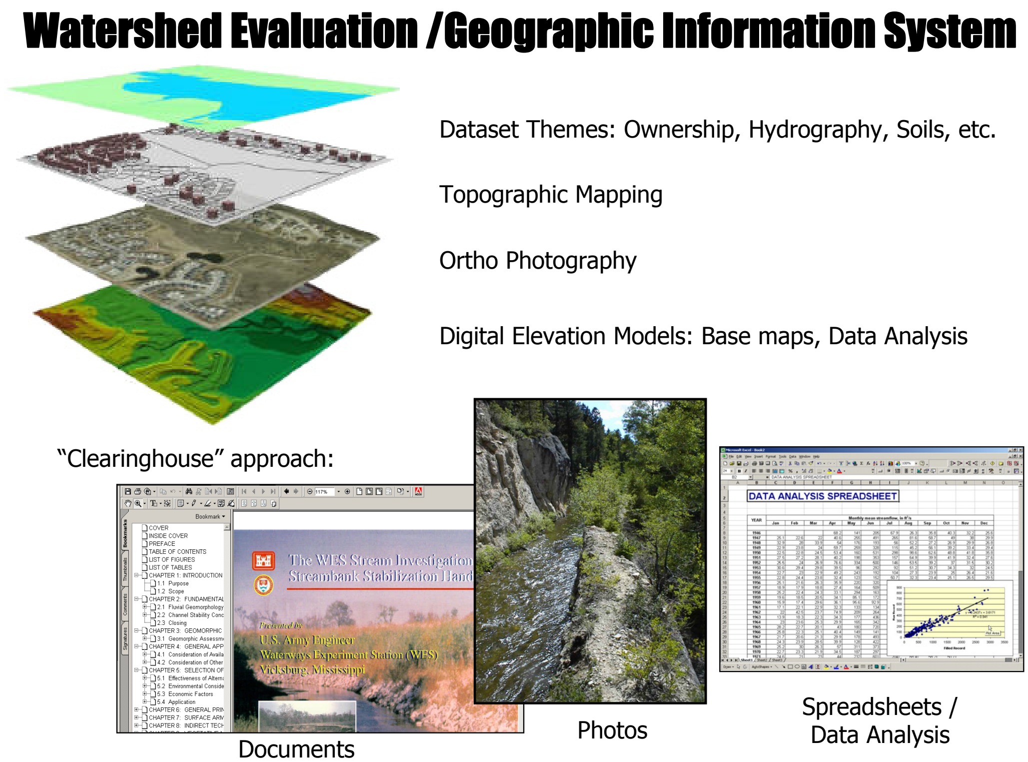

Figure 3.1 Example of the Nowood River Watershed Study GIS Structure and "Clearinghouse" Capabilities.

Spatial data pertaining to the Nowood River watershed was collected from a wide range of sources. Agencies providing information included the State of Wyoming, USDA Forest Service, USDI Bureau of Land Management, Wyoming Game and Fish Department, Washakie County, Big Horn 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.

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 Nowood River 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 is not 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.

Table 3.1 Generalized GIS Contents

Backgrounds	**Irrigation**
USGS 30 M DEM	Digitized Irrigated Acres
USGS Topogographic Mapping Tiled Mosaic	Ditch inventory locations
USGS 1:100K Topographic Mapping	Digitized Irrigation Ditches
USGS 1:250K Topographic Mapping	**Mining**
2006 NAIP County Mosaic 1M Pixel Resolution	Coal Mining Activity
2001 CIR Imagery 1M Pixel Resolution	Bentonite Mining Activity
Climate	Mine Permit Boundaries
Weather Station Locations	**Oil and Gas**
CoCoRaHS_Stations	Oil and Gas Wells
Precipitation Isohyetal Lines (PRISM)	Oil fields
Cultural / Historical	**Ownership**
Cultural Sites Eligible for the National Register of Historic Places per PLSS	Parcel Ownership
Environmental	County Subdivisions
Aquatic priority areas both crucial and enhancement areas	Land Owner Database
Terrestrial priority areas both crucial and enhancement areas	**Political Boundaries**
Invasive Species	County Boundarys
National Wetlands Inventory	UTM Coordinate zones
Combined priority areas (both crucial and enhancement).	Public Land Survey : Townships
Big game crucial ranges (All Species)	Public Land Survey : Quarter Sections
Big game migration routes (All Species)	Wilderness Study Areas (Statewide)
Big Game habitiats	State Conservation Districts (Statewide)
Bison hunt area herd unit boundaries	State Improvement Districts (Statewide)
Black bear hunt area herd unit boundaries	BLM Field Office Boundaries
Mountain lion hunt area herd unit boundaries	**Range Management**
Sage Grouse Lek Locations and Core Population Areas	BLM Rights of Way
Geology	BLM Allotment Boundaries
1:500K Bedrock Geology layer	Viable Stock Pond evaluation
1:500K Extraction of Bedrock Geology Layer containing Limestone Formations	Existing Stock Ponds
1:500K Surficial Geology Layer	Springs
Statewide Geologic Formation Layer	Guzzlers
Landslides	Stock Ponds
Geomorphology	Range Pipeline projects
BLM PFC data	Range Fences
Rosgen Level I stream classification	Ecological Site Description (ESD)
Hydrology	**Soils**
Exising Wells	SSURGO Soils Mapping: Carbon County
Streamgage locations	SSURGO Soils Mapping: Washakie County
Existing Water Quality Monitoring	SSURGO Soils Mapping: Johnson County
Surface hydrography	SSURGO Soils Mapping: Fremont County
Stream Names	Soils: Big Horn County Planning Department
Subbasins	General Soils Data: 1:250,000
HUC 5th Order Watersheds	**Watershed Management Plan**
Temporary Stream Gage Locations	**Irrigation System**
Infrastructure	Ditch Rehabilitation Sites
Electric Transmission Corridors	Ditch Alignment
Major Roads	**Potential Upland Projects**
Roads of Importance and Names	Proposed project locations and components
Minor / Secondary Roads	Proposed project locations - one mile buffers
Water Transmission	**Potential Storage Projects**
Railroads	Priority 1, 2, and 3 locations
Fiber Optics, Cell Towers, Microwave Towers	Storage site contributing watershed
Cities	Potential Supply Canal Alignments

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.

3.2.4 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. Appendix B presents a list of individual documents.

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
USDA States Forest Service
USDI United States Geologic Survey
Washakie and South Big Horn County Conservation Districts
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 History of the Project Area

The following description of the history of the study area was obtained from the Washakie County Conservation District (WCCD, 2005):

> *"Topography played an important part in the development of Washakie County. It was a deep, fertile valley, isolated by high-formidable mountains, with few negotiable passes. Agriculturally, the area was rich, and all along the Nowood valley there was good and plentiful water and vast miles of buffalo grass. Here existed a natural abundance - deer, elk, buffalo, bear, trout in the creeks, which made it a favorite hunting area and winter*

camping ground for several Indian tribes. The severe winter storms generally were shunted away from the area because of the tall mountains surrounding, making the winters mild. To the west of the foothills there were many miles of "badlands," clay soils whose nature was hidden by luxurious grass and was an ideal environment for salt sage, a high-protein superior livestock feed which was grazed during the winter months.

The first permanent settlement of the Ten Sleep area was around 1880 by cattlemen. The first large herds of cattle were brought into the area by a group of local ranchers in 1886. These cattle were driven overland from Texas to the Upper Nowood country. The following winter was severe and 80% of the cattle died because no hay or feed was available.

During the 1890's, large numbers of sheep were brought into the area. There were more cattle in the Basin than ever before, but sheep were steadily encroaching on the cattlemen's domain. The cattlemen had grown to consider it their own open range because of prior occupancy and they were concerned that when the sheep were trailed over a section it was no longer usable for cattle grazing, but the indisputable fact stands that the range had been consistently overstocked and overfed, and the near-drought conditions that prevailed for several years was also a major factor in the decline of open pasturage. The resulting feuds were terminated in 1909 in the "Ten Sleep Raid," in which three sheep men and large numbers of sheep were killed.

Irrigated farming began in the Ten Sleep area about 1883. The Town of Ten Sleep was incorporated in 1932, although it was in existence before that date. "

3.3.2 Land Ownership

The total land area within the Nowood River watershed is over 1.28 million acres (2,012 square miles). Figure 3.2 presents a map indicating the various land ownership categories within the watershed. As indicated in this figure, the watershed spans a total of six counties: Washakie, Big Horn, Johnson, Natrona, Hot Springs and Fremont Counties. Figure 3.3 shows the relative distribution of land among the counties. Washakie and Big Horn County dominate the region with 58.8 percent and 34.1 percent respectively. Johnson County (3.3 percent), Natrona County (2.8 percent), Hot Springs County (0.5 percent), and Fremont County (0.4 percent) encompass the remainder of the watershed.

Land ownership information was obtained from the respective county assessors' offices and incorporated into the project GIS. The majority of the basin is federally managed public land. The largest portion of these lands is managed by the Bureau of Land Management (632,600 acres or approximately 49.18%), followed by United States Forest Service (National Forest plus Wilderness Area are approximately 207,800 acres or 16.16%). The remainder of the basin is primarily either privately owned (341,600 acres or approximately 26.56%), or owned by the State of Wyoming (86,500 or 6.73%). The Nature Conservancy (private) owns an additional 0.78% (approximately 10,000 acres) and 0.60% (approximately 7,700 acres) are administered by the Wyoming Department of Game and Fish. A pie chart displaying the relative percentage of land ownership within the watershed is presented as Figure 3.4.

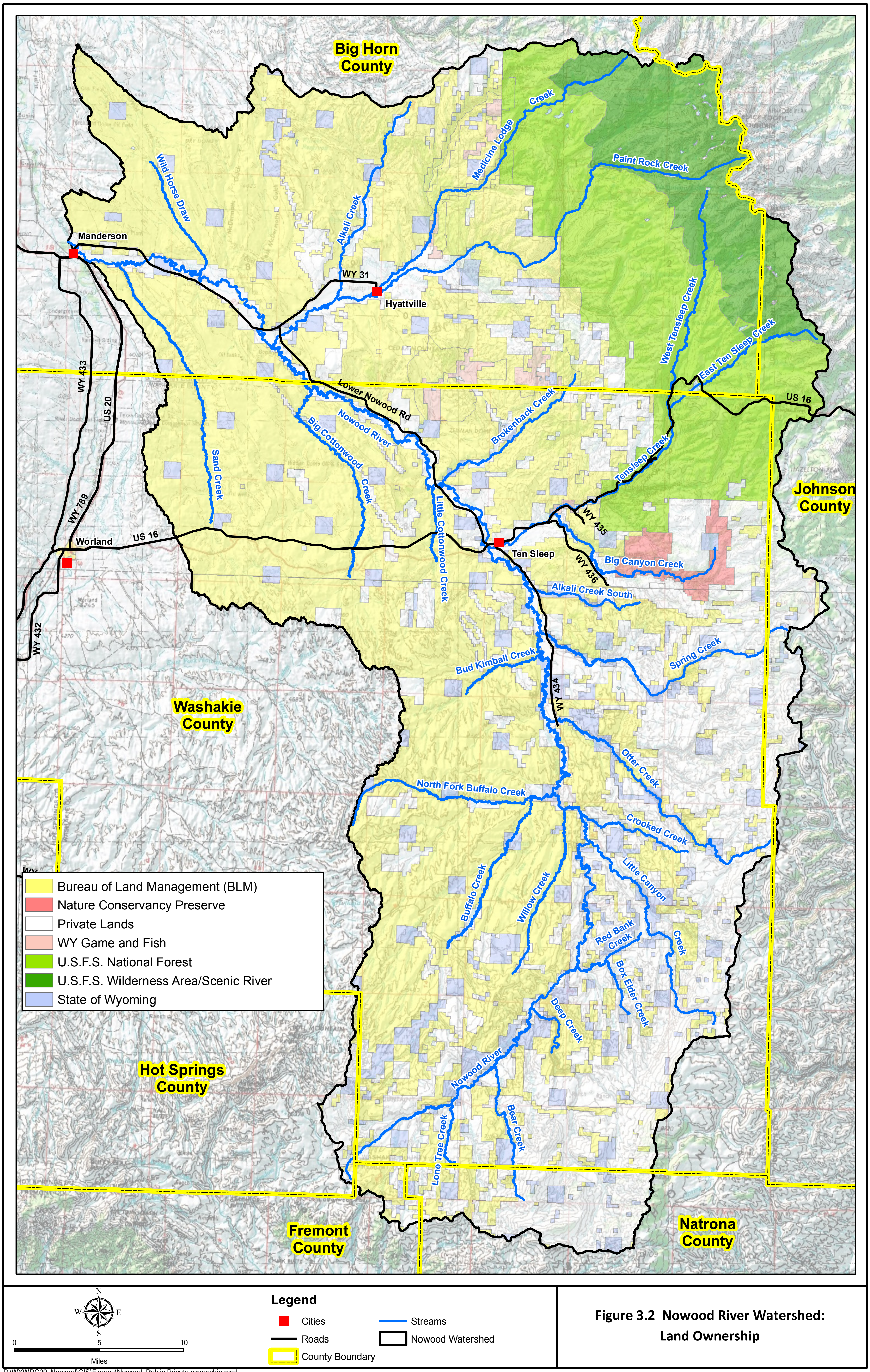

Figure 3.2 Nowood River Watershed: Land Ownership

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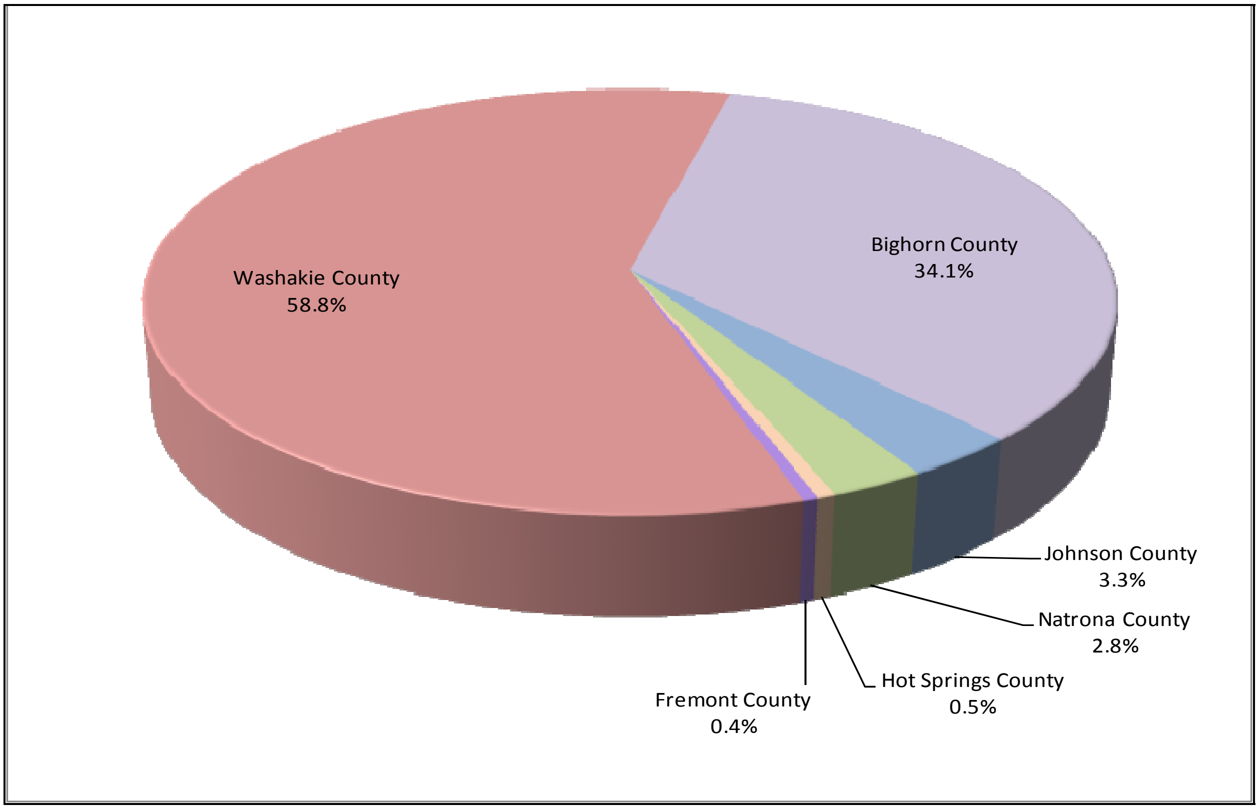

Figure 3.3 Relative Distribution of Watershed by County

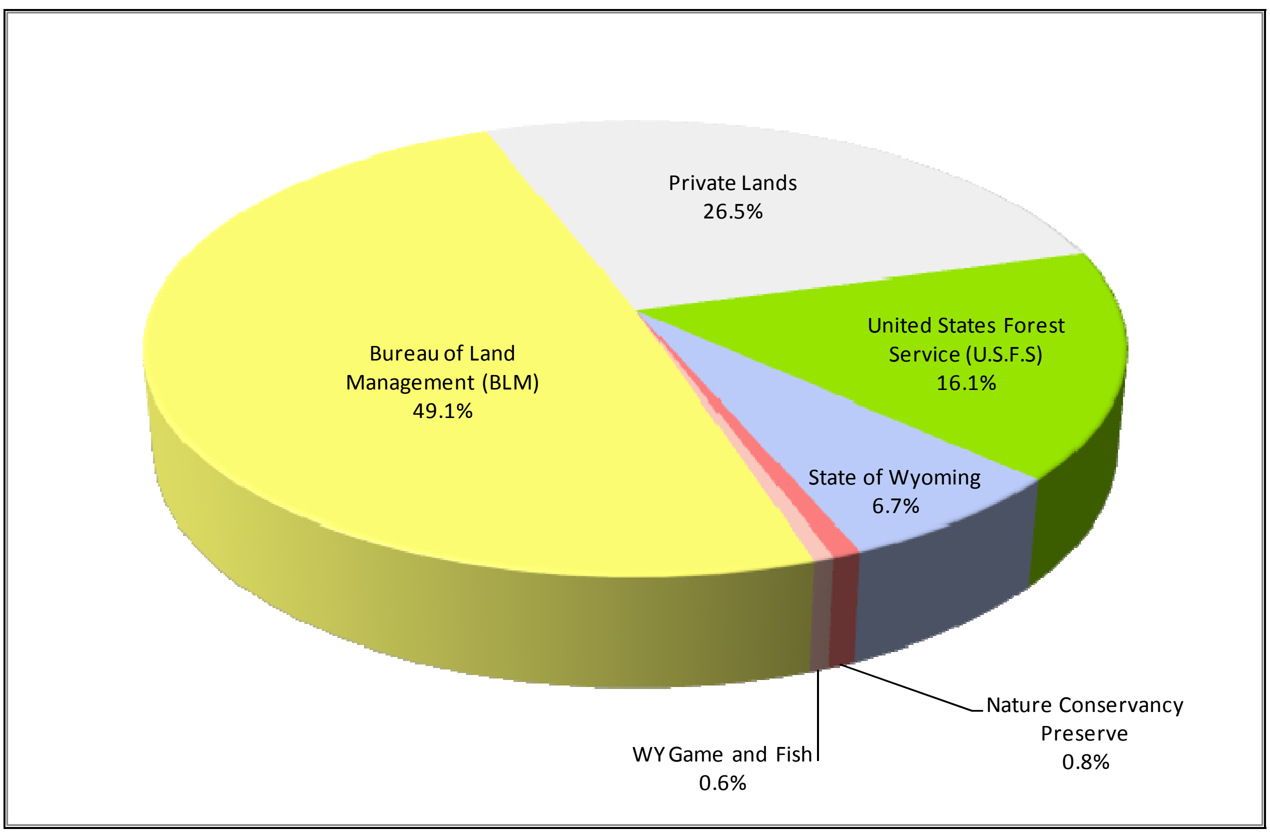

Figure 3.4 Relative Distribution of Watershed by Land Ownership

3.3.3 Transportation, Energy and Communications Infrastructure

Transportation corridors within the study area are limited to a small number of principal thoroughfares. Primary paved transportation routes traversing the study area are shown on Figure 3.5. State Highway 16 (the only State Highway in the watershed) traverses the central portion of the watershed through the towns of Worland, Tensleep and Buffalo. County Road 31 runs between Manderson and Hyattville. In addition to this main route, the Tensleep-Manderson Road (County Road 43 1/2) follows the Nowood River north from Tensleep to State Highway 31 near Hyattville. Access to the southern portion of the basin is provided primarily via the Nowood Road (County Road 434 / 82) which runs along the Nowood River valley and eventually crosses south to the town of Lysite. These represent the principal arterials within the study area. In addition to these primary arterials, there are numerous additional improved (unpaved) and "two-track" roads throughout the watershed.

Electric power service in the project area is provided by Big Horn Rural Electric Company. Mapping of their distribution infrastructure was not available; however, most of the existing distribution lines are located along the major paved and county-maintained gravel roads in the watershed.

A major fiber optics communications cable runs from Denver to Seattle (TCT West, personal communication, 2009). The cable is buried and follows the general alignment of the Nowood River floodplain from its headwaters north to Manderson before continuing north along the Big Horn River. Because of the proximity of the cable, many residents and businesses in the study area are provided with high speed internet service. In addition to these amenities, there are several additional cellular phone communications towers located within the basin.

3.3.4 Irrigation

Evaluation of Irrigated lands was initiated using mapping information generated by the Wind / Bighorn River Basin Planning Study conducted by the WWDC (BRS, 2003). During the completion of the WWDC study, irrigated lands within the Wind / Bighorn basin (which includes the entire Nowood River watershed), were mapped using GIS methods. Using aerial photography dated 1999, the irrigated parcels were delineated. This information was then provided in GIS format. At the initiation of the current project, more recent and higher quality imagery became available. Color aerial photography dated 2006 was acquired through the National Agricultural Imagery Program (NAIP). The NAIP imagery is of a higher resolution than the previously used CIR images. In an effort to update the mapping generated during the WWDC study, the previously mapped irrigated parcels were overlain on the NAIP imagery and modifications noted. Typical changes included conversion of lands to center pivot sprinklers, etc. Figure 3.6 displays the irrigated acres digitized during this effort.

The results of this effort indicate that approximately 21,103 acres are irrigated within the Nowood River watershed. The majority of these lands lie within the floodplains of the Nowood River, Tensleep Creek,

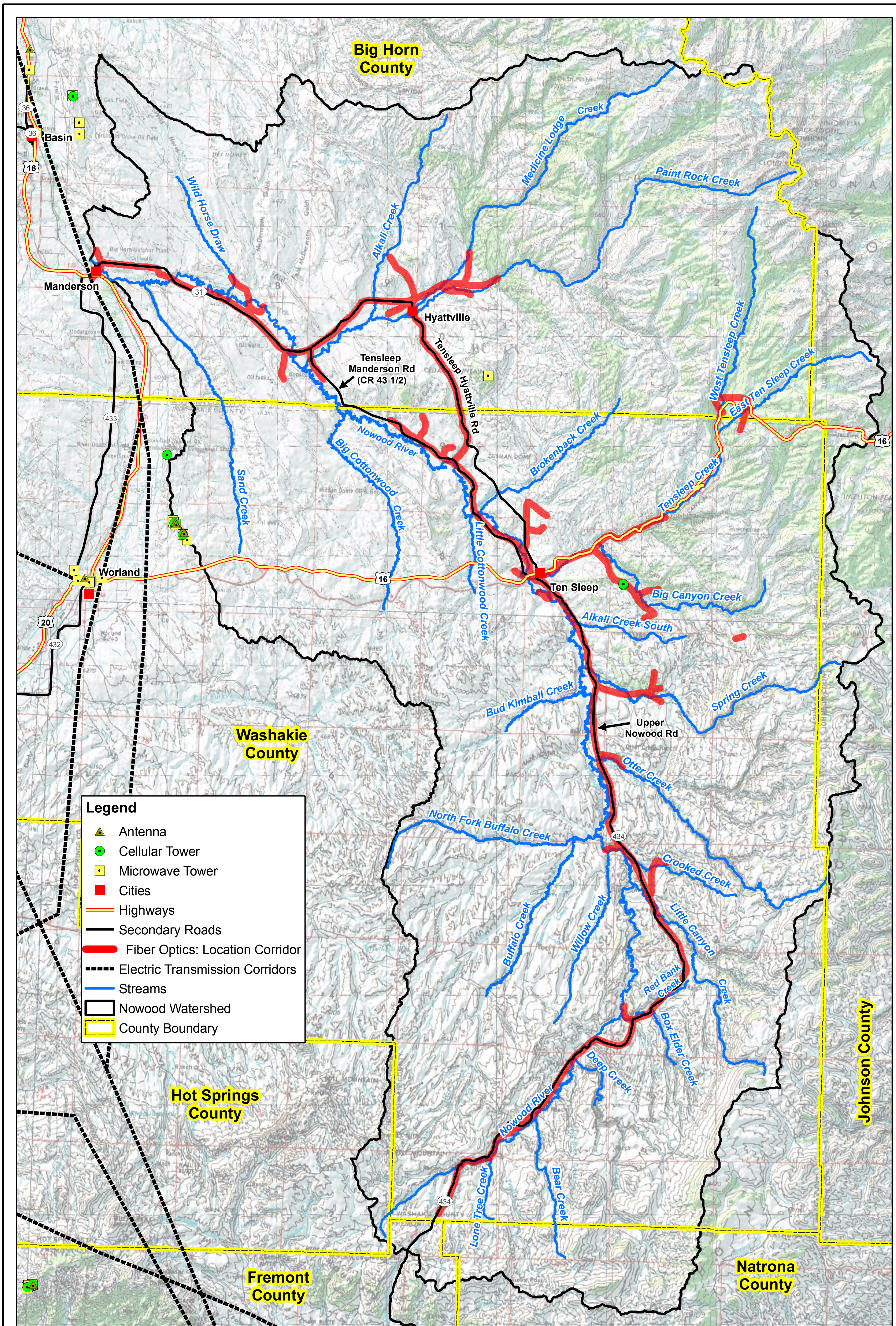

Figure 3.5 Nowood River Watershed: Communications and Transportation

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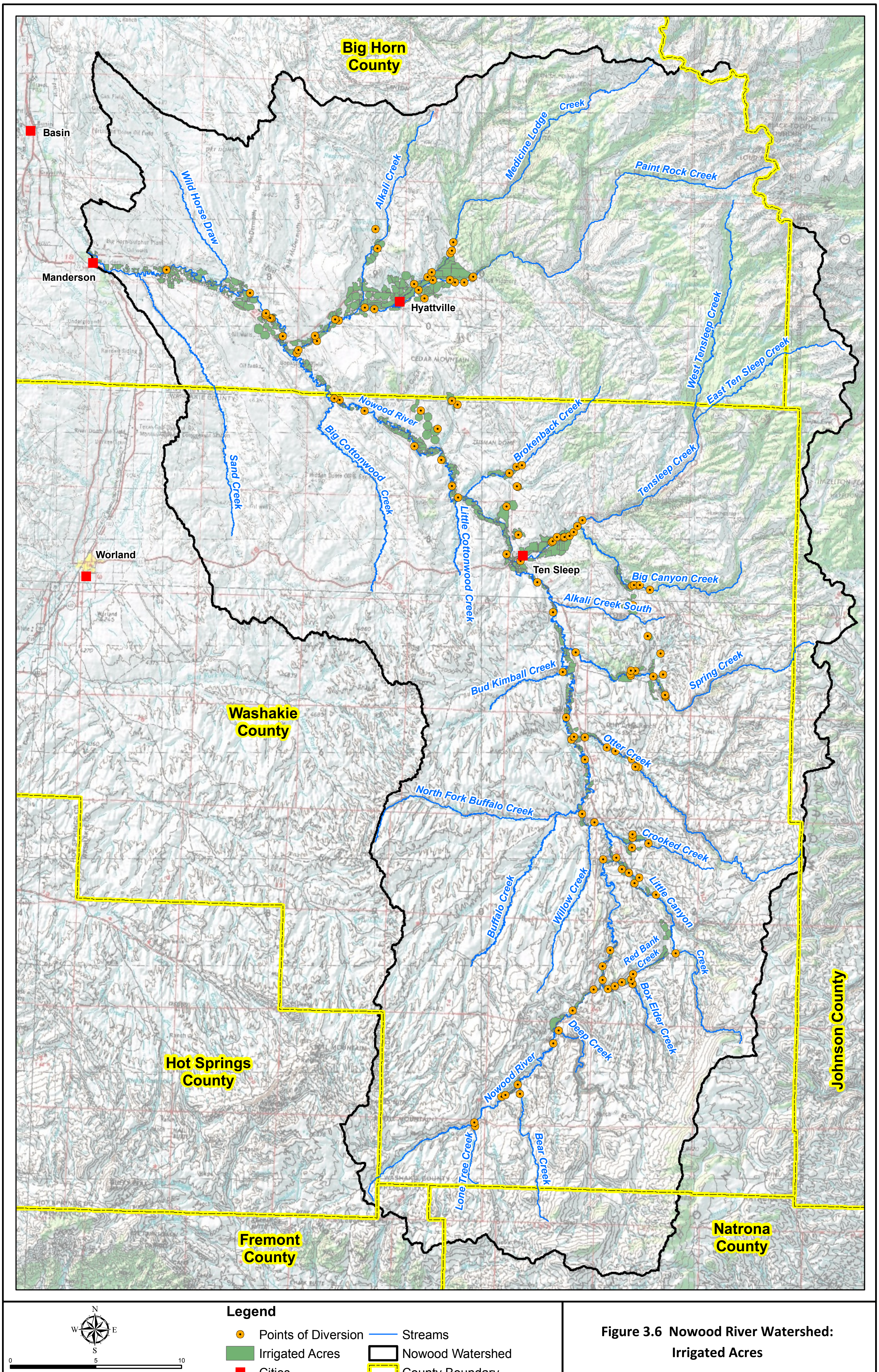

Figure 3.6 Nowood River Watershed: Irrigated Acres

P:\WYWDC29_Nowood\GIS\Figures\Nowood_Irrigated Acres.mxd and Paint Rock Creek. Additional irrigated parcels are scattered throughout the watershed, primarily within other tributary floodplains. Due to the use of groundwater as an irrigation source within the study area, there are also irrigated parcels outside of existing floodplains. At this level of study it was not feasible to conduct a thorough reconnaissance to further ground-check the irrigated lands mapping.

According to tabulations of water rights provided by the Wyoming State Engineer's office, there are at least 221 irrigation ditches within the basin. Appendix C contains a listing of irrigation ditches extracted from the tabulated surface water rights within the study area. Table 3.3 lists ditches with water rights dating prior to 1890 and their source supply. It must be kept in mind when reviewing this data, that many ditches listed in the tabulation and included in the estimated number of ditches share common points of diversion. In addition, many of the irrigated parcels are supplied by groundwater sources and will not be included in this tabulation. Figure 3.6 displays the individual points of diversion according to data provided in the Wind Bighorn Basin Planning documents.

According to the Washakie County Conservation District (WCCD), the dominant irrigated crops within the Nowood River watershed are alfalfa and grass hay. Corn and oats are grown to a lesser extent. Irrigated pastures are also found in relatively small quantities. A few fields are planted in beets in the lower portion of the watershed near Manderson. Numerical estimates of the relative amounts of crops were not available.

Data pertaining to agricultural production and related statistics for the State of Wyoming and counties within it are provided by the US National Agricultural Statistics Service (http://www.nass.usda.gov/Statistics_by_State/Wyoming/index.asp),

3.3.5 Range Conditions/Grazing Practices

3.3.5.1 Grazing Allotments Administration

Grazing on federal lands within the Nowood River 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 3.7 displays the grazing allotments found within the study area. Based upon information collected from the BLM, there are approximately 195 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. Appendix D lists the allotments and pertinent data associated with them.

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 3.3 Senior Water Rights (1890 and Prior) in the Nowood River Watershed

Ditch	Source	Senior Priority
Two Bar Ditch	Boxelder Creek	4/1884
Winn* or Wynn Ditch	Tensleep Creek	9/1/1884
Hunsinger No.1 Ditch	Big Canyon Creek	10/15/1884
Grout Ditch	Otter Creek	4/1/1885
Emge & Robinson No 2 Ditch	Spring Creek	5/1/1885
S.V. Ditch	Nowood River	5/1/1885
Waln Bros Ditch	Spring Creek	5/1/1885
Dyson Ditch	Otter Creek	5/10/1885
Carothers no. 2 Ditch	Spring Branch Creek	5/10/1885
Columbian*not Columbine Ditch	Tensleep Creek	5/10/1885
Ainsworth Ditch	Crooked Creek	5/15/1885
Bremmer No 1 Ditch	Crooked Creek	5/15/1885
Big Bear Ditch	Paint Rock Creek	5/2/1885
Bayne/George Ditch	Medicine Lodge Creek	5/20/1885
George & Bayne Ditch	Medicine Lodge Creek	5/20/1885
Helms No. 1 Ditch	Boxelder Creek	4/0/1886
Cornell#1 Ditch	Nowood River	4/2/1886
Mead#1 Ditch	Nowood River	5/1/1886
Red Bank Ditch	South Fork Little Cannon Creek	6/1886
Meyers Ditch	Paint Rock Creek	9/11/1886
Hunsinger No. 2 Ditch	Big Canyon Creek	10/1/1886
Standish & Henderson Ditch	Spring Creek	3/20/1887
Hardscrabble Ditch	Brokenback Creek	3/25/1887
Allen & Nelson Ditch	Medicine Lodge Creek	4/10/1887
Luman & Allen Ditch	Paint Rock Creek	4/8/1887
Burke Ditch	Tensleep Creek	8/1/1887
Helms No. 2 Ditch	Boxelder Creek	9/1/1887
Highland Ditch	Medicine Lodge Creek	11/0/1887
Berstein #1 Ditch	Paint Rock Creek	Fall 1887
Elk Ditch	Paint Rock Creek	Fall 1887
Bernstein Ditch	Paint Rock Creek	Summer 1887
North Fork Ditch	Spring Branch Creek	4/1/1888
Perfection Ditch	Tensleep Creek	4/10/1888
Hyatt #2 Ditch	Medicine Lodge Creek	5/101888
Higbie Ditch	Otter Creek	5/1888
Anthony Ditch	Medicine Lodge Creek	9/20/1888
Umslopogaas Ditch	Little Canyon Creek	5/0/1889
Go Ahead Ditch	Paint Rock Creek	5/1/1889
Spratt Ditch	Nowood River	5/13/1889
Dutch Ditch	Coon Hollow Creek	5/17/1889/
Rosebud Ditch	Little Canyon Creek	9/0/1889
Suez Ditch	Nowood River	3/15/1890
Harmony Canal	Nowood River	3/20/1890
Bay State #2 Ditch	Tensleep Creek	5/1890

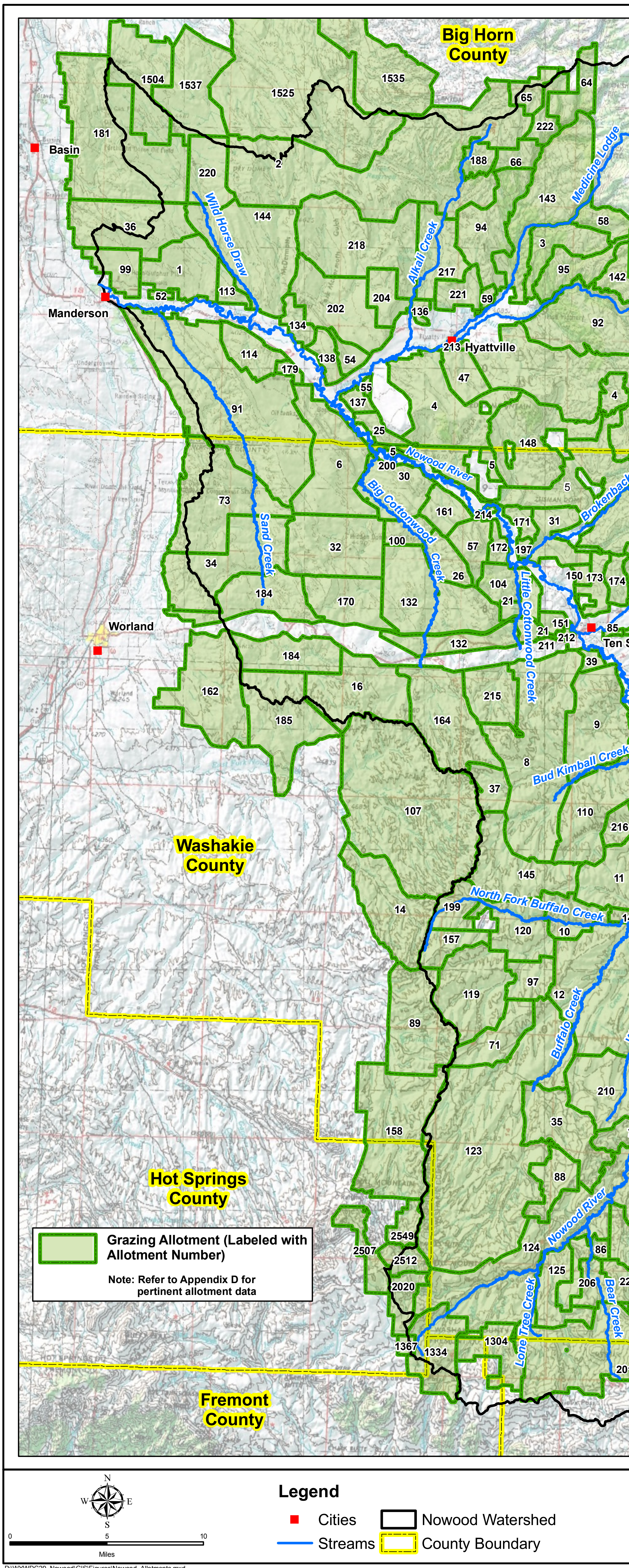

Figure 3.7 Nowood River Watershed: Grazing Allotments

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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). According to representatives of the BLM Worland Field Office, approximately 22 of the 195 allotments have had actual AMPs written (these allotments are highlighted in Appendix D). The majority of the allotments are managed subject to letters of agreement between the permittee and the BLM.

State Grazing Leases. Most of the state lands within the Nowood River watershed 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

3.3.5.2 Existing Water Supply

The Nowood River watershed has the good fortune of possessing numerous reliable water sources for wildlife and livestock. These sources include:

- Perennial and intermittent streams
- Springs
- Ponds
- Guzzlers
- Stock tanks
- Reservoirs, etc.,

Perennial and intermittent streams (when flowing) have historically served as reliable sources of water for both livestock and wildlife. The Nowood River and tributaries to the east (i.e. tributaries originating in the Bighorn Mountains) are generally perennial. Some of the eastern tributaries with basins located at lower elevations are intermittent and provide livestock and wildlife with sources of water for much, but not all, of the year.

The western, arid region of the study area is dominated by intermittent and ephemeral streams. Consequently, surface water sources do not provide reliable sources of water over a large portion of the watershed. In these areas, numerous stock reservoirs have been built throughout the years in an effort to augment existing surfaces sources by retaining spring runoff and runoff during precipitation events.

Mapping of existing stock reservoirs, springs, and guzzlers were obtained from the Worland Field Office of the BLM. This mapping indicated the presence of 584 stock reservoirs and 9 guzzlers. Mapping of springs was only partially complete and 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. It is our understanding 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 (2006). 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 3.8 displays an example of this process.

Figure 3.9 displays a map of the watershed showing the results of this classification. Based upon this analysis, it appears that a minimum of 174 remain viable water sources. This analysis also indicates that 410 are either breached, sediment filled, or in need of site visits to determine their status. This figure also indicates the location of guzzlers and mapped springs.

Additional sources include stock tanks, wells, windmills, linear projects, etc; however, mapping of these sources was not available.

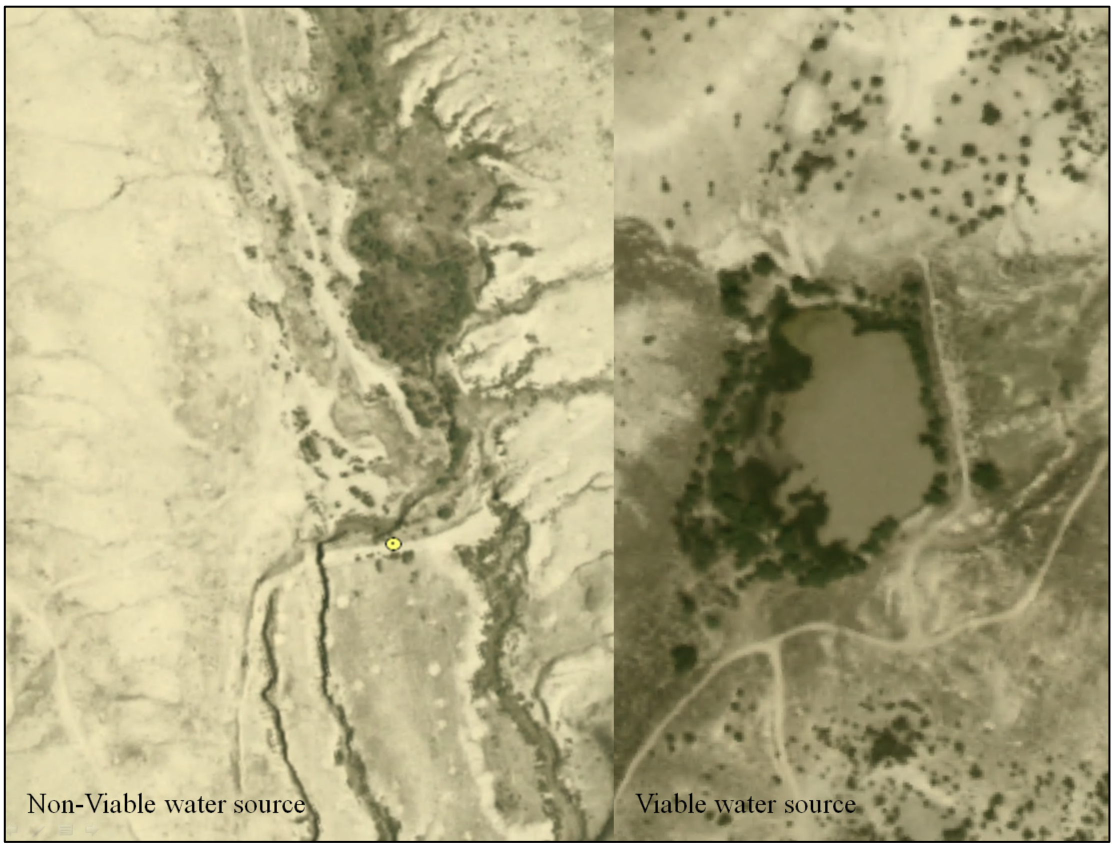

Figure 3.8 Evaluation of Stock Ponds in the Project GIS Environment

3.3.5.3 Ecological Site Descriptions

The concept of "Ecological Sites" are 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."*

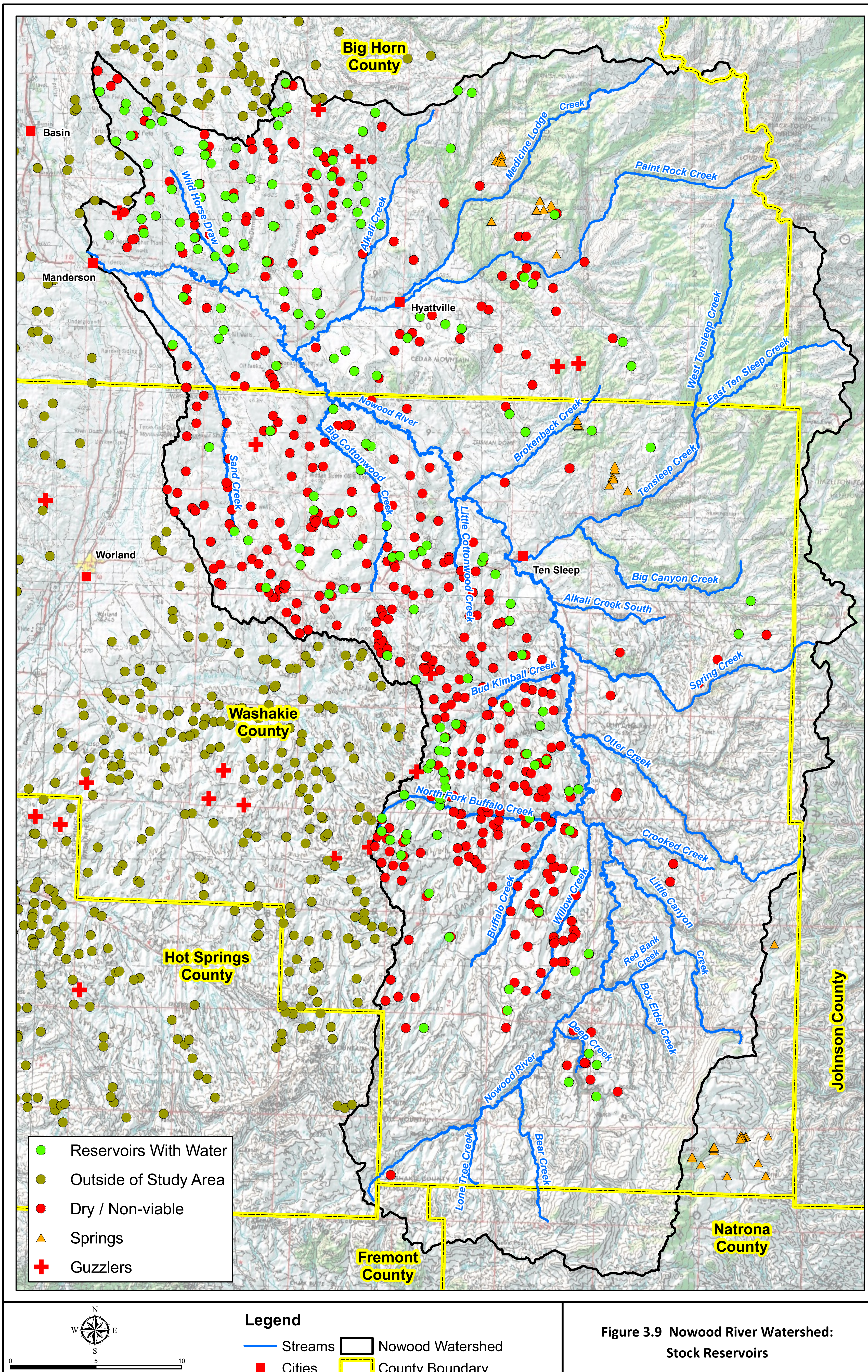

Figure 3.9 Nowood River Watershed: Stock Reservoirs

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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.
- **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. Using database tools provided by the NRCS, the available soils mapping was evaluated and Ecological Sites defined within the study area. Table 3.4 contains a list of the sites. Figure 3.10 displays their location within the study area. Note that soils data (and consequently ESD mapping) were not available for much of Bighorn County. In addition, no soils data were available for the portions of the study area lying within Hot Springs or Johnson Counties.

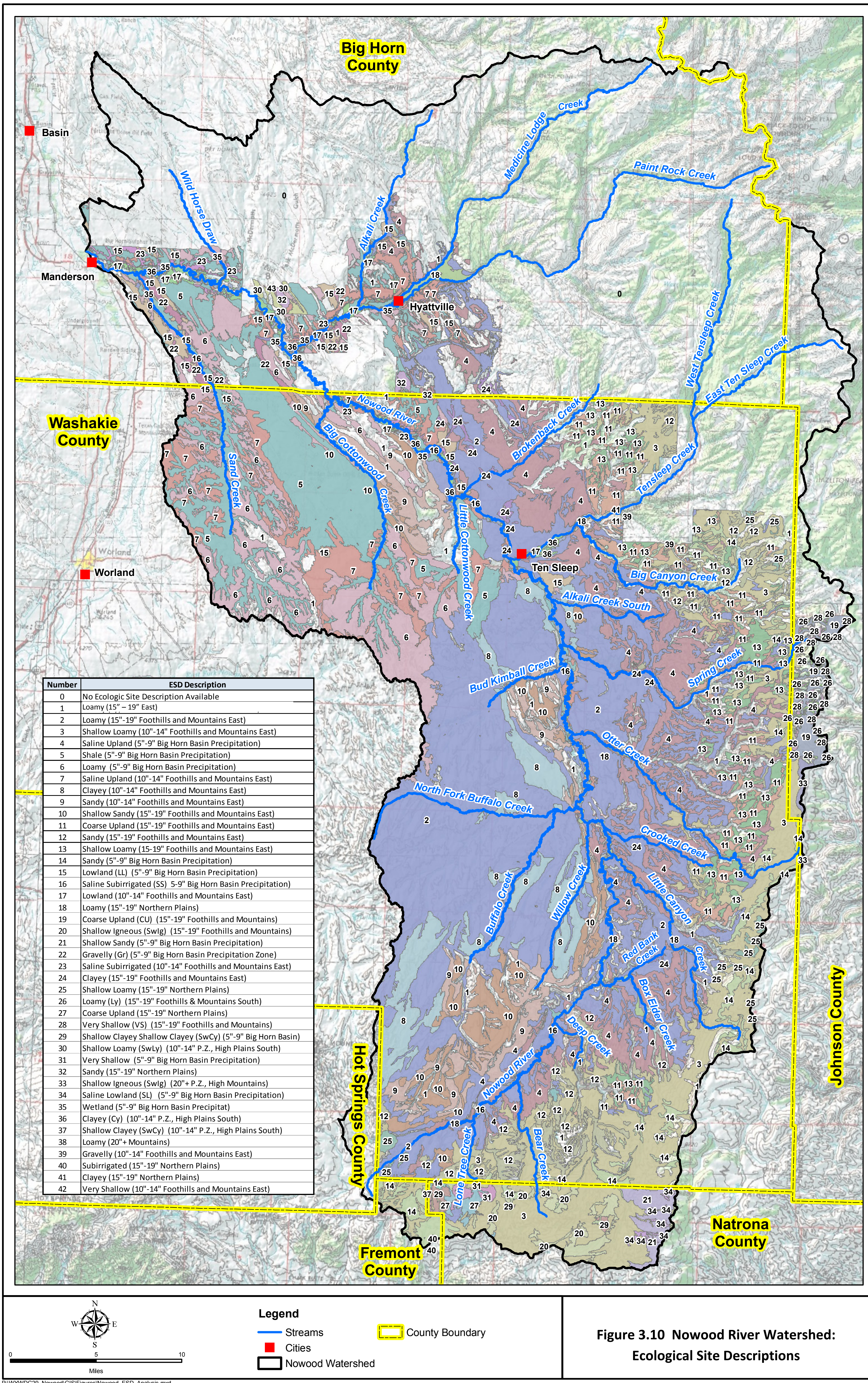
The relative distribution of the sites is displayed in Figure 3.11. As is evident in this figure, there are several ecological sites which dominate the study area; four Ecological Sites comprise over 60 percent of the mapped area. Based upon this analysis, the two ecological sites most likely to be encountered in the study area are:

- Loamy 10-14 inch precipitation zone, East
- 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).

Table 3.4 Analysis of Ecologic Site Distribution in the Nowood River Watershed

ESD Code	Number	ESD Description	Number	Acres	Percent
NA	1	No Ecologic Site Description Available	1		
R032XY322WY	2	Loamy (Ly) (10-14" East)	2	227,752.3	29.51%
R043XY322WY	3	Loamy (15-19" Foothills and Mountains East)	3	91,298.0	11.83%
R032XY362WY	4	Shallow Loamy (10-14' Foothills and Mountains East)	4	77,593.1	10.05%
R032XY144WY	5	Saline Upland (5-9" Big Horn Basin Precipitation)	5	77,195.2	10.00%
R032XY154WY	6	Shale (5-9" Big Horn Basin Precipitation)	6	54,961.7	7.12%
R032XY122WY	7	Loamy (5-9" Big Horn Basin Precipitation)	7	34,762.9	4.50%
R032XY344WY	8	Saline Upland (10-14" Foothills and Mountains East)	8	29,561.5	3.83%
R032XY304WY	9	Clayey (10-14" Foothills and Mountains East)	9	23,787.7	3.08%
R032XY350WY	10	Sandy (10-14" Foothills and Mountains East)	10	22,186.7	2.87%
R043XY366WY	11	Shallow Sandy (15-19" Foothills and Mountains East)	11	18,521.0	2.40%
R043XY308WY	12	Coarse Upland (15-19" Foothills and Mountains East)	12	18,217.6	2.36%
R043XY350WY	13	Sandy (15-19" Foothills and Mountains East)	13	17,232.2	2.23%
R043XY362WY	14	Shallow Loamy (15-19" Foothills and Mountains East)	14	16,101.2	2.09%
R032XY150WY	15	Sandy (5-9" Big Horn Basin Precipitation)	15	8,071.9	1.05%
R032XY128WY	16	Lowland (LL) (5-9" Big Horn Basin Precipitation)	16	6,483.7	0.84%
R032XY142WY	17	Saline Subirrigated (SS) 5-9" Big Horn Basin Precipitation)	17	5,544.5	0.72%
R032XY328WY	18	Lowland (10-14" Foothills and Mountains East)	18	5,529.0	0.72%
R043XY422WY	19	Loamy (15-19" Northern Plains)	19	5,107.6	0.66%
R043BY308WY	20	Coarse Upland (CU) (15-19" Foothills and Mountains)	20	4,762.9	0.62%
R043BY360WY	21	Shallow Igneous (SwIg) (15-19" Foothills and Mountains)	21	4,301.7	0.56%
R032XY166WY	22	Shallow Sandy (5-9" Big Horn Basin Precipitation)	22	3,160.6	0.41%
R032XY112WY	23	Gravelly (Gr) (5-9" Big Horn Basin Precipitation Zone)	23	2,733.9	0.35%
R032XY342WY	24	Saline Subirrigated (10-14" Foothills and Mountains East)	24	2,666.8	0.35%
R043XY304WY	25	Clayey (15-19" Foothills and Mountains East)	25	2,500.7	0.32%
R043XY462WY	26	Shallow Loamy (15-19" Northern Plains)	26	1,478.3	0.19%
R049XA122WY	27	Loamy (Ly) (15-19" Foothills & Mountains South)	27	1,434.0	0.19%
R043XY408WY	28	Coarse Upland (15-19" Northern Plains)	28	1,329.8	0.17%
R043BY376WY	29	Very Shallow (VS) (15-19" Foothills and Mountains)	29	1,282.9	0.17%
R032XY158WY	30	Shallow Clayey Shallow Clayey (SwCy) (5-9" Big Horn Basin	30	1,262.9	0.16%
R034AY362WY	31	Shallow Loamy (SwLy) (10-14" P.Z., High Plains South)	31	963.4	0.12%
R032XY176WY	32	Very Shallow (5-9" Big Horn Basin Precipitation)	32	939.3	0.12%
R043XY450WY	33	Sandy (15-19" Northern Plains)	33	856.8	0.11%
R043BY160WY	34	Shallow Igneous (SwIg) (20+ P.Z., High Mountains)	34	822.6	0.11%
R032XY138WY	35	Saline Lowland (SL) (5-9" Big Horn Basin Precipitation)	35	638.8	0.08%
R032XY178WY	36	Wetland (5-9" Big Horn Basin Precipitat)	36	509.5	0.07%
R034AY304WY	37	Clayey (Cy) (10-14" P.Z., High Plains South)	37	150.2	0.02%
R034AY358WY	38	Shallow Clayey (SwCy) (10-14" P.Z., High Plains South)	38	96.1	0.01%
R043XY122WY	39	Loamy (20+ Mountains)	39	36.1	0.005%
R034XY312WY	40	Gravelly (10-14" Foothills and Mountains East)	40	24.7	0.003%
R043BY474WY	41	Subirrigated (15-19" Northern Plains)	41	11.7	0.002%
R043XY404WY	42	Clayey (15-19" Northern Plains)	42	8.2	0.001%
R032XY376WY	43	Very Shallow (10-14" Foothills and Mountains East)	43	4.9	0.001%



Number	ESD Description
0	No Ecologic Site Description Available
1	Loamy (15” – 19” East)
2	Loamy (15"-19" Foothills and Mountains East)
3	Shallow Loamy (10"-14" Foothills and Mountains East)
4	Saline Upland (5"-9" Big Horn Basin Precipitation)
5	Shale (5"-9" Big Horn Basin Precipitation)
6	Loamy (5"-9" Big Horn Basin Precipitation)
7	Saline Upland (10"-14" Foothills and Mountains East)
8	Clayey (10"-14" Foothills and Mountains East)
9	Sandy (10"-14" Foothills and Mountains East)
10	Shallow Sandy (15"-19" Foothills and Mountains East)
11	Coarse Upland (15"-19" Foothills and Mountains East)
12	Sandy (15"-19" Foothills and Mountains East)
13	Shallow Loamy (15-19" Foothills and Mountains East)
14	Sandy (5"-9" Big Horn Basin Precipitation)
15	Lowland (LL) (5"-9" Big Horn Basin Precipitation)
16	Saline Subirrigated (SS) 5-9" Big Horn Basin Precipitation)
17	Lowland (10"-14" Foothills and Mountains East)
18	Loamy (15"-19" Northern Plains)
19	Coarse Upland (CU) (15"-19" Foothills and Mountains)
20	Shallow Igneous (SwIg) (15"-19" Foothills and Mountains)
21	Shallow Sandy (5"-9" Big Horn Basin Precipitation)
22	Gravelly (Gr) (5"-9" Big Horn Basin Precipitation Zone)
23	Saline Subirrigated (10"-14" Foothills and Mountains East)
24	Clayey (15"-19" Foothills and Mountains East)
25	Shallow Loamy (15"-19" Northern Plains)
26	Loamy (Ly) (15"-19" Foothills & Mountains South)
27	Coarse Upland (15"-19" Northern Plains)
28	Very Shallow (VS) (15"-19" Foothills and Mountains)
29	Shallow Clayey Shallow Clayey (SwCy) (5"-9" Big Horn Basin)
30	Shallow Loamy (SwLy) (10"-14" P.Z., High Plains South)
31	Very Shallow (5"-9" Big Horn Basin Precipitation)
32	Sandy (15"-19" Northern Plains)
33	Shallow Igneous (SwIg) (20"+ P.Z., High Mountains)
34	Saline Lowland (SL) (5"-9" Big Horn Basin Precipitation)
35	Wetland (5"-9" Big Horn Basin Precipitat)
36	Clayey (Cy) (10"-14" P.Z., High Plains South)
37	Shallow Clayey (SwCy) (10"-14" P.Z., High Plains South)
38	Loamy (20"+ Mountains)
39	Gravelly (10"-14" Foothills and Mountains East)
40	Subirrigated (15"-19" Northern Plains)
41	Clayey (15"-19" Northern Plains)
42	Very Shallow (10"-14" Foothills and Mountains East)

Figure 3.10 Nowood River Watershed: Ecological Site Descriptions

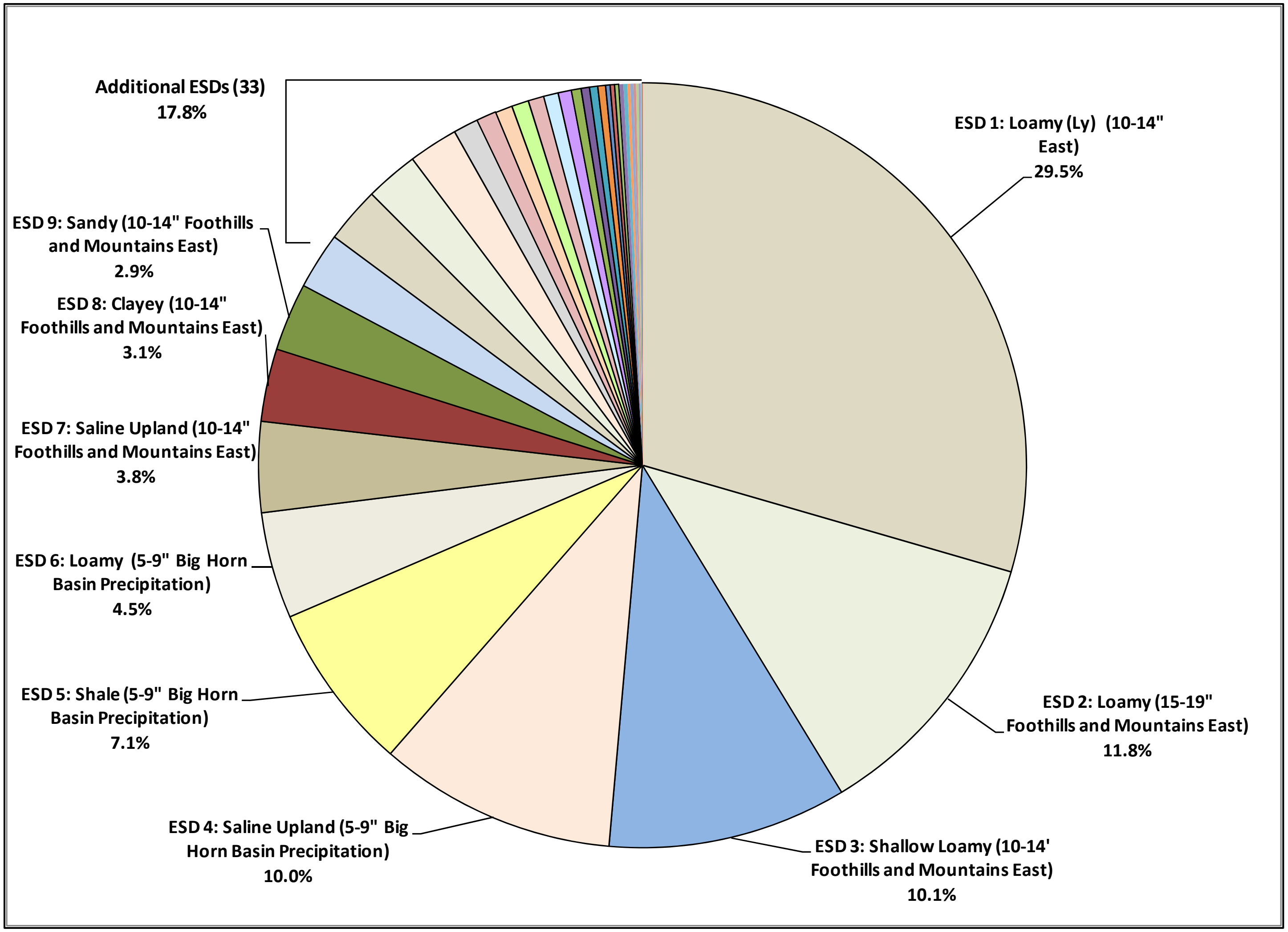


Figure 3.11 Relative Percentage of Principal Ecological Sites in the Nowood River Study Area

Loamy 10-14" East

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 (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).

Transition or pathway leading to other plant communities is described 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.*

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, 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

Appendix E contains the entire ESD associated with these two ecological sites.

3.3.5.4 Range Conditions and Needs

The Nowood River watershed 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 BLM's Washakie Resource Management Plan, which encompasses the Nowood River watershed plus areas outside of its boundary, states that of over 1.5 million total acres in allotments, approximately 149,700 acres were in excellent condition, 622,500 acres were in good condition, 308,700 were fair and 44,000 were poor. The balance of the acreage was unmapped or unclassified (BLM, 1987). BLM representatives indicated these values are still representative of conditions today. 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.

Review of available Allotment Management Plans (AMPs) substantiates this assessment of range conditions. The AMPs state that there are extensive areas in allotments in poor and / or fair ecological range condition. The majority of these areas are near dependable water sources, against fences, or in areas which naturally tend to concentrate livestock use.

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 relative ample water supplies within 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. Lastly, to work in the long term, any change in range management must be supported by the land user.

3.3.6 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 3.12. Annual oil and gas production for 2008 is summarized in Table 3.5. Total oil production was approximately 717,083 barrels from 515 active wells. Natural gas production exceeded 3 million MCF.

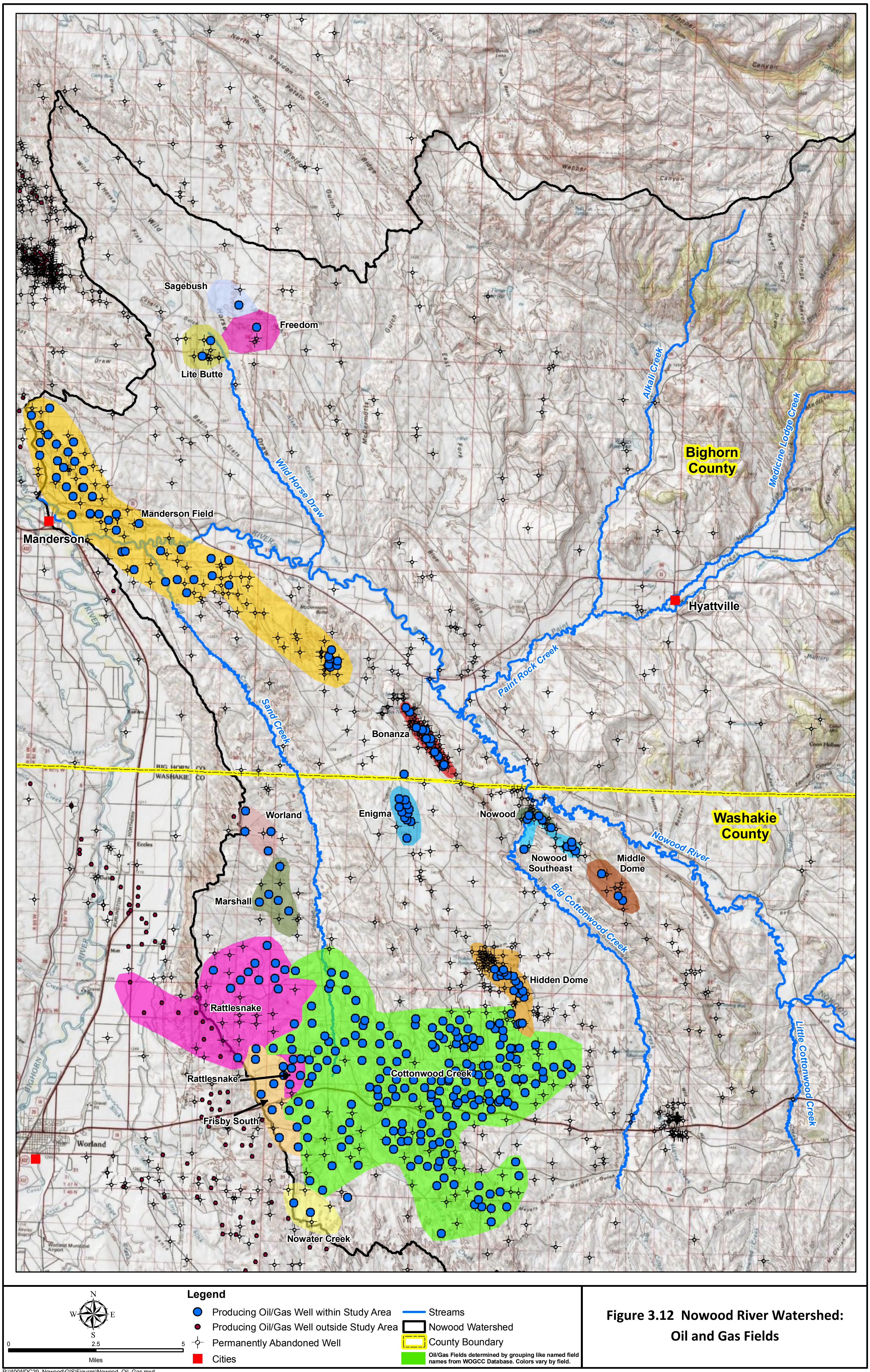


Figure 3.12 Nowood River Watershed: Oil and Gas Fields

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Table 3.5 Tabulation of 2008 Oil, Gas, and Water Production

Field Name	Production Wells	Total Oil BBLS	Total Gas MCF	Total Water BBLS
Bonanza	16	34,553	0	6,956,238
Cottonwood Creek	253	279,698	515,424	721,295
Cowley	4	13,325	0	986,762
Enigma	11	41,339	0	1,248,526
Freedom	1	1,397	0	0
Frisby South	35	60,275	30,450	25,354
Hidden Dome	24	121,323	35,403	2,641,133
Lite Butte	2	12,635	0	1,277,387
Manderson	70	35,663	569,360	2,978
Marshall	5	9,685	118	51
Middle Dome	4	20	0	10,000
Nowood	5	1,187	0	8,105
Nowood Southeast	8	1,997	0	207,277
Rattlesnake	28	45,236	73,402	23,072
Sagebrush	2	341	0	30
Worland	47	58,409	1,810,215	28,868
Nowood Study Area Total	**515**	**717,083**	**3,034,372**	**14,137,076**

In addition, over 14 million barrels of water were produced (approximately 1,800 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.

3.3.7 Mining and Mineral Resources

Current mine permit boundary information is tabulated in Table 3.6 and displayed graphically in Figure 3.13. This table indicates that bentonite is the major mineral commodity mined within the watershed area. Black Hills Bentonite LLC is the primary producer with a permitted area of nearly 9,000 acres. Their permit boundary lies within the Cottonwood Creek, McClelland Gulch, and Werner Gulch watersheds on the western side of the watershed. Active mining is limited to the Cottonwood Creek watershed. Other mining permits in the study area are limited to sand and gravel operations and a small limestone quarry.

3.3.8 Fisheries and Wildlife

3.3.8.1 Fisheries

The WGFD has written a Basin Management Plan for a portion of Nowood River watershed (WGFD, 2000). This plan has since been retired and WGFD is currently in the process of drafting a revised plan.

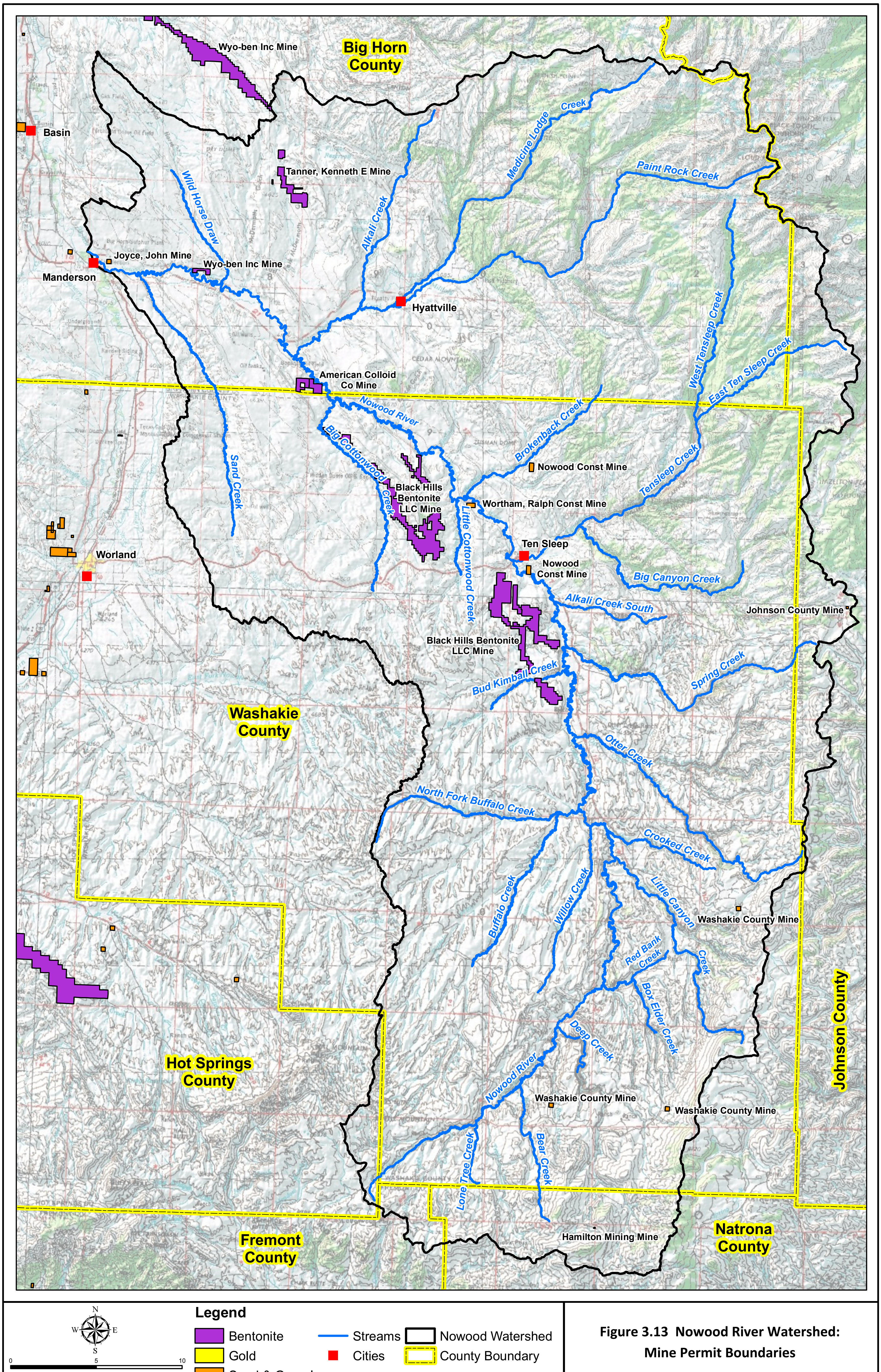

Figure 3.13 Nowood River Watershed: Mine Permit Boundaries

Much of the baseline information is pertinent for the purposes of this investigation. The following information was extracted from the documents.

Table 3.6 Tabulation of Existing Mine Permits

Permit	Company	Mine Name	Commodity	Permit Acreage
ET1128	Nowood Construction	Nowood Const Mine	Sand & Gravel	160.3
PT0281	Black Hills Bentonite LLC	Black Hills Bentonite LLC Mine	Bentonite	8881.4
PT0322	American Colloid Co	American Colloid Co Mine	Bentonite	625.7
ET0845	Hout Fencing	Hout Fencing Mine	Sand & Gravel	10.1
PT0321	Wyo-Ben, Inc.	Wyo-ben Inc Mine	Bentonite	136.1
ET 0825	Richard C. Cosgrove	Cosgrove, Richard C. Mine	Limestone	9.9
ET1021	Ralph Wortham Construction	Wortham, Ralph Const Mine	Sand & Gravel	79.0
PT0625	Kenneth Tanner	Tanner, Kenneth E Mine	Bentonite	916.4
ET0679	John Joyce	Joyce, John Mine	Sand & Gravel	40.8

According to the 2000 plan, the watershed is described as including both cold and warmwater streams originating in the southern Big Horn Mountains and Badlands west of Highway 434. Present trout populations are described as being dominated by brook trout in the higher elevation, headwater sections. Brook trout give way to rainbow trout within the canyon sections. At lower elevations brown trout predominate, but rainbow trout are also abundant. Nongame species are abundant in low elevation tributary streams and the lower Nowood River. Native species are also present in the lower Nowood River, including burbot, channel catfish, and sauger. In the upper part of the drainage, suckers (mountain and longnose) and longnose dace are the dominant species. The nongame population in the lower Nowood includes species better adapted to a big river environment: Shorthead redhorse, river carpsucker, flathead chub, carp, and white sucker. On the lower Nowood, young-of-year nongame fishes serve as the primary forage fish for sportfish.

The earliest recorded fish plants in the Nowood River include rainbow trout (1935), brown trout (1943), and channel catfish (1960). Rainbow, brown, brook, and cutthroat trout were planted extensively in tributary streams during the 1930's, 1940's and 1950's. At present, stream stocking occurs only in lower Nowood (shovelnose sturgeon). According to WGFD records, cutthroat trout were planted throughout the drainage from 1930-1960. In addition, Yellowstone cutthroat were introduced into South Fork Otter Creek in 1982, 1983, and 1984.

In general, habitat conditions could be characterized as good for the upper portion of the drainage. However, the lower Nowood suffers from lower quality trout habitat, including low stream flows, streambank erosion, warm temperatures, and sedimentation. These factors prevent establishment of trout populations, but do not inhibit other species (i.e. channel catfish, sauger, and stonecat), which are better adapted to these conditions.

The WGFD is currently conducting inventories and assessments of dams, diversions (irrigation, municipal water, power generation, etc.), culverts, and natural barriers in the State, including the Nowood River and many of its tributaries. The purpose of their effort is to determine the effect of structures on fish passage (habitat connectivity, upstream migration, downstream movements) and the effectiveness of fish screens in eliminating or reducing entrainment of fish into ditches. Water rights are not part of this investigation. In addition, many irrigation diversions consist of cobble dams "pushed up" each year. Many of these structures washout with high water each year, contributing sediment to the river system exacerbating water quality issues. More permanent, fish friendly structures can be used to benefit both the fisheries and the economics of the water user. Several structures within the watershed have been identified as potential barriers to fish migration and entrainment has been identified as a concern. However, there are many considerations to take into account before the severity of fish passage issues are fully determined. This is an ongoing project so results and conclusions of their study were not available at the time of this reporting (L. Stahl, WGFD, personal communication 2009).

3.3.8.2 Wildlife

Much of the watershed has been mapped by the Wyoming Game and Fish Department (WGFD) as crucial habitat for big game species. Specifically, approximately 502,000 acres (approximately 39 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*). Threatened species include the grey wolf (*Canis lupus*), and the grizzly bear (*Ursus arctos horribilis*).

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 within

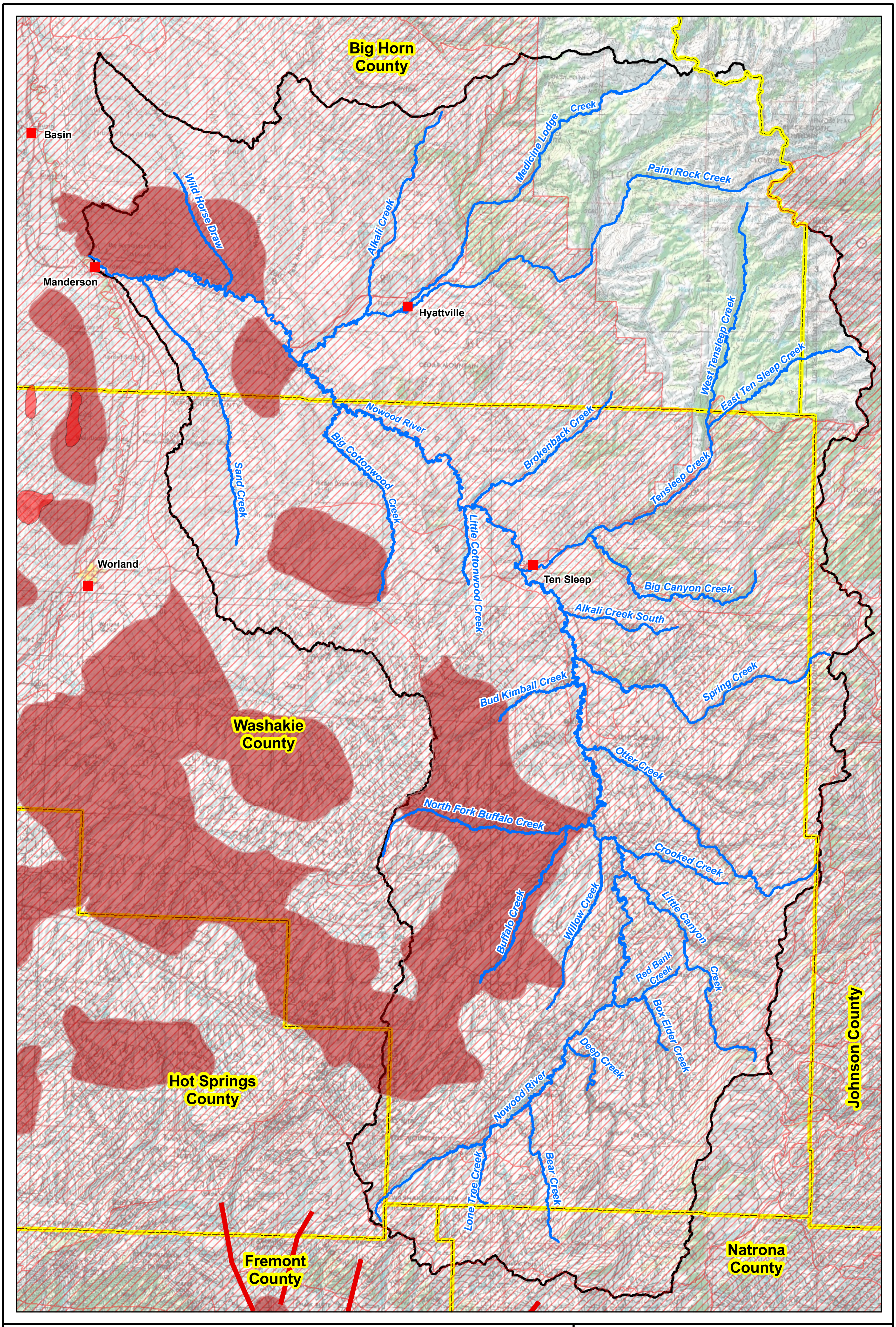

Figure 3.14 Nowood River Watershed: Antelope Habitat

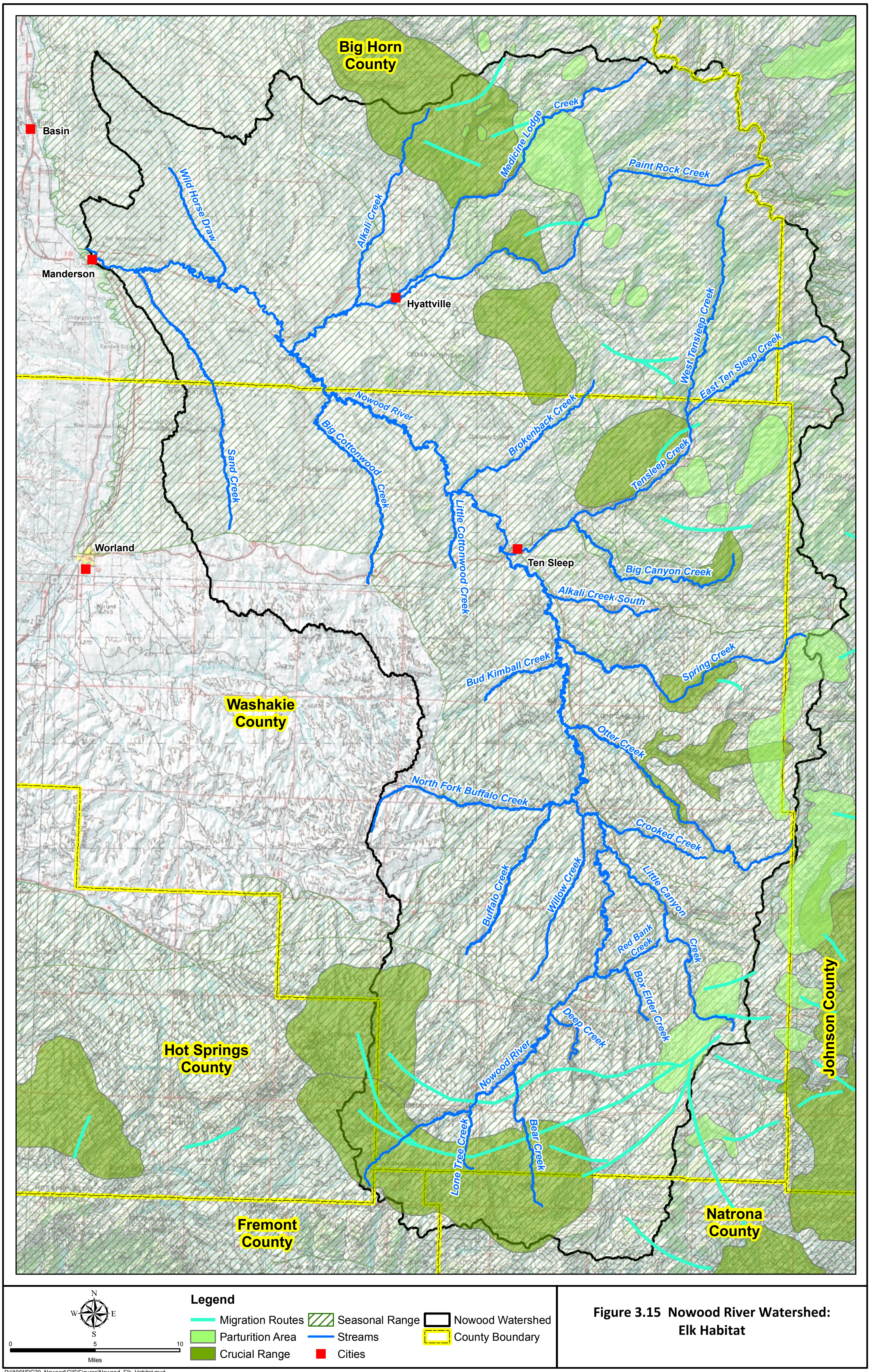

Figure 3.15 Nowood River Watershed: Elk Habitat

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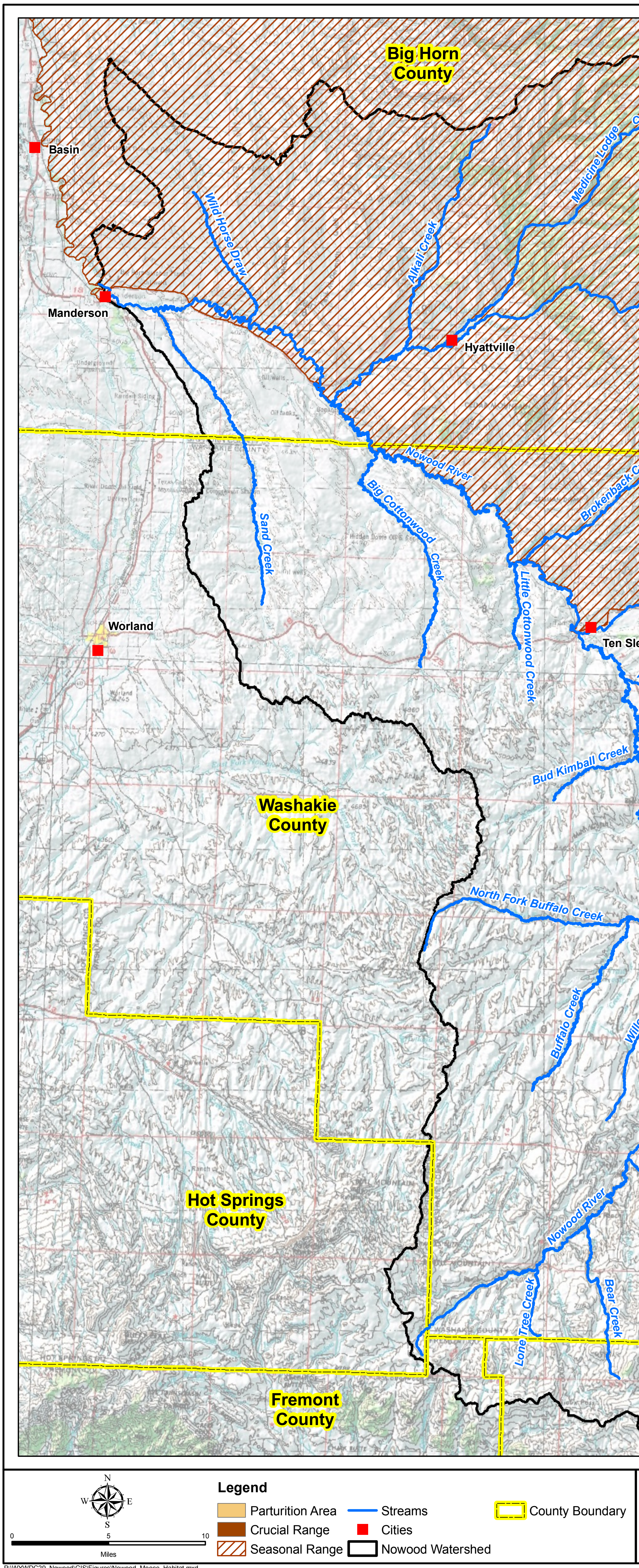

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Figure 3.16 Nowood River Watershed: Moose Habitat

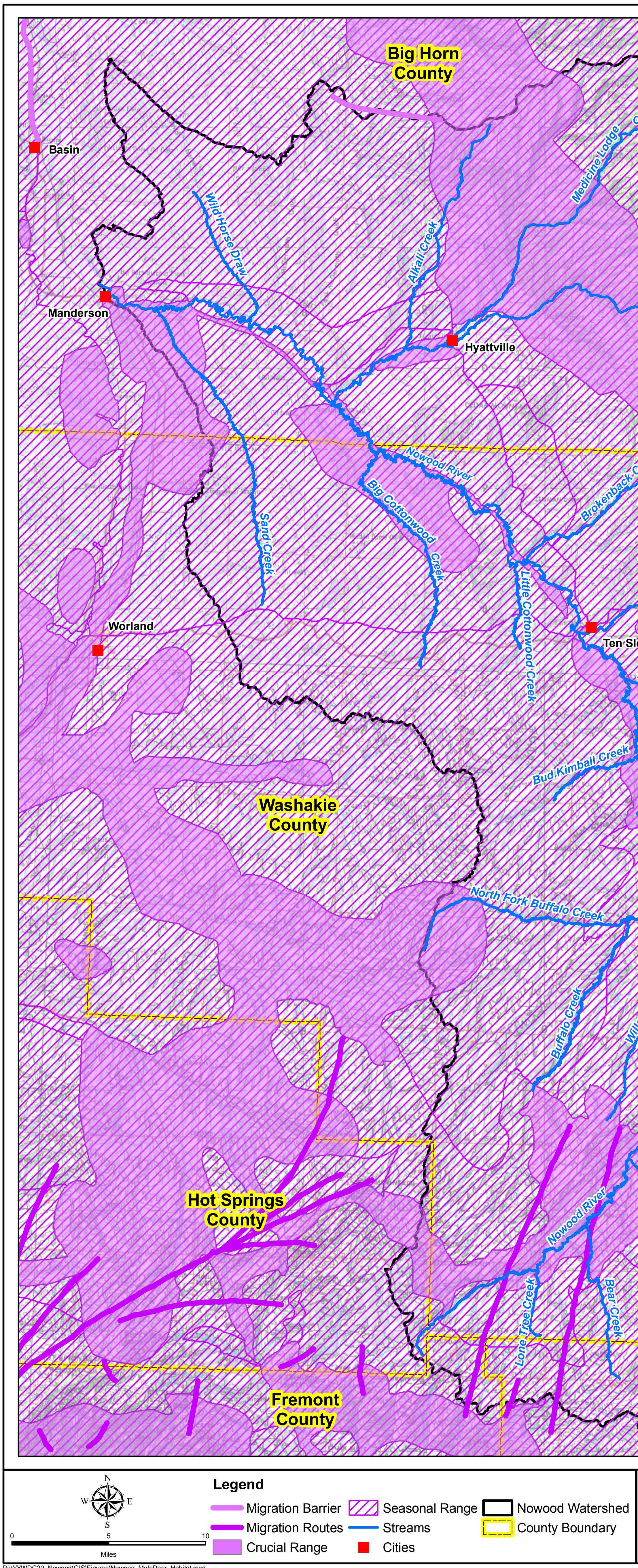

Figure 3.17 Nowood River Watershed: Mule Deer Habitat

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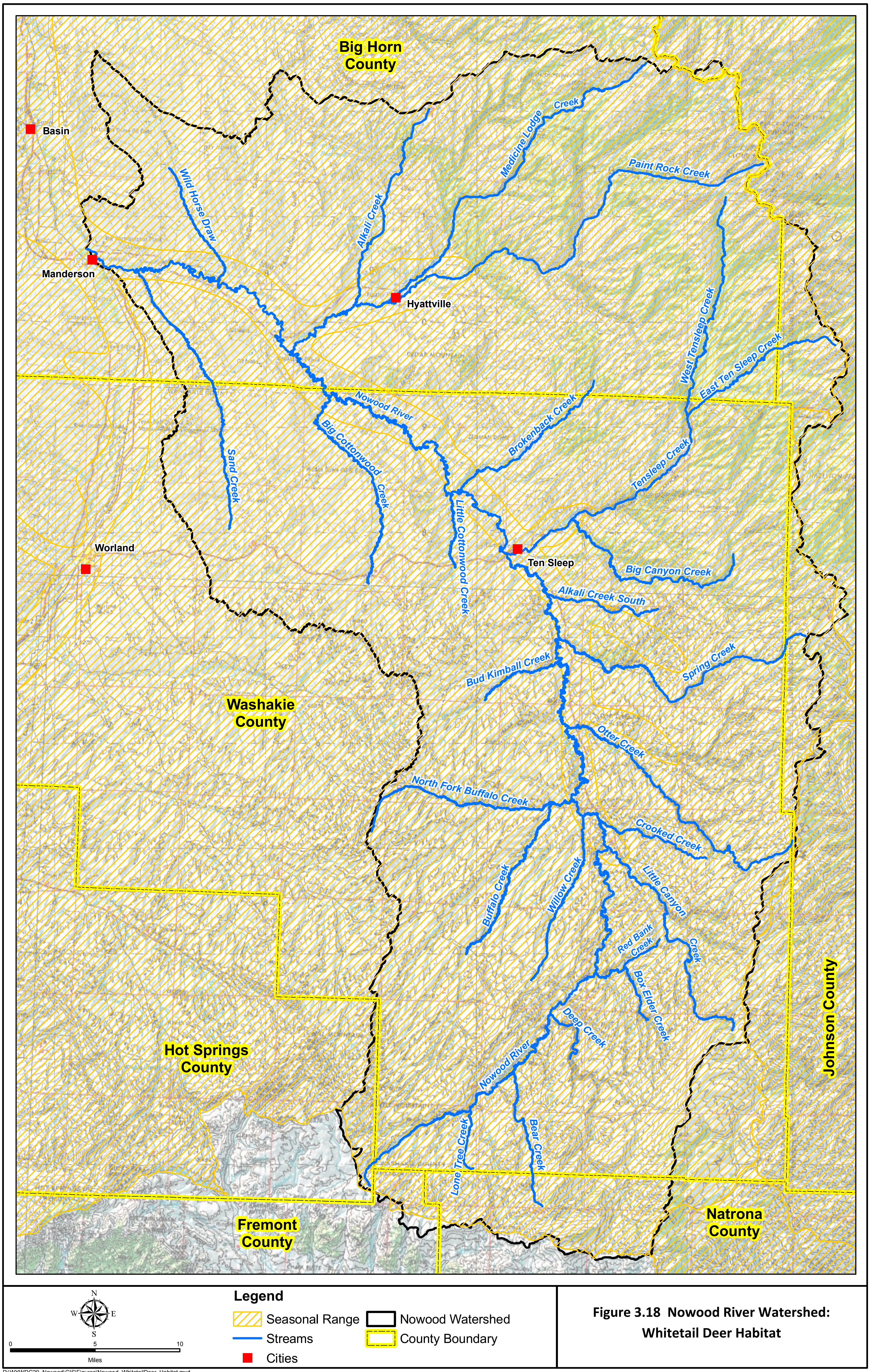

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Figure 3.18 Nowood River Watershed: Whitetail Deer Habitat

Table 3.7 Wyoming Natural Diversity Database: Wildlife Species in the Nowood Watershed			
Common Name	**Scientific Name**	**Listing Status**	**Tracked/ Watched**
Amphibians			
Boreal Western Toad	Bufo boreas boreas		Tracked
Northern Leopard Frog	Rana pipiens	Petitioned	Tracked
Birds			
American Avocet	Recurvirostra americana		Watched
American Bittern	Botaurus lentiginosus		Tracked
American Dipper	Cinclus mexicanus	Petitioned	Watched
American Peregrine Falcon	Falco peregrinus anatum	Delisted	Tracked
American Three-toed Woodpecker	Picoides dorsalis		Tracked
American White Pelican (Breeding Colonies)	Pelecanus erythrorhynchos		Tracked
Baird's Sparrow	Ammodramus bairdii		Tracked
Bald Eagle	Haliaeetus leucocephalus	Delisted	Tracked
Barn Owl	Tyto alba		Watched
Black-billed Cuckoo	Coccyzus erythropthalmus		Tracked
Black-rosy Finch	Leucosticte atrata		Tracked
Black-throated Gray Warbler	Dendroica nigrescens		Tracked
Blue Grosbeak	Passerina caerulea		Watched
Bobolink	Dolichonyx oryzivorus		Tracked
Brewer's Sparrow	Spizella breweri		Watched
Bufflehead	Bucephala albeola		Watched
Burrowing Owl	Athene cunicularia		Tracked
Calliope Hummingbird	Stellula calliope		Tracked
Canyon Wren	Catherpes mexicanus		Watched
Cassin's Sparrow	Aimophila cassinii		Watched
Clay-colored Sparrow	Spizella pallida		Watched
Common Goldeneye	Bucephala clangula		Watched
Common Loon	Gavia immer		Tracked
Eastern Phoebe	Sayornis phoebe		Watched
Eastern Screech Owl	Otus asio		Watched
Ferruginous Hawk	Buteo regalis		Tracked
Flammulated Owl	Otus flammeolus		Watched
Golden Eagle	Aquila chrysaetos		Watched
Golden-crowned Kinglet	Regulus satrapa		Watched
Grasshopper Sparrow	Ammodramus savannarum		Watched
Greater Prairie Chicken	Tympanuchus cupido		Watched
Greater Sage Grouse	Centrocercus urophasianus	Petitioned	Tracked
Hammond's Flycatcher	Empidonax hammondii		Watched
Lewis' Woodpecker	Melanerpes lewis		Tracked
Loggerhead Shrike	Lanius ludovicianus		Tracked
Long-billed Curlew	Numenius americanus		Tracked
Merlin	Falco columbarius		Watched
Mountain Plover	Charadrius montanus	Listing Denied	Tracked
Northern Goshawk	Accipiter gentilis	Listing Denied	Tracked
Osprey	Pandion haliaetus		Watched
Pygmy Nuthatch	Sitta pygmaea		Tracked
Ring-necked Duck	Aythya collaris		Watched

Table 3.7 Wyoming Natural Diversity Database: Wildlife Species in the Nowood Watershed (Continued)

Common Name	Scientific Name	Listing Status	Tracked/ Watched
Sage Sparrow	Amphispiza belli		Tracked
Sage Thrasher	Oreoscoptes montanus		Watched
Sandhill Crane	Grus canadensis		Watched
Short-eared Owl	Asio flammeus		Tracked
Trumpeter Swan	Cygnus buccinator	Listing Denied	Tracked
Tundra Swan	Cygnus columbianus		Watched
Western Screech Owl	Otus kennicottii		Watched
Western Scrub-Jay	Aphelocoma californica		Tracked
White-winged Crossbill	Loxia leucoptera		Watched
Williamson's Sapsucker	Sphyrapicus thyroideus		Tracked
Winter Wren	Troglodytes troglodytes		Watched
Mammals			
Sturgeon Chub	Hybopsis gelida	Listing Denied	Tracked
Yellowstone Cutthroat Trout (Native Populations)	Oncorhynchus clarkii bouvieri	Listing Denied	Tracked
Mammals			
Allen's Thirteen-lined Ground Squirrel	Spermophilus tridecemlineatus alleni		Tracked
American Marten (Bighorn Mountain Population)	Martes americana pop. 2		Watched
Bighorn Mountain Pika	Ochotona princeps obscura	Petitioned	Tracked
Bighorn Sheep	Ovis canadensis		Watched
Black-footed Ferret	Mustela nigripes	Endangered	Tracked
Black-tailed Prairie Dog	Cynomys ludovicianus	Listing Denied	Tracked
Eastern Cottontail	Sylvilagus floridanus		Watched
Fringed Myotis (Statewide)	Myotis thysanodes		Tracked
Gray Wolf	Canis lupus	Threatened	Tracked
Grizzly Bear	Ursus arctos horribilis	Threatened	Tracked
Hoary Bat	Lasiurus cinereus		Watched
Least Weasel	Mustela nivalis		Watched
Long-eared Myotis	Myotis evotis		Watched
Long-legged Myotis	Myotis volans		Watched
Pallid Bat	Antrozous pallidus		Tracked
Pygmy Rabbit	Brachylagus idahoensis	Petitioned	Tracked
Silver-haired Bat	Lasionycteris noctivagans		Watched
Spotted Bat	Euderma maculatum		Tracked
Townsend's Big-eared Bat	Corynorhinus townsendii		Tracked
Water Vole (Bighorn Mountain Population)	Microtus richardsoni pop. 1		Watched
Western Small-footed Myotis	Myotis ciliolabrum		Watched
White-footed Mouse	Peromyscus leucopus		Watched
White-tailed Prairie Dog	Cynomys leucurus	Petitioned	Tracked
Wyoming Ground Squirrel	Spermophilus elegans		Watched
Molluscs			
Fatmucket	Lampsilis siliquoidea		Tracked
Reptiles			
Great Basin Gopher Snake	Pituophis catenifer deserticola		Watched
Milk Snake	Lampropeltis triangulum		Watched
Rubber Boa	Charina bottae		Tracked
Spiny Softshell Turtle	Trionyx spiniferus		Watched

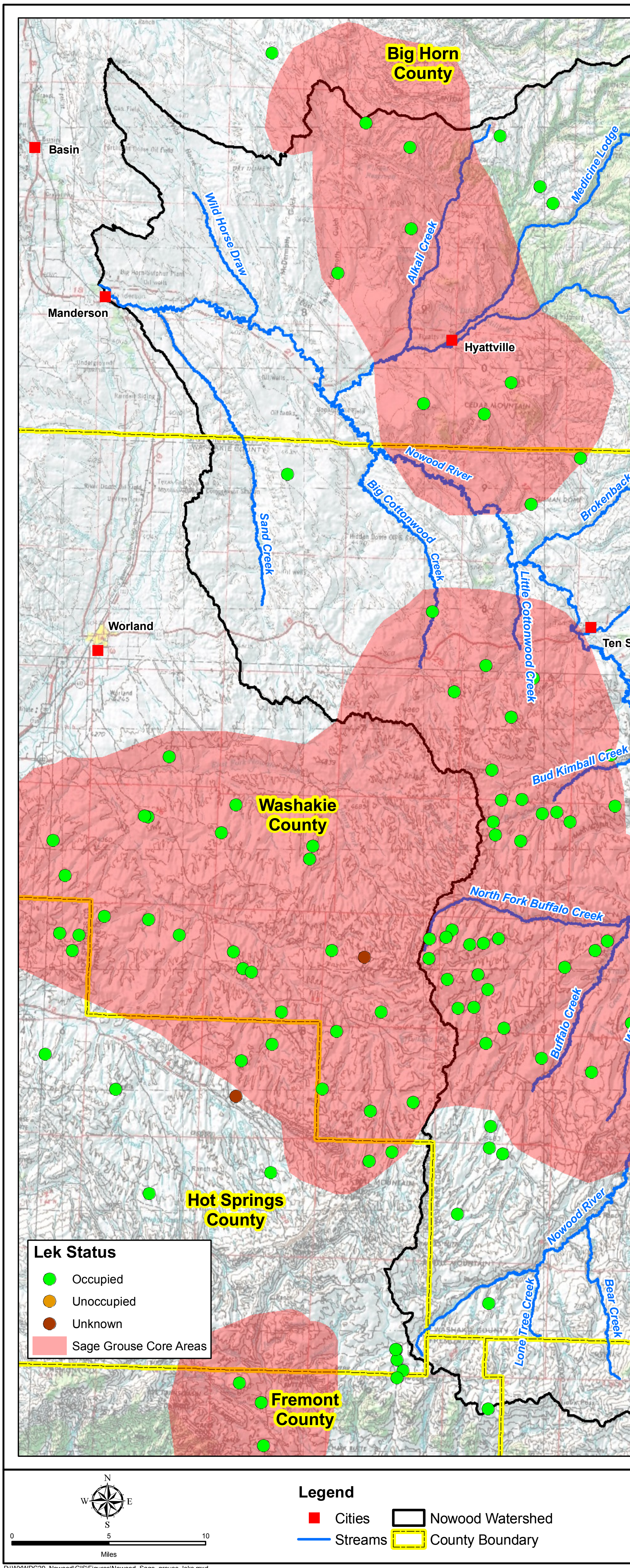

Figure 3.19 Nowood River Watershed: Sage Grouse Leks

them. The Core Sage Grouse Population Areas within the Nowood River watershed are delineated in Figure 3.19.

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.*

3.3.9 Cultural Resources

Over the last 20 years, different levels of cultural resource inventory have been performed in the watershed. Generally, these inventories were in response to proposed undertakings on federal lands, including energy exploration, highway construction, and natural resource extraction activities. Due to the location on federal land and the potential for ground disturbance, these activities required compliance with Section 106 of the National Historic Preservation Act, which stipulates that archaeological reconnaissance be conducted in the area of the ground disturbing activity.

Known Wyoming archaeological site types provide insight to the tremendous archaeological variety that exists in the Big Horn Basin of Wyoming. This variety ranges from Early Paleoindian activity at the Colby mammoth kill site, which dates to 11,000 years ago, to more modern ranching sites from the 1950's. Some of the prehistoric site types found in the basin include habitation sites, rock shelters, lithic scatters, cairns, ceramics, rock alignments, isolated hearths, trails, stone circles, quarries, graves, and rock art. There are likely additional types which have not yet been identified and there are many more known sites that have not yet been recorded or evaluated. As for the historic site types these include: ditches and canals, roads, stage and wagon routes, bridges, homesteads, corrals and livestock facilities, barns, trash dumps, graves/cemeteries, and historic inscriptions. (BLM, 2007).

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 3.20 displays the results of the database retrieval in a graphical format.

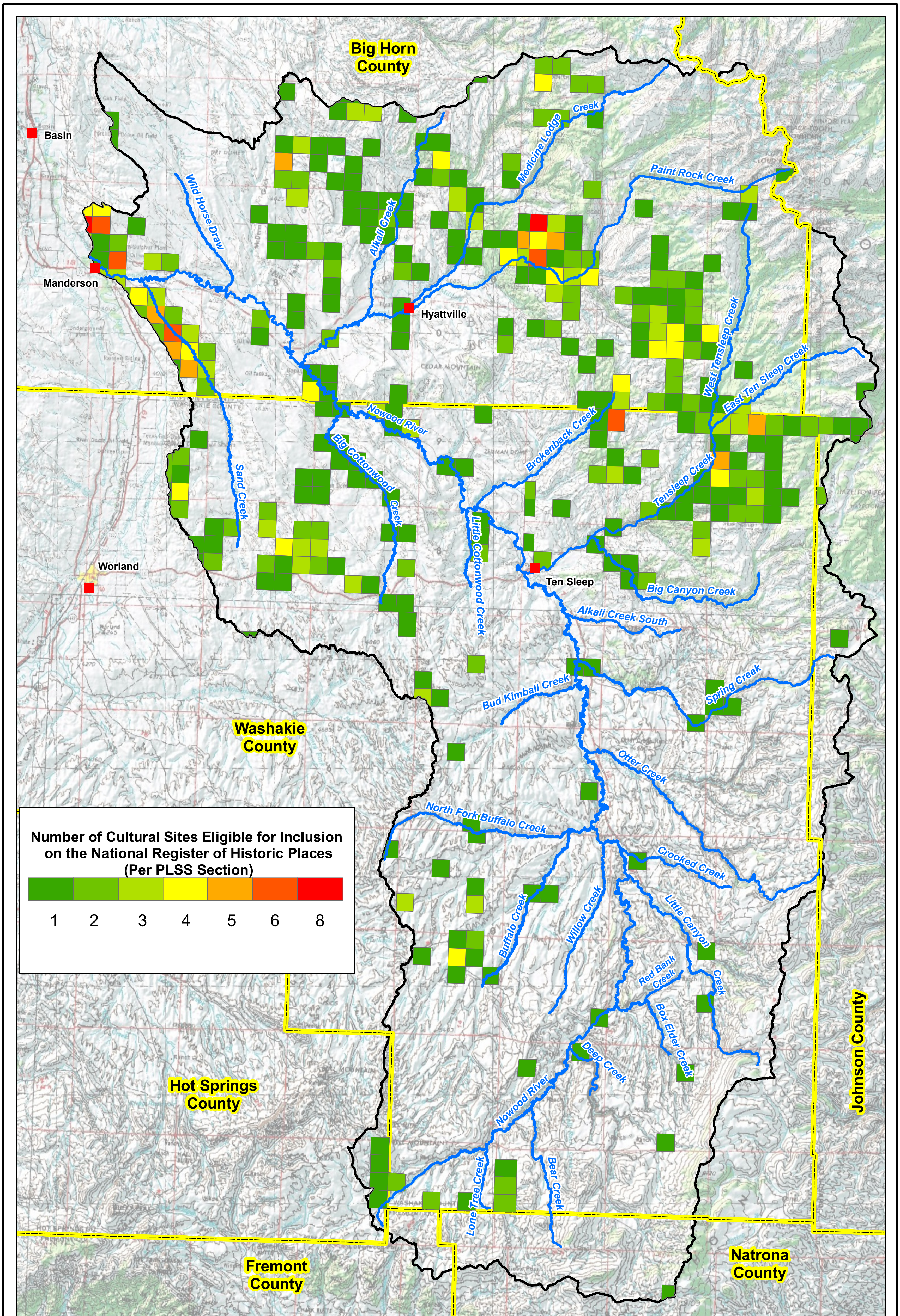

Figure 3.20 Nowood River Watershed: Cultural Sites

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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.

The National Register of Historic Places is the nation's official list of cultural resources worthy of preservation. Administered on a federal level by the National Park Service and managed locally by the State Historic Preservation Office, the National Register is part of a program to coordinate and support both public and private efforts to identify, evaluate, and protect historic and archeological resources. The National Register recognizes the accomplishments of those who have contributed to the history and heritage of the United States, the state, and local communities.

Listing a property on the National Register of Historic Places is a form of acknowledgment and prestige, which places no restraints on the property. The National Register does not restrict the rights of property owners to use, develop, or sell the property. Although placing a property on the National Register neither stops alterations to a building nor requires owners to provide the public access to the property, it can provide the owner with eligibility for certain financial incentives (NPS, 2009 at http://www.nps.gov/history/nr/).

To date, five sites within the study area have been included in the Register. The following descriptions of the sites were obtained from the Wyoming State Preservation Office website at:
http://wyoshpo.state.wy.us/NationalRegister/ :

- **County Line Bridge** was certified as a historic location on Friday February 22, 1985. This location is a protected historic place because of historical significance relating to transportation.

- The **Ainsworth House** (Figure 3.21) was one of the first permanent habitations established in the Bighorn Basin. Frank S. Ainsworth recorded his first impressions of the Ten Sleep region in 1880: ''I kept on moving down the Big Horn and trapping as I went until I reached the junction of the Nowood...then I worked my way up the Nowood Valley...this valley pleased me more than any other place I had ever been. It was a game paradise. Buffalo roamed over the valley by the hundreds''. The numerous bison trails leading over the nearby Bighorn Mountains gave a name, Big Trails, to the dispersed ranching community which Ainsworth played a role in founding.

Figure 3.21 Ainsworth House (Photo: SHPO)

  In 1884 Ainsworth placed a notched log frame on a squatters right claim along the Crooked Creek bank. In the late Spring of 1885 Ainsworth and his wife arrived on the property and settled down to founding the ranch. The Ainsworth House consists of two separate, but abutting buildings. The smaller of the two buildings, constructed in 1886, is a single story wood clad and framed structure. Outside of the frame cladding are portions of additional wall extensions. This extension was added after the winter of 1887-8. Adjoining the frame structure is a substantial one and one-half story log house. This structure was constructed in two phases. The first story was added in 1890. The second phase of construction on this structure was initiated in 1911 when a ''half'' story was added. The simple vernacular home set among the hay fields and adjacent to the deeply banked Crooked Creek drainage epitomizes the small owner-operator spreads that became prevalent and continue into the present as viable adaptations to the natural environment. Ranchers like Ainsworth set the dominant pattern of land use for the stock raising community of twentieth century Wyoming.

- The **Paint Rock Canyon Archaeological Landscape**, consists of rock shelters and open camp sites. Archaeological investigations indicate that the cultural resources within the canyon consist of a set of locations representing occupation during all major prehistoric cultural periods of the region in a largely undisturbed natural setting. Diagnostic materials recovered from the surface indicate a temporal span from late Paleo-Indian (ca. 9000 B.P.) to Late Prehistoric periods.

- The **Medicine Lodge Creek** site is located on the western slope of the Bighorn Mountains, near the confluence of the dry and running forks of Medicine Lodge Creek. The bluff, which is 750 feet long and, in places thirty to forty feet high, served to protect the campsite from the wind while reflecting the sunlight. This prehistoric site has been recognized as an outstanding manifestation of Indian petroglyphs and pictographs which have been etched upon the walls of the sandstone bluff. Archaeologists began excavations at the site in the early 1970s. The investigations revealed twelve levels of habitation recorded in 10.5 feet of deposits and extending to 23 feet below original datum. The earliest of these levels was radio carbon-dated at 8300 years old. Near the top of the stratified deposits were found small amounts of historic trade items such as glass beads. The site is a State Archaeological Site administered by the Wyoming Department of State Parks and Cultural Resources.

- The **Ten Sleep Mercantile**, (Figure 3.22) is a two story commercial structure that embodies the vernacular architecture of the frontier era and has acted as a community focal point since the turn of the century. The Ten Sleep Mercantile is representative of the detached retail store featuring tall, narrow and deep interior shop space that can be found throughout rural American towns and is a style of architecture particularly associated with frontier communities. As a significant component of community life, such structures generally served dispersed rural populations. In many instances communities derived what little identity they had from stores that served not only as the community supplier but social center. H. T. Church created the Ten Sleep Mercantile in 1902. The expansion of business led to the construction of the

Figure 3.22 The Ten Sleep Mercantile Today

permanent Ten Sleep Mercantile building in 1905 which quickly emerged as one of the town's principal focal points. Local merchant and historian Paul Frison operated the Ten Sleep Mercantile between 1919-1943. Frison was a prominent figure in county politics serving as a justice of the peace, mayor of Ten Sleep, and state legislator. An avid historian, Frison detailed the area's history and folklore in five published books and in assorted manuscripts and texts.

3.4 Natural Environment

3.4.1 Climate

The Nowood River watershed contains topography ranging in elevation from below 4,000 feet above mean sea level (msl) at the mouth to over 13,000 feet on Cloud Peak, the highest point in the watershed. Consequently, climate varies greatly within the study area.

According to the Washakie County Conservation District (WCCD) Natural Resource Land Use Plan, the area is generally protected from strong winds by the surrounding mountains. The Big Horn Mountains to the east and Absaroka Mountains to the west provide protection against strong winds, resulting in light winds much of the time. Shallow cold air masses approaching from Canada are largely blocked by the Big Horn Mountains; however, deeper cold air masses can spill into the basin. The cold air can be trapped in the basin, resulting in severely cold temperatures that persist for several days. Also, in winter a layer of cold air can form in the basin because of the loss of heat by radiation and the drainage of cold air from the surrounding mountains. This usually occurs during periods when winds are very light and the night sky is clear for several days. Moisture from the Pacific Ocean is largely blocked by the mountain chains between Worland and the west coast. This climate is classified as semiarid.(WCCD, 2005). Figure 3.23 displays a satellite perspective of the Nowood River watershed and its relation to the Big Horn Mountains and the Big Horn Basin.

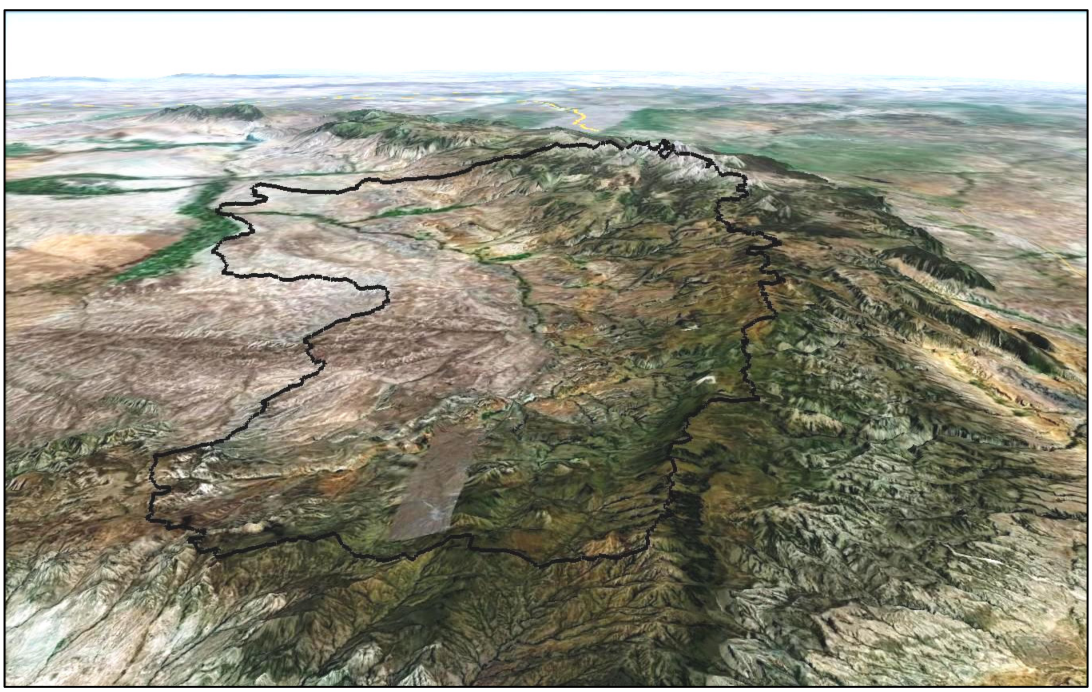


Figure 3.23 Enhanced Satellite Perspective of the Nowood River Watershed

Two weather stations are maintained in the watershed through cooperative agreements with the National Weather Service (NWS):

- Tensleep 4NE is located in the Town of Tensleep in the central portion of the watershed, and
- Tensleep 16 SSE is located on the Greet Ranch in the upper portion of the basin.

In addition, there are four stations participating in the Collaborative Rain, Hail and Snow Network (CoCoRaHS). The CoCoRaHS network consists of community volunteers collecting precipitation data. Figure 3.24 displays the location of these sites. Data recorded at the NWS stations were obtained from the High Plains Climate Center and used as the basis of a climatic analysis. Annual records for the period of record at each station are summarized in Tables 3.8 and 3.9.

Isohyetals (lines of equal precipitation) of mean annual precipitation are shown on Figure 3.24. The data used to generate this figure were obtained from the Wyoming Geographic Information Science Center (WyGISC). These data represent results of the PRISM spatial climate data generated at the Oregon Climate Center, Oregon State University *(*PRISM Climate Group. 2009). Review of this Figure shows the wide variety of climatic zones found within the study area. Mean annual precipitation in the lower portion of the basin near the Town of Manderson is approximately 7 inches per year. Annual precipitation is higher with elevation and increases to a maximum of over 37 inches on the eastern watershed divide. This figure displays the distinct difference in precipitation between the eastern and western portions of the basin. The eastern portion is situated on the flanks of the Big Horn Mountains where higher elevations and orographic effects result in significantly higher precipitation than the lower and consequently drier western portion of the basin.

Mean annual precipitation at the two stations is very similar. The lower station (Ten Sleep 4NE) has 45 years of record and the mean annual precipitation is 12.9 inches. At the upper station (Ten Sleep 16 SSE), the mean annual precipitation is only slightly higher at 13.0 inches. Figure 3.25 displays the total precipitation for each station for their periods of record.

It is interesting to note the evidence of recent drought conditions. At the Ten Sleep 4NE station (Town of Ten Sleep), the last ten years (1999 to 2008) contained seven consecutive years of below average precipitation. The years 2007 and 2008 were both above average, as is the current year (2009) which is not yet included in the analysis. The current trend indicates drought conditions may be easing.

Temperature data at the two stations are shown in Figures 3.26 and 3.27 for the Ten Sleep 4NE and Ten Sleep 16SSE gages, respectively. Superimposed on each graph is a chart of the mean monthly precipitation pattern.

Freezes late in spring and early in fall are common. The average last occurrences of 32 degrees and 28 degrees in spring are May 13 and April 30, respectively. The average first occurrences of 32 degrees and 28 degrees in fall are September 23 and October 4, respectively. Thus, the average length of the growing season is 133 days at 32 degrees and 157 days at 28 degrees (WCCD, 2005).

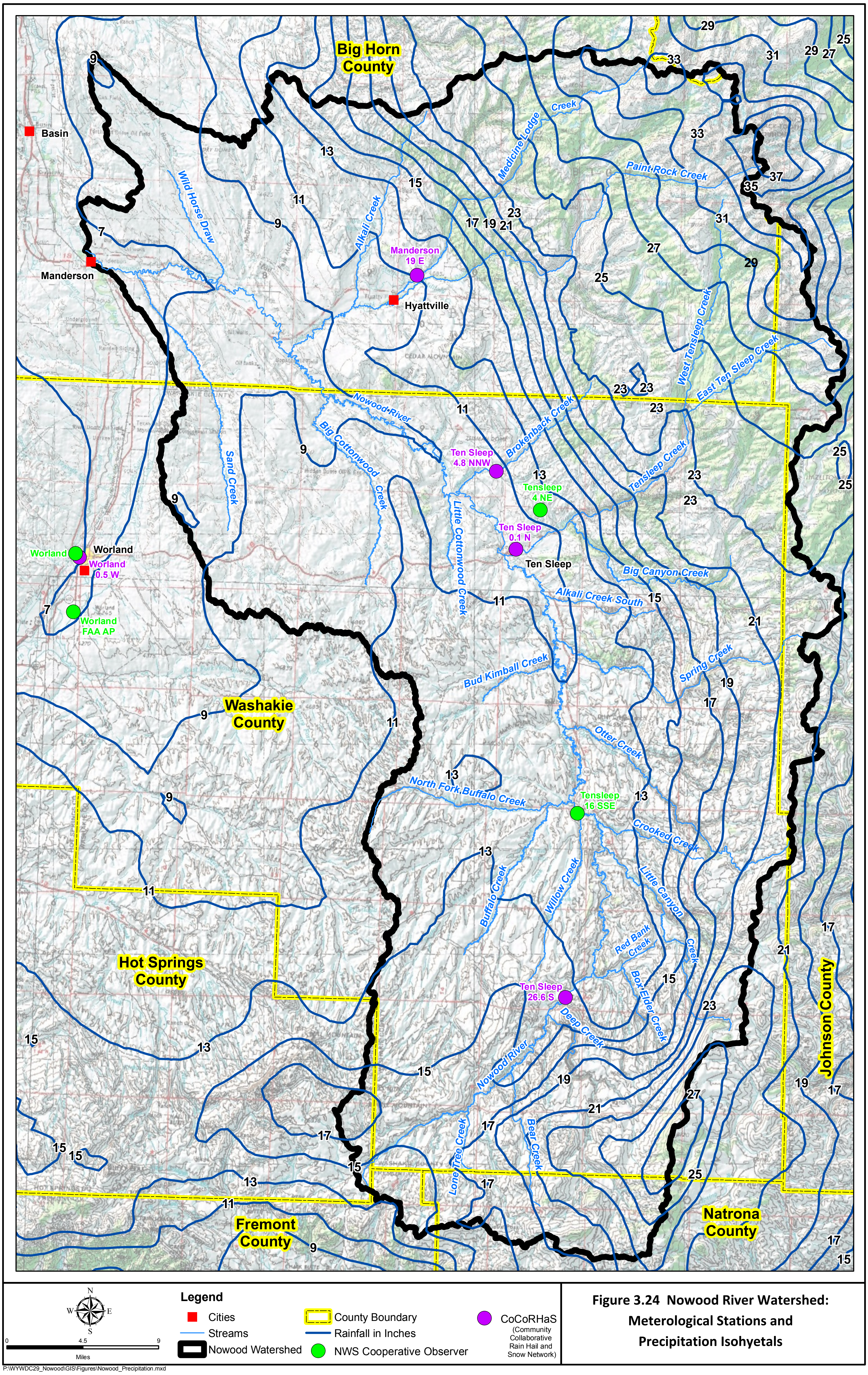


Figure 3.24 Nowood River Watershed: Meterological Stations and Precipitation Isohyetals

Table 3.8 Summary of Climatic Data: Ten Sleep 16 SSE (Greer Ranch)

Station:(488858) TEN SLEEP 16 SSE													
From Year=1955 To Year=2009													
TEMPERATURE													
Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Maximum Monthly Mean (deg F)	32.6	38.6	47.3	57.1	67.2	78.2	87.8	85.8	73.3	60.5	45.3	34.7	59
Minimun Monthly Mean (deg F)	-1.1	6.8	18.9	27.6	37	45.6	51.1	48	37.3	26.7	14.5	2.1	26.2
Mean Monthly (deg F)	15.7	22.7	33.1	42.3	52.1	61.9	69.4	66.9	55.3	43.6	29.9	18.4	42.6
Daily Extreme: High (deg F)	61	66	77	85	92	100	103	103	97	88	76	65	103
Daily Extreme: Low (deg F)	-45	-46	-24	-2	17	27	31	30	12	-8	-31	-51	-51
Highest Mean Monthly (deg F)	29.8	32.6	41.4	47.8	56.7	69.4	74.5	72.2	61.6	52.4	39.5	28.2	45
Year	2006	1963	1986	1987	1987	1988	1966	2003	1998	1963	1999	1962	2006
Lowest Mean Monthly (deg F)	-3.8	9.6	23.9	36.1	47.3	54.9	60.9	61.8	47.5	37.9	15	0.4	38.5
Year	1979	1989	2002	1975	1983	1998	1993	1987	1965	2002	1985	1983	1993
PRECIPITATION													
Mean Precipitation (in)	0.59	0.53	1.03	1.62	2.06	1.78	0.85	0.73	1.21	1.25	0.79	0.65	13.09
Highest Monthl Precipitation (in)	1.65	1.57	2.58	4.66	5.64	4.68	3.65	2.75	3.78	3.39	1.92	2.48	19.41
Year of Highest Monthly Precipitation	1963	2007	2007	1964	1978	1969	1997	1968	1961	1971	2001	1982	1998
Lowest Monthly Precipitation (in)	0	0.08	0.25	0.16	0	0.05	0	0	0	0.1	0.14	0.09	7.64
Year of Lowest Monthly Precipitation	1961	2005	1979	1987	1958	1971	1957	1970	1958	1965	1981	1962	1979
1 Day Maximum (in)	0.91	0.8	1.23	3.28	1.8	1.9	1.49	1.51	1.33	1.15	0.85	1.29	3.28

Table 3.9 Summary of Climatic Data: Ten Sleep 4 NE (Town of Ten Sleep)

Station:(488852) TEN SLEEP 4 NE													
From Year=1964 To Year=2009													
TEMPERATURE													
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Maximum Monthly Mean (deg F)	36.7	41	50	59.5	69.5	79.2	88.1	86.3	75.3	62.6	46.4	37.8	61
Minimun Monthly Mean (deg F)	13.5	18.4	26.1	34.2	42.5	50.5	57.4	55.7	45.5	35.3	24.2	15.5	34.9
Mean Monthly (deg F)	25.1	29.7	38.1	46.8	56	64.8	72.8	71	60.5	49	35.3	26.6	48
Daily Extreme: High (deg F)	64	66	79	87	91	100	105	100	95	88	74	66	105
Daily Extreme: Low (deg F)	-25	-31	-12	10	20	31	38	36	15	4	-16	-34	-34
Highest Mean Monthly (deg F)	35.3	37.9	45.4	54.7	61.5	74.2	78.6	77.1	67	54	46.6	35.5	50.4
Year	1981	1992	1986	1987	2000	1988	2007	1971	1998	2000	1999	1980	2001
Lowest Mean Monthly (deg F)	7.6	15.3	25.5	38.8	51.3	58.6	65	65.5	50.5	41.9	20.5	13.3	44.7
Year	1979	1989	1965	1975	1975	1998	1993	1980	1965	1969	1985	1983	1978
PRECIPITATION													
Mean Precipitation (in)	0.53	0.42	0.84	1.4	2.2	1.96	0.95	0.68	1.37	1.18	0.77	0.66	12.94
Highest Monthl Precipitation (in)	1.62	1.4	2.43	3.52	4.32	6.71	3.03	3.26	3.56	5.61	1.9	1.85	18.83
Year of Highest Monthly Precipitation	1978	2003	1996	1978	1975	1969	1997	1968	1986	1971	1984	1982	1967
Lowest Monthly Precipitation (in)	0	0	0.04	0.08	0.16	0.06	0.02	0	0	0	0.01	0	8.23
Year of Lowest Monthly Precipitation	1980	1966	2004	1985	1994	1971	1999	1969	1979	1984	1965	1976	2001
1 Day Maximum (in)	0.95	0.62	1.1	1.49	2.26	2.62	2.02	1.5	1.76	1.95	1.3	0.81	2.62

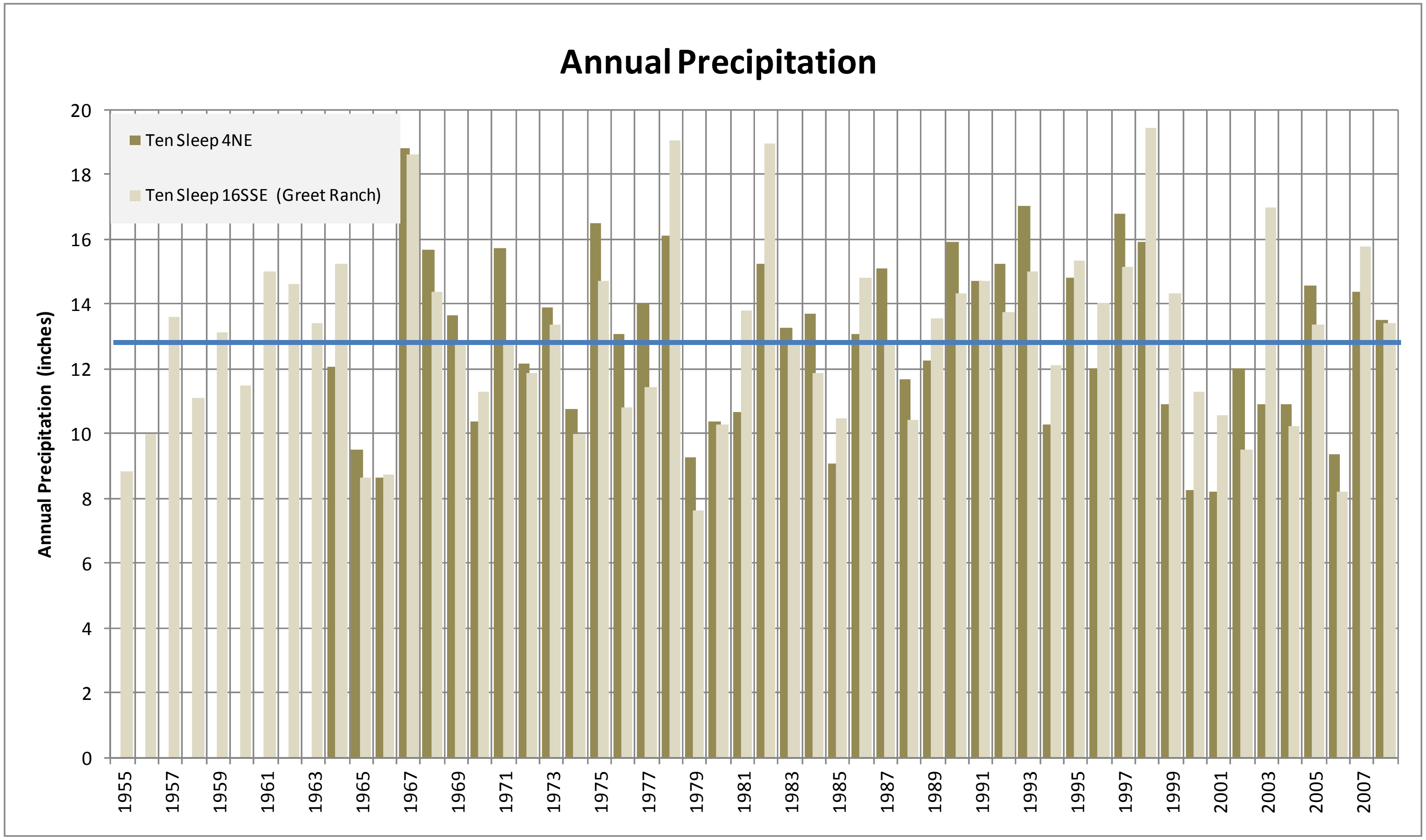


Figure 3.25 Historic Annual Precipitation

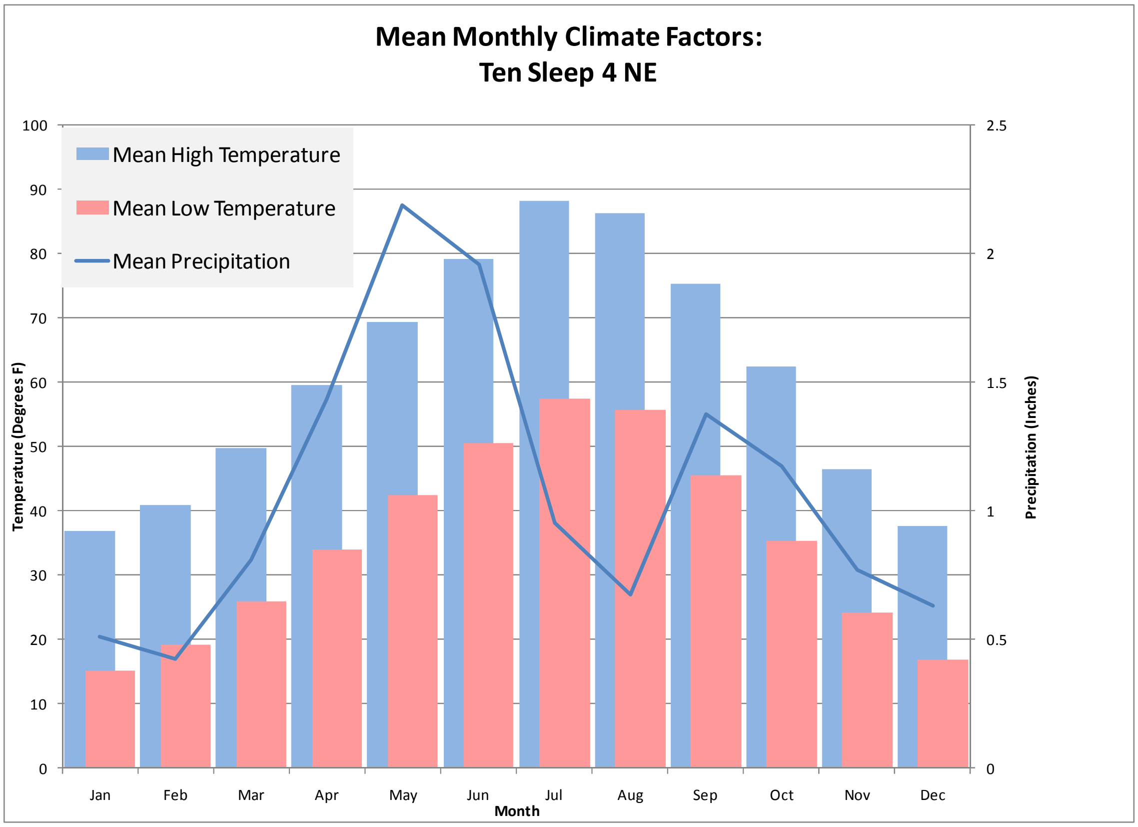


Figure 3.26 Mean Monthly Temperature and Precipitation: Ten Sleep 4 NE

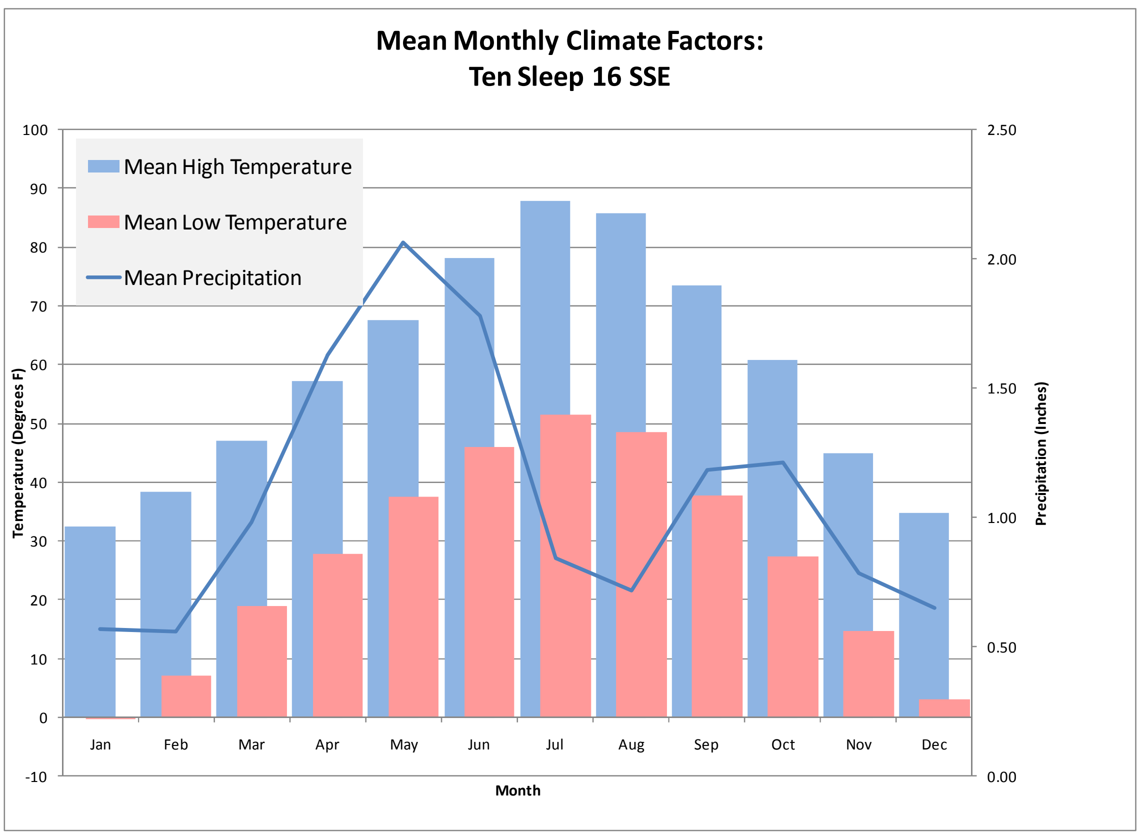


Figure 3.27 Mean Monthly Temperature and Precipitation: Ten Sleep 16 SSE

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 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 3.10. The LANDFIRE existing vegetation data indicate 60 different vegetation classes within the watershed. As is clearly indicated in this table, the two major sagebrush communities (Inter-Mountain Basins Big Sagebrush Shrubland and Inter-Mountain Basins Montane Sagebrush Steppe) dominate coverage of the study area with a total of over 42% of the watershed acreage. While the fact that the majority of the study area is covered in sagebrush or coniferous forest vegetation types 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 4.18 percent (54,000 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 3.28. (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

Table 3.10 Summary of LANDFIRE Existing Vegetation Type Data Analysis

Rank	Existing Vegetation Type	Percent of Area	Cummulative Percent
1	Inter-Mountain Basins Big Sagebrush Shrubland	29.40%	29.40%
2	Inter-Mountain Basins Montane Sagebrush Steppe	13.03%	42.43%
3	Inter-Mountain Basins Mat Saltbush Shrubland	7.57%	50.00%
4	Rocky Mountain Subalpine Dry-Mesic Spruce-Fir Forest and Woodland	6.46%	56.46%
5	Inter-Mountain Basins Big Sagebrush Steppe	4.49%	60.95%
6	Middle Rocky Mountain Montane Douglas-fir Forest and Woodland	4.27%	65.23%
7	Inter-Mountain Basins Mountain Mahogany Woodland and Shrubland	3.07%	68.30%
8	Northwestern Great Plains Mixedgrass Prairie	2.99%	71.29%
9	Southern Rocky Mountain Ponderosa Pine Woodland	2.94%	74.23%
10	Northern Rocky Mountain Subalpine-Upper Montane Grassland	2.58%	76.81%
11	Northern Rocky Mountain Lower Montane-Foothill-Valley Grassland	1.98%	78.79%
12	Introduced Riparian Vegetation	1.94%	80.73%
13	Agriculture-Pasture/Hay	1.77%	82.50%
14	Northern Rocky Mountain Subalpine Deciduous Shrubland	1.75%	84.24%
15	Introduced Upland Vegetation - Annual Grassland	1.70%	85.94%
16	Rocky Mountain Foothill Limber Pine-Juniper Woodland	1.41%	87.35%
17	Inter-Mountain Basins Semi-Desert Grassland	1.33%	88.68%
18	Rocky Mountain Subalpine/Upper Montane Riparian Systems	1.21%	89.89%
19	Introduced Upland Vegetation - Annual and Biennial Forbland	1.17%	91.07%
20	Rocky Mountain Lodgepole Pine Forest	1.03%	92.10%
21	Rocky Mountain Montane Riparian Systems	1.02%	93.12%
22	Wyoming Basins Low Sagebrush Shrubland	0.74%	93.86%
23	Western Great Plains Floodplain Systems	0.74%	94.59%
24	Inter-Mountain Basins Sparsely Vegetated Systems	0.70%	95.29%
25	Artemisia tridentata ssp. vaseyana Shrubland Alliance	0.36%	95.66%
26	Barren	0.34%	96.00%
27	Rocky Mountain Poor-Site Lodgepole Pine Forest	0.31%	96.31%
28	Developed-Open Space	0.30%	96.61%
29	Inter-Mountain Basins Aspen-Mixed Conifer Forest and Woodland	0.29%	96.91%
30	Northern Rocky Mountain Montane-Foothill Deciduous Shrubland	0.29%	97.20%
31	Rocky Mountain Lower Montane-Foothill Shrubland	0.28%	97.47%
32	Northwestern Great Plains Shrubland	0.27%	97.74%
33	Inter-Mountain Basins Semi-Desert Shrub-Steppe	0.27%	98.01%
34	Northwestern Great Plains-Black Hills Ponderosa Pine Woodland and Savanna	0.26%	98.27%
35	Rocky Mountain Subalpine-Montane Mesic Meadow	0.22%	98.48%
36	Inter-Mountain Basins Mixed Salt Desert Scrub	0.22%	98.70%
37	Western Great Plains Sand Prairie	0.20%	98.90%
38	Rocky Mountain Aspen Forest and Woodland	0.19%	99.09%
39	Agriculture-Cultivated Crops and Irrigated Agriculture	0.15%	99.24%
40	Rocky Mountain Alpine/Montane Sparsely Vegetated Systems	0.15%	99.38%
41	Inter-Mountain Basins Greasewood Flat	0.13%	99.52%
42	Open Water	0.11%	99.63%
43	Western Great Plains Shortgrass Prairie	0.09%	99.71%
44	Southern Rocky Mountain Montane-Subalpine Grassland	0.08%	99.79%
45	Developed-Low Intensity	0.06%	99.85%
46	Introduced Upland Vegetation - Perennial Grassland and Forbland	0.04%	99.89%
47	Southern Rocky Mountain Ponderosa Pine Savanna	0.03%	99.93%
48	Rocky Mountain Subalpine-Montane Limber-Bristlecone Pine Woodland	0.01%	99.94%
49	Snow/Ice	0.01%	99.95%
50	Western Great Plains Wooded Draw and Ravine	0.01%	99.96%
51	Inter-Mountain Basins Juniper Savanna	0.01%	99.97%
52	Western Great Plains Depressional Wetland Systems	0.01%	99.98%
53	Southern Rocky Mountain Dry-Mesic Montane Mixed Conifer Forest and Woodland	0.01%	99.98%
54	Developed-Medium Intensity	0.01%	99.99%
55	Colorado Plateau Pinyon-Juniper Woodland	0.01%	100.00%
56	Rocky Mountain Gambel Oak-Mixed Montane Shrubland	0.002%	100.00%
57	Northwestern Great Plains Highland Spruce Woodland	0.001%	100.00%
58	Western Great Plains Sparsely Vegetated Systems	0.001%	100.00%
59	Northern Rocky Mountain Subalpine Woodland and Parkland	0.000%	100.00%
60	Developed-High Intensity	0.0001%	100.00%

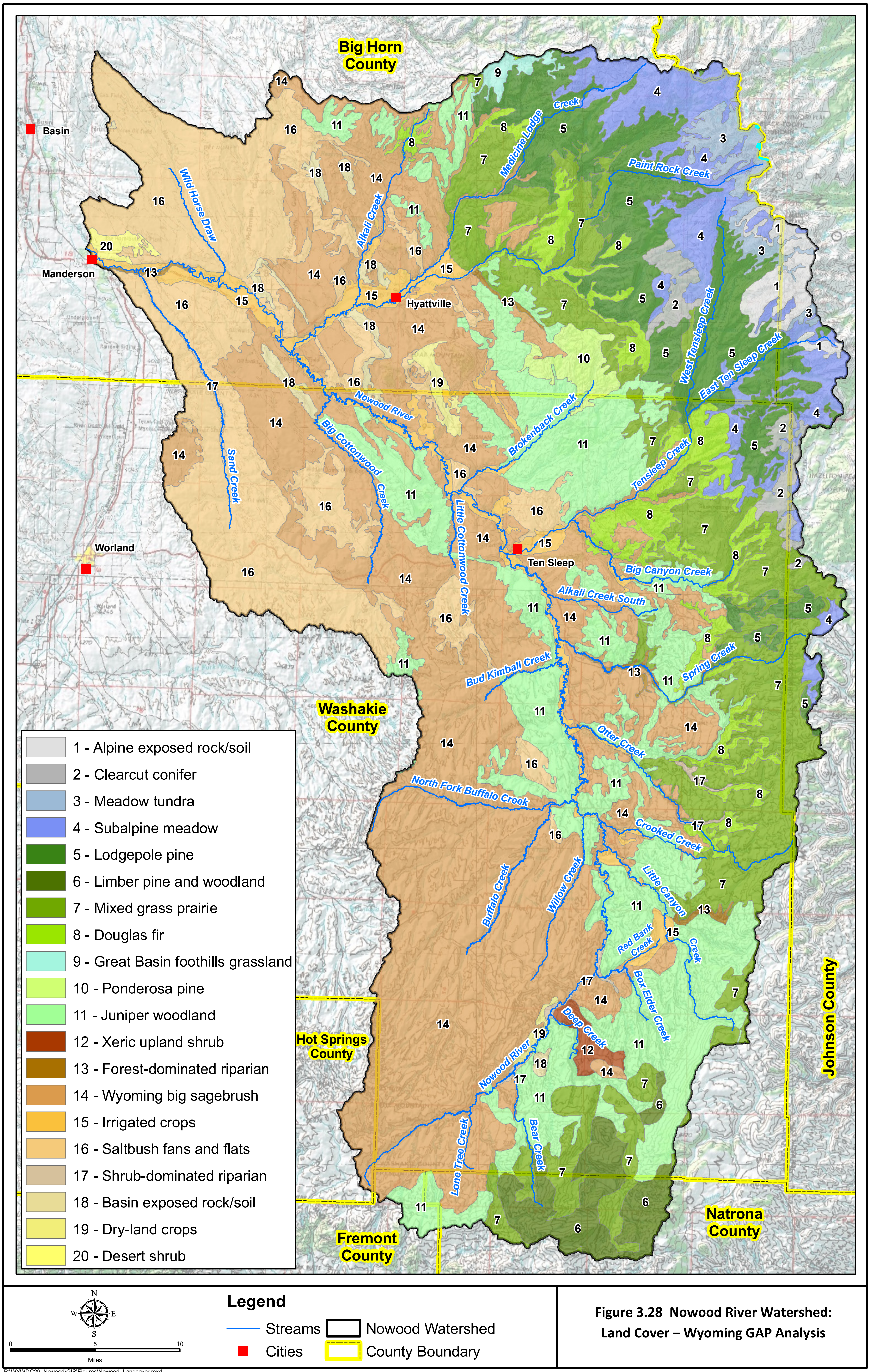


Figure 3.28 Nowood River Watershed: Land Cover – Wyoming GAP Analysis

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).

Review of this figure clearly indicates the difference in vegetation between the eastern and western portions of the watershed. The eastern portion, which lies on the west slope of the Bighorn Mountains, is dominated by mixed coniferous forests dominated by lodgepole pine and douglas fir. On the other hand, the western portion of the watershed is dominated by various arid plant communities: Wyoming big sagebrush and saltbrush communities. It is interesting to note the delineation between these two groups of vegetation communities corresponds roughly with the 14- to 16-inch isohyetals.

The WYNDD has 34 known sensitive plant species of concern located in the study area (Table 3.11). 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.

3.4.2.2 Targeted Vegetation

Salt cedar (tamarisk) and Russian-olive are non-native plant species that have heavily invaded the lower reaches of the Nowood River and its tributaries. They occur locally along the middle reaches of these mainstem streams, along many other tributary streams and irrigation canals, and around some of the small stock ponds in the watershed. These stands often form monocultures which severely limit biodiversity, transpire large volumes of water from the riparian corridor, greatly increase soil salinity, and significantly reduce grazing.

In an effort to quantify the magnitude of Russian olive and saltcedar infestation, the Washakie County Conservation District and the South Big Horn Conservation District funded a mapping effort targeting the two species. This effort consisted of visual review of aerial photography within the GIS environment and manually delineating their visible extent. Ground truthing of selected areas was conducted to confirm the methodology. Figure 3.29 displays a portion of the study area where significant infestation was visible. The scope of the mapping project was limited to the floodplain of the Nowood River and principal tributaries. Mapping on tributaries was limited to a distance of three miles from the Nowood River. Three vegetation classes were mapped: Russian olive, tamarisk, and a mix of the two species. The results of this mapping effort are included within the project GIS.

Results of the mapping indicate that Russian olive and saltcedar covered approximately 1,013 acres of the mapped region. The results must be viewed in light of the fact that much of the watershed was not evaluated. Also, this data set is subject to change as a result of ongoing invasive species eradication efforts of local entities and individuals The results of the mapping project have been incorporated within the project GIS.

Table 3.11 Tabulation of Vegetation Species in the Wyoming Natural Diversity Database Observed within the Nowood River Watershed

Common Name	Scientific Name	Listing Status	Tracked/ Watched
Fern and Fern Ally			
Green spleenwort	Asplenium trichomanes-ramosum	Not Listed	Tracked
Lance-leaved moonwort	Botrychium lanceolatum var. lanceolatum	Not Listed	Tracked
Mingan Island moonwort	Botrychium minganense	Not Listed	Tracked
Peculiar moonwort	Botrychium paradoxum	Not Listed	Tracked
Flowering Plant			
Alpine poppy	Papaver kluanense	Not Listed	Tracked
Bighorn fleabane	Erigeron allocotus	Not Listed	Watched
Cary's beardtongue	Penstemon caryi	Not Listed	Watched
Dubois milkvetch	Astragalus gilviflorus var. purpureus	Not Listed	Tracked
Entire-leaf goldenweed	Pyrrocoma integrifolia	Not Listed	Tracked
Fall knotweed	Polygonum spergulariiforme	Not Listed	Tracked
Hairy tranquil goldenweed	Pyrrocoma clementis var. villosa	Not Listed	Tracked
Hall's fescue	Festuca hallii	Not Listed	Tracked
Hapeman's sullivantia	Sullivantia hapemanii var. hapemanii	Not Listed	Watched
Hyattville milkvetch	Astragalus jejunus var. articulatus	Not Listed	Tracked
Kotzebue's grass-of-parnassus	Parnassia kotzebuei	Not Listed	Tracked
Large yellow lady's-slipper	Cypripedium parviflorum var. pubescens	Not Listed	Tracked
Lesser bladderwort	Utricularia minor	Not Listed	Tracked
Low fleabane	Erigeron humilis	Not Listed	Tracked
Marsh muhly	Muhlenbergia glomerata	Not Listed	Tracked
Moschatel	Adoxa moschatellina	Not Listed	Tracked
Mountain lady's-slipper	Cypripedium montanum	Not Listed	Tracked
Mountain lousewort	Pedicularis pulchella	Not Listed	Watched
Mud sedge	Carex limosa	Not Listed	Tracked
Nagoonberry	Rubus acaulis	Not Listed	Tracked
Northern arnica	Arnica lonchophylla	Not Listed	Tracked
Pink coil-beaked lousewort	Pedicularis contorta var. ctenophora	Not Listed	Tracked
Short-leaf sedge	Carex misandra	Not Listed	Tracked
Single-headed pussytoes	Antennaria monocephala ssp. angustata	Not Listed	Tracked
Soft aster	Symphyotrichum molle	Not Listed	Watched
Three-flower rush	Juncus triglumis var. triglumis	Not Listed	Tracked
Watson's prickly-phlox	Linanthus watsonii	Not Listed	Tracked
White arctic whitlow-grass	Draba fladnizensis var. pattersonii	Not Listed	Tracked
Williams' waferparsnip	Cymopterus williamsii	Not Listed	Tracked
Zephyr windflower	Anemone narcissiflora ssp. zephyra	Not Listed	Tracked

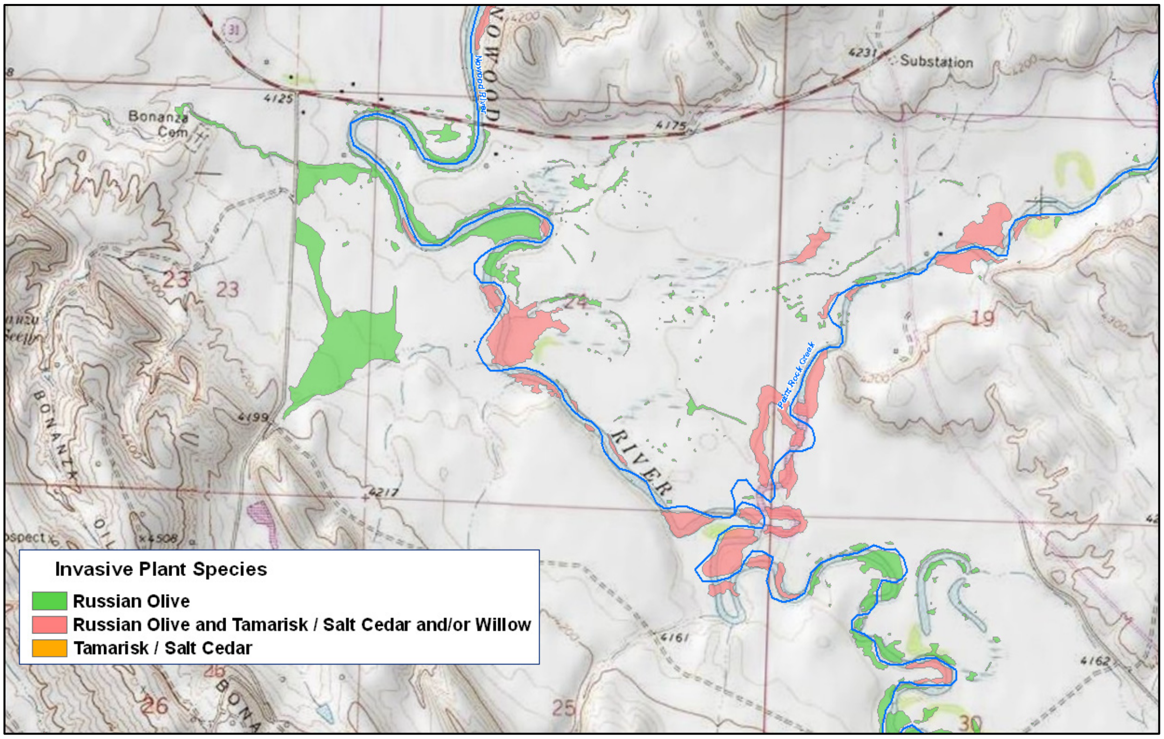
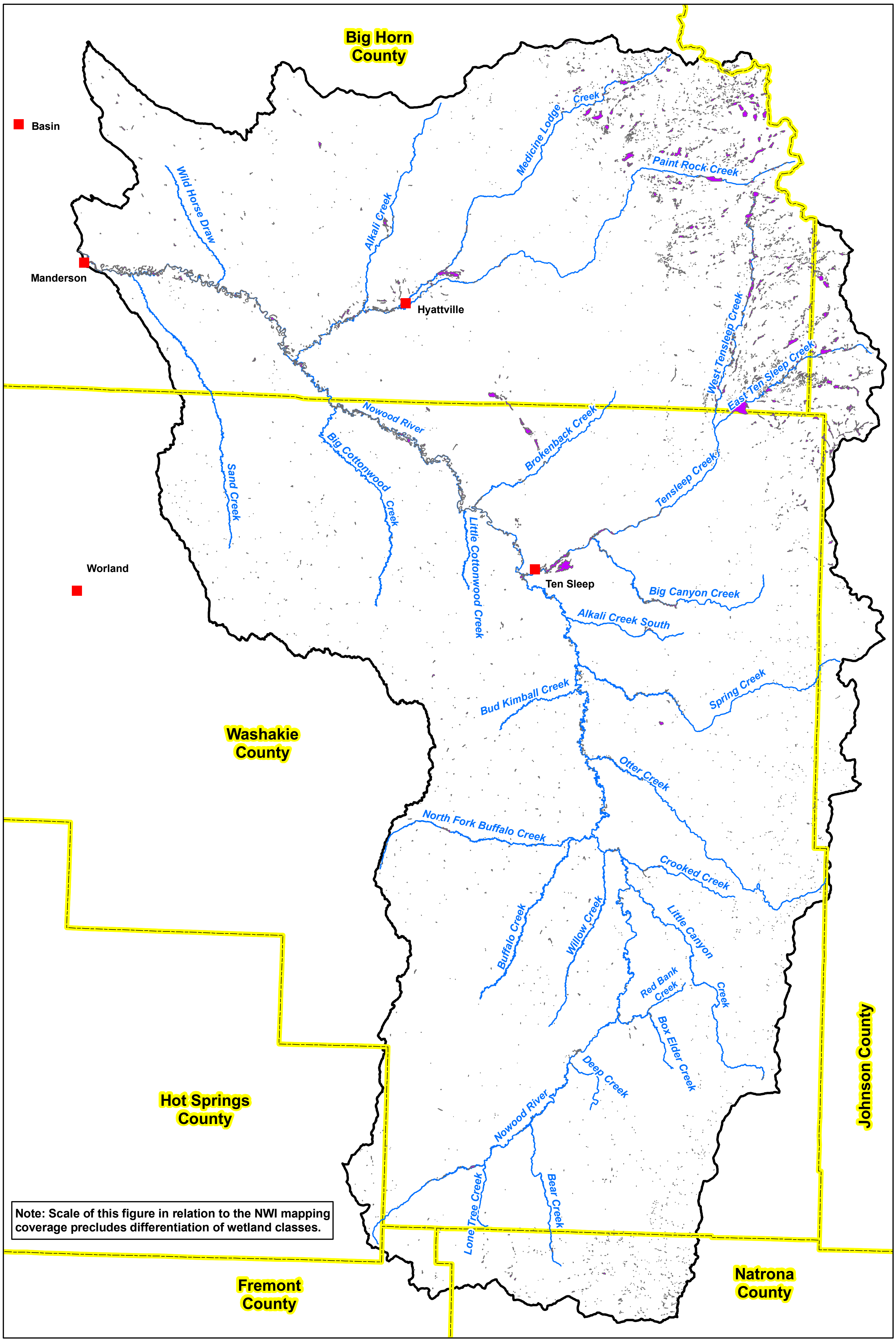


Figure 3.29 Example Invasive Vegetation Species Mapping

The consumptive use of moderate to dense stands of saltcedar has been estimated to be as much as 3-5 acre-feet/acre/year (USBR, 2007; Hart, 2004; Lacher, 1994). Large individual saltcedar plants can transpire at least 200 gallons per plant per day (Tranas, 2007). Davenport and others (1982) found that moderately dense stands of saltcedar used about 3 times as much water as sparse stands, and that dense stands used about 2½ times as much water as moderate stands. Russian olive is estimated to use on the order of about 70 percent as much water per year as saltcedar for comparable plant density (Hart, 2004). According to the Washakie County Conservation District (WCCD), eradication programs have been implemented and portions of the areas mapped have already been treated. Treatment involves both mechanical and chemical treatment.

3.4.2.3 Wetlands

Existing mapping of wetlands within the Nowood River Watershed available for this study 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 9,915 acres of wetlands exist within the watershed (Figure 3.30). 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 broadscale planning efforts such as this Level I investigation, however, before design and



N W E S

0 5 10 Miles

Legend

NWI - Wetlands | Cities | County Boundary
Streams | Nowood Watershed

Figure 3.30 Nowood River Watershed: National Wetlands Inventory (NWI)

P:\WYWDC29_Nowood\GIS\Figures\Nowood_NWI.mxd 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 approximately 95.4 acres of Western Great Plains Depressional Wetlands with the watershed. Other types of wetlands are not included in the LANDFIRE data, however, two riparian vegetation categories are found within the watershed: Rocky Mountain Subalpine/Upper Montane Riparian Systems (15,637 acres) and Rocky Mountain Montane Riparian Systems (13,167 acres) 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.

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 Nowood River watershed, the following four types are likely to be encountered: slope wetlands, depressional wetlands, lacustrine fringe 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

Lacustrine Fringe

Lacustrine fringe wetlands are adjacent to lakes where the water elevation of the lake maintains the water table in the wetland. In some cases, they consist of a floating mat attached to land. Additional sources of water are precipitation and groundwater discharge, the latter dominating where lacustrine fringe wetlands intergrade with uplands or slope wetlands. Surface water flow is bidirectional, usually controlled by water level fluctuations such as seiches in the adjoining lake. Lacustrine fringe wetlands are indistinguishable from depressional wetlands where the size of the lake becomes so small relative to fringe wetlands that the lake is incapable of stabilizing water tables. Lacustrine wetlands lose water by flow returning to the lake after flooding, by saturation surface flow, and by evapotranspiration.

Organic matter normally accumulates in areas sufficiently protected from shoreline wave erosion. Unimpounded marshes bordering the Great Lakes are a common example of lacustrine fringe 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 3.31 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

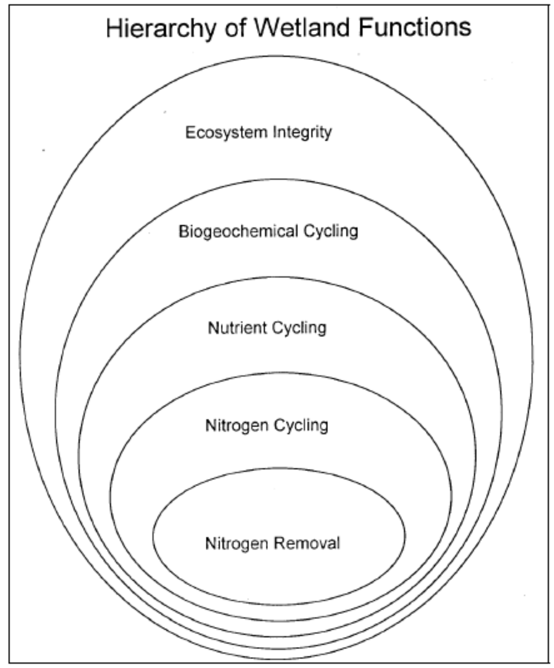


Figure 3.31 Hierarchy of Wetland Functions (USACE, 1995)

3.4.3 Geology

3.4.3.1 Surficial Units

The surficial deposits found within the Nowood watershed are presented on Figure 3.32. The figure shows the wide distribution of alluvium, glacial deposits, residuum, slope wash and colluvium within the watershed. These sediment types constitute the dominant exposed geology within the watershed. The remaining exposed geology is composed of bedrock, grus, landslide, and terrace deposits. A discussion of bedrock and landslides is presented in the bedrock geology and hazards sections below.

Alluvium is found adjacent to surface drainages and is of fluvial origin (produced by the action of a stream or river). The extent of the alluvial deposits varies with the size of the respective fluvial system. Headwater deposits are typically narrower and shallower compared to downstream areas in the watershed. Alluvium ranges from 10-50 feet in thickness and is composed of sand, gravel, and loam (Cooley and Head 1979). These deposits are actively growing with the fluvial action of existing surface drainages. Fluvial action includes flooding (vertical deposition) and point-bar migration (lateral deposition).

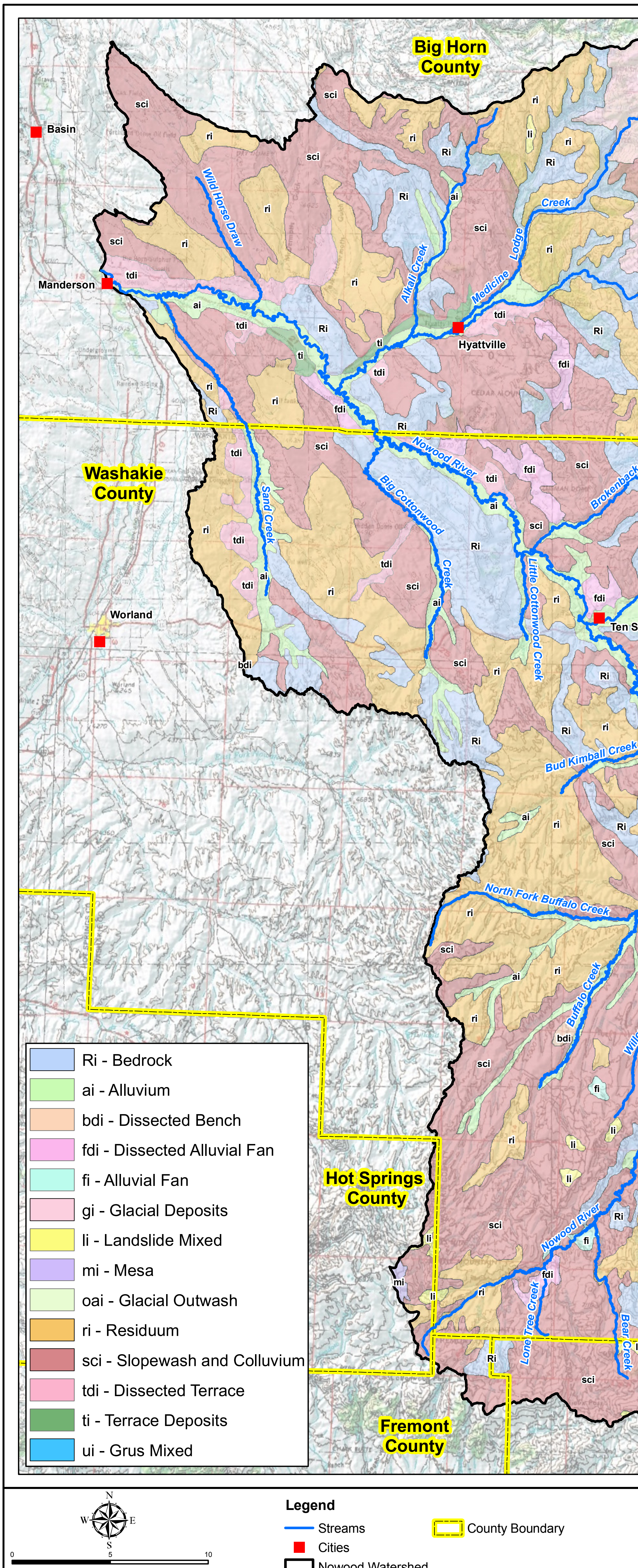


Figure 3.32 Nowood River Watershed: Surficial Geology

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Glacial till exists in the northeastern portion of the watershed and is associated with lateral and terminal moraines. The lateral moraines typically begin at an elevation about 10,000 feet and can be traced to approximately 8,000 feet, where they meet the terminal moraines (Darton, 1906). Drift composition is dominantly igneous and metamorphic rock from upland areas. Some Paleozoic sedimentary rocks also exist within the till located at lower elevations. These deposits consist of unconsolidated, poorly sorted, angular rock fragments. Some areas may display greater levels of sorting due to esker formation.

Residuum is an in-situ deposit formed from the weathering of bedrock. Soluble components of the bedrock were transported from the area by fluvial, fluvioglacial, and groundwater processes. The insoluble portions of the rock experienced some mechanical weathering from freeze-thaw and rain-drop impact with little to no transport of the remaining materials. The residuum deposits within the Nowood watershed are primarily derived from late Paleozoic to Mesozoic rocks. The deposits are relatively young and are therefore thin compared to other quaternary deposits.

Colluvium exists throughout the watershed and has a genetic origin related to mass wasting mechanisms. These sediments were derived from the movement of material down slope under the influence of gravity. The colluvial deposits are composed of material derived from bedrock at higher elevations. Grain sizes range from silt to gravel, and grain shape is predominantly angular to subangular. These deposits have a maximum thickness of 15 feet (Cooley and Head, 1979) but thin as they near the source material at higher elevations.

3.4.3.2 Bedrock Units

The bedrock geology exposed and directly underlying the Nowood watershed contains rock formations with ages ranging from the Cambrian Period to present. The bedrock geology outcropping at or near the surface is presented on Figure 3.33. The dominant formations in the Nowood watershed (from youngest to oldest include the:

- Fort Union Formation
- Mesaverde Formation
- Cody Shale
- Frontier Formation*
- Mowry Shale*
- Thermopolis Shale*
- Cloverly shale*
- Morrison Formation*
- Sundance Formation*
- Gypsum Spring Formation*
- Chugwater Formation*
- Goose Egg Formation
- Tensleep sandstone
- Amsden Formation

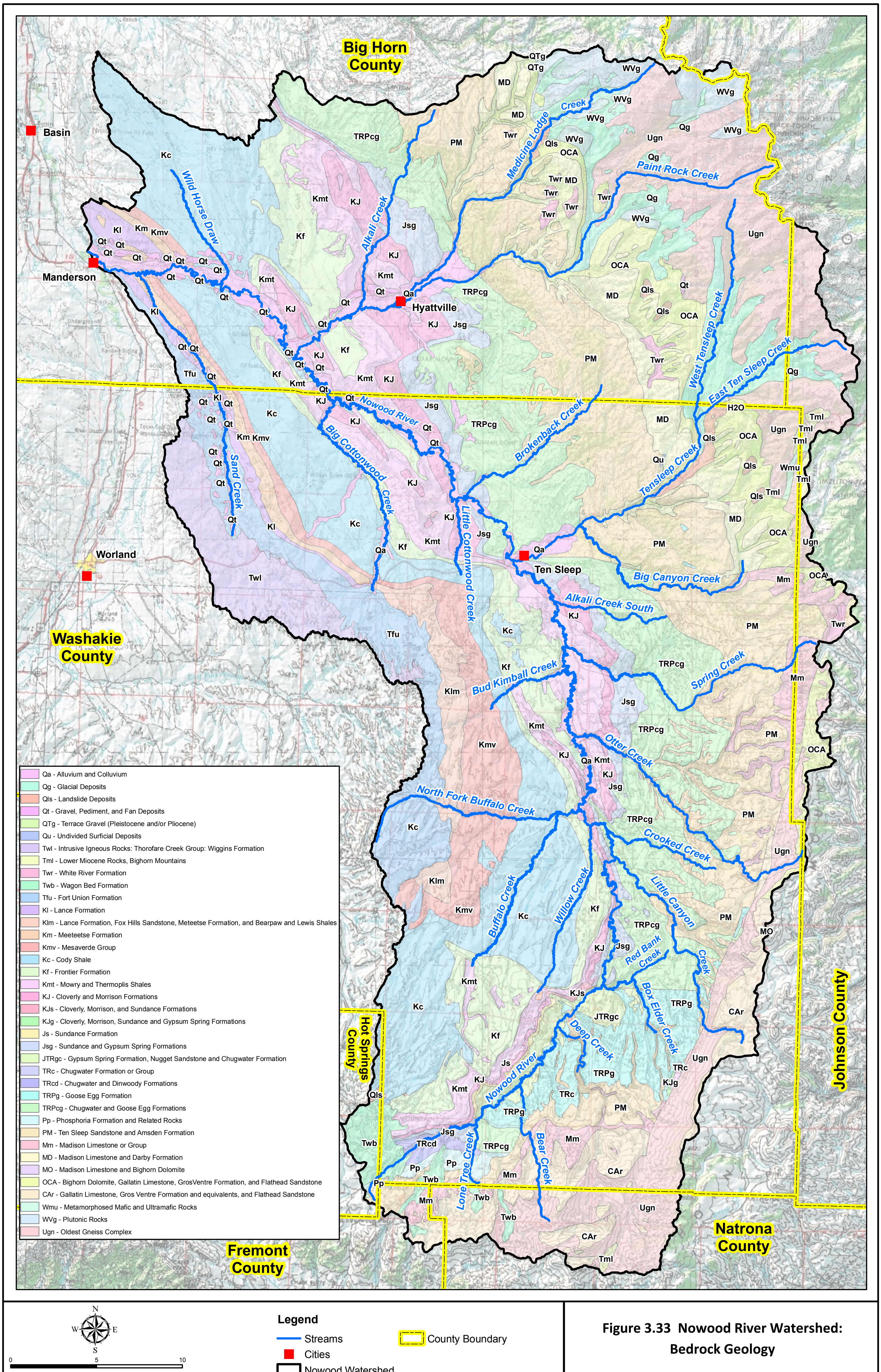

Figure 3.33 Nowood River Watershed: Bedrock Geology

- Madison limestone*
- Bighorn dolomite
- Gallatin Formation
- Gros Ventre Formation

Other formations are mapped within the Nowood River watershed, but the above units have the greatest influence on the watershed's geology. The units noted with asterisks were encountered at the various reservoir sites and are discussed in Section 3.9 described in greater detail herein below.

The general pattern of outcrop of the units is of younger formations on the western side of the watershed and older units on the eastern side (Susong et al., 1993). An exception to the pattern is the quaternary, surficial deposits discussed in the previous section. The youngest Tertiary-age rocks that crop out in the watershed are of the Fort Union Formation and are approximately 55-68 million years old (ma). This formation consists of interbedded layers of sandstone and shale. Coal seams exist within the formation but are smaller and less frequent than those found in the Fort Union of southeastern Montana. In the area of the Nowood River, the Fort Union Formation is 1,000 to 1,500 feet thick (Cooley and Head, 1979).

The next youngest rocks are of Cretaceous age (68-142 ma) and include units of the Mesaverde, Cody Frontier, Mowry, Thermopolis, and Cloverly Formations. Within the Nowood watershed, these formations comprise the bedrock (other than the Tertiary formations) found west of the Nowood River and the areas northwest of Hyattville, Wyoming. They are comprised of thick shale layers with thinner beds of sandstone. Coal is present within these rocks as well (Darton, 1906). The thickness of the entire sequence is from 6,600 to 7,500 feet (Cooley and Head, 1979; Fischer, 1906).

The Frontier Formation is Upper Cretaceous and is composed of fine to medium lenticular sandstone with gray and black marine shale. Thin bentonite and tuff beds are present as well. The Mowry Formation is Lower Cretaceous and composed of black and gray thin-bedded resistant shale interbedded with thin sandstone and bentonite. The Thermopolis Shale is a soft, black shale of the Lower Cretaceous. The Cloverly Formation is Lower Cretaceous and composed of light gray channel sandstones and pebble conglomerates interbedded with variegated bentonite mudstone (Weitz and Love, 1952).

To the east of the Cretaceous age rocks are Jurassic to Pennsylvanian age (142-320 ma) rocks, which include the Morrison, Sundance, Gypsum Spring, Chugwater, Goose Egg, Tensleep, and Amsden Formations. These formations range from reddish-brown shale to silty sandstone to sandstone. Thin beds of limestone also exist. The Tensleep Formation consists entirely of lightly cross-stratified sandstone. Gypsum exists in the Gypsum Spring and Goose Egg Formations, the solution of which has produced karst topography. The total thickness of these formations ranges from 2,000 to 2,400 feet (Susong et al., 1993; Cooley and Head, 1979).

The Morrison Formation is Upper Jurassic and composed of calcareous gray silty sandstone and sandy claystone with lenticular limestone. The Sundance Formation is Middle Jurassic and is a greenish-gray glauconitic calcareous sandstone and shale. The Gypsum Springs Formation is Middle Jurassic and an interbedded red claystone, shale, siltstone and limestone with massive gypsum beds. The Chugwater Formation is Triassic and composed of massive, cross-bedded very fine grained red sandstone, siltstone and shale.

Mississippian to Ordovician age rocks (320-505 ma) crop out further to the east and southeast. These rocks are composed of the Madison limestone and Bighorn dolomite. Both formations contain light-gray massive limestone with the Bighorn Formation also containing dolomite. Dissolution of these formations has also produced karst topography and cave systems in the Nowood watershed. The extensive cave systems associated with these formations suggests a high volume of water is exchanged during surface water-groundwater interactions. The Madison limestone has a thickness of 500 to 700 feet, while the Bighorn dolomite is 300 feet thick (Susong et al., 1993; Cooley and Head, 1979).

The Gallatin, Gros Ventre, and Flathead Formations were deposited during the Cambrian Period (505-560 ma) and are. Both formations are a greenish to gray shale. The formations are in the western portion of the watershed, adjacent to the Oldest Gneiss Formation and other plutonic rocks. These igneous and metamorphic rocks are the basement, Precambrian rocks found in the center of the broad anticlinal structure of the Bighorn Mountains (Susong et al., 1993; Darton 1906; Fischer, 1906).

3.4.3.3 Structure

The Nowood watershed is located in the southeastern portion of the Bighorn Basin. The basin was formed from folding and faulting during the Laramide orogeny, which occurred approximately 40-70 ma. The Laramide also produced the mountains that border the basin (Susong et al., 1993). To the east the basin is bordered by the Bighorn Mountains and to the south by the Owl Creek Mountains (Fischer 1906). Bounded by these mountain ranges, the Nowood watershed drains the southeastern-most portion of the Bighorn basin.

The general structure of the Bighorn Mountains is a convex uplift, and a portion of the Nowood watershed drains the southwestern homocline. Smaller scale anticlines and synclines are present within the watershed, and these local structures create variations in bed orientation.

The smaller scale anticlines and synclines are tectonically related to the larger Bighorn uplift and therefore have similar orientations. The beds within them strike to the northwest and generally dip 5-12° to the southwest. Beds with an opposite dip direction (to the northeast) are present but less prevalent. This bed reversal typically indicates the presence of a local syncline (Hosterman et al. 1989; Cooley and Head 1979). Synclines can often be found associated with an anticline of similar size and extent. One anticline-syncline pair in the Nowood watershed can be found along the western side of the Nowood River with the axial plane running from Manderson, to Crooked Creek (Cooley and Head, 1979). Similar but less extensive structures are also found in the northeastern portion of the watershed, near Hyattville and Ten Sleep, as well as in the southern part of the watershed in the vicinity of Mahogany Butte and Orchard.

Faulting is evident within the eastern portions of the Nowood watershed (Figure 3.34). These faults are characterized as high-angle (60-90°) normal faults with the downthrown side located to the west of the fault line (Hosterman et al., 1989; Darton, 1906). Faults of this type are associated with extensional tectonics. One distinctive fault that displays these characteristics is located adjacent to Big Canyon Creek and Ten Sleep. The fault displays a vertical displacement of 700 feet near Big Canyon Creek. This displacement decreases towards the west, and the fault eventually merges into a monocline approximately 4 miles west of Ten Sleep (Hosterman et al., 1989; Cooley and Head, 1979; Darton, 1906).

Also, a large prominent fault, called the Big Trails Fault System, trends generally north-south along the eastern perimeter of the watershed in the southern Bighorn Mountains (Verploeg ,1992).

3.4.3.4 Geologic Hazards

Karst, landslide, and seismic geological hazards exist within the Nowood watershed. Karst creates sinkhole hazards and occurs from the dissolution of chemical rocks (limestone, gypsum, dolomite, etc.). Landslides occur when sediment moves down slope under the influence of gravity, potentially damaging structures and altering the hydrogeology of the watershed. Seismic events create a hazard to structures and tend to occur along fault lines, but earthquakes have occurred in areas with no known respective structural feature. The potential areas at risk for these hazards are presented on Figure 3.34.

Karst topography within the Nowood watershed is predominantly located to the east of the Nowood River. Closed depressions and solution collapse features are found on the surface and have been associated with the Goose Egg and Gypsum Spring Formations (Cooley and Head, 1979). These features were developed from the dissolution of gypsum and limestone underlying surficial deposits. The surficial deposits then reflected the karst topography below them. The limestone and dolomite of the Madison, Bighorn, and Gallatin Formations have also developed a karst topography. Some of this topography is concealed by the Amsden Formation, which unconformably overlies paleokarst features of the Madison (Hosterman et al., 1989). However, extensive, recently developed caves exist in the northeastern portion of the Nowood watershed, near Medicine Lodge Creek (Susong et al., 1993).

Collapse risk due to sinkholes can be difficult to determine due to their subsurface nature. Certain features can be indicative of karst: closed depressions, sinking streams, blind valleys, and others. However, subsurface investigations (including geophysical, tracer dye, and field surveys) need to be conducted to provide an adequate assessment.

Landslide hazards exist in areas where the resisting forces (friction and cohesion/adhesion between sediment particles) have the potential to be exceeded by the driving forces (gravity). This condition can be found throughout the upland areas of the Nowood watershed. Paleolandslides ("li" unit in Figure 3.32) are indicators of future landslide activity. Slopes experiencing undercutting due to lateral erosion of streams are also at high risk. Severe erosion problems have been noted on the Nowood River, with less severe erosion on the Paint Rock, Ten Sleep, Otter, and Canyon Creeks (USDA ,1971). The lateral erosion by streams undercuts the toe of slopes and removes their underlying support. Other factors for

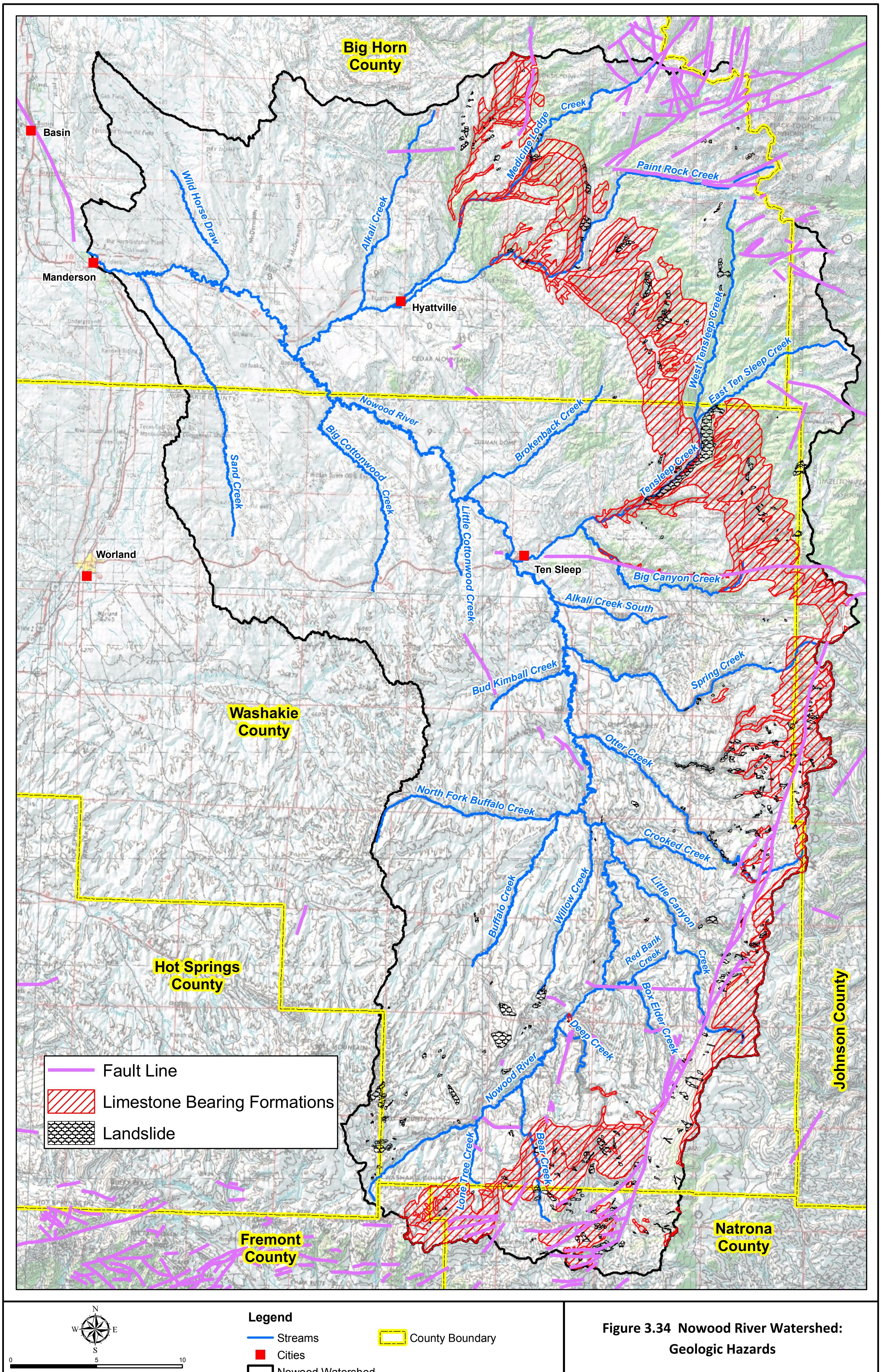

Figure 3.34 Nowood River Watershed: Geologic Hazards

P:\WYWDC29_Nowood\GIS\Figures\Nowood_Geologic_Hazards.mxd potential landslide areas include grain size and shape, lateral and underlying support, slope angle, sediment composition, and water content.

The Nowood watershed is an area with minor historical seismicity. According to Stover et al. (1984), epicenters of 11 earthquakes were recorded to have been in or near the watershed. The largest magnitude earthquake, with a magnitude of 4.9, occurred in 1970. The epicenter was located approximately 8 miles southwest of Ten Sleep. The smallest magnitude earthquakes of 3.0 occurred in 1998 and 2000 (USGS, 2009; Case et al., 2002). Two earthquakes recorded in 1925 and 1966, occurred before magnitude measurements were regularly recorded. The earthquakes were rated using the Modified Mercalli Intensity Scale. Intensity was not noted for the 1966 earthquake, and an intensity V level was applied to the 1925 event. The 1925 event was felt in Ten Sleep, Sheridan, Fort McKenzie, and Dome Lake Resort, but damage was not reported (Case et al.,2002).

Two fault systems are located adjacent to each other in the southern portion of Nowood watershed: the Cedar Ridge and Dry Fork fault systems. Evidence suggests that the fault systems are inactive. However, one confirmed case of Pleistocene-aged movement, in the form of a fault scarp, was documented in northeastern Fremont County (Case et al., 2002). If either the Cedar Ridge or Dry Fork fault systems were to become active, they could potentially generate 6.7 and 7.1 magnitude earthquakes, respectively. A 6.7 magnitude earthquake at the Cedar Ridge System could produce a peak horizontal ground acceleration of 2.9%g at Ten Sleep and 2.0%g at Big Trails. A 7.1 magnitude earthquake at the Dry Fork System would produce a peak ground acceleration of 3.8%g at Ten Sleep and 7.4%g at Big Trails (NOTE: "g" is defined as the accelearation due to gravity at the earth's surface, or 9.8 meter/sec/sec. Acceleration during an earthquake is therefore expressed as a percentage of this value). In either case, minor damage could result from these earthquakes at Big Trails, Wyoming (Case et al. ,2002).

Although active fault systems are not currently identified near the Nowood watershed, large earthquakes can still occur in areas without a known source structure. These earthquakes are known as "floating earthquakes." Federal and state regulations require a floating earthquake analysis for certain structures (mill tailing sites, landfills, etc.). If a structure within the Nowood watershed required such analysis, a 6.25 magnitude earthquake with an epicenter 15 miles from the structure could be used as a conservative estimate for design ground accelerations. An earthquake of this magnitude and distance could produce ground accelerations of 15%g (Case et al., 2002). A more detailed, site specific, design analysis of seismological hazards is performed in association with the development of significant structures, such as large dams.

Another type of seismic hazard analysis, completed by the USGS, estimates the probability of exceeding the peak horizontal ground acceleration that could occur from an earthquake in the next 50 years. This analysis was most recently updated in 2008 and can be found at http://gldims.cr.usgs.gov/nshmp2008/viewer.htm. For the Nowood watershed, the peak horizontal ground acceleration that a has 10% chance of being exceeded from 2008 to 2058, is from 4-5%g. The peak ground acceleration that has a 2% chance of being exceeded from 2008 to 2058 is from 15-17%g. This methodology uses the frequency and magnitude of past earthquakes to estimate the frequency and magnitude of future earthquakes. A weakness to this method is that it can inaccurately predict earthquake risk in areas with a low frequency of earthquakes, like the Nowood watershed. However, few other alternatives for estimating the risk exist.

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, such as those of the Persayo series, 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 and shale (SCS, 1983). 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 3.35 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.

NRCS soils mapping at the 1:24,000 level of detail is available on a county by county basis. The Nowood River watershed study area includes portions of six different counties: Big Horn, Washakie, Natrona, Fremont, Hot Springs, and Johnson. Table 3.12 describes the availability of soils data for the six counties involved. Figure 3.36 displays the various soils found within the study area where mapping is available. Table 3.13 lists the soil units displayed in Figure 3.36.

Table 3.12 Availability of Soils Data within the Nowood River Watershed

County	Spatial Data Availability	Tabular Data Availability
Washakie	Entire County Available	Entire County Available
Bighorn	Partial County Available	Partial County Available
Hot Springs	Partial County Available- None in Study Area	Entire County Available
Fremont	Partial County Available- Study Area has coverage	Partial County Available- Study Area has coverage
Natrona	Entire County Available	Entire County Available
Johnson	Partial County Available- Southern half is available	Entire County Available

The Washakie County soils mapping was obtained from the NRCS. The Big Horn County soils mapping was obtained from the Big Horn County Planning Department and was created by their staff based upon a limited number of previously completed SCS work maps (J. Waller, personal comm., 2008). Information available in the databases regarding specific soils includes:

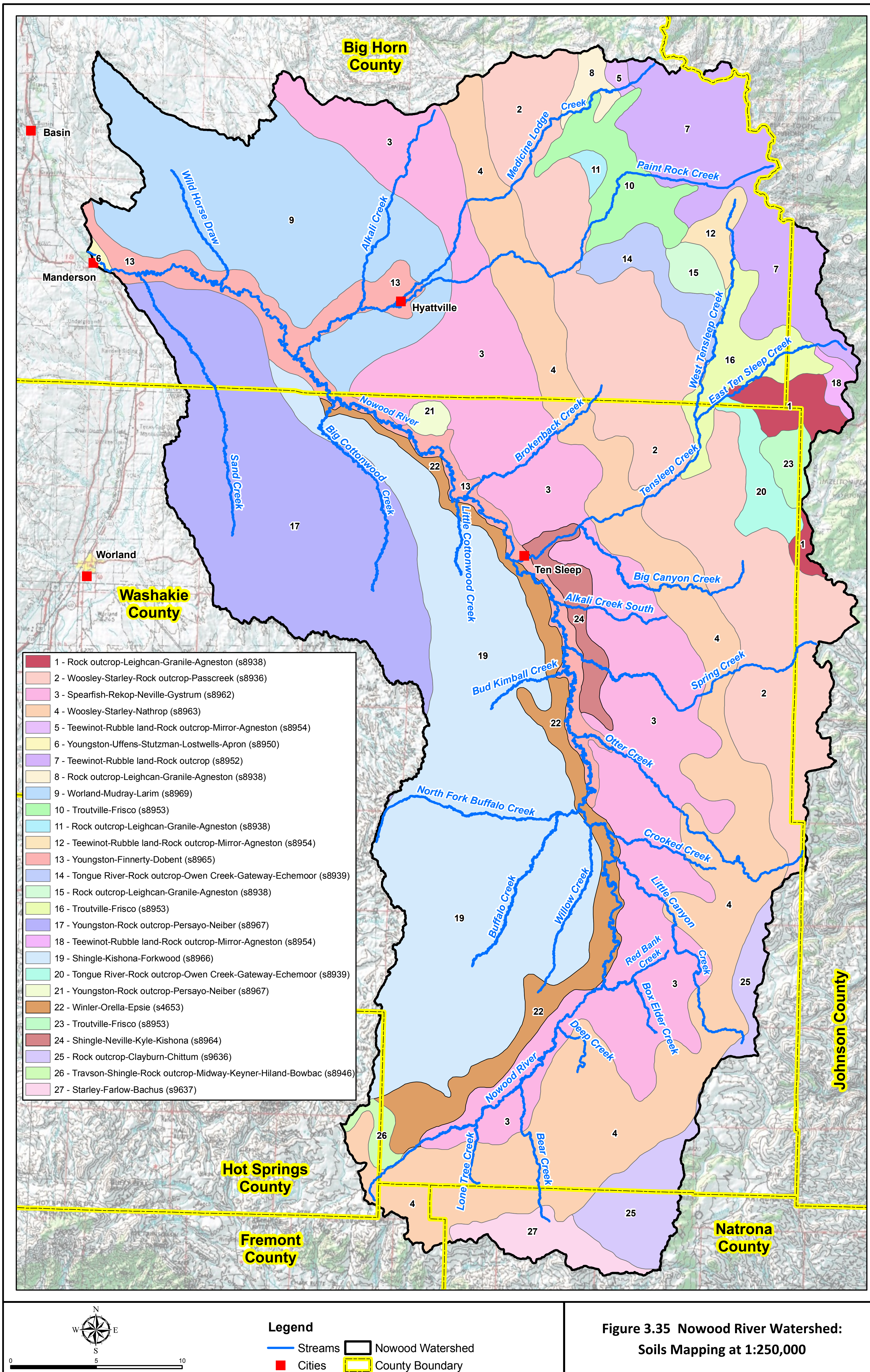

Figure 3.35 Nowood River Watershed: Soils Mapping at 1:250,000

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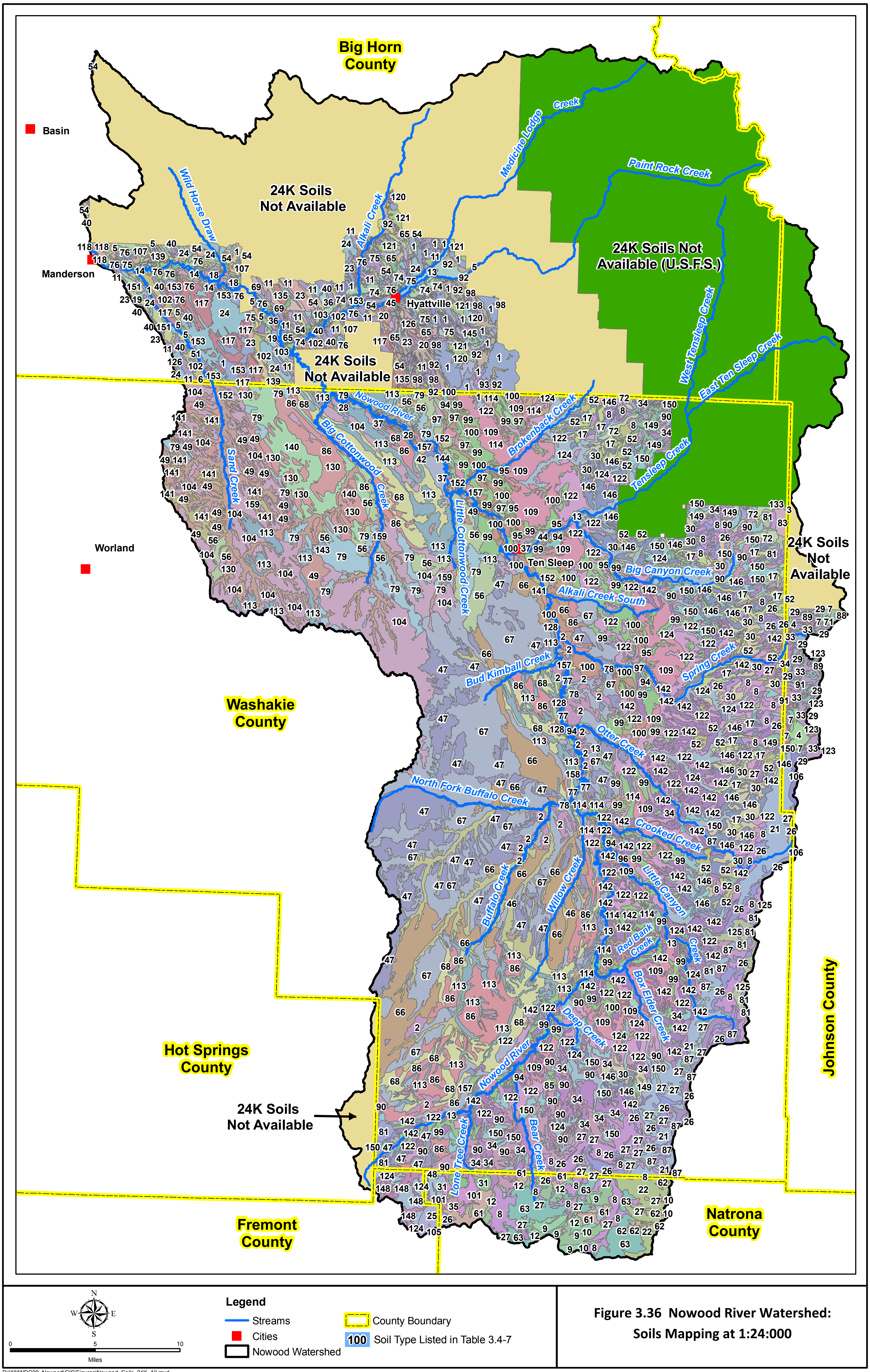


Figure 3.36 Nowood River Watershed: Soils Mapping at 1:24:000

Table 3.13 Soils Mapping Units Displayed in Figure 3.36

Mapping Identifier	Soils Unit	Mapping Identifier	Soils Unit
0	No Mapping Data	64	Meadowlake-Castino variant-Rock outcrop association
1	Absted-Forkwood association	65	Muff-Neiber fine sandy loams, 3 to 30 percent slopes
2	Agneston-Granile-Rock outcrop association, 5 to 50 percent s	66	Mughut-Bondman association
3	Apron Sandy Loam	67	Mulgon-Lucky Star association
4	Arvada-Olney association	68	Nathrop-Starley-Rock outcrop association
5	Badlands	69	Neville Loam
6	Barnum loam	70	Neville Loam, Wet
7	Baroid Las Animas Sandy Loams, Wet	71	Neville loam, 0 to 3 percent slopes
8	Baroid Sandy Loam	72	Neville loam, 3 to 6 percent slope
9	Baroid sandy loam	73	Neville loam, 6 to 10 percent slopes
10	Billycreek-Wetterhorn complex, 6 to 60 percent slopes	74	Neville loam, wet, 0 to 3 percent slopes
11	Binton Silty Clay Loam Wet	75	Neville-Spearfish Association
12	Binton-Youngston Complex	76	Neville-Spearfish-Rock outcrop association
13	Bributte Persayo Complex	77	Neville-Tensleep complex, 1 to 10 percent slopes
14	Burnette-Lucky Star association	78	Oceanet Rock outcrop
15	Chipeta-Deaver Complex	79	Pavillion Kinnear Association
16	Chipeta-Persayo-Rock OutCrop Complex	80	Persayo-Rock outcrop association
17	Chittum-Rock outcrop association	81	Preatorson Persayo Association
18	Clayburn-Bachus-Inchau association	82	Rairdent-Uffenston Complex
19	Clayburn-Wallrock association	83	Rekop-Gystrum association
20	Clifterson-Persayo association	84	River wash
21	Coutis-Greenman association	85	Rock outcrop Travesilla Complex
22	Cryaquolls, 0 to 5 percent	86	Rock outcrop-Cloud Peak association, 10 to 70 percent slopes
23	Dobent Loam	87	Rock outcrop-Persayo complex, 15 to 70 percent slopes
24	Dobent loam	88	Rock outcrop-Spearfish complex, 1 to 60 percent slopes
25	Emblem Griffy Complex	89	Rock outcrop-Starman complex, 6 to 45 percent slopes
26	Emblem garland Complex	90	Sayles Clay Loam
27	Enos-wallson Complex	91	Sayles-Persayo Association
28	Finnerty silty clay	92	Sharland Clay Loam Alkali
29	Finnerty silty clay, wet	93	Shoshone Loam
30	Fluvaquents	94	Spearfish Rock Outcrop Complex
31	Fluvents	95	Spearfish Travesilla Asso.
32	Forkwood-Haverdad association	96	Spearfish-Travessilla-Rock outcrop complex, 10 to 60 pe rcen
33	Forkwood-Kishona association	97	Stubbs-Turk association
34	Fruita-Neiber association	98	Stutzman Silty Clay Loam
35	Garland Emblem Clay Loams	99	Stutzman Silty Clay Loam Wet
36	Glenton Baroid Sandy Loams	100	Stutzman silty clay loam, 0 to 3 percent slopes
37	Greenman-Splitro association	101	Stutzman silty clay loam, wet, 0 to 3 percent slopes
38	Greybull Deaver Clay Loam	102	Stutzman-Persayo association
39	Greybull Persayo Association	103	Tensleep loam, 3 to 6 percent slopes
40	Greybull Persayo Clay Loams, wet	104	Tongue River-Gateway association, 2 to 35 percent slopes
41	Greybull-Persayo association	105	Torchlight Silty Clay Loam
42	Griffy Sandy Loam	106	Travesilla Midway Complex
43	Griffy clay loam, 0 to 3 percent slopes	107	Uffens Silty Clay Loam
44	Griffy sandy loam, 1 to 10 percent slopes	108	Uffens-Persayo complex, 1 to 30 percent slopes
45	Hanson variant-Starley association, 10 to 60 percent slopes	109	Uffens-Rairdent complex, 1 to 10 percent slopes
46	Kinnear Pavillion Clay Loam	110	Vale-Tensleep association
47	Kinnear Uffens-Rock OutCrop Complex	111	Wallson loamy fine sand, 1 to 10 percent slopes
48	Kishona-Shingle association	112	Water
49	Kishona-Shingle-Rock outcrop association	113	Welring-Shavano-rosk outcrop Complex
50	Kyle-Shingle-Bidman association	114	Whaley-Rock outcrop complex, 3 to 60 percent slopes
51	Labou 705 very Channery Loam Complex	115	Willwood Glenton Complex
52	Las Animas Sandy Loam	116	Woosley-Decross association
53	Limber-Hyattville-Rock outcrop association	117	Woosley-Morset association
54	Lostwells Clay Loam	118	Woosley-Starley-Rock outcrop association
55	Lostwells Kinnear Clay Loams	119	Worland Persayo Complex
56	Lostwells Kinnear Complex	120	Worland-Persayo complex, 3 to 30 percent slopes
57	Lostwells Youngston Soils, Wet	121	Youngston Clay Loam
58	Lostwells clay loam, 0 to 3 percent slopes	122	Youngston Mod Wet Stutzman Complex
59	Lostwells clay loam, 3 to 6 percent slopes	123	Youngston Moderately Wet
60	Lostwells-Youngston complex, 1 to 10 percent slopes	124	Youngston Uffens Complex
61	Lostwells-Youngston complex, wet, 0 to 6 percent slopes	125	Youngston clay loam, moderately wet, 0 to 3 percent slo pes
62	Lymanson-Turk-Jenkinson association	126	Youngston silty clay loam, 0 to 3 percent slopes
63	Marsh	127	Youngston-Uffens-Lostwells complex, 1 to 10 percent slopes

- Soil unit characteristics:
- particle size distribution
- soil reaction
- bulk density
- salinity
- available water capacity
- organic matter
- Relevant related conditions:
- flooding
- depth to bedrock
- water table depth
- soil subsidence
- Use and management data:
- sanitary facilities
- construction material
- building site development
- crops
- recreational development
- woodland suitability
- water management
- wildlife habitat suitability
- rangeland potential

Of specific pertinence to this study are those soils demonstrating high erosive characteristics, rangeland production potential, and agricultural value.

Soils encountered in the arid western portion of the study area are dominated by the Youngston, Persayo, Shingle, Koshona, and Forkwood series. These soils are derived from shale parent materials and range from shallow to deep, and are well drained.

Soils mapped on the Big Horn Mountain foothills on the eastern side of the watershed are dominated by the Spearfish, Rekop, Neville series.

3.5 Watershed Hydrology

3.5.1 Groundwater

Groundwater in the Nowood River watershed occurs in both shallow (alluvial) and deeper (bedrock) aquifers. Both unconfined and artesian (confined) conditions exist, often in high quantities. The quantity and quality of groundwater varies with geologic unit and is related to the lithology and geochemical properties of the material. In the following sections, the three primary groundwater sources are discussed: springs, alluvial aquifers, and bedrock aquifers.

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 3.37 displays the location of springs mapped by the USGS and the BLM. According to a paper published by the USGS (Cooley, 1986), springs in the area are generally found within Goose Egg and Chugwater Formations and arise from upward moving water from the underlying Tensleep Sandstone.

Springs and seeps help maintain perennial flows in several small streams, such as Alkali Creek (near Hyattville), Alkali Creek (south of Ten Sleep), Spring Creek, Crooked Creek, and Redbank Creek. According to Cooley (1986) many of the springs are along conspicuous linear topographic features or near their intersections, indicating that fractures along the linear features may be a principal control on the spring locations. The largest springs in the lowlands are Alkali Spring, which maintains the perennial flow of Alkali Creek north of Hyattville, and Big Spring near Big Trails, which discharges about 1,000 gal/min near a fault. An additional spring located in the southern portion of the study area (Township 42 North, Range 88 West), is reported to flow at approximately 4,500 gallons per minute (Cooley, 1986).

Springs at the Wigwam Fish Rearing Station have a combined flow of a over 2,000 gallons per minute. The two main springs maintain the ponds at the station. These springs issue from shaly redbeds that make up the upper part of the Amsden Formation.

3.5.1.2 Alluvial Aquifers

Alluvial aquifers are located along the major streams and consist of unconsolidated clay, silt, sand, gravel, and cobble. Alluvial aquifers with development potential are known to exist along the Nowood River, Tensleep Creek, Paint Rock Creek, Medicine Lodge Creek, Canyon Creek, Little Canyon Creek, Spring Creek and Otter Creek (USGS, 1961, Cooley and Ward, 1979). The width of the valley floor of the Nowood River underlain by alluvium ranges from about 0.1 mile near Big Trails to 0.75 miles downstream of Paint Rock Creek. Width of alluvium along Ten Sleep Creek extends as wide as 0.75 miles. Width of alluvium along Paint Rock Creek is as wide as 0.5 miles near its mouth (Cooley and Ward, 1979).

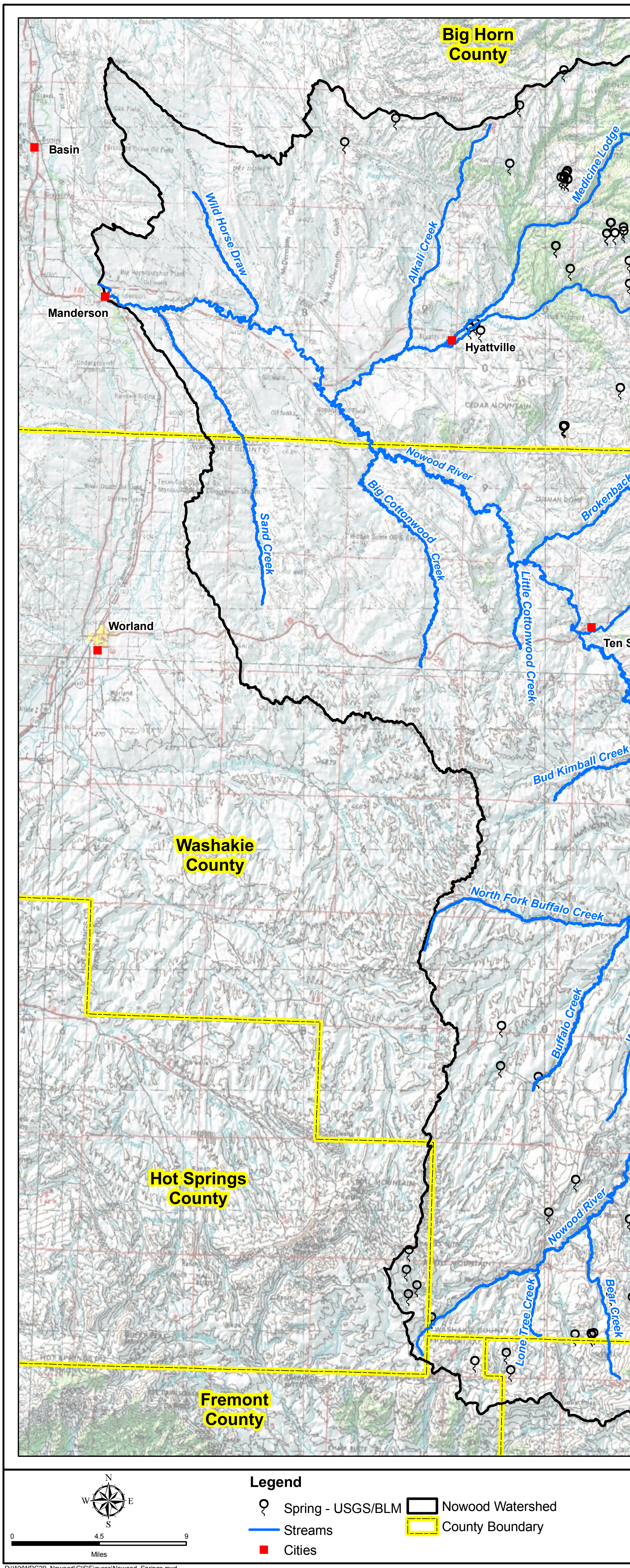


Figure 3.37 Nowood River Watershed: Springs

Thickness of the alluvium varies. Cooley and Ward (1979) reported alluvium thickness of 25 to 50 feet along the Nowood River, 80 feet along Tensleep Creek, and between 28 and 90 feet along Paint Rock Creek. Alluvium thicknesses along other tributaries will vary accordingly with the local geology, however, based upon review of available data, they are typically less than 50 feet.

Wells completed in the alluvial aquifer have been tested at rates of typically 40 gallons per minute, but may exceed 100 gallons per minute (Cooley and Ward, 1979)

The number and depth of wells completed within alluvial aquifers in the watershed cannot be definitively determined from the WSEO database because it does not specify the geologic unit in which the wells were completed. However, assuming alluvial wells would be non-flowing and between the depths of 10 and 50-feet, the number of alluvial wells is approximately 93.

3.5.1.3 Bedrock Aquifers

Bedrock aquifers provide sources of water for municipal, agricultural, and industrial uses within the watershed.

- The Town of Worland obtains its water from two wells within the watershed. The Worland well heads are located between Manderson and Hyattville. The Husky #1 is 4,210 feet deep and produces a static pressure of 190 psi and has a yield of 9,000 gallons per minute. The Town's second well, the Worland #3 well, is reported to be the largest artesian well in the world with a yield of 14,400 gallons per minute. The well is cased is 2,500 feet long and 21 inches in diameter. Water is piped about 26 miles to Worland for chlorination and use (WCCD, 2005).
- Two artesian wells were completed in the Madison Limestone as sources for the South Big Horn Rural Water Supply. These wells supply potable water, either as the primary or secondary supply, for the towns of Basin, Manderson, Greybull, Worland, Kirby and surrounding rural water systems in the basin.
- The Town of Tensleep gets its water from two artesian wells. Well #1 and #2 are reported to be 1,050 feet deep with a static pressure of 144 psi and 1,098 feet deep with a static pressure of 128 psi, respectively. These wells are reported to be completed in the Madison Formation and have a combined yield of over 4,100 gallons per minute (Lidstone and Associates, 2004).
- Water for the Town of Hyattville's municipal use is obtained from the Hyattville No. 1 well. This well was completed in the Madison Formation at a depth of 2,895 feet. The Hyattville No. 2 well was constructed in 2005 utilizing WWDC funding. The well was completed in the Madison and Big Horn Formations to a total depth of 3,572 feet (Wester Westein and Associates, 2006). Admiral Beverages bottles Aqua Vista water obtained from the Town of Hyattville's municipal wells. The water is obtained prior to treatment by the Town and trucked to Worland for filtering and bottling. The company's 6,000 gallon tanker makes up to three trips per day. Total volume of water processed by the bottler was not available but estimated to be hundreds of thousands of gallons (D. Willard, Admiral Beverages, pers. Comm., 2009).

Groundwater exists in both unconfined water table conditions (at atmospheric pressure) or under confined conditions where pressures are greater than atmospheric. Wells completed in confined aquifers in the study may potentially yield high volumes of water under significant pressures. Within the study area, the principal aquifers are primarily the formations of Paleozoic age: Goose Egg Formation, Tensleep Sandstone, and Madison Limestone. Other aquifers are used to a lesser extent, however, these aquifers represent the dominant groundwater sources. Table 3.14 tabulates the lithology and water yielding characteristics of these and other members of the stratigraphic sequence. Those bedrock aquifers identified as principal sources are highlighted in green.

The following descriptions of specific aquifers were extracted from Water Resources of Washakie County, Wyoming (Suson, et al, 1993).

Goose Egg Formation

The Goose Egg Formation is exposed along the Nowood River and its tributaries and on the lower slopes of the Bighorn Mountains. The formation consists of red shale, siltstone, and fine-grained sandstone. The upper part may contain a cherty limestone, and the lower section commonly has abundant gypsum. Collapse features caused by the dissolution of gypsum are found in lowlands along the Bighorn Mountain front. The dissolution of gypsum generally occurs along fractures that also hydraulically connect the Goose Egg Formation with the underlying Tensleep Sandstone. Cooley (1986) noted, "Much of the spring flow that discharges from the Goose Egg Formation is probably derived from the Tensleep Sandstone."

The Goose Egg Formation has a maximum thickness of 300 feet in the eastern part of Washakie County. Wells completed in the Goose Egg Formation in the county are artesian and have hydraulic heads less than 69.3 feet above land surface and reported yields of 5 to 50 gal/min. Yields of less than 10 gal/min are most commonly reported.

Tensleep Sandstone

The Tensleep Sandstone is a white to tan, massive, cross-bedded sandstone. It consists of fine- to medium-sized sand cemented with siliceous and calcareous cement. The lower part of the unit is inter-bedded sandstone, limestone, dolomite, and shale.

The Tensleep Sandstone is a source for domestic and stock water in the Nowood River watershed. It is 130 to 400 feet thick with the top of the unit less than 600 ft below land surface in many areas. Most of the small domestic and stock wells completed in the Tensleep Sandstone have hydraulic heads from 10 to 344 feet above land surface and yields of less than 50 gal/min (Cooley, 1986). The Tensleep Sandstone has the potential for future development by wells that could yield as much as 250 gal/min when properly developed.

Table 3.14 Groundwater Formations

System	Series	Formation	Thickness	Water-Bearing Properties	Reported Yield (gal/min)
Quaternery	Recent	Alluvium	0-45	Yields small to moderate supplies of water. Materials more permeable toward mountains and larger yields more likely in that part of the area. Recharge obtained both from irrigation and from streams. Water quality better in eastern part of project	10-40
	Pleistocene	Terrace Deposits	0-45	Permeable and yield moderate water supplies. Permeability of terrace deposits decreases progressively away from the mountains and only small water supplies may be available in terraces downstream from Bonanza. Water from less permeable deposits likely of poorer quality.	5-25
Tertiary	Eocene	Willwood Formation	to 2,500	Widely developed in central Washakie County. Yields usually discontinuous sandstones.	1-28
Tertiary	Paleocene	Fort Union Formation	1,000 - 1,500	Small water supplies may be obtained by wells penetrating adequate thickness of formation. Principal sources of water are from discontinuous sandstone lenses, some of which may not obtain adequate recharge. Coal beds may provide larger yields but water is generally of poor quality for domestic use. Water from formation is generally soft but somewhat mineralized.	4-10
Cretaceous	upper cretaceous	Lance Formation	600-775	Small water supplies may be obtained by wells penetrating adequate thickness of saturated formation. Difficulty is experienced in screening out fine sand without materially decreasing yield of water. Shale beds are non-water bearing and may prevent recharge to lower sandstone beds. Water is probably considerably mineralized.	6-15
		Meeteetse Formation	540-650	Small to moderate supplies may be expected from wells penetrating adequate thickness of saturated sandy beds. Water is soft but is somewhat mineralized. Water may be under slight artesian pressure in some places.	--
		Mesa Verde Formation	+/- 650	Small to moderate yields of water available to wells penetrating adequate thickness of saturated sandstone	--
		Cody Shale	3,000 - 3,500	Wells drilled into the Cody Shale can be expected to yield little or no usable water. Some very small quantities might be obtained from sandy beds in the upper 500 feet of the formation if recharge is available. Generally, not a source of water supply.	--
		Frontier Formation	+/- 550	May yield small to moderate supplies; water may be under artesian pressure under favorable condition. Water likely to be considerably mineralized and may be unfit for domestic use.	8-29
		Mowry Shale	340	Not a source of water supply	--
		Thermopolis Shale	400	Very meager supplies of strongly mineralized water may be locally available from Muddy sandstone member; remainder of formation is not a source of water supply	20
	Lower Cretaceous	Cloverly Formation	+150	May yield small supplies of water to wells penetrating adequate thickness of sandstone. Permeability of most sands is low and large yields cannot be expected. Water may be under artesian pressure and under favorable conditions flowing wells may be developed. Water is considerably mineralized.	4
Jurassic	Upper Jurassic	Morrison Formation	+300	Conglomeratic bed locally supplies moderate to large quantities of water where recharge is adequate. Sandstone beds are lenticular and cannot be depended on for perennial supplies in most cases. Water from this formation may be considerably mineralized but locally is of good quality	--
		Sundance Formation	215-320	Meager water supplies may be available in fine-grained soft sandstone beds in lower part of the formation. Water is probably highly mineralized and may be unfit for domestic use.	--
	Middle J	Gypsum spring Formation	+200	Little water available. Water probably of poor quality	--
Triassic	Upper	Chugwater Formation	+/- 700	Not a source of water supply	11
	Lower Tr	Goose Egg Formation	700-800	Little water available. Water probably of poor quality	5-50
Carboniferous	Pennsylvanian	Tensleep Sandstone	150-260	Moderate to large supplies available to wells penetrating adequate thickness of saturated sandstone	1-250
		Amsden Formation	+/- 175	Small to moderate water supplies may be available where dolomite beds are fractured. Water possibly of poor quality	--
	Mississippian	Madison Limestone	+/- 500	Large supplies of water available from fractures and caverns where they are below the water table.	15-2,500

Shaded formations denote principal aquifer within the study area

Source: Susong, et al, 1993)

Madison Limestone

The Madison-Bighorn aquifer provides water for irrigation, agriculture, and municipal supplies for the towns of Ten Sleep and Worland. The Madison Limestone and the Bighorn Dolomite are hydraulically connected and are grouped into a single aquifer, the Madison-Bighorn aquifer (Cooley, 1986). Fractures penetrate both formations, and dissolution occurs along the fractures, creating secondary permeability, cavities, and caverns. Extensive cave systems have been investigated in the Medicine Lodge Creek drainage (Huntoon, 1985b), and the upper 300 ft of the Madison Limestone contains paleokarst features. The Madison-Bighorn aquifer is about 600 to 1,000 feet thick along the west flank of the Bighorn Mountains. The depth to the top of the Madison Limestone ranges from 500 to 2,000 feet (Cooley, 1986). The Madison-Bighorn aquifer has the potential for future development with well yields as large as 2,500 gal/min when properly developed.

Wells completed in the Madison-Bighorn aquifer are artesian and have hydraulic heads 12 to 393 feet above land surface and yields as large as 2,500 gal/min. Yields generally are dependent on the fracture-dissolution secondary permeability of the aquifer. The Worland municipal well in Big Horn County has the largest reported flow for any well in Wyoming at 14,400 gal/min. This well is completed in a highly fractured area of a large anticline. Transmissivity in the Madison-Bighorn aquifer ranges increases when dissolution of materials along fractures creates secondary permeability of the aquifer (Cooley, 1986).

3.5.1.4 Nowood Study Area Well Statistics

A database of permitted well information was obtained from the Wyoming State Engineers Office (WSEO). Within the database are attributes for each well including: permit number, applicant name, well name, location, well depth, depth to water, well yield, and appropriated uses. Table 3.15 tabulates various statistics pertaining to the database. Figure 3.38 displays the locations of the wells. This figure also indicates which wells were determined to be artesian and which have yields reported to be 50 gallons per minute or greater.

3.5.2 Surface Water

The Nowood River is a subbasin of the Bighorn River system. The Nowood River watershed, as measured at its confluence with the Bighorn River, is approximately 2,020 square miles. The watershed has considerable relief; at its mouth, the elevation is less than 4,000 feet msl. At its highest points, along the crest of the Bighorn Mountains, elevations exceed 13,000 feet msl.

Figure 3.39 displays the delineation of watersheds within the study area. 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.

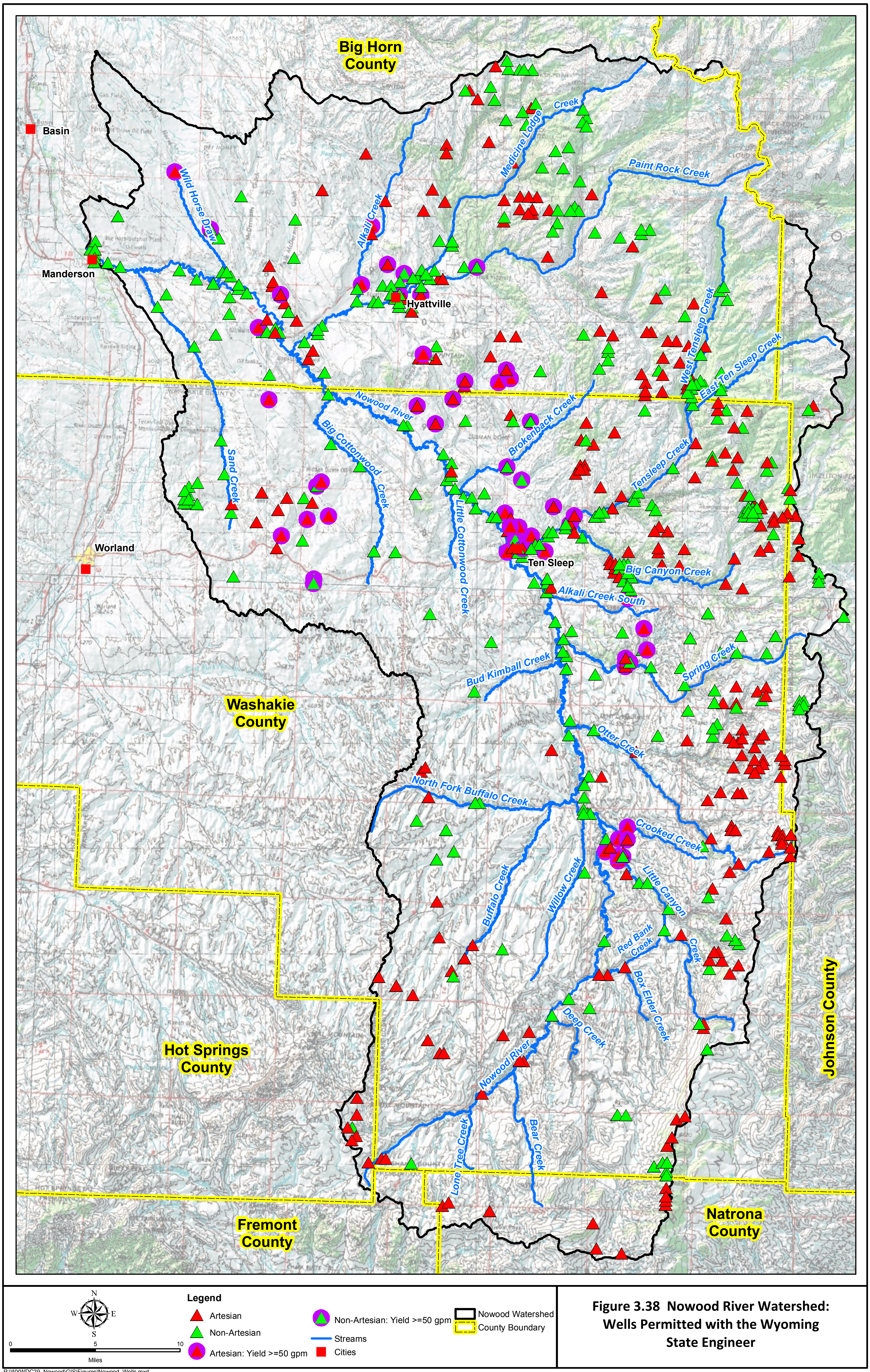
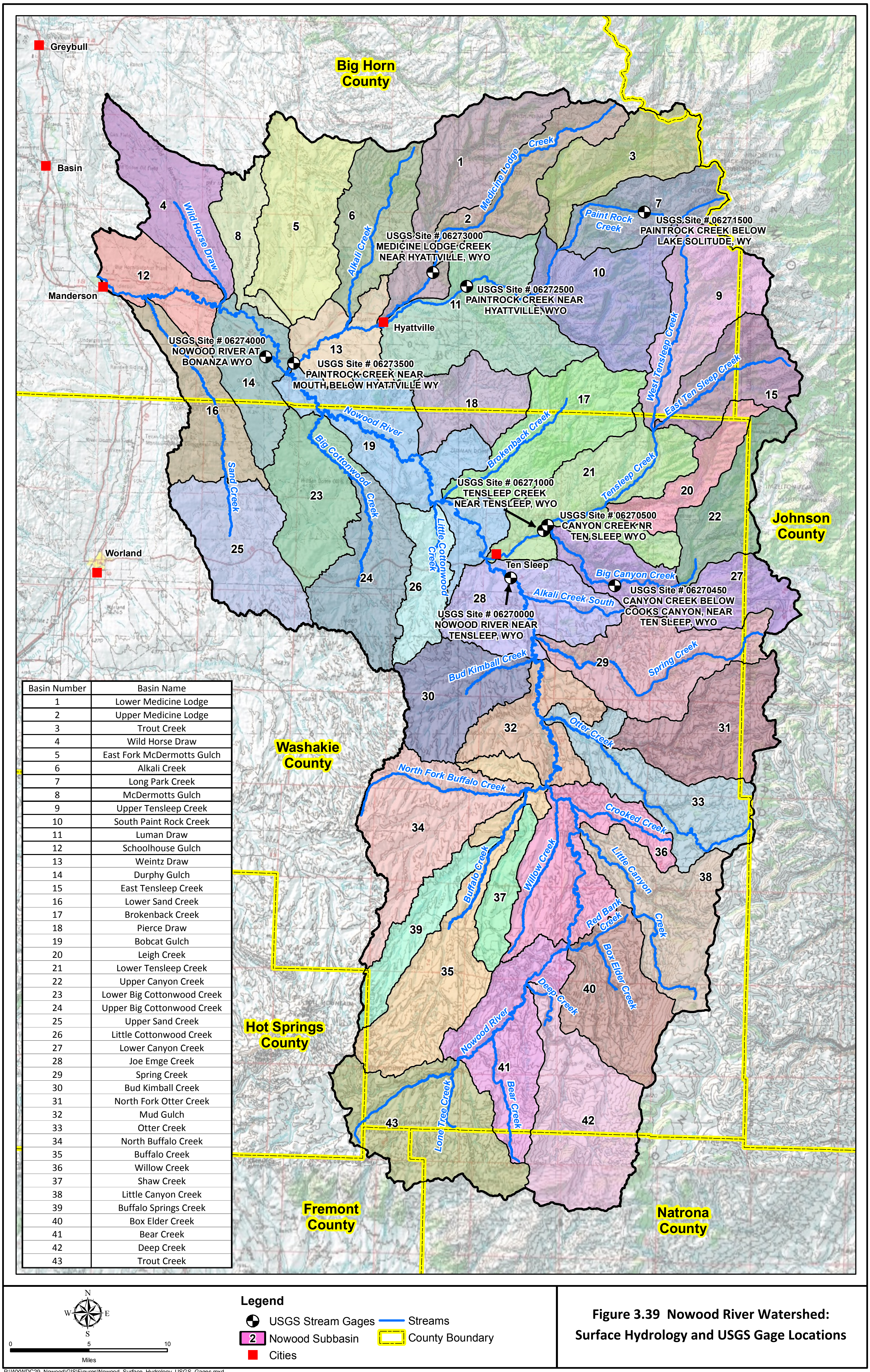


Figure 3.38 Nowood River Watershed: Wells Permitted with the Wyoming State Engineer



Basin Number	Basin Name
1	Lower Medicine Lodge
2	Upper Medicine Lodge
3	Trout Creek
4	Wild Horse Draw
5	East Fork McDermotts Gulch
6	Alkali Creek
7	Long Park Creek
8	McDermotts Gulch
9	Upper Tensleep Creek
10	South Paint Rock Creek
11	Luman Draw
12	Schoolhouse Gulch
13	Weintz Draw
14	Durphy Gulch
15	East Tensleep Creek
16	Lower Sand Creek
17	Brokenback Creek
18	Pierce Draw
19	Bobcat Gulch
20	Leigh Creek
21	Lower Tensleep Creek
22	Upper Canyon Creek
23	Lower Big Cottonwood Creek
24	Upper Big Cottonwood Creek
25	Upper Sand Creek
26	Little Cottonwood Creek
27	Lower Canyon Creek
28	Joe Emge Creek
29	Spring Creek
30	Bud Kimball Creek
31	North Fork Otter Creek
32	Mud Gulch
33	Otter Creek
34	North Buffalo Creek
35	Buffalo Creek
36	Willow Creek
37	Shaw Creek
38	Little Canyon Creek
39	Buffalo Springs Creek
40	Box Elder Creek
41	Bear Creek
42	Deep Creek
43	Trout Creek

Figure 3.39 Nowood River Watershed: Surface Hydrology and USGS Gage Locations

Table 3.15 Characterization of Permitted Nowood River Watershed Wells

Depth	Number of wells
< 5ft	241
5ft to 40 ft	110
41 ft to 100 ft	67
101 ft to 250 ft	56
251 ft to 500 ft	55
500 ft to 750 ft	32
750 ft to 1,000 ft	15
> 1,000 ft	97
No Data	155

Yield	Number of wells
0 gpm	89
1 gpm to 5 gpm	186
6 gpm to 10 gpm	131
11 gpm to 20 gpm	89
21 gpm to 50 gpm	117
51 gpm to 100 gpm	9
101 gpm to 500 gpm	29
Greater than 500 gpm	23
No Data	155

Decade Completed	Number of wells
1900's	3
1910's	1
1920's	50
1930's	12
1940's	22
1950's	29
1960's	37
1970's	111
1980's	192
1990's	129
2000's	242

Permitted Use	Number of wells
Irrigation	71
Stock	511
Domestic	330
Municipal	12
Industrial	20

Basin characteristics computed within the GIS for the HUC 12 basins are summarized in Table 3.16. Streamflows in the mountainous eastern portions of the study area are generally perennial; that is, there is streamflow year round. These streams are dominated by snowmelt runoff in the spring and early summer. During the summer, fall and winter, discharges are dominated by baseflow and bank storage, summer precipitation, and springs.

The stream reaches and tributaries in the western, arid region of the watershed typically range from intermittent in the mid-elevations to ephemeral in the lower elevation (eastern) portion of the watershed. 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

Table 3.16 Nowood River Watershed Subbasins and Pertinent Information

Map Unit	HUC_12	ACRES	Name
1	100800080606	36,943	Lower Medicine Lodge
2	100800080605	24,303	Upper Medicine Lodge
3	100800080601	26,503	Trout Creek
4	100800080704	28,939	Wild Horse Draw
5	100800080702	38,384	East Fork McDermotts Gulch
6	100800080608	26,662	Alkali
7	100800080602	22,097	Long Park Creek
8	100800080703	13,635	McDermotts Gulch
9	100800080401	33,072	Upper Tensleep Creek
10	100800080603	36,426	South Paint Rock Creek
11	100800080604	47,336	Luman Draw
12	100800080705	19,778	Schoolhouse Gulch
13	100800080607	17,971	Weintz Draw
14	100800080701	22,191	Durphy Gulch
15	100800080402	23,625	East Tensleep Creek
16	100800080707	25,480	Lower Sand Creek
17	100800080502	35,370	Brokenback Creek
18	100800080504	19,887	Pierce Draw
19	100800080501	44,326	Bobcat Gulch
20	100800080404	14,960	Leigh Creek
21	100800080403	40,769	Lower Tensleep Creek
22	100800080405	21,166	Upper Canyon Creek
23	100800080506	29,776	Lower Big Cottonwood Creek
24	100800080505	29,950	Upper Big Cottonwood Creek
25	100800080706	32,691	Upper Sand Creek
26	100800080503	16,677	Little Cottonwood Creek
27	100800080406	33,533	Lower Canyon Creek
28	100800080305	33,623	Joe Emge Creek
29	100800080306	36,491	Spring Creek
30	100800080304	27,536	Bud Kimball Creek
31	100800080302	31,841	North Fork Otter Creek
32	100800080301	23,764	Mud Gulch
33	100800080303	31,726	Otter Creek
34	100800080204	40,279	North Buffalo Creek
35	100800080201	43,761	Buffalo Creek
36	100800080105	37,937	Willow Creek
37	100800080203	10,989	Shaw Creek
38	100800080106	35,251	Little Canyon Creek
39	100800080202	16,723	Buffalo Springs Creek
40	100800080104	31,973	Box Elder Creek
41	100800080102	34,544	Bear Creek
42	100800080103	44,442	Deep Creek
43	100800080101	44,765	Trout Creek

losses from evaporation, transpiration, and seepage. The hydrologic behavior of intermittent streams/reaches is transitional between perennial and ephemeral stream hydrology. Typical intermittent streams include Willow Creek, Bud Kimball and Buffalo Creek. Typical ephemeral streams would include their tributaries. 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.

3.5.2.1 USGS Gaging Stations

There are currently no active stream gaging stations within the watershed. As indicated in Figure 3.40, historically, nine gages have been active with up to five active at one time (1946 to 1953). However, with the termination of the Nowood River near Tensleep gage (Gage Number 06270000) in 1992, gaging efforts ceased within the watershed.

Mean monthly discharges computed using the available data are presented in Table 3.17. The mean annual hydrographs at all of the gage locations reflect typical snowmelt driven runoff patterns. The bulk of the annual runoff occurs between May and July at all of the gages. The late summer through fall months (August through October) see steep declines in streamflow as the streams return to baseflow conditions through the winter. Figure 3.41 displays the mean annual hydrograph at four of the principal gages in the study area.

These data represent 'hard' data. That is, they were measured as opposed to being estimated or synthesized. Unfortunately, these data represent runoff associated with precipitation patterns and watershed characteristics which are at least 17 years old.

3.5.2.2 Temporary WWDC Gaging Stations

In an effort to gather additional streamflow data on the ungaged stream network, four temporary stream gages were installed in conjunction with this study (Figure 3.42). Two of the gages were installed on perennial streams and two on intermittent streams as indicated below:

- Otter Creek (perennial stream)
- Brokenback Creek (perennial stream)
- Cottonwood Creek intermittent stream)
- Buffalo Creek (intermittent stream)

Figure 3.42 Temporary Stream Gage Installed on Cottonwood Creek

Figure 3.40 Availability of USGS Stream Gage Data

Gage Name	Drainage area (sq mi)	Period of Record	
		Begin	End
USGS 06270500 Canyon Creek near Ten Sleep, WY	86.1	6/1/1939	9/30/1944
USGS 06270450 Canyon Creek Below Cooks Canyon near Ten Sleep, WY	72	4/1/1969	9/30/1971
USGS 06271000 Tensleep Creek near Tensleep, WY	247	10/1/1910	10/26/1972
USGS 06271500 Paintrock Creek below Lake Solitude, WY	16	9/1/1946	9/30/1953
USGS 06272500 Paintrock Creek near Hyattville, WY	164	8/1/1920	9/30/1953
USGS 06273000 Medicine Lodge Creek near Hyattville, WY	86.8	10/1/1943	9/30/1973
USGS 06273500 Paintrock Creek near Mouth below Hyattville, WY	376	8/1/1910	12/31/1922
USGS 06274000 Nowood River at Bonanza, WY	173	8/1/1910	9/30/1928
USGS 06270000 Nowood River near Tensleep, WY	803	6/1/1938	9/30/1992

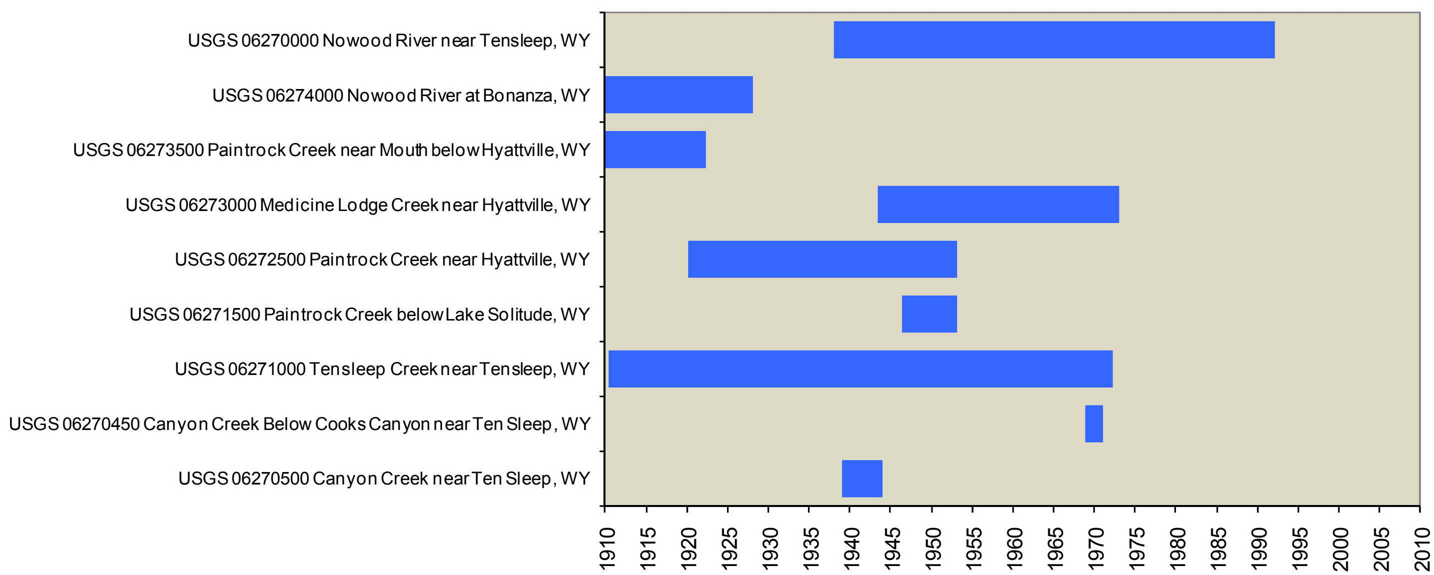


Table 3.17 Summary of Available USGS Streamflow Data

Month	Mean Stream Discharge							
	Canyon Creek near Tensleep, WY	Canyon Creek below Cooks Canyon, Near Tensleep, WY	Tensleep Creek near Tensleep, WY	Paintrock Creek below Lake Solitude, WY	Paintrock Creek near Hyattville, WY	Medicine Lodge Creek near Hyattville, WY	Paintrock Creek near mouth below Hyattville, WY	Nowood River at Bonanza, WY
	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)	(cfs)
USGS Gage	6270500	6270450	6271000	6271500	6272500	6273000	6273500	6274000
Years of Record	6/1/1939 to 9/30/1944	4/1/1969 to 9/30/1971	10/1/1910 to 10/26/1972	90/1/1946 to 9/30/1953	8/1/1920 to 9/30/1953	10/1/1943 to 9/30/1973	8/1/1910 to 12/31/1922	8/1/1910 to 9/30/1928
Jan	24	6.3	46	0.25	24	10	38	192
Feb	24	6.3	45	0.15	22	10	37	203
Mar	26	6.1	46	0.28	22	10	36	325
Apr	35	12	64	8.1	52	13	68	419
May	83	57	344	85	388	85	354	1,270
Jun	49	36	630	163	679	164	803	1,640
Jul	24	12	237	103	281	48	242	624
Aug	20	7.4	88	25	87	18	63	200
Sep	23	6.8	75	13	64	16	56	221
Oct	25	6.6	71	8	53	15	86	279
Nov	25	6.8	58	2.8	35	13	66	235
Dec	24	6.7	49	0.63	28	11	48	204
Annual	31.8	14.2	146.1	34.1	144.6	34.4	158.1	484.3

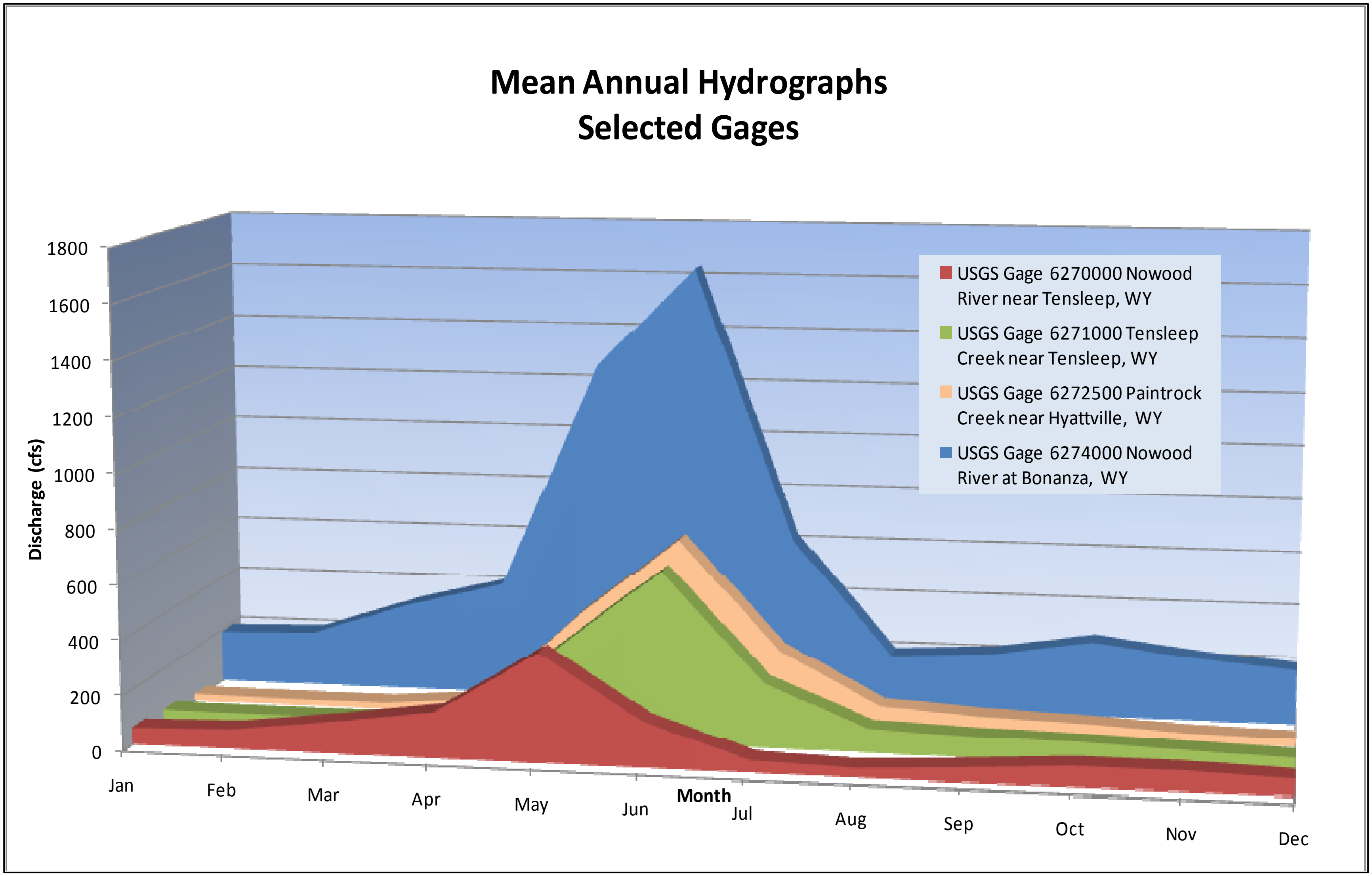


Figure 3.41 Mean Annual Hydrographs at Selected USGS Gage Locations

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.

Cross section surveys were completed for use in hydraulic modeling of each site in order to compute stage / discharge relationships needed to convert the depth data to stream discharge. Stream discharge was measured throughout the field investigation season to calibrate the stage / discharge relationship. Using these adjusted relationships, the downloaded date were converted to stream discharge data for further analysis.

Cottonwood Creek

The reason this site was selected was to characterize runoff from one of the many intermittent or ephemeral channels in the study area.

The gage is located approximately one half mile upstream of the creeks confluence with the Nowood River and west of existing oil wells. The site is located on federal lands managed by the BLM. The Cottonwood Creek watershed upstream of the temporary gage is approximately 93.2 square miles. For most of the year, the stream channel is dry. Runoff occurs primarily in direct response to precipitation events. The gage was installed on March 13, 2009 when snowmelt runoff had already occurred. The stream was dry each time the site was visited for installation, gage maintenance, and for removal. Consequently, no discharge measurements were made and the stage / discharge rating curve was developed based entirely upon hydraulic characteristics at the site and is uncalibrated.

Figure 3.43 displays the result of the data collection effort at this site. As this figure clearly shows, the watershed is extremely flashy. Runoff occurs quickly following rainfall events and recedes equally as fast. It is interesting to note that the stream rose over 2.6 feet on June 14th, 2009 in response to a thunderstorm event. There is no rain gage located within the Cottonwood Creek watershed, however,the Tensleep 4E gage recorded 0.43 inches of rainfall that day.

Stream discharge ranged from 0 cfs (67 percent of the study period) to a peak of 68.5 cfs. The total runoff at this site for the study period was estimated to be approximately 477 acre feet. This translates to approximately 5.1 acre-feet per square mile. However, it must be kept in mind that watershed yield would likely have been higher if snowmelt runoff been measured.

Buffalo Creek at Bruner Gulch

This site was identified as a potential reservoir storage location (see Section 3.9). A reservoir at this location would be an 'off-channel' reservoir storing waters diverted from the Nowood River. Consequently, this site was selected to characterize runoff characteristics of the subbasin which would augment reservoir storage. The site also affords characterization of an additional ephemeral or intermittent stream within the study area.

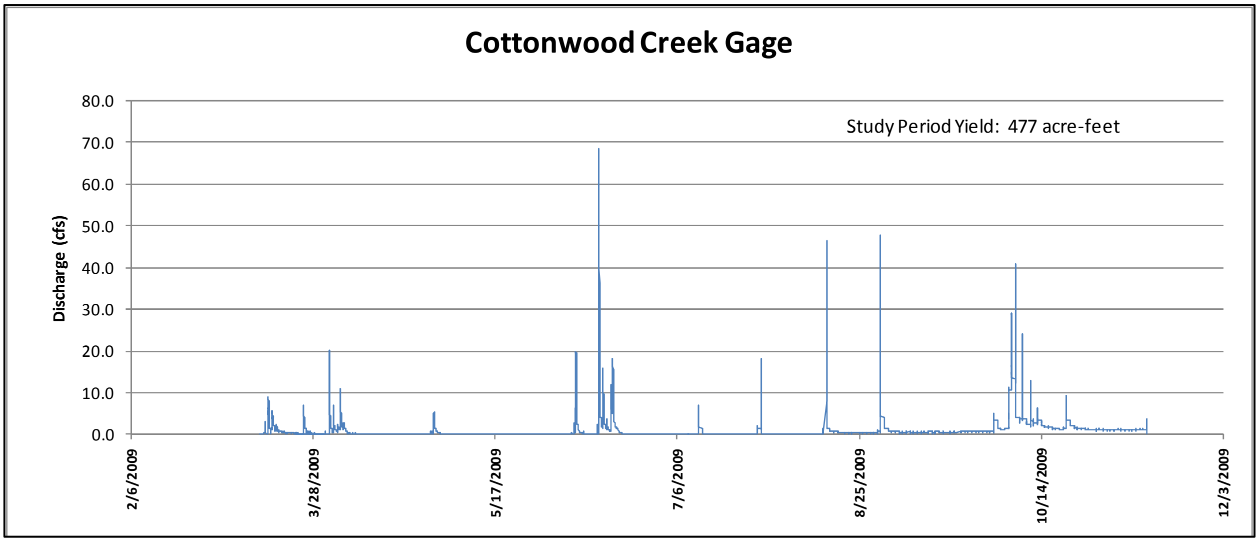


Figure 3.43 Cottonwood Creek Hydrograph: March 14 through November 11, 2009

The gage is located approximately 2,900 feet upstream of the confluence of Buffalo Creek and the Nowood River. The site is located on lands owned by the State of Wyoming and accessed through the Greet Ranch. The Buffalo Creek watershed upstream of the gage is approximately 174.6 square miles. The gage was installed on March 12, 2009 and removed on November 11, 2009. Snowmelt runoff had not completely occurred when the gage was installed. Figure 3.44 displays the hydrograph measured at this site. Note the rise in the hydrograph beginning in October. This apparent increase in stream flow is the result of bank sloughing resulting in a shift in the gage rating curve resulting in a false reporting of higher flows.

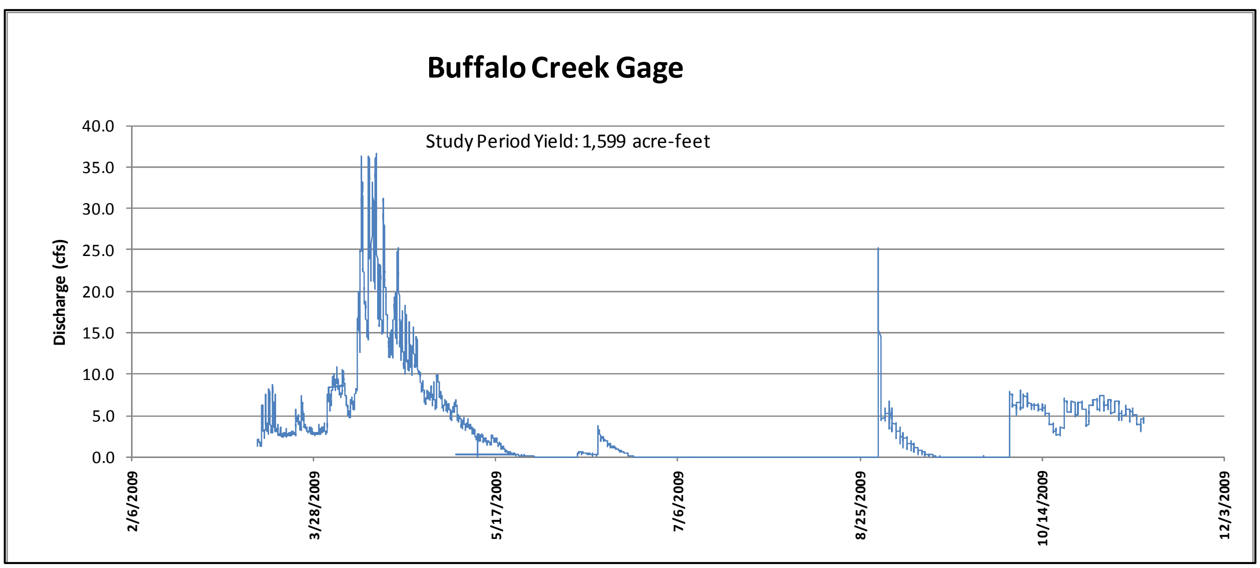


Figure 3.44 Buffalo Creek Hydrograph: March 14 through November 11, 2009

Stream discharge ranged from 0 cfs to a peak of 36.6 cfs. The total runoff at this site for the study period was estimated to be approximately 1,599 acre feet. This translates to approximately 9.1 acre feet per square mile. . However, it must be kept in mind that watershed yield would likely have been higher if snowmelt runoff been measured.

Brokenback Creek

This gage is located approximately 8,200 feet downstream of the Tensleep-Hyattville Road crossing. The site was selected to represent a small perennial stream originating on the eastern side of the Nowood River watershed. The site is located on federal lands managed by the BLM.

The contributing area at this location is approximately 53.3 square miles. Brokenback Creek is a perennial stream dominated by snowmelt runoff. Figure 3.45 displays the result of the data collection effort at this site. The figure displays that streamflows are heavily influenced by upstream irrigation usage. Beginning in early May, streamflows dropped approximately 58 percent from about 17 cfs to about 7 cfs. This coincides with the initiation of irrigation season at the Mills ranch upstream (T. Mills, personal communication, 2009).

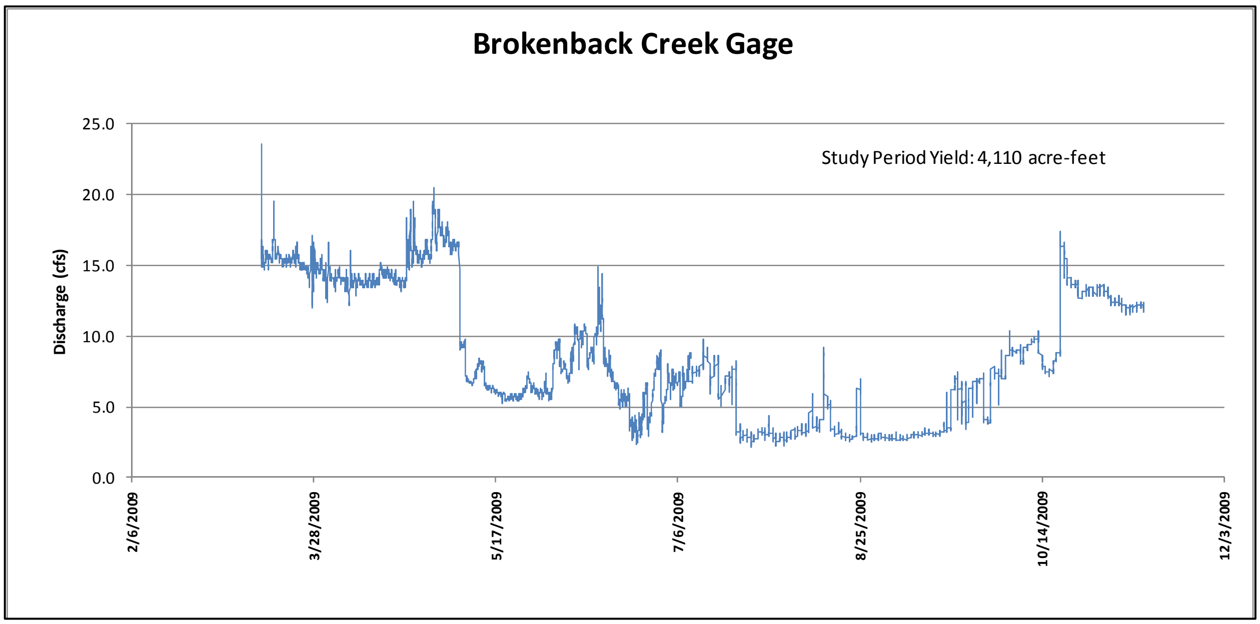


Figure 3.45 Brokenback Creek Hydrograph: March 14 through November 11, 2009

Stream discharge ranged from 2.4 cfs to a peak of 20.1 cfs on April 29th. The total runoff at this site for the study period was estimated to be approximately 4,110 acre feet. This translates to approximately 747.1 acre feet per square mile.

Otter Creek

Otter Creek is a perennial tributary to the Nowood RIver located in the upper Nowood River basin. The site was selected with the objective of characterizing a mid-sized perennial stream originating on the eastern side of the watershed. The gage is located approximately 1,700 feet downstream of the Spring Creek Road on land owned by the State of Wyoming. The Otter Creek watershed upstream of the gage is approximately 39.8 square miles. The gage was installed on March 4, 2009 and removed on November 11, 2009.

Figure 3.46 displays the results of the data collection effort at this location. Stream discharge ranged from 25 cfs to a peak of 73 cfs. The total runoff at this site for the study period was estimated to be approximately 13,152 acre feet. This translates to approximately 330 acre feet per square mile.

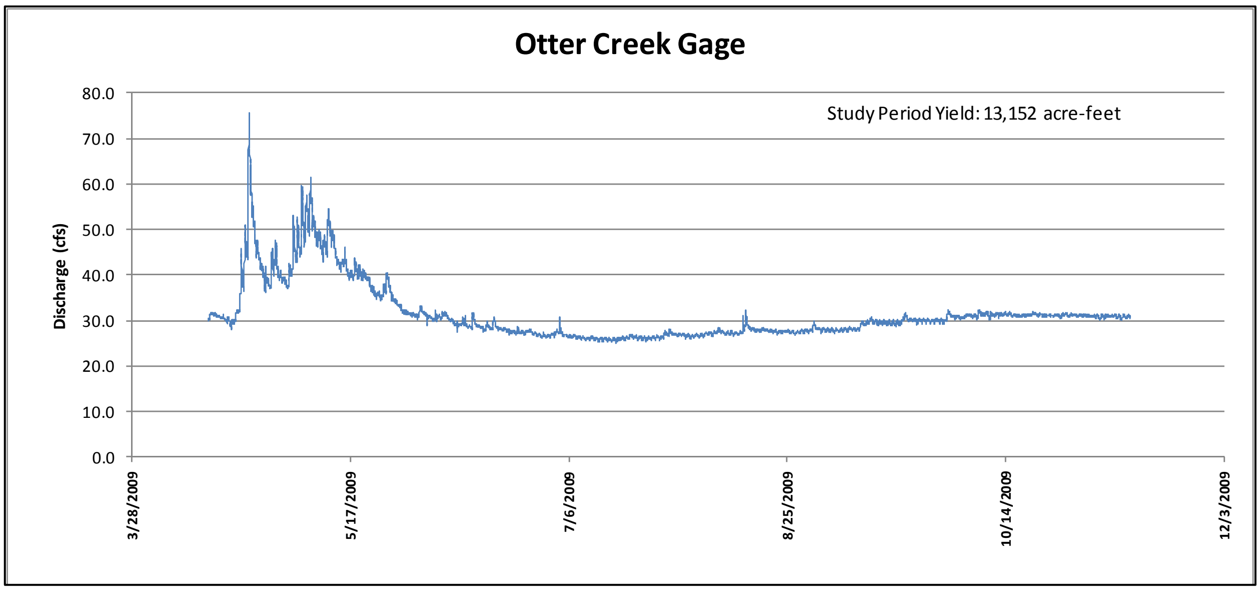


Figure 3.46 Otter Creek Hydrograph: March 14 through November 11, 2009

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 Nowood River watershed 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 3.47 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.

The Level II effort 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,

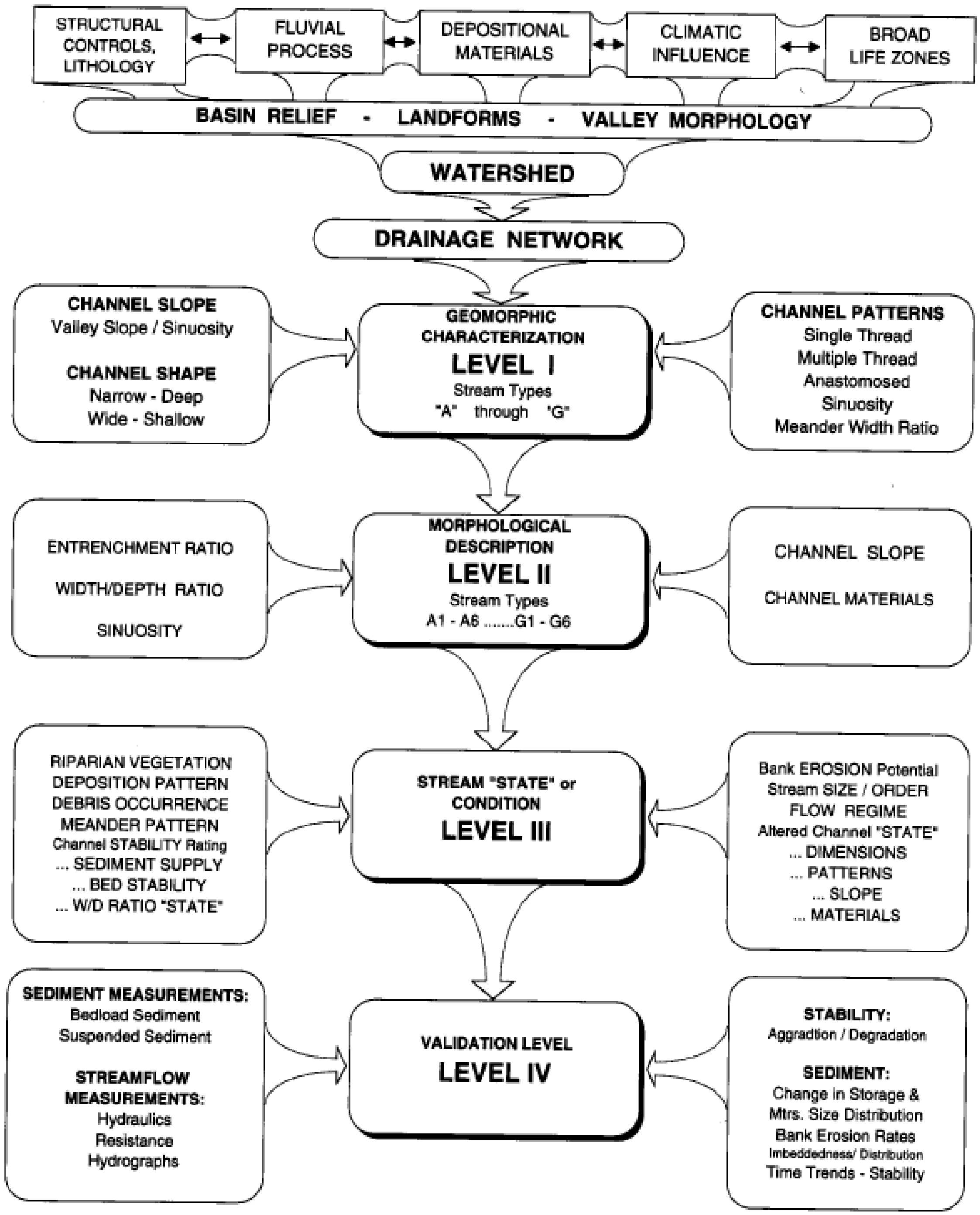


Figure 3.47 Hierarchy of the Rosgen Stream Classification System

width-to-depth ratio, water surface slope, streambed materials, and sinuosity (Figure 3.48). 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 Nowood River Watershed Study included Level I evaluation of the Nowood River and its major tributaries.

3.6.2.1 Level I Methods

The purpose of the Level I geomorphic classification is to provide an inventory of the Nowood River watershed'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.

Table 3.18 presents a brief summary of the different stream types found within the Rosgen system and Figure 3.49 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.

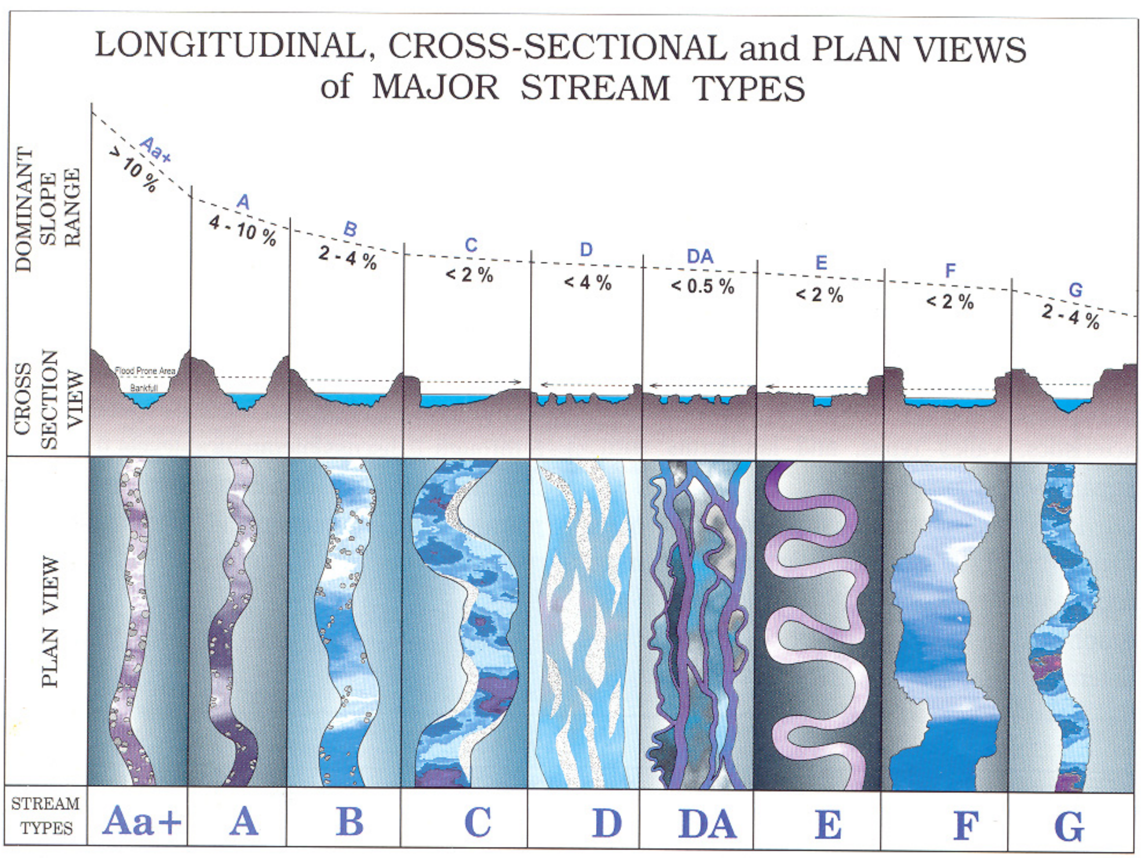


Figure 3.49 Major Stream Types within the Rosgen Classification System (Rosgen, 1996)

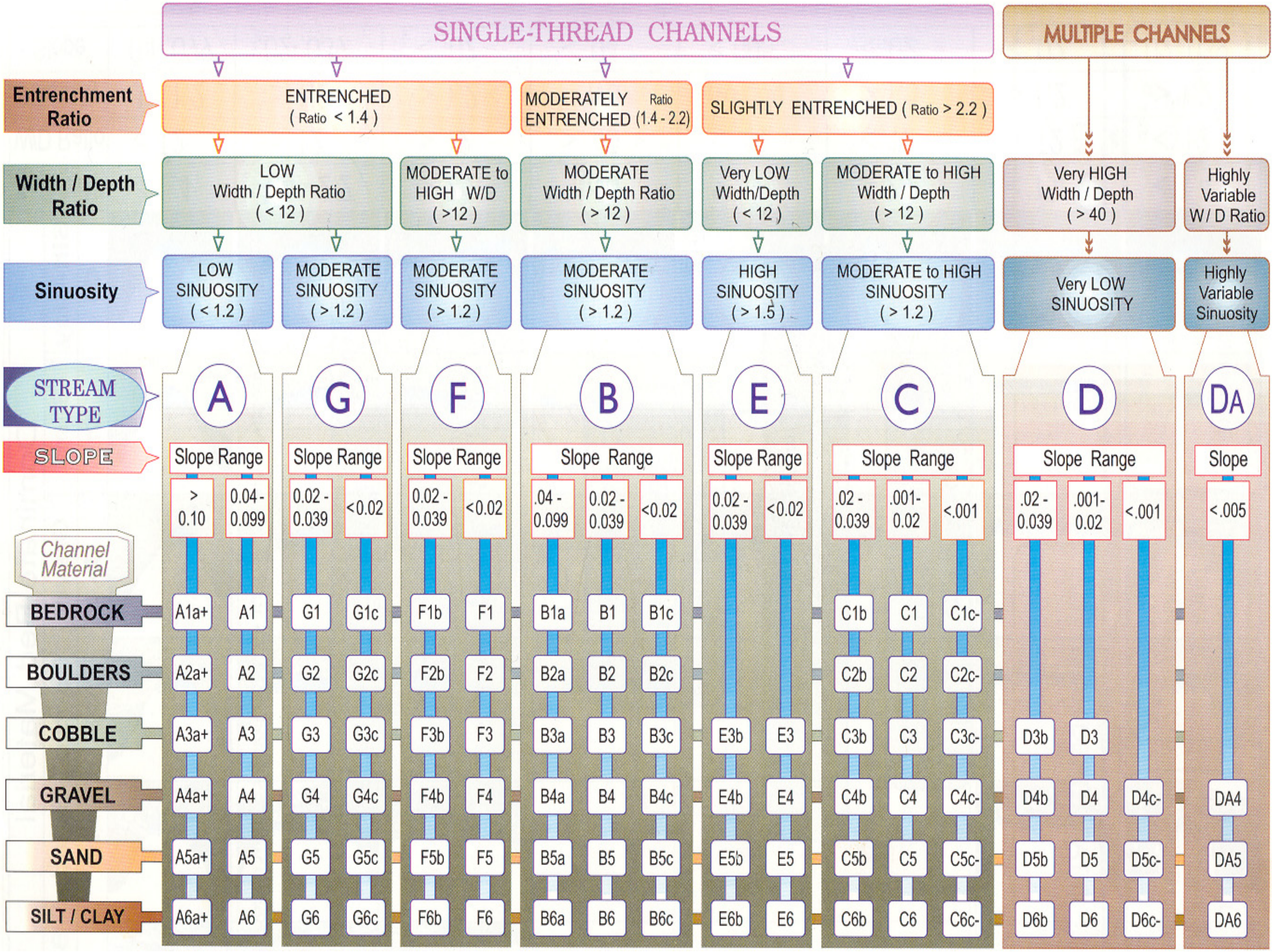


Figure 3.48 Rosgen Classification Matrix (Rosgen, 1996)

Table 3.18 Summary of Rosgen Level I Classification Results

Stream	Reach Number	Reach Definition: Station Start (ft from confluence)	Reach Definition: Station End (ft from confluence)	Reach Definition: Length (ft)	Sinuosity	Slope (ft/ft)	Rosgen Level I Classification
Alkali Creek	1	0	9,184	9,186	1.64	0.0069	F
	2	9,184	39,360	30,184	1.17	0.0095	F
	3	39,360	85,726	46,378	1.09	0.0450	G
Alkali Creek South	1	0	19,680	19,685	1.29	0.0237	B
	2	19,680	44,264	24,590	1.15	0.0326	B
Bear Creek	1	0	8,528	8,530	1.45	0.0178	F
	2	8,528	21,648	13,123	1.13	0.0651	F
	3	21,648	36,080	14,436	1.45	0.0191	B
	4	36,080	45,264	9,186	1.15	0.0446	B
	5	45,264	60,286	15,026	1.20	0.0587	A
Big Canyon Creek	1	0	24,272	24,278	1.94	0.0045	B
	2	24,272	32,144	7,874	1.18	0.0174	B
	3	32,144	66,912	34,777	2.39	0.0018	E
	4	66,912	112,829	45,928	1.21	0.0401	A
Big Cottonwood Creek	1	0	17,712	17,717	1.69	0.0037	CB
	2	17,712	37,392	19,685	1.83	0.0027	C
	3	37,392	60,352	22,966	1.30	0.0052	F
	4	60,352	123,207	62,871	2.00	0.0024	F
Box Elder Creek	1	0	3,936	3,937	1.37	0.0101	C
	2	3,936	32,144	28,215	1.72	0.0058	C
	3	32,144	47,183	15,043	1.14	0.0225	B
Brokenback Creek	1	0	28,208	28,215	1.37	0.0131	B
	2	28,208	70,992	42,795	1.20	0.0521	A
Bud Kimball Creek	1	0	17,056	17,060	1.39	0.0053	G
	2	17,056	43,086	26,037	1.67	0.0040	G
Buffalo Creek	1	0	68,880	68,898	1.85	0.0025	F
	2	68,880	137,553	68,691	2.23	0.0030	F
Crooked Creek	1	0	20,336	20,341	1.36	0.0136	B
	2	20,336	46,074	25,745	1.15	0.0712	A
Deep Creek	1	0	14,432	14,436	1.10	0.0353	B
	2	14,432	25,325	10,896	1.07	0.0283	A
East Ten Sleep Creek	1	0	17,056	17,060	1.07	0.0569	B
	2	17,056	55,760	38,714	1.48	0.0235	B
	3	55,760	69,739	13,983	1.06	0.1011	A
Little Canyon Creek	1	0	24,928	24,934	1.41	0.0098	E
	2	24,928	41,197	16,273	1.23	0.0169	B
Little Cottonwood Creek	1	0	15,744	15,748	2.06	0.0047	F
	2	15,744	28,208	12,467	1.39	0.0060	G
	3	28,208	44,972	16,768	1.91	0.0043	G
Lone Tree Creek	1	0	5,248	5,249	1.36	0.0141	A
	2	5,248	17,712	12,467	1.12	0.0335	A
	3	17,712	25,584	7,874	1.27	0.0266	A
Medicine Lodge Creek	1	0	43,952	43,963	1.42	0.0123	Cb
	2	43,952	97,088	53,150	1.12	0.0630	B
	3	97,088	149,483	52,408	1.23	0.0395	A
North Fork Buffalo Creek	1	0	39,360	39,370	1.58	0.0033	F
	2	39,360	85,280	45,932	1.57	0.0058	F
	3	85,280	101,500	16,224	1.07	0.0146	F
Nowood River	1	0	24,272	24,278	1.34	0.0022	C
	2	24,272	136,448	112,205	1.85	0.0019	C
	3	136,448	181,712	45,276	2.43	0.0008	C
	4	181,712	303,728	122,047	2.22	0.0010	C
	5	303,728	350,960	47,244	1.65	0.0017	C
	6	350,960	501,184	150,262	2.27	0.0012	C
	7	501,184	608,768	107,612	2.30	0.0013	C
	8	608,768	700,608	91,864	1.93	0.0028	C
	9	700,608	728,160	27,559	1.33	0.0051	B
	10	728,160	795,072	66,929	2.30	0.0053	B
	11	795,072	845,584	50,525	1.81	0.0103	B
	12	845,584	881,815	36,240	1.18	0.0183	A
Otter Creek	1	0	26,240	26,247	1.86	0.0042	C
	2	26,240	45,034	18,799	1.64	0.0042	Cb
Paint Rock Creek	1	0	56,416	56,430	1.58	0.0049	C
	2	56,416	98,400	41,995	1.21	0.0164	Cb
	3	98,400	198,112	99,738	1.14	0.0420	B
	4	198,112	222,128	24,022	1.08	0.0875	A
Red Bank Creek	1	0	16,443	16,447	1.11	0.0213	G
Sand Creek	1	0	25,584	25,591	1.37	0.0034	G
	2	25,584	61,008	35,433	1.88	0.0029	G
	3	61,008	138,416	77,428	1.46	0.0029	G
South Fork Little Canyon Creek	1	0	23,616	23,622	1.50	0.0121	B
	2	23,616	71,281	47,677	1.14	0.0453	A
South Fork Otter Creek	1	0	50,512	50,525	1.17	0.0355	B
	2	50,512	90,085	39,583	1.17	0.0385	A
Spring Creek	1	0	91,840	91,864	2.15	0.0048	F
	2	91,840	157,368	65,545	1.10	0.0502	B
Tensleep Creek	1	0	29,520	29,528	1.24	0.0108	C
	2	29,520	64,288	34,777	1.12	0.0352	B
	3	64,288	91,873	27,592	1.10	0.0687	A
West Tensleep Creek	1	0	45,264	45,276	1.29	0.0237	A
	2	45,264	88,422	43,169	1.20	0.0311	A
Wild Horse Draw	1	0	3,936	3,937	1.25	0.0078	B
	2	3,936	35,424	31,496	1.74	0.0016	G
	3	35,424	66,495	31,079	1.62	0.0025	G
Willow Creek	1	0	15,088	15,092	1.50	0.0069	B
	2	15,088	70,848	55,774	1.84	0.0039	G
	3	70,848	92,086	21,243	1.24	0.0287	B

A-Type Channels are relatively steep channels that form in headwater areas as well as within bedrock canyons (Figure 3.50). 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 3.50 Example Type A Channel: Upper West Ten Sleep Creek

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 3.51). 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.

Figure 3.51 Example Type-B Channel: Paint Rock Creek

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 3.52). The channels tend to occur in broad alluvial valleys, and they are typically associated with broad floodplain areas. 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 3.52 Typical Type-C Channel: Lower Nowood River

E-Type Channels are somewhat similar to C channels, as they form as single threads with defined, accessible floodplain areas (Figure 3.53). 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 3.53 Typical Type-E Channel: Canyon 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 3.54).

Figure 3.54 Typical Type-F Channel: Alkali Creek

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. Figure 3.55 displays a typical G-Type channel within the watershed.

Figure 3.55 Example Type G Channel: Bud Kimball Creek

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 3.45, 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 3.18 and graphically in Figure 3.56. This Figure displays a map of the Nowood River watershed depicting the various stream types as well as the reach designations used in the classification effort.

The Nowood River and its primary tributaries originate in the steep Big Horn Mountains. Within the mountainous areas, the channels are steep and bounded by very coarse, resistant materials that include hillslope colluvium, glacial deposits, 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 Tensleep Creek, Paint Rock Creek, and Big Canyon Creek.

As the major stream channels descend into the Nowood Basin, the lateral confinement is reduced, the slope lessens and the boundary materials become less coarse. As a result of these downstream changes in boundary conditions, the lower subreaches tend to display meandering channel dynamics; that is, pool/riffle development and increased lateral channel migration. The channels transition from B channels, which are located in transition zones at the foot of the mountains, to C, E or F channels, which are gravel bed meandering streams that dominate the lower basin.

The Nowood River was classified as a C-type channel for most of its extent. This classification is based upon the ‘processes’ observed and not strict adherence to classification based solely upon sinuosity, entrenchment, and slope. Throughout most of its extent, the Nowood River appears to have access to its floodplain on at least one of its banks. There are locations where entrenchment ratios would indicate the channel leans toward a F-type classification. A detailed geomorphic investigation of the Nowood River could likely result in alternating reaches of C-type and F-type channels.

Many of the 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. Observation of many of these channels indicates that while the major stream channels appear to have achieved a level of stability, the upper reaches of the watershed are still suffering a level of destabilization. These channels could be forming in response to one or more of numerous stimuli including but not necessarily limited to: channel realignment (straightening), road

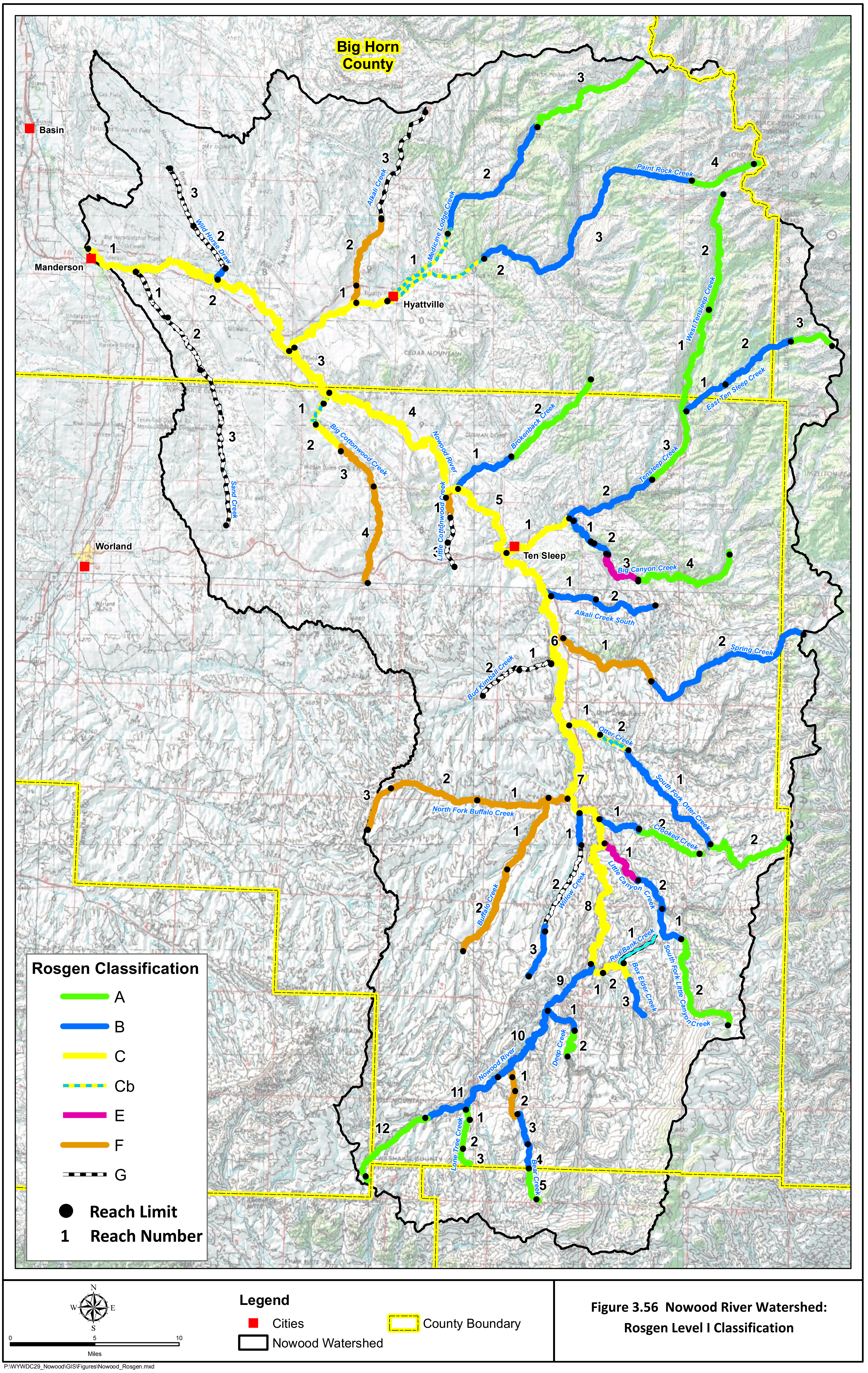


Figure 3.56 Nowood River Watershed: Rosgen Level I Classification

P:\WYWDC29_Nowood\GIS\Figures\Nowood_Rosgen.mxd and culvert construction, range management practices, or base-level lowering associated with main channel incision.

It is evident that the differences in bedrock geology between the western and eastern slopes of the watershed are important factors controlling the character of stream channels formed within them. On the eastern side of the basin lie harder bedrock formations. Bed material of streams encountered here typically consists of boulders, cobbles, and gravels. On the western flanks of the basin lie softer shales. These formations are less cohesive and consequently more easily eroded. Stream channels located here have bed materials consisting of finer gravels and sands. Headcuts encountered in this region are indicative of the erosive nature of the region (Figure 3.57).

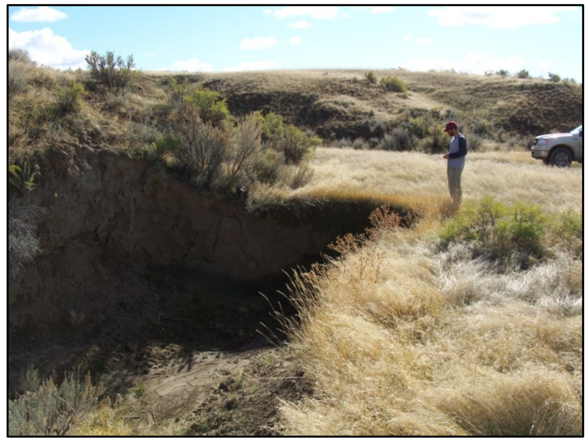


Figure 3.57 Six Foot High Headcut Located on Unnamed Tributary to West Willow Creek

3.6.3 Proper Functioning Condition

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:

> *"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 Nowood River study area, the BLM has conducted PFC assessments on selected stream segments intermittently since 1992. Results of the BLM PFC assessment are shown on Figure 3.58. As evidenced in this figure, the PFC assessment results in evaluation of specific and frequently isolated stream reaches.

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, the Nowood River has experienced lateral migration. This is evidenced by numerous locations where bare vertical banks are present. In addition, review of aerial photography shows numerous abandoned channels (oxbows) within its lower reaches (Figure 3.59). A certain degree of lateral migration is a natural occurrence and is characteristic of the stream types encountered. Without human development, a migration corridor could be established within which the river would be allowed to migrate without interference by man. However, given the fact that the floodplains have been developed as ranches, homes, and irrigated lands, the value of the resource damaged by bank erosion increases (Figure 3.60). The Nowood River can be considered to be a C-Type channel throughout most of its reach. Sinuosity in its mid - to lower-reaches ranges from 1.7 to 2.2.

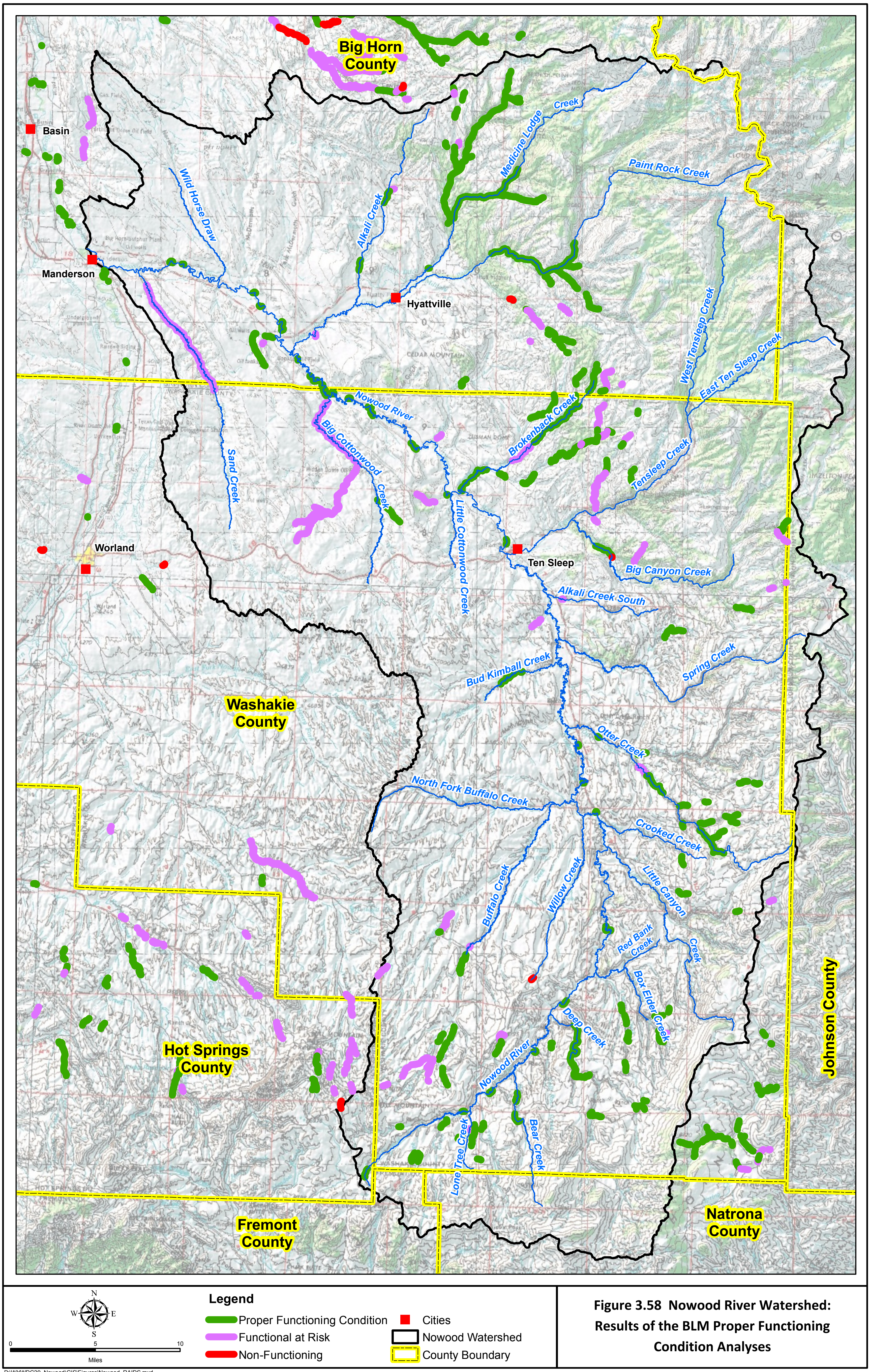


Figure 3.58 Nowood River Watershed: Results of the BLM Proper Functioning Condition Analyses

Figure 3.59 Abandoned Channels (Oxbows) On the Lower Nowood River

Channel degradation (incision) appears to be a dominant channel impairment within the western portion of the study area. Portions of each stream channel on the western flank of the Nowood River watershed evaluated in the Level I efforts displayed some form of channel incision. The channel incision process tends to follow a relatively predictable series of evolutionary stages (Schumm, et al, 1994). First, the channel begins to erode its bed, downcutting vertically. This process typically migrates in the upstream direction. The downcut channel then begins to widen, as the steep vertical banks are unstable and begin to collapse. As the channel widens, bank angle is reduced, and the banks become more stable. Ultimately, the channel widens enough to allow the formation of depositional berms on the incised channel margin that may be colonized by vegetation. These deposits eventually form a surface bounding the incised channel that serves as a new floodplain that is lower in elevation from the original floodplain. The original floodplain becomes perched as a terrace, and is effectively isolated from the channel.

Figure 3.60 Bank Erosion on the Lower Nowood River Causing Loss of Irrigated Acreage

Within the study area, F- and G-Type channels are most likely to display the channel evolution described above in the future. For example, Bud Kimball Creek and portions of Buffalo Creek exhibit the incised nature of a disturbed channel. The consequences of the incised channel evolution process can be severe. Large scale bank instability results in extensive bank failure and sediment production. As the groundwater table drops with the channel bed, the depth to groundwater from the original floodplain surface increases, commonly to the point where pre-incision vegetation patterns are not sustainable. Eventually, however, a new equilibrium condition will be achieved, as the channel develops a new equilibrium profile, and flood energies are dispersed on the new incised floodplain surface.

Riparian conditions appear to be the dominant channel impairment of the B-type channels originating on the eastern side of the basin. Streams such as lower Tensleep Creek, Paint Rock Creek, Otter Creek, and Spring Creek are effected by historic and current land use practices, including farming and grazing. Consequently, riparian vegetation is typically degraded in the lower reaches of these channels. Figure 3.61 shows a photo of Otter Creek which exemplifies the character of these channels where loss of riparian conditions has led to bank erosion and channel degradation.

Figure 3.61 Example of Loss of Riparian Vegetation: Lower Otter Creek

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). 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 Irrigation Inventory

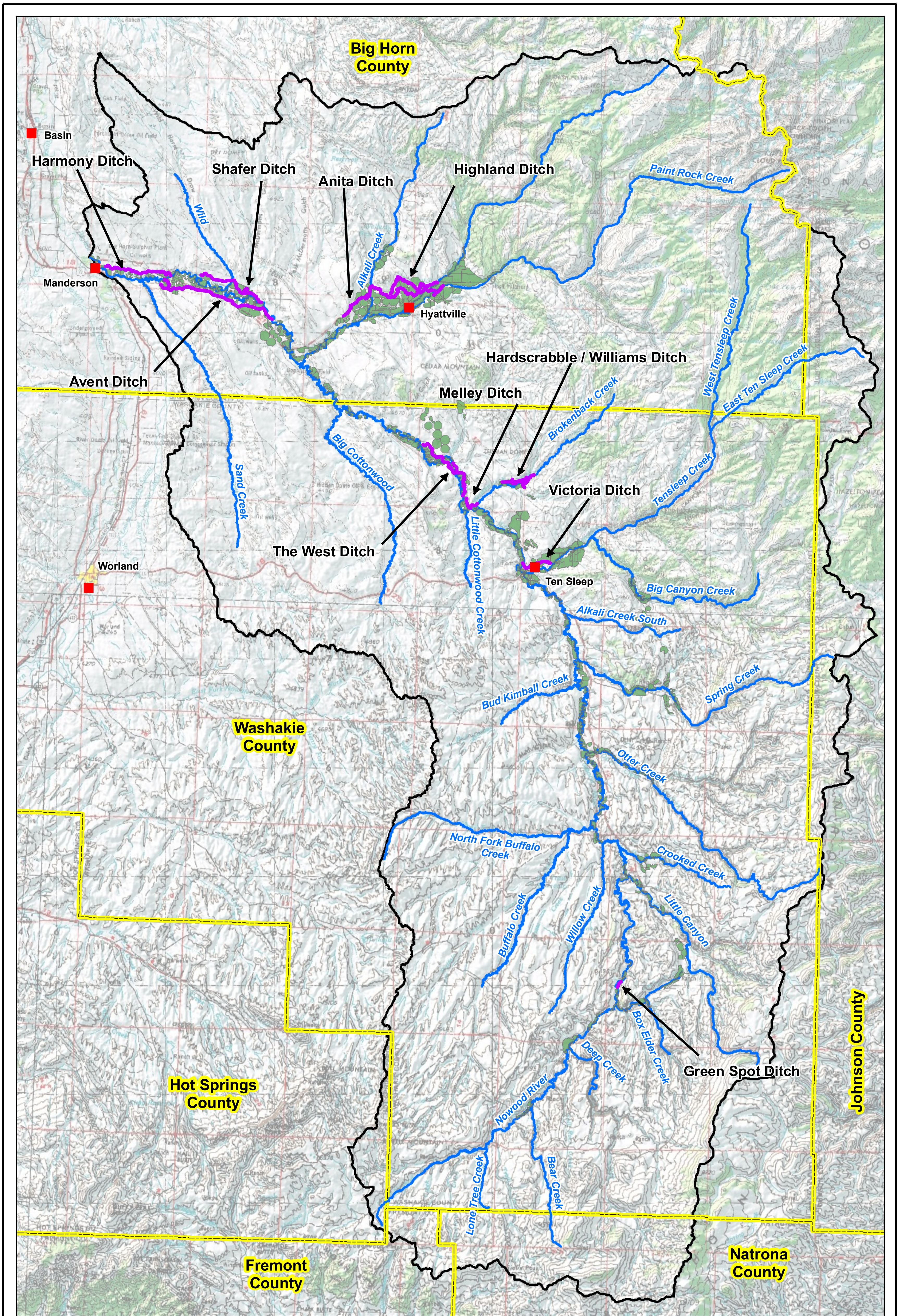
3.7.1 Overview

Irrigation ditches within the Nowood River study area can generally be characterized as small, privately owned systems. Based upon a review of water rights within the basin, irrigated acreage under the existing systems ranges from less than 20 acres on small individually owned and managed systems to approximately 1,000 acres on the largest. According to representatives of the Wyoming State Engineers Office (WSEO), the majority of the ditches are equipped with discharge measuring devices of some sort (i.e., flumes, weirs, etc).

Ditches to be inventoried were selected based upon initial input and requests at the project scoping meeting and subsequent meetings. Only those ditches volunteering to participate were evaluated. The ditch systems inventoried included the following:

- Anita Ditch
- Avent Ditch
- Green Spot
- Hardscrabble Ditch / Williams Ditch
- Harmony Ditch
- Highland Ditch
- Melley Ditch
- Shafer Ditch
- Victoria Ditch
- West Ditch

Figure 3.62 displays the general location of the inventoried ditches and their respective headgates. Each ditch was inventoried in an effort to evaluate its system-wide condition and to identify potential rehabilitation improvements. Possible improvements include rehabilitation or replacement of existing infrastructure, bank stabilization (particularly near structures), and installation of new structures. Many of the ditch system components inspected are significantly deteriorated and have exceeded their design life. Several ditches were built prior to statehood and have been nursed along over the years through the efforts of private landowners. No irrigation district is in place to manage any of the ditches; all are privately owned and maintained.



N
W E
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0 5 10
Miles

Legend

- Inventoried Irrigation Ditches
- Irrigated Acres
- Streams
- Cities
- Nowood Watershed
- County Boundary

Figure 3.62 Nowood River Watershed: Inventoried Irrigation Ditches

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Specific tasks completed during this effort included the following:

- interviewing ditch representatives and users;
- field inventory of ditch structures;
- inventory of physical ditch conditions;
- assessment of hydraulic efficiency of existing ditch structures;
- photographic documentation of structures and an assessment of their condition;
- location of the structures using GPS technology; and
- incorporation of data into the project GIS.

Objectives of the ditch and associated structure inventory were to: (a) identify structures in need of rehabilitation; and (b) evaluate opportunity for conservation savings associated with irrigation system improvements. A representative of each ditch was interviewed prior to conducting the field inventory, providing valuable insight into the ditch condition, issues, and management. In general, interviews were conducted in conjunction with a field tour of ditch facilities.

Several types of structures were identified and evaluated during the field inventory, including the following categories: (a) diversion headgates; (b) check structures; (c) measurement devices; (d) wasteway structures; and (e) crossings (e.g., roads, utilities, etc.). An assessment was also conducted of ditch conditions with specific observations noted to areas of seepage loss, erosion and/or degradation, vegetation encroachment, and access limitations.

In the paragraphs which follow, each ditch is discussed individually and general observations are noted. Recommendations pertaining to each ditch are included in Section 4: Watershed Management and Rehabilitation Plan.

3.7.2 Ditch Characterization

3.7.2.1 Anita Supply Ditch / Anita Ditch

The Anita Supply Ditch diverts water from Paint Rock creek in Section 32, Township 50 North, Range 89 West. It conveys diversions approximately 0.5 miles to Medicine Lodge Creek which then conveys them approximately 1,100 feet downstream to the main Anita Ditch headgate. At this point, they are "picked up" again in addition to Medicine Lodge Creek flows. The ditches are approximately 8.6 miles long (including one lateral) and traverse fifteen (15) private parcels and three (3) BLM parcels. The following observations were noted:

Anita Supply Ditch

- The rock check diversion structure was in fair condition at the time of its inspection. It consisted primarily of alluvial material. Seasonal maintenance is required to maintain diversions.

- The headgate structure is in fair condition, consisting of a 6.5 ft wide steel vertical slide gate.
- Ditch flows are measured at a Parshall flume (4-foot width) located about 100 feet downstream of the headgate. The flume appears to be in good condition and fully functional.

Anita Ditch

- The ditch headgate structure appears to be in good condition, with no apparent deficiencies. There is a large amount of woody debris present on both banks immediately upstream of the structure.
- A Parshall flume (5-foot width) is located about 100 feet downstream of the headgate. It appears to be in good condition and fully functional.
- A long (approximately 150 feet) concrete rectangular chute in poor condition carries ditch flows down a steep incline. Flows from the channel outlet have created a massive scour hole that have undermined the channel and caused a portion of the channel to fail. According to ditch representatives, this structure is planned for replacement based upon NRCS designs and once funding has been procured.
- Two headcuts exist along the ditch which appear to be partially arrested by underlying shale materials.
- A wasteway at Alkali Creek was observed to be in poor condition. Significant cracking of the concrete walls and undermining is occurring.
- A siphon crossing Alkali Creek has been repaired several times. Most recent repairs consist of a 36-inch inch diameter PVC pipe clamped into position. Overall, this structure was rated as being in "poor" condition.
- A total of fifteen (15) farm turnouts were observed. Of these, nine (9) were classified as being in "good" or "fair" condition and six (6) in "poor" or "failing condition". Problems associated with the farm turnouts were typically deterioration of the gates, downstream scour, and deterioration of structure headwalls.
- One check structure was inventoried; it was classified as being in "failing condition".
- A total of seventeen (17) culverts were inventoried. All were classified as being in "good" or "fair" condition.
- At the downstream end of the ditch, the ditch drops approximately twenty (20) vertical feet through a series of failed drop structures (Figure 3.63).

Figure 3.63 Erosion Near Tail End of the Anita Ditch

3.7.2.2 Avent Ditch

The Avent Ditch (also referred to as the Avant Ditch) diverts water off of the left bank of the Nowood River, downstream of its confluence with Paint Rock Creek. The ditch headgate is located in Section NW 1/4 Section 11, Township 49 North, Range 91 West. The ditch is approximately 11.4 miles long (including laterals) and traverses 18 private parcels and four (4) BLM parcels. The following observations were noted:

- The headgate structure has 2 vertical slide gates that appear to be in fair condition, with a moderately-sized crack along the left wingwall.
- The only measurement device observed on the ditch is a Parshall flume (7-foot throat width) located approximately 850 feet downstream of the headgate. It appears to be in fair condition and fully functional. The staff gage has become nearly illegible.
- A wasteway located approximately 4,500 downstream of the headgate was determined to be failing and in need of replacement. The outlet has a moderately-sized scour hole, and there is significant overbank erosion possibly due to piping around the wasteway culvert that is threatening to undermine the ditch road.
- A large drop structure located at Station 144+50 is in poor condition. The structure is a 2-foot diameter pipe drop structure with a vertical drop of approximately 20 feet. The CMP (drop) portion of the structure is in poor condition and in need of replacement. (Figure 3.64). The left overbank at the downstream end of the siphon has experienced considerable erosion with the presence of a vertical bank.

Figure 3.64 Outlet of Drop Structure in Poor Condition on the Avent Ditch

- A total of twenty three (23) farm turnouts were inventoried. Of these, fourteen (14) were classified as being in "good" or "fair" condition and nine (9) in "poor" or "failing condition". Problems associated with the farm turnouts were typically deterioration of the gates, downstream scour, and deterioration of structure headwalls.
- Two check structures were inventoried. One was classified as being in "good" condition and the other in "poor" condition.
- A total of 14 culverts were inventoried. All were classified as being in "good" or "fair" condition.

3.7.2.3 Green Spot Ditch

The Green Spot ditch is a small ditch located on the upper Nowood River near its confluence with Box Elder Creek. The ditch headgate is located in SE ¼ Section 18, Township 43 North, Range 87 West (Figure 3.65). The ditch is approximately one half mile long. at the request of the ditch owner, only the ditch headgate was evaluated. Consequently, no reference nor implications regarding the condition of the remaining ditch or associated infrastructure are made.

Figure 3.65 Green Spot Ditch Headgate on the Upper Nowood River

The ditch headgate was classified to be in “poor” condition and according to the ditch owner, it is nearly nonfunctional. During high flows during the 1970’s, the structure was undermined and collapsed into the Nowood River. It was subsequently moved back to its original position. According to the ditch owner, the structure fills with sediment during routine operations and is nonfunctional.

3.7.2.4 Hardscrabble Ditch / Williams Ditch

Hardscrabble Ditch and Williams Ditch are both located on the Brokenback Ranch and divert water from Brokenback Creek. An artesian well, located in NW ¼ Section 20, Township 48 North, Range 88 West, provides supplemental water to the system. The ditches consist of a combination of open ditch and buried pipeline. The Williams Ditch irrigates lands on the south side of Brokenback Creek and the Hardscrabble Ditch the north. The following general observations were noted:

- The existing Williams Ditch headgate consists of a culvert equipped with a sliding panel. The structure was classified as being in ‘poor’ condition due to its age and lack of a control gate mechanism.
- The Williams Ditch is primarily an open ditch irrigating lands on the south side of Brokenback Creek. The ditch is an open channel and associated infrastructure consists of several culverts and farm turnout structures which all appear to be in ‘fair’ condition.
- The Hardscrabble Ditch can be diverted into a buried pipeline serving sideroll sprinklers in the western end of the irrigated parcels. According to the ditch owner, operation of the sprinklers can be problematic due to sediment and debris entering the pipeline. When not diverted into the pipeline, the ditch services an irrigated parcel via open ditch.

3.7.2.5 Harmony Ditch

The Harmony Ditch diverts water off of the right bank of the Nowood River, immediately downstream of the intersection of State Highway 31 and the Nowood River. The ditch headgate is located in NE ¼ Section 35, Township 50 North, Range 92 West. The ditch is approximately 4.2 miles long and provides irrigation water to one user. The following general observations were noted:

- The ditch headgate was rebuilt in 2007 and is in good condition and fully functional.
- Flows are measured at a Parshall flume (3-foot width) which is in poor condition and appears to be under-sized.
- Check structures were generally in fair condition, however, there were locations where they were missing. Installation of new check structures would add to the functionality of the ditch and simplify management. For example, at station 58+00 a culvert is being used as a check structure by placing boards across its inlet. At another location (Station 17+200), concrete rubble has been placed in the ditch to check flows high enough for diversion at an upstream farm turnout.
- At the tail end of the ditch, an uncontrolled wasteway returns operational waste to the Nowood River. The last farm turnout on the ditch is located at this point as well. Ditch representatives noted that control of flows at this turnout is problematic.
- A total of nine (9) existing farm turnouts were inventoried. Of these, five (5) were classified as being either 'good' or 'fair' condition and four (4) were classified as being in 'poor' or 'failing' condition. In addition, six (6) locations were identified where farm turnout structures currently do not exist but should be installed.

3.7.2.6 Highland Ditch

The Highland Ditch diverts water off of the right bank of Medicine Lodge Creek, upstream of its confluence with Paint Rock Creek. The ditch headgate is located in Section 32 , Township 50 North, Range 89 West. The following general observations were noted:

Figure 3.66 Check Structure on Highland Ditch

- The rock/check diversion structure in Medicine Lodge Creek appears to be in fair condition, consisting of primarily larger alluvial material.
- The headgate structure is in poor condition with a malfunctioning gate mechanism. The concrete headwall portion of the structure is in "fair" condition (Figure 3.66).

- There have been reports of beaver activity in the ditch when water is flowing; efforts have been made to eliminate the beaver dams to prevent overtopping of the ditch and potential failure.
- There are long stretches of bank erosion due to either livestock crossings or field drainage entering the ditch causing head cuts.
- A total of twenty (20) farm turnouts were inventoried. Of these, fifteen (15) were classified as being in "good" or "fair" condition and five (5) in "poor" or "failing condition". Problems associated with the farm turnouts were typically deterioration of the gates, downstream scour, and deterioration of structure headwalls.
- A total of two (2) check structures were inventoried. Both were classified as being in "good" or "fair" condition.
- A total of 20 culverts were inventoried. Of these, sixteen (16) were classified as being in "good" or "fair" condition and four (4) in "poor" or "failing condition".

3.7.2.7 Melley Ditch

The Melley Ditch receives water from three separate points of diversion: one on Brokenback Creek and two pumps located on the Nowood River. The ditch main headgate is located in Section 34, Township 48 North, Range 89 West. The ditch is approximately 1.4 miles long and provides irrigation water to one user. The following general observations were noted:

- The diversion on Brokenback Creek does not have a headgate or check structure, but consists of an earthen berm with no means of controlling diversions.
- Two pumps are located on the Nowood River which can be used to supply the ditch system.
- A culvert conveys water over the Nowood River to irrigated fields on the west side.
- The Melley Ditch continues northerly along the eastern side of the Nowood River. Maintenance of the ditch is reported to be problematic in this reach due to conveyance losses.
- Existing farm turnout structures appear to be in "fair" condition.
- A Parshall flume (1-foot width) in fair condition appears to be able to function adequately.

3.7.2.8 Shafer Ditch

The Shafer Ditch diverts water off of the right bank of the Nowood River, downstream of its confluence with Paint Rock Creek. The ditch headgate is located in SE ¼, Section 3 Township 49 North, Range 91 West. The ditch is approximately 5.1 miles long. The following general observations were noted, in order from the upstream to downstream end:

- The rock/concrete rubble/check diversion structure in the Nowood River appears to be in fair condition and functional. It consists of concrete rubble and cobble, consequently, frequent maintenance is likely following high river flows.

- Immediately downstream of the diversion structure, there is an ungated concrete headgate structure which is in poor condition and is non-functional.
- Approximately 2,000 feet downstream of the main headgate, there is a wasteway and headgate structure which returns excess flows to the Nowood River. This structure is ungated and is controlled by flash boards (Figure 3.67). Overall, this structure was classified as being in "fair" condition.

Figure 3.67 Wasteway Structure on the Shafer Ditch

- Measurement of ditch flows is facilitated by a Parshall flume (5-foot throat width) located approximately 760 feet downstream of the headgate. The flume appears to be in poor condition. In addition, downstream of the structure the ditch banks are failing.
- Approximately 5,850 linear feet of the ditch showed excessive vegetation which likely results in significant losses due to plant uptake and restriction of ditch flows. Seepage was also evident at several locations along the ditch (Figure 3.68).

Figure 3.68 Reach of Shafer Ditch with Excessive Vegetation on Banks and Bed

- A total of sixteen (16) farm turnouts were inventoried. Of these, ten(10) were classified as being in "good" or "fair" condition and six (6) in "poor" or "failing condition". Problems associated with the farm turnouts were typically deterioration of the gates, downstream scour, and deterioration of structure headwalls.
- A total of eight (8) check structures were inventoried. Of these, six (6) were classified as being in "good" or "fair" condition and two (2) in "poor" or "failing condition".
- A total of five (5) culverts were inventoried; all were classified as being in "good" or "fair" condition.

3.7.2.9 Victoria Ditch

The Victoria Ditch diverts water off of the right bank of Tensleep Creek immediately east of the town of Ten Sleep. The ditch headgate is located in the SW¼ Section 15, Township 47 North, Range 88 West. The following general observations were noted, in order from the upstream to downstream end:

Figure 3.69 Headgate Structure on Victoria Ditch

- The rock/concrete rubble/check diversion structure is in poor condition, consisting of a mixture of concrete rubble and alluvial material. It is our understanding that the structure is hydraulically inefficient and diversion can be problematic during low flow periods.
- The headgate structure is in poor condition, with some leakage occurring beneath the gate and significant deterioration of the concrete (Figure 3.69).
- Flows in the ditch are monitored at a Parshall flume (2-foot width) located approximately 330 feet downstream of the headgate.
- A total of four (4) farm turnouts were inventoried. Of these, one (1) was classified as being in "good" or "fair" condition and three (3) were in "poor" or "failing condition". Problems associated with the farm turnouts were typically deterioration of the gates, downstream scour, and deterioration of structure headwalls.
- Two (2) check structures were inventoried. One (1) was classified as being in "good" or "fair" condition and the other as "failing". The "failing" check structure was a recently constructed check located at station 68+50 of the ditch (approximately 550 feet downstream of Cottonwood Street.) This structure was not adequately keyed into the ditch banks which subsequently eroded, resulting in a bypassed and non-functional structure.
- A total of six (6) culverts were inventoried. All of them were classified as being in "good" or "fair" condition.
- Approximately 1,180 feet of the ditch is buried in a 24-inch diameter concrete pipe under the Town of Ten Sleep. The pipe daylights approximately 100 feet upstream of Cottonwood Street. The open channel reach between the pipe outlet and the culvert inlet represents a safety hazard due to the proximity of the Town.

3.7.2.10 West Ditch

The West Ditch (also referred to as the Western Ditch) diverts water off of the right bank of the Nowood River, downstream of its confluence with Brokenback Creek. Its headgate is located in the NW¼ Section 33, Township 48 North, Range 89 West. The ditch is approximately 6.1 miles long (including one lateral). The following observations were noted:

- The rock/check diversion structure on the Nowood River appears to be in fair condition and according to ditch representatives, it adequately facilitates diversion at the headgate over a range of river flows.
- The headgate structure is in poor condition. A steel plated headwall is rusted and bent on one side. The headgate is aged, deteriorated, and reported to be extremely difficult to operate.
- Measurement of ditch flows is facilitated by a Parshall flume (5-foot throat width) located approximately 2,600 feet downstream of the headgate. The flume appears to be in poor condition. In addition, downstream of the structure the ditch banks are failing. A second Parshall flume, located at Station 205+00 (2-foot throat width) is also in poor condition with limited functionality. There is a moderate-sized scour hole at the downstream end of the flume.
- Two siphons under the Nowood River facilitate irrigation of crops on both the east and west sides of the river. The first siphon is located at station 106+00. The siphon consists of concrete inlet and outlet structures which appear to be in fair to good condition. However, the pipeline portion of the structure is reportedly failing due to deterioration of the CMP. Evidence of its failure includes continual bubbles mid-channel from entrained air escaping through the failure. At the time of the inventory, flows in the river precluded direct observation of the crossing; however, ditch representatives report the CMP is exposed in the river bed (Figure 3.70).

Figure 3.70 Exposed Siphon Crossing on the Nowood River

- The second siphon is located at Station 200+50. This siphon appears to be in good condition and was reported to have been replaced about 15 years ago. The bathtub inlet is made of concrete and is in good condition.
- A total of fifteen (15) farm turnouts were inventoried. Of these, twelve (12) were classified as being in “good” or “fair” condition and three (3) in “poor” or “failing condition”. Problems associated with the farm turnouts were typically deterioration of the gates, downstream scour, and deterioration of structure headwalls.

- Two (2) check structures were inventoried; both were classified as being in “good” or “fair” condition.
- A total of nineteen (19) culverts were inventoried. Of these, eighteen (18) were classified as being in “good” or “fair” condition and only one (1) in “poor” or “failing condition”.

3.8 Water Quality

3.8.1 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 Nowood River watershed as noted in the latest Wyoming Surface Water Classification List (WDEQ, 2001) are shown on Figure 3.71. 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 1, Outstanding Waters. Class 1 waters are those surface waters in which no further water quality degradation by point source discharges other than from dams will be allowed. Nonpoint sources of pollution shall be controlled through implementation of appropriate best management practices. Pursuant to Section 7 of these regulations, the water quality and physical and biological integrity which existed on the water at the time of designation will be maintained and protected. In designating Class 1 waters, the Environmental Quality Council shall consider water quality, aesthetic, scenic, recreational, ecological, agricultural, botanical, zoological, municipal, industrial, historical, geological, cultural, archaeological, fish and wildlife, the presence of significant quantities of developable water and other values of present and future benefit to the people.*
>
> *Class 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.*

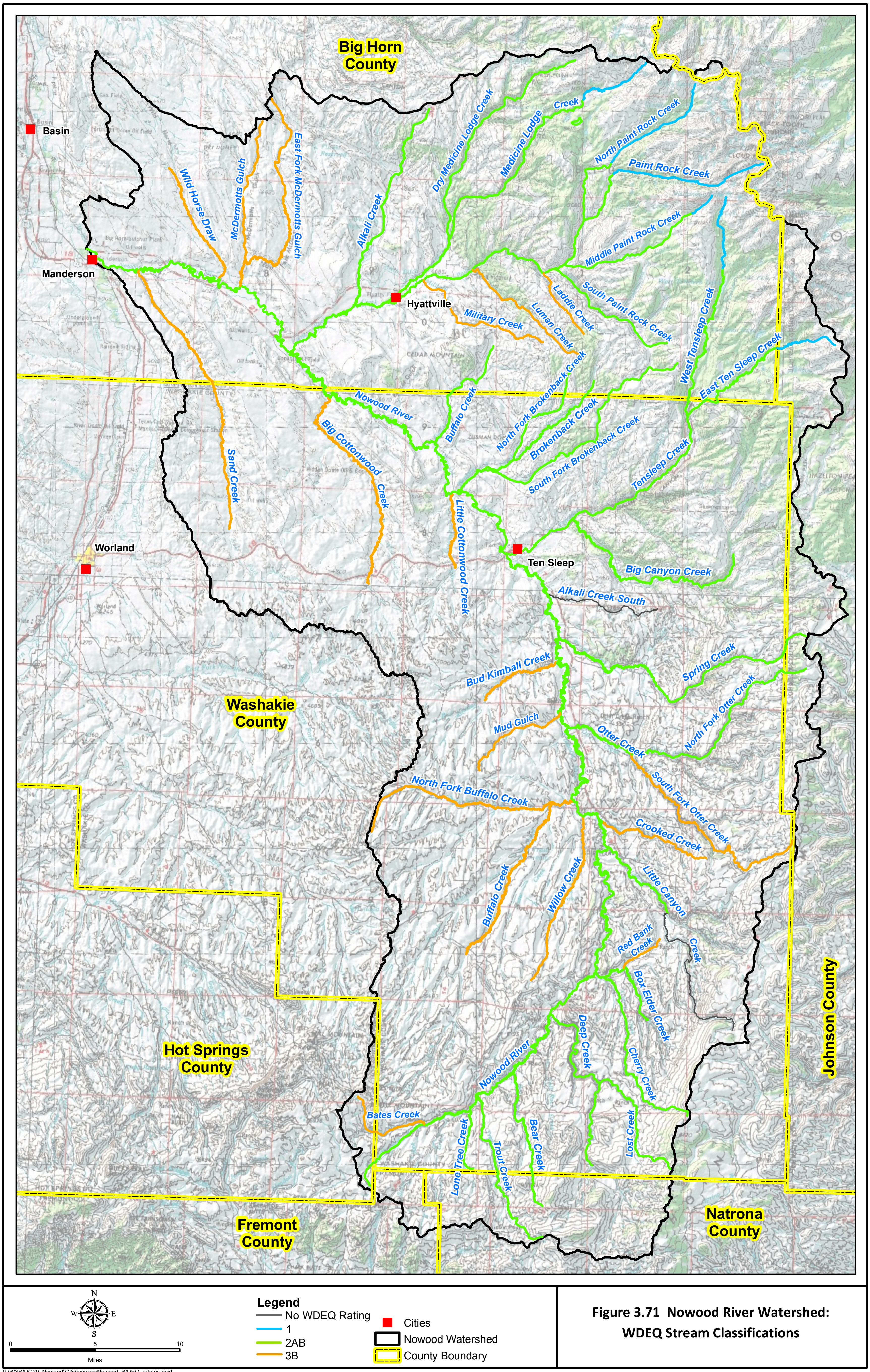


Figure 3.71 Nowood River Watershed: WDEQ Stream Classifications

Class 2B waters are those known to support or have the potential to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where it has been shown that drinking water uses are not attainable pursuant to the provisions of Section 33. Class 2B waters include 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 2B 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". Uses designated on Class 2B waters include game and nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture and scenic value…

Class 2C waters are those known to support or have the potential to support only nongame fish populations or spawning and nursery areas at least seasonally including their perennial tributaries and adjacent wetlands. Class 2C waters include all permanent and seasonal nongame fisheries and are considered "warm water". Uses designated on Class 2C waters include nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value…

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."

All streams located within the Cloud Peak Wilderness area are designated as Class 1 by virtue of their location and recognition of their high quality. These streams are protected against further water quality degradation by point source discharges.

The majority of streams in the watershed are classified as Class 2AB by the WDEQ. This classification incorporates all of the Nowood River, Paint Rock Creek, Tensleep Creek, Brokenback Creek, Otter Creek, Canyon Creek, and additional tributaries. These streams are thereby designated suitable to support game fish populations or spawning and nursery areas at least seasonally, nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture and scenic value uses.

Streams classified as Class 3B are typically located in the lower elevations and are ephemeral or intermittent streams. These include Cottonwood Creek, Bud Kimball Creek, Buffalo Creek, Sand Creek, and others.

3.8.2 NPDES Permitted Discharges

A database of permitted discharges under the National Pollution Discharge DIschage Elimination System (NPDES) was obtained from the Wyoming Department of Environmental Quality. Based upon a A total of 22 active National Pollution Discharge Elimination System (NPDES) permitted discharges are present within the study area. (This number does not include temporary permits). Table 3.19 summarizes pertinent information regarding the permits. The locations of these discharges are shown on Figure 3.72. Stormwater permits are not considered here due to the relatively low potential for significant impacts to the watershed assuming that the applicable BMPs and other controls contained in the permits are being implemented.

3.8.3 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.

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

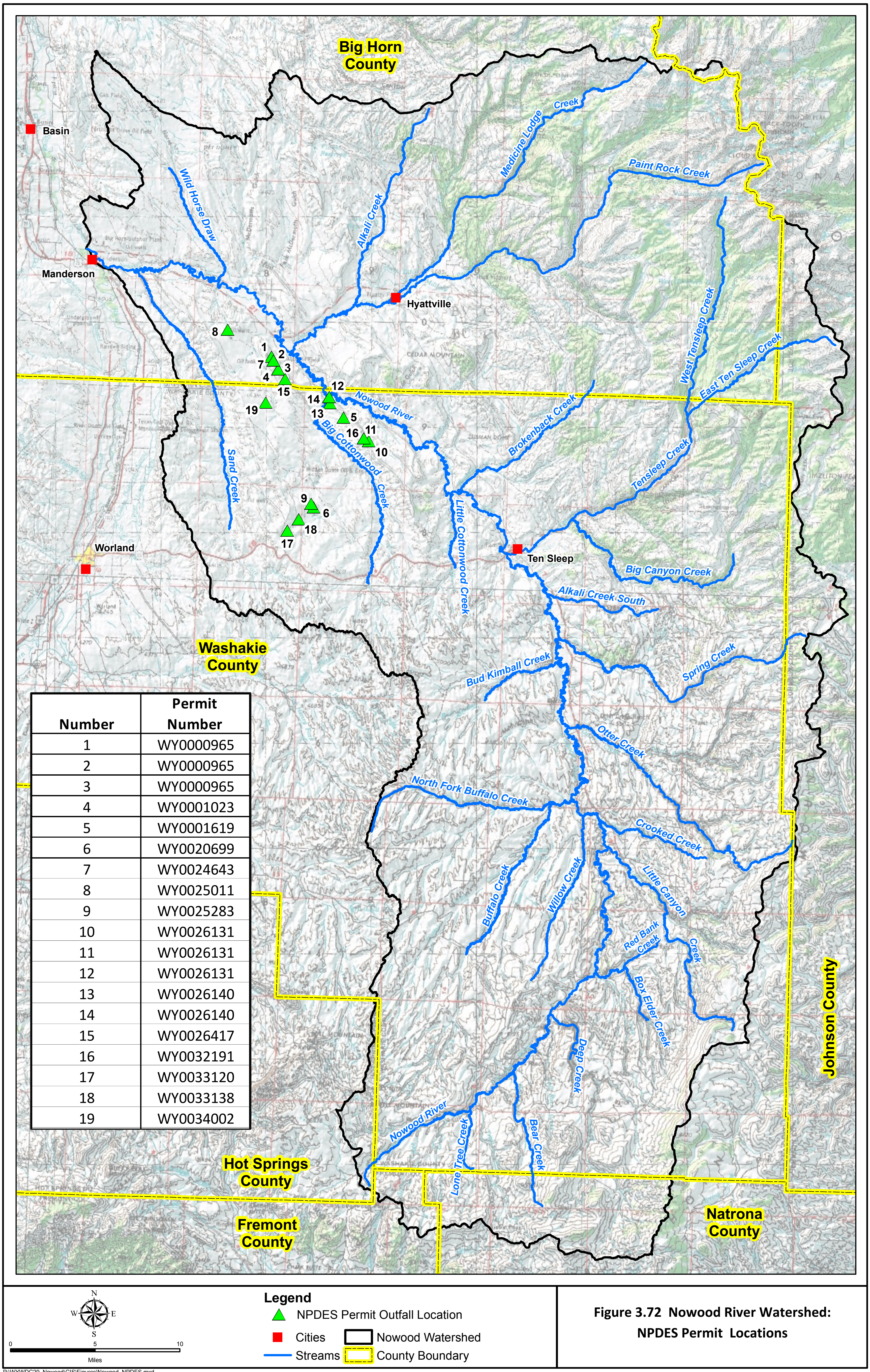
If a state does not comply with Section 303(d), the Environmental Protection Agency is required to perform these activities.

The Nowood River from the confluence with the Big Horn River upstream an ‘undetermined distance’ is included in the WDEQ’s 303(d) list Table A. This reach was first included in the list in 2002. Impairments of protected uses included contact recreation and the cause of impairments is listed as fecal coliform from undetermined sources.

In response to the listing of the Nowood River and other streams in Big Horn County and Washakie County, the Washakie County Conservation District (WCCD) and South Big Horn County Conservation Districts (SBHCD) sought and received funding through the 319(h) States Grant Project under the Wyoming Department of Environmental Quality (WDEQ) and US Environmental Protection Agency (EPA)

Table 3.19 Summary of NPDES Permitted Discharge Locations

Number	Permit Number	Permittee	Receiving Water	Permit Type
1	WY0000965	Iron Creek Energy	Nowood River (2AB), via Milton Draw (3B)	Oil Treaters
2	WY0000965		Nowood Creek (2AB), via Milton Draw (3B)	Oil Treaters
3	WY0000965		Nowood River (2AB) via Milton Draw (3B)	Oil Treaters
4	WY0001023		Nowood Creek (2AB), via Milton Draw (3B)	Oil Treaters
5	WY0001619	J and J Production	Nowood River (2AB), via Big Cottonwood Creek (3B)	Oil Treaters
6	WY0020699	Continental Resources, Inc.	Nowood River (2AB), via an unnamed ephemeral tributary (3B)	Oil Treaters
7	WY0024643	Iron Creek Energy	Nowood Creek (2AB), via Milton Draw (3B)	Oil Treaters
8	WY0025011	Beartooth Oil and Gas Company	Nowood River (2AB), via an unnamed drainage (3B)	Oil Treaters
9	WY0025283	Carol Holly Oil Corporation	Nowood River (2AB), via an unnamed drainage (3B)	Oil Treaters
10	WY0026131	Endeavor Energy, LLC	Nowood River (2AB) via an unnamed drainage (3B), Big Horn River Basin	Oil Treaters
11	WY0026131		Nowood River (2AB) via an unnamed drainage (3B), Big Horn River Basin	Oil Treaters
12	WY0026131		unnamed drainage, prior to confluence with Nowood River	Oil Treaters
13	WY0026140		Nowood River (2AB) via an unnamed drainage (3B), Big Horn River Basin	Oil Treaters
14	WY0026140		unnamed drainage, prior to confluence with Nowood River	Oil Treaters
15	WY0026417	Dolezal, George	Nowood River (2AB), via an unnamed drainage (3B)	Oil Treaters
16	WY0032191	Endeavor Energy, LLC	Nowood River(2AB) via an unnamed drainage (3B), Big Horn River Basin	Oil Treaters
17	WY0033120	Continental Resources, Inc.	Nowood River (2AB), via an unnamed ephemeral tributary (3B)	Oil Treaters
18	WY0033138		Nowood River (2AB), via an unnamed ephemeral tributary (3B)	Oil Treaters
19	WY0034002	Citation Oil and Gas Corporation	Nowood River (2AB), via an unnamed ephemeral tributary (3B)	Oil Treaters
20	**WY0020168**	Town of Tensleep	Location information not available and consequently not indicated in Figure 3.72	Municipal Wastewater Treatment
21	WY0002054	Wyoming Game and Fish Department		Fish Hatchery
22	WY0027481	Wyoming Game and Fish Department		Fish Hatchery



Number	Permit Number
1	WY0000965
2	WY0000965
3	WY0000965
4	WY0001023
5	WY0001619
6	WY0020699
7	WY0024643
8	WY0025011
9	WY0025283
10	WY0026131
11	WY0026131
12	WY0026131
13	WY0026140
14	WY0026140
15	WY0026417
16	WY0032191
17	WY0033120
18	WY0033138
19	WY0034002

Figure 3.72 Nowood River Watershed: NPDES Permit Locations

to conduct water quality monitoring. The Washakie County Conservation District was concerned with the status of streams and rivers located within the county that had been listed on the Wyoming 303(d) list as impaired or threatened due to fecal coliform. Additionally, through 319(h) funding, the District established a voluntary septic system and animal feeding operation (AFO) cost share program for landowners. The program is an effort to upgrade or replace failing septic systems and to relocate or upgrade AFOs. The Natural Resource Conservation Service (NRCS) also provided assistance to landowners for AFO projects (WWC Engineering, 2008).

The river was listed on WDEQ's 303(d) list in 2002 for fecal coliform based on two studies completed by the WDEQ. The initial study was completed in 2000 in conjunction with WDEQ's Beneficial Use Recovery Project (BURP) monitoring in an effort to "partition bacteria sources on the Big Horn River" (WDEQ, 2001). The study found fecal coliform bacteria in excess of 200 cfu/100 mL near Manderson. Further testing, completed in 2001, found that bacteria concentrations correlated to precipitation and that Paintrock Creek in Big Horn County was a significant source of loading. The study did not monitor sites upstream of the Nowood River confluence with Paintrock Creek, however it was assumed that fecal coliform concentrations were elevated due to increased bacteria concentrations downstream of the confluence. Throughout the monitoring program the Nowood River showed a decrease in *E. coli* prompting the SBHCD and WCCD to monitor the stream for delisting in 2008. For a stream to be delisted it must be sampled every month during the recreation season (May through September) and maintain an *E.coli* geometric mean below the 126 cfu/100 mL each month (WWC Engineering, 2008).

Results of the monitoring effort indicated that the geometric means exceeded the WDEQ standard during the spring and early summer sampling seasons. The following is a summary of the Nowood River monitoring results.

- Bacteria concentrations are influenced by discharge and turbidity. During peak runoff seasons bacteria concentrations were elevated.
- The single sample maximum concentration of 410 cfu/100 mL was measured in 12% of the samples.
- A flow and load duration curve illustrates that the majority of the *E. coli* sample are below both the geometric mean load limit and single sample load limit. This indicates that the stream has a strong capacity to meet future TMDLs.

The WCCD and NRCS have initiated an implementation program of Best Management Practices targeting the reduction in contribution of fecal coliform to the river. BMPs specifically target replacement or rehabilitation of septic systems and animal feed operations. At this time it is difficult to quantify the effectiveness of these BMPs on all streams because of the lack of historical data. Continued monitoring will be important to fully assess the effect BMP implementation has on each impaired stream. (WWC Engineering, 2008).

3.8.4 Suitability for Agricultural Use

The Ayers and Westcot (1985) irrigation suitability diagram is a tool used to determine irrigation suitability based upon Sodium Adsorption Ratio (SAR). The diagram displays the relationship between SAR and electrical conductivity (EC). SAR is defined as the ratio of the sodium to the combination of calcium and magnesium and reflects known effects on soil dispersibility. EC is the ability of water to conduct an electrical current and is related directly to the amount of dissolved solids in the sample. The diagonal line on the diagram is used as the threshold for SAR and EC values of the water. Water quality would be expected to be suitable for irrigation as a result of dispersion of soils by SAR below and to the right of the irrigation threshold line (Ayers and Westcot, 1985). Alternatively, waters located to the left and above the threshold line for irrigation would be likely to cause slight to moderate reduction in the rate of infiltration (Ayers and Westcot, 1985).

The EC/SAR relationship in the Ayers Westcot irrigation suitability diagram is utilized to determine the effect of irrigation water on the infiltration capacity of soils. Elevated SAR values may reduce the permeability in clayey soils, consequently reducing the infiltration rate. It should be noted that the significance of a reduction in infiltration rate varies with soil type.. In addition, the EC/SAR relationship typically indicates that as water salinity increases, the potential impacts of SAR decrease; however this relationship should not be applied without limits. The potential impact of rainfall on sodic soils can cause SAR problems by significantly lowering of the EC with little change in the SAR. An attempt to address this potential problem, along with the inherent variability in soils, is made through the application of an absolute maximum SAR during the analysis.

Figure 3.73 displays the EC/SAR relationship for the samples taken by the USGS at the stream gage which was located near Ten Sleep (USGS Gage 06270000) and by the Washakie County Conservation District on the Nowood River near the Big Horn County Line. This figure indicates that the SAR remains relatively constant and at low values as EC varies. SAR ranged from 0.2 to a maximum of 1.7.

Comparing the data to the reported threshold for irrigation suitability which is based upon the EC/SAR relationship, it is apparent that the Nowood River is rarely unsuitable for irrigation purposes. There were five instances when the EC/SAR relationship results in a plotting position within the 'unsuitable' area of the graph. Each of these samples was taken during high flow events on the Nowood River when discharge exceeded 1,000 cubic feet per second. It cannot be verified, but it can be surmised that given the high discharges in the Nowood River, ephemeral tributaries on the arid western portion of the watershed may have been flowing. Consequently, sediment laden runoff could result in those samples exceeding the irrigation threshold.

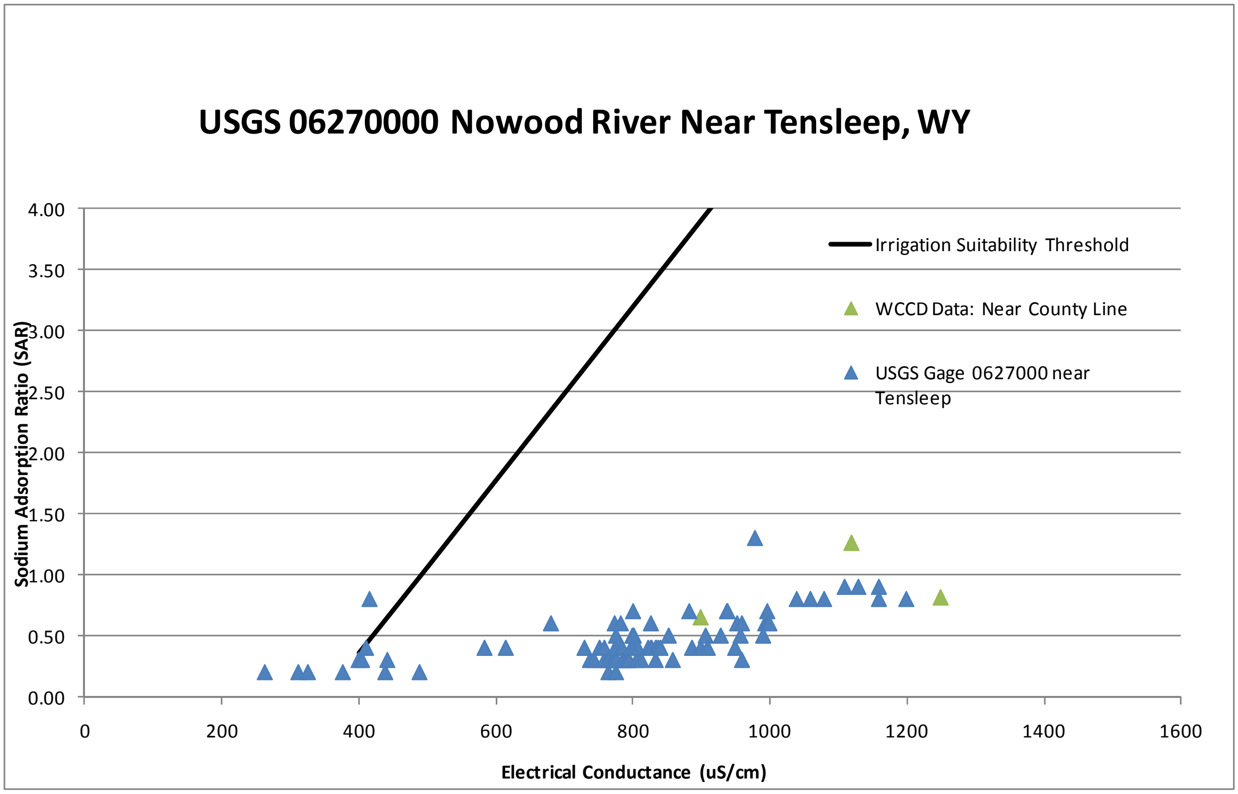


Figure 3.73 Ayers Wescott Agricultural Suitability Diagram

Nonetheless, the graph verifies that at least for the majority of time, the quality of water diverted from the Nowood River is of good quality and meets the recommended limits for its intended use associated with irrigated agriculture.

3.9 Water Storage and Retention

Identification and evaluation of opportunities to develop additional surface water storage in the Nowood River watershed is a key objective of this Level I study. A number of potential benefits of additional storage have been identified during the course of this study and are recommended for more detailed evaluation should a storage project(s) advance to the next level of study. The potential benefits of additional storage would vary as a function of the size and cost of the facility, but could include the following:

- Provision of a source of late season irrigation water,
- Enhancement/establishment of late-season stream flows to benefit aquatic and wildlife species, riparian habitat, and livestock,
- Provision of additional direct wildlife/livestock watering opportunities and potential to serve gravity-fed watering systems,
- Reduction of flooding impacts to the aquatic and riparian habitats downstream and potentially downstream municipalities,
- Improvement of stream bank/channel conditions,

- Establishment of a lake fishery,
- Improvement of water quality both in the watershed and (at least incrementally) in the Bighorn River, and
- Provision of seasonal recreational opportunities (consistent with meeting other needs and achieving other benefits).

3.9.1 Surface Water Availability and Shortages

The evaluation of flows available for potential storage projects versus irrigation shortages within the watershed was based upon results of the Wyoming Water Development Commission (WWDC) basin planning model developed for the Wind/Bighorn River watershed (MWH, et al., 2010). Much of the discussion of the model, assumptions inherent to it, and its limitations was extracted from previous reports. It is included herein to provide the background necessary to interpret model results.

3.9.1.1 Wind/Bighorn River Basin Model

The Wind/Bighorn River Basin Model is a water accounting spreadsheet that incorporates multiple diversions, gaging stations, and other water resources data within the Bighorn River Basin. One of the primary purposes of the model is to provide a planning tool for Bighorn River Basin water users and the State of Wyoming for use in determining those river reaches in which flows may be available to Wyoming water users for future development.

The WWDO is currently completing an update of the Wind / Bighorn Basin Planning document. In conjunction with that study, the spreadsheet model is being updated to reflect a period of record through 2008. This modification will result in the incorporation of baseline data reflecting recent drought conditions. Preliminary results of the effort have been incorporated within this report (MWH, 2010).

For the purposes of this study, the updated spreadsheet model was utilized without modification. The Wind/Bighorn River model consists of ten individual spreadsheet models, each representing a specific subbasin of the watershed. One of the individual spreadsheet models focused on the Nowood River watershed. The individual spreadsheet models are linked to enable data generated in one model to be "passed along" to subsequent models. Furthermore, models were generated to reflect each of three hydrologic conditions: dry, normal, and wet year water supply.

The spreadsheets each represent one calendar year of streamflow data, on a monthly time step. Each spreadsheet relies on a calibration model that reflects available historical data from the 1973 to 2001 study period to estimate the hydrologic conditions. Streamflow, consumptive use, diversions, and irrigation return flows are the basic input data to the model. For all of these data, average values drawn from the dry, normal, or wet subset of the study period were computed for use in the spreadsheets. The model does not explicitly account for water rights, reservoir operations, compact allocations, or the management of the basin water supply based on these legal constraints. It is assumed that the historic discharge data reflect effects of any limitations that may have been placed upon water users by water rights or compact restrictions as well as reservoir operations.

To mathematically represent the Bighorn River system subbasins, each basin was first divided into reaches based primarily upon the location of USGS gaging stations. Each reach was then sub-divided by identifying a series of individual nodes representing locations where diversions occur, basin imports are added, tributaries converge, or other significant water resource features are located.

At each node, a water budget computation is completed to determine the amount of water that flows out of the node. Total flow into the node and diversions or other losses from the node are calculated. The difference between total inflow and diversions/losses is the amount of flow available to the next node downstream. Mass balance, or water budget calculations, are repeated for all nodes in a reach, with the outflow of the last node being the inflow to the beginning node in the next reach. Figure 3.74 displays a graphical representation of the water balance approach. For each reach, ungaged stream gains (e.g., ungaged tributaries, groundwater inflow, and return flows from unspecified diversions) and losses (e.g., seepage, evaporation, and unspecified diversions) are taken as the difference between average historical gage flows (or outflows) and model-predicted outflow from the reach. Stream gains are input at the top of a reach to be available for diversion throughout the reach and losses are subtracted at the bottom of each reach.

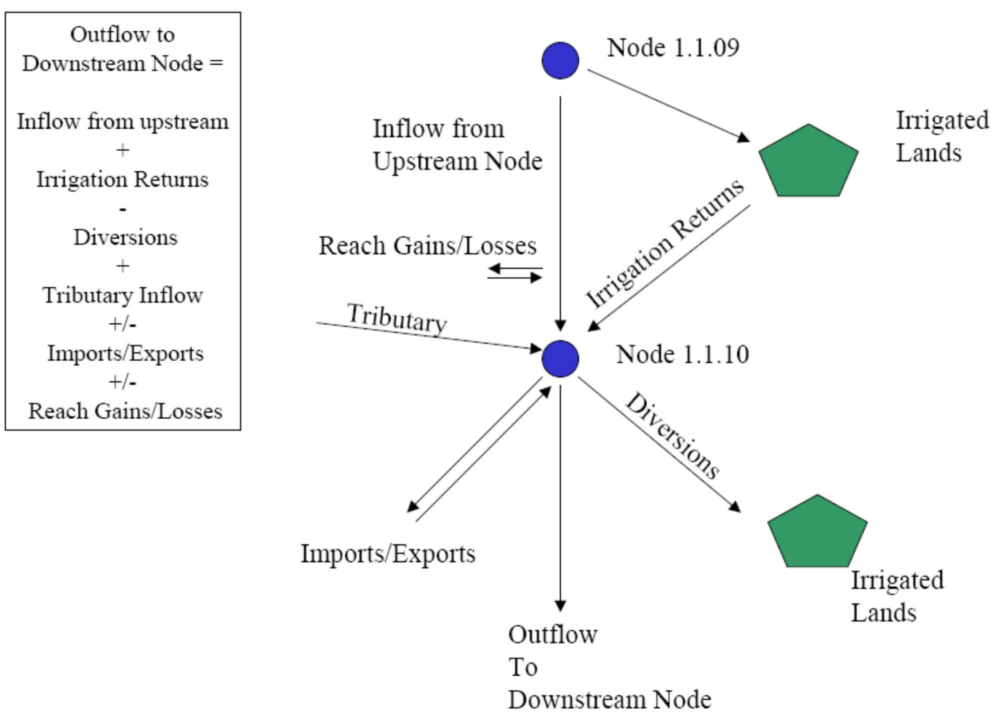


Figure 3.74 Diagram of Model Water Budget Computations

3.9.1.2 Model Limitations

There are several limitations to the model, which must be considered when reviewing the model and results generated by its use. These limitations and their implications with respect to a determination of water availability are discussed below:

- Within the Nowood watershed, there are currently no active stream gages In addition, none of the gages were active during any of the period of record incorporated within the development of the spreadsheet model (1973- 2008). Consequently ALL of the streamflow data used in the model was synthesized using methods described in detail within the Wind / Bighorn Basin Plan (BRS, 2003). The existing model excludes the time period prior to 1973 due to the lack of pre-1973 data and dam construction. Extension of the model period to reflect pre-1973 conditions would be valuable if possible, in order to estimate demands and availabilities associated with historic drought conditions.
- Use of a monthly time step in the river simulation may result in the exclusion of peak flows on 'flashier' systems. These peaks would be incorporated within the monthly average streamflows within the model, however, in instances where peaks exceed demand, the monthly time step could result in underestimation of available flows.
- The spreadsheet model does not explicitly account for diversions from the river in accordance with Wyoming water law and is not operated on these legal principals. Simply stated, this means that the model cannot forego a diversion to an upstream junior water appropriator to satisfy a downstream senior water right.
- The basin planning model was originally developed under the assumption that if this situation occurred historically, the diversion data would reflect this occurrence and the junior appropriator would incur a shortage.
- The model does not incorporate reservoir operational rules for release or storage of water. Consequently, evaluation of changes in practices that accompany reservoirs is problematic. For each simulation condition (normal-, dry- and wet-year conditions), reservoir releases do not deviate from historic releases. For example, releases from Boysen Reservoir remain consistent with historic patterns despite changes to reservoir inflow and storage. The implication of this limitation is that Boysen Reservoir behaves as a "buffer" between the upper and lower portions of the basin.
- The model uses data generated outside of the program in several instances. Consequently, evaluation of different water usage scenarios involving this data is cumbersome. For example, the model does not directly facilitate evaluation of effects of improvements to farm irrigation practices resulting in increased irrigation efficiency without recalculation of input data outside of the model environment.
- The spreadsheet model does not contain logic to evaluate impacts upon the state's obligations under the Yellowstone River Compact (Compact). The Yellowstone River Compact between Montana, North Dakota and Wyoming was signed in 1950. The compact outlines allocations for

several rivers in northern Wyoming, including the Bighorn River. On the Bighorn River, water is to be allocated 80 percent to Wyoming and 20 percent to Montana. Pre-1950 water rights are guaranteed. The Compact does not affect Native American rights to Yellowstone River water. Consequently, all estimates of available flows presented in this report do not include consideration of the Yellowstone River Compact.

Comparison of historic data with full supply diversion estimates indicates that irrigators typically operate under supply-limited conditions. The model simulates diversion data related to a multitude of uses (irrigation, municipal, industrial, etc.). Given the magnitude of the irrigation diversions, however, special attention is devoted to the water requirements associated with irrigated lands. To fully understand this potential limitation, it is important to know that the spreadsheet model can be run in three different modes:

- *Calibration (Historical):* This mode simulates the historical diversions where data are available. This mode is typically used for model calibration because historic diversion data are utilized.
- *Full Supply for Existing Irrigated Lands:* This mode reflects full supply diversions, based on computed diversion requirements for existing irrigated lands (lands presently irrigated and mapped during the planning process).
- *Full Supply for Existing Irrigated Lands and Futures Projects:* This mode simulates full supply, based on computed diversion requirements, for existing irrigated lands and Tribal futures projects. Within the Nowood watershed portion of the model, there were no Tribal Futures projects; consequently, there were no local impacts of their potential implementation.

The “Full Supply for Existing Irrigated Lands” version of the model was used for the purposes of this project. Review of results of models incorporating consideration of Tribal Futures indicated only insignificant impacts upon estimated availability within the Nowood River watershed.

3.9.1.3 Available Flows Analysis

To determine how much of the physical supply is actually available for storage at any given model node, "available water" was defined as that portion of the physically available streamflow that could be stored without causing a shortage to existing water users in any downstream river reach on Nowood River or the Bighorn River. *In other words, the water available at any node was determined as the minimum of the physically available flow at that point or the minimum available flow at any node downstream in the system (including the Bighorn River).* As noted previously, this evaluation is made on a water budget basis (inherent to the Basin Plan model) and does not directly incorporate individual water rights.

Results of the availability analyses indicate that there is flow available for storage without incurring a shortage in downstream reaches as summarized in Table 3.20 for modeled stream reaches within the watershed or downstream on the Bighorn River. The total annual available flow for the entire Nowood River watershed (represented by Reach No. 800) is estimated in the model as over 316,000 ac-ft for a normal (6 out of 10 years) condition and over 248,000 ac-ft for a dry (2 out of 10 years) condition. The model results show that the large majority of available flows occur in April, May and June as would be expected in this hydrologic setting and consistent with the pattern of gaged flows as previously described. Shortages estimated by the model are presented in Table 3.21. Figure 3.75 displays the results of the analysis of normal year availability graphically.

Table 3.20 Results of the Nowood River Watershed Available Flow Analysis: Availability

Reach	Reach Name	Dry Year (ac-ft)	Normal Year (ac-ft)
600	Nowood River aboveTen Sleep Creek	5,874	9,760
610	Lone Tree Creek	1,646	3,424
620	Bear Creek	2,547	5,631
630	Deep Creek	5,874	9,760
640	Box Elder Creek	4,213	8,081
642	Red Bank Creek	3,718	7,135
650	Little Canyon Creek	2,409	6,001
655	South Fork Little Canyon Creek	110	246
660	Crooked Creek	835	2,220
670	Otter Creek	5,689	9,545
675	South Fork Otter Creek	5,101	8,988
680	Spring Creek	3,540	6,984
684	North Fork Spring Creek	749	2,058
690	Ten Sleep Creek	1,831	5,972
692	East Fork Ten Sleep Creek	1,831	5,972
694	West Fork Ten Sleep Creek	1,831	5,972
698	Big Canyon Creek	1,831	5,931
700	Nowood River from Ten Sleep Ck. To Paint Rock Ck.	157,247	188,298
740	Broken Back Creek	1,970	8,024
750	Buffalo Flat Creek	992	3,696
790	Paint Rock Creek	69,055	90,108
794	Medicine Lodge Creek	9,817	12,071
798	Alkali Creek	1,875	5,389
800	Nowood River from Paint Rock Ck. To Bighorn River	248,963	316,886

Table 3.21 Results of the Nowood River Watershed Available Flow Analysis: Shortages

Reach	Reach Name	Shortages	
		Dry Year (ac-ft)	Normal Year (ac-ft)
600	Nowood River above Ten Sleep Creek	365	176
610	Lone Tree Creek	0	0
620	Bear Creek	0	0
630	Deep Creek	0	0
640	Box Elder Creek	17	0
642	Red Bank Creek	0	0
650	Little Canyon Creek	2,028	1,459
655	South Fork Little Canyon Creek	0	0
660	Crooked Creek	1,105	758
670	Otter Creek	0	0
675	South Fork Otter Creek	0	0
680	Spring Creek	564	384
684	North Fork Spring Creek	204	135
690	Ten Sleep Creek	0	0
692	East Fork Ten Sleep Creek	0	0
694	West Fork Ten Sleep Creek	0	0
698	Big Canyon Creek	0	0
700	Nowood River From Ten Sleep Creek to Paint Rock Creek	0	0
710	Brokenback Creek	0	0
742	Green Beret wells	0	0
750	Buffalo Flat Creek	2,990	1,950
790	Paint Rock Creek	0	0
794	Medicine Lodge Creek	2,876	1,584
798	Alkalli Creek	55	11
800	Nowood River from Paint Rock Creek to Bighorn River	0	0

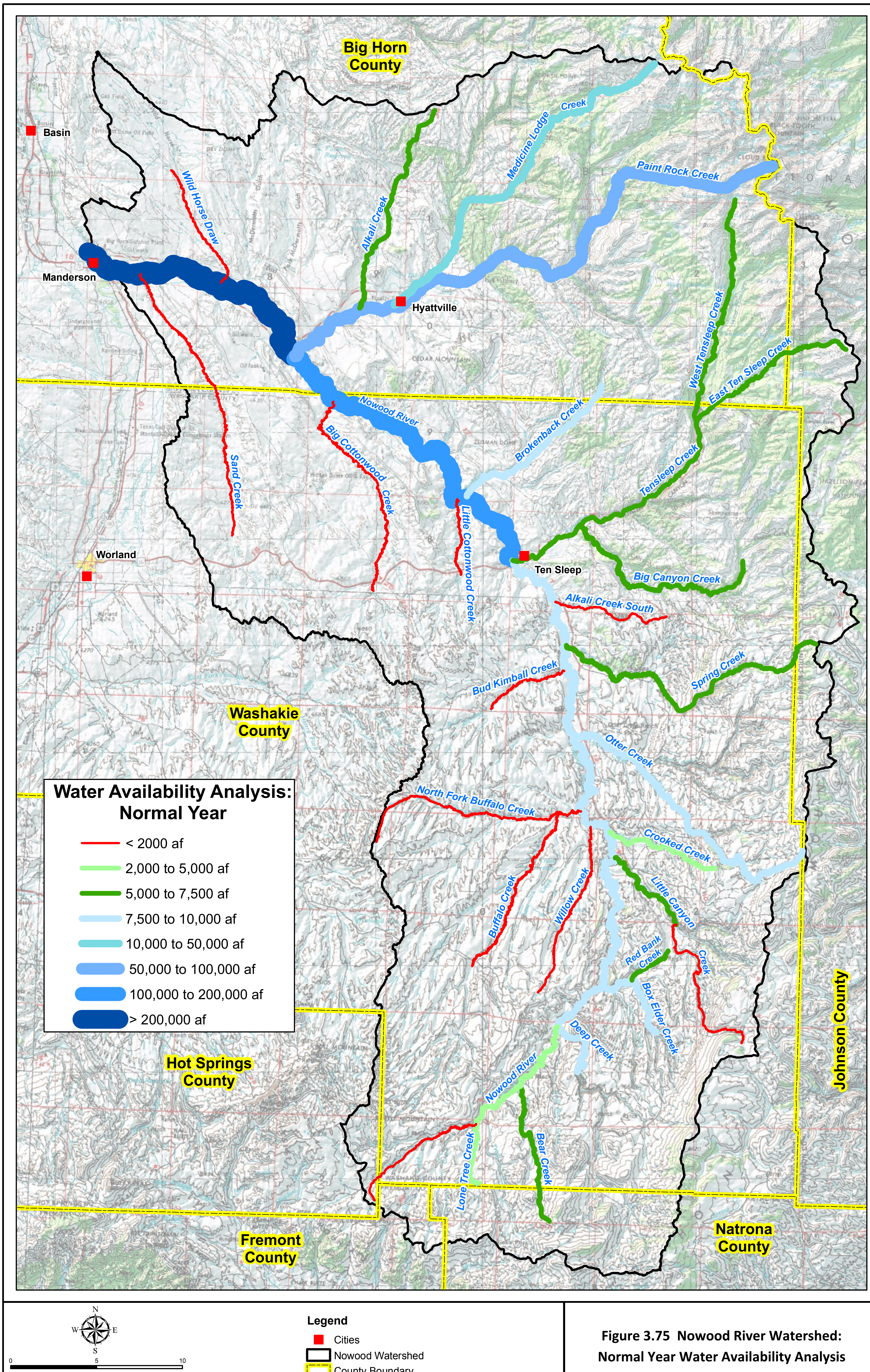


Figure 3.75 Nowood River Watershed: Normal Year Water Availability Analysis

In an effort to determine the 'reasonableness' of the model estimates, an evaluation of historic streamflow data was completed. The purpose of this effort was to compare estimated streamflows within the model to actual gage data for corresponding hydrologic conditions.

Available historic streamflow data were collected from the USGS. Based upon an analysis of precipitation data, calendar years were classified as wet, normal, and dry years. For each gage site, its corresponding data record was analyzed to determine annual stream flow for hydrologic conditions for which there were data. Measured streamflow was then compared to estimated streamflow. Table 3.22 tabulates the result of this effort. On the whole, the model appears to predict actual streamflow conditions within reasonable error for Normal years and Dry years.

As indicated in the model, shortages occur on tributaries to the Nowood River in both the normal and dry year conditions. As indicated by the model and substantiated by area landowners, the shortages occur primarily during the late season irrigation months of August and September. Total shortages (demands) were estimated to be approximately 6,483 acre-feet and 10,231 acre-feet for the normal and dry year conditions, respectively.

Note that the model results do not indicate shortages occur on the mainstem of the Nowood River. The predominate opinion heard during project meetings and communications with the project Steering Committee suggest actual shortages are greater than presented in the model and shortages do occur on the Nowood River in both normal and dry years. , Available WSEO records obtained for the period of 2001 through 2009, which spans recent drought conditions, show that calls were placed on the Nowood River in 2001, 2003,2005, 2006 and 2007. Calls were generally placed in July, August, or September of those years. Medicine Lodge and Paint Rock Creek are subjected to calls more frequently on average. Note that records pertaining to years prior to 2001 are available at the WSEO Riverton office but were not readily available at the time of this reporting.

3.9.2 Alternatives for New Surface Water Storage

3.9.2.1 Identification of Potential Sites

The identification of potential sites for additional or new surface water storage in the Nowood River watershed involved the following efforts:

- Interview locally knowledgeable stakeholders;
- Review Wyoming State Engineers Office (WSEO) dams database;
- Locate areas of irrigation shortage;
- Identify stream reaches with potentially significant available flows; and
- Review topographic mapping and digital aerial photography.

Table 3.22 Comparison of Wind/Bighorn Basin Planning Model with Historic Streamflow Data

Gaging Station	Years of Gage Data	Model Parameters		Hydrologic Condition	Data summary			Model Summary		Model vs Gage Data	
					cfs	ac-ft	No. Years	cfs	ac-ft	fference (c	Delta ac-ft
					1	2	3	4	5	6	7
USGS 06270500 CANYON CREEK NR TEN SLEEP WYO	5	Model Node	9.185	Dry Year	--	--	0	34.8	25,370	--	--
		Model Reach	698	Normal Year	33.3	24,273	2	34.1	24,862	590	2.4%
		Years of Gage Data	5	Wet Year	31.4	22,922	3	40.6	29,618	6,696	22.6%
USGS 06271000 TENSLEEP CREEK NEAR TENSLEEP, WYO	38	Model Node	9.187	Dry Year	130.2	95,026	11	124.1	90,626	(4,400)	-4.9%
		Model Reach	690	Normal Year	146.1	106,645	19	126.8	92,578	(14,067)	-15.2%
		Years of Gage Data	38	Wet Year	164.3	119,939	8	150.6	109,909	(10,030)	-9.1%
USGS 06272500 PAINTROCK CREEK NEAR HYATTVILLE, WYO	18	Model Node	9.2735	Dry Year	121.8	88,914	1	123.7	90,292	1,378	1.5%
		Model Reach	790	Normal Year	145.8	106,440	12	135.7	99,028	(7,412)	-7.5%
		Years of Gage Data	18	Wet Year	150.7	110,011	5	164.5	120,052	10,041	8.4%
USGS 06273000 MEDICINE LODGE CREEK NEAR HYATTVILLE, WYO	30	Node	9.2715	Dry Year	31.8	23,241	8	32.2	23,475	234	1.0%
		Reach	794	Normal Year	33.4	24,363	16	32.7	23,889	(474)	-2.0%
		Total Years	30	Wet Year	40.0	29,164	6	39.1	28,576	(587)	-2.1%
USGS 06273500 PAINTROCK CREEK NEAR MOUTH BELOW HYATTVILLE WY	7	Model Node	9.2795	Dry Year	137.9	100,643	3	145.2	106,017	5,375	5.1%
		Model Reach	790	Normal Year	152.9	111,617	3	164.3	119,917	8,300	6.9%
		Years of Gage Data	7	Wet Year	192.3	140,379	1	208.2	151,999	11,620	7.6%
USGS 06274000 NOWOOD RIVER AT BONANZA, WYO	13	Node	9.28	Dry Year	428.9	313,121	3	359.2	262,224	(50,897)	-19.4%
		Reach	800	Normal Year	506.3	369,609	8	423.5	309,176	(60,433)	-19.5%
		Total Years	13	Wet Year	547.4	399,602	2	600.4	438,321	38,719	8.8%
USGS 06270000 NOWOOD RIVER NEAR TENSLEEP, WY	29	Model Node	9.17	Dry Year	106.6	77,830	6	85.8	62,625	(15,205)	-24.3%
		Model Reach	600	Normal Year	109.3	79,797	18	114.4	83,537	3,740	4.5%
		Years of Gage Data	29	Wet Year	128.3	93,688	5	203.2	148,309	54,620	36.8%

1 Mean annual discharge for the given hydrologic condion computed from gage data
2 Mean annual yield for the given hydrologic condition computed from gage data
3 Number of years of data in the historic record for the given hydrologic condition
4 Mean annual discharge extracted from basin planning model
5 Mean annual yield extracted from basin planning model
6 Model Yield minus Gage Yield (col. J minus col. G)
7 Model Discharge minus Gage Discharge (col. I minus col. F)

Several previous investigations pertaining to the Nowood River and Bighorn River basins have been completed; primarily in the early 1970's. Included in these reports were recommendations of potential reservoir storage locations throughout the watershed. Many of the recommendations were identified early and repeated in subsequent studies. Each of the previously identified sites was ultimately included on the list of sites evaluated in this study. Table 3.23 summarizes the reservoir storage sites identified in the previous studies.

Table 3.23 Potential Storage Sites Identified in Previous Studies

Site	Nowood Watershed Project Site Number	USDA, 1971 (1)	WSEO, Oct 1972 (2)	WWPP, 1972 (3)	USDA / WSEO, 1974 (4)	WWDC 2007 (5)
Big Trails	2	x	x	x	x	x
Nowood River	8		x			
Upper Cloud Creek	NA		x			
Middle Cloud Creek	NA		x			
West Tensleep Lake	21		x	x		x
Tensleep Meadows	10		x	x		x
Pete's Lake	15		x			x
Medicine Lodge	11		x	x		x
Paintrock	13		x	x		x
Buffalo Creek	3		x			x
Lone Tree	34		x			x
Mahogany Buttes	23 / 24		x			x
Little Canyon Creek	22		x			x
Big Canyon Creek	33		x			x
North Brokenback	35		x			x
Brokenback	7		x			x
Alkali Creek (South)	30		x			x
Summit	17		x	x		x
Solitude	16		x	x		x

1	United States Department of Agrictulture (USDA), Nowood River Drainage Investigation Report, Type IV River Basin Survey, May 1971
2	Wyoming State Engineers Office (WSEO), Water & related Land Resources of the Bighorn River Basin, Wyoming, October 1972
3	Wyoming Water Planning Program (WWPP), Water & related Land Resources of the Bighorn River Basin, Wyoming, October 1972
4	United States Department of Agriculture (USDA), Wyoming State Engineers Office (WSEO), Wind -Bighorn-Clarks Fork River Basin, Type IV Survey, December 1974
5	Wyoming Water Development Commission (WWDC), Wind / Bighorn River Basin Planning Report , 2003

Within the project GIS, Digital U.S. Geological Survey (USGS) 7.5-minute topographic mapping was reviewed. Potential sites were identified as locations where topographic restrictions in valleys existed where a relatively small embankment could contain a relatively large amount of water.

3.9.2.2 Initial Screening of Storage Sites

A wide array of relevant information about the long list of potential storage sites was compiled from the results of the watershed inventory. The information included environmental, hydrologic, geologic, potential benefits, costs, and many others. This information was tabulated in an evaluation matrix presented as the Reservoir Evaluation Matrix (Appendix F).

Ultimately, a “long list” of 35 potential surface water storage sites was initially compiled. These sites are shown on Figure 3.76. The list contains sites previously identified, sites recommended by the steering committee and knowledgeable stakeholders, and sites identified during the topographic review.

The following attributes are included in the evaluation matrix and described below:

Category A: Reservoir Description

- On - Channel vs. Off-Channel Sites: On-Channel sites are intended to store water associated with the stream impounded. Off-channel sites are located on tributaries and store mainstem waters via diversions. Off-channel sites are generally simpler to implement due to typically reduced environmental impacts and permitting mitigation requirements.
- Direct Supply Source: the stream upon which the dam is placed (all sites).
- Indirect Supply: the stream which would be used to fill the dam (off-channel sites only).

Category B: Watershed Description

- Basic quantifiable attributes of the directly contributing watershed (ex. Basin area, elevations, relief, etc).

Category C: Reservoir Statistics

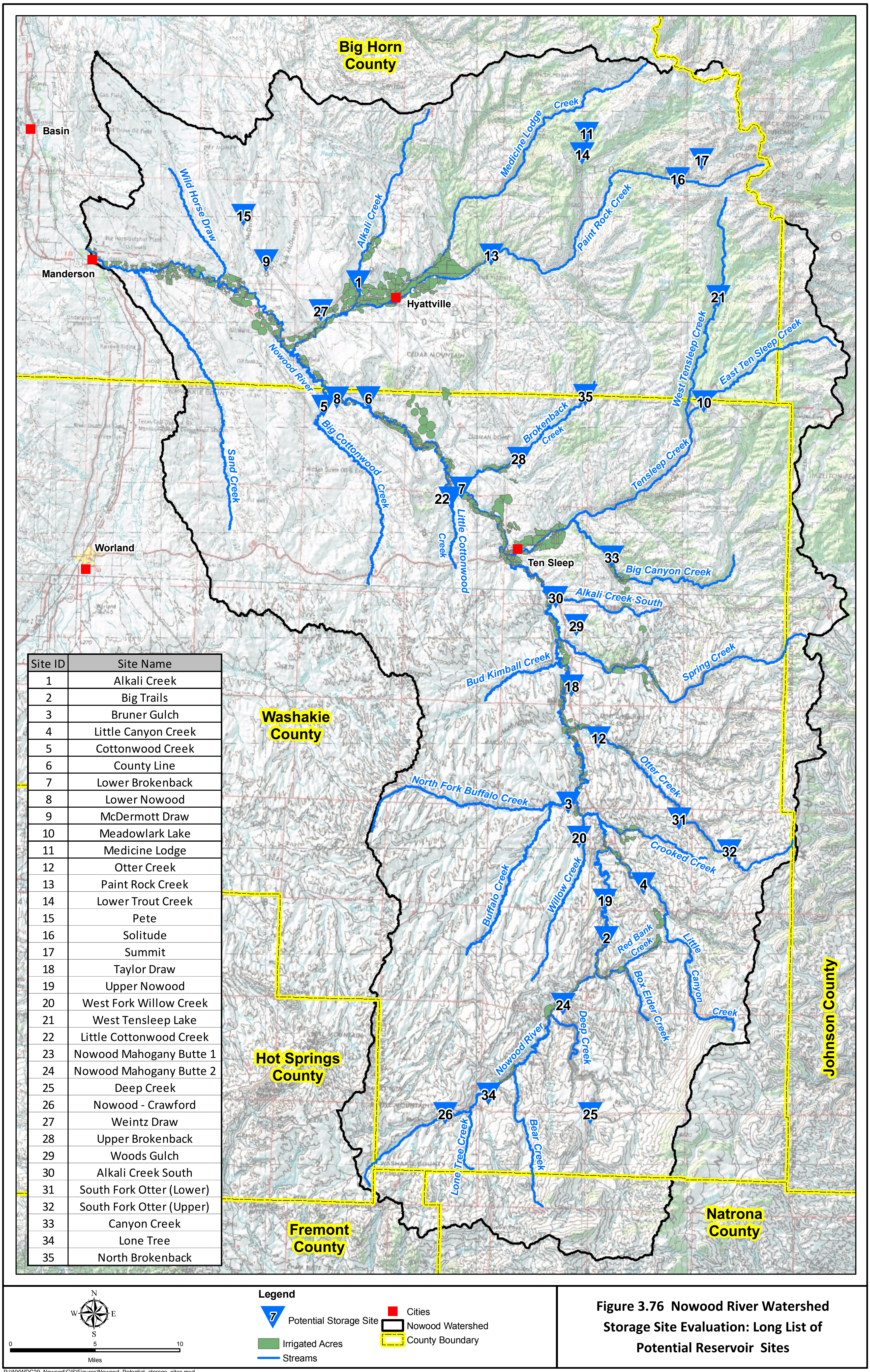
- Basic quantifiable attributes associated with the reservoir pool (ex. Maximum storage, surface area, etc).

Category D: Dam Statistics

- Basic quantifiable attributes associated with impoundment structure (ex. Height, length, volume, etc).

Category E: Hydrology

- Physically present in the stream: Based upon hydrologic estimation procedures, this value represents the amount of water expected to be physically passing the site in a given year.
- Available for storage: Based upon the Wind / Bighorn Basin Planning Model, this value represents the amount of water at the site which is available for storage without causing shortages downstream.
- Indirect supply source: The water body identified as a supply source for the site if an off-channel reservoir.



Site ID	Site Name
1	Alkali Creek
2	Big Trails
3	Bruner Gulch
4	Little Canyon Creek
5	Cottonwood Creek
6	County Line
7	Lower Brokenback
8	Lower Nowood
9	McDermott Draw
10	Meadowlark Lake
11	Medicine Lodge
12	Otter Creek
13	Paint Rock Creek
14	Lower Trout Creek
15	Pete
16	Solitude
17	Summit
18	Taylor Draw
19	Upper Nowood
20	West Fork Willow Creek
21	West Tensleep Lake
22	Little Cottonwood Creek
23	Nowood Mahogany Butte 1
24	Nowood Mahogany Butte 2
25	Deep Creek
26	Nowood - Crawford
27	Weintz Draw
28	Upper Brokenback
29	Woods Gulch
30	Alkali Creek South
31	South Fork Otter (Lower)
32	South Fork Otter (Upper)
33	Canyon Creek
34	Lone Tree
35	North Brokenback

Figure 3.76 Nowood River Watershed Storage Site Evaluation: Long List of Potential Reservoir Sites

Category F: Geology

- Bedrock Geology and Surficial geology were assigned relative 'grades' based upon the relative feasibility of constructing a reservoir at each site given the local geologic conditions. The scale ranges from "A", which indicates no potential problems identified to "F", which indicates fatal flaws associated with local geology. For this Level I site screening effort, no subsurface investigation was completed. The geologic investigation was completed primarily using existing mapping within the GIS environment. Consequently, there was insufficient information to assign A's or F's to any of the sites (refer to Section 3.4.3 for discussion of pertinent geologic factors considered in the matrix).

Category G: Environmental / Infrastructure

- Wetlands: Quantified acreage using LANDFIRE database.
- Game habitat: Type of game range affected by the embankment and reservoir: (seasonal, crucial, or parturition range).
- WYDEQ Classification: Determined from Tables A and B of Wyoming Department of Environmental Quality Surface Water Standards. (Ex. Class 1, Class 2AB, Class 3, etc as discussed in Section 3.8.1).
- Fisheries: Comments received from WGF pertaining to each location.
- Irrigated acres inundated: irrigated acres flooded by the embankment and pool.
- Infrastructure - Residences: Number of farmsteads and structures affected based upon 2006 aerial photography.
- Infrastructure - Transportation: Length of roads of various classes affected.
- Other: Infrastructure such as communications infrastructure including fiber optics.

Category H Economic Considerations

- Conceptual level cost estimate and comparative economic statistics. Approximate embankment volumes were computed using topographic mapping of each site. Conceptual costs associated with reservoir appurtenances such as emergency spillways, outlet works, etc, were estimated using previously estimated costs for reservoirs of similar size within Wyoming. Total project costs include consideration of permitting, engineering design and construction management.

Category I: Ownership

- Property ownership plays an important role in determining the relative feasibility of development of storage alternatives. For the purposes of this study, it was assumed based upon previous investigations, that the relative feasibility to construct a reservoir alternative from an ownership perspective would be as follows:

- Private Ownership: Least difficult assuming land owner concurrence
- State Ownership: Moderately difficult
- Federal Ownership: Most difficult

This assumption does mean to say that sites on federally owned lands should not be investigated further. It merely indicates that the permitting and consents process could be more problematic than with privately or state-owned parcels. Likewise, it is not meant to imply that privately owned lands are available. The State has indicated they are not interested in condemnation of private lands for the purposes of constructing reservoirs.

Category J: Potential Benefits

- Quantifiable and qualified benefits associated with each site (ex. Irrigated acres benefitting)

The Project GIS was used to quantify many of the attributes associated with the sites. For example, quantification of irrigated acres and wetlands affected by each site could be easily determined. Contributing watershed areas were delineated and their characteristics quantified using the GIS in conjunction with a digital elevation model.

The comparison matrix was used to assign relative priorities to the sites. The priorities are listed below:

Priority 1 Sites: These sites represent the most potentially feasible of the sites evaluated and provide the most benefit at the least cost or environmental impact. These sites would be recommended for further evaluation in future investigations.

Priority 2 Sites: These sites, while potentially feasible, contained attributes making them less desirable for further study than the Priority 1 Sites. For example, some sites showed potential benefits commensurate with Priority 1 sites but their costs were higher. Designation as a Priority 2 site does not preclude the alternative being included in future Level II, Phase 1 studies.

Priority 3 Sites: These sites contained either 'fatal flaws' which eliminated them from recommendation for further study (e.g., location within the wilderness area), or other attributes causing them to be highly unlikely to be implemented.

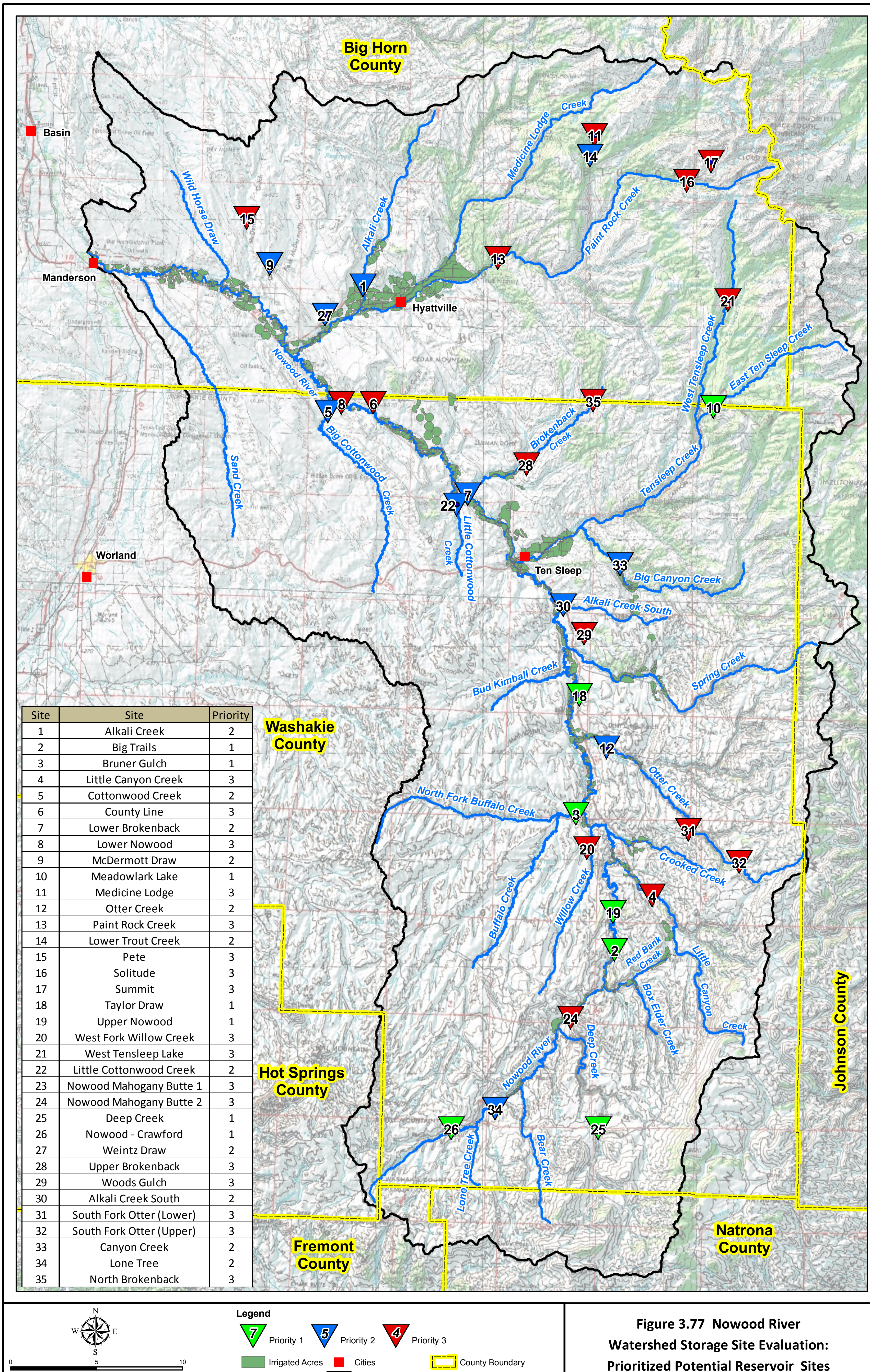
The seventeen (17) Priority 3 sites were eliminated from further considerations for several reasons as summarized in Table 3.24. Three of the sites were located within the Cloud Peak Wilderness area and should be removed from future discussions regarding potential storage opportunities within the watershed. These sites were identified prior to wilderness designation and are continued to be mentioned in regional studies. Wilderness areas are protected from construction activities, consequently, permitting and construction of a reservoir in a designated wilderness area would require federal legislative action changing designation. Other sites did not possess the hydrologic conditions necessary to support a reservoir of even moderate size without pumping from alterative sources. Capital cost increases and more importantly operation and maintenance expenses associated with pump/storage alternatives often increase financial challenges, therefore these sites were designated Priority 3. Geologic constraints were the reason the remaining Priority 3 sites were designated as such. For these sites, embankments were located on one or more of the bedrock formations determined undesirable as discussed in Section 3.4.3.

Table 3.24 Potential Storage Site Evaluation: Priority 3 Sites

Site No.	Site Name	Priority	Site Constraints and Issues
4	Little Canyon Creek	3	Ownership and Access limitations
6	County Line	3	Insufficient hydrologic potential
8	Lower Nowood	3	Impacts upon private residences, permitting constraints, negative wetlands and fisheries impacts
11	Medicine Lodge	3	Poor geologic conditions, negative fisheries and wildlife impacts, permitting constraints
13	Paint Rock Creek	3	Unsuitable geologic conditions
15	Pete	3	Insufficient hydrologic potential for large reservoir
16	Solitude	3	Wilderness area
17	Summit	3	Wilderness area
20	West Fork Willow Creek	3	Insufficient hydrologic potential for large reservoir
21	West Tensleep Lake	3	Wilderness area
23	Nowood - Mahogany Butte 1	3	Unsuitable geologic conditions
24	Nowood - Mahogany Butte 2	3	Unsuitable geologic conditions
28	Upper Brokenback	3	Very small storage capacity, high cost per acre foot of storage
29	Woods Gulch	3	Very small storage capacity, high cost per acre foot of storage
31	South Fork Otter (Lower)	3	Unsuitable geologic conditions
32	South Fork Otter (Upper)	3	Unsuitable geologic conditions, irrigated acres inundated
35	North Brokenback	3	Unsuitable geologic conditions

Designation as Priority 1 or 2 required a 'deeper' level of comparison. Several attributes can be quantitatively ranked for quantitative ranking for comparative purposes (e.g. wetlands impacted or irrigated acres inundated). Others required a qualitative comparison (e.g., geologic conditions and wildlife / fisheries impacts). Color coding in the Reservoir Evaluation Matrix (Appendix F) reflects the relative feasibility of several attributes. Green shading indicates attributes with favorable or minimal impacts, lower costs, or other beneficial attributes. Red shading indicates negative impacts, high costs, etc. Yellow indicates neutral attributes.

Once the matrix was completed to the extent possible, a work session was conducted with the objective of determining the relative priorities of the sites not screened as Priority 3 sites. The work session was attended by Anderson Consulting Engineers and representatives of the Wyoming Water Development Office. Results of the prioritization effort are displayed in Table 3.25 and graphically in Figure 3.77. The results of this effort were then presented to members of the Steering Committee for discussion and review.



Site	Site	Priority
1	Alkali Creek	2
2	Big Trails	1
3	Bruner Gulch	1
4	Little Canyon Creek	3
5	Cottonwood Creek	2
6	County Line	3
7	Lower Brokenback	2
8	Lower Nowood	3
9	McDermott Draw	2
10	Meadowlark Lake	1
11	Medicine Lodge	3
12	Otter Creek	2
13	Paint Rock Creek	3
14	Lower Trout Creek	2
15	Pete	3
16	Solitude	3
17	Summit	3
18	Taylor Draw	1
19	Upper Nowood	1
20	West Fork Willow Creek	3
21	West Tensleep Lake	3
22	Little Cottonwood Creek	2
23	Nowood Mahogany Butte 1	3
24	Nowood Mahogany Butte 2	3
25	Deep Creek	1
26	Nowood - Crawford	1
27	Weintz Draw	2
28	Upper Brokenback	3
29	Woods Gulch	3
30	Alkali Creek South	2
31	South Fork Otter (Lower)	3
32	South Fork Otter (Upper)	3
33	Canyon Creek	2
34	Lone Tree	2
35	North Brokenback	3

Figure 3.77 Nowood River Watershed Storage Site Evaluation: Prioritized Potential Reservoir Sites

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Table 3.25 Potential Storage Site Evaluation: Priority 1 and 2 Sites

Site Number	Name	Priority
Priority 1 Sites		
2	Big Trails	1
3	Bruner Gulch	1
10	Meadowlark Lake	1
18	Taylor Draw	1
19	Upper Nowood	1
25	Deep Creek	1
26	Nowood – Crawford	1
Priority 2 Sites		
1	Alkali Creek	2
5	Cottonwood Creek	2
7	Lower Brokenback	2
9	McDermott Draw	2
12	Otter Creek	2
14	Lower Trout Creek	2
22	Little Cottonwood Creek	2
27	Weintz Draw	2
30	Alkali Creek South	2
33	Canyon Creek	2
34	Lone Tree	2

The seven Priority 1 sites were recommended for further study and were evaluated in greater detail. Results of these analyses are presented in Chapter 4 of this report.

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.

- **Surface Water Storage Opportunities**. Based on flow availability and site-specific topography, potential storage reservoirs were identified, screened and evaluated. An existing reservoir was also investigated with respect to flow availability and the potential to increase existing storage capacity.

- **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.

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 flood control and low-flow augmentation, and 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. With respect to irrigation rehabilitation, the plans prepared for the inventoried irrigation systems are further prioritized to identify those improvements that provide the most benefit.

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 "U": Livestock / wildlife upland watering opportunities
- Project Components "S": Surface water storage 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 Nowood River watershed.

4.2 Irrigation System Conservation and Rehabilitation

In this section, a conceptual rehabilitation plan is presented for each of the inventoried irrigation ditches. The rehabilitation plan represents the integration of individual measures to mitigate issues identified in the inventory phase of the project. Specifically, the improvements that comprise the rehabilitation plan focus on:

- Rehabilitation/replacement of existing structures
- Mitigation of seepage losses
- Enhanced delivery of water
- Reduction in annual operation and maintenance costs
- Improvement in ditch management and efficiency through water measurement
- Economic practicality
- Physical feasibility

The plan is intended to provide the ditch owners an assessment of conditions associated with the ditch and its associated hydraulic structures. The ditch owner / manager can use the plan as a "resource or wish list" from which they can select projects for potential future funding assistance from sources such as the WWDC Small Water Project Program or NRCS EQIP.

4.2.1 Irrigation Ditch Rehabilitation Plans

Based upon the results of the field inventory, conceptual rehabilitation plans were developed for each ditch. In an effort to assist the ditch owner in prioritizing potential improvements to each ditch, relative priorities were defined as follows:

Priority 1: Install, replace, or rehabilitate aging infrastructure critical to the diversion and delivery of water.

Priority 2: Install, replace, or rehabilitate aging infrastructure critical to the operation, measurement, and management of the irrigation diversions.

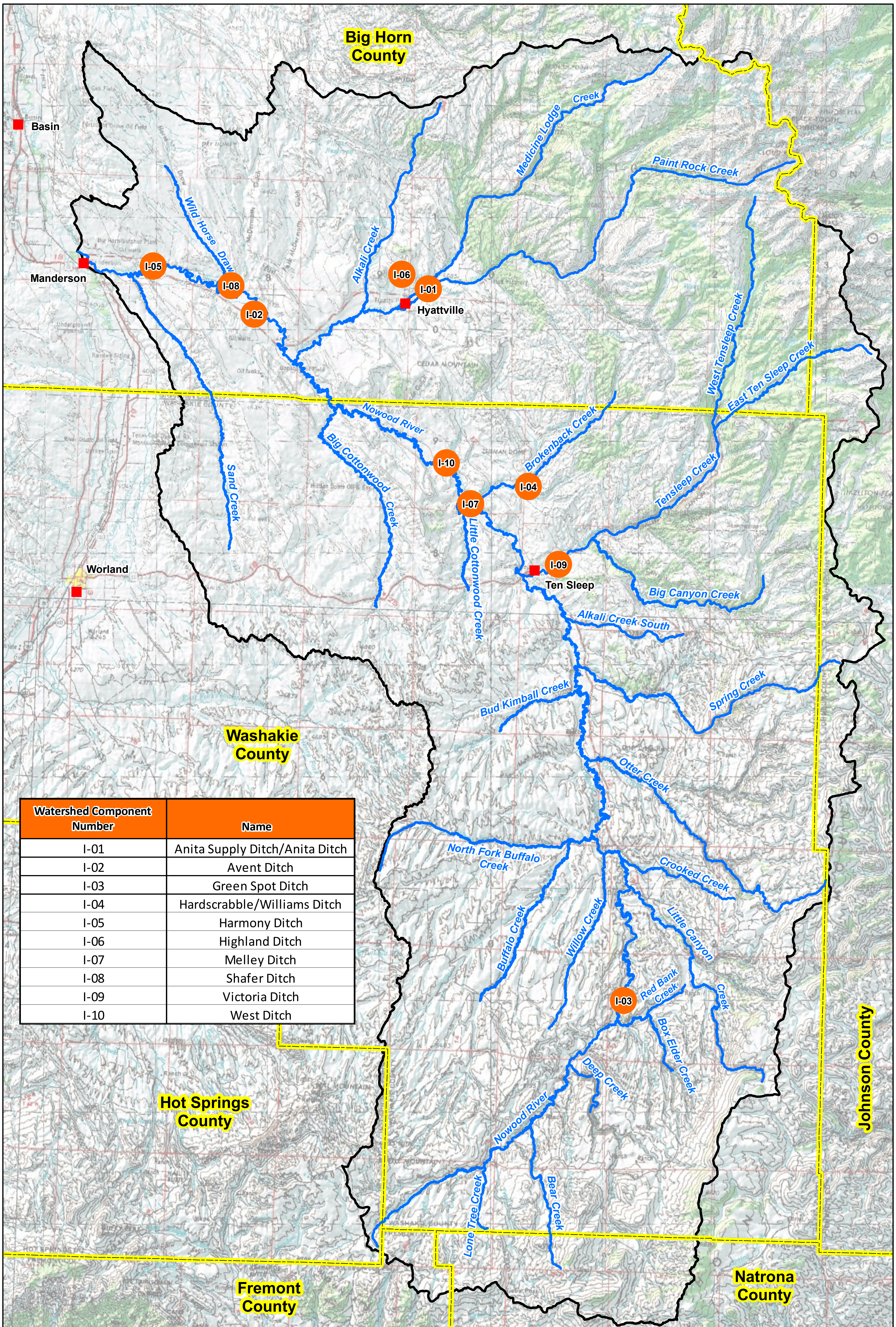
Priority 3: Install, replace, or rehabilitate aging infrastructure to provide improvements in on-farm efficiency and conservation.

In the following paragraphs, conceptual level rehabilitation plans are provided for the ten ditches inventoried. Each irrigation system improvement was assigned a unique identifier which identifies it within the watershed management plan. Within the rehabilitation plan for each ditch, each line item is given a subsequent item number. The ditches inventoried and their respective component identifiers in the watershed management plan summarized in Table 4.1. The locations of these components of the Nowood River Watershed Plan are indicated on Figure 4.1. This information has been incorporated within the Project GIS.

Table 4.1 Summary of Irrigation Components of the Watershed Management Plan.

Watershed Plan Component	Ditch	Items
I-01	Anita Ditch	I-01.1 through I-01.7
I-02	Avent Ditch	I-02.1 through I-02.4
I-03	Green Spot	I-03.1
I-04	Hardscrabble Ditch / Williams Ditch	I-04.1 through I-04.2
I-05	Harmony Ditch	I-05.1 through I-05.11
I-06	Highland Ditch	I-06.1 through I-06.5
I-07	Melley Ditch	I-07.1 through I-07.2
I-08	Shafer Ditch	I-08.1 through I-08.7
I-09	Victoria Ditch	I-09.1 through I-09.3
I-10	West Ditch	I-10.1 through I-10.7

. For each ditch, a brief narrative of the recommended improvements is presented in conjunction with a map showing the general location of the improvements.



Watershed Component Number	Name
I-01	Anita Supply Ditch/Anita Ditch
I-02	Avent Ditch
I-03	Green Spot Ditch
I-04	Hardscrabble/Williams Ditch
I-05	Harmony Ditch
I-06	Highland Ditch
I-07	Melley Ditch
I-08	Shafer Ditch
I-09	Victoria Ditch
I-10	West Ditch

Legend
Streams
Cities
Nowood Watershed
County Boundary
I-03 Inventoried Irrigation Ditch

0 5 10 Miles

Figure 4.1 Nowood River Watershed Plan: Irrigation System Components

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4.2.1.1 Irrigation Component I-01: Anita Ditch

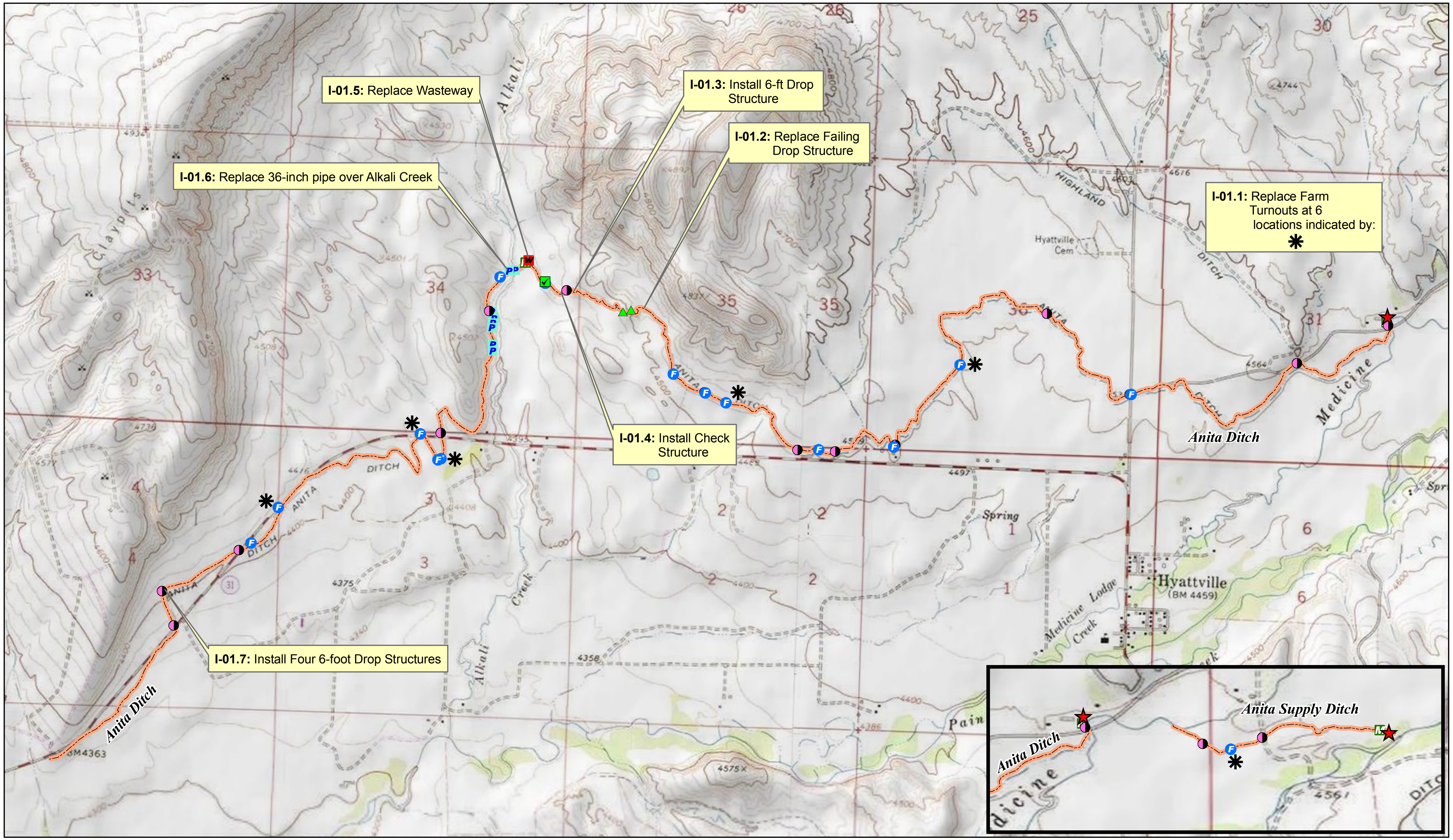
Based upon the results of the field inventory and evaluation of the Anita Ditch and the Anita Supply Ditch and input from ditch representatives, the following recommendations for improvements are made. Figure 4.2 shows the location of these improvements.

- **Item No. I-01.1**: Six farm turnouts were observed which appeared to be either failing or nonfunctional and should be replaced. This number includes turnouts consisting of improvised non-gated structures.
- **Item No. I-01.2:** The existing drop structure and concrete chute near Alkali Creek is failing and in need of replacement. This structure is included as a line item in the rehabilitation plan, however, it is our understanding that the structure is already approved for reconstruction and funding has been procured. Consequently, no cost estimate is included in this study.
- **Item No. I-01.3**: An existing headcut threatens the integrity of the ditch. Currently, the headcut appears arrested by resistant bedrock; however, bank erosion could cause the ditch to migrate laterally. A drop structure is recommended at this location.
- **Item No. I-01.4**: A check structure is recommended at the location of an improvised wood / wire fence check structure.
- **Item No. I-01.5**: The Alkali Creek Wasteway is in poor condition and replacement is recommended.
- **Item No. I-01.6**: The Alkali Creek siphon is in poor condition and should be rehabilitated. The inlet and outlet structures appear to be in fair to good condition. However, the pipeline crossing the creek is in poor condition and should be replaced.
- **Item No. I-01.7**: Near the tail-end of the delivery system, the ditch drops down slope to a culvert crossing under County Road 31. This reach is highly unstable and erosive. A series of four drop structures, (approximately 6-ft high each) are recommended at this location.

4.2.1.2 Irrigation Component I-02: Avent Ditch

Based upon the results of the field inventory and evaluation of the Avent Ditch and input from ditch representatives, the following recommendations for improvements are made. Figure 4.3 shows the location of these improvements.

- **Item No. I-02.1**: A wasteway / spill structure located approximately 4,500 feet downstream of the ditch headgate is failing and appears nonfunctional. This structure is recommended for replacement.
- **Item No. I-02.2:** The inlet to the pipe drop structure is generally in fair condition, however, the corrugated metal pipe comprising the bulk of the structure is deteriorating and replacement is recommended. In addition, cracks in the structure’s inlet should be repaired.



Legend

Canal Headgate	Drop Structure	Measurement Device	Splitter Box
Check Structure	Farm Turnout	Pipe Inlet/Outlet	Wasteway
Culvert	Lined Reach	Siphon Inlet/Outlet	Open Ditch

0 2,000 4,000
Feet

Figure 4.2 Irrigation Component I-1: Anita Ditch Rehabilitation Plan

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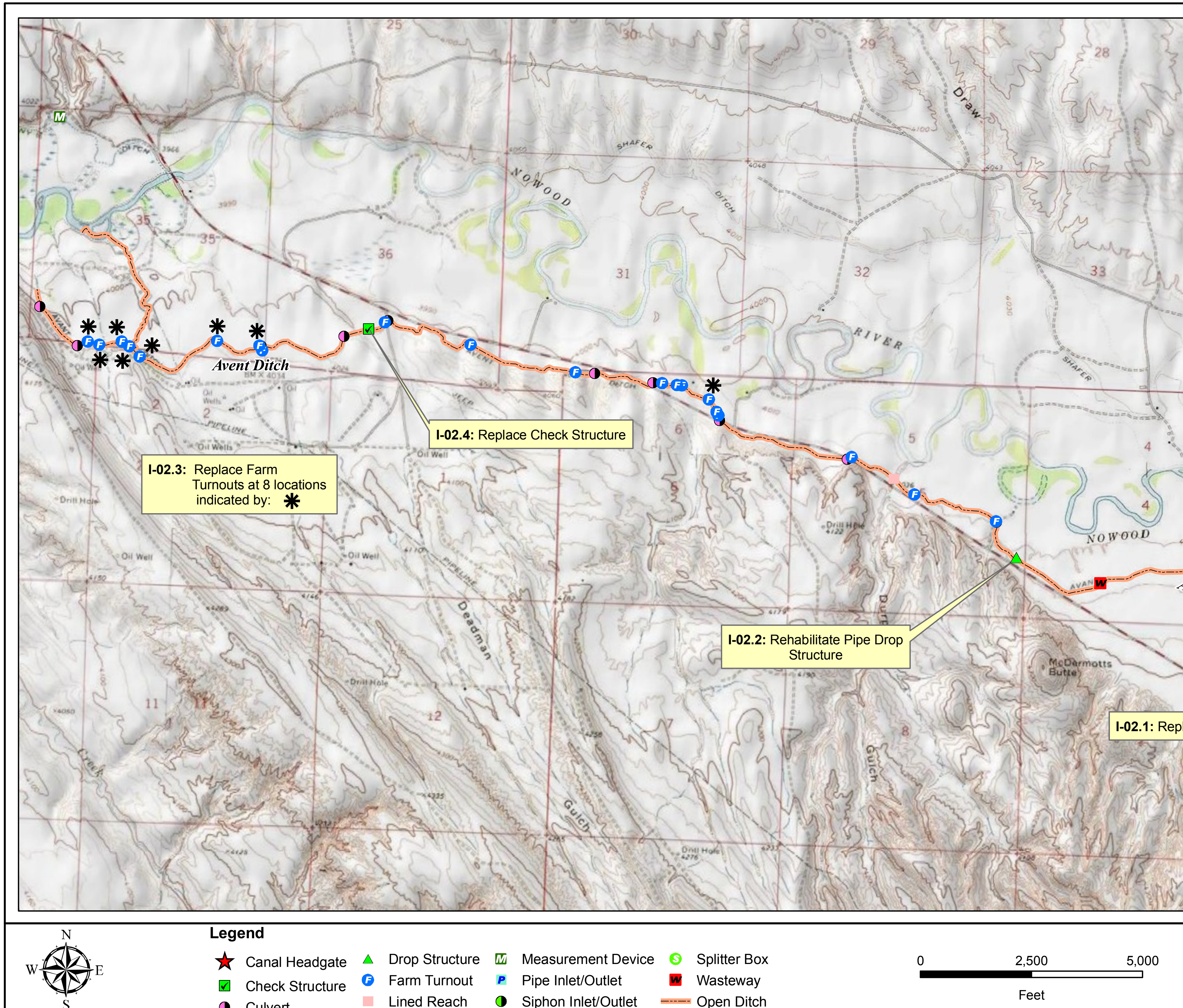

Figure 4.3 Irrigation Component I-2: Avent Ditch Rehabilitation Plan

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- **Item No. I-02.3:** Nine (9) farm turnouts were observed which appeared to be either failing or nonfunctional and should be replaced. This number includes turnouts consisting of non-gated improvised structures.
- **Item No. I-02.4:** A check structure classified as being in 'poor' or 'failing' condition should be replaced.

4.2.1.3 Irrigation Component I-03: Green Spot Ditch

At the request of the ditch owner, the headgate of the Green Spot Ditch was inventoried and included in the watershed plan. The remainder of the ditch was not inventoried, consequently, there are no recommendations regarding the remainder of the ditch. Based upon the results of the field inspection of the ditch headgate, the following recommendation is provided. Figure 4.4 displays the location of this improvement and the general layout of the Green Spot Ditch system.

- **Item No. I-03.1:** The ditch headgate appears to be in poor condition and replacement is recommended.

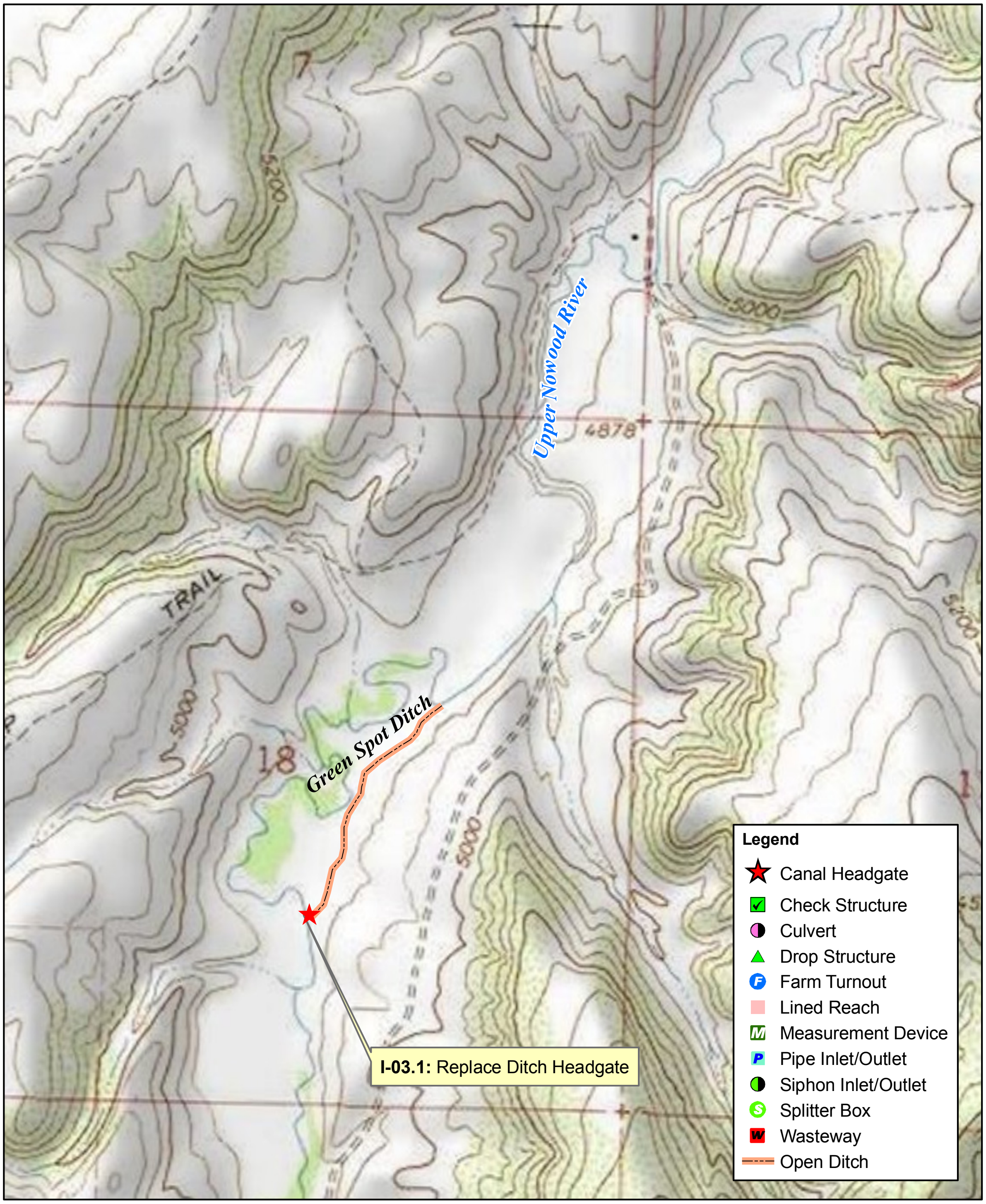
4.2.1.4 Irrigation Component I-04: Hardscrabble Ditch / Williams Ditch

The Hardscrabble Ditch / Williams Ditch system realizes the benefits of a productive artesian well located in the central portion of the system. Under the existing configuration, the well can supply supplemental water to either ditch. The Hardscrabble Ditch system includes approximately 2,200 linear feet of buried pipeline supplying a side roll sprinkler system. Based upon the results of the field inventory and input from the ditch owner, the following recommendations for improvements are made. Figure 4.5 shows the location of these improvements.

- **Item No. I-04.1:** The Williams Ditch headgate was determined to be in 'poor' condition and is recommended for replacement**.**
- **Item No. I-04.2:** Based upon input received from the ditch owner, the existing pipeline and side roll sprinkler system require frequent maintenance due to transmission of debris into the closed system. Consequently, an NRCS-style bubbler filter mechanism is recommended. Included in the installation would be approximately 100 linear feet of 10-inch PVC pipeline connecting the bubbler to the open ditch. In addition, the system should include connection to the existing pipeline from the artesian well.

4.2.1.5 Irrigation Component I-05: Harmony Ditch

The Harmony Ditch headgate has recently been replaced and it our understanding that it functions well and diversions are feasible at a range of river flows under the existing configuration. Consequently, there are no recommendations pertaining to this site. However, based upon the results of the field inventory and evaluation of the Harmony Ditch and input from ditch representatives, the



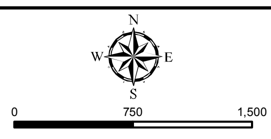


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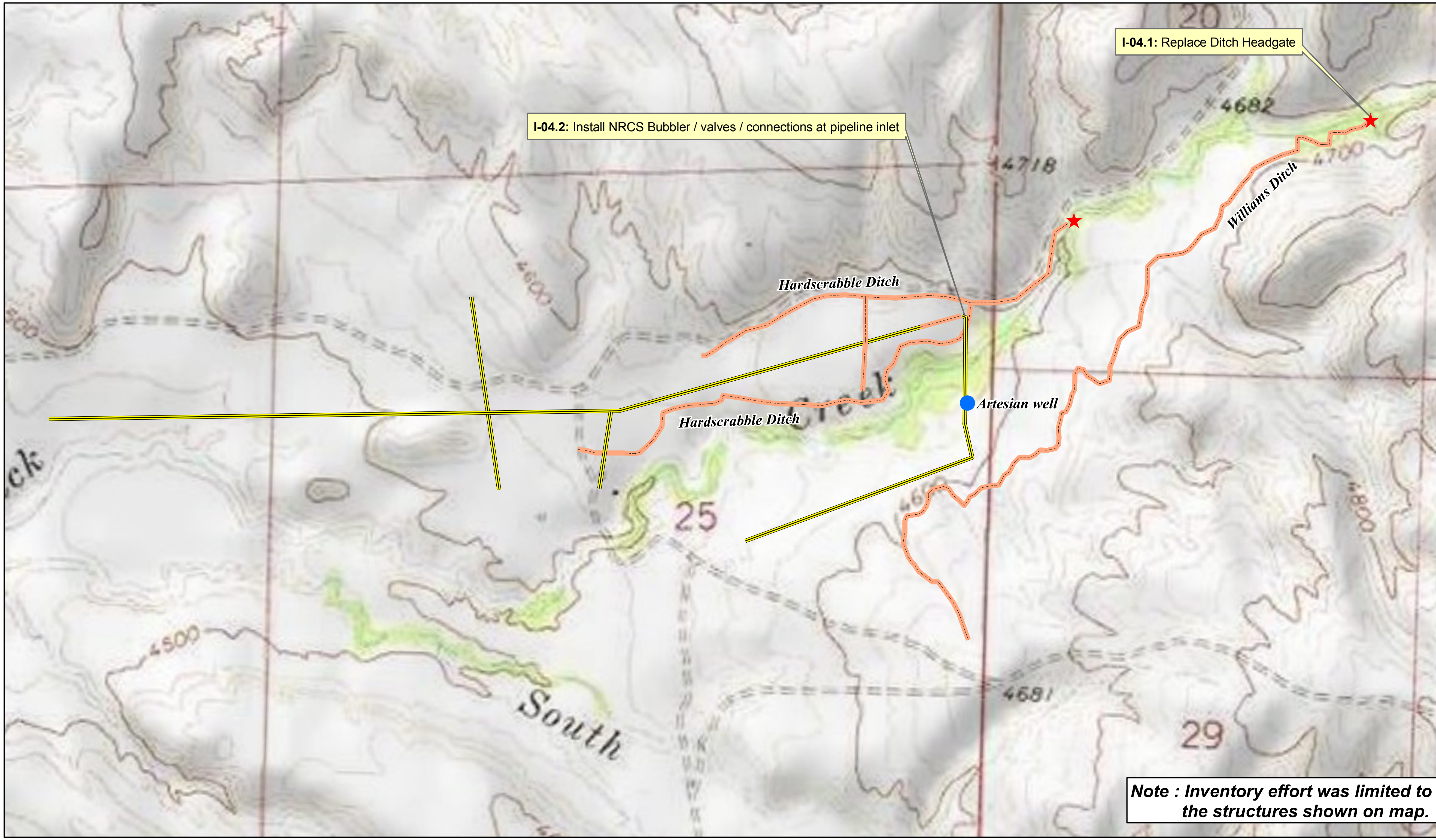
Figure 4.4 Irrigation Component I-3: Green Spot Ditch Rehabilitation Plan



N
W E
S

Legend

- Canal Headgate
- Check Structure
- Culvert
- Drop Structure
- Farm Turnout
- Lined Reach
- Measurement Device
- Pipe Inlet/Outlet
- Siphon Inlet/Outlet
- Splitter Box
- Wasteway
- Open Ditch
- Existing Pipe

0 1,000 2,000
Feet

Figure 4.5 Irrigation Component I-4: Hardscrabble / Williams Ditch Rehabilitation Plan

P:\WYWDC29_Nowood\GIS\Figures\Ditch_Rehab_Figures\Hardscrabble_Williams_Rehab.mxd following recommendations for improvements are made. Figure 4.6 shows the location of these improvements.

- **I-05.1**: The existing Parshall flume appears to be deteriorating with age and should be replaced.
- **I-05.2**: A check structure should be installed at this location.
- **I-05.3**: The existing check / drop structure is in poor condition and deteriorating with age. Replacement is recommended.
- **I-05.4**: A check structure should be installed at this location.
- **I-05.5:** Ten (10) farm turnouts were observed which appeared to be either failing or nonfunctional and should be replaced. This number includes turnouts consisting of non-gated improvised structures.
- **Item No. I-05.6:** It is our understanding the existing culvert is not needed, consequently it is recommended that this structure be removed. A check structure is then recommended for construction at this location.
- **Item No. I-05.7** Replace failing drop structure.
- **Item I-05.8 through I-05.10:** A check structure should be installed or replaced at each of these locations.
- **Item No. I-05.11:** A gated wasteway structure is recommended for this location at the tail end of the ditch system to facilitate control of operational waste.

4.2.1.6 Irrigation Component I-06: Highland Ditch

Based upon the results of the field inventory and evaluation of the Highland Ditch and input from ditch representatives, the following recommendations for improvements are made. Figure 4.7 shows the location of these improvements.

- **Item No. I-06.1:** The ditch headgate appears to be experiencing degradation with age and replacement is recommended.
- **Item No. I-06.2:** Five (5) farm turnouts were observed which appeared to be either failing or nonfunctional and should be replaced. This number includes turnouts consisting of non-gated improvised structures.
- **Item No. I-06.3:** A 60-inch diameter culvert (CMP) is deteriorated and replacement is recommended.
- **Item No. I-06.4:** A 24-inch diameter culvert (CMP) is deteriorated and replacement is recommended.
- **Item No. I-06.5:** The wasteway located near the tail-end of the ditch lacks rails for control of check boards. Rehabilitation of this structure by attaching rails and checkboards is recommended to improve functionality of the ditch.

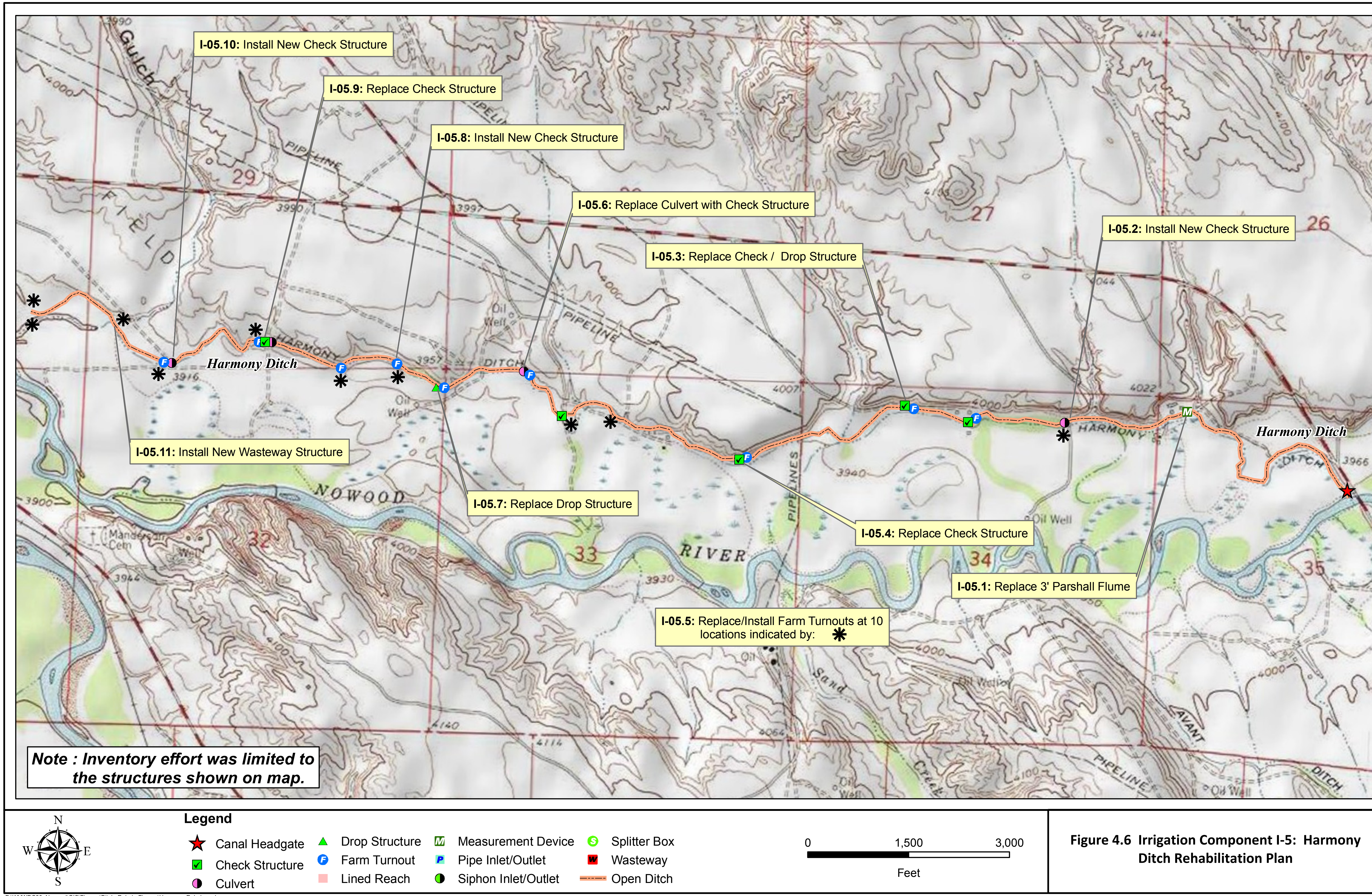


Figure 4.6 Irrigation Component I-5: Harmony Ditch Rehabilitation Plan

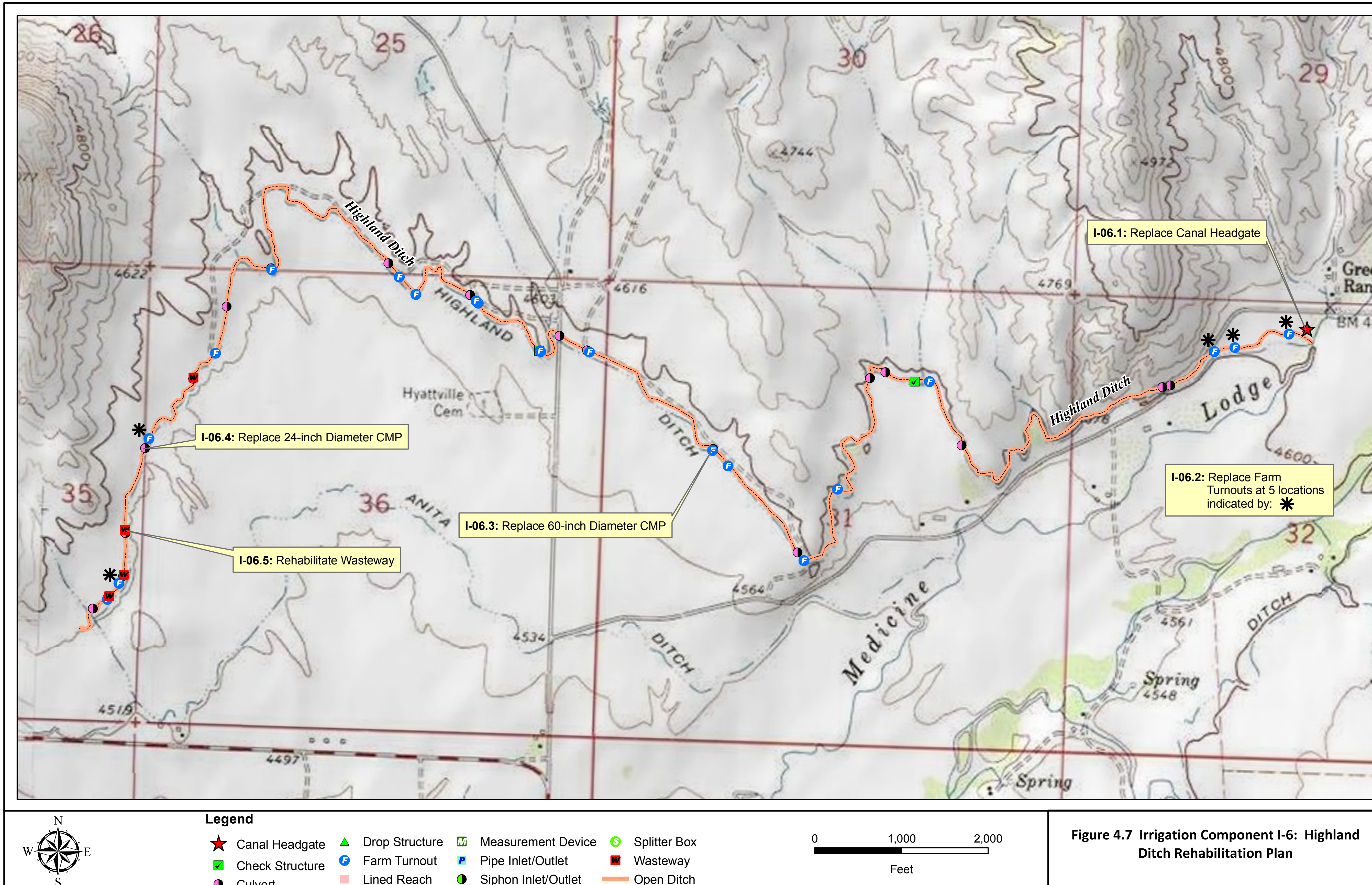


Figure 4.7 Irrigation Component I-6: Highland Ditch Rehabilitation Plan

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4.2.1.7 Watershed Plan Component I-07: Melley Ditch

Based upon the results of the field inventory and evaluation of the Melley Ditch and input from the ditch owner, the following recommendations for improvements are made. Figure 4.8 shows the location of these improvements.

- **Item No. I-07.1:** The lower portions of the Melley Ditch are reported to suffer significant seepage losses and management of ditch flow is problematic. Consequently, installation of approximately 3,800 linear feet of buried pipeline is recommended. Approximately five (5) farm turnouts would likely be required.
- **Item No. I-07.2:** There is currently no diversion structure or headgate on Brokenback Creek where the Melley Ditch originates. Consequently, construction of a diversion structure on Brokenback and a canal headgate are recommended.

4.2.1.8 Watershed Plan Component I-08: Shafer Ditch

Ditch representatives reported that sediment and general low slope of the Shafer Ditch create operational and management issues. Based upon the results of the field inventory and evaluation of the Shafer Ditch and input from ditch representatives, the following recommendations for improvements are made. Figure 4.9 shows the location of these improvements.

- **Item No. I-08.1:** The existing headgate structure located adjacent to the Nowood River has no control mechanism, catches debris, and essentially serves no remaining useful purpose. This watershed plan component recommends removal of this structure in conjunction with replacement as recommended under Watershed Plan Component No I-08.2.
- **Item No. I-08.2:** Construction of a new headgate is recommended at this location. The structure should include a spillway to enable excess flows to be spilled back to the Nowood River. In an effort to reduce entrainment of sediment into the ditch system, a sediment sluice gate should be installed.
- **Item No. I-08.3:** Six (6) farm turnouts were observed which appeared to be either failing or nonfunctional and should be replaced. This number includes turnouts consisting of non-gated improvised structures.
- **Item No. I-08.4:** A check structure at this location is in poor condition and replacement is recommended.
- **Item No. I-08.5:** The check structure at this location should be rehabilitated to improve management capabilities of the ditch. Rails to control check boards should be installed.
- **Item No. I-08.6:** Approximately 2,000 linear feet of the ditch is choked with dense vegetation which retards ditch conveyance and contributes to system losses through seepage and evapotranspiration. This reach of the ditch should be treated and cleared of excess vegetation.
- **Item No. I-08.7:** Seepage was apparent through a reach approximately 1,500 feet long. Lining of this reach with a Geotextile material is recommended.

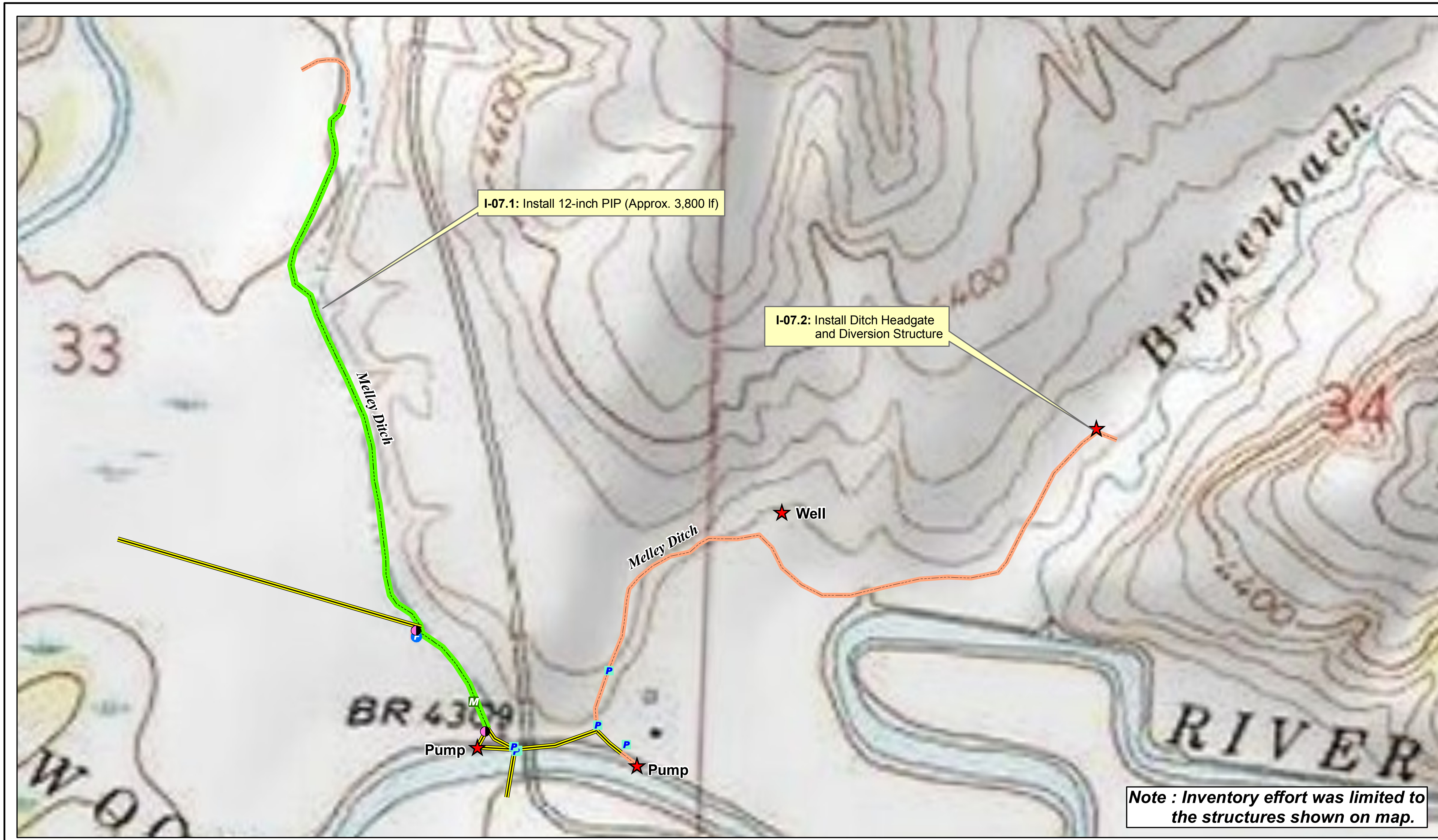

Figure 4.8 Irrigation Component I-7: Melley Ditch Rehabilitation Plan

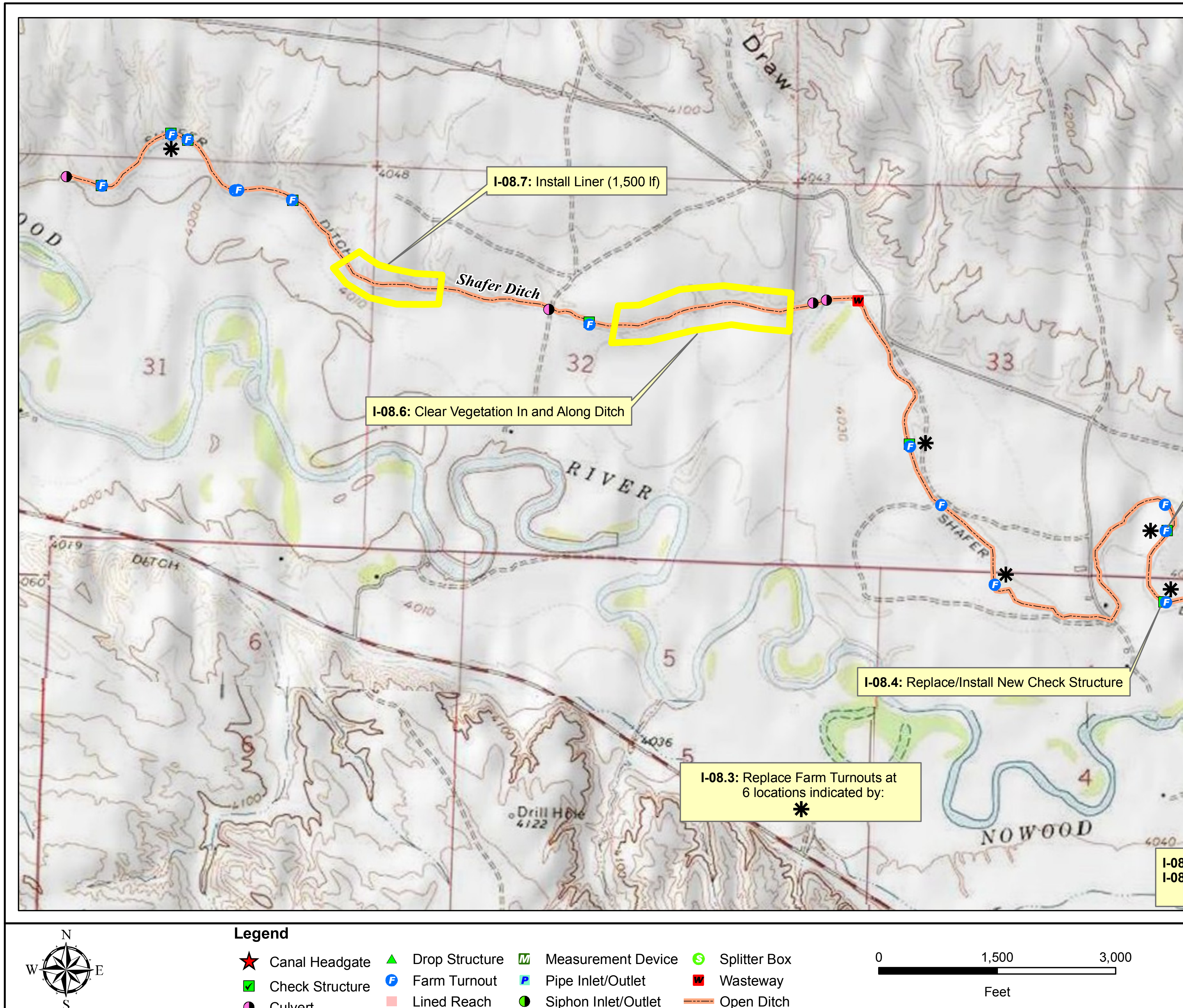

Figure 4.9 Irrigation Component I-8: Shafer Ditch Rehabilitation Plan

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4.2.1.9 Watershed Plan Component I-09: Victoria Ditch

Based upon the results of the field inventory and evaluation of the Shafer Ditch and input from ditch representatives, the following recommendations for improvements are made. Figure 4.10 shows the location of these improvements. It must be noted that portions of the ditch were not inventoried due to ownership constraints.

- **Item No. I-09.1:** The ditch headgate appears to be experiencing degradation with age and replacement is recommended.
- **Item No. I-09.2:** Three (3) farm turnouts were observed which appeared to be either failing or nonfunctional and should be replaced. This number includes turnouts consisting of non-gated improvised structures.
- **Item No. I-09.3:** The ditch is currently open in a 100-ft reach between Cottonwood Street in the Town of Tensleep and the point where it empties from a buried 12-inch diameter pipeline through town. Extension of the concrete pipeline and connecting with the culvert under the road is recommended. The existing configuration appears to limit opportunities to improve Cottonwood Street. Under the existing configuration, surface runoff from the area upslope (north) is captured by the ditch. Consequently, a storm drain inlet is recommended at this location to mitigate potential flooding of downslope properties should the improvement be completed. It is also our understanding that the site is used as a source of livestock watering during cattle drives down the road. This recommended improvement would maintain an open source of water on the downstream side of Cottonwood Street which could be used during these operations.
- **Item No. I-09.4:** A recently constructed check structure located in the lower reaches of the ditch has been rendered useless following bypass of flows around the structure. The structure was not properly tied into ditch banks. This recommended improvement calls for rehabilitation of the structure by adding concrete wingwalls which would tie the structure into the ditch banks.

4.2.1.10 Watershed Plan Component I-10: West Ditch

Based upon the results of the field inventory and evaluation of the West Ditch and input from ditch representatives, the following recommendations for improvements are made. Figure 4.11 shows the location of these improvements.

- **Item No. I-10.1:** The ditch headgate appears to be experiencing degradation with age and replacement is recommended. Ditch representatives report the headgate is aged and extremely difficult to operate.
- **Item No. I-10.2:** The initial wasteway structure was classified as being in ‘poor’ condition and replacement is recommended.
- **Item No. I-10.3:** The existing 5-ft Parshall flume appears to be deteriorating with age and should be replaced.

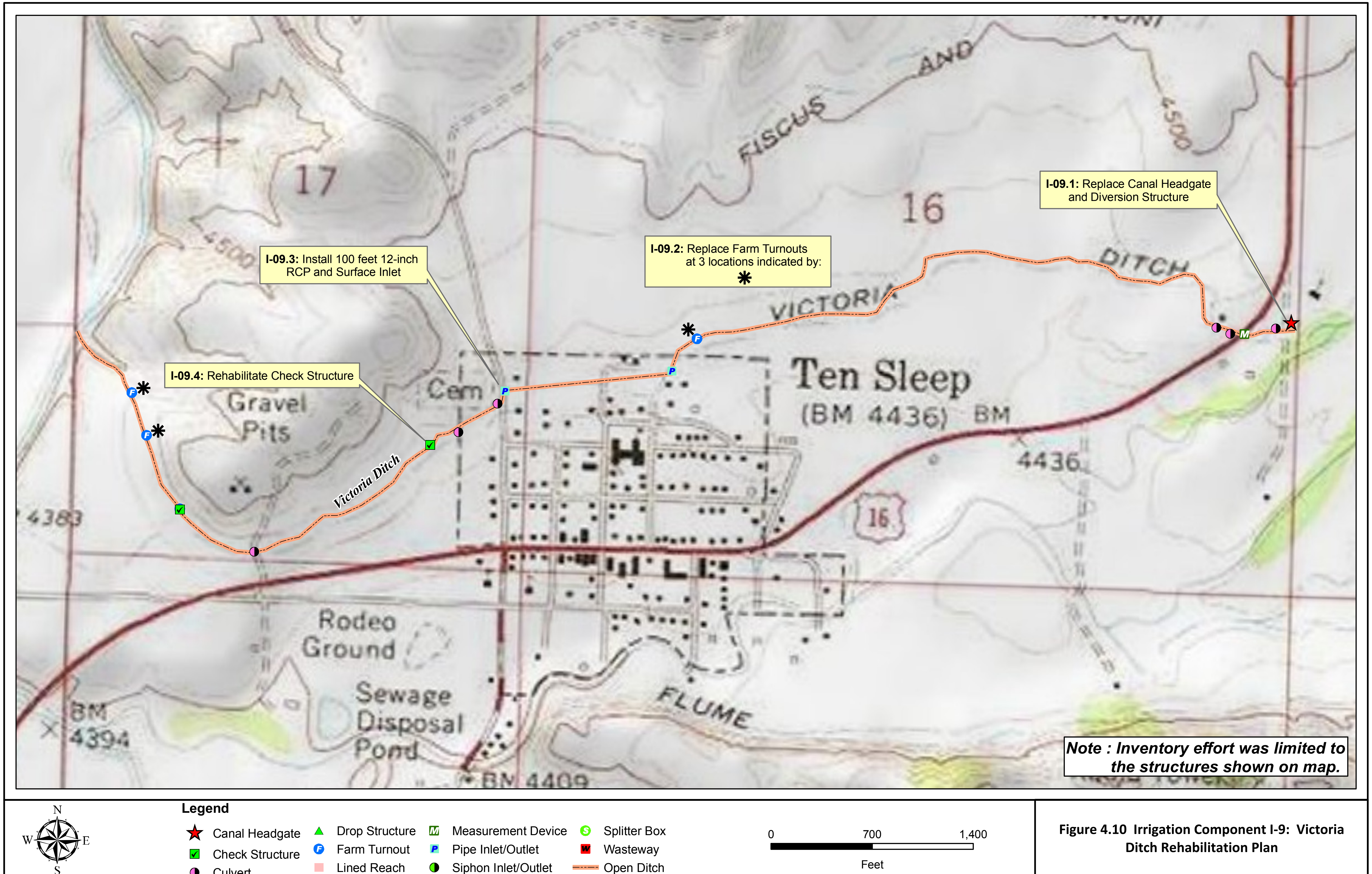

Figure 4.10 Irrigation Component I-9: Victoria Ditch Rehabilitation Plan

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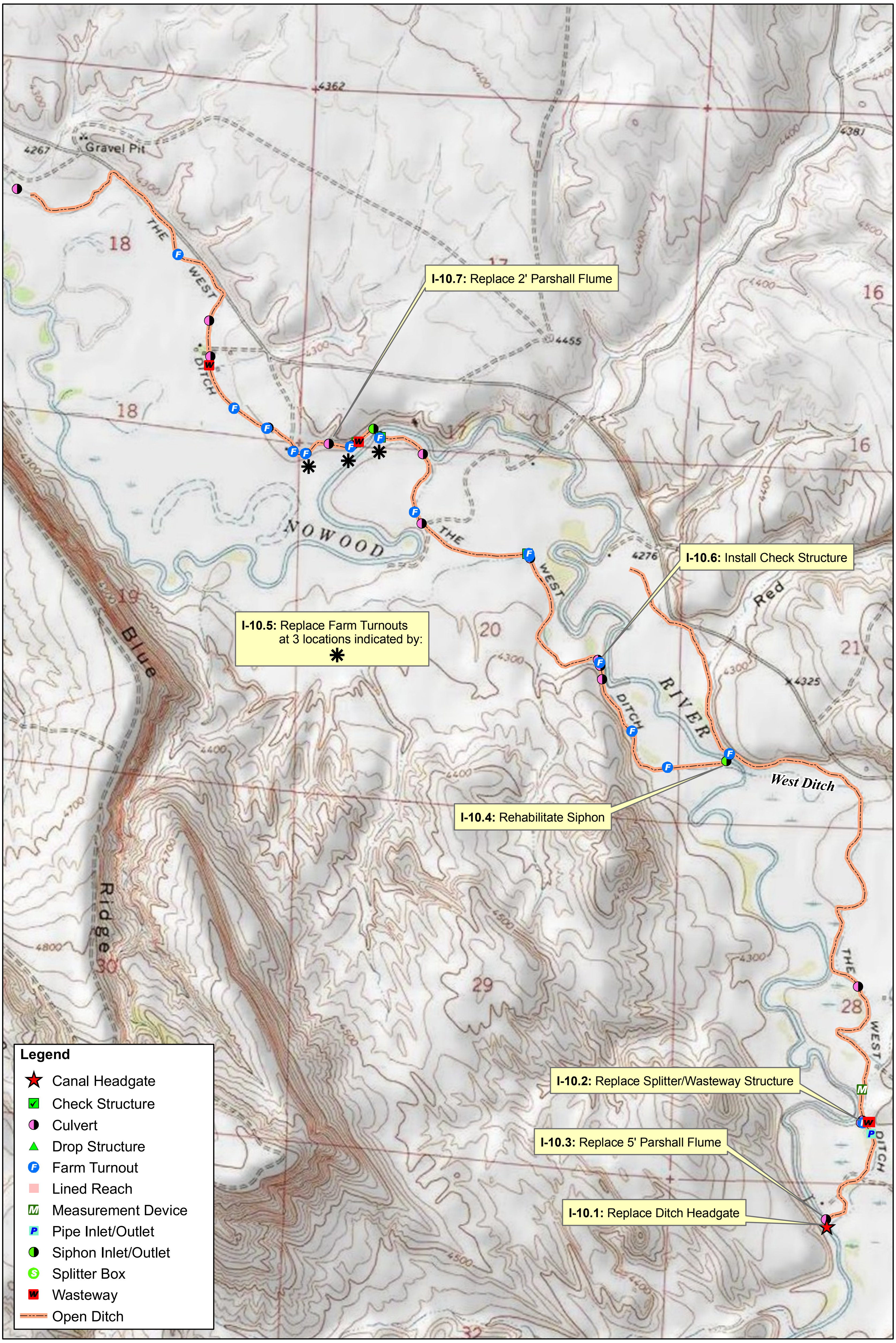

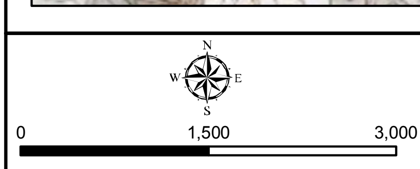

Figure 4.11 Irrigation Component I-10: West Ditch Rehabilitation Plan

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- **Item No. I-10.4:** The siphon under the Nowood River is in need of rehabilitation. The inlet and outlet portions of the structure appear to be in 'fair' to 'good' condition, however, the siphon portion of the structure (18-inch diameter) leaks and is in need of replacement. Under this improvement recommendation, the siphon portion of the structure would be replaced and tied into the existing inlet and outlets.
- **Item No. I-10.5:** Eight (8) farm turnouts were observed which appeared to be either failing or nonfunctional and should be replaced. This number includes turnouts consisting of non-gated improvised structures.
- **Item No. I-10.6:** A check structure is recommended at this location.
- **Item No. I-10.7:** The existing 2-foot Parshall flume appears to be deteriorating with age and should be replaced.

4.3 Upland Wildlife/Livestock Watering Sources

4.3.1 Alternative New Watering Opportunities

There are numerous opportunities present within the project study area to develop additional upland water supplies for livestock/wildlife watering opportunities. Potential sources which could be utilized include existing wells which are permitted for stock watering uses, springs, and stock reservoirs. The springs and wells represent a major portion of the potential water sources available to develop as individual watering sites or to use to feed multiple sites utilizing a pipeline/tank system. Springs flowing in excess of about 2 gallons per minute could be developed and provide additional upland sources. Newly constructed or rehabilitated stock reservoirs could provide upland water sources where wells or springs are not available. These could provide at least seasonal watering in locations which could open underutilized range lands to more productive use. Figure 4.12 displays the location of these potential sources. Included in this figure are:

- Stock ponds classified as 'viable' as discussed in Chapter 3;
- Spring locations determined from USGS topographic mapping and additional sources; and
- Permitted wells with livestock watering listed as a permitted use.

Given the relatively gentle topography throughout the majority of the watershed, existing water sources were assumed to be capable of providing water to livestock within a one-mile radius. It is understood that the effective radius around a water source could be shorter depending upon numerous factors including topography, natural and man-made barriers, etc. However, for the purposes of the Level 1 study, one-mile was assumed to be a reasonable radius to use for planning purposes. Based upon this premise, buffers were drawn around documented existing water sources described in Chapter 3 and included in Figure 4.12. It must be remembered that there are additional sources which are not indicated on this figure. A limited number of pipeline/tank projects have been constructed on federal lands, however, mapping of their locations was not available. *Final planning and design of additional upland wildlife / livestock water sources should include onsite consultation with BLM, landowners, and allotment permittees to verify location of the planned improvements in relation to existing sources.*

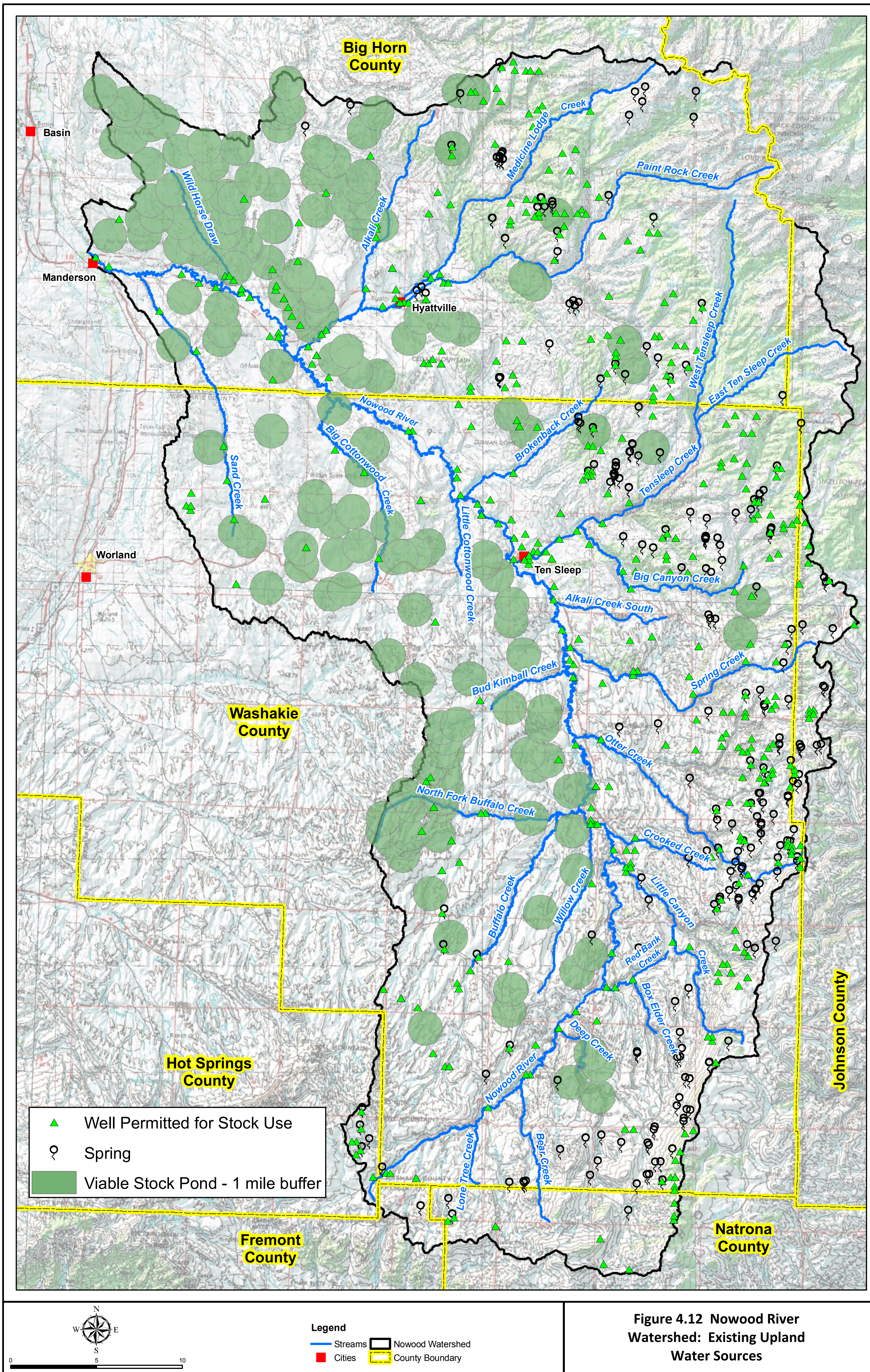

Figure 4.12 Nowood River Watershed: Existing Upland Water Sources

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One of the objectives of this phase of the project was to evaluate alternatives to surface water streams as water sources for wildlife and livestock. Consequently, Figure 4.12 does not show buffers about perennial / intermittent streams. As indicated in this figure, a large portion of the watershed appears to be adequately supplied with water sources. However, it must be kept in mind that the figure shows stock reservoirs which contained water at the time the aerial photography was obtained. The time between the previous precipitation event and the completion of the aerial photography is not known. Consequently, the length of time that the reservoirs are viable is also unknown. This factor underscores that fact that livestock water reservoirs are often an unreliable source and are not viable when needed in a rotation system of grazing. On a site specific basis, this conclusion should be verified with the individual landowner, allotment permittee, or BLM. In addition, linear projects do exist which are not included within the figure because there was inadequate mapping information to display them.

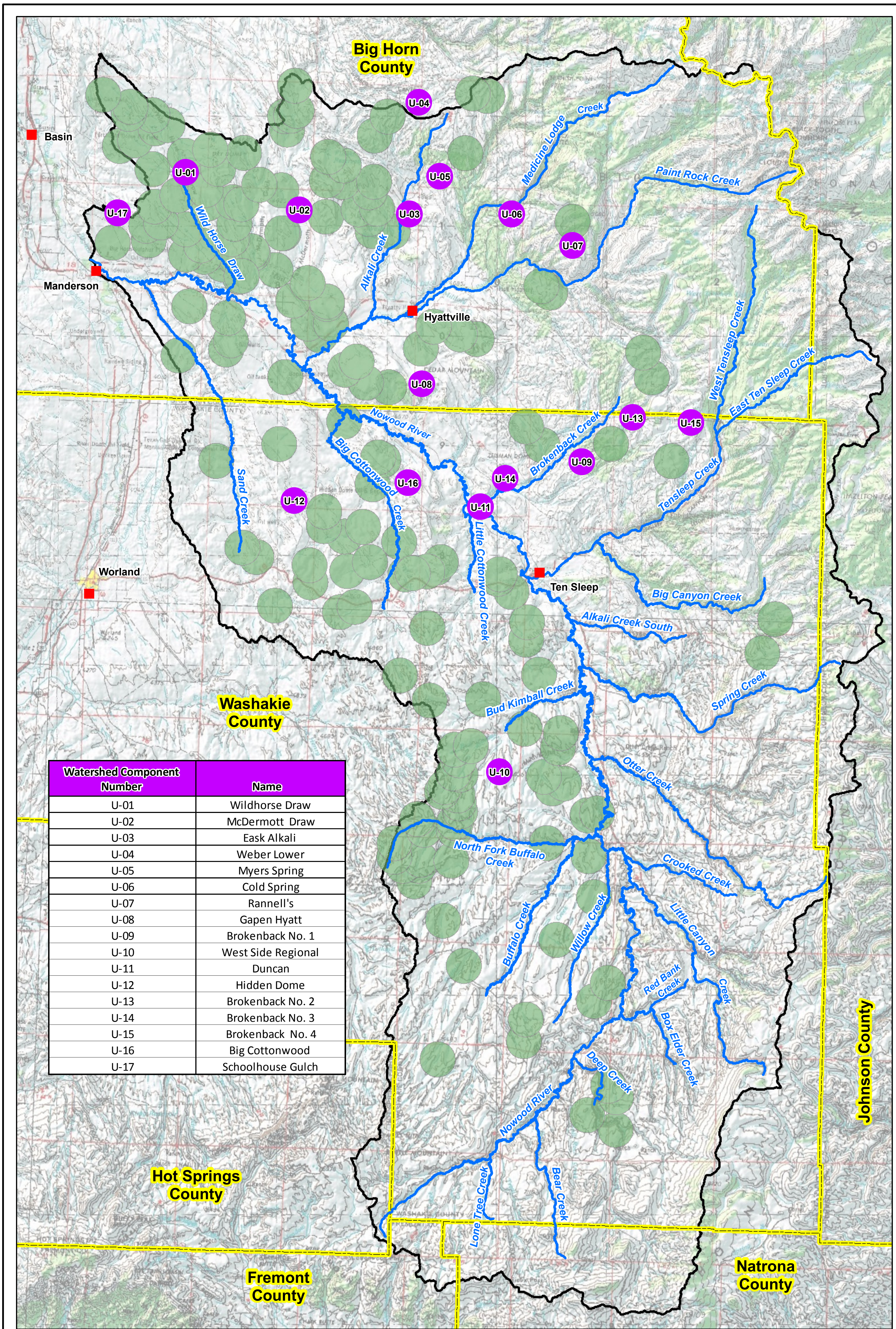
In the Appendix G, various alternative types of watering improvements/developments are described in more detail. These alternative water source improvements include:

- Spring developments,
- Existing Wells with conventional windmills, wind turbines and combined solar / wind systems,
- New Wells,
- Pipeline / tank systems,
- Stock ponds,
- Storage reservoirs, and
- Guzzlers.

Note that alternative watering tanks applicable to use with essentially any of the water sources are addressed in the discussion of pipeline / tank systems. Options for power where pumping is required is also presented in Appendix G.

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 and from project questionnaires mailed to landowners within the watershed. 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 provide 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 4.2. Figure 4.13 displays the general location of all livestock/wildlife water opportunity projects.



Watershed Component Number	Name
U-01	Wildhorse Draw
U-02	McDermott Draw
U-03	Eask Alkali
U-04	Weber Lower
U-05	Myers Spring
U-06	Cold Spring
U-07	Rannell's
U-08	Gapen Hyatt
U-09	Brokenback No. 1
U-10	West Side Regional
U-11	Duncan
U-12	Hidden Dome
U-13	Brokenback No. 2
U-14	Brokenback No. 3
U-15	Brokenback No. 4
U-16	Big Cottonwood
U-17	Schoolhouse Gulch

N W E S

0 5 10 Miles

Legend

- Reservoirs With Water / 1 Mile Buffer
- Streams
- Cities
- Nowood Watershed
- County Boundary
- U-12 Upland Water Project

Figure 4.13 Nowood River Watershed Plan: Upland Water Development Components

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Table 4.2 Summary of Wildlife/Livestock Water Development Components of the Watershed Management Plan

Watershed Plan Component	Ditch
U-01	Wildhorse Draw Pipeline Project
U-02	McDermott Draw Pipeline Project
U-03	East Alkali Pipeline Project
U-04	Weber Lower Pipeline Project
U-05	Myers Spring Pipeline Project
U-06	Cold Spring Pipeline Project
U-07	Rannell's Pipeline Project
U-08	Gapen Hyatt Pipeline Project
U-09	Brokenback No-1 Pipeline Project
U-10	West Side Regional Pipeline Project
U-11	Duncan Pipeline Project
U-12	Hidden Dome Pipeline Project
U-13	Brokenback No. 2 Pipeline Project
U-14	Brokenback No. 3 Pipeline Project
U-15	Brokenback No. 4 Project
U-16	Big Cottonwood Pipeline Project
U-17	Schoolhouse Gulch Pipeline Project

Each of the upland water development projects would 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 indentified 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.

4.3.2.1 Watershed Plan Component No. U-01: Wildhorse Draw Pipeline Project

The objective of this project would be to enhance water distribution in the northern portion of the watershed. Specifically, the project would result in a reliable source of water for livestock and wildlife in an area dominated by seasonally available water at existing stock reservoirs. The project would provide benefits within four allotments. Figure 4.14 displays the general configuration of this alternative. This project is intended to provide a viable source of wildlife/livestock water in an area where upland water sources consist primarily of small and unreliable stock ponds.

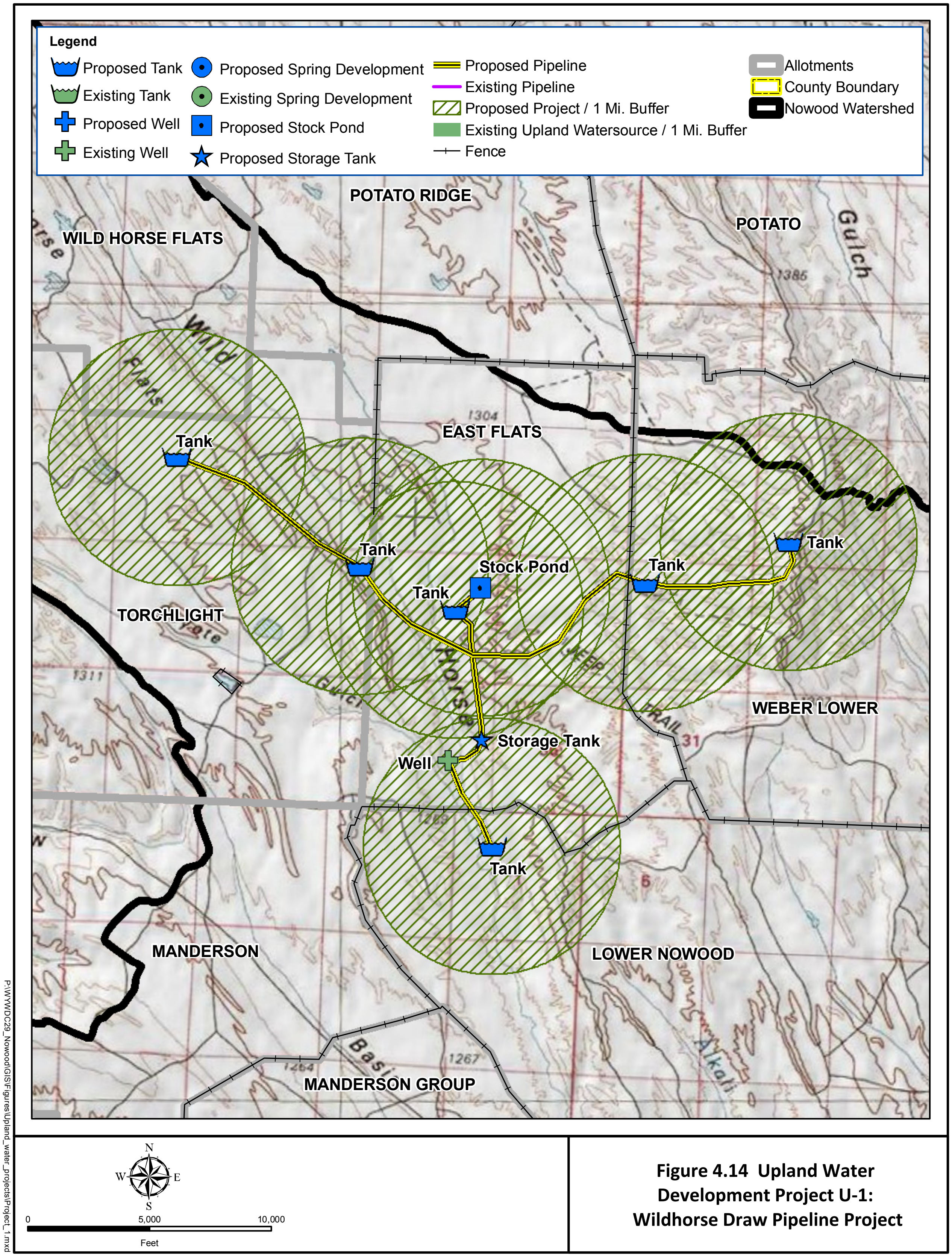


Figure 4.14 Upland Water Development Project U-1: Wildhorse Draw Pipeline Project

The project would utilize an existing well permitted to the Bureau of Land Management (Lite Butte Federal #3 Well, Permit No P105151W). Based upon review of the WSEO database, the well is artesian, is 4,250 feet deep and has a yield of 225 gallons per minute. It is our understanding that actual yield is less than this amount. Construction of the project would be contingent upon obtaining permission for use of the well from the BLM and verification of sufficient yield.

Under this alternative, the following components would be utilized:

- The existing well would be equipped with a pump and solar power source in order to pump the water upslope to a storage tank.
- A storage tank (15,000 gallon capacity) would be placed at a high point providing gravity flow conditions to the remainder of the system.
- From the storage tank, a pipeline would run northerly approximately 150 feet to a stock tank. Overflow from the tank would be contained at an existing stock reservoir.
- Pipeline extensions would run easterly to the Weber Lower Allotment and westerly to the Torchlight Allotment. An additional extension would run south to a stock tank in the northern limits of the Lower Nowood Allotment.
- The total length of HDPE pipeline (1.5-inch diameter) would be approximately 54,500 linear feet.
- Six (6) stock tanks (1,200 gallon capacity) would be constructed as indicated in Figure 4.14. Their locations would be selected to optimize management of upland resources.

4.3.2.2 Watershed Plan Component No. U-02: McDermott Draw Pipeline Project

This alternative would involve the completion of a new well in the West Alkali allotment. This portion of the watershed is arid and lacking sufficient upland livestock and wildlife water sources. Surface impoundments exist, however, the availability of water is reported to be tentative. Given the lack of surface water sources or springs in the area, a new well has been identified as the selected alternative. This project provides a reliable source of water to the West Alkali, Airport, Lower Nowood, and Weber Lower allotments. Figure 4.15 displays the general configuration of this alternative.

Under this alternative, the following components would be employed:

- A well would be constructed in the vicinity shown on Figure 4.15. Preliminary evaluation of the Wyoming State Engineers Office (WSEO) database indicates the well would likely be approximately 175 feet deep. Consequently, for the purposes of this investigation and the uncertainty of the hydrogeologic conditions at the site, a depth of 200 feet was used for cost estimation purposes.
- The proposed well would be equipped with a solar pump.
- A storage tank (15,000 gallon capacity) would be installed at the well.
- From the storage tank, a gravity pipeline would be constructed to provide water to five (5) new stock tanks.
- The total length of the HDPE pipeline (1.5-inch diameter) would be approximately 48,800 linear feet.

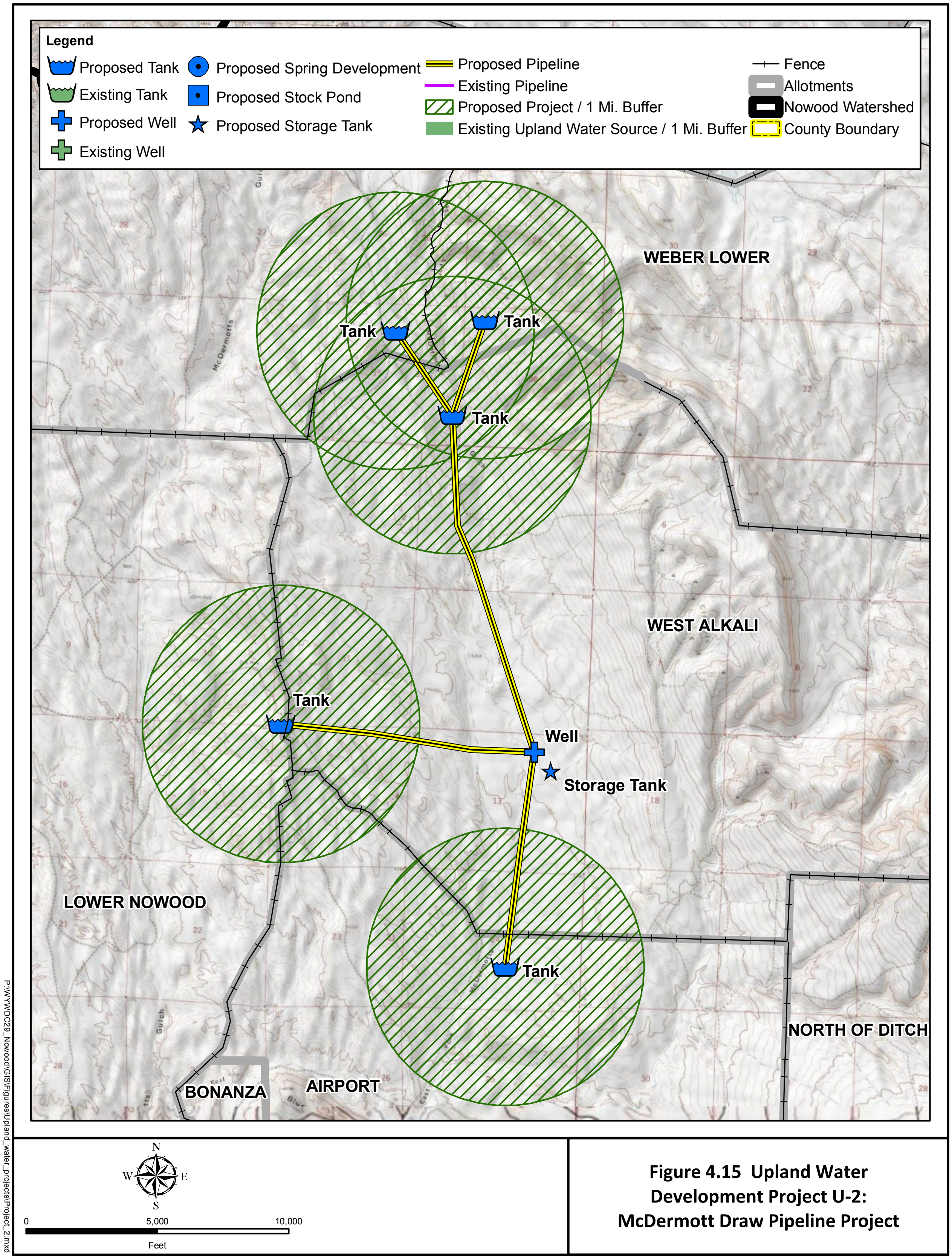


Figure 4.15 Upland Water Development Project U-2: McDermott Draw Pipeline Project

4.3.2.3 Watershed Plan Component No. U-03: East Alkali Pipeline Project

This alternative would utilize an existing well and pipeline system. The existing system consists of approximately 13,500 linear feet of pipeline providing water to three (3) stock tanks. The source of water is an artesian well reported to have adequate yield and pressure to facilitate the expansion. The existing system in located entirely within the East Alkali allotment. Under this alternative, an additional pipeline would be constructed and aligned westerly providing a reliable source of livestock and wildlife water within the West Alkali allotment. Figure 4.16 displays the general configuration of this alternative.

Under this alternative, the following components would be employed:

- An additional pipeline would be added to the existing system. The extension would be approximately 27,500 linear feet.

- Three (3) stock tanks would be constructed within the West Alkali allotment as indicated in Figure 4.16. The location of the stock tanks would be selected to optimize management of upland resources.

4.3.2.4 Watershed Plan Component No. U-04: Weber Lower Pipeline Project

This project is located at the northern limit of the watershed and originates at a spring located just outside of the watershed divide. An existing project would be extended under this project alternative. Figure 4.17 displays the general configuration of this alternative.

Currently, a pipeline / stock tank project originates at Weber Spring. The pipeline currently extends approximately 12,800 feet to the southwest and serves four stock tanks. An additional pipeline tees off of the pipeline and runs westerly along the basin divide providing water to stock tanks located within the Shell Creek watershed. It is our understanding that the spring currently provides an adequate supply to this system but it would not facilitate expansion.

The permittee using the western branch of the system has expressed wishes to complete a groundwater well to provide a source of water to that portion of the existing project. In the event that does happen, expansion of the southerly portion of the project would be feasible. Figure 4.17 displays the general configuration of this alternative and indicates that it would be feasible only if the westerly pipeline obtained a separate source of water.

Under this alternative, the following components would be utilized:

- The existing southerly pipeline would be extended approximately 12,800 linear feet with HDPE 1.5-inch diameter pipe.
- A stock tank (1,200 gallon capacity) would be installed at the end of the pipeline.

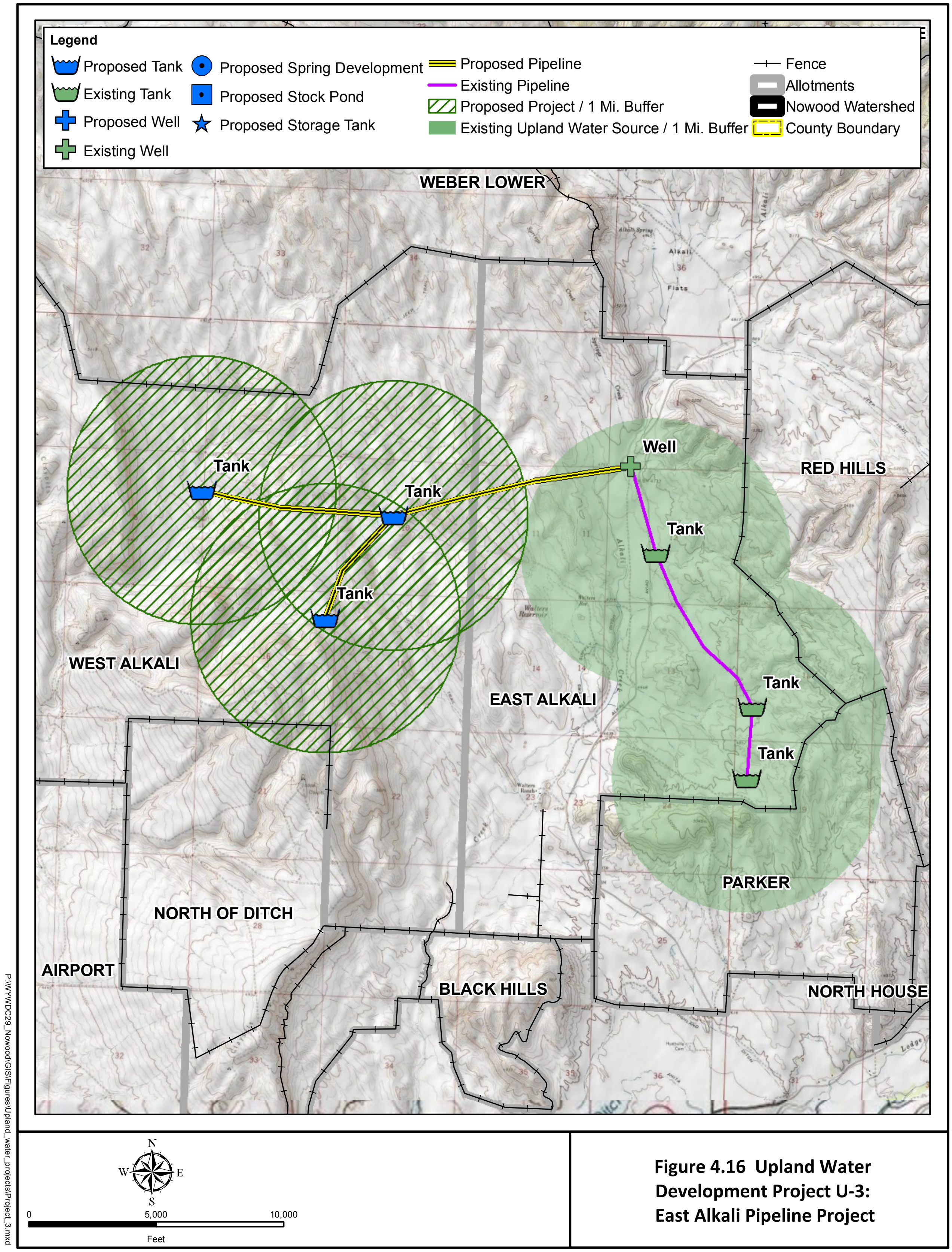


Figure 4.16 Upland Water Development Project U-3: East Alkali Pipeline Project

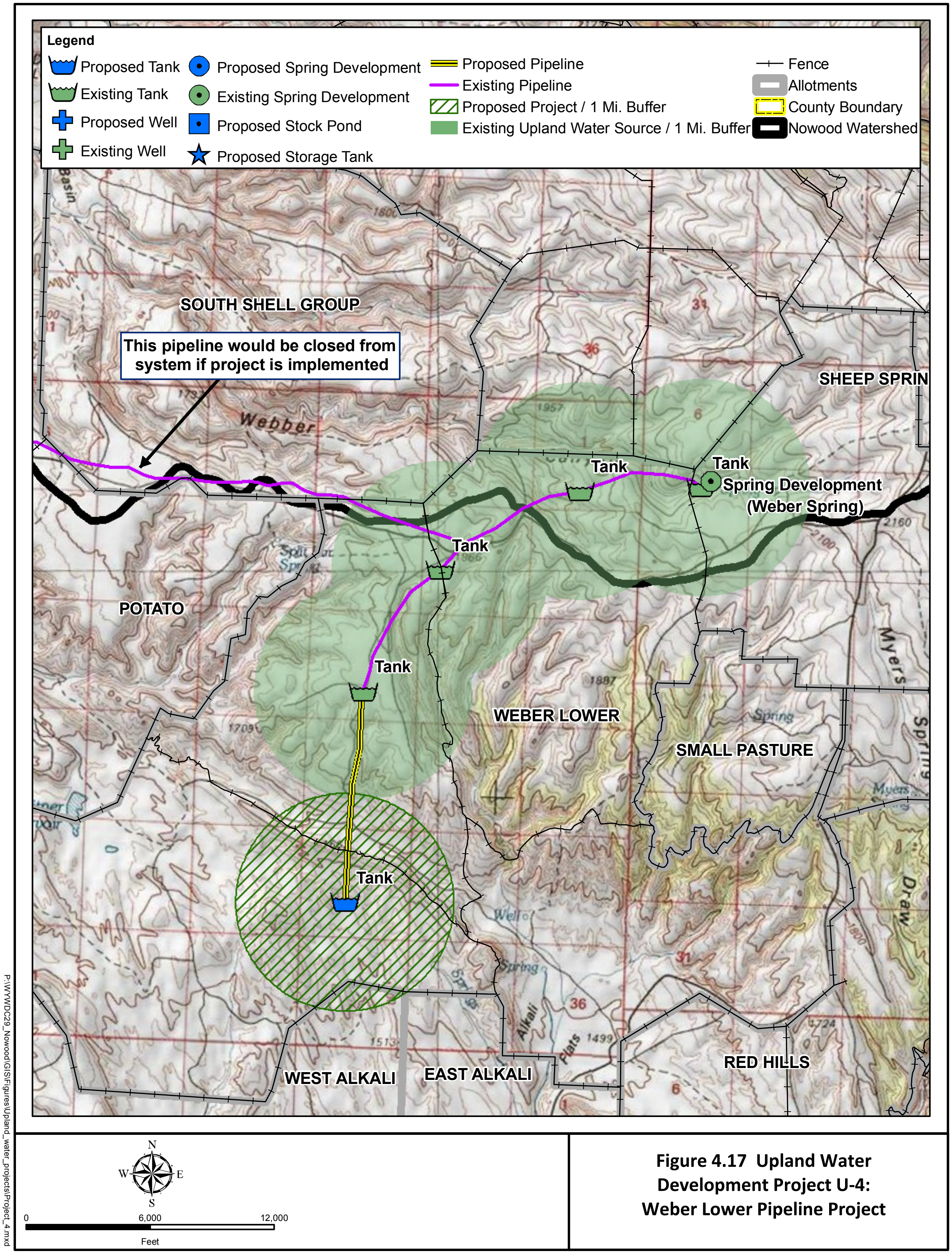


Figure 4.17 Upland Water Development Project U-4: Weber Lower Pipeline Project

4.3.2.5 Watershed Plan Component No. U-5: Myers Spring Pipeline Project

This alternative would develop water available at the Myers Spring located in the Medicine Lodge Creek watershed. The objective of the alternative would be to provide additional reliable water sources within the eastern limits of the Weber Lower allotment. Figure 4.18 displays the general configuration of this alternative. Under this alternative, the following components would be employed:

- An existing spring would be developed to facilitate diversion to a gravity pipeline.
- The pipeline would be routed downslope, generally as indicated in Figure 4.18.
- Approximately 37,500 linear feet of HDPE pipe (1.5-inch diameter) and accompanying valves, connections, vents and fittings would be installed.
- Four (4) stock tanks (1,200 gallon capacity each) would be constructed.

4.3.2.6 Watershed Plan Component No.U-06: Cold Spring Pipeline Project

This alternative replaces and enhances a system previously constructed but is no longer functional. Under this alternative, an existing spring would be developed. The objective of this alternative would be to provide reliable sources of water for livestock and wildlife within the Cold Springs allotment south of Medicine Lodge Creek. Figure 4.19 displays the general configuration of this alternative. Under this alternative, the following components would be employed:

- Existing springs in the vicinity of the confluence of Medicine Lodge Creek and Captain Jack Creek would be developed to facilitate diversion to a gravity pipeline.
- The pipeline would cross Captain Jack Creek and be aligned along the south side of the Medicine Lodge canyon. The total length of buried HDPE pipeline (1.5-inch diameter) would be approximately 24,300 lineal feet.
- Three (3) stock tanks (1,200 gallon capacity each) would be constructed.
- A small stock reservoir would be supplied by the pipeline. Capacity of the reservoir would be less than 5 acre feet.

4.3.2.7 Watershed Plan Component No. U-07: Rannell's Pipeline Project

Under this alternative, an existing spring would be developed. The objective of this alternative would be to provide reliable sources of water for livestock and wildlife within the Rannell's allotment north of Paint Rock Canyon. Figure 4.20 displays the general configuration of this alternative. Under this alternative, an existing spring located on lands administered by the USFS would be developed.

Under this alternative, the following components would be employed:

- An existing spring located at the western edge of the Bighorn National Forest (USFS) would be developed and serve as a supply source to the system.

- Approximately 3,300 linear feet of HDPE pipeline (1.5-inch diameter) would be installed.

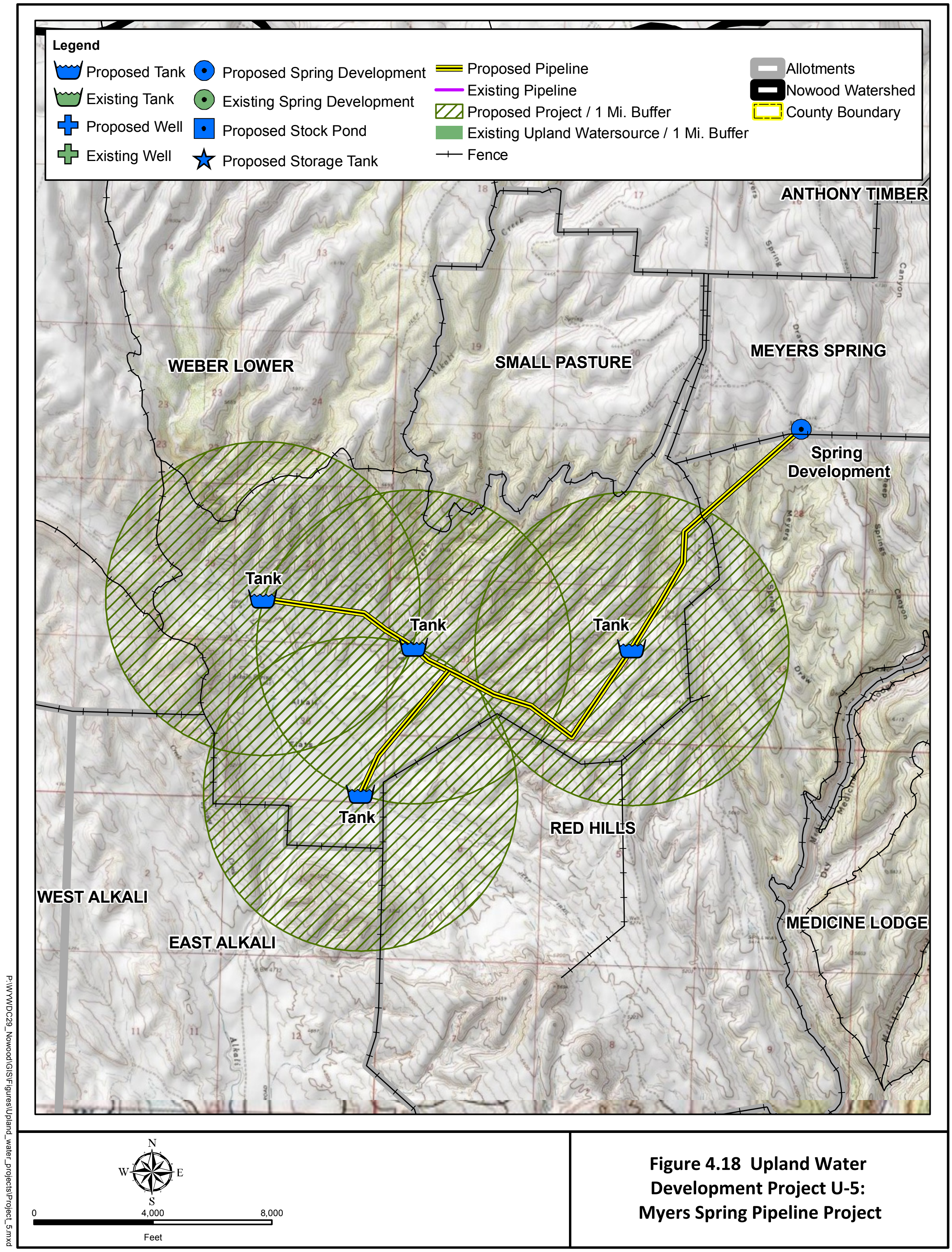


Figure 4.18 Upland Water Development Project U-5: Myers Spring Pipeline Project

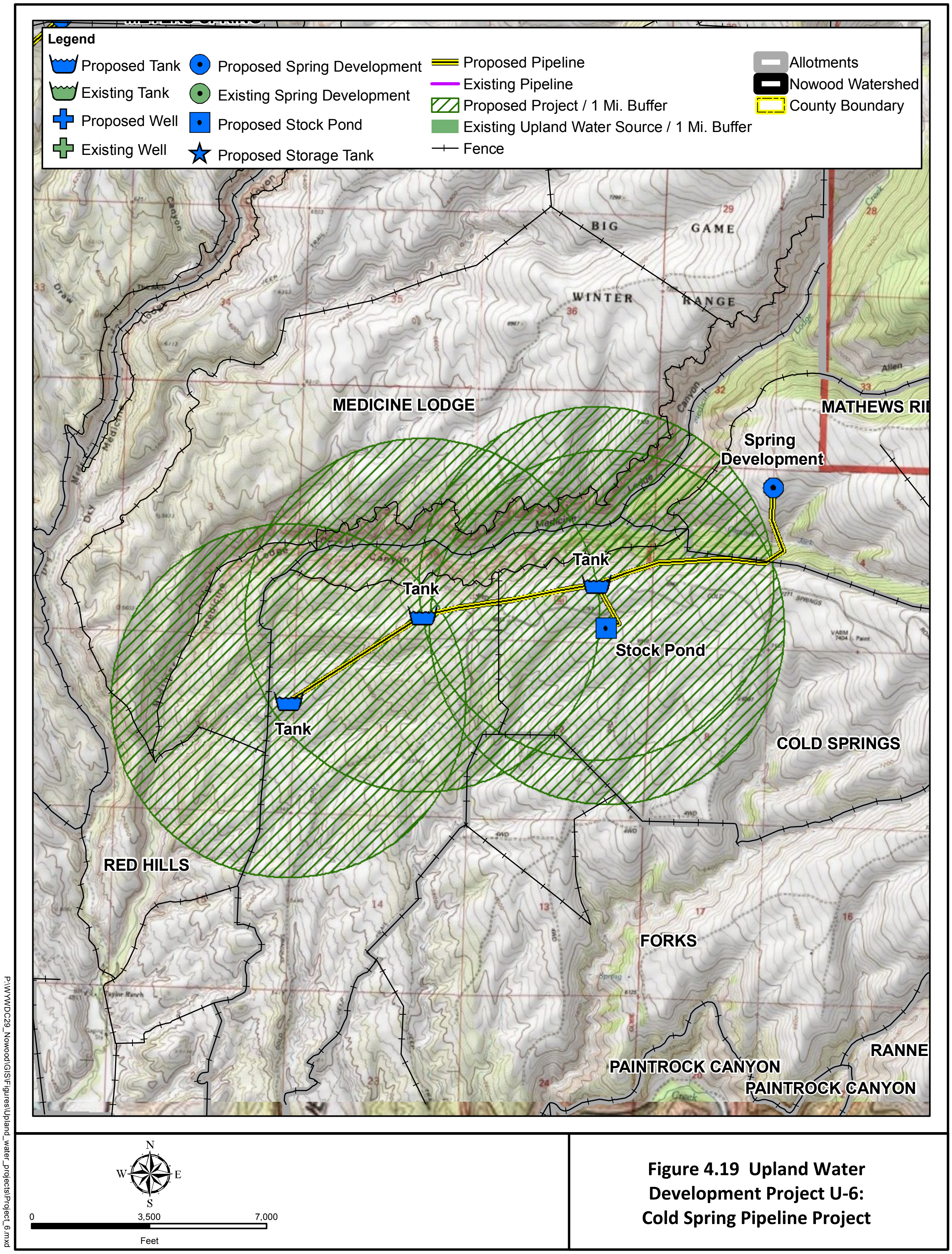


Figure 4.19 Upland Water Development Project U-6: Cold Spring Pipeline Project

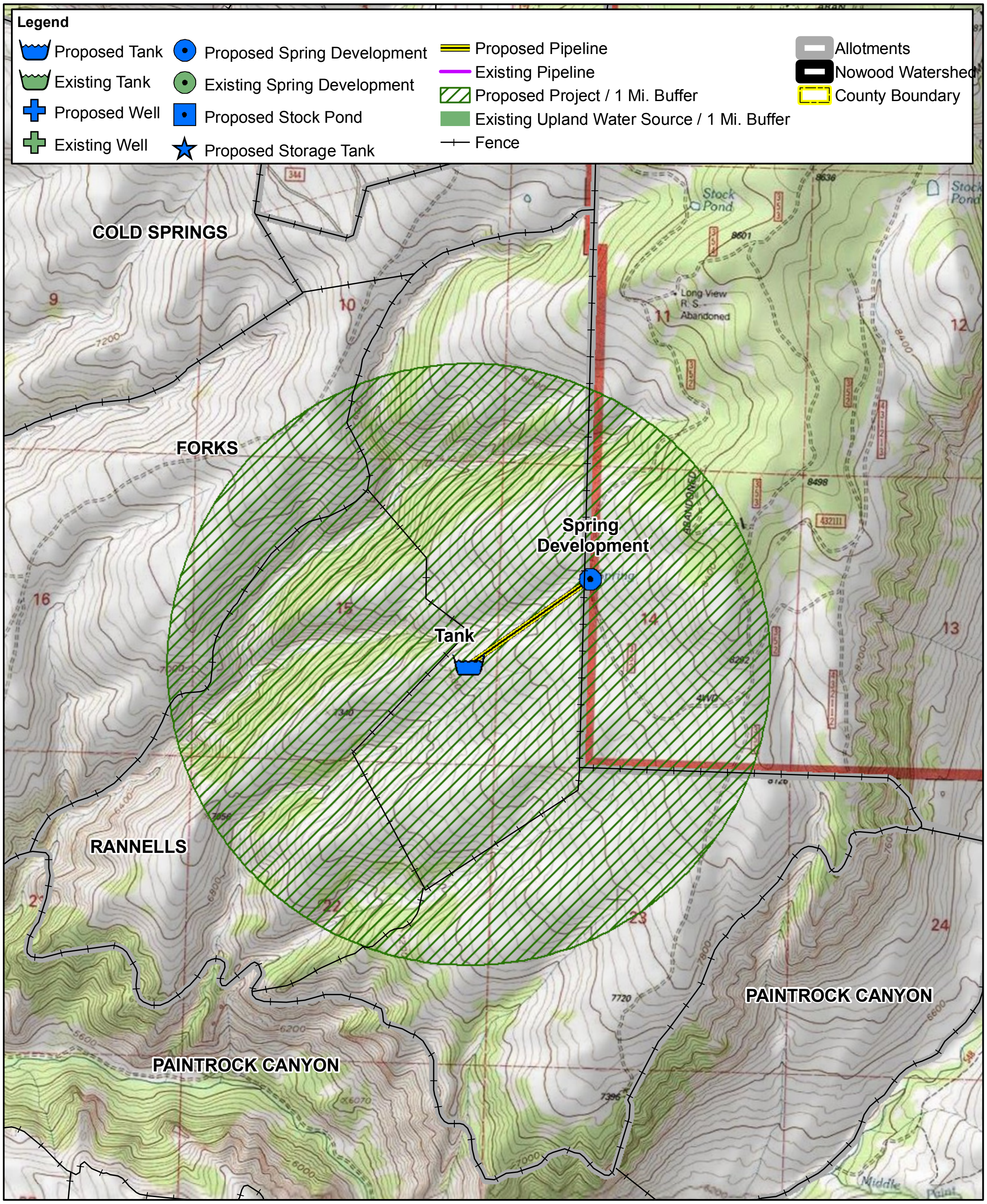


Figure 4.20 Upland Water Development Project U-7: Rannell's Pipeline Project

- One stock tank (1,200 gallon capacity) would be installed in the Rannell's allotment.

Consent and agreement to develop and use the spring would be required from the USFS.

4.3.2.8 Watershed Plan Component No. U-08: Gapen Hyatt Pipeline Project

This improvement project entails expansion of an existing system and development of an alternative water source to provide a reliable supply of water. Currently, an existing pipeline and stock tank system exists as displayed in Figure 4.21. The current source of water for the system is a well, however, consent for continued use of the well has been denied. Consequently a new source needs to be developed in order to maintain use of the existing system and for its ultimate extension. The extension of this project is currently in the design process with the NRCS.

The existing system incorporates two stock tanks and approximately 9,100 linear feet of pipeline. Under this alternative, the following component would be incorporated:

- An existing artesian well on the Wyoming Game and Fish Department's Renner Wildlife Area would be utilized as a supply source. Consent for its use would be required and an agreement obtained.
- Approximately 67,500 linear feet of HDPE pipeline (1.5-inch diameter) would be installed to connect the well to the existing pipeline.
- An additional length of HDPE pipeline (1.5-inch diameter), approximately 34,400 linear feet in length, would be added to the existing system.
- Seven (7) stock tanks would be added to the system.

4.3.2.9 Watershed Plan Component No. U- 9: Brokenback No.1 Pipeline Project

This alternative would develop water available at Sand Springs within the Brokenback Allotment. The objective of this alternative would be to provide reliable sources of livestock and wildlife water in a rugged area between perennial streams located within canyons, making access difficult. Figure 4.22 displays the general configuration of this alternative. Under this alternative, the following components would be employed:

- The existing spring (Sand Spring) would be developed to facilitate diversion to a gravity pipeline
- The pipeline would be routed downslope between Brokenback Creek and South Brokenback Creek.
- Approximately 26,200 linear feet of HDPE pipe (1.5-inch diameter) and accompanying valves, connections, vents and fittings would be installed.
- Three (3) stock tanks (1,200 gallon capacity each) would be constructed.

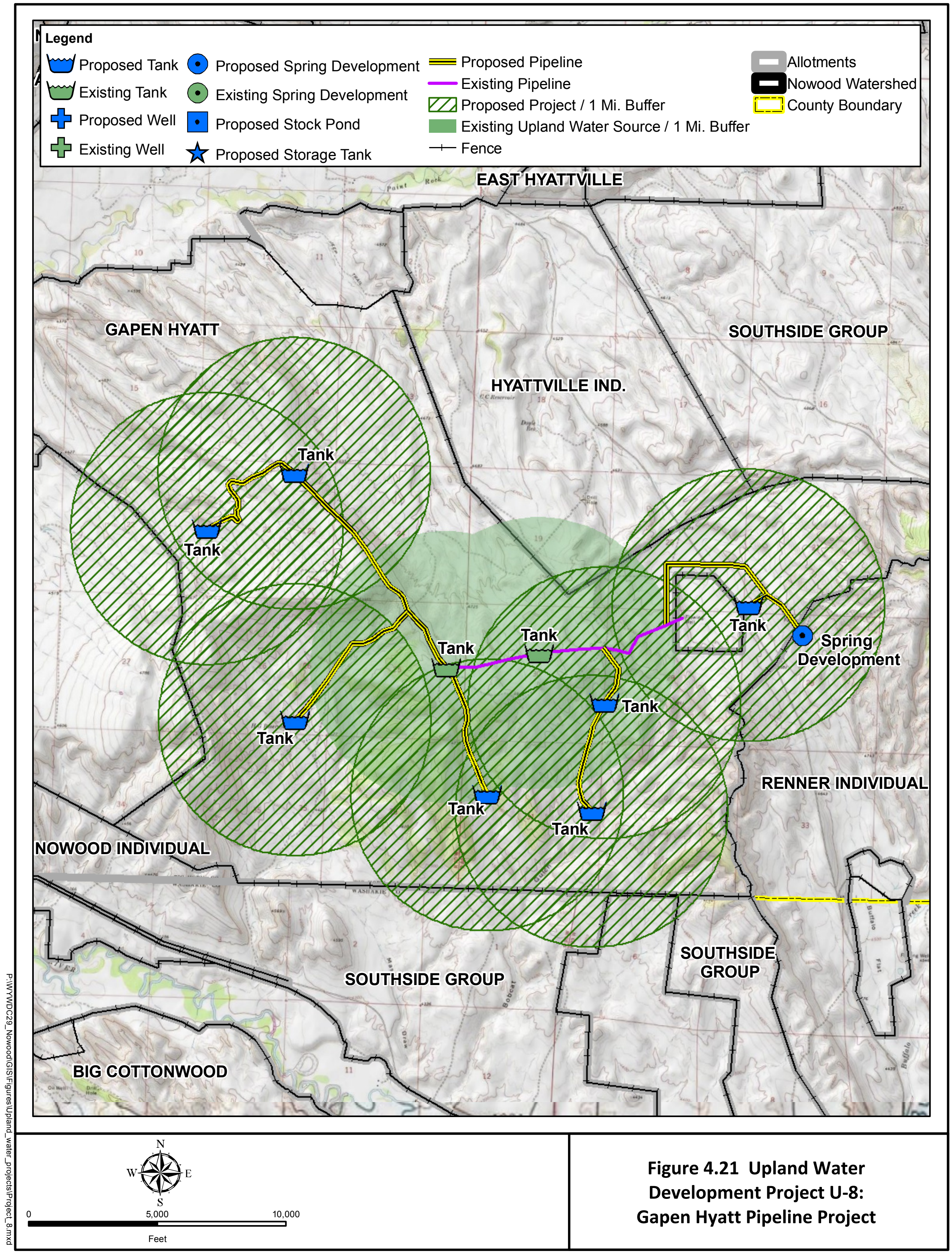


Figure 4.21 Upland Water Development Project U-8: Gapen Hyatt Pipeline Project

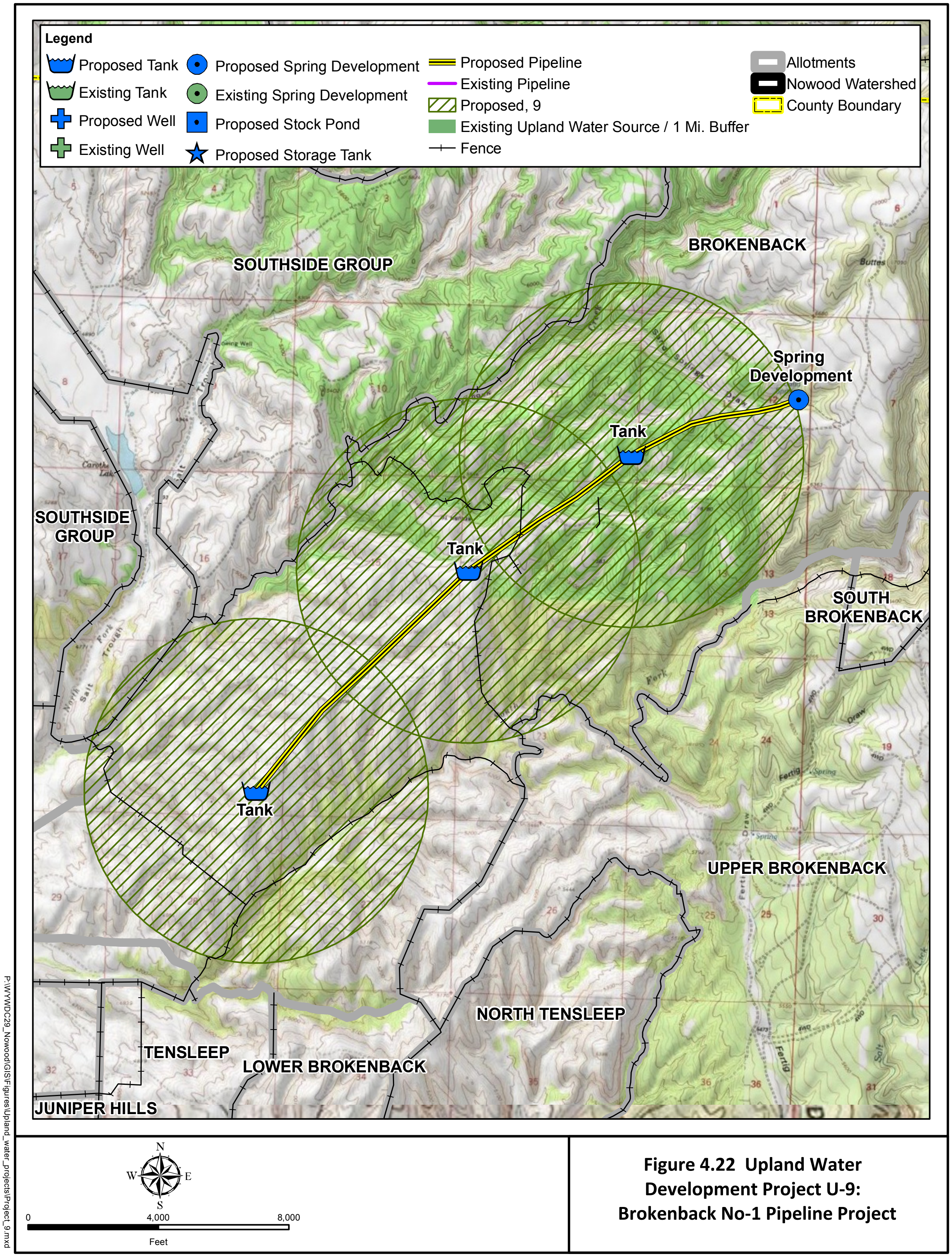


Figure 4.22 Upland Water Development Project U-9: Brokenback No-1 Pipeline Project

4.3.2.10 Watershed Plan Component No. U-10: West Side Regional Pipeline Project

The project represents a regional effort with the objective of providing reliable water sources to an extensive area encompassing several allotments. Coordination among interested parties and the BLM would require a relatively high level of effort in order to accomplish the goals associated with this project. The potential value of the project to the region is high; approximately 58,240 acres (91 square miles) of arid land within twelve (12) allotments could potentially be provided with a reliable source of water for livestock and wildlife use. Figure 4.23 displays the general configuration of this alternative. The conceptual design is presented under the assumption that an existing well in the vicinity of the Nowood River near Tensleep could be utilized as a source for the system Providing the well provides adequate flows, consent would be required for its use. As an alternative to the groundwater source, water could be pumped from the Nowood River to supply the system.

Several issues must be considered which would be unique to this improvement project:

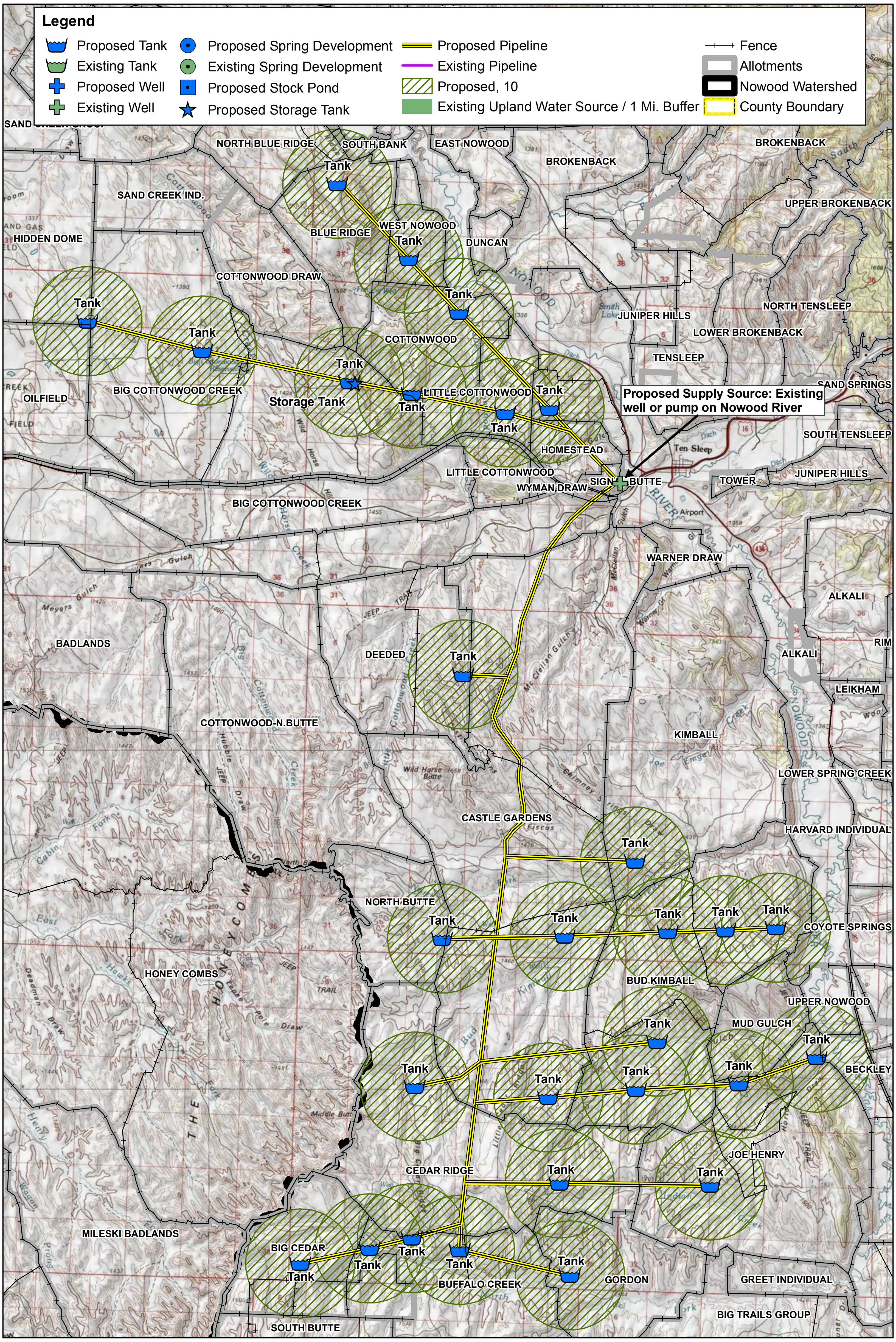
- Coordination with BLM, environmental assessment and ultimate consent for project implementation would be required.
- Given the magnitude of the project and the associated costs, formulation of a legal entity capable of funding or bearing the financial burden of debt may be required (i.e., assessments)
- Water rights to supply the project would be required.
- Easements and right of ways would be required for the project.
- Maintenance of the system would require coordination among its beneficiaries.

Under this alternative, the following components would be utilized:

- An electric pump would be installed in the existing well.
- Water would be pumped to storage tanks which would then supply the remainder of the system with gravity flow.
- Approximately 410,000 linear feet of 1.5-inch HDPE pipeline would be installed. Note that the alignment shown on Figure 4.23 is for display purposes; actual alignment would be determined based upon topography, physical restrictions, etc.
- Twenty nine (29) stock tanks (1,200 gallon capacity each) would be constructed.

4.3.2.11 Watershed Plan Component No. U-11: Duncan Pipeline Project

This alternative provides reliable sources of livestock and wildlife water within the Duncan Allotment located between Brokenback Creek and the Nowood. The project utilizes an existing artesian well as a water source. Figure 4.24 displays the general configuration of this alternative. Under this alternative, the following components would be employed:



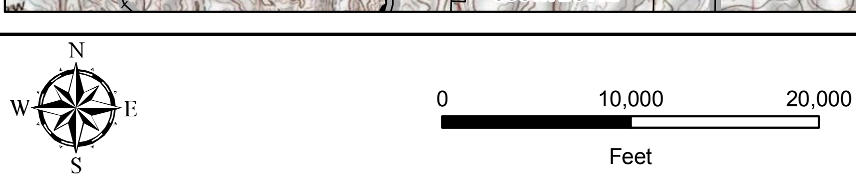


Figure 4.23 Upland Water Development Project U-10: West Side Regional Pipeline Project

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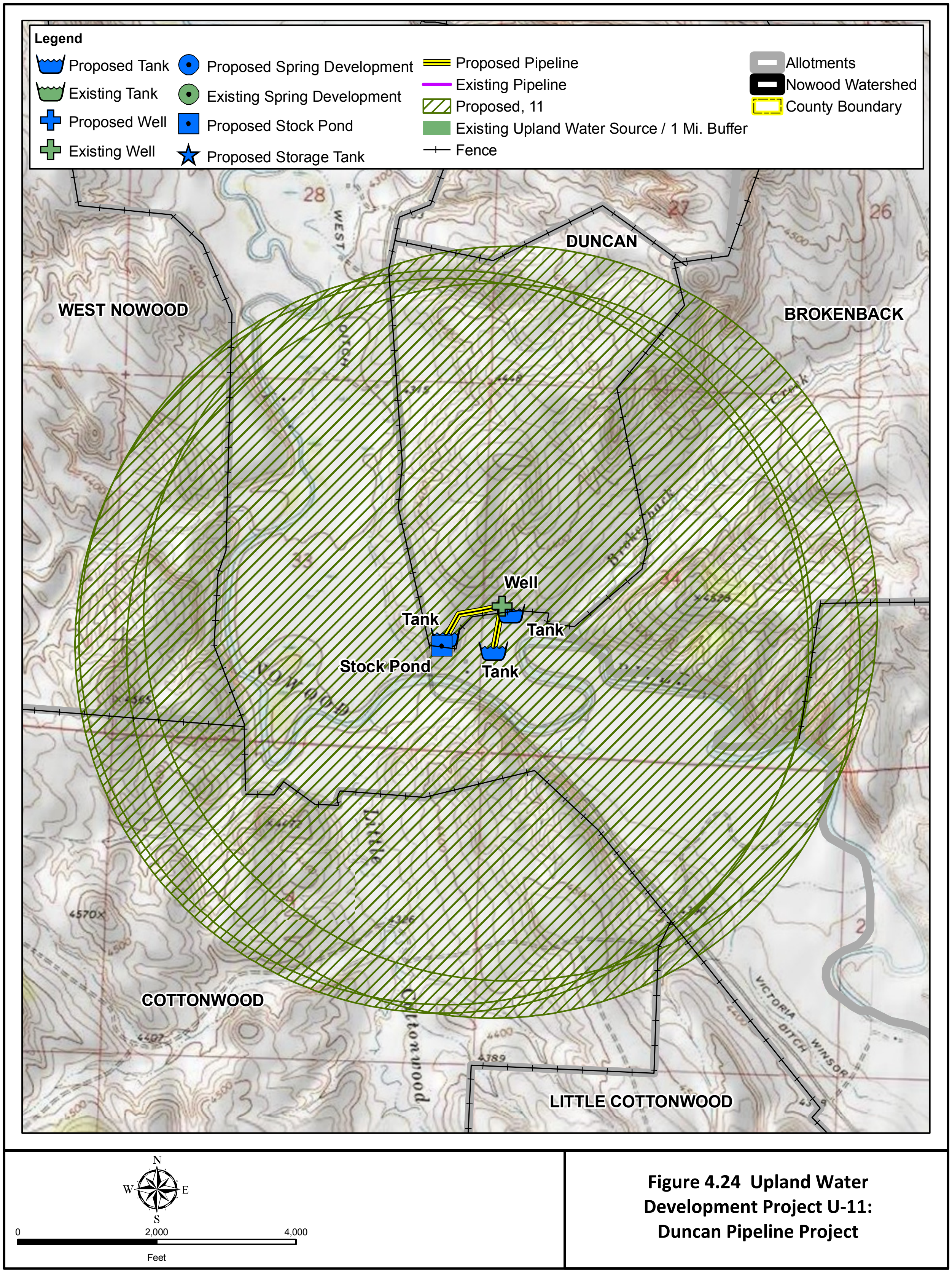

Figure 4.24 Upland Water Development Project U-11: Duncan Pipeline Project

- An existing artesian well would be utilized as a supply source. It is our understanding based upon information provided by the land owner, that the well has sufficient pressure to supply the proposed system without the need for additional pumps.
- Approximately 2,500 linear feet of HDPE pipeline (1.5-inch diameter) would be installed.
- Three (3) stock tanks would be installed to the system.
- A small excavated and lined pond (approximately 0.5 acre-foot capacity) would be constructed to collect overflow from the system and provide a source of water primarily for wildlife.

4.3.2.12 Watershed Plan Component No. U- 12: Hidden Dome Pipeline Project

This alternative provides reliable sources of livestock and wildlife water within the Hidden Dome allotment. This allotment lies within the arid western portion of the watershed. The project would utilize an existing well and provide water to five (5) stock tanks located throughout the allotment. Figure 4.25 displays the general configuration of the alternative. Under this alternative, the following components would be employed:

- An existing well would be used as a source of water for the project.
- The well currently is equipped with a pump suitable for pumping water to the ground surface.
- An additional pump would be installed to pump groundwater to an elevation providing gravity flow conditions to the remainder of the project.
- Approximately 35,900 linear feet of HDPE pipe (1.5-inch diameter) and accompanying valves, connections, vents and fittings would be installed.
- A storage tank (15,000 gallon capacity) would be installed
- Six (6) stock tanks (1,200 gallon capacity each) would be installed

4.3.2.13 Watershed Plan Component No. U-13: Brokenback No. 2 Pipeline Project

This alternative would develop water available within the Brokenback Allotment in the vicinity of Brokenback Narrows. Figure 4.26 displays the general configuration of this alternative. Under this alternative, the following components would be employed:

- An existing spring would be developed to facilitate diversion to a gravity pipeline
- The pipeline would be routed downslope between Brokenback creek and South Brokenback Creek.
- Approximately 11,600 linear feet of HDPE pipe (1.5-inch diameter) and accompanying valves, connections, vents and fittings would be installed.
- Two (2) stock tanks (1,200 gallon capacity each) would be constructed.

4.3.2.14 Watershed Plan Component No. U-14: Brokenback No. 3 Pipeline Project

The objective of this alternative is to provide a source of livestock and wildlife water to the arid northwestern portions of the Brokenback allotment. This alternative expands an existing pipeline and

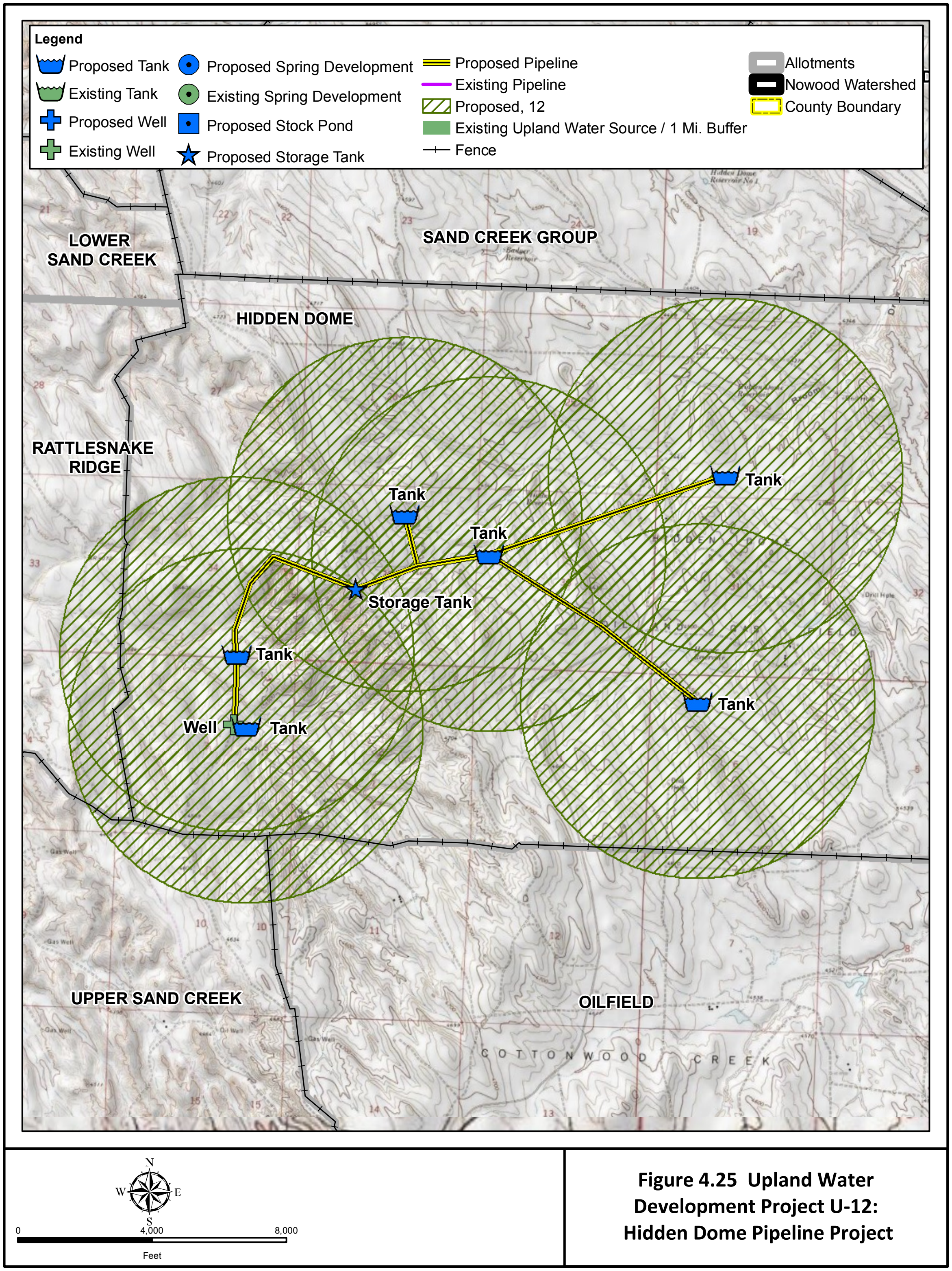

Figure 4.25 Upland Water Development Project U-12: Hidden Dome Pipeline Project

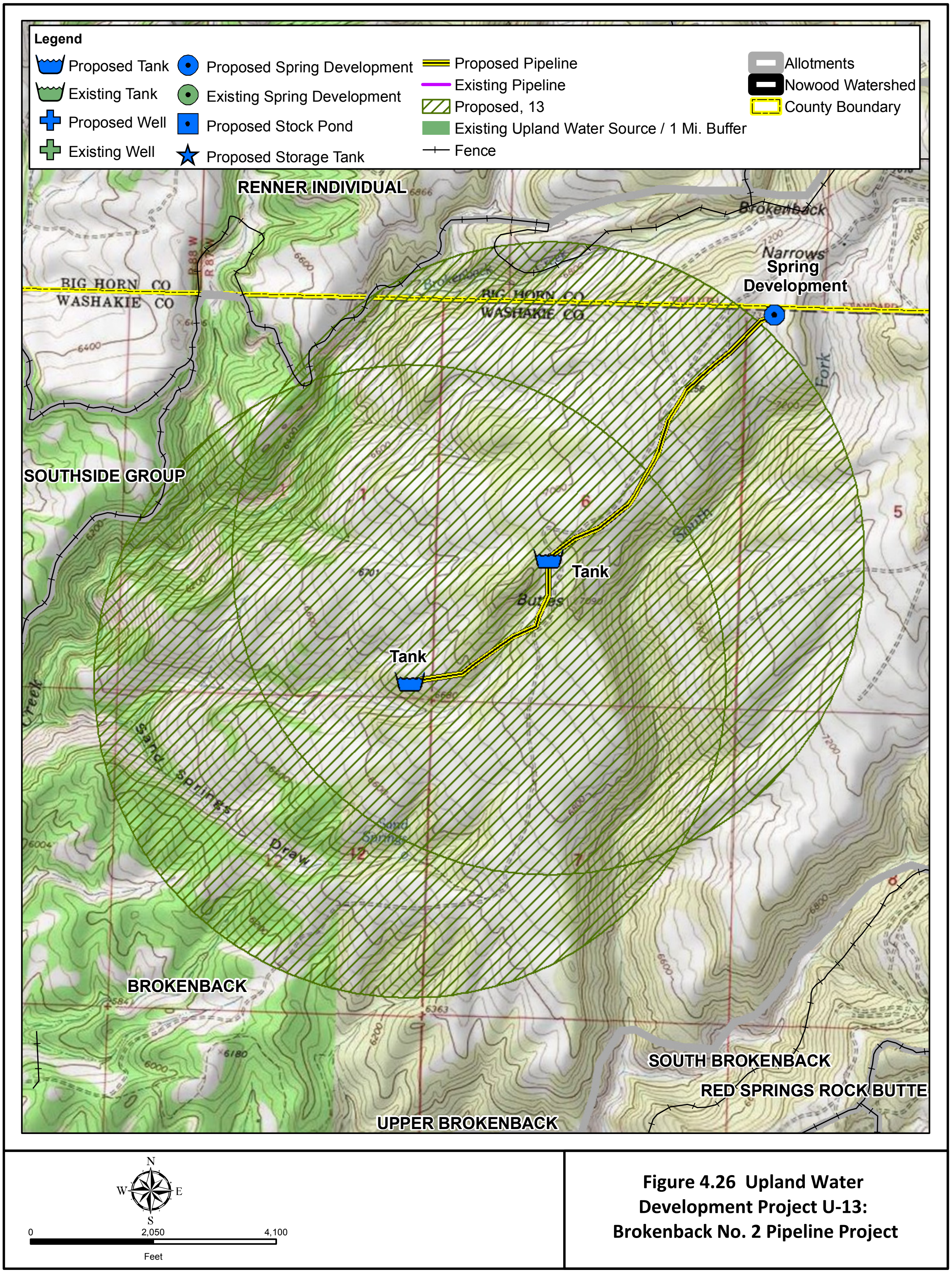

Figure 4.26 Upland Water Development Project U-13: Brokenback No. 2 Pipeline Project

stock tank system. An existing artesian well currently provides the source of water for this system as well as irrigation supply. Under this alternative the existing livestock and wildlife water system would be extended approximately one mile and an additional stock tank placed. The entire project is located within the Brokenback allotment. Figure 4.27 displays the general configuration of this alternative. Under this alternative, the following components would be employed:

- Approximately 7,100 linear feet of HDPE pipeline (1.5-inch diameter) would be installed beginning at the end of the existing pipeline.
- A single stock tank (1,200 gallon capacity) would be installed at the end of the extension

4.3.2.15 Watershed Plan Component No. U-15: Brokenback No. 4 Guzzler

Under this alternative, a source of livestock and wildlife water would be provided to a high pasture of the Brokenback allotment where there are currently no reliable sources. The alternative consists of placement of a 'guzzler' water system due to the lack of viable water sources. Based upon a review of the groundwater well database within the project GIS, construction of a well would likely require drilling greater than 2,000 in depth and was determined impractical for this alternative. Figure 4.28 displays the general location of the guzzler. Under this alternative, the following components would be employed:

- A guzzler watering system, utilizing direct precipitation as a source of supply, would be installed at this location. The guzzler consists of the following components:
    - Storage tank of capacity suitable to the watering need.
    - 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
    - Approximately 100 linear feet of HDPE pipeline (1.5-inch diameter) would be installed to connect the guzzler with the stock tank.

4.3.2.16 Watershed Plan Component No. U-16: Big Cottonwood Pipeline Project

This alternative would provide valuable water sources to five allotments within the arid western portion of the watershed. An existing well, previously capped would be utilized as a source of water for the proposed improvement. Due to the uncertainty associated with conditions of the well and the feasibility of opening a previously closed well, a new well is specified in this Level 1 investigation. Before proceeding with application for project funding or ultimate design of this project, conditions of the existing well should be further investigated and verified.

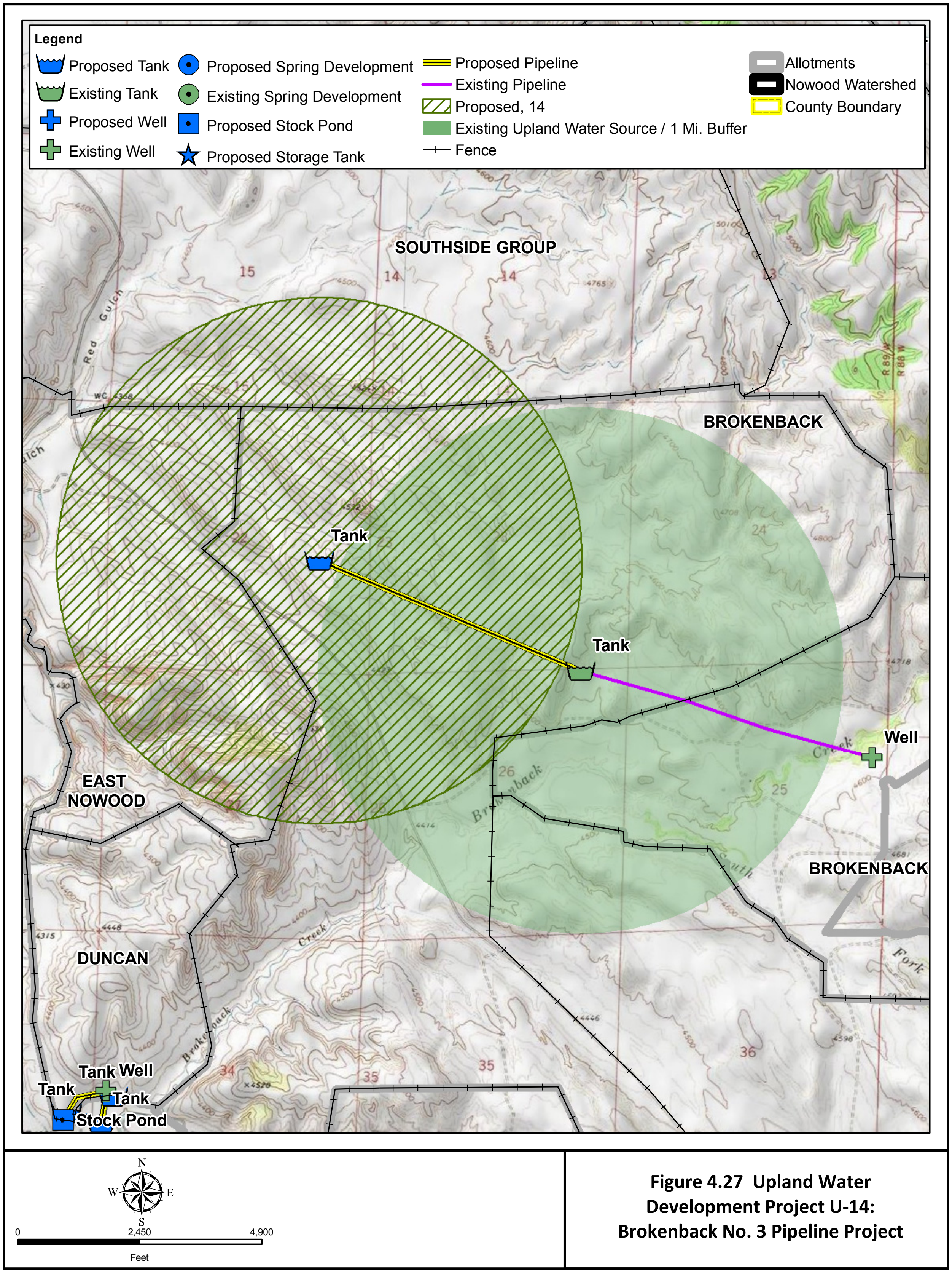

Figure 4.27 Upland Water Development Project U-14: Brokenback No. 3 Pipeline Project

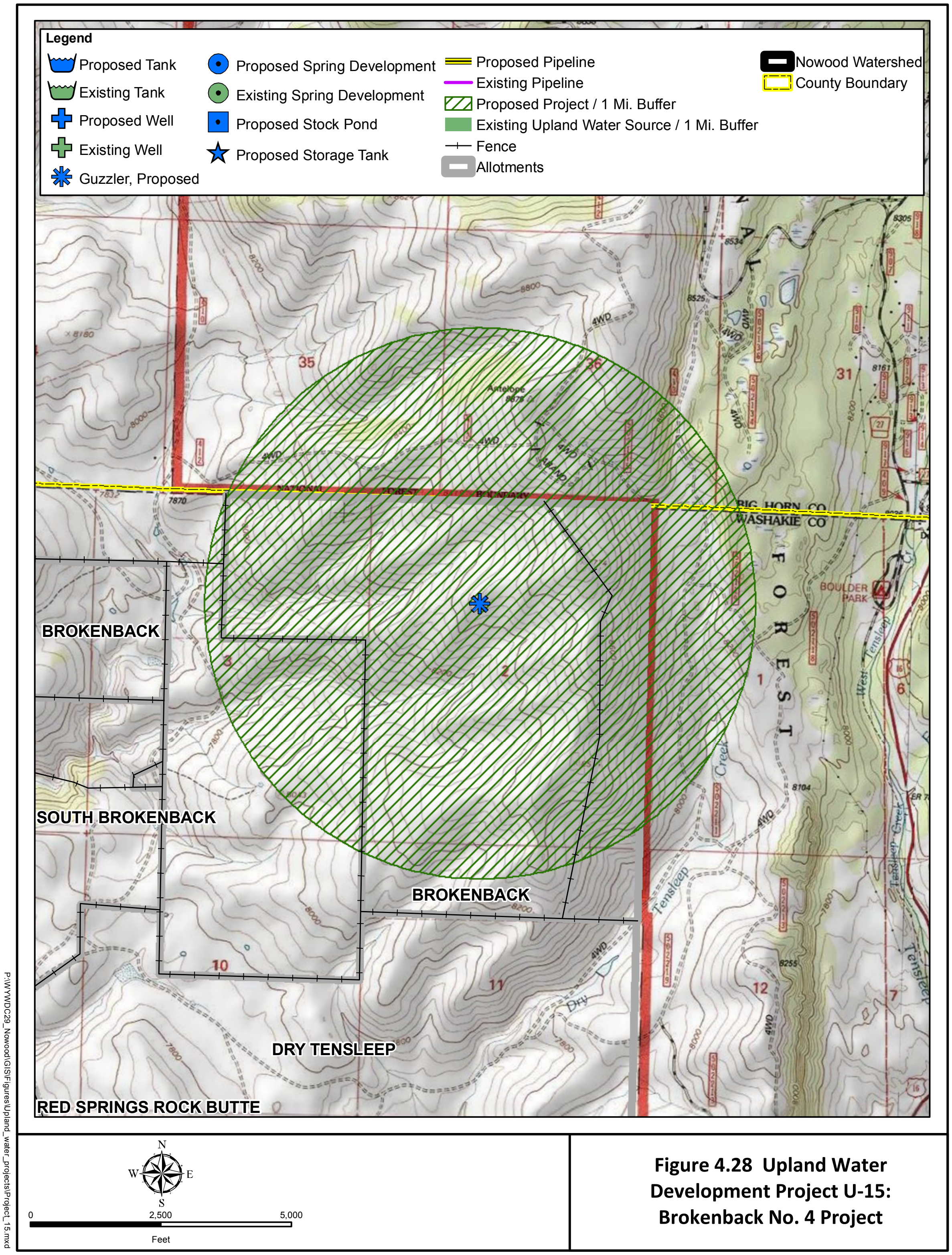

Figure 4.28 Upland Water Development Project U-15: Brokenback No. 4 Project

This proposed alternative could ultimately provide a reliable source of livestock and wildlife water opportunities to several allotments in the arid western portion of the watershed in the vicinity of Blue Ridge. Figure 4.29 displays the general configuration of this alternative. The following project components are incorporated in this improvement:

- The existing well would either be reopened or a new well drilled and completed. Based upon a review of well data in the project area obtained from the WSEO, a well in this vicinity could be on the order of 2,800 feet deep. Such a well would likely be artesian and have suitable pressure to supply the system without pumping.
- Approximately 36,000 linear feet of HDPE piping (1.5-inch diameter) would be installed.
- Five (5) stock tanks (1,200 gallon capacity each) would be installed.

4.3.2.17 Watershed Plan Component No. U-17: Schoolhouse Gulch Pipeline Project

This improvement project involves use of the Bighorn Regional Pipeline would be utilized as a source of water for a short pipeline project. Figure 4.30 displays the general configuration of the proposed improvement. Under this alternative, the following components would be utilized:

- Connection to the Big Horn Regional Water Supply Pipeline would be required. Approximately 6,150 linear feet of HDPE pipeline (1.5-inch diameter) would be installed.
- Two stock tanks (1,200 gallon capacity each) would be installed in the system.

4.4 Surface Water Storage Opportunities

4.4.1 Overview

Conceptual designs were prepared for each of the Priority 1 dam and reservoir sites identified in Chapter 3. These concept designs are based on information developed throughout the project under various work efforts and information presented in the Reservoir Evaluation Matrix (Appendix F).

Locations of the reservoir sites were initially determined based upon input from local land owners and stake holders, review of previous investigations, input received from the WWDO staff, and evaluation of topographic mapping and GIS data analyses. Figure 4.31 displays the location of the seven Priority 1 reservoir sites. Classification of the reservoir sites was completed following evaluation of the Reservoir Evaluation Matrix, collecting input from the Steering Committee, WWDO staff, and interested stakeholders, and evaluation of conceptual cost estimates.

In the following sections, the Priority 1 sites are evaluated in greater detail and the information pertaining to each is provided. Underlying assumptions used in this Level I investigation are presented and refined cost estimates provided. Onsite geologic reconnaissance was also completed for each of the seven Priority 1 reservoir locations.

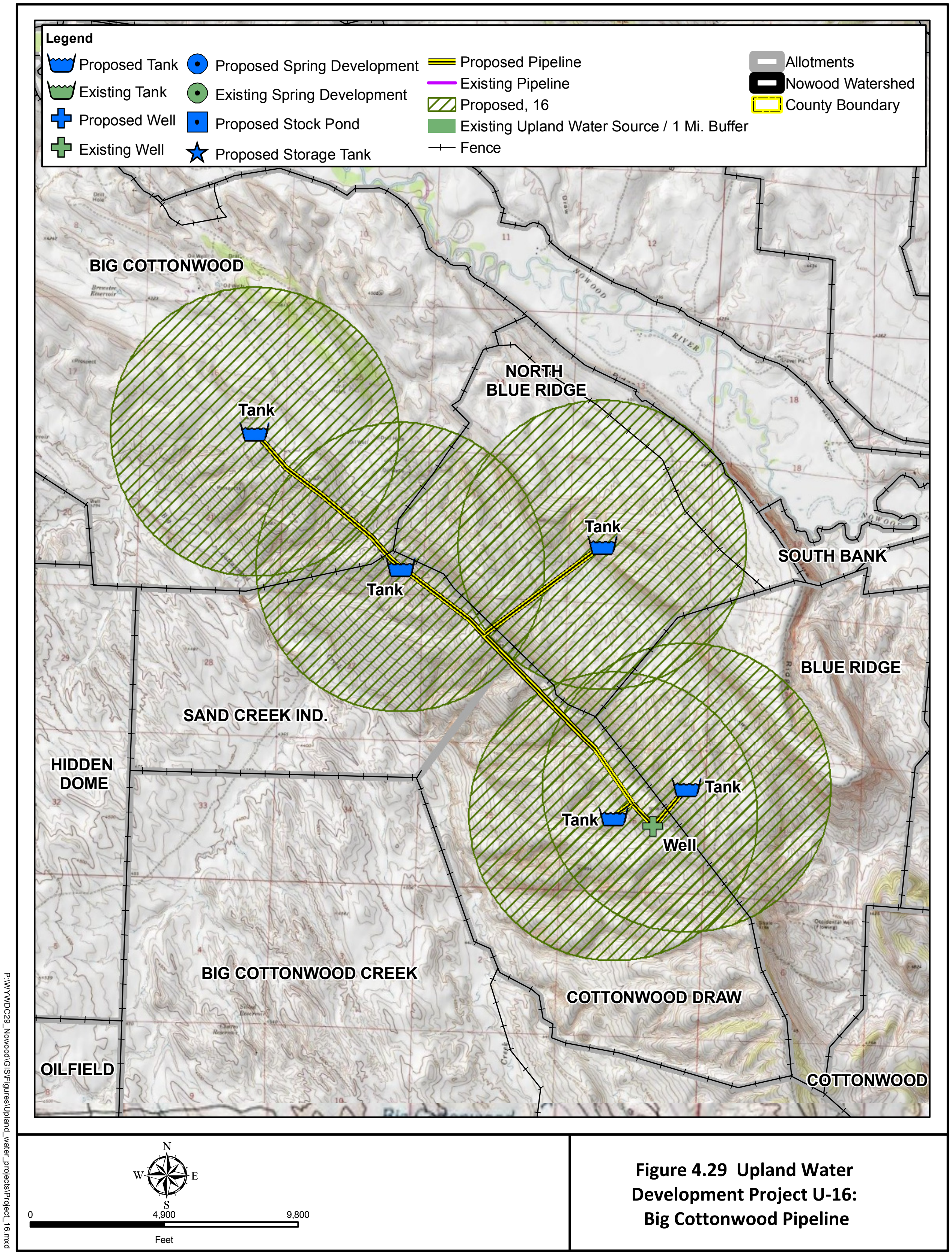

Figure 4.29 Upland Water Development Project U-16: Big Cottonwood Pipeline

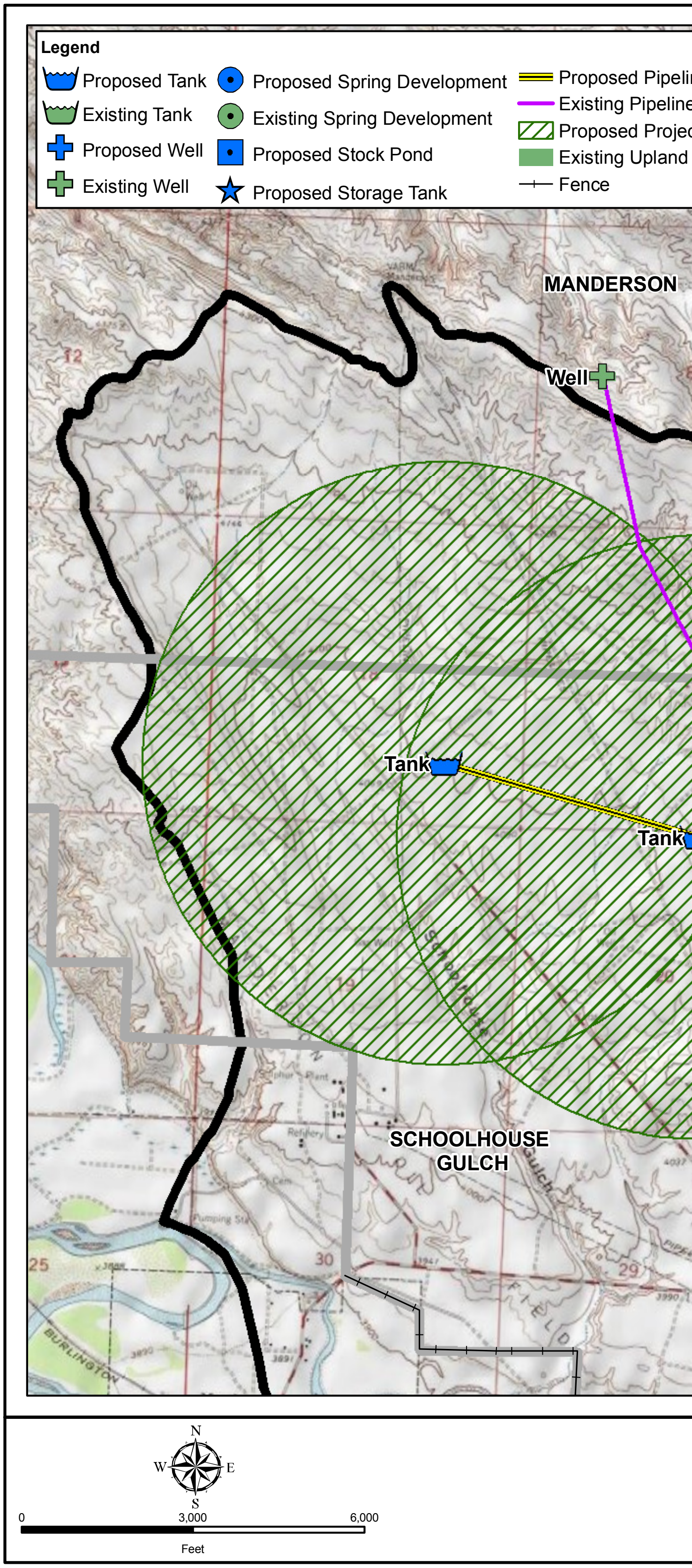

Figure 4.30 Upland Water Development Project U-17: Schoolhouse Gulch Pipeline

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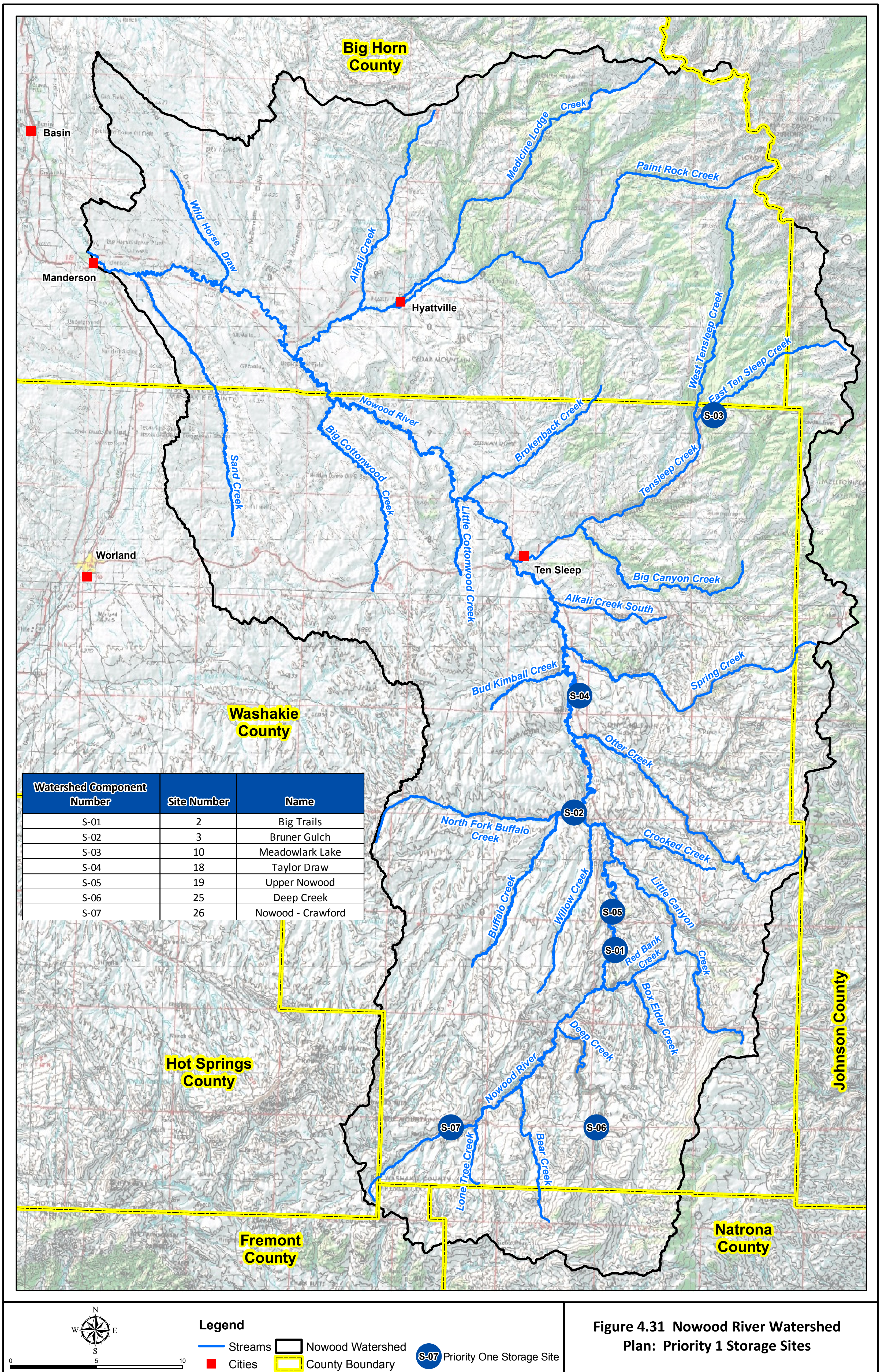


Watershed Component Number	Site Number	Name
S-01	2	Big Trails
S-02	3	Bruner Gulch
S-03	10	Meadowlark Lake
S-04	18	Taylor Draw
S-05	19	Upper Nowood
S-06	25	Deep Creek
S-07	26	Nowood - Crawford

Figure 4.31 Nowood River Watershed Plan: Priority 1 Storage Sites

At the time of this reporting, the project proponents have applied for funding through the WWDO for a Level II, Phase I investigation of reservoir storage alternatives. During the completion of that study, it is anticipated that these Priority 1 sites will be evaluated in greater detail. Priority 2 sites may also be included in the Level II, Phase I investigation. Priority 3 sites are recommended for exclusion from further investigation for one or more reasons. There is also the potential that additional sites may become apparent during a Level II study.

4.4.2 Conceptual Design of Storage Alternatives

As previously discussed in Chapter 3, a wide variety of information was collected pertaining to all of the potential reservoir sites and collated in the Reservoir Evaluation Matrix (Appendix F). The matrix includes information and data regarding physical characteristics, environmental considerations, infrastructure impacts, hydrologic factors, and other items. A comparative ranking of selected parameters/conditions for each of the alternative sites is shown by the color-coding on the Reservoir Evaluation Matrix. The color coding displays the relative degree to which each site may be impacted by various factors or how well the sites are suited to the opportunities for storage. This information was utilized to complete conceptual designs at each of the sites.

Key factors influencing the conceptual design and estimated cost of each site include reservoir capacity and dam size, anticipated geological conditions, flood hydrology and the associated spillway sizing, and permitting and environmental considerations and mitigation. The storage potential for each site was determined based upon the physical topography and initial optimization of the reservoir capacity. That is, an iterative approach was used to determine an embankment height and corresponding reservoir pool capacity commensurate with the contributing basin's hydrologic characteristics, including the flows which were physically existing and available for storage without injury to downstream users. For off-stream sites, the reservoir capacity was determined with consideration of diversion and conveyance facilities. That is, an off-channel reservoir must be filled by means of a supply ditch of appropriate capacity to convey the flow diverted from the water source.

4.4.2.1 Geologic Considerations

The overall surficial, bedrock, and geologic hazards in the watershed were previously presented in Chapter 3. Relevant information for the selected alternative dam and reservoir sites from the available geologic mapping and reports is summarized in the Reservoir Evaluation Matrix. This information was used to assess the relative effects, both positive and negative, that site geology might have on foundation conditions and borrow availability and quality at each site. In an effort to determine the viability of each of the Priority 1 sites from a geologic perspective, geologists visited each location and completed onsite inspections. Appendix H presents the Technical Memorandum completed during this effort.

4.4.2.2 Dam Safety Classification and Inflow Design Flood Requirements

Requirements for dam safety, including inflow design flood (IDF) size, for any jurisdictional dam and reservoir project are promulgated and administered by the Safety of Dams Program, Surface Water Division of the Wyoming State Engineer's Office. The size of the IDF required for any new storage reservoir is determined by the hazard classification of the dam. There are four classifications (I through IV) based on the potential for loss of life and/or significant property damage in the event of dam failure. For the purposes of hazard classification, an assumption is made that the dam under review fails in a clear weather breach. The likely consequences of that failure are then evaluated to arrive at the dam's classification. The definitions for each of the four classes are as follows:

- A "Class I" dam is a dam for which loss of human life is expected in the event of the failure of the dam.
- A "Class II" dam is a dam for which significant damage is expected to occur, but no loss of human life is expected in the event of failure of the dam. Significant damage is defined as damage to structures where people generally live, work, or recreate, or public or private facilities exclusive of non-primary roads and picnic areas. Damage means rendering the structures uninhabitable or inoperable.
- A "Class III" dam is a dam for which loss of human life is not expected, and damage to structures and public facilities as defined for a "Class II" dam is not expected in the event of failure of the dam.
- A "Class IV" dam is a dam for which no loss of human life is expected, and for which damage will occur only to the dam owner's property in the event of failure of the dam.

4.4.2.3 Conceptual-Level Hazard Classification

Hazard classification requires determination of the potential for inundation of existing structures, recreational areas or primary roads. Completing such an analysis requires dam break analysis and routing of flood waters and is beyond the scope of this Level I study. Accordingly, judgment has been used to "select" hazard classifications and provide an initial basis for sizing the IDF and thereby the conceptual spillway type and size. In general, sparsely populated areas with structures well out of the floodplain and/or significantly downstream from the reservoir (enabling dissipation of a flood wave), and/or small reservoirs which would provide minimal impacts on failure offer a reduced threat to property and human life. Based on this concept and a review of topographic mapping downstream from each site, the alternative dam sites were preliminarily classified as Class II or III.

Sizing of spillways and corresponding cost estimates were based upon the relative size of the contributing area, and the relative capacity and dam height of each site. Each site was classified as a small, medium, or large reservoir with respect to anticipated spillway design.

4.4.2.4 Conceptual Dam and Appurtenances Design

Based upon the factors presented above, conceptual dam designs were completed for each of the seven Priority 1 sites. It is important to note, however, that these parameters will have to be appropriately modified should further studies regarding needs, reservoir operations, and site-specific hydrologic and geologic/geotechnical conditions be undertaken.

In particular, storage capacity should be tied to the desired reservoir yield and operations, and spillway capacity should reflect appropriate project-, site- and/or region-specific analyses to account for factors such as IDF determination, reservoir routing and attenuation (i.e., flood storage), incremental downstream damage/loss of life potential, and practicality of downstream warning/evacuation. Finally, note that the storage capacities reported for each site are assumed to include normal storage, carry-over storage, and a modest minimum pool to accommodate sedimentation, recreation, fishery maintenance, and perhaps other operational or environmental factors. More detailed evaluation of the need for and required capacity for each of these storage components should be carried out if any of these alternatives are advanced to the next level of study.

The following design components are inherent in the conceptual designs:

- The low-level outlet works are assumed to be a cut-and-cover, low-level pipe outlet with gate control. The outlet works are assumed to be located on one side or the other of the valley section, founded on rock or otherwise competent material.
- Outlet works may require inclined, multi-level design to accommodate downstream fisheries.
- A typical zoned earthfill dam section used in estimating earthwork quantities is shown on Figure 4.32. This typical dam section assumed a zoned embankment with a 3:1 upstream slope, 2.5:1 downstream slope, 20-foot crest width, and a nominal 15-foot foundation cutoff excavation.
- The dam design would incorporate an impervious core zone/core trench founded on competent foundation, internal filters and drains to control seepage and prevent internal erosion/piping, and upstream slope protection (either riprap or RCC/soil cement depending on material availability and cost). If needed, a grout curtain (or possibly a relief well system) would be installed to control seepage and pore pressures in the deeper foundation.

4.4.3 Site Descriptions

In the following sections, each of the seven Priority 1 reservoir sites are discussed. Each discussion includes a summary of the underlying assumptions and pertinent information of the site, conceptual diagrams, and discussion of appurtenances where appropriate. In addition, results of the onsite geologic investigation are presented.

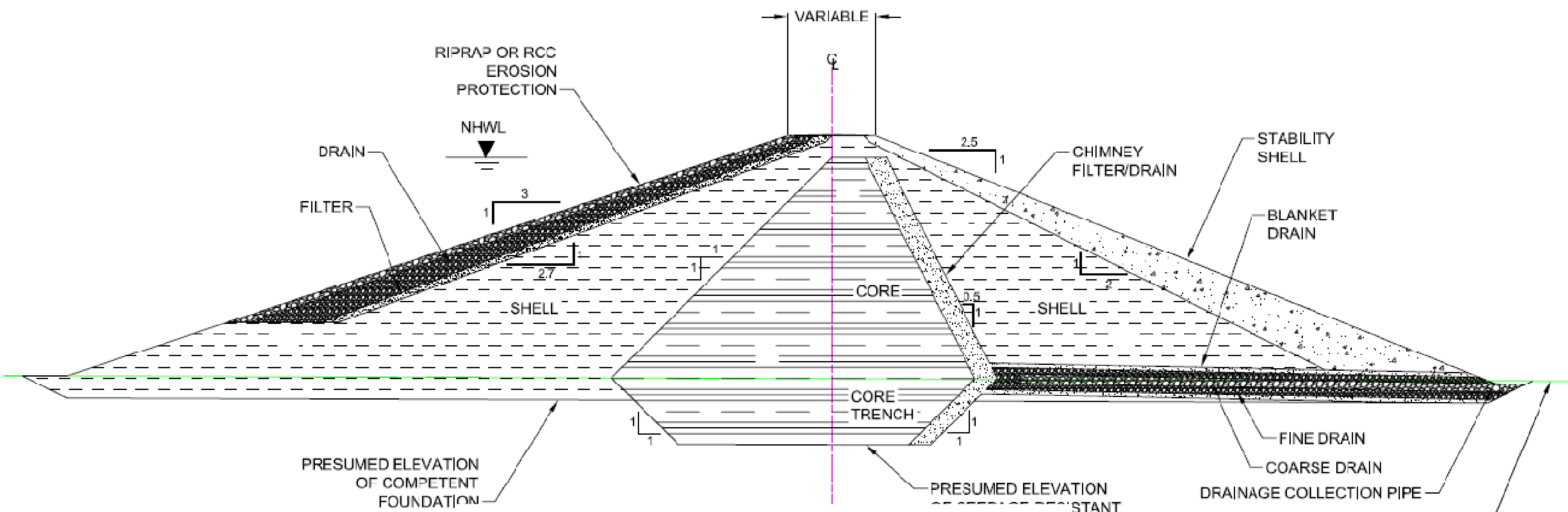


Figure 4.32 Typical Design of Zoned Earthfill Dam

4.4.3.1 Watershed Plan Component S-01: Reservoir Site No. 2 Big Trails

Figure 4.33 displays the conceptual level design of the impoundment. This potential reservoir site is located on the mainstem of the Nowood River approximately five miles upstream of its confluence with Little Canyon Creek in the SW ¼ Section 8, Township 43 North, Range 87 West. Reference to this site was found in several published reports. Review of these reports indicates that the first published documentation of this site was in 1971 (USDA, 1971). This site represents one of the larger reservoirs considered in this Level I investigation.

The drainage area contributing to this reservoir is approximately 247.2 square miles. Figures 4.34 and 4.35 display an enhanced satellite perspectives of the reservoir site and the contributing upper Nowood River watershed, respectively. The reservoir would be an on-channel facility. The storage capacity of the reservoir would be approximately 16,850 acre-feet with an embankment approximately 80 feet high. According to the Wind / Bighorn Basin Plan water use model (referred hereafter as "the model"), the estimated runoff in a normal year would exceed 75,629 acre-feet of which about 5,874 acre feet would be available for storage while still meeting demands of downstream users.

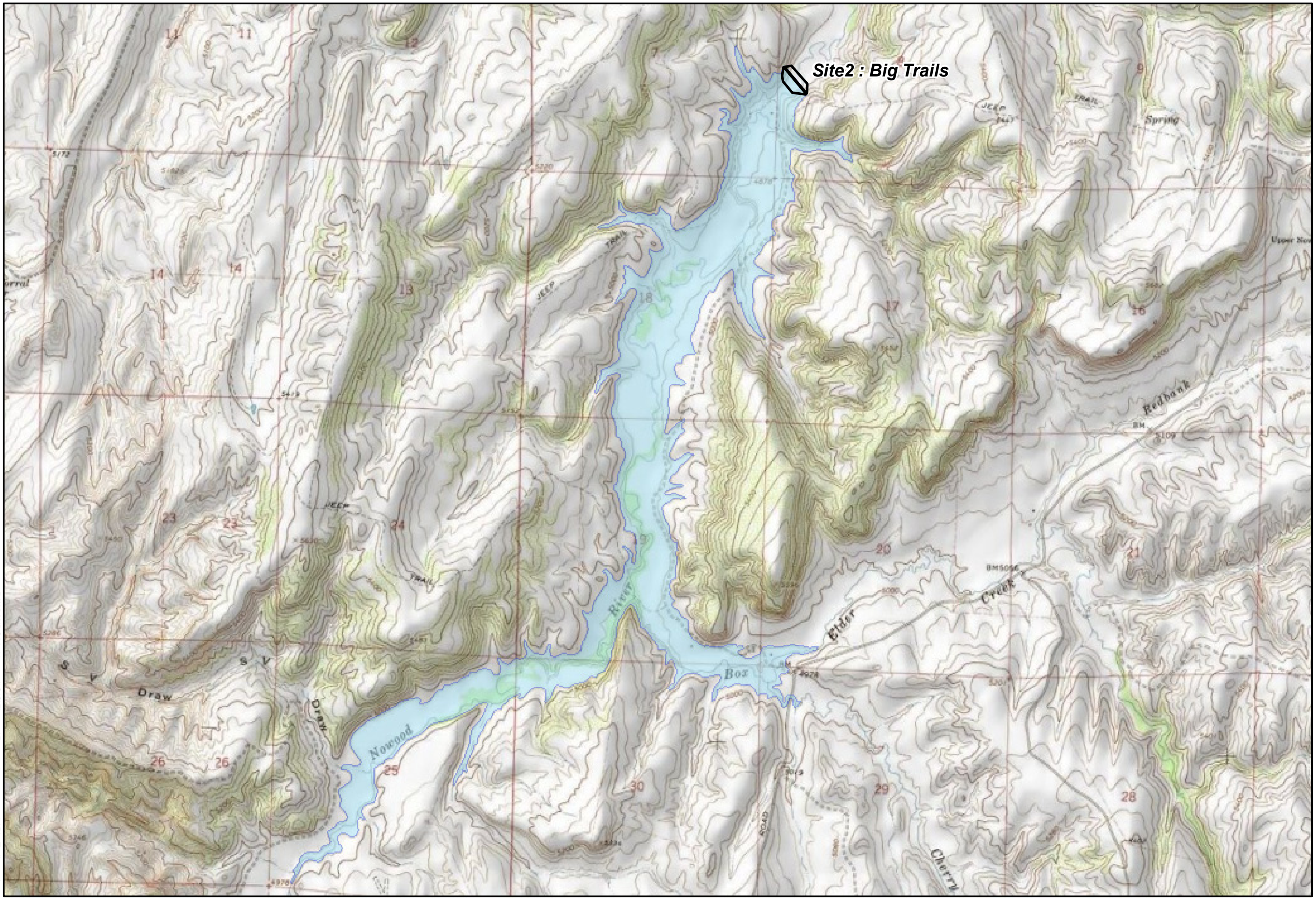
The embankment of the reservoir would be located on privately-owned lands and the reservoir pool would lie on a mix of private, state, and federally owned lands (BLM).

Benefits provided by this reservoir include the ability to provide late season irrigation water for approximately 5,853 acres downstream. Given the location of the reservoir on the mainstem of the Nowood River and its contributing area, this site would provide the greatest amount of flood protection of any sites considered.

Infrastructure potentially affected by this project would include the buried fiber-optics communications cable discussed in Chapter 3. Because the location of the cable cannot be precisely located given the available mapping data, the magnitude of this impact nor the costs associated with mitigating impacts can be determined at this time; however, it appears that approximately 0.5 miles could be affected. Based upon a review of aerial photography, it also appears that up to twelve individual buildings associated with three ranches could be impacted.

Environmental impacts of this site include inundation of about 265 acres of currently irrigated land and approximately 6.6 acres of wetlands based upon National Wetlands Inventory (NWI) mapping.

Based upon preliminary geologic investigations of the site, construction of a reservoir may be problematic due to underlying geologic strata. The embankment location is within the Jurassic part of the section, with both abutments primarily within the Gypsum Springs Formation. Sandstones of the Sundance Formation were observed cropping out as capstone above both abutments, but the abutments themselves would be located within very soft, erodible gypsum. Future consideration of this location would require more detailed investigation of geologic conditions.



N W E S

Legend

Conceptual Layout

Inundated Area

0 2,000 4,000

Feet

Figure 4.33 Conceptual Reservoir Layout: Site 2 - Big Trails

Figure 4.34 Enhanced Satellite Perspective of Reservoir Layout: Site 2 - Big Trails

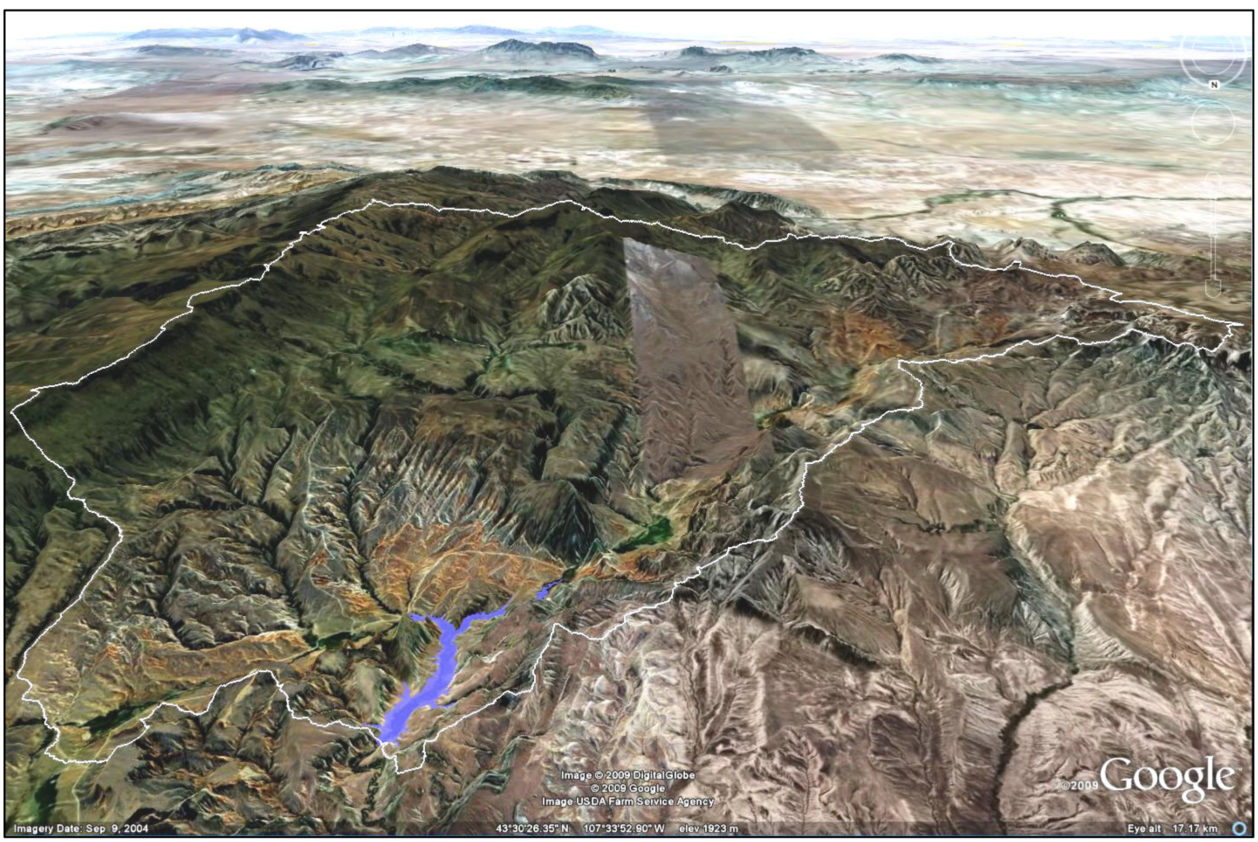


Figure 4.35 Enhanced Satellite Perspective of Drainage Area: Site 2 - Big Trails

4.4.3.2 Watershed Plan Component S-02: Reservoir Site No. 3 Bruner Gulch

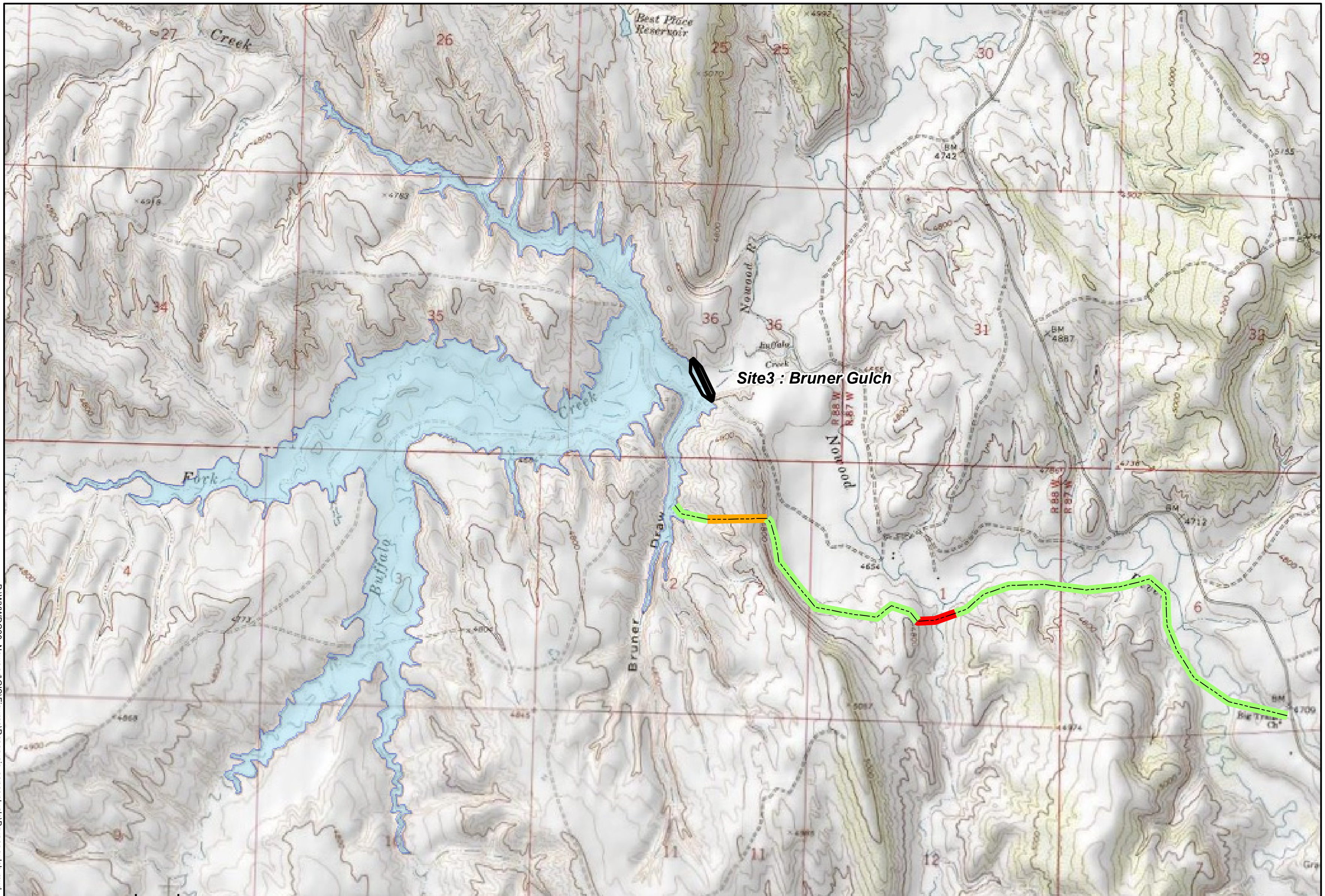
This potential reservoir site is located in the SW¼ of Section 36 Township 45 North, Range 88 West on Buffalo Creek near its confluence with the Nowood River. The reservoir is intended to serve as an off-channel site storing flows diverted from the Nowood River and conveyed via a canal and tunnel. Figure 4.36 displays the conceptual level configuration of the impoundment and supply canal. The embankment of the reservoir would be located on State lands. The lands within the reservoir pool area are under a mix of private, State, and federal (BLM) ownership.

The drainage area directly contributing to this reservoir is approximately 173.4 square miles. Figures 4.37 and 4.38 display enhanced satellite perspectives of the reservoir site, and its contributing areas, respectively. Note that the contributing areas include the directly contributing Buffalo Creek watershed and the upper Nowood River watershed. The drainage area is located on the drier west side of the Nowood River watershed; consequently, the average precipitation of the basin is only about 14.3 inches. As a result, the direct runoff of the watershed would not support a large reservoir at this site without the supplemental water from the Nowood River. According to the model, the estimated runoff in a normal year would be approximately 3,600 acre-feet from Buffalo Creek and 9,760 acre-feet from the Nowood River. Detailed hydrologic investigations would be inherent in any future investigations regarding a reservoir site, particularly sites located on ephemeral channels such as Buffalo Creek where hydrologic evaluations may be complicated. During the temporary stream gage investigation discussed in Chapter 3, approximately 1,600 acre-feet was measured during the study period which would be considered a normal year.

As evaluated in this Level I investigation, the storage capacity of the reservoir would be approximately 7,700 acre-feet with an embankment of approximately 45 feet. The surface area of the reservoir at maximum capacity would be approximately 557 acres.

A supply canal would be required to convey water from the Upper Nowood River from a point downstream of the County Road 434 crossing. The canal would require a diversion structure to be placed on the Nowood River and construction of a supply canal approximately 2.8 miles long. The supply canal would likely require a siphon crossing at Willow Creek and approximately one quarter mile of tunnel in order to complete the conveyance to the proposed reservoir site. The supply canal would be designed to convey flows during the peak runoff period and during the non-irrigation season to the reservoir for storage. Water stored in the reservoir would be released as needed and conveyed back to the Nowood River via Buffalo Creek.

Design of the diversion facility would require consideration of the operational management of the facility. For instance, if the objective were to divert approximately 5,000 acre-feet during peak runoff, the system must be capable of conveying approximately 85 cfs in order to capture available flows during the peak runoff period. A design alternative which could be evaluated in future studies could include diverting flows from the Nowood River in the vicinity of Cornell Gulch (Section 30, Township 42 North,



Legend

- Reservoir Supply Canal - Open
- Reservoir Supply Canal - Siphon
- Reservoir Supply Canal - Tunnel
- Inundated Area
- Conceptual Layout

N E S W

0 2,000 4,000
Feet

Figure 4.36 Conceptual Reservoir Layout: Site 3 – Bruner Gulch

Figure 4.37 Enhanced Satellite Perspective of Reservoir Layout: Site 3 - Bruner Gulch

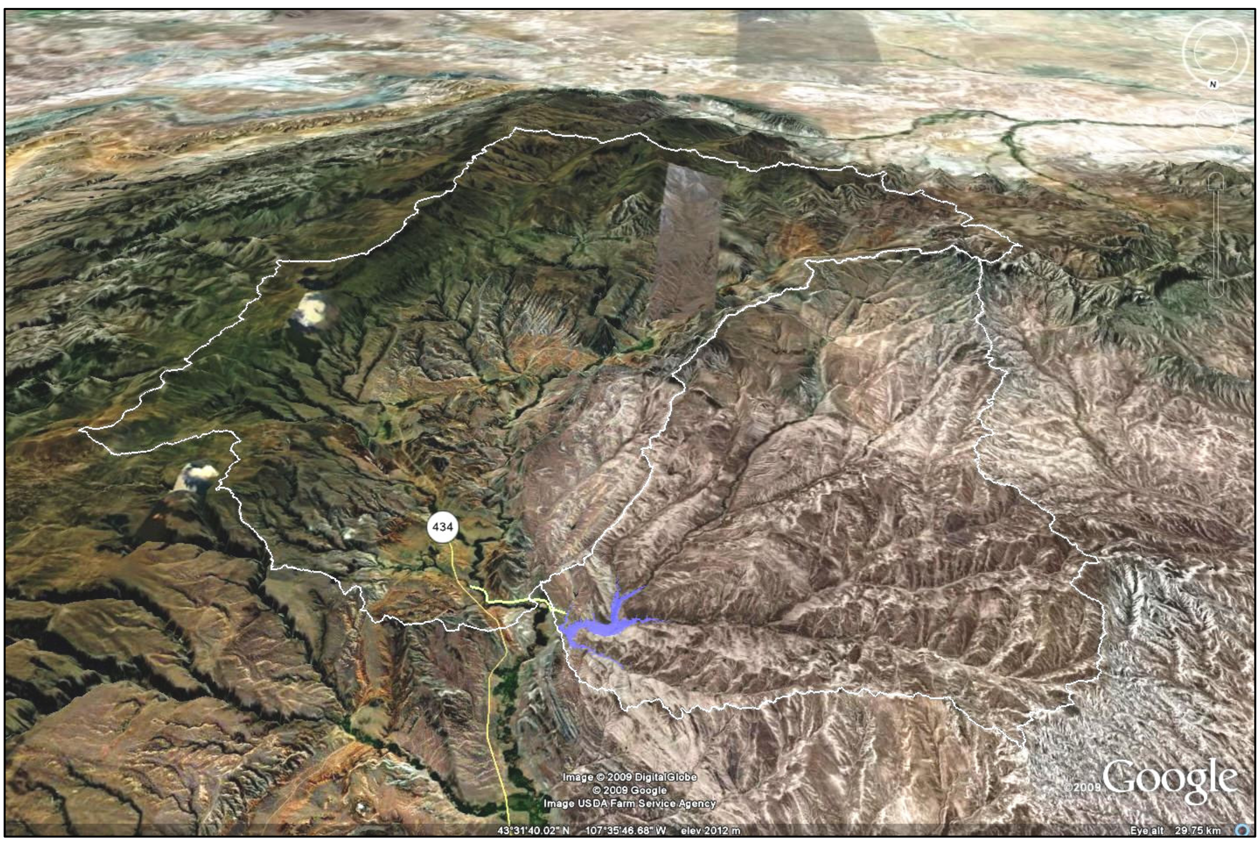


Figure 4.38 Enhanced Satellite Perspective of Drainage Area: Site 3 - Bruner Gulch

Range 88 West). At this location, a gravity-fed diversion could potentially be constructed to convey flows from the Nowood River into upper Buffalo Creek.

This reservoir would provide direct benefits to approximately 5,667 irrigated acres downstream. Additional benefits to irrigators could be obtained through exchanges among users. A reservoir at this site would provide minimal protection against floods of the Nowood River because flood storage would be limited by the capacity of the diversion and supply canal. Flood peaks within Buffalo Creek could be captured; however, these floods would be nominal in relation to the Nowood River.

Minimal existing infrastructure would be affected by this project. No residences, structures or infrastructure were identified which would be directly affected by the embankment, pool or supply canal. However, access to the site for construction would affect ranches located on the Nowood River.

The reservoir would not flood any irrigated acres. However, approximately 1.1 acres of wetlands would be inundated based upon National Wetlands Inventory (NWI) mapping. The reservoir would also flood grazing areas used by the current BLM allottees. According to the WGF, there are no known fisheries concerns associated with the site.

Based upon preliminary geologic investigations of the site, construction of a reservoir is feasible and additional subsurface investigation is warranted.

4.4.3.3 Watershed Plan Component S-03: Reservoir Site No. 10 Meadowlark Lake

This alternative involves enlargement of the existing dam at Meadowlark Lake to increase its storage capacity and to make the additional storage available to downstream irrigators. Figure 4.39 displays the conceptual level configuration of the impoundment. The existing reservoir is located in the NE ¼ of Section 6, Township 48 North, Range 86 West.

The reservoir was built in 1934 by the Civilian Conservation Corps (CCC) and water rights are owned by the USFS (Permit 4923R).All lands involved in this alternative are federally-owned and administered by the USFS. Allocated uses associated with the reservoir are irrigation, domestic, water power, livestock, fish culture, recreation, flood control, erosion control and fire protection. Based upon Wyoming water law, the USFS is not obligated to release water from storage for irrigation purposes. Also, based upon initial review of existing water rights, there does not appear to be any irrigated lands with supplemental supply rights associated with the reservoir.

If downstream users wanted to use water stored in the reservoir, they could petition the USFS and contract for use of water awarded at their discretion and at costs determined by the USFS. According to representatives of the USFS, this is feasible. In such an event, the WSEO would need to be notified triggering regulation of the river to essentially ‘shepherd’ released water to the user’s headgate.

Figure 4.39 Conceptual Reservoir Layout: Site 10 - Meadowlark Lake

However, based upon results of similar efforts elsewhere in the state, such a request of the USFS could initiate NEPA compliance issues making completion of a contract problematic and likely very expensive. The alternative would involve raising the existing embankment approximately 23 feet to gain approximately 4,150 acre-feet of storage. Assuming approximately 5 feet of freeboard and raising the water surface 18 feet, it appears that the State Highway 31 would not be affected by the project based upon available topographic mapping. Structures associated with Meadowlark Lodge and Ski Area may be impacted.

For the purposes of this Level I investigation, it was assumed that the existing appurtenances (outlet, spillway, and fish ladder) would need to be replaced.

The existing storage capacity of the reservoir is approximately 3,500 acre-feet with an embankment of approximately 31 feet. Upon completion of this project the embankment would be approximately 54 feet high and the total reservoir capacity would be approximately 7,650 acre feet.

Figures 4.40 and 4.41 display enhanced satellite perspectives of the reservoir site and its contributing area. Based upon preliminary hydrologic estimates, the estimated runoff in a normal year would be approximately 5,256 acre-feet from East Tensleep Creek all of which would be available for storage. The surface area of the reservoir at maximum capacity would be approximately 324 acres. The drainage area directly contributing to this reservoir is approximately 36.3 square miles.

This reservoir would provide direct benefits to approximately 5,368 irrigated acres downstream along Tensleep Creek and the lower Nowood River. Additional benefits to irrigators could be obtained through exchanges among users.

The reservoir would not flood any irrigated acres. However, approximately 12.2 acres of wetlands would be inundated based upon National Wetlands Inventory (NWI) mapping. Wetland delineation and determination of adequate mitigation locations According to the WGF, completion of this alternative could impact existing trout fisheries in the lake and Tensleep Creek.

A reservoir at this site would provide minimal protection against floods of the Nowood River because the contributing drainage area and storage capacity of the impoundment would be small in relation to the magnitude of flood flows on both the Nowood River and Tensleep Creek.

4.4.3.4 Watershed Plan Component S-04: Reservoir Site No. 18 Taylor Draw

This potential reservoir site is located in the SE ¼ of Section 25, Township 46 North, Range 88 West on Taylor Draw which is a tributary to the Nowood River as indicated in Figure 4.42. The reservoir is intended to serve as an off-channel site storing flows diverted from Otter Creek and conveyed via a supply canal. All lands involved with this alternative are owned by the State of Wyoming. The storage capacity of the reservoir would be approximately 5,050 acre-feet with an embankment height of approximately 80 feet.

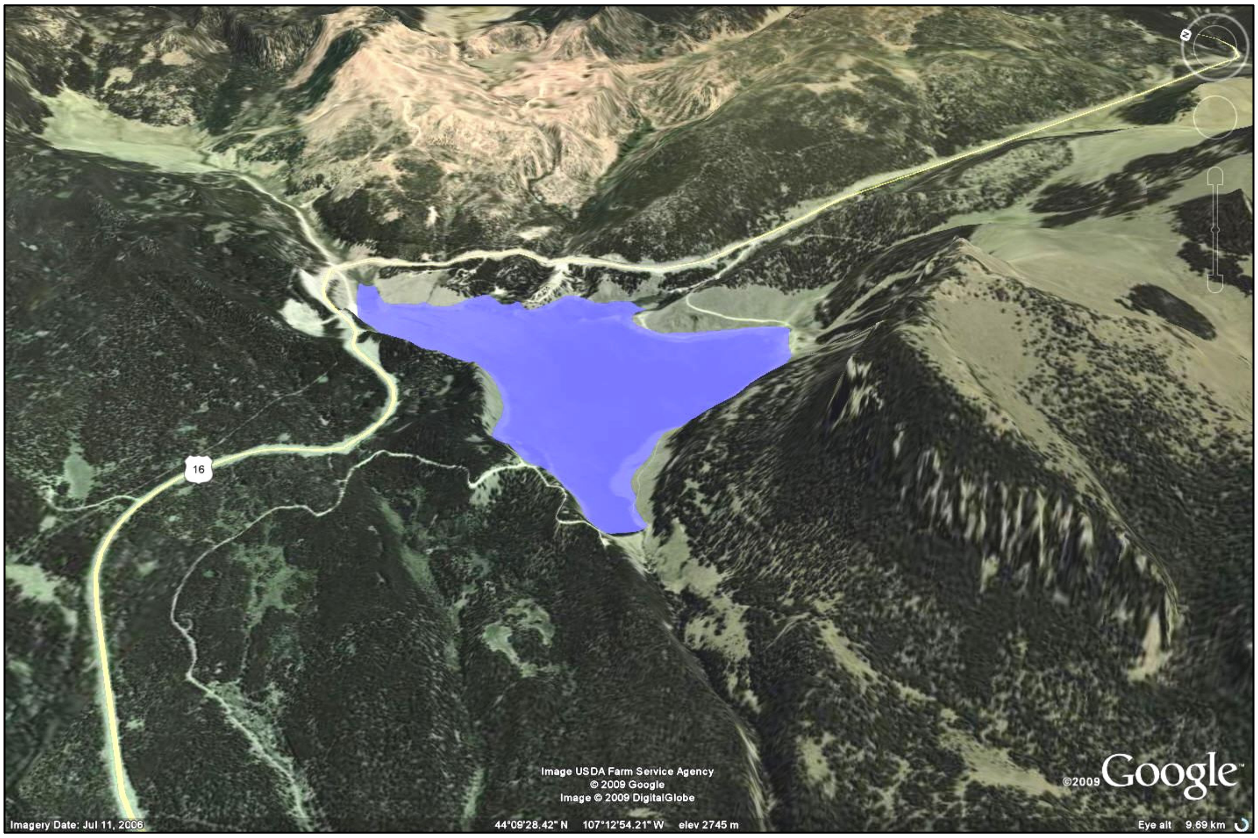


Figure 4.40 Enhanced Satellite Perspective of Reservoir: Site 10 - Meadowlark Lake

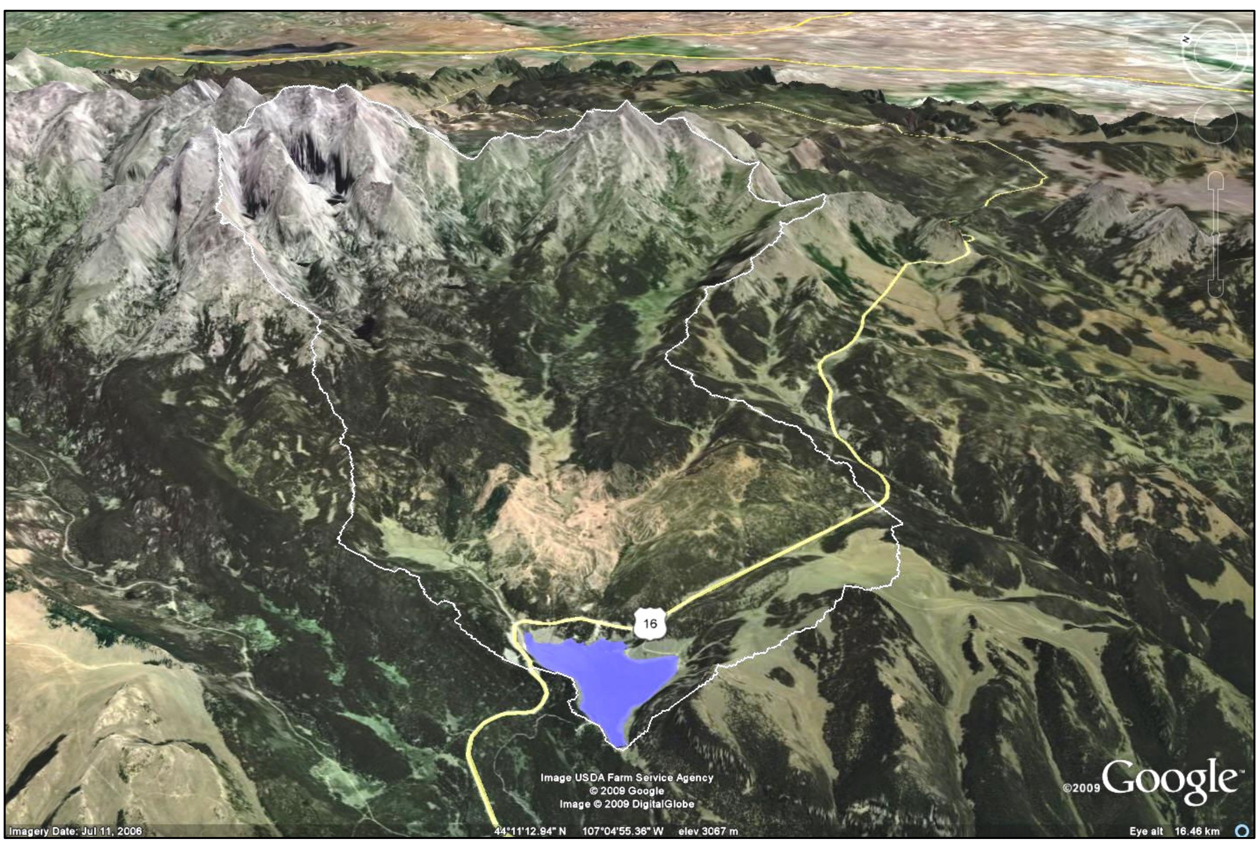


Figure 4.41 Enhanced Satellite Perspective of Drainage Area: Site 10 - Meadowlark Lake

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N W E S

Conceptual Layout
Inundated Area
Taylor Reservoir Supply Canal - Otter Creek

0 3,500 7,000
Feet

Figure 4.42 Conceptual Reservoir Layout Site 18 - Taylor Draw

The drainage area contributing to this reservoir is relatively small (approximately 6.9 square miles) Mean annual precipitation for the contributing drainage area is approximately 13 inches. Consequently, the direct runoff of the watershed would not support a large reservoir at this site without the supplemental water from Otter Creek. Based upon preliminary hydrologic estimates, the estimated runoff in a normal year from Taylor Draw would be approximately 2,075 acre-feet. Estimated runoff for a dry year would be approximately 1,096 acre-feet. Available stream flows from Otter Creek were estimated in the WWDC basin planning model to be nearly 8,988 acre feet in a normal year and over 2,101 acre-feet in a dry year.

Conceptual design of this reservoir includes an earthen supply canal conveying flows from Otter Creek to the reservoir. As an alternative, a canal could be built from Spring Creek to the reservoir; however a greater amount of water is available for storage in Otter Creek. Consequently, that alignment was considered in this Level I investigation. The supply canal would require construction of a diversion structure on Otter Creek near the Spring Creek Road crossing. Figures 4.43 and 4.44 display enhanced satellite perspectives of the reservoir site and its contributing area. Note that the contributing area includes the directly contributing Otter Creek . Conveyance capacity of the supply canal would be determined contingent upon final operational plans for the site. It's assumed that the supply canal direct at least minimal flows most of the year with the bulk being diverted during peak runoff. Assuming approximately 3,000 acre-feet must be diverted in 30 days would require a conveyance capacity of approximately 50 cubic feet per second after accounting for potential seepage losses.

Minimal existing infrastructure would be affected by this project. No residences, structures or infrastructure were identified within the limits of the project. Construction would require access roads along Otter Creek in order to build the supply canal.

The surface area of the reservoir at maximum capacity would be approximately 160 acres. This reservoir would provide local benefits to approximately 4,972 irrigated acres. The reservoir would inundate about 0.2 acres of wetlands based upon National Wetlands Inventory (NWI) mapping. WGF has not identified initial fisheries concerns associated with this site

Based upon preliminary geologic investigations of the site, construction of a reservoir is feasible and additional subsurface investigation is warranted.

4.4.3.5 Watershed Plan Component S-05: Reservoir Site No. 19 Upper Nowood

This potential reservoir site is located on the mainstem of the Nowood River approximately 2.5 miles downstream of the previously discussed Site No. 1: Big Trails in the NE ¼ of Section 31, Township 44 North, Range 87 West. Figure 4.45 displays the conceptual level configuration of the impoundment. Topography at this site does not afford as great a storage capacity as at the Big Trails site. The embankment of the reservoir would be located on lands currently owned by private parties and the State of Wyoming. The reservoir pool would lie on lands owned by private individuals, the State of Wyoming, and the federal government (BLM).

Figure 4.43 Enhanced Satellite Perspective of Reservoir: Site 18 - Taylor Draw

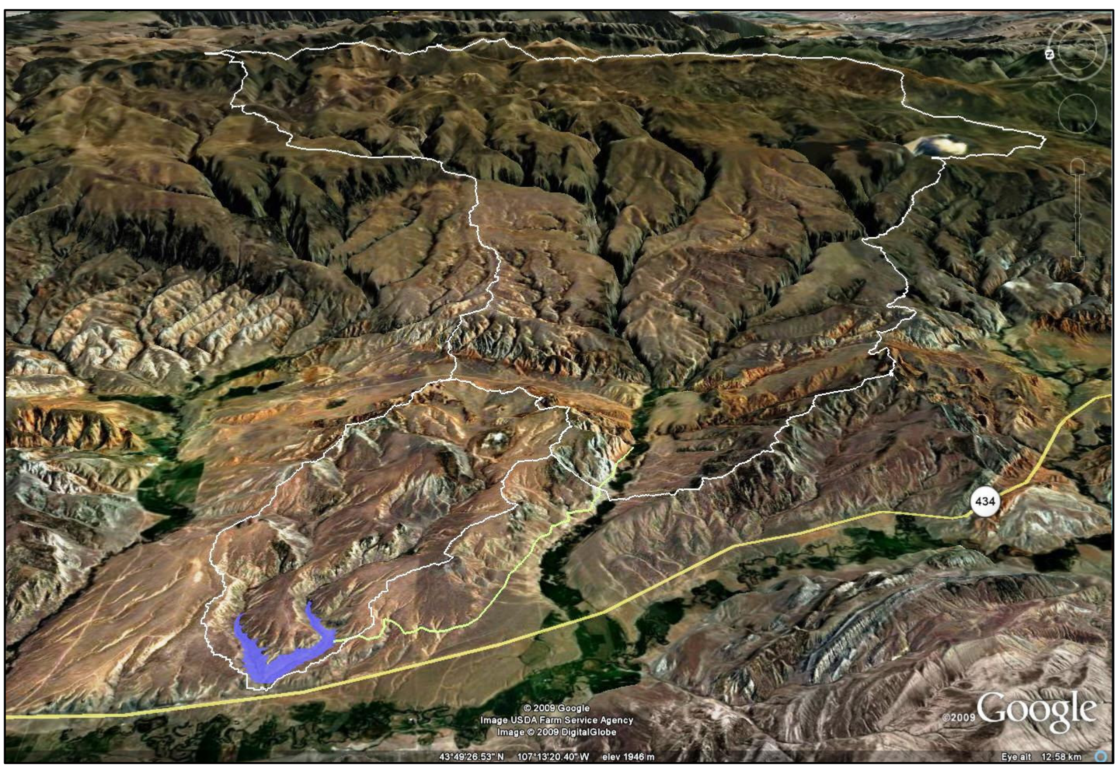
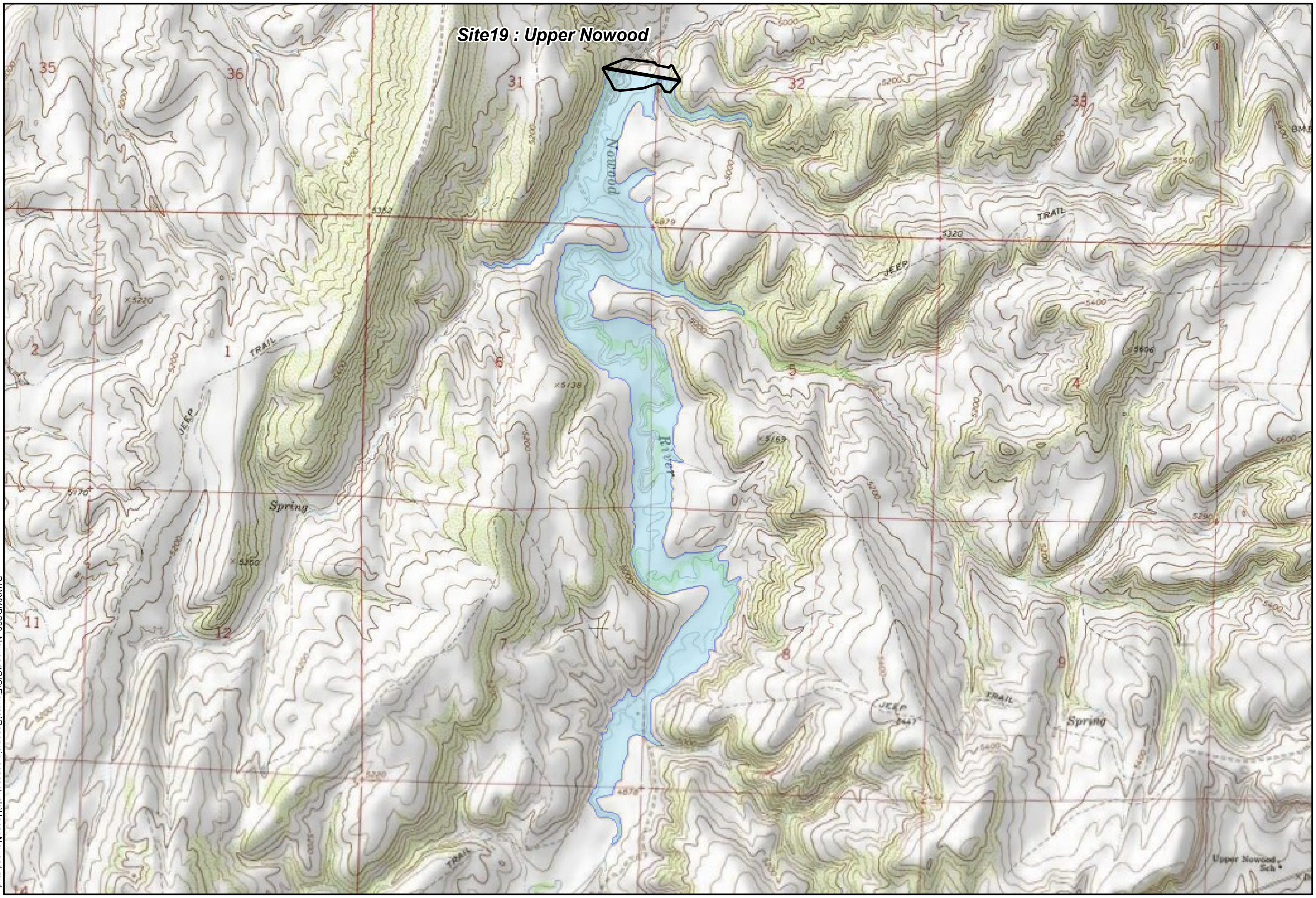


Figure 4.44 Enhanced Satellite Perspective of Drainage Area: Site 18 - Taylor Draw



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Legend

Conceptual Layout

Inundated Area

0 2,000 4,000
Feet

Figure 4.45 Conceptual Reservoir Layout Site 19- - Upper Nowood

The drainage area contributing to this reservoir is approximately 255 square miles. The storage capacity of the reservoir would be approximately 5,250 acre-feet with an embankment height of approximately 80 feet. Based upon preliminary hydrologic estimates, the estimated runoff in a normal year would exceed 75,629 acre-feet of which about 9,760 acre feet would be available for storage while still meeting demands of downstream users. The surface area of the reservoir at maximum capacity would be approximately 321 acres. Figures 4.46 and 4.47 display enhanced satellite perspectives of the reservoir site and the contributing upper Nowood River watershed, respectively.

Based upon review of aerial photographs and analyses conducted within the project GIS, it appears that a reservoir at this location and configured as described herein would avoid existing ranch buildings. However, irrigation ditches and approximately 64.3 acres of irrigated lands would be inundated. In addition, approximately 2.82 miles of County Road 434 would need to be relocated.

Benefits provided by this reservoir include the ability to provide late season irrigation water for approximately 5,853 acres downstream. Given the location of the reservoir on the mainstem of the Nowood River and its contributing area, this site would provide the similar level of flood protection as the Big Trails site; however, the storage capacity is lower.

The reservoir would approximately 1.5 acres of wetlands based upon National Wetlands Inventory (NWI) mapping. According to the WGF, this site could impact brown trout fisheries in the Nowood River.

Based upon preliminary geologic investigations of the site, construction of a reservoir appears feasible; however, due to questionable suitability of bedrock for construction of an embankment, additional subsurface investigation is warranted. It appears that a sufficient volume of borrow material could likely be found in the valley bottom, assuming that the properties of this material are suitable for embankment fill.

4.4.3.6 Watershed Plan Component S-06: Reservoir Site No. 25 Deep Creek

This potential reservoir site is located in the upper portion of the watershed on Deep Creek at the location where the Cherry Creek Stock Road crosses the stream. This location is approximately 9.2 miles upstream of its confluence with the Nowood River in the NW ¼ of Section 6, Township 41 North, Range 87 West. Figure 4.48 displays the conceptual level configuration of the impoundment.

The drainage area contributing to this reservoir is approximately 41.8 square miles. The storage capacity of the reservoir would be approximately 9,600 acre-feet with an embankment height of approximately 100 feet. Based upon preliminary hydrologic estimates, the estimated runoff in a normal year would exceed 55,456 acre-feet of which about9,760 acre feet would be available for storage while still meeting demands of downstream users. The surface area of the reservoir at maximum capacity would be approximately 147 acres. Figures 4.49 and 4.50 display enhanced satellite perspectives of the reservoir site and the contributing upper Nowood River watershed, respectively.

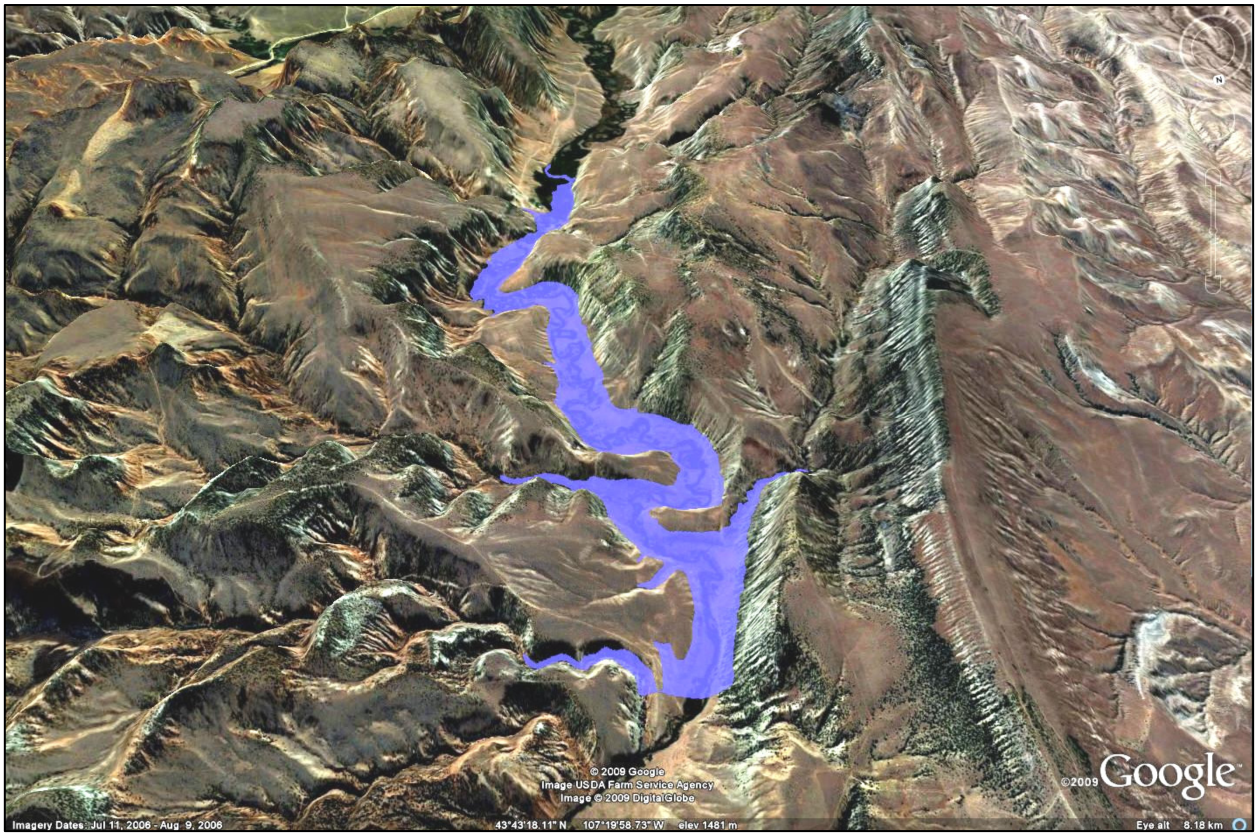

Figure 4.46 Enhanced Satellite Perspective of Reservoir: Site 19- - Upper Nowood

Figure 4.47 Enhanced Satellite Perspective of Drainage Area: Site 19- - Upper Nowood

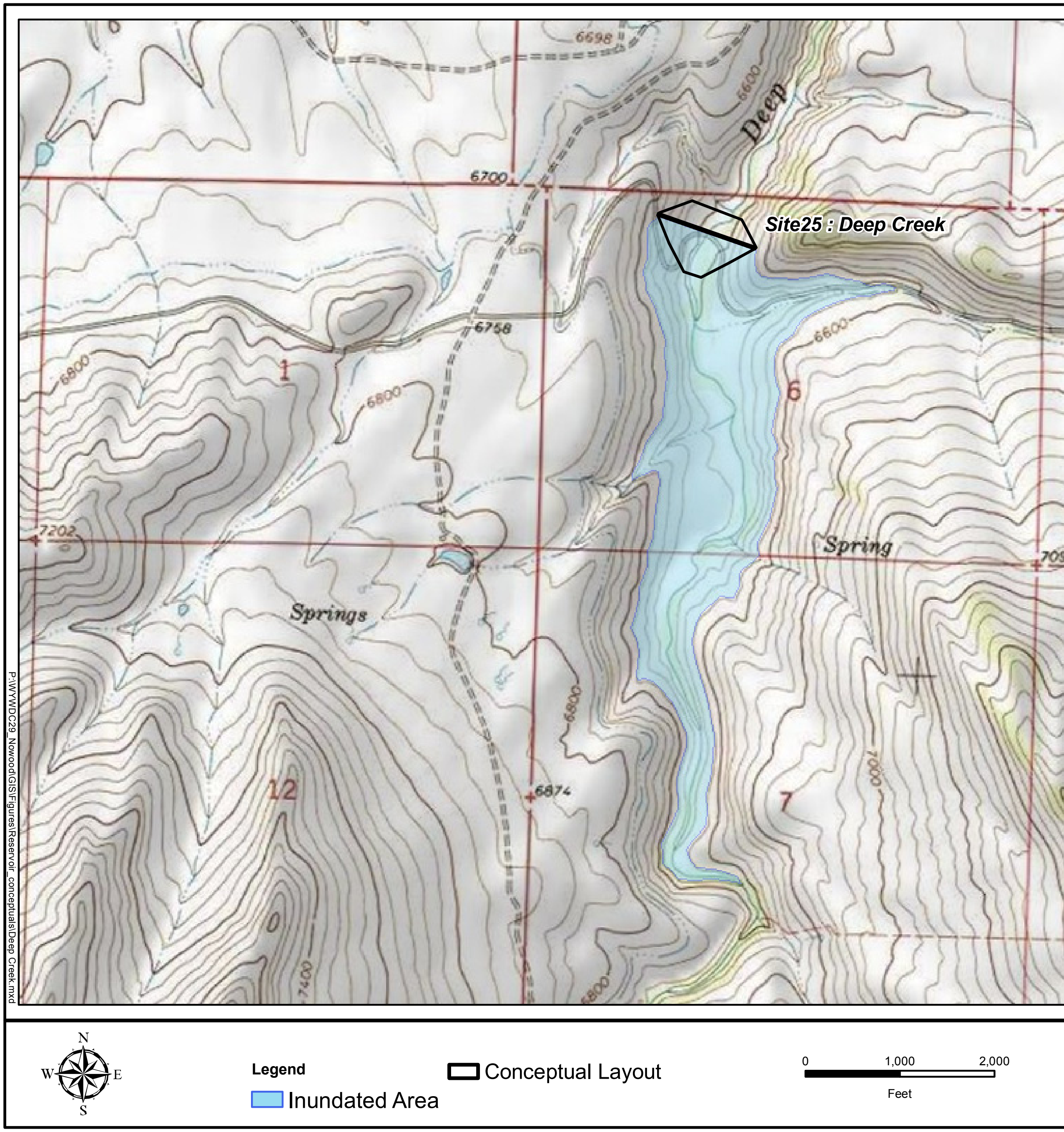

Figure 4.48 Conceptual Reservoir Layout
Site 25 - Deep Creek

Figure 4.49 Enhanced Satellite Perspective of Reservoir: Site 25 - Deep Creek

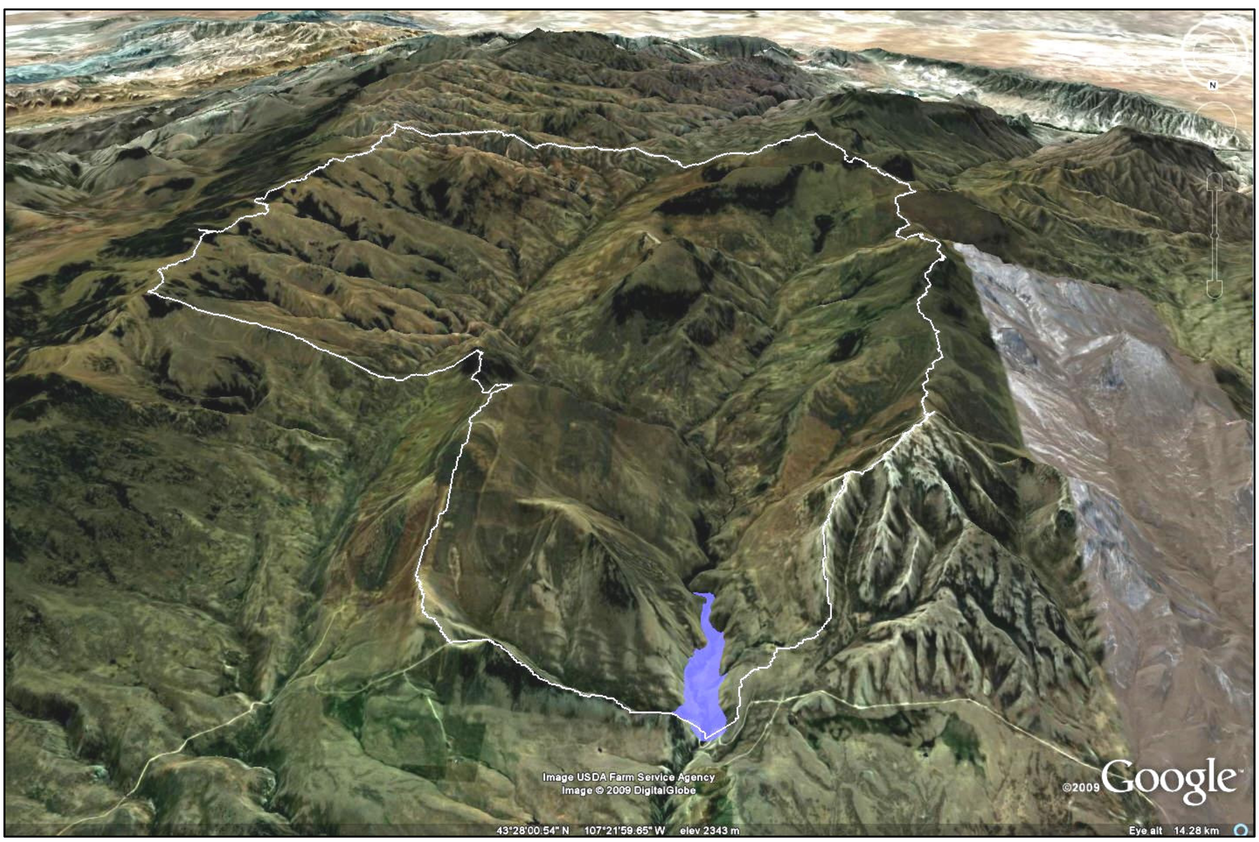

Figure 4.50 Enhanced Satellite Perspective of Drainage Area: Site 25 - Deep Creek

The embankment of the reservoir would be located entirely on lands owed by the Bureau of Land Management . Ownership of lands within the reservoir pool area is a mix of deeded and BLMlands.

Benefits provided by this reservoir include the ability to provide late season irrigation water for approximately 6,301 acres downstream. Given the location of the reservoir on a tributary to the Nowood River and its relatively small drainage area, a dam and reservoir constructed at this location would provide only minimal flood protection to downstream land owners.

Minimal existing infrastructure would be affected by this project. No residences, structures or infrastructure were identified other than approximately 0.5 miles of Cherry Creek Stock Road.

The reservoir would inundate no lands currently irrigated and approximately 4.3 acres of wetlands based upon National Wetlands Inventory (NWI) mapping. According to the WGF, this site could impact brook trout, brown trout, rainbow trout and Yellowstone Cutthroat trout in Deep Creek.

Based upon preliminary geologic investigations, this site may be feasible for an embankment, but a significant subsurface investigation would be required to determine the competency of the underlying bedrock for holding water in the reservoir and serving as a foundation for the embankment. Borrow material for an earthen embankment may be difficult to locate in this part of the basin. Given the potential foundation conditions and the possible borrow limitations, a concrete structure may be more appropriate for this location than an earthen embankment. The dam would likely need to be designed with a spillway running down the downstream face, due to the fact that a good spillway location was not identified at this site.

4.4.3.7 Watershed Plan Component S-07: Reservoir Site No. 26 Nowood River - Crawford

This potential reservoir site is located in the upper portion of the watershed on the mainstem of the Nowood River (SW ¼ of Section 2, Township 41 North, Range 89 West) as indicated on. Figure 4.51 displays the conceptual level configuration of the impoundment.

The drainage area contributing to this reservoir is approximately 36 square miles. The reservoir would be relatively small with a storage capacity of the reservoir of approximately 1,100 acre-feet and an embankment height of approximately 70 feet. Based upon preliminary hydrologic estimates, the estimated runoff in a normal year would exceed 8,092 acre-feet, all of which would be potentially available for storage while still meeting demands of downstream users. Orchard Reservoir is located about one mile downstream of the site. The permitted storage capacity of Orchard Reservoir is 223.98 acre-feet (Permit 5480R). Given the potential combined pool sizes and the amount of stream flows estimated as being available for storage, construction of a reservoir at this location should be feasible without affecting Orchard Reservoir. The surface area of the reservoir at maximum capacity would be approximately 118 acres. Figures 4.52 and 4.53 display enhanced satellite perspectives of the reservoir site and the contributing upper Nowood River watershed, respectively.

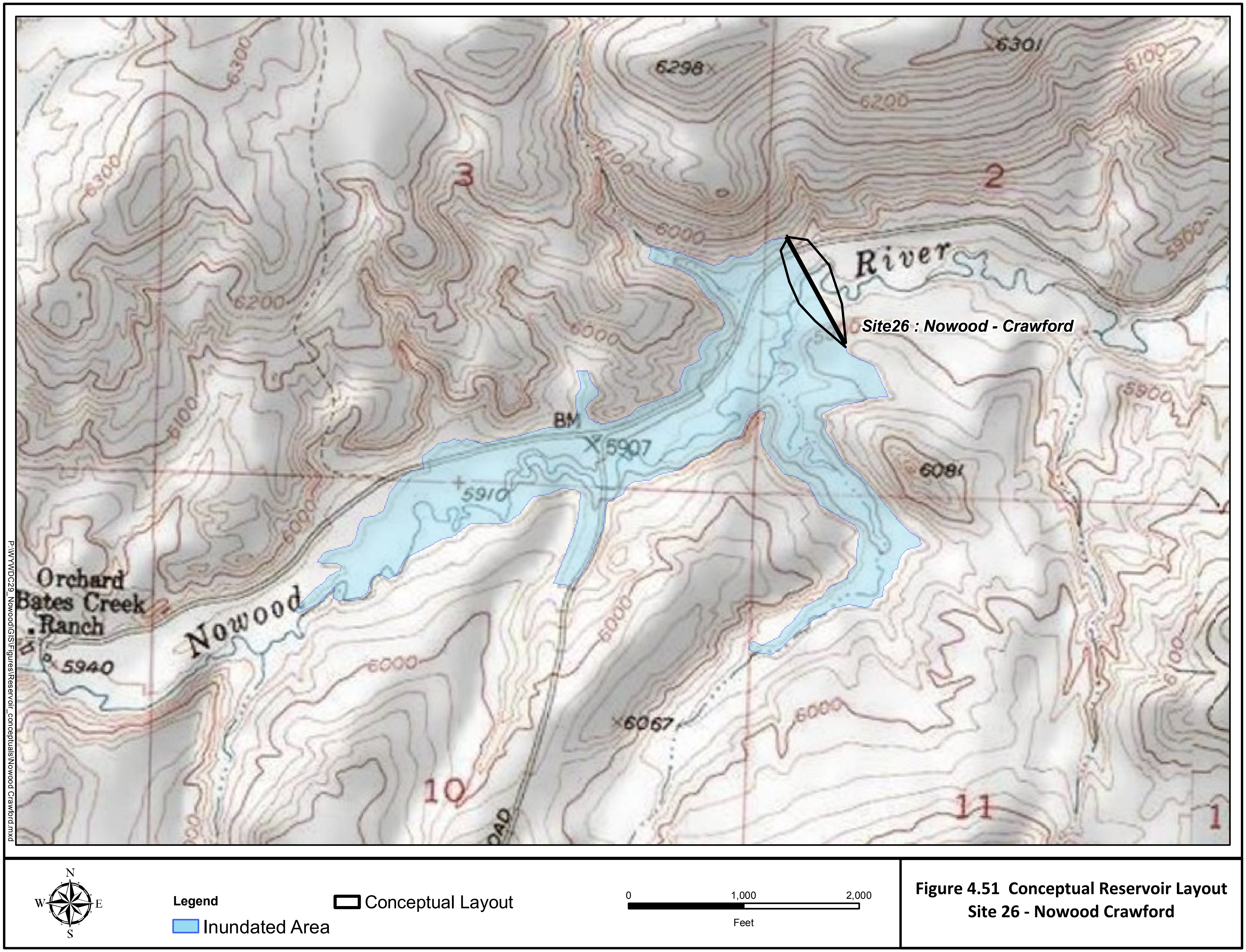

Figure 4.51 Conceptual Reservoir Layout
Site 26 - Nowood Crawford

Figure 4.52 Enhanced Satellite Perspective of Reservoir: Site 26 - Nowood Crawford

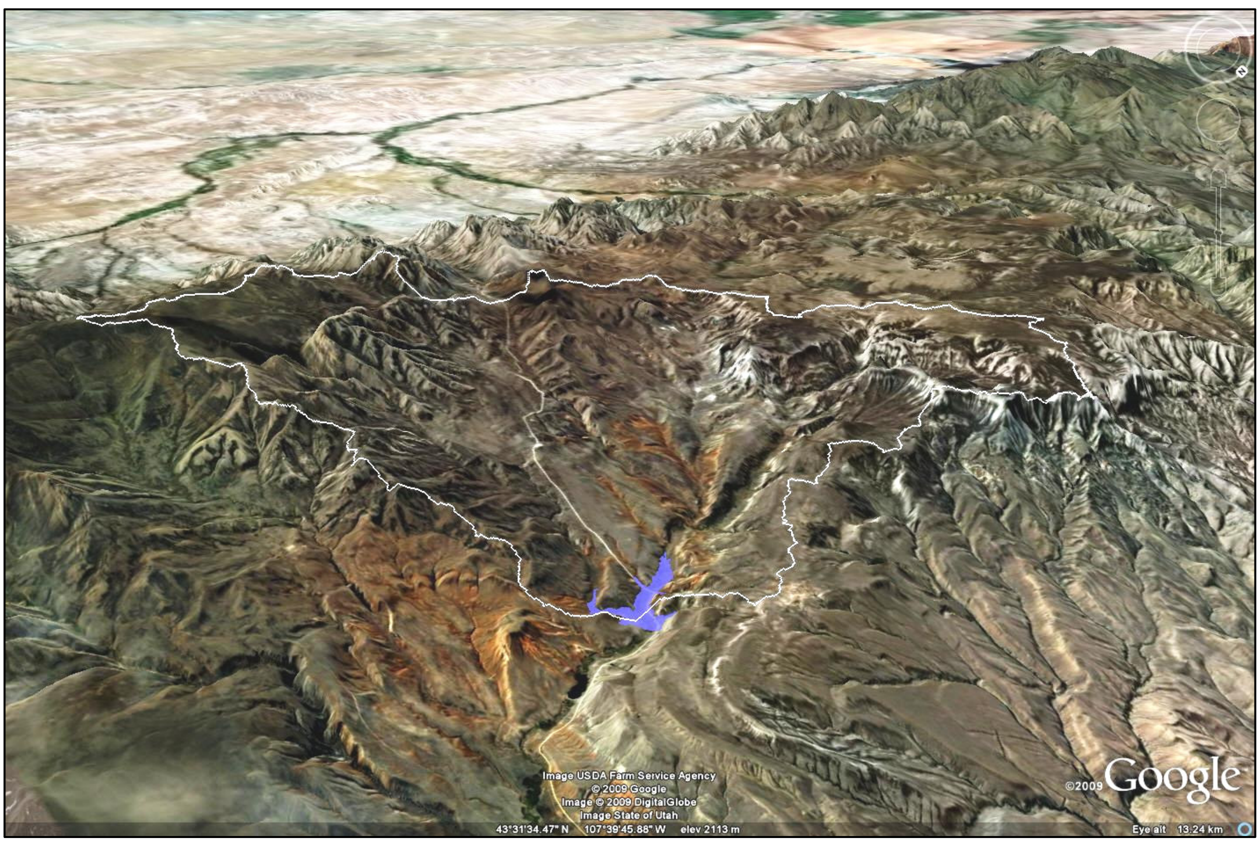

Figure 4.53 Enhanced Satellite Perspective of Drainage Area: Site 26 - Nowood Crawford

The embankment of the reservoir would be located entirely on privately owned lands and State of Wyoming lands. Ownership of lands within the reservoir pool area is a mix of private, State, and Federally owned lands.

Benefits provided by this reservoir include the ability to provide late season irrigation water for approximately 6,421 acres downstream. Given the very high location of the reservoir within the Nowood River watershed, and its relatively small drainage area, a dam and reservoir constructed at this location would provide only minimal flood protection to downstream land owners.

Infrastructure potentially affected by this project would include the buried fiber-optics communications cable discussed in Chapter 3. Because the location of the cable cannot be precisely determined given the available mapping data, the magnitude of this impact and the costs associated with mitigating impacts are uncertain, however, it appears that approximately 3,500 linear feet could be affected. Based upon a review of aerial photography, it appears there are no structures affected by this project, however approximately 1 mile of County Road 82 would need to be relocated.

The reservoir would inundate no currently irrigated lands and would inundate approximately 2.0 acres of wetlands based upon National Wetlands Inventory (NWI) mapping. The WGF has not identified fisheries concerns in this portion of the watershed.

The proposed embankment alignment is near the contact between the Gypsum Springs and Sundance Formations which was observed in an outcrop on the left side of the drainage approximately 400 feet upstream of the left abutment. The Gypsum Springs Formation was also observed outcropping in the bottom of the drainage near the embankment location and is likely overlain by the alluvium and colluvium in the valley bottom and right abutment. Although this formation was flagged as a high risk in the reconnaissance-level assessment, an existing dam and reservoir is located in a similar geologic setting approximately 1 mile downstream of the identified site. The existing dam embankment appeared to be stable; however, observation of the sediment accumulated within the upstream portion of the existing reservoir indicates this portion of the watershed has a high siltation potential. A sufficient volume of borrow material could likely be found in the valley bottom, assuming that the properties of this material are suitable for embankment fill. Improvements to the spillway at Orchard Reservoir could be required by the Wyoming State Engineers Office in order to meet Dam Safety requirements associated with dams placed in series.

4.5 Stream Channel Condition and Stability

4.5.1 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 three 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.

In addition, as discussed in Chapter 3, the Wyoming Game and Fish Department is currently inventorying diversion structures and other structures in the stream channels which may pose barriers to fish passage or entrainment. Consequently, a third impairment to stream channel condition is added here:

- Barriers to fish passage/entrainment by diversions.

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 4.54 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 4.55 shows an alternative form of stream stabilization: the rock filled gabion.

Figure 4.55 Stream Stabilization Structure: Rock Filled Gabion

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

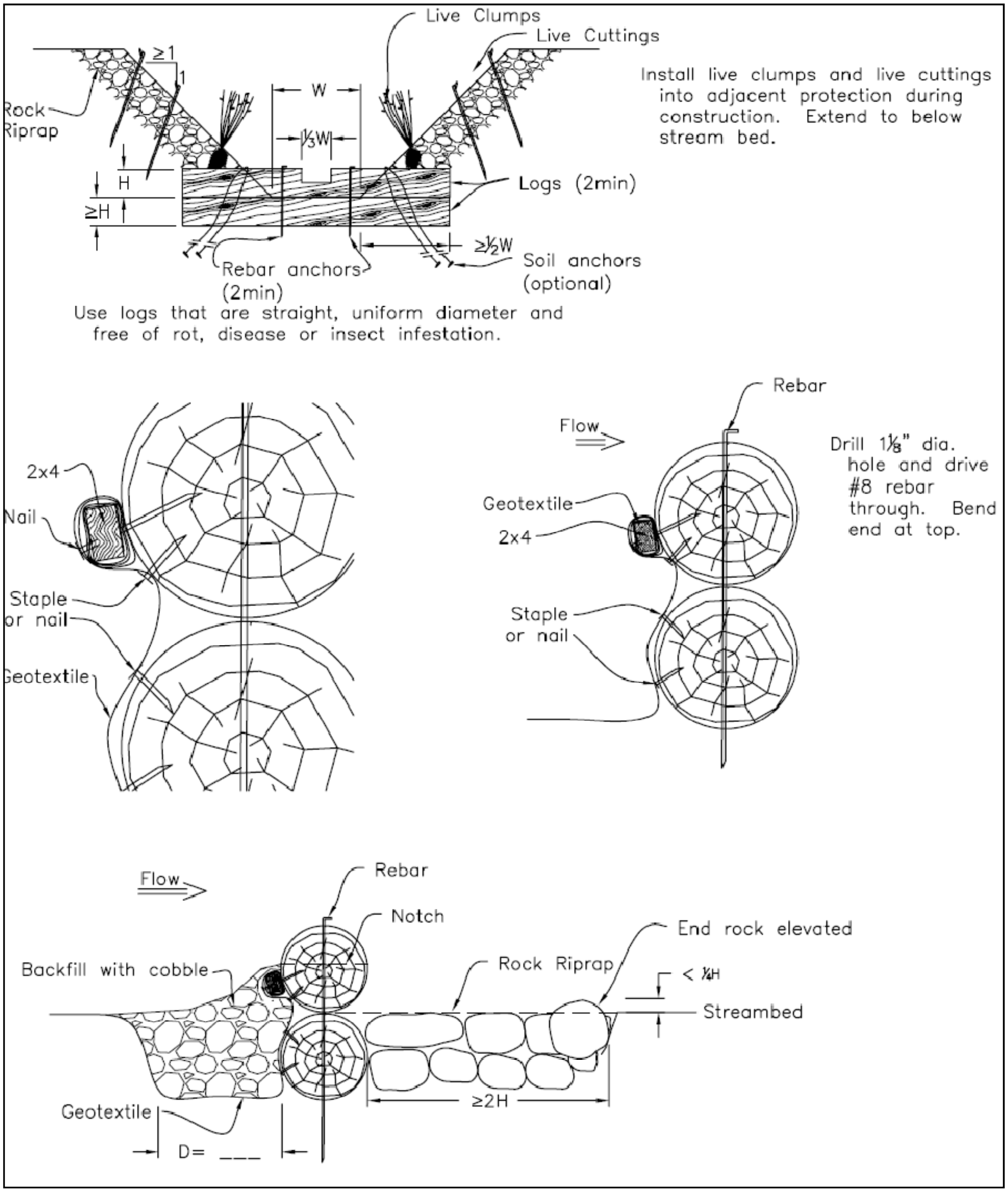

Figure 4.54 Conceptual Design: Log Check Dam

impairment related to historic or current grazing practices that have resulted in overutilization of riparian areas or adjacent upland range. Figure 4.56 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 4.56 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 4.3 presents a summary of some of these channel restoration strategies which can be employed during future restoration efforts. 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.

4.5.2 Stream Channel Components of the Watershed Management Plan

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

Table 4.3 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

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.

Watershed Plan Component C-3: Rehabilitation/replacement of structures posing barriers to fish migration and / or entrainment.

4.6 Grazing Management Opportunities

4.6.1 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 analysis presented in Chapter 3, the two dominant ecological sites found within the Nowood Watershed are:

- Loamy 10-14 inch precipitation zone, Foothills and Mountains East; and
- Loamy 15-19 inch precipitation zone, Foothills and Mountains East.

These two ecological sites comprise over 40% of the entire watershed.

4.6.1.1 ESD: Loamy 10-14 Inch Precipitation Zone, Foothills and Mountains East

According to the ESD for this site, the historic climax plant community is the Bluebunch wheatgrass/Rhizomatous Wheatgrass Community. Figure 4.57 displays the state and transition model for the loamy 10-14 inch precipitation zone Foothills and Mountains East. The following description of the ecological site was extracted from the NRCS ESD for the site:

"This plant community is the interpretive plant community for this site and is considered to be the Historic Climax Plant Community (HCPC). 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.

According to the ESD state and transition model, moderate, continuous season-long grazing will convert the plant community to the Perennial Grass/Big Sagebrush Plant Community. Prolonged drought will

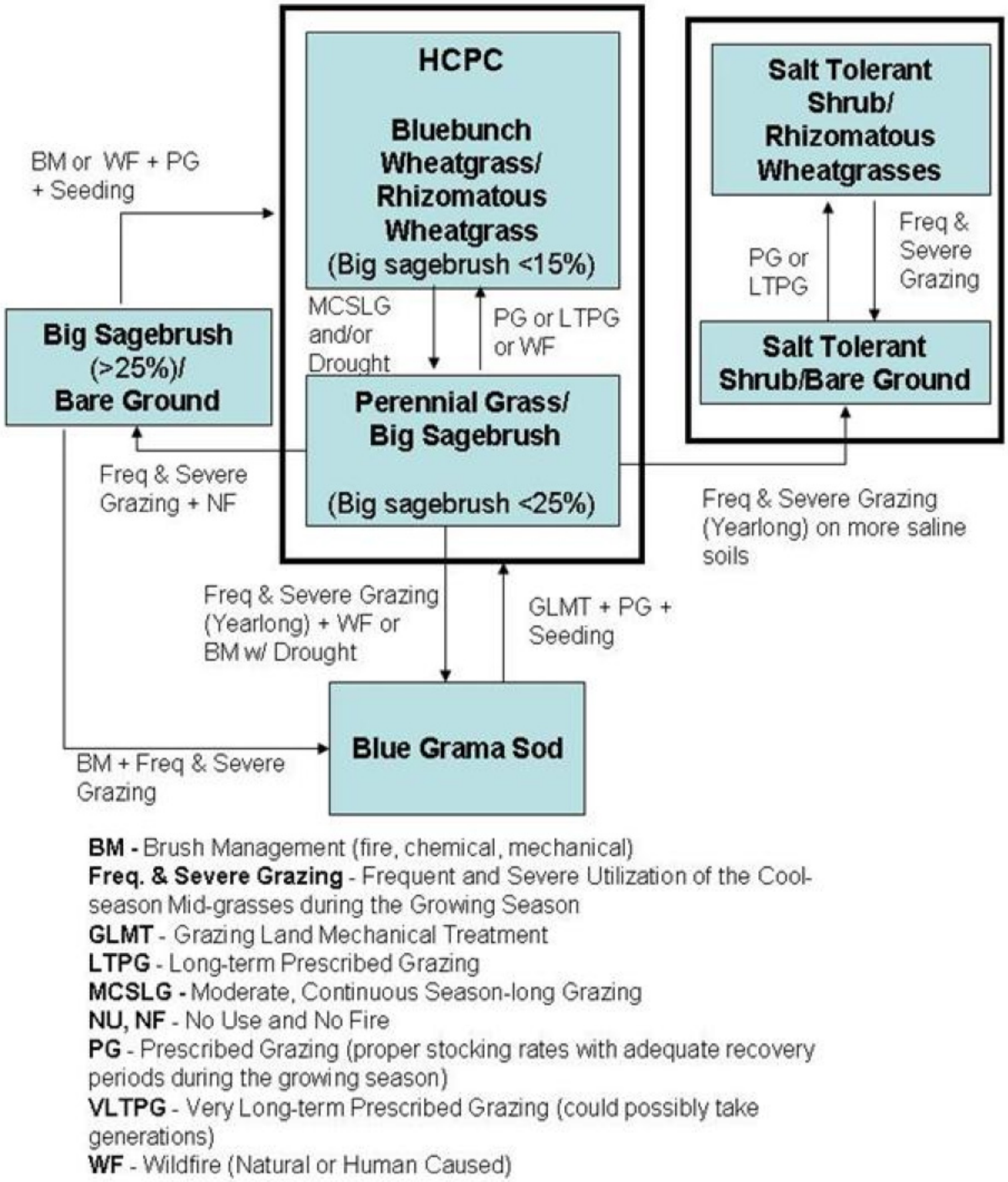

Figure 4.57 State and Transition Model for the Loamy 10-14 Inch Precipitation Zone, Foothills and Mountains East Ecological Site

exacerbate this transition." As indicated in Figure 4.57, this ecological site could shift from perennial grass/big sagebrush community towards the HCPC with prescribed burning or prescribed grazing applying proper stocking with adequate recovery during the growing season.

4.6.1.2 ESD 15-19 Inch Precipitation Zone Foothills and Mountains East Site

The second most prevalent ecological site within the watershed is the 15-19 inch precipitation zone Foothills and Mountains East site. Figure 4.58 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:

Historic Climax Plant Community: Columbia Needlegrass/Spikefescue Plant Community

"The interpretive plant community for this site is the Historic Climax 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."*

4.6.2 Range and Grazing Management Components of the Watershed Plan

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

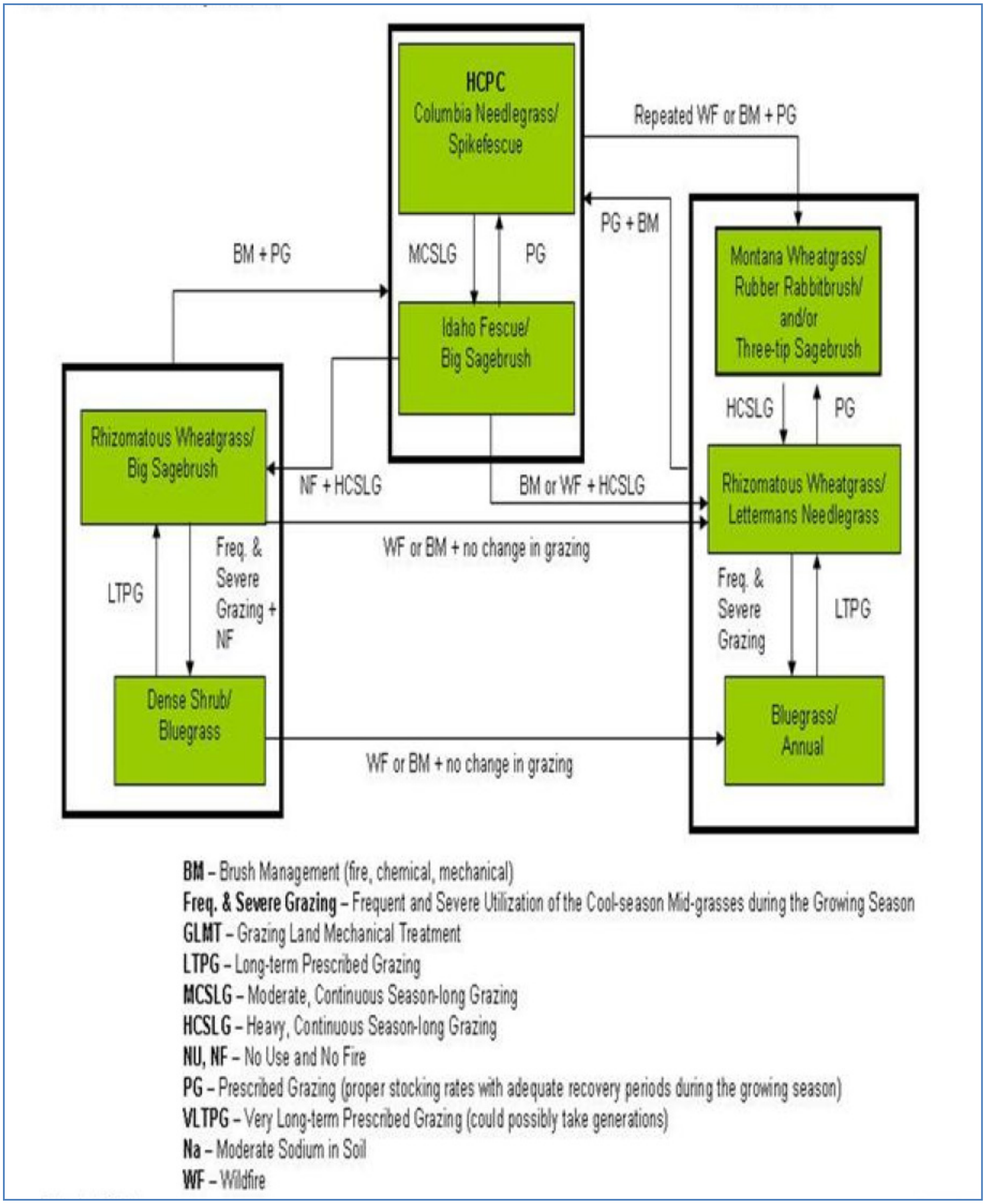

Figure 4.58 State and Transition Model for the Loamy 15-19 Inch Precipitation Zone, Foothills and Mountains East Ecological Site

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 to create pastures of similar ecological condition can enable a rest-rotation 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 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.

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

4.7 Other Upland Management Opportunities

4.7.1 Prescribed Fire

As discussed above, prescribed fire can be used as a tool to restore conditions promoting desirable range species and reduction of invasive species and other species affecting rangeland production and watershed function. As a result of these treatments production of desirable forage increases, benefiting both livestock and wildlife. Watershed values improve overall by decreasing bare ground, decreasing runoff, and improving infiltration, again to the benefit of wildlife and stock. Base flows in creeks sustained by groundwater discharges can extend later into the summer, benefiting the riparian environment and aquatic habitat in these reaches.

Prescribed burning has been utilized in the watershed since the late 1970's. At that time, the Soil Conservation Service (SCS, now called NRCS) conducted burns in the Paint Rock watershed with favorable results (D. Tranas, 2009 pers. comm.). Since that time, the BLM has also initiated prescribed burning within the watershed.

4.7.2 Invasive Species Treatment

As previously discussed in Chapter 3, tamarisk (salt cedar) and Russian olive have invaded the watershed and become well established in the lower reaches of the Nowood River and several of its tributaries. Mapping completed on behalf of the NRCS shows the extent of the problem.

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

- Prevention – seed disturbed or reclaimed areas with native species.
- Prescribed burning – reducing biomass prior to chemical treatment.
- Manual/mechanical removal – root plowing and cutting, bulldozing, hand pulling (seedling stage), mowing, chain sawing (followed by spot chemical treatment); deep root removal necessary for permanent eradication without chemical treatment.
- Chemical treatment - Habitat®+Rodeo®, Pathfinder II®, RoundupPro®, Arsenal®, Garlon 3A®, Garlon4®, etc. as foliar spray or spot application as appropriate to chemical being used.

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); predominance of tamarisk versus more desirable native species; location in the floodplain/overbank; accessibility; season/weather; etc. It is important to implement appropriate management practices to encourage development of healthy riparian and related vegetation in any areas in which tamarisk and/or Russian olive have been removed to prevent a return of the target species or invasion by other noxious weeds and undesirable plant species. It may also be desirable to plant appropriate species to replace lost wildlife habitat values (i.e., Silverleaf buffaloberry to replace Russian olive).

4.7.3 Noxious Weed and Undesirable Plant Control

The Big Horn County and Washakie County Weed and Pest Districts are implementing aggressive, well planned, and cost-effective treatment and control measures for saltcedar, Russian olive and noxious and other weeds as available staffing and funding allow. Both Districts have 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 Districts in applying for additional grant funding, participate with in-kind efforts on work days and attend/support workshops and planning sessions.

4.7.4 Other Upland Components of the Watershed Management Plan

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

Watershed Plan Component O-1: Eradication efforts targeting tamarisk and Russian olive should continue. Extensive areas have been treated in recent years with favorable success. Continuation of these efforts and continued education of land owners of the benefits of removal of these species is recommended.

Watershed Plan Component O-2: Noxious weed management programs currently being conducted by the respective weed and pest control districts of Washakie and Big Horn Counties should continue. Education opportunities for land owners and managers should continue to be made available.

4.8 The Nowood River Watershed Management

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

- Irrigation System Rehabilitation,
- Upland Wildlife/Livestock Water Opportunities,
- Surface Water Storage 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 Nowood River watershed, the watershed management plan consists of a compilation of the recommendations for each category. The plan is summarized in Tables 4.4 and 4.5.

Table 4.4 Nowood River Watershed Plan (Part 1)

Watershed Plan Component: Irrigation System Rehabilitation					
Watershed Component	**Description**	**Priority**	**Watershed Component**	**Description**	**Priority**
Anita Supply Ditch/Anita Ditch System Improvements (I-01)			**Highland Ditch System Improvements (I-06)**		
I-01.1	Replace/install 6 farm turnouts	3	I-06.1	Replace canal headgate	2
	Replace concrete channel - see Mercer for		I-06.2	Replace/install 6 farm turnouts and clean 1	3
I-01.2	Replace failing drop structure	1	I-06.3	Replace 60-inch diameter CMP	3
I-01.3	Install 6-foot drop structure	2	I-06.4	Replace 24-inch diameter CMP	3
I-01.4	Install check structure	3	I-06.5	Rehabilitate wasteway	3
I-01.5	Replace wasteway with pipe drop structure	2	**Melley Ditch System Improvements (I-07)**		
I-01.6	Replace 36-inch pipe over Alkali Creek	1	I-07.1	Install 12-inch PIP, (Approx. 3,800 lf with 6	2
I-01.7	Install four 6-foot drop structures	2	I-07.2	Install ditch headgate and diversion	2
Avent Ditch System Improvements (I-02)			**Shafer Ditch System Improvements (I-08)**		
I-02.1	Replace wasteway structure	2	I-08.1	Remove existing headgate	2
I-02.2	Rehabilitate pipe drop structure	2	I-08.2	Install new headgate with sediment sluice	1
I-02.3	Replace/install 8 farm turnouts	3	I-08.3	Replace/install 6 farm turnouts	3
I-02.4	Replace check structure	2	I-08.4	Replace/install new check structure	2
Green Spot Ditch System Improvements (I-03)			I-08.5	Rehabilitate check structure	3
I-03.1	Replace ditch headgate	1	I-08.6	Clear vegetation in and along ditch	2
Hardscrabble / Williams Ditch System Improvements (I-04)			I-08.7	Install liner (1,500 lf)	2
I-04.1	Replace Williams Ditch Headgate	2	**Victoria Ditch System Improvements (I-09)**		
I-04.2	Install NRCS tubulent fountain/valves/connections at pipeline inlet	1	I-09.1	Replace canal headgate and diversion structure	2
Harmony Ditch System Improvements (I-05)			I-09.2	Install / replace 3 farm turnouts	3
I-05.1	Replace 3-ft Parshall flume	3	I-09.3	Install 100 feet 12-inch RCP and surface inlet	2
I-05.2	Install check structure	2	I-09.4	Rehabilitate check structure	1
I-05.3	Install new drop structure with check	1	**West Ditch System Improvements (I-10)**		
I-05.4	Replace/install new check structure	2			
I-05.5	Replace/install 9 farm turnouts	3	I-10.1	Replace ditch headgate	2
I-05.6	Replace culvert with check structure	2	I-10.2	Replace splitter/wasteway	2
I-05.7	Install new drop structure	2	I-10.3	Replace 5' Parshall flume	1
I-05.8	Install new check structure	2	I-10.4	Rehabilitate siphon	1
I-05.9	Install new check structure	2	I-10.5	Replace/install 8 farm turnouts	3
I-05.10	Install new check structure	2	I-10.6	Install check structure	2
I-05.11	Install new wasteway structure	2	I-10.7	Replace 2’ Parshall flume	2

Table 4.5 Nowood River Watershed Plan (Part 2)

Watershed Plan Component: Upland Wildlife / Livestock Water Projects

Watershed Component	Project Name	Allotment Directly Benefitted	Pipeline (lineal feet)	Stock Tanks (number each)	Storage tanks (Number each)	Stock Ponds (Number Each)	Guzzlers (Number Each)
U-01	Wildhorse Draw Pipeline Project	Torchlight, East Flats, Weber , Lower Nowood	54,500	6	1	0	0
U-02	McDermott Draw Pipeline Project	Airport, West Alkali, Weber Lower, Lower Nowood	48,800	5	0	0	0
U-03	Eask Alkali Pipeline Project	East Alkali, West Alkali	27,500	3	0	0	0
U-04	Weber Lower Pipeline Project	Weber Lower	12,800	3	0	1	0
U-05	Myers Spring Pipeline Project	Meyers Spring, Weber Lower	37,500	5	0	0	0
U-06	Cold Spring Pipeline Project	Mathews Ridge, Cold Spring	24,300	3	0	1	0
U-07	Rannell's Pipeline Project	Rannell's	3,300	1	0	0	0
U-08	Gapen Hyatt Pipeline Project	Renner Individual, Gapen Hyatt	67,500	7	0	0	0
U-09	Brokenback No. 1 Pipeline Project	Brokenback	26,200	3	0	0	0
U-10	West Side Regional Pipeline Project	Blue Ridge, West Nowood, Hidden Dome, Little Cottonwood, Castle Gardens, Kimball, Bud Kimball, North Butte, Cedar Ridge, Joe Henry, Big Cedar, Gordon, and Buffalo Creek	410,000	29	2	0	0
U-11	Duncan Pipeline Project	Duncan	2,500	3	0	1	0
U-12	Hidden Dome Pipeline Project	Hidden Dome	35,900	6	1	0	0
U-13	Brokenback No. 2 Pipeline Project	Brokenback	11,600	2	0	0	0
U-14	Brokenback No. 3 Pipeline Project	Brokenback	7,100	1	0	0	0
U-15	Brokenback No. 4 Guzzler	Brokenback	100	1	0	0	1
U-16	Big Cottonwood Pipeline Project	Big Cottonwood, North Blue Ridge, Sand Creek,	36,000	5	0	0	0
U-17	Schoolhouse Gulch Pipeline Project	Schoolhouse	6,150	2	0	0	0

Watershed Plan Component: Surface Water Storage Opportunities

Watershed Component	Project Name	On-Channel / Off-Channel	Capacity (acre-feet)	Surface Area (acres)	Dam Height (feet)	Embankment (feet)	Total Dam Volume (cy)
S-2	Big Trails	On Channel	16,850	623	80	765	650,000
S-3	Bruner Gulch	Off Channel	7,700	557	45	650	164,742
S-10	Meadowlark Lake Enlargement	On Channel	4,150	324	23	580	26,074
S-18	Taylor Draw	Off Channel	5,050	160	80	1,050	827,852
S-19	Upper Nowood	On Channel	5,250	321	80	1,260	927,585
S-25	Deep Creek	On Channel	9,600	147	100	1,085	672,000
S-26	Nowood - Crawford	On Channel	1,100	118	70	1,100	695,139

Watershed Plan Component: Stream Channel Restoration Projects

C-1	Installation of stream channel degradation/incision mitigation measures.
C-2	Installation of stream bank erosion mitigation measures
C-3	Rehabilitation/replacement of structures posing barriers to fish migration and / or entrainment

Watershed Plan Component: Grazing Management Opportunities

G-1	Expansion of grazing distribution / limited reliance on riparian areas.
G-2	Fencing to create pastures of similar ecological condition to enable a rest-rotation grazing system.
G-3	Strategic salting and herding are other tools that can be used to enhance grazing distribution.
G-4	Consideration of wildlife needs in upland water source development (escape ramps, wildlife watering facilities, etc).
G-5	Utilization of Ecological Site Description State and Transition Modeling to optimize range conditions.
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 mode

Watershed Plan Component: Other Management Opportunities

O-1	Continuaton of eradication efforts targeting tamarisk and Russian olive
O-1	Continuation of noxious weed management programs currently being conducted by the weed and pest districts.

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 Popo Agie River Watershed Investigation (ACE, 2003) and the Cottonwood Creek / Grass Creek Watershed Management Plan, Level I (SEH, 2007) 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.

5.1.1 NEPA Process for Reservoir Storage Projects

The following discussion characterizes the basic steps of the NEPA process applicable to a reservoir storage project. A separate discussion in Section 5.1.2 addresses other potential watershed rehabilitation or improvement projects.

Prepare a Purpose and Need Statement for the Project. It is important to develop an accurate and defensible Purpose and Need statement for the project as one of the first steps in the NEPA process. The Purpose and Need statement provides an overall or basic purpose for the proposed action and presents details supporting various needs for the project. The Purpose and Need statement should provide enough information to develop and support a "reasonable range" of alternatives. More specifically, the Purpose and Need statement guides the alternative development and screening process. With the COE as the lead agency, the Purpose and Need would include a reference to finding the "least damaging practicable alternative." This reference relates to the Clean Water Act Section 404 requirements that are under the jurisdiction of the COE and is an important part of the NEPA process for a reservoir storage project. Additional details about the Section 404 process are provided in Section 5.2. Develop Project Alternatives and NEPA Documentation Determination. The NEPA process requires analysis of the No Action alternative and a reasonable range of alternatives that fully address the project's purpose and need. The reasonable range of alternatives may include one or more "build" alternatives, depending on the nature and extent of anticipated project impacts and level of NEPA documentation to be provided.

For new, expanded or reconstructed reservoir storage projects, key issues associated with alternative development will or may include:

- loss of wetland and riparian habitat from direct inundation by a new, expanded or reconstructed reservoir;
- potential impacts on threatened and endangered species;
- potential impacts on fish and other aquatic species; and
- potential impacts on other wildlife (e.g., sage grouse; big game).

Given these issues and risk management considerations, the project team anticipates that an EIS will likely be the appropriate NEPA documentation for reservoir storage projects. An EIS involves analysis of more than one build alternative and typically takes up to several years to complete. An Environmental Assessment (EA) may or may not involve analysis of more than one build alternative and can typically be completed in less than 18 months. The outcome of an EA is either a Finding of No Significant Impact (FONSI) or a recommendation to prepare an EIS. If an EA is prepared, there is a possibility that the outcome might be that an EIS is needed. This could occur as a result of "significant impact findings" or as a result of substantial public controversy over the project's effects. If this occurs at the end of the EA process, the EIS process would need to start from the beginning, wasting a considerable amount of time and money. At this time, it appears it would be prudent to assume that an EIS process would be applicable, while leaving the option open for an EA/FONSI, rather than to proceed with an EA and take the risk that an EIS will ultimately be needed. This decision should be reviewed during a Level II study (should the project advance) when more detailed information is available on a preferred proposed action and its appropriate alternatives.

Conduct a Proactive Public Involvement Program. The NEPA process begins with public and agency outreach and related input focused on alternatives and potential impacts. Education about the project's purpose and need, project details and issues is provided and input is solicited in various ways. It is very important that the public have a clear understanding of the benefits and potential adverse impacts of the proposed action and alternatives. Public involvement is continuous throughout the project and can influence alternative development, alternative screening, issues addressed, mitigation measures, the level of NEPA documentation to be prepared (EA or EIS), and the selection of the preferred alternative.

Collect and Analyze Environmental Baseline Data. It is important to carefully identify environmental constraints and considerations early and incorporate them into alternative development efforts as a means of avoiding and minimizing potential impacts. Early field investigations and agency consultation and coordination efforts help to focus this effort and streamline subsequent analysis methods, schedule needs, and budget requirements. Creating "self-mitigating" alternatives is highly advantageous and fully consistent with the intent of NEPA.

Many NEPA analyses relate to compliance with various laws and regulations. Integrating the NEPA, National Historic Preservation Act, Endangered Species Act and other compliance processes will reduce overall permitting timeframes and costs, and streamline agency decision-making. These issues are discussed in Section 5.2.

Prepare the Draft and Final Environmental Impact Statement. The Draft EIS would be prepared in two versions. A Preliminary Draft EIS would be prepared for internal review. The Draft EIS would respond to comments on the Preliminary Draft EIS. The Draft EIS would be circulated for public review and would be the subject of a public hearing. The Final EIS would also be prepared in two versions. A Preliminary Final EIS would be prepared for internal review. The Final EIS would respond to comments on the Preliminary Final EIS. The Final EIS would be circulated for public review and would be the subject of a public hearing. A Record of Decision would be prepared to complete the NEPA process.

5.1.2 NEPA Process for Other Project Types

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 both reservoir storage projects and other types of 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

5.2.1 Dam and Reservoir Construction

In addition to the U.S. Army Corps of Engineers (COE) Section 404 Permit, there are numerous other permits and/or approvals required for new dam and reservoir construction. Presented below are the primary additional permits and/or approvals that would be required for any of the alternative projects under consideration.

Section 404 Permit. Like all water development projects, any dam and reservoir storage project in the Nowood River watershed will face environmental permitting issues. Typically the most significant environmental permit to be secured is a Section 404 Dredge and Fill permit from the COE, Omaha District. Even when impacts are anticipated to be modest, the process of obtaining a Section 404 permit for new storage projects may take several years from initiation of the NEPA process.

The primary guidance in embarking on the permitting process for a new dam and reservoir storage project is the development of a defensible Purpose and Need for the project. The NEPA process dictates that the least environmentally damaging practicable alternative that addresses the purpose and need be pursued. This is the alternative most likely to be successfully permitted.

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 l974 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.

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; the U.S. Forest Service would use their equivalent special use 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.).

5.2.2 Other Project Types

Permits, clearances and approvals for projects other than major dams and storage reservoirs will depend on the specific nature and location of the project. Various permits and clearances discussed above in Section 5.2.1 may also apply to other types of projects. The specific permits and clearances necessary for a particular project should be determined early in the planning stages of the project to ensure compliance with applicable laws and regulations, and to avoid possible delays, increased costs and possibly re-design later during project implementation.

5.3 Environmental Considerations

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

Endangered: Black-footed Ferret (*Mustela nigripes)*
Threatened: Gray Wolf *Canis lupus*
Grizzly Bear *Ursus arctos horribilis*

(Wyoming Natural Diversity Database [WYNDD], 2007).

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 2 amphibians, 4 reptiles, 2 fish, 53 birds, 24 mammals, and 1 mollusk.

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.

Rare Plant Species of Concern. The WYNDD has 34 known sensitive plant species of concern located in the watershed as discussed in Chapter 3 of this report. The potential exists for some of these species to occur within appropriate habitats within the project area. However, none of these species receive federal or state protection.

Big Game. The Nowood River watershed 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 it's self at a certain level over a long period of time.

Fisheries. Most of the alternative reservoir sites are located on tributaries that are considered perennial and contain viable fisheries resources. WGFD has provided initial comments on each site as indicated in Chapter 4 and in Appendix F. Impacts to the various streams and associated fishery resources will occur with any of the alternative dam and reservoir storage alternatives and should be considered during further environmental evaluation of these sites.

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 Mitigation

Based on prior experience, mitigation could be required at any of the identified alternative dam and reservoir sites to address impacts to wetlands, riparian vegetation, stream channel habitat, cultural resources, fish and game resources, and possibly threatened or endangered species. It is preferred to avoid the need for mitigation of a potentially significant impact by relocation and/or “self-mitigating” design if technically and economically feasible.

Detailed mitigation plans would need to be prepared and approved to replace any lost wetlands identified and quantified by formal wetlands delineation, and riparian vegetation communities. However, given the relatively small acreages of wetlands at the alternative dam and reservoir sites (ranging from less than 1 to 12.2 acres), it is anticipated that mitigation of this resource will be possible at any of the sites by constructing additional wetlands nearby, ideally in the same mainstem stream and/or in a close-by tributary.

Mitigation of potential raptor and big game impacts would generally involve control of certain construction activities during sensitive time periods, and avoidance of direct disturbance of the subject species. Mitigation of potential sage grouse lek impacts will be given special consideration as discussed previously. If any T&E species were encountered at a given site special studies would be required to determine if appropriate mitigation could be implemented. In general, any such impacts would be avoided to the greatest extent possible by relocation of site facilities.

Additional cultural and historic resource fieldwork would need to be completed to identify and document any such resources that would be inundated or otherwise impacted as a result of constructing any one (or more) of the alternative dams and reservoirs or other potential projects described in Chapter 4 above. This would include, in turn, a class I (literature search) survey, a Class II (reconnaissance inventory) survey, and if needed, a class III (intensive inventory) survey. Ultimately, a mitigation plan for cultural resources would be developed which would culminate in a Memorandum of Agreement (MOA) between the Wyoming SHPO and the lead federal agency with concurrence by the project sponsor(s), and possibly affected Native American tribes. The agreement would require approval from the Advisory Council on Historic Preservation.

5.5 Bighorn National Forest (USDA)

Construction of projects within the boundary of the Bighorn National Forest will require coordination through the United Stated Department of Agriculture. Special Use Permits, with respect to NEPA, will likely be required for any facility place on forest lands. In this case, the USFS would likely be the lead federal agency.

5.6 Land Ownership and Property Owners

Where applicable, permission should be negotiated for easement/right-of-access for all construction activities associated with the project. ***It is important to note that the WWDC has stated that lands will NOT be 'taken' or condemned in order to construct projects recommended within the watershed management plan. Representatives of the WWDO have stated that the State is not interested in condemning lands for the purpose of constructing a reservoir built with objective of benefitting those who's lands would be used. Participation must be voluntary.***

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

Costs associated with irrigation system components of the watershed management plan were estimated based upon current itemized unit costs for individual improvements. NRCS EQIP cost data were used where feasible for typical design items. These costs are included in Table 6.1.

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 6.2 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.

Conventional Windmills: Typical costs associated with installation of a windmill in an existing well is from $5,000 to $10,000 for the windmill, mechanical pump, tank pad, and tank depending on well yield, tank size, and depth to water.

Wind Turbine/Tower: A cost of $5,000 was used for a 1kW, 24 VDC turbine, controller, and 80-foot tilt-up tower for installation at an existing well.

Wells: $10,000-$15,000 (see discussion in Section 6.4 below).

Pipelines: A cost of approximately $1.34 / lineal foot (installed) for 1.5-inch diameter pipe was used and is based upon recently completed projects in the Bighorn Basin. Length of pipe associated with each project was approximated within the GIS environment.

Water Tanks (Stock and Storage): A cost of $3,000 per stock tank was used for a typical rubber-tire type tank. Cost of storage tanks were assumed to be approximately $1 per gallon of storage.

Table 6.1 Conceptual Cost Estimates: Irrigation System Components

Rehabilitation Item Number	Description	Priority	Cost
Anita Supply Ditch/Anita Ditch System Improvements (I-01)			
I-01.1	Replace/install 6 farm turnouts	3	$ 21,300
I-01.2	Replace failing drop structure	1	NA (1)
I-01.3	Install 6-foot drop structure	2	$ 28,700
I-01.4	Install check structure	3	$ 9,000
I-01.5	Replace wasteway with pipe drop structure	2	$ 45,000
I-01.6	Replace 36-inch pipe over Alkali Creek	1	$ 10,000
I-01.7	Install four 6-foot drop structures	2	$ 115,000
Avent Ditch System Improvements (I-02)			
I-02.1	Replace wasteway structure	2	$ 10,000
I-02.2	Rehabilitate pipe drop structure	2	$ 15,000
I-02.3	Replace/install 8 farm turnouts	3	$ 36,000
I-02.4	Replace check structure	2	$ 8,000
Green Spot Ditch System Improvements (I-03)			
I-03.1	Replace ditch headgate	1	$ 12,000
Hardscrabble / Williams Ditch System Improvements (I-04)			
I-04.1	Replace Williams Ditch Headgate	2	$ 8,000
I-04.2	Install NRCS tubulent fountain/valves/connections at pipeline inlet	1	$ 4,000
Harmony Ditch System Improvements (I-05)			
I-05.1	Replace 3-ft Parshall flume	3	$ 8,700
I-05.2	Install check structure	2	$ 9,000
I-05.3	Install new drop structure with check	1	$ 30,000
I-05.4	Replace/install new check structure	2	$ 9,000
I-05.5	Replace/install 9 farm turnouts	3	$ 34,000
I-05.6	Replace culvert with check structure	2	$ 9,000
I-05.7	Install new drop structure	2	$ 29,000
I-05.8	Install new check structure	2	$ 8,000
I-05.9	Install new check structure	2	$ 9,000
I-05.10	Install new check structure	2	$ 10,000
I-05.11	Install new wasteway structure	2	$ 18,000
Highland Ditch System Improvements (I-06)			
I-06.1	Replace canal headgate	2	$ 35,000
I-06.2	Replace/install 6 farm turnouts and clean 1 farm turnout	3	$ 19,500
I-06.3	Replace 60-inch diameter CMP	3	$ 4,700
I-06.4	Replace 24-inch diameter CMP	3	$ 1,800
I-06.5	Rehabilitate wasteway	3	$ 3,200
Melley Ditch System Improvements (I-07)			
I-07.1	Install 12-inch PIP, (Approx. 3,800 lf with 6 valves)	2	$ 40,200
I-07.2	Install ditch headgate and diversion	2	$ 45,000
Shafer Ditch System Improvements (I-08)			
I-08.1	Remove existing headgate	2	$ 5,000
I-08.2	Install new headgate with sediment sluice	1	$ 45,000
I-08.3	Replace/install 6 farm turnouts	3	$ 27,400
I-08.4	Replace/install new check structure	2	$ 9,000
I-08.5	Rehabilitate check structure	3	$ 500
I-08.6	Clear vegetation in and along ditch	2	$ 3,000
I-08.7	Install liner (1,500 lf)	2	$ 120,000
Victoria Ditch System Improvements (I-09)			
I-09.1	Replace canal headgate and diversion structure	2	$ 28,000
I-09.2	Install / replace 3 farm turnouts	3	$ 11,000
I-09.3	Install 100 feet 12-inch RCP and surface inlet	2	$ 5,000
I-09.4	Rehabilitate check structure	1	$ 4,500
West Ditch System Improvements (I-10)			
I-10.1	Replace ditch headgate	2	$ 45,000
I-10.2	Replace splitter/wasteway structure	2	$ 15,800
I-10.3	Replace 5' Parshall flume	1	$ 15,800
I-10.4	Rehabilitate siphon	1	$ 20,800
I-10.5	Replace/install 8 farm turnouts	3	$ 31,800
I-10.6	Install check structure	2	$ 4,000
I-10.7	Replace 2’ Parshall flume	2	$ 7,500

(1) This structure is currently being designed and funded through the NRCS. Costs were not estimated herein.

Table 6.2 Conceptual Costs: Upland Wildlife/Livestock Water Components

Project		Watershed Component U-01	Watershed Component U-02	Watershed Component U-03	Watershed Component U-04	Watershed Component U-05	Watershed Component U-06	Watershed Component U-07	Watershed Component U-08	Watershed Component U-09	Watershed Component U-10	Watershed Component U-11	Watershed Component U-12	Watershed Component U-13	Watershed Component U-14	Watershed Component U-15	Watershed Component U-16	Watershed Component U-17
Project Name		Wildhorse Draw Pipeline Project	McDermott Draw Pipeline Project	Eask Alkali Pipeline Project	Weber Lower Pipeline Project	Myers Spring Pipeline Project	Cold Spring Pipeline Project	Rannell's Pipeline Project	Gapen Hyatt Pipeline Project	Brokenback No. 1 Pipeline Project	West Side Regional Pipeline Project	Duncan Pipeline Project	Hidden Dome Pipeline Project	Brokenback No. 2 Pipeline Project	Brokenback No. 3 Pipeline Project	Brokenback No. 4 Guzzler	Big Cottonwood Pipeline Project	Schoolhouse Gulch Pipeline Project
Project Component	Allotment Directly Benefitted	Torchlight, East Flats, Weber , Lower Nowood	Airport, West Alkali, Weber Lower, Lower Nowood	East Alkali, West Alkali	Weber Lower	Meyers Spring, Weber Lower	Mathews Ridge, Cold Spring	Rannell's	Renner Individual, Gapen Hyatt	Brokenback	Blue Ridge, West Nowood, Hidden Dome, Little Cottonwood, Castle Gardens, Kimball, Bud Kimball, North Butte, Cedar Ridge, Joe Henry, Big Cedar, Gordon, and Buffalo Creek	Duncan	Hidden Dome	Brokenback	Brokenback	Brokenback	Big Cottonwood, North Blue Ridge, Sand Creek, Cottonwood Draw, Blue Ridge	Schoolhouse
Well Construction / Spring Development	Mobilization	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$6,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
	Well / Spring	Existing Well	Well	Well	Well	Spring Development	Spring Development	Spring Development	Well	Well	Well	Existing well	Existing Well	Spring Development	Existing Spring Development	Guzzler Installation	New Well Construction	Existing Municipal Pipe
	Units (each)	0	1	0	0	1	1	1	0	0	0	0	0	1	0	0	1	0
	Depth Each	NA	200	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	2,800	NA
	Unit Cost ($/LF wells ror $/EA springs	$5,000	$40	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$30	$5,000
	Well Screen (LF each well)		50														84,000	
	Well Screen ($/LF)		$50															
	Component Subtotal	$3,000	$13,500	$3,000	$3,000	$8,000	$8,000	$8,000	$3,000	$3,000	$6,000	$3,000	$3,000	$8,000	$3,000	$3,000	$87,000	$3,000
Stock Pond / Guzzler Construction	Mobilization																	
	Units (each)						1					1				1		
	Pond / Guzzler Unit Cost ($ EA)						$10,000					$10,000				$10,000		
	Liner (SF each pond)	NA	NA	NA	NA	NA		NA	NA	NA	NA	3,600	NA	NA	NA		NA	NA
	Linet Unit Cost ($/SF)											$1.45				NA		
	Liner Cost per Pond											$5,220						
	Component Subtotal						$10,000					$15,220				$10,000		
Pump	Units (EA)	1	1		0						1		1					
	Type	Solar	Solar	NA	Solar	NA	NA	NA	NA	NA	Electric	NA	Solar	NA	NA	NA	NA	NA
	Unit Cost (EA)	$8,640	$8,640		$8,640						$8,600		$8,640					
	Component Subtotal	$8,640	$8,640		$0						$8,600		$8,640					
Pipeline	Units (LF)	54,500	48,800	27,500	12,800	37,500	24,300	3,300	67,500	26,200	410,000	2,500	35,900	11,600	7,100	100	36,000	6,150
	Unit Cost (EA)	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34	$1.34
	Component Subtotal	$73,030	$65,392	$36,850	$17,152	$50,250	$32,562	$4,422	$90,450	$35,108	$549,400	$3,350	$48,106	$15,544	$9,514	$134	$0	$8,241
Additional Storage Tanks / Fencing / Etc	Units (EA)	1			0		3		0		2		1					
	Size (gal)	15,000	NA	NA	15,000	NA	15,000	NA	15,000	NA	15,000	NA	15,000	NA	NA	NA	NA	NA
	Unit Cost ($/gal)	$1			$1		$1		$1		$1		$1					
	Component Subtotal	$15,000			$0		$45,000		$0		$30,000		$15,000					
Water Tanks	Units (EA)	6	5	3		5		1	7		29	3	6	2	1	1	5	2
	Size (gal)	1,200	1,200	1,200	NA	1,200	NA	1,200	1,200	NA	1,200	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	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000	$3,000
	Component	$18,000	$15,000	$9,000		$15,000		$3,000	$21,000		$87,000	$9,000	$18,000	$6,000	$3,000	$3,000	$15,000	$6,000
Miscellaneous	Item																	Tap Fee
	Units (Each)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	1
	Unit Cost ($/ea)																	$1,500
	Component Subtotal																	$1,500
Construction Subtotal		$117,670	$102,532	$48,850	$20,152	$73,250	$95,562	$15,422	$114,450	$38,108	$681,000	$30,570	$92,746	$29,544	$15,514	$16,134	$102,000	$18,741
Engineering (10%)		$11,767	$10,253	$4,885	$2,015	$7,325	$9,556	$1,542	$11,445	$3,811	$68,100	$3,057	$9,275	$2,954	$1,551	$1,613	$10,200	$1,874
Constuction and Engineering Subtotal		$129,437	$112,785	$53,735	$22,167	$80,575	$105,118	$16,964	$125,895	$41,919	$749,100	$33,627	$102,021	$32,498	$17,065	$17,747	$112,200	$20,615
Contingency (15%)		$19,416	$16,918	$8,060	$3,325	$12,086	$15,768	$2,545	$18,884	$6,288	$112,365	$5,044	$15,303	$4,875	$2,560	$2,662	$16,830	$3,092
Total Construction Cost		$148,853	$129,703	$61,795	$25,492	$92,661	$120,886	$19,509	$144,779	$48,207	$861,465	$38,671	$117,324	$37,373	$19,625	$20,410	$129,030	$23,707
Final Plans and Specs		$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$2,000	$30,000	$2,000	$2,000	$2,000	$2,000	$500	$2,000	$2,000
Additional		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Permitting / Legal Fees / Access and Rights of Way		$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$50,000	$500	$1,000	$1,000	$1,000	$500	$1,000	$1,000

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 Surface Water Storage

Conceptual level estimates for each of the surface water storage alternatives identified in Chapter 4 were prepared using data presented in previous reports and from previous cost estimation experience. A review of cost estimates associated with storage projects of similar magnitude was conducted. Based upon this review, relationships between costs of various reservoir project components and the size of the embankment were determined as described below.

For each site, a conceptual layout of the embankment and reservoir pool was first prepared. USGS topographic mapping was used within the GIS environment coupled with a spreadsheet analysis to complete this task. This method enabled the project team to efficiently compute reservoir stage / storage curves at each site and to complete estimation of embankment volumes.

Based upon the review of cost estimation information discussed above, it was concluded that $7 per installed cubic yard of embankment provided an approximate cost for a dam for this Level I investigation. This value includes cost of the dam shell, core, riprap, drain, etc.

Costs of dam spillways, outlets, and preparation of final plans and specifications were directly proportional to the size of the embankment and corresponding reservoir pool. Consequently, each site was categorized by the size of its embankment: small embankments (<500,000 cubic yards), medium embankments (500,000 cubic yards to 1,500,000 cubic yards), and large embankments (>1,500,000 cubic yards).

Table 6.3 presents the results of this analysis and the protocols used to estimate costs at each of the Priority 1 sites.

It is important to understand that these opinions of cost are very preliminary, and that a number of potentially significant factors must be further investigated to support refinement of these costs. Among these factors, probably the most significant involve storage capacity, site topographic mapping, foundation design/improvement requirements and spillway sizing/locations.

Using these methodologies, conceptual level costs were estimated for each of the seven Priority 1 reservoir sites. Tables 6.4 through 6.10 present the conceptual cost estimates generated for each reservoir site..

Table 6.3 Summary of Cost Estimation Approach Used for Priority 1 Reservoir Sites

Cost Item	Embankment Size		
	Small (<.5MCY)	**Medium (.5MCY to 1.5MCY)**	**Large (>1.5MCY)**
Dam Cost	$7/cy		
Mobilization	9% Dam Cost		
Spillway	$1.5M	$1.75M	$2.0M
Outlet	12% Dam Cost	10% Dam Cost	9% Dam Cost
Component Cost	**Sum of the Above**		
Property	Rangeland $410/ac / Irrigated Land $1,306 / ac		
Residences	Assessed Value		
Infrastructure			
Fiber Optic Relocation	$250,000 / mile		
Improved Road Relocation	$250,000 / mile		
Appurtenances			
Conveyance Canal	$200,000 / mile		
Tunneling	$3,000,000 / mile		
Diversion Structures	Varies		
Siphons	Varies		
Construction Cost Subtotal	**Sum of the Above**		
Engineering	Construction Cost Subtotal x 10%		
Subtotal	**Construction Cost Subtotal plus Engineering**		
Contingency	Subtotal 1 x 15%		
Construction Cost Total	**Subtotal 1 Plus Contingency**		
Preparation of Final Designs and Specifications	10% Component Cost	7.5% Component Cost	5% Component Cost
Mitigation	1.2% x Dam Cost		
Legal Fees	0.8% x Dam Cost		
Rights of Way	3.8% x Dam Cost		
Permitting	Private ($0.5M), State ($1.0M), Federal ($1.5M)		
Total Project Costs	**Sum of the Above**		

Table 6.4 Conceptual Cost Estimate: Site 2 Big Trails

Site: 2 Big Trails	**Size Category: Medium**		
Cost Item		**Cost Estimate**	
Project Components			
Dam Volume	cy	650,000	
Dam Cost		$ 4,550,000	
Mobilization		$ 409,500	
Spillway		$ 1,750,000	
Outlet Works		$ 455,000	
Appurtenances			
Miscellaneous		$ 250,000	
Component Cost		$	8,064,500
Property		$ 500,000	
Residences		$ 250,000	
Infrastructure		$ 600,000	
Non-Construction Cost Subtotal		$	1,350,000
Construction Cost Subtotal			$ 9,414,500
Engineering Costs = Construction Cost Subtotal x 10%			$ 941,450
Subtotal			$ 10,355,950
Contingency = Subtotal x 15%			$ 1,553,393
Construction Cost Total			**$ 11,909,343**
Preparation of Final Designs and Specifications		$ 604,838	
Mitigation		$ 54,600	
Legal Fees		$ 36,400	
Acquisition of Access and Rights of Way		$ 172,900	
Permitting		$ 1,000,000	
Total Project Costs			**$ 13,778,080**

Table 6.5 Conceptual Cost Estimate: Site 3 Bruner Gulch

Site: 3 Bruner Gulch	Size Category: Small	
Cost Item	**Cost Estimate**	
Project Components		
Dam Volume (cubic yards)	190,000	
Dam Cost	$ 1,330,000	
Mobilization	$ 119,700	
Spillway	$ 1,500,000	
Outlet Works	$ 159,600	
Appurtenances (Supply canal / diversion / tunnel)		
Diversion Structure on Nowood River	$ 500,000	
Supply canal (2.8 miles)	$ 560,000	
Tunnel (0.5 miles)	$ 1,500,000	
Willow Creek Siphon	$ 500,000	
Miscellaneous	$ 750,000	
Component Cost	$	7,109,300
Property		
Residences	$ -	
Infrastructure	$ -	
Non-Construction Cost Subtotal	$	-
Construction Cost Subtotal		$ 7,109,300
Engineering Costs = Construction Cost Subtotal x 10%		$ 710,930
Subtotal		$ 7,820,230
Contingency = Subtotal x 15%		$ 1,173,035
Construction Cost Total		**$ 8,993,265**
Preparation of Final Designs and Specifications	$ 710,930	
Mitigation	$ 750,000	
Legal Fees	$ 100,000	
Acquisition of Access and Rights of Way	$ 100,000	
Permitting	$ 1,500,000	
Total Project Costs		**$ 12,154,195**

Table 6.6 Conceptual Cost Estimate: Site 10 Meadowlark Lake

Site: 10 Meadowlark Lake Size Category: Small		
Cost Item	**Cost Estimate**	
Project Components		
Dam Volume (cubic yards)	95,000	
Dam Cost	$ 665,000	
Mobilization	$ 59,850	
Spillway	$ 1,500,000	
Outlet Works	$ 79,800	
Appurtenances		
Fish Ladder	$ 750,000	
Miscellaneous (inc. removal of exist. Spillway/outlet)	$ 1,250,000	
Component Cost	$	4,399,650
Property	$ 220,000	
Residences	$ -	
Infrastructure	$ -	
Non-Construction Cost Subtotal	$	220,000
Construction Cost Subtotal		$ 4,619,650
Engineering Costs = Construction Cost Subtotal x 10%		$ 461,965
Subtotal		$ 5,081,615
Contingency = Subtotal x 15%		$ 762,242
Construction Cost Total		**$ 5,843,857**
Preparation of Final Designs and Specifications	$ 439,965	
Mitigation	$ 7,980	
Legal Fees	$ 5,320	
Acquisition of Access and Rights of Way	$ 25,270	
Permitting	$ 2,000,000	
Total Project Costs		**$ 8,322,392**

Table 6.7 Conceptual Cost Estimate: Site 18 Taylor Draw

Site: 18 Taylor Draw	Size Category: Medium	
Cost Item	**Cost Estimate**	
Project Components		
Dam Volume (cubic yards)	570,000	
Dam Cost	$ 3,990,000	
Mobilization	$ 359,100	
Spillway	$ 150,000	
Outlet Works	$ 478,800	
Appurtenances (diversion / supply canal)		
Diversion on Otter Creek	$ 250,000	
Supply Canal (5.8 miles)	$ 1,160,000	
Miscellaneous	$ 250,000	
Component Cost	$	7,207,900
Property	$ -	
Residences	$ -	
Infrastructure	$ -	
Non-Construction Cost Subtotal	$	-
Construction Cost Subtotal		$ 7,207,900
Engineering Costs = Construction Cost Subtotal x 10%		$ 720,790
Subtotal		$ 7,928,690
Contingency = Subtotal x 15%		$ 1,189,304
Construction Cost Total		**$ 9,117,994**
Preparation of Final Designs and Specifications	$ 720,790	
Mitigation	$ 47,880	
Legal Fees	$ 31,920	
Acquisition of Access and Rights of Way	$ 151,620	
Permitting	$ 1,000,000	
Total Project Costs		**$ 11,070,204**

Table 6.8 Conceptual Cost Estimate: Site 19 Upper Nowood

Site: 19 Upper Nowood Size Category: Medium		
Cost Item	**Cost Estimate**	
Project Components		
Dam Volume (cubic yards)	875,000	
Dam Cost	$ 6,125,000	
Mobilization	$ 551,250	
Spillway	$ 1,500,000	
Outlet Works	$ 735,000	
Appurtenances		
Miscellaneous	$ 250,000	
Component Cost	$	9,786,250
Property	$ -	
Residences	$ -	
Infrastructure (fiber optics)	$ 500,000	
Non-Construction Cost Subtotal	$	500,000
Construction Cost Subtotal		$ 10,286,250
Engineering Costs = Construction Cost Subtotal x 10%		$ 1,028,625
Subtotal		$ 11,314,875
Contingency = Subtotal x 15%		$ 1,697,231
Construction Cost Total		**$ 13,012,106**
Preparation of Final Designs and Specifications	$ 978,625	
Mitigation	$ 73,500	
Legal Fees	$ 49,000	
Acquisition of Access and Rights of Way	$ 232,750	
Permitting	$ 1,500,000	
Total Project Costs		**$ 15,845,981**

Table 6.9 Conceptual Cost Estimate: Site 25 Deep Creek

Site: 25 Deep Creek	Size Category: Medium	
Cost Item	**Cost Estimate**	
Project Components		
Dam Volume (cubic yards)	673,000	
Dam Cost	$ 4,711,000	
Mobilization	$ 423,990	
Spillway	$ 1,750,000	
Outlet Works	$ 565,320	
Appurtenances		
Miscellaneous	$ 250,000	
Component Cost	$	8,123,310
Property	$ -	
Residences	$ -	
Infrastructure (road relocation)	$ 500,000	
Non-Construction Cost Subtotal	$	500,000
Construction Cost Subtotal		$ 8,623,310
Engineering Costs = Construction Cost Subtotal x 10%		$ 862,331
Subtotal		$ 9,485,641
Contingency = Subtotal x 15%		$ 1,422,846
Construction Cost Total		**$ 10,908,487**
Preparation of Final Designs and Specifications	$ 812,331	
Mitigation	$ 56,532	
Legal Fees	$ 37,688	
Acquisition of Access and Rights of Way	$ 179,018	
Permitting	$ 1,000,000	
Total Project Costs		**$ 12,994,056**

Table 6.10 Conceptual Cost Estimate: Site 26 Nowood Crawford

Site: 26 Nowood - Crawford	Size Category: Medium			
Cost Item	**Cost Estimate**			
Project Components				
Dam Volume (cubic yards)		428,000		
Dam Cost	$	2,996,000		
Mobilization	$	269,640		
Spillway	$	1,750,000		
Outlet Works	$	359,520		
Appurtenances				
Orchard Reservoir Spillway Replacement				
Miscellaneous	$	250,000		
Component Cost	$			5,803,160
Property	$	-		
Residences	$	-		
Infrastructure (road relocation)	$	500,000		
Non-Construction Cost Subtotal	$			500,000
Construction Cost Subtotal			$	6,303,160
Engineering Costs = Construction Cost Subtotal x 10%			$	630,316
Subtotal			$	6,933,476
Contingency = Subtotal x 15%			$	1,040,021
Construction Cost Total			**$**	**7,973,497**

6.4 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 5.2 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/habitat/ExtBulletinsCont/index.asp .

In addition, discussions of several funding programs were extracted from previous watershed investigations completed on behalf of the Wyoming Water Development Commission. Specifically, the Popo Agie River Watershed Investigation (Anderson Consulting Engineers, 2003) and the Cottonwood Creek / Grass Creek Watershed Investigation (SEH, 2007) 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:

- South Big Horn County Conservation District (307-765-2483)
- Washakie County Conservation District (307.347.2456)
- 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). Big Horn County receives 42.2 percent and Washakie County 31.80 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 South Big Horn and Washakie Conservation Districts

The South Big Horn County and Washakie County Conservation Districts (SBCCD and WCCD) serve 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					
South Big Horn County Conservation District	n/a	Liaison, in-kind administrative and technical assistance, program coordination/partnering	www.conservewy.com/sbhcd	307.765.2483	janet.hallsted@wy.nacdnet.net
Washakie County Conservation District	n/a	Liaison, in-kind administrative and technical assistance, program coordination/partnering	http://www.conservewy.com/wccd.html	307.347.2456	wccd@rtconnect.net
Worland Grazing District	Range Improvement Fund	Range and related improvements	NA	Na	wsgb@wyoming.com
Big Horn County Weed and Pest District	n/a	Noxious weed and undesirable plant control	www.wyoweed.org	307.765.2855	sbhcwp@tctwest.net
Washakie County Weed and Pest District	n/a	Noxious weed and undesirable plant control	http://www.conservewy.com/wccd.htm	307.347.8582	wcwp@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	307.777.4565	gbutle@state.wy.us
	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://slf-web.state.wy.	307.777.7331	lboomg@state.wy.us
	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	jwade@state.wy.us
	Small Water Project Program	Small reservoirs and stock			rvore@state.wy.us
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.doi.gov/water2025/	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	center.water-resource@epa.gov
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	307.261-5081	cindy. ottel@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/inde x.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) 307.347.2456 (Worland Office)	shelly.thomas@wy.usda.gov (State) rory.karhu@wy.usa.gov (Worland)
	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/programs/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/programs/glci/		
Federal					
Ducks Unlimited	n/a	Waterfowl aquatic and upland habitat protection, restoration and enhancement	http://www.ducks.org/Page1856.aspx	307.472.6980	carol.m.perry@wellsfargo.com
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 Big Horn County/Washakie 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.

The Bureau of Land Management (BLM) in Wyoming is partnering in the implementation of several section 319 watershed plans statewide as part of their Watershed and Water Quality Improvement efforts. Given the distribution of private, state and federal (primarily BLM) lands within the Nowood watershed, this type of partnering may be applicable to future BMP projects that might best be implemented across land ownerships.

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, 2005):

"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 Nowood River watershed 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.

- <u>Groundwater Grant Program</u> -- 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 Nowood watershed 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 Nowood watershed, 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.

Appendix I contains additional information pertaining to district formation and the various types of districts which can be formed.

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; and
- wetland developments.

Irrigation works/projects may be eligible if they are already documented in a conservation district's existing watershed plan or a resource management plan or environmental evaluation prepared by a state or federal agency. These types of projects are only eligible if they cannot be addressed by the Water Development Program. Benefits associated with SWPP projects may include, but are not necessarily limited to:

- improved water quality;
- habitat and water for fish and wildlife;
- improved riparian habitat; and
- increased recreational opportunities.

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 Nowood River watershed 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 Programm .** 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 Nowood River watershed 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 Nowood River watershed 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.
- **Flood Plain 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 USDA Forest Service

A number of Federal laws direct or authorize watershed management on National Forest Service lands. Some of these laws provide broad authority while others deal more narrowly with specific watershed management activities.

The objectives of the Forest Service watershed management program are to protect and enhance soil productivity, water quality, water quantity and timing of water flows and to maintain favorable conditions of stream flow and continuous production of resources from National Forest System water sheds.

It is the policy of the Forest Service to implement watershed management activities on National Forest System lands in accordance with general objectives of multiple use and the specific objectives in the forest land management plans for the area involved. It is also the intent to design management activities of other resources to minimize short term impacts on soil and water resources and to maintain or enhance long term productivity, water quality and water quantity.

The Clean Water Action Plan provides broad water quality direction for the Forest Service. Specific direction for water quality is contained in the Land and Resource Management Plan for each National Forest. The forests in Wyoming are in the process of completing the Inland West Water Reconnaissance which will provide a classification of watersheds and stream reach conditions. Forest Service water quality programs are coordinated with Wyoming Department of Environmental Quality and other appropriate agencies. The Forest Service also has a water rights program that is coordinated with the Wyoming State Engineer.

The Forest Service, in conjunction with other federal, state and local agencies, provides watershed management and condition training. T-WALK and Proper Functioning Condition surveys are field methods used to assess stream reach and other water body condition.

7.4.9 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 Nowood watershed 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

In a proactive effort to evaluate their watershed, a group of interested landowners joined together to approach the WWDC in request of funding for a watershed investigation involving the Nowood River watershed. That group, now referring to itself as the Proponents of Nowood Drainage Storage, or PONDS, was successful in its application and funding was awarded to the project.

A multidisciplinary inventory of the Nowood River 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. Potential solutions to the primary issues and problems associated with irrigation system infrastructure were identified for 10 individual ditch systems. Conceptual level cost estimates were completed for the recommended improvements.

2. Of the irrigation systems inventoried and evaluated during this study, several structures are in immediate need of rehabilitation. Several improvements have been identified to reduce potential seepage and conserve water.

3. Individual improvements range from rehabilitating a small check structure at a cost of approximately $500 to lining 1,500 feet of a ditch at a cost of about $120,000.

4. The recommended improvements to each irrigation system can be implemented individually, in combination, or as a complete package depending on the needs, preferences and financial ability of the owner. Funding assistance 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 17 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 29 individual wildlife / livestock water tanks and approximately 77 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 Surface Water Storage Opportunities

1. The results of the flow availability investigation confirmed that water is available and flows out of the watershed during the spring runoff period, predominantly during May and June.

2. Based on the flow availability analysis and site-specific topography, 35 potential storage sites were evaluated. For each site, numerous attributes were assessed and collated in a reservoir evaluation matrix included as Appendix F. Following completion of a screening process and meetings with the project steering committee, the list was reduced to seven sites recommended for further study.

3. Conceptual designs and cost estimates were completed for the seven Priority 1 reservoir sites. Table 8.1 summarizes pertinent information regarding this effort. Review of this table shows that reservoir capacity ranged from 1,100 acre-feet at Site Number 26 - Nowood – Crawford, to 16,850 acre-feet at Site Number 2 – Big Trails. Cost per acre foot of storage ranged from $819 at the Big Trails site to $8,900 at the Nowood – Crawford site.

Table 8.1 Summary of Surface Water Storage Components of the Watershed Management Plan

Site #	2	3	10	18	19	25	26
Site Name	Big Trails	Bruner Gulch	Meadowlark Lake	Taylor Draw	Upper Nowood	Deep Creek	Nowood - Crawford
On-Channel / Off-Channel	On Channel	Off Channel	On Channel	Off Channel	On Channel	On Channel	On Channel
Direct Supply Source	Nowood River	Buffalo Creek	Ten Sleep Creek	Taylor Draw	Nowood River	Deep Creek	Nowood River
Capacity (acre-feet)	16,850	7,700	4,150	5,050	5,250	9,600	1,100
Surface Area (acres)	623	557	324	160	321	147	118
Maximum Water Depth (feet)	75	40	50	75	75	95	65
Average Water Depth (feet)	27.1	13.8	12.8	31.6	16.4	65.3	9.3
Dam Height (feet)	80	45	16	80	80	100	70
Capacity (acre-feet)	16,850	7,700	4,150	5,050	5,250	9,600	1,100
Embankment Length (feet)	765	650	580	1050	1260	1085	1100
Total Dam Volume (cy)	650,000	164,742	26,074	827,852	927,585	672,000	695,139
Method of Reservoir Fill	None / On channel	Diversion Structure / canal	None / On channel	Diversion Structure / canal	None / On channel	None / On channel	None / On channel
Key Appurtenances	NA	Nowood River Supply Canal	NA	Otter Creek Supply canal	NA	NA	NA
Size Category	Medium	Small	Small	Medium	Medium	Large	Medium
Estimated Construction Cost	$13,800,000	$12,200,000	$8,300,000	$11,100,000	$15,900,000	$13,000,000	$9,800,000
Total Project per cubic yard of fill	$21	$74	$318	$13	$17	$19	$14
Total Project per ac-ft of storage	$819	$1,584	$2,000	$2,198	$3,029	$1,354	$8,909

4. During a subsequent, and more detailed investigation of potential storage sites, several institutional constraints must be addressed. These include the release of water from storage and the administration of water rights associated with all downstream diversions, and cooperative agreements likely required to “shepherd” the water to reaches in need of supplemental flows. In addition, objectives of the recently completed Wind River/Big Horn River Basin Plan, which is currently being updated, must be considered and the impact of these storage sites evaluated in the context of the basin plan. Finally, stipulations and conditions in the Yellowstone River Compact should be more fully evaluated.

5. Permitting efforts and NEPA compliance associated with completion of reservoir projects will likely be complicated, lengthy, and involve coordination with several regulatory agencies.

6. The ‘need’ for reservoir storage and benefits accrued from completion of storage projects must be fully examined and documented. Based upon existing water availability modeling associated with the Wind / Bighorn Basin Planning Study, existing shortages associated with irrigation usage do not support the need for construction of reservoirs of the magnitude presented herein. However, the general consensus among landowners interviewed during the completion of this study indicates that late-season shortages are common and farmers must frequently make difficult decisions related to their farm management and irrigation practices which results in irrigation of less than the acreage associated with the individual water rights.

7. It is recommended that consideration be given to development of a StateMod (or equivalent) hydrologic model for the watershed during Level II so that appropriate exercise of water rights and reservoir operations can be included in the more detailed evaluations.

8. Irrigation needs and requirements may not support the construction of a reservoir on their own. In order for any reservoir to ultimately be constructed, it will have to demonstrate multiple benefits, including irrigation supply, flood mitigation, power generation, fish and wildlife habitat, recreation, etc.

8.1.4 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. The WGFD is in the process of inventorying channel structures which pose threats to fish passage and allow capture by irrigation ditches. Upon completion of their study, the structures identified as being potential barriers should be considered for improvement or replacement.

4. Community-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.

8.1.5 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.

8.1.6 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 the respective weed and pest control districts of Washakie and Big Horn Counties 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:

1. Many of the irrigation rehabilitation alternatives and 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. 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.

   Several alternative sources exist for funding of improvements within the watershed including on-farm improvements, irrigation rehabilitation projects, stream enhancements/restoration projects, and conservation and flood control projects. Creative strategies for funding/financing of projects should be more fully investigated following identification of projects worthy of additional evaluation and potential implementation. As an example, replacement of a failing ditch headgate and diversion which are also identified by WGFD as a barriers to fish passage, could potentially be eligible for funding through SWPP (if total project cost meets SWPP criteria). Additional funding could also be attained through WGFD, Trout Unlimited, and other sources because of the fisheries and stream habitat benefits achievable with completion of the project. *By combining funding sources, the owner could conceivably obtain grants for most, if not all, of the project costs.*

2. PONDS should continue investigation of potential entity formation requirements and alternatives. Larger projects listed included in the watershed management plan will require formation of a district or entity capable of incurring the debt required for construction. PONDS

can move forward several steps, however, without the need for district formation. For reservoir projects to be completed, there are three phases of Level II investigations, each building upon the previous in terms of level of detail. Level II, Phases I and II investigations are eligible for funding through the WWDC without creation of an 'entity' in the form of a district.

3. Collection of stream gage data should continue for streams and tributaries within the watershed. State and Federal agencies should be contacted in an effort to determine the potential for re-establishment of permanent stream gages to assist in future planning efforts.

4. One of the most critical issues facing PONDS and the community, is the need for a concise consensus among the parties/entities within the watershed in order for larger projects (i.e., storage projects) to successfully move towards completion. PONDS and the community have made significant progress in this area through public meetings and the successful application for funding of this Level I project. It is anticipated that as small projects are successfully completed, awareness of the watershed management plan, its benefits, and opportunities presented with it, will increase and participation will increase accordingly.

5. Results of the investigation indicate that there is water available for storage and several potential storage sites have been identified. PONDS should proceed with an application to the WWWC for Level II, Phase I funding project for feasibility of storage sites. Work should include, but not be limited to:

    a. investigation of sites prioritized by the WWDC / PONDS committee and additional sites identified during the Level II project;
    b. determination of project purpose and need;
    c. refinement of hydrology information;
    d. revised design / cost information;
    e. permitting requirements; and
    f. economic / financial evaluation for ability to pay.

IX. REFERENCES

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APPENDIX A

LANDOWNER QUESTIONNAIRE

NOWOOD RIVER WATERSHED STUDY
LANDOWNER/ALLOTTEE QUESTIONNAIRE

Landowner Name: Date:
Landowner Address:
Landowner Telephone Number:
Landowner email address:

1. How long have you been living/working on the property?

2. What is the approximate number of acres owned/managed?

GRAZING

1. Do you lease a grazing allotment from the BLM?

2. If so, what is the name of the allotment?

3. Have there been any Allotment Management Plans developed for the allotment? How recently or what was the most recent year?

4. Who is your contact at BLM regarding your grazing permit?

5. Do you have a grazing system for your allotment? If so, what type (e.g., rest-rotation, deferred rotation, etc)?

6. Do you have any range resource concerns (e.g., low production, low plant vigor, problem plants such as noxious weeds, salt-cedar, excessive sagebrush, larkspur, etc.)?

7. Do you have adequate fencing? Adequate number of pastures? Misplaced fences, etc?

LIVESTOCK/WILDLIFE WATER SUPPLY

1. Are there any existing water projects (wells, springs, ponds, or pipelines/stock tanks, etc) on the private land or within the allotment boundary?

2. If so, please describe them and their general location.

3. Do you have adequate, well distributed, livestock water? Or are there locations where you would like to provide additional water sources?

4. Do you or BLM where applicable, have any planned livestock water development projects (pipeline/stock ponds, springs, wells, etc.) on the private land or within the allotment boundary?

5. If so, please describe them and their general location.

6. Do you desire to have the study team assess your resources, land and water, and provide rehab recommendations?

IRRIGATION

1. Do you own or operate any irrigation facilities?

2. Groundwater Supplied?
3. Surface water Supplied?
4. Ditch Name?

5. Are there any problems related to seepage, deterioration of structures, inefficient structures, etc.?

6. Do you feel you have an adequate supply of water? If not, when do you experience shortages?

STREAM CHANNELS

1. What stream or drainage channels are located on your private land or within your allotment?

2. Are there locations where the channel appears to be eroding or unstable?

3. Is sedimentation a problem?

4. Are banks bare/void of vegetation?

5. Is there presence of woody vegetation in the riparian areas? e.g. – willows

6. Are there active headcuts within your allotment/property?

7. Is flooding a problem on your property/allotment?

SUPPLEMENTAL WATER SUPPLIES

1. Would supplemental irrigation water or flood storage be of value?

2. Would you be interested in construction of surface water storage within the basin?

3. If so, would the water supply be used for livestock/wildlife, irrigation, flood control, etc?

4. If so, where would the storage be located and what would be the anticipated size of the impoundment (1-20 AF, 20-200 AF, 200-2000 AF, > 2000 AF)?

5. Are you aware of potential dams/reservoirs locations within the watershed?

6. What would be the approximate location of the dam/reservoir?

OVERALL

1. Are there any other issues or opportunities you would like to inform the project team regarding grazing conditions, irrigation infrastructure/needs, stream channel conditions, water quality, etc?

2. Would you like a project team member to contact you personally to discuss this questionnaire or any other issues? If so, when is a preferred time to contact you?

3. Are there any problem areas or rangeland issues that should be identified and considered within the private land or allotment boundary?

4. Do you wish the field crews to conduct an inventory of the facilities to identify/evaluate existing problems and provide rehabilitation recommendations?

5. Would members of our project team have your permission to access stream channels on your property?

6. Any other questions or comments?

APPENDIX B

DIGITAL LIBRARY CONTENTS

Nowood River Storage / Watershed Study
Digital Library Contents

Source: Bureau of Land Management

- BLM Resource Management Plan ROD washakie-rmp.pdf
- EA Hyattville travel management and route designations.pdf
- Riparian Area Managemt - Guide to PFC - FinalTR1737-15.pdf
- Summary of Analysis Bighorn Basin Resource Management Plan Revision Project AMS_Summary.pdf
- Water Quality Data

Source: Conservation Districts

- Big Horn River Watershed Management Plan.pdf
- Living on a Few Acres in Washakie County.pdf
- South Big Horn County Watershed Plan.pdf
- Upper Bighorn Watershed and Nowood River Data Analysis Report.pdf
- Washakie County Conservation District Natural Resource Land Use Plan 2005.pdf

Source: Misc

- Descriptions of Ecological Systems for Modeling of LANDFIRE Biophysical Data.pdf
- Ecological systems of the United States.pdf
- Introduction-to-invasive-plant-species-in-the-west.pdf
- Northern Wyoming Daily News Article regarding Level I project.pdf
- Preliminary Engineering Report of West Tensleep Lake Baldwin 1960.pdf
- Washington State Stream Restoration Handbook.pdf
- WeedControlMethodsHandbook.pdf

Source: Natural Resources Conservation Service

- General Soils Map Washakie County.pdf
- Nowood_Drainage_Invest_Rpt_SCS_1971.pdf
- NRCS washakie county soils.pdf
- Wind_Big_Horn_Clarks_Fk_WY_Supp_SCS_1974.pdf

Source: United States Army Corps of Engineers

- Approach for Assessing Wetland Functions.pdf

Source: United States Environmental Protection Agency

- Handbook for Developing Watershed Plans to Restore and Protect Our Waters.pdf
- Occurrence and Characterization of Groundwater - Bighorn Basin Volume_II-B_-_Plates.pdf
- Occurrence and Characterization of Groundwater - Bighorn Basin.pdf

Source: United States Forest Service

- Aquatic Riparian and Wetland Ecosystem Report Bighorn National Forest.pdf
- Paintrock Creek Geographic Area Assessment.pdf
- Tensleep Creek Geographic Area Assessment.pdf

Source: United States Geologic Survey

- Documentation for the 2008 Update of the United States OF08-1128_v1.1.pdf
- Geologic Map Water bearing and Non bearing formations of Nowood Basin Geology of the Bighorn Mountains circa 1899 pp_51.djvu
- Geology of the Bighorn Mountains circa 1899 pp_51.djvu
- Hydrogeologic features of the alluvial deposits in the Nowood River Drainage Area ofr_79_1291.djvu
- Map Showing Location of Selected Wells and Springs Washakie county wrir_91_4044_plt.djvu
- Map Showing locations of surface wter stations and selected wells big horn county wrir_93_4021_plt.djvu
- Map Showing locations of surface wter stations and selected wells big horn county wsp_2289_plt.djvu
- Potentiometric Surface map Tensleep formation in Bighorn Basin ofr_72_461_plt.djvu
- pp_53 Geology and Water Resources of the Big Horn Basin USGS 1906.djvu
- UGSS Groundwater Resources of the Paintrock Irrigation Project USGS circ_96.djvu
- USGS Artesian Pressures and Water Quality wsp_2289.djvu
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- USGS Assessment of Undeveloped Oil and Gas FS08-3050_508.pdf
- USGS Digital Mining Claim Density Map OF99-542.pdf
- Water Resources of Washakie County wrir_91_4044.djvu
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- WDEQ Water Quality Rules and Regulations Chapter 1.pdf
- Wyoming 303(d) List - Waters Requiring TMDLs.pdf
- Wyoming Surface Water Classification List.pdf

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- Sage Grouse Report 2007%20Big%20Horn%20Basin%20JCR.pdf
- Management and Status of the Yellowstone Cutthroat.pdf
- Sage Funding Opps 03-06.pdf
- Sage Grouse Conservation Plan Big Horn Basin BHB%20SgConservPlanFinal.pdf

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- 2003_Animals_Species of Concern.pdf
- Wyoming Natural Diversity Database Data Dictionary.pdf

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Documents

- Safety Of Dams program.pdf
- Wyoming DEQ Surface Water Standards 2-3648-doc.pdf
- Wyoming_Water_Law_History.pdf

Miscellaneous Water Rights Maps

- Alkali Creek Reservoir M_P00005236_0R_001[1].pdf
- Big Trails No 1 Reservoir M_P00005321_0R_001[1].pdf
- bonanza canal M_P00015353_0D_001.pdf
- Brokenback ranch M_P00007096_0E_001.pdf
- Brokenback ranch2 M_P00007096_0E_001.pdf
- Brokenback Reservoir document D_CR00001068_0_001[1].pdf
- Brokenback reservoir map 1 M_P00003736_0R_001[1].pdf
- Brokenback Reservoir Map 2 M_P00003736_0R_002[1].pdf
- Buffalo Flat Reservoir M_P00011469_0R_001[1].pdf
- Dry Lakebed Reservoir M_P00011465_0R_001[1].pdf
- East Basin Reservoir M_P00004957_0R_001[1].pdf
- Flathead Reservoir M_P00011235_0R_001[1].pdf
- Little Cottonwood Reservoir M_P00005134_0R_001[1].pdf
- Louis Holland Reservoir M_P00011461_0R_001[1].pdf
- Medicine Lodge Creek Reservoirs M_P00001185_0R_001[1].pdf
- M_P00001329_0R_001.pdf
- M_P00004557_0R_001.pdf
- Nowood canal 1 M_P00000877_0D_001.pdf
- Nowood Canal 2 M_P00000877_0D_002.pdf
- Paint Rock Canal.jpg
- Knoll Reservoir M_P00005138_0R_001[1].pdf
- Summit and Solitude Reservoirs M_P00001179_0R_001[1].pdf

- Tensleep Meadows (meadowlark) USFS M_P00004923_0R_001.pdf
- West Tensleep meadows (meadowlark reservoir) M_P00004557_0R_001.pdf
- West Tensleep Meadows Reservoir (Meadowlark Lake) D_CR00001156_0_001.pdf
- West Tensleep Meadows Reservoir (Meadowlark Lake) D_P00004923_0R_001.pdf
- West Tensleep Meadows Reservoir (Meadowlark Lake) D_P00004923_0R_002.pdf
- West Tensleep Meadows Reservoir (Meadowlark Lake) M_P00001329_0R_001.pdf

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- Conservation Directory Final.pdf
- Hyattville-Water_Supply_Project_Level_II-Final_Report-2006.pdf
- Map Wyoming Supplement 1974.pdf
- Nowood_Drainage_Invest_Rpt_SCS_1971.pdf
- SCS_Montana_Supplement_Rpt_1974.pdf
- Ten_Sleep-Water_Supply_Project_Level_II-Final_Report-2004.pdf
- Text Wyoming Supplement 1974.pdf
- Upper_Missouri_River_Basin.pdf
- Wind_Big_Horn_Clarks_Fk_WY_Supp_SCS_1974.pdf
- Wind_River_Survey_Main_Report_1974.pdf
- WWDC Small Water Project Program 2008_Adopted_Revised_Operating_Criteria.pdf

APPENDIX C

LIST OF IRRIGATION DITCHES AND SENIOR WATER RIGHTS

Listing of Irrigation Ditches in the Nowood River Study Area

Number	Ditch Name	Source	Oldest Priority
1	Ainsworth	Crooked Creek	5/15/1885
2	Ainsworth No 2	Crooked Creek	1/16/1959
3	Ainsworth Reservoir	Crooked Creek	1/16/1959
4	Alexander	Nowood River	5/24/1898
5	Allen	Nowood River	12/19/1974
6	Allen & Nelson	Medicine Lodge Creek	4/10/1887
7	Allen Sprinkler System	Nowood River	11/22/1971
8	Anita	Medicine Lodge Creek	4/11/1896
9	Anita Supp.	Paint Rock Creek	3/28/1904
10	Anthony	Medicine Lodge Creek	9/20/1888
11	Avent	Nowood River	7/5/1895
12	Ayers	Nowood River	3/13/1905
13	Baldwin	Paintrock Creek	9/27/1905
14	Bay State #1	Tensleep Creek	2/27/1905
15	Bay State #2	Tensleep Creek	5/1890
16	Bayne/George	Medicine Lodge Creek	5/20/1885
17	Becker	Deep Creek	4/21/1930
18	Beckly Sprinkler Irr. System	Nowood River	8/81975
19	Benson	Deep Creek	2/11/1904
20	Bernstein	Paint Rock Creek	Summer 1887
21	Bernstein #2	Paint Rock Creek	9/4/1913
22	Berstein #1	Paint Rock Creek	Fall 1887
23	Betty	Deep Creek	1/29/1904
24	Big Bear	Paint Rock Creek	5/2/1885
25	Big Springs	North Fork Otter Creek	8/14/1900
26	Bluebank	Nowood River	4/8/1907
27	Bodtke Irr. System	Nowood River	12/19/1974
28	Boyd	Lost creek	7/30/1901
29	Bragg	Lost creek	9/5/1902
30	Breeden Ditch and Irrigation system	Otter Creek	6/23/1975
31	Bremmer No 1	Crooked Creek Creek	5/15/1885
32	Bremmer No 2	Little Canyon Creek	1/23/1904
33	Brokenback	Nowood River	4/8/1963
34	BrokenBack Rservoir	Spring Branch Creek	3/31/1921
35	Buckhorn	Tensleep Creek	12/6/1901
36	Bud	Little Canyon Creek	3/17/1902
37	Buffalo Flat	Buffalo Flat Creek	3/27/1897
38	Bunker	Brokenback Creek	3/23/1905
39	Burke	Tensleep Creek	8/1/1887
40	Canon Creek	Big Canyon Creek	9/4/1893
41	Carothers No. 3	Spring Branch Creek	3/1/1905
42	Carothers no.1	Spring Branch Creek	3/1/1905
43	Carothers no.2	Spring Branch Creek	5/10/1885
44	Carothers No5	Spring Branch Creek	3/4/1905
45	Carothers North Fork	Spring Branch Creek	3/1/1905
46	Carpio	Deep Creek	10/15/1904
47	Carter#1 Pipeline	Nowood River	3/19/1981
48	Cascade	Little Canyon Creek	1/29/1904
49	Cedar Ridge pit stock Reservoir	North Fork Otter Creek	11/1/1982
50	Chabot no 1	Canyon creek	1/30/1905

Listing of Irrigation Ditches in the Nowood River Study Area

Number	Ditch Name	Source	Oldest Priority
1	Ainsworth	Crooked Creek	5/15/1885
2	Ainsworth No 2	Crooked Creek	1/16/1959
51	Chabot no 2	Canyon creek	1/30/1905
52	Chabot no 3	Prong Creek	1/30/1905
53	Chenney	Nowood River	12/11/1974
54	Cherry Ditch	Cherry Creek	7/23/1895
55	Clifford	Tensleep Creek	9/14/1910
56	Columbian*not Columbine	Tensleep Creek	5/10/1885
57	Conant	Paint Rock Creek	3/8/1904
58	Contention	Nowood River	9/3/1897
59	Cook & Ellis	Paint Rock Creek	2/12/1900
60	Coon Hollow	Coon Hollow Creek	11/5/1914
61	Cornell#1	Nowood River	4/2/1886
62	Cornell#2	Nowood River	3/3/1905
63	Cranky Jack	Brokenback Creek	2/27/1905
64	Croathers No 6	Spring Branch Creek	3/4/1905
65	Croft	Deep Creek	9/1/1904
66	Crowley	Lone tree	7/3/1901
67	Cullison Sprinkler System	Nowood River	5/2/1974
68	Daly	Otter Creek	3/1/1905
69	Donahue	Deep Creek	10/15/1904
70	Dow	Nowood River	1/1/1897
71	Dry Fork	Brokenback Creek	3/3/1905
72	Dutch	Coon Hollow Creek	5/17/1889/
73	Dutcher	Deep Creek	10/15/1904
74	Dyke	Nowood River	7/5/1895
75	Dyson	Otter Creek	5/10/1885
76	Early	Big Spring Creek	10/7/1902
77	Early no 2	Big Spring Creek	6/6/1905
78	Elk	Paint Rock Creek	Fall 1887
79	Emge & Robinson No 2	Spring Creek	5/1/1885
80	Farmers	Nowood River	5/3/1898
81	Faure	Otter Creek	8/30/1905
82	Fiscus & Vanoni	Tensleep Creek	10/10/1900
83	Florance	West Fork Little deep Creek	12/18/1903
84	Gardner	Paint Rock Creek	5/15/1906
85	Gayheart (Bayheart)	Deep Creek	9/1/1904
86	George & Bayne	Medicine Lodge Creek	5/20/1885
87	Go Ahead	Paint Rock Creek	5/1/1889
88	Green Spot	Nowood River	3/3/1905
89	Greet	Spring Creek	1/3/1899
90	Grout	Otter Creek	4/1/1885
91	Gypsum	Little Canyon Creek	5/14/1898
92	H.E.W.	Tensleep Creek	7/26/1912
93	Hanson	Bates Creek	4/21/1897
94	Hardscrabble	Brokenback Creek	3/25/1887
95	Harmony canal	Nowood River	3/20/1890
96	Harvard	Nowood River	6/9/1898
97	Harvard #2	Deep Creek	3/13/1905
98	Helms No 3	Cherry Creek	7/11/1895
99	Helms No. 1	Boxelder Creek	4/0/1886
100	Helms No. 2	Boxelder Creek	9/1/1887

Listing of Irrigation Ditches in the Nowood River Study Area

Number	Ditch Name	Source	Oldest Priority
1	Ainsworth	Crooked Creek	5/15/1885
2	Ainsworth No 2	Crooked Creek	1/16/1959
101	Henderson	Spring Creek	3/13/1905
102	Hereford	Deep Creek	4/3/1901
103	Herenita	Deep Creek	10/15/1904
104	Higbie	Otter Creek	5/1888
105	Highland	Medicine Lodge Creek	11/0/1887
106	Hillside	Little Canyon Creek	2/16/1894
107	Himes	Lost creek	9/10/1908
108	Hollywood	Spring Creek	2/28/1905
109	Hollywood#2	Nowood River	8/5/1942
110	Hoskins	Nowood River	10/12/1896
111	Hunsinger No. 2	Big Canyon Creek	10/1/1886
112	Hunsinger No.1	Big Canyon Creek	10/15/1884
113	Hyatt # 4	Paintrock Creek	10/26/1918
114	Hyatt #2	Medicine Lodge Creek	5/101888
115	Hyatt #3	Medicine Lodge Creek	5/17/1910
116	Hyattville	Paint Rock Creek	7/2/1894
117	Ilg	Nowood River	10/16/1893
118	Island	Paintrock Creek	10/26/1918
119	J Smith Reservoir	Alkali Springs Creek	1/15/1942
120	J&J No.2 Reservoir	Kirby Creek	4/20/1953
121	J&J No.3 Reservoir	Kirby Creek	4/29/1953
122	Johnson	Luman Creek	3/13/1905
123	Jumbo	Nowood River	12/6/1901
124	Kimball	Nowood River	9/17/1896
125	Kirby Creek Reservoir	Kirby Creek	12/12/1952
126	La Clede	Tensleep Creek	8/10/1896
127	Lake	Spring Branch Creek	2/23/1903
128	Leithead#2 Ditch	Nowood River	12/18/1974
129	Lena	Bates Creek	7/101/1903
130	Lone Tree no 2	Lone tree	10/15/1902
131	Lone Tree no 2 (Raive)	Little deep creek	12/16/1905
132	Lower Reservoir	Spring Branch Creek	3/31/1921
133	Lucy Wells	Nowood River	7/1/1903
134	Lulu Ainsworth	Crooked creek	11/17/1902
135	Luman & Allen	Paint Rock Creek	4/8/1887
136	Luman & Allen	Paint Rock Creek	4/81887
137	Mallard	Alkali Springs Creek	9/4/1899
138	Manderson Sulfur Plant	Nowood River	11/17/1953
139	Marcum	Alkali trib Nowood	5/6/1905
140	Mead no. 2	Bear Creek	6/5/1894
141	Mead#1	Nowood River	5/1/1886
142	Melly	Nowood River	3/9/1905
143	Meyers	Paint Rock Creek	9/11/1886
144	Military	Paint Rock Creek	9/4/1896
145	Monument stock reservoir	North Fork Otter Creek	4/20/1962
146	Mt Meadow	Prong of Canyon Creek	10/18/1916
147	New line	Prong of Canyon Creek	10/3/1913
148	Nichols	Deep Creek	10/15/1904
149	Ninety Six	Nowood River	10/27/1896
150	North Fork	Spring Branch Creek	4/1/1888

Listing of Irrigation Ditches in the Nowood River Study Area

Number	Ditch Name	Source	Oldest Priority
1	Ainsworth	Crooked Creek	5/15/1885
2	Ainsworth No 2	Crooked Creek	1/16/1959
151	North Fork	North Fork Otter Creek	8/14/1900
152	Norton	Tensleep Creek	7/24/1909
153	Nowood	Nowood River	6/21/1898
154	Oscar McCellan	Nowood River	3/13/1905
155	Percy	Deep Creek	1/29/1904
156	Perfection	Tensleep Creek	4/10/1888
157	Phonograph	Prong Creek	2/10/1911
158	Prarie Dog	Paintrock Creek	4/29/1902
159	Problem	Big Canyon Creek	6/4/1902 Irr
160	Red Bank	South Fork Little Cannon Creek	6/0/1886
161	Red Dog	Medicine Lodge Creek	11/21/1910
162	Red spring	Red Spring creek	6/7/1915
163	Redbutte	N.F. Spring Creek	5/7/1906
164	Rennels	Trout Creek	8/18/1899
165	Renner Reservoir	Buffalo Flat Creek	11/20/1950
166	Reservoir Ditch	Kirby Creek	12/12/1952
167	Rineheart	Paintrock Creek	1/23/1894
168	Rose Leaf	Big Canyon Creek	11/17/1911
169	Rosebud	Little Canyon Creek	9/0/1889
170	Rowe	Little deep creek	1/29/1904
171	Roy	Deep Creek	10/15/1904
172	S.V.	Nowood River	5/1/1885
173	Sawyer	Otter Creek	3/8/1905
174	Secesh	Nowood River	1/17/1895
175	Second Enl. Tharp Ditch	Nowood River	2/2/1976
176	Shafer	Nowood River	7/5/1895
177	Shuck & Wilson	Paint Rock Creek	3/20/1893
178	Southside	Paint Rock Creek	7/51895
179	Split Rock	Split Rock Creek	7/10/1899
180	Spratt	Nowood River	5/13/1889
181	Spring	Hanson Spring Creek	7/10/1903
182	Standard	Tensleep Creek	10/19/1895
183	Standish & Henderson	Spring Creek	3/20/1887
184	Sturdevent#1	Nowood River	2/6/1962
185	Sturdevent#2	Nowood River	2/6/1962
186	Suez	Nowood River	3/15/1890
187	Swander#2	Nowood River	12/27/1960
188	Ten Sleep Pipeline	Tensleep Creek	11/26/1932
189	Ten Sleep Sewage Lagoon Reservoir	Tensleep Creek	1/8/1987
190	Tharp	Nowood River	3/20/1950
191	Three Ring	Nowood River	9/19/1899
192	Tolman	Cherry Creek	12/31/1957
193	Turkey Track	Nowood River	4/19/1905
194	Two Bar Ditch	Boxelder Creek	4/1884
195	Umslopogaas	Little Canyon Creek	5/0/1889
196	Umslopograss #2	Nowood River	3/4/1905
197	Upper Reservoir	Spring Branch Creek	3/31/1921
198	Van Alstine	Nowood River	2/10/1904
199	Van Alstine	Nowood River	2/10/1904
200	VeBqar Sprinkler Irrigation System	Kirby Creek	8/29/1967

Listing of Irrigation Ditches in the Nowood River Study Area

Number	Ditch Name	Source	Oldest Priority
1	Ainsworth	Crooked Creek	5/15/1885
2	Ainsworth No 2	Crooked Creek	1/16/1959
201	Victoria	Tensleep Creek	3/9/1905
202	Walker	N.F. Spring Creek	6/26/1911
203	Waln #2	Medicine Lodge Creek	3/1/1905
204	Waln Bros	Spring Creek	5/1/1885
205	Walters Ditch	Alkali Creek	6/18/1915
207	Walters Reservoir	Alkali Creek	6/18/1915
206	Walters Reservoir	Alkali Creek	11/18/1924
208	Walters Supply Ditch	Alkali Creek	6/18/1915
209	Weintz	Paint Rock Creek	7/5/1895
210	Western	Nowood River	8/2/1892
211	Westside	Nowood River	9/12/1945
212	Wickwire	Medicine Lodge Creek	2/27/1905
213	Wigwam #3	Tensleep Creek	8/1/1917
214	Wigwam #4	Tensleep Creek	8/1/1917
215	Williams	Brokenback Creek	7/10/1894
216	Willo	Prong Of canyon Creek	10/29/1913
217	Willoughby	Trout Creek	11/16/1904
218	Willow	Tom Spring Creek	6/7/1915
219	Winn* or Wynn	Tensleep Creek	9/1/1884
220	Winsor	Nowood River	2/3/1902
221	Wyman	Tensleep Creek	7/2/1892

APPENDIX D

LIST OF GRAZING ALLOTMENTS

Nowood River Storage / Watershed Study

BLM Grazing Allotments Within the Project Study Area

Allotment Number	Allotment Name	Field Office	Allotment Acreage		
			Total Acres	Acres In Nowood Basin	Percent Of Allotment in Study Area
0001	MANDERSON GROUP	WORLAND	6,276.3	6,276.3	100.0%
0002	WEBER LOWER	WORLAND	34,785.7	29,626.5	85.2%
0003	COLD SPRINGS	WORLAND	4547.41	4547.4	1.0
0004	GAPEN HYATT	WORLAND	12,934.2	12,934.1	100.0%
0005	SOUTHSIDE GROUP	WORLAND	35181.73	35181.6	1.0
0006	SAND CREEK GROUP	WORLAND	11,030.9	11,030.8	100.0%
0008	CASTLE GARDENS	WORLAND	20811.39	20811.3	1.0
0009	KIMBALL	WORLAND	9700.6	9700.6	1.0
0010	GORDON	WORLAND	3,394.0	3,394.0	100.0%
0011	JOE HENRY	WORLAND	8,187.5	8,187.5	100.0%
0012	BIG TRAILS GROUP	WORLAND	24858.1	24858.0	1.0
0014	MILESKI BADLANDS	WORLAND	9,632.3	24.9	0.3%
0016	BADLANDS	WORLAND	9,423.3	8,914.7	94.6%
0017	BILLY CREEK	WORLAND	1,441.9	1,441.9	100.0%
0019	DOUBLE H	WORLAND	10,658.9	10,658.9	100.0%
0021	LITTLE COTTONWOOD	WORLAND	2,660.5	2,660.5	100.0%
0022	SOUTH BROKENBACK	WORLAND	1,377.7	1,377.7	100.0%
0023	LEIKHAM	WORLAND	1,958.8	1,958.8	100.0%
0024	BECKLEY	WORLAND	1,746.2	1,746.2	100.0%
0025	NOWOOD INDIVIDUAL	WORLAND	1,438.7	1,438.7	100.0%
0026	COTTONWOOD DRAW	WORLAND	2,718.2	2,718.2	100.0%
0028	UPPER NOWOOD	WORLAND	677.7	677.7	100.0%
0029	WEST LOST CREEK	WORLAND	1,905.9	1,905.9	100.0%
0030	BIG COTTONWOOD	WORLAND	5,706.5	5,706.4	100.0%
0031	BROKENBACK	WORLAND	16,321.8	16,321.8	100.0%
0032	HIDDEN DOME	WORLAND	9,938.9	9,938.8	100.0%
0033	ALKALI	WORLAND	3,544.9	3,544.9	100.0%
0034	RATTLESNAKE RIDGE	WORLAND	11,558.0	8,100.3	70.1%
0035	BUFFALO CANYON	WORLAND	7,976.5	7,976.5	100.0%
0036	MANDERSON	WORLAND	9,615.4	4,464.8	46.4%
0037	NORTH BUTTE	WORLAND	2,588.9	2,528.9	97.7%
0039	WARNER DRAW	WORLAND	703.6	703.6	100.0%
0041	FATTY ALLEN	WORLAND	1,352.1	1,352.1	100.0%
0043	NORTH TENSLEEP	WORLAND	2,317.2	2,317.2	100.0%
0044	SOUTH TENSLEEP	WORLAND	948.6	948.6	100.0%
0045	SOUTH PASTURE	WORLAND	1,331.2	1,331.2	100.0%
0046	SAND SPRINGS	WORLAND	1,600.0	1,600.0	100.0%
0047	HYATTVILLE IND.	WORLAND	2,934.8	2,934.8	100.0%
0052	PREVO INDIVIDUAL	WORLAND	287.4	287.4	100.0%
0053	RANCH	WORLAND	252.4	252.4	100.0%
0054	NORTH PAINTROCK	WORLAND	1,391.9	1,391.9	100.0%
0055	LOST PASTURE	WORLAND	250.1	250.1	100.0%
0056	SCOTT MTN	WORLAND	1,734.7	1,734.7	100.0%
0057	BLUE RIDGE	WORLAND	2,964.1	2,964.0	100.0%
0058	MATHEWS RIDGE	WORLAND	2330.03	2330.0	1.0
0059	NORTH HOUSE	WORLAND	488.4	488.4	100.0%
0060	MESA	WORLAND	1,037.8	1,037.8	100.0%
0061	AINSWORTH INDIVIDUAL	WORLAND	1,296.8	1,296.8	100.0%
0062	AINSWORTH	WORLAND	1,965.0	1,965.0	100.0%
0064	SPANISH POINT	WORLAND	3,411.2	2,945.1	86.3%
0065	SHEEP SPRINGS	WORLAND	2,067.3	1,045.9	50.6%
0066	MEYERS SPRING	WORLAND	1,805.8	1,805.8	100.0%
0067	DEETER	WORLAND	5,393.2	5,393.2	100.0%
0068	BOX ELDER	WORLAND	2,823.0	2,823.0	100.0%
0069	MAHOGANY BUTTE	WORLAND	3,391.8	3,391.8	100.0%
0070	S V	WORLAND	3,273.7	3,273.7	100.0%
0071	CHALK BUTTE	WORLAND	4,758.4	4,714.4	99.1%
0072	HELMS	WORLAND	1,070.9	1,070.9	100.0%
0073	LOWER SAND CREEK	WORLAND	12,833.9	9,369.8	73.0%
0085	TOWER	WORLAND	198.8	198.8	100.0%
0086	DAUGHERTY DEWITT	WORLAND	2,596.8	2,596.7	100.0%
0087	MOUNTAIN IND	WORLAND	3,659.3	3,659.3	100.0%
0088	PATRAS	WORLAND	3,553.4	3,553.4	100.0%
0089	BIG BEND	WORLAND	10,148.4	439.3	4.3%
0090	SPLIT ROCK - V'S	WORLAND	11,104.0	11,104.0	100.0%
0091	SAND CREEK	WORLAND	28,571.4	25,269.7	88.4%
0092	PAINTROCK CANYON	WORLAND	13033.24	13033.2	1.0
0094	RED HILLS	WORLAND	7664.13	7664.1	1.0
0095	FORKS	WORLAND	4141.63	4141.6	1.0
0097	DEADLINE DRAW	WORLAND	2,931.7	2,931.6	100.0%
0099	SCHOOLHOUSE GULCH	WORLAND	3,203.4	2,745.3	85.7%
0100	SAND CREEK IND.	WORLAND	2,036.9	2,036.8	100.0%
0101	RANCH INDIVIDUAL	WORLAND	2,911.6	2,911.6	100.0%

Allotment Number	Allotment Name	Field Office	Allotment Acreage		
			Total Acres	Acres In Nowood Basin	Percent Of Allotment in Study Area
0102	MOUNTAIN LOST CREEK	WORLAND	906.2	906.2	100.0%
0103	LITTLE LOST CREEK	WORLAND	975.7	975.7	100.0%
0104	COTTONWOOD	WORLAND	2,705.5	2,705.5	100.0%
0107	HONEY COMBS	WORLAND	31,247.8	294.2	0.9%
0108	DIXON CANYON	WORLAND	954.9	954.9	100.0%
0109	COYOTE SPRINGS	WORLAND	2,514.2	2,514.2	100.0%
0110	BUD KIMBALL	WORLAND	9141.17	9141.1	1.0
0111	OTTER CREEK	WORLAND	625.2	625.2	100.0%
0113	NORTH NOWOOD	WORLAND	1,396.5	1,396.5	100.0%
0114	SOUTH NOWOOD	WORLAND	3,528.8	3,528.8	100.0%
0116	BRUSH CABIN	WORLAND	180.6	180.6	100.0%
0117	PIERSON MOUNTAIN	WORLAND	1,777.5	1,777.5	100.0%
0119	BLUEBANK	WORLAND	9,499.4	9,490.1	99.9%
0120	BUFFALO CREEK	WORLAND	5,995.4	5,995.4	100.0%
0122	HARVARD INDIVIDUAL	WORLAND	2,946.5	2,946.5	100.0%
0123	BUFFALO SAND POINT	WORLAND	41,236.6	40,889.3	99.2%
0124	WEST SIDE SUMMER	WORLAND	22,249.6	22,249.5	100.0%
0125	EAST SIDE SUMMER	WORLAND	4,428.5	4,428.5	100.0%
0127	OTTER CREEK PASTURES	WORLAND	6,099.3	6,099.3	100.0%
0129	MAZET	WORLAND	2,060.3	2,060.3	100.0%
0130	LOWER V'S	WORLAND	3,423.7	3,423.6	100.0%
0131	HIGH CAMP	WORLAND	1,684.5	1,684.5	100.0%
0132	BIG COTTONWOOD CREEK	WORLAND	16,277.7	16,277.6	100.0%
0134	BONANZA	WORLAND	1,707.8	1,707.8	100.0%
0136	BLACK HILLS	WORLAND	611.4	611.4	100.0%
0137	PAINTROCK SOUTH	WORLAND	1,000.0	1,000.0	100.0%
0138	HURTIG	WORLAND	1,798.2	1,798.2	100.0%
0141	GREET INDIVIDUAL	WORLAND	947.5	947.5	100.0%
0142	RANNELLS	WORLAND	2482.52	2482.5	1.0
0143	MEDICINE LODGE	WORLAND	13,007.5	13,007.4	100.0%
0144	LOWER NOWOOD	WORLAND	13,847.7	13,847.6	100.0%
0145	CEDAR RIDGE	WORLAND	8,889.5	8,824.5	99.3%
0146	EAST ALLOTMENT	WORLAND	4,117.3	4,117.3	100.0%
0147	WEST ALLOTMENT	WORLAND	3,588.3	3,588.2	100.0%
0148	RENNER INDIVIDUAL	WORLAND	15679.02	15679.0	1.0
0149	LOST CREEK	WORLAND	2,075.5	2,075.5	100.0%
0150	JUNIPER HILLS	WORLAND	1,247.9	1,247.9	100.0%
0151	HOMESTEAD	WORLAND	917.8	917.8	100.0%
0155	MARY'S CREEK	WORLAND	4,369.7	4,369.7	100.0%
0156	ROME HILL	WORLAND	6,487.9	6,487.9	100.0%
0157	SOUTH BUTTE	WORLAND	2,810.7	2,804.5	99.8%
0158	SEAMAN	WORLAND	15226.15	93.7	0.0
0160	SPRING CREEK COMMON	WORLAND	5,328.3	5,328.3	100.0%
0161	NORTH BLUE RIDGE	WORLAND	2,583.2	2,583.2	100.0%
0162	SLICK WATER	WORLAND	11,366.0	73.1	0.6%
0164	COTTONWOOD-N.BUTTE	WORLAND	10,548.5	10,513.6	99.7%
0166	JACOBS CREEK	WORLAND	1,779.3	1,779.3	100.0%
0167	SWITCHBACK	WORLAND	3,276.8	3,276.8	100.0%
0168	LOWER SPRING CREEK	WORLAND	3,058.3	3,058.3	100.0%
0169	BADER GULCH	WORLAND	1,778.0	1,778.0	100.0%
0170	OILFIELD	WORLAND	6,160.5	6,160.5	100.0%
0171	EAST NOWOOD	WORLAND	1,193.8	1,193.8	100.0%
0172	WEST NOWOOD	WORLAND	1,107.7	1,107.7	100.0%
0173	TENSLEEP	WORLAND	2167.86	2167.8	1.0
0174	LOWER BROKENBACK	WORLAND	1697	1697.0	1.0
0175	UPPER BROKENBACK	WORLAND	6502.96	6502.9	1.0
0177	RED SPRINGS ROCK BUTTE	WORLAND	1645.19	1645.2	1.0
0178	DRY TENSLEEP	WORLAND	2597.48	2597.5	1.0
0179	THARP INDIVIDUAL	WORLAND	633.06	633.1	1.0
0180	LOST CREEK	CASPER	4,037.3	4,037.3	100.0%
0181	TORCHLIGHT	WORLAND	20,858.4	7,047.6	33.8%
0182	BUTTES	WORLAND	8,593.5	8,593.5	100.0%
0183	ONION GULCH	WORLAND	3,304.5	3,304.5	100.0%
0184	UPPER SAND CREEK	WORLAND	13,332.4	12,383.3	92.9%
0185	HEALY	WORLAND	10,725.9	2,762.2	25.8%
0186	RIM	WORLAND	3,791.6	3,791.6	100.0%
0188	SMALL PASTURE	WORLAND	1,690.9	1,690.9	100.0%
0197	DUNCAN	WORLAND	442.1	442.1	100.0%
0199	BIG CEDAR	WORLAND	2,958.1	2,933.7	99.2%
0200	SOUTH INDIVIDUAL	WORLAND	46.2	46.2	100.0%
0202	AIRPORT	WORLAND	8,786.2	8,786.2	100.0%
0204	NORTH OF DITCH	WORLAND	2,902.6	2,902.6	100.0%
0206	BEAR CREEK COMMON	WORLAND	2,231.5	2,231.5	100.0%
0210	WILLOW CREEK	WORLAND	9,140.5	9,140.5	100.0%
0211	WYMAN DRAW	WORLAND	246.5	246.5	100.0%
0212	SIGNAL BUTTE	WORLAND	233.7	233.7	100.0%
0213	EAST HYATTVILLE	WORLAND	135.4	135.4	100.0%
0214	SOUTH BANK	WORLAND	282.4	282.4	100.0%
0215	DEEDED	WORLAND	4851.84	4851.8	1.0

Allotment Number	Allotment Name	Field Office	Allotment Acreage		
			Total Acres	Acres In Nowood Basin	Percent Of Allotment in Study Area
0216	MUD GULCH	WORLAND	1,815.3	1,815.3	100.0%
0217	EAST ALKALI	WORLAND	5,799.4	5,799.3	100.0%
0218	WEST ALKALI	WORLAND	14,214.8	14,214.7	100.0%
0219	ROBSON MTN	WORLAND	952.2	952.2	100.0%
0220	EAST FLATS	WORLAND	4,727.4	4,509.6	95.4%
0221	PARKER	WORLAND	2,490.5	2,490.5	100.0%
0222	ANTHONY TIMBER	WORLAND	2,173.1	2,109.1	97.1%
0223	WOOD'S SPLIT ROCK	WORLAND	2,334.8	2,334.7	100.0%
0294	O'BRIEN CAMP	WORLAND	828.5	62.0	7.5%
0598	POWDER RIVER	WORLAND	8,730.0	744.8	8.5%
0667	TURK	WORLAND	3,153.0	3,153.0	100.0%
1304	CRAWFORD CREEK	LANDER	4,318.5	4,318.5	100.0%
1334	COTTONWOOD PASS	LANDER	6,444.2	4,364.3	67.7%
1367	HENRICH PASTURE	LANDER	561.4	135.2	24.1%
1504	WILD HORSE FLATS	WORLAND	8,673.8	3,357.0	38.7%
1525	POTATO	WORLAND	31,422.8	8,558.7	27.2%
1535	SOUTH SHELL GROUP	WORLAND	12,729.6	78.4	0.6%
1537	POTATO RIDGE	WORLAND	9,130.9	576.5	6.3%
2001	WILLOW SPRINGS	WORLAND	1,126.7	1,126.7	100.0%
2003	ROSE MTN	WORLAND	2,294.9	2,294.8	100.0%
2005	TALLON V	WORLAND	1,907.2	1,907.2	100.0%
2007	OTTER CREEK MOUNTAIN	WORLAND	8,160.7	8,160.6	100.0%
2008	BOX CANYON	WORLAND	2,471.9	2,471.9	100.0%
2010	DRY FARM	WORLAND	1,882.9	1,882.9	100.0%
2012	NATRONA	WORLAND	15,020.4	14,986.9	99.8%
2013	HARRIET	WORLAND	2,332.7	2,213.1	94.9%
2014	CHERRY CREEK HILL	WORLAND	2,650.2	1,497.9	56.5%
2015	BEATON PLACE	WORLAND	1,336.2	1,197.3	89.6%
2016	S.F. LITTLE CANYON CREEK	WORLAND	3,176.7	2,339.6	73.6%
2020	TANNER-MOUNTAIN	WORLAND	2,745.8	1,891.8	68.9%
2269	RECULUSA WASHAKIE	BUFFALO	1,123.4	1,123.4	100.0%
2395	GOSNEY, ELMER	BUFFALO	1,268.1	124.4	9.8%
2402	DONLIN	BUFFALO	686.7	42.5	6.2%
2444	N. SCOTCH	BUFFALO	1,188.7	1,188.7	100.0%
2445	MARTON	BUFFALO	1,217.3	1,217.3	100.0%
2507	BRIDGER CREEK	WORLAND	3,062.4	42.2	1.4%
2512	BILLYS FLATS	WORLAND	2,043.3	1,316.7	64.4%
2549	HAWKS BUTTE	WORLAND	1,824.7	24.3	1.3%
2565	LITTLE CANYON CRK #2	WORLAND	2,274.1	1,494.3	65.7%
2566	LITTLE CANYON CR MED	WORLAND	837.7	837.7	100.0%
10067	RED FORK	CASPER	2,569.8	3.9	0.2%
12137	SCOTCH	BUFFALO	4,897.4	4,648.7	94.9%
20503	BIGHORN MOUNTAINS	CASPER	2,078.7	712.1	34.3%

APPENDIX E

ECOLOGICAL SITE DESCRIPTIONS OF DOMINANT ECOLOGICAL TYPES

Ecological Site Description

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

ECOLOGICAL SITE DESCRIPTION

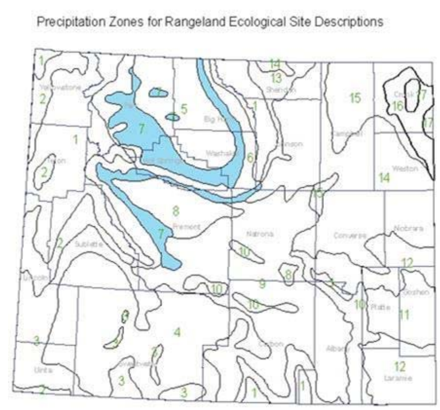
ECOLOGICAL SITE CHARACTERISTICS

Site Type: Rangeland

Site Name: Loamy (Ly) 10-14" East Precipitation Zone

Site ID: R032XY322WY

Major Land Resource Area: 032 - Northern Intermountain Desertic Basins



Physiographic Features

This site occurs on near level to gently undulating rolling land and on slope generally less than 20%.

Land Form:	(1) Hill	
	(2) Alluvial fan	
	(3) Ridge	
	Minimum	Maximum
Elevation (feet):	5400	7500
Slope (percent):	0	30
Water Table Depth (inches):		
Flooding:		
Frequency:		
Duration:	None	None
Ponding:		

Depth (inches):	0	0
Frequency:		
Duration:	None	None
Runoff Class:	Negligible	High
Aspect:	No Influence on this site	

Climatic Features

Annual precipitation ranges from 10-14 inches per year. The normal precipitation pattern shows the least amount of precipitation in December, January, and February, increasing to a peak during the latter part of May. Amounts decrease through June, July, and August and then increase some in September. Much of the moisture that falls in the latter part of the summer is lost by evaporation and much of the moisture that falls during the winter is lost by sublimation. Average snowfall exceeds 20 inches annually. Wide fluctuations may occur in yearly precipitation and result in more dry years than those with more than normal precipitation.

Temperatures show a wide range between summer and winter and between daily maximums and minimums, due to the high elevation and dry air, which permits rapid incoming and outgoing radiation. Cold air outbreaks from Canada in winter move rapidly from northwest to southeast and account for extreme minimum temperatures. Chinook winds may occur in winter and bring rapid rises in temperature. Extreme storms may occur during the winter, but most severely affect ranch operations during late winter and spring.

Winds are generally not strong as compared to the rest of the state. Daytime winds are generally stronger than nighttime and occasional strong storms may bring brief periods of high winds with gusts to more than 75 mph.

Growth of native cool-season plants begins about April 15 and continues to about July 15. Cool weather and moisture in September may produce some green up of cool season plants that will continue to late October.

The following information is from the “Thermopolis 2” climate station:
Minimum Maximum 5 yrs. out of 10 between
Frost-free period (days): 74 149 May 23 – September 16
Freeze-free period (days): 112 180 May 8 – October 1
Annual Precipitation (inches): 7.6 21.9

Mean annual precipitation: 12.35 inches
Mean annual air temperature: 46.2 F (30.1 F Avg. Min. to 62.3 F Avg. Max.)
For detailed information visit the Natural Resources Conservation Service National Water and Climate Center at http://www.wcc.nrcs.usda.gov/ website. Other climate station(s) representative of this precipitation zone include” Grass Creek 1E”, “Thermopolis”, Thermopolis 25NW”, “Buffalo Bill Dam” and “Black Mountain”.

	Minimum	Maximum
Frost-free period (days):	74	149
Freeze-free period (days):	112	180
Mean annual precipitation (inches):	10.0	14.0

Monthly precipitation (inches) and temperature (°F):

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precip. Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Precip. Max.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Temp. Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Temp. Max.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Climate Stations:

Influencing Water Features

Stream Type: None

Wetland Description:	System	Subsystem	Class

Representative Soil Features

The soils of this site are very deep to moderately deep (greater than 20" to bedrock), moderately well to well-drained & moderately slow to moderate permeable. The soil characteristic having the most influence on plant community is the available moisture and the potential to develop soluble salts near the surface.

Major Soil Series correlated to this site include: Lupinto, Frisite, Rock River, Sinkson, Elkol, Grieves, Yamac, Luhon, Rootel

Predominant Parent Materials:
Kind: Alluvium
Origin: Sandstone and shale

Surface Texture: (1) Loam
(2) Fine sandy loam
(3) Sandy loam

Subsurface Texture Group: Loamy

	Minimum	Maximum
Surface Fragments <=3" (% Cover):	0	10
Surface Fragments > 3" (% Cover):	0	0
Subsurface Fragments <=3" (% Volume):	0	15
Subsurface Fragments > 3" (% Volume):	0	10

Drainage Class: Moderately well drained To Well drained

Permeability Class: Moderately slow To Moderate

	Minimum	Maximum
Depth (inches):	20	60

Electrical Conductivity (mmhos/cm):	0	8
Sodium Absorption Ratio:	0	13
Calcium Carbonate Equivalent (percent):	0	20
Soil Reaction (1:1 Water):	7.4	9.0
Soil Reaction (0.01M CaCl2):		
Available Water Capacity (inches):	3.0	6.3

Plant Communities

Ecological Dynamics of the Site

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.

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 Historic Climax Plant Community (description follows the plant community diagram) has been determined by study of rangeland relic areas, or areas protected from excessive disturbance. Trends in plant communities going from heavily grazed areas to lightly grazed areas, seasonal use pastures, and historical accounts have also been used.

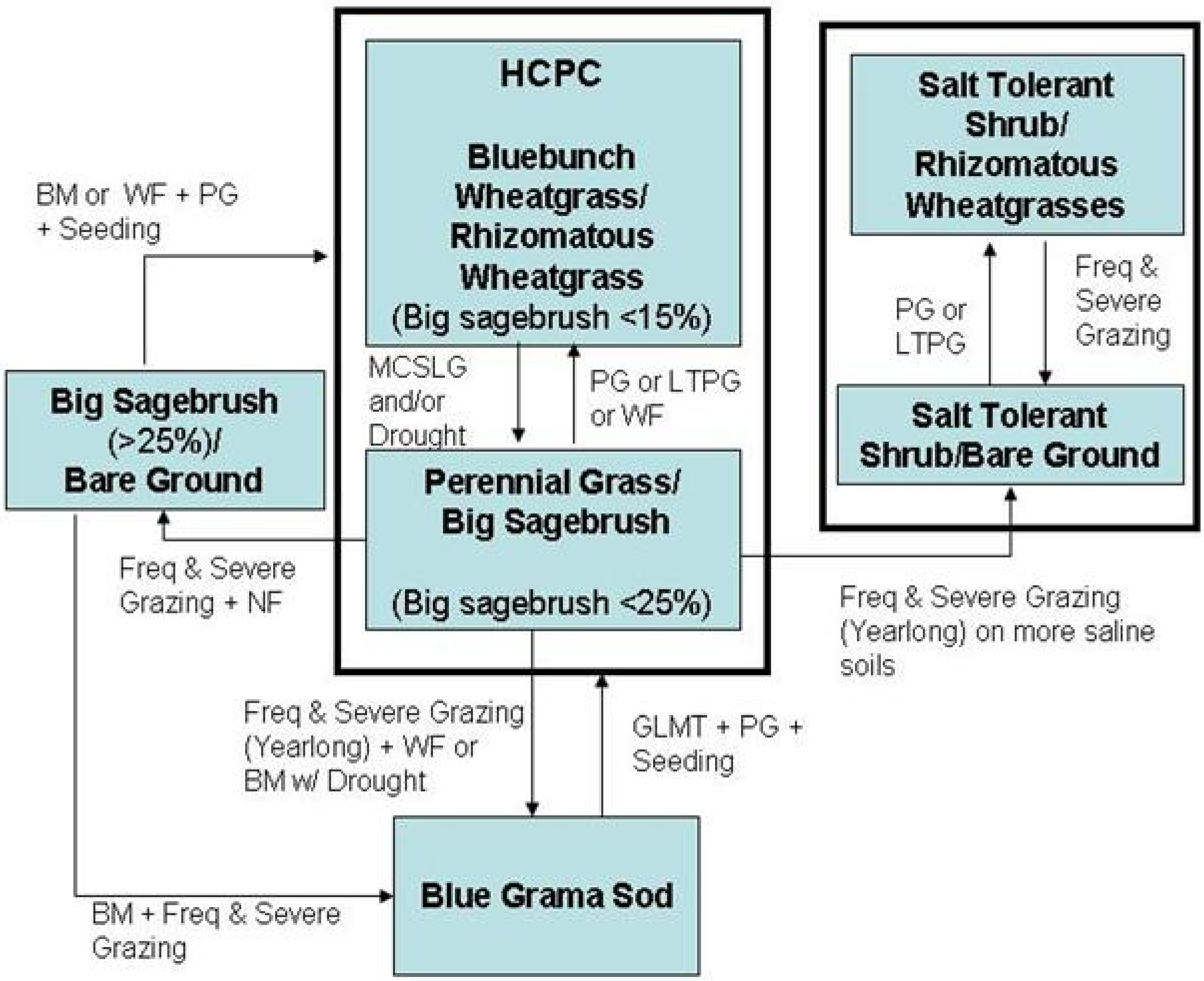
The following is a State and Transition Model Diagram that illustrates the common plant communities (states) that can occur on the site and the transitions between these communities. The ecological processes will be discussed in more detail in the plant community narratives following the diagram.

Plant Community Narratives
Following are the narratives for each of the described plant communities. These plant communities may not represent every possibility, but they probably are the most prevalent and repeatable plant communities. The plant composition tables shown above have been developed from the best available knowledge at the time of this revision. As more data is collected, some of these plant communities may be revised or removed, and new ones may be added. None of these plant communities should necessarily be thought of as “Desired Plant Communities”. According

to the USDA NRCS National Range and Pasture Handbook, Desired Plant Communities (DPC's) will be determined by the decision-makers and will meet minimum quality criteria established by the NRCS. The main purpose for including any description of a plant community here is to capture the current knowledge and experience at the time of this revision.

Site Type: Rangeland
MLRA: 32 – Northern Intermountain Desertic Basins

Loamy 10-14" E
032XY322WY



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
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)
WF - Wildfire (Natural or Human Caused)

Bluebunch Wheatgrass/Rhizomatous Wheatgrass

This plant community is the interpretive plant community for this site and is considered to be the Historic Climax Plant Community (HCPC). 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.

Bluebunch Wheatgrass/Rhizomatous Wheatgrass Plant Species Composition:

Grass/Grasslike

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
1				280	400
		Montana wheatgrass	*Elymus albicans*	280	400
		bluebunch wheatgrass	*Pseudoroegneria spicata*	280	400
2				0	80
		needle and thread	*Hesperostipa comata*	0	80
3				40	120
		western wheatgrass	*Pascopyrum smithii*	40	120
4				0	80
		green needlegrass	*Nassella viridula*	0	80
5				0	80
		Indian ricegrass	*Achnatherum hymenoides*	0	80
6				0	80

		spike fescue	*Leucopoa kingii*	0	80
7				0	80
		Grass, perennial		0	40
		blue grama	*Bouteloua gracilis*	0	40
		threadleaf sedge	*Carex filifolia*	0	40
		squirreltail	*Elymus elymoides*	0	40
		prairie Junegrass	*Koeleria macrantha*	0	40
		basin wildrye	*Leymus cinereus*	0	40
			Poa canbyi (Syn)	0	40
		Sandberg bluegrass	*Poa secunda*	0	40

Forb

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
8				40	120
		Forb, perennial		0	40
		textile onion	*Allium textile*	0	40
		small-leaf pussytoes	*Antennaria parvifolia*	0	40
		rosy pussytoes	*Antennaria rosea*	0	40
		prairie sagewort	*Artemisia frigida*	0	40
		Missouri milkvetch	*Astragalus missouriensis*	0	40
		wavyleaf Indian paintbrush	*Castilleja applegatei ssp. martinii*	0	40
		bastard toadflax	*Comandra umbellata*	0	40
		tapertip hawksbeard	*Crepis acuminata*	0	40
		little larkspur	*Delphinium bicolor*	0	40
		threadleaf fleabane	*Erigeron filifolius*	0	40
		parsnipflower buckwheat	*Eriogonum heracleoides*	0	40
		bigseed biscuitroot	*Lomatium macrocarpum*	0	40
		leafy wildparsley	*Musineon divaricatum*	0	40
		white locoweed	*Oxytropis sericea var. speciosa*	0	40
		beardtongue	*Penstemon*	0	40
		spiny phlox	*Phlox hoodii*	0	40
		scarlet globemallow	*Sphaeralcea coccinea*	0	40
		stemless mock goldenweed	*Stenotus acaulis*	0	40
		smooth woodyaster	*Xylorhiza glabriuscula*	0	40
		meadow deathcamas	*Zigadenus venenosus*	0	40

Shrub/Vine

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
9				40	120
		big sagebrush	*Artemisia tridentata*	40	120
10				0	40
		antelope bitterbrush	*Purshia tridentata*	0	40
11				0	40
		rubber rabbitbrush	*Ericameria nauseosa*	0	40
12				0	40
		winterfat	*Krascheninnikovia*	0	40

13		0	40
	Shrub (>.5m)	0	40

Plant Growth Curve:
Growth Curve Number: WY0701
Growth Curve Name: 10-14E upland sites
Growth Curve Description:

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	25	40	10	5	10	5	0	0

Perennial Grass/ Big Sagebrush

Historically, this plant community evolved under grazing and a low fire frequency. Currently, it is found under moderate, season-long grazing by livestock and will be exacerbated by prolonged drought conditions. In addition, the fire regime for this site has been modified and extended periods without fire is now common. This plant community is still dominated by cool-season grasses, while short warm-season grasses and miscellaneous forbs account for the balance of the understory.
Wyoming big sagebrush is now a conspicuous part of the overall production and accounts for the majority of the overstory.

The dominant grasses include Griffiths and bluebunch wheatgrasses, rhizomatous wheatgrasses, and needleandthread. Grasses and grass-like species of secondary importance include prairie junegrass, blue grama, Sandberg bluegrass, and threadleaf sedge. Forbs commonly found in this plant community include scarlet globemallow, fringed sagewort, wavyleaf paintbrush, little larkspur, and Hood's phlox. Sagebrush can make up to 25% of the annual production. The overstory of sagebrush and understory of grasses and forbs provide a diverse plant community.

When compared to the Historic Climax Plant Community, big sagebrush and blue grama have increased. Plains pricklypear cactus will also have invaded, but occurs only in small patches. Indian ricegrass has decreased and may occur in only trace amounts under the sagebrush canopy or within the patches of pricklypear. In addition, the amount of winterfat may or may not have changed depending on the season of use.

The total annual production (air-dry weight) of this state is about 600 pounds per acre, but it can range from about 400 lbs./acre in unfavorable years to about 900 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.

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

• Prescribed grazing or possibly long-term prescribed grazing, will convert this plant community to the HCPC. The probability of this occurring is high especially if rotational grazing along with short deferred grazing is implemented as part of prescribed method of use. In addition, the removal of fire suppression will allow a somewhat natural fire regime to reoccur to more easily transition between this plant community and the HCPC. A prescribed fire treatment can be useful to hasten this transition, if desired.

• Frequent and severe grazing plus no fire on soils with limited soluble salts, will convert the plant community to the Big Sagebrush/Bare Ground Plant Community. The probability of this occurring is high. This is especially evident on areas with historically higher precipitation and the sagebrush stand is not adversely impacted by drought or heavy browsing.

• Frequent and severe grazing (yearlong grazing) plus wildfire or brush control, will convert the plant community to the Blue Grama Sod Plant Community. The probability of this occurring is high, especially if the sagebrush stand has been severely affected by drought or heavy use or has been removed altogether.

• Frequent and severe grazing (yearlong grazing) on more saline soils, will convert the plant community to the Salt Tolerant Shrub/Bare Ground Plant Community. The probability of this occurring is high especially on soils with elevated salts and the sagebrush stand has been severely affected by drought and heavy use or has been removed altogether.

Plant Growth Curve:
Growth Curve Number: WY0701
Growth Curve Name: 10-14E upland sites
Growth Curve Description:

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	25	40	10	5	10	5	0	0

Big Sagebrush/ Bare ground

This plant community is the result of frequent and severe grazing and protection from fire. Sagebrush dominates this plant community, as the annual production of sagebrush excess 25%. Wyoming big sagebrush is a significant component of the plant community and the preferred cool season grasses have been greatly reduced.

The dominant grasses are prairie junegrass, Sandberg bluegrass, and blue grama. Weedy annual species such as cheatgrass may occupy the site if a seed source is available. Cactus and sageworts often invade. Noxious weeds such as Russian knapweed, leafy spurge, or Canada thistle may invade the site if a seed source is available. The interspaces between plants have expanded leaving the amount of bare ground more prevalent. As compared with the HCPC or the Perennial Grass/Big Sagebrush Plant Communities, the annual production is less, but the shrub production compensates for some of the decline in the herbaceous production.

The total annual production (air-dry weight) of this state is about 500 pounds per acre, but it can range from about 300 lbs./acre in unfavorable years to about 700 lbs./acre in above average years.

This plant community is resistant to change as the stand becomes more decadent. These areas may actually be more resistant to fire as less fine fuels are available and the bare ground between the sagebrush plants is increased. Continued frequent and severe grazing or the removal of grazing does not seem to affect the composition or structure of the plant community. Plant diversity is moderate to poor. The plant vigor is diminished and replacement capabilities are limited due to the reduced number of cool-season grasses. Plant litter is noticeably less when compared to the HCPC.

Soil erosion is accelerated because of increased bare ground. Water flow patterns and pedestalling are obvious. Infiltration is reduced and runoff is increased. Rill channels may be noticeable in the interspaces and gullies may be establishing where rills have concentrated down slope.

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

• Brush management, followed by prescribed grazing, will return this plant community at or near the HCPC. If prescribed fire is used as a means to reduce or remove the shrubs, sufficient fine fuels will need to be present. This may require deferment from grazing prior to treatment. Post management is critical to ensure success. This can range from two or more years of rest to partial growing season deferment, depending on the condition of the understory at the time of treatment and the growing conditions following treatment. In the case of an intense wildfire that occurs when desirable plants are not completely dormant, the length of time required to reach the HCPC may be increased and seeding of natives is recommended.

• Brush management, followed by frequent and severe grazing, will convert the plant community to the Blue Grama Sod Plant Community.

Plant Growth Curve:
Growth Curve Number: WY0701
Growth Curve Name: 10-14E upland sites
Growth Curve Description:

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	25	40	10	5	10	5	0	0

Blue grama Sod

This plant community is the result of frequent and severe yearlong grazing, which has adversely affected the perennial grasses as well as impacted the shrub component. Other factors that can affect the shrubs include drought, heavy browsing, wildfires, and/or human brush control measures. A dense sod of blue grama with patches of threadleaf sedge dominates this state. Pricklypear cactus can become dense enough in patches so that livestock cannot graze forage growing within the cactus clumps. Big sagebrush has been reduced to small patches or in some cases removed. Rubber rabbitbrush may be the sole remaining shrub on the site.

When compared to the Historic Climax Plant Community, blue grama and threadleaf sedge,have increased. Pricklypear has invaded. All cool-season mid-grasses, forbs, and most shrubs have been greatly reduced. Production has been significantly decreased.

The total annual production (air-dry weight) of this state is about 200 pounds per acre, but it can range from about 100 lbs./acre in unfavorable years to about 300 lbs./acre in above average years.

This sod is extremely resistant to change and continued frequent and severe grazing or the removal of grazing does not seem to affect the plant composition or structure of the plant community. The biotic integrity of this state is not functional and plant diversity is extremely low. The plant vigor is significantly weakened and replacement capabilities are limited due to the reduced number of cool-season grasses.

This sod bound plant community is very resistant to water infiltration. While this sod protects the site itself, off-site areas are affected by excessive runoff that can cause rills and gully erosion. Water flow patterns are obvious in the bare ground areas and pedestalling is apparent along the sod edges. Rill channels are noticeable in the interspaces and down slope. The watershed may or may not be functioning, as runoff may affect adjoining sites.

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

• Grazing land mechanical treatment (chiseling, etc.) and pricklypear cactus control (if needed), followed by prescribed grazing, and possibly seeding of natives will return this plant community to near Historic Climax Plant Community condition.

Plant Growth Curve:
Growth Curve Number: WY0701
Growth Curve Name: 10-14E upland sites
Growth Curve Description:

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	25	40	10	5	10	5	0	0

Salt Tolerant Shrub/ Bare Ground

This plant community can occur on sites subjected to frequent and severe grazing and on soils influenced by elevated amounts of soluble salts. Salt tolerant shrubs replace Wyoming big sagebrush as the major overstory species while the preferred cool season grasses have been eliminated or greatly reduced. Bare ground and weedy grasses and forbs dominate the understory.

This state is dominated by an overstory of salt tolerant shrubs, such as greasewood, birdfoot sagebrush and saltbushes, which can vary widely in their composition and production. The leaves of some of these plants contain high amounts of sodium and other salts, and when shed these soluble salts are transferred to the soils underneath the plants. Consequently, the soil can exhibit wide variations in soluble salts, which can explain the variation in shrub composition. Big sagebrush and rubber rabbitbrush are present but are mostly in small patches.

Perennial cool season mid-grasses have been removed leaving mostly patches of blue grama and annuals. Cheatgrass and weedy annual forbs such as halogeton, Russian thistle, and kochia, will occupy the site if a seed source is available. Noxious weeds such as Russian knapweed may also invade the site. Plant diversity is moderate to poor.

When compared to the HCPC, grass production has diminished but is off set by the increase in shrub production. The interspaces between plants have expanded leaving the amount of bare ground more prevalent. Surface salts have increased, especially on sites dominated by greasewood and saltbushes.

The total annual production (air-dry weight) of this state is about 450 pounds per acre, but it can range from about 250 lbs./acre in unfavorable years to about 550 lbs./acre in above average years.

This plant community is resistant to change. These areas are actually more resistant to fire as less fine fuels are available and the bare ground between the shrubs has increased. Continued frequent and severe grazing does not affect the composition or structure of the plant community. Plant diversity is moderate to poor. The biotic integrity of this state is mostly dysfunctional because of the predominant salt tolerant shrub overstory and absence of perennial cool-season grasses.

Soil erosion is accelerated because of increased bare ground. Water flow patterns and pedestalling are obvious. Infiltration is reduced and runoff is increased. Rill channels may be noticeable in the interspaces and gullies may be establishing where rills have concentrated down slope.

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

• Prescribed grazing or possibly long-term prescribed grazing, will convert this plant community to the Salt Tolerant Shrub/Rhizomatous Wheatgrass Plant community. Recovery to near Historic Climax Plant Community condition is difficult to impossible due to the resistance of these shrubs to herbicides and other brush management techniques. In addition, the increase in surface salts has had accumulated effects on the soil so most of the herbaceous plants associated with the HCPC are no longer suitable for this site. The most notable exception is the rhizomatous wheatgrasses and bottlebrush squirreltail. Soil remediation to reduce the surface salts is not recommended, as this is mostly ineffective and extremely costly. Seeding more salt-tolerant native grasses and forbs will improve the productivity of site and plant cover.

Plant Growth Curve:
Growth Curve Number: WY0701
Growth Curve Name: 10-14E upland sites
Growth Curve Description:

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	25	40	10	5	10	5	0	0

Salt Tolerant Shrub/ Rhizomatous Wheatgrasses

This plant community can occur where the Salt Tolerant/Bare Ground Plant Community is rested and a prescribed grazing management practice is implemented. Salt tolerant shrubs and Wyoming big sagebrush remain a significant component of the plant community but preferred cool season grasses have reestablished.

This site is dominated by an overstory of a variety of shrubs, such as Wyoming big sagebrush, rubber rabbitbrush, greasewood, and a variety of saltbushes. Some perennial cool season mid-grasses have once again reestablished such as rhizomatous wheatgrasses and bottlebrush squirreltail. Other important grasses include prairie junegrass, Sandberg bluegrass and blue grama. Patches of annuals such as cheatgrass and other weedy annual forbs such as halogeton, Russian thistle, and kochia, will persist on this site. Noxious weeds such as Russian knapweed may also remain if not treated. The interspaces between plants will have diminished in size. When compared with the HCPC or the Perennial Grass/Big Sagebrush Plant Communities, the annual production is somewhat similar, but the plant species are mostly unique.

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 800 lbs./acre in above average years.

This plant community is mostly resistant to change, but species composition can be altered through long-term overgrazing. The herbaceous component is stable, but does not include most climax species. Plant vigor and replacement capabilities are sufficient. The biotic community is not intact because of the predominant salt tolerant shrub overstory and lack of climax grass species. Plant diversity is moderate.

Soils are mostly stable and recent soil loss is minimal. This should not be confused with evidence of remnant erosion. Water flow patterns and litter movement is stable but is still occurring on steeper slopes. Incidence of pedestalling is improving. The watershed may or may not be functioning

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

• Frequent and severe grazing will convert the plant community to the Salt Tolerant Shrub/Bare Ground Plant Community.

• Recovery to near Historic Climax Plant Community condition is difficult to impossible due to the resistance of these shrubs to herbicides and other brush management techniques. In addition, the increase in surface salts has had accumulated effects on the soil so most of the herbaceous plants associated with the HCPC are no longer suitable for this site. The most notable exception is the rhizomatous wheatgrasses and bottlebrush squirreltail. Soil remediation to reduce the surface salts is not recommended, as this is mostly ineffective and extremely costly. Seeding more salt-tolerant grasses and forbs will improve the productivity of site and plant cover, but will not improve the biotic integrity.

Plant Growth Curve:
Growth Curve Number: WY0701
Growth Curve Name: 10-14E upland sites
Growth Curve Description:

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	25	40	10	5	10	5	0	0

Ecological Site Interpretations

Animal Community:

Animal Community – Wildlife Interpretations

Bluebunch Wheatgrass/Rhizomatous Wheatgrasses (HCPC): The predominance of grasses in this plant community favors grazers and mixed-feeders, such as bison, elk, and antelope. Suitable thermal and escape cover for deer may be limited due to the low quantities of woody plants. However, topographical variations could provide some escape cover. When found adjacent to sagebrush dominated states, this plant community may provide brood rearing/foraging areas for sage grouse, as well as lek sites. Other birds that would frequent this plant community include western meadowlarks, horned larks, and golden eagles. Many grassland obligate small mammals would occur here.

Perennial Grass/Big Sagebrush Plant Community: The combination of an overstory of sagebrush and an understory of grasses and forbs provide a very diverse plant community for wildlife. The crowns of sagebrush tend to break up hard crusted snow on winter ranges, so mule deer and antelope may use this state for foraging and cover year-round, as would cottontail and jack rabbits. It provides important winter, nesting, brood-rearing, and foraging habitat for sage grouse. Brewer's sparrows' nest in big sagebrush plants and hosts of other nesting birds utilize stands in the 20-30% cover range.

Big Sagebrush/Bare Ground Plant Community: This plant community can provide important winter foraging for elk, mule deer and antelope, as sagebrush can approach 15% protein and 40-60% digestibility during that time. This community provides excellent escape and thermal cover for large ungulates, as well as nesting habitat for sage grouse.

Blue Grama Sod Plant Community: These communities provide limited foraging for antelope and other grazers. They may be used as a foraging site by sage grouse if proximal to woody cover and if the Historic Climax Plant Community or the Perennial Grass/ Big Sagebrush Plant Community is limited. Generally, these are not target plant communities for wildlife habitat management.

Salt Tolerant Shrub/Bare Ground Plant Community: This plant community exhibits a low level of plant species diversity due to the accumulation of salts near the soil surface. It may provide some thermal and escape cover for deer and antelope if no other woody community is nearby, but in most cases, it is not a desirable plant community to select as a wildlife habitat management objective.

Salt Tolerant Shrub/Rhizomatous Wheatgrass Plant Community: The combination of an overstory of sagebrush and an understory of grasses and forbs provide a diverse plant community for wildlife. The crowns of these shrubs tend to break up hard crusted snow on winter ranges, so mule deer and antelope may use this state for foraging and cover year-round, as would cottontail and jack rabbits. It provides important winter nesting, brood-rearing, and foraging habitat for sage grouse and other upland birds. Brewer's sparrows' nest in big sagebrush plants and hosts of other nesting birds utilize stands in the 20-30% cover range.

Animal Community – Grazing Interpretations

The following table lists suggested stocking rates for cattle under continuous season-long grazing under normal growing conditions. These are conservative estimates that should be used only as guidelines in the initial stages of the conservation planning process. Often, the current plant composition does not entirely match any particular plant community (as described in this ecological site description). Because of this, a field visit is recommended, in all cases, to document plant composition and production. More precise carrying capacity estimates should eventually be calculated using this information along with animal preference data, particularly when grazers other than cattle are involved. Under more intensive grazing management, improved harvest efficiencies can result in an increased carrying capacity. If distribution problems occur, stocking rates must be reduced to maintain plant health and vigor.

Plant Community Production Carrying Capacity*
(lb./ac) (AUM/ac)
Bluebunch Wheatgrass/ Rhizomatous Wheatgrasses 500-1100 .40
Perennial Grass/Big Sagebrush 400-900 .30
Big Sagebrush/Bare Ground 300-700 .20
Blue Grama Sod 100-300 .10
Salt Tolerant Shrub/Bare Ground 250-550 .13
Salt Tolerant Shrub/Rhizomatous Wheatgrasses 400-800 .22

* - Continuous, season-long grazing by cattle under average growing conditions.

Grazing by domestic livestock is one of the major income-producing industries in the area. Rangeland in this area may provide yearlong forage for cattle, sheep, or horses. During the dormant period, the forage for livestock use needs to be supplemented with protein because the quality does not meet minimum livestock requirements.

Plant Preference by Animal Kind:

Animal Kind: ALL Antelope

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
agoseris	*Agoseris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
textile onion	*Allium textile*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	*Antennaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	*Artemisia cana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
threeawn	*Aristida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	*Artemisia nova*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
birdfoot sagebrush	*Artemisia pedatifida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Fendler threeawn	*Aristida purpurea var. longiseta*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
big sagebrush	*Artemisia tridentata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
milkvetch	*Astragalus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fourwing saltbush	*Atriplex canescens*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
shadscale saltbush	*Atriplex confertifolia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Gardner's saltbush	*Atriplex gardneri*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
blue grama	*Bouteloua gracilis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	*Carex aquatilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
golden sedge	*Carex aurea*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
threadleaf sedge	*Carex filifolia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
inland sedge	*Carex interior*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
prairie sandreed	*Calamovilfa longifolia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Nebraska sedge	*Carex nebrascensis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sedge	*Carex*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beaked sedge	*Carex rostrata*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pond water-starwort	*Callitriche stagnalis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Indian paintbrush	*Castilleja*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
yellow rabbitbrush	*Chrysothamnus viscidiflorus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
pale bastard toadflax	*Comandra umbellata ssp. pallida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Deschampsia caespitosa (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
saltgrass	*Distichlis spicata*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Canada wildrye	*Elymus canadensis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
squirreltail	*Elymus elymoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	*Elymus trachycaulus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
horsetail	*Equisetum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
fleabane	*Erigeron*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
buckwheat	*Eriogonum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
rubber rabbitbrush	*Ericameria nauseosa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
aster	*Eucephalus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spiny hopsage	*Grayia spinosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
needle and thread	*Hesperostipa comata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
iris	*Iris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Juncus balticus (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Rocky Mountain juniper	*Juniperus scopulorum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
prairie Junegrass	*Koeleria macrantha*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
winterfat	*Krascheninnikovia lanata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
basin wildrye	*Leymus cinereus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
desertparsley	*Lomatium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
tufted evening primrose	*Oenothera caespitosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
nailwort	*Paronychia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	*Pascopyrum smithii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beardtongue	*Penstemon*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	*Phlox*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
bud sagebrush	*Picrothamnus desertorum*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal Kind: all Antelope

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
	Poa juncifolia (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal Kind: ALL Antelope

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
cottonwood	*Populus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Sandberg bluegrass	*Poa secunda*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	*Pseudoroegneria spicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Nuttall's alkaligrass	*Puccinellia nuttalliana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
skunkbush sumac	*Rhus trilobata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Woods' rose	*Rosa woodsii var. woodsii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dock	*Rumex*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	*Salix*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
greasewood	*Sarcobatus vermiculatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	*Sedum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver buffaloberry	*Shepherdia argentea*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
blue-eyed grass	*Sisyrinchium*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: All Antelope

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
alkali sacaton	*Sporobolus airoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal Kind: ALL Antelope

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
scarlet globemallow	*Sphaeralcea coccinea*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sand dropseed	*Sporobolus cryptandrus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: all Antelope

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
alkali cordgrass	*Spartina gracilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: ALL Antelope

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
princesplume	*Stanleya*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
stemless four-nerve daisy	*Tetraneuris acaulis var. acaulis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arrowgrass	*Triglochin*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
salsify	*Tragopogon porrifolius*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
false carrot	*Turgenia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
woodyaster	*Xylorhiza*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
yucca	*Yucca*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal Kind: ALL Cattle

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
agoseris	*Agoseris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
textile onion	*Allium textile*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	*Antennaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	*Artemisia cana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threeawn	*Aristida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	*Artemisia nova*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
birdfoot sagebrush	*Artemisia pedatifida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Fendler threeawn	*Aristida purpurea var. longiseta*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
big sagebrush	*Artemisia tridentata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
milkvetch	*Astragalus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fourwing saltbush	*Atriplex canescens*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
shadscale saltbush	*Atriplex confertifolia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Gardner's saltbush	*Atriplex gardneri*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
blue grama	*Bouteloua gracilis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	*Carex aquatilis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
golden sedge	*Carex aurea*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threadleaf sedge	*Carex filifolia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
inland sedge	*Carex interior*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
prairie sandreed	*Calamovilfa longifolia*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Nebraska sedge	*Carex nebrascensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
sedge	*Carex*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beaked sedge	*Carex rostrata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pond water-starwort	*Callitriche stagnalis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Indian paintbrush	*Castilleja*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
yellow rabbitbrush	*Chrysothamnus viscidiflorus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pale bastard toadflax	*Comandra umbellata ssp. pallida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Deschampsia caespitosa (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

saltgrass	*Distichlis spicata*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Canada wildrye	*Elymus canadensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
squirreltail	*Elymus elymoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	*Elymus trachycaulus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
horsetail	*Equisetum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
fleabane	*Erigeron*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
buckwheat	*Eriogonum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
rubber rabbitbrush	*Ericameria nauseosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
aster	*Eucephalus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spiny hopsage	*Grayia spinosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
needle and thread	*Hesperostipa comata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
iris	*Iris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Juncus balticus (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Rocky Mountain juniper	*Juniperus scopulorum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
prairie Junegrass	*Koeleria macrantha*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
winterfat	*Krascheninnikovia lanata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
basin wildrye	*Leymus cinereus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
desertparsley	*Lomatium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
tufted evening primrose	*Oenothera caespitosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
nailwort	*Paronychia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	*Pascopyrum smithii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beardtongue	*Penstemon*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	*Phlox*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
bud sagebrush	*Picrothamnus desertorum*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal Kind: all Cattle

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
	Poa juncifolia (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal Kind: ALL Cattle

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
cottonwood	*Populus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Sandberg bluegrass	*Poa secunda*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	*Pseudoroegneria spicata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Nuttall's alkaligrass	*Puccinellia nuttalliana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
skunkbush sumac	*Rhus trilobata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Woods' rose	*Rosa woodsii var. woodsii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dock	*Rumex*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	*Salix*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
greasewood	*Sarcobatus vermiculatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	*Sedum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver buffaloberry	*Shepherdia argentea*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
blue-eyed grass	*Sisyrinchium*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: All Cattle

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
alkali sacaton	*Sporobolus airoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal Kind: ALL Cattle

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
scarlet globemallow	*Sphaeralcea coccinea*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

sand dropseed	*Sporobolus cryptandrus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal Kind: all Cattle

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
alkali cordgrass	*Spartina gracilis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal Kind: ALL Cattle

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
princesplume	*Stanleya*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
stemless four-nerve daisy	*Tetraneuris acaulis var. acaulis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arrowgrass	*Triglochin*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
salsify	*Tragopogon porrifolius*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
false carrot	*Turgenia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
woodyaster	*Xylorhiza*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
yucca	*Yucca*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal Kind: ALL Deer

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
agoseris	*Agoseris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
textile onion	*Allium textile*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	*Antennaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	*Artemisia cana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
threeawn	*Aristida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	*Artemisia nova*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
birdfoot sagebrush	*Artemisia pedatifida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Fendler threeawn	*Aristida purpurea var. longiseta*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
big sagebrush	*Artemisia tridentata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
milkvetch	*Astragalus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fourwing saltbush	*Atriplex canescens*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
shadscale saltbush	*Atriplex confertifolia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Gardner's saltbush	*Atriplex gardneri*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
blue grama	*Bouteloua gracilis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	*Carex aquatilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
golden sedge	*Carex aurea*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
threadleaf sedge	*Carex filifolia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
inland sedge	*Carex interior*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
prairie sandreed	*Calamovilfa longifolia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Nebraska sedge	*Carex nebrascensis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sedge	*Carex*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beaked sedge	*Carex rostrata*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pond water-starwort	*Callitriche stagnalis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Indian paintbrush	*Castilleja*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
yellow rabbitbrush	*Chrysothamnus viscidiflorus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
pale bastard toadflax	*Comandra umbellata ssp. pallida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Deschampsia caespitosa (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
saltgrass	*Distichlis spicata*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Canada wildrye	*Elymus canadensis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
squirreltail	*Elymus elymoides*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
thickspike wheatgrass	*Elymus lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	*Elymus trachycaulus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

horsetail	*Equisetum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
fleabane	*Erigeron*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
buckwheat	*Eriogonum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
rubber rabbitbrush	*Ericameria nauseosa*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	*Eucephalus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spiny hopsage	*Grayia spinosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
needle and thread	*Hesperostipa comata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
iris	*Iris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Juncus balticus (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Rocky Mountain juniper	*Juniperus scopulorum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
prairie Junegrass	*Koeleria macrantha*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
winterfat	*Krascheninnikovia lanata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
basin wildrye	*Leymus cinereus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
desertparsley	*Lomatium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
tufted evening primrose	*Oenothera caespitosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
nailwort	*Paronychia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	*Pascopyrum smithii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beardtongue	*Penstemon*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	*Phlox*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
bud sagebrush	*Picrothamnus desertorum*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal Kind: all Deer

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
	Poa juncifolia (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal Kind: ALL Deer

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
cottonwood	*Populus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Sandberg bluegrass	*Poa secunda*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	*Pseudoroegneria spicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Nuttall's alkaligrass	*Puccinellia nuttalliana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
skunkbush sumac	*Rhus trilobata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Woods' rose	*Rosa woodsii var. woodsii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dock	*Rumex*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	*Salix*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
greasewood	*Sarcobatus vermiculatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	*Sedum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver buffaloberry	*Shepherdia argentea*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
blue-eyed grass	*Sisyrinchium*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: All Deer

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
alkali sacaton	*Sporobolus airoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal Kind: ALL Deer

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
scarlet globemallow	*Sphaeralcea coccinea*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sand dropseed	*Sporobolus cryptandrus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: all Deer

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
alkali cordgrass	*Spartina gracilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: ALL Deer

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
princesplume	*Stanleya*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
stemless four-nerve daisy	*Tetraneuris acaulis var. acaulis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arrowgrass	*Triglochin*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
salsify	*Tragopogon porrifolius*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
false carrot	*Turgenia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
woodyaster	*Xylorhiza*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
yucca	*Yucca*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal Kind: ALL Horses

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
agoseris	*Agoseris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
textile onion	*Allium textile*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	*Antennaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	*Artemisia cana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threeawn	*Aristida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	*Artemisia nova*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
birdfoot sagebrush	*Artemisia pedatifida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Fendler threeawn	*Aristida purpurea var. longiseta*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
big sagebrush	*Artemisia tridentata*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
milkvetch	*Astragalus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fourwing saltbush	*Atriplex canescens*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
shadscale saltbush	*Atriplex confertifolia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Gardner's saltbush	*Atriplex gardneri*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
blue grama	*Bouteloua gracilis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	*Carex aquatilis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
golden sedge	*Carex aurea*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threadleaf sedge	*Carex filifolia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
inland sedge	*Carex interior*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
prairie sandreed	*Calamovilfa longifolia*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Nebraska sedge	*Carex nebrascensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
sedge	*Carex*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beaked sedge	*Carex rostrata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pond water-starwort	*Callitriche stagnalis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Indian paintbrush	*Castilleja*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
yellow rabbitbrush	*Chrysothamnus viscidiflorus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale bastard toadflax	*Comandra umbellata ssp. pallida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Deschampsia caespitosa (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
saltgrass	*Distichlis spicata*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Canada wildrye	*Elymus canadensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
squirreltail	*Elymus elymoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	*Elymus trachycaulus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
horsetail	*Equisetum*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
fleabane	*Erigeron*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
buckwheat	*Eriogonum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
rubber rabbitbrush	*Ericameria nauseosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
aster	*Eucephalus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

spiny hopsage	*Grayia spinosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
needle and thread	*Hesperostipa comata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
iris	*Iris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Juncus balticus (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Rocky Mountain juniper	*Juniperus scopulorum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
prairie Junegrass	*Koeleria macrantha*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
winterfat	*Krascheninnikovia lanata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
basin wildrye	*Leymus cinereus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
desertparsley	*Lomatium*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
tufted evening primrose	*Oenothera caespitosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
nailwort	*Paronychia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	*Pascopyrum smithii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beardtongue	*Penstemon*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	*Phlox*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
bud sagebrush	*Picrothamnus desertorum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal Kind: all Horses

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
	Poa juncifolia (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal Kind: ALL Horses

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
cottonwood	*Populus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Sandberg bluegrass	*Poa secunda*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	*Pseudoroegneria spicata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Nuttall's alkaligrass	*Puccinellia nuttalliana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
skunkbush sumac	*Rhus trilobata*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Woods' rose	*Rosa woodsii var. woodsii*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
dock	*Rumex*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	*Salix*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
greasewood	*Sarcobatus vermiculatus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
stonecrop	*Sedum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver buffaloberry	*Shepherdia argentea*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
blue-eyed grass	*Sisyrinchium*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: All Horses

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
alkali sacaton	*Sporobolus airoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal Kind: ALL Horses

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
scarlet globemallow	*Sphaeralcea coccinea*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sand dropseed	*Sporobolus cryptandrus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal Kind: all Horses

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
alkali cordgrass	*Spartina gracilis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal Kind: ALL Horses

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
princesplume	*Stanleya*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
stemless four-nerve daisy	*Tetraneuris acaulis var. acaulis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arrowgrass	*Triglochin*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T

salsify	*Tragopogon porrifolius*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
false carrot	*Turgenia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
woodyaster	*Xylorhiza*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
yucca	*Yucca*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: ALL Sheep

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
agoseris	*Agoseris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
textile onion	*Allium textile*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	*Antennaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	*Artemisia cana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threeawn	*Aristida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	*Artemisia nova*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
birdfoot sagebrush	*Artemisia pedatifida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Fendler threeawn	*Aristida purpurea var. longiseta*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
big sagebrush	*Artemisia tridentata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
milkvetch	*Astragalus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fourwing saltbush	*Atriplex canescens*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
shadscale saltbush	*Atriplex confertifolia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Gardner's saltbush	*Atriplex gardneri*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
blue grama	*Bouteloua gracilis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	*Carex aquatilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
golden sedge	*Carex aurea*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threadleaf sedge	*Carex filifolia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
inland sedge	*Carex interior*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
prairie sandreed	*Calamovilfa longifolia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Nebraska sedge	*Carex nebrascensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
sedge	*Carex*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beaked sedge	*Carex rostrata*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pond water-starwort	*Callitriche stagnalis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Indian paintbrush	*Castilleja*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
yellow rabbitbrush	*Chrysothamnus viscidiflorus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pale bastard toadflax	*Comandra umbellata ssp. pallida*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Deschampsia caespitosa (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
saltgrass	*Distichlis spicata*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Canada wildrye	*Elymus canadensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
squirreltail	*Elymus elymoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	*Elymus trachycaulus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
horsetail	*Equisetum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
fleabane	*Erigeron*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
buckwheat	*Eriogonum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
rubber rabbitbrush	*Ericameria nauseosa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
aster	*Eucephalus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spiny hopsage	*Grayia spinosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
needle and thread	*Hesperostipa comata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
iris	*Iris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Juncus balticus (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Rocky Mountain

juniper	*Juniperus scopulorum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
prairie Junegrass	*Koeleria macrantha*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
winterfat	*Krascheninnikovia lanata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
basin wildrye	*Leymus cinereus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
tufted evening primrose	*Oenothera caespitosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
nailwort	*Paronychia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	*Pascopyrum smithii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
beardtongue	*Penstemon*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	*Phlox*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
bud sagebrush	*Picrothamnus desertorum*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal Kind: all Sheep

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
	Poa juncifolia (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

Animal Kind: ALL Sheep

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
cottonwood	*Populus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Sandberg bluegrass	*Poa secunda*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	*Pseudoroegneria spicata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Nuttall's alkaligrass	*Puccinellia nuttalliana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
skunkbush sumac	*Rhus trilobata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Woods' rose	*Rosa woodsii var. woodsii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dock	*Rumex*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	*Salix*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
greasewood	*Sarcobatus vermiculatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	*Sedum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver buffaloberry	*Shepherdia argentea*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
blue-eyed grass	*Sisyrinchium*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: All Sheep

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
alkali sacaton	*Sporobolus airoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal Kind: ALL Sheep

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
scarlet globemallow	*Sphaeralcea coccinea*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sand dropseed	*Sporobolus cryptandrus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Animal Kind: all Sheep

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
alkali cordgrass	*Spartina gracilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: ALL Sheep

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
princesplume	*Stanleya*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
stemless four-nerve daisy	*Tetraneuris acaulis var. acaulis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arrowgrass	*Triglochin*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
salsify	*Tragopogon porrifolius*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
false carrot	*Turgenia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
woodyaster	*Xylorhiza*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
yucca	*Yucca*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Legend: P = Preferred D = Desirable U = Undesirable N = Not consumed E = Emergency T = Toxic X = Used, but degree of utilization unknown

Hydrology Functions:
Water is the principal factor limiting forage production on this site. This site is dominated by soils in hydrologic group B and C, with localized areas in hydrologic group D. Infiltration ranges from moderately slow to moderate. Runoff potential for this site varies from low to moderate depending on soil hydrologic group and ground cover. In many cases, areas with greater than 75% ground cover have the greatest potential for high infiltration and lower runoff. An example of an exception would be where short-grasses form a strong sod and dominate the site. Areas where ground cover is less than 50% have the greatest potential to have reduced infiltration and higher runoff (refer to Part 630, NRCS National Engineering Handbook for detailed hydrology information).

Rills and gullies should not typically be present. Water flow patterns should be barely distinguishable if at all present. Pedestals are only slightly present in association with bunchgrasses. Litter typically falls in place, and signs of movement are not common. Chemical and physical crusts are rare to non-existent. Cryptogamic crusts are present, but only cover 1-2% of the soil surface.

Recreational Uses:
This site provides hunting opportunities for upland game species. The wide varieties of plants which bloom from spring until fall have an esthetic value that appeals to visitors.

Wood Products:
No appreciable wood products are present on the site.

Other Products:
none noted

Other Information:

Supporting Information

Associated Sites:

Site Name	Site ID	Site Narrative
Clayey (Cy) 10-14" East Precipitation Zone	R032XY304WY	
Lowland (LL) 10-14" East Precipitation Zone	R032XY328WY	
Sandy (Sy) 10-14" East Precipitation Zone	R032XY350WY	
Shallow Loamy (SwLy) 10-14" East Precipitation Zone	R032XY362WY	

Similar Sites:

Site Name	Site ID	Site Narrative
Loamy (Ly) 5-9” Big Horn Basin Precipitation Zone	R032XY122WY	
Loamy (Ly) 5-9” Wind River Basin Precipitation Zone	R032XY222WY	

State Correlation:

This site has been correlated with the following states:
WY

Inventory Data References:
Information presented here has been derived from NRCS inventory data. Field observations from range trained personnel were also used. Those involved in developing this site include: Chris Krassin, Range Management Specialist, NRCS and Everet Bainter, Range Management Specialist. Other sources used as references include USDA NRCS Water and Climate Center, USDA NRCS National Range and Pasture Handbook, USDI and USDA Interpreting Indicators of Rangeland Health Version 3, and USDA NRCS Soil Surveys from various counties.

Type Locality:

Relationship to Other Established Classifications:

Other References:

Site Description Approval:

Author	Date	Approval	Date
D. Tranas	10/31/2002	E. Bainter	5/23/2008

Reference Sheet

Author(s)/participant(s): Ray Gullion, E. Bainter

Contact for lead author: ray.gullion@wy.usda.gov or 307-347-2456

Date: 5/1/2008 **MLRA:** 032X **Ecological Site:** Loamy (Ly) 10-14" East Precipitation Zone R032XY322WY This *must* be verified based on soils and climate (see Ecological Site Description). Current plant community cannot be used to identify the ecological site.

Composition (indicators 10 and 12) based on: X Annual Production, Foliar Cover, Biomass

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Indicators. For each indicator, describe the potential for the site. Where possible, (1) use numbers, (2) include expected range of values for above- and below-average years for **each** community and natural disturbance regimes within the reference state, when appropriate and (3) cite data. Continue descriptions on separate sheet.

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1. **Number and extent of rills:** Rare to nonexistent. Where present, short and widely spaced.

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2. **Presence of water flow patterns:** Barely observable.

3. **Number and height of erosional pedestals or terracettes:** Rare to nonexistent.

4. **Bare ground from Ecological Site Description or other studies (rock, litter, standing dead, lichen, moss, plant canopy are not bare ground):** Bare ground can range from 10-30%.

5. **Number of gullies and erosion associated with gullies:** Active gullies should not be present.

6. **Extent of wind scoured, blowouts and/or depositional areas:** Rare to nonexistent.

7. **Amount of litter movement (describe size and distance expected to travel):** Herbaceous litter expected to move only in small amounts (to leeward side of shrubs). Large woody debris from sagebrush will show no movement.

8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil Stability Index ratings range from 1 (interspaces) to 6 (under plant canopy), but average values should be 3.0 or greater.

9. **Soil surface structure and SOM content (include type and strength of structure, and A-horizon color and thickness):** Soil data is limited for this site. Described A-horizons vary from 1-12 inches (3-30 cm) with OM of 1 to 2%.

10. **Effect on plant community composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Plant community consists of 55-75% grasses, 15% forbs, and 10-30% shrubs. Evenly distributed plant canopy (50-75%) and litter plus moderate to moderately rapid infiltration rates result in minimal runoff. Basal cover is typically less than 5% for this site and does very little to effect runoff on this site.

11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None

12. **Functional/Structural Groups (list in order of descending dominance by above-ground weight using symbols: >>, >, = to indicate much greater than, greater than, and equal to) with dominants and sub-dominants and "others" on separate lines:**
Dominant: Mid-size, cool season bunchgrasses>> perennial shrubs=cool season rhizomatous grasses>>perennial forbs>short cool season bunchgrasses
Sub-dominant:
Other:
Additional:

13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Minimal decadence, typically associated with shrub component.

14. **Average percent litter cover (30 - 70%) and depth (.1 - .4 inches):** Litter ranges from 5-30% of total canopy measurement with total litter (including beneath the plant canopy) from 30-70% expected. Herbaceous litter depth typically ranges from 3-10mm. Woody litter can be up to a couple inches (4-6 cm).

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15. **Expected annual production (this is TOTAL above-ground production, not just forage production:** English: 500-1100 lb/ac (800 lb/ac average); Metric 560-1232 kg/ha (896 kg/ha average).

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16. **Potential invasive (including noxious) species (native and non-native). List Species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicator, we are describing what in NOT expected in the reference state for the ecological site:** Bare ground greater than 50% is the most common indicator of a threshold being crossed. Blue grama, Sandberg bluegrass, big sagebrush, buckwheat, and phlox are common increasers. Annual weeds such as kochia, mustards, lambsquarter, and Russian thistle are common invasive species in disturbed sites.

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17. **Perennial plant reproductive capability:** All species are capable of reproducing, except in drought years.

Reference Sheet Approval:

Approval	Date
E. Bainter	5/1/2008

United States Department of Agriculture
NRCS Natural Resources Conservation Service

Ecological Site Description

UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

ECOLOGICAL SITE DESCRIPTION

ECOLOGICAL SITE CHARACTERISTICS

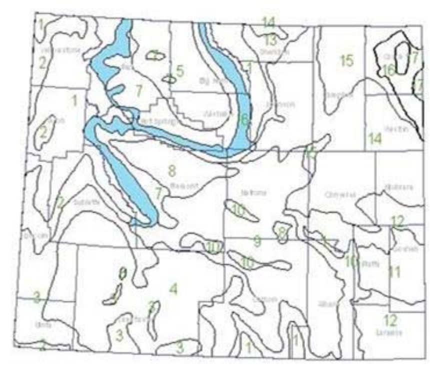
Site Type: Rangeland

Site Name: Loamy (Ly) 15-19” Foothills and Mountains East Precipitation Zone

Site ID: R043BY322WY

Major Land Resource Area: 043B - Central Rocky Mountains

Precipitation Zones for Rangeland Ecological Site Descriptions



Physiographic Features

This site typically occurs on gently undulating rolling land, but can occur on steeper gradual slopes.

Land Form:
(1) Hill
(2) Alluvial fan
(3) Ridge

	Minimum	Maximum
Elevation (feet):	6000	9000
Slope (percent):	0	30
Water Table Depth (inches):		
Flooding:		
Frequency:	None	None
Duration:	None	None
Ponding:		

Depth (inches):	0	0
Frequency:	None	None
Duration:	None	None
Runoff Class:	Negligible	High
Aspect:	No Influence on this site	

Climatic Features

Annual precipitation ranges from 15-19 inches per year. June is generally the wettest month. July, August, and September are somewhat less with daily amounts rarely exceeding one inch.

Snowfall is quite heavy in the area. Annual snowfall averages about 150 inches.

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

Growth of native cool-season plants begins about May 1 to May 15 and continues to about October 10.

The following information is from the “Crandall Creek” climate station, at the lower end of this precipitation zone:
Minimum Maximum 5 yrs. out of 10 between
Frost-free period (days): 16 80 July 8 – August 20
Freeze-free period (days): 37 120 June 17 – September 5
Mean Annual Precipitation (inches): 10.24 21.23

Mean annual precipitation: 14.90 inches
Mean annual air temperature: 38.16 F (21.88 F Avg. Min. to 54.66 F Avg. Max.)
For detailed information, visit the Natural Resources Conservation Service National Water and Climate Center at http://www.wcc.nrcs.usda.gov/ website. There are no other climate station(s) known to be representative of this precipitation zone.

	Minimum	Maximum
Frost-free period (days):	16	80
Freeze-free period (days):	37	120
Mean annual precipitation (inches):	15.0	19.0

Monthly precipitation (inches) and temperature (°F):

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precip. Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Precip. Max.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Temp. Min.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Temp. Max.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Climate Stations:

Influencing Water Features

Stream type: None

Wetland Description:	System	Subsystem	Class

Representative Soil Features

The soils of this site are deep to moderately deep (greater than 20" to bedrock), moderately well to well-drained & moderately slow to moderately permeable. The surface soil will vary from 3" to 6" in thickness depending on the texture and permeability of the subsoil. The soil characteristic having the most influence on the plant community is the available moisture and depth to a root restrictive barrier.

Predominant Parent Materials:
Kind: Alluvium
Origin: Sandstone and shale

Surface Texture: (1) Loam
(2) Silt loam
(3) Very fine sandy loam

Subsurface Texture Group: Loamy

	Minimum	Maximum
Surface Fragments <=3" (% Cover):	0	0
Surface Fragments > 3" (% Cover):	0	10
Subsurface Fragments <=3" (% Volume):	0	15
Subsurface Fragments > 3" (% Volume):	0	10

Drainage Class: Moderately well drained To Well drained
Permeability Class: Moderately slow To Moderate

	Minimum	Maximum
Depth (inches):	20	60
Electrical Conductivity (mmhos/cm):	0	4
Sodium Absorption Ratio:	0	5
Calcium Carbonate Equivalent (percent):	0	10
Soil Reaction (1:1 Water):	6.6	8.4
Soil Reaction (0.01M CaCl2):		
Available Water Capacity (inches):	3.0	6.3

Plant Communities

Ecological Dynamics of the Site

Ecological Dynamics of the Site:

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.

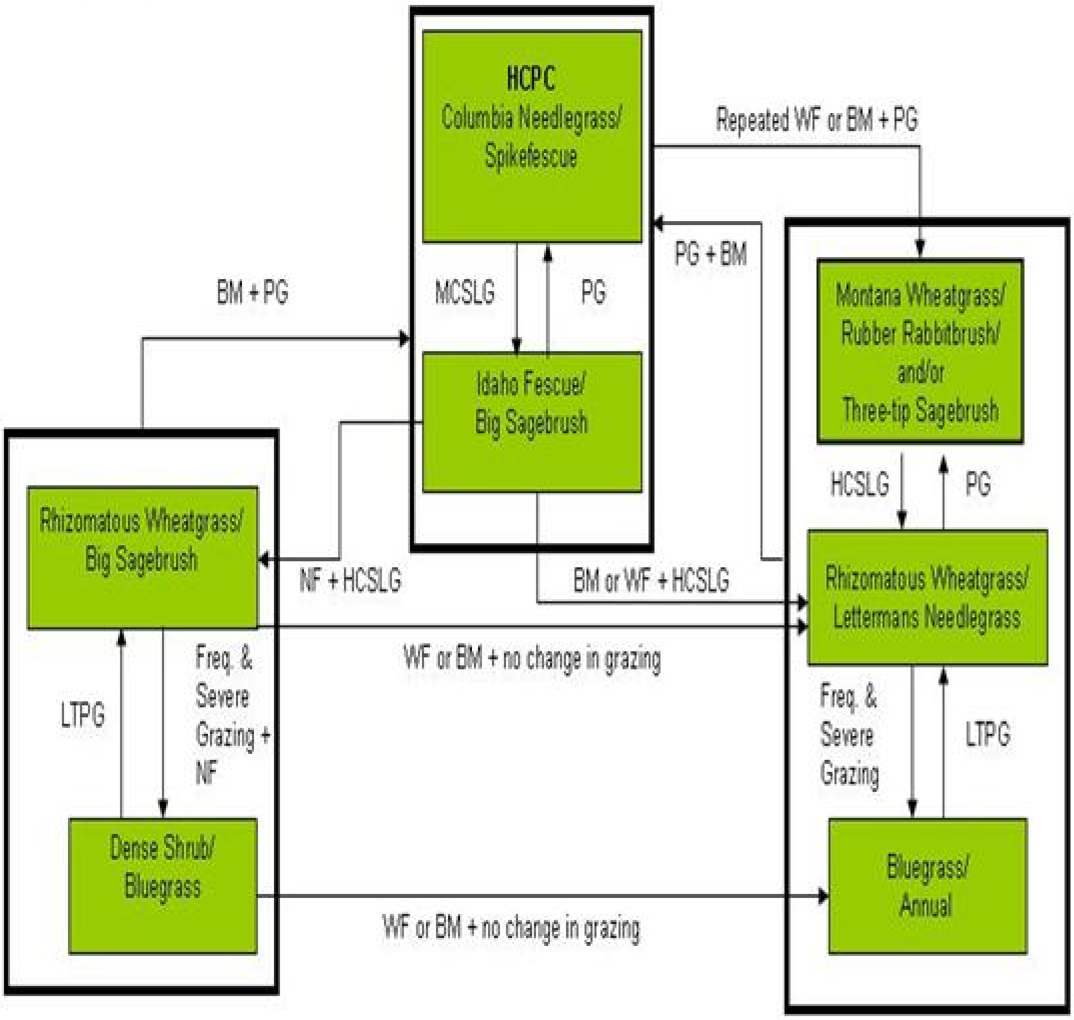
The big sagebrush component may not be as resilient once it has been removed or severely reduced, if a vigorous stand of grass exists and is maintained. The exception to this is where the herbaceous component is severely degraded at the time of treatment, growing conditions are unfavorable after treatment, 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 Historic Climax Plant Community (description follows the plant community diagram) has been determined by study of rangeland relic areas, or areas protected from excessive disturbance. Trends in plant communities going from heavily grazed areas to lightly grazed areas, seasonal use pastures, and historical accounts have also been used.

The following is a State and Transition Model Diagram that illustrates the common plant communities (states) that can occur on the site and the transitions between these communities. The ecological processes will be discussed in more detail in the plant community narratives following the diagram.

Site Type: Rangeland
MLRA: 43BY – Central Rocky Mountains

Loamy (Ly) 15"-19" East P.Z.
R043BY322WY



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

Columbia Needlegrass/Spikefescue Plant Community

The interpretive plant community for this site is the Historic Climax 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.

Columbia Needlegrass/Spikefescue Plant Community Plant Species Composition:

Grass/Grasslike

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
1				135	338
		Columbia needlegrass	*Achnatherum nelsonii*	135	338
2				135	338
		spike fescue	*Leucopoa kingii*	135	338
3				135	338
		Idaho fescue	*Festuca idahoensis*	135	338
4				68	203
		bluebunch wheatgrass	*Pseudoroegneria spicata*	68	203
5				135	338
		Grass, perennial		0	68
		Letterman's needlegrass	*Achnatherum lettermanii*	0	68
		nodding brome	*Bromus anomalus*	0	68

		Pumpelly's brome	*Bromus inermis ssp. pumpellianus var. pumpellianus*	0	68
		mountain brome	*Bromus marginatus*	0	68
		sedge	*Carex*	0	68
		California oatgrass	*Danthonia californica*	0	68
		onespike danthonia	*Danthonia unispicata*	0	68
		Montana wheatgrass	*Elymus albicans*	0	68
		slender wheatgrass	*Elymus trachycaulus*	0	68
		needle and thread	*Hesperostipa comata*	0	68
		prairie Junegrass	*Koeleria macrantha*	0	68
		western wheatgrass	*Pascopyrum smithii*	0	68
			Poa ampla (Syn)	0	68
			Poa canbyi (Syn)	0	68
		muttongrass	*Poa fendleriana*	0	68
		Sandberg bluegrass	*Poa secunda*	0	68
		spike trisetum	*Trisetum spicatum*	0	68

Forb

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
6 - null				68	203
		Forb, perennial		0	68
		yarrow	*Achillea*	0	68
		agoseris	*Agoseris*	0	68
		pussytoes	*Antennaria*	0	68
		milkvetch	*Astragalus*	0	68
		balsamroot	*Balsamorhiza*	0	68
		corn gromwell	*Buglossoides arvensis*	0	68
		Indian paintbrush	*Castilleja*	0	68
		field chickweed	*Cerastium arvense*	0	68
		tapertip hawksbeard	*Crepis acuminata*	0	68
		buckwheat	*Eriogonum*	0	68
		green gentian	*Frasera*	0	68
		common sneezeweed	*Helenium autumnale*	0	68
		flax	*Linum*	0	68
		wild bergamot	*Monarda fistulosa*	0	68
		lousewort	*Pedicularis*	0	68
		beardtongue	*Penstemon*	0	68
		phlox	*Phlox*	0	68
		silky phacelia	*Phacelia sericea*	0	68
		American vetch	*Vicia americana*	0	68
		mule-ears	*Wyethia*	0	68

Shrub/Vine

Group	Group Name	Common Name	Scientific Name	Annual Production in Pounds Per Acre Low	High
7				0	135
		big sagebrush	*Artemisia tridentata*	0	135
8				0	68
		rubber rabbitbrush	*Ericameria nauseosa*	0	68

9		0	68
	Shrub (>.5m)	0	68

Plant Growth Curve:
Growth Curve Number: WY0601
Growth Curve Name: 15-19E all upland sites
Growth Curve Description:

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	15	40	20	10	10	0	0	0

Idaho Fescue/Big Sagebrush Plant Community

Historically, this plant community evolved under grazing by large ungulates and a low fire frequency. Currently, this site is normally found under a moderate, season-long grazing regime and will be exacerbated by prolonged drought conditions. In addition, the fire regime for this site has been modified and extended periods without fire is now common. Big sagebrush is an important component of this plant community. Cool-season grasses make up the majority of the understory with the balance made up of miscellaneous forbs.

Dominant grasses include Idaho fescue and bluebunch wheatgrass and of less frequency Columbia needlegrass and spikefescue. Grasses of secondary importance include prairie junegrass, rhizomatous wheatgrasses, bluegrasses, and spike trisetum. Forbs commonly found in this plant community include agoseris, balsamroot, phlox, buckwheat, pussytoes, hawksbeard, paintbrush, and western yarrow. Sagebrush and rubber rabbitbrush make up to 20% of the total annual production.

When compared to the Historical Climax Plant Community, big sagebrush, rubber rabbitbrush, rhizomatous wheatgrasses, and bluegrasses have increased. Columbia needlegrass and spikefescue have decreased, often occurring only where protected from grazing by the sagebrush canopy. Some weedy species such as cheatgrass and annual forbs may have invaded the site but are in small patches.

This state produces between 1000 and 1500 pounds annually, depending on the growing conditions.

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.

Transitions or pathways leading to other plant communities are as follows:
• Prescribed grazing will convert this plant community to the HCPC. The probability of this occurring is high especially if rotational grazing along with short deferred grazing is implemented as part of the prescribed method of use. In addition, the removal of fire suppression will allow a somewhat natural fire regime to reoccur to more easily transition between this plant community and the HCPC. A prescribed fire treatment can be useful to hasten this transition if

desired.

• Heavy, continuous, season-long grazing plus no fires will convert the plant community to the Rhizomatous Wheatgrass/ Big Sagebrush Plant Community. The probability of this occurring is high. This is especially evident on areas where drought or heavy browsing does not adversely impact the shrub stand.

• Heavy, continuous, season-long grazing plus wildfire or brush management, will convert the plant community to a Rhizomatous Wheatgrass/Lettermans Needlegrass Plant Community. The probability for this is high, especially on areas were the shrubs have been heavily browsed or removed by natural or human causes. Drought can also exacerbate this transition.

• Repeated Wild Fire or Brush Management plus Prescribed Grazing will convert the this plant community to the Montana Wheatgrass/Rubber Rabbitbrush and/or Three-tip Sagebrush Plant Community.

Plant Growth Curve:
Growth Curve Number: WY0601
Growth Curve Name: 15-19E all upland sites
Growth Curve Description:

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	15	40	20	10	10	0	0	0

Rhizomatous Wheatgrass/Big Sagebrush Plant Community

This plant community currently is found under heavy continuous season-long grazing by livestock and protection from fire. Big sagebrush is a significant component of this plant community although rubber rabbitbrush may be as abundant. Cool-season grasses make up the majority of the understory, but some of the preferred grasses have been reduced or are absent.

Dominant grasses include rhizomatous wheatgrasses, Lettermans needlegrass, bluegrasses, and of less frequency Columbia needlegrass, spikefescue, Idaho fescue and bluebunch wheatgrass. Grasses of secondary importance include prairie junegrass, slender wheatgrass, spike trisetum and native bromes. Forbs commonly found in this plant community include balsamroot, hawksbeard, paintbrush, groundsel, buckwheat, phlox, lupine, larkspur, sneezeweed, pussytoes, and American vetch. Big Sagebrush and rubber rabbitbrush can make up to 30% of the total annual production.

When compared to the Historic Climax Plant Community, big sagebrush, rubber rabbitbrush, bluegrasses, Lettermans needlegrass, and rhizomatous wheatgrasses have increased. Most of the preferred grasses have been reduced and some are absent. Some annuals, such as cheatgrass, as well as noxious weeds such as leafy spurge have invaded the site, but are not yet abundant.

Annual production ranges from 800 to 1300 pounds.

This plant community is resistant to change as the shrubs become more abundant. These areas may actually be more resistant to fire as less fine fuels are available and the bare ground between the shrubs is increased. The herbaceous component is not as diverse and plant vigor and species regeneration capabilities of some cool-season perennials are deficient. The removal of grazing does not seem to affect the plant composition or structure of the plant community.

Soil erosion is accelerated because of increased bare ground. Water flow patterns and pedestalling is more noticeable. Infiltration is reduced and runoff is increased. Rill channels may be noticeable in the interspaces on steeper areas and gullies may be establishing where rills have concentrated down slope.

Transitions or pathways leading to other plant communities are as follows:
• Prescribed grazing plus brush management will convert this plant community to near HCPC. If prescribed fire is used as a means to reduce or remove the shrubs, sufficient fine fuels will need to be present. This may require deferment from grazing prior to treatment. Post management is critical to ensure success. This can range from two or more years of rest to partial growing season deferment, depending on the condition of the understory at the time of treatment and the growing conditions following treatment. Seeding will be required regardless of the brush treatment to reestablish the major cool-season grasses.

• Frequent and severe grazing plus no fires will convert the plant community to the Dense Shrub/Bluegrass Plant Community. The probability of this occurring is high and is especially evident on areas where drought or heavy browsing does not adversely impact the shrub stand.

• Brush management or Wildfire with no change in grazing management will convert this plant community to the Rhizomatous Wheatgrass/Lettermans Needlegrass Plant Community.

Plant Growth Curve:
Growth Curve Number: WY0601
Growth Curve Name: 15-19E all upland sites
Growth Curve Description:

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	15	40	20	10	10	0	0	0

Dense Shrub/Bluegrass Plant Community

This plant community is the result of frequent and severe grazing and protection from fire. Big sagebrush and rubber rabbitbrush are the dominant shrubs of this plant community as the annual production will exceed 30%. Preferred cool season grasses have been eliminated or greatly reduced. The interspaces between plants have expanded leaving the amount of bare ground more prevalent and more soil surface exposed to erosive elements.

Bluegrasses such as Sandberg, mutton, big, and Canby dominate the understory. Weedy annual species such as cheatgrass, kochia, Russian thistle, and a variety of mustards may occupy the site. Noxious weeds such as Canada thistle and leafy spurge may invade the site if a seed source is available. When compared with the HCPC the annual production is less, as the major cool-season grasses are reduced, but the shrub production has increased significantly and compensates for some of the decline in the herbaceous production.

Annual production ranges from 700 to 1000 pounds.

This plant community is resistant to change as the stand becomes more decadent. These areas may actually be more resistant to fire as less fine fuels are available and the bare ground between the shrubs is increased. The herbaceous component is not as diverse and plant vigor and species regeneration capabilities of cool-season perennials are deficient. The removal of grazing does not seem to affect the plant composition or structure of the plant community.

Soil erosion is accelerated because of increased bare ground. Water flow patterns and pedestalling are obvious. Infiltration is reduced and runoff is increased. Rill channels may be noticeable in the interspaces and gullies may be establishing where rills have concentrated down slope.

Transitions or pathways leading to other plant communities are as follows:
• Prescribed grazing plus brush management will convert this plant community to near HCPC. If prescribed fire is used as a means to reduce or remove the shrubs, sufficient fine fuels will need to be present. This may require deferment from grazing prior to treatment. Post management is critical to ensure success. This can range from two or more years of rest to partial growing season deferment, depending on the condition of the understory at the time of treatment and the growing conditions following treatment. Seeding will be required regardless of the brush treatment to reestablish the major cool-season grasses.

• Long-term prescribed grazing will convert this plant community to the Rhizomatous Wheatgrass/Big Sagebrush Plant Community.

• Brush management or Wildfire with no change in grazing management will convert this plant community to the Bluegrass/Annual Plant Community.

Plant Growth Curve:
Growth Curve Number: WY0601
Growth Curve Name: 15-19E all upland sites
Growth Curve Description:

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	15	40	20	10	10	0	0	0

Montana Wheatgrass/Rubber Rabbitbrush and/or Three-tip Sagebrush Plant Community

This plant community currently is found under prescribed grazing or possibly no use by livestock and is perpetuated by a fire cycle that maintains the removal of big sagebrush. Rubber rabbitbrush and three-tip sagebrush are significant components of this plant community. Cool-season grasses remain an important component, but some bunchgrasses are not as abundant.

Dominant grasses include Montana wheatgrass, Lettermans needlegrass, and rhizomatous wheatgrasses, and of less frequency Columbia needlegrass, Idaho fescue, bluebunch wheatgrass, and spikefescue. Grasses of secondary importance include prairie junegrass, slender wheatgrass, spike trisetum, and bluegrasses. Forbs commonly found in this plant community include balsamroot, paintbrush, phlox, groundsel, penstemon, larkspur, lupine, pussytoes, hawksbeard, and American vetch. Rubber rabbitbrush and/or three-tip sagebrush can comprise as much as 25% of the total production.

When compared to the Historical Climax Plant Community, Montana wheatgrass, rhizomatous wheatgrasses, three-tip sagebrush and rubber rabbitbrush have increased. Columbia needlegrass, bluebunch wheatgrass, spikefescue, and Idaho fescue have decreased. Production of cool-season grasses has remained about the same. Cheatgrass can be common and in large patches, but mostly invaded areas are relatively small.

Annual production ranges from 1000 to 1500 pounds.

This plant community is resistant to change as once three-tip sagebrush and rubber rabbitbrush become the dominant shrubs it is difficult for other shrubs to become established. 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.

Transitions or pathways leading to other plant communities are as follows:
• Prescribed grazing and brush management will convert this plant community to the HCPC. Controlling three-tip sagebrush and rubber rabbitbrush is difficult as both are strong resprouters. Reestablishing the big sagebrush stand may be difficult and may take many years.

• Heavy, continuous, season-long grazing will convert this plant community to a Rhizomatous Wheatgrass/Lettermans Needlegrass Plant Community. More than likely, three-tip sage and rubber rabbitbrush will persist in varying degrees, as both are strong resprouters and difficult to control.

Plant Growth Curve:
Growth Curve Number: WY0601
Growth Curve Name: 15-19E all upland sites
Growth Curve Description:

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	15	40	20	10	10	0	0	0

Rhizomatous Wheatgrass/Lettermans Needlegrass Plant Community

This plant community currently is found under heavy continuous season-long grazing by livestock and is perpetuated by either brush management or a wildfire, which removes big sagebrush from this plant community. Three-tip sagebrush and/or rubber rabbitbrush can be significant components of this plant community, but also may be lacking. Some of the major cool-season bunchgrasses have been reduced and some may have been removed.

Dominant grasses include rhizomatous wheatgrasses, Lettermans needlegrass, bluegrasses, prairie junegrass, spike trisetum, and Montana wheatgrass, and of less frequency Columbia needlegrass, Idaho fescue, bluebunch wheatgrass, and spikefescue. Forbs commonly found in this plant community include phlox, groundsel, balsamroot, paintbrush, larkspur, lupine, pussytoes, hawksbeard, and American vetch. Three-tip sagebrush and/or rubber rabbitbrush can comprise as much as 25% of the total production.

When compared to the Historical Climax Plant Community, rhizomatous wheatgrass, prairie junegrass, Montana wheatgrass, three-tip sagebrush and rubber rabbitbrush have increased. Columbia needlegrass, bluebunch wheatgrass, Idaho fescue, and big sagebrush have decreased or been removed. Production of the preferred cool-season grasses has been reduced. Cheatgrass can be common and in large patches, but mostly invaded areas are relatively small.

Annual production ranges from 700 to 1000 pounds.

This plant community is resistant to change as the herbaceous species present are well adapted to grazing and if three-tip and rubber rabbitbrush become the dominant shrubs it is difficult for other shrubs to become established. However, species composition can be altered through long-term overgrazing. The herbaceous component is mostly intact, but some cool-season bunchgrasses associated with the site have been reduced or removed. Plant vigor and replacement capabilities are sufficient for some species but not all. Water flow patterns and litter movement is occurring but only on steeper slopes. Incidence of pedestalling is moderate to slight. Soils are mostly stable and the surface shows minimum soil loss. The watershed is functioning and the biotic community is partially intact.

Transitions or pathways leading to other plant communities are as follows:
• Prescribed grazing plus brush management will convert this plant community to near HCPC. Controlling three-tip sagebrush and rubber rabbitbrush, if present, is difficult as these are strong resprouters. Reestablishing big sagebrush may be difficult and may take many years. Seeding may be required to reestablish any of the lost major bunchgrasses.

• Prescribed grazing will convert this plant community to the Montana Wheatgrass/Rubber Rabbitbrush and/or Three-tip Sagebrush Plant Community.

• Frequent and severe grazing will convert this plant community to a Bluegrass/Annual Plant Community. If three-tip sage and rubber rabbitbrush are present more than likely, they will persist in varying degrees as both are difficult to control.

Plant Growth Curve:
Growth Curve Number: WY0601
Growth Curve Name: 15-19E all upland sites
Growth Curve Description:

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	15	40	20	10	10	0	0	0

Bluegrass/Annual Plant Community

This plant community evolved under frequent and severe heavy grazing and the big sagebrush shrub component has been removed by heavy browsing, wildfire or human means. Weedy annuals and bluegrasses are the most dominant plants and occupy any open bare ground area. Three-tip sagebrush and rubber rabbitbrush may or may not be present. However, it is common for these shrubs to occur as both are strong resprouters and may quickly re-establish the site after a disturbance.

Compared to the HCPC, weedy annual species and bluegrasses are widespread and virtually all of the major cool-season mid-grasses are absent or severely decreased. Big sagebrush has also been removed. Weedy annuals may include cheatgrass, kochia, Russian thistle, and a variety of mustards. Bluegrass species will include Sandberg, mutton, Canby, and big. Noxious weeds such as Canada thistle and leafy spurge may invade the site if a seed source is available. The interspaces between plants have expanded leaving the amount of bare ground more prevalent and more soil surface exposed to erosive elements.

Annual production ranges from 350 to 650 pounds.

This plant community is relatively stable and resistant to overgrazing. Annuals and bluegrasses are effectively competing against the establishment of perennial cool-season grasses. Plant diversity is greatly altered and the herbaceous component is not intact. Recruitment of the major perennial grasses is not occurring and the replacement potential is absent. The biotic integrity is missing.

The soils are unstable and not protected from excessive erosion. Rill channels and maybe even gullies may be present on site and adjacent areas are impacted by excessive runoff. Water flow patterns and pedestalling are obvious. The watershed is not functioning.

Transitions or pathways leading to other plant communities are as follows:
• Prescribed grazing plus brush management may convert this plant community to near HCPC, although it will require major investment and time. Controlling three-tip sagebrush and rubber rabbitbrush, if present, is difficult as both are strong resprouters. Reestablishing the big sagebrush stand may be difficult and may take many years. Seeding will be required to reestablish any of the lost major bunchgrasses.

• Prescribed grazing will convert this plant community to the Rhizomatous Wheatgrass/Lettermans Needlegrass Plant Community.

Plant Growth Curve:
Growth Curve Number: WY0601
Growth Curve Name: 15-19E all upland sites
Growth Curve Description:

Percent Production by Month

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	5	15	40	20	10	10	0	0	0

Ecological Site Interpretations

Animal Community:
Animal Community – Wildlife Interpretations
Columbia Needlegrass/Spikefescue Plant Community (HCPC): The predominance of grasses in this plant community favors grazers and mixed-feeders, such as deer, bison, elk, and antelope. Suitable thermal and escape cover for deer may be limited due to the low quantities of woody plants. However, topographical variations could provide some escape cover. Due to the location of these sites on the foot slopes of mountains they are valuable for elk and deer winter ranges.

When found adjacent to sagebrush dominated states, this plant community may provide brood rearing/foraging areas for sage grouse, as well as lek sites. Other birds that would frequent this plant community include western meadowlark, lark bunting, sage thrasher, horned larks, red-tail and ferruginous hawks, and golden eagles. Many grassland obligate small mammals would occur here.

Idaho Fescue/Big Sagebrush Plant Community: The combination of an overstory of big sagebrush and an understory of grasses and forbs provides a very diverse plant community for wildlife. The crowns of sagebrush tend to break up hard crusted snow on winter ranges, so mule deer, elk, and antelope may use this state for foraging and cover year-round, as would cottontail and jack rabbits. It provides important winter, nesting, brood-rearing, and foraging habitat for sage grouse. Brewer's sparrows' nest in big sagebrush plants and hosts of other nesting birds utilize stands in the 20-30% cover range. Other birds that would frequent this plant community include western meadowlark, lark bunting, sage thrasher, horned larks, red-tail and ferruginous hawks, and golden eagles.

Rhizomatous Wheatgrass/Big Sagebrush Plant Community: The combination of an overstory of big sagebrush and an understory of grasses and forbs provides a very diverse plant community for wildlife. The crowns of sagebrush tend to break up hard crusted snow on winter ranges, so mule deer, elk, and antelope may use this state for foraging and cover year-round, as would cottontail and jack rabbits. It provides important winter, nesting, brood-rearing, and foraging habitat for sage grouse. Brewer's sparrows' nest in big sagebrush plants and hosts of other nesting birds utilize stands in the 20-30% cover range. Other birds that would frequent this plant community include western meadowlark, lark bunting, sage thrasher, horned larks, red-tail and ferruginous hawks, and golden eagles.

Dense Shrub/Bluegrass Plant Community: This plant community can provide important winter foraging for elk, mule deer and antelope, as sagebrush can approach 15% protein and 40-60% digestibility during that time. This community provides escape and thermal cover for large ungulates, as well as nesting and brood rearing habitat for sage grouse. Other birds that would frequent this plant community include western meadowlark, lark bunting, sage thrasher, horned larks, red-tail and ferruginous hawks, and golden eagles.
Due to the lack of herbaceous production and diversity of mid cool season grasses on this site, it is not as beneficial to grazers.

Montana Wheatgrass/Rubber Rabbitbrush and/or Three-tip Sagebrush Plant Community: The production of herbaceous species provided for good foraging to grazers. However, the lack of tall or mid growing shrubs does not benefit browsers nor provides cover for many wildlife species. As these site greens-up sooner in the spring, this site tends to provide early new growth for foraging large and small mammals. If located adjacent to shrub dominated sites, It provides good foraging habitat for sage grouse. Other birds that would frequent this plant community include western meadowlark, lark bunting, sage thrasher, horned larks, red-tail and ferruginous hawks, and golden eagles.

Rhizomatous Wheatgrass/Lettermans Needlegrass Plant Community: The production of herbaceous species provided for good foraging for grazers. However, the lack of tall or mid growing shrubs does not benefit browsers nor provides cover for many wildlife species. As these site greens-up sooner in the spring, this site tends to provide early new growth for foraging large and small mammals. If located adjacent to shrub dominated sites, It provides good foraging habitat for sage grouse.

Bluegrass/Annual Plant Community: This community provides limited foraging for elk and other grazers. They may be used as a foraging site by sage grouse if proximal to woody cover. Generally, these are not target plant communities for wildlife habitat management.

Animal Community – Grazing Interpretations

The following table lists suggested stocking rates for cattle under continuous season-long grazing under normal growing conditions. These are conservative estimates that should be used only as guidelines in the initial stages of the conservation planning process. Often, the current plant composition does not entirely match any particular plant community (as described in this ecological site description). Because of this, a field visit is recommended, in all cases, to document plant composition and production. More precise carrying capacity estimates should eventually be calculated using this information along with animal preference data, particularly when grazers other than cattle are involved. Under more intensive grazing management, improved harvest efficiencies can result in an increased carrying capacity. If distribution problems occur, stocking rates must be reduced to maintain plant health and vigor.

Plant Community Production Carrying Capacity*
(lb./ac) (AUM/ac)
Columbia Needlegrass/Spikefescue 1100-1600 .6
Idaho Fescue/Big Sagebrush 1000-1500 .5
Rhizomatous WG/Big Sagebrush 800-1300 .4
Dense Shrub/Bluegrass 700-1000 .3
Montana WG/R. Rabbitbrush/Three-tip Sagebrush 1000-1500 .5
Rhizomatous WG/Lettermans Needlegrass 700-1000 .3
Bluegrass/Annual 350-650 .2

* - Continuous, season-long grazing by cattle under average growing conditions.

Grazing by domestic livestock is one of the major income-producing industries in the area. Rangeland in this area may provide seasonal forage for cattle, sheep, or horses. During the dormant period, the forage for livestock use needs to be supplemented with protein because the quality does not meet minimum livestock requirements.

Plant Preference by Animal Kind:

Animal Kind: ALL Antelope

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	*Achnatherum lettermanii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
western yarrow	*Achillea millefolium var. occidentalis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Columbia needlegrass	*Achnatherum nelsonii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
boxelder	*Acer negundo var. interius*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale agoseris	*Agoseris glauca*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Saskatoon serviceberry	*Amelanchier alnifolia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pussytoes	*Antennaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	*Artemisia cana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

sandwort	*Arenaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	*Arnica*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	*Artemisia nova*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
big sagebrush	*Artemisia tridentata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threetip sagebrush	*Artemisia tripartita*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water birch	*Betula occidentalis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bog birch	*Betula pumila*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	*Bromus anomalus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Pumpelly's brome	*Bromus inermis ssp. pumpellianus var. pumpellianus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain brome	*Bromus marginatus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water sedge	*Carex aquatilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Macoun's reedgrass	*Calamagrostis canadensis var. macouniana*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Nebraska sedge	*Carex nebrascensis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slough sedge	*Carex obnupta*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dunhead sedge	*Carex phaeocephala*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
sedge	*Carex*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	*Calamagrostis stricta ssp. inexpansa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
field chickweed	*Cerastium arvense*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	*Cercocarpus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
snowbrush ceanothus	*Ceanothus velutinus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
rabbitbrush	*Chrysothamnus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
water hemlock	*Cicuta*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	*Cornus sericea*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
California oatgrass	*Danthonia californica*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Dasiphora floribunda (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber oatgrass	*Danthonia intermedia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
onespike danthonia	*Danthonia unispicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Deschampsia caespitosa (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	*Elymus albicans*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
squirreltail	*Elymus elymoides ssp. elymoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	*Elymus trachycaulus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fleabane	*Erigeron*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	*Eucephalus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	*Festuca idahoensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
woodland strawberry	*Fragaria vesca*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Glyceria elata (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
needle and thread	*Hesperostipa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
meadow barley	*Hordeum brachyantherum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	*Hydrophyllum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
iris	*Iris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Juncus balticus (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
alpine laurel	*Kalmia microphylla*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
prairie Junegrass	*Koeleria macrantha*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
spike fescue	*Leucopoa kingii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
lupine	*Lupinus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	*Muhlenbergia montana*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mat muhly	*Muhlenbergia richardsonis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	*Oligoneuron*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

western wheatgrass	*Pascopyrum smithii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	*Phleum alpinum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
phlox	*Phlox*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	*Pinus flexilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	*Pinus ponderosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
American bistort	*Polygonum bistortoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Poa canbyi (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
muttongrass	*Poa fendleriana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Sandberg bluegrass	*Poa secunda*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	*Prunus virginiana var. virginiana*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
bluebunch wheatgrass	*Pseudoroegneria spicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
antelope bitterbrush	*Purshia tridentata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
dock	*Rumex*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	*Salix*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
stonecrop	*Sedum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	*Symphoricarpos occidentalis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spike trisetum	*Trisetum spicatum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mule-ears	*Wyethia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: ALL Bighorn Sheep

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	*Achnatherum lettermanii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Columbia needlegrass	*Achnatherum nelsonii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
boxelder	*Acer negundo var. interius*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale agoseris	*Agoseris glauca*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Saskatoon serviceberry	*Amelanchier alnifolia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	*Antennaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	*Artemisia cana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sandwort	*Arenaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	*Arnica*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	*Artemisia nova*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
big sagebrush	*Artemisia tridentata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threetip sagebrush	*Artemisia tripartita*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water birch	*Betula occidentalis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bog birch	*Betula pumila*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	*Bromus anomalus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Pumpelly's brome	*Bromus inermis ssp. pumpellianus var. pumpellianus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain brome	*Bromus marginatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	*Carex aquatilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Macoun's reedgrass	*Calamagrostis canadensis var. macouniana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Nebraska sedge	*Carex nebrascensis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slough sedge	*Carex obnupta*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dunhead sedge	*Carex phaeocephala*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
sedge	*Carex*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	*Calamagrostis stricta ssp. inexpansa*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
field chickweed	*Cerastium arvense*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	*Cercocarpus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

snowbrush ceanothus	*Ceanothus velutinus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
rabbitbrush	*Chrysothamnus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water hemlock	*Cicuta*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	*Cornus sericea*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
California oatgrass	*Danthonia californica*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Dasiphora floribunda (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber oatgrass	*Danthonia intermedia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
onespike danthonia	*Danthonia unispicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Deschampsia caespitosa (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	*Elymus albicans*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
squirreltail	*Elymus elymoides ssp. elymoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	*Elymus trachycaulus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fleabane	*Erigeron*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	*Eucephalus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	*Festuca idahoensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
woodland strawberry	*Fragaria vesca*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Glyceria elata (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
needle and thread	*Hesperostipa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
meadow barley	*Hordeum brachyantherum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	*Hydrophyllum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
iris	*Iris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Juncus balticus (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
alpine laurel	*Kalmia microphylla*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
prairie Junegrass	*Koeleria macrantha*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
spike fescue	*Leucopoa kingii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
lupine	*Lupinus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	*Muhlenbergia montana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mat muhly	*Muhlenbergia richardsonis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	*Oligoneuron*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	*Pascopyrum smithii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	*Phleum alpinum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
phlox	*Phlox*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	*Pinus flexilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	*Pinus ponderosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
American bistort	*Polygonum bistortoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Poa canbyi (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
muttongrass	*Poa fendleriana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Sandberg bluegrass	*Poa secunda*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	*Prunus virginiana var. virginiana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	*Pseudoroegneria spicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
antelope bitterbrush	*Purshia tridentata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
dock	*Rumex*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	*Salix*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	*Sedum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	*Symphoricarpos occidentalis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spike trisetum	*Trisetum spicatum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mule-ears	*Wyethia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: ALL Cattle

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	*Achnatherum lettermanii*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
western yarrow	*Achillea millefolium var. occidentalis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Columbia needlegrass	*Achnatherum nelsonii*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
boxelder	*Acer negundo var. interius*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale agoseris	*Agoseris glauca*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Saskatoon serviceberry	*Amelanchier alnifolia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	*Antennaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	*Artemisia cana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sandwort	*Arenaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	*Arnica*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	*Artemisia nova*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
big sagebrush	*Artemisia tridentata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threetip sagebrush	*Artemisia tripartita*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water birch	*Betula occidentalis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bog birch	*Betula pumila*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	*Bromus anomalus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Pumpelly's brome	*Bromus inermis ssp. pumpellianus var. pumpellianus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mountain brome	*Bromus marginatus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
water sedge	*Carex aquatilis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Macoun's reedgrass	*Calamagrostis canadensis var. macouniana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Nebraska sedge	*Carex nebrascensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
slough sedge	*Carex obnupta*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dunhead sedge	*Carex phaeocephala*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
sedge	*Carex*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	*Calamagrostis stricta ssp. inexpansa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
field chickweed	*Cerastium arvense*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	*Cercocarpus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
snowbrush ceanothus	*Ceanothus velutinus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
rabbitbrush	*Chrysothamnus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water hemlock	*Cicuta*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	*Cornus sericea*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
California oatgrass	*Danthonia californica*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Dasiphora floribunda (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber oatgrass	*Danthonia intermedia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
onespike danthonia	*Danthonia unispicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Deschampsia caespitosa (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	*Elymus albicans*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
squirreltail	*Elymus elymoides ssp. elymoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	*Elymus trachycaulus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
fleabane	*Erigeron*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	*Eucephalus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	*Festuca idahoensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
woodland strawberry	*Fragaria vesca*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

	Glyceria elata (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
needle and thread	*Hesperostipa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
meadow barley	*Hordeum brachyantherum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	*Hydrophyllum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
iris	*Iris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Juncus balticus (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine laurel	*Kalmia microphylla*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
prairie Junegrass	*Koeleria macrantha*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
spike fescue	*Leucopoa kingii*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
lupine	*Lupinus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	*Muhlenbergia montana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mat muhly	*Muhlenbergia richardsonis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	*Oligoneuron*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	*Pascopyrum smithii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	*Phleum alpinum*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	*Phlox*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	*Pinus flexilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	*Pinus ponderosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
American bistort	*Polygonum bistortoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Poa canbyi (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
muttongrass	*Poa fendleriana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Sandberg bluegrass	*Poa secunda*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	*Prunus virginiana var. virginiana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	*Pseudoroegneria spicata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
antelope bitterbrush	*Purshia tridentata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
dock	*Rumex*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	*Salix*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	*Sedum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	*Symphoricarpos occidentalis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spike trisetum	*Trisetum spicatum*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mule-ears	*Wyethia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: ALL Deer

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	*Achnatherum lettermanii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
western yarrow	*Achillea millefolium var. occidentalis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Columbia needlegrass	*Achnatherum nelsonii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
boxelder	*Acer negundo var. interius*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale agoseris	*Agoseris glauca*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Saskatoon serviceberry	*Amelanchier alnifolia*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
pussytoes	*Antennaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	*Artemisia cana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
sandwort	*Arenaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	*Arnica*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	*Artemisia nova*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
big sagebrush	*Artemisia tridentata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threetip sagebrush	*Artemisia tripartita*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water birch	*Betula occidentalis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

bog birch	*Betula pumila*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	*Bromus anomalus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Pumpelly's brome	*Bromus inermis ssp. pumpellianus var. pumpellianus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain brome	*Bromus marginatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	*Carex aquatilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Macoun's reedgrass	*Calamagrostis canadensis var. macouniana*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Nebraska sedge	*Carex nebrascensis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slough sedge	*Carex obnupta*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dunhead sedge	*Carex phaeocephala*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
sedge	*Carex*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	*Calamagrostis stricta ssp. inexpansa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
field chickweed	*Cerastium arvense*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	*Cercocarpus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
snowbrush ceanothus	*Ceanothus velutinus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
rabbitbrush	*Chrysothamnus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water hemlock	*Cicuta*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	*Cornus sericea*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
California oatgrass	*Danthonia californica*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Dasiphora floribunda (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber oatgrass	*Danthonia intermedia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
onespike danthonia	*Danthonia unispicata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Deschampsia caespitosa (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	*Elymus albicans*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
squirreltail	*Elymus elymoides ssp. elymoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	*Elymus trachycaulus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fleabane	*Erigeron*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	*Eucephalus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	*Festuca idahoensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
woodland strawberry	*Fragaria vesca*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Glyceria elata (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
needle and thread	*Hesperostipa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
meadow barley	*Hordeum brachyantherum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	*Hydrophyllum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
iris	*Iris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Juncus balticus (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
alpine laurel	*Kalmia microphylla*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
prairie Junegrass	*Koeleria macrantha*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
spike fescue	*Leucopoa kingii*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
lupine	*Lupinus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	*Muhlenbergia montana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mat muhly	*Muhlenbergia richardsonis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	*Oligoneuron*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	*Pascopyrum smithii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	*Phleum alpinum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
phlox	*Phlox*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	*Pinus flexilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	*Pinus ponderosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

American bistort	*Polygonum bistortoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Poa canbyi (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
muttongrass	*Poa fendleriana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Sandberg bluegrass	*Poa secunda*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	*Prunus virginiana var. virginiana*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
bluebunch wheatgrass	*Pseudoroegneria spicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
antelope bitterbrush	*Purshia tridentata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
dock	*Rumex*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	*Salix*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
stonecrop	*Sedum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	*Symphoricarpos occidentalis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
spike trisetum	*Trisetum spicatum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mule-ears	*Wyethia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: ALL Elk

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	*Achnatherum lettermanii*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
western yarrow	*Achillea millefolium var. occidentalis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Columbia needlegrass	*Achnatherum nelsonii*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
boxelder	*Acer negundo var. interius*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale agoseris	*Agoseris glauca*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Saskatoon serviceberry	*Amelanchier alnifolia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	*Antennaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	*Artemisia cana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sandwort	*Arenaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	*Arnica*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	*Artemisia nova*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
big sagebrush	*Artemisia tridentata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threetip sagebrush	*Artemisia tripartita*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water birch	*Betula occidentalis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bog birch	*Betula pumila*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	*Bromus anomalus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Pumpelly's brome	*Bromus inermis ssp. pumpellianus var. pumpellianus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mountain brome	*Bromus marginatus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
water sedge	*Carex aquatilis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Macoun's reedgrass	*Calamagrostis canadensis var. macouniana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Nebraska sedge	*Carex nebrascensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
slough sedge	*Carex obnupta*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dunhead sedge	*Carex phaeocephala*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
sedge	*Carex*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	*Calamagrostis stricta ssp. inexpansa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
field chickweed	*Cerastium arvense*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	*Cercocarpus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
snowbrush ceanothus	*Ceanothus velutinus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
rabbitbrush	*Chrysothamnus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water hemlock	*Cicuta*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	*Cornus sericea*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

California oatgrass	*Danthonia californica*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Dasiphora floribunda (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber oatgrass	*Danthonia intermedia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
onespike danthonia	*Danthonia unispicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Deschampsia caespitosa (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	*Elymus albicans*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
squirreltail	*Elymus elymoides ssp. elymoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	*Elymus trachycaulus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
fleabane	*Erigeron*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	*Eucephalus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	*Festuca idahoensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
woodland strawberry	*Fragaria vesca*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Glyceria elata (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
needle and thread	*Hesperostipa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
meadow barley	*Hordeum brachyantherum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	*Hydrophyllum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
iris	*Iris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Juncus balticus (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine laurel	*Kalmia microphylla*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
prairie Junegrass	*Koeleria macrantha*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
spike fescue	*Leucopoa kingii*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
lupine	*Lupinus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	*Muhlenbergia montana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mat muhly	*Muhlenbergia richardsonis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	*Oligoneuron*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	*Pascopyrum smithii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	*Phleum alpinum*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	*Phlox*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	*Pinus flexilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	*Pinus ponderosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
American bistort	*Polygonum bistortoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Poa canbyi (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
muttongrass	*Poa fendleriana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Sandberg bluegrass	*Poa secunda*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	*Prunus virginiana var. virginiana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	*Pseudoroegneria spicata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
antelope bitterbrush	*Purshia tridentata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
dock	*Rumex*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	*Salix*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	*Sedum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	*Symphoricarpos occidentalis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spike trisetum	*Trisetum spicatum*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mule-ears	*Wyethia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: ALL Horses

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	*Achnatherum lettermanii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

western yarrow	Achillea millefolium var. occidentalis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Columbia needlegrass	Achnatherum nelsonii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
boxelder	Acer negundo var. interius	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale agoseris	Agoseris glauca	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Saskatoon serviceberry	Amelanchier alnifolia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pussytoes	Antennaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	Artemisia cana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sandwort	Arenaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	Arnica	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	Artemisia nova	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
big sagebrush	Artemisia tridentata	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
threetip sagebrush	Artemisia tripartita	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water birch	Betula occidentalis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bog birch	Betula pumila	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	Bromus anomalus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Pumpelly's brome	Bromus inermis ssp. pumpellianus var. pumpellianus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain brome	Bromus marginatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	Carex aquatilis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Macoun's reedgrass	Calamagrostis canadensis var. macouniana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Nebraska sedge	Carex nebrascensis	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
slough sedge	Carex obnupta	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dunhead sedge	Carex phaeocephala	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
sedge	Carex	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	Calamagrostis stricta ssp. inexpansa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
field chickweed	Cerastium arvense	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	Cercocarpus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
snowbrush ceanothus	Ceanothus velutinus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
rabbitbrush	Chrysothamnus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water hemlock	Cicuta	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	Cornus sericea	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
California oatgrass	Danthonia californica	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Dasiphora floribunda (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber oatgrass	Danthonia intermedia	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
onespike danthonia	Danthonia unispicata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Deschampsia caespitosa (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
larkspur	Delphinium	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	Elymus albicans	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
squirreltail	Elymus elymoides ssp. elymoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	Elymus lanceolatus ssp. lanceolatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	Elymus trachycaulus	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
fleabane	Erigeron	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	Eucephalus	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	Festuca idahoensis	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
woodland strawberry	Fragaria vesca	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Glyceria elata (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
needle and thread	Hesperostipa	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
meadow barley	Hordeum brachyantherum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	Hydrophyllum	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

iris	Iris	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Juncus balticus (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine laurel	Kalmia microphylla	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
prairie Junegrass	Koeleria macrantha	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
spike fescue	Leucopoa kingii	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
lupine	Lupinus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	Muhlenbergia montana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mat muhly	Muhlenbergia richardsonis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	Oligoneuron	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	Pascopyrum smithii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	Phleum alpinum	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	Phlox	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	Pinus flexilis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	Pinus ponderosa	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
American bistort	Polygonum bistortoides	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Poa canbyi (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
muttongrass	Poa fendleriana	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Sandberg bluegrass	Poa secunda	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	Prunus virginiana var. virginiana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	Pseudoroegneria spicata	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
antelope bitterbrush	Purshia tridentata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dock	Rumex	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	Salix	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
stonecrop	Sedum	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	Symphoricarpos occidentalis	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spike trisetum	Trisetum spicatum	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mule-ears	Wyethia	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: ALL Moose

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	Achnatherum hymenoides	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	Achnatherum lettermanii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Columbia needlegrass	Achnatherum nelsonii	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
boxelder	Acer negundo var. interius	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale agoseris	Agoseris glauca	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Saskatoon serviceberry	Amelanchier alnifolia	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
pussytoes	Antennaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	Artemisia cana	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sandwort	Arenaria	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	Arnica	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	Artemisia nova	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
big sagebrush	Artemisia tridentata	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threetip sagebrush	Artemisia tripartita	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water birch	Betula occidentalis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bog birch	Betula pumila	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	Bromus anomalus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Pumpelly's brome	Bromus inermis ssp. pumpellianus var. pumpellianus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain brome	Bromus marginatus	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water sedge	Carex aquatilis	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

Macoun's reedgrass	*Calamagrostis canadensis var. macouniana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Nebraska sedge	*Carex nebrascensis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slough sedge	*Carex obnupta*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dunhead sedge	*Carex phaeocephala*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
sedge	*Carex*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	*Calamagrostis stricta ssp. inexpansa*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
field chickweed	*Cerastium arvense*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	*Cercocarpus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
snowbrush ceanothus	*Ceanothus velutinus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
rabbitbrush	*Chrysothamnus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
water hemlock	*Cicuta*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	*Cornus sericea*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
California oatgrass	*Danthonia californica*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Dasiphora floribunda (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber oatgrass	*Danthonia intermedia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
onespike danthonia	*Danthonia unispicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Deschampsia caespitosa (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	*Elymus albicans*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
squirreltail	*Elymus elymoides ssp. elymoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	*Elymus trachycaulus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fleabane	*Erigeron*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	*Eucephalus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	*Festuca idahoensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
woodland strawberry	*Fragaria vesca*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Glyceria elata (Syn)	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
needle and thread	*Hesperostipa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
meadow barley	*Hordeum brachyantherum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	*Hydrophyllum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
iris	*Iris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Juncus balticus (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
alpine laurel	*Kalmia microphylla*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
prairie Junegrass	*Koeleria macrantha*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
spike fescue	*Leucopoa kingii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
lupine	*Lupinus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	*Muhlenbergia montana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mat muhly	*Muhlenbergia richardsonis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	*Oligoneuron*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	*Pascopyrum smithii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	*Phleum alpinum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
phlox	*Phlox*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	*Pinus flexilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	*Pinus ponderosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
American bistort	*Polygonum bistortoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Poa canbyi (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
muttongrass	*Poa fendleriana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Sandberg bluegrass	*Poa secunda*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	*Prunus virginiana var. virginiana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D

bluebunch wheatgrass	*Pseudoroegneria spicata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
antelope bitterbrush	*Purshia tridentata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
dock	*Rumex*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	*Salix*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
stonecrop	*Sedum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	*Symphoricarpos occidentalis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spike trisetum	*Trisetum spicatum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mule-ears	*Wyethia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Animal Kind: ALL Sheep

Common Name	Scientific Name	Plant Part	J	F	M	A	M	J	J	A	S	O	N	D
Indian ricegrass	*Achnatherum hymenoides*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Letterman's needlegrass	*Achnatherum lettermanii*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
western yarrow	*Achillea millefolium var. occidentalis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Columbia needlegrass	*Achnatherum nelsonii*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
boxelder	*Acer negundo var. interius*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
pale agoseris	*Agoseris glauca*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Saskatoon serviceberry	*Amelanchier alnifolia*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
pussytoes	*Antennaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
silver sagebrush	*Artemisia cana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
sandwort	*Arenaria*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
arnica	*Arnica*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
black sagebrush	*Artemisia nova*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
big sagebrush	*Artemisia tridentata*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
threetip sagebrush	*Artemisia tripartita*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
water birch	*Betula occidentalis*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bog birch	*Betula pumila*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
nodding brome	*Bromus anomalus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Pumpelly's brome	*Bromus inermis ssp. pumpellianus var. pumpellianus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
mountain brome	*Bromus marginatus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
water sedge	*Carex aquatilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Macoun's reedgrass	*Calamagrostis canadensis var. macouniana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Nebraska sedge	*Carex nebrascensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
slough sedge	*Carex obnupta*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
dunhead sedge	*Carex phaeocephala*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
sedge	*Carex*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
northern reedgrass	*Calamagrostis stricta ssp. inexpansa*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
field chickweed	*Cerastium arvense*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
mountain mahogany	*Cercocarpus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
snowbrush ceanothus	*Ceanothus velutinus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
rabbitbrush	*Chrysothamnus*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
water hemlock	*Cicuta*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
redosier dogwood	*Cornus sericea*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
California oatgrass	*Danthonia californica*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Dasiphora floribunda (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
timber oatgrass	*Danthonia intermedia*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
onespike danthonia	*Danthonia unispicata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Deschampsia caespitosa (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P

larkspur	*Delphinium*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
Montana wheatgrass	*Elymus albicans*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
squirreltail	*Elymus elymoides ssp. elymoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
thickspike wheatgrass	*Elymus lanceolatus ssp. lanceolatus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
slender wheatgrass	*Elymus trachycaulus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
fleabane	*Erigeron*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
aster	*Eucephalus*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
Idaho fescue	*Festuca idahoensis*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
woodland strawberry	*Fragaria vesca*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
	Glyceria elata (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
needle and thread	*Hesperostipa*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
meadow barley	*Hordeum brachyantherum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
waterleaf	*Hydrophyllum*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
iris	*Iris*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Juncus balticus (Syn)	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
alpine laurel	*Kalmia microphylla*	Entire plant	T	T	T	T	T	T	T	T	T	T	T	T
prairie Junegrass	*Koeleria macrantha*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
spike fescue	*Leucopoa kingii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
lupine	*Lupinus*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mountain muhly	*Muhlenbergia montana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mat muhly	*Muhlenbergia richardsonis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
goldenrod	*Oligoneuron*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western wheatgrass	*Pascopyrum smithii*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
alpine timothy	*Phleum alpinum*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
phlox	*Phlox*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
limber pine	*Pinus flexilis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
ponderosa pine	*Pinus ponderosa*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
	Poa ampla (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
American bistort	*Polygonum bistortoides*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
	Poa canbyi (Syn)	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
muttongrass	*Poa fendleriana*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
Sandberg bluegrass	*Poa secunda*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
chokecherry	*Prunus virginiana var. virginiana*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
bluebunch wheatgrass	*Pseudoroegneria spicata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
antelope bitterbrush	*Purshia tridentata*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
dock	*Rumex*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
willow	*Salix*	Entire plant	P	P	P	P	P	P	P	P	P	P	P	P
stonecrop	*Sedum*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
western snowberry	*Symphoricarpos occidentalis*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U
spike trisetum	*Trisetum spicatum*	Entire plant	D	D	D	D	D	D	D	D	D	D	D	D
mule-ears	*Wyethia*	Entire plant	U	U	U	U	U	U	U	U	U	U	U	U

Legend: P = Preferred D = Desirable U = Undesirable N = Not consumed E = Emergency T = Toxic
X = Used, but degree of utilization unknown

Hydrology Functions:

Water is the principal factor limiting forage production on this site. This site is dominated by soils in hydrologic group C, with localized areas in hydrologic group B and D. Infiltration ranges from moderately slow to moderate. Runoff potential for this site varies from low to moderate depending on soil hydrologic group and ground cover. In many cases, areas with greater than 75% ground cover have the greatest potential for high infiltration and lower runoff. An example of an exception would be where short-grasses form a strong sod and dominate the site. Areas where ground cover is less than 50% have the greatest potential to have reduced infiltration and higher runoff (refer to Part 630, NRCS National Engineering Handbook for detailed hydrology information).

Rills and gullies should not typically be present. Water flow patterns should be barely distinguishable if at all present. Pedestals are only slightly present in association with bunchgrasses. Litter typically falls in place, and signs of movement are not common. Chemical and physical crusts are rare to non-existent. Cryptogamic crusts are present, but only cover 1-2% of the soil surface.

Recreational Uses:

This site provides hunting opportunities for upland game species. The wide varieties of plants that bloom from spring until fall have an esthetic value that appeals to visitors. Other recreational uses may included hiking, camping, mountain biking, and in the winter snowshoeing and cross-country skiing.

Wood Products:

No appreciable wood products are present on the site.

Other Products:

None noted.

Other Information:

Supporting Information

Associated Sites:

Site Name	Site ID	Site Narrative
Coarse Upland (CU) 15-19" Foothills and Mountains East Precipitation Zone	R043BY308WY	Coarse Upland
Overflow (Ov) 15-19" Foothills and Mountains East Precipitation Zone	R043BY330WY	Overflow
Shallow Loamy (SwLy) 15-19" Foothills and Mountains East Precipitation Zone	R043BY362WY	Shallow Loamy
Shallow Sandy (SwSy) 15-19" Foothills and Mountains East Precipitation Zone	R043BY366WY	Shallow Sandy

Similar Sites:

Site Name	Site ID	Site Narrative
Loamy (Ly) 10-14" East Precipitation Zone	R032XY322WY	Loamy 10-14" Foothills and Basins East P.Z., has lower production.

State Correlation:

This site has been correlated with the following states:

WY

Inventory Data References:

Information presented here has been derived from NRCS clipping data and other inventory data. Field observations from range trained personnel were also used. Those involved in developing this site include: Chris Krassin, Range Management Specialist, James Haverkamp, Range Management Specialist, Steven Gullion, Range Management Specialist, James Mischke, District Conservationist, and Everet Bainter, State Range Management Specialist. Other sources used as references include USDA NRCS Water and Climate Center, USDA NRCS National Range and Pasture Handbook, and USDA NRCS Soil Surveys from various counties.

Type Locality:

Relationship to Other Established Classifications:

Other References:

Site Description Approval:

Author	Date	Approval	Date
J. Haverkamp	2/22/2006	E. Bainter	5/1/2008

Reference Sheet

Author(s)/participant(s): Ray Gullion, E. Bainter

Contact for lead author: ray.gullion@wy.usda.gov 307-347-2456

Date: 5/1/2008 **MLRA:** 043B **Ecological Site:** Loamy (Ly) 15-19” Foothills and Mountains East Precipitation Zone R043BY322WY This *must* be verified based on soils and climate (see Ecological Site Description). Current plant community cannot be used to identify the ecological site.

Composition (indicators 10 and 12) based on: X Annual Production, Foliar Cover, Biomass

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Indicators. For each indicator, describe the potential for the site. Where possible, (1) use numbers, (2) include expected range of values for above- and below-average years for **each** community and natural disturbance regimes within the reference state, when appropriate and (3) cite data. Continue descriptions on separate sheet.

1. **Number and extent of rills:** Rare to nonexistent. Where present, short and widely spaced.
2. **Presence of water flow patterns:** Barely observable.
3. **Number and height of erosional pedestals or terracettes:** Rare to nonexistent.
4. **Bare ground from Ecological Site Description or other studies (rock, litter, standing dead, lichen, moss, plant canopy are not bare ground):** Bare ground can range from 0-

20%.

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5. **Number of gullies and erosion associated with gullies:** Active gullies should not be present.

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6. **Extent of wind scoured, blowouts and/or depositional areas:** Rare to nonexistent.

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7. **Amount of litter movement (describe size and distance expected to travel):** Herbaceous and large woody litter not expected to move.

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8. **Soil surface (top few mm) resistance to erosion (stability values are averages - most sites will show a range of values):** Soil Stability Index ratings range from 3 (interspaces) to 6 (under plant canopy), but average values should be 4.0 or greater.

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9. **Soil surface structure and SOM content (include type and strength of structure, and A-horizon color and thickness):** Soil data is limited for this site. Described A-horizons vary from 6-23 inches (15-58 cm) with OM of 2 to 5%.

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10. **Effect on plant community composition (relative proportion of different functional groups) and spatial distribution on infiltration and runoff:** Plant community consists of 70-80% grasses, 15% forbs, and 5-15% shrubs. Evenly distributed plant canopy (60-95%) and litter plus moderate infiltration rates result in minimal runoff. Basal cover is typically 5-15% for this site and does affect runoff on this site.

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11. **Presence and thickness of compaction layer (usually none; describe soil profile features which may be mistaken for compaction on this site):** None.

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12. **Functional/Structural Groups (list in order of descending dominance by above-ground weight using symbols: >>, >, = to indicate much greater than, greater than, and equal to) with dominants and sub-dominants and "others" on separate lines:**
    Dominant: Mid-size, cool season bunchgrasses>> perennial shrubs=perennial forbs>tall, cool season bunchgrasses>cool season rhizomatous grasses=short cool season bunchgrasses
    Sub-dominant:
    Other:
    Additional:

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13. **Amount of plant mortality and decadence (include which functional groups are expected to show mortality or decadence):** Minimal decadence, typically associated with shrub component.

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14. **Average percent litter cover (50 - 90%) and depth (.2 - .6 inches):** Litter ranges from 5-40% of total canopy measurement with total litter (including beneath the plant canopy) from 50-90% expected. Herbaceous litter depth typically ranges from 5-15mm. Woody litter can be up to a couple inches (4-6 cm).

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15. **Expected annual production (this is TOTAL above-ground production, not just forage production:** English: 1100-1600 lb/ac (1350 lb/ac average); Metric 1232-1792 kg/ha (1512 kg/ha average).

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16. **Potential invasive (including noxious) species (native and non-native). List Species which BOTH characterize degraded states and have the potential to become a dominant or co-dominant species on the ecological site if their future establishment and growth is not actively controlled by management interventions. Species that become dominant for only one to several years (e.g., short-term response to drought or wildfire) are not invasive plants. Note that unlike other indicator, we are describing what in NOT expected in the reference state for the ecological site:** Bare ground greater than 30% is the most common indicator of a threshold being crossed. Big sagebrush, rubber rabbitbrush, and bluegrasses are common increasers. Kentucky bluegrass, common dandelion, thistles, and annual weeds such as kochia and mustards are common invasive species in disturbed sites.

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17. **Perennial plant reproductive capability:** All species are capable of reproducing, except in extreme drought years.

Reference Sheet Approval:

Approval	Date
E. Bainter	5/1/2008

APPENDIX F

RESERVOIR EVALUATION MATRIX

Site #	1	2	3	4	5	6	7	8	9
Site Name	Alkali Creek	Big Trails	Bruner Gulch	Little Canyon Creek	Cottonwood Creek	County Line	Lower Brokenback	Lower Nowood	McDermott Draw
s Ranked Priority	2	1	1	3	2	3	2	3	2
Latitude	44.25874	43.705095	43.818915	43.751925	44.151512	44.159997	44.085502	44.159079	44.274293
Longitude	-107.646799	-107.330069	-107.379319	-107.288093	-107.683274	-107.630692	-107.516432	-107.667806	-107.756957
Category A: Reservoir Description									
On-Channel / Off-Channel	Off Channel	On Channel	Off Channel	On Channel	Off Channel	Off Channel	On Channel	On Channel	Off Channel
Direct Supply Source	Alkali Creek	Nowood River	Buffalo Creek	Canyon Creek	Cottonwood	Unnamed	Brokenback	Nowood River	McDermott Draw
Indirect Supply Source	Paint Rock Creek	NA	Nowood River	NA	Nowood River	NA	NA	NA	Paint Rock Creek
Supply Mechanism	Anita Ditch	Mainstem Dam	New Diversion	Tributary Dam	New Diversion	Tributary Dam	Tributary Dam	Mainstem Dam	New Diversion
Category B: Watershed									
Contributing Drainage Area -Direct (square miles)	40.84	247.19	173.4	46.19	91.91	3.34	54.94	1254.17	58.55
Contributing Drainage Area -Indirect (square miles)	285.02	NA	355.8	NA	1254.24	1245.31	NA	NA	352.27
Maximum Elevation (feet MSL)	7,228	9,053	7,071	8,127	5,437	5,011	9,334	12,395	6,320
Minimum Elevation (Feet MSL)	4,407	4,875	4,650	4,950	4,179	4,267	4,319	4,176	4,158
Basin perimeter in miles	43.39	109.65	89.67	47.94	59.91	10.65	54.89	273.18	53.9
Maximum basin relief in feet	2,821	4,178	2,421	3,177	1,258	744	5,015	8,219	2,162
Mean annual precipitation	15.5	19.2	14.3	20.5	11.3	11.3	20.0	17.9	12.6
Category C: Reservoir Statistics									
Capacity / Enlargement (acre-feet)	2,900	16,850	7,700	2,500	11,100	3,850	4,200	40,650	1,800
Surface Area (acres)	180	623	557	73	555	149	167	1,630	184
Maximum Water Depth (feet)	60	75	40	155	85	95	60	40	40
Average Water Depth (feet)	16.1	27.1	13.8	34.3	20.0	25.8	25.2	24.9	9.8
Category D: Dam Description									
Dam Statistics									
Proposed Type	Earthen	Earthen	Earthen	Earthen	Earthen	Earthen	Earthen	Earthen	Earthen
Dam Height (feet)	65	80	45	160	90	100	65	45	45
Embankment Length (feet)	2,000	765	650	1,575	1,300	1,000	1,400	3,000	1,170
Total Dam Volume (cy)	428,000	650,000	164,742	1,201,146	311,007	1,230,000	695,640	755,986	302,910
Storage Efficiency (ac-ft/1000cy fill)	6.8	25.9	46.7	2.1	35.7	3.1	6.0	53.8	5.9
Method of Reservoir Fill	Diversion via exist. irrigation	None / On channel	Diversion Structure / canal	None / On channel	Diversion Structure / canal		None / On channel	None / On channel	Diversion Structure / canal
Appurtenances	Anita Ditch Improvements		Nowood Diversion, canal with tunnel						
Size Class (<1000 small, <10,000 Int, >10,000 large	Small	Medium	Small	Medium	Small	Medium	Medium	Medium	Small
Category E: Hydrology									
Hydrology Method	Basin Plan Reach 798 Outflow	Basin Plan Node (Node 9.0700 / Reach 600)	Nowater Basin Gage Comparison	Basin Plan Reach 650 Outflow	Nowater Comparison	Nowater Comparison	Basin Plan Reach 740 Outflow	Basin Plan Node (Node 9.26 / Reach 800)	Nowater Comparison
Storage Availability									
Normal Year (ac ft) - Physically in the stream	5,608	75,629	3,607	6,588	1,912	69	8,987	214,189	1,218
Dry Year (ac ft) - Physically in the stream	1,947	42,292	3,520	2,429	1,866	68	2,738	176,148	1,189
Normal Year (Available)	5,389	9,760	3,607	6,001	1,912	69	8,024	214,189	1,218
Dry Year (Available)	1,875	5,874	3,520	2,409	1,866	68	1,970	176,148	1,189
Indirect Supply Source	Paint Rock Creek via Anita Ditch	None	Nowood River (Reach 600)	None	Nowood River (Reach 700)	None	None	None	Paint Rock Creek via Anita Ditch
Normal Year (Indirect)	90,108	NA	9,760	NA	188,298	NA	NA	NA	123,710
Dry Year (Indirect)	69,055	NA	5,874	NA	157,247	NA	NA	NA	98,947
Category F: Geology									
Dam embankment foundation	B+	D	B-	C+	B	B	D	B	C
Reservoir pool area	B	C-	B	C+	B	B	C-	B	B
Contributing watershed	B	C-	B	B	B	B	C-	C	B
Category G: Environmental Issues / Infrastructure									
Environmental Issues									
Wetlands (acres impacted) From NWI data	0	6.6	1.08	0	0.39	0	14.2	238.4	0
Game: Antelope	Seasonal Range	Seasonal Range	Seasonal Range, Crucial Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range
Game: Elk	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range
Game: Moose	Seasonal Range	None Noted	None Noted	None Noted	None Noted	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range
Game: Mule Deer	Seasonal Range	Seasonal Range, Crucial Range	Seasonal Range, Crucial Range	Seasonal Range, Crucial Range	Seasonal Range, Crucial Range	Seasonal Range	Seasonal Range, Crucial Range	Seasonal Range	Seasonal Range
Game: White Tailed Deer	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range
Sage Grouse Leks within 2 miles	0	Seasonal Range, Crucial Range	Seasonal Range, Crucial Range	0	0	1	0	0	1
Sage Grouse Core Population Area	Seasonal Range, Crucial Range	Seasonal Range, Crucial Range	Seasonal Range, Crucial Range	None of pool in core area	None of pool in core area	Pool entirely within core area	None of pool in core area	Pool almost entirely within core area	None of pool in core area
WDEQ Stream Classification	2AB	2AB	3B	2AB	3B	3B	2AB	2AB	3B
Fisheries	Paintrock Cr is brown trout fishery in this area.	Excellent brown trout fishery near Mahogany Butte.	No known fisheries concerns.	Important fishery, brook, brown, rainbow, longnose sucker, LN Dace.	No known fisheries concerns.	No known fisheries concerns.	No known fisheries; unsuitable for year round fishery	Fisheries concerns, block migation of native fish such as sauger.	No known fisheries concerns.
Irrigated Acreage Inundated	20	265	0	4.3	0	0	0	541.4	0
Infrastructure									
Residences	1 Ranch, 5 outbuildings	12 Buildings (possibly 3 different ranches)	2 Out Buildings	None Identified	Oil Field Infrastructure	None Identified	None Identified	20 buildings (2 ranches)	None Identified
Transportation	.1 miles driveway, .4 miles dirt	2.2 miles improved, 3.25 miles dirt	3.63 miles dirt rd	.5 miles improved .36 miles dirt	2.6 miles dirt	1 mile dirt	1.23 miles dirt rd	.63 miles paved 2.34 miles improved 5.85 miles dirt rd	1 mile dirt rd
Other		Fiber Optics (.5 Miles)	Would require over 2 miles of canal or 2 tunnel to gravity flow water to the site		Would require over 6 miles of canal or tunnel to gravity flow water to the site	requires pumping		Fiber Optics (possibly 7200ft?)	
Category H: Economic Considerations									
Estimated Construction Cost	$10,500,000	$13,800,000	$12,200,000	$16,007,339	$9,000,000		$11,274,437	$12,886,826	$7,109,485
Total Project per cubic yard of fill	$25	$21	$74	$13	$29		$16	$17	$23
Total Project per ac-ft of storage	$3,621	$819	$1,584	$6,403	$811		$2,684	$317	$3,950
Category I: Ownership									
Embankment	Private	Private	State	Private	BLM	BLM	State/BLM	Private	BLM
Impoundment	Private	Private / State / BLM	Private / State / BLM	Private / State	Private / BLM	BLM	BLM	Private / BLM	Public (ST/BLM)
Category J: Potential Benefits									
Location Relative to Demand (Irrigated Acres downstrea	2,656	5,853	5,667	6,053	1,960	2,063	3,154	1,960	1,115
Demand Potential (downstream shortages) (Dry/Normal)	40 / 0	0 / 0	0 / 0	1552 / 778	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Potential for flood protection	Limited	Moderate	Limited	Low	Limited	None	Low	Highest	Limited

Site #	10	11	12	13	14	15	16	17	18
Site Name	**Meadowlark Lake Enlargement**	**Medicine Lodge**	**Otter Creek**	**Paint Rock Creek**	**Lower Trout Creek**	**Pete**	**Solitude**	**Summit**	**Taylor Draw**
s **Ranked Priority**	**1**	**3**	**2**	**3**	**2**	**3**	**3**	**3**	**1**
Latitude	44.165157	44.391696	43.875655	44.285345	44.373927	44.312359	44.355029	44.37207	43.919142
Longitude	-107.232061	-107.380505	-107.345908	-107.489633	-107.385275	-107.785882	-107.270791	-107.242543	-107.379389
Category A: Reservoir Description									
On-Channel / Off-Channel	On Channel	On Channel	On Channel	On Channel	On Channel	On Channel	On Channel	On Channel	Off Channel
Direct Supply Source	Ten Sleep Creek	Medicine Lodge	Otter Creek	Paint Rock Creek	Paintrock	Unnamed Trib	Paint Rock Creek	Unnamed Trib	Taylor Draw
Indirect Supply Source	NA	NA	NA	NA	NA	NA	NA	NA	Otter Creek
Supply Mechanism	Dam Enlargement	Tributary Dam	Tributary Dam	Tributary Dam	Tributary Dam	Tributary Dam	Tributary Dam	Tributary Dam	New Diversion
Category B: Watershed									
Contributing Drainage Area -Direct (square miles)	36.28	2.68	96.41	155.19	6.67	9.48	14.239114	0.521446	6.94
Contributing Drainage Area -Indirect (square miles)	NA	NA	NA	NA	NA	NA	NA	NA	655.23
Maximum Elevation (feet MSL)	12,287	10,793	8,650	13,148	10,793	4,790	13,148	11,793	5,275
Minimum Elevation (Feet MSL)	8,465	9,186	4,667	5,141	8,716	4,197	9,262	10,397	4,540
Basin perimeter in miles	37.55	11.04	69.92	84.43	17.14	22.78	22.780713	3.273509	16.32
Maximum basin relief in feet	3,822	1,607	3,983	8,007	2,077	593	3,886	1,396	735
Mean annual precipitation	28.6	30.0	19.3	28.5	29.4	10.6	34.5	33.5	13.0
Category C: Reservoir Statistics									
Capacity / Enlargement (acre-feet)	4,150	11,100	15,300	9,400	750	1,600	4,570	0	5,050
Surface Area (acres)	324	236	443	126	49	100	150	24	130
Maximum Water Depth (feet)	50	85	80	165	75	75	55	25	75
Average Water Depth (feet)	12.8	47.0	34.5	74.7	15.3	16.0	30.4	0.0	38.8
Category D: Dam Description									
Dam Statistics									
Proposed Type	Earthen Enlargement	Earthen	Earthen	Earthen	Earthen	Earthen	Earthen	Earthen	Earthen
Dam Height (feet)	23	90	85	170	80	80	60	30	80
Embankment Length (feet)	580	2,200	3,500	750	1,700	1,350	615	220	1,050
Total Dam Volume (cy)	26,074	2,085,767	1,779,113	2,478,705	593,185	992,119	0	0	827,852
Storage Efficiency (ac-ft/1000cy fill)	126.6	5.3	8.6	3.8	1.3	1.6			6.1
Method of Reservoir Fill	None / On channel	None / On channel	None / On channel	None / On channel	None / On channel	None / On channel	None / On channel	None / On channel	Diversion Structure / canal
Appurtenances									
Size Class (<1000 small, <10,000 Int, >10,000 large	Small	Large	Large	Large	Medium	Medium	Small	Small	Medium
Category E: Hydrology									
Hydrology Method	Basin Plan Reach 690 Inflow	Miselis	Basin Plan Reach 670 Outflow	Basin Plan Reach 790 Inflow	Miselis	Nowater Comparison	Miselis	Miselis	Miselis
Storage Availability									
Normal Year (ac ft) - Physically in the stream	35,256	2,715	30,710	123,710	5,544	197	15,271	699	2,075
Dry Year (ac ft) - Physically in the stream	19,503	1,265	16,510	98,947	2,589	192	6,910	322	1,096
Normal Year (Available)	5,972	2,715	9,545	90,108	5,544	197	15,271	699	2,075
Dry Year (Available)	1,831	1,265	5,689	69,055	2,589	192	6,910	322	1,096
Indirect Supply Source	None	None	None	None	None	None	None	None	Otter Creek
Normal Year (Indirect)	NA	NA	NA	NA	NA	NA	NA	NA	8,988
Dry Year (Indirect)	NA	NA	NA	NA	NA	NA	NA	NA	2,101
Category F: Geology									
Dam embankment foundation	C	C	C	D	C	B	B	B	B
Reservoir pool area	C	C	C	D	C	B	B	B	B
Contributing watershed	C	B	C	C	B	B	B	B	C
Category G: Environmental Issues / Infrastructure									
Environmental Issues									
Wetlands (acres impacted) From NWI data	12.2	51.9	6.4	0.02	0	3.3	0	0	0.2
Game: Antelope	Seasonal Range	None Noted	Seasonal Range	Seasonal Range	None Noted	Seasonal Range, Crucial Range	None Noted	None Noted	Seasonal Range
Game: Elk	Seasonal Range	Seasonal Range, Parturition Range	Seasonal Range	Seasonal Range, Crucial Range	Seasonal Range, Parturition Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range
Game: Moose	Seasonal Range	Seasonal Range	None Noted	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	None Noted
Game: Mule Deer	Seasonal Range	Seasonal Range	Seasonal Range, Crucial Range	Seasonal Range, Crucial Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range, Crucial Range
Game: White Tailed Deer	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range
Sage Grouse Leks within 2 miles	0	0	3	0	0	0	0	0	2
Sage Grouse Core Population Area	None of pool in core area	None of pool in core area	None of pool in core area	None of pool in core area	None of pool in core area	None of pool in core area	None of pool in core area	None of pool in core area	None of pool in core area
WDEQ Stream Classification	2AB	2AB	2AB	2AB	2AB	2AB	2AB	2AB	
Fisheries	Popular fishery. Lake contains brook, brown, rainbow, RXC and Yellowstone Cutthroat, and enlargement should provide fish passage.	Fishery concerns--stocked with rainbow and Yellowstone Cutthroat.	An important brown, rainbow and (native) mountain sucker fishery.	Important fishery forbrook, mountain whitefish, rainbow, brown and an occasional YSC.	Brook trout fishery - potential fishery issues to consider	No known fisheries concerns.	Fisheries concerns, lake trout and brook trout fishery-on wilderness	All fishless waters based on existing information	Located downstream of Otter Creek higher in the Nowood Drainage.
Irrigated Acreage Inundated	0	0	130.5	0	0	0	0	0	0
Infrastructure									
Residences	None Identified	2 buildings (park area, outhouses?)	None Identified	None Identified	None Identified	None Identified	None Identified	None Identified	None Identified
Transportation	.35 miles improved	.84 miles improved .22 miles dirt rd	.54 miles improved, 1.6 miles dirt rd	1.19 miles dirt rd	None	.63 dirt rd	None	None	2.11 miles dirt rd
Other	Fiber Optics (4300 ft)								Diversion on Otter Creek and 4 miles ditch
Category H: Economic Considerations									
Estimated Construction Cost	$8,300,000	$24,338,415	$22,119,394	$27,017,244	$9,890,556				$11,100,000
Total Project per cubic yard of fill	$318	$12	$12	$11	$17				$13
Total Project per ac-ft of storage	$2,000	$2,193	$1,446	$2,874	$13,187				$2,198
Category I: Ownership									
Embankment	USFS	USFS	Private, BLM, State	Private	USFS	BLM	USFS	USFS	State
Impoundment	Public (USFS)	USFS	Private / State / BLM	Private / BLM	USFS	BLM	USFS	USFS	State
Category J: Potential Benefits									
Location Relative to Demand (Irrigated Acres downstrea	5,368	4,027	5,411	4,027	4,027	1,115	4,027	2,939	4,972
Demand Potential (downstream shortages) (Dry/Normal)	0 / 0	1607 / 1343	0 / 0	1607 / 1343	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Potential for flood protection	Low	Low	Low	Low	Low	None	None	None	Limited

Site #	19	20	21	22	23	24	25	26	27
Site Name	Upper Nowood	West Fork Willow Creek	West Tensleep Lake	Little Cottonwood Creek	Nowood - Mahogany Butte 1	Nowood - Mahogany Butte 2	Deep Creek	Nowood - Crawford	Weintz Draw
s Ranked Priority	1	3	3	2	3	3	1	1	2
Latitude	43.73688	43.790051	44.25546	44.076659	43.64691	43.64691	43.554334	43.550728	44.233049
Longitude	-107.332899	-107.365292	-107.218302	-107.529189	-107.378651	-107.378651	-107.343234	-107.513509	-107.690194
Category A: Reservoir Description									
On-Channel / Off-Channel	On Channel	On Channel	On Channel	Off Channel	On Channel	On Channel	On Channel	On Channel	On Channel
Direct Supply Source	Nowood River	West Fork Willow	Tensleep Creek	Little Cottonwood	Nowood River	Nowood River	Deep Creek	Nowood River	Weintz Draw
Indirect Supply Source	NA	Nowood River	NA	Nowood River	NA	NA	NA	NA	Paint Rock Creek
Supply Mechanism	Mainstem Dam	Tributary Dam	Tributary Dam	Tributary Dam	Mainstem Dam	Mainstem Dam	Tributary Dam	Tributary Dam	Anita Ditch
Category B: Watershed									
Contributing Drainage Area -Direct (square miles)	255.69	4.76	15.42	26.03	185.07	185.07	41.8	36.15	1.37
Contributing Drainage Area -Indirect (square miles)	NA	NA	NA	1092.25	NA	NA	NA	NA	285.02
Maximum Elevation (feet MSL)	9,053	5,209	12,336	5,447	9,053	9,053	9,053	7,826	4,571
Minimum Elevation (Feet MSL)	4,804	4,753	9,079	4,321	5,035	5,035	6,395	5,854	4,285
Basin perimeter in miles	110.18	16.06	23.77	37.64	94.78	94.78	38.57	41.93	6.69
Maximum basin relief in feet	4,249	456	3,257	1,126	4,018	4,018	2,658	1,972	286
Mean annual precipitation	19.0	13.0	31.6	12.1	20.0	20.0	24.1	16.4	9.9
Category C: Reservoir Statistics									
Capacity / Enlargement (acre-feet)	5,250	9,600	75	8,400	4,300	28,000	9,600	1,100	1,120
Surface Area (acres)	321	577	106	336	245	617	147	118	124
Maximum Water Depth (feet)	75	65	37	85	75	125	95	65	40
Average Water Depth (feet)	16.4	16.6	0.7	25.0	17.6	45.4	65.3	9.3	9.0
Category D: Dam Description									
Dam Statistics									
Proposed Type	Earthen	Earthen	Earthen	Earthen	Concrete Arch	Concrete Arch	Earthen or Concrete Arch	Earthen	Earthen
Dam Height (feet)	80	70	42	90	80	130	100	70	45
Embankment Length (feet)	1,260	1,325	1,175	1,775	275	400	1,085	1,100	960
Total Dam Volume (cy)	927,585	859,444	0	1,824,978	238,795	885,926	672,000	695,139	272,729
Storage Efficiency (ac-ft/1000cy fill)	5.7	11.2		4.6	18.0	31.6	14.3	1.6	4.1
Method of Reservoir Fill	None / On channel	None / On channel	None / On channel	Diversion Structure / canal	None / On channel	None / On channel	None / On channel	None / On channel	None / On channel
Appurtenances									
Size Class (<1000 small, <10,000 Int, >10,000 large	Medium	Medium	Small	Large	Small	Medium	Large	Medium	Small
Category E: Hydrology									
Hydrology Method	Basin Plan Node (Node 9.0700 / Reach 600)	Nowater Comparison	Basin Plan Reach 694 Inflow	Nowater Comparison	Basin Plan Node (Node 9.0500 / Reach 600)	Basin Plan Node (Node 9.0500 / Reach 600)	Basin Plan Reach 630 Inflow	Basin Plan Reach 600 Inflow	Nowater Comparison
Storage Availability									
Normal Year (ac ft) - Physically in the stream	75,629	99	61,244	541	54,891	54,891	30,860	8,092	29
Dry Year (ac ft) - Physically in the stream	42,292	97	33,815	528	31,800	31,800	12,188	3,135	28
Normal Year (Available)	9,760	99	5,972	541	9,760	9,760	9,760	8,092	29
Dry Year (Available)	5,874	97	1,831	528	5,874	5,874	5,874	3,135	28
Indirect Supply Source	None	None	None	Nowood River at Reach 700	None	None	None	None	Paint Rock Creek via Anita Ditch
Normal Year (Indirect)	NA	NA	NA	188,298	NA	NA	NA	NA	123,710
Dry Year (Indirect)	NA	NA	NA	157,247	NA	NA	NA	NA	98,947
Category F: Geology									
Dam embankment foundation	C-	B	C	B	D	D	D	D	C
Reservoir pool area	C-	B	C	B	D	D	D	C-	B
Contributing watershed	C-	B	B	B	D	D	C	C-	B
Category G: Environmental Issues / Infrastructure									
Environmental Issues									
Wetlands (acres impacted) From NWI data	1.5	5.5	0	0	22.5	23.5	4.3	2	0.34
Game: Antelope	Seasonal Range	Seasonal Range	None Noted	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range
Game: Elk	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range, Migration Route	Seasonal Range	Seasonal Range
Game: Moose	None Noted	None Noted	Seasonal Range	None Noted	None Noted	None Noted	None Noted	None Noted	Seasonal Range
Game: Mule Deer	Seasonal Range, Crucial Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range, Crucial Range	Seasonal Range, Crucial Range	Seasonal Range	Seasonal Range, Crucial Range	Seasonal Range
Game: White Tailed Deer	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range
Sage Grouse Leks within 2 miles	5	5	0	0	0	1	2	1	0
Sage Grouse Core Population Area	Pool almost entirely within core area	Pool entirely within core area	None of pool in core area	Partial pool in core area	Pool almost entirely within core area	Pool almost entirely within core area	None of pool in core area	None of pool in core area	None of pool in core area
WDEQ Stream Classification	2AB	3B	2AB	3B	2AB	2AB	2AB	2AB	NA
Fisheries	Excellent brown trout fishery upstream of this site	No fisheries information is available; this small tributary located upstream of Bruner Draw.	Fishery concerns, brook trout, and occasional brown trout, popular recreation site on Bighorn National Forest	No known fisheries concerns.	Fisheries concerns here. This is an excellent wild trout population at this site.	Fisheries concerns here. This is an excellent wild trout population at this site.	Fisheries concerns, yellow stream of brk, brn, rainbow and Yellowstone Cutthroats.	Fisheries concerns unknown.	Would change the downstream water temperatures on Nowood if large res.
Irrigated Acreage Inundated	64.3	0	0	0	134	232	0	0	0
Infrastructure									
Residences	2 structures (outbuildings)	None Identified	None Identified	None Identified	9 buildings (1 ranch)	9 buildings (1 ranch)	None Identified	None Identified	None Identified
Transportation	2.82 miles dirt rd	1.17 miles dirt rd	.07 miles improved	3.2 miles dirt rd	.84 miles improved, 1.55 miles dirt rd	1.1 miles improved, 4 miles dirt rd	.6 miles improved rd	1 mile improved rd, .4 miles dirt rd	.49 miles dirt rd
Other				Diversion on Nowood, 3.5 miles ditch, 0.5 mile tunnel	Fiber Optics (2428 ft)	Fiber Optics (7306 ft)		Fiber Optics (3500 ft)	extension of Anita Ditch
Category H: Economic Considerations									
Estimated Construction Cost	$15,900,000	$12,748,445	$3,590,853	$21,165,017	$6,409,725	$12,996,017	$13,000,000	$9,800,000	$6,653,617
Total Project per cubic yard of fill	$17	$15		$12	$27	$15	$19	$14	$24
Total Project per ac-ft of storage	$3,029	$1,328	$47,878	$2,520	$1,491	$464	$1,354	$8,909	$5,941
Category I: Ownership									
Embankment	Private / State	State/BLM	USFS	BLM	BLM	BLM	State	Private/State	BLM
Impoundment	Private / State / BLM	Public (ST/BLM)	USFS	Public (BLM)	Private / State / BLM	Private / State / BLM	Private / State	Private / State / BLM	Public (BLM)
Category J: Potential Benefits									
Location Relative to Demand (Irrigated Acres downstrea	5,840	5,753	5,368	3,120	6,079	6,079	6,301	6,421	2,097
Demand Potential (downstream shortages) (Dry/Normal)	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Potential for flood protection	Moderate	Limited	Limited	Low	Moderate	Moderate	Limited	Low	None

Site #	28	29	30	31	32	33	34	35
Site Name	Upper Brokenback	Woods Gulch	Alkali Creek South	South Fork Otter (Lower)	South Fork Otter (Upper)	Canyon Creek	Lone Tree	North Brokenback
s Ranked Priority	3	3	2	3	3	2	2	3
Latitude	44.112333	43.970945	43.994251	43.808036	43.781972	44.030263	43.568274	44.16755
Longitude	-107.448956	-107.375975	-107.401154	-107.248039	-107.187836	-107.336053	-107.463131	-107.373224
Category A: Reservoir Description								
On-Channel / Off-Channel	On Channel	On Channel	On Channel	On Channel	On Channel	On Channel	On Channel	On Channel
Direct Supply Source	Brokenback	Woods Gulch	Alkali Creek	Otter Creek	Otter Creek	Canyon Creek	Nowood River	North Fork
Indirect Supply Source	NA	NA	NA	NA	NA	NA	NA	NA
Supply Mechanism	Tributary Dam	Tributary Dam	Tributary Dam	Tributary Dam	Tributary Dam	Tributary Dam	Mainstem Dam	Tributary Dam
Category B: Watershed								
Contributing Drainage Area -Direct (square miles)	17.37	3.66	13.28	26.6	7.39	79.63	71.78	7.73
Contributing Drainage Area -Indirect (square miles)	NA	NA	NA	NA	NA	NA	NA	NA
Maximum Elevation (feet MSL)	8,700	5,354	5,570	8,287	8,212	10,484	8,568	8,700
Minimum Elevation (Feet MSL)	4,705	4,537	4,486	5,499	6,760	4,930	5,708	6,379
Basin perimeter in miles	32.967747	12.36	22.12	31.31	15.13	69.92	56.87	15.22
Maximum basin relief in feet	3,995	817	1,084	2,788	1,452	5,554	2,860	2,321
Mean annual precipitation	21.8	12.9	13.4	21.0	22.4	22.5	17.4	24.6
Category C: Reservoir Statistics								
Capacity / Enlargement (acre-feet)	225	336	1,461	1,579	1,023	46,650	5,700	820
Surface Area (acres)	18	90	89	50	80	852	313	18
Maximum Water Depth (feet)	60	45	65	115	115	115	75	115
Average Water Depth (feet)	12.2	3.7	16.4	31.7	12.8	54.8	18.2	45.6
Category D: Dam Description								
Dam Statistics								
Proposed Type	Earthen	Earthen	Earthen	Earthen	Earthen	Earthen	Earthen	Earthen
Dam Height (feet)	65	50	70	120	120	120	80	120
Embankment Length (feet)	376	825	980	485	890	315	300	750
Total Dam Volume (cy)	205,031	273,173	607,509	1,594,311	1,594,311	502,519	220,543	1,310,815
Storage Efficiency (ac-ft/1000cy fill)	1.1	1.2	2.4	1.0	0.7	92.8	25.8	0.6
Method of Reservoir Fill	None / On channel	None / On channel	None / On channel	None / On channel	None / On channel	None / On channel	None / On channel	None / On channel
Appurtenances								
Size Class (<1000 small, <10,000 Int, >10,000 large	Small	Small	Medium	Large	Large	Medium	Small	Medium
Category E: Hydrology								
Hydrology Method	Basin Plan Reach 740 Outflow	Miselis	Miselis	Basin Plan Reach 675 Outflow	Basin Plan Reach 675 Inflow	Basin Plan Reach 698 Outflow	Basin Plan Reach 610 Inflow	Basin Plan Reach 740 Inflow
Storage Availability								
Normal Year (ac ft) - Physically in the stream	8,987	1,174	3,738	18,917	13,045	26,710	3,156	8,987
Dry Year (ac ft) - Physically in the stream	2,738	617	1,983	8,014	4,550	30,095	1,029	2,738
Normal Year (Available)	8,024	1,174	3,738	8,988	8,988	5,931	3,156	8,024
Dry Year (Available)	1,970	617	1,983	2,101	4,550	1,831	1,029	1,970
Indirect Supply Source	None	None	None	None	None	None	None	None
Normal Year (Indirect)	NA	NA	NA	NA	NA	NA	NA	NA
Dry Year (Indirect)	NA	NA	NA	NA	NA	NA	NA	NA
Category F: Geology								
Dam embankment foundation	D	B	B	C	D	D-	D	C+
Reservoir pool area	C-	B	B	C-	D	D	D	C+
Contributing watershed	C-	C	C	C-	D	D	D	D
Category G: Environmental Issues / Infrastructure								
Environmental Issues								
Wetlands (acres impacted) From NWI data	0.45	0	0	0.48	0	47.4	0.4	0
Game: Antelope	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range
Game: Elk	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range, Crucial Range	Seasonal Range	Seasonal Range	Seasonal Range, Migration Route	Seasonal Range
Game: Moose	Seasonal Range	None Noted	None Noted	None Noted	None Noted	Seasonal Range	None Noted	Seasonal Range
Game: Mule Deer	Seasonal Range	Seasonal Range, Crucial Range	Seasonal Range, Crucial Range	Seasonal Range, Crucial Range	Seasonal Range	Seasonal Range, Crucial Range	Seasonal Range, Crucial Range	Seasonal Range, Crucial Range
Game: White Tailed Deer	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range	Seasonal Range
Sage Grouse Leks within 2 miles	0	0	0	0	0	0	0	0
Sage Grouse Core Population Area	None of pool in core area	None of pool in core area	None of pool in core area	None of pool in core area	None of pool in core area	None of pool in core area	None of pool in core area	None of pool in core area
WDEQ Stream Classification	2AB	NA	NA	2AB	2AB	2AB	2AB	2AB
Fisheries	No known fisheries concerns.	No known fisheries concerns.	No known fisheries concerns - stream unsuitable for year round fishery	Fisheries concerns- North fork of the South Fork Otter Creek is restored Yellowstone Cutthroat Population.	Fisheries concerns- North fork of the South Fork Otter Creek is restored Yellowstone Cutthroat Population.	Fisheries concerns-- excellent brown trout fishery.	Fishery studies are needed	No known fisheries concerns.
Irrigated Acreage Inundated	0	0	0	0	0	378	0	0
Infrastructure								
Residences	None Identified	None Identified	None Identified	3 buildings (1 Ranch)	None Identified	golf course, several buildings , residences	One Ranch with numerous buildings	None Identified
Transportation	None	None	.2 miles improved rd	.18 miles improved rd	.66 miles dirt rd	3 miles dirt rd	.25 miles improved rd	None Identified
Other						Fiber Optics	Fiber Optics	
Category H: Economic Considerations								
Estimated Construction Cost	$5,887,914	$6,207,824	$10,148,834	$12,531,344	$18,480,575	$9,559,754	$6,148,110	$16,851,913
Total Project per cubic yard of fill	$29	$23	$17	$8	$12	$19	$28	$13
Total Project per ac-ft of storage	$26,169	$18,476	$6,946	$7,936	$18,065	$205	$1,079	$20,551
Category I: Ownership								
Embankment	BLM	Private	State	Private	State	BLM	Private	Private
Impoundment	Public (BLM)	Private / BLM	State, BLM	Private / BLM	Private / State	BLM/Private	State / Private	BLM/Private
Category J: Potential Benefits								
Location Relative to Demand (Irrigated Acres downstreal	3,415	4,633	4,505	5,529	5,529	5,315	6,421	3,415
Demand Potential (downstream shortages) (Dry/Normal)	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0	0 / 0
Potential for flood protection	Low	Low	Low	Low	Limited	Limited	Moderate	Low

APPENDIX G

LIVESTOCK AND WILDLIFE WATER SOURCE IMPROVEMENTS

APPENDIX G - LIVESTOCK AND WILDLIFE WATER SOURCE IMPROVEMENTS

G.1 Spring Developments

Individual springs can be developed as local watering sites or supply sources to feed pipelines conveying flows to multiple tanks. The specific method(s) used to develop a spring or seep area depend on the site-specific conditions. In general, the following factors and recommendations should be considered and implemented/adopted as appropriate:

- Carefully examine the spring/seep to determine the source (or "eye"), and to determine if any known or potential sources of contamination exist.
- Observe the rate of flow (estimated or measured) during a dry season or the season of intended use to determine if flow rate will be sufficient or to guide design of the spring development.
- Remove obstructions to spring flow (fine grained soils, surficial deposits, dense vegetation, etc.).
- Remove phreatophytic vegetation that can significantly reduce the amount of spring flow via transpiration (in accordance with any necessary environmental analysis, permitting and mitigation).
- Collect the available flow by appropriate means/methods (perforated pipe; ditching; drainage trench/gallery; etc.).
- Construct a means to settle sediment, protect the spring flow from external debris or contaminants, and facilitate maintenance of the spring (e.g., a spring box).
- Consider lowering the outlet elevation of the spring to increase the head at the discharge and thereby increase the flow.
- Use of explosives for spring development is discouraged as this practice can result in lower instead of higher flows and is dangerous unless performed by fully qualified personnel.
- Protect the spring development from washout or sediment burial during periods of flooding by diking and ditching as appropriate.
- Construct and maintain fencing or other barrier around the source to minimize impact to the source by wildlife or livestock.

Detailed information on the occurrence and characteristics of springs and the design of spring development, collection and protection is included in Chapter 12 – Springs and Wells of the Engineering Field Handbook (NRCS, 1983). This reference may be downloaded at the following website:

http://www.info.usda.gov/CED/ftp/CED/EFHCh12.pdf.

Alternative guidance for the design, construction and maintenance of spring developments as published by USAID (1982) is available at the following website:

http://www.lifewater.org/resources/rural_water_supply.html.

Figure G.1 shows several typical spring development schemes abstracted from these two references.

Figure G.1 Schematics of Typical Spring Developments

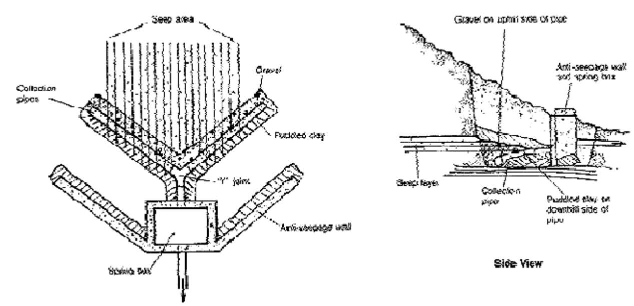


Figure 3. Seep Collection System

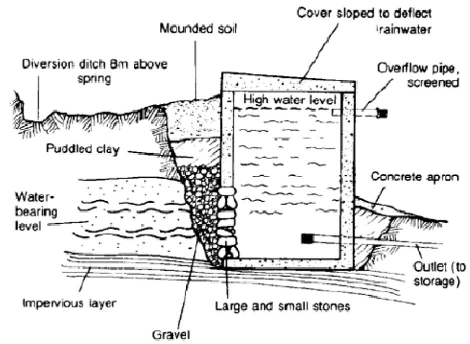


Figure 1. Spring Box with Pervious Side

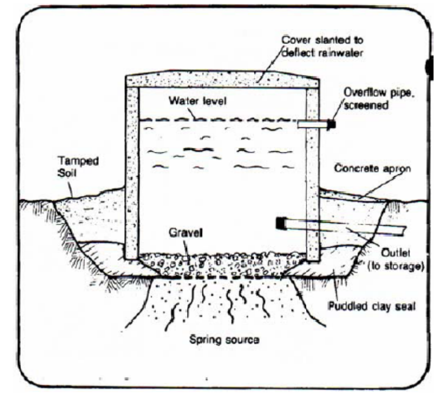


Figure 2: Spring box with permeable bottom for collecting spring water flowing from an opening on level ground (Courtesy of USAID, 1982, available online at www.lifewater.org).

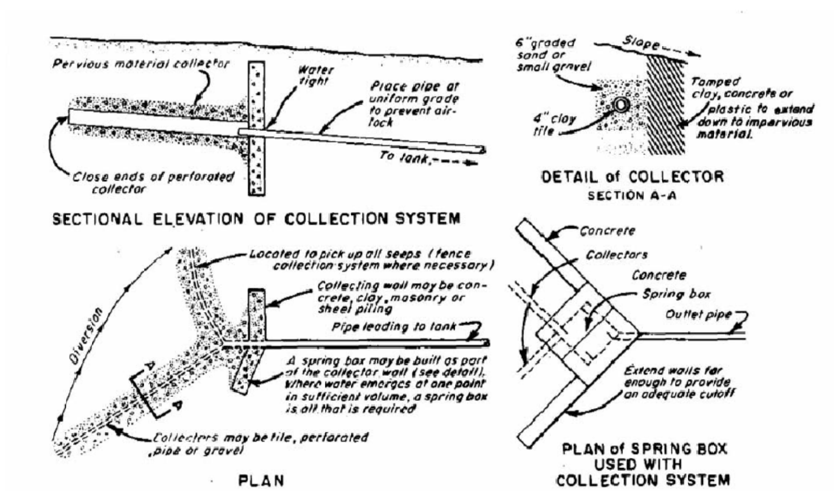
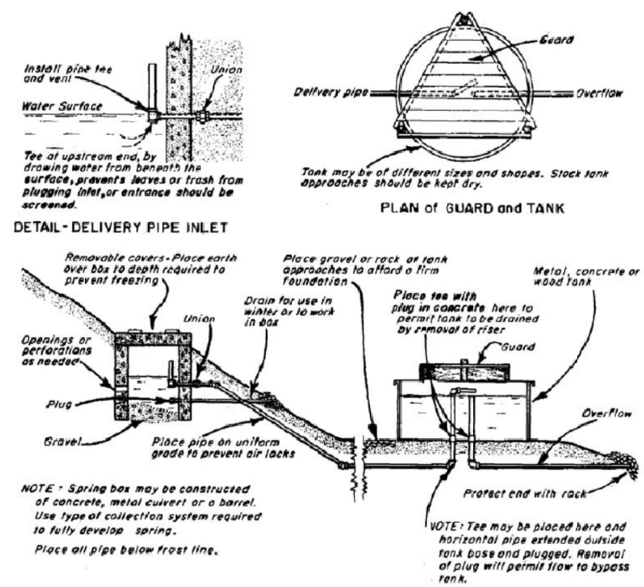


Figure 12-11.—Spring collection system.



G.2 Existing Wells with Conventional Windmills, Wind Turbines and Combined Solar/Wind Systems

Conventional Windmills. Windmills are a traditional method used to collect groundwater by means of a conventional well equipped with a mechanical pump powered by the wind-driven rotation of a set of high-torque, low-speed gears. Windmills are most typically used where: distance to power lines is greater than about a mile; reliability of supply is not crucial; high pumping rates are not required; ease of maintenance is important or desirable (i.e., no electrical and associated control components); and where cost per gallon of water produced needs to be low compared to other alternatives. Modern windmills are capable of pumping from depths up to about 1000 feet if needed (at low pumping rates); however, most applications are where relatively shallow groundwater is available (typically less than a few hundred feet). Pumping rates from shallow depths typically range from a less than 50 to as much as several thousand gallons per hour (gph) under favorable conditions. Mechanical single action piston pumps are most commonly used. Performance parameters for a high efficiency, modern-era Oasis 3 windmill manufactured by WINDTech International, LLC are presented on Figure G.2. Wind speeds necessary to drive modern windmills may be as low as about 5 miles per hour (mph) for highly efficient designs; more typically winds of at least 12 mph are needed, with efficiency increasing notably at wind speeds greater than about 18 mph. The life of a windmill is usually on the order of 20 years under a normal range of operating and environmental conditions.

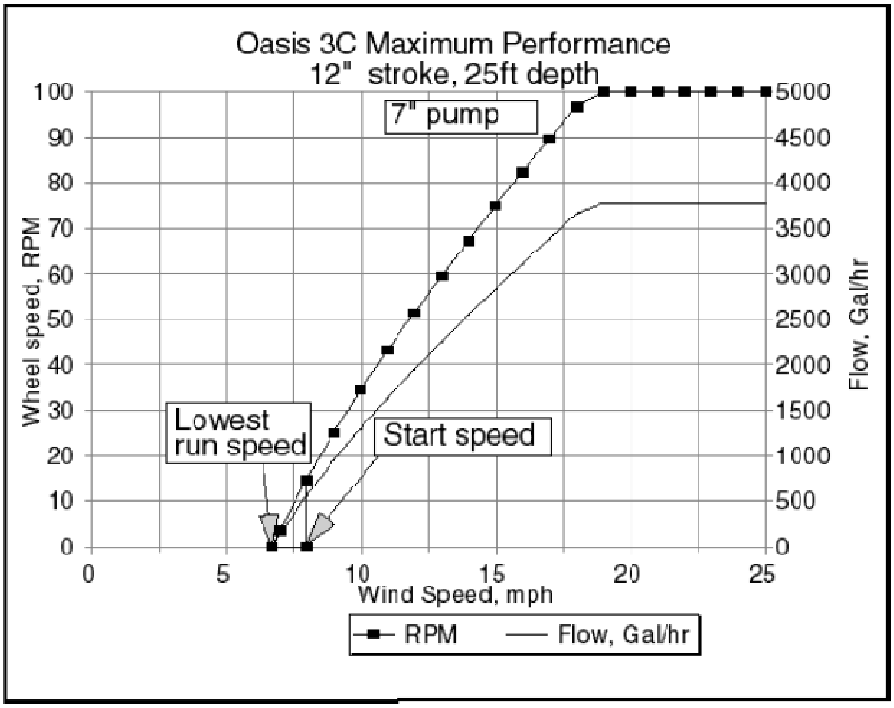
A windmill would normally fill a local tank and serve as a single point source of wildlife and livestock watering. A typical mechanical windmill set-up is shown schematically on Figure G.3.

Wind Turbines. A wind turbine can be used as an alternate source of power for a conventional pump installed in a groundwater well. In this type of system a wind turbine is mounted on a tower either at the site of the groundwater well or a more wind-suitable site near the well. The turbine converts wind energy to electrical energy through a generator or alternator that in turn powers a conventional submersible pump. If desired, storage batteries could be included in the system so that pumping could continue during times when the wind velocities are not sufficient. Information about wind turbines in a water pumping application is available from the U.S. Department of Energy Efficiency and Renewable Energy (EERE) website at:

http://www.eere.energy.gov/consumer/your_home/electricity/indeH.cfm/mytopic=10 890.

Information on commercial wind water pumping systems utilizing a Bergey wind turbine and Grundfos submersible pumps are available from Bitterroot Solar at: http://www.bitterrootsolar.com/pumping/windpump.htm. These particular systems range from 4,800 to 40,000 gal/day production with an 11 mph wind and a pumping/head of 100 feet. Additional technical and cost information for these systems is available at:

http://www.bergey.com/Products/XL1.html.



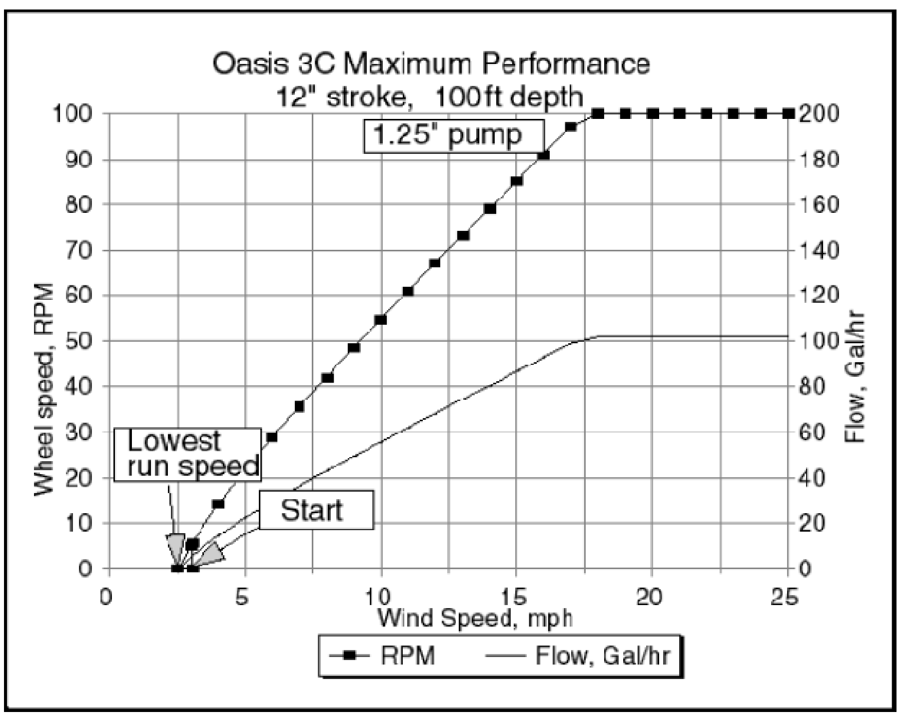


Figure G.2 Windmill Performance Curves

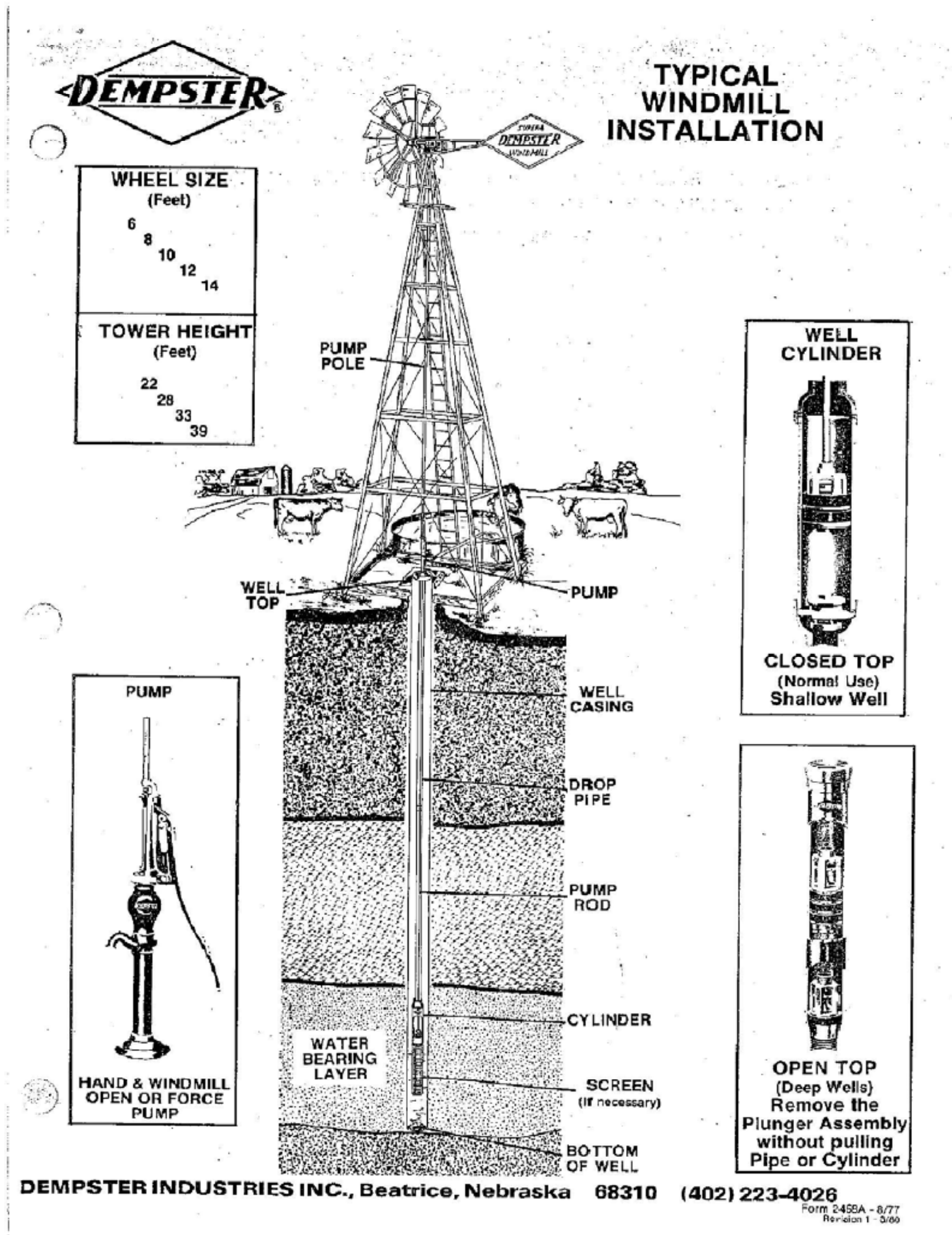


Figure G.3 Windmill Schematic

Combined Solar/Wind Powered Systems. An alternative to a conventional windmill or a wind turbine powered pumping system is a combined system that includes both a wind turbine and solar panels as power sources for a generator and conventional submersible water pump. This system allows the pump to be operated by solar power alone, wind power alone, or a combination of both sources depending on environmental conditions at the site at any given time. Although more expensive to install and maintain, this system provides more reliable power for stock water pumping than either single source alone. A commercially available source of this type of system is produced by Grundfos; information on this system is available at:

http://net.grundfos.com/doc/webnet/sqflex/home.htm.

G.3 Wells

Wells are a potential source of water for wildlife and livestock watering. Because of the cost of drilling and completing a well and the unavoidable uncertainty as to the production that will be achieved (without very expensive prior site-specific exploration), a new well would usually only be considered as a source where no other more practical and cost-effective options are available. On the other hand, conversion of an existing well to serve as a source of wildlife/livestock watering may be very cost-effective. For this to be the case, some or all of the following conditions should be met:

- Located near an area in need of additional watering opportunities
- Sufficient capacity to serve this and any other existing uses (or potential to increase well yield through re-conditioning or possibly deepening)
- Capable of operation by wind or solar power (unless already served by a power line)

It may be possible to convert a dormant oil (or gas) well to water production; however, there are a number of factors that may render this impractical. First, the well must be open to at least the depth of the target aquifers(s). If open deeper, it may be necessary to plug the hole up to or for some distance below the base of the lowest target aquifer to minimize pumping residual oil and/or natural gas. Depending on the nature of the aquifer(s) (hydrocarbon content) it may be necessary to install a "treater" or "skimmer" at the surface to separate the hydrocarbons from the water. If the well is cased across the producing zone(s), it will have to be perforated, and depending on formation properties, protection against piping of the sidewall provided by some means. Unless conditions are generally favorable, the cost of conversion of an existing oil well may end up exceeding the cost of drilling and completing a new well. This is not to say that such opportunities do not exist or are always impractical. Oil wells have been reportedly successfully converted and serve as a year-round watering installation. Any such conversion opportunities should be carefully evaluated on a case-by-case basis.

Conditions most advantageous to use of a new well are summarized as follows:

- Shallow depth to aquifer(s) with adequate transmissivity to meet projected needs.

- Located where hydrogeologic conditions are reasonably well known from prior drilling and/or well installation.
- Either close to existing power lines or suitable for wind or solar operation.
- Location upgradient of an area or areas of significant wildlife/livestock watering
- Shortage.

If a new well is planned, it is recommended that a water well driller with substantial experience in the local area be utilized to take best advantage of prior experience with the relevant geologic units and conditions. Depending on the size (depth and anticipated yield) of the well, it may be worthwhile to consult a groundwater geologist with experience in this or similar geologic settings prior to finalizing a decision as to drilling a new well.

Information on the planning, design, drilling, completion, development of groundwater wells is available from many sources. One source of such information is available from the NRCS (1983) Engineering Field Handbook at the following website:

http://www.info.usda.gov/CED/ftp/CED/EFH-Ch12.pdf.

G.4 Pipeline/Tank Systems

Pipeline/tank systems are generally considered to be the best method for conveyance of flows from any suitable source of water, since they can put the water where it is needed (at multiple locations), when it is needed. These systems can operate by gravity, be fed by a pumped source, or combine both gravity and pumping reaches (usually with a surge/storage tank in the system). Sources of water may include any of those described in this section, including a groundwater well, developed spring, pond, reservoir, or stream diversion.

Considerations in the layout and design of a pipeline/tank system include, but are not limited to the following:

- *Location of the source relative to the points of use* – ideally the water source will be located upgradient of the points of use so that all delivery can be by gravity
- *Temporary storage* - if necessary, one or more locations for temporary storage of pumped supply can be provided that then feed the remainder of the system by gravity; typically a 2-3 day supply for the wildlife and livestock using the system is provided
- *Terrain* – an alignment with some variation in grade is desirable to minimize problems with air-locking by installation of air relief valves at appropriate locations; very rugged terrain is less desirable due to the higher installation costs
- *Geologic conditions* – ideally pipeline alignments will be located where rock excavation and/or adverse soils conditions are avoided or minimized to the degree practical (adverse soils conditions may include landslides, areas of significant active erosion, etc.)

- *System length/size* – the longer the system and the more tanks planned or desired, the greater the flow capacity from the source required; friction losses in the pipe and through the fittings can be significant over long distances relative to the available energy of the source water
- *Property ownership* – systems may be designed to serve a single landowner; alternatively, there may be opportunities for cooperative projects in which the system is designed to serve two or more entities (see additional discussion later in this section)
- *Environmental conditions/issues* – it is necessary, to the extent feasible, to avoid impacts to the environment including but not limited to wetlands, riparian zones, high value sage grouse habitat, and cultural resources

The pipeline/tank systems planned and/or installed already in the watershed include some or all of the following elements/components:

- Spring development or well as water source
- HDPE piping
- Air release vents/valves
- Pipeline drains
- Tanks (with pressure reducing valves, rescue ladders, gate or ball valves, float valves, air and vacuum release or pressure relief valves, overflow piping, and pump manifold gages, valves and fittings)

There is a wide array of different wildlife/livestock watering tanks that can be used in a pipeline/tank system or with any of the other water sources described in this section. At present, converted heavy equipment tires appear to be the preferred tank type in the watershed. This is due to their relative availability, comparative cost effectiveness, durability, freeze-resistance, long-life, and ease of installation (with the proper equipment available). A typical 12-foot by 2.5-foot tire tank holds on the order of 1500 gallons when full. Other types of tanks that could be considered on a case-by-case basis include, but are not necessarily limited to:

- Cast-in-place or precast concrete tank or trough
- Bottomless corrugated metal tanks
- Pit/pond (sealed or lined where necessary)
- Fiberglass or galvanized tanks

The larger pipeline/tank systems are typically are designed to fill the tanks automatically as the contents are drawn down. There is provision for taking individual tanks out of service when necessary for maintenance or repair. Overflow drainage is provided in the event of malfunction.

G.5 Ponds

Small ponds can provide seasonal watering opportunities to both wildlife and livestock. Watering can occur directly from the pond, or a pipeline can be fed from the pond to deliver water to one or more tanks downgradient. For purposes of this study, a watering (“stock”) pond is defined as a reservoir or pit/dugout (excavation below original grade) with a maximum capacity of less than 20 acre-feet and a dam height less than 20 feet. Reservoirs/pits of this size qualify for application to the State Engineer’s Office as “stock reservoirs” and thereby avoid the more restrictive and costly administrative, design, and construction requirements associated with permitting under the standard reservoir regulations.

A pond is typically created by excavation of soils in the pond area and placing the excavated soil as embankment fill to create a dam. This approach is most cost effective initially; however, it may be more cost-effective in the long run to secure soils from areas near but not immediately at the reservoir site depending on the properties of the soils. In particular, clay soils with dispersive properties or with significant percentages of soluble salts should not be used for embankment fill if other more suitable soils are available nearby. Embankment fill should be placed in relatively thin horizontal lifts, compacted with rubber-tired (versus tracked) equipment, and not placed too wet or too dry. This will result in a more erosion resistant embankment.

An overflow earthen spillway should be provided for ponds constructed in ephemeral or intermittent drainages and in swales with relatively large drainage areas. If possible, the spillway section should be excavated in or to rock. If this is not feasible, the spillway should be constructed with as broad a crest and as shallow a discharge channel as practical to lower flow velocities and thereby limit erosion during times of use. Revegetating the spillway with grasses will also increase its erosional resistance. The arrangement of the spillway relative to the dam embankment and the general configuration of the spillway are shown by the centerline profiles shown in Figure G.4. An outlet pipe is usually only included in this type of pond if it is needed to feed one or more tanks downgradient (supply pipe) or if there is enough spring-fed flow or intermittent runoff events to cause excessive use of the overflow spillway (“trickle tube”). A supply pipe is placed with its inlet near but not at the lowest point of the foundation (to allow for some sediment accumulation). Flow is controlled by a downstream valve (e.g., a float valve regulated by water level in the down-gradient tank or pipeline/tank system being supplied). The trickle tube is an appropriately sized open pipe installed through the embankment dam at an elevation slightly lower than the overflow crest elevation of the spillway.

If direct watering is intended (which allows for watering more animals at a time), then it is recommended that protection of the dam embankment, spillway (and outlet if present) be considered to reduce the need for and cost of future maintenance. Although initially more costly, consideration should also be given to armoring of the pond rim to lessen erosion and excessive sedimentation. This decision should be based on the site soils conditions, planned usage, and estimated cost of future maintenance in the absence of such protection. One alternative on larger ponds may be to selectively armor only portions of the rim and fence the remainder to exclude use by wildlife and livestock. If armoring is used it should consist of reasonably durable gravel (over larger rock if necessary) to encourage use by wildlife/livestock and minimize sloughing and erosion of the pond banks.

Information on the planning, design and construction of small ponds is available from the NRCS at: http://www.info.usda.gov/CED/ftp/CED/EFH-Ch11.pdf. The local NRCS staff in Thermopolis and Worland

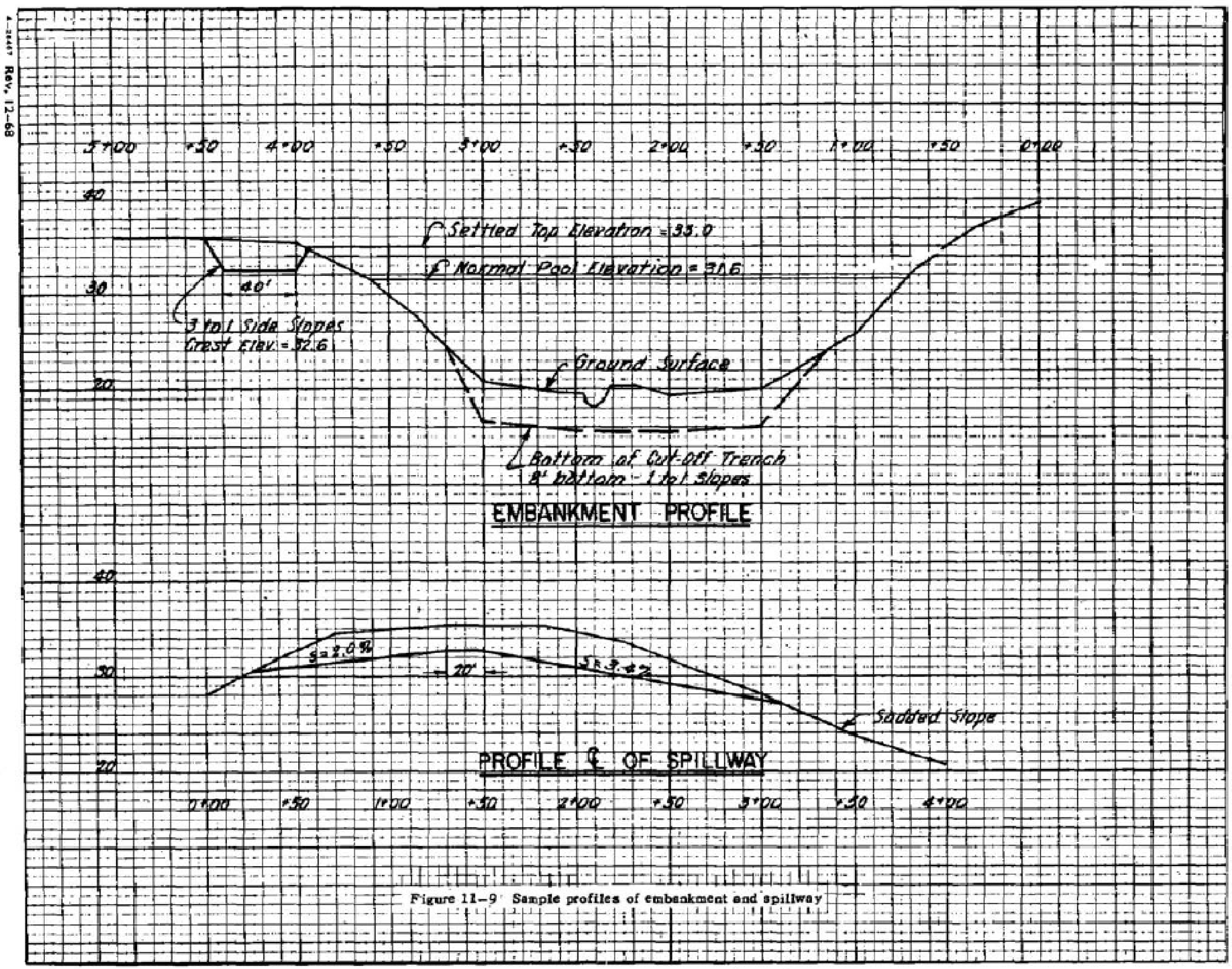


Figure G.4 Pond Embankment and Spillway Profile Schematics (and other staff they may contact) may also be able to provide technical assistance for projects to be constructed under an NRCS program.

G.6 Reservoirs

A new surface water storage reservoir could serve as a source of supply to a wildlife/livestock watering system. This could involve direct gravity to one or more pipeline/tank systems arrayed downgradient of the reservoir. Alternatively, the reservoir could serve as the source for pumping water to one or more pipeline/tank systems.

Any new reservoir could also serve as a direct source of wildlife and livestock watering. Depending on the location of the reservoir relative to grazing locations, it may be appropriate to include one or several watering access sites around the reservoir rim. These sites should be sized to accommodate the anticipated or desired use, and designed with appropriate grades to and in the near-shore pool to facilitate watering. The access ramps and watering areas should be adequately armored as described above in the section above regarding stockponds.

G.7 Guzzlers

A guzzler is a wildlife watering system utilizing direct precipitation as a source of supply, with a storage tank of capacity suitable to the watering need, and designed to discourage use and protect from damage 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 (Figure G.5).
- 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 (1800-gallon tank with patented features is available from Boss Tanks and Elko Bighorns Unlimited, Elko,Nevada).
- Overflow pipe – with erosion protection at discharge.

Figure G.5 Guzzler installed in the Cottonwood Creek watershed.

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. Figure G.6 shows a typical set up

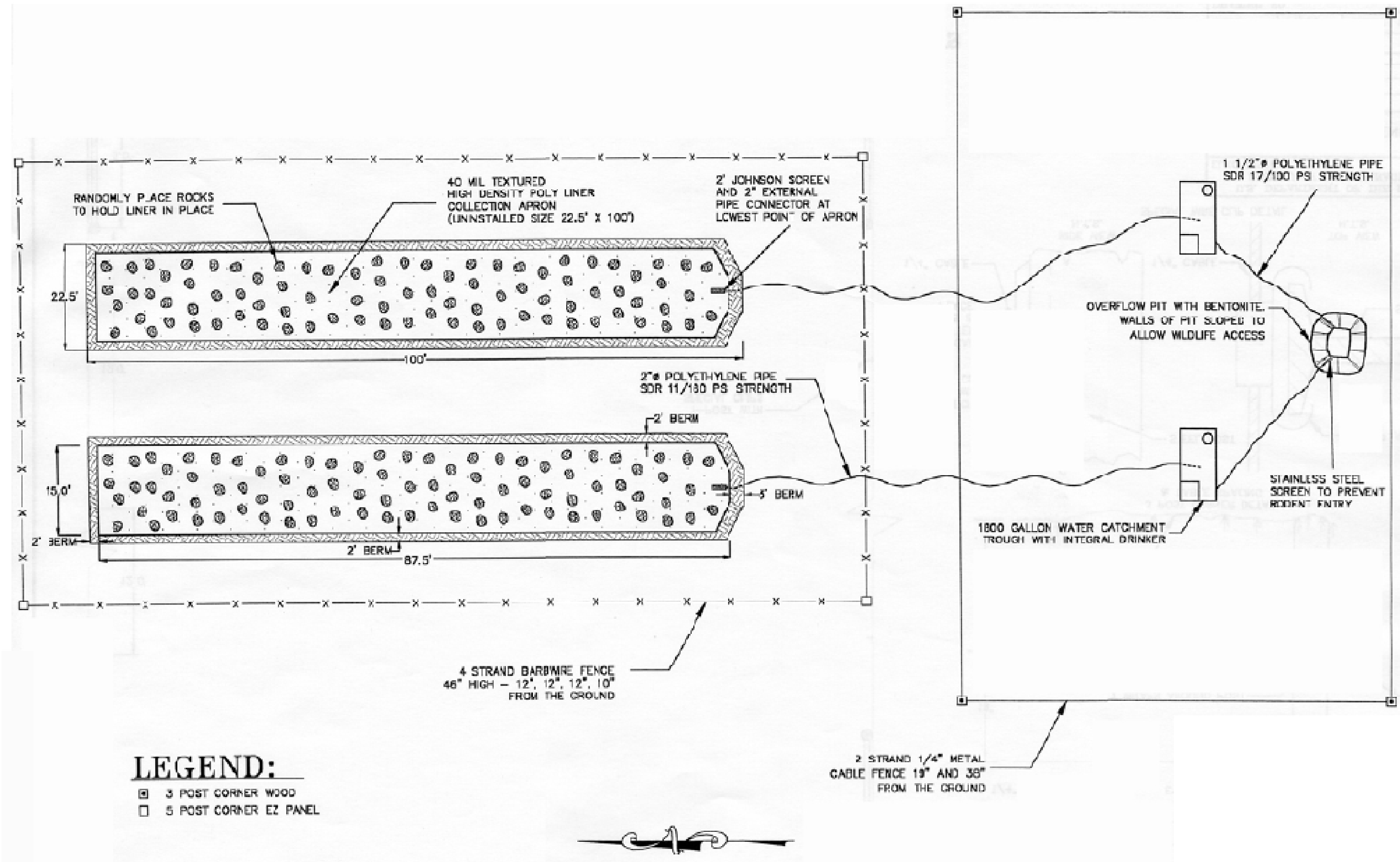


Figure G.6 Schematic of Typical Guzzler Installation

with dual catchments and tanks. Information on a commercially available system compatible with the design described above is available from Boss Tanks and Elkhorn Bighorns Unlimited at: http://www.bosstanks.com/guzzler.htm. A self contained guzzler is available from Wildlife Water Guzzler; information on this product line is available at: http://www.wildlifewaterguzzler.com/.

G.8 Power Sources

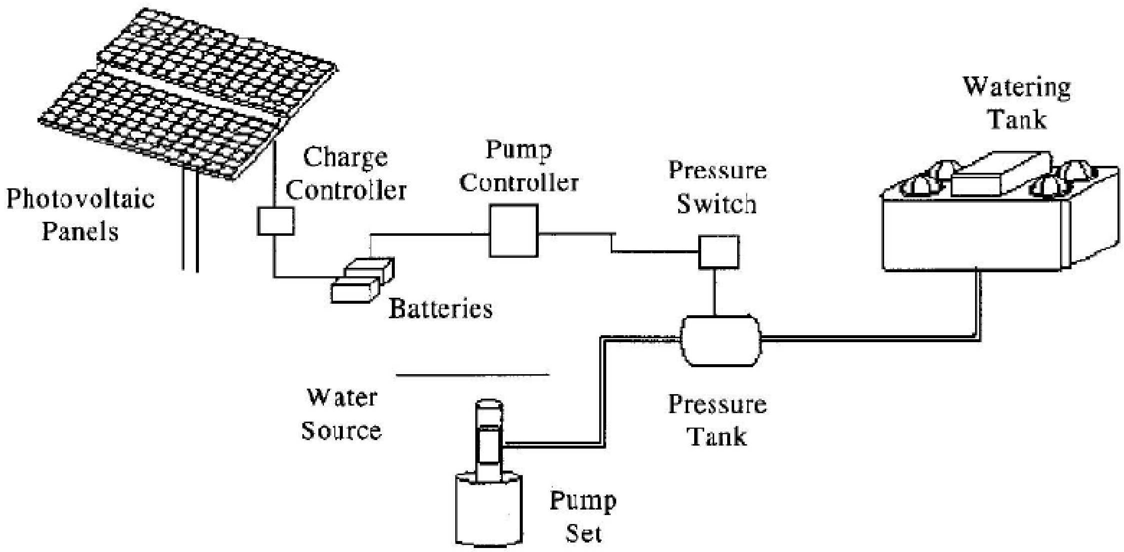
Conventional Electrical Service. In most cases the cost to bring overhead power to a single well or lift station site for wildlife/livestock watering would probably be prohibitive. This option should normally be considered only when the point of power use is close to existing service (usually less than about ¼ to ½ mile) or the power demands are higher than can be feasibly supplied by other sources (wind, solar).

Portable/Remote Generator. Although possible, the use of portable or remotely installed gasoline or diesel powered generators is generally not an economically feasible alternative to operate pumps to supply wildlife/livestock water. This type of power is usually only considered in temporary or emergency conditions. If used, special care is required to ensure safe transport, storage and use of fuel to prevent accidental fires and/or releases of fuel to the environment.

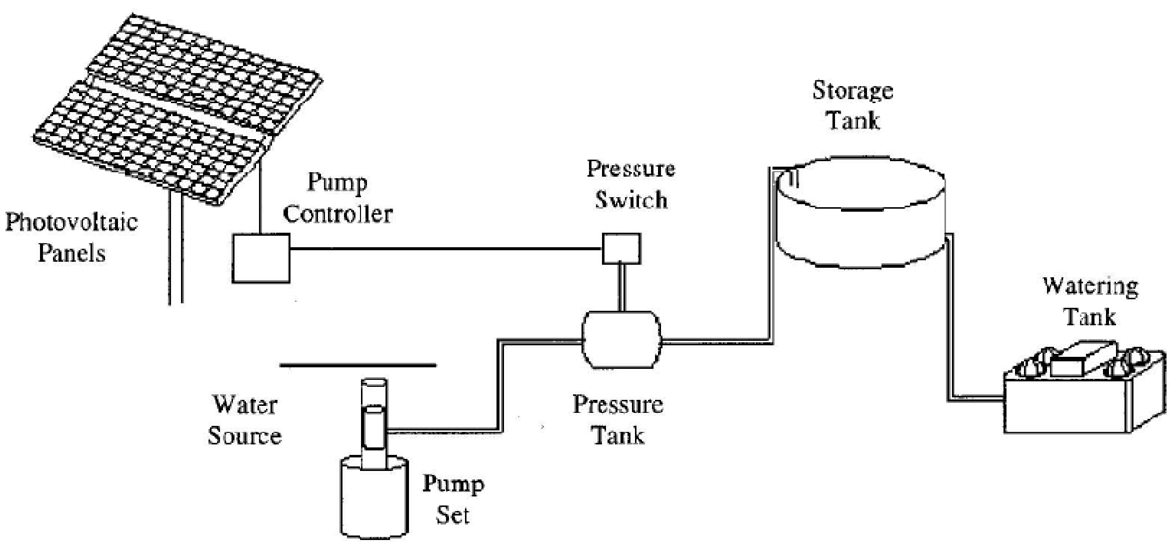
Solar Water Pump. Solar power can be an appropriate, efficient and long-term cost-effective means to power a pump used to extract groundwater from a well or to convey water upgradient from another source of supply (pond, spring, storage tank, etc.) to temporary storage or point of use (watering tank or pipeline/tanks system). This type of system is best suited to remote locations with sufficient sunlight, typical of conditions where additional wildlife/livestock watering is needed in the Nowood watershed. Solar water pump systems are typically comprised of one or more photovoltaic (PV) panels, sometimes a set of storage batteries, and a DC-capable pump. Figure G.7 shows two typical set-ups, one with storage batteries and direct delivery to the watering tank(s) and the other with a storage tank set above the watering tank(s) and without storage batteries. Other arrangements are also possible. Batteries are used where pumping during low-light and nighttime periods is necessary or desirable (e.g., to fill a storage tank or refill a watering tank overnight when watering demands are low).

Overall, solar water pump systems are relatively easy to install and maintain. However, the solar panels are relatively fragile and need to be mounted in a suitable location and well-secured against wind and livestock damage. The other components in the system (pump, controller, switches and possibly batteries) also need to be properly installed, protected from weather and incidental damage, and require some periodic maintenance and/or replacement.

Solar water pumps are specially designed to work efficiently with DC solar power, including during low-light (reduced voltage) conditions. Many different types of pumps can be used depending on the pumping head and flow rates for the particular application. These include positive displacement types (piston and jack pumps, diaphragm, vane and screw pumps) that maintain lift capacity at slow, varying speeds resulting from changing light conditions. In low-lift and/or high-volume applications, centrifugal-type pumps are often used. The pumping rates that can be achieved vary with the lift (head) from the



Battery-coupled solar watering system



Direct-coupled solar watering system

Figure G.7 Schematic of Typical Water Pump

pump to storage or point of use and the amount of power supplied by the solar system. At relatively low heads (say less than 100 feet) and with modest power (say less than 150 watts), pumping rates on the order of 150-200 gph (3.0-3.5 gpm) are possible. With greater available power at low heads (50-100 feet), pumping rates up to several thousand gph (25-75 gpm) are possible with centrifugal pumps. For high lifts (say 400-500 feet) and sufficient power, pumping rates of several hundred gph are attainable with helical rotor pumps.

APPENDIX H

TECHNICAL MEMORANDUM: GEOLOGIC ASSESSMENT

Technical memorandum

To: Jay Schug, ACE
From: Joel Farber, Rob Venczel, and John Meyer
CC:
Date: October 9, 2009
Re: Nowood River Watershed, Geological Assessment

Introduction

This memorandum summarizes the findings from a reconnaissance-level study and field evaluation of the geotechnical feasibility of potential reservoir sites completed by Trihydro Corporation in the Nowood watershed in north-central Wyoming. Investigation activities were performed from May through August of 2009. The scope of the investigation encompassed review of 35 potential reservoir storage sites indentified by Anderson Consulting Engineers (ACE). Additionally ACE requested Trihydro provide an overview of the geologic characteristics of the watershed as part of this technical memorandum.

The first phase of the project involved a reconnaissance-level assessment of the 35 sites ACE provided. The assessment was based on statewide geologic mapping of bedrock, structures, surficial geology, and geologic hazards. Each reservoir site was evaluated in terms of the expected geologic conditions along the dam embankment, within the reservoir pool area, and within the contributing drainage area. Trihydro assigned a letter grade (A-F) to each of these three focus areas for each of the sites. A grade of "A" indicated favorable conditions and a grade of "F" indicated the site had a fatal flaw. No sites were determined to have a fatal flaw (received a grade of F) during the first phase of the investigation. Likewise, none of the sites advanced for further consideration received an "A" grade. The results of the first phase resulted in a highest letter grade of B and a lowest letter grade of D.

The results of the reconnaissance-level assessment are provided in Table 1. Bedrock geology had the greatest influence on the grading process because of the regional risks for karstic formations and formations comprised primarily of erodible gypsum. The formations determined at highest risk for karst features are as follows: Gypsum Springs, Madison, Goose Egg, and Ten Sleep.

General Geology

The Following sections provide the general geology of the Nowood watershed. The watershed lies mostly within Big Horn and Washakie Counties in north central Wyoming. Small portions of the watershed however, overlap into Johnson, Natrona, Fremont and Hot Springs Counties. This assessment includes the surficial geology, bedrock geology, geological structure and geological hazards of the watershed.

Surficial Geology

The surficial deposits found within the Nowood watershed are presented on Figure 1. The figure shows the wide distribution of alluvium, glacial deposits, residuum, slopewash and colluvium within the watershed. These sediment types constitute the dominant exposed geology within the watershed. The remaining exposed geology is composed of bedrock, grus, landslide, and terrace deposits. A discussion of bedrock and landslides are presented in the bedrock geology and hazards sections below.

Alluvium is found adjacent to surface drainages and is of fluvial genetic origin. The extent of the alluvial deposits varies with the size of the respective fluvial system. Headwater deposits are typically narrower and shallower compared to downstream areas in the watershed. Alluvium ranges from 10-50 feet in thickness and is composed of sand, gravel, and loam (Cooley and Head 1979). These deposits are actively growing with the fluvial action of existing surface drainages. Fluvial action includes flooding (vertical deposition) and point-bar migration (lateral deposition).

Glacial till exists in the northwestern portion of the watershed and is associated with lateral and terminal moraines. The lateral moraines typically begin at an elevation of ~10,000 feet and can be traced to ~8,000 feet, where they meet the terminal moraines (Darton, 1906). Drift composition is dominantly igneous and metamorphic rock from upland areas. Some Paleozoic sedimentary rocks also exist within the till located at lower elevations. These deposits consist of unconsolidated, poorly sorted, angular rock fragments. Some areas may display greater levels of sorting due to esker formation.

Residuum is an in-situ deposit formed from the weathering of bedrock. Soluble components of the bedrock were transported from the area by fluvial, fluvioglacial, and groundwater processes. The insoluble portions of the rock experienced some mechanical weathering from freeze-thaw and rain-drop impact with little to no transport of the remaining materials. The residuum deposits within the Nowood watershed are primarily derived from late Paleozoic to Mesozoic rocks. The deposits are relatively young and are therefore thin compared to other quaternary deposits.

Colluvium exists throughout the watershed and has a genetic origin related to mass wasting mechanisms. These sediments were derived from the movement of material down slope under the influence of gravity. The colluvial deposits are composed of material derived from bedrock at higher elevations. Grain sizes range from silt to gravel, and grain shape is predominantly angular to subangular. These deposits have a maximum thickness of 15 feet (Cooley and Head 1979) but thin as they near the source material at higher elevations.

Bedrock Geology

The bedrock geology exposed and directly underlying the Nowood watershed contains rock formations with ages ranging from the Cambrian Period to present. The bedrock geology outcropping at or near the surface is presented on Figure 2. The dominant formations in the Nowood watershed (from youngest to oldest, top to bottom, then left to right) include the:

- Fort Union Formation
- Mesaverde Formation
- Cody Shale
- Frontier Formation*
- Mowry Shale*
- Thermopolis Shale*
- Cloverly shale*
- Morrison Formation*
- Sundance Formation*
- Gypsum Spring Formation*
- Chugwater Formation*
- Goose Egg Formation
- Tensleep sandstone
- Amsden Formation
- Madison limestone*
- Bighorn dolomite
- Gallatin Formation
- Gros Ventre Formation

Other geological units exist within the Nowood watershed, but the above units have the greatest influence on the watershed's geology. The starred units were encountered at the various reservoir sites and are described in greater detail.

The general chronological pattern of the units is that of younger formations on the eastern side of the watershed and older units on the western side (Susong et al. 1993). An exception to the pattern is the quaternary, surficial deposits discussed in the previous section. The youngest (Tertiary) rocks are of the Fort Union Formation and are approximately 2-68 million years old (ma). This formation consists of interbedded layers of sandstone and shale. Coal seams exist within the formation but are smaller and less frequent than those found in the Fort Union of southeastern Montana. In the area of the Nowood River, the Fort Union Formation is 1,000 to 1,500 feet thick (Cooley and Head 1979).

The next youngest rocks are of Cretaceous age (68-142 ma) and include units of the Mesaverde, Cody Frontier, Mowry, Thermopolis, and Cloverly Formations. Within the Nowood watershed, these formations comprise the bedrock (other than the Tertiary formations) found east of the Nowood River and the areas northeast of Hyattville, WY. They are comprised of thick shale layers with thinner beds of sandstone. Coal is present within these rocks as well (Darton 1906). The thickness of the entire sequence is from 6,600 to 7,500 feet (Cooley and Head 1979; Fischer 1906).

The Frontier Formation is Upper Cretaceous and composed of fine to medium lenticular sandstones with gray and black marine shales. Thin bentonite and tuff beds are present as well. The Mowry Formation is Lower Cretaceous and composed of black and gray thin-bedded resistant shale interbedded with thin sandstone and bentonite. The Thermopolis Shale is a soft black shale of the Lower Cretaceous. The Cloverly Formation is Lower Cretaceous and composed of light gray channel sandstones and pebble conglomerates interbedded with variegated bentonite mudstone (Weitz and Love 1952).

To the west of the cretaceous rocks are Jurassic to Pennsylvanian age (142-320 ma) rocks, and include the Morrison, Sundance, Gypsum Spring, Chugwater, Goose Egg, Tensleep, and Amsden Formations. These formations range from redish-brown shale to silty sandstone to sandstone. Thin beds of limestone also exist. The Tensleep Formation consists entirely of lightly cross-stratified sandstone. Gypsum exists in the Gypsum Spring and Goose Egg Formations, the solution of which has produced karst topography. The total thickness of these formations ranges from 2,000 to 2,400 feet (Susong et al. 1993; Cooley and Head 1979).

The Morrison Formation is Upper Jurassic and composed of calcareous gray silty sandstone and sandy claystone with lenticular limestone. The Sundance Formation is Middle Jurassic and is a greenish-gray glauconitic calcareous sandstone and shale. The Gypsum Springs Formation is Middle Jurassic and an interbedded red claystone, shale, siltstone and limestone with massive gypsum beds. The Chugwater Formation is Triassic and composed of massive, cross-bedded very fine grained red sandstone, siltstone and shale.

Mississippian to Ordovician aged rocks (320-505 ma) exist further to the west and northwest. These rocks are composed of the Madison limestone and Bighorn dolomite. Both formations contain light-gray massive limestone with the Bighorn Formation also containing dolomite. Dissolution of these formations has also produced karst topography and cave systems in the Nowood watershed. The extensive cave systems associated with these formations suggests a high volume of water is exchanged during surface water-groundwater interactions. The Madison limestone has a thickness of 500 to 700 feet, while the Bighorn dolomite is 300 feet thick (Susong et al. 1993; Cooley and Head 1979).

The oldest Phanerozoic rocks in the watershed were deposited during the Cambrian Period (505-560 ma) and are the Gallatin and Gros Ventre Formations. Both formations are a greenish to gray shale. The formations are in the northwest portion of the watershed, adjacent to the Oldest Gneiss Formation and other plutonic rocks. These igneous and metamorphic rocks represent the basement, Precambrian rocks found in the center of the anticlinal structure of the Bighorn Mountains (Susong et al. 1993; Darton 1906; Fischer 1906).

Structure

The Nowood watershed is located in the southeastern portion of the Bighorn Basin. The basin was formed from folding and faulting during the Laramide orogeny, which occurred approximately 40-70 ma. The Laramide also produced the mountains that border the basin (Susong et al. 1993). To the east the basin is bordered by the Bighorn Mountains and to the west by the Absaroka, Beartooth, and Shoshone Mountains (Fischer 1906). The Nowood watershed drains the southwestern portion of the Bighorn Mountains, with no interaction with the mountains on the western border of the basin.

The general structure of the Bighorn Mountains is an anticline, and a portion of the Nowood watershed drains the southwestern limb. The axial plane of the anticline strikes northwest to southeast, causing the west-east age pattern in the Phanerozoic rocks. The attitude of Phanerozoic rocks is similar to the anticline, with strikes ranging from north to south to northwest to southeast. However, smaller scale anticlines and synclines are present within the watershed, and these local structures create variations in bed orientation.

The smaller scale anticlines and synclines are genetically related to the larger Bighorn anticline and therefore have similar orientations. The beds within them strike to the northwest and generally dip 5-12° to the southwest. Beds with an opposite dip direction (to the northeast) are present but less prevalent. This bed reversal typically indicates the presence of a local syncline (Hosterman et al. 1989; Cooley and Head 1979). Synclines can often be found associated with an anticline of similar size and extent. One anticline-syncline pair in the Nowood watershed can be found along the western side of the Nowood River with the axial plane running from Manderson, WY, to Crooked Creek (Cooley and Head 1979). Similar but less extensive structures are also found in the northeastern portion of the watershed, near Hyattville, WY, and north of Ten Sleep, WY.

Faulting is present within the western portions of the Nowood watershed (Figure 3). These faults are characterized as high-angle (60-90°) normal faults with the downthrown side located to the southeast of the fault line (Hosterman et al., 1989; Darton, 1906). Faults of this type are associated with extensional tectonics. One distinctive fault that displays these characteristics is located adjacent to Big Canyon Creek and Ten Sleep. The fault displays a vertical displacement of 700 feet east of Big Canyon Creek. This displacement decreases towards the west, and the fault eventually merges into a south-dipping monocline located 4 miles west of Ten Sleep (Hosterman et al. 1989; Cooley and Head 1979; Darton 1906).

Hazards

Karst, landslide, and seismic geological hazards exist within the Nowood watershed. Karst creates sinkhole hazards and occurs from the dissolution of chemical rocks (limestone, gypsum, dolomite, etc.). Landslides occur when sediment moves downslope under the influence of gravity, potentially damaging structures and altering the hydrogeology of the watershed. Seismic events create a hazard to structures and tend to occur along fault lines, but earthquakes have occurred in areas with no known respective structural feature. The potential areas at risk for these hazards are presented on Figure 3.

Karst topography within the Nowood watershed is found west of the Nowood River. Closed depressions and solution collapse features are found on the surface and have been associated with the Goose Egg and Gypsum Spring Formations (Cooley and Head, 1979). These features were developed from the dissolution of gypsum and limestone underlying surficial deposits. The surficial deposits then reflected the karst topography below them. The limestone and dolomite of the Madison, Bighorn, and Gallatin Formations have also developed a karst topography. Some of this topography is concealed by the Amsden Formation, which unconformably overlies paleokarst features of the Madison (Hosterman et al., 1989). However, extensive, recently developed caves exist in the northeastern portion of the Nowood watershed, near Medicine Lodge Creek (Susong et al., 1993).

Collapse risk due to sinkholes can be difficult to determine due to their subsurface nature. Certain features can be indicative of karst: closed depressions, sinking streams, blind valleys, and others. However, subsurface investigations (including geophysical, tracer dye, and field surveys) need to be conducted to provide an adequate assessment.

Landslide hazards exist in areas where the resisting forces (friction and cohesion/adhesion between sediment particles) have the potential to be exceeded by the driving forces (gravity). This condition can be found throughout the upland areas of the Nowood watershed. Paleolandslides ("li" unit in Figure XX) are indicators of future landslide activity. Slopes experiencing undercutting due to lateral erosion of streams are also at high risk. Severe erosion problems have been noted on the Nowood River, with less severe erosion on the Paintrock, Ten Sleep, Otter, and Canyon Creeks (USDA 1971). The lateral erosion by streams undercuts the toe of slopes and removes their underlying support. Other factors for potential landslide areas include grain size and shape, lateral and underlying support, slope angle, sediment composition, and water content.

The Nowood watershed is an area with minor historical seismicity. Since 1350, epicenters of 11 earthquakes have been in or near the watershed. The largest magnitude earthquake, with a magnitude of 4.9, occurred in 1970. The epicenter was located approximately 8 miles southwest of Ten Sleep. The smallest magnitude earthquakes of 3.0 occurred in 1998 and 2000 (USGS 2009; Case et al. 2002). Two earthquakes recorded in 1925 and 1966, occurred before magnitude measurements were regularly recorded. The earthquakes were rated using the Modified Mercalli Intensity Scale. Intensity was not noted for the 1966 earthquake, and an intensity V level was applied to the 1925 event. The 1925 event was felt in Ten Sleep, Sheridan, Fort McKenzie, and Dome Lake Resort, but damage was not reported (Case et al. 2002).

Two fault systems are located adjacent to each other in the southern portion of Nowood watershed: the Cedar Ridge and Dry Fork fault systems. Evidence suggests that the fault systems are inactive. However, one confirmed case of Pleistocene-aged movement, in the form of a fault scarp, was documented in northeastern Fremont County (Case et al. 2002). If either the Cedar Ridge or Dry Fork fault systems were to become active, they could potentially generate 6.7 and 7.1 magnitude earthquakes, respectively. A 6.7 magnitude earthquake at the Cedar Ridge System could produce a peak horizontal ground acceleration of 2.9%g at Ten Sleep and 2.0%g at Big Trails. A 7.1 magnitude earthquake at the Dry Fork System would produce a peak ground acceleration of 3.8%g at Ten Sleep and 7.4%g at Big Trails. In either case, minor damage could result from these earthquakes at Big Trails, WY (Case et al. 2002).

Although active fault systems are not currently located near the Nowood watershed, large earthquakes can still occur in areas without a known source structure. These earthquakes are known as "floating earthquakes." Federal and state regulations require a floating earthquake analysis for certain structures (mill tailing sites, landfills, etc.). If a structure within the Nowood watershed required such analysis, a 6.25 magnitude earthquake with an epicenter 15 miles from the structure could be used as a conservative estimate for design ground accelerations. An earthquake of this magnitude and distance could produce ground accelerations of 15%g (Case et al. 2002). Some structures (e.g. dams) may require a more detailed risk analysis.

Another type of seismic hazard analysis, completed by the USGS, estimates the probability of exceeding the peak horizontal ground acceleration that could occur from an earthquake in the next 50 years. This analysis was most recently updated in 2008 and can be found at http://gldims.cr.usgs.gov/nshmp2008/viewer.htm. For the Nowood watershed, the peak horizontal ground acceleration that a has 10% chance of being exceeded from 2008 to 2058, is from 4-5%g. The peak ground acceleration that has a 2% chance of being exceeded from 2008 to 2058 is from 15-17%g. This methodology uses the frequency and magnitude of past earthquakes to estimate the frequency and magnitude of future earthquakes. A weakness to this method is that it can inaccurately predict earthquake risk in areas with a low frequency of earthquakes, like the Nowood watershed. However, few other alternatives for estimating the risk exist.

Site Conditions

After the reconnaissance-level assessment, ACE provided Trihydro a list of the following nine sites for additional field investigation: Little Canyon, Nowood-Crawford, Cottonwood Creek, Meadowlark Lake (enlargement of existing reservoir), Taylor Draw, Deep Creek, Bruner Gulch, Upper Nowood, and Big Trails. The field evaluations consisted of verifying and describing the bedrock conditions along the embankment alignment, collecting samples of foundation and potential embankment fill materials, identifying possible spillway locations, and photo documenting the site. The remainder of this memorandum provides summary findings from field investigations of the nine identified reservoir sites, an overview of the geology of the Nowood River watershed and detailed documentation of the results of the field investigations.

Little Canyon

The project was discussed in detail with the landowner, but access to the reservoir site was not granted. Therefore, ACE excluded this site from further consideration by Trihydro.

Nowood-Crawford

The proposed dam location for the Nowood-Crawford site is on the Nowood River, approximately 800 feet downstream of the Crawford Creek confluence. The embankment location is within the Jurassic part of the section, with sandstones of the Sundance Formation outcropping at the left abutment (Figure 4A) and siltstones of the Gypsum Springs Formations outcropping near the right abutment (Figure 4B). Sandstones of the Chugwater Formation were observed to the south of the right abutment. The beds near the left and right abutments are similarly oriented. Near the left abutment, the beds dip to the north at 15 ° (degrees) along a strike of 98°. Near the right abutment, the beds dip to the north at 20° along a strike of 101°.

Three samples were collected from this site. The first sample was collected from an outcrop to the south of the right abutment and consists of yellow, fine-grained sandstone with well-sorted, subrounded quartz grains and a very minor lithic fragment component. The sandstone is well-cemented but friable. The cement in the sandstone did not react with dilute hydrochloric acid. The second sample was taken from the alluvium near the right bank of the Nowood River and consists of red silty clay with sand and gravel. The fine fraction of the alluvium holds a weak thread when wet. The third sample was collected from an outcrop near the base of the left abutment and consists of greenish-gray, hard, glauconitic, very fine-grained sandstone or siltstone, with minor lithic fragment and gypsum components.

The proposed embankment alignment is near the contact between the Gypsum Springs and Sundance Formations and was observed in an outcrop on the left side of the drainage approximately 400 feet upstream of the left abutment. The Gypsum Springs Formation was also observed outcropping in the bottom of the drainage near the embankment location (Figure 4C) and is likely overlain by the alluvium and colluvium in the valley bottom and right abutment. Although this formation was flagged as a high risk in the reconnaissance-level assessment, an existing dam and reservoir is located in a similar geologic setting approximately 1 mile downstream of the identified site. (Figure 4D). The existing dam embankment appeared to be stable; however, observation of the sediment accumulated within the upstream portion of the existing reservoir indicates this portion of the watershed has a high siltation potential.

A sufficient volume of borrow material could likely be found in the valley bottom, assuming that the properties of this material are suitable for embankment fill. The second sample described for this site was collected to represent this locally available borrow material. A source of coarse material for riprap and embankment drainage was not observed near the site, and this material would likely need to be imported. Depending on the embankment height, a possible spillway location was identified near the right abutment (Figure 4B). For construction at this site, the Nowood River Road and the Bates Creek road would need to be rerouted.

Cottonwood Creek

The proposed dam location for the Cottonwood Creek site is on Cottonwood Creek approximately 4,400 feet upstream of its confluence with the Nowood River. The alignment evaluated in the field is located approximately 850 feet upstream of the alignment provided by ACE. The embankment location is within the lower Cretaceous part of the section, with sandstones of the Cloverly Formation outcropping at the left and right abutments (Figures 5A and 5B). The sandstone bedding planes in the area of the abutments dip to the south at 11° along a strike of 264°.

A small cave has eroded in the sandstone near the base of the left abutment (Figure 6B), which suggests a potential leakage risk for the reservoir that would need to be evaluated during a subsequent subsurface investigation. However, this erosional pattern did not appear to be widespread and may be an isolated occurrence.

Three samples were collected at this site. The first sample was collected near the right abutment and consists of dark red, hard, glauconitic silt shale. The second sample was taken from the alluvium in the bottom of the Cottonwood Creek valley and consists of light tan silty clay that holds a weak thread when wet. The third sample was collected near the base of the left abutment and consists of yellow-tan, fine-grained sandstone with well-sorted, frosted, subrounded quartz grains and a very minor mafic component. The sandstone is well-cemented but friable. The cement in the sandstone did not react with dilute hydrochloric acid.

A sufficient volume of borrow material could likely be found in the valley bottom, assuming that the properties of this material are suitable for embankment fill. The second sample described for this site was collected to represent this locally available borrow material. A source of coarse material for riprap and embankment drainage was not observed at the site, and this material would likely need to be imported. A possible spillway location was identified near the right abutment, which would utilize an existing drainage immediately downstream of the abutment (Figure 6A).

Meadowlark Lake Enlargement

Meadowlark Lake is an existing reservoir on Tensleep Creek near the confluence with East Tensleep Creek. The reservoir was constructed in the late 1930s as a work project for the Civilian Conservation Corps (CCC). An enlargement project would likely require consideration for preserving the historical value of the site.

The existing dam consists of a 30-foot tall embankment with a primary outlet channel near the right-center of the embankment, an emergency spillway near the left side of the embankment, and what appears to be a fish ladder adjacent to the spillway (Figure 7). The primary outlet and spillway channels are in need of repair, and the condition of the internal primary outlet plumbing could not be assessed. Based on the surface area of the reservoir from the SEO filing, raising the water level would yield approximately 300 acre-feet of additional storage per foot of water surface elevation.

Taylor Draw

The proposed dam location for the Taylor Draw site is near the mouth of Taylor draw approximately 2,100 feet upstream of the confluence with the Nowood River. The embankment location is within the lower Cretaceous part of the section, with Thermopolis Shale outcropping near the left and right abutments (Figures 8A and 8B). The shale at the ground surface is easily erodible, but the material becomes more competent with depth. The shale in outcrops on both sides of the drainage consistently dips to the west.

Two samples were collected at this site. The first sample was taken from the right abutment and consists of moderately hard, but easily friable, black clay shale. The second sample was collected from the channel bottom and consists of brownish-tan silty clay that holds a fine-diameter thread when wet.

The channel morphology of Taylor Draw suggests that the drainage basin does not receive enough runoff to directly support a large reservoir (Figure 8C). However, the site may be feasible for an off-channel reservoir storing water from the Nowood. A sufficient volume of borrow material could likely be found in the valley bottom, assuming that the properties of this material are suitable for embankment fill. The second sample described for this site was collected to represent this locally available borrow material. A source of coarse material for riprap and embankment drainage was not observed near the site, and this material would likely need to be imported. A possible spillway location was identified near the left abutment.

Deep Creek

The proposed dam location for the Deep Creek site is just downstream of the Cherry Creek road crossing. The location is within the lower Mississippian part of the section, with limestone of the Madison Formation outcropping at the left and right abutments (Figure 9). The limestone in the area of the embankment appeared to be resistant, but karstic erosional features were observed in downstream outcrops (Figure 10A). Compared to the downstream outcrops, the outcrop near the left abutment appeared relatively resistant, with minor dissolution along fracture planes. A geode was observed in the outcrop, suggesting the potential for dissolution (Figure 10B).

Two samples were collected at this site. The first sample was collected from an outcrop at the left abutment near the bottom of the drainage and consists of massive gray limestone/mudstone with little to no allochems. The second sample was collected on the north side of the access road approximately 600 feet upstream of the provided dam location. This sample consists of a greenish-gray, hard siltstone or shale with quartz veins interbedded with a green conglomerate with subangular to subrounded, flat pebble clasts.

This site may be feasible for an embankment, but a significant subsurface investigation would be required to determine the competency of the underlying bedrock for holding water in the reservoir and serving as a foundation for the embankment. Borrow material for an earthen embankment may be difficult to locate in this part of the basin. Given the potential foundation conditions and the possible borrow limitations, a concrete structure may be more appropriate for this location than an earthen embankment. The dam would likely need to be designed with a spillway running down the downstream face, because a good spillway location was not identified at this site.

Bruner Gulch

The proposed dam location for the Bruner Gulch site is on Buffalo Creek immediately upstream of Bruner Draw. The embankment location is within the upper Cretaceous part of the section, with sandstone of the Frontier Formation outcropping at the left abutment and sandstone and shale of the Frontier Formation outcropping at the right abutment (Figures 11A and 11B). The sandstone beds near the left and right abutments are similarly oriented. Near the left abutment, the beds dip to the west at 17° along a strike of 353°. Near the right abutment, the beds dip to the west at 17° along a strike of 350°. Shale of either the Frontier Formation or the Mowry Shale was observed downstream of the left and right abutments. Downstream of the left abutment, this shale dips to the west at 21° along a strike of 344°.

Four samples were collected at this site. The first sample was taken from the left abutment and consists of gray, fine- to medium-grained lithic arenite with poorly sorted, subrounded quartz grains and lithic fragments. The sandstone is well-cemented but friable. The second sample was collected from the channel bottom near the left abutment and consists of gray silty clay that holds a fine diameter thread when wet. The third sample was collected from a shale outcrop near the right abutment and consists of gray, easily friable, silt shale with faint, thin laminations. The fourth sample was collected from a shale outcrop downstream of the Bruner Draw confluence near the right abutment and consists of gray, moderately soft to hard, friable, silt shale.

A sufficient volume of borrow material could likely be found in the valley bottom, assuming that the properties of this material are suitable for embankment fill. The second sample described for this site was collected to represent locally available borrow material. A source of coarse material for riprap and embankment drainage was not observed at the site, and this material would likely need to be imported. A possible spillway location was identified near the left abutment, which would utilize an existing drainage immediately downstream of the abutment.

Upper Nowood

The proposed dam location for the Upper Nowood site is on the Nowood River approximately 3 miles upstream of the Little Canyon Creek confluence. Two potential embankment locations were evaluated at this site: one at the location provided by ACE (Figure 12) and one approximately 500 yards upstream of the provided location (Figure 13). This site is located in the upper Jurassic part of the section, with sandstones of the Sundance Formation outcropping near each abutment. The sandstones higher on the slope comprising the left abutment may be of the Morrison Formation. The sandstone beds near each abutment are similarly oriented. Near the right abutment of the upstream location, the beds dip to the west at 2° along a strike of 32°. Near the left abutment of the downstream location, the beds dip to the west at 7° along a strike of 36°. Along with sandstone outcrops, the hill slope comprising the left abutment at the upstream location consists of thick beds of soft, erodible siltstone or claystone (Figure 14A).

Three samples were collected from this site. The first sample was collected from the right abutment of the upstream location and consists of tan, well-cemented, very fine-grained quartz sandstone with calcareous cement. The second sample was collected in the floodplain on the left side of the river and consists of red silty clay. The clay holds a fine diameter thread when wet, but is less dense than the silty clays at the other sites. The third sample was taken from left abutment of the original location and consists of the same sandstone as the first sample.

The hydrology of the site would support a large reservoir, assuming that unappropriated water is available. For an earthen embankment, a sufficient volume of borrow material could likely be found in the valley bottom, assuming that the properties of this material are suitable for embankment fill. The second sample described for this site was collected to represent this locally available borrow material. Gravel and cobble lenses were observed in the bank of the Nowood, representing former channel deposits (Figure 14B). Borrow material from the floodplain would need to be segregated to separate the fine material from these gravels and cobbles. The coarse material from the former channel deposits could likely be used for embankment drainage. A source of coarse material for riprap was not observed at the site, and this material would likely need to be imported. Depending on the height of the embankment, two small drainages east of the right abutments could be used in the construction of spillways (Figures 12C and 13C).

Big Trails

The proposed dam location for the Big Trails site is on the Nowood River, approximately 5 miles upstream of the Little Canyon Creek confluence. The embankment location is within the Jurassic part of the section, with both abutments primarily within the Gypsum Springs Formation (Figure 15A). Sandstones of the Sundance Formation were observed cropping out as capstone above both abutments, but the abutments themselves would be located within very soft, erodible gypsum (Figure 15B). Because of these foundation conditions, this site is not recommended for further consideration as a potential reservoir location.

Two samples were collected at this site. The first sample was taken near the base of the left abutment and consists of gypsum. The second sample was collected from the capstone outcropping at the top of the left abutment and consists of greenish-gray, glauconitic, hard, very fine-grained sandstone.

<u>Summary Findings</u>

The geologic conditions for each embankment location were evaluated by mapping outcrops at the surface and by inferring subsurface conditions based on observed structure and published regional stratigraphy. The findings presented in this memorandum regarding each site would need to be verified by subsurface investigations, including investigative borings.

Based on this surface investigation, Cottonwood Creek, Meadowlark Lake, Taylor Draw, Bruner Gulch, and Upper Nowood would warrant additional subsurface study to evaluate the competency of the foundation materials. Outstanding geologic risk was not found at these sites.

If other driving factors favor development of the Nowood-Crawford and Deep Creek sites, these sites would also warrant additional subsurface investigation. The geology at these two sites was not as favorable as the aforementioned. A high potential for karstic features exists in the foundation of Deep Creek, and there is a high risk of gypsum being one of the primary foundation materials for Nowood-Crawford.

The only site not recommended for further investigation is Big Trails because of the amount of gypsum outcropping at the embankment location. This material is too erodible to serve as an appropriate dam foundation.

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Table 1 Reservoir Site Evaluation

ID	Dam and Reservoir Site Name	Description of site geology	Rating Dam embankment foundation	Reservoir pool area	Contributing watershed	Note
1	Alkali Creek	Quaternary alluvium in footprint of dam embankment; Cloverly - Morrison Formations within reservoir pool area	B+	B	B	No outstanding geologic risk evident
2	Big Trails	Sundance and Gypsum Springs at the embankment; Chugwater/Goose Egg in pool; Goose Egg and Ten Sleep in basin; faulting in basin	D	C-	C-	Embankment within mapped Gypsum area
3	Bruner Gulch	Embankment on alluvium/colluvium over Frontier; Cody in pool; Mesaverde, Fort Union, Lance, Mowry/Thermopolis in basin	B-	B	B	Field verify alluvium and potential for seepage through Frontier
4	Canyon Creek	Tensleep/Amsden at embankment and pool; Goose Egg in pool; some Madison near faulting in basin; some Gneiss and Gallatin in headwaters	C+	C+	B	Edge of mapped gypsum area, field verify Tensleep condition
5	Cottonwood Creek	Quaternary alluvium/colluvium underlying embankment footprint, potential for Cloverly and Morrison; Mowry and Thermopolis, Cody within pool and contributing watershed	B	B	B	No outstanding geologic risk evident
6	County Line	Quaternary terrace and fan deposits, Mowry and Thermopolis shales ; Cloverly and Morrision Formations within contributing watershed	B	B	B	No outstanding geologic risk evident
7	Lower Brokenback	Alluvium/colluvium, Sundance/Gypsum springs at embankment; Chugwater/Goose Egg in pool and basin; Tensleep/Amsden, Madison in basin;	D	C-	C-	Embankment within mapped Gypsum area, field verify Gypsum Springs condition
8	Lower Nowood	Quaternary alluvium in footprint of dam embankment; Mowry and Thermopolis shales with pool area, mixed bag with contributing watershed	B	B	C	No outstanding geologic risk evident
9	McDermott Draw	Frontier Formation at embankment; Mowry and Thermopolis Shales	C	B	B	Field verify potential for foundation seepage
10	Meadowlark Lake	Glacial and landslide deposits near Madison at embankment; Gallatin, Bighorn, gneiss in pool and basin	C	C	C	Existing lake, south end of embankment on mapped landslide hazard, karst risk from ACE layer
11	Medicine Lodge	Glacial deposits	C	C	B	Need to field verify nature of glacial deposits
12	Otter Creek	Alluvium/colluvium, Cloverly/Morrison, Sundance/Gypsum Springs at embankment; Chugwater/Goose Egg in pool; Tensleep/Amsden in basin; some Madison, Gneiss, Bighorn, Gallatin near faulting high in basin	C	C	C	Embankment on edge of mapped gypsum area, field verify Gypsum Springs versus Cloverly/Morrison mapping
13	Paint Rock Creek	Contact between Madison and Tensleep near the embankment; Madison with area projected to be inundated by the reservoir;	D	D	C	Karst risk from ACE layer
14	Lower Trout Creek	Glacial deposits, PreCambrian	C	C	B	Need to field verify nature of glacial deposits
15	Pete	Cody shale and Frontier Formation	B	B	B	No outstanding geologic risk evident
16	Solitude	PreCambrian (oldest gneiss complex)	B	B	B	Existing lake, mapped fault, field verify foundation compentency
17	Summit	PreCambrian (oldest gneiss complex)	B	B	B	Field verify foundation competency
18	Taylor Draw	Mowry/Thermopolis at the embankment and pool; Cloverly/Morrison, Sundance/Gypsum Springs, Chugwater/Goose Egg in basin	B	B	C	No outstanding geologic risk evident at the embankment
21	Upper Nowood	Cloverly/Morrison, Sundance and Gypsum Springs at the embankment; Chugwater/Goose Egg in pool; Goose Egg and Tensleep in basin; faulting in basin	C-	C-	C-	Embankment on edge of mapped gypsum area, field verify Gypsum Springs versus Cloverly/Morrison mapping
22	West Fork Willow Creek	Frontier Formation at embankment; Cody shale in pool	B	B	B	Field verify potential for foundation seepage
23	West Tensleep Lake	Embankment on glacial deposits; embankment and pool on Precambrian gneiss complex	C	C	B	Embankment near mapped landslide, field verify nature of glacial deposits, existing lake
24	Little Cottonwood Creek	Cloverly/Morrison at the embankment and pool; Mowry/ Thermopolis pool basin; Frontier, Cody, Mesaverde, Lance, Fort Union, igneous in basin	B	B	B	No outstanding geologic risk evident
25	Nowood Mahogany Butte 1	Madison at the embankment; Tensleep in pool; Goose Egg, Gyp. Springs in pool; Gallatin, Frontier, Thermopolis in basin;	D	D	D	Karst risk from ACE layer, gypsum mapping surrounding embankment
26	Nowood Mahogany Butte 2	Madison at the embankment; Tensleep in pool; Goose Egg, Gyp. Springs in pool; Gallatin, Frontier, Thermopolis in basin;	D	D	D	Karst risk from ACE layer, gypsum mapping surrounding embankment
27	Deep Creek	Madison at the embankment; Gallatin in pool, embankment, basin; gneiss in basin	D	D	C	Karst risk from ACE layer
28	Nowood - Crawford	Sundance and Gypsum Springs at the embankment; Madison, Ten Sleep, Wagon Bed, Gallatin in basin	D	C-	C-	Embankment on mapped gypsum area
29	Weintz Draw	Frontier Formation underlying embankement; Course colluvium	C	B	B	Field verify potential for foundation seepage
30	Upper Brokenback	Chugwater/Goose Egg at the embankment; Tensleep/Amsden, Madison in basin	D	C-	C-	Embankment on mapped gypsum area
29	Woods Gulch	Mowry and Thermopolis shales at embankment and in pool area; Cloverly/Morrison, Sundance/Gypsum Springs, and Chugwater/Goose Egg in basin	B	B	C	No outstanding geologic risk evident at the embankment
30	Alkali Creek South	Cloverly/Morrison at embankment and in pool area; Sundance/Gypsum Springs and Chugwater/Goose Egg in basin	B	B	C	No outstanding geologic risk evident at the embankment

Table 1 Reservoir Site Evaluation

ID	Dam and Reservoir Site Name	Description of site geology	Rating: Dam embankment foundation	Rating: Reservoir pool area	Rating: Contributing watershed	Note
31	South Fork Otter (Lower)	Tensleep/Amsden at embankment and in pool; Chugwater/Goose Egg in pool; Tensleep/Amsden, Chugwater/Goose Egg, Madison limestone, basement Gneiss in basin; mapped landslide in pool	C	C-	C-	Embankment on edge of mapped gypsum area, field verify Gypsum Springs versus Tensleep/Amsden mapping, field verify condition of Tensleep, field verify mapped landslide in pool
32	South Fork Otter (Upper)	Tensleep/Amsden at embankment; Madison Limestone in pool; Gneiss in basin; faulting near embankment and in basin; mapped landslide in pool and near embankment	D	D	D	Karst risk from ACE layer, verify structure near embankment, field verify mapped landslides
33	Canyon Creek	Madison limestone, Chugwater/Goose Egg, Tensleep/Amsden at embankment and in pool; Tensleep/Amsden and Madison in basin; fault at the embankment; mapped landslide deposits near embankment	D-	D	D	Karst risk from ACE layer, verify structure and landslides near embankment
34	Lone Tree	Tensleep/Amsden, Goose Egg, and Gypsum Springs near embankment, pool and basin; Madison and Gallatin in basin; faulting near pool	D	D	D	Embankment within mapped Gypsum area
35	North Brokenback	Tensleep/Amsden at embankment and in pool; Madison/Darby in basin	C+	C+	D	Field verify Tensleep condition

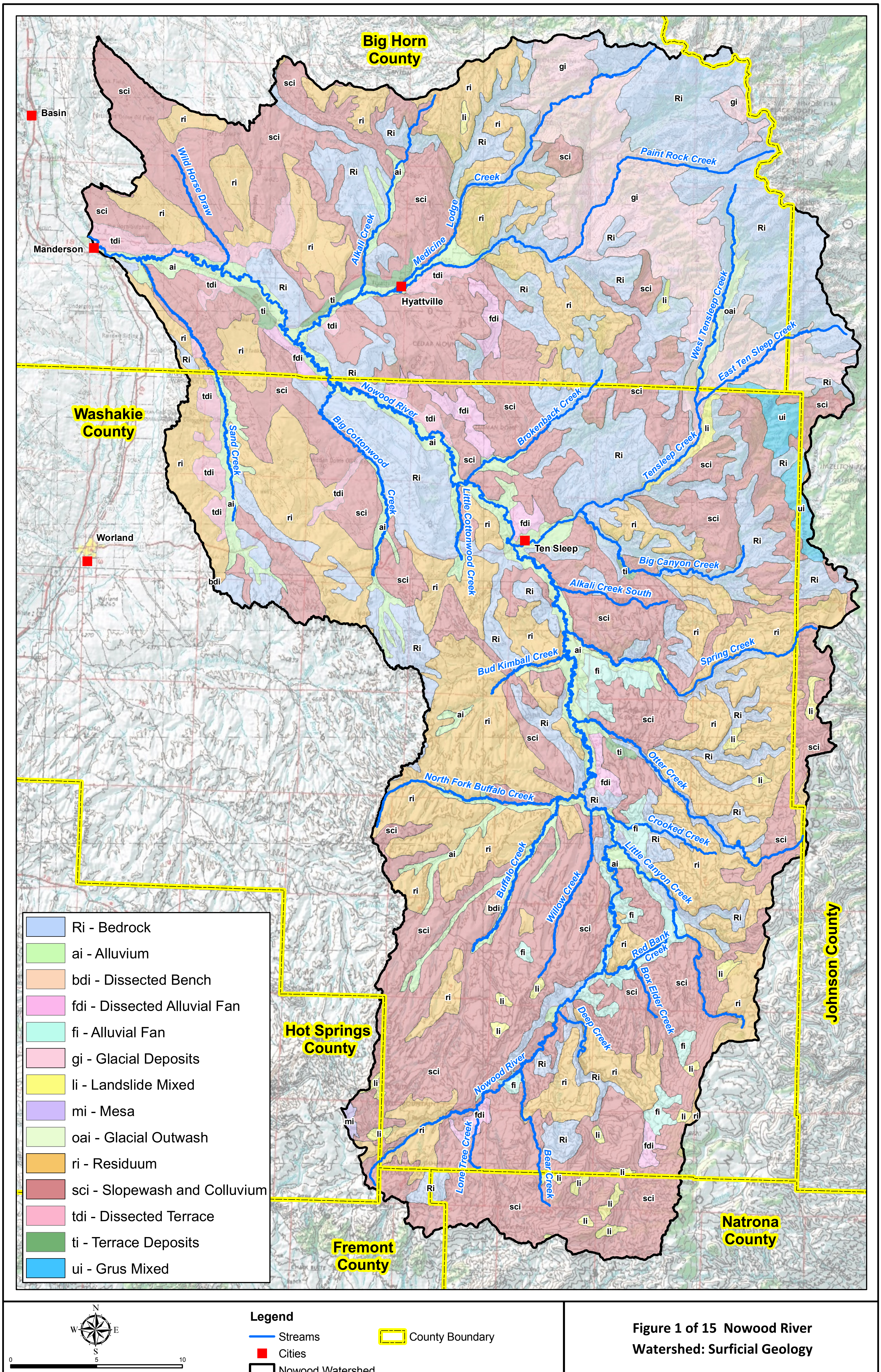

Figure 1 of 15 Nowood River Watershed: Surficial Geology

P:\WYWDC29_Nowood\GIS\Figures\Nowood_Surficial_Geology.mxd

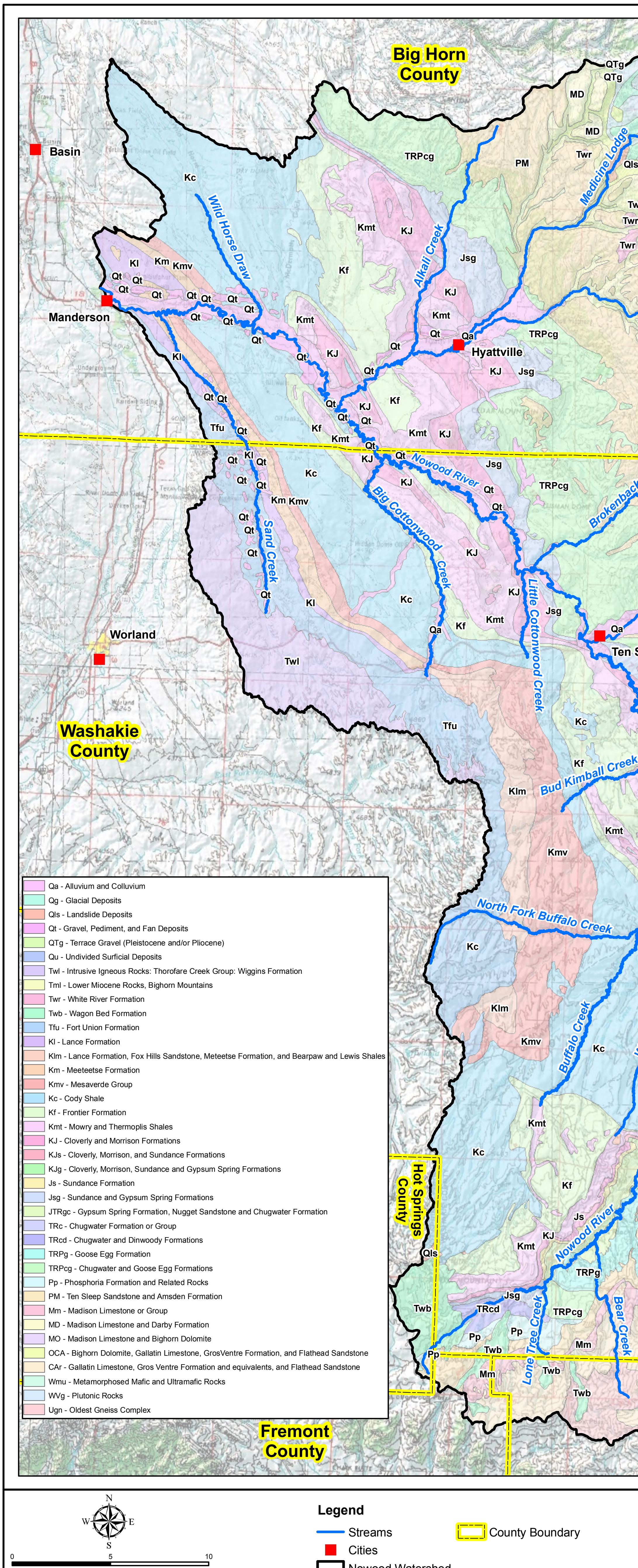

Figure 2 of 15 Nowood River Watershed: Bedrock Geology

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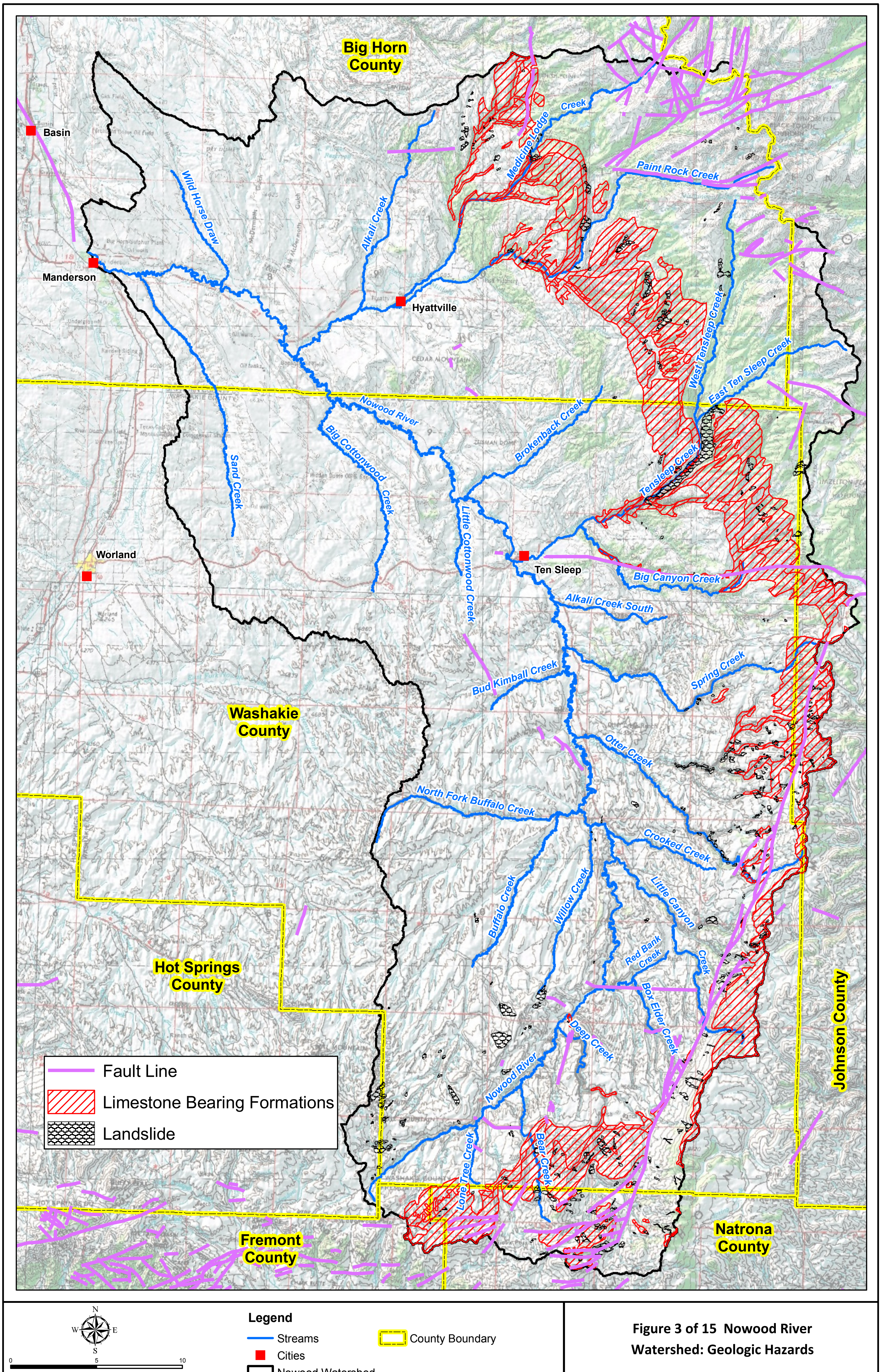

Figure 3 of 15 Nowood River Watershed: Geologic Hazards

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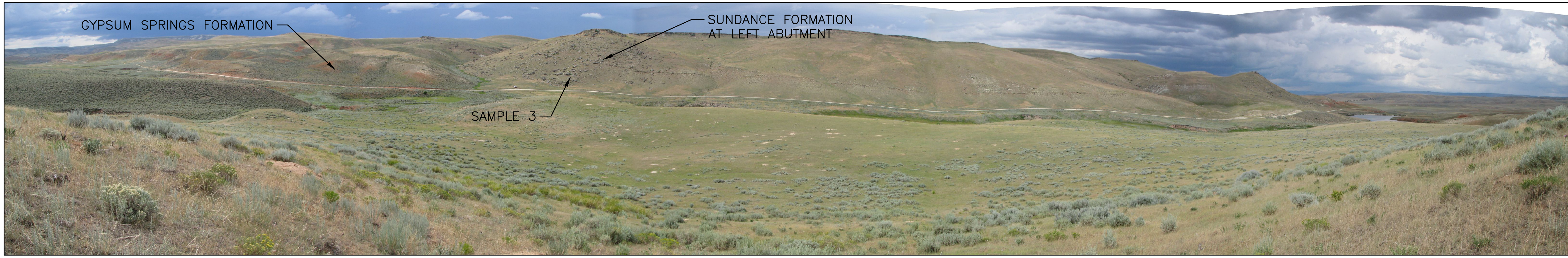
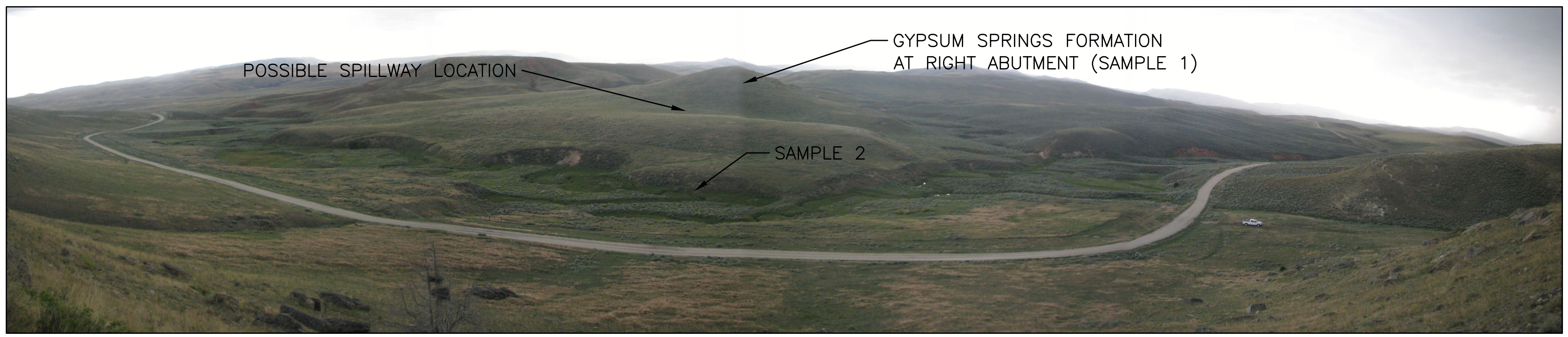
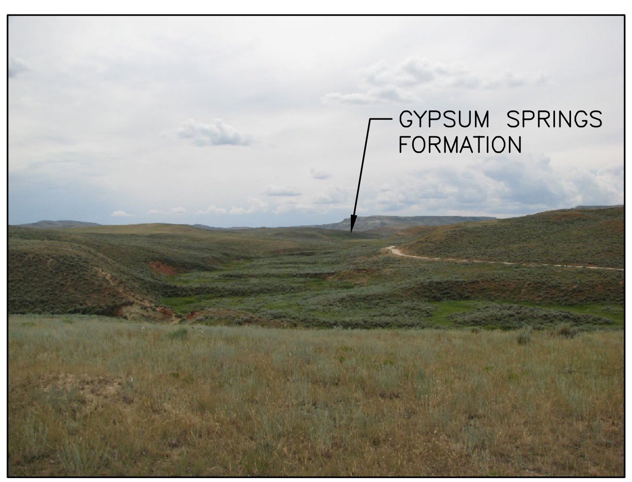


(A) **VIEW OF LEFT ABUTMENT**



(B) **VIEW OF RIGHT ABUTMENT**



(C) **DRAINAGE BOTTOM UPSTREAM OF EMBANKMENT LOCATION**

(D) **DOWNSTREAM RESERVOIR**

NOTES:

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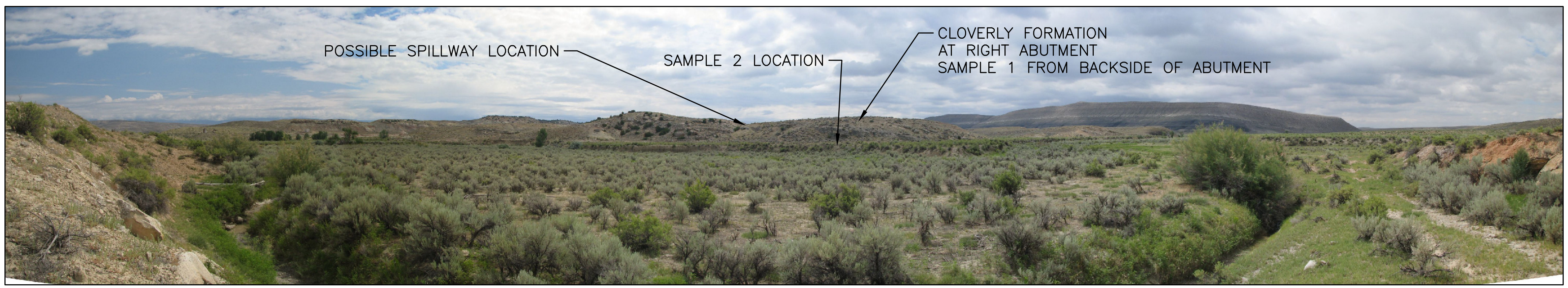
FIGURE 4 OF 15

NOWOOD-CRAWFORD SITE PHOTOS

NOWOOD RIVER WATERSHED STUDY

Drawn By: JM	Checked By: JF	Scale: N/A	Date: 9/4/09	File: NOWOOD-CRAWFORD

A VIEW OF LEFT ABUTMENT



B VIEW OF RIGHT ABUTMENT

NOTES:

1. PHOTOS TAKEN ON JULY 28, 2009.

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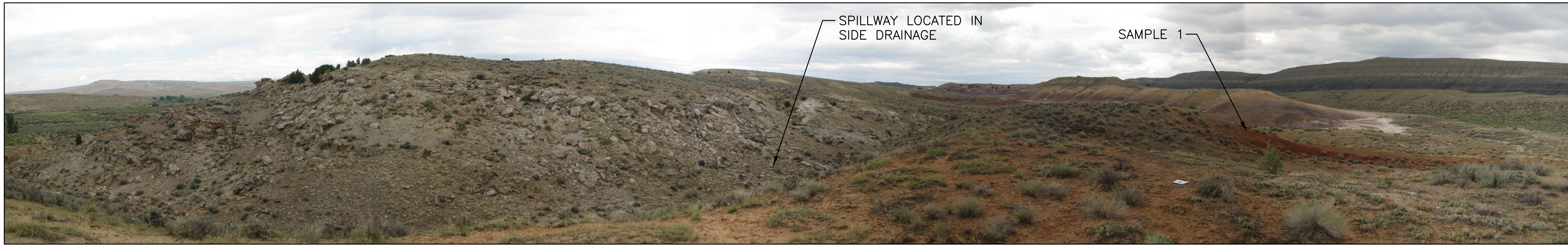
FIGURE 5 OF 15

COTTONWOOD CREEK SITE PHOTOS

NOWOOD RIVER WATERSHED STUDY

Drawn By: JM	Checked By: JF	Scale: N/A	Date: 9/4/09	File: COTTONWOOD



(A) VIEW OF POSSIBLE SPILLWAY LOCATION

(B) SMALL CAVE AT BASE OF LEFT ABUTMENT

NOTES:

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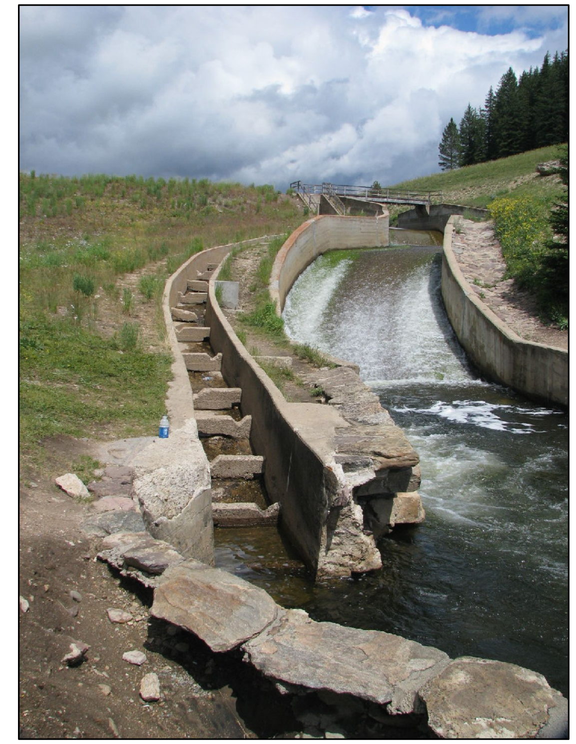
FIGURE 6 OF 15

COTTONWOOD CREEK SITE PHOTOS

NOWOOD RIVER WATERSHED STUDY

Drawn By:	Checked By:	Scale:	Date:	File:
JM	JF	N/A	9/4/09	COTTONWOOD

A UPSTREAM FACE OF EMBANKMENT



C SPILLWAY AND FISH LADDER

E EROSION DOWNSTREAM OF FISH LADDER

B PRIMARY OUTLET CHANNEL

D DOWNSTREAM END OF PRIMARY OUTLET CHANNEL

F EROSION DOWNSTREAM OF SPILLWAY ALONG LEFT BANK

NOTES:

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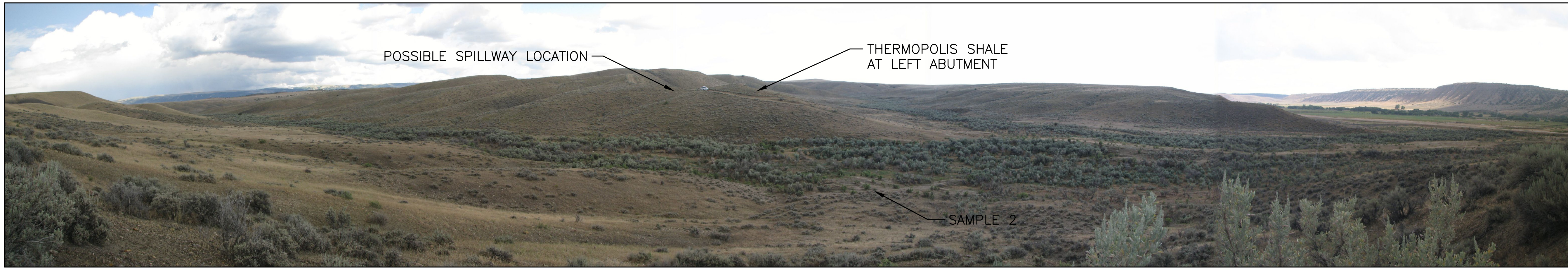
FIGURE 7 OF 15

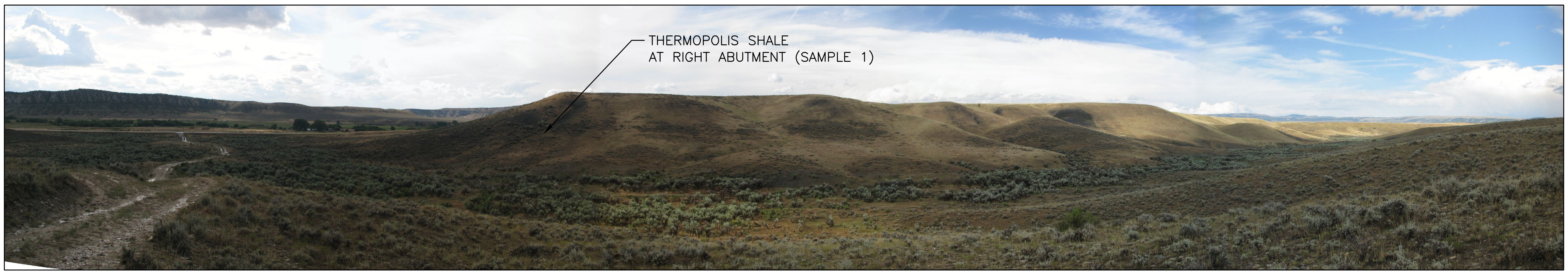
MEADOWLARK LAKE SITE PHOTOS

NOWOOD RIVER WATERSHED STUDY

Drawn By:	Checked By:	Scale:	Date:	File:
JM	JF	N/A	9/4/09	MEADOWLARKLAKE



(A) VIEW OF LEFT ABUTMENT



(B) VIEW OF RIGHT ABUTMENT

(C) DRAINAGE BOTTOM UPSTREAM OF EMBANKMENT LOCATION

NOTES:

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FIGURE 8 OF 15

TAYLOR DRAW SITE PHOTOS

NOWOOD RIVER WATERSHED STUDY

Drawn By:	Checked By:	Scale:	Date:	File:
JM	JF	N/A	9/4/09	TAYLORDRAW

A VIEW OF LEFT ABUTMENT

B VIEW OF RIGHT ABUTMENT

NOTES:

1. PHOTOS TAKEN ON JULY 29, 2009.

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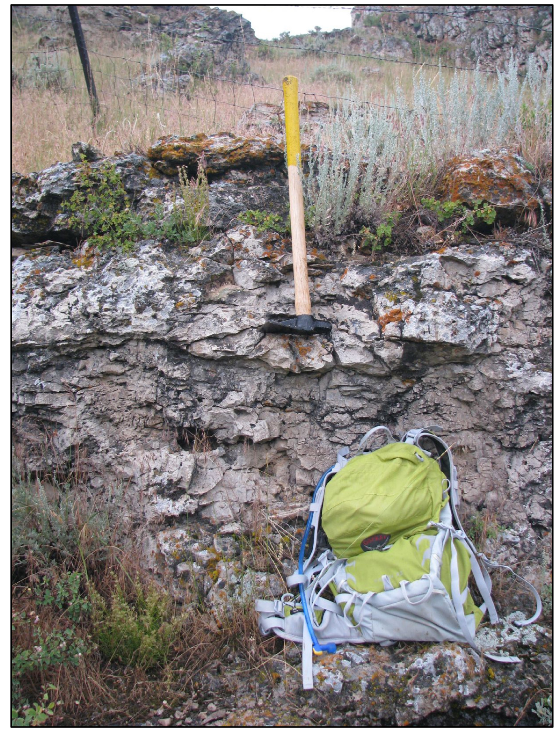
FIGURE 9 OF 15

DEEP CREEK SITE PHOTOS

NOWOOD RIVER WATERSHED STUDY

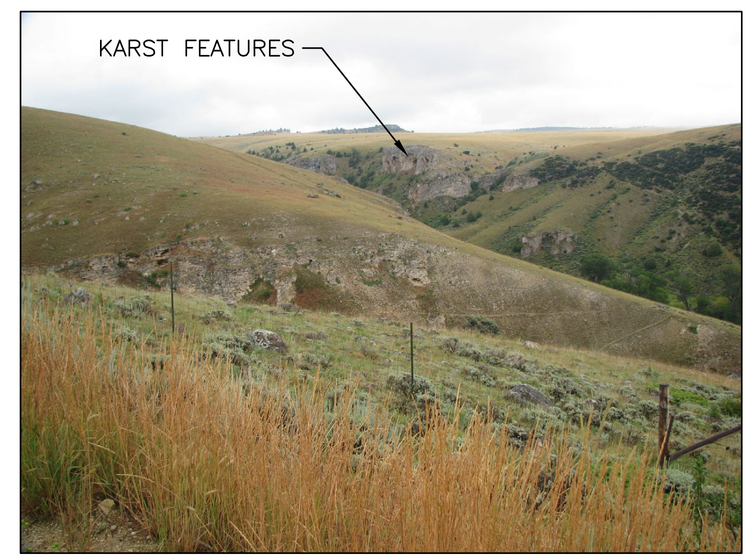
Drawn By:	Checked By:	Scale:	Date:	File:
JM	JF	N/A	9/4/09	DEEPCREEK



A LIMESTONE OUTCROP NEAR LEFT ABUTMENT

C SMALL KARST FEATURE IN LIMESTONE NEAR EMBANKMENT ALIGNMENT

B SOLUTION FEATURE IN OUTCROP NEAR LEFT ABUTMENT



D LARGE KARST FEATURES IN LIMESTONE DOWNSTREAM OF EMBANKMENT

NOTES:

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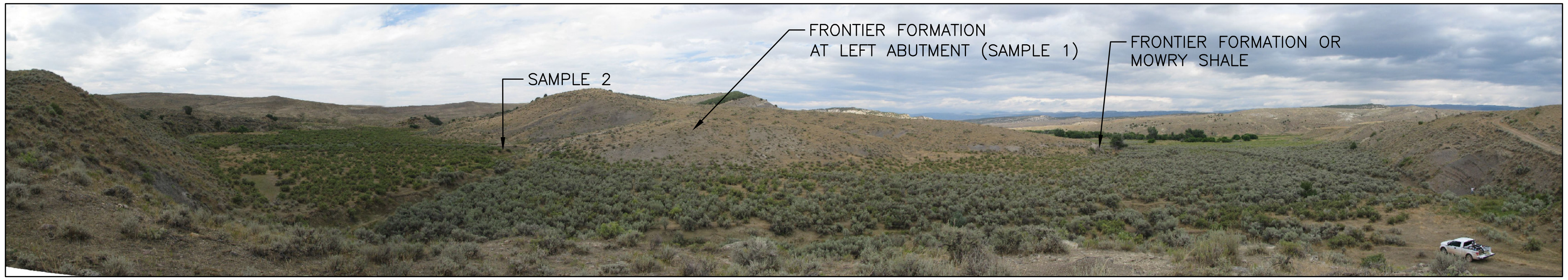
FIGURE 10 OF 15

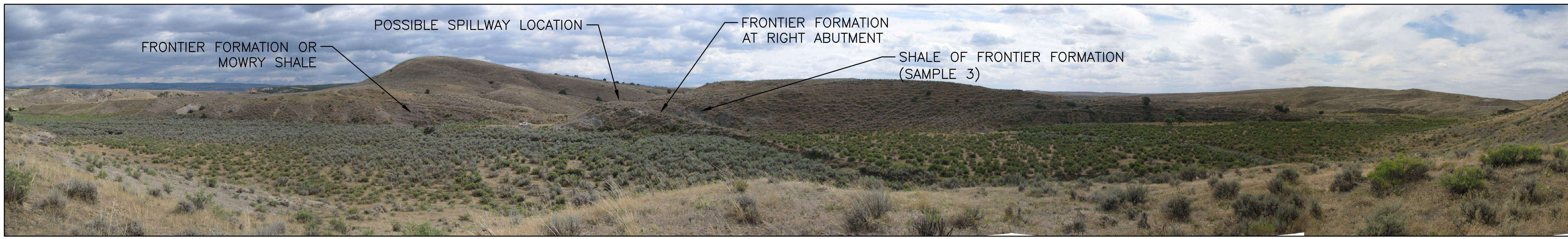
DEEP CREEK SITE PHOTOS

NOWOOD RIVER WATERSHED STUDY

Drawn By:	Checked By:	Scale:	Date:	File:
JM	JF	N/A	9/4/09	DEEPCREEK



A VIEW OF LEFT ABUTMENT



B VIEW OF RIGHT ABUTMENT

C DRAINAGE BOTTOM UPSTREAM OF EMBANKMENT LOCATION

NOTES:

1. PHOTOS TAKEN ON JULY 29, 2009.

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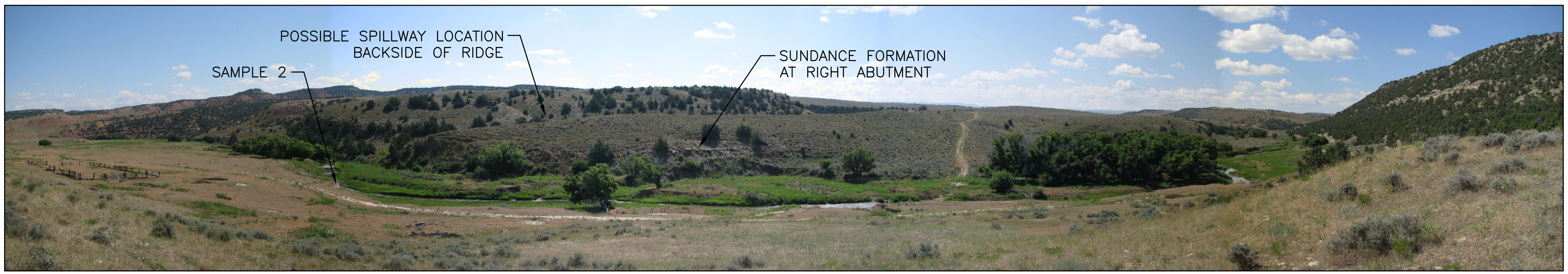
FIGURE 11 OF 15

BRUNER GULCH SITE PHOTOS

NOWOOD RIVER WATERSHED STUDY

Drawn By:	Checked By:	Scale:	Date:	File:
JM	JF	N/A	9/4/09	BRUNERGULCH

(A) VIEW OF LEFT ABUTMENT



(B) VIEW OF RIGHT ABUTMENT

(C) VIEW OF POSSIBLE SPILLWAY CHANNEL
BEHIND RIDGE AT RIGHT ABUTMENT

NOTES:

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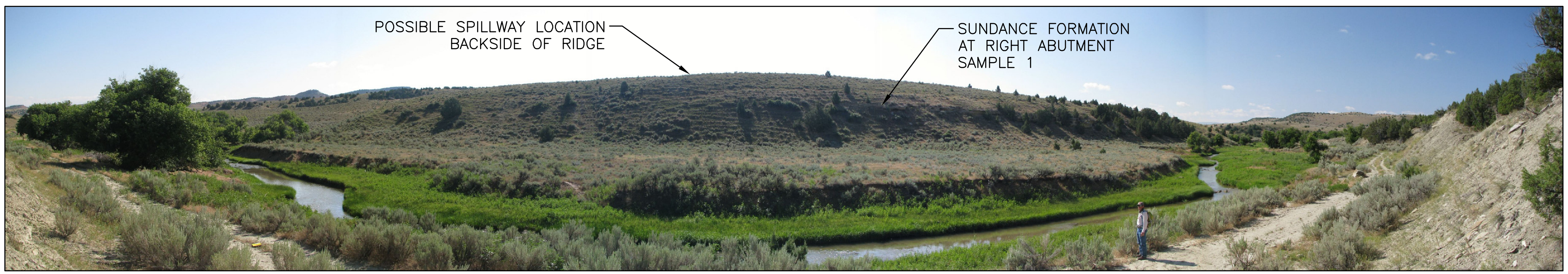
FIGURE 12 OF 15

UPPER NOWOOD LOWER SITE PHOTOS

NOWOOD RIVER
WATERSHED STUDY

Drawn By:	Checked By:	Scale:	Date:	File:
JM	JF	N/A	9/4/09	UPPERNOWOOD

A VIEW OF LEFT ABUTMENT



B VIEW OF RIGHT ABUTMENT

C VIEW OF POSSIBLE SPILLWAY CHANNEL BEHIND RIDGE AT RIGHT ABUTMENT

NOTES:

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FIGURE 13 OF 15

UPPER NOWOOD UPPER SITE PHOTOS

NOWOOD RIVER WATERSHED STUDY

Drawn By:	Checked By:	Scale:	Date:	File:
JM	JF	N/A	9/4/09	UPPERNOWOOD

A BASE OF LEFT ABUTMENT
UPPER LOCATION

B SOIL HORIZONS AND FORMER CHANNEL BED
RIGHT BANK OF NOWOOD RIVER

NOTES:

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FIGURE 14 OF 15

UPPER NOWOOD SITE PHOTOS

NOWOOD RIVER
WATERSHED STUDY

Drawn By:	Checked By:	Scale:	Date:	File:
JM	JF	N/A	9/4/09	UPPERNOWOOD

A **VIEW OF RIGHT ABUTMENT SHOWING CONTACT BETWEEN SUNDANCE AND GYPSUM SPRINGS**

B **VIEW OF LEFT ABUTMENT SHOWING SANDSTONE CAP OVER GYPSUM**

NOTES:

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FIGURE 15 OF 15

BIG TRAILS SITE PHOTOS

NOWOOD RIVER WATERSHED STUDY

Drawn By:	Checked By:	Scale:	Date:	File:
JM	JF	N/A	9/4/09	BIGTRAILS

APPENDIX I

ENTITY FORMATION

IRRIGATION DISTRICTS:

This entity is covered in Chapter 7 of Title 41 of the Wyoming Statutes (W.S. 41-7-101 through 1006). An irrigation district is created by a petition to the district court. The lands to be included in the district must be defined and the state engineer is included in the approval process. With existing ditch system, the state engineer approval is usually a mylar map showing the district boundaries and detailing all of the water rights within the district boundaries.

■ An irrigation district is a subdivision *of* the state and as such is capable o£ contracting with the Water Development Commission for funds.

■ The district is split into commissioner districts. A commissioner is elected from each district and function to direct the operation *of* the district.

■ All actions of the District must be approved by the district court.

■ For all non-federal districts, after approval *of* assessment schedule by the district court, the assessments are collected by the county and forwarded to the district for their operation.

■ The District can define their operations through the establishment *of* by-laws.

■ District can act on behalf *of* the landowners in water right matters.

■ Wyoming Statute 41-7-210 lists a number *of* powers for an irrigation district as follows:

- ■ To sue and be sued;
- ■ To adopt and use a corporate seal; .To have perpetual succession;
- ■ To file on and acquire the right to use of water for domestic and irrigation purposes; to acquire sites for reservoirs, and rights *of* way for ditches, canals and laterals;
- ■ To exercise the power *of* eminent domain under chapter 316 (C.S. 1920), and all acts or parts *of* acts amendatory thereto;
- ■ To contract with the state of Wyoming for the reclamation and segregation of public lands pursuant to the laws of the United States and the state of Wyoming and to contract for the sale of water rights by it acquired pursuant to said laws, and to purchase and acquire state lands;
- ■ To acquire by purchase or otherwise irrigation works, water rights, land and other property and to sell, lease or otherwise dispose of the same, to buy, develop, sell and distribute electrical energy as an incident to the ownership, control and operation of irrigation works of the district or the cooperative works of

the district and the United States as the district may deem expedient or suitable for the development of the district.

- Irrigation districts formed under Wyoming Statute 41-7-201 through 210 are exempt from sale tax (Wyoming Statute 39-6- 405) .

- The District must advertise for bids on work which will exceed $7,500.

WATERSHED IMPROVEMENT DISTRICTS:

This district is formed under Chapter 8, Title 41 of the Wyoming Statutes.

- District can receive grants and loans from the Water Development Commission.
- District for the prevention and control of erosion, floodwater and sediment damages.
- District may be formed as a subdistrict of conservation districts.
- The land area of a district must lie within the same or adjoining watershed or sub-watershed areas.
- Formed by filing a petition with the board of supervisors of the conservation district.
- District formed by referendum vote after board of supervisors holds a public hearing.
- Board of supervisors holds election for board of directors who will be the governing body for the watershed improvement district.
- Main powers listed in Wyoming Statute 41-8-113:
    - Levy and collect assessments for special benefits accruing to lands
    - Acquire by purchase, exchange, lease, gift, grant, bequest, devise, or otherwise, any property, real or personal, or rights or interests therein; maintain, administer, and improve any such property; and sell, lease, or otherwise dispose of any such property in furtherance of the purposes and provisions of this act;
    - Exercise the power of eminent domain and in the manner provided by law for the condemnation of private property for public use;
    - Construct, improve, operate and contract for the maintenance of such structures as may be necessary for the performance of any authorized function of the watershed improvement district;
    - Borrow such money as is necessary to carry out any of the purposes and provisions of this act, and issue, negotiate, sell its bonds or other evidence of indebtedness as provided in section 14[41-8-114];
    - Cooperate with, and receive from or grant assistance to, towns, cities, counties, and state and federal agencies in carrying out the purposes and provisions of the act.

WATER CONSERVANCY DISTRICTS:

These districts are formed under Article 7, Chapter 3 of Title 41 of the Wyoming Statutes. The District is to provide for the conservation of water resources of the state of Wyoming and for the greatest beneficial use of water within this state.

- The organization of water conservancy districts and the construction of works as herein defined by such districts are a public use and will:
  - Be essentially for the public benefit and advantage of the people of the state of Wyoming;
  - Indirectly benefit all industries of the state;
  - Indirectly benefit the state of Wyoming in the increase of its taxable property valuation;
  - Directly benefit municipalities by providing adequate supplies of water for domestic use;
  - Directly benefit lands to be irrigated or drained from works to be constructed;
  - Directly benefit lands now under irrigation by stabilizing the flow of water in streams and by increasing flow and return flow of water to such streams;
  - Promote the comfort, safety and welfare of the people of the, state of Wyoming, and it is therefore declared to be the policy of the state of Wyoming:
    - To control, make use of and apply to beneficial use all unappropriated water in this state to a direct and supplemental use of such water for domestic, transportation, industrial, manufacturing, irrigation, power, recreation and other beneficial uses;
    - To obtain from water in Wyoming the highest duty for domestic uses and irrigation of lands in Wyoming within the terms of interstate compacts;
    - To cooperate with the United States under the federal reclamation laws now existing, or hereafter enacted, and agencies of the state of Wyoming for the construction and financing of works in the state of Wyoming as herein defined and for the operation and maintenance thereof;
    - To promote the greater prosperity and general welfare of the people of the state of Wyoming by encouraging the organization of water conservancy districts.

- A water conservancy district is formed by petition to the district court.

- The district court must hold a hearing on the formation of the district and the state engineer shall become an interested party in all court proceedings.

- Subdistricts may be formed upon petition of the district court.

- District controlled by a board of directors.

- General powers:
  - To have perpetual succession;
  - To obtain or dispose of water, water works, water rights and sources of water supply; to acquire construct or operate, control and use any and all works, facilities and means necessary or convenient to the exercise of its powers.
  - To have and to exercise the power of eminent domain.
  - To construct and maintain works and establish and maintain facilities and obtain the necessary rights-of-ways for same.
  - To contract with the United States or any agency thereof , or with an agency of the state of Wyoming
  - To list in separate ownership the lands within the district which are susceptible of irrigation from district sources and to make an allotment of water to all such lands; to levy assessments.
  - To fix rates at which water not allotted to lands shall be sold, leased or otherwise disposed of.
  - To enter into contracts, employ and retain personal services and employ laborers; to create, establish and maintain such offices and positions as shall be necessary and convenient for the transaction of business of the district; and to elect, appoint and employ such officers, attorneys, agents and employees therefore as shall be found by the board to be necessary.
  - To adopt plans and specifications for the works for which the district was organized.
  - To appropriate and otherwise acquire water and water rights within or without the state for use within the district.
  - To invest any surplus money in the district treasury .To adopt rules and regulations for investing funds. .To incur bonded indebtedness and to borrow money. .To adopt by-laws.

- The district is capable of contracting with the Water Development Commission for funds.

Districts	Authority	Purpose	Formation	Structure	Authorities	Funding
Watershed Improvement Districts	WS 41-8-101 through 41-8-126	Provide for the prevention and control of erosion, floodwater and sedimentation damages, ag uses, and the storage, conservation development, utilization and disposal of water, preserve and protect land and water resources	-Petition to the Conservation District Board of Supervisors. -Hearing and referendum held. - A majority of votes representing the majority of acreage must be obtained to form the district.	-5 member board elected by electors and landowners within the district -Board members Must be landowners within the district -Annually elected on staggered terms	-Levy and collect assessments -Acquire, maintain, and dispose of property -Have power of eminent domain -Construct structures -Borrow money -Cooperate with towns, cities, counties, state and federal agencies	-Levy taxes - Obtain grants and receive gifts -Issue Bonds

ATTACHMENT G

Districts	Authority	Purpose	Formation	Structure	Authorities	Funding
Irrigation Districts	WS 41-7-101 through 41-7-1006	Provide irrigation; improve the existing water supply; or purchase, extend, operate, or maintain constructed irrigation works; or to cooperate with the United States under the federal reclamation laws.	-Petition to the County District Court -Majority of private landowners embracing the majority of the land must sign petition to be valid. -Hearings are held by the court -Court makes the final decision to form district	-3 or 5 commissioners appointed by the court and at all times under the direction of the court. -After original appointments, commissioners are elected by landowners within the district. -Staggered terms -Landowners may cast 1 vote per irrigable acre.	-Established and have the powers of a corporation -Own, operate, maintain, construct, improve, or purchase any irrigation works. -Powers of eminent domain -Acquire water rights. -Court can levy assessments to be enforced by commissioners. -Perpetual succession -Undertake hydroelectric power projects	-Levy assessments -Obtain grants and receive gifts -Issue interest bearing warrants

Districts	Authority	Purpose	Formation	Structure	Authorities	Funding
Water Conservancy Districts	WS 41-3-701 through 41-3-779	Provide for the conservation of water resources; provide adequate municipal water supplies; benefit irrigation by stabilizing the flow of water in streams by increasing stream flows; to control, make use of and apply to beneficial use of all unappropriated water; promote the comfort, safety and welfare of Wyoming citizens	-Petition filed with the clerk of District court -Petition signed by at least 25% of the owners on not less than 25% of irrigated land. -Bond filed with petition to cover formation costs. -Hearing held by the District court or judge -State Engineer becomes an interested party -District court determines if district is feasible -District becomes a corporation	-District court appoints a board of directors consisting of not less than 5 or more than 9 -Board members must be landowners within the proposed district. -Staggered terms -After the initial appointment, directors are then elected by landowners within the district -Subdistricts can be formed	-Perpetual succession -Hold water rights; own and control water works and sources of supply; own real and personal property - Power of eminent domain -Construct and maintain water works -Enter into maintenance contracts with the state -Allocate water within the district -Sell or lease water -Acquire water rights -Borrow money -Invest money	-Levy and collect taxes -Issue bonds -Obtain grants and receive gifts