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Water Resources Data System
University of Wyoming, Dept 3943
1000 E University Avenue
Laramie, WY 82071

Physical Address:
Wyoming Hall, Room 249
University of Wyoming
Laramie, WY 82071

Phone: (307) 766-6651
Fax: (307) 766-3785

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GOOSE CREEK WATERSHED
LEVEL I STUDY

Prepared for:

Wyoming Water Development Commission

Submitted by:

EnTech Inc.
Professional Engineers
1949 Sugarland Drive, Suite 205
Sheridan, WY 82801

In association with

SWCA ENVIRONMENTAL CONSULTANTS
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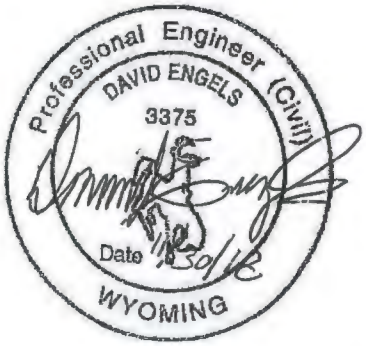
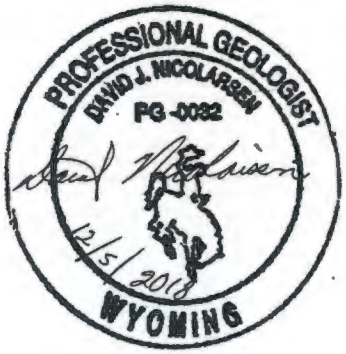
Anderson Consulting Engineers, Inc
Civil • Water Resources • Environmental

November, 2018

GOOSE CREEK WATERSHED
LEVEL I STUDY





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APPENDICES

APPENDIX A: PROPOSED PROJECTS, COST ESTIMATES AND MAPS FOR WATERSHED MANAGEMENT AND REHABILITATION PLAN

LIST OF ACRONYMS

ACRONYM	DEFINITION
A-F	Acre-feet
ACEP	Agricultural Conservation Easement Program
AL	Alliance Lateral Ditch
AMA	Agricultural Management Assistance
BGEPA	Bald and Golden Eagle Protection Act
BGWTP	Big Goose Water Treatment Plant
BLM	Bureau of Land Management
BMPs	Best Management Practices
BNF	Bighorn National Forest
BOC	Board of Control
CBM	Coal Bed Methane
CFR	Code of Federal Regulations
cfs	Cubic Feet per Second
CIG	Conservation Innovation Grants
City	City of Sheridan
CMP	Corrugated Metal Pipe
County	Sheridan County
CRISP	Cultural Research Information Summary
CRMStat	Database used to convey sensitive archaeological site data
CRMTracker	Cultural Resource Management Tracker
CRP	Conservation Reserve Program
CSP	Conservation Stewardship Program
CWA	Clean Water Act
DDCT	Density and Disturbance Calculation Tool
DEM	Digital Elevation Model
DU	Ducks Unlimited
ECP	Emergency Conservation Program
EE	Environmental Evaluation
EIS	Environmental Impact Statement
EnTech	EnTech, Inc. Professional Engineers
EQIP	Environmental Quality Incentives Program
ESA	Endangered Species Act
ESD	Ecological Site Description
ETS	Enterprise Technology Services
EWPP	Emergency Watershed Protection Program
FAO	Food and Agriculture Organization of the United Nations
FEMA	Federal Emergency Management Agency
FM	Fisheries Mitigation
FSA	Farm Service Agency
FWP	Farmable Wetlands Program
GAP	Gap Analysis Program

ACRONYM	DEFINITION
GIS	Geographic Information System
gpm	Gallons Per Minute
ha	Hectare
HUC	Hydrologic Unit Code
I&S	Improvement and Service District
IPaC	Information for Planning and Conservation
ISI	Irrigation System Infrastructure
LANDFIRE	Landscape Fire and Resource Management Planning Tools Project
LANDSAT	Land and Remote Sensing Satellite
MBTA	Migratory Bird Treaty Act
meq/L	Milli-equivalents Per Liter
MG	Million Gallons
mg/L	Milligrams Per Liter
MGD	Million Gallons per Day
µg/L	Micrograms Per Liter
MLRA	Major Land Resource Area
MRG	Mineral Royalty Grant
NAD	North American Datum
NEPA	National Environmental Policy Act
NFWF	National Fish and Wildlife Foundation
NHPA	National Historic Preservation Act
NOAA	National Oceanic and Atmospheric Administration
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NREX	Natural Resource and Energy Explorer
NRHP	National Register of Historic Places
NVC	National Vegetation Classification
NWI	National Wetland Inventory
NWS	National Weather Service
OSLI	Office of State Lands and Investment
pCi/L	Picocuries Per Liter
PCN	Pre-construction Notification
PDWSC	Prairie Dog Water Supply Company
PLSS	Public Land Survey System
ppt	Parts Per Thousand
PRfV	Pressure Relief Valve
PRV	Pressure Reducing Valve
PSC	Public Service Commission
RCPP	Regional Conservation Partnership Program
SAR	Sodium Adsorption Ratio
SAWSJPB	Sheridan Area Water Supply Joint Powers Board
SCCD	Sheridan County Conservation District
SDVC	Spatial Data Visualization Center

ACRONYM	DEFINITION
SGI	Sage Grouse Initiative
SHPO	State Historical Preservation Office
SLIB	State Loan and Investment Board
SMUs	Soil Mapping Units
SRF	State Revolving Fund
State	State of Wyoming
SWPP	Small Water Projects Program
SWSO	Surface Water Storage Opportunity
SWTP	Sheridan Water Treatment Plant
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
USACOE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USFS	U.S. Forest Service
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
UWDO	Upland Water Development Opportunity
VAMC	Veterans Affairs Medical Center
WACD	Wyoming Association of Conservation Districts
WaterSMART	Sustain and Manage America's Resources for Tomorrow
WDEQ	Wyoming Department of Environmental Quality
WFPO	Watershed Protection and Flood Prevention Operations
WG&FD	Wyoming Game & Fish Department
WISDOM	Wyoming Interagency Spatial Database and Online Management System
WMA	Weed Management Area
WOGCC	Wyoming Oil and Gas Conservation Commission
WPA	Wyoming Pipeline Authority
WR	Wild Rose
WRCC	Western Regional Climate Center
WSEO	Wyoming State Engineer's Office
WSFR	Wildlife and Sport Fish Restoration
WSGS	Wyoming State Geological Survey
WSP	Watershed Surveys and Planning
WSS	Web Soil Survey
WWDC	Wyoming Water Development Commission
WWDO	Wyoming Water Development Office
WWNRT	Wyoming Wildlife and Natural Resource Trust
WWTP	Wastewater Treatment Plant
WYCRO	Wyoming Cultural Records Office

ACRONYM	DEFINITION
WyDOT	Wyoming Department of Transportation
WyGISC	Wyoming Geographic Information Science Center
WYNDD	Wyoming Natural Diversity Database
WYPDES	Wyoming Public Discharge Elimination System

1. INTRODUCTION AND OVERVIEW

1.1. Introduction

In 2015, the Sheridan County Conservation District (SCCD) of Sheridan County, Wyoming requested that the Wyoming Water Development Commission (WWDC) conduct a comprehensive study of the Goose Creek watershed in Sheridan and Johnson Counties. The SCCD made this request because it had received requests to sponsor such a study due to concerns with existing irrigation infrastructure and efficiency within this watershed area. A Level I study was previously required by the WWDC to become eligible for monies that the WWDC makes available for projects that can be used to improve such infrastructure and efficiency. While the SCCD, in working with the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS), has been successful in completing several irrigation structure projects within the Goose Creek watershed over the past few years (most notably, improvements to the Flume Ditch, the Robinson Hardee Ditch and the Heald Ditch), the SCCD believes that additional funding is necessary to address the numerous infrastructure deficiencies that currently exist.

In 2016, the Wyoming State Legislature appropriated funding for the Goose Creek Watershed Level I Study and, soon after, the WWDC entered into a contract with EnTech, Inc. Professional Engineers of Sheridan (EnTech) to provide the necessary services to prepare this watershed study. As the name implies, this Goose Creek Watershed Level I Study is a detailed evaluation and inventory of the water and land resources within the study area. Its principal purposes are to evaluate watershed function, assess upland, wetland and riparian conditions, develop geomorphic classifications, and identify resource concerns and water development opportunities within the watershed.

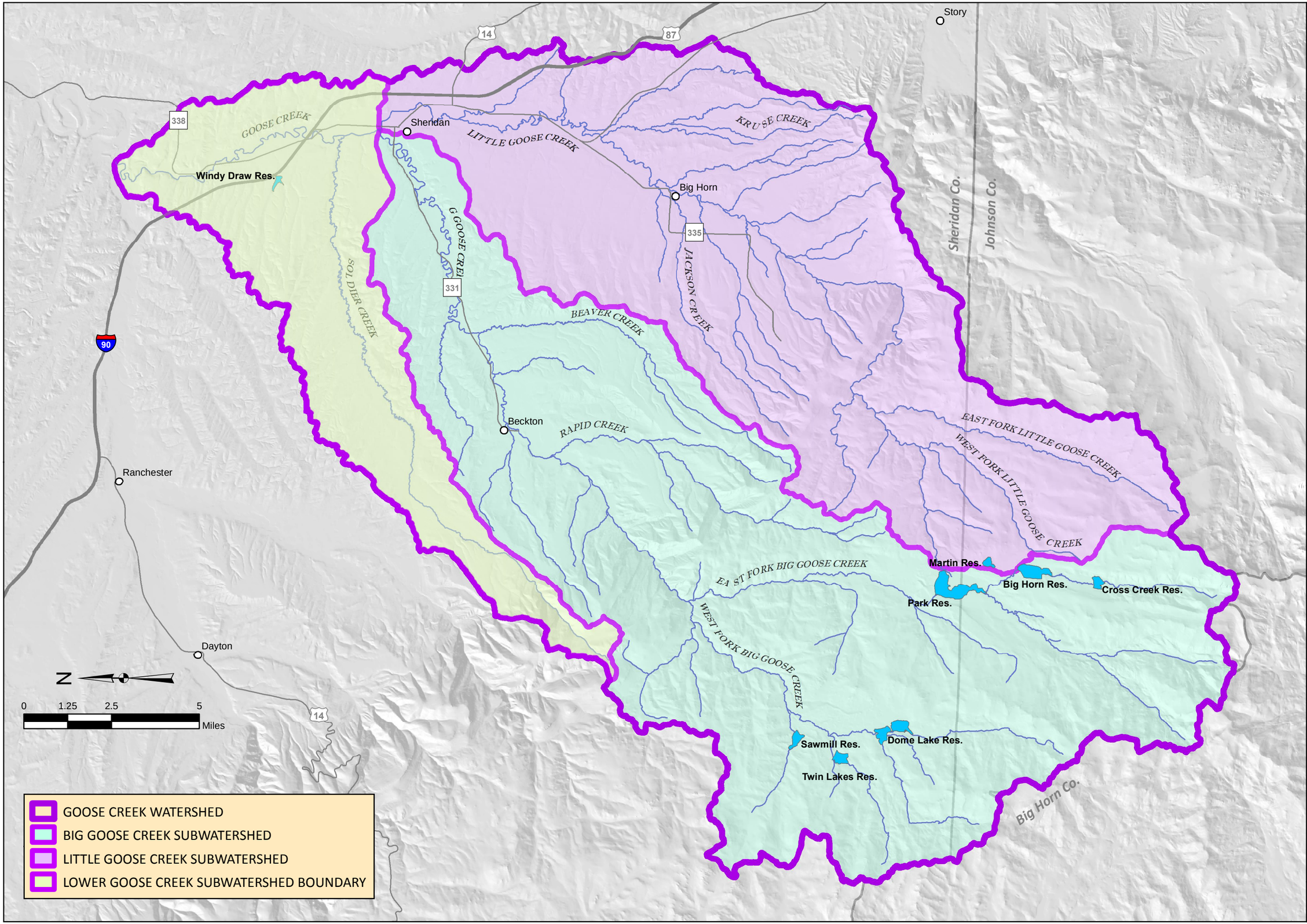
1.2. Project Overview

The Level I study area is defined as a subbasin of the Tongue River delineated in the United States Geological Survey (USGS) Hydrologic Unit Code as HUC10 – 1009010102, named as Big Goose Creek. Figure 1.2.1 shows the general location of the watershed within the State of Wyoming (State), and Figure 1.2.2 portrays the watershed itself. Henceforth throughout this study, the Goose Creek Watershed Level I Study will also be referred to as "the Level I Study". The Goose Creek watershed will also be referred to as "the Watershed" and as "the Level I Study Area".

The total area encompassed by the Watershed is 415.4 square miles. For ease of identification and discussion within the Level I Study, the Watershed has been divided into three principal subwatersheds, all shown in Figure 1.2.2:

- Big Goose Creek Subwatershed, containing 203.4 square miles and encompassing the following HUC12 watersheds:
  - 100901010201;
  - 100901010202;
  - 100901010203;
  - 100901010204;
  - 100901010205;
- Little Goose Creek Subwatershed, containing 150.9 square miles and encompassing the following HUC12 watersheds:
  - 100901010206;
  - 100901010207;
  - 100901010208; and

EnTech Inc. Professional Engineers	SWCA / Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	***GOOSE CREEK WATERSHED LEVEL I STUDY***	***VICINITY MAP***	***FIG. 1.2.1***



LOCATION MAP

GOOSE CREEK WATERSHED
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FIG. 1.2.2

- Lower Goose Creek Subwatershed, containing 61.1 square miles and encompassing the following HUC12 watershed;
    - 100901010209.

1.3. Purpose and Scope

The primary purposes of this Level I Study are listed below:

- Develop a team approach among the SCCD, various landowners within the Watershed, and the WWDC to facilitate achievement of the groups' varied objectives.
- Foster public interest and participation in the Level I Study.
- Collect relevant available information on the Watershed.
- Describe and characterize the various attributes of the Watershed.
- Conduct a geomorphic investigation of the primary channels within the Watershed, and identify potential mitigation measures to improve impaired channel reaches.
- Identify needed water-related infrastructure within the Watershed by inventorying and characterizing existing facilities, with particular emphasis upon those facilities utilized for irrigation.
- Develop a watershed management plan which will provide recommendations on:
    - new facilities that will best utilize the water resources within the Watershed (particularly those that entail new water storage opportunities to augment water available for livestock and wildlife); and
    - improvements to existing water-related facilities.
- Include within the watershed management plan:
    - conceptual-level cost estimates associated with any recommended new facilities or improvements to existing ones;
    - an economic analysis of based upon the cost estimates identified; and
    - information on the various means of public financing available for the recommended new facilities or improvements to existing ones.
- Assemble a Geographic Information System (GIS) that will utilize the considerable amount of spatial data, background mapping and orthographic imagery currently available, as well as new data created and developed as part of this Level I Study, to enable project stakeholders and other interested parties to easily access the GIS data.
- In conjunction with assembly of the GIS, create a Digital Library that allows for access to the information that has been inventoried and developed as part of the Level I Study.

2. PROJECT MEETINGS

An important aspect of the Level I Study has been the efforts expended to engage the public. Because the end result of this document should be a tool that can be utilized again and again by interested parties, it is important that the public play a role in the development of a scope for the Level I Study. Furthermore, the public should be kept informed of the Level I Study's progress and be allowed to comment on the progress of the work. Finally, prior to submittal of the final version of the Level I Study, the public should be provided the opportunity to weigh in on the conclusions reached so that it can become the valuable tool that everyone seeks.

In order to achieve these objectives, a scoping meeting was held in Sheridan on July 7, 2016, soon after the contract between EnTech and the WWDC was executed. Not only was there an advertisement placed in The Sheridan Press announcing the meeting, but individual letters/emails were sent to all relevant water managers within the Watershed, inviting them to attend. During this first scoping meeting, EnTech outlined the Level I Study's objectives as detailed in the contract between EnTech and the WWDC. Representatives of the Wyoming Water Development Office (WWDO) were in attendance to explain the WWDC's objectives from a State perspective. Those in attendance were also requested to provide their ideas on what the study's scope should be.

Besides attempting to engage the public early on via the scoping meeting, a website was developed that outlined the objectives of the Level I Study. This website was available by both searching the web as well as through a link found on the SCCD's website.

Following the initial scoping meeting, a considerable effort was expended by EnTech to inventory existing water-related infrastructure. Meetings were scheduled and infrastructure inventories were conducted with all irrigation companies or special districts that have water diversion rates exceeding 5 cubic feet per second. Additionally, any other interested party who participated in the initial scoping and requested a similar inventory received the same level of scrutiny. A total of approximately 35 meetings and/or site visits were conducted in an effort to evaluate the various irrigation delivery systems and receive recommendations from the various interested parties.

In January, 2017, a second public meeting was held, this one utilizing an "open house" concept. As with the initial scoping meeting, an ad was placed in The Sheridan Press notifying the public of the meeting, and letters/emails were sent out to all of those parties with whom EnTech representatives had met during the previous year. The primary purpose of this meeting was to deliver to the interested parties the information that had been collected to date, the conceptual designs that had been prepared, and the conceptual-level cost estimates that had been developed. The objective of this interim meeting was to assure all stakeholders that the Level I Study was addressing the areas of concern that had been raised during the meetings and inventories that had taken place since the time of project initiation.

In June of 2017, and prior to the delivery of the draft report to the WWDC, a third public meeting was advertised and held. This meeting again utilized to a degree the "open house" concept, in that the conceptual designs and conceptual-level cost estimates that had been developed were again made available by laying out information on large tables for public dissemination. Meeting attendees were requested to review this information and provide any additional information on the work that had been completed to date. Also as part of this meeting, some of the major projects included as part of the proposed watershed and rehabilitation plan were highlighted for discussion.

Finally, in December 2017 and after incorporating review comments received from the WWDO and SCCD, a meeting was held for the purpose of informing the public about the results of the study. As part of the public meeting, a "path forward" was discussed which provided a road map to follow for stakeholders who desired to implement the projects identified in the Level I Study.

Because of the fact that the SCCD's and EnTech's offices were located in the same building for the duration of the Level I Study, there was an opportunity for considerable interaction between the project sponsor and study author. This close proximity is believed to have enhanced achieving the goal of meeting the project sponsor's expectations for the Level I Study.

3. WATERSHED DESCRIPTION AND INVENTORY

3.1 Introduction and Purpose

Considerable information is available concerning the land and water resources located within the Watershed. This section's principal purpose is to utilize this information to describe and inventory the Watershed by assimilating, reviewing and compiling the data available in reports, studies, and both digital and hard copy databases. The compiled information is then developed into a digital library and GIS systems.

This section includes information on the Watershed's key features, including, but not necessarily limited to, natural resources, land use, land ownership, zoning, climate, ecological sites, wetlands, wildlife, irrigation, hydrology, geology, soils, and vegetation. Summarized information is provided via text, tables and figures, with references cited in the last section of this Level I Study that allows the reader to locate this information online.

3.2 Data Collection and Management

3.2.1 Data Sources

Considerable amounts of information were obtained on the characteristics of this Watershed and have been incorporated into this Level I Study. Much of the accumulated data was obtained from local, state, and federal agencies, via either personal contact or by visiting online websites for these various agencies. Agencies from which information has been obtained include the following:

- City of Sheridan (City), including
    - Planning Department;
    - Engineering Department; and
    - Public Utilities Division;
- Sheridan County, including:
    - Assessor's Office;
    - Information Technology Department;
    - Engineering Department; and
    - Emergency Management Division;
- Sheridan County Conservation District (SCCD);
- Johnson County, including:
    - Information Technology Department; and
    - Planning Department;
- Wyoming Water Development Commission (WWDC);
- Wyoming State Engineer's Office (WSEO);
- Wyoming State Board of Control (BOC);
- Wyoming Department of Transportation (WyDOT);
- Wyoming Game & Fish Department (WG&FD);
- Wyoming Department of Environmental Quality (WDEQ);
- Wyoming State Geological Survey (WSGS);
- Wyoming Geographic Information Science Center (WyGISC);
- Wyoming Oil and Gas Conservation Commission (WOGCC);
- Wyoming Office of State Lands and Investments (OSLI);
- Wyoming State Loan and Investment Board (SLIB);

- Wyoming State Historical Preservation Office (SHPO) through the Cultural Records Office (WYCRO);
- U.S. Department of Agriculture (USDA), including
    - Farm Service Agency (FSA);
    - Natural Resources Conservation Service (NRCS); and
    - Forest Service (USFS), in particular the Bighorn National Forest (BNF);
- U.S. Environmental Protection Agency (EPA);
- U.S. Army Corps of Engineers (USACOE);
- Veterans Affairs Medical Center (VAMC) in Sheridan;
- U.S. Department of the Interior, including;
    - U.S. Geological Survey (USGS);
    - Bureau of Land Management (BLM);
    - U.S. Bureau of Reclamation (USBR)
    - National Park Service (NPS); and
    - U.S. Fish and Wildlife Service (USFWS);
- U.S. Department of Commerce, including:
    - National Weather Service (NWS).

3.2.2. Geographic Information System

Data collected and created for this study has been compiled and generated into a GIS using ESRI's ArcGIS 10.3.1. This format allows data to be visualized, analyzed, compared, and evaluated to interpret and understand the multiple number of resource attributes associated with this Level I Study. The use of GIS assists in integrating the spatial and tabular data associated with the attributes, and it allows for linkage of spreadsheets, reference documents, photographs, and field data. Such linkage is often referred to as a "clearinghouse approach". Generally, procedures followed included creation of ESRI ArcMap documents with a .mxd file extension. GIS data is stored in a file structure that is easily accessible and that uses a geodatabase format with feature datasets and feature classes to represent geometric locations and attributes for geographic features represented by points, lines, and polygons. Additional attributes are stored in database tables which can be joined to feature classes. All feature classes are in the North American Datum (NAD) of 1983 Universal Transverse Mercator (UTM) Zone 13 North projected coordinate system, with information stored in feet. Geographic coordinates have been stored in decimal degrees.

Spatial data collected as part of this Level I Study was obtained from many of the local, state and federal agencies listed above, with the information typically provided in electronic format via either downloading information from various websites or email transmission of various files. It was also obtained via use of equipment with GPS capabilities of sub-meter accuracy, utilizing a "data dictionary" where appropriate.

3.2.3. Digital Library

This Level I Study includes a "digital library" as a stand-alone electronic document. The digital library includes reference documents, maps, figures, spreadsheets, and images collected and produced as part of the data collection and inventorying associated with the Level I Study. It contains a list of all available documents, which can be viewed by clicking on supplied links, performing a keyword search, or merely browsing the information contained within the library.

3.3 Land Uses and Management Activities

3.3.1 Land Ownership

Land ownership within the Watershed includes federal, state and private (including City and County) interests, with the total areas and percentages for each being:

- Federal: 186.1 square miles (44.8%)
- State 14.2 square miles (3.4%)
- Private (inc. City and County) 215.1 square miles (51.8%).

415.4 square miles (100%).

Of the 186.1 square miles of federally-owned lands, they are managed by three federal agencies, as follows:

- USFS (BNF): 179.3 square miles (43.2%)
- BLM: 1.7 square miles (0.4%)
- Department of Veterans Affairs 5.1 square miles (1.2%).

186.1 square miles (44.8%).

Figure 3.3.1 depicts the various land ownerships within the Watershed.

Of the 415.4 square miles of land within the Watershed, 345.2 square miles (83.1%) of those lands are within Sheridan County, and the remaining 70.2 square miles (16.9%) of lands are within Johnson County. All of the Watershed's lands within Johnson County are also within the boundaries of the BNF, with the exception of approximately a one square mile area surrounding and including Big Horn Reservoir.

The City, with an estimated July 1, 2015 population of 17,873 (U.S. Census Bureau, 2016), is the only incorporated municipality situated within the Watershed.

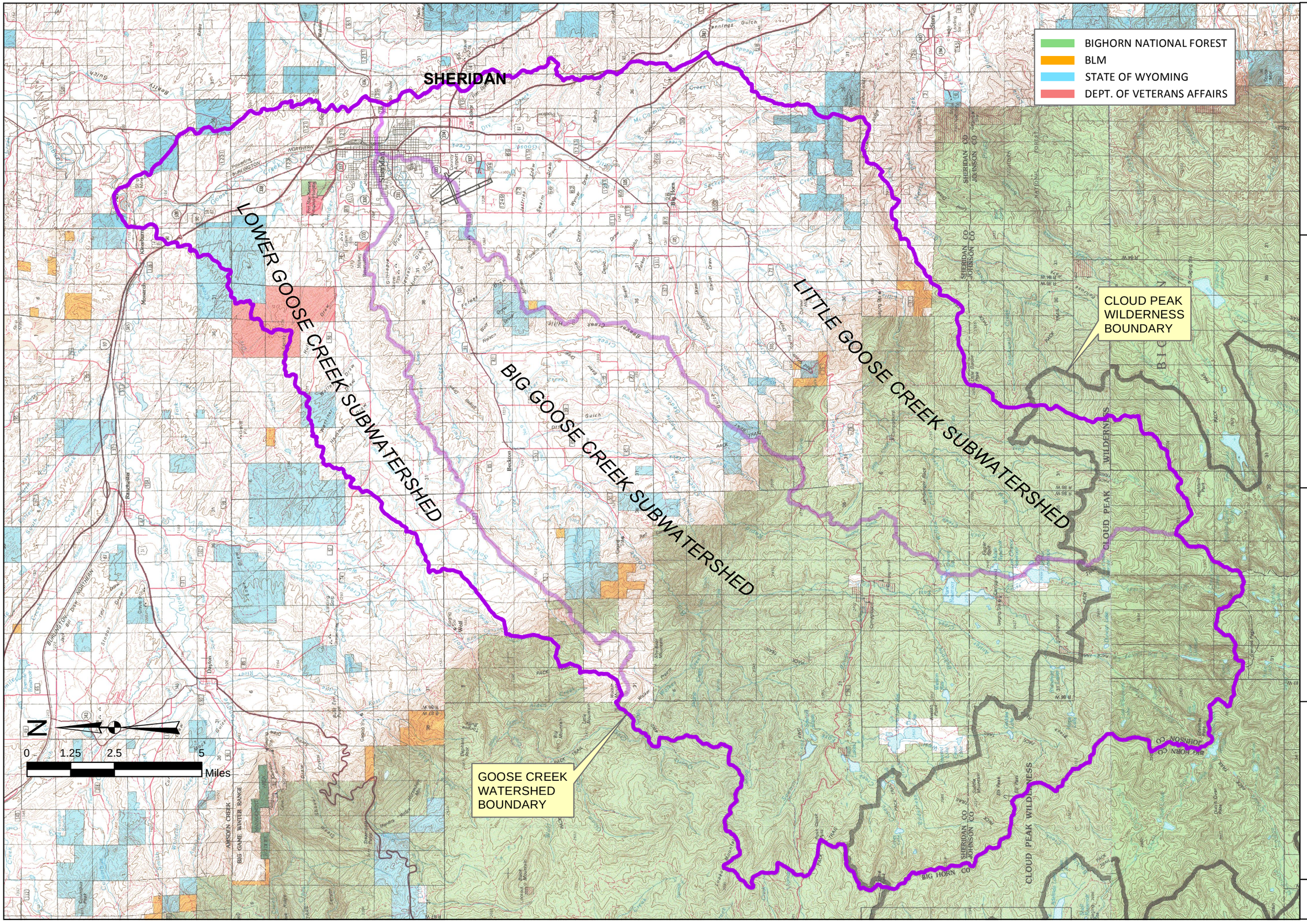
3.3.2 Comprehensive Land Use Planning

In December 2008, the Board of Commissioners for Sheridan County adopted the *Sheridan County Comprehensive Plan* (Sheridan County, 2008). Similarly, in March 2005, the Board of Commissioners for Johnson County adopted the *Johnson County Comprehensive Land Use Plan* (Johnson County 2005). As all of the lands within the Watershed that are within Johnson County are within the boundaries of the BNF, and as the USFS has primary responsibility for land use planning within the BNF, the Sheridan County comprehensive plan is the one most applicable to land use within the Watershed.

The issues addressed in the Sheridan County land use document include the following: 1) planning for growth and fiscal responsibility; 2) provision of utilities, services, adequate water and sewer; 3) fiscal responsibility; 4) property rights; 5) workforce housing; 6) agriculture; 7) open lands; 8) planning for commercial and business locations; 9) transportation planning; and 10) historic preservation.

3.3.3 Land Uses

Figure 3.3.2 depicts existing land uses within the Watershed. Note that, for all lands not within the BNF, the dominant land use is agriculture, which has been the case since Sheridan County became inhabited by non-native settlers. Residential, commercial, industrial and multi-use



LAND OWNERSHIP

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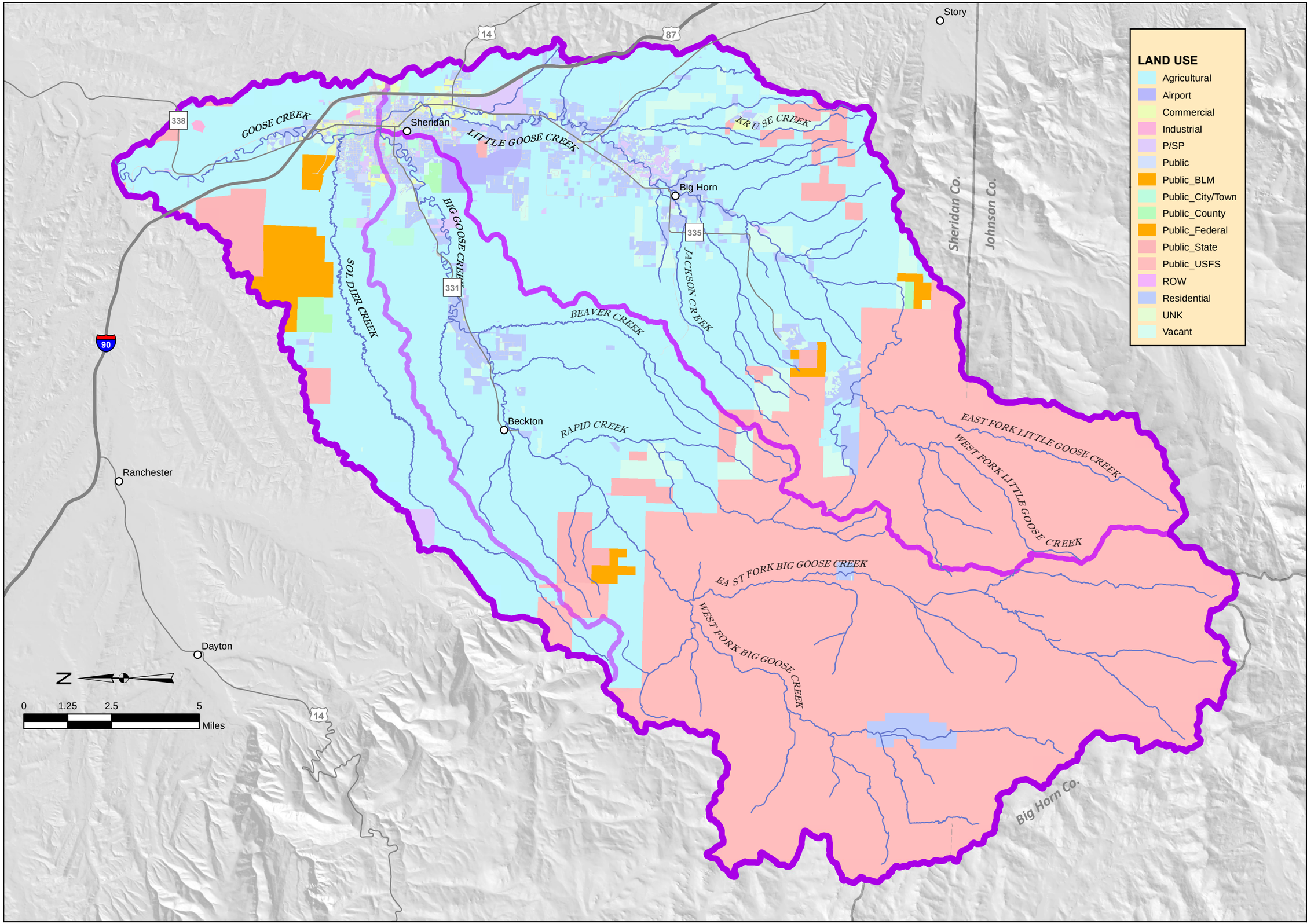
FIG. 3.3.1



LAND USE

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FIG. 3.3.2

developments together comprise a much smaller part of existing land use within the Watershed. Essentially all of this non-agricultural use has occurred within or directly adjacent to the City.

Figure 3.3.3 portrays existing zoning within the Watershed, which parallels in many ways existing land use. Based upon Sheridan County zoning requirements, new, non-agricultural development will occur in the general locations where it has occurred historically; i.e., within the Big Goose Creek and Little Goose valleys, and adjacent to previous development. Essentially all of the Watershed's lands within Johnson County are located within the BNF.

An important aspect of Sheridan County subdivision requirements is the fact that the County has elected to require any land area less than 80 acres being divided into smaller parcels to adhere to the County's subdivision requirements. W.S. 18-5-316 allows counties to elect to apply subdivision requirements on lands that are being divided into parcels greater than 35 acres but less than 140 acres. Sheridan County has elected to impose these requirements on lands being divided into parcels that are 80 acres or less. By electing to use a requirement more stringent than 35 acres, and because adhering to subdivision requirements is a more extensive procedure to follow, the result is that house spacing is and will be less dense than the minimum allowed by State law. This provision has meant that there are fewer residences in unplatted areas, with corresponding less cluttered vistas in areas such as along the face of the Big Horn Mountains (Sheridan County Planning 2017).

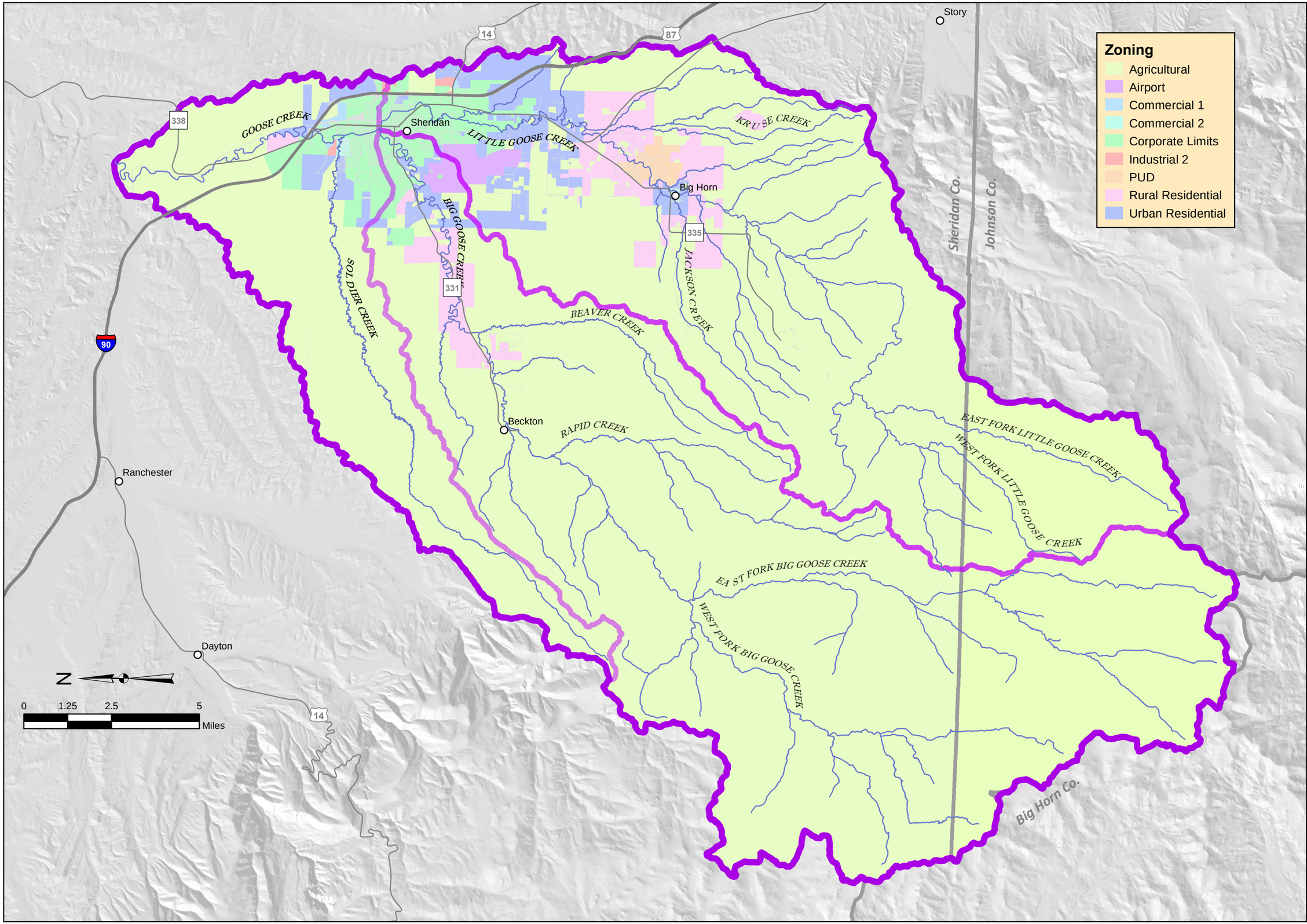
In the late 1990s and most of the first decade of the 2000s, coal bed methane (CBM) development occurred rapidly in northeast Wyoming, with a very small portion of that development occurring within the Watershed. Figure 3.3.4 shows the permitted CBM wells within the Watershed. Note that the majority of these CBM wells were drilled north of the City. Although there are 163 wells permitted within the Watershed, a review of data from the WOGCC website shows no gas production occurring in 2016 in either the Upper or the Lower Tongue River drainages (WOGCC 2017).

Industrial development within the Watershed has not occurred to a great extent. Nonetheless, private industries such as VacuTech, EMIT Technologies, Craftco and L&H Manufacturing constitute relatively small (50 employees or less) but vibrant employers. There are no active coal mines within the Watershed, although the nearby coal mines of southern Montana (Decker and Spring Creek) represent important employers for many of those who reside within the Watershed. Institutions such as Sheridan County School District #1, Sheridan County School District #2, the VAMC, Sheridan College, and the City and Sheridan County represent major public employers. Both the State and federal government have local or regional offices with the City (and thus the Watershed) (Sheridan County Chamber of Commerce 2017).

3.3.3.4 Irrigation

Although municipal and industrial are important uses within the Watershed, they pale in comparison to overall water use for irrigation. Per data made available by the United States Geological Survey in 2000, irrigation uses accounted for over 97 percent of the water used within Sheridan County (USGS 2000). With the City incorporating in 1884 and the first water rights on Big Goose and Little Goose Creeks being filed in 1880 (Gerdel – Little Goose Creek), it is obvious that agricultural production linked to irrigation has been paramount to the area's growth since its original settlement by people of European ancestry (WSEO, 2017). Furthermore, essentially all water used for irrigation within the Watershed comes from surface streams versus groundwater (Schroeder, 2016).

Irrigation activities are limited primarily to the following streams within the Watershed:



ZONING

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FIG. 3.3.3

PERMITTED CBM WELLS
GOOSE CREEK WATERSHED

Story
Sheridan
Big Horn
Beckton
Ranchester
Dayton
14
87
338
335
331
90
LITTLE GOOSE CREEK
BIG GOOSE CREEK
SOL DIER CREEK
KRUSE CREEK
JACKSON CREEK
BEAVER CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK
Sheridan Co.
Johnson Co.
Big Horn Co.

N

0 1.25 2.5 5
Miles

PERMITTED COAD BED METHANE WELLS

GOOSE CREEK WATERSHED LEVEL I STUDY

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FIG. 3.3.4

- Big Goose Creek;
- Rapid Creek, a tributary of Big Goose Creek;
- Little Goose Creek;
- Goose Creek below the confluence; and
- Soldier Creek.

Some irrigated acreages are located on other, smaller streams within the Watershed; however, due to their limited drainage areas, irrigation water is unavailable from these smaller streams except during springtime runoff or immediately after large precipitation events. There are diversions within the Watershed into the drainage areas of some of these smaller streams from the five larger streams listed above, in order to take advantage of irrigable lands within the smaller stream drainage areas. However, as a general rule, these irrigable lands within the smaller stream drainage areas are isolated and less extensive than the irrigated areas on the five larger streams.

Grass hay and alfalfa are the predominant crops now irrigated within the Watershed (Schroeder, 2016). The growing season within the Watershed typically extends from early May to late September. Springtime snowmelt runoff from Big Goose Creek and Little Goose Creek typically ends in early-to-mid July. Once this runoff diminishes, irrigated lands with all but the most senior direct flow rights must have their irrigation water augmented with storage water to the end of September.

It is estimated that there are 34,681 acres of land currently irrigated within the Watershed (RESPEC Powder/Tongue River Basin Update 2017). Methods of irrigation vary. Principal methods utilized include:

1. flood irrigation (including use of gated pipe);
2. use of center pivots;
3. use of siderolls;
4. use of other sprinkler systems such as "big guns".

Center pivot irrigation comprises approximately 14% of the lands irrigated, sideroll irrigation comprises approximately 10% and all remaining irrigation methods comprise 76%.

All water used for irrigation originates within the Watershed, except for three transbasin diversions that deliver water into the Watershed. Those three transbasin diversions are:

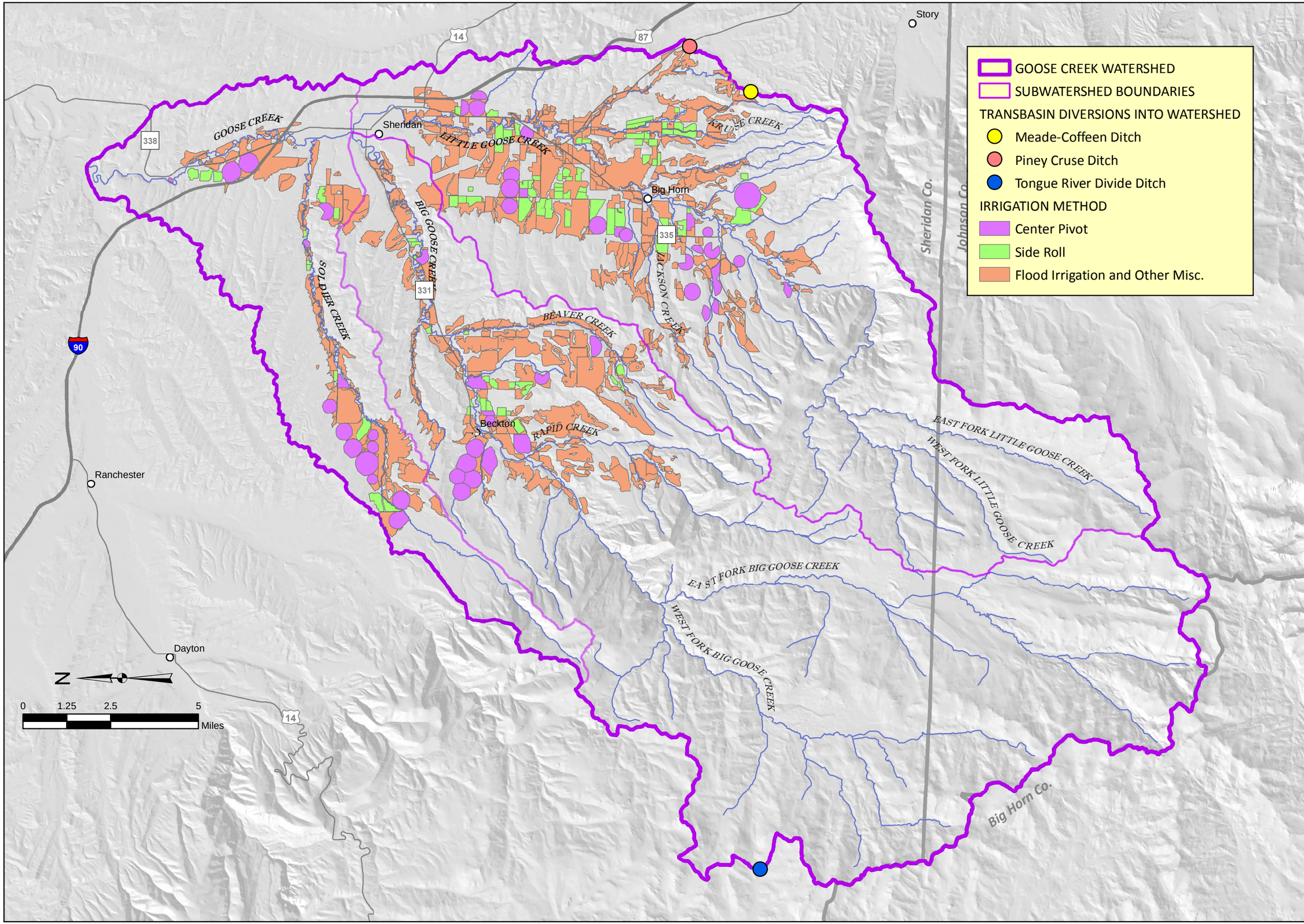
1. Piney-Cruse Ditch, delivering irrigation water through Tunnel Hill near Story from Piney Creek (tributary of the Powder River) into the Little Goose Creek Subwatershed;
2. Meade-Coffeen Ditch, also delivering irrigation water through Tunnel Hill near Story from Piney Creek (tributary of the Powder River) into the Little Goose Creek Subwatershed; and
3. Tongue River Divide Ditch, delivering irrigation water from the headwaters of the South Fork of the Tongue River into Sawmill Creek, a tributary of Big Goose Creek. (Prairie Dog Level I Study 2001, Knapp 2012).

Figure 3.3.5 depicts the land currently being irrigated within the Watershed. Included within this figure are:

1. locations of the various irrigation methods utilized within the Watershed; and
2. the locations of the three delivery points of irrigation being delivered into the Watershed from other basins, as described above.

3.3.5 Cultural Resources

Cultural resource investigations and known archaeological sites are tracked by the SHPO through the WYCRO. Data included in this section were collected primarily from the WYCRO



EXISTING IRRIGATED LANDS

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FIG. 3.3.5

CRMStat database, WYCRO Geographic Information Systems data, the Wyoming SHPO website, and National Park Service National Historic Trails data acquired through the SHPO.

Within the Level I Study area, many of the previous cultural resource investigations were carried out to fulfill the requirements of Section 106 of the National Historic Preservation Act, as published in 36 Code of Federal Regulations (CFR) Part 800, "Protection of Historic Properties" (see Section 5 Permits). Section 106 would apply on any proposed undertaking that has a federal nexus, which would include the following:

- any surface disturbance on federal properties;
- any connected action areas for federal actions (e.g., a federal agency may take regulatory oversight of infrastructure that uses federal resources, such as an entire pipeline carrying federal oil regardless of the ownership of the land crossed by the pipeline);
- use of any federal funding programs; and/or
- any federal permits that may be required (e.g. USACOE Section 404 permit).

According to Wyoming SHPO data on previous investigations, only a few areas within the Watershed have been thoroughly investigated. The Watershed area that is the most covered by inventories is directly north of the City, within an area related to mine and National Guard activities. Other previously-investigated areas include portions of the BNF, particularly in high-use areas, such as within T53N, R86W where numerous reservoirs (Park, Big Horn, Weston, Martin, Last Chance and Granger) and several USFS campgrounds are located. Additional investigations in the Sheridan area are related to Wyoming Department of Transportation activities. Approximately 300 sections within the Watershed remain unsurveyed, according to the records.

Before any undertaking with a federal nexus as described above, the lead agency for the undertaking (or portion thereof) must determine whether the proposed action could affect historic properties and initiate the Section 106 process. Historic properties are any properties included in, or eligible for, inclusion in the National Register of Historic Places. If there are no historic properties within the proposed area of potential effect (i.e., area of possible disturbance due to construction), the Section 106 process is not initiated. If there **are** historic properties within this area, Section 106 requires that the project proponent explore methods to avoid or mitigate any possible effects to the historic properties.

Cultural resources within the Level I Study Area are summarized based on those properties eligible or listed on the National Register of Historic Places (NRHP), which is the "official list of the Nation's historic places worthy of preservation" (National Park Service 2016a). The program is administered by the National Park Service and managed by each individual State's SHPO. Cultural resources included in or eligible for the NRHP are referred to as "historic properties." This term covers any prehistoric or historic district, site, building, structure, or object included in or eligible for the NRHP. This summary omits discussion of non-eligible sites and sites that remain unevaluated. It also does not take into account the many sites of potential tribal significance within the area that have not been recorded or remain undocumented. While any member of the public may nominate a property for the NRHP, known cultural resources in the Watershed are limited mainly to those located in previously inventoried areas. Thus, the following summary of known cultural resources is based primarily on a non-randomized sample of previous Class II (sampling) and Class III (intensive) inventory findings.

Within the Watershed, historic properties include segments of the Bozeman Trail, railroad features, irrigation features and canals, historic camps and homesteads, historic mining sites, urban development, and prehistoric sites. Within the Big Horn Mountains, eligible sites are primarily related to early travel routes. Irrigation and ranching-related sites are more common in

lower-elevation areas. The City of Sheridan and the community of Big Horn each support a downtown national historic district that may include several eligible properties. NRHP-eligible prehistoric sites exist within both the mountainous areas of the Watershed and the Basin but are less well known than historic sites.

Because of the sensitivity and non-renewable quality of archaeological resources, federal land managers generally restrict specific information about the nature and location of those resources per 43 CRF 7.18: "Confidentiality of Archaeological Resource Information." Federal land managers may provide these data under certain circumstances, such as for purposes of protecting the resource. For the purpose of this cultural overview, spatial data from the CRMStat database is used to convey sensitive archaeological site data at the Public Land Survey System (PLSS) section level. Information on NRHP-listed properties is available via the Wyoming SHPO website and is considered public knowledge.

The Watershed currently features 116 existing NRHP-listed properties. Figure 3.3.6 illustrates the number of these historic properties within each section and the location of historic trails. The following descriptions and contexts for these properties are derived from the SHPO website, NRHP database and available NRHP nomination forms. Most of these properties are historic and are buildings within the historic district of the city of Sheridan. For example, the Sheridan Railroad Historic District (48SH1435), which is significant for its association with transportation and community planning and development during the late 1800s through mid-1900s, includes 91 contributing buildings. The Chicago, Burlington and Quincy Railroad (48SH258) itself is also listed on the NRHP. The Sheridan Downtown Historic District (48SH686) includes several properties along Main Street between Burkitt and Mandel Streets that contribute to this district's historic significance as a representation of the center of trade, commerce and government.

Additional NRHP-listed historic properties within Sheridan include the Sheridan County Courthouse (48SH472), the former railroad passenger depot (now Rails Brews and Cues) (48SH117), St. Peter's Episcopal Church (48SH1839), Sheridan Flouring Mill (48SH954), the Oddfellows Hall (48SH550), the Sheridan Inn (48SH253), Holy Name Catholic School (48SH1840), the Trails End Museum (John B. Kendrick Mansion) (48SH122), and a handful of residences (48SH926, 48SH955, 48SH1011, and 48SH1873).

Two additional historic districts lie outside of the commercial center of the City. The VAMC (48SH124), established ca. 1889 as Fort MacKenzie, is an NRHP-listed historic district within the northwest sector of the City. The fort was active into the early 1900s but was transferred to the Veterans Administration in 1922. Many of the early brick buildings there are preserved. The Sheridan County Fairgrounds (48SH1753), west of the City's downtown area, is a listed historic district representing a center for the area's entertainment and recreation activities. The fairgrounds celebrate the importance of agriculture and rodeo to Sheridan County.

Big Horn Johnson Street (48SH688) in the nearby community of Big Horn is listed as a national historic district and encompasses a small group of historic buildings characteristic of early Western construction. To the south of the Big Horn community, the Quarter Circle A Ranch (commonly known as the Bradford Brinton Memorial) (48SH121) is listed on the NRHP.

Two historic bridges in Sheridan County are on the NRHP but have been destroyed. These are 48SH722, a bridge that spanned Little Goose Creek south of Sheridan, and 48SH683, a bridge that spanned Big Goose Creek near Beckton. Both structures represented early examples of vehicular truss bridges.

HISTORIC TRAILS
NRHP LISTED PROPERTIES
NO. OF SITES ELIGIBLE FOR NRHP PER SECTION

Sheridan
Big Horn
Beckton
Ranchester
Dayton
Story

GOOSE CREEK
LITTLE GOOSE CREEK
KRUSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
JACKSON CREEK
BEAVER CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK

Sheridan Co.
Johnson Co.
Bighorn Co.

14
87
338
90
335
331

N
0 1.25 2.5 5
Miles

LOCATIONS OF NATIONAL REGISTER OF HISTORIC PLACES

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FIG. 3.3.6

The only NRHP-listed historic property within the BNF portion of the Level I Study Area is the Spear-O-Wigwam Ranch in Johnson County (48JO3686). This property is significant as a representation of early dude ranching in the Big Horn Mountains. Several historic dams and reservoirs are present in the Big Horn Mountains portion of the Watershed, but none are currently listed on the NRHP.

Only one prehistoric site within the Watershed is listed in the NRHP. The Big Goose Creek Buffalo Jump (48SH313) is a bison jump site within Big Goose Creek west of Sheridan. While this is the only prehistoric site in the area that is listed on the NRHP, many other prehistoric sites within the Watershed are eligible for listing.

Known NRHP-listed properties are clustered primarily within City limits, whereas sites eligible for listing in the NRHP are dispersed throughout the Watershed. Based on Wyoming SHPO CRMstat data, Figure 3.3.6 shows each square-mile section within the Level I Study Area shaded with a color gradient and a corresponding number that indicate the total number of sites eligible for the NRHP. As previously stated, data has not been previously collected for many other areas within the Watershed.

3.4 Natural Environment

3.4.1 Climate

The Watershed is sharply divided into a high-elevation, montane climate regime and a low-elevation, semiarid climate regime. Elevation in the Watershed ranges from 3,644 feet (1,110 m) at Acme to more than 11,760 feet (3,584 m) in the Big Horn Mountains, although the majority of the land lies at elevations of less than 5,000 feet (1,524 m). The dramatic difference in elevation and the orographic influence of the mountains result in a wide range of annual precipitation values across the Watershed. Precipitation ranges from under 13 inches at the lowest point in the Watershed to more than 30 inches at the highest point of the Big Horn Mountains. Figure 3.4.1 illustrates the annual precipitation variance across the Watershed according to the Parameter-Elevation Regressions on Independent Slopes Model (PRISM). The majority of the surface water supply in the Watershed is provided by mountain snowpack and supplemented by spring and summer rainfall.

While several weather stations are located in and around the Watershed, only two—the Sheridan County Airport Station (coop ID 488155) and the Sheridan Field Station (coop ID 488160)—have periods of record long enough to characterize the Watershed's climate. The NWS, through its coop program, participates in the maintenance of these two stations. The airport site is located at an elevation of 3,960 feet (1,207 m), while the field station site is located at an elevation of 3,750 feet (1,143 m). Data for NWS coop stations are archived through the Western Regional Climate Center (WRCC). Average, minimum, and maximum temperatures, as well as average total monthly precipitation and snowfall recorded over the period of record for the two stations, are listed in Tables 3.4.1 and 3.4.2. The elevation difference between the two sites is 210 feet (64 m), and the observed average temperature and precipitation for the two sites are relatively similar. For all data available at these stations, the annual precipitation varies by only 0.5 inch, and average annual temperatures differ by only a couple of degrees Fahrenheit (ºF). However, the airport site receives almost double the amount of snowfall relative to the field station site, presumably because the former is closer to the Big Horn Mountains than is the latter.

ANNUAL PRECIPITATION (INCHES)

- 13 - 15
- 15 - 19
- 19 - 23
- 23 - 27
- 27 - 31
- 31 - 35

Sheridan
Big Horn
Beckton
Ranchester
Dayton
Story

Sheridan Co.
Johnson Co.
Bighorn Co.

GOOSE CREEK
LITTLE GOOSE CREEK
KRUSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
JACKSON CREEK
BEAVER CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK

14
87
338
90
335
331
14

N

0 1.25 2.5 5 Miles

ANNUAL PRECIPITATION (1981-2010 PRISM)

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FIG. 3.4.1

Table 3.4.1 – Sheridan County Airport Monthly Climate Data Summary (May,1948 - June,2016)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Avg. Max. Temp. (ºF)	33.8	38.4	46.4	56.7	66.4	76.4	86.7	85.7	74.1	61.2	45.9	36.2	59.0
Avg. Min. Temp. (ºF)	9.4	14.4	21.4	30.4	39.4	47.4	53.9	52.3	42.3	32.0	20.2	11.9	31.2
Avg. Total Precip (in)	0.68	0.64	1.03	1.79	2.43	2.14	1.05	0.81	1.26	1.28	0.78	0.61	14.5
Avg. Total Snow (in)	11.0	10.3	12.4	10.5	1.7	0.1	0.0	0.0	1.4	4.7	8.5	11.1	71.7

Table3.4.2 – Sheridan Field Station Monthly Climate Data Summary (January,1920 - May,2016)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANN
Avg. Max. Temp. (ºF)	32.5	36.7	45.1	57.2	67.3	76.7	87.8	86.8	74.9	61.8	45.3	35.5	59.0
Avg. Min. Temp. (ºF)	6.3	10.7	19.6	29.7	39.3	47.6	53.5	50.9	40.6	30.4	18.6	9.6	29.7
Avg. Total Precip (in)	0.50	0.46	0.91	1.77	2.58	2.69	1.24	0.87	1.40	1.28	0.70	0.49	15.0
Avg. Total Snow (in)	7.3	6.6	9.0	5.0	0.8	0.1	0.0	0.0	0.3	2.1	5.3	6.4	43.0

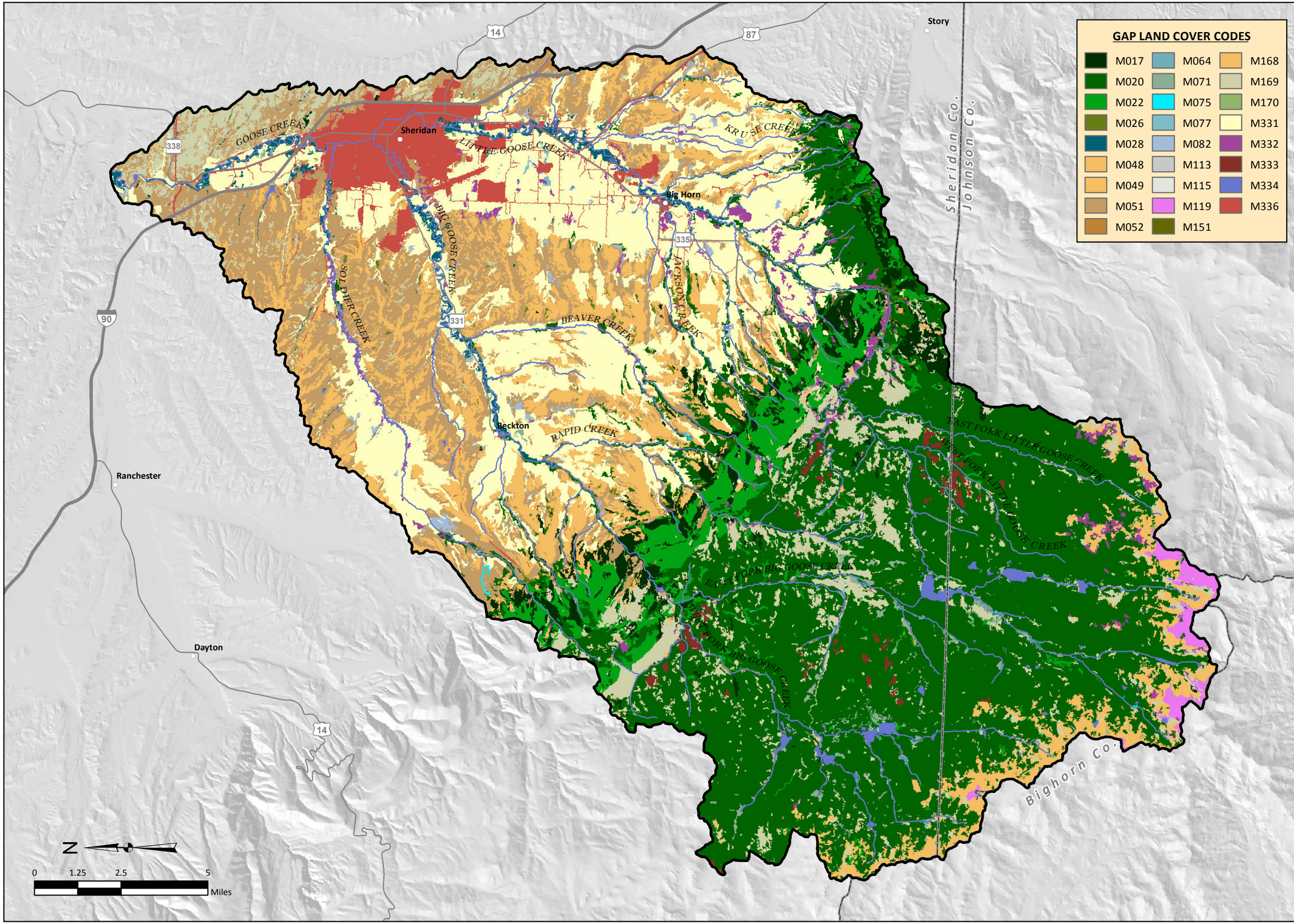
3.4.2 Vegetation and Land Cover

3.4.2.1 Land Cover

Land cover data was obtained from the USGS National Gap Analysis Program (GAP), which uses data primarily derived from Land and Remote Sensing Satellite (LANDSAT) imagery. Several land cover datasets cover the Level I Study Area; however, GAP was determined to be the most appropriate to this Level I Study. GAP is most applicable for evaluating detailed information relating to ecological systems and communities at a moderate and fine scale (Story et al. 2010). The GAP data uses the NatureServe ecological classification system (U.S. National Vegetation Classification [NVC]), which allows compatibility across different vegetation and habitat systems, e.g., NRCS ecological sites compared with WG&FD habitat types. The GAP dataset used for mapping is "cross-walked" within the dataset to the NVC dataset macrogroup-level, which uses combinations of diagnostic plant species and diagnostic growth forms that reflect biogeographic differences (NVC 2016). The Landscape Fire and Resource Management Planning Tools Project (LANDFIRE) dataset was considered for further analysis of the Watershed, but it was determined that GAP was better suited for those purposes and that LANDFIRE added no applicable data to the assessment. LANDFIRE also uses the NVC but is focused on fire and fuels management (Story et al. 2010). LANDFIRE data for the Watershed were included with the Level I Study GIS layers.

Land cover within the Watershed falls under twenty-six classification categories. Table 3.4.3 depicts each land cover classification and its acreage and percentage within the Watershed. The table also contains the map codes that correspond to the Watershed land cover classifications shown on Figure 3.4.2.

Rocky Mountain Subalpine & High Mountain Conifer Forest is the dominant land cover classification at 90,716 acres, covering 34.12% of the Watershed. This classification is concentrated in the upper elevations of the Watershed in the Big Horn Mountains. The other dominant land cover classification in the upper portion of the Watershed is Northern Rocky Mountain-Vancouverian Montane & Foothill Grassland and Shrubland at 31,712 acres, covering 11.93% of the Watershed. Herbaceous Agricultural Vegetation and Great Plains Mixedgrass Prairie & Shrubland are the two dominant land cover classifications in the lower portion of the Watershed at 48,621 acres (covering 18.29% of the Watershed) and 34,756 acres (covering 13.07% of the Watershed), respectively.



GAP LAND COVER CLASSIFICATIONS (NVC MACROGROUP)

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FIG. 3.4.2

Table 3.4.3 - GAP Land Cover Classifications in the Watershed

Map Code	GAP Macrogroup Land Cover Classifications	Acres	Percentage
M064	Rocky Mountain Subalpine & High Montane Conifer Forest	90,716	34.12%
M331	Herbaceous Agricultural Vegetation	48,621	18.29%
M051	Great Plains Mixedgrass Prairie & Shrubland	34,756	13.07%
M017	Northern Rocky Mountain-Vancouverian Montane & Foothill Grassland & Shrubland	31,712	11.93%
M169	Great Basin & Intermountain Tall Sagebrush Shrubland & Steppe	16,984	6.39%
M022	Southern Rocky Mountain Lower Montane Forest	10,512	3.95%
M336	Developed & Urban	10,154	3.82%
M048	Northern Rocky Mountain Lower Montane & Foothill Forest	7,550	2.84%
M332	Introduced & Semi Natural Vegetation	3,027	1.14%
M028	Great Plains Floodplain Forest	2,584	0.97%
M071	Great Plains Wet Meadow, Wet Prairie & Marsh	2,450	0.92%
M113	Rocky Mountain Alpine Cliff, Scree & Rock Vegetation	1,589	0.60%
M334	Open Water	1,295	0.49%
M333	Recently Disturbed or Modified	1,168	0.44%
M082	Cool Semi-Desert Alkali-Saline Wetland	1,053	0.40%
M151	Northern Great Plains Woodland	572	0.22%
M026	Intermountain Singleleaf Pinyon - Western Juniper Woodland	463	0.17%
M077	Great Plains Brackish Marsh & Saline Wet Meadow	175	0.07%
M075	Western North American Montane Wet Meadow & Low Shrubland	118	0.04%
M170	Great Basin & Intermountain Dwarf Sage Shrubland & Steppe	116	0.04%
M052	Great Plains Sand Grassland & Shrubland	81	0.03%
M115	Great Plains Badlands Vegetation	55	0.02%
M168	Rocky Mountain Subalpine & Montane Fen	47	0.02%
M020	Rocky Mountain Cliff, Scree & Rock Vegetation	46	0.02%
M049	Southern Rocky Mountain Montane Grassland & Shrubland	16	0.01%
M119	Rocky Mountain-Vancouverian Subalpine & High Montane Mesic Grass & Forb Meadow	5	0.00%

3.4.2.2 Ecological Sites

Ecological sites were mapped in the Level I Study Area using soil survey information from the NRCS web soil survey (NRCS 2016a) and the BNF Soil Survey (Nesser 1986). Ecological sites are the basic component of a land-type classification system that describes ecological potential and ecosystem dynamics of land areas. An ecological site is a specific kind of land defined by its physical characteristics that differs from other communities within a landscape in its ability to produce and support a distinctive type and amount of vegetation and in its ability to respond similarly to management actions and natural disturbances (NRCS 2016b). Ecological site classifications and descriptions provide a consistent framework for stratifying and describing rangelands and their soil, vegetation, and abiotic features, thereby delineating units that share similar capabilities to respond to management activities or disturbance processes (Caudle et al. 2013).

Attributes of an ecological site, such as plant community, productivity, land use values, and response to disturbance, are described in an ecological site description (ESD) report. ESDs are living documents that are updated as new information becomes available. The NRCS houses and updates the ESDs on the agency's website (NRCS 2016b). ESDs can be used to determine, analyze, and develop planning options, incorporating plant community and soil health, vegetation production potential, forage suitability, hydrologic functioning, wildlife habitat, and the means by which disturbance or other improvements and impacts may affect these factors.

Ecological sites are correlated on the basis of soils and the resulting difference in species composition, proportion of species, and total production of the historic climax plant community. Mapping of the Watershed was completed using GIS software to correlate the ecological site for the dominant soil series within each soil map unit on the NRCS and BNF soil survey maps (NRCS 2016a; Nesser 1986). These soil surveys each cover a portion of the Watershed, but neither overlap; however, together they provide full soil mapping of the Level I Study Area (see Section 3.4.6) and therefore full ecological site mapping of the entire Watershed. (See Figure 3.4.3.)

The Level I Study Area lies in two NRCS Major Land Resource Areas (MLRAs):

- the 58B Northern Rolling High Plains, Southern Part (58B), and
- the 43B Central Rocky Mountains (43B) (NRCS 2016c).

Starting at the foothills, the eastern half of the Watershed lies in MLRA 58B. The western half lies in MLRA 43B, which is almost entirely within the BNF. MLRA 58B is in a 10-14" precipitation zone, while MLRA 43B is in a 15-19" precipitation zone.

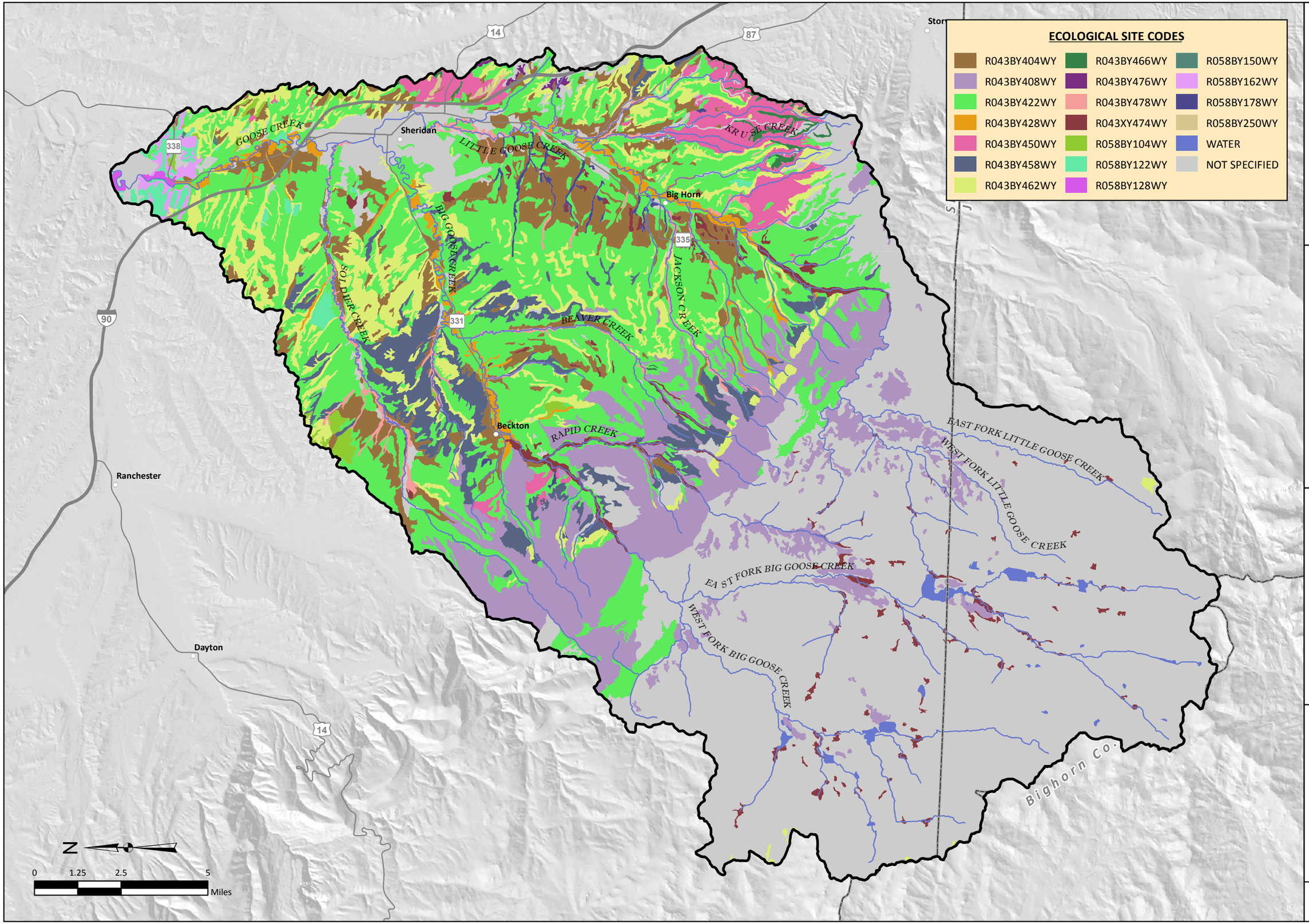
The Level I Study Area features 18 ecological sites along with areas that do not correlate to an ecological site or consist of open water. Table 3.4.4 shows the ecological site codes that correspond to the ecological sites shown on Figure 3.4.3, the corresponding ecological site name, the number of acres for each ecological site, and the percentage of that ecological site within the Watershed.

"Not specified" is the largest mapped area for ecological sites in the Watershed at 117,605 acres, covering 44.24% of the Level I Study Area. "Not specified" areas include rock outcrops and barren areas with little to no vegetation, residential and urban areas (particularly around Sheridan), and a small area of low vegetation floodplain at the confluence of Goose Creek and the Tongue River. These areas are concentrated in the higher elevations of the Big Horn Mountains, where there is exposed bedrock and low soil development. The soils information allowed for the mapping of 1,077 acres of open water. "Not specified" and water areas do not have ESDs.

The Watershed features 147,158 acres (55.36% of the Level I Study Area) of specified ecological sites with ESDs. The Loamy (Ly) 15-19" Northern Plains Precipitation Zone ecological site has the most acreage of the ecological sites in the Watershed at 57,231 acres, covering 21.53% of the Level I Study Area.

Table 3.4.4 - Ecological Sites in the Watershed

ESD Code	Ecological Site Name	Acres	Percentage
Not Specified	Not Specified	117,605	44.24%
R043BY422WY	Loamy (Ly) 15-19" Northern Plains Precipitation Zone	57,231	21.53%
R043BY408WY	Coarse Upland (CU) 15-19" Northern Plains Precipitation Zone	26,836	10.09%
R043BY462WY	Shallow Loamy (SwLy) 15-19" Northern Plains Precipitation Zone	16,941	6.37%
R043BY404WY	Clayey (Cy) 15-19" Northern Plains Precipitation Zone	15,467	5.82%



ECOLOGICAL SITES

GOOSE CREEK WATERSHED
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FIG. 3.4.3

ESD Code	Ecological Site Name	Acres	Percentage
R043BY458WY	Shallow Clayey (SwCy) 15-19" Northern Plains Precipitation Zone	9,611	3.62%
R043BY450WY	Sandy (Sy) 15-19" Northern Plains Precipitation Zone	6,014	2.26%
R043XY474WY	Subirrigated 15-19" Northern Plains Precipitation Zone	3,820	1.44%
R043BY428WY	Lowland (LL) 15-19" Northern Plains Precipitation Zone	3,013	1.13%
R043BY478WY	Wetland (WL) 15-19" Northern Plains Precipitation Zone	2,852	1.07%
R058BY122WY	Loamy (Ly) 10-14" Northern Plains Precipitation Zone	1,598	0.60%
Water	Water	1,077	0.41%
R058BY104WY	Clayey (Cy) 10-14" Northern Plains Precipitation Zone	861	0.32%
R058BY162WY	Shallow Loamy (SwLy) 10-14" Northern Plains Precipitation Zone	813	0.31%
R043BY466WY	Shallow Sandy (SwSy) 15-19" Northern Plains Precipitation Zone	712	0.27%
R058BY178WY	Wetland (WL) 10-14" Northern Plains Precipitation Zone	707	0.27%
R058BY250WY	Sandy (Sy) 15-17" Northern Plains Precipitation Zone	281	0.11%
R058BY128WY	Lowland (LL) 10-14" Northern Plains Precipitation Zone	190	0.07%
R043BY476WY	Very Shallow (VS) 15-19" Northern Plains Precipitation Zone	180	0.07%
R058BY150WY	Sandy (Sy) 10-14" Northern Plains Precipitation Zone	32	0.01%

3.4.2.3 Wetlands and Riparian Areas

3.4.2.3.1 Wetlands

Wetlands provide a multitude of ecological, economic, and social benefits. They provide habitat for fish, wildlife, and plants (many of which have commercial or recreational value); recharge groundwater; reduce flooding; provide clean drinking water; regulate the climate; offer food and fiber; and support cultural and recreational activities (USFWS 2016).

Wetlands are habitats in which the soil is annually saturated with water or covered by water at some time during the growing season of each year. Much of Wyoming lacks the precipitation needed to support expansive wetland complexes such as those found in wetter regions of the country.

Wyoming wetlands can be divided into several morphological groups depending on their location and origin. The plains and intermountain basins are typified by low densities of shallow, playa-type wetlands that formed either in blowouts or, in some cases, as a result of tectonic activity. Kettle, cirque, and moraine type wetlands and lakes are present in higher elevations once covered by montane glaciers; however, the Pleistocene glacial sheets that left dense wetland complexes throughout the United States and Canadian prairie pothole region did not reach Wyoming. Springs, bogs, and seeps are scattered throughout the state but are most common in the montane areas (WG&FD 2010).

Natural wetlands covered about 3.2% of what is now Wyoming before settlement of the state (Dahl 1990) and were predominantly associated with riparian corridors and glaciated montane regions. By the mid-1980s, the total area of Wyoming wetlands had been reduced to approximately 2.0%, for an approximately 38.0% loss of wetlands (Dahl 1990). Since the late 1800s, wetlands have been created, both deliberately and coincidentally, as a result of human activities. Manmade wetlands vary in quality and can be associated with livestock impoundments; spring developments; windmill basins; irrigation seepage or runoff; sediment retention basins; reclaimed and abandoned mine impoundments; produced water from oil and

gas operations; highway ditches and borrow pits; reservoir backwaters; mitigation sites; habitat areas on private, state, and federally-managed lands; and other miscellaneous activities (Tessmann 2004).

The USFWS National Wetland Inventory (NWI) (USFWS 2017a) was used to map the wetlands in the Level I Study Area. The NWI is a publically-available resource that provides detailed information on the abundance, characteristics, and distribution of U.S. wetlands. Natural resource managers within the USFWS and throughout the nation use NWI data to promote the understanding, conservation, and restoration of wetlands. The NWI classification system is the official USFWS wetland classification system (Cowardin et al. 1979) and the federal standard for wetland classification (USFWS 2017a). The wetland data can be further refined by on-the-ground surveys, which are beyond the scope of this Level I Study. Figure 3.4.4 shows the wetlands in the Watershed and their NWI classification codes. Table 3.4.5 identifies the NWI classification codes of the wetlands in the Level I Study Area (which correspond to the codes on Figure 3.4.4), the associated classification names, the acreage of each class, and the percentage of the Level I Study Area that each class covers.

The wetlands in the Level I Study Area are comprised of three wetland systems: Lacustrine, Palustrine, and Riverine (Cowardin et al. 1979). The wetlands in the Level I Study Area total approximately 5,491.54 acres: 1,126.48 acres of lacustrine system wetlands, 4,030.97 acres of palustrine system wetlands, and 334.09 acres of riverine system wetlands. The predominant wetland class is PEMB, which is a palustrine system with emergent vegetation that is seasonally saturated; this class covers 1,913.94 acres (34.85%) of the total wetland area in the Watershed.

The Lacustrine System includes wetlands and deepwater habitats with all of the following characteristics:

(1) situated in a topographic depression or a dammed river channel;
(2) lacking trees, shrubs, persistent emergents, emergent mosses, or lichens with 30 percent or more areal coverage; and
(3) total area of at least 8 hectares (ha) (20 acres).

Similar wetlands and deepwater habitats totaling less than 8 ha are also included in the Lacustrine System if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the water depth in the deepest part of the Basin equals or exceeds 2.5 m (8.2 feet) at low water. Lacustrine waters may be tidal or nontidal, but ocean-derived salinity of such waters is always less than 0.5 parts per thousand (ppt) (USFWS 2017a).

The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 ppt. The Palustrine System also includes wetlands that lack such vegetation but possess the following four characteristics:

(1) area less than 8 ha (20 acres);
(2) lack of active wave-formed or bedrock shoreline features;
(3) water depth in the deepest part of basin less than 2.5 m (8.2 ft) at low water; and
(4) salinity due to ocean-derived salts less than 0.5 ppt (USFWS 2017a)

The Riverine System includes all wetlands and deep water habitats contained within a channel, with two exceptions:

(1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens; and
(2) habitats with water containing ocean-derived salts of 0.5 ppt or greater.

NWI WETLANDS

L1UBH	PABKx	PFOA	PUBHh
L1UBHh	PEMA	PFOAh	PUSA
L2ABFh	PEMAh	PFOB	PUSAh
L2ABGx	PEMB	PFOCh	PUSC
L2USCh	PEMC	PSSA	PUSCh
PABF	PEMCb	PSSAh	R2UBH
PABFh	PEMCh	PSSB	R2USA
PABFx	PEMCx	PSSC	R2USAx
PABG	PEMF	PSSCb	R2USC
PABGb	PEMFh	PSSCh	R2USCx
PABGh	PEMFx	PUBFx	R3USA

Story
Sheridan
Big Horn
Beckton
Ranchester
Dayton
Sheridan Co.
Johnson Co.
Bighorn Co

GOOSE CREEK
LITTLE GOOSE CREEK
KRUSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
JACKSON CREEK
BEAVER CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK

14 87 338 335 331 90 14

N

0 1.25 2.5 5 Miles

NWI WETLANDS

GOOSE CREEK WATERSHED LEVEL I STUDY

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Professional Engineers
Sheridan, WY 82801

FIG. 3.4.4

A channel is a naturally or artificially created open conduit that periodically or continuously contains moving water or that forms a connecting link between two bodies of standing water (USFWS 2017a).

Table 3.4.5 - Wetlands in the Watershed

NWI Class Code	NWI Class Description*	Acres	Percentage
PEMB	Palustrine, Emergent, Seasonally Saturated	1,913.94	34.85%
L1UBHh	Lacustrine, Limnetic, Unconsolidated Bottom, Permanently Flooded, Diked/Impounded	626.43	11.41%
PABG	Palustrine, Aquatic Bed, Intermittently Exposed	590.05	10.74%
PEMC	Palustrine, Emergent, Seasonally Flooded	459.71	8.37%
L2USCh	Lacustrine, Littoral, Unconsolidated Shore, Seasonally Flooded, Diked/Impounded	337.66	6.15%
PABFh	Palustrine, Aquatic Bed, Semipermanently Flooded, Diked/Impounded	282.37	5.14%
R2UBH	Riverine, Lower Perennial, Unconsolidated Bottom, Permanently Flooded	277.47	5.05%
L1UBH	Lacustrine, Limnetic, Unconsolidated Bottom, Permanently Flooded	111.49	2.03%
PSSB	Palustrine, Scrub-Shrub, Seasonally Saturated	111.26	2.03%
PFOB	Palustrine, Forested, Temporary Flooded, Seasonally Saturated	98.72	1.80%
PEMCh	Palustrine, Emergent, Seasonally Flooded, Diked/Impounded	90.59	1.65%
PSSA	Palustrine, Scrub-Shrub, Temporary Flooded	84.44	1.54%
PEMF	Palustrine, Emergent, Semipermanently Flooded	66.82	1.22%
PEMA	Palustrine, Emergent, Temporarily Flooded	56.19	1.02%
R2USA	Riverine, Lower Perennial, Unconsolidated Shore, Temporary Flooded	44.91	0.82%
PSSC	Palustrine, Scrub-Shrub, Seasonally Flooded	38.45	0.70%
PEMCb	Palustrine, Emergent, Seasonally Flooded, Beaver	33.52	0.61%
PEMAh	Palustrine, Emergent, Temporarily Flooded, Diked/Impoundment	33.04	0.60%
PUBFx	Palustrine, Unconsolidated Bottom, Semipermanently Flooded	32.14	0.59%
L2ABFh	Lacustrine, Littoral, Aquatic Bed, Semipermanently Flooded, Diked/Impounded	28.01	0.51%
L2ABGx	Lacustrine, Littoral, Aquatic Bed, Intermittently Exposed	22.90	0.42%
PUSCh	Palustrine, Unconsolidated Shore, Seasonally Flooded, Diked/Impounded	21.84	0.40%
PUBHh	Palustrine, Unconsolidated Bottom, Permanently Flooded, Diked/Impounded	16.89	0.31%
PABF	Palustrine, Aquatic Bed, Semipermanently Flooded	14.54	0.26%
PFOA	Palustrine, Forested, Temporary Flooded	13.99	0.25%
PABGh	Palustrine, Aquatic Bed, Intermittently Exposed, Diked/Impounded	12.38	0.23%
PFOAh	Palustrine, Forested, Temporary Flooded, Diked/Impounded	10.62	0.19%
PABGb	Palustrine, Aquatic Bed, Intermittently Exposed, Beaver	9.80	0.18%
PEMFh	Palustrine, Emergent, Semipermanently Flooded, Diked/Impounded	8.08	0.15%

NWI Class Code	NWI Class Description*	Acres	Percentage
PSSCb	Palustrine, Scrub-Shrub, Seasonally Flooded, Beaver	5.77	0.11%
PFOCh	Palustrine, Forested, Temporary Flooded, Seasonally Flooded, Diked/Impounded	5.74	0.10%
PUSAh	Palustrine, Unconsolidated Shore, Temporary Flooded, Diked/Impounded	5.61	0.10%
R2USC	Riverine, Lower Perennial, Unconsolidated Shore, Seasonally Flooded	4.41	0.08%
PUSA	Palustrine, Unconsolidated Shore, Temporary Flooded	3.71	0.07%
R2USCx	Riverine, Lower Perennial, Unconsolidated Shore, Seasonally Flooded, Excavated	3.41	0.06%
PEMCx	Palustrine, Emergent, Seasonally Flooded, Excavated	3.16	0.06%
R3USA	Riverine, Upper Perennial, Unconsolidated Shore, Temporary Flooded	2.93	0.05%
PSSAh	Palustrine, Scrub-Shrub, Temporary Flooded, Diked/Impounded	2.75	0.05%
PUSC	Palustrine, Unconsolidated Shore, Seasonally Flooded	1.74	0.03%
PABFx	Palustrine, Aquatic Bed, Semipermanently Flooded, Excavated	1.27	0.02%
PABKx	Palustrine, Aquatic Bed	1.09	0.02%
R2USAx	Riverine, Lower Perennial, Unconsolidated Shore, Temporary Flooded, Excavated	0.97	0.02%
PSSCh	Palustrine, Scrub-Shrub, Seasonally Flooded, Diked/Impounded	0.40	0.01%
PEMFx	Palustrine, Emergent, Semipermanently Flooded, Excavated	0.35	0.01%
	TOTAL	**5,491.54**	**100.00%**

*Cowardin et al. (1979)

As part of the Level I Study, the NWI wetlands mapping was assessed against historical imagery in Google Earth (accessed on January 10, 2017) to determine if there have been any significant size, vegetation, or hydrologic changes over the last 10 years. The emphasis of the assessment was on wetlands larger than 10 acres. The Level I Study Area contains 81 wetlands larger than 10 acres; with all but 14 of these areas larger than 10 acres occurring within the BNF boundary. These wetlands are primarily concentrated in the upper portions of the Big Goose Creek Watershed and the Little Goose Creek Watershed and include the major reservoirs in the Level I Study Area. Most of the wetlands are palustrine emergent. No major changes to these 10+ acre sites were identified.

3.4.2.3.2 Riparian Areas

Riparian and wetland ecosystems have various functions that occur at the landscape scale, including flood storage and flood-peak desynchronization, recharging the groundwater aquifer, flood-flow attenuation, purification of water via removal of nutrients and toxic compounds, and recreation (Carter 1986). These functions apply to all riparian zones in the Level I Study Area. The functions of riparian and wetland ecosystems at the community scale depend on the hydrology of the Watershed. The rates of sedimentation and nutrient deposition, in addition to water flow energy and soil types, affect the vegetation community in the riparian zone. Other factors that influence the riparian vegetation include elevation and moisture gradients, floodplain width, and shallow groundwater depth.

Riparian areas within the Watershed are concentrated along the floodplains of its major streams. These riparian areas are found in the ecological sites Subirrigated, 58B Wetlands, and 43B Wetlands. (See Table 3.4.4.) These three ecological sites comprise 7,379 acres (2.78%) of the Watershed. These riparian areas, which may include portions of wetlands and adjacent floodplains, have diverse plant communities that can be dominated by wetland and upland plants. Common riparian species in the Level I Study Area include plains cottonwood (*Populus deltoides* ssp. *monilifera*), narrowleaf cottonwood (*Populus angustifolia*), box elder (*Acer negundo*), willow (*Salix* spp.), chokecherry (*Prunus virginiana*), silver sagebrush (*Artemisia cana*), reed canary grass (*Phalaris arundinacea*), tufted hairgrass (*Deschampsia caespitosa*), sedges (*Carex* spp.), spikerush (*Eleocharis* spp.), and foxtail barley (*Hordeum jubatum*).

3.4.3 Wildlife

3.4.3.1 General Wildlife Presence

Wildlife species in the Level I Study Area are protected under a variety of federal and state laws and regulations, including the Endangered Species Act (ESA) of 1973, Migratory Bird Treaty Act (MBTA), Bald and Golden Eagle Protection Act (BGEPA), and State of Wyoming Executive Order 2015-4 (State of Wyoming 2015). Additionally, the BLM and the USFS administer federal lands within the Level I Study Area, where those agencies manage wildlife in accordance with their respective agency's goals and requirements.

The Wyoming Natural Diversity Database (WYNDD) is a network program dedicated to gathering and developing biological information on species of conservation concern and natural vegetation communities. WYNDD develops and maintains lists of species in Wyoming that are rare, endemic, disjunct, threatened, or otherwise biologically sensitive. Table 3.4.6 lists the species of concern that have been documented in the Level I Study Area between the years 1892 and 2014 along with their status as species of concern for the USFWS, BLM, and USFS (WYNDD 2016). The Level I Study Area may support additional species that have not been documented in publications or inventories.

Table 3.4.6 - Wyoming Natural Diversity Database Wildlife Species of Concern

Common Name	Scientific Name	USFWS Status	BLM Status	USFS Status
Amphibians				
Bighorn Mountains spotted frog	*Rana luteiventris - Bighorn Mountains*	None	Sensitive	Sensitive
Bighorn Mountains wood frog	*Lithobates sylvaticus - Bighorn Mountains*	None	None	Sensitive
Northern leopard frog	*Lithobates pipiens*	Not Warranted for Listing	Sensitive	Sensitive
Birds				
American bittern	*Botaurus lentiginosus*	None	None	Sensitive
American dipper	*Cinclus mexicanus*	None	None	
American three-toed woodpecker	*Picoides dorsalis*	None	None	Sensitive
American white pelican	*Pelecanus erythrorhynchos*	None	None	None
Baird's sparrow	*Ammodramus bairdii*	None	Sensitive	
Bald eagle	*Haliaeetus leucocephalus*	Delisted, formally monitored	Sensitive	Sensitive
Black-billed cuckoo	*Coccyzus erythropthalmus*	None	None	None
Black-crowned night-heron	*Nycticorax nycticorax*	None	None	None

Common Name	Scientific Name	USFWS Status	BLM Status	USFS Status
Bobolink	*Dolichonyx oryzivorus*	None	None	None
Brewer's sparrow	*Spizella breweri*	None	Sensitive	Sensitive
Burrowing owl	*Athene cunicularia*	None	Sensitive	Sensitive
Calliope hummingbird	*Selasphorus calliope*	None	None	None
Clay-colored sparrow	*Spizella pallida*	None	None	None
Common goldeneye	*Bucephala clangula*	None	None	None
Common loon	*Gavia immer*	None	None	Sensitive
Dark-eyed junco	*Junco hyemalis*	None	None	None
Dickcissel	*Spiza americana*	None	None	None
Eastern bluebird	*Sialia sialis*	None	None	None
Eastern screech-owl	*Megascops asio*	None	None	None
Ferruginous hawk	*Buteo regalis*	None	Sensitive	Sensitive
Golden eagle	*Aquila chrysaetos*	None	None	None
Golden-crowned kinglet	*Regulus satrapa*	None	None	None
Grasshopper sparrow	*Ammodramus savannarum*	None	None	Sensitive
Greater sage-grouse	*Centrocercus urophasianus*	Not Warranted for Listing	Sensitive	Sensitive
Indigo bunting	*Passerina cyanea*	None	None	None
Loggerhead shrike	*Lanius ludovicianus*	None	Sensitive	Sensitive
Long-billed curlew	*Numenius americanus*	None	Sensitive	Sensitive
Merlin	*Falco columbarius*	None	None	None
Northern bobwhite	*Colinus virginianus*	None	None	None
Northern goshawk	*Accipiter gentilis*	Not Warranted for Listing	Sensitive	Sensitive
Northern pygmy-owll	*Glaucidium gnoma*	None	None	None
Osprey	*Pandion haliaetus*	None	None	None
Peregrine falcon	*Falco peregrinus*	Delisted, formally monitored	Sensitive	Sensitive
Pygmy nuthatch	*Sitta pygmaea*	None	None	None
Red-eyed vireo	*Vireo olivaceus*	None	None	None
Rose-breasted grosbeak	*Pheucticus ludovicianus*	None	None	None
Sandhill crane	*Grus canadensis*	None	None	None
Short-eared owl	*Asio flammeus*	None	None	Sensitive
Townsend's warbler	*Setophaga townsendi*	None	None	None
Tundra swan	*Cygnus columbianus*	None	None	None
Western screech-owl	*Megascops kennicottii*	None	None	None
White-winged crossbill	*Loxia leucoptera*	None	None	None
White-winged junco	*Junco hyemalis aikeni*	None	None	None
Williamson's sapsucker	*Sphyrapicus thyroideus*	None	None	None
Winter wren	*Troglodytes hiemalis*	None	None	None
Yellow-billed cuckoo	*Coccyzus americanus*	Listed Threatened	Sensitive	Sensitive
Insects				

Common Name	Scientific Name	USFWS Status	BLM Status	USFS Status
Monarch butterfly	*Danaus plexippus plexippus*	Petition Under Review	None	None
Snow scorpionfly	*Boreus bomari*	None	None	None
Tawny crescent	*Phyciodes batesii*	None	None	None
Mammals				
Bear lodge meadow jumping mouse	*Zapus hudsonius campestris*	None	None	None
Bighorn Mountains marten	*Martes caurina - Bighorn Mountains*	None	None	Sensitive
Bighorn Mountains pika	*Ochotona princeps princeps - Bighorn Mountains*	Not Warranted for Listing	None	None
Bighorn Mountains red squirrel	*Tamiasciurus hudsonicus - Bighorn Mountains*	None	None	None
Bighorn Mountains snowshoe hare	*Lepus americanus seclusus*	None	None	None
Bighorn Mountains water vole	*Microtus richardsoni - Bighorn Mountains*	None	None	Sensitive
Bighorn sheep	*Ovis canadensis*	None	None	Sensitive
Black-tailedpPrairie dog	*Cynomys ludovicianus*	Not Warranted for Listing	Sensitive	Sensitive
CanadalLynx	*Lynx canadensis*	Listed Threatened	None	None
Fringed myotis	*Myotis thysanodes*	None	Sensitive	Sensitive
Gray wolf	*Canis lupus*	Experimental Population, Non-Essential	None	Sensitive
Grizzly bear	*Ursus arctos horribilis*	Listed Threatened	None	None
Hayden's shrew	*Sorex haydeni*	None	None	None
Hoary bat	*Lasiurus cinereus*	None	None	Sensitive
Least weasel	*Mustela nivalis*	None	None	None
Little brown myotis	*Myotis lucifugus*	Petition Under Review	None	None
Long-legged myotis	*Myotis volans*	None	None	None
Silver-haired bat	*Lasionycteris noctivagans*	None	None	None
Thirteen-lined ground squirrel	*Ictidomys tridecemlineatus*	None	None	None
Townsend's big-eared bat	*Corynorhinus townsendii*	None	Sensitive	Sensitive
Western small-footed myotis	*Myotis ciliolabrum*	None	None	None
White-footed deermouse	*Peromyscus leucopus*	None	None	None
Molluscs				
A mountainsnail	*Oreohelix*	None	None	None
Fatmucket	*Lampsilis siliquoidea*	None	None	None
Pygmy mountain snail	*Oreohelix pygmaea*	Not Warranted for Listing	None	Sensitive
Reptiles				
Bullsnake	*Pituophis catenifer sayi*	None	None	None
Northern rubber boa	*Charina bottae*	None	None	None

3.4.3.2 Federally Protected Species

The USFWS (2017b) identifies two species listed under the ESA (7 U.S.C. § 136, 16 U.S.C. § 1531 et seq.) as potentially occurring within Level I Study Area:

(1) the Listed Threatened Canada lynx (*Lynx canadensis*); and
(2) the Listed Threatened Ute ladies' tresses (*Spiranthes diluvialis*).

Suitable habitat for the Ute ladies' tresses occurs in the Level I Study Area; however, there are no known occurrences. The closest known Ute ladies'-tresses occurrence is over 100 miles to the southeast. Suitable habitat is present for Canada lynx in the Big Horn Mountains, but there are no known occurrences in the Level I Study Area.

In addition to the two listed ESA species identified by the USFWS for assessment within the Level I Study Area, there are records of the occurrence of the following Listed Threatened species in the Level I Study Area (WYNDD 2016):

1. the grizzly bear (*Ursus arctos horribilis*); and
2. the yellow-billed cuckoo (*Coccyzus americanus*).

There are also records of the occurrence of the nonessential, experimental gray wolf (*Canis lupus*) in the Study Area (WYNDD 2016).

Bald eagles (*Haliaeetus leucocephalus*) and golden eagles (*Aquila chrysaetos*) are federally protected under the BGEPA; both species have been documented throughout the entire Level I Study Area. A total of 44 bird species federally protected under the MBTA are known to occur within the Level I Study Area during at least part of the year. Sixteen wildlife species in the Level I Study Area are designated as sensitive by the BLM, and 27 species are designated as sensitive by the USFS. (See Table 3.4.6.) These sensitive species have special management considerations on BLM and USFS lands.

3.4.3.3 Wyoming Game and Fish Department Managed Species

3.4.3.3.1 Greater Sage-Grouse

In September 2015, the USFWS determined that the greater sage-grouse (*Centrocercus urophasianus*) does not warrant protection under the ESA. USFWS determined that the threats identified in 2010 that caused the agency to initially designate the greater sage-grouse "warranted but precluded" have been significantly reduced as a result of the implementation of federal and state land use conservation plans and voluntary private conservation commitments. Currently, the greater sage-grouse receives state protection under State of Wyoming Executive Order 2015-4 (State of Wyoming 2015). The executive order describes the regulatory framework for the greater sage-grouse core area protection strategy, which aims to protect and enhance greater sage-grouse populations and habitat.

The Level I Study Area contains no greater sage-grouse core areas. The closest core area to the Watershed is approximately 12.4 miles to the southwest. The northernmost portion of the Watershed (Township [T] 57 North [N] Range [R] 84 West [W], T56N R85W, and T56N R84W) is located in the current range of greater sage-grouse (State of Wyoming 2015). Three leks are known to exist within the Level I Study Area. These leks are located in the northernmost portion of the Level I Study Area (T56N, R85W) (WG&FD 2016a). Figure 3.4.5 portrays the greater sage-grouse habitat distribution area and lek locations within the Level I Study Area.

3.4.3.3.2 Big Game

The WG&FD has mapped seasonal and crucial ranges and parturition areas for big game species throughout Wyoming. Seasonal range is the area in which a population or portion of a

KNOWN LEKS
GENERAL DISTRIBUTION

Story
Sheridan
Big Horn
Beckton
Ranchester
Dayton

GOOSE CREEK
LITTLE GOOSE CREEK
KRUSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
JACKSON CREEK
BEAVER CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK

Sheridan Co.
Johnson Co.
Bighorn Co.

14
87
338
335
331
90
14

N
0 1.25 2.5 5
Miles

GREATER SAGE-GROUSE HABITAT AND LEK LOCATIONS

GOOSE CREEK WATERSHED LEVEL I STUDY

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FIG. 3.4.5

population of animals makes general use of the suitable habitat within the range on a year-round basis. Crucial range is any seasonal range or habitat component that has been documented as the determining factor in a population's ability to maintain itself at a certain level (theoretically at or above the population objective) over the long term. Parturition areas are where lambing, fawning, or calving occur.

Big game is found throughout the entire Watershed. The Level I Study Area is located in the seasonal range of antelope (*Antilocapra americana*), elk (*Cervus canadensis*), mule deer (*Odocoileus hemionus*), moose (*Alces alces*), and white-tailed deer (*Odocoileus virginianus*). Pronghorn use only the northern half of the Level I Study Area, while elk, mule deer, moose, and white-tailed deer occupy the entire Level I Study Area.

Extensive portions of the Level I Study Area (approximately 55,000 acres) have been classified as crucial range for elk and moose. Elk crucial range consists of a narrow strip of land across the center of the Level I Study Area, while moose crucial range is spread out over the southern half of the Level I Study Area. Approximately 32,000 acres within the Level I Study Area have been classified as parturition areas for elk and moose. Parturition areas for both species are concentrated in the center of the Level I Study Area. See Figures 3.4.6 through 3.4.10 for big game ranges for antelope, elk, moose, mule deer, and white-tailed deer.

3.4.3.3.3 Habitat Priority Areas

The WG&FD updated its Strategic Habitat Plan in August 2015 (WG&FD 2015). The Plan defines how the WG&FD will conserve and improve habitat. The 2015 updates:

- incorporated recent information on species distribution and seasonal habitat delineation (primarily for crucial big game winter range and greater sage-grouse core areas);
- improved linkages between the Strategic Habitat Plan and priority areas;
- clarified how proposed habitat projects will be ranked relative to priority areas and opportunities; and
- incorporated species of greatest conservation need as identified in the 2010 State Wildlife Action Plan (WG&FD 2015).

The Strategic Habitat Plan divides wildlife habitat into two distinct categories: crucial habitat priority areas and enhancement habitat priority areas. Crucial habitat priority areas are crucial to conserving and maintaining populations of terrestrial and aquatic wildlife for the present and the future. These areas are based on significant biological and ecological values, including habitats that support important life stages needed for maintaining game species, sensitive native non-game species, unique species assemblages, and ecologically important species or communities (WG&FD 2015). Enhancement habitat priority areas are important wildlife areas that can or should be actively enhanced or improved by the WG&FD and the agency's partners. These areas are selected based on habitat issues (e.g., habitat fragmentation, invasive species, or degraded habitat) and the potential for successful conservation work (WG&FD 2015). Enhancement habitat priority areas may overlap crucial habitat priority areas.

The Level I Study Area contains a variety of habitat priority areas: six terrestrial crucial, three terrestrial enhancement, two aquatic crucial, three aquatic enhancement, two combined crucial, and one combined enhancement areas. Table 3.4.7 provides a list of these crucial habitat priority areas and enhancement habitat priority areas that overlap the Level I Study Area.

ANTELOPE WINTER RANGE

Sheridan
Big Horn
Beckton
Ranchester
Dayton
Story

GOOSE CREEK
LITTLE GOOSE CREEK
KRUSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
JACKSON CREEK
BEAVER CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK

Sheridan Co.
Johnson Co.
Bighorn Co.

14
87
338
335
331
90
14

N

0 1.25 2.5 5
Miles

ANTELOPE WINTER RANGE

GOOSE CREEK WATERSHED LEVEL I STUDY

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FIG. 3.4.6

ELK HABITAT TYPE

- CRUCIAL WINTER
- CRUCIAL WINTER & PARTURITION
- SPRING, SUMMER, FALL
- SPRING, SUMMER, FALL & PARTURITION

Sheridan
Story
Big Horn
Beckton
Ranchester
Dayton
Sheridan Co.
Johnson Co.
Bighorn Co.
GOOSE CREEK
LITTLE GOOSE CREEK
KRUSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
JACKSON CREEK
BEAVER CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK
14
87
338
90
335
331

N

0 1.25 2.5 5 Miles

ELK HABITAT

GOOSE CREEK WATERSHED LEVEL I STUDY

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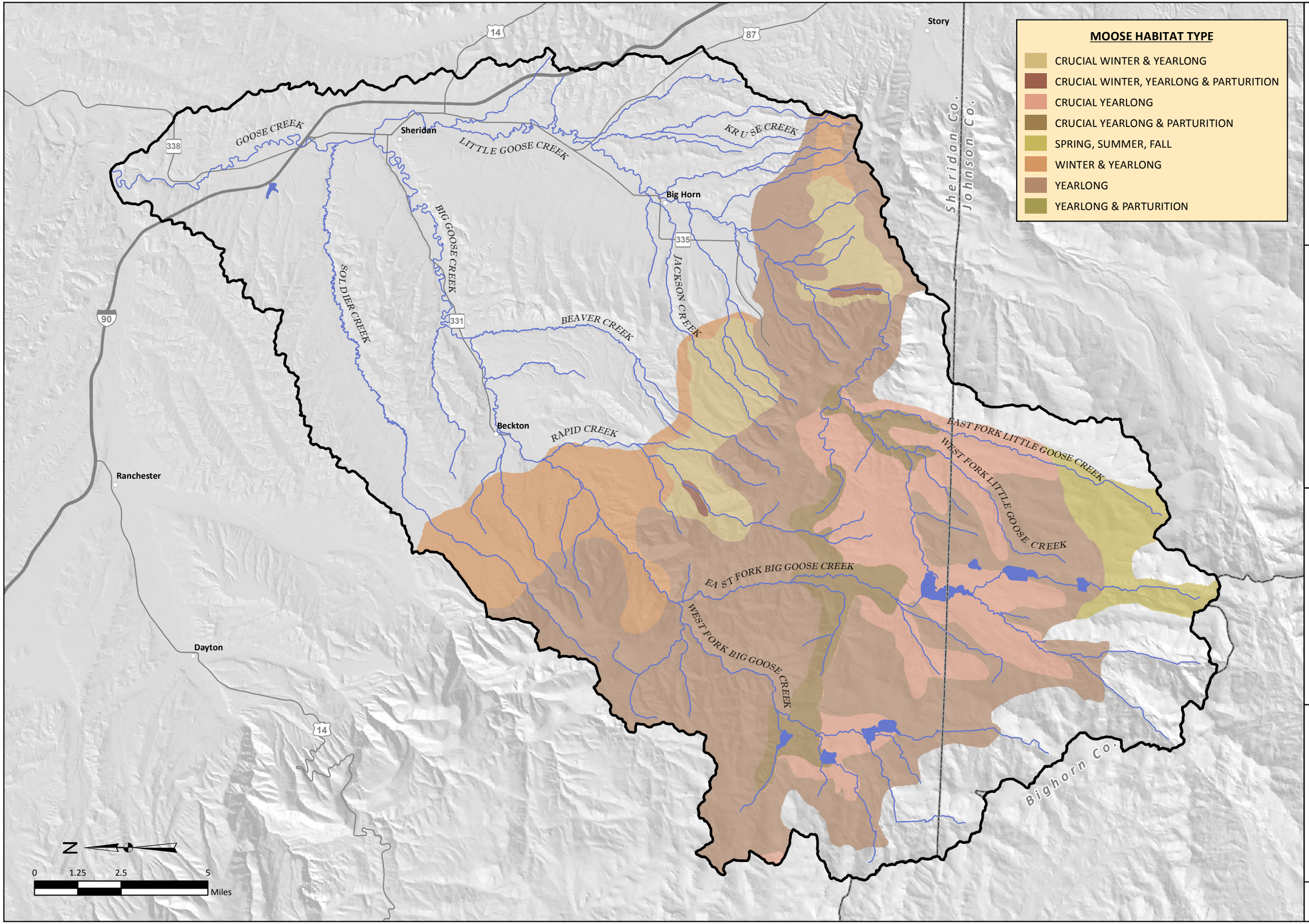
FIG. 3.4.7



MOOSE HABITAT

GOOSE CREEK WATERSHED
LEVEL I STUDY

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FIG. 3.4.8

MULE DEER HABITAT TYPE

- SPRING, SUMMER, FALL
- YEARLONG & WINTER
- YEARLONG GENERAL

Sheridan
Big Horn
Beckton
Ranchester
Dayton
Story
Sheridan Co.
Johnson Co.
Bighorn Co.
GOOSE CREEK
LITTLE GOOSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
KRUSE CREEK
JACKSON CREEK
BEAVER CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK
14
87
338
90
331
335

N

0 1.25 2.5 5 Miles

MULE DEER HABITAT

GOOSE CREEK WATERSHED LEVEL I STUDY

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FIG. 3.4.9

WHITE-TAILED DEER HABITAT

Story
Sheridan
Big Horn
Beckton
Ranchester
Dayton
Sheridan Co.
Johnson Co.
Bighorn Co.
14
87
338
90
335
331
GOOSE CREEK
LITTLE GOOSE CREEK
KRUSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
JACKSON CREEK
BEAVER CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK

WHITE-TAILED DEER HABITAT

N

0 1.25 2.5 5
Miles

GOOSE CREEK WATERSHED LEVEL I STUDY

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FIG. 3.4.10

Table 3.4.7 - Crucial and Enhancement Habitat Priority Areas within the Level I Study Area

Habitat Priority Area Type	Name
Terrestrial Crucial Habitat Priority Area	Bighorn National Forest Riparian and Aspen Communities
	Deciduous Woodlands in the Sheridan Area and along the Little Missouri River
	Powder-Tongue Rivers and Tributaries Cottonwood-Willow Riparian Ecosystem
	Spruce-fir Stands
	Big Game Crucial Range
	Big Game Parturition Areas
Terrestrial Enhancement Habitat Priority Area	Crucial Elk Winter Ranges with a High Probability of Being Encroached
	Deciduous Woodlands - Sheridan Area and Little Missouri River
	Powder and Tongue Rivers and Tributaries Cottonwood-Willow Riparian Ecosystem
Aquatic Crucial Habitat Priority Area	Foothills Stream and Riparian Corridors
	Prairie Stream and Riparian Corridors
Aquatic Enhancement Habitat Priority Area	Community Fishing Ponds
	Foothills Stream and Riparian Corridors
	Prairie Stream and Riparian Corridors
Combined Crucial Habitat Priority Area	Bighorn Mountains Riparian and Aspen Communities
	Riparian
Combined Enhancement Habitat Priority Area	BNF Aspen Riparian Communities

Table 3.4.8 lists the acres within the Level I Study Area that are classified as crucial or enhancement habitat priority areas.

Table 3.4.8 - Acreages of Crucial and Enhancement Habitat Priority Areas within the Level I Study Area

Habitat Priority Area	Acres
Terrestrial Crucial Habitat Priority Areas	327,552
Terrestrial Enhancement Habitat Priority Areas	55,011
Aquatic Crucial Habitat Priority Areas	49,365
Aquatic Enhancement Habitat Priority Areas	35,547
Combined Crucial Habitat Priority Areas	152,820
Combined Enhancement Habitat Priority Areas	113,479

3.4.4 Fisheries

3.4.4.1 Species Occurrence

The Watershed is dominated by both warm-water and cold-water game and non-game species, including brown trout, rainbow trout, brook trout, mountain whitefish, longnose sucker, longnose dace, white sucker, mountain sucker, black bullhead, carp, fathead minnow, golden shiner, green sunfish, shorthead redhorse, stonecate, crappie, and yellow perch (SWCA 2010). A limited amount of fish species sampling has occurred in the Watershed. Fish population trends for the Big Goose Creek Subwatershed, the Little Goose Creek Subwatershed, and the Lower Goose Creek Subwatershed are generally the same for the abundance and distribution of cold-water and warm-water game species. No fisheries information exists for Soldier Creek, which is within the subwatershed that is downstream of the confluence. Within the City, extensive channelization has resulted in limited fishery habitat (SCCD 2003).

Fish species present within the Level I Study Area are brook trout, brown trout, carp, creek chub, fathead minnow, smallmouth bass, lake chub, longnose dace, longnose sucker, mountain sucker, mountain whitefish, rainbow trout, rock bass, and white sucker (personal communication,

email from Bill Bradshaw, WG&FD, to Jason Kline, SWCA, December 7, 2016). The WDEQ classifies the majority of the Watershed as a cold-water fishery.

Little Goose Creek begins to contain warm-water species downstream of U.S. Highway 87, and the WG&FD recorded no cold-water game species from the Woodland Park Bridge downstream to the City. The Goose Creek warm-water species transition zone occurs just upstream of the City limits (SWCA 2010). Warm-water species are primarily present in the subwatershed downstream of the confluence of Big Goose Creek and Little Goose Creek, excluding Soldier Creek; however, brown trout are known to occasionally reside there.

WYNDD fisheries data (WYNDD 2016) lists state and/or federal agency species of concern, including Yellowstone cutthroat trout, and plains minnow. No ESA-listed fish species were listed in the WYNDD fisheries within the Level I Study Area. (See Table 3.4.9.)

Table 3.4.9 – Fisheries Species of Concern in the Watershed

Scientific Name	Common Name	USFWS ESA	WY BLM	USFS	WG&FD	Species Rank	Notes
Oncorhynchus clarkii bouvieri	Yellowstone cutthroat trout	N/A	Not Warranted for Listing (NW)	Sensitive	Region 2 Sensitive; Region 4 Sensitive	NSS2 (Ba); Tier 1	Historically, Yellowstone cutthroat trout lived in lakes, rivers, and streams of the Yellowstone River drainage (including Yellowstone Lake). Also found in the Snake, Tongue, Bighorn, and Clarks Fork drainages.
Prosopium williamsoni	Mountain Whitefish	N/A				NSS4 (Bc); Tier 2	Inhabits large, clear, cold rivers and lakes, favoring deep pools in otherwise fast moving water. Common in many Wyoming drainages west of the Continental Divide, as well as portions of the Madison, Yellowstone, Bighorn, and Tongue River drainages.
Sander canadensis	Sauger	N/A				NSS3 (Bb); Tier 2	Occurs in large rivers with deep pools, low channel slope, low stream velocity, and often with turbid water. Can also be found in reservoirs. In Wyoming, sauger is native east of the Continental Divide. The species was historically found in the North Platte River but now seems to be limited to the Wind, Bighorn, Tongue, and Powder River drainages.
Hybognathus placitus	Plains minnow	N/A			Region 2 Sensitive	NSS3 (Bb); Tier 2	Prefers slow-moving, turbid streams and side pools where it feeds on stream-bottom vegetation. In Wyoming, the species occurs in the Bighorn, Powder, and Missouri River drainages, including Clear Creek.

3.4.4.2 Fish Passage

The WG&FD is in the process of cataloging existing structures throughout the State that may inhibit fish passage. This cataloging was reviewed as part of this Level I Study. As of 2016, the WG&FD has identified 16 structures that potentially inhibit fish passage on streams in the Level I Study Area. Of the 16 documented structures, five of these structures had previously been identified and inventoried by the WG&FD, and 11 had been identified but not inventoried.

A task of this Level I Study is to augment WG&FD's statewide cataloging efforts, specifically within the Watershed. As will be discussed in subsequent sections, an inventory of major irrigation ditches within the Watershed is being performed, which includes information on these ditches' diversion structures. In order to meet WG&FD's request to obtain information on these structures (specifically with respect to their impact upon fisheries migration), EnTech filled out and submitted to WG&FD this state agency's Fish Passage Inventory Form 2016 for each structure. Documentary photos were included with the submittal. The 11 structures previously identified but not inventoried by WG&FD were part of those for which information was submitted.

Figure 3.4.11 shows the location of the fish passage structures previously identified by the WG&FD, along with those inventoried in this Level I Study.

3.4.5 Geology

3.4.5.1 Surficial Geology

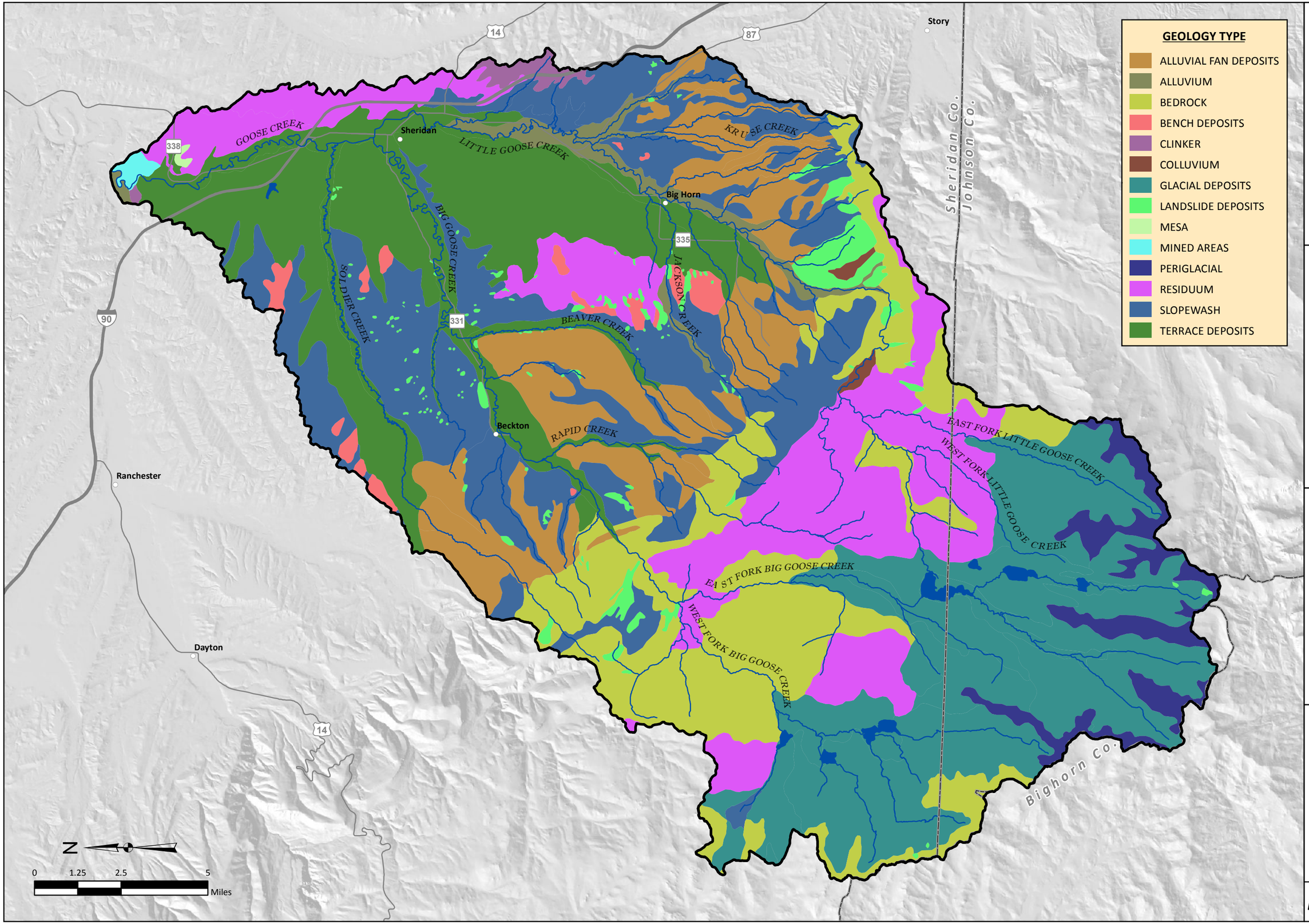
Geologic mapping information and data for the Watershed were obtained from the USGS and the Wyoming State Geological Survey. The Watershed is on the eastern dip slope of the central structural segment of the Bighorn Mountain Range. This segment is characterized by steeply-dipping Paleozoic- and Mesozoic- age strata along the edge of extensive, high-elevation Precambrian rock outcrops forming the core of the Range. Eastward-directed thrust faulting is common in this segment. Individual thrust blocks are bounded by high-angle faults trending obliquely to the mountain range.

Surficial deposits found within the Watershed are a wide distribution of alluvium, bench deposits, terrace deposits, landslide deposits, mesa, slope wash, colluvium, glacial deposits, and residuum (Hallberg and Case 1999a; Hallberg and Case 1999b; Ver Ploeg and Boyd 2001). Figure 3.4.12 depicts the surficial deposits within the Watershed. The deposits lie on the eastern slope of the Bighorn Mountains and dip at 30 to 40 degrees to the northeast into the Powder River Basin. These sediment types constitute a portion of the exposed geology within the Watershed. The remaining exposed geology is composed of bedrock from Precambrian age through Recent, as described in Section 3.4.5.2.

Each of the surficial deposits will produce soils and vegetation as a function of its physical and chemical composition, slope, slope aspect, local precipitation, other climatic factors, age, etc., which vary widely across the Level I Study Area.

3.4.5.2 Bedrock Units

The geologic formations that underlie the Watershed range in age from Precambrian to Recent. Table 3.4.10 identifies the bedrock geology units in the Watershed, their acreage, the percentage of the Watershed they cover, and the geologic codes that correspond to those on Figure 3.4.13. This figure also shows the bedrock units in the Watershed (Love and Christiansen 1985).



SURFICIAL GEOLOGY

GOOSE CREEK WATERSHED
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FIG. 3.4.12

GEOLOGIC UNITS

QA	TFU	KMT
QT	TFTR	KJG
QG	KL	^PCG
QLS	KLM	PM
QU	KFB	MD
TW	KMV	O_
TWMO	KC	WVG
TWK	KF	UGN

Sheridan
Story
Big Horn
Beckton
Ranchester
Dayton
Sheridan Co.
Johnson Co.
Bighorn Co.
GOOSE CREEK
LITTLE GOOSE CREEK
KRUSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
BEAVER CREEK
JACKSON CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK
14
87
338
335
331
90
14

N

0 1.25 2.5 5 Miles

BEDROCK GEOLOGY

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FIG. 3.4.13

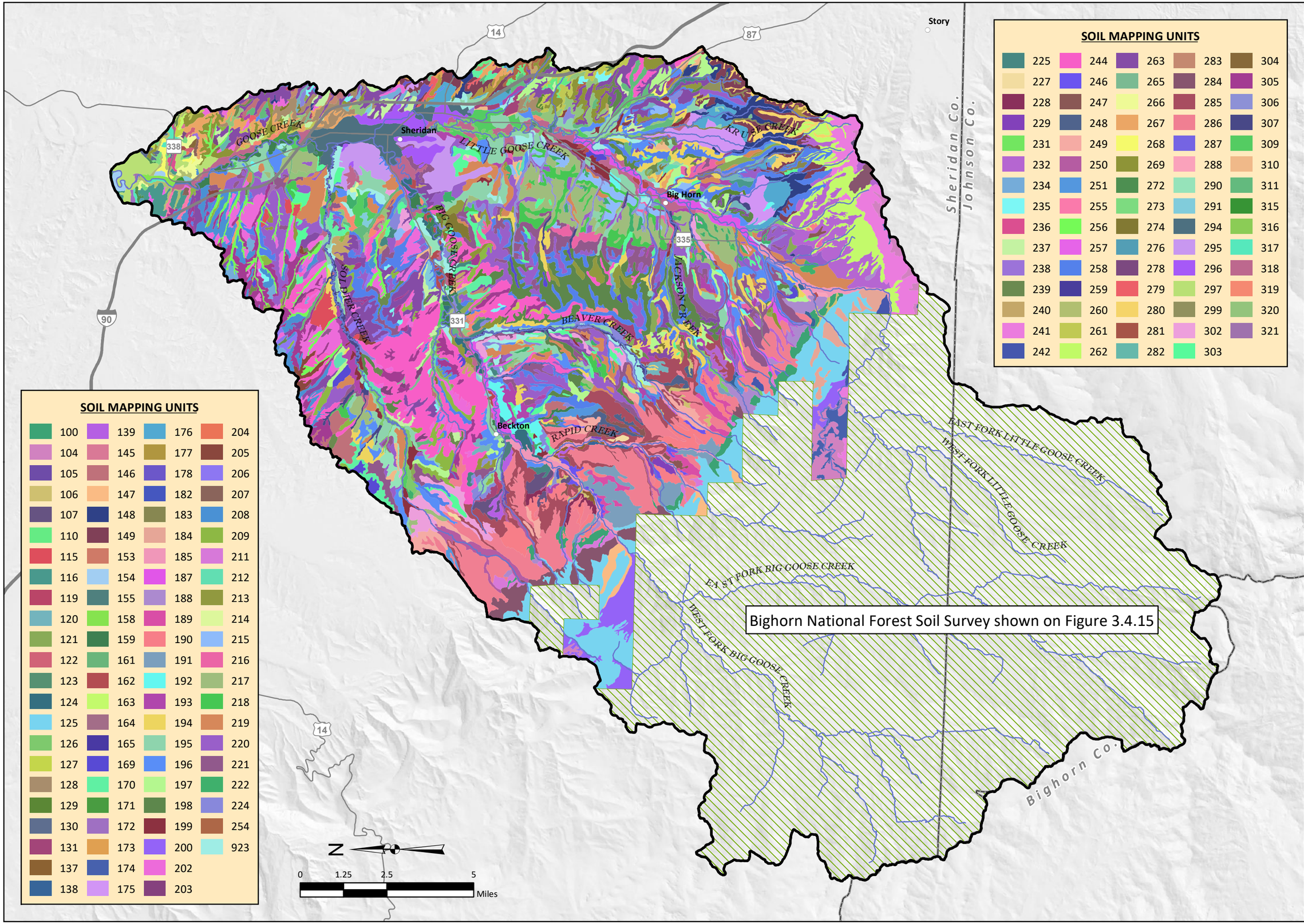
Table 3.4.10 - Bedrock Geology Formations

Geologic Code	Bedrock Geology Units	Acres	Percentage
WVg	Plutonic rocks	9,8283	36.97%
Tfu	Fort Union Formation	49,810	18.74%
Qa	Alluvium and colluvium	22,718	8.55%
Tw	Wasatch Formation	15,442	5.81%
Qg	Glacial deposits	13,847	5.21%
Tftr	Tongue River Member of Fort Union Formation	9,704	3.65%
Qu	Undivided surficial deposits	7,153	2.69%
Twk	Kingsbury Conglomerate Member of Wasatch Formation	6,615	2.49%
O_	Bighorn Dolomite, Gallatin Limestone, and Gros Ventre Formation (TB); Bighorn Dolomite, Snowy Range Formation, Pilgrim Limestone, Park Shale, Meagher Limestone, Wolsey Shale, and Flathead Sandstone (Y); Bighorn Dolomite, Gallatin Limestone, Gros Ventre F	6,575	2.47%
Kc	Cody Shale	6,394	2.41%
MD	Madison Limestone or Group, and Darby Formation, or Madison Group, and Three Forks and Jefferson Formations	5,717	2.15%
Klm	Lance Formation, Fox Hills Sandstone, Meeteetse Formation, and Bearpaw and Lewis Shales	5,640	2.12%
PM	Tensleep Sandstone and Amsden Formation	3,268	1.23%
Twmo	Moncrief Member of Wasatch Formation	2,301	0.87%
KJg	Cloverly, Morrison, Sundance, and Gypsum Spring Formations	1,979	0.74%
^Pcg	Chugwater and Goose Egg Formations	1,966	0.74%
Kmv	Mesaverde Formation (N) or Mesaverde Group (S)	1,775	0.67%
Kmt	Mowry and Thermopolis Shales	1,435	0.54%
Qls	Landslide deposits	1,294	0.49%
Kfb	Fox Hills Sandstone and Bearpaw Shale	1,280	0.48%
Kl	Lance Formation	1,224	0.46%
Kf	Frontier Formation	949	0.36%
Qt	Gravel, pediment, and fan deposits	451	0.17%
Ugn	Oldest gneiss complex	19	0.01%

3.4.6 Soils

The soils in the Watershed have been mapped in two separate efforts. The NRCS has mapped the Sheridan County portion of the Watershed (see Figure 3.4.14) that is not within the BNF (NRCS 2016a), and the USFS has mapped those portions of Sheridan County and Johnson County located within the BNF portion of the Watershed (Nesser 1986). (See Figure 3.4.15.)

The soils are mapped to polygons that include soil associations or complexes with some consociations and undifferentiated groups at scales of 1:20,000 to 1:63,360 (NRCS 2016d). These mapped soil polygons are called soil map units (SMUs). Each SMU is assigned a soil number. The soil numbers in Figures 3.4.14 and 3.4.15 correlate to the soil numbers in Table 3.4.11, which also contains the associated SMUs, soil survey source, acreages within the Watershed, and percentages of acreage within the Watershed.



NRCS SOIL SURVEY

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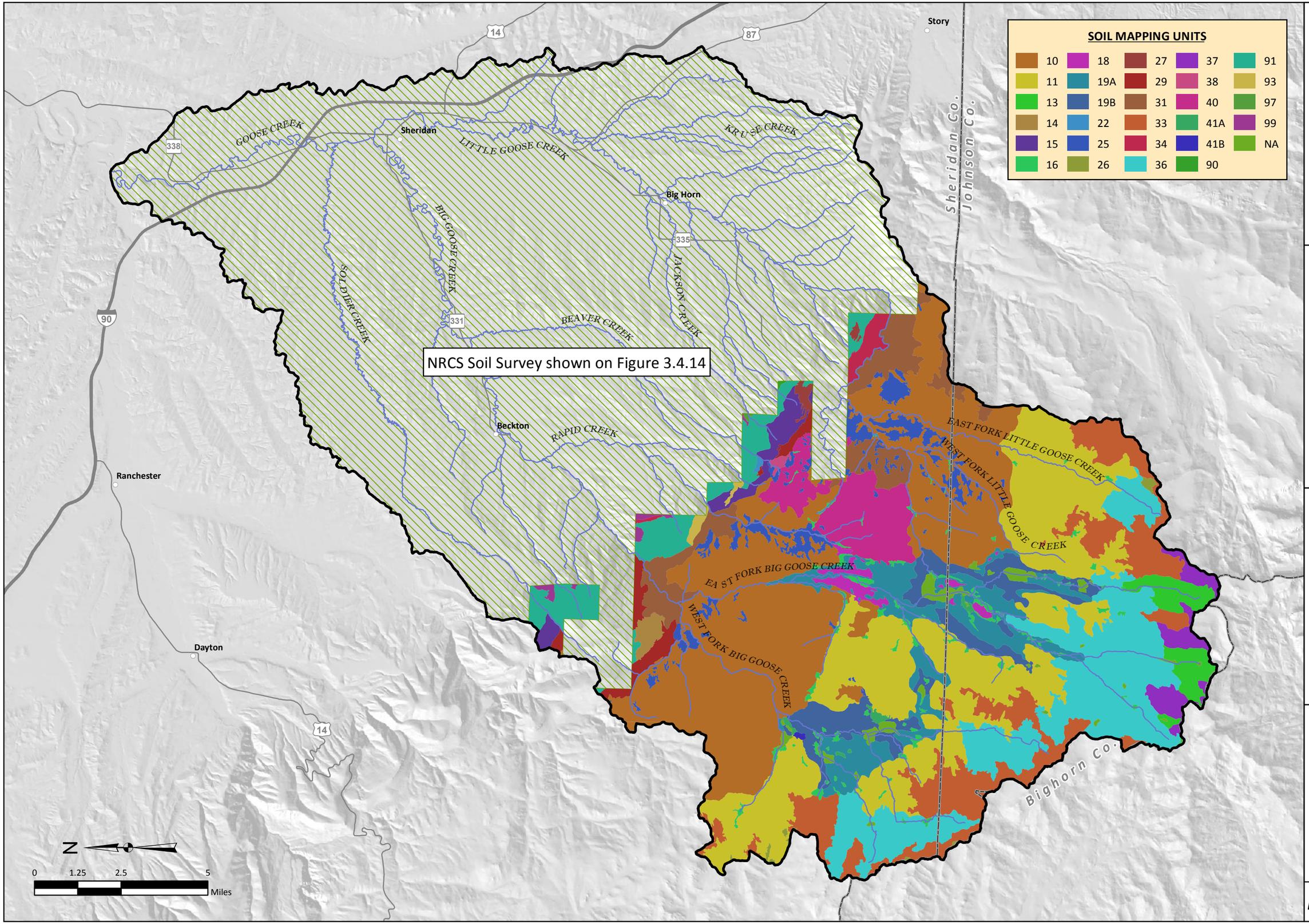
FIG. 3.4.14



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SOIL SURVEY

GOOSE CREEK WATERSHED
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FIG. 3.4.15

The Level I Study Area contains 192 SMUs: 163 in the NRCS soil survey (NRCS 2016a) and 29 in the BNF soil survey (Nesser 1986). The Level I Study Area contains fewer BNF soil survey SMUs because the geology and vegetation becomes more heterogeneous as elevation increases into the Bighorn Mountains. Exposed bedrock on montane and subalpine slopes has little to no soil development. The four SMUs with the most acreage in the Watershed are located in the high elevations of the BNF. The highest acreage SMU is Agneston-Granite-Rock outcrop associated on montaine and subalpine mountain slopes, 5 to 50 percent slopes, and covering 29,516 acres (11.10%) of the Watershed.

The SMUs cover fewer acres and become more numerous in the lower elevation foothills and valleys of the Level I Study Area as a result of increasing variation in surficial geology, topography, climate, and vegetation. The SMU with the most acreage in the lower elevations is the Trimad-Trivar complex, 0 to 25 percent slopes, covering 6,599 acres (2.48%) of the Watershed. The 10 lowest-acreage SMUs are all in the lower elevation areas of the Watershed, and each cover fewer than 20 acres, which is less than 1/1,000 of a percent of the Watershed (SWCA 2010).

The Big Goose Creek Subwatershed soils are dominated by sandy loam-textured soils at middle to higher elevations, whereas the plains below Big Goose Canyon mainly consist of shallow to deep loamy soils characteristic of mountain slopes, terraces, and alluvial fans. The Little Goose Creek Subwatershed soils are dominated by channery loam-textured soils at middle elevations, by loam-textured soils characteristic of terraces and alluvial fans in the lower plains, and by fine sandy loam-textured soils typical of gently sloping floodplains and alluvial fans near the confluence of Big Goose and Little Goose Creeks. The soils downstream of the confluence are primarily dominated by deep, loam-textured soils typically found in floodplains, alluvial fans, and terraces, with soils associated with Soldier Creek consisting primarily of shallow to deep loamy soils, and the soils along Goose Creek dominated by find sandy loam-textured soils.

Table 3.4.11 - Soil Map Units in the Level I Study Area

Soil No.	Soil Map Unit (SMU)	Soil Survey Source*	Acres	Percentage
10	Agneston-Granite-Rock outcrop associated on montane and subalpine mountain slopes, 5 to 50 percent slopes	BNF	29,516	11.10%
11	Agneston-Leighcan association on montane and subalpine mountain slopes, 5 to 30 percent slopes	BNF	23,068	8.68%
36	Rock outcrop-Teewinot-Agneston association on subalpine mountain slopes, 5 to 35 percent slopes	BNF	13,671	5.14%
33	Rock outcrop-Mirror-Teewinot association on subalpine and alpine mountain slopes, 5 to 35 percent slopes	BNF	9,991	3.76%
286	Trimad-Trivar complex, 0 to 25 percent slopes	NRCS	6,599	2.48%
244	Samday-Gayhart-Hilight clay loams, moist, 2 to 60 percent slopes	NRCS	6,540	2.46%
19A	Frisco-Troutville association on montane and subalpine glacial till, 2 to 40 percent slopes	BNF	6,464	2.43%
220	Platsher-Wolfvar loams, 3 to 6 percent slopes	NRCS	6,213	2.34%
258	Shingle-Nihill complex, moist, 3 to 80 percent slopes	NRCS	5,499	2.07%
125	Cloud Peak-Tolman complex, 10 to 75 percent slopes	NRCS	5,225	1.97%

Soil No.	Soil Map Unit (SMU)	Soil Survey Source*	Acres	Percentage
263	Shingle-Samday clay loams, 3 to 55 percent slopes, moist	NRCS	5,200	1.96%
31	Rock outcrop-Agneston-Rubble association on montane and subalpine mountain slopes, 5 to 60 percent slopes	BNF	4,903	1.84%
221	Platsher-Wolfvar complex, 6 to 9 percent slopes	NRCS	4,728	1.78%
19B	Frisco-Troutville association on montane and subalpine glacial moraines, 2 to 40 percent slopes	BNF	4,490	1.69%
40	Tellman-Granile-Agneston association on montane and subalpine mountain slopes, 2 to 20 percent slopes	BNF	4,461	1.68%
198	Nuncho-Emigrant association, 9 to 15 percent slopes	NRCS	3,844	1.45%
91	Cloud Peak-Tolman complex on montane mountain slopes, 10 to 75 percent slopes	BNF	3,839	1.44%
217	Platsher clay loam, 0 to 3 percent slopes	NRCS	3,626	1.36%
195	Nuncho clay loam, 0 to 3 percent slopes	NRCS	3,482	1.31%
285	Trimad-Doney-Wayden complex, 15 to 45 percent slopes	NRCS	3,301	1.24%
219	Platsher-Wolfvar loams, 0 to 3 percent slopes	NRCS	3,292	1.24%
25	Lucky-Burgess-Hazton association on montane and subalpine mountain slopes, 2 to 30 percent slopes	BNF	3,238	1.22%
305	Worfka-Shingle-Samday complex, moist, 6 to 30 percent slopes	NRCS	2,611	0.98%
202	Parmleed-Bidman association, moist, 3 to 9 percent slopes	NRCS	2,576	0.97%
163	Hesperus variant-Reget association, 10 to 65 percent slopes	NRCS	2,428	0.91%
196	Nuncho clay loam, 3 to 6 percent slopes	NRCS	2,400	0.90%
194	Nuncho loam, 6 to 9 percent slopes	NRCS	2,362	0.89%
232	Reget variant-Reget association, 10 to 65 percent slopes	NRCS	2,241	0.84%
13	Cirque Land, 10 to 130 percent slopes	BNF	2,097	0.79%
241	Rock outcrop-Agneston-Rubble land association, 20 to 50 percent slopes	NRCS	1,945	0.73%
190	Norbert-Reget-Savar association, 3 to 35 percent slopes	NRCS	1,708	0.64%
126	Coaliams-Worthenton, moist, complex, 0 to 3 percent slopes	NRCS	1,684	0.63%
923	Recluse loam, 0 to 3 percent slopes	NRCS	1,668	0.63%
149	Hargreave-Moskee fine sandy loams, 9 to 15 percent slopes	NRCS	1,659	0.62%
16	Cryaquolls on montane and subalpine mountain slopes, 0 to 5 percent slopes	BNF	1,643	0.62%
318	Zigweid-Kishona-Cambria complex, moist, 0 to 3 percent slopes	NRCS	1,636	0.62%
37	Rubble land on subalpine and alpine mountain slopes, 5 to 50 percent slopes	BNF	1,613	0.61%
294	Urban land-Kishona, moist-Clarkelen complex, 0 to 3 percent slopes	NRCS	1,575	0.59%
295	Urban land-Platsher-Wolfvar complex, 0 to 6 percent slopes	NRCS	1,565	0.59%

Soil No.	Soil Map Unit (SMU)	Soil Survey Source*	Acres	Percentage
187	Nesda variant-Havertel complex, 0 to 3 percent slopes	NRCS	1,530	0.58%
302	Wolf loam, 0 to 3 percent slopes	NRCS	1,461	0.55%
15	Cloud Peak-Eutroboralfs-Argiborolls association on montane mountain slopes, 10 to 65 percent slopes	BNF	1,455	0.55%
200	Owen Creek-Echemoor-Bynum association, 9 to 30 percent slopes	NRCS	1,449	0.55%
197	Nuncho-Emigrant complex, 3 to 9 percent slopes	NRCS	1,445	0.54%
208	Parmleed-Worfka association, moist, 0 to 9 percent slopes	NRCS	1,435	0.54%
284	Tolman-Beeno-Beenom complex, 5 to 45 percent slopes	NRCS	1,404	0.53%
218	Platsher clay loam, 3 to 6 percent slopes	NRCS	1,403	0.53%
191	Norbert-Rock outcrop complex, 15 to 35 percent slopes	NRCS	1,395	0.52%
185	Nesda stony silt loam, 0 to 3 percent slopes	NRCS	1,390	0.52%
303	Wolf loam, 3 to 6 percent slopes	NRCS	1,384	0.52%
148	Hargreave-Moskee sandy loams, 3 to 9 percent slopes	NRCS	1,316	0.50%
269	Shingle-Theedle-Kishona association, moist, 3 to 30 percent slopes	NRCS	1,313	0.49%
29	Owen Creek-Echjemoor-Bynum association on montane and subalpine mountain slopes, 2 to 30 percent slopes	BNF	1,310	0.49%
175	Moskee sandy loam, 0 to 3 percent slopes	NRCS	1,297	0.49%
224	Recluse loam, 3 to 6 percent slopes	NRCS	1,177	0.44%
104	Agneston-Granite-Rock outcrop association, 10 to 50 percent slopes	NRCS	1,172	0.44%
193	Nuncho loam, 3 to 6 percent slopes	NRCS	1,170	0.44%
307	Worthenton-Recluse complex, 0 to 3 percent slopes	NRCS	1,168	0.44%
256	Shingle-Haverdad association, moist, 0 to 80 percent slopes	NRCS	1,156	0.43%
176	Moskee sandy loam, 3 to 6 percent slopes	NRCS	1,093	0.41%
WA	Water	BNF	1,077	0.41%
209	Parmleed-Worfka association, moist, 9 to 25 percent slopes	NRCS	1,076	0.40%
296	Urban land-Wyarno-Nuncho complex, 0 to 3 percent slopes	NRCS	1,047	0.39%
100	Abac-Rock outcrop complex, 35 to 50 percent slopes	NRCS	1,006	0.38%
309	Wyarno clay loam, 0 to 3 percent slopes	NRCS	943	0.35%
249	Savage-Farnuf silt loams, 0 to 6 percent slopes, gravelly substratum	NRCS	905	0.34%
213	Platmak loam, 3 to 6 percent slopes	NRCS	843	0.32%
267	Shingle-Theedle loams, moist, 45 to 75 percent slopes	NRCS	843	0.32%
237	Renohill, moist-Ulm association, 3 to 10 percent slopes	NRCS	835	0.31%
199	Nuncho variant clay loam, 0 to 6 percent slopes	NRCS	817	0.31%
18	Fourmile loam on montane and subalpine mountain slopes, 2 to 30 percent slopes	BNF	801	0.30%
222	Platsher variant loam, 0 to 3 percent slopes	NRCS	787	0.30%

Soil No.	Soil Map Unit (SMU)	Soil Survey Source*	Acres	Percentage
215	Platsher loam, 0 to 3 percent slopes	NRCS	773	0.29%
146	Gayhart-Bahl association, moist, 6 to 15 percent slopes	NRCS	768	0.29%
311	Wyarno clay loam, 6 to 9 percent slopes	NRCS	760	0.29%
320	Zigweid-Kishona-Cambria loams, moist, 6 to 9 percent slopes	NRCS	757	0.28%
128	Cushman-Forkwood association, moist, 0 to 9 percent slopes	NRCS	754	0.28%
170	Jonpol-Platmak association, 9 to 25 percent slopes	NRCS	733	0.28%
188	Norbert-Doney-Rock outcrop complex, 8 to 45 percent slopes	NRCS	713	0.27%
306	Worthenton clay loam, 0 to 3 percent slopes	NRCS	707	0.27%
121	Cedak-Recluse association, 9 to 15 percent slopes	NRCS	694	0.26%
250	Savage-Korchea loams, 0 to 3 percent slopes	NRCS	688	0.26%
120	Cedak-Recluse loams, 6 to 9 percent slopes	NRCS	659	0.25%
297	Ustic Torriorthents-Pits complex, 0 to 100 percent slopes	NRCS	652	0.25%
280	Treoff-Xema complex, 10 to 65 percent slopes	NRCS	649	0.24%
192	Nuncho loam, 0 to 3 percent slopes	NRCS	643	0.24%
34	Rock outcrop-Starman association on montane and subalpine mountain slopes, 5 to 70 percent slopes	BNF	633	0.24%
216	Platsher loam, 3 to 6 percent slopes	NRCS	633	0.24%
189	Norbert-Eltsac complex, 15 to 35 percent slopes	NRCS	627	0.24%
159	Haverdad-Draknab complex, moist, 0 to 3 percent slopes	NRCS	621	0.23%
261	Shingle, moist-Rock outcrop complex, 30 to 50 percent slopes	NRCS	620	0.23%
184	Nathrop-Passcreek-Starley association, 3 to 40 percent slopes	NRCS	614	0.23%
239	Renohill-Worfka association, moist, 3 to 20 percent slopes	NRCS	560	0.21%
183	Moskee-Worthenton, moist, association, 0 to 45 percent slopes	NRCS	548	0.21%
225	Recluse loam, 6 to 9 percent slopes	NRCS	530	0.20%
116	Big Horn-Wolf, dry, loams, 0 to 6 percent slopes	NRCS	488	0.18%
124	Clarkelen fine sandy loam, moist, 0 to 3 percent slopes	NRCS	471	0.18%
169	Jonpol-Platmak association, 0 to 9 percent slopes	NRCS	470	0.18%
290	Ulm clay loam, 0 to 3 percent slopes	NRCS	455	0.17%
147	Hardhart-Starley association, 10 to 60 percent slopes	NRCS	455	0.17%
14	Cloud Peak gravelly silt loam on montane and subalpine mountain slopes, 5 to 45 percent slopes	BNF	451	0.17%
131	Cushman-Worf association, moist, 3 to 15 percent slopes	NRCS	437	0.16%
107	Assinniboine-Dast complex, 3 to 65 percent slopes	NRCS	425	0.16%
115	Bidman, moist-Ulm loams, 0 to 6 percent slopes	NRCS	422	0.16%
174	Lucky-Burgess-Hazton associaiton, 8 to 30 percent slopes	NRCS	421	0.16%
251	Savage-Reget association, 4 to 30 percent slopes	NRCS	416	0.16%
248	Savage silt loam, 9 to 15 percent slopes	NRCS	390	0.15%
211	Peritsa-Abac association, 9 to 35 percent slopes	NRCS	388	0.15%

Soil No.	Soil Map Unit (SMU)	Soil Survey Source*	Acres	Percentage
240	Renohill, moist-Wyarno association, 6 to 9 percent slopes	NRCS	388	0.15%
321	Water	NRCS	382	0.14%
162	Havertel silt loam, 0 to 3 percent slopes	NRCS	363	0.14%
310	Wyarno clay loam, 3 to 6 percent slopes	NRCS	351	0.13%
247	Savage silt loam, 6 to 9 percent slopes	NRCS	340	0.13%
234	Renohill-Savageton complex, 3 to 10 percent slopes, moist	NRCS	324	0.12%
205	Parmleed-Renohill complex, moist, 3 to 9 percent slopes	NRCS	319	0.12%
274	Shingle-Worf complex, moist, 9 to 15 percent slopes	NRCS	303	0.11%
319	Zigweid-Kishona-Cambria complex, moist, 3 to 6 percent slopes	NRCS	302	0.11%
246	Savage loam, 0 to 6 percent slopes	NRCS	283	0.11%
177	Moskee fine sandy loam, 6 to 15 percent slopes	NRCS	281	0.11%
206	Parmleed-Renohill complex, moist, 9 to 25 percent slopes	NRCS	278	0.10%
106	Arnegard-Farnuf association, 6 to 25 percent slopes	NRCS	277	0.10%
161	Haverdad, moist-Worthenton complex, 0 to 3 percent slopes	NRCS	273	0.10%
260	Shingle-Rock outcrop complex, 30 to 50 percent slopes	NRCS	268	0.10%
27	Nathrop-Passcreek-Starley association on montane and subalpine mountain slopes, 2 to 30 percent slopes	BNF	259	0.10%
203	Parmleed-Bidman association, moist, 9 to 25 percent slopes	NRCS	252	0.09%
99	Tolman-Beeno-Beenom complex on montane mountain slopes, 5 to 45 percent slopes	BNF	232	0.09%
155	Haverdad loam, moist, 0 to 3 percent slopes	NRCS	226	0.09%
212	Platmak loam, 0 to 3 percent slopes	NRCS	225	0.08%
235	Renohill-Savageton clay loams, moist, 10 to 15 percent slopes	NRCS	224	0.08%
291	Ulm clay loam, 3 to 6 percent slopes	NRCS	222	0.08%
93	Hardhart-Starley association on montane mountain slopes, 10 to 60 percent slopes	BNF	215	0.08%
41A	Tine-Fourmile association on montane and subalpine glacial moraines, 2 to 30 percent slopes	BNF	215	0.08%
266	Shingle-Theedle complex, 45 to 75 percent slopes	NRCS	214	0.08%
129	Cushman-Forkwood association, moist, 9 to 15 percent slopes	NRCS	203	0.08%
228	Reeder-Farnuf complex, 9 to 15 percent slopes	NRCS	202	0.08%
139	Farnuf loam, 9 to 15 percent slopes	NRCS	201	0.08%
26	Mirror-Teewinot-Bross association on subalpine and alpine mountain slopes, 2 to 40 percent slopes	BNF	193	0.07%
110	Baux-Bauxson-Kirtley complex, 3 to 60 percent slopes	NRCS	180	0.07%
242	Rock outcrop-Starman association, 15 to 45 percent slopes	NRCS	178	0.07%
254	Fairburn-Baux-Rock outcrop complex, 30 to 60 percent slopes	NRCS	178	0.07%
268	Shingle-Theedle-Kishona association, 6 to 25 percent slopes	NRCS	167	0.06%
229	Reget silt loam, o to 6 percent slopes	NRCS	138	0.05%

Soil No.	Soil Map Unit (SMU)	Soil Survey Source*	Acres	Percentage
279	Taluce-Tullock-Vonalee association, moist, 9 to 30 percent slopes	NRCS	131	0.05%
138	Farnuf loam, 6 to 9 percent slopes	NRCS	126	0.05%
38	Sapphire-Bottle-Foxton association on montane mountain and subalpine slopes, 2 to 35 percent slopes	BNF	108	0.04%
154	Haverdad very fine sandy loam, 0 to 3 percent slopes	NRCS	108	0.04%
273	Shingle-Worf complex, 6 to 15 percent slopes	NRCS	107	0.04%
317	Zigweid-Kishona-Cambria complex, 6 to 15 percent slopes	NRCS	106	0.04%
137	Farnuf loam, 0 to 6 percent slopes	NRCS	105	0.04%
265	Shingle-Taluce complex, moist, 9 to 15 percent slopes	NRCS	104	0.04%
283	Theedle-Kishona association, moist, 9 to 15 percent slopes	NRCS	100	0.04%
255	Shingle-Haverdad, frequently flooded complex, 0 to 80 percent slopes	NRCS	99	0.04%
282	Theedle-Kishona association, moist, 6 to 9 percent slopes	NRCS	85	0.03%
119	Cedak-Recluse association, 3 to 6 percent slopes	NRCS	84	0.03%
288	Twin Creek loam, 0 to 6 percent slopes	NRCS	83	0.03%
158	Haverdad-Draknab complex, 0 to 3 percent slopes	NRCS	82	0.03%
178	Moskee-Noden complex, 0 to 9 percent slopes	NRCS	78	0.03%
130	Cushman-Worf loams, 3 to 25 percent slopes	NRCS	74	0.03%
236	Renohill-Ulm, dry, association, 6 to 15 percent slopes	NRCS	73	0.03%
299	Wetterdon-Recluse complex, 0 to 9 percent slopes	NRCS	67	0.03%
227	Reeder-Farnuf association, 3 to 9 percent slopes	NRCS	67	0.03%
173	Lambman-Hargreave association, 3 to 15 percent slopes	NRCS	64	0.02%
262	Shingle-Samday clay loams, 6 to 60 percent slopes	NRCS	61	0.02%
127	Cushman-Forkwood association, 3 to 15 percent slopes	NRCS	61	0.02%
207	Parmleed-Worfka association, 0 to 15 percent slopes	NRCS	54	0.02%
105	Arnegard-Farnuf association, 0 to 6 percent slopes	NRCS	49	0.02%
171	Kishona-Cambria complex, 0 to 3 percent slopes	NRCS	47	0.02%
22	Hanson Variant-Starley association on montane mountain slopes, 10 to 60 percent slopes	BNF	43	0.02%
281	Theedle-Kishona association, 6 to 15 percent slopes	NRCS	43	0.02%
257	Shingle-Nihill complex, 3 to 80 percent slopes	NRCS	42	0.02%
122	Cedak-Recluse association, dry, 3 to 15 percent slopes	NRCS	41	0.02%
272	Shingle-Wibaux complex, cool, 15 to 80 percent slopes	NRCS	41	0.02%
41B	Tine-Fourmile association on montane and subalpine glacial till, 2 to 30 percent slopes	BNF	34	0.01%
278	Taluce-Tullock-Vonalee association, 6 to 15 percent slopes	NRCS	29	0.01%
214	Platmak loam, dry, 0 to 9 percent slopes	NRCS	28	0.01%
172	Kishona-Cambria complex, 3 to 6 percent slopes	NRCS	27	0.01%

Soil No.	Soil Map Unit (SMU)	Soil Survey Source*	Acres	Percentage
97	Norbert-Doney-Rock outcrop complex on montane mountain slopes, 8 to 45 percent slopes	BNF	23	0.01%
153	Harlan-Kirtley loams, 9 to 15 percent slopes	NRCS	22	0.01%
231	Reget-Savar association, 3 to 45 percent slopes	NRCS	21	0.01%
304	Worfka-Shingle-Samday complex, 6 to 30 percent slopes	NRCS	20	0.01%
90	Abac-Rock outcrop association on montane mountain slopes, 35 to 50 percent slopes	BNF	17	0.01%
182	Moskee-Nuncho complex, 3 to 6 percent slopes	NRCS	15	0.01%
238	Renohill-Worfka association, 6 to 15 percent slopes	NRCS	13	0.00%
287	Trimad-Twin Creek association, 0 to 6 percent slopes	NRCS	10	0.00%
315	Zigweid loam, 0 to 3 percent slopes	NRCS	10	0.00%
259	Shingle, moist-Nuncho association, 3 to 45 percent slopes	NRCS	9	0.00%
316	Zigweid-Cambria loams, 0 to 6 percent slopes	NRCS	9	0.00%
276	Spearman-Wibaux association, 6 to 25 percent slopes	NRCS	9	0.00%
145	Gayhart-Bahl association, 6 to 30 percent slopes	NRCS	7	0.00%
123	Clarkelen loam, 0 to 3 percent slopes	NRCS	7	0.00%
204	Parmleed-Renohill complex, 3 to 25 percent slopes	NRCS	5	0.00%
164	Hiland-Bowbac complex, 3 to 15 percent slopes	NRCS	3	0.00%
165	Hiland-Bowbac association, moist, 3 to 15 percent slopes	NRCS	0	0.00%

*SC = NRCS Soil Survey (NRCS 2016a); BNF = Bighorn National Forest Soil Survey (Nesser 1986).

3.5 Hydrology

3.5.1 Groundwater

Groundwater in the Watershed exists in shallow, unconfined, water table conditions. As a general rule, groundwater resources in the Watershed are not abundant, which is a major reason why irrigation and municipal water systems in the Watershed primarily use surface water. Some shallow, alluvial residential and livestock wells are located within the Watershed; however, these sources of groundwater are not considered to be significant. Drilling to deeper aquifers is possible, but such deep drilling has generally shown to not be cost-effective. Dips along the mountain front within the Watershed are generally between 30 and 40 degrees northeast, creating long bands of outcrop parallel to the range. Very few wells have been drilled to depth through these formations.

The following subsections provide more information on the quantity and quality of groundwater available in the two specific aquifer types in the Watershed and from the springs that discharge groundwater to the surface.

3.5.1.1 Springs

Groundwater is naturally discharged by springs and seeps, evapotranspiration, and discharge to streams and other aquifers. Springs and seeps occur when the water table intersects the land surface, commonly as 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) outcrops at an elevation below the ambient groundwater table in the bedrock unit at that location, a spring will typically 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 because of 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. Flows can be concentrated or diffuse, again depending on the nature of the geologic conditions that allow for the existence of the spring (Anderson & Kelly 1985).

The National Hydrography Dataset 2016 site (USGS 2016) was used to map spring locations and spring location data. The locations were mapped in order to provide data for further investigation, if deemed necessary. Figure 3.5.1 shows the location of springs identified in the dataset. In addition to other uses, these springs serve as water sources for wildlife and livestock watering.

3.5.1.2 Alluvial Aquifers

Shallow aquifers in the Watershed consist of unconsolidated Quaternary deposits of alluvium beneath and adjacent to streams within the Watershed. Recharge of the unconfined alluvial aquifers comes from infiltration and percolation of precipitation, infiltration of diverted surface water from unlined irrigation canals and ditches, water applied to hayfields and gardens, and water from domestic septic systems (Bartos et al. 2008). Recharge of the shallow aquifers is expected to occur along losing stream segments. Similarly, discharge from shallow aquifers is expected to occur along gaining stream segments. However, the locations of losing and gaining segments have not been identified in the Watershed (SWCA 2010).

In 2001, the USGS installed 10 monitoring wells in the Watershed to collect data on shallow aquifers adjacent to the Watershed's two principal streams: Big Goose Creek and Little Goose Creek (Bartos et al. 2008). Two of these wells are located in the Big Goose Creek Subwatershed, and the remaining eight wells are located in the Little Goose Creek Subwatershed. The depths of these monitoring wells ranged from approximately 13 to 29 feet below land surface. Groundwater levels measured in the monitoring wells indicate that the water table was approximately 5 to 25 feet below land surface in the two wells installed along Big Goose Creek and approximately 2 to 15 feet below land surface in the eight wells installed along Little Goose Creek (Bartos et al. 2008). Table 3.5.1 summarizes the depth-to-initial groundwater for each of the three subwatersheds.

Table 3.5.1 - Depth to Initial Groundwater

Subwatershed	Minimum (feet)	Maximum (feet)	Average (feet)
Big Goose Creek	0	60	18
Little Goose Creek	0	40	12
Lower Goose Creek	0	44	20

(Hamerlinck and Ameson 1998)

3.5.1.3 Bedrock Aquifers

Groundwater availability in the watershed can be variable and drilling has been limited in the Watershed. There are 2,625 wells currently permitted in the Level I Study Area. These wells include wells that are both related to CBM, and unrelated to CBM. There are a number of deep wells that are over 2,000 feet deep which access pre-Tertiary formations. Permitted wells that are located within the Watershed are shown on Figure 3.5.2, along with their general range of depth. This layer is obtained from the WSEO (WSEO 2017). The layer also contains the permit number, applicant name, well name, priority status, location, well depth, depth to water, well yield, and appropriated uses. The layer is included in the Level I Study GIS record.

SPRINGS & SEEPS

Sheridan
Big Horn
Beckton
Ranchester
Dayton
Story

GOOSE CREEK
LITTLE GOOSE CREEK
KRUSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
JACKSON CREEK
BEAVER CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK

Sheridan Co.
Johnson Co.
Bighorn Co.

14
87
338
335
331
90
14

N

0 1.25 2.5 5
Miles

SPRINGS LISTED IN THE 2016 NATIONAL HYDROGRAPHY DATA SET

GOOSE CREEK WATERSHED LEVEL I STUDY

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FIG. 3.5.1

WELL DEPTH

NOT CBM
- 0 - 299 FT
- 300 - 999 FT
- 1,000 - 1,999 FT
- 2,000 - 2,499 FT
- > 2,500 FT

CBM-RELATED
- 0 - 299 FT
- 300 - 999 FT
- 1,000 - 1,999 FT
- 2,000 - 2,499 FT
- > 2,500 FT

Sheridan
Big Horn
Story
Beckton
Ranchester
Dayton
Sheridan Co.
Johnson Co.
Bighorn Co.
GOOSE CREEK
LITTLE GOOSE CREEK
KRUSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
JACKSON CREEK
BEAVER CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK
14
87
338
90
331
335
14

N

0 1.25 2.5 5 Miles

PERMITTED WELLS

GOOSE CREEK WATERSHED LEVEL I STUDY

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FIG. 3.5.2

Artesian conditions in the Level I Study Area are generally present in the pre-Tertiary and the deeper Tertiary aquifers (USGS 1966). Water levels in the Tertiary Fort Union and Wasatch Formations are generally less than 100 feet and have yields of less than 10 gallons per minute (gpm). The Tensleep Sandstone is the first formation encountered in the pre-Tertiary that generally meets these artesian conditions. The formations after the Tensleep Sandstone are the Amsden Formation, Madison Limestone, Unnamed Devonian-age section, Bighorn Dolomite, Gallatin Formation, Gros Ventre Formation, and Flathead Sandstone. See Figure 3.4.13 for general locations of these bedrock units; the legend from Table 3.4.10 describes the figure geologic codes.

Three wells that are generally representative of deep wells in the Level I Study Area are the Hidden Valley #1, Big Goose Well and the Little Goose Well. The Hidden Valley Well is located along Hurlburt Creek in the SE ¼ SW ¼ Section 26, T54N, R85W, Sheridan County. The Hidden Valley Well was cased to 1,247 feet and drilled open hole from 1,247 to 2,100 into the top one-third of the Madison limestone (Wester, Big Goose Well Drilling Foreman, to Dave Nicolarsen, SWCA Geologist, on November 22, 2016) and produced 275 GPM artesian flow. The Big Goose Well is located along Big Goose Creek in the SW ¼ NE ¼ Section 35, T55N, R86W, Sheridan County. The Big Goose Well was cased to the top of the Madison limestone and drilled open hole to the bottom elevation of 2,538 feet into the Gros Ventre Formation (Anderson & Kelly 1985). Table 3.5.2 shows the records from the lithologic log completed during the Big Goose well drilling. The Little Goose Well is located along Little Goose Creek in the SE ¼ SW ¼ Section 26, T54N, R85W, Sheridan County. The well penetrates an unfaulted geologic section. The Little Goose Well was cased to the top of the Madison limestone at 560 feet and drilled open hole to the bottom elevation of 2,499 feet into Flathead Sandstone (Anderson & Kelly 1985). The Little Goose well produces an average of 80 gpm (HKM Associates 1990). The Little Goose Well has a more complex geologic structure, which increases the volume of water compared to the structure at the Big Goose Well (WSGS website).

Table 3.5.2 - Big Goose Well Formation Records

Formation	Formation Depth (feet)	Formation Water Flow (gpm)	Cumulative Water Flow (gpm)
Tensleep to Amsden	346 to 1,054	3.2	3.2
Upper Madison	1,054 to 1,311	4.3	7.5
Madison Limestone	1,311 to 1,789	no change	7.5
Devonian Unnamed	1,789to 1,920	no change	7.5
Bighorn Dolomite	1,920 to 2,355	15.5	23.0
Gallatin Formation	2,355 to 2,510	20.0	43.0

3.5.1.4 Groundwater Sources for Wildlife and Livestock Watering

Many of the permitted wells within the Watershed discussed in the previous subsection are permitted for stock watering, either exclusively or in combination with other uses (including CBM). These wells can (and in many cases, do) provide water for both wildlife and livestock. Figure 3.5.3 depicts the locations for these permitted stockwater wells.

3.5.2 Surface Water

3.5.2.1 Hydrologic Unit Codes

The boundary of the Level I Study Area as defined by the WWDC is the "*10th Order Hydrologic Unit Code (HUC) Big Goose Creek Number 1009010102*".

NOTE: STOCKWATER WELLS SHOWN MAY BE PERMITTED FOR OTHER USES

Story
Sheridan
Big Horn
Beckton
Ranchester
Dayton
Sheridan Co.
Johnson Co.
Big Horn Co.
GOOSE CREEK
LITTLE GOOSE CREEK
KRUSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
JACKSON CREEK
BEAVER CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EA ST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK
14
87
338
335
331
90
14

N

0 1.25 2.5 5 Miles

● PERMITTED STOCKWATER WELLS

PERMITTED STOCKWATER WELLS

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FIG. 3.5.3

The USGS has assigned watersheds in the United States with numeric identifiers called Hydrologic Unit Codes, or HUCs. According to the USGS, "The United States is divided and sub divided into successively smaller hydrologic units which are classified into four levels: regions, sub-regions, accounting units, and cataloging units. The hydrologic units are arranged within each other, from the smallest (cataloging units) to the largest (regions). Each hydrologic unit is identified by a unique hydrologic unit code (HUC) consisting of two to eight digits based on the four levels of classification in the hydrologic unit system."

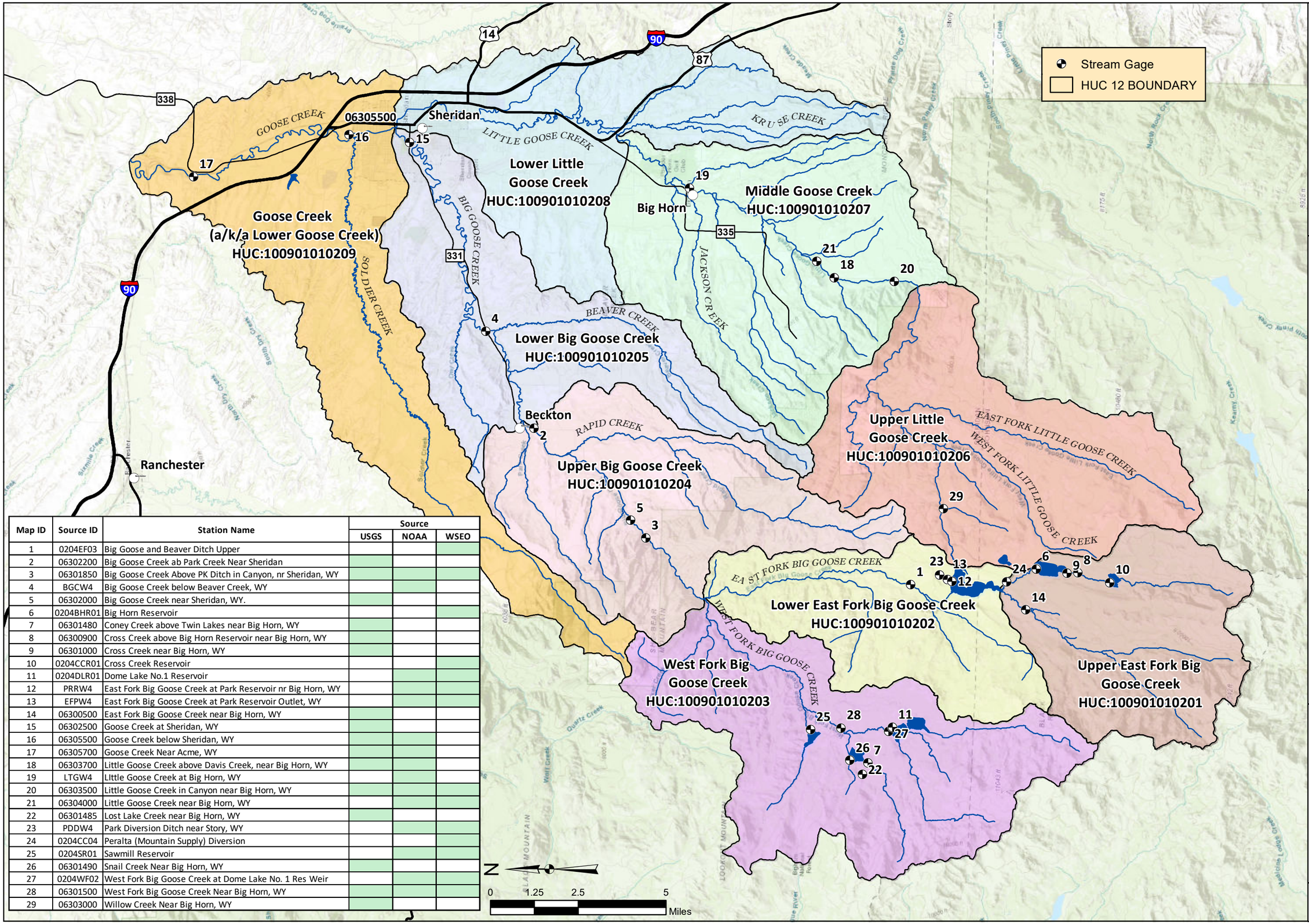
The first level of classification divides the U.S. into 21 major geographic areas, or regions. These geographic areas typically contain the drainage area of a major river, such as the Missouri region. Eighteen of the regions make up the land area of the lower 48 states. As regions are subdivided, the HUC identifier is extended. At this time, the smallest subdivision is referred to as the 12th Order HUC, due to the fact that the identifier has 12 digits. The following information is provided as an example of the HUC system as it refers part of the Watershed: West Fork Goose Creek.

Region:	10 Missouri River	(2nd Order HUC)
Subregion:	1009 Powder-Tongue River	(4th Order HUC)
Accounting Unit:	100901 Tongue River	(6th Order HUC)
Cataloging Unit:	10090101 Upper Tongue River	(8th Order HUC)
Sub-basin:	1009010102 Goose Creek	(10th Order HUC)
Sub-basin:	100901010203 W. Fork Goose Creek	(12th Order HUC)

Table 3.5.3 summarizes the HUC system as it pertains to the Level I Study Area, and as indicated in Figure 3.5.4.

Table 3.5.3 - Hydrologic Unit Code Breakdown

HUC 2 Number / Name	HUC 4 Number / Name	HUC 6 Number / Name	HUC 8 Number / Name	HUC 10		HUC 12	
				Number	Name	Number	Name
Region 10: Missouri River	Region 1009: Powder-Tongue River	Accounting Unit: 100901 Tongue River	HUC 8 10090101: Upper Tongue River	1009010102	Goose Creek	100901010209	Goose Creek (a/k/a Lower Goose Creek Subwatershed)
				1009010102	Goose Creek	100901010205	Lower Big Goose Creek
				1009010102	Goose Creek	100901010208	Lower Little Goose Creek
				1009010102	Goose Creek	100901010204	Upper Big Goose Creek
				1009010102	Goose Creek	100901010207	Middle Goose Creek
				1009010102	Goose Creek	100901010203	West Fork Big Goose Creek
				1009010102	Goose Creek	100901010202	Lower East Fork Big Goose Creek
				1009010102	Goose Creek	100901010206	Upper Little Goose Creek
				1009010102	Goose Creek	100901010201	Upper East Fork Big Goose Creek



Map ID	Source ID	Station Name	Source		
			USGS	NOAA	WSEO
1	0204EF03	Big Goose and Beaver Ditch Upper			
2	06302200	Big Goose Creek ab Park Creek Near Sheridan			
3	06301850	Big Goose Creek Above PK Ditch in Canyon, nr Sheridan, WY			
4	BGCW4	Big Goose Creek below Beaver Creek, WY			
5	06302000	Big Goose Creek near Sheridan, WY.			
6	0204BHR01	Big Horn Reservoir			
7	06301480	Coney Creek above Twin Lakes near Big Horn, WY			
8	06300900	Cross Creek above Big Horn Reservoir near Big Horn, WY			
9	06301000	Cross Creek near Big Horn, WY			
10	0204CCR01	Cross Creek Reservoir			
11	0204DLR01	Dome Lake No.1 Reservoir			
12	PRRW4	East Fork Big Goose Creek at Park Reservoir nr Big Horn, WY			
13	EFPW4	East Fork Big Goose Creek at Park Reservoir Outlet, WY			
14	06300500	East Fork Big Goose Creek near Big Horn, WY			
15	06302500	Goose Creek at Sheridan, WY			
16	06305500	Goose Creek below Sheridan, WY			
17	06305700	Goose Creek Near Acme, WY			
18	06303700	Little Goose Creek above Davis Creek, near Big Horn, WY			
19	LTGW4	LIttle Goose Creek at Big Horn, WY			
20	06303500	Little Goose Creek in Canyon near Big Horn, WY			
21	06304000	Little Goose Creek near Big Horn, WY			
22	06301485	Lost Lake Creek near Big Horn, WY			
23	PDDW4	Park Diversion Ditch near Story, WY			
24	0204CC04	Peralta (Mountain Supply) Diversion			
25	0204SR01	Sawmill Reservoir			
26	06301490	Snail Creek Near Big Horn, WY			
27	0204WF02	West Fork Big Goose Creek at Dome Lake No. 1 Res Weir			
28	06301500	West Fork Big Goose Creek Near Big Horn, WY			
29	06303000	Willow Creek Near Big Horn, WY			

HYDROLOGIC UNITS AND STREAM GAGE LOCATIONS

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FIG. 3.5.4

3.5.2.2 Existing Stream Gaging Stations

There are currently twenty nine (29) active and inactive stream gages located within the Level I Study Area. (See Figure 3.5.4.) Information pertaining to the gages is available via the following three websites:

1. the National Oceanic and Atmospheric Administration (NOAA) National Weather Service at http://water.weather.gov/ahps/region.php?state=wy. ;
2. the WSEO at http://seoflow.wyo.gov/Data/Map/Parameter/NoParameter/Interval/Latest. , and
3. the USGS at https://waterdata.usgs.gov/nwis.

As shown in the table within Figure 3.5.4, depending upon the specific gage, information can be obtained at one or more of the websites listed above. Generally, those gages served by the USGS have more complete and accessible data than those served by NOAA or the WSEO. However, it is important to note that several of the USGS gages are not operating at this time.

3.5.2.3 Streamflow Characteristics

Mean monthly discharges were computed using the available data at the USGS gage located at the downstream end of the Level I Study Area, which is USGS Gage 06305700 Goose Creek near Acme. (See Figure 3.5.5.) Table 3.5.4 presents this data in tabular format. The mean annual hydrograph at this gage reflects a typical snowmelt-driven runoff pattern. The bulk of the annual runoff occurs between April and July. The late summer through fall months (August through October) see steep declines in streamflow as the streams return to baseflow conditions through the winter.

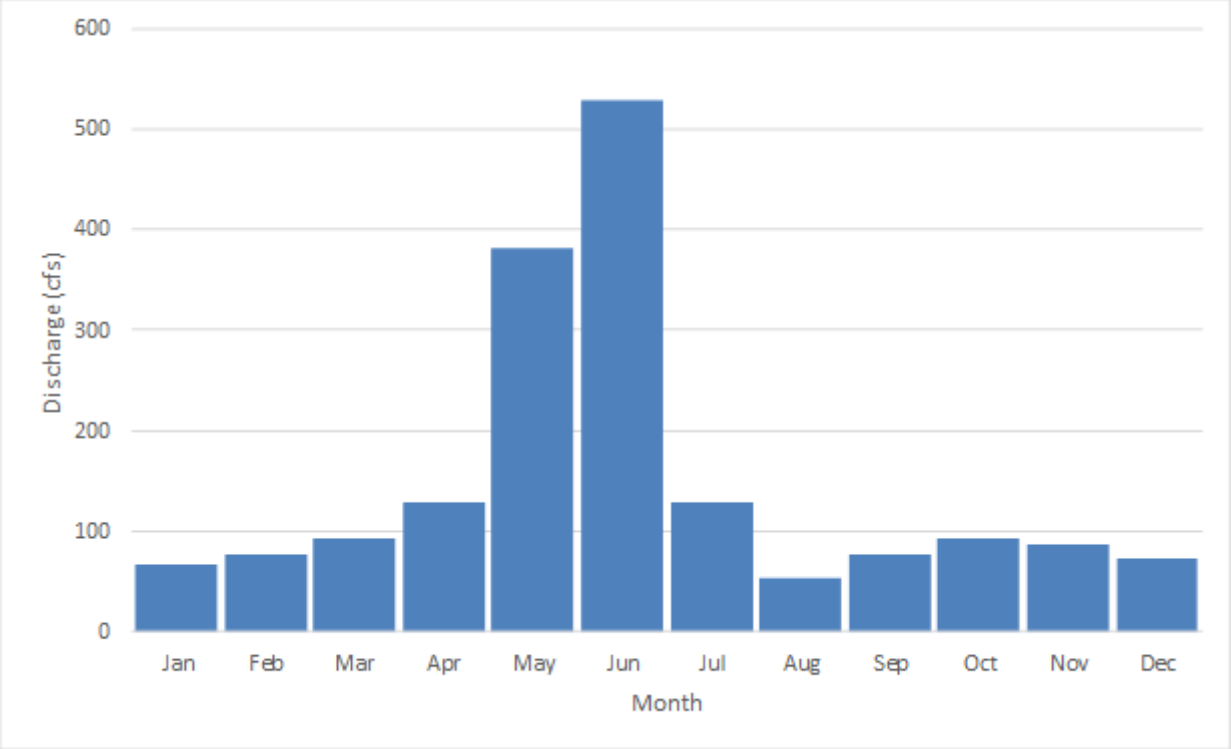


Figure 3.5.5 - Mean Monthly Discharge Hydrograph: USGS Stream Gage 06305700 on Goose Creek near Acme (1984-2016)

Table 3.5.4 - Mean Monthly Discharges for USGS Stream Gage 06305700 near Acme

Month	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Mean Discharge (cfs)	67	78	94	128	381	529	129	54	78	93	87	73

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

Using regional methods described by the USGS (Miller, 2003), peak flow characteristics were calculated for each of the nine subwatersheds (HUC12) within the Level I Study Area. Results are shown in Table 3.5.5. The methodology used to compute these discharges is based upon regression analyses of gaged data against various basin characteristics. These estimates are intended to be used for regional planning efforts only. Project-specific estimates should be prepared in analyzing the potential for future watershed projects; e.g., reservoir storage.

Similarly, mean annual discharge was also computed for each of the subwatersheds (HUC12) within the Level I Study area using regional methods described by Lowham (1988). The methodology used to compute these discharges also relies upon statistical relationships between basin area, mean annual precipitation and measured stream discharge. Results of this analysis are presented in Table 3.5.6. These data can be used in planning potential water development projects such as stock reservoirs. Using the mean annual yield per square mile for the appropriate sub-basin, approximate yield can be pro-rated for a specific area.

Table 3.5.5 - Results of Peak Flow Analysis: Miller Methodology

HUC12 Basin Name	Hydrologic Region (Miller)	Peak Flows for Various Return Periods (CFS)										
		Area (mi2)	1.5 yr	2 yr	2.33 yr	5 yr	10 yr	25 yr	50 yr	100 yr	200 yr	500 yr
HUC 100901010204-Upper Big Goose Creek	Region 1	45.1	3.7	8.5	12.0	44.4	103.0	245.2	428.4	708.4	1127	1995
HUC 100901010203-West Fork Big Goose Creek	Region 1	53.1	4.2	9.8	13.8	50.9	117.6	279.1	486.5	802.9	1275	2251
HUC 100901010202-Lower East Fork Big Goose Creek	Region 1	30.6	2.6	6.1	8.6	32.2	75.3	180.6	317.3	527.2	842.8	1499
HUC 100901010206-Upper Little Goose Creek	Region 1	50.5	4.1	9.3	13.3	48.8	112.9	268.2	467.9	772.7	1228	2169
HUC 100901010201-Upper East Fork Big Goose Creek	Region 1	32.2	2.7	6.3	9.0	33.6	78.4	187.9	329.8	547.6	875.0	1555
HUC 100901010209-Goose Creek	Region 2	61.1	131.3	210.8	256.3	525.4	842.0	1368	1853	2432	3102	4179
HUC 100901010205-Lower Big Goose Creek	Region 2	42.4	110.0	177.3	215.9	445.1	715.4	1166	1582	2079	2655	3579
HUC 100901010208-Lower Little Goose Creek	Region 2	44.5	112.6	181.4	220.9	455.0	731.1	1191	1615	2123	2711	3654

HUC12 Basin Name	Hydrologic Region (Miller)	Peak Flows for Various Return Periods (CFS)										
		Area (mi2)	1.5 yr	2 yr	2.33 yr	5 yr	10 yr	25 yr	50 yr	100 yr	200 yr	500 yr
HUC 100901010207-Middle Goose Creek	Region 2	55.9	125.8	202.1	245.8	504.5	809.2	1316	1782	2341	2987	4024

Table 3.5.6 - Results of Mean Annual Runoff Analysis: Lowham Methodology

Label	Hydrologic Region (Lowham)	Area (mi^2)	Mean Annual Precipitation (In)	Mean Annual Runoff (CFS)	CFS per Sq mile	Acre-Ft/year	Acre-Ft/year/m^2
HUC 100901010204-Upper Big Goose Creek	Mountainous Region	45.1	19.8	32.1	0.7	23,413	519.3
HUC 100901010203-West Fork Big Goose Creek	Mountainous Region	53.1	28.4	62.6	1.2	45,693	860.3
HUC 100901010202-Lower East Fork Big Goose Creek	Mountainous Region	30.6	25.9	32.9	1.1	24,023	784.4
HUC 100901010206-Upper Little Goose Creek	Mountainous Region	50.5	25.1	50.1	1.0	36,555	723.6
HUC 100901010201-Upper East Fork Big Goose Creek	Mountainous Region	32.2	31.8	46.2	1.4	33,698	1047
HUC 100901010209-Goose Creek	Plains Region	61.1	17.3	2.3	0.04	1,694	27.7
HUC 100901010205-Lower Big Goose Creek	Plains Region	42.4	18.1	1.8	0.04	1,300	30.7
HUC 100901010208-Lower Little Goose Creek	Plains Region	44.5	17.9	1.8	0.04	1,340	30.1
HUC 100901010207-Middle Goose Creek	Mountainous Region	55.9	21.3	43.5	0.8	31,754	568.4

3.5.2.4 WWDC Basin Planning Studies

The evaluation of flows available for potential storage projects was conducted using the basin planning spreadsheet model developed for the Powder/Tongue River watershed. The basin plan was initially completed in 2002 (HKM, et al.) and was updated in 2018 (RESPEC, 2018). Much of the following discussion of the model, assumptions inherent to it, and its limitations were extracted from previous basin planning reports and supporting technical memoranda. It is included herein to provide the background necessary to interpret model results.

3.5.2.4.1 Powder/Tongue River Basin Model

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

In conjunction with the 2018 basin plan update, the original spreadsheet model, developed in 2002, was updated to reflect a period of record through 2015. Consequently, the updated model simulates conditions associated with recent drought conditions (i.e., 2001/2002). The Powder/Tongue River model consists of six individual spreadsheet models, each representing a specific subbasin of the larger watershed. One of the individual spreadsheet models focused on the Tongue River, to which Goose Creek is tributary. 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 in the 2018 study relies on a calibration model that reflects available historical data from the 1975 to 2014 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 watershed, each subbasin 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 is 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, is 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 3.5.6 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.

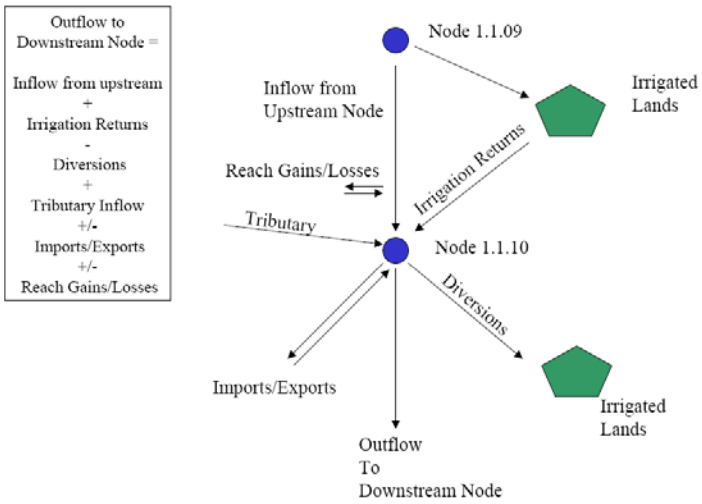


Figure 3.5.6 -Diagram of Water Balance Approach

3.5.2.4.2 Model Limitations

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

- 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 principles. 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
- 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 Compact among Montana, North Dakota and Wyoming was signed in 1950, and it outlines allocations for several rivers in northern Wyoming, including the Powder and Tongue Rivers.

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 two different modes:

1. 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.
2. 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).

3.5.2.4.3 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. In other words, the water available in any stream reach 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. As noted previously, this evaluation is

made on a water budget basis (inherent to the Powder/Tongue 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 3.5.7 for modeled stream reaches within the Watershed or downstream on the Tongue River. The total annual available flow for the entire Watershed is estimated in the model as over 136,000 A-F for a normal (6 out of 10 years) condition and over 85,000 A-F for a dry (2 out of 10 years) condition. The model results show that the large majority of available flows occur in May, June and July, as would be expected in this hydrologic setting and consistent with the pattern of gaged flows as previously described.

Table 3.5.7 - Available Flow in Acre-Feet for Goose Creek Watershed (Tongue River Spreadsheet Model, RESPEC, 2018)

Wet Year Hydrologic Conditions														
Reach Number	**Reach Name**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Annual**
Reach 6	Big Goose Creek above Rapid Creek	904	1,286	2,907	3,441	20,529	46,059	15,638	2,951	3,483	1,898	1,341	1,169	101,606
Reach 7	Rapid Creek	69	73	140	48	623	1,271	950	0	0	113	91	79	3,457
Reach 8	Big Goose Creek above Beaver Creek	1,124	1,461	3,103	3,483	21,123	47,246	16,489	2,953	3,660	2,400	1,725	1,471	106,238
Reach 9	Beaver Creek	93	60	52	73	492	715	186	89	80	238	186	142	2,407
Reach 10	Big Goose Creek above Little Goose Creek	1,400	1,633	3,209	3,561	21,649	48,030	16,767	3,237	4,048	3,126	2,286	1,896	110,842
Reach 11	Little Goose Creek	2,224	2,093	3,152	3,297	17,881	21,368	4,964	2,118	3,705	4,438	3,329	2,757	71,326
Reach 12	Goose Creek above Soldier Creek	3,952	3,983	6,542	7,735	41,796	70,136	20,934	4,960	6,376	5,948	5,002	4,266	181,629
Reach 13	Soldier Creek	980	690	596	535	1,360	1,604	490	436	579	1,021	928	822	10,043
Reach 14	Goose Creek below Soldier Creek	5,033	4,767	7,306	8,477	44,499	75,198	22,253	5,480	7,142	7,133	6,062	5,193	198,542
Reach 15	Goose Creek above Tongue River	5,033	5,011	9,233	10,550	51,668	78,502	24,930	6,146	8,136	7,133	6,182	5,193	217,717
Normal Year Hydrologic Conditions														
Reach 6	Big Goose Creek above Rapid Creek	1,635	1,718	2,316	2,493	13,582	20,113	3,309	0	0	1,801	2,111	1,792	50,870
Reach 7	Rapid Creek	69	59	60	0	0	870	0	0	0	0	96	81	1,234
Reach 8	Big Goose Creek above Beaver Creek	1,912	1,921	2,460	2,430	13,452	20,818	3,143	68	177	2,321	2,640	2,184	53,526
Reach 9	Beaver Creek	88	50	28	0	207	368	106	26	0	215	204	155	1,447
Reach 10	Big Goose Creek above Little Goose Creek	2,225	2,113	2,563	2,345	13,569	21,231	3,323	164	380	3,136	3,352	2,710	57,112
Reach 11	Little Goose Creek	4,735	4,308	4,283	1,399	8,255	7,903	989	1,215	1,775	6,366	6,320	5,436	52,985
Reach 12	Goose Creek above Soldier Creek	3,422	3,588	5,634	6,765	24,884	33,874	9,107	3,091	3,819	4,945	4,221	3,547	106,897
Reach 13	Soldier Creek	384	334	383	485	789	856	969	713	723	772	557	434	7,399
Reach 14	Goose Creek below Soldier Creek	4,729	5,627	6,080	8,953	24,129	38,842	8,919	4,325	6,185	6,974	6,107	5,341	126,211
Reach 15	Goose Creek above Tongue River	4,729	5,627	7,828	9,348	26,108	40,870	10,554	5,393	7,200	6,974	6,107	5,341	136,079
Dry Year Hydrologic Conditions														
Reach 6	Big Goose Creek above Rapid Creek	1,293	1,046	1,497	1,591	7,175	3,249	0	0	0	1,734	1,949	1,657	21,191
Reach 7	Rapid Creek	62	51	53	0	0	729	0	0	0	0	88	77	1,061
Reach 8	Big Goose Creek above Beaver Creek	1,471	1,176	1,599	1,494	7,020	3,895	14	0	0	2,121	2,350	1,935	23,073
Reach 9	Beaver Creek	49	22	16	0	320	232	74	0	0	184	173	109	1,180
Reach 10	Big Goose Creek above Little Goose Creek	1,679	1,295	1,668	1,367	7,315	4,309	222	69	121	2,846	2,972	2,334	26,195
Reach 11	Little Goose Creek	3,914	3,512	3,543	105	4,020	1,032	843	798	930	5,479	5,347	4,551	34,073
Reach 12	Goose Creek above Soldier Creek	2,460	2,466	4,029	4,330	12,204	9,213	2,041	1,205	2,265	4,021	3,303	2,733	50,269
Reach 13	Soldier Creek	282	253	312	768	810	756	600	345	581	639	438	331	6,114
Reach 14	Goose Creek below Soldier Creek	4,084	3,730	6,277	7,133	21,677	17,157	3,147	2,146	2,927	6,185	5,536	4,858	84,857
Reach 15	Goose Creek above Tongue River	4,084	3,730	6,277	7,133	21,677	17,157	3,147	2,146	3,182	6,185	5,536	4,858	85,112

3.5.2.4.4 Peak Flows

Flood frequency calculations were completed for the USGS stream gages with a sufficient period of record to complete the analysis. The Log-Pearson III methodology (Water Resources Council, 1977) was used to estimate peak discharge associated with the 2-year through the 500-year events. Figure 3.5.7 displays the results of the analysis for the USGS Gage 06305700 (Goose Creek near Acme).

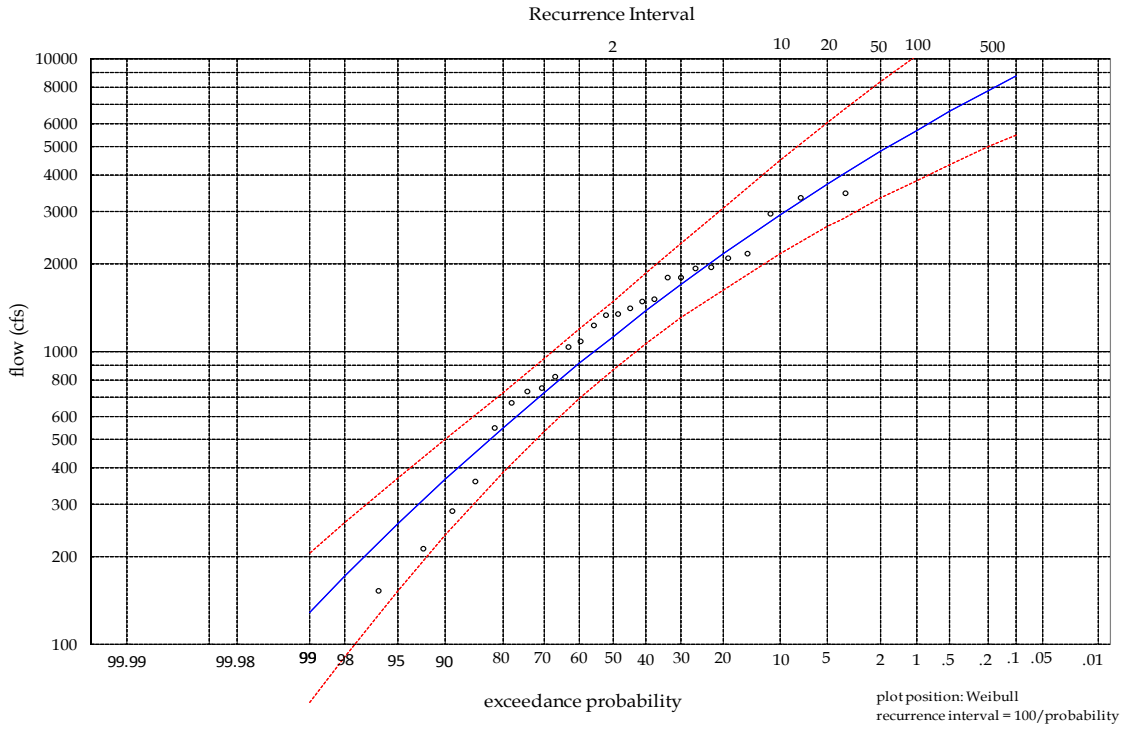


Figure 3.5.7 - Flood Frequency Analysis: USGS Gage 06305700 Goose Creek near Acme

3.6 Stream Geomorphology

3.6.1 Background

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 Level I Study Area is to determine the nature of this balance, and where the balance has been upset.

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

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

A commonly used term today for this type of stability is dynamic equilibrium. A stream in dynamic equilibrium has adjusted its width, depth, and slope such that the channel is neither aggrading nor degrading. However, change may be occurring in the stream bank, erosion may result, and bank stabilization may be necessary even on the banks of a stream in dynamic equilibrium.

The equilibrium concept of streams discussed above can also be described by various qualitative relationships. One of the most widely used relationships is the one proposed by Lane (1955) which states that:

$$Q_s \times D_{50} \propto Q_w \times S$$

where Qs is the bed material load, D_{50} is the median size of the bed material, Qw is the water discharge, and S is the slope. This relationship, commonly referred to as Lane's Balance, is illustrated in Figure 3.6.1.

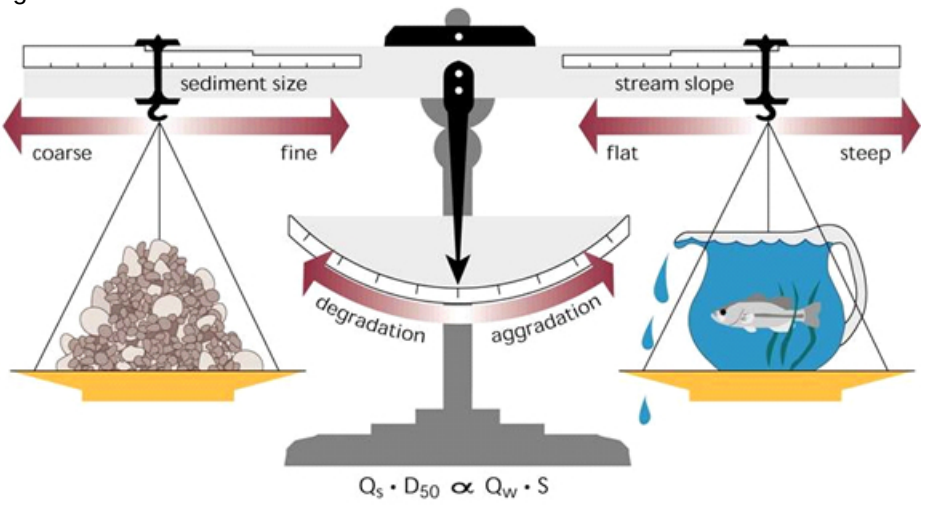


Figure 3.6.1 - Lane's Balance

This graphic indicates that a change in any of the four variables will cause a change in the others such that equilibrium is restored. When a channel is in equilibrium, it will have adjusted these four variables such that the sediment being transported into the reach is transported out, without significant deposition of sediment in the bed (aggradation), or excessive bed scour (degradation). It should be noted that, by this definition of stability, a channel is free to migrate laterally by eroding one of its banks and accreting the one opposite at a similar rate.

In summary, a stable river, from a geomorphic perspective, is one that has adjusted its width, depth, and slope such that there is no significant aggradation or degradation of the stream bed or significant planform changes (meandering to braided, etc.). By this definition, a stable river is not in a static condition but rather is in a state of dynamic equilibrium, where it is free to adjust laterally through bank erosion and bar building (Watson, et al, 1999).

Impairments to geomorphic function reflect a significant loss of the functional potential of the river 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 Level I 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 3.6.2 displays the hierarchy of the assessment levels and the general nature of effort associated with each. Much of the Level I Rosgen geomorphic classification 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 Rosgen Level II classification provides a more detailed description of the stream using measurements at selected locations. Stream types are further subdivided into 94 subtypes based upon degree of entrenchment, width-to-depth ratio, water surface slope, streambed materials, and sinuosity. (See Figure 3.6.3.) 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. This Level I Study included a Level I evaluation of the mainstem streams and their principal tributaries within the Watershed.

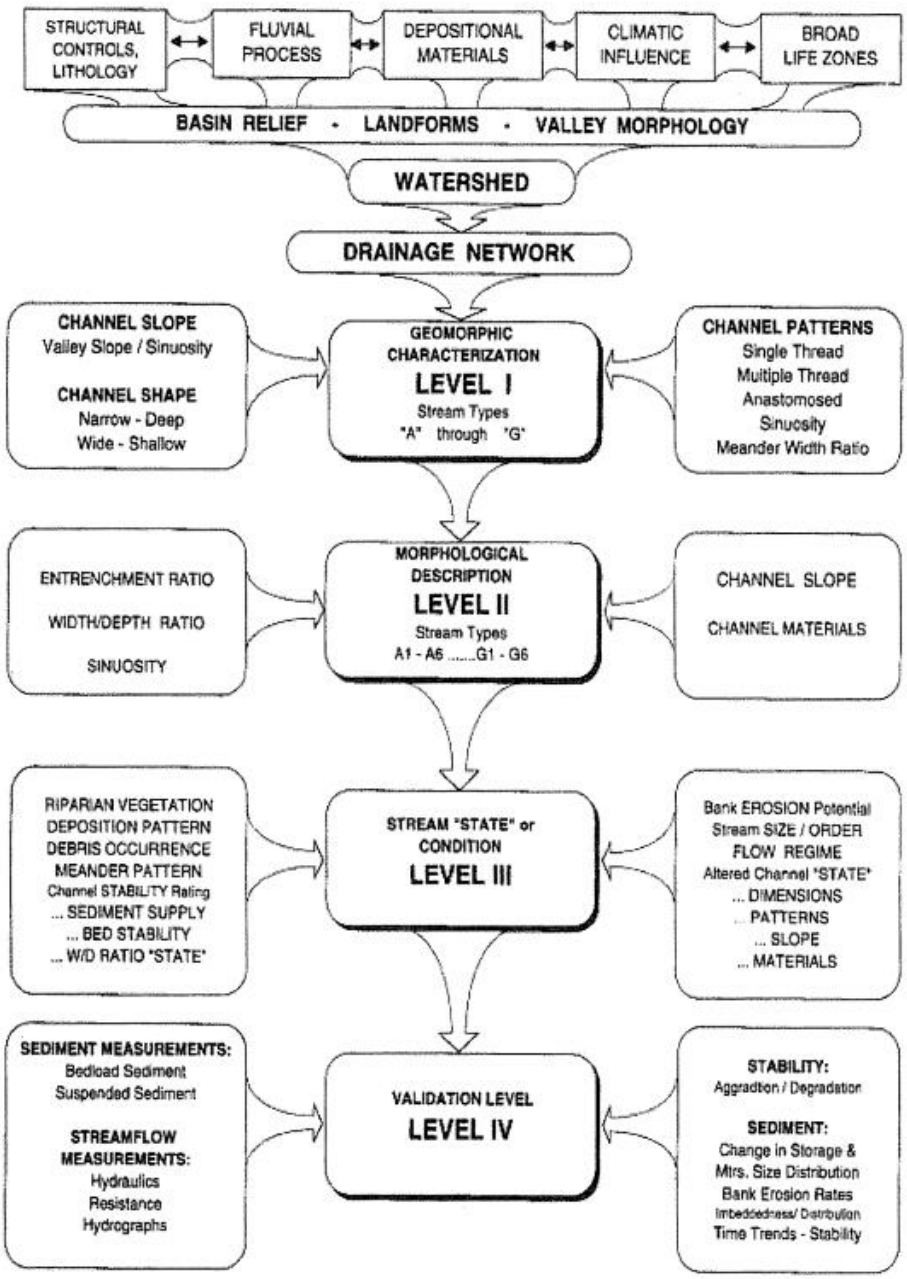


Figure 3.6.2 - Hierarchy of the Rosgen Level II Stream Classification System

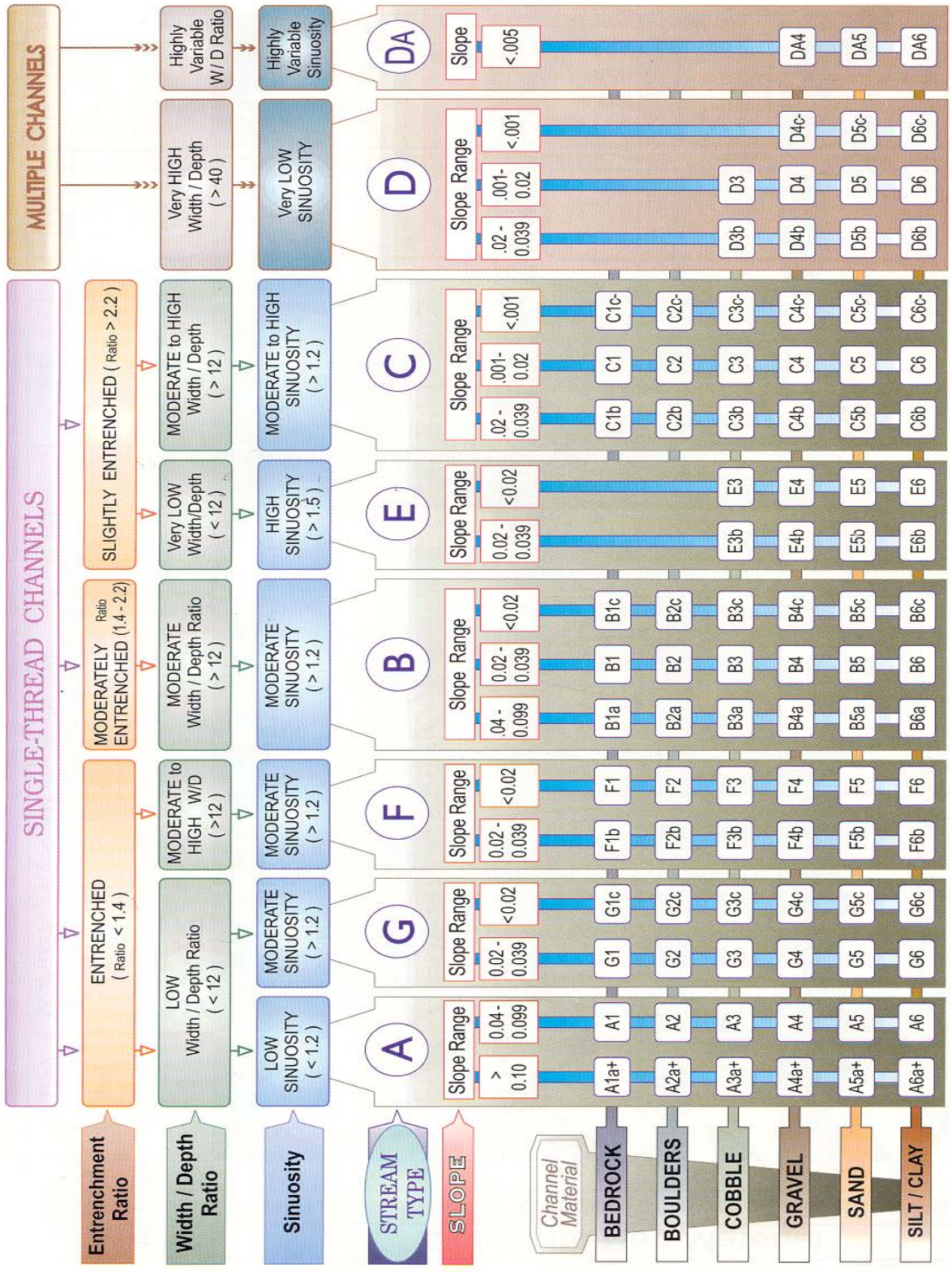


Figure 3.6.3 - Rosgen Classification Matrix (Rosgen, 1996)

3.6.2.1Level I Methods

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

Figure 3.6.4 shows the major stream types within the Rosgen Classification System. Brief descriptions of the various stream types encountered in the Watershed are presented in the following paragraphs.

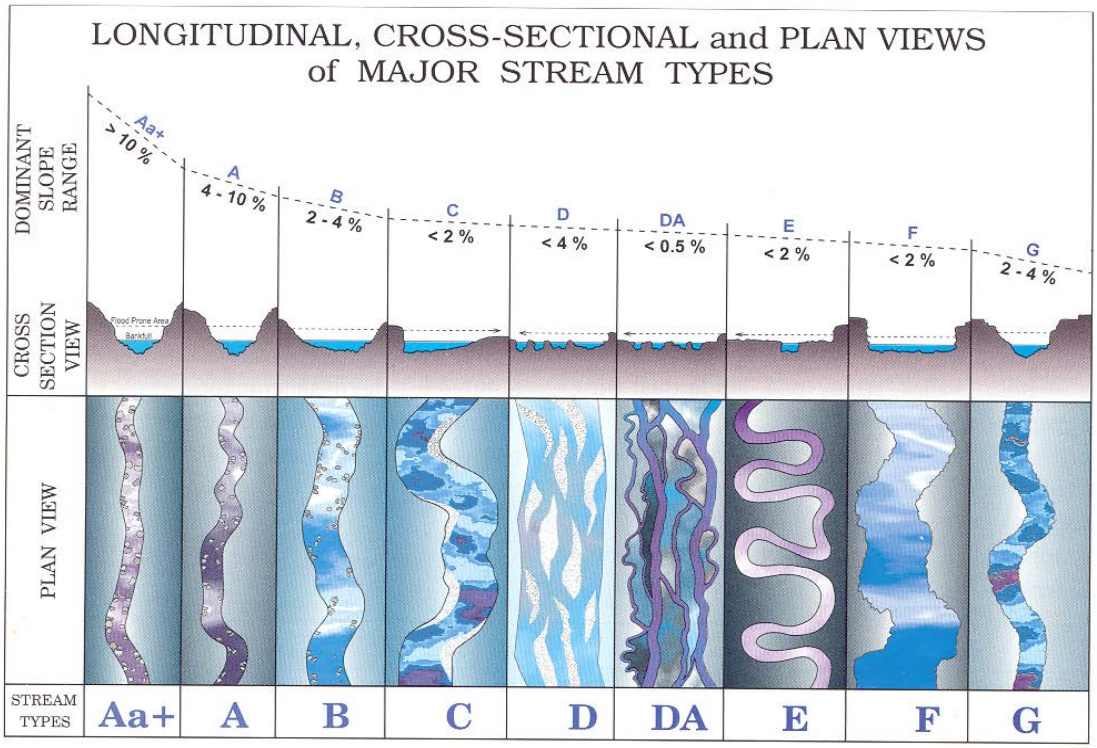


Figure 3.6.4 - Major Stream Types within the Rosgen Classification System

A-Type channels are relatively steep channels that form in headwater areas as well as within bedrock canyons. 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.

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. (See Figure 3.6.5.) 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-Type channels are moderately resistant to human impacts. However, 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 3.6.5 - Example of B-Type Channel: Upper Little Goose Creek Canyon (Source: NWS)

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. (See Figure 3.6.6.) The channels tend to occur in broad alluvial valleys, and they are typically associated with broad floodplain areas. They are not entrenched and still have 'access' to their floodplains. C-Type 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.

F-Type channels typically have relatively low slopes (<2%), similar to C-Type and E-Type channels. The primary difference between C-Type channels and F-type channels is with respect to entrenchment. F-Type 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 a historic downcutting event. Channels can also be classified as F-Type by virtue of the fact that they have been channelized as flood control conveyance elements. (See Figure 3.6.7.)

Additional stream types exist which were not delineated at this level of investigation. D-type channels are braided, multiple channels with very high width/depth ratios. E-type streams are slightly entrenched, have low width/depth ratios and high sinuosity. They often develop inside of wide, entrenched F-Type channels. Although not mapped during this Level I investigation, they may exist within the study area and could be delineated with greater detailed study.

Figure 3.6.6 - Example of C-Type Channel:
Big Goose Creek near Beaver Creek (Source: NWS)

Figure 3.6.7 – Example of F-Type Channel:
Goose Creek within Sheridan City Limits

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.

3.6.2.2 Geomorphic Characterization

Level I Classification

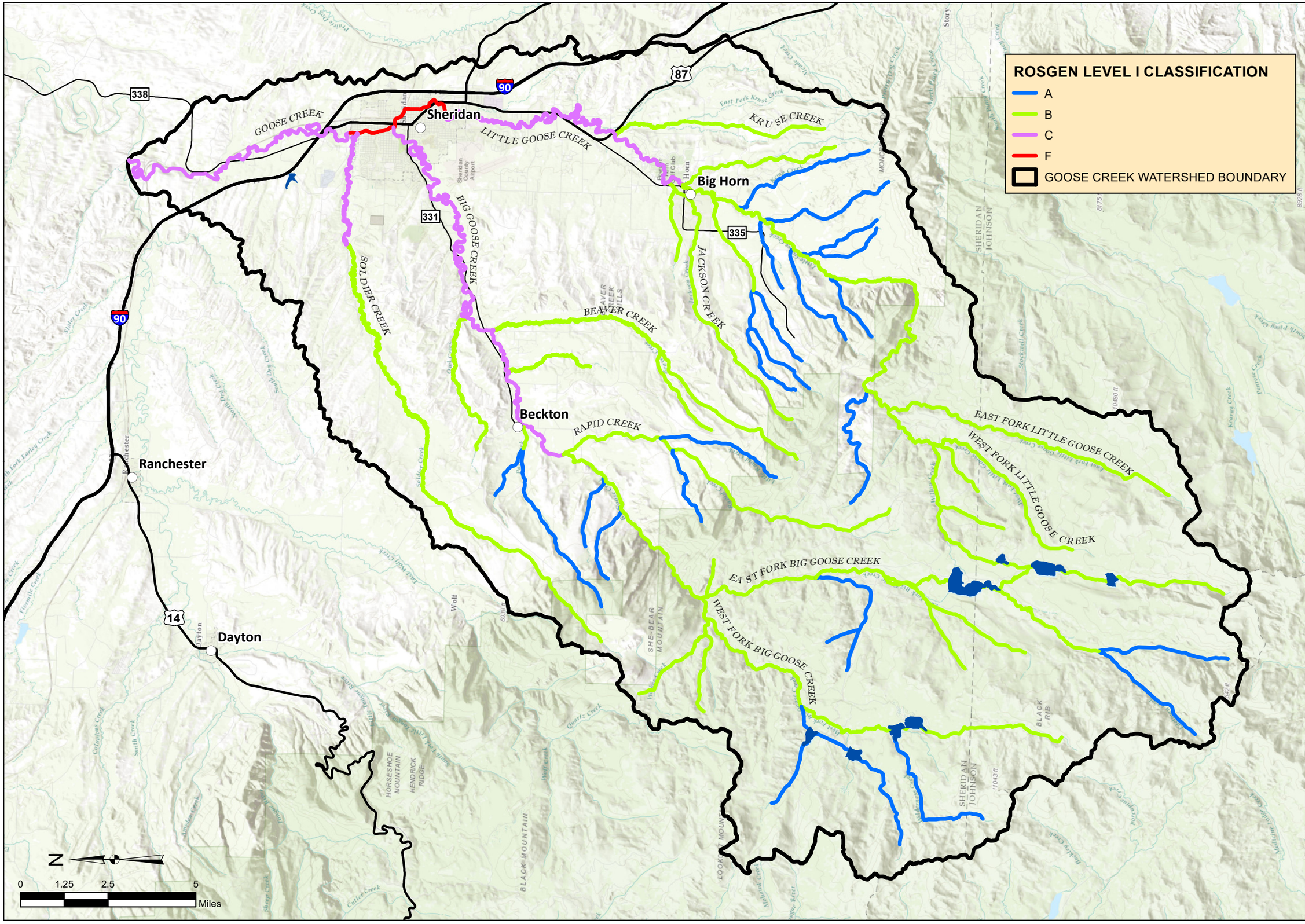
The Level I classification effort was conducted primarily using existing information incorporated into the project GIS. Several analytical tools were developed and integrated into the GIS which allowed for the evaluation of various geomorphic parameters (sinuosity, slope, and stream

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. Unfortunately, no Proper Function Condition assessments (performed by the BLM) or comprehensive Stream Visual Assessment Protocol assessments (performed by the NRCS) were identified as being completed within the Watershed, However, a limited number of site-specific assessments have been completed in support of local NRCS stream projects.

The most current data available were used in the geomorphic evaluation. Because the DEM was limited to a 10-meter grid, elevations and subsequent slope calculations are approximate. Stream alignments were digitized using 2014 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 3.6.2, 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.

In addition, Federal Emergency Management Agency (FEMA) mapping exists for Big Goose Creek, Little Goose Creek, and Goose Creek downstream of the confluence. FEMA mapping indicates the extent of the floodplain associated with the 100-year storm event. As displayed in Figure 3.6.8, the FEMA mapping clearly displays areas where the floodplains are accessible to the streams (i.e., non-entrenched) and those where they are not (entrenched, or restricted). The FEMA mapping was used to further define the extent of various stream types. The 50-year recurrence interval flood discharge is generally associated with floodplain connectivity. Consequently, it is assumed that if the 100-year event is confined to the channel, the reach is entrenched and would also restrict the 50-year event from the floodplain. Conversely, reaches where the 100-year event does spill over streambanks to the floodplain could not be assumed to similarly connected at the 50-year event stage.



ROSGEN LEVEL I CLASSIFICATION

GOOSE CREEK WATERSHED LEVEL I STUDY

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FIG. 3.6.9

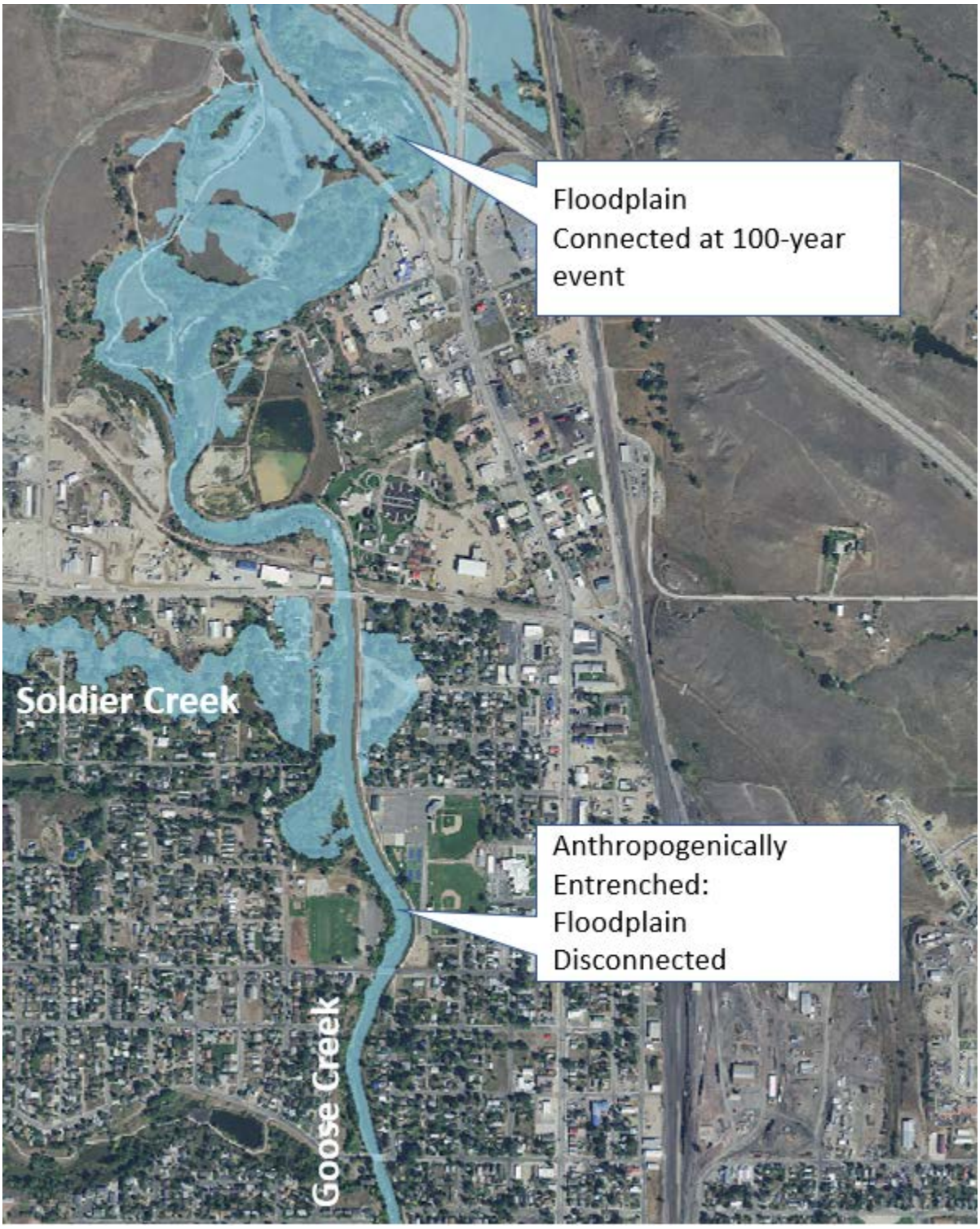

Figure 3.6.8 - Use of FEMA Mapping in Level I Study Area Geomorphic Characterization

Results of the Level I classification effort are shown graphically in Figure 3.6.9. This figure displays a map of the Level I Study Area depicting the various stream types as well as the reach designations used in the classification effort.

The headwater reaches of both Big Goose Creek and Little Goose Creek (the two mainstem streams within the Watershed) are located in steep, mountainous terrain comprised of plutonic igneous and metamorphic bedrock, colluvial deposits, and forested landscapes. In a manner typical of the Rosgen classification scheme, the dominant stream types in these reaches are A at the higher elevations transitioning to B. (See Figure 3.6.10.) These stream reaches are generally laterally and vertically stable, and they are typically resistant to local anthropogenically-caused changes in independent variables. Tributaries to Big and Little Goose Creeks follow the same trends, in that they begin as A-Type channels and transition to B-Type channels.

Figure 3.6.10 - Upper Little Goose Creek: Typical B-Type Channel

As the steeper B-Type streams enter the lower valley reaches, their character changes as channel slope decreases. The widening valley floor reduces lateral confinement, sediment size tends to reduce, and boundary conditions typically weaken in conjunction with a change from narrow colluvial valleys to broad, riparian alluvial valleys. The common stable stream type within these settings is the C-Type channel. (See Figure 3.6.11.)

Figure 3.6.11 - Lower Big Goose Creek: Typical C-Type Channel

Within the limits of the City, major portions of Big Goose Creek, Little Goose Creek and Goose Creek downstream of the confluence have been channelized in order to convey flood events

and contain peak stream flows. Figure 3.6.12 displays a portion of Little Goose Creek within the city limits where concrete walls have been built to increase channel conveyance capacity and contain floods. Downstream of the confluence, Goose Creek has been channelized until it nears the end of the city limits. Consequently, these portions of the stream system were classified as F-type channels by virtue of the fact that the channels have been anthropogenically disconnected from their floodplains.

Figure 3.6.12 - Flood Control Improvements: Little Goose Creek (left) and Goose Creek (right). Both are F-Type channels.

Bank erosion does not appear to be a systemic issue; the nature of a meandering stream channel means there will be areas of erosion as well as areas of deposition. When existing infrastructure or property is threatened, channel stabilization is often warranted. Using the project GIS and the 2014 aerial photography, visible bank erosion and stream stabilization efforts were delineated. Figure 3.6.13 displays an extract of the results which are not visible when viewed at a watershed-wide scale (The data are, however, fully available in the project GIS).

Likewise, "hardpoints", or locations where either naturally occurring bedrock or manmade features provide protection against potential channel degradation, were identified. Typical hardpoints are culverts at road crossings, irrigation diversion structures, large boulder placement, etc.

Based upon the GIS classification effort followed by field verification, we concluded that the Goose Creek system is essentially non-entrenched, with the exception of the modified reaches in the vicinity of the City.

3.6.2.3 Impairments

Based upon this basin-wide overall review, Level I Study Area history and existing or on-going studies, impairments to stream channels within the Level I Study Area appear to fall into the following broad and interrelated categories:

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

3.6.2.4 Management Implications

The objective of a Rosgen classification is to provide insight into the inherent resiliency of the stream and where there may be stability issues. This insight can then be included in future planning efforts or consideration with project-specific designs.

Figure 3.6.13 - Examples of streambank erosion and channel stabilization delineation within project GIS

For instance, A-Type and B-Type channels are typically headwater streams and are inherently resilient to disturbance. Bedrock and valley-type typically confine the channels to a narrow corridor, their migration is minimal, and they are generally geomorphically stable. Management implications of these types of channels could be how to stabilize culverts, irrigation diversions, etc.

C-Type channels (e.g., Big Goose Creek / Little Goose Creek) are non-entrenched and have "access" to their floodplains. These channels migrate, oxbow features exist, and bank erosion is a natural feature (within limits). Management implications could include irrigation diversion design, bank stabilization, wetland creation / enhancement (i.e., oxbow wetlands), etc.

From a watershed planning perspective, knowing where the various types of channels lie and their extent all adds to the understanding of the Watershed's health and function. With an abundance of F-Type channels (entrenched), systemic issues may be indicated. G-Type channels (gullies) indicate other Watershed health issues, such as overgrazing, energy development, roads, etc. These all add to the understanding of sediment loading to the mainstems which affects habitat, receiving stream stability, etc.

Within the Level I Study Area, there do not appear to be systemic geomorphic issues associated with channel degradation. In general, streams appear to be relatively stable from a geomorphic standpoint. Bank erosion and incision were evident, but they were not prevalent. There are areas where channel widening is evidenced by active bank erosion and high width

depth ratios. For instance, both Big and Little Goose Creeks in the vicinity of the City have been modified by anthropogenic activities and appear to be in the process of recovering, particularly in consideration of recent channel improvement projects.

Tributaries to the system mainstems were observed to be degrading and would be classified as G-Type channels under the Rosgen system. However, again it is important to keep in mind that these channels do not appear to be associated with widespread systemic watershed rejuvenation as would be expected if the mainstems were degraded. In other words, there was not sufficient evidence of channel degradation in the tributaries to indicate instabilities associated with base-level lowering of the mainstems. The G-Type channels observed through the course of this Level I Study were likely caused by local land use practices.

3.6.3 Recommendations on Temporary Stream Gaging

Temporary stream gages can oftentimes augment information obtained from permanent gages. BOC and SCCD personnel were polled as to prospective locations for temporary gages within the Watershed. Preliminary feedback identified two possible sites:

1. Rapid Creek above the location where the Big Goose Beaver Ditch enters this Big Goose Creek tributary; and
2. Soldier Creek above the point where transbasin water from Big Goose Creek enters this Goose Creek tributary.

For the prospective Rapid Creek site, it was determined that the drainage area that would be measured would be only 275 acres (0.43 square miles). As a result, it was later surmised that only limited data would be obtained from a temporary gage at this location.

For the prospective Soldier Creek site, the owner of the property where this temporary stream gage would be located denied access to establish and monitor this gage, even though it was recognized that the stream gage would be temporary in nature. As a result, this temporary gage was also not installed.

3.7 Water Quality

3.7.1 Stream Classifications

The Water Quality Division of the WDEQ lists surface water classifications in the state in two parts, referred to as "Table A" and "Table B" (WDEQ 2001). The waters listed in Table A are referred to as "Primary Classifications" and are those that are either named on the USGS 1:500,000-scale hydrologic map of Wyoming or specifically classified by the WDEQ. The waters listed in Table B are those contained in the WG&FD "Streams and Lakes Inventory" and are based on the presence or absence of fish species. Where there are differences in classification, Table A takes precedence.

The State has designated surface water uses, water quality criteria to protect those uses, and anti-degradation policies and procedures in WDEQ's *Water Quality Rules and Regulations Chapter 1, Wyoming Surface Water Quality Standards* (hereafter referred to as Wyoming's surface water quality standards; WDEQ 2013). Section 2(b)(ix) of Wyoming's surface water quality standards defines *designated uses* as "those uses specified in water quality standards for each water body or segment whether or not they are being attained" (WDEQ 2013). The designated uses that are protected for Wyoming's surface waters are listed and described in Section 3 of Wyoming's surface water quality standards. These designated uses include

agriculture, fisheries, industry, drinking water, recreation, scenic value, aquatic life other than fish, wildlife, and fish consumption. These uses are defined in Wyoming's surface water quality standards as follows (WDEQ 2013):

(a) Agriculture. For purposes of water pollution control, agricultural uses include irrigation and/or livestock watering.

(b) Fisheries. The fisheries use includes water quality, habitat conditions, spawning and nursery areas, and food sources necessary to sustain populations of cold-water game fish, warm-water game fish, and nongame fish. This use does not include the protection of aquatic invasive species or other fish which may be considered "undesirable" by the WG&FD or the USFWS within their appropriate jurisdictions.

(c) Industry. Industrial use protection involves maintaining a level of water quality useful for industrial purposes.

(d) Drinking water. The drinking water use involves maintaining a level of water quality that is suitable for potable water or intended to be suitable after receiving conventional drinking water treatment.

(e) Recreation. Recreational use protection involves maintaining a level of water quality that is safe for human contact. It does not guarantee the availability of water for any recreational purpose. The recreation-designated use includes primary contact recreation and secondary contact recreation subcategories.

(f) Scenic value. Scenic value use involves the aesthetics of the aquatic systems themselves (odor, color, taste, settleable solids, floating solids, suspended solids, and solid waste) and is not necessarily related to general landscape appearance.

(g) Aquatic life other than fish. This use includes water quality and habitat necessary to sustain populations of organisms other than fish in proportions that make up diverse aquatic communities common to the waters of the state. This use does not include the protection of human pathogens, insect pests, aquatic invasive species or other organisms that may be considered "undesirable" by the WG&FD or the USFWS within their appropriate jurisdictions.

(h) Wildlife. The wildlife use includes protection of water quality to a level that is safe for contact and consumption by avian and terrestrial wildlife species.

(i) Fish consumption. The fish consumption use involves maintaining a level of water quality that will prevent any unpalatable flavor and/or accumulation of harmful substances in fish tissue.

Wyoming's surface waters are classified according to their designated uses using a hierarchical system described in Wyoming's surface water quality standards (WDEQ 2013). There are four major classes of surface water in Wyoming with various subcategories within each class. Waters are placed into Classes 1–4 based on their designated uses, with Class 1 waters being managed for the highest water quality and Class 4 waters being managed for the lowest water quality (WDEQ 2013). All of the streams located within the Watershed are classified as 2AB by the WDEQ for being waters known to support cold-water game fish. The definition of the stream class applicable to the Watershed is quoted from the Water Quality Rules and Regulations, Chapter 1, Wyoming Surface Water Quality Standards (WDEQ 2013) as follows:

> *"Class 2AB waters are those known to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where 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."

The designated uses for 2AB streams are drinking water, game and fish, non-game fish, fish consumption, other aquatic life, recreation, wildlife, agriculture, industry, and scenic values.

3.7.2 Groundwater Vulnerability

In 1998, the WDEQ, in conjunction with the Wyoming Water Resources Center, State of Wyoming Geological Survey, the University of Wyoming, and the Spatial Data Visualization Center (SDVC), completed the *Wyoming Ground Water Vulnerability Assessment Handbook*. Contained within that handbook was statewide information on the vulnerability of groundwater. Several areas within the Watershed were determined to have a vulnerability class of 5 (High) on a scale of 1-5. Figure 3.7.1 depicts the results of WDEQ's work regarding groundwater vulnerability within the Watershed.

As a result of this vulnerability assessment, Sheridan County has adopted stringent development standards for those lands with high groundwater tables. For those lands within the County that have a Groundwater Vulnerability rating of 5, the County requires that rural residential development with no centralized wastewater system occur at a density of not less than 5 acres per dwelling unit (Sheridan County, 2017). For those areas which have a Groundwater Vulnerability rating of 4 or less, Rural Residential development with no centralized wastewater disposal system may occur at a density of not less than two acres per dwelling unit.

3.7.3 WYPDES Permitted Discharges

Figure 3.7.2 shows the locations of standard, individual Wyoming Public Discharge Elimination System (WYPDES) permits that have been previously issued by WDEQ within the Watershed and that are currently active (WDEQ 2017). Of the 11 discharge permits that have been issued:

- five (5) permits have been issued for outfalls from wastewater treatment plants (WWTPs):
  - two (2) for the City's WWTP (of which one is only used during an emergency overflow situation);
  - one (1) for the Big Horn School's WWTP;
  - one (1) for the Powder Horn's WWTP; and
  - one (1) for the KOA Campground's WWTP (which will soon become moot, as they have paid plant investment fees to the City and have been authorized to connect to the City's sewage collection system);
- two (2) permits have been issued for outfalls for small discharges of process water from the two City/SAWSJPB water treatment plants:
  - one (1) for the Sheridan water treatment plant (SWTP); and
  - one (1) for the Big Goose water treatment plant (BGWTP);
- four (4) permits for various small industrial discharges:
  - one (1) for the Phillips 66 tank farm at the intersection of U.S. Highway 87 and State Highway 342 (Meade Creek Road), which provides for discharges of accumulated precipitation runoff within its oil storage tank berms; and
  - three (3) for Mullinax Concrete's aggregate settling ponds.

SHERIDAN

Story

Sheridan

Big Horn

Beckton

Ranchester

Dayton

GOOSE CREEK

LITTLE GOOSE CREEK

BIG GOOSE CREEK

SOLDIER CREEK

N

0 1.25 2.5 5

Miles

CLASS

- HIGH
- LOW
- MEDHIGH
- MEDIUM
- MEDLOW
- GOOSE CREEK WATERSHED BOUNDARY

GROUNDWATER VULNERABILITY

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FIG. 3.7.1

WYPDES PERMIT LOCATIONS
GOOSE CREEK WATERSHED
SUBWATERSHED BOUNDARIES

Story
Sheridan
Big Horn
Beckton
Ranchester
Dayton

14
87
338
335
331
90

GOOSE CREEK
LITTLE GOOSE CREEK
KRUSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
JACKSON CREEK
BEAVER CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK

Sheridan Co.
Johnson Co.
Big Horn Co.

N

0 1.25 2.5 5
Miles

WYPDES PERMITS

GOOSE CREEK WATERSHED LEVEL I STUDY

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FIG. 3.7.2

3.7.4 Waters Requiring TMDLs

Section 303(d) of the Clean Water Act (CWA) requires states to develop lists of waterbodies that do not meet water quality standards for their designated uses and to submit updated lists to the EPA every two years. Waterbodies on this list, called the 303(d) list, are considered to be not supporting their designated uses and are referred to as "impaired." For waterbodies on the 303(d) list, the CWA requires that a pollutant load reduction plan or total maximum daily load (TMDL) be developed to correct each impairment. A TMDL must document the nature of the water quality impairment, determine the maximum amount of a pollutant that can be discharged and still meet water quality standards, and identify allowable loads from the contributing sources.

Also quantified by a TMDL is the necessary reduction in load of a given pollutant to comply with WDEQ water quality standards. A TMDL must be established for each of the pollutants found to be in violation of the water quality standards, and each TMDL must consider both point and non-point source pollutant loads, natural background conditions, and a margin of safety.

Wyoming's Methods for Determining Surface Water Quality Condition and TMDL Prioritization (WDEQ 2014) outlines the methodology used by WDEQ for making designated use support determinations, or assessments, on surface waters. Once designated use support determinations are made by WDEQ, USEPA requires that all surface waters of the state be placed into one of five categories (EPA 2005). Because designated uses, water quality standards, and designated use support methodologies are not consistent across all states, tribal governments, and territories, surface water categorizations are used to standardize various approaches for USEPA's national reporting purposes. In Wyoming, designated use support determinations translate directly into the following five categories:

Category 1 - Available data and/or information indicate that all designated uses are supported and no use is threatened.

Category 2 - Available data and/or information indicate that at least one designated use is supported, while one or more other uses are either indeterminate or not assessed.

Category 3 - Available data and/or information are either insufficient or inconclusive, and designated use support cannot be determined for any uses.

Category 4 - Available data and/or information indicate that at least one designated use is impaired but a TMDL is not needed. There are three sub-categories of category 4:

4A. Impaired waters with TMDLs approved by USEPA.

4B. A use impairment that is being addressed by the state through other pollution control measures.

4C. A use impairment not caused by a pollutant but instead by anthropogenic non-pollutant stressor(s).

Category 5 - Available data and/or information indicate that at least one designated use is not supported or is threatened. Category 5 waters are those added to Wyoming's 303(d) list of impaired waters requiring TMDLs. Each pollutant/segment combination is considered a separate 303(d) listing.

Wyoming's biennial Integrated 305(b) and 303(d) Report (hereafter referred to as the Integrated Report) combines the requirements of the CWA into a single document. The waterbodies listed in Table 3.7.1 were listed in Wyoming's 2014 Integrated Report (WDEQ 2016) as needing TMDL

assessments. Table 3.7.1 shows the surface water classifications, cause of impairment, year of 303(d) listing, and year of TMDL completion for the various waters in the Watershed.

Table 3.7.1 - Stream Classification, Cause of Impairment, Year of Initial 303(d) Listing, and Year of TMDL Completion for the Various Waters in the Goose Creek Watershed

Water Body	Class	Impairment	Initial 303(d) Listing Year	Year TMDL Completed
Park Creek	2AB	Fecal Coliform	2000	2010
Rapid Creek	2AB	Fecal Coliform	2000	2010
Big Goose Creek	2AB	Fecal Coliform	1996	2010
Beaver Creek	2AB	Fecal Coliform	2000	2010
Sackett Creek	2AB	Fecal Coliform	2000	2010
Jackson Creek	2AB	Fecal Coliform	2000	2010
Little Goose Creek	2AB	Fecal Coliform, Habitat Alteration, Sediment	1996 (Fecal Coliform), 2006 (Habitat Alterations, Sediment)	2010
McCormick Creek	2AB	Fecal Coliform	2004	2010
Kruse Creek	2AB	Fecal Coliform	2000	2010
Goose Creek	2AB	Fecal Coliform, Habitat Alterations, Sediment	2000 (Fecal Coliform), 2006 (Habitat Alterations, Sediment)	2010
Soldier Creek	2AB	Fecal Coliform	2000	2010

Wyoming's 2014 Integrated 305(b) and 303(d) Report (WDEQ 2016)

Big and Little Goose Creeks were placed on the 303(d) list in 1996 because of exceedances of the fecal coliform criterion. Subsequent monitoring by WDEQ in 1998 and 1999 revealed exceedances in several other locations within these subwatersheds, including:

- within the Little Goose Creek Subwatershed:
  - Kruse Creek,
  - Sackett Creek, and
  - Jackson Creek irrigation canal, and
- within the Big Goose Creek Subwatershed:
  - Beaver Creek,
  - Park Creek, and
  - Rapid Creek.

SCCD monitored fecal bacteria in the Watershed in 2001 and 2002, and the results corroborate the 1998–1999 WDEQ data (SCCD 2003). The SCCD study also resulted in the extension of the impaired reach of Goose Creek from the confluence of Big and Little Goose Creeks downstream to the Wyoming Highway 339 bridge crossing. This study also indicated that McCormick Creek was not meeting its contact recreation uses from the confluence of Little Goose Creek upstream for an undetermined distance. SCCD, with the guidance of a local watershed steering committee, developed a watershed plan, which was approved by WDEQ in 2005. Implementation of projects to improve stream water quality has begun, which include septic system improvements, establishment of animal feeding operations, riparian buffer development, streambank stabilization, reservoir development, and changes in grazing management.

The EPA approved TMDLs for the 13 listed waters in the Watershed in 2010. This included portions of Goose Creek, Big Goose Creek and Little Goose Creek, as well as the following tributaries:

- Goose Creek tributary:
  - Soldier Creek, and

MONITORING SITE

GC1 GC2 GC3 GC4 GC5 GC6
LG1 LG2 LG3 LG4 LG5 LG6 LG7 LG8 LG9 LG10 LG11 LG12 LG13 LG14 LG15 LG16 LG17 LG18 LG19 LG20 LG21 LG22
BG1 BG2 BG3 BG4 BG5 BG6 BG7 BG8 BG9 BG10 BG11 BG12 BG13 BG14 BG15 BG16 BG17 BG18

GOOSE CREEK
LITTLE GOOSE CREEK
KRUSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
JACKSON CREEK
BEAVER CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK

Story
Big Horn
Beckton
Ranchester
Dayton
Sheridan Co.
Johnson Co.
Bighorn Co.

14 87 338 90 331 335 14

N
0 1.25 2.5 5
Miles

WATER QUALITY MONITORING LOCATIONS

GOOSE CREEK WATERSHED LEVEL I STUDY

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FIG. 3.7.3

- Big Goose Creek tributaries:
    - Park Creek,
    - Rapid Creek,
    - Beaver Creek, and
- Little Goose Creek tributaries:
    - Sackett Creek,
    - Jackson Creek, ,
    - McCormick Creek, and
    - Kruse Creek,

As a result, Wyoming's 2014 Integrated Report lists these waters as Category 4A waters that are "impaired waters with TMDLs approved by USEPA." This report lists no waterbodies in the Watershed as requiring TMDLs.

3.7.5 Water Quality Assessment

The water quality of the Watershed is characterized by the water quality of its three subwatersheds: Big Goose Creek, Little Goose Creek, and Lower Goose Creek. The USGS, the WDEQ, and the SCCD have traditionally conducted monitoring of and collected data for the Watershed. In 1998, the WDEQ implemented a more detailed monitoring program on Big and Little Goose Creeks following their placement on the 1998 303(d) list. In 2001, the SCCD initiated a comprehensive monitoring program at 46 different stations within the three subwatersheds, including along the eight tributaries listed above. The SCCD dataset is the most comprehensive, as it includes numerous water quality parameters and data for sites throughout the Watershed. The water quality monitoring locations utilized for the collection of this data are shown in Figure 3.7.3.

A series of publications have documented the water quality of the Watershed since 2005. These consist of SCCD watershed reports from 2005 through 2016, the Goose Creek Watershed Assessment Report (SCCD 2003), and the various TMDL analyses that SWCA conducted for the Watershed, including the Goose Creek Watershed TMDL (SWCA 2010). In general, these reports describe an overall degradation of water quality from upstream to downstream (SCCD 2003). Additionally, water quality in the eight tributaries listed above has generally been found to be of lower quality than that of the "main stem" Goose Creek, Big Goose Creek and Little Goose Creek, indicating degradation is occurring in the upper part of the Watershed. The main water quality parameters of concern are fecal bacteria (*E. coli*), sediment, and temperature.

3.7.6 Suitability for Agricultural Use

SCCD water quality data for the Watershed was used to evaluate the suitability of surface water for agricultural use, mainly irrigation and livestock watering. The most influential water quality parameter with respect to agricultural use is salinity, given its ability to cause physiological drought. Two types of salinity problems may exist in irrigation water; those associated with total salinity as measured by total dissolved solids (TDS) or conductivity and those associated with sodium as measured by the sodium adsorption ratio (SAR). Additionally, many other parameters influence the suitability of irrigation water for agriculture as listed in Table 3.7.2 (Bauder et al. 2014). There are multiple water quality parameters that can serve as proxies for salinity. In the water quality context, salinity is a measure of dissolved compounds in water. Salinity can be broken down into two components: total salinity and sodium, as the proportion of sodium to other ions can result in a hardening of the soil. Total salinity is the traditional measure of salinity, which is measured in TDS, hardness and electrical conductivity (conductivity or specific conductance). Total dissolved solids and hardness are both measures of the amount of minerals dissolved in water, while specific conductance is the ability of a solution to conduct electricity, which is dependent on the amount of dissolved ions within the solution. (Bauder et al. 2014)

suggests that conductivity (or specific conductance) is the best measure of salinity, given that it is a measure of the amount of dissolved ions within the solution, which prohibit plants from obtaining sufficient water.

Table 3.7.2 - Water Quality Recommended Maximum Levels for Irrigation and Animal Watering

Constituent	Units	Recommended Maximum Level for Irrigated Agriculture			Recommended Maximum Level for Livestock and Wildlife Watering		
		WDEQ (2013)	Ayers and Westcot (1994)	Bauder et al. (2014)	WDEQ (2013)	Ayers and Westcot (1994)	Raisbeck, et al. (2007)
Aluminum	µg/L	5000	5000	--	5000	5000	--
Arsenic	µg/L	100	100	--	200	200	1000
Beryllium	µg/L	100	100	--	--	100	--
Boron	µg/L	750	--	4100-6000[2]	5000	5000	--
Cadmium	µg/L	10	10	--	50	50	--
Chloride	mg/L	100	-	141-350[3]	2000	--	--
Chromium	µg/L	100	100	--	50	1000	--
Cobalt	µg/L	50	50	-	--	1000	--
Copper	µg/L	200	200	--	500	500	-
Fluoride	µg/L	--	1000	--	--	2000	2000
Iron	µg/L	5000	5000	--	--	--	--
Lead	µg/L	5000	5000	--	100	100	--
Lithium	µg/L	2500	2500	--	--	--	--
Magnesium	µg/L	--	--	--	--	250-500	--
Manganese	µg/L	200	200	--	--	50	--
Mercury	µg/L	--	--	--	0.05	10	--
Molybdenum	µg/L	--	10	--	--	10	300
Nickel	µg/L	200	200	--	--	200	--
Nitrate ($N0_3$-N)	mg/L	--	--	--	10	--	500
Nitrite (N02-N)	mg/L	--	-	--	100	--	100
Total Nitrate and Nitrite (N03+N02)-N	mg/L	--	5-30[1]	--	10	100	--
Selenium	µg/L	20	20	--	50	50	100
Sulfate	mg/L	200	--	--	3000	--	1800 - acute 1000 - chronic
Vanadium	µg/L	100	100	--	100	100	--
Zinc	µg/L	2000	2000	--	25000	24000	--
Oil and Grease	mg/L	10	--	--	10	--	--
Radium 226 and 228	pCi/L	5	--		5	--	
Total Strontium 90	pCi/L	8	--	--	8	--	--
Gross alpha particle radioactivity (inc. Radium 226 but exc. Radon and Uranium)	pCi/L	15	--	-	15	--	-
Total Dissolved Solids (TDS)	mg/L	2000	450-2000[1]	-	5000	-	-
pH	Std. Units	4.5-9.0	--	--	6.5-8.5	-	--
Residual Sodium Carbonate (RSC)	meq/L	1.25	--	--	--	--	--
Sodium Adsorption Ratio (SAR)	n/a	8	--	9	--	--	--
Specific Conductance	µS/cm	--	2000	1,510 – 3,000[4] ≥3,000[5]	--	5000-8000	-

1 Range of slight to moderate use restriction; i.e., no use restrictions on lower values, severe use restrictions higher values
2 Alfalfa tolerance range

3 Range that causes injury for moderately tolerant plants; concentrations in the range of 351–700 mg/L causes foliar damage to alfalfa
4 Leaching required at higher range
5 Good drainage needed, and sensitive plants may have difficulty at germination.

The data shown in Tables 3.7.3 through 3.7.5 summarize the available and applicable SCCD water quality data collected in the Watershed in 2001-2002 and in 2015. Values shown are averages of sample concentrations. Results marked with an asterisk exceed the water quality standards for irrigation or animal watering listed in Table 3.7.2. LG3 in Table 3.7.5 shows exceedances for conductivity and total sulfate. However, the LG3 station was not an "in-stream" sampling station, as it is located on a storm drain inlet next to Coffeen Avenue located in the City.

Table 3.7.3 - Available Water Quality Data for the Lower Goose Creek Subwatershed

Site	pH	Specific Conductance (µmhos/cm)	Alkalinity (mg/L)	Chloride (mg/L)	Total Hardness as CaCO3 (mg/L) Hardness not shown in WQ3	Total Ammonia Nitrogen (mg/L) Total Ammonia Nitrogen not shown in WQ3	Total Nitrite and Nitrate as N (mg/L)	Total Phosphorus (mg/L) Phosphorus not shown in WQ3	Sulfate (mg/L)
GC1-Bottom	8.4	631.6	252.9	7.8	350.2	0.3	0.1	0.2	151.3
GC2	8.3	597.0	230.1	7.8	316.6	0.4	0.3	0.3	130.9
GC3	8.3	691.1	238.5	5.0	328.0	0.1	0.1	0.1	131.6
GC4-Soldier Ck	8.1	964.2	376.8	8.9	572.2	0.2	0.3	0.1	*278.9
GC5	8.3	714.8	239.1	8.0	328.0	0.1	0.1	0.1	132.5
GC6	8.3	707.8	229.0	11.0	322.5	0.2	0.1	0.1	137.9

Table 3.7.4 - Available Water Quality Data for the Big Goose Creek Subwatershed

Site	pH	Conductivity (mhos/cm)	Alkalinity (mg/L)	Total Chloride (mg/L)	Total Hardness as CaCO3 (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Nitrite + Nitrate as N (mg/L)	Total Phosphorus (mg/L)	Total Sulfate (mg/L)
BG1-Bottom	8.35	530.35	227.35	3.12	277.73	0.28	0.22	0.38	145.88
BG2	8.23	636.36	179.57	2.71	326.50	0.32	0.19	0.24	150.84
BG3	8.26	584.54	189.36	2.59	295.25	0.31	0.12	0.30	155.71
BG4	8.10	677.19	194.42	2.16	332.96	0.26	0.16	0.30	142.60
BG5	8.22	592.83	177.38	1.94	294.18	0.33	0.15	0.41	103.51
BG6	8.27	561.41	209.08	2.02	308.12	0.25	0.14	0.31	105.98
BG7	8.19	559.15	226.63	1.90	248.29	0.32	0.15	0.38	112.25
BG8	8.22	533.12	198.38	1.51	302.62	0.31	0.26	0.28	119.58
BG9-Beaver Ck	8.30	834.47	253.15	2.39	414.57	0.26	0.29	0.30	113.58
BG10	8.30	472.17	188.07	1.43	238.62	0.23	0.19	0.36	116.15
BG11	8.17	447.10	202.35	1.16	268.13	0.39	0.18	0.26	103.99
BG12	8.16	457.63	159.46	0.91	218.36	0.29	0.17	0.34	101.96

Site	pH	Conductivity (mhos/cm)	Alkalinity (mg/L)	Total Chloride (mg/L)	Total Hardness as CaCO3 (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Nitrite + Nitrate as N (mg/L)	Total Phosphorus (mg/L)	Total Sulfate (mg/L)
BG13-ParkCk	7.86	784.74	331.29	4.04	283.00	0.29	0.40	0.59	159.71
BG14	8.33	389.78	153.00	0.78	236.54	0.36	0.21	0.24	109.90
BG15	8.43	358.45	122.12	0.55	217.77	0.30	0.20	0.43	129.15
BG16-Rapid Ck	8.31	397.87	185.00	0.70	196.08	0.26	0.25	0.43	68.55
BG17	8.25	306.36	104.64	0.50	183.18	0.26	0.23	0.35	56.43
BG18	8.27	80.65	37.58	0.50	45.04	0.39	0.19	0.36	10.31

Table 3.7.5 - Available Water Quality Data for the Little Goose Creek Subwatershed

Site	pH	Conductivity (mhos/cm)	Alkalinity (mg/L)	Total Chloride (mg/L)	Total Hardness as CaCO3 (mg/L)	Total Ammonia Nitrogen (mg/L)	Total Nitrite + Nitrate as N (mg/L)	Total Phosphorus (mg/L)	Total Sulfate (mg/L)
LG1-Bottom	8.23	787.63	288.29	4.91	389.29	0.14	0.04	0.05	150.74
LG2	8.16	631.63	289.64	4.69	387.29	0.11	0.02	0.05	150.20
LG3	7.97	*2290.83	280.00	20.89	1425.29	0.18	1.24	0.14	*1089.79
LG4	8.17	783.52	288.86	3.86	371.36	0.08	0.02	0.06	129.01
LG5	8.09	737.23	300.00	3.41	368.07	0.13	0.03	0.04	116.78
LG6	8.05	663.78	299.36	2.89	336.43	0.22	0.04	0.05	75.53
LG7	8.04	640.89	274.14	3.31	327.43	0.07	0.03	0.05	83.31
LG8	8.20	497.43	282.29	3.29	321.57	0.09	0.08	0.07	76.56
LG9-McCormick Ck	8.13	1006.08	344.79	4.10	492.29	0.11	0.09	0.09	*221.64
LG10	8.08	546.33	268.36	3.34	291.50	0.12	0.14	0.06	51.66
LG11-Kruse Ck	8.28	587.22	281.57	2.44	293.57	0.13	0.30	0.09	47.90
LG12	8.00	515.83	265.57	3.59	289.79	0.13	0.06	0.04	49.11
LG13	8.37	423.64	259.93	2.98	285.14	0.08	0.15	0.07	46.54
LG14	8.35	479.63	238.79	3.03	290.71	0.11	0.04	0.06	77.57
LG15	8.39	389.96	215.43	1.71	224.93	0.09	0.05	0.04	19.34
LG16	8.40	383.22	209.50	1.64	219.14	0.13	0.06	0.05	19.02
LG17-Jackson Ck	8.25	616.25	318.50	2.02	326.71	0.13	0.14	0.09	29.66
LG18	8.33	371.50	204.86	1.56	211.64	0.09	0.07	0.05	17.48
LG19-Sackett Ck	8.19	609.00	239.29	2.38	248.07	0.07	0.06	0.07	33.35
LG20	8.29	306.65	169.64	0.98	176.93	0.14	0.07	0.05	12.82
LG21	8.24	224.00	109.86	0.58	118.89	0.10	0.04	0.03	11.72
LG22	7.83	119.00	45.00	0.05	58.00	0.06	0.01	0.02	0.03

The available and applicable SCCD water quality data and the water quality criteria for agricultural uses listed in Table 3.7.2 indicate that the water discharging from the Watershed appears to be generally suitable for agricultural use. However, Tables 3.7.3 – 3.7.5 contain a few exceedances of the water quality criteria for agricultural uses (marked with an asterisk). As shown, the agricultural maximum recommended level for sulfate was exceeded at GC-4 (Soldier Creek) in the Lower Goose Creek Subwatershed, and at LG-3 and LG-9 (McCormick Creek) in the Little Goose Creek Subwatershed. At site LG-3, the average conductivity was also found to exceed the agricultural criteria. The majority of exceedances above the agricultural criteria recommended levels appear to be in tributaries in the upper part of the Watershed.

As previously observed in other reports, this data depicts degrading water quality with distance downstream. However, there are some areas in the upper portions of the Watershed that have degraded water quality. Most of the sites located on the tributary streams appear to have higher conductivity, hardness, and turbidity than sites along the "main stem" subwatersheds (Big Goose Creek, Little Goose Creek, and Lower Goose Creek). However, these tributary inflows are diluted when they converge with the "main stem" streams, where the hardness and turbidity is generally lower than in the upper tributaries. The cumulative effect of these tributary inflows, in addition to agricultural return flows and non-point sources, results in water quality degradation in the lowest reaches of the Watershed.

Comparison of the available and applicable water quality data from the SCCD with the water quality recommended levels for agricultural use reveals significant data gaps, particularly in the analysis of metals, Total Dissolved Solids (TDS), and sodium adsorption ratio (SAR), which are water quality parameters of concern for agricultural uses. Many of the parameters (metals and others) are expected to be below water quality standards for agriculture in the Watershed, given the lack of historic mining and industry within the watershed area. While monitoring for all of these parameters (particularly metals) would be costly, it may be worth considering pursuing opportunities to expand monitoring efforts to collect a more comprehensive dataset of parameters that influence suitability for agricultural use.

3.8 Water Systems

3.8.1 Municipal and Industrial Systems

3.8.1.1 City/SAWSJPB Municipal Water System

3.8.1.1.1 System Description

The City and SAWSJPB each own water systems that jointly serve the area in and around the Sheridan city limits. Figure 3.8.1 depicts both the SAWSJPB service area (which includes that of the City) and the location of existing City and SAWSJPB pipelines within that service area. The City's and SAWSJPB's water systems are constructed to operate as one regional system, thus water continually flows in and out of the two individual systems. There are no master meters within this regional system that distinguish which water belongs to the two entities (Ownership Agreement 1998). Just one public water system permit is held for the two systems: Community Water System Permit WY5600052 (Manolis 2016). This permit was issued to the City by EPA, which is the regulatory agency that oversees public water systems in Wyoming.

An agreement exists between the City and SAWSJPB which stipulates that the City is to operate both systems and bill the SAWSJPB for those services it provides for the SAWSJPB system (Operating Agreement 1998). The SAWSJPB does not have any employees, but instead

N

0 0.75 1.5 3
Miles

VAMC

DOWNER

WTP

WTP

KENDRICK
GOLF COURSE

WTP

CITY/SAWSJPB SERVICE AREA
CITY/SAWSJPB WATER MAINS
CITY/SAWSJPB WTPs
CITY/SAWSJPB PUMP STATIONS
CITY/SAWSJPB WATER TANKS
VAMC WTP
VAMC WATER TANK
GOOSE CREEK WATERSHED BOUNDARY

CITY OF SHERIDAN AND SAWSJPB MUNICIPAL WATER SYSTEM

GOOSE CREEK WATERSHED LEVEL I STUDY

SWCA®
Anderson Consulting Engineers, Inc.
Civil • Water Resources • Environmental

EnTech Inc.
Professional Engineers
Sheridan, WY 82801

FIG. 3.8.1

contracts with Sheridan County to provide one person who serves as the SAWSJPB's project manager and administrator. As a result, there is little duplication of services for the two systems.

This regional water system has two water treatment plants:

1. The SWTP (located northwest of the city limits), owned totally by the City, and
2. The BGWTP (located approximately one mile east of the mouth of the Big Goose Creek canyon that exits from the Big Horn Mountains). This water treatment plant is owned jointly by the City and SAWSJPB.

These two treatment plants, as well as the Kendrick Golf Course and the VAMC, receive their raw water from an intake located at the mouth of the canyon. One 30" steel transmission main delivers this raw water to "drop off" points for each of the four facilities (HKM 2008). This transmission main was constructed in the early 1990s. A second, redundant 20" ductile iron transmission main also is in place to serve raw water to these four facilities. The 20" main was installed in the 1960s. However, due to external corrosion of this ductile iron pipe through areas within the Big Goose valley containing corrosive soils, this 20" transmission main can no longer be used in many areas. Consideration has been given to replacing the corroded sections of the 20" transmission main with new pipe, or using the ductile iron pipe as a sleeve and pulling new, smaller pipe inside of the ductile iron pipe within the corroded sections. However, to date this has not been accomplished (Hirschman, 2016).

The two treatment plants have the following rated capacities:

1. SWTP: 14 MGD
2. BGWTP: 4 MGD

18 MGD

The SWTP serves mostly City customers, and a majority of the BGWTP customers are SAWSJPB customers. However, due to the interconnection of the two systems, some customers may at certain times of the day be served with SWTP water, and at other times be served by the BGWTP.

Both treatment plants use a common coagulation/flocculation/sedimentation method of treatment, followed by chlorination for disinfection. The SWTP generates its own liquid sodium hypochlorite for disinfection, while the BGWTP relies upon a gas chlorination system. Beginning approximately three years ago, both treatment plants began adding fluoride to inhibit tooth decay among the citizenry (Manolis 2016).

The water distribution systems are jointly comprised of the following:

- Seven pressure zones. Table 3.8.1 lists these zones and reservoir overflow elevations or hydraulic grade lines (where no reservoir exists to serve the zone) of the booster stations serving them.

Table 3.8.1 - Pressure Zones within City/SAWSJPB System

Zone	Reservoir Overflow Elevation or Hydraulic Grade Line of Booster Station (ft)
Low	3952
Zone 1	4040
Zone 2	4160
Zone 3	4276
Zone 4	4390
Zone 5	4506
Zone 6	4622
Zone 7	4736

- Approximately 210 miles of pipe, ranging in size from 4" to 30". A majority of the distribution system within the City is constructed of cast iron or ductile iron pipe, whereas

all but a few of the larger distribution system mains within the SAWSJPB system are constructed of PVC.

- Nine (9) treated water storage tanks/reservoirs. Table 3.8.2 provides information on these storage tanks, which are also shown on Figure 3.8.1. All of these treated storage facilities are buried, which improves overall water quality and eliminates ice buildup. The table does not include the City's 0.3 million gallons (MG) standpipe located on the east side of the City, which is currently not in use and not envisioned to be used in the future (HKM 2008).

Table 3.8.2 - Storage Tanks/Reservoirs within City/SAWSJPB System

Treated Storage Tank/Reservoir	Ownership	Capacity (MG)	Overflow Elevation (ft)	Additional Information
SWTP Clearwell	City	4.0	4040	
BGWTP Clearwell	City/SAWSJPB	1.5	4396	
Northwest	City	1.0	4160	
North High	City	0.7	3974	(all flow goes to North Low)
North Low	City	2.1	3951	Two Reservoirs
Airport	City	2.0	3953	Three Reservoirs
Southeast	SAWSJPB	1.3	4040	
Big Horn	SAWSJPB	1.0	4160	
Bradford Brinton	SAWSJPB	0.5	4276	
	Total	14.1		

- Twenty (20) pump stations. (See Table 3.8.3.) There are seven pressure zones within the joint system, of which most of them are served with these pump stations. Although almost all of the pressure zones within the City and some of those within the SAWSJPB system can be served via gravity from the two treatment plants, some of the zones require pumping in order to provide adequate pressure and flow. This is particularly true in some parts of the SAWSJPB system, where some rural residential development exists above the Big Goose Creek and Little Goose Creek valleys that benefit from the gravity service.

Table 3.8.3 - Pump Stations within City/SAWSJPB System

Booster Station	Ownership	Valley Served
Rapid Creek	SAWSJPB	Big Goose
Beckfon Hall Road	SAWSJPB	Big Goose
Timm Drive	SAWSJPB	Big Goose
Beaver Creek Road	SAWSJPB	Big Goose
Golf Course	SAWSJPB	Big Goose
Northwest	City	Big Goose, Soldier Ck.
Soldier Creek 1	SAWSJPB	Soldier Ck.
Soldier Creek 2	SAWSJPB	Soldier Ck
Southeast	SAWSJPB	Little Goose
Rocky Hills	SAWSJPB	Prairie Dog
Airport	SAWSJPB	Little Goose
Paradise Park	SAWSJPB	Little Goose
Woodland Hills	SAWSJPB	Little Goose
Powder Horn	SAWSJPB	Little Goose
Box Cross	SAWSJPB	Little Goose
Knode Ranch	SAWSJPB	Little Goose
Big Horn	SAWSJPB	Little Goose
Big Horn West	SAWSJPB	Little Goose
Parker Draw	SAWSJPB	Little Goose
Big Horn Ranch	SAWSJPB	Little Goose

- Twenty-five (25) pressure-reducing valves (PRVs) which sustain adequate pressures throughout the system's service area, with its considerable elevation differences. In

addition to these PRVs, there are also pressure-relief valves (PRfVs) which are located in areas where there is no storage tank downstream of a PRV. Without the benefit of a storage tank or a PRfV, a PRV failure could result in system pressures greatly exceeding safe pressure levels, creating the opportunity for damage to the system or the residences/businesses served.

The City and SAWSJPB are currently implementing a "Smart Meter" project, which will provide for state-of-the-art metering capabilities throughout the joint system. The smart meters will provide for enhancements such as the following:

- meter readings which can be obtained remotely, speeding data collection;
- meter readings which can be taken as frequently as 15-minute intervals, which allows for much more accurate information on peak-usage times;
- enhanced information on abnormal usage, leak detection and meter tampering;
- generation of alarms if usage greatly increases (such as due to a leak); and
- backflow prevention by detecting when backflow through the meter occurs and notifying the utility of this dangerous situation.

The Smart Meter system is anticipated to be online sometime in 2018 (Schoen 2017).

3.8.1.1.2 System Usage

Figure 3.8.2 portrays water diverted from the City's intake on Big Goose Creek for the past five years, which includes water diverted for:

- The two treatment plants;
- The Kendrick Golf Course; and
- The VAMC.

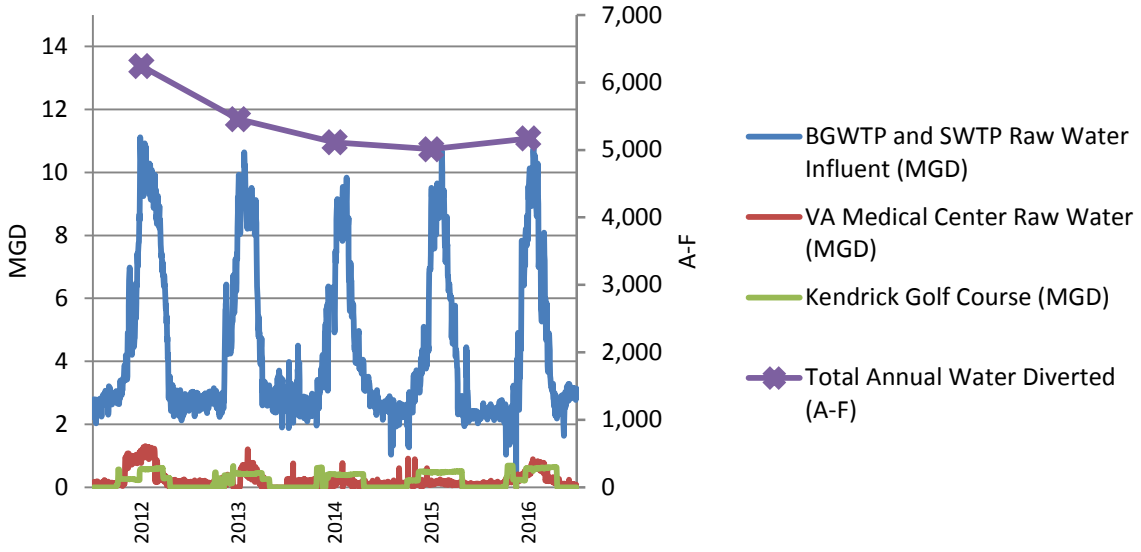

Figure 3.8.2 – Water Diversions at City Intake on Big Goose Creek

Figure 3.8.3 shows the amount of water produced by the two treatment plants on an annual basis. As can be seen, the amount produced to meet the peak day for each of the five years (between 8 MGD and 11 MGD) is far below the current treatment plant rated capacity of 18 MGD (Manolis 2017).

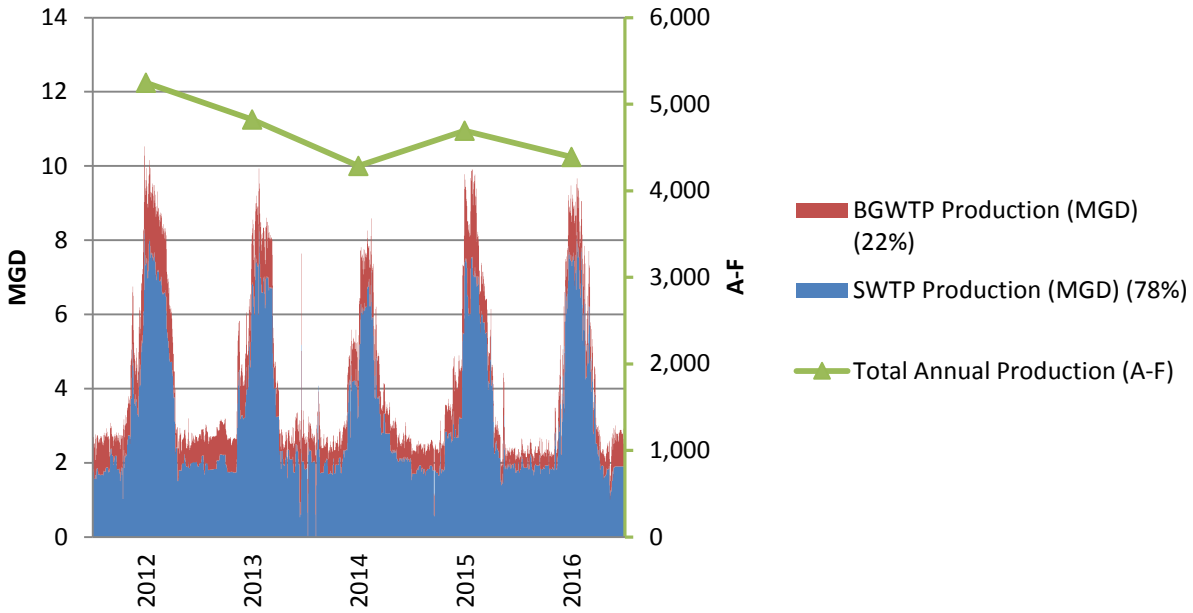

Figure 3.8.3 – Production at City and SAWSJPB Water Treatment Plants

The Downer Neighborhood I&S District also owns a water system within the SAWSJPB service area. The Downer water system (which is designated as Community Water System WY5601537) is actually only a water distribution system. It does not have its own source of supply, nor any tanks or booster stations. It is operated and maintained by the City under an agreement between the two entities. The City sells wholesale water to the Downer neighborhood under this agreement (Downer Agreement 2004). Other than the fact that there are two designated public water systems, the principal difference between the City/Downer relationship and the City/SAWSJPB relationship is there are two master meters at points where the City's water enters into the Downer area, versus (as stipulated previously) no master meters between the City and SAWSJPB.

All industries located in the Watershed that require water for uses other than domestic purposes obtain their water from the City.

For treated water that is used inside the homes and businesses within the City, the City owns a sanitary sewer system which flows into a WWTP that discharges to Goose Creek on the north side of the City. (The majority of SAWSJPB customers, being outside the City, rely upon onsite wastewater disposal systems, with the exception being Powder Horn residents and the Big Horn School, which are served with WWTPs at each location.) Figure 3.8.4 shows effluent flows at the City WWTP for the past five years, as well as the total annual effluent for each year. Wastewater treatment influent and resulting effluent is heavily influenced by infiltration and inflow, as can be seen in Figure 3.8.4. Effluent flows are much greater in the April through July periods of the year, which is the same period that maximum precipitation occurs.

Also note, in the year 2014 that the total effluent flow of 3,262 acre-feet (A-F) was approximately 80% of the total annual production of the two water treatment plants (Rideout 2017). As municipalities within the Rocky Mountain West typically see approximately 50% of their produced water find its way into the wastewater system (with the remaining 50% being used for irrigation), this shows that there may be excessive amounts of infiltration and inflow finding its way into the City's wastewater system.

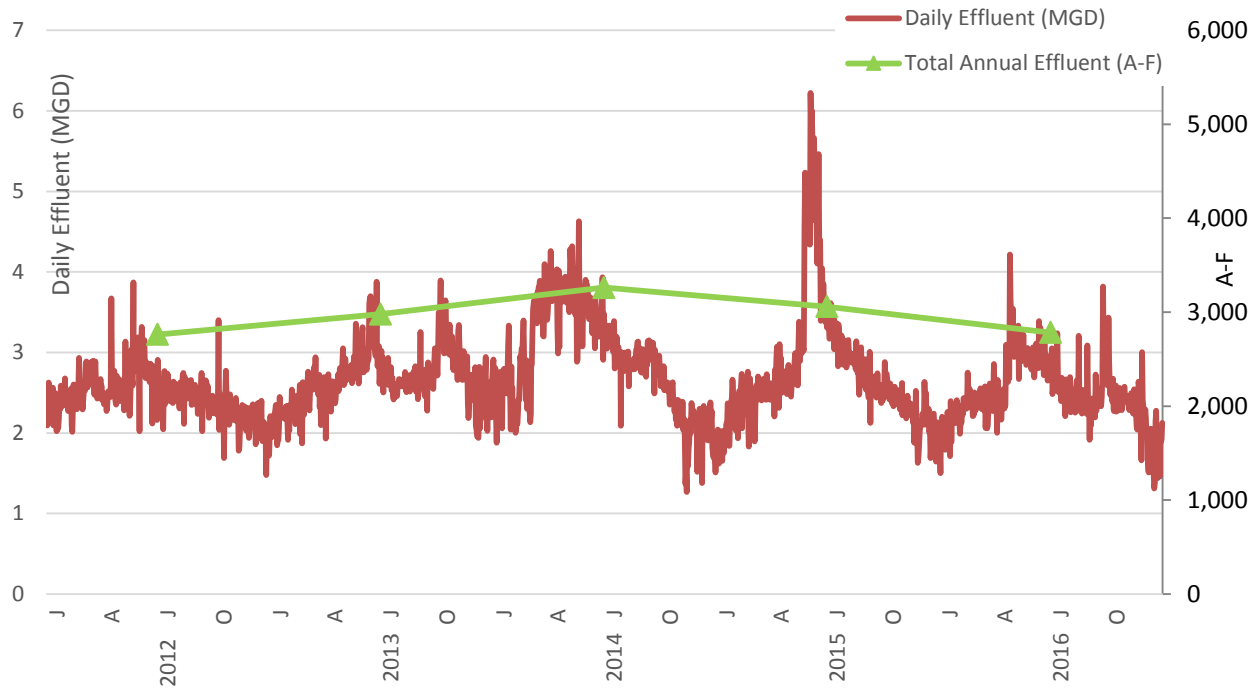

Figure 3.8.4 – Effluent Flow from the City Wastewater Treatment Plant

3.8.1.1.3 Recommended System Improvements

Contained within the 2008 Sheridan County Comprehensive Plan were recommended improvements for the City/SAWSJPB water system: These recommendations are listed below.

1. Water Supplies. While the City is perceived to have adequate water supplies for the immediate future, the same is not true of SAWSJPB. Per the 2008 Comprehensive Plan, approximately 183 A-F of water was available for additional SAWSJPB use. Based upon 350 gallons per day per residential dwelling unit, this would provide for approximately 450 new homes: more if outside-the-home irrigation was limited. In 2014, SAWSJPB purchased an additional 122 A-F of stored water from Dome Lake Reservoir, utilizing funds from a Long-term Water Supply Fund originally created in the early 1990s. An existing agreement between the City and SAWSJPB stipulates that 2/3 of any water purchased through use of the Long-term Water Supply Fund must go to the City, meaning that an additional 40 A-F of Dome Lake Reservoir water was acquired specifically for SAWSJPB customers. (Coughlin email dated 1/3/2017).

   More information about the City's and SAWSJPB's efforts to procure additional water supplies is available in Section 3.10.

2. Treated Water Storage Capacity. Per the 2008 Sheridan County Comprehensive Plan, the City/SAWSJPB regional system included 9.25 MG of treated water storage. Industry standards recommend that a municipal water system have treated water storage equal to peak day demand, which in this case would be approximately 10 MGD. (See Figure 3.8.3.)

   In actuality, in 2008 the City/SAWSJPB system included 12.1 MG of treated water storage, thus the system did in fact meet industry standards for this criteria at that time. Also, since

2008, an additional 2.0 MG of treated water storage has been added to the system's capabilities. It can therefore be concluded that there is adequate treated water storage for the system; however, it will be necessary to continue adding storage tank capacity to accommodate future growth.

3.8.1.2 VAMC Water System

The VAMC also owns and operates a community water system (WY5680001) within the Watershed. This public water system includes a water treatment plant that utilizes raw water delivered from the City's 30" raw water transmission main. The VAMC's peak annual treated usage is approximately 0.2 MGD. Additionally, raw water from the 30" transmission is delivered to the VAMC's grounds for irrigation purposes during the summer months, increasing total daily flows to as much as 1.2 MGD.

Figure 3.8.1 depicts the location of the VAMC's water treatment plant and sole treated water storage tank (a 0.6 MG standpipe), and Figure 3.8.5 portrays the VAMC's water usage – both treated water usage and raw water usage - for the past five years. Figure 3.8.1 also shows the location of the VAMC's standpipe storage tank located on the west side of the VAMC's grounds (Saltzman 2017).

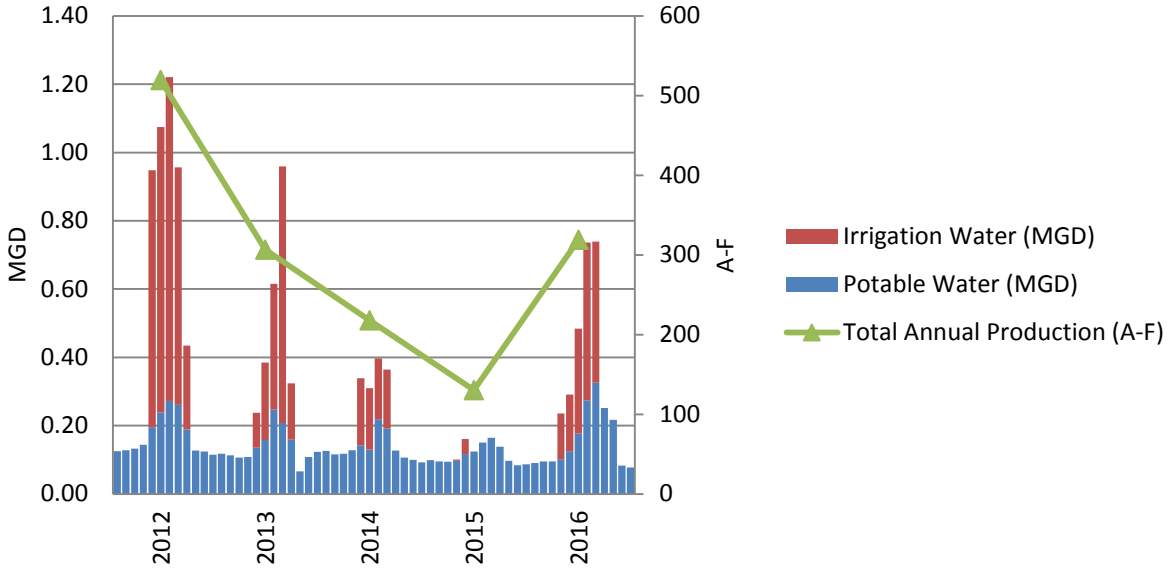

Figure 3.8.5 – VAMC Water Production

3.8.1.3 Other Public Water Systems

In addition to the three community water systems described in the previous two sections, there are two transient non-community water systems situated within the Watershed. Table 3.8.4 lists these two systems, their EPA public water system number and the approximate number of people that they serve:

Table 3.8.4 – Transient Non-Community Water Systems

Transient Non-community Water Systems	Public Water System Number	Approximate No. of Persons Served
Big Horn Mtn. KOA Campground[(1)]	WY5600242	150
BNF Burgess Ranger Station	WY560244	20

[(1)] *This public water system has paid plant investment fees to the City and will soon connect to the City's water system.*

Source: List of Water Systems in SDWIS, U.S. EPA

3.8.2 Irrigation Systems

3.8.2.1 Introduction

It is estimated that there are 34,681 acres of land currently irrigated within the Watershed. Almost all of the various surface water diversions within the Watershed relate to irrigation. The exceptions generally relate to minor uses such as stockwater or domestic purposes. The only significant non-irrigation use is the domestic/municipal purposes included in the City's water rights. Monitored diversions range in size from 0.04 cfs (Hanslip No. 2 Pump in the Little Goose Creek Subwatershed) to 133 cfs (Colorado Colony Ditch, also in the Little Goose Creek Subwatershed) (Boyd 2016).

For the Watershed's larger ditch systems, ditch companies exist to operate, maintain and manage the systems. These ditch companies assess annual levies or assessments on the landowners benefitting from the irrigation water in order to recover costs. Some smaller systems have their pumps, diversion structures and/or ditch conveyance facilities owned and operated by only one or two irrigators.

As part of this Level I Study, a review was conducted of potentially irrigable lands within the Watershed. In conducting the review, it became apparent that the construction of ditches relying on gravity was a principal limiting factor in originally developing lands for irrigation. Irrigators in the 1880s and later constructed their ditches as high as possible in the area below the BNF. They then constructed their ditches as flat as possible to maximize the number of lands that could be physically irrigated by gravity, as well as to minimize water-related erosion within the ditches. The result has been that most of the land within the Watershed that does not have excessive slope has at one time or another seen attempts at irrigation.

Notwithstanding the fact that gravity ditches have been the primary mechanism in locating ditches for irrigation, there are still some areas that have utilized mechanical pumping equipment to irrigate lands above ditches. For example, the University of Wyoming has recently installed center pivot irrigation equipment in an area south of Sheridan College that now irrigates lands from water supplied by and above the Burn Cleuch Ditch. Figure 3.8.6 portrays approximately 5,443 acres of potentially irrigable lands within the Watershed. Most of these lands are located above existing ditches, thus those lands would also require pumping equipment. Those lands located above existing ditches generally do not currently have water rights attached to them, whereas several of the lands below existing ditches already have water rights attached to them but, for whatever reason, are not currently being irrigated. In the formulation of this tabulation, both NRCS soils classification data and site topography were considered.

The majority of the infrastructure used for the delivery of irrigation water is old and suffering from deterioration or obsolescence, or both. As a result, there is considerable opportunity to conserve water and make its use more efficient by improving water-related infrastructure.

3.8.2.2 Irrigation Systems Inventory - Selection and Evaluation Methodology

An important aspect of this Level I Study is the mapping and description of irrigation water systems within the Watershed. The following methodology was utilized in selecting the irrigation systems to be investigated for this inventory effort involved with this Level I Study:

1. Information was obtained from the BOC for all diversions that this state agency monitors within the Watershed (Schroeder, Boyd 2016 and 2017).

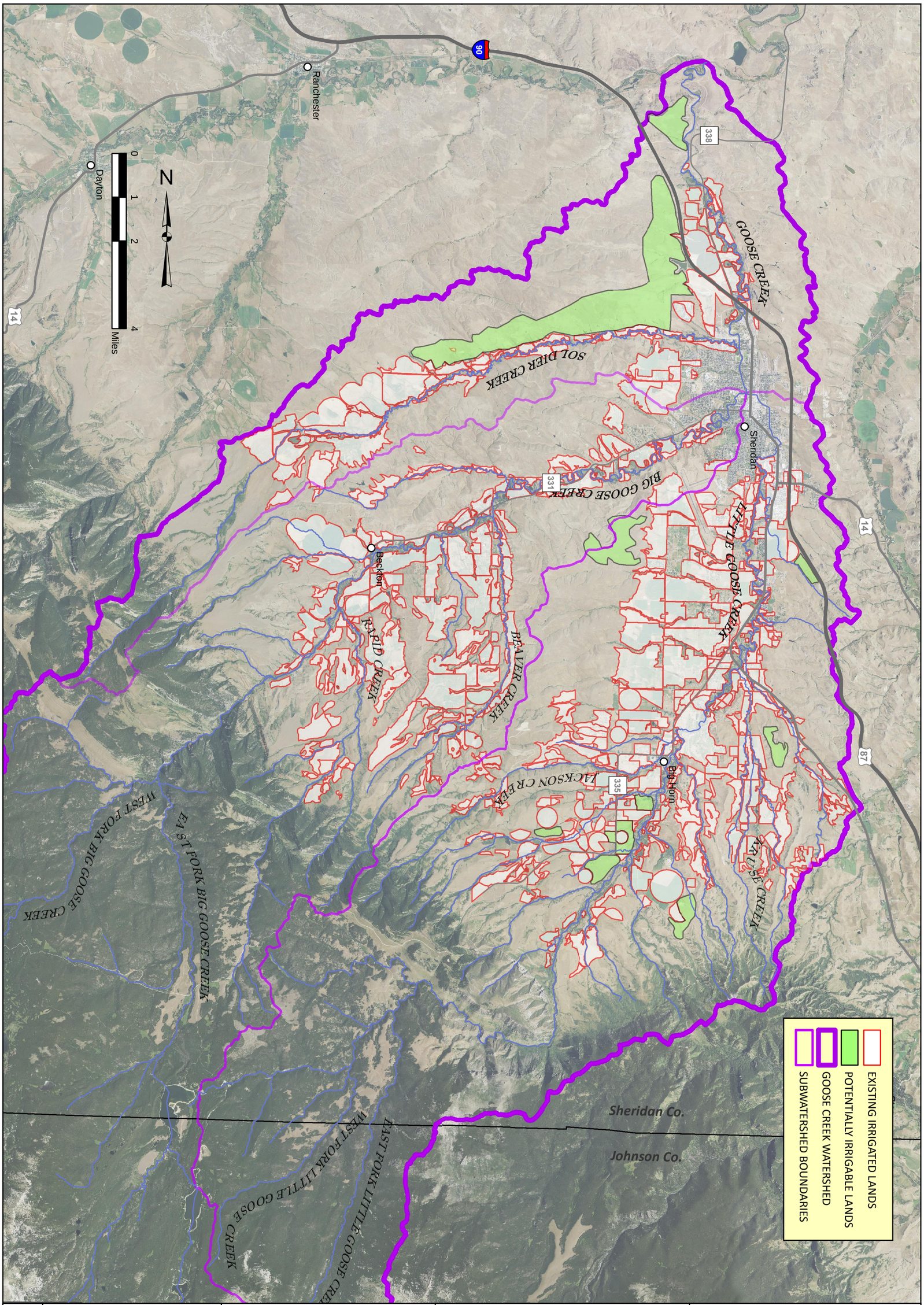

FIG. 3.8.6

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GOOSE CREEK WATERSHED LEVEL I STUDY

EXISTING AND POTENTIALLY IRRIGABLE LANDS

POINTS OF DIVERSION - IRRIGATION SYSTEMS
- Big Goose Creek Subwatershed
- Lower Goose Creek Subwatershed
- IRRIGATION SYSTEMS INVENTORIED
- BIG GOOSE CREEK SUBWATERSHED BOUNDARY
- LOWER GOOSE CREEK SUBWATERSHED BOUNDARY

N

0 0.75 1.5 3 Miles

Grinnell Ditch

Soldier Creek Ditch

PK Ditch

Alliance Lateral Ditch

Wild Rose System

Flume Ditch

Alliance Ditch

Daisy Ditch

No. 9 Ditch

Rocky Ditch

Big Goose and Beaver Ditch

Snively Ditch

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IRRIGATION SYSTEMS INVENTORIED IN BIG GOOSE CREEK AND LOWER GOOSE CREEK SUBWATERSHEDS

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FIG. 3.8.7

Piney Cruse Creek Ditch (Transbasin Diversion from Piney Creek)

Burn Cleuch Ditch

Meade-Coffeen Ditch (Transbasin Diversion from Piney Creek)

Reed Ditch

East Side Ditch

Metz Ditch

Last Chance Ditch

Paradise Pk. South Ditches

Muskrat Ditch

Gerdel Ditch

Negro John Ditch

Colo. Colony Ditch

Peralta Ditch

N

0 0.5 1 2 Miles

POINTS OF DIVERSIONS - IRRIGATION SYSTEMS

IRRIGATION SYSTEMS INVENTORIED

LITTLE GOOSE CREEK SUBWATERSHED BOUNDARY

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IRRIGATION SYSTEMS INVENTORIED IN LITTLE GOOSE CREEK SUBWATERSHED

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FIG. 3.8.8

2. Letters and accompanying survey forms were sent to representatives utilizing these various diversions. For all respondents to these letters, their systems were included in the inventory. If there was no response to the letters, follow-up inquiries were made by phone for all diversions of 5 cfs or greater to determine interest in the inventory program. While most representatives of ditches with diversions greater than 5 cfs willingly participated in the inventory program, some diversions (including the largest one in the Little Goose Creek Subwatershed – the Colorado Colony Ditch Company) declined the opportunity to participate.

Inventories of irrigation facilities for those who agreed to participate were conducted according to the following general procedures:

- Ditch representatives and some associated irrigators were interviewed. The ditch representatives provided valuable insight into the ditch condition, issues, and management.
- Field inventories were performed of the system's hydraulic structures and their current conditions, including:
    - diversion facilities,
    - measurement devices,
    - wasteways,
    - representative portions of conveyance systems (e.g., lined and unlined ditches, pipes, etc.),
    - siphons, and
    - representative turnouts.
- The field inventories included specific observations of areas of seepage loss, erosion and degradation, and vegetation encroachment.
- The field inventories were documented with various photographs and, where applicable, measurements.
- Locations of appropriate facilities were determined using equipment that enabled incorporation of those locations into the GIS network developed as part of this Level I Study.

This information was then incorporated into the Level I Study's GIS database.

3.8.2.3 Irrigation Systems Inventory

Using the methodology described above, irrigation systems were inventoried by evaluating and mapping each system. They are listed in Table 3.8.5, along with their allocated flow rates and locations of their respective points of diversion. The irrigation systems and their respective PODs are also depicted in Figures 3.8.7 and 3.8.8.

Table 3.8.5 – Irrigation Systems Inventoried in Level I Study

IRRIGATION SYSTEM	LAT/LONG FOR POINT OF DIVERSION	DIRECT FLOW RIGHTS (CFS) AND PRIORITY DATES
BIG GOOSE CREEK SUBWATERSHED		
Snively Ditch	44.6620477676661, -107.162901596045	6.59 (5/1897) 4.57 (5/1897) 1.13 (11/1903)
Big Goose and Beaver Ditch (1) (2)	44.6699092527307 -107.156004372753	88.7 (8/1885)
PK Ditch	44.696414,-107.190879	26.5 (8/1887) 4.38 (6/1891)
Alliance Ditch	44.702408,-107.181374	9.16 (6/1884) 1.26 (6/1884) 1.42 (10/1886)

IRRIGATION SYSTEM	LAT/LONG FOR POINT OF DIVERSION	DIRECT FLOW RIGHTS (CFS) AND PRIORITY DATES
		24.01 (6/1891) 0.57 (6/1891)
Alliance Lateral Ditch[3]	44.772352,-107.141504 44.767775,-107.157363	Same as Alliance Ditch
Rocky Ditch	44.713883,-107.154709	1.45 ((11/1884)
No. 9 Ditch	44.721932,-107.147701	5.01 (Fall 1882)
Daisy Ditch	44.7607480,-107.073782	5.03 (10/1882) 1.28 (10/1882)
Wild Rose System[3]	44.79698196,-107.043748	0.2 (10/1987)
Flume Ditch	44.777571,-107.003466	6.79 (10/1882)
LITTLE GOOSE CREEK SUBWATERSHED		
Peralta Ditch	44.596240,-107.0397781	1.07 (4/1883) 0.71 (11/1887) 13.86 (11/1921)
Last Chance Ditch	44.600032,-107.038573	5.34 (12/1881) 5.71 (3/1883) 9.70 (3/1888) 1.28 (1/1908) 4.04 (1/1943)
Colorado Colony Ditch[4]	44.628201,-107.029783	5.35 (11/1881) 83.86 (7/1883) 1.42 (11/1887) 0.5 (1/1896) 0.50 (7/1898) 11.64 (3/1915) 7.29 (11/1921) 2.43 (12/1942)
Muskrat Ditch	44.6528486402586 -107.001954156924	0.09 (5/1881) 1.43 (Spring 1882) 0.20 (1/1943)
East Side Ditch	44.663511,-106.995680	12.13 (4/1880) 0.50 (6/1884)
Negro John Ditch	44.6753957,-107.0055506	0.64 (4/1884)
Gerdel Ditch	44.691544,-106.983758578082	10.25 (4/1880) 0.90 (4/1881) 0.46 (6/1920)
Metz Ditch[5]	44.7265325420259 -107.010956110625	Same as Colorado Colony Ditch
Burn Cleuch Ditch	44.727811,-106.944347	12.35 (10/1881) 0.86 (6/1883)
Paradise Park South Ditches[5]	44.747863,-107.002391 44.745712,-107.001722	Same as Colorado Colony Ditch
Reed Ditch	44.7774756,-106.948003806904	4.15 (5/1881) 0.21 (11/1938)
Meade Coffeen Ditch[6]	Piney Creek Drainage	N/A
Piney Cruse Creek Ditch[6]	Piney Creek Drainage	N/A
LOWER GOOSE CK. SUBWATERSHED		
Grinnell Ditch	44.823832,-106.966251718293	7.50 (9/1890)
Soldier Creek Ditch	44.823059,-107.008891	55.1 (3/1962)

(1) also conveys water into Little Goose Creek Subwatershed

(2) first diversion is out of East Fork of Big Goose Creek in BNF into Rapid Creek, with second diversion out of Rapid Creek then used by ditch's irrigators

(3) point of diversion From Big Goose Creek same as Alliance Ditch, POD shown in table for Alliance Lateral Ditch is from Alliance Ditch

(4) ditch representatives elected to not participate in Level I Study evaluations, but nonetheless listed due to its importance in the Watershed

(5) point of diversion out of Colorado Colony Ditch

(6) water source is Piney Creek drainage, tributary to Powder River, through Tunnel Hill

A general description of each system listed in Table 3.8.5 follows in the next three subsections. For each system, information on water rights utilized to divert irrigation water is discussed. This information is based upon data provided by the BOC.

3.8.2.4 Big Goose Creek Irrigation Systems

Snively Ditch

The Snively Ditch diverts irrigation water near the mouth of Rapid Creek. As opposed to the majority of users who also divert water from this stream, it has a direct flow right utilizing water originating in the Rapid Creek drainage area. Most users within this drainage area are part of the Big Goose and Beaver Ditch Company, which diverts out of the East Fork of Big Goose Creek just below Park Reservoir and conveys it into the Rapid Creek drainage (Pickrel 2016 and 2017).

During normal operations, the Snively Ditch actually takes water both to the north and south of Rapid Creek, irrigating pastures on each side of the stream. The ditch to the north also conveys water for the Diamond Ditch, the Rapid Creek Canon #2 Ditch, and the Hammondtree Ditch. Some of the return flow from these ditches eventually makes its way into Big Goose Creek drainage upstream of the confluence of Rapid Creek with Big Goose.

The Snively Ditch is not currently operational, due to repairs that are needed at the point of diversion. Of particular concern is a large (+/-48") CMP flume which conveys Snively Ditch water from the north side of Rapid Creek to the south side. This flume now leaks and cannot perform this conveyance (Pickrel 2016 and 2017).

Big Goose and Beaver Ditch

The Big Goose and Beaver Ditch is the largest ditch on both Rapid Creek and within the Big Goose Creek Subwatershed, with a direct flow water right of approximately 89 cfs and maximum recorded flow in 2017 of 65.5 cfs at its Rapid Creek diversion point. The Big Goose and Beaver Ditch's main source of water is the East Fork of Big Goose Creek. As indicated in the discussion on the Snively Ditch, the Big Goose and Beaver Ditch diverts water immediately below Park Reservoir (located within the BNF) and conveys it via an open ditch into the Rapid Creek drainage. Approximately 2/3 of a mile downstream of the mouth of Rapid Creek is located the diversion structure for the Big Goose and Beaver Ditch, followed by a 6'-wide Parshall flume.

With the Big Goose and Beaver Ditch possessing an 1885 direct flow water right, it is one of the more senior rights on the East Fork of Big Goose Creek. Many of its users also have shares in Park Reservoir Company, which are used to supplement water flows into the Rapid Creek drainage once runoff is completed (Ankney 2016 and 2017).

The Big Goose and Beaver Ditch provides water to lands located along tributaries of Big Goose Creek, including Rapid Creek, Dry Gulch, Baker Creek and Beaver Creek. It also extends southeast and eventually crosses into the Little Goose Creek drainage, where it provides irrigation water to lands located along Jackson Creek, a tributary of Little Goose Creek.

According to the ditch rider for the Big Goose and Beaver Ditch, the principal areas of concern for the ditch relate to erosion control, seepage and sloughing along the upstream side of the ditch.

PK Ditch

The PK Ditch is one of the larger ditches within the Big Goose Creek Subwatershed, with direct flow water rights totaling approximately 30 cfs and a maximum recorded flow in 2017 of approximately 25 cfs. While the 1887 and 1891 priority dates for the two direct flow rights associated with the PK Ditch are somewhat senior, it is nonetheless necessary to rely upon stored water once runoff ends during the irrigation season. The PK Ditch's sole source of stored water is Park Reservoir.

The main diversion for the PK Ditch is located at a stream bend in the Big Goose Creek canyon just above its mouth, and approximately 650 feet upstream of the City's intake. The diversion dam is comprised of large boulders placed into position that will, in conjunction with plastic tarps, allow water during low stream flows to flow into the ditch rather than solely down the main channel. A 4'-wide Parshall flume located approximately ¼ mile downstream of the main diversion dam is used to measure flow in this ditch.

The PK Ditch's estimated capacity is approximately 25 cfs. Above that flow rate, there are problems with overtopping of the ditch banks. While the ditch originates in the Big Goose Creek drainage, all of its users (with the exception of the Alliance Lateral Ditch Company) have irrigated lands within the Soldier Creek drainage, which is within the Lower Goose Creek Subwatershed. As a result, the PK Ditch conveys water for over 15 "ditch miles" before it delivers its first water.

According to the ditch rider for the PK Ditch, the principal problems now existing with the ditch are the following:

1. There are no structures at stream crossings that allow for the streams to bypass the ditch. As a result, during rainfall events the ditch receives considerable amounts of runoff, which can initiate bank overtopping during high precipitation events. Overtopping water then flows down into the Alliance Ditch immediately below the PK, which creates overtopping problems for that ditch as well.
2. There are seepage problems from the ditch in areas where permeable soils are crossed.
3. Sloughing of the upstream side of the ditch occurs in areas where steep cuts were constructed to enable gravity flow. Some areas where sloughing previously occurred had culverts installed. Due to settlement or continued sloughing, these culverts have not always proven to be successful remedies (Elchinger 2016).

Alliance Ditch

The Alliance Ditch is approximately the same size as the PK Ditch, thus it is also one of the larger ditches within the Big Goose Creek Subwatershed with direct flow water rights totaling approximately 36 cfs and a maximum recorded flow in 2017 of approximately 25 cfs. With priority dates for these direct flow rights being between the somewhat senior dates of 1884 and 1889, the Alliance Ditch – like the PK Ditch – must rely upon stored water once runoff ends during the irrigation season. However, unlike the PK Ditch, the Alliance Ditch conveys stored water from Dome Lake and Sawmill Reservoirs in addition to Park Reservoir stored water. Most of the water conveyed via the Alliance Ditch is used in the Big Goose drainage, although some water flows into the Soldier Creek drainage for use in that subwatershed. The Soldier Creek drainage receives Alliance Ditch water at the ditch's ending point in the Big

Goose Creek drainage (which is where the Alliance Lateral Ditch begins) and at the end of the Alliance Lateral Ditch on the west side of the City.

The main diversion for the Alliance Ditch is located approximately ½ mile downstream of the mouth of Big Goose Creek canyon. The diversion dam is located along the north edge of the stream, and – due to rock and a submerged concrete wall in the channel at this location – stream flow is diverted into the ditch. During low flows, plastic tarps are also necessary to divert sufficient flow. Even though the concrete wall exists, there is no problem with fish passage through the diversion. A 5'-wide Parshall flume located approximately 650 feet downstream of the main diversion dam is used to measure flow in this ditch.

The ditch also has two siphons located near its top end that are built below Cave Creek and an unnamed tributary of Big Goose Creek. At the Park Creek crossing further downstream, Park Creek is piped beneath the ditch.

According to one of the owners of the Alliance Ditch, the principal problems now existing with the ditch are as follows:

1. Sloughing of the upstream side of the ditch occurs in some areas where steep cuts were constructed to enable gravity flow. In these areas, culverts should be installed to convey ditch water.
2. Seepage and overflow from the PK Ditch located above the Alliance Ditch creates problems for the Alliance. As discussed in the PK Ditch section, seepage exists in sections along the PK Ditch. This water eventually flows into the Alliance Ditch. Similarly, during rainfall events in which the PK Ditch overflows, this water also flows into the Alliance (Forbes 2016).

Alliance Lateral Ditch

The Alliance Lateral Ditch (the Alliance Lateral) obtains its irrigation water from both the PK Ditch and Alliance Ditch near the point that the latter two ditches deliver their remaining water into the Soldier Creek drainage. The Alliance Lateral then proceeds along the north side of Big Goose Creek until it approaches the westerly limits of the City. The ditch flows for a distance of approximately 10.6 miles before it reaches its first turnout, which is for the Wild Rose I&S District (0.2 cfs) and the Big Goose Ditch (1 cfs). The next turnout (which is located approximately 1.6 miles down ditch) is for the purposes of filling a small reservoir in the Soldier Creek drainage (belonging to the Sheridan Heights Ranch), and that turnout conveys roughly 0.3 cfs. The first significant turnout downstream of the turnout for the small Sheridan Heights reservoir located in the Soldier Creek drainage is another 0.8 miles downstream, for an amount of approximately 2-5 cfs. Therefore, the Alliance Lateral conveys irrigation water for a distance of approximately 13 miles before it makes its first major delivery.

Per the Alliance Lateral Ditch manager, the Alliance Lateral Ditch currently has a carrying capacity of approximately 13 cfs (Bateman 2017). If flows increase much above this rate, it begins to overtop in some locations. Despite this limited flow capacity, ditch users have historically worked together to make sure that everyone receives enough water for their irrigation needs.

Water conveyed via the Alliance Lateral has varied uses. Usage ranges from typical agricultural usage for the Sheridan Heights Ranch, to the Hidden Bridge Golf Club, to rural residential lot owners who use the water to irrigate lawns and gardens.

Throughout most its length, the Alliance Lateral incurs both considerable seepage and sloughing from above the ditch. The seepage appears to be the result of the unlined ditch being built through sections of permeable soils. The sloughing from above the ditch generally occurs in areas where the original ditch construction cut into relatively steep hillsides which typically collect windblown snow. As the snow melts in the spring, the runoff seeps into the ground and lubricates the relatively steep soil sections, creating the sloughed reaches. Maintaining an open Alliance Lateral from its diversion point out of the Alliance and PK Ditches to its points of use requires continual effort addressing the sloughing and seepage conditions. Related to this problem is the ongoing corrosion of CMP culverts that were previously installed to address the then-existing seepage and sloughing. CMP corrosion has resulted in many of the culverts capsizing and plugging with soil. These culverts also occasionally plug on the upstream end due to fallen trees and limbs which are conveyed by the ditch water. Fallen trees and limbs become less of a problem as the ditch proceeds further downstream due to fewer trees growing alongside the ditch.

A related, significant problem for the Alliance Lateral at this time is a large deep cut along the Alliance Lateral, referred to by some as the "Grand Canyon". Located approximately 1,000 feet upstream of the first turnout (serving the Wild Rose irrigation system and the Big Goose Ditch), this canyon is the product of original construction and erosion resulting from the conveyance of irrigation water. At its deepest point, the canyon is approximately 100 feet lower than the original land elevation. Due to the steep and unstable sideslopes that exist, the canyon walls are continually falling off and into the ditch channel. The fallen material creates a dam that backs up water until it overflows the dam crest, and the resulting erosion creates a condition whereby considerable silt is conveyed downstream. (See Figure 3.8.9.) Silt also enters the ditch when hillside runoff erodes the ditch's length sideslopes. (See Figure 3.8.10.)

Figure 3.8.9 – Alliance Lateral "Grand Canyon" showing fallen surrounding material and creating dam and resulting erosion

Figure 3.8.10 – Silt buildup along Alliance Lateral near Wild Rose and Big Goose Ditch caused by "Grand Canyon" erosion

Silt accumulation is a major problem for the Wild Rose system, and it is a somewhat smaller problem for other downstream points along the ditch. (See section on Wild Rose.) According to the manager of the Alliance Lateral Ditch, this downstream section is the only area along the ditch where siltation is a concern. At one time, a settling basin (known as "the frog pond") was constructed immediately upstream of the Wild Rose diversion, in an attempt to decrease the ditch water's velocity and allow the silt being conveyed to settle in the pond. A dragline was retained at the frog pond to occasionally dredge the settled material. However, this practice was eventually abandoned, the frog pond filled with silt, and now the frog pond no longer functions according to its original purpose (Bateman 2016).

In 2004, the NRCS developed plans to place a 20" HDPE pipe in the Grand Canyon, thereby alleviating erosion problems associated with conveyance of irrigation water through the Grand Canyon. For whatever reason, the improvements shown in these plans were never constructed.

Rocky Ditch

The Rocky Ditch is a relatively small ditch within the Big Goose Creek Subwatershed, with direct flow water rights totaling 1.43 cfs. It has an 1884 direct flow right, and only one person uses the water from this ditch. This one landowner does not utilize any stored water during times when the direct flow right is not in priority. As a result, this water right is occasionally shut off during times of water shortages (Burke 2016).

The diversion dam is merely a collection of large rocks within the stream. These rocks are moved into position during periods of low flow and, coupled with plastic tarps, the creek water is directed to the ditch which conveys the irrigation water into his private system.

According to the one user of Rocky Ditch water, the principal problems now existing with the ditch are the following:

1. There is a length of ditch of approximately 100 yards just north of his house that leaks badly.

2. The existing headgate is old and should be replaced.

No. 9 Ditch

The No. 9 Ditch has a direct flow right on Big Goose Creek for just over 5 cfs, with an 1882 priority date. As a result, it is one of the more senior rights on the creek. Four different landowners make use of No. 9 Ditch water who, due to the ditch's direct flow seniority, have no storage rights in upstream reservoirs because they almost never get regulated.

The main diversion for the No. 9 Ditch is approximately 3200 feet upstream of the confluence of Rapid Creek and Big Goose Creek. Once diverted from Big Goose Creek, No. 9 Ditch water flows downstream until it enters Rapid Creek. Water then flows in Rapid Creek for approximately 500 feet before it is diverted for a second time, this time into the actual ditch that eventually provides service to the four landowners.

The diversion dam on Big Goose Creek is essentially a group of boulders that are moved around as stream flows vary in order to move the stream towards and through the ditch's headgate. The diversion dam on Rapid Creek is an old Civilian Conservation Corps concrete structure that is in poor condition. It is often necessary to place plastic tarps in the stream at both locations in order to check the water up enough to get it into the ditch.

Both diversion dams (one on Big Goose and one on Rapid) have Parshall flumes located immediately below them to measure diverted flows. Both headgates work sufficiently, with the one off to the side of Rapid Creek being rebuilt approximately ten years ago.

According to the president of the No. 9 Ditch, the sole recommended improvement for the No. 9 system is the replacement of the existing diversion dam on Rapid Creek (Spell 2016).

Daisy Ditch

The Daisy Ditch has an 1882 direct flow right on Big Goose Creek for just over 5 cfs and an 1885 right for1.3 cfs. The first right is one of the more senior rights on the creek. Additionally by having the diversion dam only 350 feet below the confluence of Big Goose Creek and Beaver Creek, it can take advantage of the additional flows in Big Goose Creek in this section due to the return flow coming from Beaver Creek, (Much of the water in Beaver Creek during the irrigation season is return flow from the Big Goose and Beaver Ditch.) As a result, no storage water is conveyed in the Daisy Ditch, and this diversion rarely if ever gets regulated. Flow out of the diversion is measured by a 4'-wide Parshall flume.

According to an officer of the Daisy Ditch Company, the principal problems now existing with the ditch are the following:

1. At the tail end of the ditch, the ditch company has difficulty being able to return this water back to Big Goose Creek. An affected landowner to date has not allowed construction of the necessary drainage facilities for this return flow.
2. A new headgate should be installed, because the existing one leaks (Barkan 2016).

Wild Rose System

The Wild Rose System consists of the following:

1. A diversion structure that withdraws water from the Alliance Lateral Ditch, approximately 1500 feet downstream of the end of the "Grand Canyon" described in the previous section on the Alliance Lateral Ditch;

2. A 3" pipeline that extends from the diversion structure down Jensen Draw for a distance of approximately 3,000 feet, discharging into Jensen Draw and then flowing into the Wild Rose Reservoir;
3. The Wild Rose Dam and Reservoir, which has a capacity of approximately 9.7 A-F;
4. A pipeline consisting of both 6" and 8" pipe that conveys irrigation water from the Wild Rose Reservoir to the northwest corner of the Don Ena Estates Subdivision of Sheridan County;
5. A 6" meter and associated vault at the point of entry into the Don Ena Estates Subdivision; and
6. A distribution system for the Don Ena Estates residents.

These facilities are all owned by the Wild Rose I&S District.

The Wild Rose System has a 1987 direct flow right in the amount of 0.2 cfs. It derives this flow from its connection to the Alliance Lateral Ditch. Due to this very junior right, the I&S District supplements its irrigation water with 72 A-F of Park Reservoir water, which is made available once spring runoff is completed within the Big Goose Creek drainage. The Wild Rose Dam and Reservoir also has 78 acres of drainage area from which it can obtain precipitation runoff to provide for additional storage when the reservoir is not full.

A comparison of historical usage by the Don Ena Estates homeowners and the amount made available by the 0.2 cfs reveals that there is insufficient supply during some years for the irrigation of the lawns and gardens within this county subdivision. However, as the Don Ena Estates homeowners have reportedly never experienced irrigation water shortages from this system, this means that one or both of the following may be occurring:

1. Rainstorm runoff during the irrigation season is captured by and added to the Wild Rose Reservoir; and/or
2. Amounts larger than the 0.2 cfs are being diverted from the Alliance Lateral Ditch system, such as when there is excess water in the system. Due to the fact that the I&S District owns Park Reservoir storage water, flow rates greater than 0.2 cfs could conceivably be legally diverted – if there is adequate capacity within the Alliance Lateral Ditch. Diversion of more than 0.2 cfs is more a function of the system capacity and the conveyance capacity of the Alliance Lateral Ditch. (It has been reported that the Sheridan Heights Ranch allows the I&S District to divert up to 0.5 cfs during periods when it is not utilizing its total allotted flow. Conveyance takes place by bypassing the existing diversion structure located on the Alliance Lateral Ditch and instead utilizing the adjacent Big Goose Ditch to flow the 0.5 cfs amount to a point where the water can be turned out of the Big Goose Ditch and into a 6" pipeline, which delivers water to the Wild Rose Reservoir.)

The principal problems expressed by representatives of the Wild Rose system are the following:

1. High sediment loads resulting from upstream erosion in the Grand Canyon create a large maintenance problem at the diversion structure. Deposited silt and debris must be manually removed from this structure on a daily basis throughout most of the irrigation season.
2. The volume of Park Reservoir storage water may be insufficient to meet the needs of the Don Ena Estates Subdivision during dry years when the I&S District's direct flow right cannot be utilized.
3. Existing agreements with the owner of the Sheridan Heights Ranch regarding rights-of-way and water exchange agreements are due to expire in 2018. The District is concerned that if, for whatever reason, these agreements are not successfully extended or renegotiated, it could be left without a reliable irrigation water supply.

4. The existing 6" meter that measures irrigation water as it enters the subdivision is old and in need of replacement.
5. The slide gate and shaft that are operated to allow water stored in Wild Rose Reservoir to flow to the subdivision are old and in need of replacement.
6. Rip rap should be placed on the upstream face of the Wild Rose Dam (Wild Rose application 2015).

Flume Ditch

The Flume Ditch has the most senior right on Big Goose Creek, with a priority date of October 1882 at a flow of 6.8 cfs. There is one major user of Flume Ditch water, and two minor users. Being located immediately upstream of the Sheridan city limits, it enjoys the benefit of upstream return flows, hence there is almost always enough water in the stream to satisfy this ditch's direct flow right. Correspondingly, Flume Ditch users do not typically have to place a call on the stream to obtain their water, and they also do not own any storage water.

The diversion for the ditch consists first of a rock cross-vane structure with large precast concrete retaining wall blocks buried below Big Goose Creek. (The concrete blocks are used to prevent rocks in the cross-vane structure from being undercut during high flows.) This structure diverts the Flume Ditch's share of the Big Goose water into an oxbow of the channel. This structure was installed approximately five years ago. During periods of low flow in Big Goose Creek, it is sometimes necessary to place plastic taps between the rocks in the cross-vane structure to increase the water level in Big Goose Creek so that water will flow into the oxbow.

A few hundred yards downstream of the main diversion structure on Big Goose Creek, along the oxbow, is another diversion structure, which actually allows for flow into the Flume Ditch. This diversion consists primarily of large rocks placed in the oxbow to check the water up. A 1'-wide Parshall flume to measure diverted water is located within 100' of the oxbow diversion.

Although the diversion is located along the north side of Big Goose Creek, many of the irrigated lands are located along the south side of Big Goose Creek. To accomplish this, there is a siphon that delivers water beneath Big Goose Creek to the south side. Other improvements are being made to the ditch, including new turnout structures and culvert road crossings.

According to the principal user of Flume Ditch water, the following problems now existing with the ditch should be addressed:

1. A wasteway should be installed on the ditch to return unneeded irrigation water back to Big Goose Creek.
2. Due to seepage concerns along the ditch, several of them should be lined – most likely using bentonite.
3. Culverts conveying irrigation water and for purposes of drainage should be installed at fence lines to minimize livestock impacts at these locations (Jost 2016).

3.8.2.5 Little Goose Creek Irrigation Systems

Peralta Ditch

The Peralta Ditch is the first ditch diverting from Little Goose Creek below the BNF. It has direct flow rights totaling approximately 15.6 cfs; however, only 1.1 cfs of those rights are

relatively senior in priority (April 1883). As a result, the Peralta Ditch water users also possess storage rights in several mountain reservoirs to augment their flows, specifically Willitts, Martin, Last Chance, Cross Creek, Big Horn and Park Reservoirs.

In addition to its historic users, the Peralta Ditch also conveys water for former users of the Red Hill Ditch. The Red Hill Ditch diversion is located downstream of the Peralta Ditch diversion, and it previously diverted water to the same (westerly) side of Little Goose Creek. Due to hillside sloughing of the Red Hill Ditch, much of the Red Hill water is now conveyed by the Peralta Ditch, with the remainder of the water formerly conveyed by Red Hill now being conveyed by the Colorado Colony Ditch.

The Peralta diversion is located at a bend in the Little Goose Creek channel. Boulders in the stream increase the water surface elevation sufficiently to divert the necessary flows into the ditch, without the need for plastic tarps during low flows. Water in the Peralta Ditch is measured with a 6'-wide Parshall flume approximately 400 feet downstream of the diversion.

According to one of the main users of the Peralta Ditch, the principal problems now existing with the ditch are the following:

1. There is a leak around the west side and beneath the headgates at the main diversion. Because of this leak, it is not currently possible to completely shut off water diverted into the ditch. The ditch company does have some wasteways further downstream where it can return this leaked flow back to Little Goose Creek, thus keeping it out of the ditch throughout its entire length.
2. The bottom of the 6'-wide Parshall flume is close to rusting out and should be replaced.
3. There are several locations along the ditch where sideslopes are steep due to the original construction cutting into them. In many of these locations where sloughing eventually occurred, the ditch company installed culverts. At this time, there is no immediate need for culvert installation due to sideslope sloughing.
4. The far north end of the ditch was breached several years back. As a result, stormwater runoff collected by the ditch flows into this breach and cascades down the hillside into the south fork of Denio Draw. It then flows into an unnamed small reservoir on this tributary, which appears to be receiving considerable silt that is deposited in the reservoir bottom.
5. Approximately ¼ mile upstream of the breach there is also a collapsed pipe on a turnout, with a large headcut that occurred just below this collapsed pipe. This turnout (which serves the Box Cross Ranch irrigated lands) should be replaced, the head cut repaired, and piping installed to prevent future headcuts (Garber 2016).

Last Chance Ditch

The Last Chance Ditch is the second ditch to divert from Little Goose Creek below the BNF. While the Peralta Ditch diverts water along the west side of Little Goose Creek, the Last Chance Ditch diverts water along the east side of the creek. It has direct flow rights totaling approximately 26.1 cfs, of which 5.34 cfs possess a December, 1881 right. The remaining rights have priority dates ranging from 1883 to 1943, thus the ditch's direct flow rights are augmented with stored water from Martin, Cross Creek, Big Horn and Park Reservoirs.

The Last Chance diversion is located on a side channel of the main channel of Little Goose Creek. Precast concrete retaining wall blocks have been placed in the side channel to increase the water surface elevation and allow for diversion into the ditch. A rubber-like hypalon liner has been placed on the upstream side of the concrete blocks to prevent

seepage through the blocks. In the center of the stream (between the concrete blocks) is a 5'-wide rectangular weir, where check boards can be placed to increase the water surface elevation. Per a representative of the Last Chance Ditch, this diversion works well and it is unnecessary to utilize plastic tarps to further check up the water during low flow.

Water in the Last Chance Ditch is measured with a 5'-wide Parshall flume approximately ¼ mile downstream of the diversion. At that point, a 12" culvert (with headgate) exists to act as a wasteway for the ditch, returning any unwanted water back to the creek.

The main ditch includes an impressive structure that crosses over Trabing Creek. Here is located a 3'-diameter CMP that is approximately 470' long. This pipe, which is all above ground, follows the grade of the west slope of Trabing Creek until it reaches the creek, at which point it is relatively flat as it passes over the top of the creek.

According to a representative of the Last Chance Ditch, the principal problems now existing with the ditch are the following:

1. A steep red rock wall (Chugwater formation) along the east side of the ditch channel between the diversion dam and headgate occasionally spalls off (particularly during the spring) and drops rock into the channel. An incident approximately two years ago involving this dropped rock almost completely blocked the ditch.
2. An approximately 5'-wide "half pipe" CMP extends over the channel of the East Fork of Davis Creek, which is lined with the hypalon material. This crossing structure should be replaced.
3. There are two locations near the easterly end of the ditch where sloughing has occurred. These locations are in areas where steep sideslopes exist due to the initial ditch construction. Both are approximately 100' long. Culverts should be installed in these reaches of the ditch to allow for continued service (Baker 2016).

Colorado Colony Ditch

The Colorado Colony Ditch is by far the largest ditch in the Watershed, with a peak flow delivered through the ditch in 2016 of just over 82 cfs. The ditch has several direct flow rights with priority dates varying from 1881 to 1942. Its largest direct flow right totals 83.9 cfs with a priority date of July 1883. Because it does not have the most senior rights, and due to its considerable conveyance capability, this ditch's water supply is supplemented with storage water from Martin, Granger, Cross Creek, Big Horn and Park Reservoirs, with Big Horn Reservoir being historically the largest supplier of storage water for Colorado Colony Ditch users.

Colorado Colony Ditch representatives were contacted about meeting with EnTech personnel to inventory aspects of their ditch system. This invitation was declined. As a result, little information is currently available as to what, if any, improvements should be performed to improve this large ditch (Veal 2016).

Muskrat Ditch

The Muskrat Ditch is a relatively small ditch in the Little Goose Creek drainage, with direct flow rights totaling 1.63 cfs. It also conveys 0.09 cfs of Garden Ditch direct flow water. The Garden Ditch has a priority date of May 1881, thus it is a very senior direct flow right on the creek. Of Muskrat's 1.63 cfs, 1.43 cfs is a Spring 1882 right, and 0.20 cfs is a 1943 right. Small numbers of shares of Park Reservoir are owned by some users of the Muskrat Ditch, which allow for some storage water to be conveyed in the ditch.

The existing diversion is located on a bend in the channel of Little Goose Creek, with large boulders being the means of increasing the creek's water surface elevation to enable water to flow into the ditch. A 1'-wide Parshall flume located approximately 500 feet downstream of the main diversion dam is used to measure flow in this ditch.

According to representatives of the Muskrat Ditch, the principal problems now existing with the ditch are the following:

1. Creek water flows beneath the concrete wall which supports the main headgate on Little Goose Creek. As it exists, they cannot completely shut off their diverted water. They are concerned that this may undercut eventually, and they would then lose the entire wall. Plans are currently in the works with the NRCS to replace this structure.
2. Some areas below the ditch do not receive water in an efficient manner. A new turnout and slide gate are proposed in this location to allow for better spreading of the irrigation water.
3. Irrigation water flows beneath the turnout and associated structures on one of the turnouts along the ditch (Valdez and Hubbard 2017).

East Side Ditch

The East Side Ditch has the second most senior priority date for its earliest direct flow rights on Little Goose Creek, which is 12.13 cfs (April 1880). Its only additional direct flow right is for 0.50 cfs (June 1884). As such, only one user of the East Side Ditch conveys storage water, that coming from Park Reservoir.

The main diversion for the East Side Ditch is located at a stream bend along Little Goose Creek. Similar to many diversion structures in the Watershed, the diversion dam is comprised of large boulders placed into position that increase the water surface elevation sufficiently to direct creek water into the ditch. A 3'-wide cutthroat flume located approximately 400 feet downstream of the main diversion dam is used to measure flow in this ditch.

According to the manager of and ditch rider for the East Side Ditch (who is also an officer of the ditch company), the principal problems now existing with the ditch are the following:

1. Due to flooding which occurred during the spring of 2015, the easterly ditch bank at the main diversion needs additional large rock to prevent erosion along this bank.
2. The boulders in Little Goose Creek do not always act sufficiently to direct creek water into the ditch. It would be desirable to replace these rocks with a more modern structure, such as a cross-vane type of diversion structure.
3. There are 3-5 large cottonwood trees along the westerly ditch bank approximately 4,800 feet downstream of the main diversion. Irrigation water is undercutting these trees. If nothing is done, there is concern that the trees may fall over, thereby jeopardizing the stability of the ditch bank.
4. Precipitation runoff is a major problem entering the ditch and potentially overtopping it during storm events. In order to return some of this stormwater to Little Goose Creek, one new wasteway should be constructed, and a second, existing wasteway should be repaired.
5. The crossing of Sackett Creek does not function effectively and should be repaired. Improvements should consider the need to utilize Sackett Creek water during dry periods by having this water flow into the ditch.
6. Two 42" siphons beneath the Powder Horn golf course (both roughly 1300 feet long) are constructed of CMP. There is concern that, over time, these CMP will rust out. Due to their considerable depth, there is concern that these siphons may be difficult

to replace. (The Powder Horn development has nonetheless committed to pay for all operation, maintenance and replacement costs for the ditch within the Powder Horn property.)

7. There is a section of the ditch located in the southeast corner of the Knode Ranch Subdivision where a steep, 25' deep sideslope was constructed with the original ditch. This sideslope has occasionally sloughed off into the ditch, and there is concern that this sloughing will continue. Culvert installation at this location has been considered.
8. The existing concrete-lined ditch section paralleling Kruse Creek is old (+/- 60 years) and in poor condition due to heaving and vegetation growing up through the existing joints.
9. The existing concrete pipe siphon beneath Kruse Creek is assumed to be of the same age as the concrete-lined ditch section, and therefore should be replaced at the same time as the latter.
10. The CMP located in the wasteway at the "official end" of the ditch has corroded to the point that it is now unusable and allows for considerable erosion to occur. Improvements should be made along this wasteway to replace the CMP and prevent further erosion.
11. There is no current means to measure the amount of water being returned to Little Goose Creek. A measurement flume should be installed at some point at the end of the ditch to measure this water (Pattison, 2016 and 2017).

Negro John Ditch

The Negro John Ditch is a small ditch that diverts water from Jackson Creek, a tributary of Little Goose Creek that enters Little Goose just north of the community of Big Horn. The diversion dam is located approximately 4,000 feet southwest of the Big Horn School property. This ditch holds the #1 priority on Jackson Creek, with a priority date of April 1881 for a flow rate of 0.64 cfs.

The diversion dam for the Negro John Ditch is no longer operable, due to the fact that Jackson Creek has moved from the location where the dam was originally constructed. However, the Negro John ditch continues to flow further downstream from the diversion dam, presumably due to return flow from the considerable amount of irrigation that occurs upstream of the ditch (Whyard, 2016).

Gerdel Ditch

The Gerdel Ditch has the most senior right on Little Goose Creek, with its earliest priority date being April 1880 (for 10.25 cfs). It also has an April 1881 priority date of 0.9 cfs, and a 1920 priority for 0.46 cfs. Due to its senior status, the Gerdel Ditch does not need to convey stored water for its +/-60 users, because they have historically always been in priority.

The main diversion for the Gerdel Ditch is located at a stream bend in Little Goose Creek on the Powder Horn property. The diversion dam is comprised of a driven sheet pile weir. There is an approximate elevation difference of two feet between the top of the sheet pile and the Little Goose Creek water surface elevation downstream of this weir during low flows. However, on the south end of this weir, this elevation difference is less: approximately 4-5 inches. A recently-installed 3'-wide Parshall flume located approximately 250 feet downstream of the diversion dam is used to measure flow in this ditch. As with the East Side Ditch, the Powder Horn development has committed to pay for all operation, maintenance and replacement costs for the ditch within the Powder Horn property.

According to the ditch rider for the Gerdel Ditch, the principal problems now existing with the ditch are the following:

1. The ditch experiences significant leakage in a few locations approximately ½ mile north of the intersection of State Highway 335 and US87. This leakage shows up in an irrigated field downgradient from the ditch. Those areas in the field where the leakage is occurring cannot be hayed with farm machinery. Previous efforts involving the use of bentonite to seal these leaking sections have not proven successful.
2. A recently-installed 24" culvert along the ditch may be undersized, as it acts as a ditch constriction during periods of high flow.
3. There are no special structures at stream crossings, meaning that water flows into the ditch during rainfall events (Washut 2016).

Metz Ditch

The Metz Ditch diverts irrigation water out of the Colorado Colony Ditch. The diversion consists of a turnout headgate on this large ditch, followed by a Parshall flume. Much of the land irrigated with this water has fairly junior direct flow water rights. Correspondingly, these landowners rely heavily upon storage water from Big Horn Reservoir. The ditch company is allocated 12 cfs from Colorado Colony Ditch Company, but only 6 cfs is actually diverted due to downstream ditch capacity.

After flowing through the Parshall flume, water flows to the east to the lands to be irrigated via open, concrete-lined ditches. With time, the concrete liner has cracked, and in jointed areas, vegetation has protruded. In some areas, irrigation water is actually flowing beneath the existing concrete ditch. As a result, the ditch company would like to replace this concrete-lined ditch with pipe. An additional benefit to using pipe is the fact that there is considerable elevation difference between the Colorado Colony Ditch and the first user. This large elevation difference provides the opportunity to utilize gravity-pressurized sprinklers in lieu of flood irrigation. Approximately 15 years ago, the NRCS designed a pressurized pipe system for the area. However, the project never moved forward due to a lack of enough support from affected landowners (NRCS 2002).

Burn Cleuch Ditch

The Burn Cleuch Ditch holds the #7 priority for direct flow rights on Little Goose Creek, with a 12.35 cfs, October 1881 right. It also possesses a 0.86 cfs, June 1883 right. Due to its location relatively close to the City (and thus downstream of more senior users), even though it does not have the most senior rights, it nonetheless has never been called out of priority during recent times. Therefore, only one user of the Burn Cleuch Ditch uses it to convey stored water, and that is Whitney Benefits to convey its Park Reservoir storage right.

The main diversion for the Burn Cleuch Ditch is located at a bend in Little Goose Creek approximately 700 feet downstream of the confluence of Little Goose with Coyote Creek. The diversion dam is comprised of 4-2" x 12" x 16' long checkboards in slots located on top of a concrete structure. Plastic tarps are placed on the upstream side of the checkboards to seal off and allow water to flow into the ditch. The checkboards are removed in late September after the irrigation season. Care is taken once the checkboards are installed, because, if precipitation events cause the water surface elevation behind the checkboards to rise high enough, the neighboring properties become flooded. A 6'-wide Parshall flume

located approximately 600 feet downstream of the main diversion dam is used to measure flow in this ditch.

Due to the Burn Cleuch being in or in close proximity to the City, water is conveyed via several different types of facilities, including open and unlined ditch, open and concrete-lined ditch, pipelines, and siphons (beneath I-90 and Dry Creek), The University of Wyoming owns and operates a diesel-powered motor which drives a pump that delivers water to a large center pivot above the ditch. UW also owns and operates similarly-driven center pivot pumps for its agricultural properties below the ditch. Finally, Sheridan College diverts water from the Burn-Cleuch and pumps this water that it owns onto landscaped areas within the college grounds.

According to the ditch rider for the Burn Cleuch Ditch and representatives of both UW and Sheridan College, the following facilities are proposed for construction to enhance the ability of the Burn Cleuch Ditch to deliver irrigation water (Rucki, Houck and Mealor 2016):

1. The main diversion dam should be reconfigured so that it is easier to install the checkboards in the concrete slots in the diversion dam.
2. Moss buildup in the ditch is a big problem every year. Moss growth is the result of the slow velocity in the stream.
3. The open, concrete lined ditch that is currently broken should be replaced with a new concrete-lined ditch.
4. UW would like to replace its existing diesel-powered motor that powers a center pivot pump with one that uses electricity as a power source.
5. Sheridan College would like to modernize its existing campus-wide irrigation control system. Currently the College has controllers scattered throughout the campus, some on pedestals, some mounted on walls. They would like to incorporate them all together with one master controller for the entire campus. In this way, they don't have to worry about overlapping zones when they water.
6. UW would also like to more accurately measure the irrigation water that it utilizes. One way to do this would be to install four new meter devices:
    a. One on the Burn Cleuch Ditch upstream of the UW property;
    b. One on each of the two main turnouts from the Ditch as it traverses the UW property; and
    c. One on the ditch immediately downstream of the UW property.

    Due to flat slopes in the area, it is anticipated that the flumes being installed will be cutthroat weirs.

Paradise Park South Ditches

The Paradise Park South Ditches are two separate ditches that take water out of the Colorado Colony Ditch. Both "diversions" consist of turnout headgates on this large ditch. At the present time, they flow via open ditches down to the Paradise Park Subdivision, where the water is used to irrigate small acreages. Seepage losses into the ground below these open ditches are significant. The water used consists of both direct flow and stored water from Big Horn Reservoir. The entity that contracts with the Colorado Colony Ditch Company is the South Paradise Park Subdivision Homeowners Association.

The homeowners association utilizing these two ditches would like to place the irrigation water into pipe. The pipe would achieve two purposes:

1. It would reduce seepage, thus increase the water supply available for irrigation; and

2. Due to the elevation difference between the Colorado Colony Ditch and the points of use within the subdivision, it would provide the opportunity for pressurized sprinkler systems (Landon and Arno 2016).

Reed Ditch

The Reed Ditch is the last significant diversion from Little Goose Creek prior to its confluence with Big Goose Creek. The diversion is located within the Sheridan city limits, and is used for irrigating lawns and gardens inside and immediately adjacent to city limits. Approximately 45 homes and businesses make use of this irrigation water. It has a 4.15 cfs, October 1881 direct flow right and a 0.21 cfs, 1938 direct flow right. While these may not be the most senior rights on Little Goose Creek, they have never been called out of priority. This is most likely due to the fact that its location on the creek enjoys the benefit of upstream return flows, hence there is enough water in the stream to satisfy this ditch's demands. This location has historically obviated the need for a measurement flume, because there is no diversion below this ditch that would call these rights out of priority. No stored water is conveyed for users of the Reed Ditch.

The main diversion on Little Goose Creek is located at a bend in the stream. As a result of recent improvements to Little Goose Creek in the City's South Park, a new diversion dam was constructed, which is a cross-vane structure consisting of strategically placed boulders. While the ditch company has been the beneficiary of this "free" installation, this structure allows small amounts of water to migrate between the boulders during periods of low flow and correspondingly does not always divert sufficient water into the ditch during these low-flow periods.

The ditch includes a structure that supports a flume that crosses Little Goose Creek approximately 2,100 feet downstream of the main diversion. While the structure itself appears to be in acceptable condition, there have been several generations of flumes supported by this creek crossing. Most recently, the ditch company placed a new culvert within the existing one, which prevents leakage out of the flume as it crosses the creek. There is also a siphon that allows for an underground crossing of Sheridan Avenue near its intersection with Avoca Avenue.

According to representatives of the ditch company, the principal problems now existing with the ditch are the following:

1. During construction of the South Park improvements, the existing headgate was damaged and will no longer seal. This headgate should be replaced.
2. Improvements should be made to the new diversion dam to allow sufficient water during low-flow periods to be diverted into the ditch.
3. With the recent emphasis on measuring stream diversions created by the Montana v. Wyoming lawsuit dealing with the Yellowstone River Compact, there should be a measuring device placed on the ditch immediately downstream of the main diversion.
4. During significant storm events, roof runoff from the large Knecht Lumber building flows into the ditch. (The ditch is located approximately 20 feet west of and parallel to the building.) This runoff creates flooding problems downstream as it is being conveyed by the ditch (Burgess and Culligan 2016).

Meade Coffeen Ditch

The Meade-Coffeen Ditch diverts approximately 15 cfs during the peak summer months from the Piney Creek drainage and into the Prairie Dog Creek drainage via a pipe beneath

Tunnel Hill near the community of Story. The transbasin diversion water then flows in a ditch, with some of the irrigation water making its way northwest and into the Little Goose Creek drainage.

In discussions with representatives of the Meade-Coffeen Ditch Company, there are no recommended improvements to the ditch that is located within the Watershed (Roach 2017). However, an owner of land below the Meade-Coffeen Ditch within the Watershed would like to see a sideroll irrigation system installed on his property.

Piney Cruse Creek Ditch

The Piney Cruse Creek Ditch also diverts approximately 15 cfs during the peak summer months from the Piney Creek drainage and into the Prairie Dog Creek drainage. The transbasin diversion is accomplished through a canyon that has been cut out of Tunnel Hill near the community of Story. The canyon was created approximately 100 years ago, when water flowing through a pipe originally installed through Tunnel Hill began eroding the sandy soil prevalent in Tunnel Hill. With time, head cuts caused by irrigation water eroding the sandy soil caused the pipe to be undercut and eventually fall, leaving the canyon as the sole means of transbasin conveyance through Tunnel Hill.

Similar to the Meade-Coffeen Ditch, the transbasin diversion water flows in a ditch in a northerly direction that eventually makes its way out of the Prairie Dog Creek drainage and into the McCormick Creek drainage, which is a tributary of Little Goose Creek.

Representatives of the Piney Cruse Creek Ditch Company did not provide any information on recommended improvements within that portion of its delivery system that is within the Watershed.

3.8.2.6 Lower Goose Creek Irrigation Systems

Grinnell Ditch

The Grinnell Ditch diverts out of Goose Creek approximately 1,600 feet downstream of the outfall for the City's WWTP. A diversion dam in Goose Creek is assembled each year after runoff composed of tarps draped over and around steel pipe that has been permanently driven into the creek bed at this location.

In discussions with the principal user of the Grinnell Ditch, no substantive problems exist with either the diversion dam or ditch system, including no major seepage or sloughing problems. There is, however, a temporary headgate east of State Highway 338 (Decker Highway) that should be replaced with a more permanent structure (Jellis 2016).

Soldier Creek Ditch

This ditch diverts out of Soldier Creek. Its principal purpose is to fill Windy Draw Reservoir. Due to the limited drainage area, Soldier Creek in and of itself is not a reliable water supply. In light of that, the Wrench Ranch (the only current user of Soldier Creek Ditch water) owns water in Dome Lake Reservoir. This Dome Lake water is conveyed from the Big Goose Creek Subwatershed into Soldier Creek via the PK Ditch. Due to the lack of available capacity in the PK for the main irrigation months, the Wrench Ranch can only convey its Dome Lake storage water during the month of September. This storage water then supplements the direct flow water that is available in Soldier Creek to fill the Windy Draw Reservoir (Jellis 2016).

Windy Draw Reservoir water flows beneath I-90 to irrigate lands along Goose Creek (and above the Grinnell Ditch) below the confluence of Big Goose Creek and Little Goose Creek. The principal concern of the users of this water has been the condition of the siphon that conveys this water beneath the interstate (Jellis 2016), although it is now reported that this siphon will be sliplined in the very near future, obviating the need to have this project included in the Watershed Management and Rehabilitation Plan.

There is a location along Soldier Creek Ditch that flows through lands owned by the VAMC that requires a new headgate. The previous headgate required removal due to seepage around it. This headgate is also included in the Watershed Management and Rehabilitation Plan.

3.8.2.7 Irrigation System Infrastructure Improvements

The discussions with representatives of the various ditch companies, as well as with other irrigation stakeholders, have led to the listing of recommended improvements to the Watershed's irrigation systems. These recommended improvements are discussed in more detail in Section 4 and included within Appendix A of this Level I Study.

3.9 Fisheries Mitigation

Field reconnaissance and information provided by ditch representatives associated with the municipal, industrial and irrigation systems inventory identified several diversion structures located within the Watershed that inhibit fish movement up and down perennial streams. Supplementing this data was GIS information provided by the WG&FD on known fisheries migration impediments within the Watershed. (See Section 3.4.4.) The reconnaissance and information that was provided also identified diversion structures that did not necessarily inhibit migration, but – for various reasons - were not operating correctly to the point that replacement is warranted.

The facilities identified by EnTech that inhibit fish migration within the Watershed are all concrete or steel structures that check up and divert water from Big Goose, Little Goose and Rapid Creeks into adjacent pipelines or ditches. While they are generally efficient in maximizing the diversion of water, the fact that they are more or less a vertical wall constructed directly in the stream creates a migration impediment. Per WG&FD representatives, any "wall height" greater than 5 inches impedes fish passage (Cundy 2017).

Table 3.9.1 is a list of diversion structures evaluated within the Watershed that are recommended for replacement, either because:

- they currently inhibit fish migration due to the fact that their diversion dam's wall height is too high, or
- they do not operate acceptably (e.g., too much leakage through the diversion dam).

Table 3.9.1 – Listing of Diversion Structures Recommended for Replacement

Creek on Which Diversion is Located	Owner/Entity Utilizing Diversion Structure	Reason Why Diversion Structure is Recommended for Replacement
Big Goose	City of Sheridan	Existing diversion dam exceeds 5 inches vertical drop
Rapid (tributary to Big Goose)	No. 9 Ditch Company	Existing diversion dam height exceeds 5 inches vertical drop, is old broken structure in need of replacement
Little Goose	Reed Ditch Company	Existing rock cross-vane structure leaks through at low flow, preventing adequate water diversion
Little Goose	East Side Ditch Company	Existing structure is merely rocks rolled into place
Little Goose	Burn Cleuch Ditch Company	Existing concrete structure with check boards is difficult to adjust when stream is high, and has dam height exceeding 5 inches and.

Section 4 of this Level I Study includes information on the recommended structures that will replace the existing facilities. In all cases, the recommended structure will both provide for proper diversion and suitable fish migration either over or around the diversion structure.

3.10 Surface Water Storage and Flood Control Needs

3.10.1 Existing Surface Water Storage

3.10.1.1 Existing Surface Water Storage Exceeding 500 A-F

Within the Watershed, there are eight water storage reservoirs with capacities exceeding 500 A-F. These eight reservoir facilities and their respective locations and capacities are listed in Table 3.10.1 and depicted in Figure 3.10.1.

Table 3.10.1 – Water Storage Reservoirs with Capacities Exceeding 500 A-F

RESERVOIR	LATITUDE	LONGITUDE	CAPACITY (A-F)
Park	44.56944° N	107.21178° W	10,362
Big Horn	44.53569° N	107.20256° W	4,624
Twin Lakes	44.60861° N	107.31042° W	3,380
Dome Lake Reservoirs #1 & 2	44.58556° N	107.29822° W	1,506 & 525
Sawmill	44.6255° N	107.29953° W	1,275
Cross Creek	44.50383° N	107.21008° W	798
Martin	44.54983° N	107.20061° W	561
Windy Draw	44.84580° N	106.98663° W	533

Source: WSEO website

Of the eight reservoirs listed above, all but two (Martin and Windy Draw) are located within the Big Goose Creek Subwatershed. The six reservoirs located within the Big Goose Creek Subwatershed are on lands located high up within that subwatershed on lands owned or surrounded by the BNF. Park and Cross Creek Reservoirs, while located within the Big Goose Creek Subwatershed, both have the capability of delivering water to water users in both the Big Goose Creek and Little Goose Creek drainages. On the other hand, Big Horn Reservoir is located in the Big Goose Creek Subwatershed, but this reservoir provides stored water to users solely in the Little Goose Creek drainage.

Martin Reservoir is located within the Little Goose Creek Subwatershed, although it stores water from streams located in both the Big Goose Creek and Little Goose Creek Subwatersheds. As with Big Horn Reservoir, Martin Reservoir delivers water solely to users in the Little Goose Creek Subwatershed.

Windy Draw Reservoir is located within the Lower Goose Creek Subwatershed. Windy Draw's diversion point is at the lower (easterly) end of Soldier Creek, although it is recognized that much of this water is actually return flow from irrigation within the Soldier Creek drainage, which has as its principal irrigation water source the Alliance and PK Ditches, both of which have diversion points on Big Goose Creek. The owner of the Windy Draw Reservoir also owns water in both Dome Lake and Park Reservoirs, with the stored water from these mountain reservoirs delivered via Soldier Creek and the Alliance, PK and Soldier Creek ditches to the Windy Draw site.

Of the eight reservoirs listed above, all are used principally for irrigation purposes, except for Twin Lakes, which is used by the City and SAWSJPB to supplement their municipal water supplies. Small volumes of water allocated to municipal and/or domestic use are also stored in Park and Dome Lake. There are no reservoirs within the Watershed that are currently utilized solely for

EXISTING STORAGE RESERVOIRS AND SURFACE WATER STORAGE OPPORTUNITIES

GOOSE CREEK WATERSHED LEVEL I STUDY

LAKE DESMET RESERVOIR (EXISTING RESERVOIR IN CLEAR CREEK DRAINAGE) APPROXIMATELY 8 1/2 MILES SSE OF THIS POINT

GILLISPIE DRAW RESERVOIR

WINDY DRAW

PK/ALLIANCE STOCKWATER DAM ENLARGEMENT

MARTIN

BIG HORN

CROSS CREEK

PARK

DOME LAKE

SAWMILL

TWIN LAKES

Story

Big Horn

Beckton

Ranchester

Dayton

GOOSE CREEK

LITTLE GOOSE CREEK

KRUSE CREEK

BIG GOOSE CREEK

SOLDIER CREEK

BEAVER CREEK

JACKSON CREEK

RAPID CREEK

EAST FORK LITTLE GOOSE CREEK

WEST FORK LITTLE GOOSE CREEK

EAST FORK BIG GOOSE CREEK

WEST FORK BIG GOOSE CREEK

Sheridan Co.

Johnson Co.

Big Horn Co.

14 87 338 90 335 331 14

N

0 1.25 2.5 5 Miles

- EXISTING STORAGE RESERVOIRS
- SURFACE WATER STORAGE OPPORTUNITIES
- GOOSE CREEK WATERSHED
- BIG GOOSE CREEK SUBWATERSHED
- LITTLE GOOSE CREEK SUBWATERSHED
- LOWER GOOSE CREEK SUBWATERSHED

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FIG. 3.10.1

industrial purposes. As mentioned previously, all industries located in the watershed that require significant volumes of water obtain their water from the City.

With the exception of Twin Lakes and Park, all reservoirs listed above are owned and operated by private reservoir companies. Twin Lakes is owned by the City (with some storage space allocated to the SAWSJPB). Park is owned by the Park Reservoir Irrigation District. The Park Reservoir Irrigation District was formed by the shareholders of the Park Reservoir Company in 1981 in order to secure a WWDC grant and loan to make repairs to the dam at that time. Not only is Park Reservoir the largest storage facility within the Watershed (10,262 A-F), it is also uniquely situated such that it can deliver water into both the Big Goose and Little Goose Creek Subwatersheds. In 2016, approximately 1/2 of the stored water delivered from Park was conveyed into the Big Goose drainage, and the remaining 1/2 was delivered into the Little Goose drainage.

None of the eight reservoirs listed above has space allocated for flood control purposes. Despite that lack of designation, dam and reservoir operators typically manipulate their facilities so that space is available during peak runoff periods to attenuate possible flooding events.

In 2016, the WSEO allowed Big Horn Reservoir to fill only to an elevation that is approximately seven feet below the reservoir's overflow elevation. Fill material previously placed on the crest of the dam to increase freeboard had slipped down onto the downstream face of the dam. The slip was exacerbated due to the fact that the fill material had been graded to drain towards the dam's downstream face in lieu of back into the reservoir. Repairs made in 2017 to address this potential safety problem included:

- adding more material on the downstream face to lessen the slope;
- extending the existing outlet pipe to accommodate the flatter downstream slope face; and
- controlling the seepage through a blanket and French drain that were installed on the downstream face and toe.

Once these repairs were made, the WSEO authorized the Big Horn Reservoir operators to fill the reservoir to its customary high water level, beginning in 2018.

3.10.1.2 Existing Wildlife and Livestock Surface Water Storage Reservoirs

Numerous small reservoirs, smaller than those depicted in Figure 3.10.1, have been constructed within the Watershed over the years for the purpose of providing water for wildlife and livestock. These reservoirs have been constructed almost exclusively on lands not within the BNF, presumably because streams, lakes and springs existing within the BNF can be used for this purpose.

The WSEO does not currently have GIS reservoir data for the area encompassed by the Watershed. Furthermore, the SCCD had no tabulation of these reservoirs within its records. As an alternative, aerial imagery was used to locate the small reservoirs located within the Watershed that address wildlife and livestock watering purposes. Figure 3.10.2 denotes the locations for these small reservoirs, as well as the area within one mile of them.

3.10.2 Surface Water Storage Opportunities

Existing surface water storage facilities within the Watershed were discussed in the previous subsection. Increasing the amount of surface water stored within the Watershed has been the focus of several water supply planning studies over the past 40 years, all of which have been

Story
Sheridan
Big Horn
Beckton
Ranchester
Dayton
GOOSE CREEK
LITTLE GOOSE CREEK
KRUSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
BEAVER CREEK
JACKSON CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK
Sheridan Co.
Johnson Co.
Big Horn Co.
14
87
338
335
331
90
N
0 1.25 2.5 5
Miles

EXISTING WILDLIFE AND STOCK RESERVOIRS

AREA WITHIN ONE MILE OF STOCK RESERVOIR

EXISTING WILDLIFE AND LIVESTOCK SURFACE WATER STORAGE RESERVOIRS

GOOSE CREEK WATERSHED LEVEL I STUDY

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FIG. 3.10.2

funded at least in part by the WWDC. These studies (which are all accessible via the WWDC website) include the following:

- Wyoming Water Development Commission, Water Development Potential in the Tongue River Basin, Level I Reconnaissance Study, Mar, 1984;
- Banner Associates, Inc., Tongue River Level I, Final Report, Jan, 1985;
- Howard Needles Tammen & Bergendoff, Sheridan Area Water Supply Investigation Level II, Volume I, Report of Findings, Nov, 1985;
- Howard Needles Tammen & Bergendoff, Sheridan Area Water Supply Investigation Level II, Phase 2, 1986 Program., Jan, 1987;
- HKM Engineering, Swig/Sheridan Area Development Analysis Level II, Final Report, Nov, 1988;
- HKM Engineering, Final Report, Swig/Sheridan Area Water Supply Study Level II, Stage II, Jan, 1990 ;
- HKM Engineering, City of Buffalo-Sheridan Area Water System-Lake DeSmet Level I Study, Final Report, Jun, 2008;
- DOWL HKM, Sheridan Supplemental Supply Study Level II, Phase I, Final Report, May, 2011; and
- EnTech Inc., Sheridan Supplemental Storage Level II Phase II Study, Final Report, Dec, 2013.

The studies identified above have primarily focused on additional supplies being procured for domestic and municipal use (i.e., the City and SAWSJPB) instead of supplies for new or existing agricultural irrigation use. The focus on domestic and municipal use has been predicated upon population projections for Sheridan County showing an increase over time, resulting in the projected need for additional water. No increased demands from agriculture within the Watershed have been brought forward for analysis.

Of the studies listed above, only one new identified storage facility has been constructed: the enlargement of Twin Lakes for the City and SAWSJPB. A major impediment to development of new storage has been the current federal Clean Water Act standards. These standards include two requirements that must be met in order to construct facilities that impact existing wetlands and/or waters of the United States:

1. There must be an identified purpose and need for the project; and
2. The project must be determined to be "the least-damaging, most practicable alternative" to meet the identified purpose and need.

Both of these requirements must be met as determined by the USACOE, the federal agency which administers the Clean Water Act. As all identified sites to date have been projected to impact wetlands and/or waters of the United States, moving forward with projects identified in the above studies has proven difficult – particularly because most of the projects recommended for construction are proposed to be located on federal USFS lands.

The most recent study that evaluated the entire spectrum of possible water storage opportunities was the May 2011 *Sheridan Supplemental Supply Study, Level II Phase I Final Report* by Dowl HKM. That 2011 Study considered the following alternatives:

- Conservation (by reducing water use, improving system efficiencies, or sharing improvements with agriculture);
- Acquisition of existing water rights by
    - Utilizing water previously used on agricultural lands which have now been annexed by the City or otherwise converted into residential vs. agricultural property;
    - Purchasing senior direct flow rights on Big Goose Creek; and

    - Purchasing water from agricultural storage reservoirs located in the Big Horn Mountains;
- Enlarging existing storage facilities such as Twin Lakes, Sawmill and Weston Reservoirs;
- Developing new storage facilities in the Big Horn Mountains;
- Developing new storage facilities on off-channel, lower elevation sites such as:
    - In the Owl Creek drainage;
    - In the Gillispie Draw drainage; and
    - In the Little Goose Creek drainage.
- Acquiring water from Lake DeSmet Reservoir, located in the adjacent Piney Creek drainage, which is a tributary of Clear Creek, a tributary of Powder River;
- Developing groundwater; and
- Other miscellaneous options brought to Dowl HKM's attention by other parties.

The conclusions of the May 2011 Study regarding the viability of the various alternatives indicated that the following alternatives warranted further consideration, with all other alternatives deemed to be impractical, unavailable or too expensive:

- Acquisition of water rights by purchasing water from existing agricultural storage reservoirs located in the Big Horn Mountains, specifically Park Reservoir and Sawmill Reservoir;
- Developing new storage facilities on off-channel, lower elevation sites, specifically in the Gillispie Draw drainage; and
- Acquiring water from Lake DeSmet Reservoir.

The first alternative (i.e., acquisition of existing water rights by purchasing water from Park Reservoir or Sawmill Reservoir) became the principal scope of the December 2013 *Sheridan Supplemental Storage Level II Phase II Study Final Report* by EnTech, Inc. The findings in the Level II Phase II Study eventually led to the 2015 Wyoming State Legislature appropriating monies to the City and SAWSJPB for the purpose of acquiring shares of water in Park Reservoir. Therefore, by appropriating funds for the purchase of **existing** storage water, the WWDC acknowledged the difficulty and high cost involved in constructing new storage within the Watershed.

Notwithstanding the acknowledgement of the difficulty involved in constructing new storage within the Watershed, the remaining two recommended alternatives outlined in the 2011 Study (i.e., Gillispie Draw Reservoir and Lake DeSmet Reservoir) warrant consideration as potential water storage opportunities within the Watershed. A description and analysis of both of these potential water storage opportunities within the Watershed are discussed in Section 4 of this Level I Study. Additional to these two water storage opportunities is one much smaller water storage opportunity that was identified as part of the public involvement process associated with the inventory of existing irrigation facilities within the Watershed. That project is the PK/Alliance Stockwater Dam Enlargement, which involves the capture and storage of water that currently seeps from the PK Ditch and is located above the Alliance Ditch. The proposed enlargement would provide additional storage capacity of less than 10 A-F.

The locations of these three water storage opportunities to potentially benefit the Watershed are depicted in Figure 3.10.1. They are discussed in more detail in Section 4 of this Level I Study.

3.10.3 Possible Impact of Montana v. Wyoming Lawsuit Relative to Yellowstone River Compact

In 1951, the states of Montana, Wyoming and North Dakota ratified, and the United States Congress consented to, the Yellowstone River Compact (Compact) among the three states (WSEO website). The Compact deals basically with dividing the water of the four tributaries to the Yellowstone River, one of which is the Tongue River, to which Goose Creek is a tributary. For

all four tributaries of the Yellowstone River, the Compact states that existing water rights as of January 1, 1950 shall continue to be enjoyed, whereas, for the Tongue River, "the remainder of the unused and unappropriated water is allocated to each State for storage or direct diversions for beneficial use on new lands or for other purposes as follows:

a. To Wyoming: 40%; and
b. To Montana: 60%."

In 2007, Montana filed suit against Wyoming, citing – in part – that Montana water users suffered a water shortage to its pre-1950 water rights due to Wyoming's use of water by post-1950 water rights. On February 20, 2018, the U.S. Supreme Court issued a Judgment and Decree stating that Wyoming did indeed reduce the volume of water available in the Tongue River at the State line between the two states by 1,300 A-F in 2004 and 56 A-F in 2006. (State of Montana v. State of Wyoming and State of North Dakota 2018). As a result of these reductions, Montana was awarded an amount of $20,340, together with pre-judgment and post-judgment interest of seven percent (7%) per annum from the year of each violation. The Judgment further stated that Montana was to use these monies "for improvements to the Tongue River Reservoir or related facilities in Montana.

The Supreme Court's Decree included other provisions relevant to the use of the water in the Tongue River Watershed, which therefore affect water users in Goose Creek as well. Those provisions included the following:

1. To protect pre-1950 rights in Montana, the State of Montana must place a call on the Tongue River and its tributaries (including Goose Creek) whenever:
   a. A pre-1950 direct flow right in Montana is not receiving its water; or
   b. Montana reasonably believes, based on substantial evidence, that the Tongue River Reservoir might not fill before the end of the water year. The term "fill" means that up to 72,500 A-F may be stored in the reservoir, less carryover storage in excess of 6,571 A-F. In conjunction with the filling of this reservoir, "reasonable" outflows from the reservoir to address wintertime ice jams and springtime flooding are allowed – as long as water is not being wasted.

   Regarding the pre-1950 Montana direct flow rights, almost all post-1950 direct flow rights within the Watershed are relatively small, and many are typically called out of priority by senior Wyoming water right holders long before any of Montana's pre-1950 direct flow rights would no longer be receiving their water. Therefore, this first provision is not particularly onerous to Wyoming. However, in regards to the filling of Tongue River Reservoir, Montana's call to fill this reservoir may have a more significant impact upon post-1950 **storage** rights within the Watershed. Table 3.10.2 depicts the post-1950 storage rights for significant reservoirs within the Watershed. Note that these rights total approximately 9,735 A-F. Park, Sawmill and Twin Lakes reservoirs all have minimum instream flow requirements placed upon them via special use permits executed between the USFS and the operators of these reservoirs. Because the flows required for these instream flow requirements are in the range of wintertime flows, the majority of these reservoirs' capacities are filled with streamflows occurring during the months of May, June and July via late spring and early summer runoff resulting from snowmelt and precipitation. Although the other reservoirs do not have similar instream flow requirements, they too rely principally upon late spring and early summer runoff in order to fill.

   If Montana places a call on the Tongue River (and, thus, Goose Creek) during this springtime period in order to fill Tongue River Reservoir, it is possible that the post-1950

reservoir space will not be able to be filled until this Montana reservoir has reached its capacity. Such an inability to store could prove very detrimental to water users within the Watershed who utilize water stored during the spring and early summer in these Big Horn Mountain reservoirs to meet their demands during the late summer and fall seasons.

2. Upon receiving a call for regulation from Montana, Wyoming must "promptly initiate action to ensure, **to the degree physically possible** [emphasis added], that only pre-1950 appropriators in Wyoming are diverting or storing surface water". This provision is particularly important to Wyoming, because it may not be "physically possible to prevent the storage of water" in many of the Watershed's reservoirs with post-1950 rights. This is due to the fact that these high-mountain reservoirs may be inaccessible, or their facilities may be inoperable due the reservoirs' and their respective facilities' frozen condition. In those situations where it is not physically possible to prevent the storage of water, Wyoming must "deliver such water to Montana as soon as it is physically possible to do so after a request from Montana". This allowance for a postponement of water deliveries has resulted in the State of Wyoming utilizing existing or installing monitoring devices that can record the elevation of water stored in the post-1950 reservoirs on the date that Montana places a call. Wyoming is then allowed to continue to store water until it is "physically possible" to operate its storage facilities. Such operation may not be possible until June, meaning that these reservoirs can continue to store water on an interim basis. If springtime precipitation is sufficient in the Tongue River Watershed to allow for Tongue River Reservoir to fill during this interim period (such as occurred in 2015 and 2016), Wyoming will have been able to continue to store water during the period when the call was in effect. This ability to store water during this period is of great advantage to Wyoming, vs. having to pass flows through the system and jeopardize the ability to eventually fill these post-1950 reservoirs.

3. The Decree states that "the same seniority level to all pre-1950 water users in Montana and Wyoming" is assigned. This provision eliminates the concern that the pre-1950 users in Wyoming would potentially be called out by pre-1950 Montana water users with more senior priority dates in the order of their dates, which is the method used in Wyoming for the administration of streamflow. Having to be regulated by priority date in both Wyoming and Montana would be administratively very cumbersome.

4. The Decree states that "water stored under post-January 1, 1950 appropriative rights in Wyoming, when a call is not in effect, has been legally stored under the Compact and can be subsequently used at any time, including when pre-1950 appropriative rights in Montana are unsatisfied. The Compact does not require Wyoming to release such water to Montana in response to a call." This provision relieves any concerns on the part of owners of Wyoming reservoirs with post-1950 rights that they would have to release legally-stored water to satisfy pre-1950 Montana users placing a call on the stream. (This provision obviously does not apply if the water was stored during the time that a call had been placed by Montana but it was not physically possible to prevent storage, as discussed in Item 2 above.)

Table 3.10.2 – Post-1950 Storage Rights in Major Reservoirs within the Watershed

RESERVOIR	NAME	NO.	PRIORITY DATE	DESIGNATED USE	CAPACITY (A-F)
Park	Enl. Big Goose Park Res.	6179R	10-25-1954	Irrigation	676
	Enl. Big Goose Park Res.	6448R	10-30-1957	Irrigation	885
	Union No. 1	7227R	8-19-1958	Irrigation	461.39
	Enl. Union No. 1	7228R	12-18-1959	Irrigation	872.16
	Hansen No. 3	7229R	05-27-1960	Irrigation	120.63
			SUBTOTAL	**3015.18 A-Ft**	
Sawmill	Sawmill Res.	6890R	11-10-1960	Irrigation	970.0
	Enl. Sawmill Res.	7268R	07-30-1969	Irrigation	287.8
	Enl. Sawmill Res.	9819R	11-7-1991	Irrigation	17.2
			SUBTOTAL	**1275.0 A-F**	
Cross Creek	Cross Creek Res.	CR09/066	06-04-1952	Irrigation	323.8
	Enl. Cross Creek Res.	CR09/067	04-01-1955	Irrigation	171.99
	Enl. Cross Creek Res.	CR09/068	10-07-1971	Irrigation	301.87
			SUBTOTAL	**797.66 A-F**	
Twin Lakes	Twin Lakes No. 2 Res.	CR07/066	05-06-1955	Domestic, Indulstrial	202.9
	Enl. Twin Lakes No. 1 Res.	CR07/067	01-23-1962	Municipal	136.9
	Enl. Twin Lakes Res.	CR15/327	08-23-1989	Domestic, Industrialr	1877.3
			SUBTOTAL	**2217.1 A-Fft**	
Dome Lake	Enl. Dome Lake No. 1 Res.	CR05/432	12-04-1967	Irrigation, Recreation	188.0
			SUBTOTAL	**188.0 A-Ft**	
Big Horn	Enl. of Big Horn Res.	6946R	02-08-1960	Irrigation	1652.5
	Enl. of Big Horn Res.	6947R	11-18-1960	Irrigation	223.3
			SUBTOTAL	**1875.8 A-Ft**	
				TOTAL	**9368.74**

3.10.4 Flood Control Needs

Unlike many water storage facilities throughout Wyoming (particularly those owned and operated by the U.S. Bureau of Reclamation), there are presently no water storage facilities situated within the Watershed with a flood control component among their designated uses. Notwithstanding that fact, certain larger reservoir owners – such as the Park Reservoir Company –manage the filling of their reservoirs so that they have some storage available during peak runoff periods in order to attenuate higher flows. They do so, however, recognizing that their primary mission is to be left with a full reservoir after runoff occurs.

Both the Sheridan County Emergency Management Coordinator and Sheridan County Engineer were polled regarding flood control needs within the Watershed. They were also asked if they were cognizant of any specific documents that recommended areas where flood control facilities were warranted. They responded with the following information (Edwards and Muller 2017):

1. FEMA flood plain maps exist which portray areas where flooding is likely to occur during major precipitation events. These maps are used to dictate where new development can occur (i.e., outside of designated flooding areas, above established flood plain elevations).
2. There are four flood-prone areas that consistently pose problems within the Watershed:
   a. Within the Soldier Creek drainage near its confluence with Goose Creek;
   b. Along Jackson Creek (tributary of Little Goose Creek) as it flows through the community of Big Horn;
   c. Along Little Goose Creek in the vicinity of the northerly US 87 bridge over this creek immediately south of the city limits; and
   d. Along Big Goose Creek immediately west of the city limits along Leopard Street.

These four locations are shown in Figure 3.10.3.

3. In 2010, the City, County, the National Oceanic and Atmospheric Administration (NOAA) and University of Wyoming entered into a joint project agreement providing for the installation and maintenance of rain and stream gaging stations at three locations within the Watershed, all for the purpose of predicting possible flood flows. The locations of these three flood stream gaging stations are shown in Figure 3.10.3, and they are among those gages shown in Figure 3.5.4. Three separate rain gaging stations were also installed at other key locations throughout the Watershed. Of the approximate $82,000 in capital costs needed to install these gaging stations, the City and County each paid approximately 40%, NOAA paid approximately 7%, and the University paid approximately 13%. The City and County currently share the operation and maintenance costs associated with these gaging stations, which is approximately $3,500 each annually (Muller 2017). Stream gaging information for these installations is available at: http://water.weather.gov/ahps/region.php?state=wy.

In the mid-1960s, the USACOE constructed a flood levee system through the majority of the City for the purpose of protecting the City during major flood events in Big Goose Creek, Little Goose Creek and Goose Creek downstream of the confluence. The extent of this levee system is shown in Figure 3.10.4. The second phase of this system – which was to protect residents along Big Goose Creek upstream of Kendrick Park to a point where sufficient elevation exists to direct all floodwater into and through the levee system – was never constructed. As a result, flooding has occasionally occurred in parts of the City along Big Goose Creek upstream of Kendrick Park and on the back side of the levee system on Big Goose Creek due to the failure to construct the system's second phase.

3.11 Upland Water Development Opportunities

As part of the selection and evaluation process used for the irrigation systems inventory, several upland water development opportunities were brought forth for consideration by area ranchers. Each proposed opportunity involves enhancing livestock watering opportunities by either:

- developing existing springs, or
- utilizing existing streams, groundwater or ditch water and expanding their use for this livestock watering purpose (Connell and Reinke 2017).

These upland water development opportunities are listed below, and they are described further in Section 4:

1. Walker Prairie Spring Development,
2. Buffalo Jump Spring Development,
3. Beaver Creek Hills Upland Water Development,
4. Tepee Upland Water Development,
5. Poverty Flat Upland Water Development,
6. East Fork Little Goose Creek Upland Water Development,
7. Flume Ditch Solar Collector Stockwater Pumping Systems,
8. Flume Ditch Spring Development, and
9. Clark Upland Water Development.

The location of these nine upland water development opportunities to potentially benefit the Watershed are also depicted in Figure 3.11.1. They are discussed in more detail in Section 4 and Appendix A.

GOOSE CREEK

Sheridan

LITTLE GOOSE CREEK

KRUSE CREEK

338

Big Horn

335

BIG GOOSE CREEK

331

SOLDIER CREEK

JACKSON CREEK

BEAVER CREEK

Beckton

RAPID CREEK

EAST FORK BIG GOOSE CREEK

N

0 0.75 1.5 3

Miles

NOAA FLOOD GAGING STATIONS

FLOOD PRONE AREAS

FLOOD PRONE AREAS

GOOSE CREEK WATERSHED
LEVEL I STUDY

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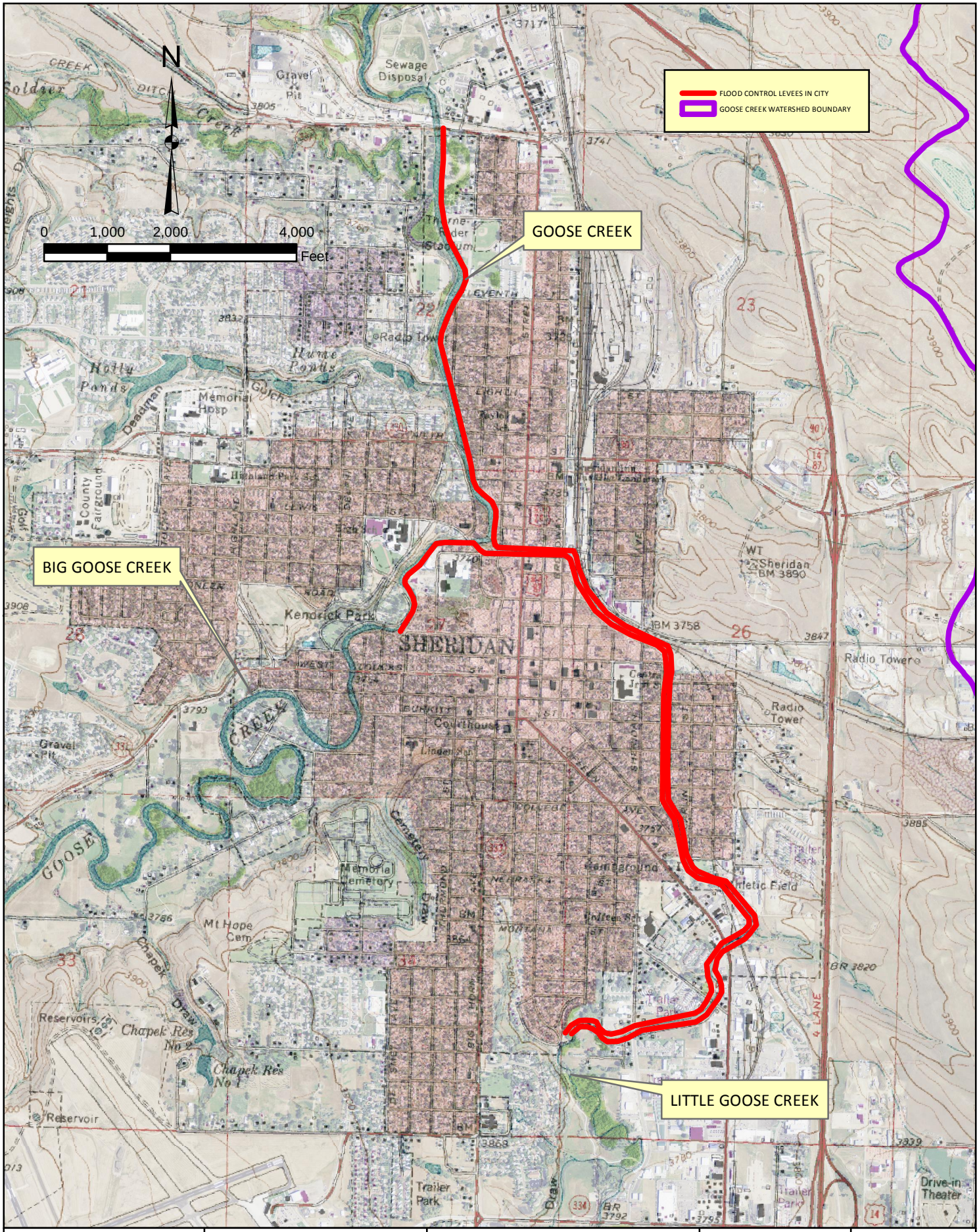
FIG. 3.10.3



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	**GOOSE CREEK WATERSHED LEVEL I STUDY**	**FLOOD CONTROL LEVEES IN CITY OF SHERIDAN**	**FIG. 3.10.4**

UPLAND WATER DEVELOPMENT OPPORTUNITIES
- Beaver Creek Hills
- Buffalo Jump Spring
- Clark
- East Fork Little Goose Creek
- Flume Ditch Solar Collector Stockwater Pumping Systems
- Flume Ditch Spring
- Poverty Flat
- Tepee
- Walker Prairie Spring
- BIG GOOSE CREEK SUBWATERSHED
- LITTLE GOOSE CREEK SUBWATERSHED
- LOWER GOOSE CREEK SUBWATERSHED

Sheridan
Big Horn
Story
Ranchester
Dayton
Beckton
Sheridan Co.
Johnson Co.
Big Horn Co.
GOOSE CREEK
LITTLE GOOSE CREEK
KRUSE CREEK
BIG GOOSE CREEK
SOLDIER CREEK
BEAVER CREEK
JACKSON CREEK
RAPID CREEK
EAST FORK LITTLE GOOSE CREEK
WEST FORK LITTLE GOOSE CREEK
EAST FORK BIG GOOSE CREEK
WEST FORK BIG GOOSE CREEK
14
87
338
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Miles

UPLAND WATER DEVELOPMENT OPPORTUNITIES

GOOSE CREEK WATERSHED LEVEL I STUDY

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FIG. 3.11.1

4. WATERSHED MANAGEMENT AND REHABILITATION PLAN

4.1 Overview

In conjunction with the development of the Level I Study's GIS, the Chapter 3 inventory provided a baseline illustrating and assessing existing conditions within the Watershed. This baseline has led to the development of this chapter's Watershed Management and Rehabilitation Plan. One of the principal purposes of this Level I Study is to develop a plan that is useful to the stakeholders in the Watershed. As such, the goal of this plan is to provide recommendations that are technically feasible and accurate at a concept level in regards to costs.

This plan includes a listing and description of recommended projects that are segregated into the following categories:

- **Irrigation System Infrastructure Rehabilitation and Improvements Projects (ISI).** The field inventory conducted for this Level I study concentrated on the structures that were requested by the water users. Each structure was evaluated as it relates to the needs of the overall system and improvements within the Watershed. Typically, each ditch company representative, water user and/or landowner identified the structures to be evaluated during the site investigation. Existing structures identified for rehabilitation included infrastructure such as irrigation diversions, ditches, pipelines, flumes, siphons, energy dissipation structures, headgates, turnouts and wasteways.
- **Surface Water Storage Opportunities (SWSO).** The results of discussions with water users pertaining to developing water storage opportunities within the Watershed were incorporated into this Level I Study. Included within this group were results of previous studies that assessed the need for additional reliable water supplies and provided recommendations on projects to address these needs.
- **Upland Water Development Opportunities (UWDO).** The results of discussions with ranchers owning livestock and SCCD representatives relating to potential upland watering opportunities were also incorporated into this Level I Study. Possible projects centered principally on spring development in upland areas, although other projects included transmission of existing water sources to upland locations that offer opportunity for livestock or wildlife grazing that are currently devoid of water sources.
- **Fisheries Mitigation (FM).** Field reconnaissance associated with the irrigation system infrastructure rehabilitation and improvement projects resulted in development of a listing of potential projects that would enable or enhance fish migration through or around structures that are currently a barrier to such migration. This information was supplemented with data provided by the WG&FD that also showed where fish migration was being deterred.

4.2 Project Identification

Table 4.2.1 lists the projects associated with the four categories defined above. Figures 4.2.1, 4.2.2 and 4.2.3 depict the various locations for the Irrigation System Infrastructure projects within the Watershed, and Figure 4.2.4 portrays the locations for the proposed Fisheries Mitigation projects. Surface Water Storage Opportunities were previously depicted in Figure 3.10.1, and Upland Water Development Opportunities were shown previously in Figure 3.11.1. Within Appendix A are descriptions of each project, as well as conceptual design cost estimates to implement them. More detailed descriptions of some of these proposed projects are also included in subsequent sections of this Section 4.

N

0 0.75 1.5 3

Miles

Grinnell Ditch

ISI-LOG-GR-01

ISI-LOG-SC-02

ISI-LOG-SC-01

Soldier Creek Ditch

PK Ditch

Alliance Lateral Ditch

ISI-BG-WR-03

ISI-BG-WR-02

ISI-BG-WR-04

Wild Rose System

Flume Ditch

ISI-BG-FL-02

ISI-BG-FL-03

ISI-BG-FL-01

ISI-BG-DA-01

ISI-BG-DA-02

Daisy Ditch

ISI-BG-PK-01

Alliance Ditch

#9 Ditch

ISI-BG-AL-01

ISI-BG-RO-01

ISI-BG-RO-02

Rocky Ditch

Big Goose and Beaver Ditch

Snively Ditch

ISI-BG-BGB-02

ISI-BG-BGB-01

ISI-BG-SN-02

ISI-BG-SN-01

BIGHORN NATIONAL FOREST

WATERSHED PROJECTS (n/i ALLIANCE LATERAL DITCH)

LOWER GOOSE CREEK SUBWATERSHED BOUNDARY

BIG GOOSE CREEK SUBWATERSHED BOUNDARY

GOOSE CREEK WATERSHED BOUNDARY

PROPOSED IRRIGATION SYSTEM INFRASTRUCTURE PROJECTS IN BIG GOOSE CREEK AND LOWER GOOSE CREEK SUBWATERSHEDS - NOT INCLUDING ALLIANCE LATERAL DITCH

GOOSE CREEK WATERSHED LEVEL I STUDY

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Professional Engineers
Sheridan, WY 82801

FIG. 4.2.1

N

0 0.25 0.5 1 Miles

+/-10.6 DITCH MILES

ISI-BG-ALL-01
ISI-BG-ALL-02
ISI-BG-ALL-03
ISI-BG-ALL-04
ISI-BG-ALL-05
ISI-BG-ALL-06
ISI-BG-ALL-07
ISI-BG-ALL-08
ISI-BG-ALL-09
ISI-BG-ALL-10
ISI-BG-ALL-11
ISI-BG-ALL-12
ISI-BG-ALL-13
ISI-BG-ALL-14
ISI-BG-ALL-15
ISI-BG-ALL-16
ISI-BG-ALL-17
ISI-BG-ALL-18
ISI-BG-WR-03
ISI-BG-ALL-19
ISI-BG-ALL-20

First Turnout from Alliance Lateral Ditch (Wild Rose)

Wild Rose Reservoir

Start of Alliance Lateral Ditch

WATERSHED PROJECTS - ALLIANCE LATERAL DITCH
ALLIANCE LATERAL DITCH
BIG GOOSE CREEK SUBWATERSHED BOUNDARY

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PROPOSED IRRIGATION SYSTEM INFRASTRUCTURE PROJECTS - ALLIANCE LATERAL DITCH ONLY

GOOSE CREEK WATERSHED LEVEL I STUDY

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FIG. 4.2.2

PROPOSED IRRIGATION SYSTEM INFRASTRUCTURE PROJECTS IN LITTLE GOOSE CREEK SUBWATERSHED

GOOSE CREEK WATERSHED LEVEL I STUDY

Piney Cruse Creek Ditch (Transbasin Diversion from Piney Creek)

Meade-Coffeen Ditch (Transbasin Diversion from Piney Creek)

Burn Cleuch Ditch

Reed Ditch

East Side Ditch

Metz Ditch

Paradise Pk. South Ditches

Gerdel Ditch

Negro John Ditch

Muskrat Ditch

Last Chance Ditch

Colo. Colony Ditch

Peralta Ditch

ISI-LG-MC-01

ISI-LG-BU-02

ISI-LG-BU-03

ISI-LG-BU-01

ISI-LG-RE-02

ISI-LG-RE-01

ISI-LG-RE-03

ISI-LG-RE-04

ISI-LG-ES-11

ISI-LG-GE-01

ISI-LG-ES-10

ISI-LG-ES-09

ISI-LG-ES-08

ISI-LG-ES-07

ISI-LG-ES-06

ISI-LG-LC-03

ISI-LG-ES-04

ISI-LG-ES-05

ISI-LG-ES-03

ISI-LG-ES-02

ISI-LG-MU-02

ISI-LG-MU-01

ISI-LG-ES-01

ISI-LG-LC-02

ISI-LG-PP-01

ISI-LG-ME-01

ISI-LG-JD-01

ISI-LG-LC-01

ISI-LG-PE-03

ISI-LG-PE-04

ISI-LG-PE-05

ISI-LG-PE-02

ISI-LG-PE-01

N

0 0.5 1 2 Miles

LITTLE GOOSE SUBWATERSHED PROJECTS

LITTLE GOOSE CREEK SUBWATERSHED IRRIGATION SYSTEMS

LITTLE GOOSE CREEK SUBWATERSHED BOUNDARY

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FIG. 4.2.3

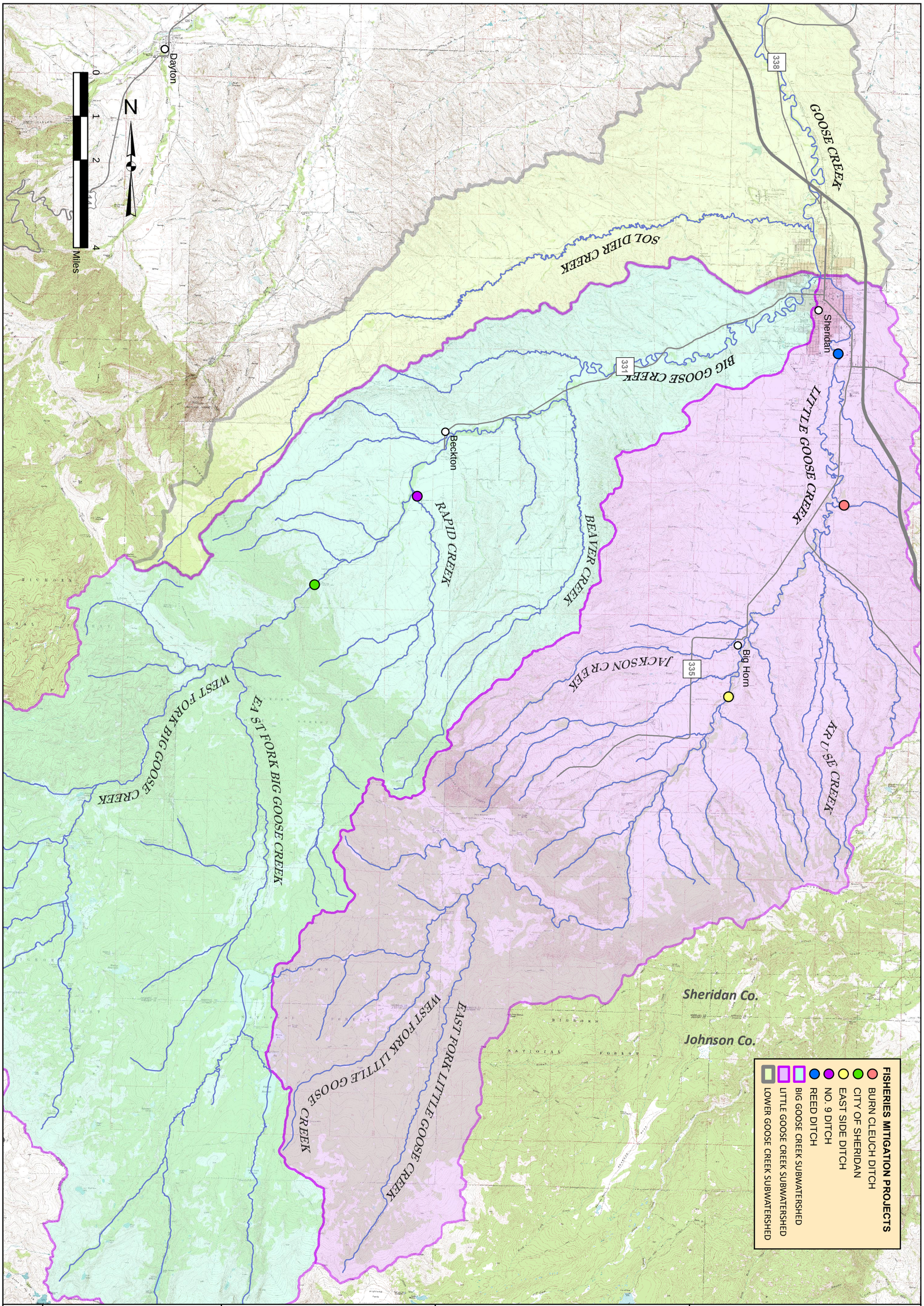

FIG. 4.2.4

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GOOSE CREEK WATERSHED
LEVEL I STUDY

PROPOSED FISHERIES
MITIGATION PROJECTS

For purposes of delineating individual irrigation system infrastructure projects of the watershed management and rehabilitation plan, each project was designated a unique project identification number based on its Watershed location and abbreviated ditch name upon which ditch it is located. Project identification numbers were also designated using a similar procedure for projects associated with surface water storage opportunities, upland water development opportunities and fisheries mitigation.

Table 4.2.1 – Proposed Projects in Watershed and Management Plan

Irrigation System Infrastructure Rehabilitation and Improvements			
Big Goose Creek Projects		Little Goose Creek and Lower Goose Creek Projects	
ID	Name	ID	Name
ISI-BG-AL-01	Alliance Ditch Slide Area Repair	ISI-LG-NE-01	Negro John Diversion Dam
ISI-BG-ALL-01	Alliance Lateral Ditch Wasteway Gate Removal	ISI-LG-ME-01	Metz Ditch Pipeline Installation
ISI-BG-ALL-02	Alliance Lateral Ditch Culvert Replacement 1	ISI-LG-MU-01	Muskrat Ditch Turnout
ISI-BG-ALL-03	Alliance Lateral Ditch Culvert Installation 1	ISI-LG-MU-02	Muskrat Ditch Turnout Replacement
ISI-BG-ALL-04	Alliance Lateral Ditch Culvert Installation 2	ISI-LG-GE-01	Gerdel Ditch Seepage Rehabilitation
ISI-BG-ALL-05	Alliance Lateral Ditch Trash Rack 1	ISI-LG-RE-01	Reed Ditch Headgate Replacement
ISI-BG-ALL-06	Alliance Lateral Ditch Trash Rack 2	ISI-LG-RE-02	Reed Ditch Measuring Device
ISI-BG-ALL-07	Alliance Lateral Ditch Culvert Installation 3	ISI-LG-RE-03	Reed Ditch Knecht Drainage
ISI-BG-ALL-08	Alliance Lateral Ditch Culvert Replacement 2	ISI-LG-RE-04	Reed Ditch Flume Structure Replacement
ISI-BG-ALL-09	Alliance Lateral Ditch Erosion Control Structure 1	ISI-LG-ES-01	East Side Ditch Diversion Rehabilitation
ISI-BG-ALL-10	Alliance Lateral Ditch Culvert Installation 4	ISI-LG-ES-02	East Side Ditch Wasteway
ISI-BG-ALL-11	Alliance Lateral Ditch Culvert Replacement 3	ISI-LG-ES-03	East Side Ditch Improvements
ISI-BG-ALL-12	Alliance Lateral Ditch Culvert Installation 5	ISI-LG-ES-04	East Side Ditch Culvert Installation 1
ISI-BG-ALL-13	Alliance Lateral Ditch Erosion Control Structure 2	ISI-LG-ES-05	East Side Ditch Sackett Creek Wasteway
ISI-BG-ALL-14	Alliance Lateral Ditch Culvert Replacement 4	ISI-LG-ES-06	East Side Ditch Culvert Installation 2
ISI-BG-ALL-15	Alliance Lateral Ditch Culvert Installation 5	ISI-LG-ES-07	East Side Ditch Culvert Installation 3
ISI-BG-ALL-16	Alliance Lateral Ditch Erosion Control Structure 3	ISI-LG-ES-08	East Side Ditch Garber Measuring Device
ISI-BG-ALL-17	Alliance Lateral Ditch Culvert Installation 6	ISI-LG-ES-09	East Side Ditch Concrete Ditch Replacement
ISI-BG-ALL-18	Alliance Lateral Ditch Culvert Installation 7	ISI-LG-ES-10	East Side Ditch Siphon
ISI-BG-ALL-19	Alliance Lateral Ditch Turnout 1	ISI-LG-ES-11	East Side Ditch Maverick Lane Pipeline Installation
ISI-BG-ALL-20	Alliance Lateral Ditch Turnout 2	ISI-LG-PP-01	South Paradise Park Pipeline
ISI-BG-WR-01	Wild Rose Meter Replacement	ISI-LG-BU-01	Burn-Cleuch Ditch Measuring Flume
ISI-BG-WR-02	Wild Rose Dam Improvements	ISI-LG-BU-02	Burn- Cleuch Ditch UW Center Pivot Electrification
ISI-BG-WR-03	Wild Rose Headgate Improvements	ISI-LG-BU-03	Burn-Cleuch Ditch SC Control System
ISI-BG-SN-01	Snively Ditch Flume Replacement	ISI-LG-LC-01	Last Chance Ditch Flume Replacement at East Fork Davis Creek
ISI-BG-SN-02	Snively Ditch Culvert Installation	ISI-LG-LC-02	Last Chance Ditch Culvert Installation 1

Irrigation System Infrastructure Rehabilitation and Improvements			
Big Goose Creek Projects		Little Goose Creek and Lower Goose Creek Projects	
ID	Name	ID	Name
ISI-BG-BGB-01	Big Goose Beaver Ditch Culvert Installation	ISI-LG-LC-03	Last Chance Ditch Culvert Installation 2
ISI-BG-BGB-02	Big Goose Beaver Ditch Energy Dissipation Structures	ISI-LG-PE-01	Peralta Ditch Headgate Rehabilitation
ISI-BG-PK-01	PK Ditch Culvert Replacement	ISI-LG-PE-02	Peralta Ditch Measuring Flume
ISI-BG-RO-01	Rocky Ditch Seepage Rehabilitation	ISI-LG-PE-03	Peralta Ditch Dow Ranch Turnout Rehabilitation
ISI-BG-RO-02	Rocky Ditch Headgate Replacement	ISI-LG-PE-04	Peralta Ditch Breach Restoration
ISI-BG-DA-01	Daisy Ditch Wasteway Installation	ISI-LG-PE-05	Peralta Ditch Turnout Installation
ISI-BG-DA-02	Daisy Ditch Headgate Replacement	ISI-LG-MC-01	Kruse Creek Sideroll Irrigation System
ISI-BG-FL-01	Flume Ditch Wasteway Gate Replacement	ISI-LoG-SC-01	Soldier Creek Ditch VAMC Turnout Replacement
ISI-BG-FL-03	Flume Ditch Culverts	ISI-LoG-GR-01	Grinnell Ditch Turnout Replacement

Surface Water Storage Opportunities		Upland Water Development Opportunities	
ID	*Name*	ID	Name
SWSO-01	PK/Alliance Stockwater Dam Enlargement	UWDO-01	Walker Prairie Spring Development
SWSO-02	Gillispie Draw Dam and Reservoir	UWDO-02	Buffalo Jump Spring Development
SWSO-03	Lake DeSmet Reservoir Transbasin Diversion – Municipal Water Source	UWDO-03	Beaver Creek Hills Upland Water Development
SWSO-04	Lake DeSmet Reservoir Transbasin Diversion – Irrigation Water Source	UWDO-04	Tepee Upland Water Development
SWSO-05	Lake DeSmet Reservoir Transbasin Diversion – Watershed Supplemental Supply Source	UWDO-05	Poverty Flat Upland Water Development
		UWDO-06	East Fork Little Goose Creek Upland Water Development
		UWDO-07	Flume Ditch Solar Collector Stockwater Pumping Systems
		UWDO-08	Flume Ditch Spring Development
		UWDO-09	Clark Upland Water Development

Fisheries Migration Projects			
ID	Name	ID	Name
FM-BG-CS-01	City of Sheridan Intake Diversion Dam Fish Ladder	FM-LG-ES-01	East Side Ditch Diversion Dam Replacement
FM-BG-N9-01	No. 9 Ditch Diversion Dam Replacement	FM-LG-BU-01	Burn-Cleuch Ditch Diversion Dam
FM-LG-RE-01	Reed Ditch Diversion Dam Rehabilitation		

4.3 Project Effects and Benefits

An essential purpose of this Watershed Management and Rehabilitation Plan is to provide a road map for the various stakeholders within the Watershed to improve the use and availability of water for both man and the natural environment. The plan utilizes, in part, best management practices (BMPs) to accomplish this essential purpose. Implementation of these BMPs provides both quantitative and qualitative benefits within the Watershed. As the name implies, the term "best" connotes constantly evolving management practices, versus always remaining static. An example of such evolution is the construction and use of diversion dams installed to direct streamflow from the stream channel into a ditch or pipeline.

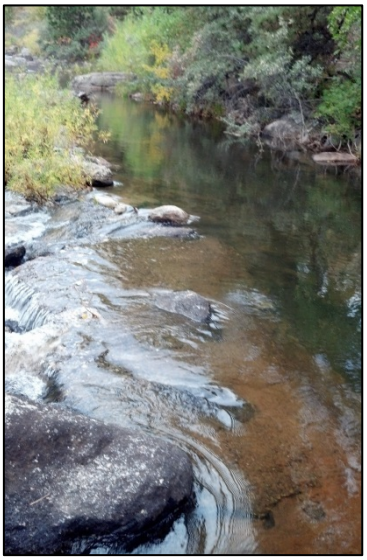


Figure 4.3.1 - Alliance Ditch Diversion Dam

The first diversion dams constructed in the 19th century (and still some existing ones) consisted merely of strategically placed large boulders or logs within the channel. The boulders or logs were then periodically relocated during the course of the irrigation season to "check up" the stream to the required elevation. An example of this type of diversion dam is the one utilized by the Alliance Ditch along Big Goose Creek. (See Figure 4.3.1.)

With time, and in order to divert as much water as possible, diversion dams oftentimes became larger immovable hydraulic structures such as concrete walls or steel sheet piles. An example of this type of diversion dam is the City's structure on Big Goose Creek at the mouth of Big Goose Creek canyon. (See Figure 4.3.2.) While very hydraulically efficient, these types of barriers are significant barriers to fish passage.

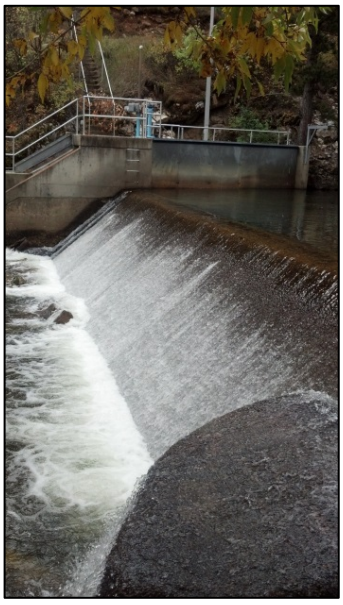


Figure 4.3.2 - City of Sheridan Diversion Dam

With the evolution of thought that ecological benefits derived from obstruction-free streams are important to society as well as the environment, BMPs for diversion dams migrated towards structures that both efficiently divert water while allowing for acceptable fish passage. The result was the development of facilities such as cross-vane types of diversion structures, which reinstituted use of large boulders providing the ability to "check up" the stream, but with boulder characteristics being such that water could flow both over and between the boulders, thereby allowing for fish passage. An example of a structure such as this is the diversion dam for Reed Ditch on Little Goose Creek. (See Figure 4.3.3.)

One of the most recent BMPs for streams the size of Big Goose Creek or Little Goose Creek provides for a ramped type of structure leading up to and descending from a control structure that is actually located below the channel surface. The recently-constructed, NRCS-designed N.B. Held diversion dam on Big Goose Creek (just west of the City) exhibits these BMPs for diversion dams. (See Figure 4.3.4.) It has both a gradual increase and decrease to the weir level, allowing for both water to flow into the N.B. Held Ditch as well as provide for easy fish migration over the weir.

Figure 4.3.3 – Reed Ditch Cross-Vane Diversion Dam

Figure 4.3.4 – N.B. Held Diversion Dam

Numerous benefits can potentially be gained from implementing BMPs such as the above example, as well as from conservation practices. These benefits can be quantitative, qualitative, or both. Geographically, benefits can be local, regionwide, or even global, depending on the BMP or conservation practice being implemented. The cited BMP example relates to the diversion of water from Big Goose Creek, the largest stream in the Watershed. However, implementation of BMPs and conservation practices can also potentially be used within the Watershed to reduce grazing pressure on riparian areas adjacent to streams, as well as maximize use of grazing opportunities in upland areas by providing stockwater at key locations within those upland areas. All of these practices can achieve both economic and ecological benefits by promoting plant diversity, resisting proliferation of invasive species, and improving forage production.

The SCCD has implemented programs throughout this Watershed, as well as adjacent watersheds and other, larger watersheds in Sheridan County, of which this Watershed is a part (specifically, the Tongue River watershed). These programs have utilized BMPs and other conservation practices to achieve significant economic and ecological benefits within the various watersheds located in Sheridan County. Examples of such programs include the following (SCCD website):

- The SCCD Septic System Improvements Program is a local improvements program that provides voluntary, locally-directed, financial and technical assistance for repair or replacement of existing septic systems that likely impact water quality. In 2003, SCCD was awarded Federal grant monies to initiate a local program geared towards the repair or replacement of faulty septic systems which may potentially be contaminating local streams.

  Funding for the program is provided by a combination of Federal and State grants administered by the SCCD, and landowner contributions. Federal grants come from EPA via Section 319 of the Clean Water Act and are administered through the WDEQ. State grants come from the Wyoming Department of Agriculture. Approximately 50% cost-share is available on contracts at this time.

- The SCCD-NRCS Livestock and Other Pastured Animals Improvement Program is a local improvements program that provides voluntary, locally-directed, financial and technical

assistance to producers wishing to minimize the impact of a livestock operation on adjacent waterways. The program provides incentives to landowners for the rearrangement or relocation of corrals and feeding areas that have the potential to negatively impact water quality. Storm water run-off from corrals often contains bacteria (many of which are pathogenic to humans), nutrients, sediment, and organic materials which are delivered to local streams. By mitigating the impacts of these storm waters, landowners also reduce their risk of possible regulatory enforcement actions.

Funding for the program is provided by a combination of Federal and State grants administered by the SCCD, USDA program funds, and landowner contributions. Federal grants come from EPA through Section 319 of the Clean Water Act and are administered through the WDEQ. State grants come from the Wyoming Department of Agriculture. USDA program funds generally come from the Environmental Quality Incentives Program (EQIP) or the Agricultural Management Assistance (AMA) Programs. Depending on the individual project and funding availability, landowners may qualify to have 50% to 80% of their improvement project cost-shared.

- Subdivision Review Process relating to Natural Resource considerations for Subdivision Reviews. The SCCD is responsible for addressing all natural resource issues (W.S. 11-16 101, *et seq*) and are given the authority to provide subdivision reviews and recommendations (W.S. 18-5-306(b)). The SCCD's role is to assist developers and other County authorities in the use of good conservation practices in subdivision planning by offering recommendations on resource issues, such as "land, soil, water, vegetation, trees, wild rivers, wilderness, natural beauty, scenery, and open space".

Implementation of BMPs and conservation practices is one of the types of projects that are eligible for the WWDC's Small Water Projects Program (SWPP). Section 6 of this Level I Study provides more information on the use of the SWPP for projects in general and for use on BMP projects in particular.

Recommendations discussed as part of this Level I Study's Watershed Management and Rehabilitation Plan can contribute to the overall health of the Watershed. Proposed improvements relating to irrigation system infrastructure offer the following benefits:

- Increased water use efficiency. Several of the proposed improvements reduce the waste of water by lining ditches, replacing existing-but leaking concrete-lined ditches, installing pipe where leaking ditches now exist, replacing meters and measuring devices, and replacing leaking structures that do not properly close. More efficient use of available water supplies bodes well in semi-arid regions such as northern Wyoming. It can also improve the economics associated with agricultural production.

- Reduction of erosion and water quality degradation. Some of the proposed irrigation system infrastructure improvements address existing ditches where adjacent sideslopes continue to slough off. Such sloughing not only directly increases turbidity in the ditch water being conveyed, it also temporarily blocks ditch channels. Such blockage eventually erodes away as the water in the ditch dams up and eventually flows over the blockage, conveying with it substantial amounts of silt. Siltation in downstream ditches adds to maintenance costs, creates problems for irrigation pumps, and degrades the quality of any water being returned to streams. The photos in Figure 4.3.5 show the detrimental effects (e.g., water quality degradation and silt deposition) of such a blockage and eventual overtopping within and downstream of the Grand Canyon of the Alliance Lateral Ditch that occurred in the spring of 2017.

- Sustainability. Many of the irrigation systems located in the Watershed still use components originally constructed as early as the 1880s. These components have exceeded their useful lives several times over. However, due to the relatively small profit margin afforded those in the agricultural industry within the Watershed, monies have generally not been available to replace these components, forcing users to make due with these antiquated facilities.

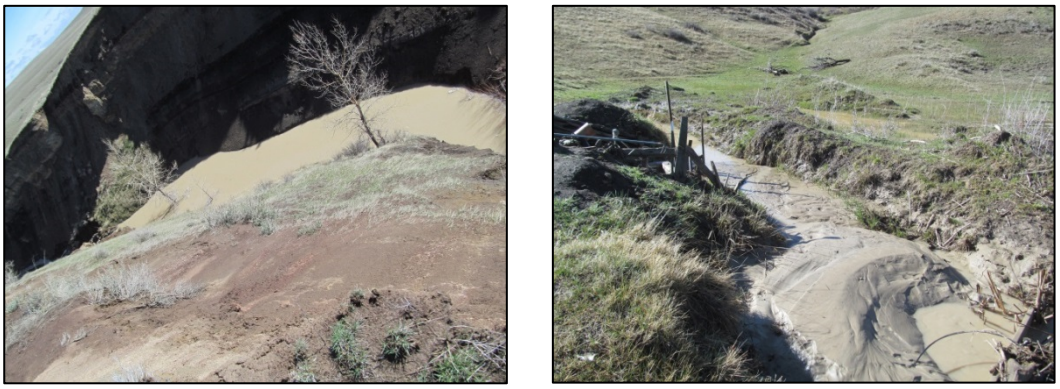


Figure 4.3.5 – Examples of Water Quality Degradation and Silt Deposition at the Grand Canyon of the Alliance Lateral Ditch

By implementing the recommendations made as part of this Level I Study, the agricultural sector of the economy within the Watershed can be much more readily sustained. Such sustainability can not only assist in maintaining agriculture as a viable industry, it can also:

1. create business opportunities that cater to the agricultural sector, such as implement dealers, lending institutions and farm and ranch supply stores; and
2. preserve the agricultural heritage of Wyoming and the West.

- Impacts to water rights. As discussed previously, all but the most senior water right holders in the Watershed require the use of stored water for irrigation purposes, once annual springtime runoff has been completed. Due principally to impacts to wetlands and areas in which the "Waters of the U.S." are located, development of additional storage facilities has become increasingly expensive and difficult. With many of the proposed improvements focusing on reduction of water waste, this means that less stored water is needed, thereby reducing pressure to build additional storage to meet increasing demands.

  Correspondingly, recent decisions made regarding the MT v. WY lawsuit on the Yellowstone River Compact resulted in Montana's increased oversight of the provisions stipulated in the Compact (Schroeder 2017). The result of this increased enforcement will both deter possible construction of new water storage facilities (because, per the Compact, 60% of all of the post-1950 water belongs to Montana) and require Wyoming to release water for pre-1950 water rights in Montana, which it has not done previously.

Proposed improvements relating to new surface water storage opportunities offer the following benefits to those residents and businesses residing in the Watershed:

- Increased water use efficiency. For the PK/Alliance Stockwater Dam Enlargement, which is the smallest of the three surface water opportunities identified in the Watershed Management and Rehabilitation Plan, this project proposes to take advantage of water

currently being unused and capturing it to provide additional stock water. Use of this water is seen as increasing overall water use efficiency. For the two larger proposed surface water storage opportunities, (i.e., Lake DeSmet Reservoir and Gillespie Draw Reservoir), increased water use efficiency will be gained for the following reasons:

- Lake DeSmet Reservoir: Currently this 235,000-A-F capacity reservoir provides storage water to relatively few users. Those currently utilizing Lake DeSmet Reservoir are downstream irrigators along Piney Creek and Clear Creek. The 2008 HKM Level I Study on Lake DeSmet Reservoir estimated the annual loss due to evaporation and seepage was just under 4,000 A-F. Making use of this water in the Watershed can offset the cost associated with this evaporation/seepage loss by providing a revenue source to the owners of Lake DeSmet Reservoir for any stored water used in the Watershed.
- Gillispie Draw Reservoir. This project proposes storage of Big Goose Creek water during the non-irrigation season and during spring runoff, when excess water is available in the stream. With the City owning an 1882 direct flow right that can conceivably be utilized to store water during the non-irrigation and spring runoff times, its pre-1950 designation will allow Wyoming to capture this water for summertime use and attenuate problems associated with Montana placing a call on post-1950 use to meet the demands of its pre-1950 rights, which include the filling of Tongue River Reservoir.

- Sustainability. Development of surface water for storage has always been of long-term benefit to Wyoming and the western United States, as it has both provided a supply of water for agricultural, industrial, municipal, domestic and stockwatering purposes during the late summer and fall when direct flow supplies have been depleted. As opposed to "mining" groundwater from formations that do not recharge, the annual cycle of accumulating snow followed by springtime runoff presents a long-term, sustainable water source that can be captured via the use of storage facilities.

- Impacts to water rights. Per the discussion for increased water use efficiency, development of surface water storage can reduce pressure on direct flow rights (because of the ability to augment direct flow with stored water) and attenuate effects imposed upon Wyoming water users within the Watershed that may be negatively affected by increased administration of the provisions in the Yellowstone River Compact.

The proposed improvements relating to upland water opportunities can enhance the ability to graze lands that cannot otherwise be grazed due to lack of available stockwater. It has been estimated that cattle will roam no more than 600 – 800 feet from a water source. http://fsrc.cafnr.org/distance-cattle-travel-to-water-affects-pasture-utilization-rate/ The proposed projects are examples of the type of projects that make use of these otherwise ungrazed lands by reducing the length to a water source.

Proposed improvements relating to fisheries mitigation all deal with enhancements that allow for fish to migrate both upstream and downstream. Such migration can sustain or even grow existing fish populations. For all but the City of Sheridan's diversion dam, the proposed fisheries migration projects are irrigation diversion dams already in need of replacement (due to obsolescence or malfunction). These projects will therefore offer the secondary benefit of allowing for fish passage.

4.4 Projects Warranting Further Discussion

Of the various projects listed in Table 4.2.1, and as described in Appendix A, some of these warrant additional discussion and analysis. Those projects are:

- Irrigation System Infrastructure (ISI) projects relating to the Alliance Lateral Ditch (ALL) and Wild Rose system (Wild Rose);
- the following Surface Water Storage Opportunities projects:
  - Gillispie Draw Dam and Reservoir (SWS0-02) Surface Water Storage Opportunity Project; and
  - the following Lake DeSmet Reservoir Transbasin Diversion Surface Water Storage Opportunity Projects:
    - Municipal Water Source (SWSO-03);
    - Irrigation Water Source (SWSO-04); and
    - Watershed Supplemental Supply Source (SWSO-05).

Discussion and analysis on each of these projects are provided in the following subsections.

4.4.1 Irrigation System Infrastructure (ISI) Projects Relating to the Alliance Lateral Ditch (ALL) and Wild Rose System (Wild Rose)

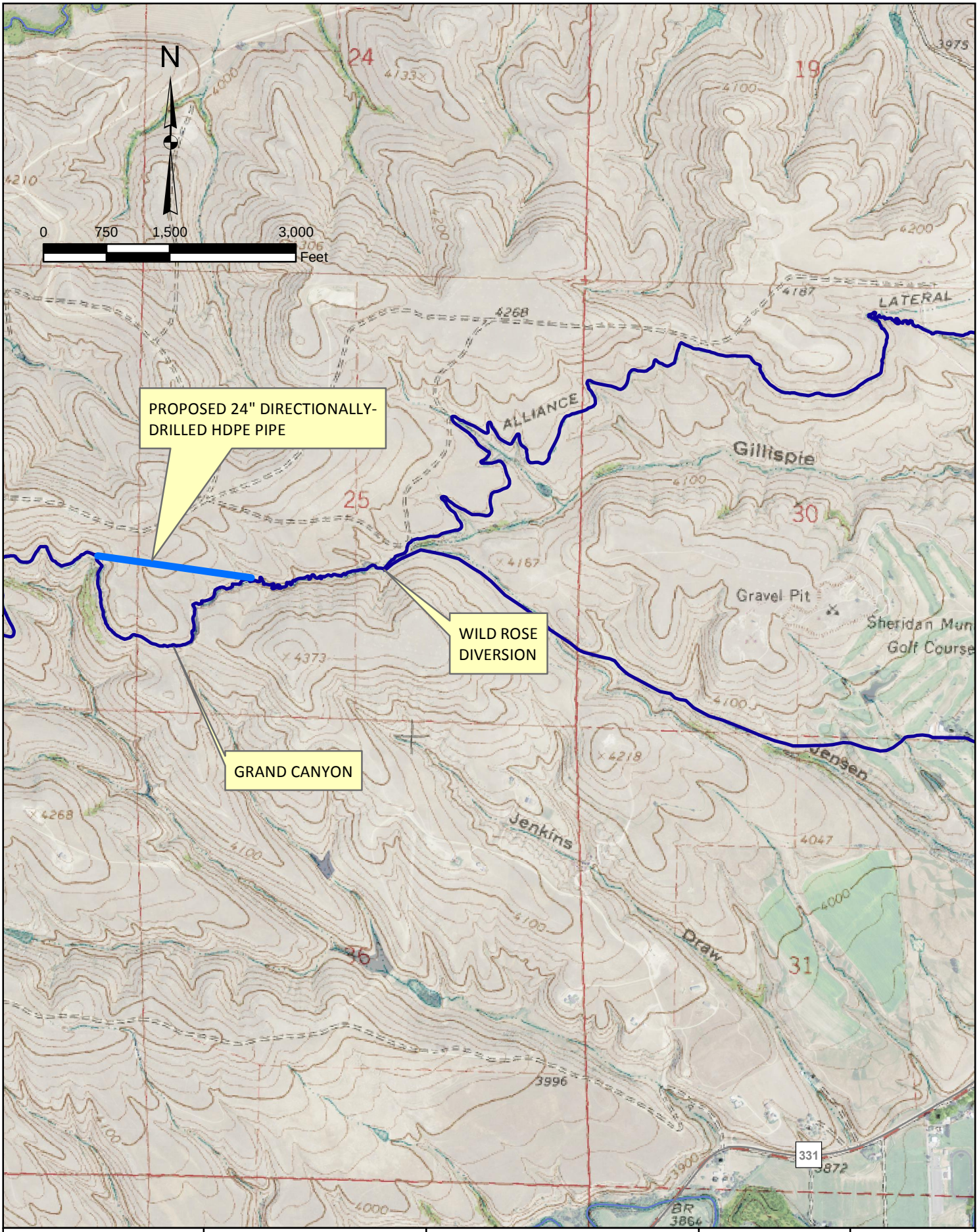
4.4.1.1 Proposed Solutions for Alliance Lateral Ditch

4.4.1.1.1 Directionally-drilled Pipe at Grand Canyon

Figure 4.4.1 – Sloughing in Grand Canyon of the Alliance Lateral Ditch

The majority of the projects identified for the Alliance Lateral Ditch in Table 4.2.1 and Appendix A relate to sloughing of the existing ditch either directly or indirectly (e.g., replacement of culverts originally installed in areas of sloughing). Of those projects, by far the largest and most expensive is Project ISI-BG-ALL-17: Alliance Lateral Ditch Culvert Installation 6. This project proposes to remedy the current situation faced by the Alliance Lateral Ditch Company relating to the Grand Canyon, which was previously discussed in Section 3.8. (See Figure 4.4.1.) It is also likely the most important project for the Alliance Lateral Ditch Company, as ongoing maintenance issues associated with the sediment generated due to sloughing of sideslopes and conveyed by ditch water or precipitation runoff are expensive and time-consuming. (According to the manager of the Alliance Lateral Ditch system, there are no siltation issues throughout the length of the ditch except for the area immediately below the Grand Canyon [Bateman 2017].) Additionally, there is a concern that a major slough occurring at the Grand Canyon during critical periods of irrigation deliveries (e.g., July or August) could prove disastrous for downstream irrigators.

Project ISI-BG-ALL-17 proposes that the remedy for the Grand Canyon sloughing problem be the installation of a 24" directionally-drilled pipe in a location that would eliminate the existing "oxbow" of the Alliance Lateral where the Grand Canyon now exists. Figure 4.4.2 portrays this proposed project. In discussions with local directionally-drilling companies, a project of this pipeline length (1,850 feet) and size (24") is technically feasible. An inlet structure would be constructed at the beginning of the directionally-drilled pipe within the ditch, and an energy dissipation structure would be constructed at the end of the pipe to prevent erosion from occurring. Provisions would be made for safely diverting additional water away from the



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	***GOOSE CREEK WATERSHED LEVEL I STUDY***	***ALLIANCE LATERAL DITCH DIRECTIONALLY-DRILLED PIPE***	***FIG. 4.4.2***

proposed structures that may periodically flow down the ditch during large precipitation events. The cost estimate for this project is shown in Appendix A.

Use of directionally-drilled pipe vs. installing pipe within the canyon itself with traditional open-cut methods is proposed due primarily to safety concerns. Given the steep and unstable sideslopes of the existing canyon (as verified by the continued ongoing sloughing that occurs), operation of construction equipment and related manpower in the depth of the cut would likely be very dangerous. Added to these safety concerns is the mere fact that the length of pipe needed for the directionally-drilled pipe would be approximately 1,850 feet in comparison to the approximate 3,300 feet if the pipe was laid along the alignment of the existing oxbow.

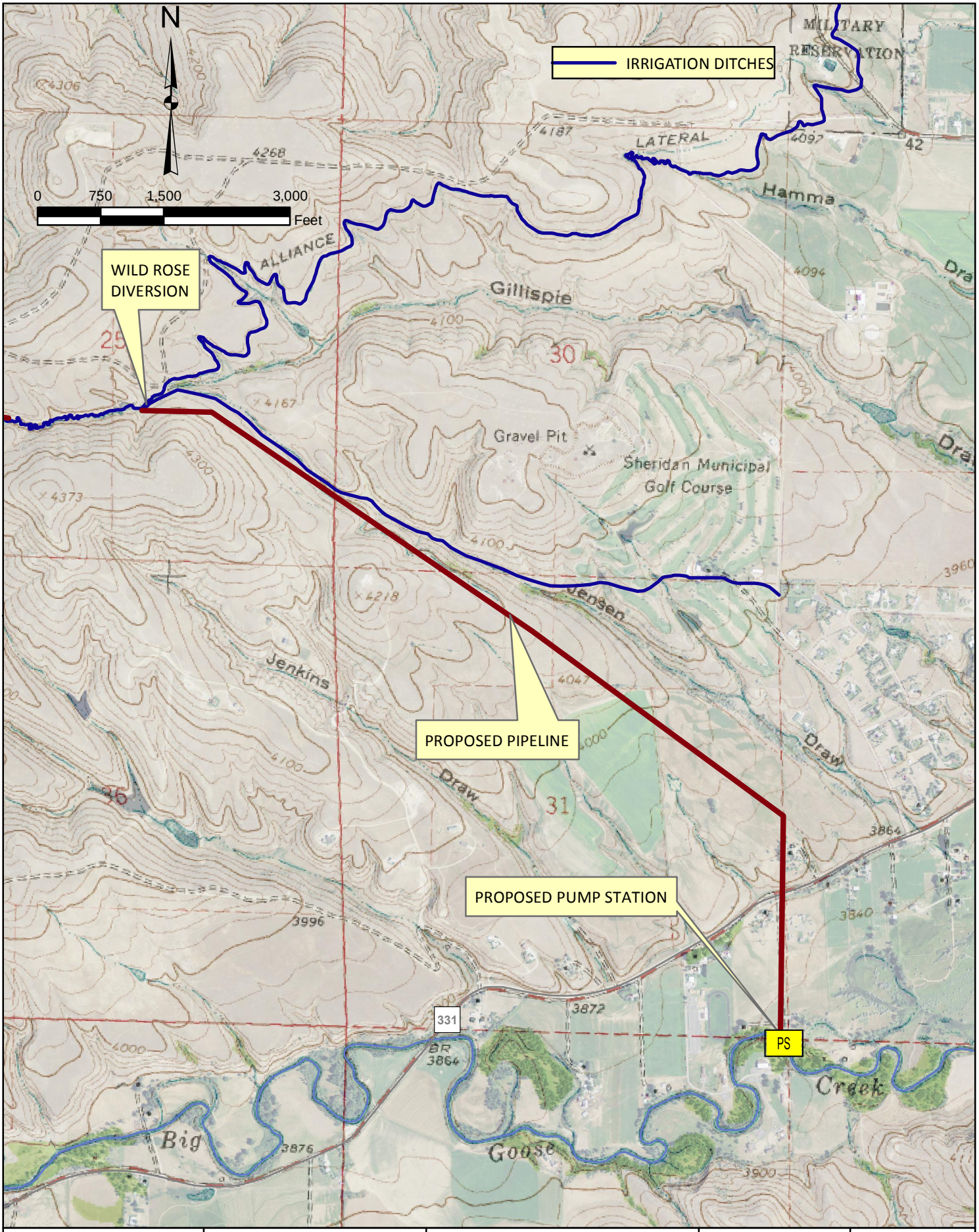
Due to the considerable cost associated with this project (see Appendix A), it may prove advantageous to form a special district or other public entity that would provide a means to access public funds that could offset a major portion of this cost. Alternatively, it may be possible for the Alliance Lateral Ditch Company to approach the Wild Rose I&S District (being a special district eligible for public funds) to act as the vehicle to access these funds. More information about the formation of a public entity – and thus becoming eligible for public funding – is found in Section 6.

4.4.1.1.2 Conveyance of Alliance Lateral Ditch Down Big Goose Creek

The Grand Canyon is just one location of many along the Alliance Lateral Ditch's alignment where sloughing and/or seepage are an ongoing maintenance issue. Figure 4.2.2 showed 20 projects identified in Table 4.2.1 and Appendix A that relate exclusively to the Alliance Lateral Ditch. Of these 20 projects, 17 of them are directly or indirectly related to sloughing and/or seepage either above or below the ditch. (The sloughing/seepage-related projects include those in which culvert improvements are recommended, which were originally installed due to sloughing or seepage issues.)

Figure 4.2.2 also shows the location of the Alliance Lateral Ditch turnout off of the Alliance Ditch, as well as its first delivery turnout, which is the Wild Rose system and Big Goose Ditch. The "ditch distance" between these two points is approximately 10.6 miles. Along this 10.6-mile section are the 17 proposed projects to remedy sloughing stated above (which includes culvert extensions or culvert replacements). ISI-BG-ALL-17 (the proposed project to remedy the Grand Canyon) is one of those projects. The number of proposed projects related to sloughing along the Alliance Lateral Ditch highlights the fact that this ditch has and will continue to incur considerable expense in maintaining a long reach of ditch before it makes its first water delivery. Added to that fact are related maintenance costs associated with the conveyance of Alliance Lateral Ditch water in the Alliance Ditch from the latter's point of diversion on Big Goose Creek to the Alliance Lateral Ditch turnout from the Alliance Ditch.

In lieu of continuing to incur these maintenance costs (which will likely increase with time), the Alliance Lateral Ditch Company should consider changing its historical point of diversion from Big Goose Creek at the Alliance Ditch diversion structure (located just downstream from the mouth of Big Goose Creek canyon) downstream to a point much closer to its existing points of use. Figure 4.4.3 depicts the location for a proposed pump station and pipeline that would divert and convey Alliance Lateral Ditch irrigation water from Big Goose Creek to a point immediately upstream of the Wild Rose turnout. Table 4.4.1 depicts the estimated cost associated with such a project.



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	***GOOSE CREEK WATERSHED LEVEL I STUDY***	***PROPOSED PIPELINE PROJECT FROM BIG GOOSE CREEK TO ALLIANCE LATERAL DITCH***	***FIG. 4.4.3***

Table 4.4.1 - Capital Cost Estimate for Pump Station and Pipeline to Deliver Water to Alliance Lateral Ditch Directly from Big Goose Creek

Item	Total
Transmission Pipeline	$ 1,962,675
Pump Station	$ 638,000
Construction Subtotal	$ 2,600,675
Construction Contingency (10%)	$ 390,200
Subtotal	$ 2,990,875
Engineering & CA (20%)	$ 598,200
TOTAL PROJECT COST	**$ 3,589,075**

This alternative means of delivering water to Alliance Lateral Ditch customers offers the following advantages and disadvantages:

Advantages

1. The need to operate and maintain the +/-10.6-mile section of the Alliance Lateral Ditch upstream of the first (i.e., Wild Rose and Big Goose Ditch) delivery turnout would be eliminated. This would reduce long-term operation, maintenance and replacement costs for the Alliance Lateral Ditch Company associated with the +/-10.6-mile length of ditch, including the Grand Canyon.

2. Costs to operate and maintain the Alliance Ditch would be correspondingly reduced because it would no longer convey Alliance Lateral Ditch water.

3. Additional flow would exist in Big Goose Creek between the existing and proposed new points of diversion from this creek. This additional flow would be beneficial for fisheries and other wildlife.

Disadvantages

1. The costs to construct, operate and maintain the required intake structure, pump station and pipeline are substantial. However, if one were to compare these costs to future anticipated costs to continue to repair sloughs along the +/-10.6-mile length of Alliance Lateral Ditch (as well as to install the directionally-drilled pipe needed to address the Grand Canyon situation), this concept may prove to be more cost-effective over time.

2. This concept requires a change in the point of diversion for the Alliance Lateral Ditch's Big Goose Creek's direct flow rights, from the existing diversion point at the Alliance Ditch diversion structure to the proposed new diversion point further downstream. Such a change requires approval by the BOC after notifying and receiving input from intervening appropriators. Most of the Alliance Lateral Ditch's direct flow rights have priority dates of 1906 or later, thus they are fairly junior and go out of priority fairly soon after runoff. However, storage water conveyed by the Alliance Lateral Ditch comes from Dome Lake, Sawmill and Park Reservoirs, none of which has storage water attached to lands. As a result, this storage water can move to this alternative point of diversion without the need for formal BOC approval. BOC approval will still be necessary, however, for a new point of diversion.

Should the storage water be conveyed down Big Goose Creek to a new point of diversion, BOC officials would be responsible for "shepherding" this water through the various diversion points downstream to the new point of diversion. This procedure would be analogous to the current procedure that the BOC uses to "shepherd" Dome Lake Reservoir storage water down Soldier Creek for delivery to the Soldier Creek Ditch Company's diversion point, located north of the City. That said, BOC officials have preliminarily indicated that Big Goose Creek is a "losing" stream, which may not be the case for Soldier Creek. These officials have also indicated that the sheer number of diversion points along Big Goose Creek when compared to Soldier Creek could render conveyance of this stored water to a new downstream diversion point on Big Goose Creek a more difficult administrative procedure than the conveyance of the Dome Lake Reservoir water down Soldier Creek (Boyd 2017).

4.4.1.2 Proposed Solutions for Wild Rose

In Section 3.8, the following existing problems/issues were listed for the Wild Rose system:

1. High sediment loads resulting from upstream erosion in the Grand Canyon create a large maintenance problem at the diversion structure. Deposited silt and debris must be manually removed from this structure on a daily basis throughout most of the irrigation season.
2. The volume of Park Reservoir storage water may be insufficient to meet the needs of the Don Ena Estates Subdivision during dry years when the I&S District's direct flow right cannot be utilized.
3. Existing agreements with the owner of the Sheridan Heights Ranch regarding rights-of-way and water exchanges are due to expire in 2018. The District is concerned that if, for whatever reason, these agreements are not successfully extended or renegotiated, it could be left without a reliable irrigation water supply.
4. The existing 6" meter that measures irrigation water as it enters the subdivision is old and in need of replacement.
5. The slide gate and shaft that are operated to allow water stored in Wild Rose Reservoir to flow to the subdivision are old and in need of replacement.
6. Rip rap should be placed on the upstream face of the Wild Rose Dam.

Table 4.2.1 and Appendix A identify two projects relating to the Wild Rose system which propose solutions to Problems 4, 5 and 6 listed above. Those two projects are:

1. ISI-BG-WR-01: Wild Rose Meter Replacement; and
2. ISI-BG-WR-02; Wild Rose Dam Improvements.

Discussion on the first three (i.e., remaining) Wild Rose problems/issues follows below.

<u>High Sediment Loads Creating Maintenance Problems at Wild Rose Diversion Structure.</u> The overall objective of the Wild Rose I&S District is to deliver irrigation water to its supply reservoir, from which this water is conveyed via a 6" and 8" pipeline to the Don Ena Estates for use. The high sediment loads resulting from being downstream of the Grand Canyon, in addition to floating debris being conveyed down the Alliance Lateral Ditch, are impeding this delivery to the reservoir. There appear to be two remedies to address this situation:

1. Reduce sediment loads coming from the Alliance Lateral Ditch, or
2. Relocate the Wild Rose diversion structure to a location where sediment is not as significant of an issue.

For the reduction of the sediment loads, two options can be considered. One option is for the Alliance Lateral Ditch to address the continued sloughing occurring in the Grand Canyon. As was discussed previously, conversations with the Alliance Lateral Ditch manager indicated that the only sediment issue along the entire Alliance Lateral Ditch was below the Grand Canyon. If the Alliance Lateral Ditch Company completes the project identified as ISI-BG-ALL-17: (Alliance Lateral Ditch Culvert Installation 6, which was also discussed in the previous Section 4.4.1.1.1), the Grand Canyon can be bypassed, and sediment loading in the Alliance Lateral Ditch in the vicinity of the Wild Rose diversion would be greatly reduced.

A second option to reduce sediment loads would be for the Alliance Lateral Ditch Company to implement the project discussed in Section 4.4.1.1.2, which proposes to convey Alliance Lateral Ditch water downstream in Big Goose Creek to a location much closer to its first delivery point; i.e., immediately above the Wild Rose and Big Goose Ditch diversion. As discussed, this option would eliminate the continued cost to maintain the approximate 10.6 miles of Alliance Lateral Ditch from its diversion out of the Alliance Ditch to the Wild Rose diversion. The +/-10.6 mile section includes the Grand Canyon.

Regarding the relocation of the Wild Rose diversion structure, proposed Project ISI-BG-WR-03 (Wild Rose Headgate Improvements) recommends relocation of the diversion structure to a point on the Big Goose Ditch in lieu of directly off of the Alliance Lateral Ditch. (The Big Goose Ditch conveys approximately 1 cfs to two downstream water users. The horizontal distance between the turnout for Wild Rose and the Big Goose Ditch is approximately 30 lineal feet.) In actuality, this "new" diversion point off of the Big Goose Ditch has been in use for several years, providing water to the Wild Rose Reservoir when the existing Wild Rose turnout structure on the Alliance Lateral Ditch is unavailable or cannot deliver enough water. The recommended project, however, also includes (among other appurtenances) the installation of a measuring device and an automatic control mechanism to allow for remote monitoring and operation of water deliveries. As part of this project's implementation, it is also important that a formal agreement be reached with the other two users of the Big Goose Ditch, if one has not been reached previously.

<u>Insufficient Volume of Park Reservoir Storage Water.</u> The Wild Rose I&S District currently owns 72 A-F of Park Reservoir storage water. Standard practice regarding use of this water has been for the BOC and various ditch companies to assess the following conveyance losses:

- 10% from Park Reservoir to the Alliance Ditch diversion structure;
- 10% from the Alliance Ditch diversion structure along the Alliance Ditch to the Alliance Lateral Ditch diversion structure; and
- 10% from the Alliance Lateral Ditch diversion structure along the Alliance Lateral Ditch to the Wild Rose diversion structure.

Based upon these conveyance losses, the actual amount of Park Reservoir water available to Wild Rose at its diversion point is calculated to be 52.5 A-F. Typically, Wild Rose orders its Park Reservoir water at the minimum allowable flow rate, which is 0.5 cfs. As a result, "net" Park Reservoir water is delivered to the Wild Rose diversion at a rate of 0.36 cfs (Bateman 2017).

Wild Rose has a 1987 direct flow water right issued by the WSEO for the amount of 0.2 cfs. The 0.2 cfs flow rate is the same flow capacity as derived from the capacity of the 3" pipeline that conveys irrigation water from its diversion structure on the Alliance Lateral Ditch to the Wild Rose water supply reservoir. However, because Park Reservoir water is

stored water (vs. direct flow), Wild Rose can utilize its 52.5 A-F water at any flow rate it desires, subject to:

- its call for water made to the operator of Park Dam and Reservoir; and
- the available flow capacity in the Alliance and Alliance Lateral Ditches.

Thus, there is no problem in receiving 0.36 cfs of water even though the Wild Rose direct flow right is 0.2 cfs – as long as Wild Rose can physically divert water at the 0.36 cfs flow rate. Based upon the calculated 0.2 cfs flow capacity of the 3" pipeline, this means that Wild Rose must utilize its diversion from Big Goose Ditch in order to fully utilize its Park Reservoir water over and above 0.2 cfs.

Wild Rose's 1987 direct flow right is the most junior right conveyed in the Alliance Lateral Ditch. The majority of the Alliance Lateral Ditch direct flow water being conveyed has a priority date of 1906. While the 1906 rights are senior to Wild Rose's, they are nonetheless relatively junior rights on Big Goose Creek. As a result, when Big Goose Creek goes into regulation, both the 1906 rights and 1987 right are essentially cut off simultaneously. The Alliance Lateral Ditch manager has historically treated them the same from an administrative standpoint; i.e., once he receives notice that the 1906 rights are out of priority, he notifies all users of the Alliance Lateral Ditch that they must begin utilizing their stored water, which comes from Park, Sawmill or Dome Lake Reservoirs in the Big Horn Mountains. For most years, this notification occurs around the 2nd or 3rd week of July. However, according to the Alliance Lateral Ditch manager, he has received this notification as early as the end of June when snowpack and resulting runoff levels are significantly below average.

Using 10-year metered water use data provided by the I&S District, Figure 4.4.4 portrays the existing need for Park Reservoir water based upon historical usage of Park storage water (Wild Rose I&S District, 2017). Wild Rose metered water use for each of the ten years was compared to the need for Park Reservoir water during an "average year" (i.e., when Big Goose Creek regulation begins during the 3rd week of July) as well as during a "dry year" (i.e., Big Goose Creek regulation begins at the end of June due to low snowpack and runoff.) Note that:

5. for an "average year", there was sufficient water available from Park Reservoir during all ten years, but that
6. for a "dry year", there would have been an insufficient supply from Park Reservoir to meet the demands in 2012.

As Wild Rose representatives have not indicated that additional water purchases were made in 2012, this means that 2012 must have been an "average year" regarding available direct flow from Big Goose Creek.

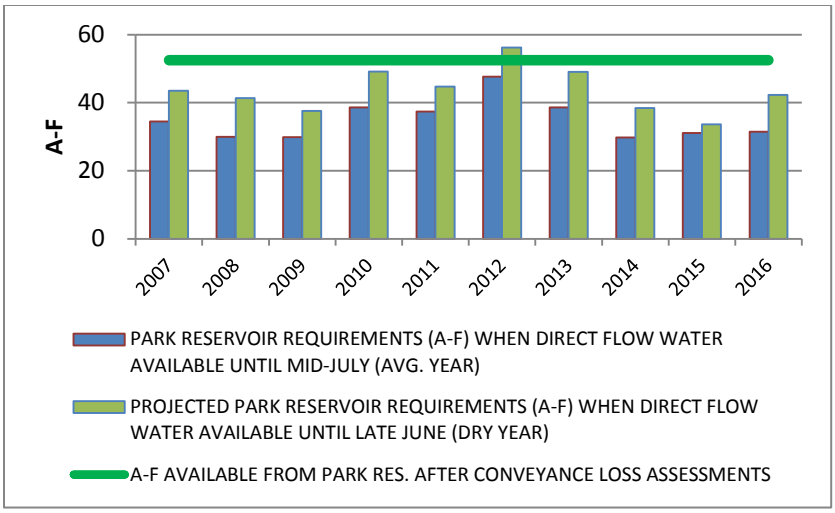


Figure 4.4.4 – Need for Park Reservoir Water by Wild Rose based upon Historical Usage

Based upon this analysis, it appears that there is enough Park Reservoir water available to Wild Rose in 9 out of 10 years. In order to make sure that sufficient water is available to Wild Rose in 10 out of 10 years, it initially appears that additional Park Reservoir water should be purchased.

An alternative to purchasing additional Park Reservoir water would be to file for more direct flow rights over and above the currently allocated 0.2 cfs, enlarge the Wild Rose Dam and Reservoir, and – by so doing – make available additional late season water. Due to the limited capacity of the 3" line, this alternative would also require increasing the capacity of the Big Goose Ditch from its turnout point on the Alliance Lateral Ditch to the point that water is turned out of the Big Goose Ditch into a pipeline that cascades downhill to fill the Wild Rose Reservoir. Increasing the capacity of this ditch section would require approval of the other landowners utilizing this ditch.

A major impediment to utilizing either of the two above-mentioned water supply alternatives, however, is the limited conveyance capacity in the Alliance Lateral Ditch. As was discussed previously, the existing capacity of this ditch has been reported to be 13 cfs. The original capacity of the ditch was 15-17 cfs; however, because the ditch has not been cleaned for quite some time, any flow greater than 13 cfs results in overtopping of the ditch bank. The 13 cfs delivery capacity must meet the needs of both Wild Rose and the following users downstream of the Wild Rose diversion:

1. Sheridan Heights and LD Ranches;
2. Hidden Bridge Golf Course;
3. the new development that occupies the old Sheridan Country Club site;
4. the "Villagers" and other irrigation water users along W. 5th Street; and
5. a stockwater reservoir in the Soldier Creek drainage.

Per the Alliance Lateral Ditch manager, all of these needs cannot be met simultaneously due to the limited 13 cfs of ditch capacity. As a result, there appear to be two options available to Wild Rose to allow for increased Park Reservoir water or direct flow water deliveries to its turnout point:

1. convince the Alliance Lateral Ditch Company to clean the +/-10.6-mile upstream ditch in order to increase capacity; or
2. implement the project discussed in Section 4.4.1.1.2, which proposes to convey Alliance Lateral Ditch water downstream in Big Goose Creek to a location much

closer to its first delivery point (i.e., immediately above the Wild Rose diversion) and then pump water from Big Goose Creek into the Alliance Lateral Ditch. If Wild Rose would like to obtain water from this pumping system over and above its historical use, the new facilities proposed with this alternative could be increased in size to allow for higher flow rates being delivered.

Existing agreements with the owner of the Sheridan Heights Ranch regarding rights-of-way and water exchanges are due to expire in 2018. These agreements are a matter between Wild Rose and the owner of the Sheridan Heights Ranch. While no recommendations are provided in this Level I Study to address the concerns that are preventing an extension of these agreements, it is hoped that information contained in this study can form the basis for successful negotiations.

4.4.2 Gillispie Draw Dam and Reservoir (SWS0-02) Surface Water Storage Opportunity Project

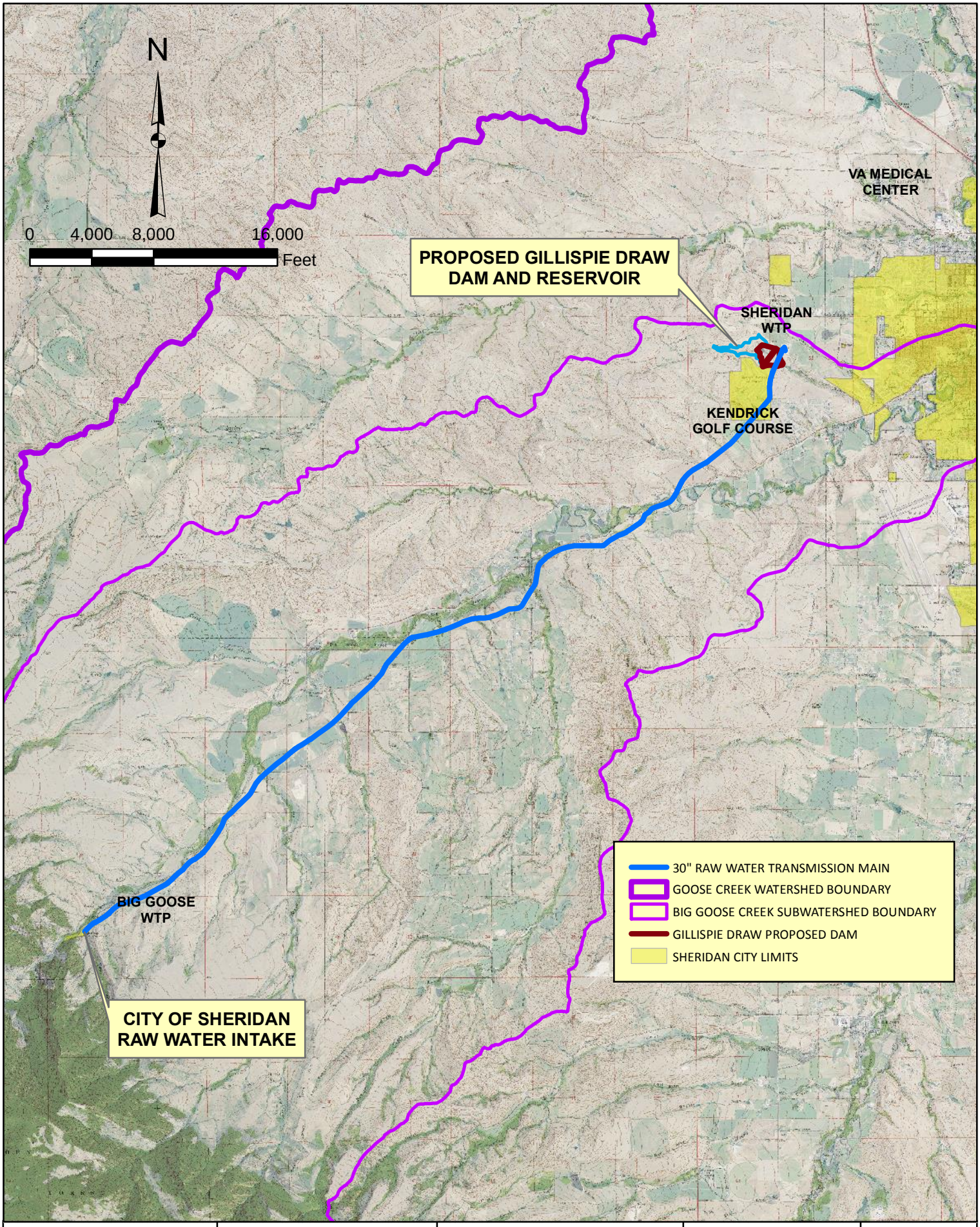
Gillispie Draw has been considered since the 1960s as a potential location for additional storage for the Sheridan area water system. The facility configuration analyzed in the 2011 Dowl HKM study is depicted in Figure 4.4.5 and consists of an earthen embankment in the Gillispie Draw channel very near the SWTP. Portions of the dam or reservoir would actually be located within the Sheridan city limits. As a result of this close proximity, it provides opportunity for multiple use. A recreational facility comprised of parkways, wildlife habitat improvements and picnic areas could easily be incorporated into the project at this location.

The 2011 Study investigated several sizes and locations along Gillispie Draw for such a dam and reservoir site. These investigations resulted in the recommendation to construct a reservoir with a capacity of 2,660 A-F at normal high water line. A dam containing a reservoir of this capacity would have a maximum dam height of approximately 115'. This dam height, coupled with the recommended reservoir volume, places this alternative in the WSEO's high-hazard classification.

The reservoir would be filled from the existing 30-inch raw water main that currently supplies the SWTP and VAMC. The 30-inch main would be utilized during times when Big Goose Creek is not in regulation, i.e., when excess flow is available for diversion at the City intake. Diversion of the water to fill Gillispie Draw Reservoir would occur beginning in October and extend through April, prior to irrigation season demands being placed upon Big Goose Creek. The stored water would then be pumped into the SWTP when demand necessitated its use during the summer months. Per the 2011 study, a firm yield of 2,000 A-F per year could be realized for Gillispie Draw Reservoir storage while maintaining a minimum base flow in Big Goose Creek at all times of approximately 15 cfs. This operational strategy would in theory mollify possible concerns that may be raised by the WG&FD of possible environmental impacts along Big Goose Creek, due to depletion of historical flows during the non-irrigation season.

Although no active faults were identified in the 2011 study within the proposed Gillispie Draw dam and reservoir area, there are several areas in the vicinity of the project site where landslides have occurred. This is a result of the Fort Union Formation and overlying colluvium containing high plasticity materials. As a result, the 2011 Study recommended a homogeneous earthfill dam with the following attributes:

- a dam crest width of 15 feet;
- an impervious core section (15 feet wide at the crest) that would have a 0.5 to 1 slope extending down to solid bedrock.
- relatively flat upstream slope of 10H:1V and a downstream slope of 7.5H:1V; and



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- a grout curtain for the entire length of the embankment due to the potential for significant seepage in the highly permeable zones of the sandstone and coal layers of the bedrock.

Three significant disadvantages exist with this alternative, all dealing essentially with operational parameters that must be followed. First of all, because of the proposed location for Gillispie Draw Reservoir, water could only be utilized from this proposed reservoir at the SWTP; i.e., it could not be used at the BGWTP. This problem could theoretically be partially rectified by using more existing City/SAWSJPB direct flow and storage water at the BGWTP, resulting in less of this water being conveyed down the 30" raw water main during the irrigation season.

The second disadvantage to this alternative is the fact that the water quality entering the SWTP from the Gillispie Draw Reservoir will not be of the same high level as what now is delivered via the 30" raw transmission main directly to the SWTP. Currently, raw water entering the 30" transmission main is diverted at the City intake, located at the mouth of the Big Goose Creek canyon. This raw water is usually of very high quality, typical of most mountain streams. However, in the case of the Gillispie Draw Reservoir water, it will be delivered during the non-irrigation season and stored until needed – oftentimes not until late summer or early fall. This raw water will degrade in quality with time as it resides in the reservoir, with the potential for vegetative growth as the water warms and runoff occurs from upstream agricultural lands.

The third disadvantage of using water in Gillispie Draw Reservoir is that pumping facilities will be required to boost water from the reservoir into the SWTP. At the present time, raw water is delivered to both water treatment plants via gravity. Gravity flow would also be the means by which Park or Sawmill water would be conveyed to the two water treatment plants. However, use of Gillispie Draw Reservoir water would require construction and operation of a pump station near the downstream toe of the reservoir.

Public acceptance of new storage opportunities in Gillispie Draw has been mixed. Because of the close proximity to developed areas of the City, a number of residents have expressed concern regarding safety. Because of its likely "high hazard" classification, it could possibly elicit public concern. However, it seems possible that public acceptance of a new storage facility at this location could be obtained, provided it is shown to be the most viable alternative and if other benefits could be demonstrated.

Impacts to an estimated 9.4 acres of existing wetlands will occur if this project is constructed. The existing wetlands are comprised of 4.5 acres of wet meadow, 3.6 acres of shallow marsh and 1.3 acres of open water, which could be mitigated by permittee-responsible methods. A typical mitigation ratio for the wetlands at this site is 2.0, meaning that the total mitigation area could be 18.8 acres. The best opportunity for mitigation success would be to create wetlands immediately downstream of the proposed embankment. It is assumed that the USACOE would consider such mitigation appropriate due to the fact that these wetlands are not of the same high quality as wetlands that occur in the Big Horn Mountains that could potentially be impacted if other, high mountain sites are proposed for a reservoir storage project in lieu of Gillispie Draw.

4.4.3 Lake DeSmet Reservoir Transbasin Surface Water Storage Opportunity Projects

4.4.3.1 General

Due to the considerable amount of water potentially available in Lake DeSmet Reservoir and the allocation for municipal use, this reservoir is included in the listing of viable alternatives for long-term water supply for the Sheridan area water system. It has been the subject of several studies

over the last three decades with respect to the possibility of using it as a potential municipal water supply, principally for the Sheridan regional area. Those studies are:

- HKM Engineering, Swig/Sheridan Area Development Analysis Level II, Final Report, Nov, 1988;
- HKM Engineering, Final Report, Swig/Sheridan Area Water Supply Study Level II, Stage II, Jan, 1990 ;
- HKM Engineering, Lake DeSmet Level II Master Plan and Reservoir Rehabilitation Plan, Final Report, Dec, 2003 ;
- HKM Engineering, City of Buffalo-Sheridan Area Water System-Lake DeSmet Level I Study, Final Report, Jun, 2008 ; and
- DOWL HKM, Sheridan Supplemental Supply Study Level II, Phase I, Final Report, May, 2011.

In addition, a November 2004 study entitled Lake DeSmet Level II Master Plan and Reservoir Rehabilitation Plan Phase 2: Final Report by Lake Engineering Consultants offered solutions to some problems at the dam and reservoir site.

Lake DeSmet Reservoir is a reservoir located in northern Johnson County, approximately 20 miles south of the City of Sheridan. It is located within the Piney Creek watershed, Piney Creek being a tributary of Clear Creek, a tributary of the Powder River. (See Figure 4.4.6.) Lake DeSmet Reservoir is currently a very popular recreational facility, providing an outstanding location for boaters, anglers, picnickers and sightseers.

At its full elevation of 4620 feet, Lake DeSmet Reservoir has a capacity of 234,987 A-F. However, it has been reported that significant leakage begins to occur at the east abutment of the North dam above elevation 4615 feet. As a result, the reservoir is operated so that the maximum water level never exceeds the 4615-foot elevation. The reservoir capacity at this elevation is approximately 218,172 A-F.

The reservoir is managed by Johnson County, which also owns many of the facilities and water rights (both direct flow and storage) associated with the reservoir. Johnson County obtained these facilities and 159,113 A-F of water rights from the Lake DeSmet Counties Coalition Joint Powers Board (LDCCJPB), a now-defunct governmental entity that was formed by Johnson County, Sheridan County and Campbell County for the purpose of receiving these same facilities and water rights from Texaco, which had originally developed them for the purpose of energy production (LDCCJPB 2012).

The Lake DeSmet Reservoir facilities now owned by Johnson County include:

- The North dam and outlet works and associated land;
- the South dike and associated land;
- the East dikes and spillways and associated land;
- land encompassing the lake up to the high water level of 4620;
- the Piney Creek diversion dam and associated land;
- the Piney Creek diversion tunnel; and
- an easement to the land up to 4630', and other access easements.

Included within Johnson County's total volume of 159,113 A-F are the following:

- Dead storage in the amount of 38,960 A-F, which is situated below the levels of Lake DeSmet dams' outlet works.
- Irrigation contract commitments amounting to 10,870 A-F. These commitments were originally made by Texaco and have been inherited by the various successors, including Johnson County.

- An amount of 2,500 A-F of storage each has been set aside for both Sheridan and Johnson Counties for municipal use. (The terms of the agreement dissolving the LDCCJPB stipulate that Sheridan County shall be entitled to utilize up to 2500 A-F annually of Lake DeSmet Reservoir water.) This 5,000 A-F total would come out of the more senior priority portion of LDCC storage rights (Permit 973R). As this permit does not list municipal as one of its uses, a petition would need to be submitted to the BOC to change this storage right's type of use.
- In 2014, Johnson County entered into an agreement with the WG&FD which leased for 99 years a volume of 66,024 A-F of its 159,113 A-F total water stored.

After subtracting the above allocations from the 159,113 A-F total, there is currently 38,259 A-F of storage space owned by Johnson County that is uncommitted and available for other currently undefined purposes.

The 2008 Level I Study analyzed the reservoir's firm yield from the storage rights now owned by Johnson County. Of the 159,113 A-F available, the 2008 study estimated that a firm yield of 52,500 A-F was in fact available over and above the 38,960 A-F of dead storage below the reservoir's outlets. After subtracting the irrigation contract commitments (10,870 A-F) and 5,000 A-F future municipal use commitment, this means that a firm yield of 36,630 A-F remains available for the WG&FD lease (66,024 A-F) and uncommitted purposes. Clearly, if Johnson County desires to market any of its excess storage to provide a firm yield water supply to a future user, there will be years when it cannot fill the volume of storage meant for the WG&FD.

Other entities also own water rights associated with Lake DeSmet Reservoir. Those entities are:

- State of Wyoming (purchased in 2018 from Sasol Synfuels International Pty Ltd., a South African company which originally secured them for energy development from the M&M Ranch Company, a sister company of the former PacifiCorp) (62,199 A-F);
- Lower Clear Creek Irrigation District, which utilizes water for irrigation downstream on Clear Creek (11,800 A-F);
- T Cross T, LLC (995 A-F); and
- the Belus Ranch, which utilizes water for irrigation along Box Elder Creek, a tributary of Piney Creek (880 A-F).

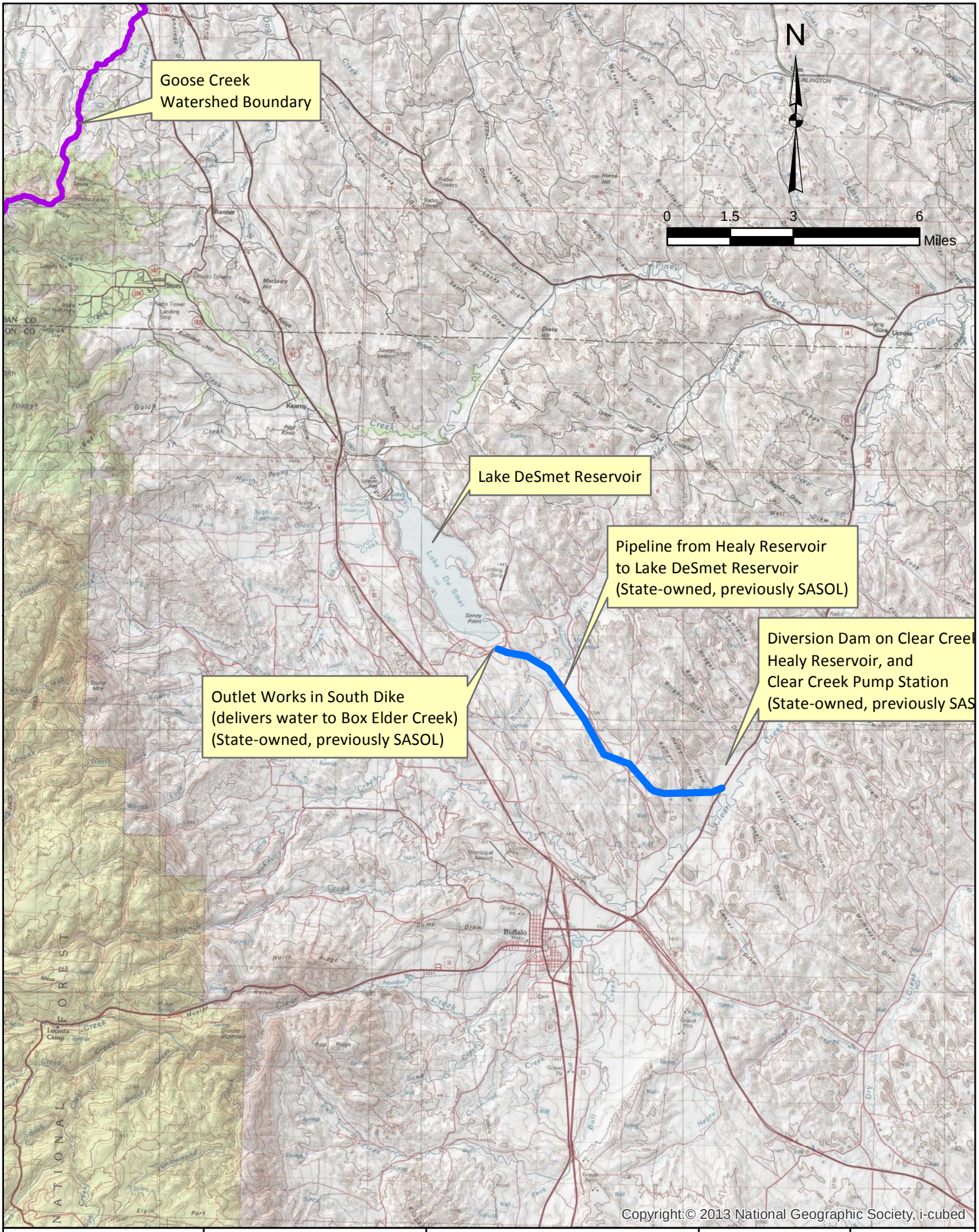
Other facilities associated with Lake DeSmet Reservoir are located in the Clear Creek watershed, and they are owned by the State as recently purchased from Sasol. These facilities include:

- a diversion dam on Clear Creek ;
- Healy Reservoir, an off-channel reservoir which stores water for pumping from Clear Creek into Lake DeSmet Reservoir;
- the Clear Creek Pump Station at Healy Reservoir;
- the pipeline which extends from Healy Reservoir to Lake DeSmet Reservoir; and
- the outlet works in the South dike which delivers water to Box Elder Creek.

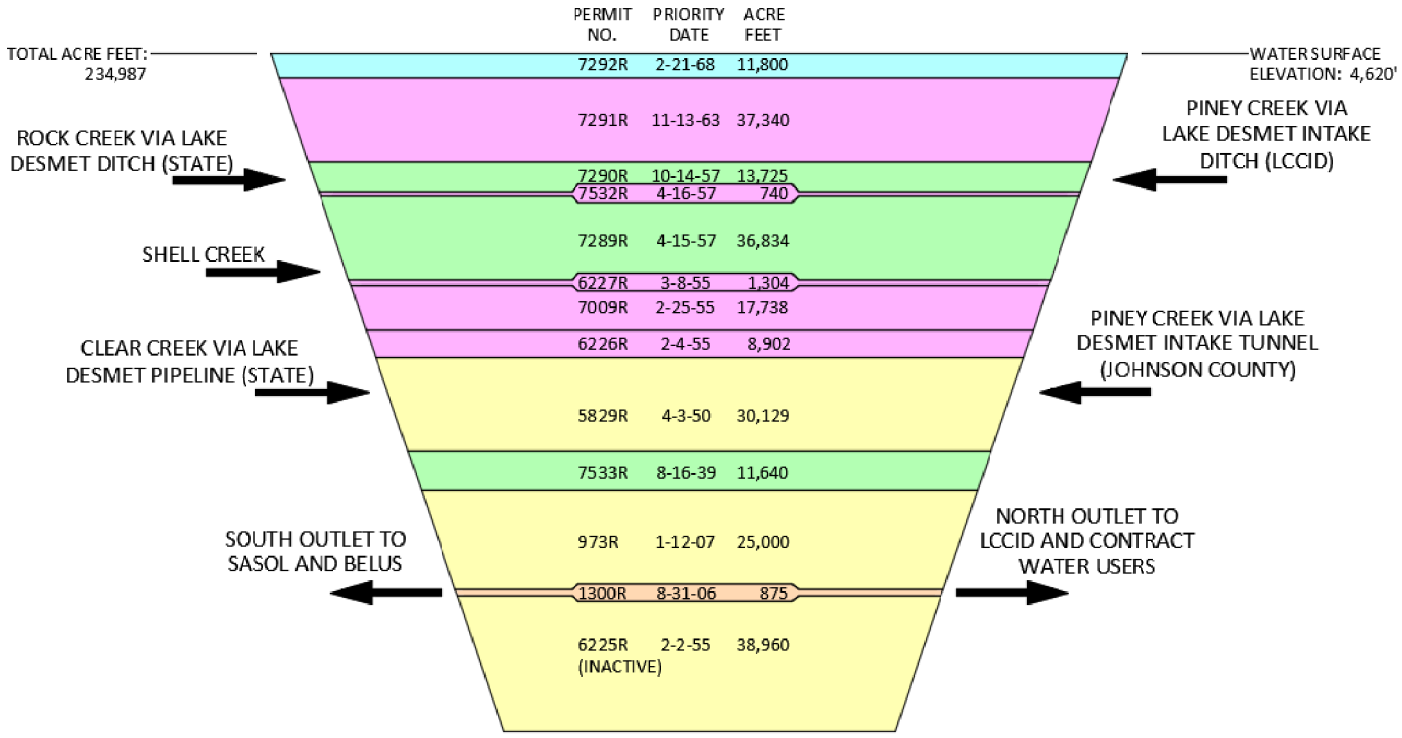
Figure 4.4.6 depicts the location of the facilities listed above with respect to Lake DeSmet Reservoir. Figure 4.4.7 portrays the various ownerships of water rights stored in the reservoir, including the water being leased by Johnson County to the WG&FD.

4.4.3.2 Water Quality

As part of the scope for the 2008 Level I Study, and as reported in both the 2008 and 2011 Level I studies, water quality of Lake DeSmet Reservoir was measured at various sites. Previous water quality studies had been performed over the years beginning in the 1950s. Table 4.4.2 shows the water quality information reported in the 2008 and 2011 studies.



EnTech Inc. Professional Engineers	SWCA / Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	***GOOSE CREEK WATERSHED LEVEL I STUDY***	***LAKE DESMET RESERVOIR AND STATE-OWNED FACILITIES***	***FIG. 4.4.6***



COLOR CODE FOR WATER RIGHTS OWNERS

- JOHNSON COUNTY
- JOHNSON COUNTY LEASED TO WYOMING GAME & FISH DEPARTMENT
- STATE (FORMERLY SASOL)
- BELUS
- LOWER CLEAR CREEK IRRIGATION DISTRICT

FROM: JUNE 2008 FINAL REPORT FOR THE CITY OF BUFFALO - SHERIDAN AREA WATER SYSTEM - LAKE DESMET LEVEL I STUDY, AMENDED TO PORTRAY 2018 PURCHASES BY STATE OF WYOMING FROM SASOL

EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	***GOOSE CREEK WATERSHED LEVEL I STUDY***	***LAKE DESMET RESERVOIR WATER RIGHTS***	***FIG. 4.4.7***

Table 4.4.2 - Lake DeSmet Reservoir Water Quality Data

Constituents	Remarks
Total Dissolved Solids and Conductivity	High, close to the EPA secondary Maximum Contaminant Level (MCL)
pH	High, but within standards
Turbidity, Total Suspended Solids	Low TSS, yet high turbidity in July
Alkalinity	High
Clarity (Secchi-Disk Depth)	Very clear in July, much clearer than measured historically
Chlorophyll *a*	Low concentrations, indicative of an oligotrophic-mesotrophic trophic state
Major Nutrients (Nitrogen and Phosphorus)	Concentrations place lake in oligotrophic-mesotrophic trophic state category and are lower than historical measurements for phosphorus
Major Ions	High sulfate and calcium
Other Inorganics	Most well below standards. Sulfide and aluminum high
Total Coliform	Typical of water with little anthropogenic impact
E. coli	Very low
Giardia and Cryptosproridum	Below detention limit
Hardness	Very hard
Organic Compounds	Organic carbon is above the level requiring reduction by water treatment plants. BTEX, MTBE and atrazine concentrations are blow the detection limits. Trihalomethane formation potential is high.
Radionuclides	Low

While the water quality is of sufficient use for both agricultural and municipal drinking water purposes, there are several water quality characteristics that are considerably different than the raw water quality that is currently provided to the three water treatment plants in the Watershed that utilize Big Goose Creek as a source. Those differing characteristics include the following:

- Total Dissolved Solids and Conductivity – As opposed to the Lake DeSmet Reservoir water being close to the EPA Secondary MCL of 500 mg/l, raw water delivered to the three water treatment plants is generally around 50 mg/l. Water with high TDS can often taste salty, cause scale buildup on plumbing piping and fixtures, and leave a residue on washed glassware.
- Alkalinity – As opposed to the Lake DeSmet Reservoir water being relatively high in alkalinity concentration, raw water delivered to the three water treatment plants is very low. Higher alkalinity typically makes water treatment plant processes more effective when compared to those with very low alkalinity. However, in higher concentrations, alkalinity can give water an objectionable "soda" taste, and - if too high – may disrupt the body's normal pH.
- Hardness – As opposed to the Lake DeSmet Reservoir water being classified as "very hard" (300 mg/l as CaCO3), raw water delivered to the three water treatment plants is less than 40 mg/l. Hard water requires additional soap consumption, causes scale buildup on plumbing piping and fixtures, and leaves a residue on washed glassware and dishware. Soft water can corrode pipes unless corrosion-controlling chemicals are added to the water.
- Organic compounds – As opposed to the Lake DeSmet Reservoir water being **above** the level requiring reduction by water treatment plants, raw water from Big Goose Creek and utilized by the three water treatment plants has a level **below** the level requiring reduction. As such, water produced from the three water treatment plants is less apt to form trihalomethanes, some of which are known carcinogens.

After historically utilizing water from the BGWTP and SWTP, Sheridan area residents may find water produced from a plant treating Lake DeSmet Reservoir water to be less desirable than to what they have become accustomed.

4.4.3.3 Pipeline Geotechnical Issues

In order to utilize Lake DeSmet Reservoir water in the Watershed, it will be necessary to construct a pipeline from the dam's outlet works located at the north end of the reservoir (located in the

Piney Creek watershed, tributary of Clear Creek, tributary of Powder River) over into the Watershed. A reconnaissance level geotechnical investigation was conducted as part of the 2008 Level I Study of potential pipeline alignments associated with Lake DeSmet Reservoir development as part of the 2008 Level I study. The reconnaissance level evaluation included:

- an investigation of the general superficial and bedrock geology along the various pipeline alignments,
- an assessment of the general impact of geologic conditions on location, design, and construction of pipelines and ancillary facilities; and
- opinions on the feasibility of construction relating to these considerations.

The Wasatch formation was determined to be the most common bedrock unit along the various pipeline alignments. This geological formation consists primarily of inter-bedded poorly indurated sandstone, shale and coal. In general, hillsides formed in the Wasatch formation are very unstable, particularly with the introduction of water. This generalization is substantiated by the numerous landslides and slope failures that are present along the proposed pipeline alignments that were proposed.

High plasticity soils are also generally present. These soils have expansive characteristics that could potentially damage pipelines and structures if not properly designed and constructed. The areas along the pipeline alignments have relatively low seismic activity, with no active faults having been identified.

4.4.3.4 Lake DeSmet Reservoir Diversions into the Watershed

As mentioned in the previous section, in order for users within the Watershed to take advantage of water from Lake DeSmet Reservoir, there must be a transbasin diversion from the Piney Creek watershed into the Watershed. Additionally, there must be identified uses of the Lake DeSmet Reservoir water in order to justify any such transbasin diversion. Three different scenarios are identified in this section as possible uses of the Lake DeSmet Reservoir water. All three scenarios require installation of a pump station at the base of the main Lake DeSmet dam and a pipeline that conveys water into the Watershed. The three scenarios are summarized as follows:

1. Municipal water source for the Sheridan Regional Area;
2. Irrigation water source, which could be used either for direct irrigation, or to make available Park Reservoir water to meet future Sheridan Regional Water demands by exchanging the "new" Lake DeSmet Reservoir for Park Reservoir historically used by Little Goose Creek water users ; and
3. Supplemental supply source, which could be used to offset State of Montana demands.

These three scenarios are described in more detail below.

A principal question with all of the scenarios pertaining to the use of Lake DeSmet Reservoir water in the Watershed (as well as for any proposed use in the Tongue River drainage) relates to the language in Article X of the Yellowstone Compact. This article states as follows:

> *"No water shall be diverted from the Yellowstone River Basin without the unanimous consent of all the signatory States. In the event water from another river basin shall be imported into the Yellowstone River Basin or transferred from one tributary basin to another by the United States of America, Montana, North Dakota, or Wyoming, or any of them jointly, the State having the right to the use of such water shall be given proper credit therefore in determining its share of the water apportioned in accordance with Article V herein."* (Yellowstone Compact 1950)

This article can be interpreted to mean that a transfer from Lake DeSmet Reservoir (in the Powder River Subbasin of the Yellowstone River Basin) into the Tongue River would require the approval of the other signatories to the Compact; i.e., Montana and North Dakota. To others, however, this article could be interpreted such that the Powder River Subbasin is in fact a "tributary basin". If that is indeed the case, Montana would not necessarily need to give approval of the transbasin diversion, as long as it is given "proper credit in determining its share of the water apportioned".

4.4.3.4.1 Lake DeSmet Reservoir Municipal Water Source (SWSO-03)

The 2008 Level I Study analyzed two alternatives for supplementing the municipal water provided by the City and the SAWSJPB via the Sheridan Area Water System. Both alternatives included a water treatment plant and pump station (both located near the toe of the north Lake DeSmet Dam) as well as transmission pipelines which would connect to the SAWSJPB's 10" waterline on Bird Farm Road. This 10" waterline currently terminates approximately ½ mile east of the Big Horn storage tank.

The 2008 Level I Study's first alternative pipeline alignment (entitled Route A in that study) proposed to convey treated Lake DeSmet Reservoir water to the SAWSJPB system as well as to the Story community. Transmission main alignment Route B did not provide water to Story, but instead conveyed water more directly to the SAWSJPB system in lieu of via Story.

As the Story community is not within the Watershed, and because it includes pumping water higher and a separate distribution system to serve Story, a modified Route B has been selected for this scenario versus Route A. In lieu of conveying treated water north to Kruse Creek Road alongside I-90 (which was the case with Route B of the 2008 Level I Study), this scenario proposes that the transmission main from Lake DeSmet Reservoir be extended along U.S. 87 to Kruse Creek Road before turning west to the SAWSJPB system.

Figure 4.4.8 shows the proposed location for the various facilities associated with this municipal water source scenario. Note that a water treatment plant and pump station would be required at the toe of the north dam of Lake DeSmet Reservoir.

A conceptual cost estimate for these facilities was prepared as part of the 2008 Level I Study. This cost estimate has been updated to reflect today's costs and modified pipeline alignment, and it is shown in Appendix A.

4.4.3.4.2 Lake DeSmet Reservoir Transbasin Diversion – Irrigation Water Source (SWSO-04)

The 2011 *Sheridan Supplemental Storage Level II Phase 1 Study* recommended that shares of Park Reservoir be purchased by the City and SAWSJPB to satisfy future water supply needs. The 2011 Study was followed up with the 2013 *Sheridan Supplemental Storage Level II Phase II Study* which not only continued with the concept of using Park Reservoir water as a long-term water supply, but also identified costs associated with pursuing this alternative. Subsequently, the City and SAWSJPB entered into an agreement with the WWDC whereby the latter would participate in the purchase of these Park Reservoir shares.

A principal reason why Park Reservoir is perceived to be the long-term supply of choice is due to its location upstream of the City's intake. Similar to the City's Twin Lakes Reservoir water source, utilization of Park Reservoir is a relatively simple matter of opening the gate at Park's outlet facilities to allow water to flow into the East Fork of Big Goose Creek, then into Big Goose Creek, from which the City can divert water at its intake location at the mouth of Big Goose Creek

N

0 0.75 1.5 3 Miles

BIG HORN

KRUSE CK. RD.

BIRD FARM RD.

LITTLE GOOSE CREEK

PRAIRIE DOG CREEK

87

14

90

PINEY CREEK

Sheridan Co.

Johnson Co.

PIPELINE FROM LAKE DESMET RES. - MUNICIPAL WATER SOURCE
PIPELINE FROM LAKE DESMET RES. - IRRIGATION WATER SOURCE
PIPELINE FROM LAKE DESMET RES. - SUPPLEMENTAL SUPPLY SOURCE
GOOSE CREEK WATERSHED BOUNDARY
CITY/SAWSJPB WATER MAINS
CITY/SAWSJPB WATER TANKS

WATER TREATMENT PLANT (MUNICIPAL WATER SOURCE SCENARIO ONLY)

LAKE DESMET RESERVOIR

PUMP STATION (ALL SCENARIOS)

PS

WTP

LAKE DESMET RESERVOIR PIPELINE ROUTES FOR ALTERNATIVE USES

GOOSE CREEK WATERSHED LEVEL I STUDY

SWCA®

Anderson Consulting Engineers, Inc.
Civil • Water Resources • Environmental

EnTech Inc.
Professional Engineers
Sheridan, WY 82801

FIG. 4.4.8

canyon. As a result, there is not a need to utilize pipelines or pumps to deliver its water supplies to the intake.

Unfortunately, since consummation of the City/SAWSJPB/WWDC agreement, to date there has been no actual purchases of Park Reservoir shares. The lack of purchases is presumed to be due, in part, to reluctance on the part of agricultural shareholders to forfeit their late season water supply provided by the Park Reservoir shares.

In an effort to continue with the practice of delivering late season storage water to irrigators in the Little Goose Valley, this scenario proposes that Lake DeSmet water serve as a substitute for agricultural users who have historically relied upon Park Reservoir. Lake DeSmet water would be delivered at a flow rate similar to the historical flow rates of Park Reservoir being delivered to the five diversion points. Over the past five years, Park Reservoir flows into Little Goose Creek have averaged 6,765 A-F, with a peak daily flow rate approximating 35 cfs (2013).

In order to implement this scenario, a pump station would be constructed at the toe of the north dam of Lake DeSmet Reservoir to deliver water from the Piney Creek drainage into the Prairie Dog Creek drainage via a 20" transmission pipeline. This pipeline would extend along U.S. 87 until it reached Bird Farm Road. From there, the pipeline would extend westerly along Bird Farm Road, crossing into the Little Goose Creek Subwatershed along this county road. The pipeline would continue westerly along Bird Farm Road and through some private lands until it reached Brinton Road. From there, it would extend southwesterly up Little Goose Creek to a point just above the point of diversion for the Colorado Colony Ditch, at which point water would flow into Little Goose. Via an exchange agreement with the Big Horn Reservoir Company, the two ditches upstream from the Colorado Colony Ditch (Peralta and Last Chance) would be satisfied with reservoir water.

A critical component involved with implementation of this scenario is a willingness on the part of the Little Goose users of Park Reservoir storage water to substitute Lake DeSmet Reservoir water for Park Reservoir water. At a minimum, these water users should see no additional cost associated with the use of Lake DeSmet Reservoir water when compared to their historical use of Park Reservoir storage water.

Figure 4.4.8 shows the proposed pump station and alignment for the transmission pipeline. A conceptual cost estimate for this scenario is shown in Appendix A.

4.4.3.4.3 Lake DeSmet Reservoir Transbasin Diversion – Watershed Supplemental Supply Source (SWSO-05)

Section 3.10 discussed the current anticipated impacts for Wyoming associated with the Montana v. Wyoming lawsuit relative to the Watershed. Table 3.10.2 within Section 3.10 listed the storage rights in reservoirs located within the Watershed that are post-1950, and therefore must accede to the filling of the pre-1950 Tongue River Reservoir in Montana before they can store water. Those storage rights totaled 9,735 A-F.

This scenario proposes that an amount of approximately 9,800 A-F be delivered to Montana from Lake DeSmet. The means of delivery is proposed to be a pump station (to be located at the toe of the north dam of Lake DeSmet Reservoir) and a transmission pipeline that would convey water from the pump station into the Prairie Dog Creek basin. The transmission pipeline would extend to the confluence of Murphy Gulch and Prairie Dog Creek, at which point an energy dissipation structure would be constructed, with Lake DeSmet water flowing through this structure into Prairie

Dog Creek. Water would then flow in Prairie Dog Creek to its confluence with the Tongue River immediately south of the state line, for delivery to Montana.

The Prairie Dog Water Supply Company (PDWSC) delivers water into the Prairie Dog Creek watershed just north of the Story community, with a 2016 maximum flow rate of 67 cfs diverted from South Piney Creek, then into North Piney Creek, and finally into the Prairie Dog Creek watershed. After taking into account water deliveries upstream of Murphy Gulch, and based upon BOC historical data, it is assumed that a maximum of 60 cfs is delivered into Prairie Dog Creek by the PDWSC (BOC 2016). The 60 cfs flow rate is therefore assumed to be a flow rate that can be safely handled by the Prairie Dog Creek channel, and is therefore the flow rate used in sizing a pump station and transmission pipeline. Using a flow rate of 60 cfs, a required volume of 9,435 A-F (see Table 3.10.2), and a 10% conveyance loss between Murphy Gulch and the Tongue River Reservoir, the required volume could be delivered in 88 days, or approximately three months.

Although this scenario does not propose the construction of any facilities within the Watershed itself, it nonetheless benefits water users within the Watershed by utilizing Lake DeSmet Reservoir water to satisfy Montana's demands under the lawsuit that would otherwise negatively affect the ability of the reservoirs listed in Table 3.10.2 to store water.

Figure 4.4.8 shows the proposed locations for the various facilities associated with this third scenario. A conceptual cost estimate for this scenario is provided in Appendix A.

4.5 Project Ranking

In order to provide additional information on the relative importance of the various projects proposed with the Watershed Management and Rehabilitation Plan, a matrix has been prepared which summarizes the opportunities and challenges affecting the projects identified as part of the plan. This matrix (which is Table 4.4.3 of this Level I Study) can assist the reader in identifying interrelationships among the various proposed projects, as well as to facilitate screening and prioritization of these projects to guide in the ultimate selection and implementation of the various projects being proposed.

The matrix is formatted utilizing a 1 to 3 ranking criteria for each project, with 1 being the highest ranking and 3 being the lowest ranking. The matrix includes a column entitled SWPP Priority and WWDC Account (I or II) which provides information on funding availability from the WWDC's SWPP. This column shows two numbers for each project:

1. The project priority number for SWPP funding, according to the WWDC's project priority listings; and
2. Roman numeral I or II, indicating whether or not the project could be funded out of the SWPP's Account I (New Development) or Account II (Rehabilitation).

Project priorities for the SWPP's Account I and Account II are as follows (from highest to lowest priority);

Account I (New Development) Project Priorities:

1. Source Water Development;
2. Storage;
3. Pipelines, conveyance facilities, solar platforms and windmills;
4. Irrigation;
5. Environmental; and
6. Recreational.

TABLE 4.4.3 - PROJECT MATRIX

ID	NAME	PROJECT COST	PRACTICAL IMPLEMENTATION?	RELATIVE COST	ECONOMIC FEASIBILITY AND ABILITY TO FUND	NET HYDROLOGIC EFFECTS	INCREASED WATER USE EFFICIENCY	REDUCTION OF EROSION AND/OR WATER QUALITY DEGRADATION	SUSTAINABILITY	IMPACTS TO WATER RIGHTS AND EXISTING COMPACTS	EASE OF PERMITTING	PUBLIC ACCEPTABILITY	POTENTIAL FATAL FLAWS?	SWPP PRIORITY AND WWDC ACCOUNT (I OR II)	OVERALL RANKED PRIORITY
Irrigation System Infrastructure - Big Goose Creek Subwatershed															
ISI-BG-AL-01	Alliance Ditch Slide Area Repair	$40,131	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-ALL-01	Alliance Lateral Ditch Wasteway Gate Removal	$4,914	Yes	Low	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-BG-ALL-02	Alliance Lateral Ditch Culvert Replacement 1	$57,184	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-ALL-03	Alliance Lateral Ditch Culvert Installaton 1	$17,176	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-ALL-04	Alliance Lateral Ditch Culvert Installation 2	$18,029	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-ALL-05	Alliance Lateral Ditch Trash Rack 1	$10,374	Yes	Low	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-BG-ALL-06	Alliance Lateral Ditch Trash Rack 2	$3,822	Yes	Low	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-BG-ALL-07	Alliance Lateral Ditch Culvert Installation 3	$193,156	Yes	Medium	Possibly	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-ALL-08	Alliance Lateral Ditch Culvert Replacement 2	$4,304	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-ALL-09	Alliance Lateral Ditch Erosion Control Structure 1	$14,514	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-BG-ALL-10	Alliance Lateral Ditch Culvert Installation 4	$17,367	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-ALL-11	Alliance Lateral Ditch Culvert Replacement 3	$19,728	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-ALL-12	Alliance Lateral Ditch Culvert Installation 5	$25,448	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-ALL-13	Alliance Lateral Ditch Erosion Control Structure 2	$6,938	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-BG-ALL-14	Alliance Lateral Ditch Culvert Replacement 4	$18,718	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-ALL-15	Alliance Lateral Ditch Culvert Installation 5	$24,588	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-ALL-16	Alliance Lateral Ditch Erosion Control Structure 3	$9,600	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-BG-ALL-17	Alliance Lateral Ditch Culvert Installation 6	$1,479,954	Yes	High	Possibly	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	Directional drilling is a proven technology, but possible risk in drilling at that depth.	3(II)	1
ISI-BG-ALL-18	Alliance Lateral Ditch Culvert Installation 7	$11,470	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-ALL-19	Alliance Lateral Ditch Turnout 1	$29,184	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-BG-ALL-20	Alliance Lateral Ditch Turnout 2	$39,818	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-BG-BGB-01	Big Goose Beaver Ditch Culvert Installation	$186,876	Yes	Medium	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-BGB-02	Big Goose Beaver Energy Dissipation Structures	$34,371	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-BG-DA-01	Daisy Ditch Wasteway Installation	$132,638	Yes	Low	Possibly	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-BG-DA-02	Daisy Ditch Headgate Replacement	$14,196	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	1(II)	2
ISI-BG-FL-01	Flume Ditch Wasteway Gate Replacement	$5,106	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-BG-FL-02	Flume Ditch Seepage	$217,189	Yes	Medium	Possibly	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-BG-FL-03	Flume Ditch Culverts	$2,198	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-PK-01	PK Ditch Culvert Replacement	$72,253	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-RO-01	Rocky Ditch Seepage Rehabilitation	$12,285	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-BG-RO-02	Rocky Ditch Headgate Replacement	$12,422	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	1(II)	2
ISI-BG-SN-01	Snively Ditch Flume Replacement	$29,894	Yes	Low	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-SN-02	Snively Ditch Culvert Installation	$21,649	Yes	Low	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-BG-WR-01	Wild Rose Meter Replacement	$2,321	Yes	Low	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-BG-WR-02	Wild Rose Dam Improvements	$150,778	Yes	Medium	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	2(II)	2
ISI-BG-WR-03	Wild Rose Headgate Improvements	$52,280	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	1(II)	1

TABLE 4.4.3 - PROJECT MATRIX

ID	NAME	PROJECT COST	PRACTICAL IMPLEMENTATION?	RELATIVE COST	ECONOMIC FEASIBILITY AND ABILITY TO FUND	NET HYDROLOGIC EFFECTS	INCREASED WATER USE EFFICIENCY	REDUCTION OF EROSION AND/OR WATER QUALITY DEGRADATION	SUSTAINABILITY	IMPACTS TO WATER RIGHTS AND EXISTING COMPACTS	EASE OF PERMITTING	PUBLIC ACCEPTABILITY	POTENTIAL FATAL FLAWS?	SWPP PRIORITY AND WWDC ACCOUNT (I OR II)	OVERALL RANKED PRIORITY
Irrigation System Infrastructure - Little Goose Creek Subwatershed and Lower Goose Creek Subwatershed															
ISI-LG-BU-01	Burn-Cleuch Ditch Measuring Flume	$12,695	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(I)	2
ISI-LG-BU-02	Burn-Cleuch Ditch UW Center Pivot Electrification	$79,853	Yes	Low	Possibly	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(I)	2
ISI-LG-BU-03	Burn-Cleuch Ditch SC Control System	$20,475	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(I)	2
ISI-LG-ES-01	East Side Ditch Diversion Rehabilitation	$6,655	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-LGES-02	East Side Ditch Wasteway	$26,263	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-LG-ES-03	East Side Ditch Improvements	$27,255	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-LG-ES-04	East Side Ditch Culvert Installation 1	$6,460	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-LG-ES-05	East Side Ditch Sackett Creek Wasteway	$10,511	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-LG-ES-06	East Side Ditch Culvert Installation 2	$14,558	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-LG-ES-07	East Side Ditch Culvert Installation 3	$94,411	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-LG-ES-08	East Side Ditch Garber Measuring Device	$4,413	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(I)	2
ISI-LG-ES-09	East Side Ditch Concrete Ditch Replacement	$189,189	Yes	Medium	Possibly	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-LG-ES-10	East Side Ditch Siphon	$50,743	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-LG-ES-11	East Side Ditch Maverick Lane Pipeline Installation	$24,165	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(I)	2
ISI-LG-GE-01	Gerdel Ditch Seepage Rehabilitation	$21,417	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-LG-LC-01	~~Last Chance Ditch Flume~~ Replacement at East Fork Davis ~~Creek~~	$18,537	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-LG-LC-02	Last Chance Ditch Culvert Installation 1	$49,072	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-LG-LC-03	Last Chance Ditch Culvert Installation 2	$33,720	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-LG-MC-01	Kruse Creek Sideroll Irrigation Sytem	$67,800	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(I)	2
ISI-LG-ME-01	Metz Ditch Pipeline Installation	$1,077,079	Yes	High	Possibly	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-LG-MU-01	Muskrat Ditch Turnout	$10,511	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-LG-MU-02	Muskrat Ditch Turnout Replacement	$29,894	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-LG-NE-01	Negro John Diversion Dam	$53,485	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	1(II)	2
ISI-LG-PE-01	Peralta Ditch Headgate Rehabilitation	$22,523	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	1(II)	2
ISI-LG-PE-02	Peralta Ditch Measuring Flume	$17,513	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-LG-PE-03	Peralta Ditch Dow Ranch Turnout Rehabilitation	$15,794	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-LG-PE-04	Peralta Ditch Breach Restoration	$26,448	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-LG-PE-05	Peralta Ditch Turnout Installation	$26,448	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-LG-PP-01	South Paradise Park Pipeline	$277,619	Yes	Medium	Possibly	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	3(II)	2
ISI-LG-RE-01	Reed Ditch Headgate Replacement	$5,597	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	1(II)	2
ISI-LG-RE-02	Reed Ditch Measuring Device	$2,048	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(I)	2
ISI-LG-RE-03	Reed Ditch Knecht Drainage	$6,689	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-LG-RE-04	Reed Ditch Flume Structure Replacement	$47,871	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-LoG-GR-1	Grinnell Ditch Turnout Replacement	$20,639	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
ISI-LoG-SC-01	Soldier Creek Ditch VAMC Turnout Replacement	$14,640	Yes	Low	Yes	No negative effects	Yes	Yes	Yes	None	Likely to be little problem	Yes	None	4(II)	2
	TOTAL ALL INFRASTRUCTURE SYSTEM IMPROVEMENTS PROJECTS	**$5,292,840**													

TABLE 4.4.3 - PROJECT MATRIX

ID	NAME	PROJECT COST	PRACTICAL IMPLEMENTATION?	RELATIVE COST	ECONOMIC FEASIBILITY AND ABILITY TO FUND	NET HYDROLOGIC EFFECTS	INCREASED WATER USE EFFICIENCY	REDUCTION OF EROSION AND/OR WATER QUALITY DEGRADATION	SUSTAINABILITY	IMPACTS TO WATER RIGHTS AND EXISTING COMPACTS	EASE OF PERMITTING	PUBLIC ACCEPTABILITY	POTENTIAL FATAL FLAWS?	SWPP PRIORITY AND WWDC ACCOUNT (I OR II)	OVERALL RANKED PRIORITY
Surface Water Storage Opportunities															
SWSO-01	PK/Alliance Stockwater Dam Enlargement	$240,657	Yes	Medium	Yes		Yes	N/A	Yes	None	Likely to be little problem	Yes	None	2(I)	2
SWSO-02	Gillispie Dam and Reservoir	$22,731,424	Yes	High	Possibly		Yes	N/A	Yes	Possibly	May have permitting issues due to decreased non-irrigation flows in Big Goose Creek	May have permitting issues due to decreased non-irrigation flows in Big Goose Creek	None known at this time	2(I)	2
SWSO-03	Lake DeSmet Reservoir Transbasin Diversion - Municipal Water Source	$62,901,320	Yes	High	Unlikely		Yes	N/A	Yes	Possibly	Possible permitting issues	Drawdown of Lake DeSmet Reservoir may be an issue	None known at this time	3(I)	2
SWSO-04	Lake DeSmet Reservoir Transbasin Diversion - Irrigation Water Source	$59,939,910	Yes	High	Unlikely		Yes	N/A	Yes	Possibly	Possible permitting issues	Drawdown of Lake DeSmet Reservoir may be an issue	None known at this time	3(I)	2
SWSO-05	Lake DeSmet Reservoir Transbasin Diversion - Watershed Supplemental Supply Source	$35,209,747	Yes	High	Unlikely		Yes	N/A	Yes	Possibly	Possible permitting issues	Drawdown of Lake DeSmet Reservoir may be an issue	None known at this time	3(I)	2
Upland Water Development Opportunities															
UWDO-01	Walker Prairie Spring Development	$8,690	Yes	Low	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	1(I)	1
UWDO-02	Buffalo Jump Spring Development	$9,190	Yes	Low	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	1(I)	1
UWDO-03	Beaver Creek Hills Upland Water Development	$74,529	Yes	Low	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	1(I)	1
UWDO-04	Tepee Upland Water Development	$55,508	Yes	Low	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	1(I)	1
UWDO-05	Poverty Flat Upland Water Development	$45,271	Yes	Low	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	1(I)	1
UWDO-06	East Fork Little Goose Creek Upland Water Development	$32,894	Yes	Low	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	1(I)	1
UWDO-07	Flume Ditch Solar Collector Stockwater Pumping Systems	$23,274	Yes	Low	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	3(I)	1
UWDO-08	Flume Ditch Spring Development	$17,905	Yes	Low	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	1(I)	1
UWDO-09	Clark Upland Water Development	$8,559	Yes	Low	Yes	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	1(I)	1
	TOTAL UPLAND WATER DEVELOPMENT OPPORTUNITIES PROJECTS	**$275,820**													
Fisheries Mitigation															
FM-BG-CS-01	City of Sheridan Intake Diversion Dam Fish Ladder	$297,520	Yes	Medium	Likely to need several funding sources	No negative effects	N/A	N/A	Yes	None	Likely to be little problem	Yes	None	1,5(I)	2
FM-BG-N9-01	No. 9 Ditch Diversion Dam Replacement	$177,195	Yes	Medium	Likely to need several funding sources	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	1,5(II)	2
FM-LG-RE-01	Reed Ditch Diversion Dam Rehabilitation	$36,498	Yes	Low	Likely to need several funding sources	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	1,5(II)	2
FM-LG-ES-01	East Side Ditch Diversion Dam Replacement	$235,928	Yes	Medium	Likely to need several funding sources	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	1,5(II)	2
FM-LG-BU-01	Burn-Cleuch Ditch Diversion Dam	$339,835	Yes	Medium	Likely to need several funding sources	No negative effects	Yes	N/A	Yes	None	Likely to be little problem	Yes	None	1,5(II)	2
	TOTAL FISHERIES MITIGATION PROJECTS	**$1,086,976**													

Account II (Rehabilitation) Project Priorities:

1. Diversion structures and spring developments;
2. Storage;
3. Pipelines, conveyance facilities, solar platforms and windmills;
4. Irrigation other than the above;
5. Environmental; and
6. Recreational.

It is anticipated that the SWPP will be an important funding source for projects listed in the Watershed Management and Rehabilitation Plan, thus the reason for the priority listing in the matrix. More information about the SWPP is available in Section 6.

4.6 Wildfire Hazard Mitigation

A particular hazard within the Watershed that has thus far gone relatively unmitigated is the risk associated with wildfires within the upper parts of the Watershed, specifically the lands in and surrounding the BNF. Of particular concern from a water quality perspective is the impact that a wildfire could have on the City's and SAWSJPB's municipal water system, which also delivers water to the VAMC. Somewhat unique to the raw water intake system of the City/SAWSJPB system is the fact that untreated water is diverted from Big Goose Creek and delivered to their two water treatment plants with no intermediary storage facilities. As such, not only does the lack of these intermediary storage facilities prevent the temporary bypassing of Big Goose Creek water that would be laden with ash and debris, this means that raw water delivered directly to the treatment plants will have no treatment at all (such as sedimentation) in the event of a fire.

Both Fort Collins and Denver have recently been impacted by wildfires located above their water supply facilities in the Front Range area of Colorado (The Cadmus Group 2013). Both short-term and long-term problems have resulted from these events. Short-term problems included water quality degradation of their raw water due to the floating and dissolved material contained within the water. Long-term problems have resulted due to loss of vegetation which previously prevented soil erosion. The soil erosion increased turbidity levels in the source water, especially after major rainstorm events. It also increased the buildup of sediment in their mountain reservoirs, hence reducing capacity and clogging intake facilities.

Similar problems could result should a major wildfire occur within the Watershed, with these problems affecting not only the municipal water suppliers, but all water users. Those owning reservoirs within the BNF would be particularly impacted, for the reasons cited above for Fort Collins and Denver.

SAWSJPB has recently received funding trom the WWDC and has embarked upon a wildfire hazard mitigation study, which would address the issues and concerns discussed above. Both the cities of Cheyenne and Buffalo have recently had similar types of studies performed (RESPEC 2017). These studies recommended several strategies which, if fully implemented, could significantly attenuate the effects that would result should a wildfire occur within their respective watersheds.

5. PERMITS

5.1 Overview

This section of the Level I Study provides information on the various permits that will be required in order to implement the projects recommended in Section 4. The number and complexity of required permits will vary depending upon the projects' complexities and ownership of the land upon which the proposed projects are located (i.e., federal, state or private land). Some state and/or federal permits will be required even if a prospective project is to be situated on private lands.

A considerable amount of permit information made available in this section was obtained from previous Level I studies, specifically the recently-completed *Upper Laramie River Watershed Level I Study* and the *Black Forks River Watershed Level I Study.* Both Level I studies were prepared previously for the WWDC by Anderson Consulting Engineers, a subconsultant to EnTech on this Level I Study.

5.2 Property Access, Easements, and Land Procurement

Verbal permission was obtained from the various landowners, lessees, or ditch companies prior to any fieldwork that was performed as part of this Level I Study. For future work on any proposed project, in which project specific field data needs to be collected and/or potential project alternatives developed, written permission should be considered. Once actual plans for work are developed, subsequent negotiations will likely be necessary for securing easements, licenses, or rights-of-way. It may also be necessary to secure approval from various utility and energy entities to cross their facilities, which may be impacted by proposed construction.

Information regarding state land parcels and surface leases can be accessed from the OSLI's State Land Access website: (*http://gis.statelands.wyo.gov/GIS/OSLIGIS/StateLandAccess/*) and OSLI's Search Surface Plat Book website :(*http://statelands.wyo.gov/surfaceplatbook/*). Sheridan County parcel data can be obtained via an online map: *http://gis.sheridancounty.com/map#zcr=3/-11907500/5585000/0&lyrs=publand,water,corplimits,roads,ownership*.

All lands within the Watershed located in Johnson County are within the BNF, with the exception of approximately one square mile of private land surrounding the Big Horn Reservoir.

5.2.1 Trespassing to Collect Data

W.S. 6-3-414 states that it is unlawful to trespass in order to collect resource data. This statute protects landowners' property rights by allowing law enforcement officials to file criminal charges if an individual or entity trespasses onto private property for the purpose of collecting data. Furthermore, the statute:

- prohibits any information from being used by a government entity if it is collected by someone who trespassed on or across private land; and
- if information was illegally collected and provided to a government agency, it will be expunged by the agency and retained to use as evidence against the trespasser.

Because participation in the Level I Study is voluntary, EnTech worked with the WWDC, local sponsors, and landowners to gain verbal permission before entering any private lands in order to collect field data. Additionally, global positioning system (GPS) units with 2016 and 2017 parcel

data and a GPS-enabled camera were used to collect field data, which ensures that field data collection occurred only on the participating landowners' properties.

5.2.2 Land Procurement, Right-of-Way, or Easement Acquisition

The proposed projects described in the Level I Study predominantly involve private lands and are situated within the parcel boundaries of the participating landowners. Some of the proposed projects' components that would involve access to rights-of-way along a state highway or county road, or access to irrigation district infrastructure, will likely require temporary or conditional use permits obtained from those entities. If a proposed project were to be located entirely or partially on federal lands (such as some of the Upland Water Development Opportunities discussed in Sections 3 and 4 which are located on BNF lands), would cross federal lands, or be funded by federal agencies or programs, additional requirements for compliance with the National Environmental Policy Act (NEPA) would apply, which is described in more detail in subsequent subsections of this Section 5.

5.2.3 Utilities

Permits or right-of-way access are required for numerous utility and energy entities when project construction involves their easements and properties. In the State, the "Wyoming Underground Facilities Notification Act" requires everyone who owns underground facilities in the state to be a member of One-Call of Wyoming. Before any excavation begins, the excavator is required to provide advance notice (at least two business days before intending to dig) to the One-Call of Wyoming Notification Center at 811. More information about One Call of Wyoming is available at: *http://www.onecallofwyoming.com/.*

5.3 Permitting for Proposed Projects

In the following sections, the permit requirements of specific types of projects within the watershed management plan are presented, including:

- Irrigation System Infrastructure Projects;
- Fisheries Mitigation Projects;
- Upland Water Development Opportunities; and
- Surface Water Storage Opportunities.

5.3.1 The National Environmental Policy Act (NEPA) and the Federal Permitting Process

Compliance with NEPA typically applies whenever a proposed project is located on federal lands, needs passage across federal lands, is funded entirely or partially by federal agencies or programs, or needs to secure a federal permit. The NEPA process is intended to help sponsors and agencies review the potential project effects and involve the public in making informed decisions about the environmental consequences of a project. If any proposed project occurs on BLM, USFS or DOD-federally managed lands, or would be a recipient of USDA Farm bill funding, the BLM, USFS, DOD or NRCS would likely be considered the "lead or action agency" in the NEPA process. Typically, federal agencies develop a Memorandum of Understanding (MOU) to outline responsibilities and roles of the agencies when a proposed project involves multiple agencies.

The National Environmental Policy 610.40 Overview of NEPA Requirements, 610.43 Federal Actions and Major Federal Actions states the following about federal actions involving the NRCS:

A. Federal Actions

> (1*) NEPA compliance is triggered when NRCS proposes a Federal action. A Federal action occurs when NRCS has control or responsibility over the implementation of a proposed activity including technical or financial assistance. Most NRCS Federal actions involve financial assistance through Farm Bill and watershed programs, or approvals, but Federal actions also include activities such as granting compatible uses agreements for easements where NRCS exercises control.*
>
> *(2) Federal actions do not usually include situations in which NRCS is only providing technical assistance because NRCS cannot control what the client ultimately does with that assistance. However, there may be instances where a project can become "federalized" due to a substantial input of Federal resources in the form of technical assistance or when NRCS has some control or responsibility in the result. When NRCS provides technical designs, standards, or specifications, the RFO should evaluate and determine whether NRCS has control or responsibility over the action, thus making it a Federal action subject to NEPA.*
>
> *(3) Important note: NEPA only applies to Federal actions. It is NRCS policy and required by NRCS regulations to conduct an EE [Environmental Evaluation] as a part of every planning activity, even if it is not considered a Federal action (highly erodible land and wetland determinations are technical determinations and not considered planning activities). The results of this process are documented on the NRCS-CPA- 52 worksheet, to- (i) Inform the landowner of the plan's impacts, and (ii) Provide a record that the EE was conducted. (NEPA NRCS)*

The size and complexity of any proposed project involving NEPA will determine which type of environmental document would have to be prepared. It could be:

- a categorical exclusion (for small, relatively incidental projects),
- an environmental assessment (for somewhat larger, but relatively insignificant projects), or
- an environmental impact statement (EIS).

The BLM or the USFS would likely be the lead agency for any project that is proposed to be situated on federal lands, and the NRCS would likely be the lead agency for any such project funded on private lands that is funded in whole or in part by USDA.

In addition to the federal land management agencies listed previously, the USACOE has a role in reviewing proposed projects that involve placement of dredged or fill material into Waters of the US, which often applies around water-related projects. The USACOE permit is entitled a 404 permit (after Section 404 of the Clean Water Act). Issuance of a 404 permit can only be made after it is determined by the USACOE that the proposed project is "the least environmentally damaging, most practicable alternative", and that the proposed project does not have other significant adverse environmental consequences (e.g., impacts to endangered species or historic properties that are always addressed under NEPA requirements). More information about this USACOE permit's role in project implementation is included in following sections.

5.3.2 Irrigation System Infrastructure Projects and Fisheries Mitigation Projects

Rehabilitation of existing diversions, ditches, or pipelines for diverting irrigation water from a river, creek, or reservoir to irrigated lands are typical projects identified as being Irrigation System Infrastructure Projects in the Watershed Rehabilitation and Management Plan. Similarly,

replacement or modification of existing diversion dams in a manner that would provide for fish passage are identified as Fisheries Mitigation Projects as part of this same plan. In addition to any federal requirements that may be imposed, these types of projects will usually require verification of the applicable water rights to ensure the appropriation has been approved by the WSEO. Generally, if the proposed project does not involve a change in the point of use, point of diversion, or an enlargement, additional approval from the WSEO or BOC is not likely to be required. Before initiating any irrigation structure or diversion structure project, however, the WSEO and BOC should be consulted for a final determination of their requirements.

Notwithstanding the above, any enlargement or change in point of use of the structure or facility will require the submittal of an application and/or petition to the WSEO and/or the BOC for approval. Necessary application forms and instructions including the SW-2 Enlargement of Ditches, Pipelines and Change in Point of Diversion and Means of Conveyance petition examples can be obtained via the WSEO's website:
(*https://sites.google.com/a/wyo.gov/seo/regulations-instructions*).
Similarly, any individual or entity intending to construct a new diversion structure, ditch, or pipeline from a stream that does not use an existing, permitted structure or facility must make application to the WSEO using this agency's Application for Permit to Appropriate Surface Water (S.W.1 Form) and cannot commence construction until the permit is approved by the WSEO in accordance with W.S. 41-3-101. It is recommended that coordination with the WSEO occur prior to any rehabilitation or new construction.

In addition to the WSEO requirements, the construction or rehabilitation of a diversion structure (including a headgate, weir, or diversion dam along with any associated in-stream or streambank work) involving the discharge of dredged or fill material into the Waters of the U.S. may require a Section 404 permit issued by the USACOE. More information can be obtained by contacting the USACE's Wyoming Regulatory Office via the website:
http://www.nwo.usace.army.mil/Missions/Regulatory-Program/Wyoming/

When an applicant submits a Section 404 permit application to the USACOE, the application is forwarded to the WDEQ for review under Section 401 of the Clean Water Act to determine compliance with surface water quality standards or TMDLs. Information about the WDEQ's 401 Certification is available via the website:
http://deq.wyoming.gov/wqd/401-certification/

5.3.3 Upland Water Development Opportunities

The Upland Water Development Opportunities identified in Sections 3 and 4 of this Level I Study involve construction of facilities that would aid in providing water to livestock and wildlife. These projects will include components such as spring development, stock tanks, solar panels, and pipelines. In addition to any federal requirements that may be imposed, any proposed spring developments (which can be technically considered wells) will need to be permitted by the WSEO in accordance with either this agency's ground water or surface water rules and regulations. If a spring is:

- for stock and/or domestic use,
- yields 25 gallons per minute or less,
- includes a man-made development (i.e., no machinery used), and
- is identifiable as groundwater,

then the spring is permitted by submitting an application to the WSEO to appropriate groundwater. If a spring development doesn't meet all of these above conditions, then the spring is permitted by completing a surface water application. Either application can be submitted electronically via the SEO's website:

https://sites.google.com/a/wyo.gov/seo/regulations-instructions

5.3.4 Surface Water Storage Opportunities

The five Surface Water Storage Opportunities identified in the Watershed Rehabilitation and Management Plan can be summarized as follows:

1. one is an enlargement of a small stockwater dam and reservoir (SWSO-01: PK/Alliance Stock Dam Enlargement,
2. one is a new, 2,660 A-F dam and reservoir to be used for municipal supply purposes (SWSO-02: Gillispie Dam and Reservoir); and
3. three are various methods of utilizing water from the existing Lake DeSmet Reservoir located in the Piney Creek drainage in Johnson County (SWSO-03, SWSO-04 and SWSO-05 .

For both the proposed Surface Water Storage Opportunity involving enlargement of a small existing stockwater dam and reservoir, and the one involving construction of a new, 2,660 A-F reservoir, a permit from the WSEO will be required before commencing construction. The approval from the WSEO will be in addition to any federal requirements that might be imposed. Per WSEO requirements, stockwater reservoirs must not exceed 20 acre-feet in capacity, cannot have a dam height greater than 20 feet, and the use of the stored water should be for stock purposes only (W.S. 41-3-301). The individual or entity proposing to construct the stockwater reservoir enlargement, or the new 2,660 A-F reservoir, must submit application forms to the WSEO. These forms can be accessed via the WSEO's website:
https://sites.google.com/a/wyo.gov/seo/regulations-instructions

Wyoming's Safety of Dams legislation (W.S. 41-3-307 through 41-3-318), which is administered by the WSEO, typically does not apply to reservoirs when the dam height is less than 20 feet high and reservoir capacity is less than 50 acre-feet. However, it would most certainly apply to the proposed Gillispie Dam and Reservoir project. Because this new dam will have a height greater than 20 feet, a capacity of more than 50 A-F, or a diversion system with headgates or diversion structures conveying more than 50 cfs, it must have plans and specifications prepared by a Wyoming licensed Professional Engineer and shall be submitted to the State Engineer for approval. On-site inspections of any new or rehabilitated facilities are conducted by the SEO personnel.

Additionally, the water quality of a completed stock reservoir or pond must be suitable for agriculture water supply (including livestock watering) and cannot exceed any of the Class 2D, Class 3D, and Class 4 surface water quality standards (Appendix B) of Chapter 1, Wyoming Surface Water Quality Standards (W.S. 35-11-101) found at the website:
http://deq.wyoming.gov/wqd/surface-water-quality-standards/

In addition, the construction of a new reservoir, enlargement of an existing reservoir, or rehabilitation of an existing reservoir typically involves the discharge of dredged or fill material into waters of the United States and could require a 404 permit. This discharge will be true for both the enlargement and new reservoir projects. Because numerous waterbodies and wetlands are considered “Waters of the U.S.”, they are subject to USACOE regulatory authority. Permit applications can be obtained by contacting the USACOE Omaha District Wyoming Regulatory Office in Cheyenne via the website (http://www.nwo.usace.army.mil/Missions/Regulatory- Program/Wyoming/).

As part of the 404 permitting process, when an applicant submits a pre-construction notification (PCN) to the USACOE, the PCN is forwarded to the WDEQ for review under Section 401 of the

CWA. WDEQ then determines compliance with Chapter 1, Wyoming Surface Water Quality Standards (W.S. 35-11-101). If the project is compliant, then the WDEQ issues a 401 Water Quality Certification. Information about the WDEQ's 401 Certification process can be obtained by visiting their website:
http://deq.wyoming.gov/wqd/401-certification/

DEQ's involvement may also involve allowance of a temporary increase in the numeric value for turbidity for those waters disturbed or released during construction-related activities. This allowed increase is both time-limited and project-specific. More information about the procedures involved to secure a temporary turbidity increase for construction can be found at: http://deq.wyoming.gov/wqd/storm-water-permitting/resources/construction-general-permits/.

Because none of the five Surface Water Storage Opportunities involves construction of facilities on federal lands, and none will likely utilize federal funding, one might surmise that NEPA will not be applicable. However, due to the requirement for a federal 404 permit anticipated on the Gillispie Dam and Reservoir Project, many of the requirements contained within NEPA will nonetheless still have to be addressed in order to implement the project.

5.3.5 Mitigation

Mitigation may be necessary for a proposed project to address impacts to wetlands, riparian vegetation, stream-channel habitat, cultural resources, fish and wildlife resources, and possibly threatened or endangered species. In developing the listing of proposed projects within this Level I Study, consideration was given where feasible to avoid potential impacts by evaluating and considering these resources as part of the conceptual plans. When necessary, the plan designs were and should be adjusted accordingly in order to minimize the need for mitigating significant impacts. Avoiding potential impacts to species of concern and their associated habitats can sometimes be accomplished by scheduling construction activities outside of the relevant nesting, parturition, breeding, or migration seasons.

5.3.6 Summary of Required Permits

Table 5.3-1 presents a summary of the permits that each of the various agencies may require for the projects proposed as part of the Watershed Management and Rehabilitation Plan.

Table 5.3.1 – Listing of Agencies and Pertinent Permit Requirements

Agency	Potential Permit and/or Clearance
Federal	
USACOE	Authorization of Permit for Discharge of Dredged or Fill Material (Section 404 permit). Requires further delineation of jurisdictional wetlands and a wetland mitigation plan.
USFWS	Endangered Species Act
BLM	BLM clearance necessary if located or crossing BLM lands, NEPA review required
USFS	USFS clearance necessary if located or crossing USFS lands, NEPA review required
NRCS	NRCS approval necessary if funded by Farm Bill or USDA, NEPA review may be required
State	
Wyoming State Engineer's Office (WSEO)	Ground Water Division approval of Water Well Permits Ground or Surface Water Division Approval of Spring Development Permits Surface Water Division Approval of Ditches, Pipelines, and Changes in Points of Diversion Surface Water Division Approval of Diversion or Headgates carrying 50 cfs Surface Water Division Approval of Reservoir Permits Safety of Dams Approval of Dam Modifications Platte River Recovery Implementation Program (PRRIP)

Agency	Potential Permit and/or Clearance
Wyoming State Historical Preservation Office (SHPO)	SHPO compliance letter for projects on federal land or that include a federal action
Wyoming Game and Fish Department (WG&FD)	Coordination for terrestrial and aquatic wildlife under the NEPA, the ESA, Section 404 of the federal CWA, and the Federal Fish and Wildlife Coordination Act Greater Sage-Grouse Core Area Protection
Wyoming Department of Environmental Quality (WDEQ)	401 Certification for 404 Permits under the federal Clean Water Act WYPDES Construction General Permit (CGP) for Large Construction Activity (>5 acres) or Small Construction Activity (between 1 acre and 5 acres) Applicable Water Quality Standards for Wells, Reservoirs, and Streams Temporary Turbidity Waivers
Wyoming Office of State Lands and Investments (OSLI)	Construction of Improvements on State Land application approval
Wyoming Department of Fire Protection and Electrical Safety	Electrical Wiring Permit to install electrical equipment on new construction or remodeling. Electrical installations must be performed by licensed electricians unless exempted
Local	
Sheridan County	Permits for building structures, wind energy systems, aquifer protection, and floodplain development
Special Districts	Permits or clearances from special districts including water and sewer, sanitary and improvement, flood control, irrigation, road, and improvement/service districts

5.4 Evaluations Required for Permit Attainment

5.4.1 NEPA Requirements for the Endangered Species Act and National Historic Preservation Act

As stated in an earlier section of this Level I Study, compliance with the NEPA typically applies whenever a proposed project included in the Watershed Management and Rehabilitation Plan is located on federal lands, needs passage across federal lands, and is funded entirely or partially by federal agencies or programs, or needs to secure a federal permit. The NEPA process requires adherence to all federal laws and executive orders. Two of the more important laws as they relate to NEPA are the Endangered Species Act (ESA) and the National Historic Preservation Act (NHPA).

Section 3 of this Level I Study provided information on various plant and animal species that could fall under the ESA. This section also addressed cultural resources that must be addressed under the NHPA, including a determination on whether the proposed action could affect historic properties to the extent that there would be initiation of the Section 106 process. Finally, it included much of the information that would be required in order to fulfill the requirements of the various federal agencies identified in Table 5.3.1. However, it is important to understand that each proposed project in the Watershed Management and Rehabilitation Plan must address the requirements for their particular site on a case-by-case basis.

5.4.2 Planning Resources and Tools

Sources of technical support and assistance for project planning and implementation within the Watershed are often provided through partnerships between local landowners, SCCD, NRCS, BLM, USFS, WG&FD, and/or the Nature Conservancy. In addition, online planning tools and publicly available maps are also available for planning efforts for any proposed projects. These web-based mapping applications can help local sponsors with assisting landowners who are interested in moving forward with a proposed project. Online tools that are currently available for this purpose are discussed below.

5.4.2.1 Wyoming Department of Enterprise Technology Services (ETS)

The Wyoming Department of ETS was established to increase the ability of state agencies to deliver quality cost-effective services to the Wyoming citizens. The ETS' "State Agency Map Portal", which can be accessed via the website (gis.wyo.gov), provides links for GIS web applications with publicly accessible maps. These links are shown in Table 5.4.1.

Table 5.4.1 – Wyoming Department of Enterprise Technology Services State Agency Map Portal GIS Web Applications

Agency	Address	Description
Enterprise Technology Services (ETS)	http://gis.wyo.gov/parcels/	Wyoming Statewide Parcels
	http://gis.wyo.gov/Wyofires/	Wyoming Current Fire Map
State Parks and Historic Trails	http://gis.wyo.gov/WYOutsideResourceGuide/	State Parks Events Info
Office of State Lands and Investment (OSLI)	http://www.onanypc.com/statelandaccess/	Public Access to State Lands
	http://www.onanypc.com/osligis/oilandgas/	State Oil and Gas Information
Wyoming Pipeline Authority (WPA)	http://www.wyopipeline.com	Pipeline Data
Public Service Commission (PSC)	http://psc.state.wy.us/htdocs/Dwnload/CertMaps/electric.pdf	Electric Utilities Areas Map
	http://psc.state.wy.us/htdocs/Dwnload/CertMaps/Gas.pdf	Gas Utilities Certificate Area Map
WSEO	http://seo.maps.arcgis.com/home/index.html	State Engineer's Office Information
WDEQ	http://deq.state.wy.us/lqd_permit_public/	Viewer of Active Mining Permits
WG&FD	http://wisdom.wygisc.org/.	G&F decision support system
WSGS	http://www.wsgs.uwyo.edu/data/maps/published.html	Geologic Maps
	http://www.wsgs.uwyo.edu/Data/GIS/IMS-Projects.aspx	Various geologic mapping
	http://www.wsgs.uwyo.edu/Data/GIS/	Digital data by theme
Wyoming Geographic Information Science Center (WyGISC)	http://www.uwyo.edu/wygisc	Home page for WYGISC
Wyoming Climate Office	http://www.wrds.uwyo/sco/data/PRISM/PRISM.html	PRISM Climate Data Server
	http://ims2.wrds.uwyo.edu/Website/Statewide/	Water/Climate Map Server

5.4.2.2 Wyoming Association of Conservation Districts - SuiteWater

The Wyoming Association of Conservation Districts (WACD), in partnership with the Wyoming Geographic Information Science Center (WyGISC), have created SuiteWater: which is a web-based mapping application and planning tool developed by and for Wyoming conservation districts. SuiteWater provides users with integrated geospatial data, digital imagery, background information and documents, and user-generated data for developing natural resource plans. However, access to SuiteWater is limited to the conservation district boards and employees and WACD Directors, staff, and advisors. Requests for access to SuiteWater must be submitted to the WACD for approval. *http://suitewater.wygisc.org/*

5.4.2.3 Natural Resources Conservation Service - Web Soil Survey

Local sponsors, landowners, managers, and water users can access soils information via the NRCS' Web Soil Survey (WSS). *http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm*

The WSS provides soils information produced by the National Cooperative Soil Survey in updated soil maps and data. Soil mapping data and interpretations can be used for general or local

planning. No online account is necessary unless datasets are downloaded from the website. Site-specific soil maps of an area can be created and customized using the online tools to create a soil map report, measure distances, explore interpretations and ratings, and download associated geospatial data. Although the WSS is useful in analyzing soils data during project planning, on-site soil investigations are recommended for most implementation activities, including (but not limited to) reservoir, irrigation, and wetland construction or rehabilitation projects.

5.4.2.4 Wyoming Cultural Resource Information System

SHPO has created online applications and web services for researching cultural resources within any proposed project area. The SHPO's online resources include the Natural Resource and Energy Explorer (NREX) via: *https://nrex.wyo.gov/.*

SHPO has also created the Cultural Resource Management Tracker (CRMTracker) via: *http://www.gnomon.com/CRMTracker/CRMTracker_AllOrg/CRMTrackerHome.aspx*

NREX has replaced the Cultural Research Information Summary Program (CRISP) and is discussed further in the following section. Additional cultural resource web service information can be obtained by contacting SHPO at: *http://wyoshpo.state.wy.us/OLResources/Index.aspx.*

5.4.2.5 Natural Resource and Energy Explorer

The Natural Resource and Energy Explorer (NREX) is a web GIS-based software tool that supports preplanning development considerations by enabling discovery; energy analysis and assessment, environmental, cultural, socioeconomic, and infrastructural assets for user-defined, project-scale areas of interest in the state. The tool is designed to support the Energy Atlas concept within Governor Mead's Energy Strategy Initiative by providing public access to credible geographic data and information maintained by state agencies. NREX could be used by developers, conservationists, consultants, planners, policy makers, and managers for resource assessment. NREX can be accessed via the website: *https://nrex.wyo.gov*

5.4.2.6 Wyoming State Engineer's Office e-Permit System

The WSEO's e-Permit system facilitates the supervision and protection of surface water and groundwater for the purpose of appropriation, distribution, and application to beneficial use of water in Wyoming. The WSEO's e-Permit system is a web-based, online application that allows registered users to submit applications, petitions, and other requests; search the SEO's database of water rights; track the application process; access water right related documents; and download streamflow and reservoir data. This online permit system can be accessed via the website at: *http://seoweb.wyo.gov/e-Permit/.*

5.4.2.7 Wyoming Interagency Spatial Database and Online Management System

The Wyoming Interagency Spatial Database and Online Management (WISDOM) System is another online planning tool that allows individuals to access data about Wyoming's wildlife resources for use in developing project plans. WISDOM was developed as a partnership between the Western Governors' Association, WG&FD, WyGISC, WYNDD, WDEQ, OSLI, WYDOT, NRCS, the Nature Conservancy, and USFWS. WISDOM provides users with landscape-level information for initial project planning phases; however, site-specific analysis with applicable agencies is still warranted regarding crucial wildlife habitat requirements and conservation potential. WISDOM preserves the confidentiality of sensitive data by displaying land ownership

as federal, state, or private, and the records for certain species are generalized to prevent users from viewing specific location data. WISDOM is available online at: *http://wisdom.wygisc.org/.*

5.4.2.8 Wyoming Density and Disturbance Calculation Tool for Greater Sage-Grouse

The Wyoming Geographic Information Science Center (WyGISC), in partnership with the WG&FD, the BLM, and the USFS, created the Greater Sage-Grouse Online Density and Disturbance Calculation Tool (DDCT), which is a web-based application tool that calculates both the number of disruptive activities averaged per square mile and total surface disturbance within the DDCT assessment area for proposed projects in protected sage-grouse core areas. The DDCT web application is used by individuals in preparation of required permits for development activities. Users must register before the web application can be used. The DDCT is available online at: *http://ddct.wygisc.org/*

5.4.2.9 USFWS Service Information for Planning and Conservation (IPaC)

The USFWS Information for Planning and Conservation (IPaC) is a web-based application that is available to anyone needing assistance in determining how their activities may impact sensitive natural resources. Such natural resources include migratory birds, species listed under the ESA, or wetlands. Information that users obtain from IPaC is produced by USFWS field offices and can assist in improving the efficiency of project planning, discussions, and recommendations. IPaC is available online at: https://ecos.fws.gov/ipac/.

Additional assistance regarding IPaC or USFWS requirements can be obtained by contacting the Wyoming Ecological Services Field Office at: *https://www.fws.gov/wyominges/index.php*.

6. FUNDING OPPORTUNITIES

In order to assist the District and various funding agencies in determining a fair and equitable financing plan for any of the alternatives identified in Sections 3 and 4, it is necessary to conduct an economic analysis associated with such a proposed financing plan. This analysis and plan must be adequate to address the needs of not only the WWDC, but also any other possible funding agency requirements. Potential funding sources can have requirements and/or limitations on the types of projects eligible for assistance.

There are many local, state and federal agencies that administer programs that fund system improvements such as those identified in previous sections of this study. The agencies from which grants and loans are typically requested for funding such improvement projects are described below, segregated into the three categories identified above. Similar to Section 5 (Permits), a considerable amount of this information on funding was obtained from previous Level I studies, specifically the recently-completed *Upper Laramie River Watershed Level I Study* and the *Black Forks River Watershed Level I Study.* Both Level I studies were prepared for the WWDC by Anderson Consulting Engineers, a subconsultant to EnTech on this Level I Study.

6.1 Local Funding Sources

6.1.1 Sheridan County Conservation District

The SCCD serves as a liaison among local landowners, resource users and state and federal government agencies. In addition to their many other roles and responsibilities, the SCCD can also provide funding assistance as follows:

- 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; and
- assistance in developing leveraged, partnered programs and projects.

Programs offered by the SCCD to assist in implementation of BMPs and other conservation practices were discussed in Section 4.3 – Project Effects and Benefits. These programs sometimes offer funding assistance, which were also discussed in that previous section.

Some state and federal agencies, as well as some non-profit organizations, make available funding directly to conservation districts, which can then be utilized to finance projects such as those identified in this Level I Study through the applicable district. Examples of such agencies and organizations offering this type of funding include the WG&FD and The Nature Conservancy.

The SCCD's website is located at www.sccdwy.org.

6.1.2 Sheridan County Weed and Pest Control District

The Sheridan County Weed and Pest Control District provides in-kind support to landowners and other agencies/entities including, but not necessarily limited to, the following:

- 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.

Statewide weed and pest information can be obtained from: http://www.wyoweed.org/.

6.2 State Funding Sources

6.2.1 WWDC

This state agency provides grants and loans to be utilized for the development of water within the State. Funding for the WWDC originates from a tax placed upon extracted minerals, principally coal. Eligible projects include those associated with the development and transmission of water, but not the treatment or distribution of water. Monies could potentially come from any one of four accounts:

6.2.1.1 New Development Program

The New Development Program, also known as Water Development Account No. I, 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 the following types that are relevant to the Level I Study Area:

- 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. Grants are usually available for 67% of the cost for project development. Loans for the non-grant share of project-eligible costs are available at a current rate of 4% and term of 30 years, but longer terms may be considered.

Public entities such as cities, towns, joint powers boards, and special districts (e.g., irrigation districts, watershed improvement districts, water districts, etc.) are eligible for New Development Program Level II and Level III funding. Level III design and construction funding is typically preceded by a Level II study, although sometimes the WWDO may determine that there is sufficient information available from other work previously performed that would allow for bypassing the Level II step.

The cost to create a special district varies primarily upon the number of landowners who would have property included within the boundaries of the district, and the level of interest in any proposed project. For instance, the Piney and Cruse Creek Ditch Company Irrigation District, a recently-established special district formed for the purpose of securing WWDC funding for a project in the Piney Creek drainage, was created at a cost of approximately $70,000. This irrigation district includes approximately 4,370 acres of irrigated lands owned by approximately 178 property owners.

The **potential** exists that an existing special district may act as a project sponsor in order to qualify for WWDC funding, which could save both time and money for those interested in utilizing this WWDC funding program. Table 6.1 lists the existing special districts located within the

Watershed, with the exception of the Wild Rose I&S District, which could very well move forward (and have the legal ability to do so) with applications for Level II and III funding for their proposed projects. This table also provides reasons why these special districts are **not** recommended for use as project sponsors for the projects identified in Chapter 4.

Table 6.1 – Listing of Special Districts within Watershed

Special Districts located within the Watershed	Reason Why Special District is Not Recommended to be a Project Sponsor
Don Ena Estates I&S District	Already affiliated with Wild Rose I&S District, as they serve the same county subdivision.
Parker Draw I&S District	No identified projects located within or directly benefitting area served by this district.
Powder Horn I&S District	No identified projects located within or directly benefitting area served by this district.
Southeast W&S District	No identified projects located within or directly benefitting area served by this district.
Woodland Hills I&S District	No identified projects located within or directly benefitting area served by this district.
Downer Neighborhood I&S District	No identified projects located within or directly benefitting area served by this district.
Mead Creek Ditch Company Irrigation District	Only two small projects (ISI-MC-01 and ISI-LG-LC-03)) located within or directly benefiting area served by this district, thus unlikely to pursue Level II or III funding.
Park Reservoir Irrigation District	Originally formed in 1980s for the express purpose of funding remedial improvements to Park Reservoir.
Piney & Cruse Creek Ditch Company Irrigation District	Only one small project ISI-MC-01) located within or directly benefiting area served by this district, thus unlikely to pursue Level II or III funding.
Big Horn Water District	Per 41-10-101(a), water districts are created for the purpose of supplying water for **domestic** purposes.
Little Goose Valley Water District	Per 41-10-101(a), water districts are created for the purpose of supplying water for **domestic** purposes.
Big Goose/Soldier Creek Water District	Per 41-10-101(a), water districts are created for the purpose of supplying water for **domestic** purposes.
Sheridan School District No. 1 Recreation District	Recreation districts are not created for the purpose of funding water projects.
Sheridan County Conservation District	Overall Level I Study Sponsor and SWPP Sponsor
Big Horn Fire District	Fire districts are not created for the purpose of funding water projects.
Sheridan Area Rural Fire District	Fire districts are not created for the purpose of funding water projects.

6.2.1.2 Rehabilitation Program

The Rehabilitation Program, also known as Water Development Account No. II, provides funding assistance for the improvement of water projects completed and in use for at least fifteen (15) years. As with the New Development Program, grants for 67% of the project development costs, and 4% loans with a term of 30 years (or possibly longer) for the remainder of the cost, are available from the WWDC.

As with the WWDC's New Development Program, only public entities are eligible for Level II and Level III funding from the Rehabilitation Program.

6.2.1.3 Dam and Reservoir Program

Proposed new dams with storage capacities of 2,000 A-F or more, and proposed expansions of existing dams of 1,000 A-F or more, qualify for the Dam and Reservoir Program, also known as Water Development Account No. III. Dams and reservoirs typically provide opportunities for many potential uses. While providing a reliable water supply is emphasized in the development of reservoir operating plans, recreation, environmental enhancement, flood control, erosion control and hydropower uses are typically explored as secondary purposes.

As opposed to the New Development and Rehabilitation Programs, the grant/loan mix is not fixed for the Dam and Reservoir Program. Instead, the WWDC may approve a loan/grant mix "based on the sponsor's ability to pay a portion of the project costs and all of the operation, maintenance, and replacement costs". Furthermore, and in order to reduce costs to the project sponsor, the WWDC may further recommend that:

- permitting and design costs be paid by the program in lieu of through the grant/loan financial package; and
- the State pay for the storage capacity needed to provide water for environmental mitigation and enhancements.

As with both the WWDC's New Development Program and Rehabilitation Program, only public entities are eligible for Level II and Level III funding from the Dam and Reservoir Program.

6.2.1.4 The Small Water Projects Program

The WWDC's Small Water Projects Program (SWPP) is intended to be compatible with the conventional WWDC funding programs described above. Small water projects are defined as providing multiple benefits, and where the WWDC's maximum financial contribution is $35,000 or less, with the WWDC's participation being 50% of the total project costs up to $70,000. Monies from the SWPP represent a one-time grant; i.e., no ongoing operation and maintenance costs are eligible for funding. Loans are not available from the SWPP. Applicants may use in-kind services to meet a portion of the match for SWPP money.

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

- small reservoirs;
- wells;
- solar platforms;
- pipelines and conveyance facilities;
- springs;
- wetland development;
- environmental;
- irrigation;
- windmills;
- rural community fire suppression; and
- recreational.

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 through eligible public entities including, but not necessarily limited to, conservation districts such as the SCCD, watershed improvement districts, water conservancy districts, and irrigation districts.

Details of the application and evaluation process and program administrative procedures are provided in the SWPP Operating Criteria, available online at: http://wwdc.state.wy.us/small_water_projects/SWPPopCriteria.html. Important aspects of the process and procedures applicable to the potential projects identified previously in Section 4 include the following:

A. Applications shall be received by January 1 of each calendar year. Applications meeting criteria requirements will be considered during the WWDC's annual March meeting. 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.

B. Small water projects must demonstrate a public benefit. Public benefit may be demonstrated for projects included in WWDC watershed studies. Eligible projects may be located on Federal, State, public or private lands.
C. Project priorities for the SWPP's Account I and Account II are as follows (from highest to lowest priority);

For Account I (New Development):

1. Source Water Development
2. Storage
3. Pipelines, conveyance facilities, solar platforms and windmills
4. Irrigation
5. Environmental
6. Recreational

For Account II (Rehabilitation):

1. Diversion structures and spring developments
2. Storage
3. Pipelines, conveyance facilities, solar platforms and windmills
4. Irrigation other than the above
5. Environmental
6. Recreational

In order to obtain the greatest likelihood of funding success, the project should be as "shovel ready" as possible.

6.2.2 Wyoming Department of Environmental Quality

6.2.2.1 Section 319 Program

The 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. As such, Section 319 funds are actually federal funds; however, they are administered in Wyoming by WDEQ, and projects are prioritized by the Governor's Nonpoint Source Task Force.

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, special districts or other types of governmental entities (e.g., the SCCD, watershed improvement districts, irrigation districts, etc.), and/or non-profit organizations (e.g., Trout Unlimited or Ducks Unlimited). Proposals for use of funds are considered on a semi-annual basis, with applications normally being due in August or September of each year.

The amount of requests for funding from this program typically exceeds the amount appropriated, and competition for these dollars has increased with time. As such, funding availability becomes a matter of priority. Additionally, use of these funds requires adherence to certain federal procurement requirements that can increase overall project costs.

6.2.2.2 Section 205(j) Program

Funding is available via this WDEQ non-point source program for cities, towns, counties and conservation districts. It can be used for water quality management planning and assessment projects; i.e., they are not intended for actual construction of facilities. As with the Section 319 funds, funds for this program originate with the federal government but are administered by WDEQ via a primacy agreement between the State and federal government.

Information on both the Section 319 and 205(j) non-point source programs is available at; http://deq.wyoming.gov/wqd/non-point-source/resources/grant-resources/.

6.2.2.3 State Revolving Funds Program

WDEQ's State Revolving Funds Program (SRF) consists of two separate loan funds that can be used to assist public entities with funding for water or wastewater infrastructure improvement projects. These funds are made available to the State through the U.S. EPA.

The first program is entitled the Drinking Water SRF, which, as the name implies, is used for drinking water systems, including source, treatment plant, storage tank, and transmission and distribution line projects. The second program is entitled the Clean Water SRF. This program can be used to fund sanitary sewer treatment and collection, storm water control, landfill water pollution control, and other water pollution control projects.

Loans for eligible projects are available at a current rate of 2.5% and a term of 20 years. Although funding is technically available only through loans, up to 50% of these loans can have their principal "forgiven", meaning that monies available can oftentimes prove to be very attractive. Additionally, monies available from this program can serve as matching funds for other grant funding programs, such as the WWDC or other state funding programs.

DEQ annually updates a ranking of projects eligible for these loan programs, with the ranking for each program being known as the Intended Use Plan. Information on the program is available at: http://deq.wyoming.gov/wqd/state-revolving-loan-fund/.

6.2.3 Wyoming Game and Fish Department

The WG&FD offers various funding mechanism to assist landowners, conservation groups, institutions, land managers, government agencies, industry and non-profit organizations develop and/or maintain water sources for fish and wildlife. Assistance may also be provided for protecting or improving riparian areas/wetlands, restoring streams, and upgrading irrigation infrastructure in a manner that provides improved fish passage or diversion screening.

These funding mechanisms also assist in the improvement and/or protection of riparian/wetland areas for fish and wildlife resources in Wyoming.

A listing of the various WG&FD funding mechanisms follows. This information was obtained from the Water Management & Conservation Assistance Program Directory (WWDC, 2014). The full document can be accessed at:
http://wwdc.state.wy.us/wconsprog/2014WtrMgntConsDirectory.html.

6.2.3.1 Habitat Trust Fund

Funds can be used for acquiring, maintaining, or improving wildlife habitat; or for promoting human understanding and enjoyment of the fish and wildlife resource (habitat or information and education projects). Funds can be used for internal projects or paid as grants to an outside entity. All proposals must have a WG&FD sponsor and be entered into a department proposal database by early January or early August annually. Project proposals will be prioritized for funding by department staff during January through March, with the Wyoming Game and Fish Commission granting preliminary approval in March, followed by final approval in July for funds available in July. No cost share is required but is strongly recommended. Projects need to occur in priority habitats or watersheds.

Approximately $600,000 to $1,200,000 is allocated annually to projects across Wyoming. For more information related to the Habitat Trust fund, contact Paul Dey at the WG&FD (paul.dey@wyo.gov).

6.2.3.2 Fish Passage Grants

Grant funds available through this program can be used for creating or improving upstream or downstream passage for fish in Wyoming waterways. They can also be used for screening diversions. Examples include developing fishways or fish ladders, assisting with the replacement of traditional push-up diversion dams with more fish-friendly options, and installing various screening technologies to keep fish from becoming entrained into irrigation ditches.

All proposals must have a WG&FD sponsor and be entered into a WG&FD proposal database by early January annually. Project proposals will be prioritized for funding by department staff during January through March, followed by the Wyoming Game and Fish Commission granting preliminary approval in March, with final approval for funding occurring in July. As with the Habitat Trust Fund, no cost share is required, but it is strongly recommended.

Projects should occur in priority habitats or watersheds. Approximately $25,000 to $90,000 is allocated annually to projects across the State.

6.2.3.3 Wyoming Sage Grouse Conservation Fund

The WG&FD also administers the Wyoming Sage-Grouse Conservation Fund (WSGCF). 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. Implementation of projects consistent with local sage-grouse conservation plans are intended to assist in keeping the sage grouse from being listed under the federal Endangered Species Act.

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 typically 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
- funding adequacy.

Application may be made at any time, but typically are made by February 1st of each year 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 on a reimbursable basis, versus being provided “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.

A detailed listing of sage grouse funding opportunities is available from the WG&FD at: *http://wgfcms.wyo.gov/WGFD/media/content/PDF/Habitat/Sage%20Grouse/SGC_FUNDINGOPPS_REVISED0414.pdf*.

Requests for Wyoming Sage Grouse Conservation funding directly through WG&FD must be made on a separate project proposal form, available (along with other related information on sage grouse conservation) at: *http://wgfcms.wyo.gov/Habitat/Sage-Grouse-Management*.

6.2.4 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 Section 4. Specifics on each program follow.

6.2.4.1 Regular Farm Loans

These loans are made for a wide range of agricultural purposes, including as most applicable to the potential projects identified in Section 4, 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.

6.2.4.2 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 special 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, with a maximum loan term being 40 years.

6.2.4.3 Mineral Royalty Grants

The Mineral Royalty Grant (MRG) program awards grants to:

- alleviate an emergency situation which poses a direct and immediate threat to public health, safety or welfare;
- comply with federal or state mandates; or
- provide an essential public service.

Funds are generated by fees placed on mineral extraction on federal lands; the federal government remits a portion of those fees back to the State. Eligible applicants are incorporated cities and towns, counties, special districts and joint powers boards.

Grants are typically provided for up to 50% of an eligible project's costs, and they are distributed semi-annually. They are typically used to fund water and sewer projects in order to allow local communities to comply with federal and state mandates on these public utilities.

More information on this grants program is available at:
https://sites.google.com/a/wyo.gov/osli/grantsloans/grants/mrg.

6.2.5 Wyoming Department of Agriculture's Water Quality Grant Program

This state department provides funding to conservation districts throughout Wyoming for water quality-related assessments, planning, and implementation activities. A portion of this funding is available in grants to individual districts. The maximum available amount to a district is $20,000 per year. Although there is considerable competition statewide for this limited amount of funding, the SCCD has nonetheless been successful historically in their procurement. Possible uses of these funds could be for upland water development projects, irrigation infrastructure and bank stabilization projects.

6.2.6 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, and
- 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, such as 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; and
    - 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. Applications are due by March 1st and September 1st of each year.

6.3 Federal Funding Sources

6.3.1 National Resources Conservation Service

6.3.1.1 Environmental Quality Incentives Program (EQIP)

The NRCS administers the Environmental Quality Incentives Program (EQIP), which was reauthorized in the Agricultural Act of 2014. This program is a voluntary conservation program for farmers and ranchers which is designed to promote agricultural production and environmental quality as compatible national goals. EQIP offers federal financial and technical assistance to eligible participants to implement both structural and management practices on eligible agricultural lands.

EQIP offers contracts with a maximum term of ten years. These contracts provide incentive payments and cost-shares to implement conservation practices. Persons who are engaged in livestock or agricultural production on eligible land may participate in the EQIP program. As a result, landowners within the Level I Study Area who are not engaged in such production cannot apply for such funds.

EQIP activities are carried out according to a conservation plan developed in conjunction with the producer that identifies the appropriate conservation practice or practices to address the resource concerns. In the case of the proposed projects identified, improved conservation practices could possibly include reduction of stream sediment loading by constructing pipelines or energy dissipation structures where water-related erosion has historically occurred.

These conservation practices are subject to NRCS technical standards adapted for local conditions. The local conservation district approves the plan; in this case, the SCCD.

Unlike the WWDC, the EQIP program does not provide grants to public entities. Instead, it is a cost-share program designed to reimburse private landowners up to 75% of the costs of certain conservation practices. Therefore, neither the SCCD nor any other public entity will be the EQIP funding recipient. Individual landowners will be reimbursed eligible costs. Eligible recipients must have an annual Adjusted Gross Income of less than $900,000. Generally, the maximum payment of EQIP funds to one individual cannot exceed $450,000.

The amount of EQIP participation is based upon allowable unit costs (as determined by an NRCS regional cost index) and the actual quantities of items installed. As a result, it is important to note that a cost-share amount designated by the NRCS from the EQIP does not necessarily mean that that total amount can actually be used to finance project costs.

In order to avoid the administration of several EQIP grants to various landowners being used for one project, oftentimes one landowner benefiting from the proposed improvements receives the entire EQIP funding amount required for the project. That one person then contributes these funds to a special district comprised of other landowners benefitting from the project, with that special district then using the EQIP funds as a match for other funding sources, such as the WWDC. That landowner receiving the EQIP funding becomes responsible for making sure that the special district implements the project. He or she needs to recognize that the IRS considers

EQIP grants to be taxable. This procedure was recently followed by the local NRCS for improvements to the N.B. Held Ditch diversion dam immediately west of the City on Big Goose Creek.

6.3.1.2 PL-566 Program

Another program administered by the NRCS that is a possible funding source is the Watershed Protection and Flood Prevention Act (PL-566), which authorizes the NRCS to assist local organizations and governmental entities in the planning and implementation of watershed projects. PL-566 works through local government sponsors such as the District and helps participants solve natural resource and related economic problems on a watershed basis. It can offer assistance for both on-farm and off-farm improvements. Applicants compete nationwide (vs. statewide) for funding. There is a good deal of competition for such funding.

Projects can include:

- flood prevention and damage reduction;
- development of rural water supply sources;
- erosion and sediment control;
- fish and wildlife habitat enhancement;
- wetland creation and restoration; and
- increased recreational opportunities.

Receipt of funding under the 566 program is conditioned upon successful demonstration of a benefit/cost ratio of greater than one, as determined by a feasibility study conducted by NRCS staff. This study is performed at no cost to the applicant, and takes approximately six months to complete. There is an approximate two-year lag between the time of feasibility request and receipt of design and construction funding, assuming that the benefit/cost ratio makes receipt of the federal funding possible.

There is no set match; therefore, it is possible that up to 100% of the project costs could potentially be provided via this program. However, matching these monies with other sources can make the project more attractive to federal administrators reviewing applications.

Use of PL-566 monies may sometimes be a possibility; however, statewide NRCS officials have indicated that the last three to four years of federal budget cuts have essentially gutted funding for this program. Per these officials, until there is a change in philosophy in Washington regarding the importance of this program, therefore the likelihood of obtaining funding from this program for the projects identified in this study is very remote.

6.3.1.3 Joint Chiefs' Landscape Restoration Program

The NRCS and USFS jointly utilize this program to improve the health of forests where public forests and grasslands connect to privately owned lands. Funding is available to restore landscapes, reduce wildfire threats to communities and landowners, protect water quality, and enhance wildlife habitat. This federal partnership was initiated in 2014, and each year these two federal agencies select new three-year projects. In fiscal year 2017, a total of $32 million will be available to fund new and active projects in 29 states.

6.3.1.4 Regional Conservation Partnership Program (RCPP).

The RCPP promotes coordination between the NRCS and its partners to deliver conservation assistance to producers and landowners. The NRCS provides assistance to producers through

partnership agreements and through program contracts or easement agreements. With this funding, there is an emphasis on irrigation infrastructure, bank stabilization, and livestock water development projects. Assistance is delivered in accordance with the rules of EQIP, CSP, and the Agricultural Conservation Easement Program (ACEP), and in certain areas the Watershed Operations and Flood Prevention Program.

The SCCD was one of only two partnerships in Wyoming that was funded in the inaugural round of funding available through the RCPP. Initial funding secured by the SCCD was used for the Tongue River watershed as well as this Watershed.

This program represents a partnership among the SCCD, The Nature Conservancy, the Sheridan Community Land Trust, and the WG&FD.

6.3.1.5 Other Miscellaneous NRCS Programs

Other miscellaneous programs administered by the NRCS that may be relevant to many of the projects discussed in Section 4 include the following:

- Emergency Watershed Protection (EWP) Program. This program assists in implementing emergency measures, including the purchase of floodplain easements, for runoff retardation and soil erosion prevention to safeguard lives and property from floods, drought, and the products of erosion on any watershed whenever fire, flood, or any other natural occurrence is causing or has caused a sudden impairment of the watershed.
- Watershed Protection and Flood Prevention Operations (WFPO) Program. This program provides technical and financial assistance to entities of state and local governments and tribes for planning and installing watershed projects.
- Watershed Surveys and Planning (WSP). The WSP authorizes the NRCS to cooperate with federal, state, and local agencies and tribal governments to protect watersheds from damage caused by erosion, floodwater, sediment, and to conserve and develop water and land resources.
- Conservation Stewardship Program (CSP). The CSP encourages land stewards to improve their conservation performance by installing and adopting additional activities, and improving, maintaining, and managing existing activities on agricultural land and non-industrial private forest land.
- Agricultural Management Assistance (AMA). The AMA provides financial assistance to agricultural producers to address resource issues such as water management, water quality, invasive species control, and erosion control by incorporating conservation into their farming or ranching operations. The purpose of the AMA is to assist producers in reducing risk to their operation.
- Conservation Innovation Grants (CIG) Program. The CIG is intended to stimulate the development and adoption of innovative conservation approaches and technologies while leveraging federal investment in environmental enhancement and protection, in conjunction with agricultural production. Under CIG, EQIP funds are used to award competitive grants to nonfederal governmental or nongovernmental organizations, tribes, or individuals.
- Agricultural Conservation Easement Program. The ACEP provides financial and technical assistance to help conserve agricultural lands and wetlands and their related benefits. Under the Agricultural Land Easements component, NRCS helps tribes, state and local governments, and nongovernmental organizations protect working agricultural lands and limit non-agricultural uses of the land. Under the Wetlands Reserve Easements component, the NRCS helps to restore, protect and enhance enrolled wetlands.

- Sage Grouse Initiative. The Sage Grouse Initiative (SGI) is an organization of public and private entities conserving at-risk wildlife through voluntary cooperation, incentives, and community support. The NRCS launched SGI in 2010, applying the power of the Farm Bill to target lands where habitats are intact and sage grouse numbers are highest – covering 78 million acres across 11 western states. While private lands are the primary focus, the Initiative serves as a catalyst for public land enhancements. The SGI applies Farm Bill dollars and certifies conservation projects in the core areas for sage grouse with a dual goal of sustaining rangelands and sage grouse. In addition to directing dollars to private lands where 40% of sage grouse live, SGI dollars can be applied on public lands where ranchers have grazing leases. Detailed information related to the SGI can be found at the following website: *http://www.sagegrouseinitiative.com/*.

6.3.2 Environmental Protection Agency

The EPA has several grant programs that could potentially provide funding opportunities for projects described in this Level I Study. They are discussed briefly below.

6.3.2.1 Urban Waters Program

This program was established in 2012 to help local residents and their organizations, particularly those in underserved communities, restore their urban waters in ways that also benefit community and economic revitalization. The two types of grants available through this program are listed below:

- The Five Star/Urban Waters Restoration Grant Program projects include on-the-ground activities (for example: wetland or river habitat restoration), integrated education, outreach and training, measurable ecological and community benefits, and community partnership-building emphasis.
- The Urban Waters Small Grants are competed and awarded every two years. Since its inception in 2012, the program has awarded approximately $5.3 million in Urban Waters Small Grants to 92 organizations across the country, with individual award amounts of up to $60,000. Urban Waters Small Grants Program projects must address local water quality issues related to urban runoff pollution, provide additional community benefits, actively engage underserved communities, and foster partnerships. Specific information pertaining to the types of projects funded was not available.

6.3.2.2 Healthy Watersheds Program

After decades of focusing almost exclusively on restoring impaired waters, EPA created the Healthy Watersheds Program to help address the "maintain" component of the "restore and maintain" goal intended by Congress in the 1972 Federal Water Pollution Control Act amendments. Through a multi-year cooperative agreement awarded in 2015, EPA is helping to support watershed protection via a healthy watershed grants consortium. This consortium brings together like-minded partners from all levels of government, private organizations and industry to support individual watershed protection projects through grants, using leveraged funding from government and non-government sources together. Details and contact information on healthy watersheds grants can be found at:
https://www.epa.gov/hwp/what-epa-doing-healthy-watersheds.

6.3.3 Bureau of Land Management

6.3.3.1 Range Improvement Planning and Development

This program is a cooperative effort not only with the livestock operator but also with other outside interests including the various environmental/conservation groups. Water development, whether it be for better livestock distribution or improved wetland habitats for wildlife, is key to healthy rangelands and biodiversity. Before actual range improvement development occurs, an approved management plan must be in place. 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.

6.3.3.2 Watershed and Water Quality Improvement Program

Under this program, efforts are undertaken in a cooperative approach with the State, 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 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 TMDLs 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 BMPs, e.g. prescribed burns, vegetation treatments, instream structures, enhancement of vegetative cover, control of accelerated soil erosion, increasing water infiltration, and enhancing 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 BMPs to address identified acid mine drainage and runoff problems from mine tailings and waste rock piles.

6.3.4 Farm Service Agency

The Farm Service Agency (FSA) administers three different programs that may be applicable to some of the projects identified in Section 4. Technical assistance for the FSA programs is provided by the NRCS. Each of these three programs is briefly discussed below.

6.3.4.1 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.

6.3.4.2 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.

6.3.4.3 Farmable Wetlands Program

The Farmable Wetlands Program (FWP) is designed to restore previously farmed wetlands and wetland buffer zones to improve both vegetation and water flow. FWP provides annual rental payments in return for restoring wetlands and establishing plant cover. Eligible land must have been used for agricultural purposes for three of the past ten crop years.

6.3.4.4 Grassland Reserve Program

The Grassland Reserve Program is designed to prevent grazing and pasture land from being converted to cropland, urban development, or other non-grazing uses. Participants in the program voluntarily limit future development of their grazing and pasture land, while still being able to use the land for livestock grazing and activities related to forage and seed production.

6.3.5 Fish and Wildlife Service

Technical and financial assistance is available through the USFWS 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). Applicable USFWS programs include the following:

6.3.5.1 Partners for Fish and Wildlife Program

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

6.3.5.2 Wildlife and Sport Fish Restoration Program

This USFWS program works with states and the District of Columbia to conserve, protect, and enhance fish, wildlife, their habitats, and the hunting, sport fishing, and recreational boating

opportunities they provide. The WSFR Program provides oversight and/or administrative support for the following grant programs: Wildlife Restoration Grant Program, Sport Fish Restoration Grant Program, Boating Infrastructure Grant Program, State Wildlife Grant Program, Tribal Wildlife Grant Program, and Tribal Landowner Incentive Grant Program.

6.3.5.3 Cooperative Endangered Species Conservation Fund

This program is available to states that have a cooperative agreement with the Secretary of the Interior. The intent is to provide Federal assistance to any state 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.

6.3.5.4 North American Wetlands Conservation Act Grant Program

This 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 acquisitioning, enhancing, and restoring wetlands and wetlands-associated habitat. This program encourages voluntary, public-private partnerships. Public or private, profit or nonprofit entities, or individuals establishing public/private sector partnerships are eligible. Cost-share partners must at least match grant funds with non-federal monies.

6.3.5.5 USFWS' Challenge Cost Share Program

This program started in 1988 as a way to enhance partnerships with state and local governments, individuals, and public and private groups. The program enables the FWS to manage cooperatively its natural and cultural resources and fulfill stewardship responsibilities to fish and wildlife management. Under this program, projects must occur on a refuge or directly benefit a refuge (which may not be applicable in this watershed). The program encourages refuge managers to form partnerships and leverage allocated funds to complete the projects. Appropriated funds may be used to pay for no more than 50% of the cost of a project. Nonfederal sources, including state/local governments, private individuals/ organizations, business enterprises, and philanthropic and charitable groups provide the matching 50% cost share. The cooperator share may be a nonmonetary contribution. Cooperative agreements are signed with the cost-share partners.

6.3.6 U.S. Army Corps of Engineers

The USACOE 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 USACOE is responsible for a worldwide military construction program, an extensive environmental program and a broad national civil works program. The USACOE 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 resource-related projects and respond to water resource needs.

6.3.6.1 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.

6.3.6.2 Floodplain Management Service.

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.

6.3.6.3 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 USACOE 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 being federally funded. 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 costs, as well as a maximum of 50% of the total project costs, are the sponsor's responsibility.

6.3.6.4 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.

6.3.6.5 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 as river channel reconnection, wetland creation or improving water quality. Conditions are similar to the Project Modification program with sponsor cost share being 35%.

6.3.6.6 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 USACOE 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 a 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.

6.3.6.7 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.

6.3.6.8 Regulatory Authority/Responsibility

The USACOE has regulatory authority under the Clean Water Act and the River and Harbor Act. The purposes of these laws are 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 USACOE 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.

6.3.7 Rural Development

The United States Department of Agriculture, Rural Development's utilities program (also known as the Rural Utilities Service, or RUS) 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 RUS 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.

6.3.8 U.S. Forest Service

A number of federal laws direct or authorize watershed management on USFS lands. Some of these laws provide broad authority, whereas others deal more narrowly with specific watershed management activities. The objectives of the USFS' watershed management program are to protect and enhance soil productivity, water quality, water quantity, and timing of water flows, as well as to maintain favorable conditions of streamflow and continuous production of resources from USFS watersheds.

The policy of the USFS is to implement watershed management activities on its 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 USFS' intent to design management activities of other resources in order to minimize short-term impacts on soil and water resources, and also to maintain or enhance long-term productivity, water quality, and water quantity. Specific direction for water quality is contained in the Land and Resource Management Plan for each respective national forest.

Funding for projects mentioned in this report could potentially be available via the Secure Rural Schools Program Title II mechanism. Title II funds may be used for the protection, restoration and enhancement of fish and wildlife habitat. They may also be used coincident with other resource objectives consistent with the Act on federal and non-federal lands where projects would benefit the resources on the federal lands.

Projects that implement stewardship objectives to enhance forest ecosystems, or restore and improve land health and water quality, would potentially be eligible. Projects need to have broad-based support with objectives that may include, but are not limited to: road, trail, and infrastructure maintenance or obliteration; soil productivity improvement; improvements in forest ecosystem health; watershed restoration and maintenance; restoration, maintenance and improvement of wildlife and fish habitat; control of noxious and exotic weeds; and reestablishment of native species.

More information related to Title II funding is available at:
http://www.fs.usda.gov/main/pts/specialprojects.

6.3.9 U.S. Bureau of Reclamation

The USBR's mission is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the public. The USBR has a major responsibility, in partnership with states, water users, and other interested parties, to help improve water resources and the water use efficiency in the western United States. Although there are no USBR-managed facilities located within the Watershed, the opportunity nonetheless exists to utilize funding programs available through this federal agency.

The USBR Sustain and Manage America's Resources for Tomorrow (WaterSMART) Program establishes a framework to provide federal leadership and assistance on the efficient use of water, integrating water and energy policies to support the sustainable use of all natural resources, and coordinating the water conservation activities of various department bureaus and offices. Through the WaterSMART Program, the department is working to achieve a sustainable water management strategy to meet the nation's water needs through projects that conserve and use water more efficiently, increase the use of renewable energy and improve energy efficiency, protect endangered and threatened species, facilitate water markets, or

carry out other activities to address climate-related impacts on water or prevent any water-related crisis or conflict.

A major component of WaterSMART is the Water and Energy Efficiency Grant Program, through which the USBR provides funding in two groups. In Funding Group I, up to $300,000 in federal funding is available per project, for smaller on-the-ground projects. In Funding Group II, up to $1 million in funding is available for larger, phased, on-the-ground projects that may take up to three years to complete. Water and Energy Efficiency Grants are awarded through a west-wide competitive process that requires a minimum 50 percent cost share by the recipient.

On the ground projects are also now being funded through a new grant category under WaterSMART Grants, which provides a newly dedicated funding source. Information on this new program is available at: *http://www.usbr.gov/watersmart/grants.html*.

6.4. Non-profits and Other Organizations

6.4.1 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.

6.4.2 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 Level I Study Area include the following:

- Pulling Together Initiative. This program 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.
- Acres for America. Acres for America is one of the most effective public-private partnerships in the history of U.S. conservation efforts. The Acres for America program conserves lands of national significance, protects critical fish and wildlife habitat and benefits people and local economies.
- Bring Back the Natives Grant Program. This program funds to restore damaged or degraded riverine habitats and their native aquatic species provided by BLM, USBR, USFWS, USFS, and NFWF. A minimum 2:1 non-federal match is required.
- Conservation Partners Program. The primary goals of this program are targeting funds made available by the federal Farm Bill toward priority conservation objectives and maximizing the funds benefits. Through these regional grants, this conservation program has begun to place expert staff where they can maximize outreach to the private landowner.
- Five-Star Urban Waters Restoration Program. This 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. The average grant is approximately $13,000.

- Environmental Solutions for Communities Initiative. This program was designed to support projects that link economic development and community well-being to the stewardship and health of the environment. Funding is available for projects that conserve critical land and water resources or improve local water quality. Another priority of this initiative is restoring and managing natural habitat, species and ecosystems that are important to community livelihoods.

Information about all of these and other NFWF grants/programs is available at their website: http://nfwf.org/.

6.4.3 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.

Of special concern are Wyoming's four subspecies of native cutthroat trout that currently inhabit a tiny fraction of their historic range. Working with federal and state agencies, local officials and landowners, Wyoming Trout Unlimited is actively engaged in a battle to keep these fish from being listed under the Endangered Species Act.

7. COST ESTIMATES

Appendix A provides information on the various recommended projects to be implemented as part of the Watershed Management and Rehabilitation Plan. The information provided includes conceptual design level cost estimates and a map of each project's location within the Watershed. Figures 4.2.1 – 4.2.3 function as vicinity maps for these projects. A compilation of those projects listed in Appendix A and their associated estimated costs are shown in Table 4.4.3.

8. CONCLUSIONS AND RECOMMENDATIONS

This Level I Study is the culmination of the need for development of a Watershed Management and Rehabilitation Plan within the Goose Creek drainage area. Both the SCCD and WWDC have recognized the need to develop this plan. With the SCCD acting as project sponsor and the WWDC as both project manager and funding agency, these agencies have stepped forward to meet this need.

The results of this Level I Study are summarized herein and represent an important opportunity for the State and the local community (through the SCCD) to thoughtfully plan for the future of the Watershed and its water resources.

1. Irrigation water use dominates water usage within the watershed and accounts for approximately 97% of the Watershed's total use of surface water. Upon conducting an inventory of irrigation system infrastructure within the Watershed, it is evident that improvements to this infrastructure are very necessary. This Level I Study has outlined specific improvements and associated costs to implement 71 projects which address many of these needed improvements. As discussed in Section 6, there are funding mechanisms available to offset the capital costs associated with many of these projects.

2. Solicitation of possible projects to implement upland water development opportunities has led to nine possible projects being identified in this Level I Study. This relatively small number of possible projects appears to indicate that the agricultural community is generally satisfied with the current state of furnishing water to livestock in the upland areas located throughout the Watershed.

3. There are several diversion facilities within the Watershed that currently impede fisheries migration. This Level I Study has identified five projects that would provide continued water diversions while simultaneously benefitting fisheries by allowing for their required periodic migrations. Several of these fisheries migration projects will also improve these facilities' ability to divert streamflows.

4. The existing water supply within the Watershed has been generally sufficient to satisfy the existing demands associated with all of the water users; with mountain reservoirs filled with springtime runoff used to augment flows in the mid-and-late summer. However, due to an expected increase in the population residing within the Watershed, there is a need for additional water for municipal purposes. (The need to increase water for irrigation purposes was not similarly identified, although there are some lands within the Watershed that are potentially irrigable.) This Level I Study has highlighted the fact that groundwater development is not a solution to address future needs.

   A 2011 study indicated that a viable method of meeting this growing municipal need is to purchase existing agricultural water storage in mountain reservoirs. In lieu of using this method to address the growing need, two potential surface water storage opportunities are discussed in this Level I Study:
   - Gillispie Draw Reservoir; and
   - Lake Desmet Reservoir, an existing reservoir actually located in the Piney Creek drainage.

The need to consider additional water supplies has been exacerbated by recent decisions reached in the Montana v. Wyoming Yellowstone River Compact case. If nothing else, it is evident that the State of Montana is much more closely monitoring Wyoming's use of its share of water per the Compact in the Tongue River watershed, of which this Watershed is a part. As a result, a potential surface water storage opportunity addressed in this Level I Study includes the importation of Lake DeSmet Reservoir water to supplement Wyoming's supplies by allowing this water to flow into Montana, thereby replenishing supplies and allowing water within the Watershed with post-1950 rights to continue to be used for irrigation and municipal purposes.

5. As stated previously, implementation of a Watershed Management and Rehabilitation Plan will require funding from several sources. Funding for smaller projects may come from the SWPP, although the maximum amount of funding available from this program is $35,000. For larger projects0, some type of public entity (typically a special district) must be formed that has the capability to incur debt and assess its users. This issue must be addressed to facilitate the progression of this Level I Study into a Level II study, which can much more closely evaluate the feasibility of selected project improvements. Results of a Level II study can then eventually lead to authorization of WWDC Level III funding, which provides for actual preparation of plans and specifications, followed by construction.

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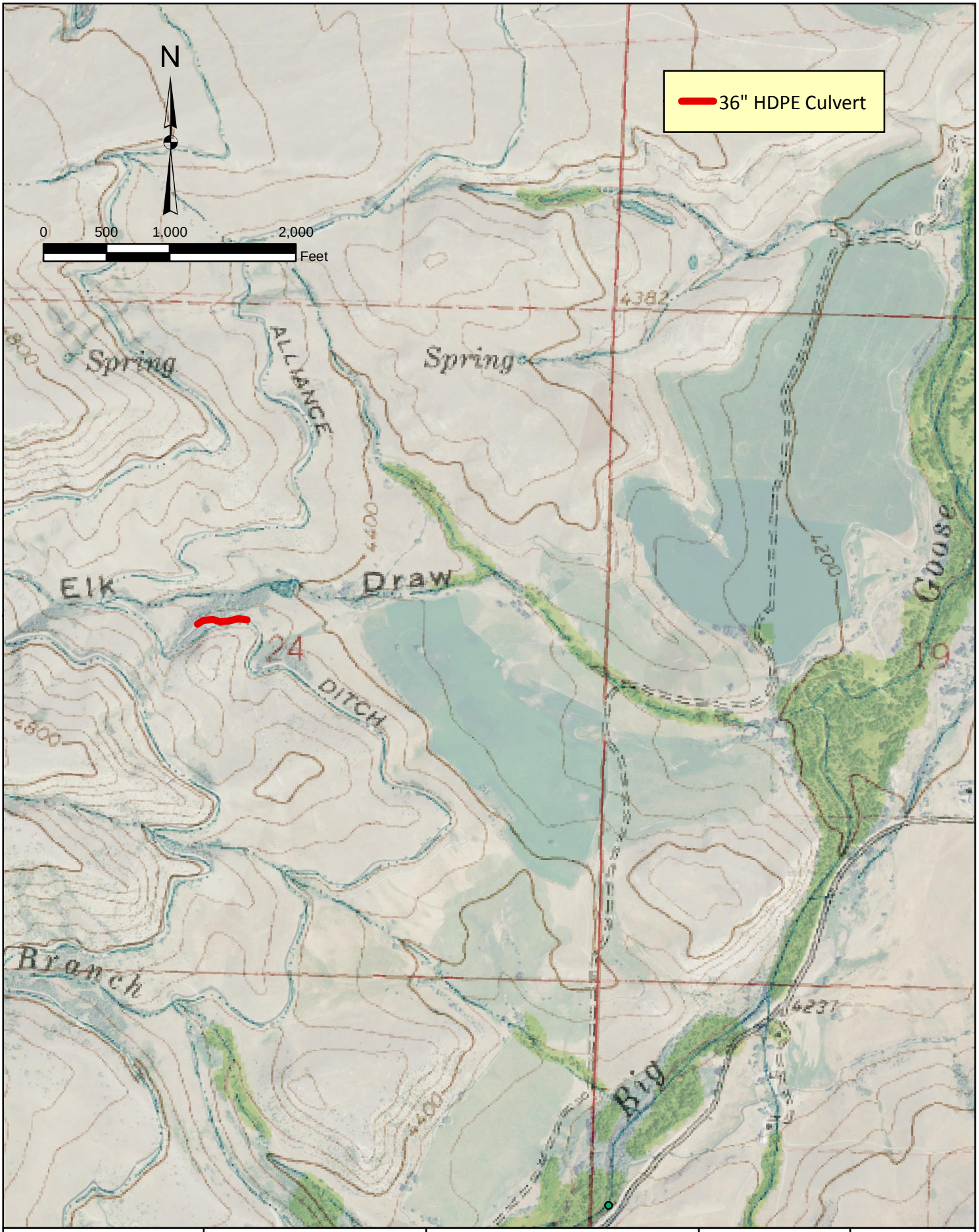
APPENDIX A

PROPOSED PROJECTS, COST ESTIMATES
AND MAPS FOR WATERSHED MANAGEMENT
AND REHABILITATION PLAN



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Project Name: Alliance Ditch Slide Area Repair

Project ID:	**ISI-BG-AL-01**	**Structure Type:**	**Culvert Installation**
Ditch Name:	Alliance	Coordinates:	44.726317, -107.167123
Contact Persons:	Cam Forbes, Alliance Ditch Company		
Description:	Install approximately 400 feet of 36" culvert in area of hillside slippage.		
Project Benefits:	More efficient use of available irrigation water.		

Project Costs

Preparation of Final Design and Specifications				$2,940	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$0	
			Pre-Construction Costs (Subtotal #1)		$2,940

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$3,000	$3,000
36" Culvert (HDPE)	400	LF	$51	$20,400
Flared End Section - 36"	2	EA	$400	$800
Trash Rack	2	EA	$2,100	$4,200
Reclamation	LS	LS	$1,000	$1,000

Total Component Cost (Subtotal #2)	$29,400	
Construction Engineering Cost (Subtotal #2 x 10%)	$2,940	
Components and Engineering Costs (Subtotal #3)	$32,340	
Contingency (Subtotal #3 x 15%)	$4,851	
Construction Cost Total (Subtotal #4)		$37,191
Total Project Cost (Subtotal #1 + Subtotal #4)		$40,131

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Project Name: Alliance Lateral Ditch Wasteway Gate Removal

Project ID:	**ISI-BG-ALL-01**	**Structure Type:**	**Wasteway**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.773536, -107.135107
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	The existing control gate is in bad condition and should be removed, thereby improving the hydraulics of the ditch.		
Project Benefits:	Increasing and extending irrigation water availability.		

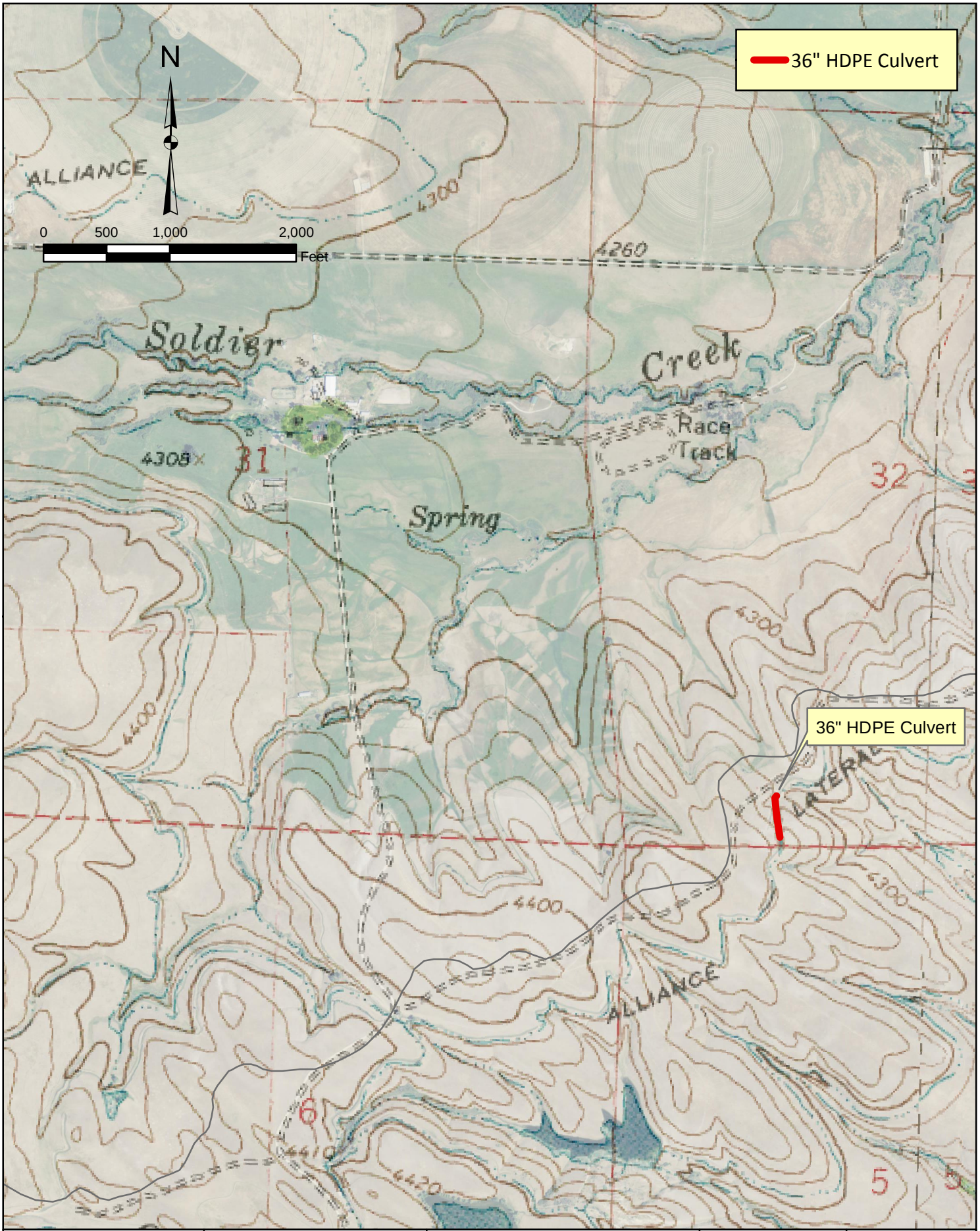
Project Costs

Preparation of Final Design and Specifications	$360	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$360

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$400	$400
Demo/remove Existing Diversion Dam	2	CY	$1,100	$2,200
Minor/ditch work to maintain flow	1	LS	$1,000	$1,000

Total Component Cost (Subtotal #2)	$3,600	
Construction Engineering Cost (Subtotal #2 x 10%)	$360	
Components and Engineering Costs (Subtotal #3)	$3,960	
Contingency (Subtotal #3 x 15%)	$594	
Construction Cost Total (Subtotal #4)		$4,554
Total Project Cost (Subtotal #1 + Subtotal #4)		$4,914



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Project Name: Alliance Lateral Ditch Culvert Replacement 1

Project ID:	**ISI-BG-ALL-02**	**Structure Type:**	**Culvert Replacement**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.776516, -107.130112
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Replace approximately 340 LF of 36" culvert with new headwall, culvert and energy dissipation structure.		
Project Benefits:	Increasing and extending irrigation water availability.		

Project Costs

Preparation of Final Design and Specifications	$4,116	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$5,116

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$3,800	$3,800
Demo/Remove Existing Structures	LS	LS	$2,500	$2,500
Corr. HDPE Culvert - 36 in	340	LF	$51	$17,340
Headwall (Concrete)	4	CY	$840	$3,360
Trash Guard 36 in	2	EA	$2,100	$4,200
Culvert Flared End Section - 36 in	1	EA	$400	$400
Rip Rap (small) 12"	80	CY	$110	$8,800
Seeding	760	SY	$1	$760

Total Component Cost (Subtotal #2)	$41,160	
Construction Engineering Cost (Subtotal #2 x 10%)	$4,116	
Components and Engineering Costs (Subtotal #3)	$45,276	
Contingency (Subtotal #3 x 15%)	$6,792	
Construction Cost Total (Subtotal #4)		$52,068
Total Project Cost (Subtotal #1 + Subtotal #4)		$57,184

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Project Name: Alliance Lateral Ditch Culvert Installaton 1

Project ID:	**ISI-BG-ALL-03**	**Structure Type:**	**Culvert**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.778867, -107.129031
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Install approximately 150 LF of 36" culvert in area where plastic liner was previously installed on the ditch banks to prevent erosion. Ditch banks are currently collapsing beneath the liner.		
Project Benefits:	Increasing and extending irrigation water availability.		

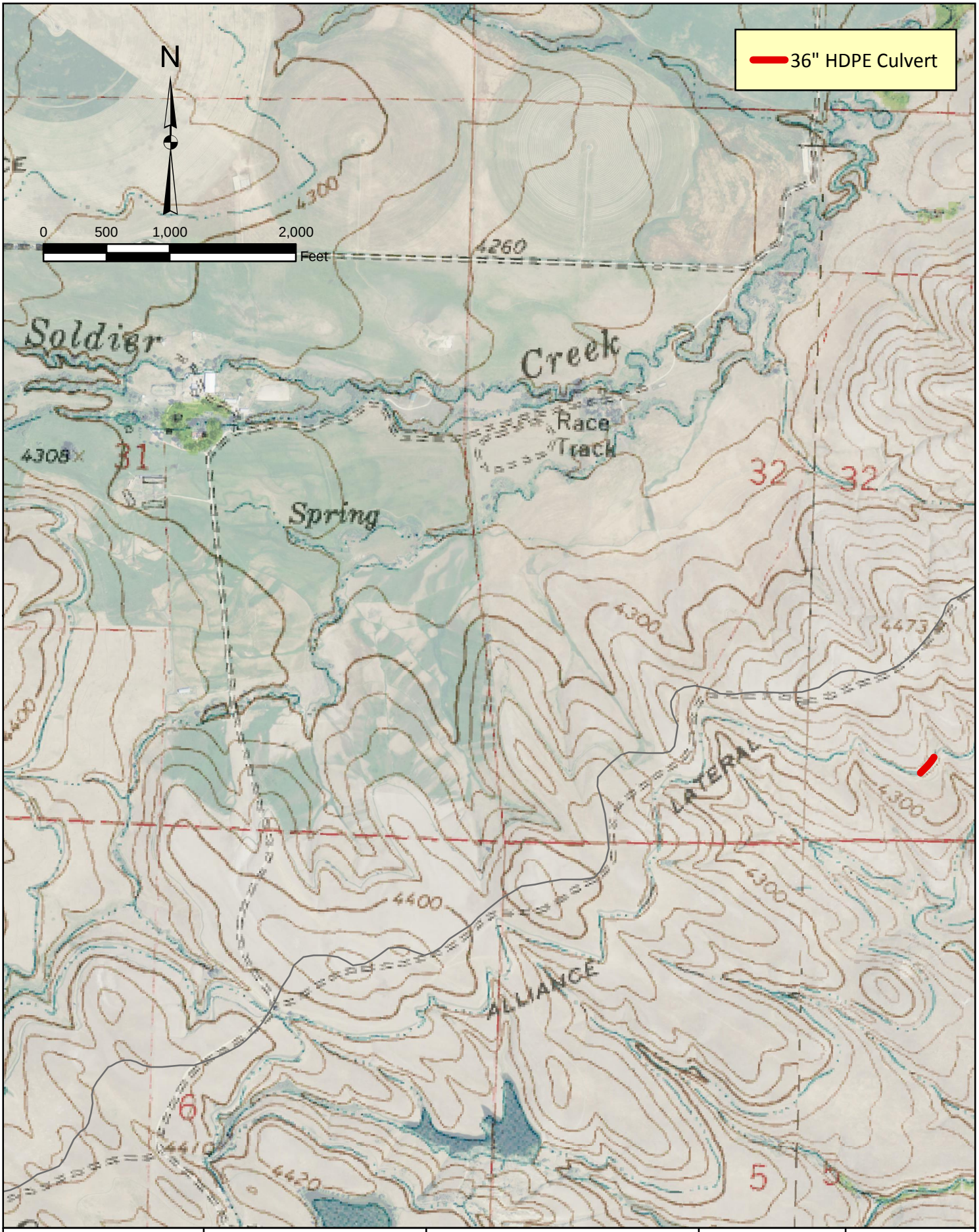
Project Costs

Preparation of Final Design and Specifications				$1,185	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$1,000	
			Pre-Construction Costs (Subtotal #1)		$2,185

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$1,100	$1,100
Corr. HDPE Culvert - 36 in	150	LF	$51	$7,650
Culvert Flared End Section - 36 in	2	EA	$400	$800
Trash Guard 36 in	1	EA	$2,100	$2,100
Seeding	200	SY	$1	$200

Total Component Cost (Subtotal #2)	$11,850	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,185	
Components and Engineering Costs (Subtotal #3)	$13,035	
Contingency (Subtotal #3 x 15%)	$1,956	
Construction Cost Total (Subtotal #4)		$14,991
Total Project Cost (Subtotal #1 + Subtotal #4)		$17,176



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Project Name: Alliance Lateral Ditch Culvert Installation 2

Project ID:	**ISI-BG-ALL-04**	**Structure Type:**	**Culvert Installation**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.778218, -107.122134
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Install approximately 160 LF of 36" culvert in area where sloughing is occurring above ditch.		
Project Benefits:	Increasing and extending irrigation water availability.		

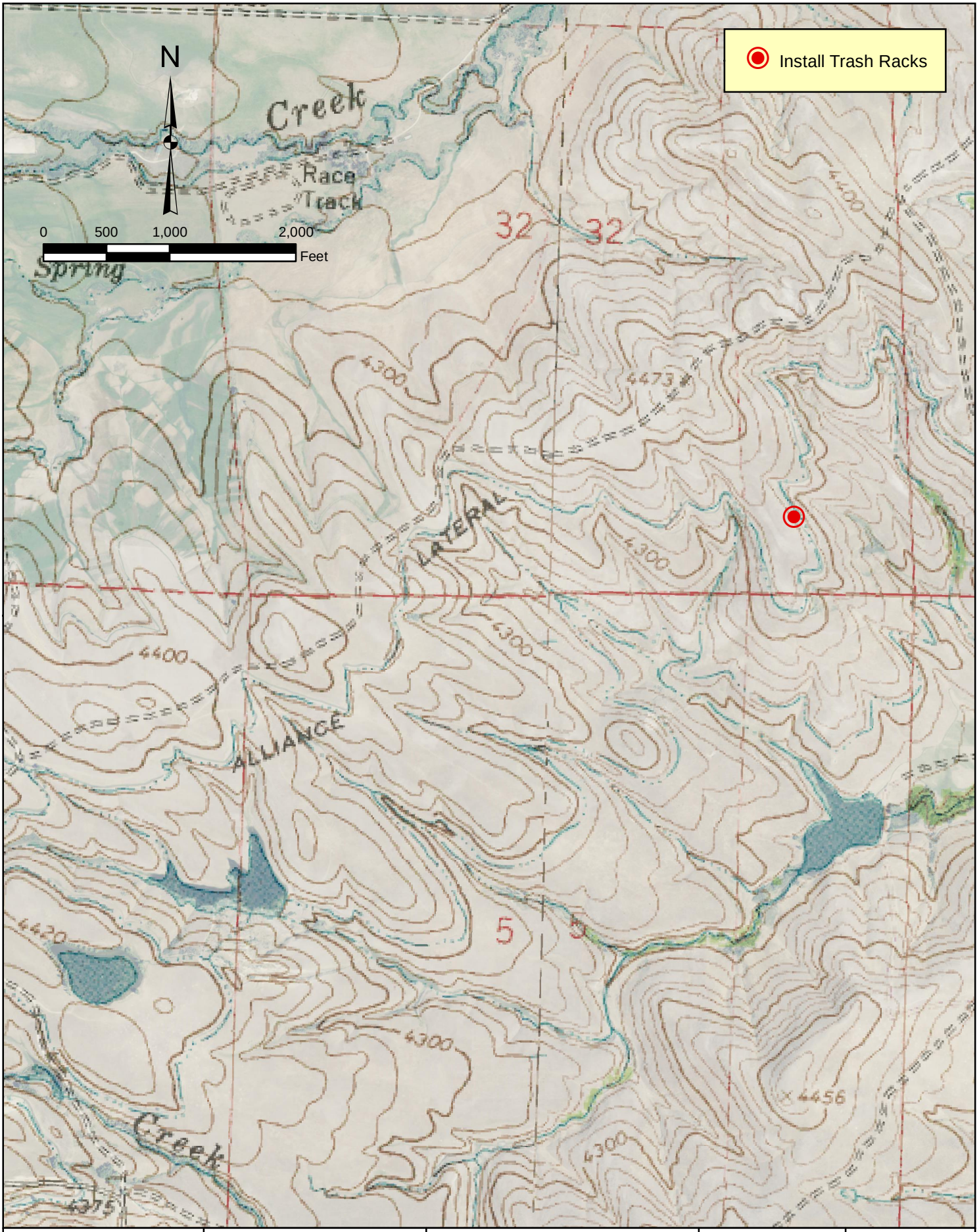
Project Costs

Preparation of Final Design and Specifications	$1,248	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$2,248

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$1,200	$1,200
Corr. HDPE Culvert - 36 in	160	LF	$51	$8,160
Culvert Flared End Section - 36 in	2	EA	$400	$800
Trash Guard 36 in	1	EA	$2,100	$2,100
Seeding	215	SY	$1	$215

Total Component Cost (Subtotal #2)	$12,475	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,248	
Components and Engineering Costs (Subtotal #3)	$13,723	
Contingency (Subtotal #3 x 15%)	$2,059	
Construction Cost Total (Subtotal #4)		$15,782
Total Project Cost (Subtotal #1 + Subtotal #4)		$18,029



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Project Name: Alliance Lateral Ditch Trash Rack 1

Project ID:	**ISI-BG-ALL-05**	**Structure Type:**	**Trash Rack**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.778324, -107.118281
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Install trash racks on three sections of 36" culvert extending through approximately 260 feet of ditch section.		
Project Benefits:	Increasing and extending irrigation water availability.		

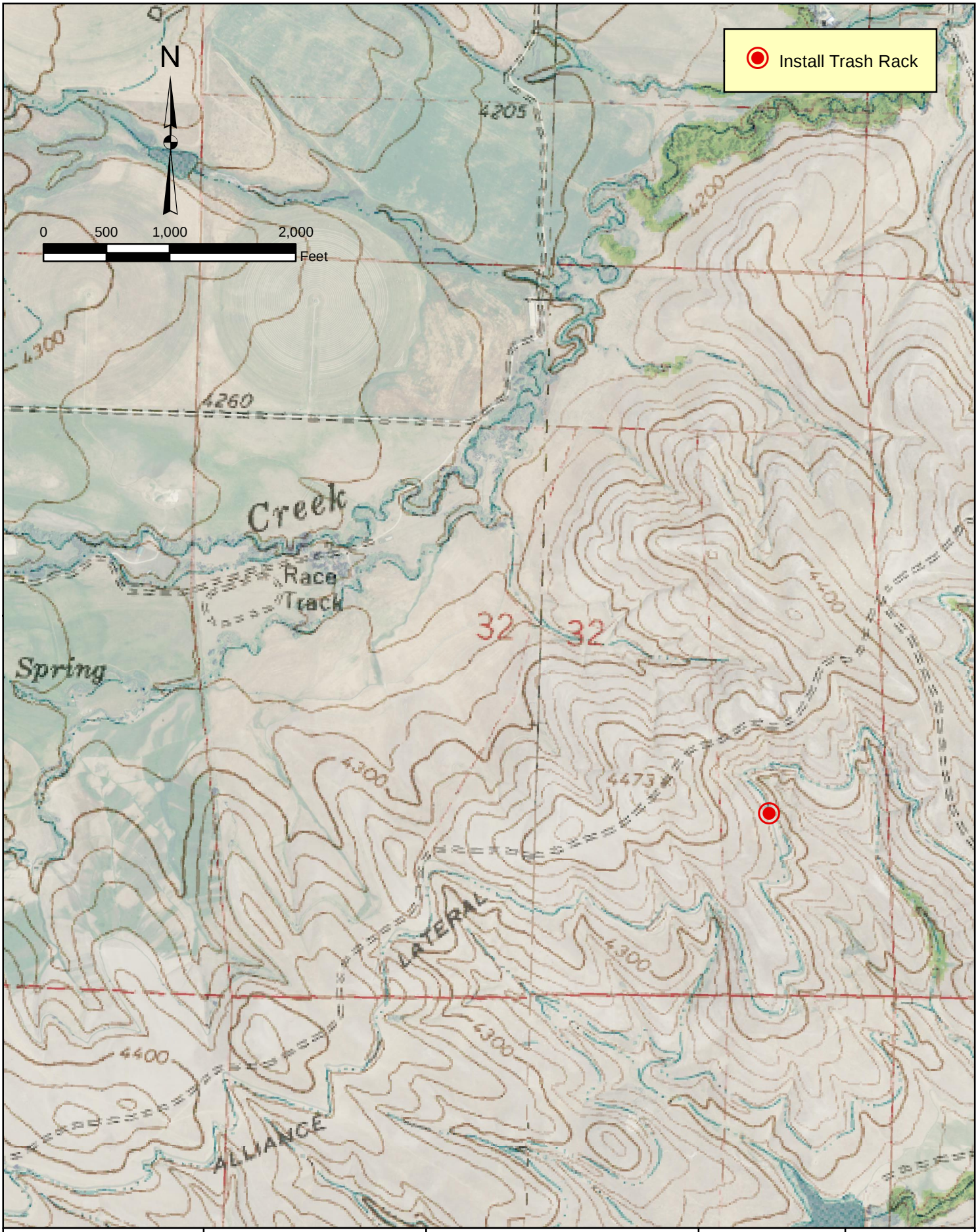
Project Costs

Preparation of Final Design and Specifications	$760	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$760

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$700	$700
Trash Guard 36 in	3	EA	$2,100	$6,300
Culvert Flared End Section 36 in	4	EA	$400	$400
Reclamation	LS	LS	$200	$200

Total Component Cost (Subtotal #2)	$7,600	
Construction Engineering Cost (Subtotal #2 x 10%)	$760	
Components and Engineering Costs (Subtotal #3)	$8,360	
Contingency (Subtotal #3 x 15%)	$1,254	
Construction Cost Total (Subtotal #4)		$9,614
Total Project Cost (Subtotal #1 + Subtotal #4)		$10,374



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Project Name: Alliance Lateral Ditch Trash Rack 2

Project ID:	**ISI-BG-ALL-06**	**Structure Type:**	**Trash Rack**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.780590, -107.118526
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Install new trash rack on existing 36" culvert.		
Project Benefits:	Increasing and extending irrigation water availability.		

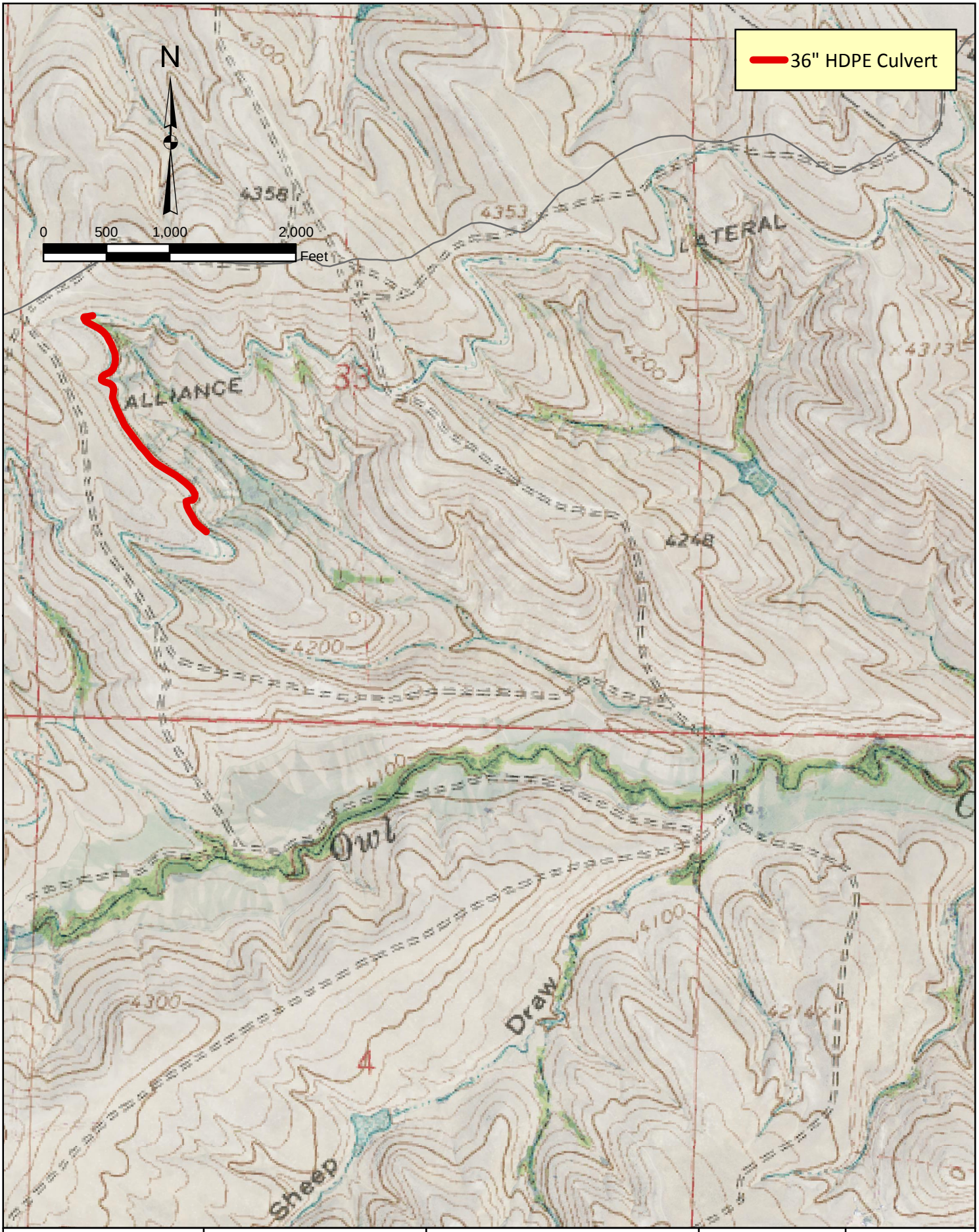
Project Costs

Preparation of Final Design and Specifications				$280	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$0	
			Pre-Construction Costs (Subtotal #1)		$280

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$300	$300
Culvert Flared End Section 36 in	1	EA	$400	$400
Trash Guard 36 in	1	EA	$2,100	$2,100

Total Component Cost (Subtotal #2)	$2,800	
Construction Engineering Cost (Subtotal #2 x 10%)	$280	
Components and Engineering Costs (Subtotal #3)	$3,080	
Contingency (Subtotal #3 x 15%)	$462	
Construction Cost Total (Subtotal #4)		$3,542
Total Project Cost (Subtotal #1 + Subtotal #4)		$3,822



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Project Name: Alliance Lateral Ditch Culvert Installation 3

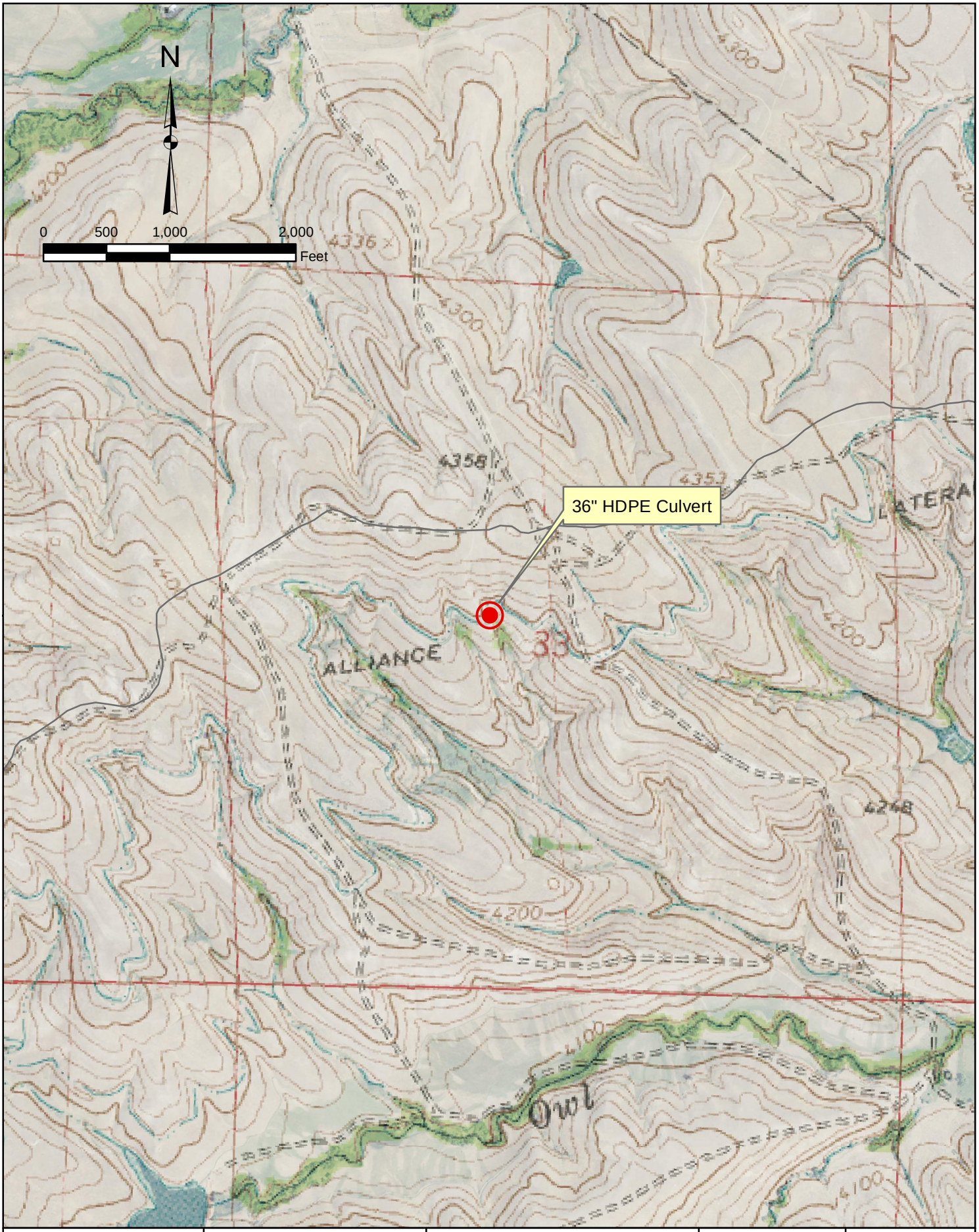
Project ID:	**ISI-BG-ALL-07**	**Structure Type:**	
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.780790, -107.109670
Contact Persons:	Brett Bateman, Alliance Lateral Ditch Company		
Description:	Install approximately 2350 LF of 36" culvert in area where considerable seepage is occurring below ditch.		
Project Benefits:	Increasing and extending irrigation water availability.		

Preparation of Final Design and Specifications	$14,077	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$15,077

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$12,800	$12,800
Corr. HDPE Culvert - 36 in	2350	LF	$51	$119,850
36 in	2	EA	$400	$800
Trash Guard 36 in	1	EA	$2,100	$2,100
Seeding	5223	SY	$1	$5,223

Total Component Cost (Subtotal #2)	$140,773	
Construction Engineering Cost (Subtotal #2 x 10%)	$14,077	
Components and Engineering Costs (Subtotal #3)	$154,850	
Contingency (Subtotal #3 x 15%)	$23,228	
Construction Cost Total (Subtotal #4)		$178,078
Total Project Cost (Subtotal #1 + Subtotal #4)		$193,156



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Project Name: Alliance Lateral Ditch Culvert Replacement 2

Project ID:	**ISI-BG-ALL-08**	**Structure Type:**	**Culvert Replacement**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.784719, -107.107157
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Replace 20 feet of 36" culvert on downstream end of section (existing pipe corroded).		
Project Benefits:	Increasing and extending irrigation water availability.		

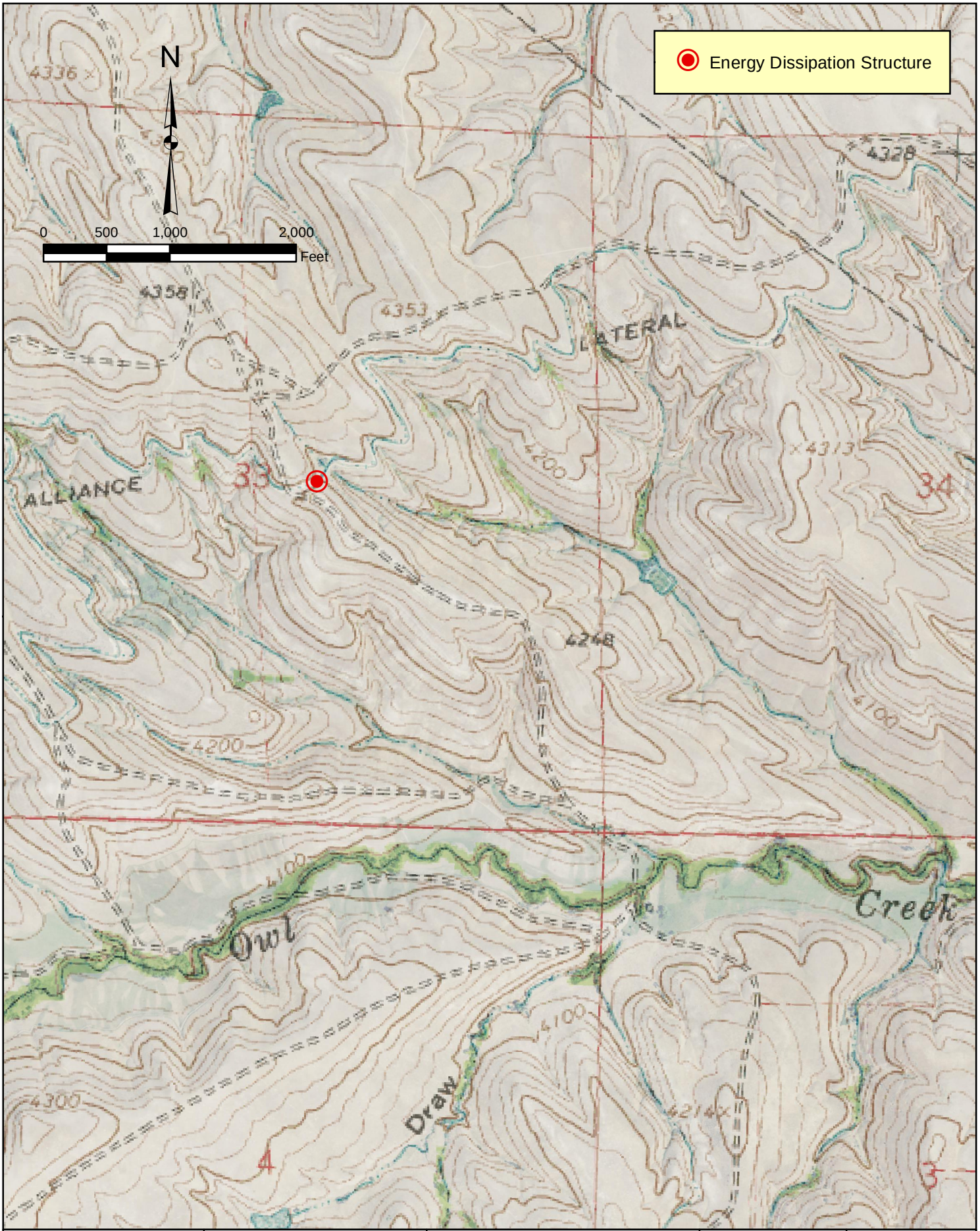
Project Costs

Preparation of Final Design and Specifications	$242	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$1,242

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$300	$300
(20')	LS	LS	$500	$500
Corr. HDPE Culvert - 36 in	20	LF	$51	$1,020
Culvert Flared End Section - 36 in	1	EA	$400	$400
Reclamation	LS	LS	$200	$200

Total Component Cost (Subtotal #2)	$2,420	
Construction Engineering Cost (Subtotal #2 x 10%)	$242	
Components and Engineering Costs (Subtotal #3)	$2,662	
Contingency (Subtotal #3 x 15%)	$400	
Construction Cost Total (Subtotal #4)		$3,062
Total Project Cost (Subtotal #1 + Subtotal #4)		$4,304



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Project Name: Alliance Lateral Ditch Erosion Control Structure 1

Project ID:	**ISI-BG-ALL-09**	**Structure Type:**	**Energy Dissipation Structure**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.784153, -107.103286
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Install energy dissipation structure and riprap at downstream end of +/-300 LF long culvert installed approximately five years ago (which allowed for a ditch abandonment around the hillside). At the present time, both the opposite hillside is being eroded and the downstream end of the culvert are being undermined.		
Project Benefits:	Increasing and extending irrigation water availability.		

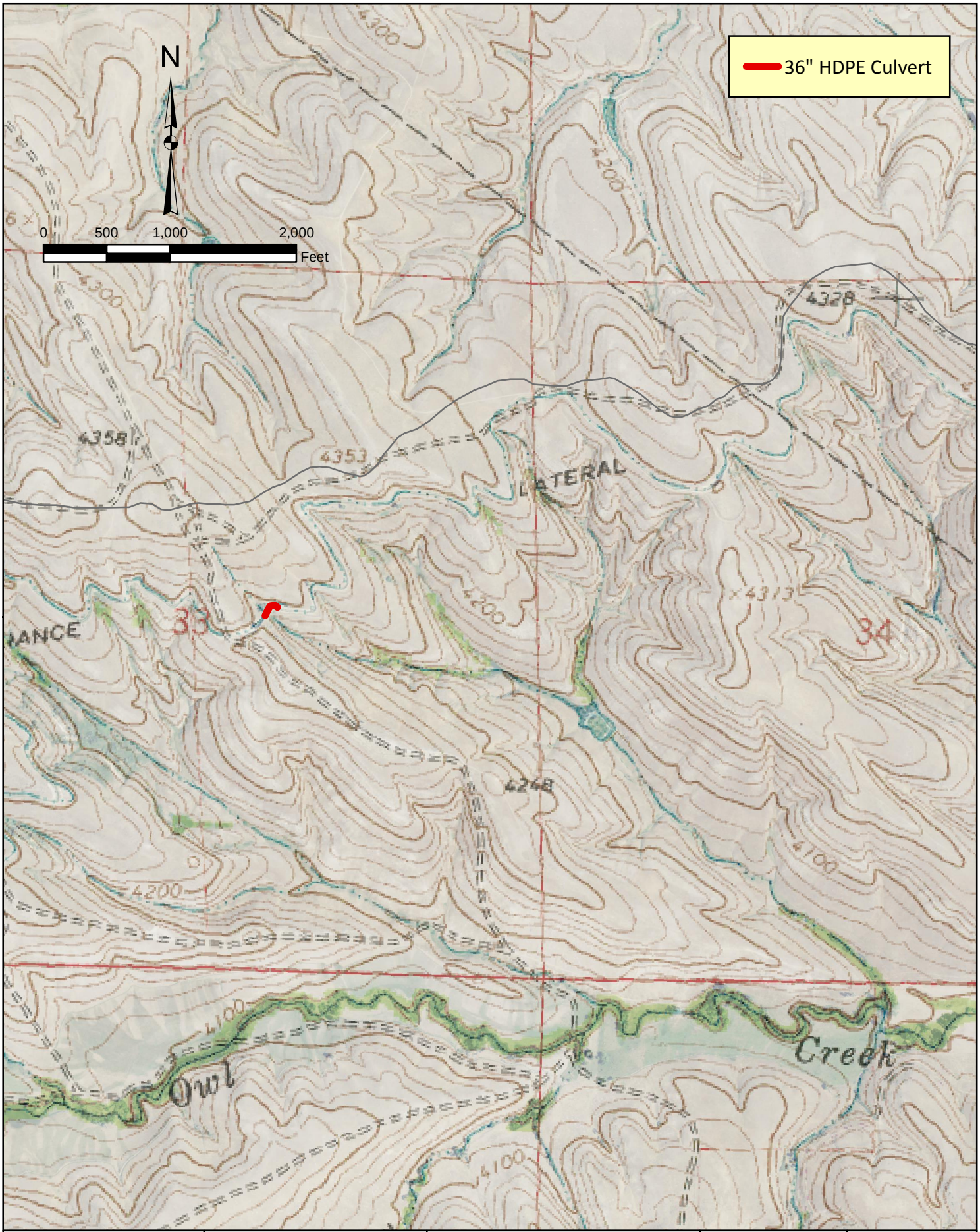
Project Costs

Preparation of Final Design and Specifications				$990	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$1,000	
			Pre-Construction Costs (Subtotal #1)		$1,990

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$900	$900
Rip Rap (small) 12"	80	CY	$110	$8,800
Reclamation	LS	LS	$200	$200

Total Component Cost (Subtotal #2)	$9,900	
Construction Engineering Cost (Subtotal #2 x 10%)	$990	
Components and Engineering Costs (Subtotal #3)	$10,890	
Contingency (Subtotal #3 x 15%)	$1,634	
Construction Cost Total (Subtotal #4)		$12,524
Total Project Cost (Subtotal #1 + Subtotal #4)		$14,514



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Project Name: Alliance Lateral Ditch Culvert Installation 4

Project ID:	ISI-BG-ALL-10	Structure Type:	Culvert Installation
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.784588, -107.102636
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Install approximately 150 feet of 36" culvert in area of hillside being eroded by bend in ditch.		
Project Benefits:	Increasing and extending irrigation water availability.		

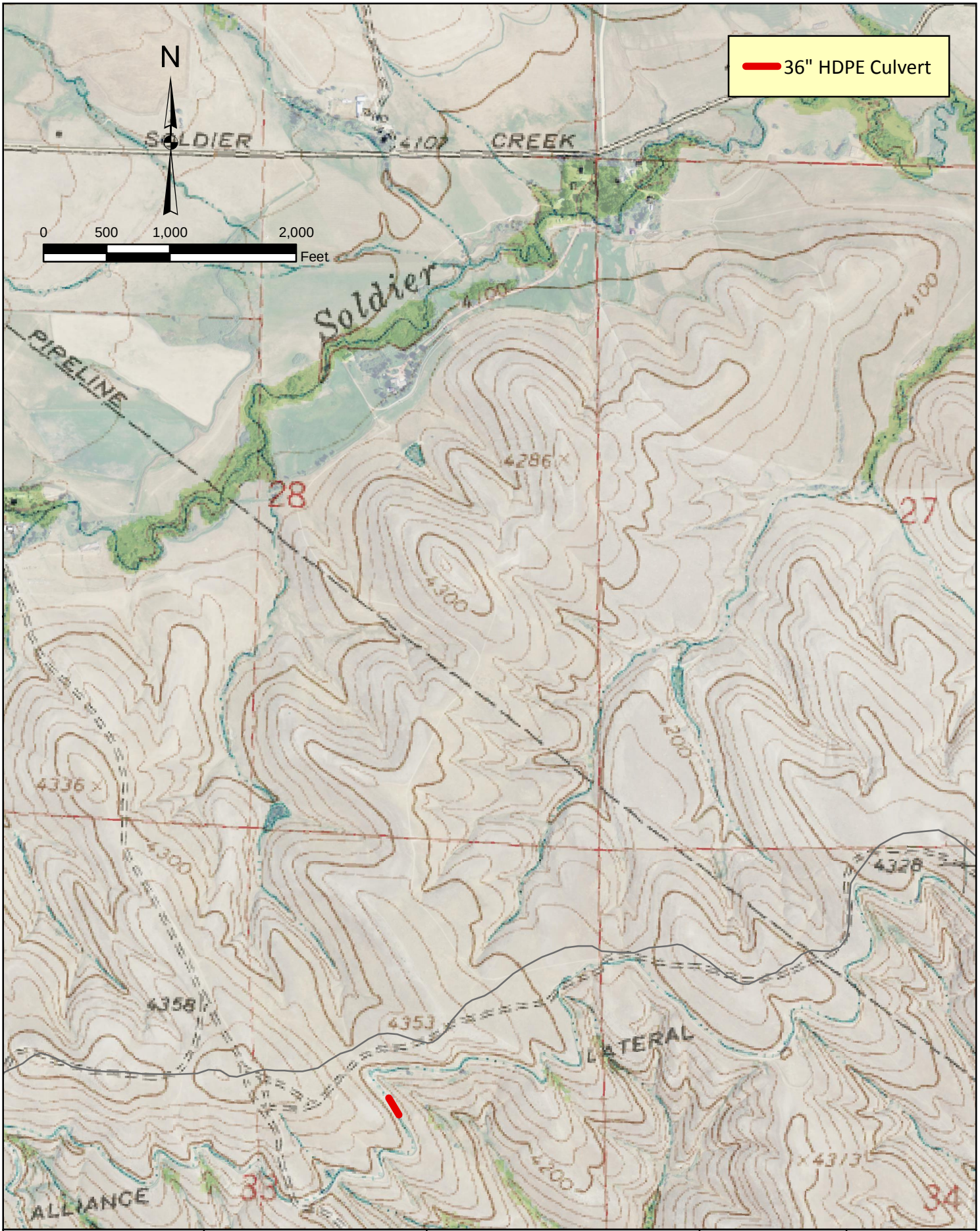
Project Costs

Preparation of Final Design and Specifications	$1,199	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$2,199

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$1,100	$1,100
Corr. HDPE Culvert - 36 in	150	LF	$51	$7,650
Culvert Flared End Section - 36 in	2	EA	$400	$800
Trash Guard 36 in	1	EA	$2,100	$2,100
Seeding	340	SY	$1	$340

Total Component Cost (Subtotal #2)	$11,990	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,199	
Components and Engineering Costs (Subtotal #3)	$13,189	
Contingency (Subtotal #3 x 15%)	$1,979	
Construction Cost Total (Subtotal #4)		$15,168
Total Project Cost (Subtotal #1 + Subtotal #4)		$17,367



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Project Name: Alliance Lateral Ditch Culvert Replacement 3

Project ID:	**ISI-BG-ALL-11**	**Structure Type:**	**Culvert Replacement**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.786025, -107.101218
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Replace 160 feet of 36" culvert. Currently there are two 36" culverts in series at this location.		
Project Benefits:	Increasing and extending irrigation water availability.		

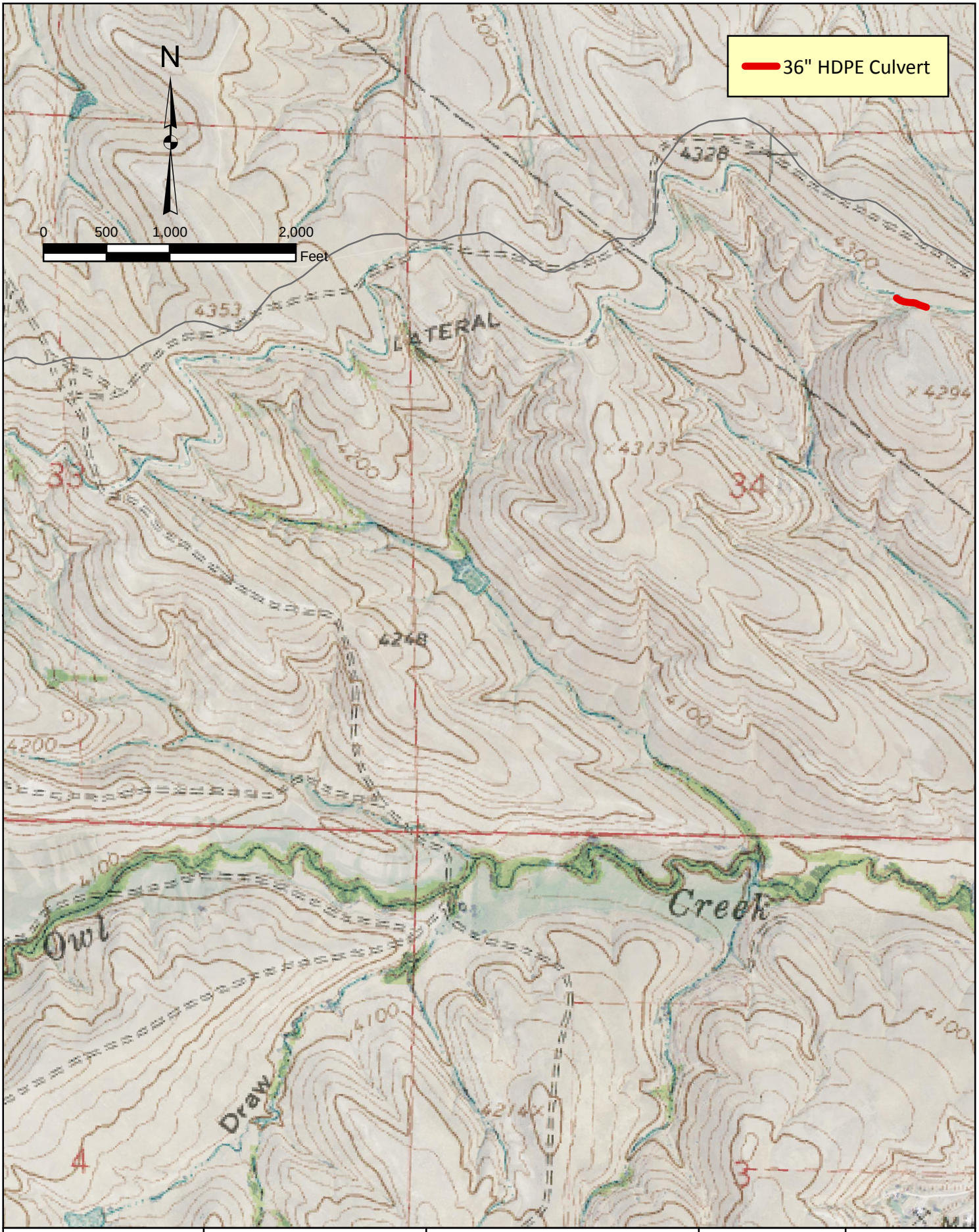
Project Costs

Preparation of Final Design and Specifications	$1,372	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$2,372

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$1,300	$1,300
(160')	LS	LS	$1,000	$1,000
Corr. HDPE Culvert - 36 in	160	LF	$51	$8,160
Culvert Flared End Section - 36 in	2	EA	$400	$800
Trash Guard 36 in	1	EA	$2,100	$2,100
Seeding	360	SY	$1	$360

Total Component Cost (Subtotal #2)	$13,720	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,372	
Components and Engineering Costs (Subtotal #3)	$15,092	
Contingency (Subtotal #3 x 15%)	$2,264	
Construction Cost Total (Subtotal #4)		$17,356
Total Project Cost (Subtotal #1 + Subtotal #4)		$19,728



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Project Name: Alliance Lateral Ditch Culvert Installation 5

Project ID:	**ISI-BG-ALL-12**	**Structure Type:**	**Culvert Installation**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.788468, -107.079774
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Install 250 LF of 36" culvert in area of considerable seepage.		
Project Benefits:	Increasing and extending irrigation water availability.		

Project Costs

Preparation of Final Design and Specifications	$1,791	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$2,791

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$1,700	$1,700
Corr. HDPE Culvert - 36 in	250	LF	$51	$12,750
Culvert Flared End Section - 36 in	2	EA	$400	$800
Trash Guard 36 in	1	EA	$2,100	$2,100
Seeding	560	SY	$1	$560

Total Component Cost (Subtotal #2)	$17,910	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,791	
Components and Engineering Costs (Subtotal #3)	$19,701	
Contingency (Subtotal #3 x 15%)	$2,956	
Construction Cost Total (Subtotal #4)		$22,657
Total Project Cost (Subtotal #1 + Subtotal #4)		$25,448

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Project Name: Alliance Lateral Ditch Erosion Control Structure 2

Project ID:	**ISI-BG-ALL-13**	**Structure Type:**	**Energy Dissipation Structure**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.788569, -107.072748
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	A section of the north ditch bank about 40' long has eroded in the area of the outfall of a 36" CMP. An energy dissipation structure and/or riprap are recommended at the downstream end of this pipe to control the erosion which, in addition to eroding the hillside opposite, is undermining the pipe.		
Project Benefits:	Increasing and extending irrigation water availability.		

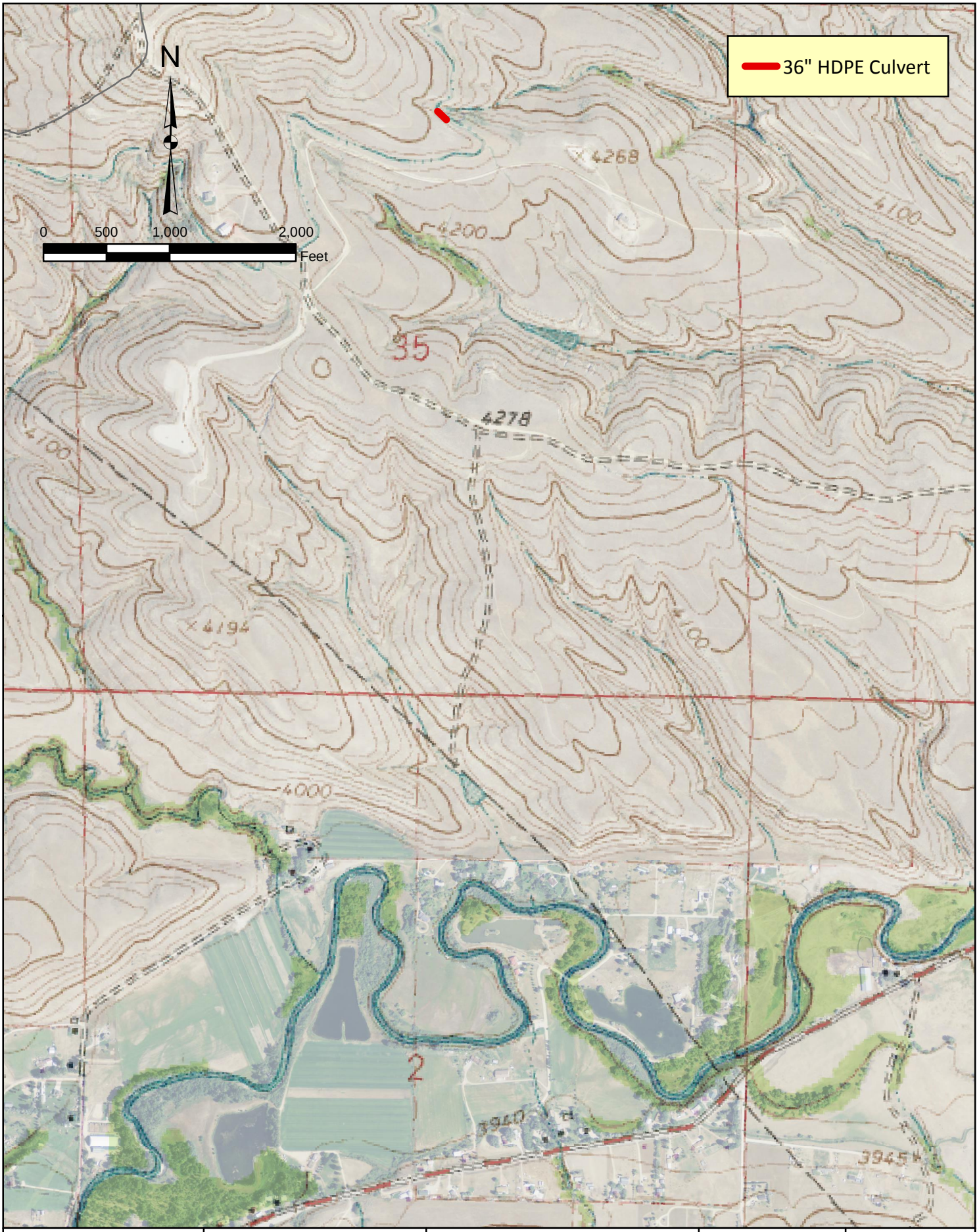
Project Costs

Preparation of Final Design and Specifications	$435	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$1,435

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$400	$400
Rip Rap 24"	30	CY	$125	$3,750
Reclamation	LS	LS	$200	$200

Total Component Cost (Subtotal #2)	$4,350	
Construction Engineering Cost (Subtotal #2 x 10%)	$435	
Components and Engineering Costs (Subtotal #3)	$4,785	
Contingency (Subtotal #3 x 15%)	$718	
Construction Cost Total (Subtotal #4)		$5,503
Total Project Cost (Subtotal #1 + Subtotal #4)		$6,938



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Project Name: Alliance Lateral Ditch Culvert Replacement 4

Project ID:	**ISI-BG-ALL-14**	**Structure Type:**	**Culvert Replacement**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.789544, -107.063798
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Install 100 LF of 36" culvert with riprap on downstream end. (Existing downstream end has washed out due to erosion.)		
Project Benefits:	Increasing and extending irrigation water availability.		

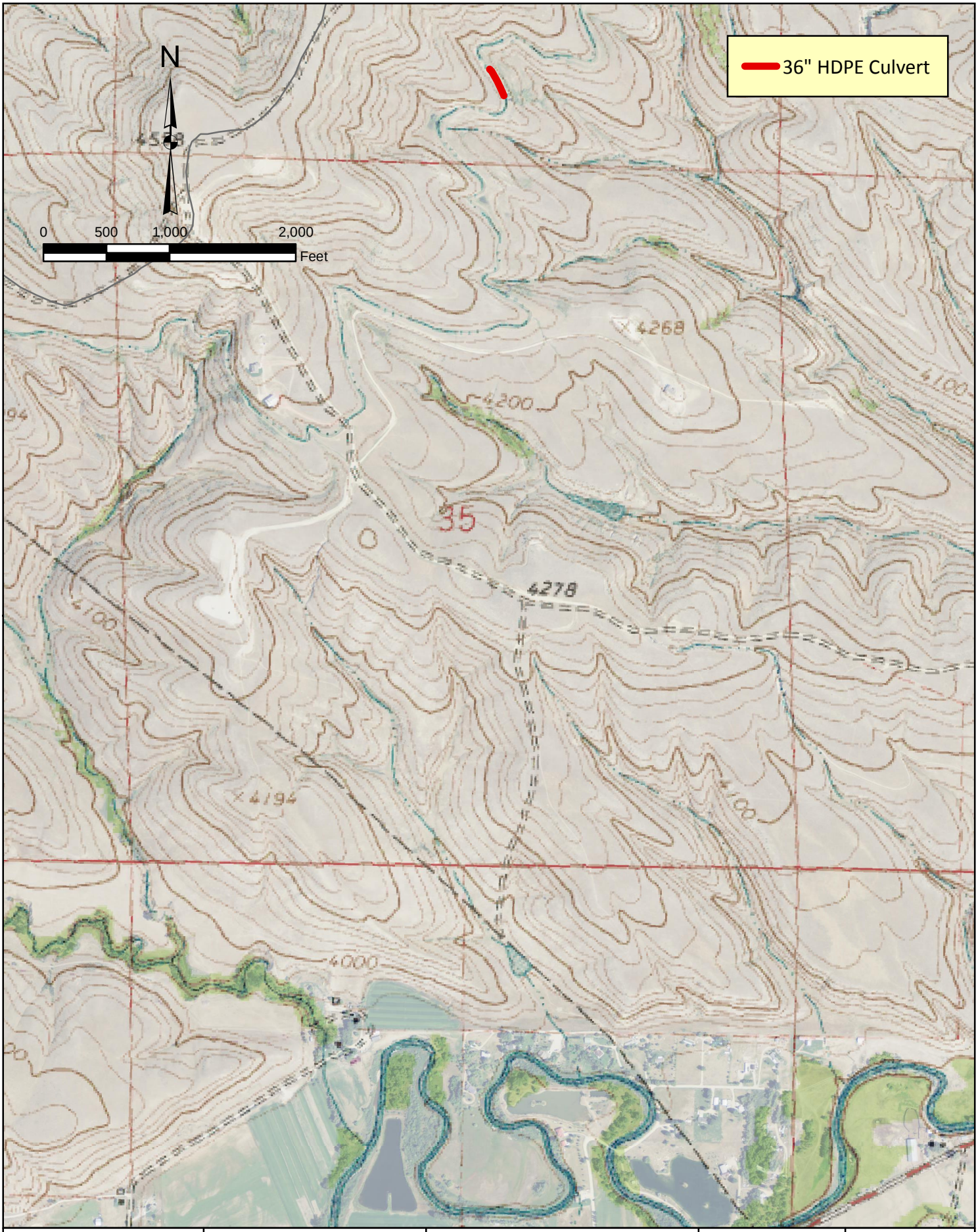
Project Costs

Preparation of Final Design and Specifications	$1,298	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$2,298

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$1,200	$1,200
(100')	LS	LS	$800	$800
Corr. HDPE Culvert - 36 in	100	LF	$51	$5,100
Culvert Flared End Section - 36 in	2	EA	$400	$800
Trash Guard 36 in	1	EA	$2,100	$2,100
Rip Rap (small) 12"	25	CY	$110	$2,750
Seeding	230	SY	$1	$230

Total Component Cost (Subtotal #2)	$12,980	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,298	
Components and Engineering Costs (Subtotal #3)	$14,278	
Contingency (Subtotal #3 x 15%)	$2,142	
Construction Cost Total (Subtotal #4)		$16,420
Total Project Cost (Subtotal #1 + Subtotal #4)		$18,718



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Project Name: Alliance Lateral Ditch Culvert Installation 5

Project ID:	**ISI-BG-ALL-15**	**Structure Type:**	**Culvert Installation**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.793884, -107.063431
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Install 240 feet of 36" culvert in area of considerable seepage.		
Project Benefits:	Increasing and extending irrigation water availability.		

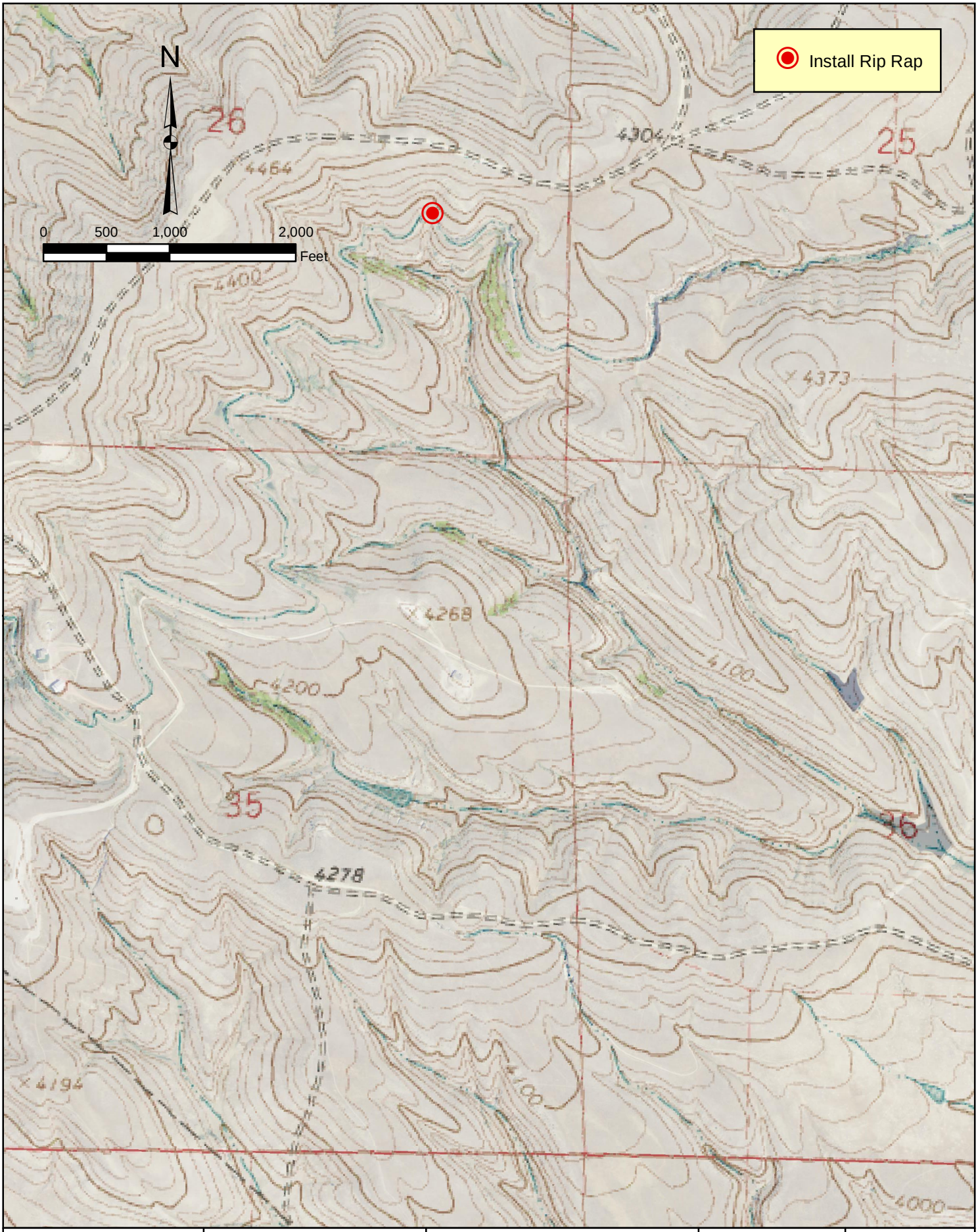
Project Costs

Preparation of Final Design and Specifications	$1,728	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$2,728

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$1,600	$1,600
Corr. HDPE Culvert - 36 in	240	LF	$51	$12,240
36 in	2	EA	$400	$800
Trash Guard 36 in	1	EA	$2,100	$2,100
Seeding	540	SY	$1	$540

Total Component Cost (Subtotal #2)	$17,280	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,728	
Components and Engineering Costs (Subtotal #3)	$19,008	
Contingency (Subtotal #3 x 15%)	$2,852	
Construction Cost Total (Subtotal #4)		$21,860
Total Project Cost (Subtotal #1 + Subtotal #4)		$24,588



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Project Name: Alliance Lateral Ditch Erosion Control Structure 3

Project ID:	**ISI-BG-ALL-16**	**Structure Type:**	**Erosion Control**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.797453, -107.059246
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Install riprap in bend in ditch where significant erosion is occurring.		
Project Benefits:	Increasing and extending irrigation water availability.		

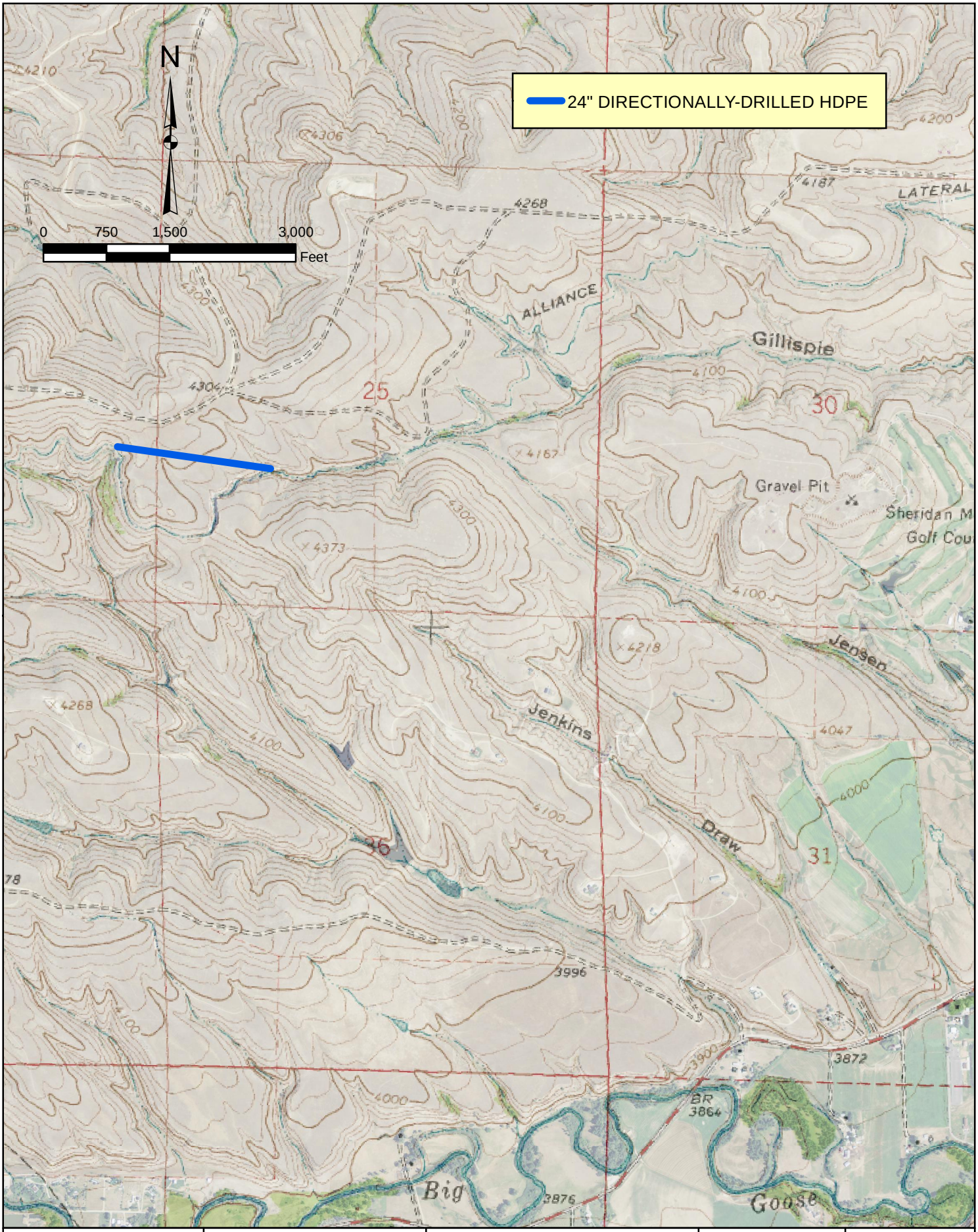
Project Costs

Preparation of Final Design and Specifications	$630	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$1,630

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$600	$600
Rip Rap (small) 12"	50	CY	$110	$5,500
Reclamation	LS	LS	$200	$200

Total Component Cost (Subtotal #2)	$6,300	
Construction Engineering Cost (Subtotal #2 x 10%)	$630	
Components and Engineering Costs (Subtotal #3)	$6,930	
Contingency (Subtotal #3 x 15%)	$1,040	
Construction Cost Total (Subtotal #4)		$7,970
Total Project Cost (Subtotal #1 + Subtotal #4)		$9,600



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Project Name: Alliance Lateral Ditch Culvert Installation 6

Project ID:	**ISI-BG-ALL-17**	**Structure Type:**	**Culvert Installation**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.794964, -107.052316
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Install 1850 LF of directionally-drilled 24" HDPE to bypass existing deep eroded canyon. Installing direct bury pipe in the existing canyon is deemed to be too dangerous due to steep, slipping canyon walls.		
Project Benefits:	Increasing and extending irrigation water availability.		

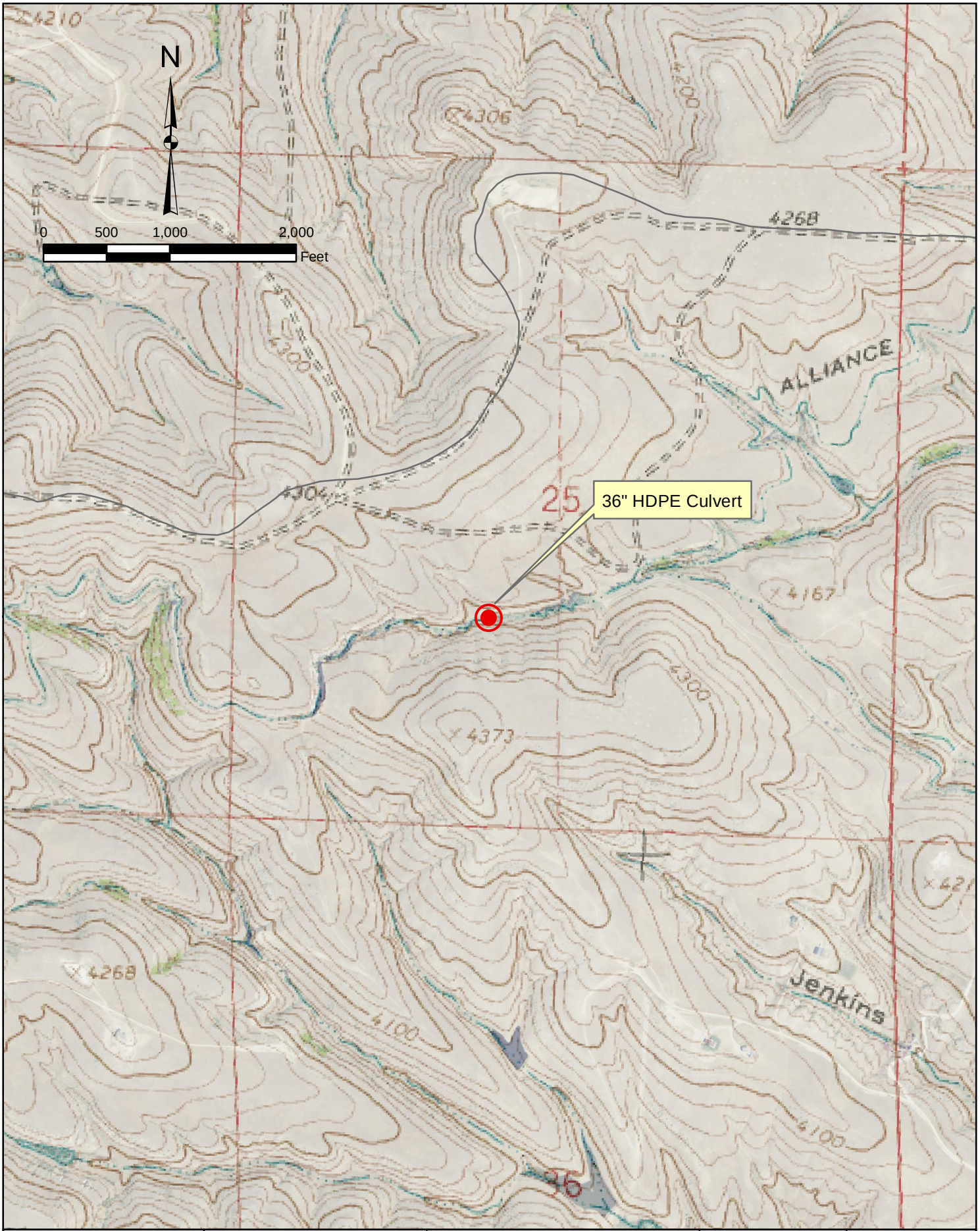
Project Costs

Preparation of Final Design and Specifications	$108,275	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$2,000	
Pre-Construction Costs (Subtotal #1)		$110,275

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$98,500	$98,500
Pollution Control	LS	LS	$40,000	$40,000
HDPE Directionally-drilled 24" Pipe	1850	LF	$445	$823,250
Inlet Structure	LS	LS	$55,000	$55,000
Stilling Well Outlet	LS	LS	$47,000	$47,000
Grading (Construction & Reclaim Roads)	500	CY	$28	$14,000
Seeding	2	AC	$2,500	$5,000

Total Component Cost (Subtotal #2)	$1,082,750	
Construction Engineering Cost (Subtotal #2 x 10%)	$108,275	
Components and Engineering Costs (Subtotal #3)	$1,191,025	
Contingency (Subtotal #3 x 15%)	$178,654	
Construction Cost Total (Subtotal #4)		$1,369,679
Total Project Cost (Subtotal #1 + Subtotal #4)		$1,479,954



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Project Name: Alliance Lateral Ditch Culvert Installation 7

Project ID:	**ISI-BG-ALL-18**	**Structure Type:**	**Culvert Installation**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.796674, -107.047204
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Install 50 feet of 36" culvert in area of small uphill slide.		
Project Benefits:	Increasing and extending irrigation water availability.		

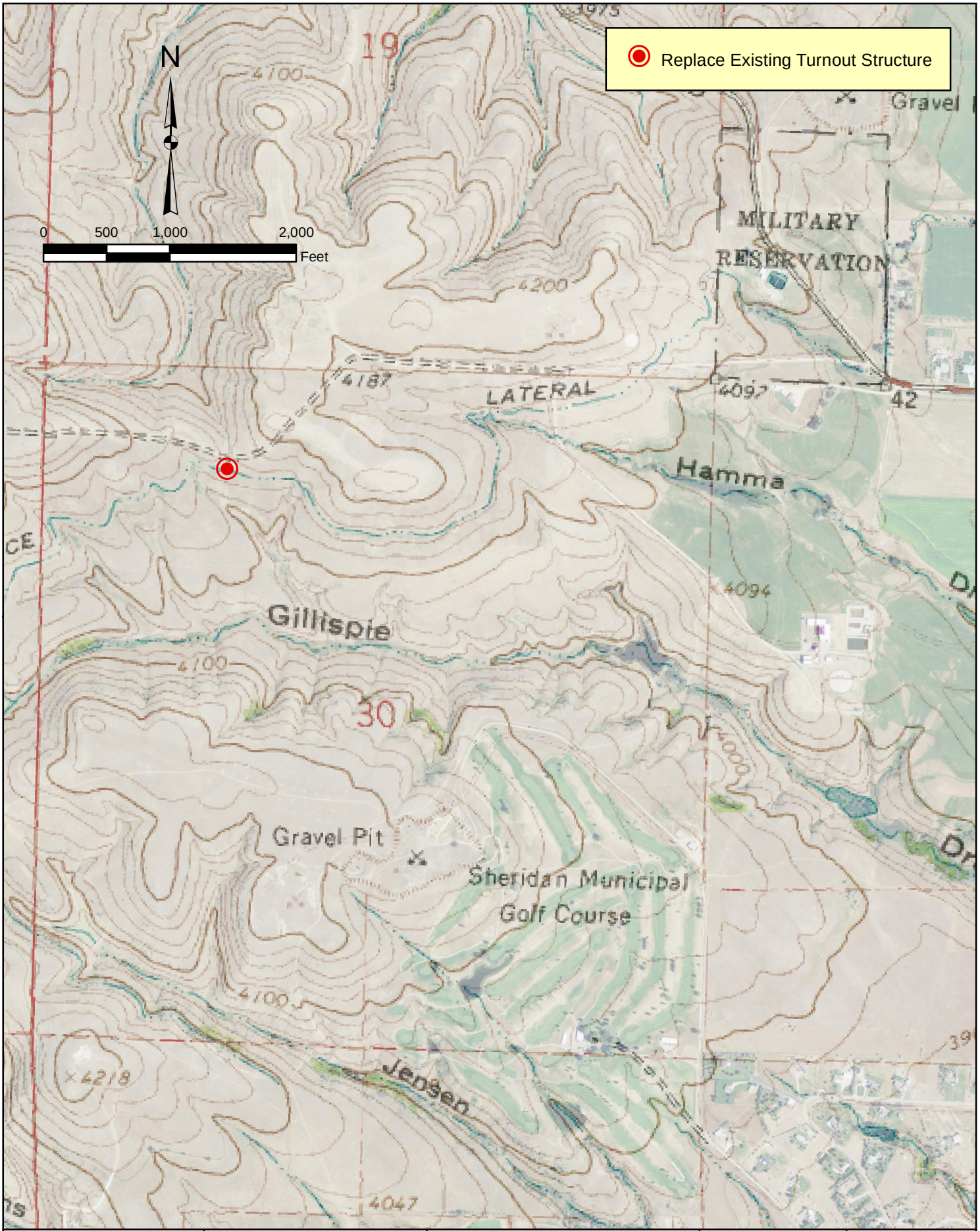
Project Costs

Preparation of Final Design and Specifications	$767	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$1,767

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$700	$700
Corr. HDPE Culvert - 36 in	50	LF	$51	$2,550
Culvert Flared End Section - 36 in	2	EA	$400	$800
Trash Guard 36 in	1	EA	$2,100	$2,100
Rip Rap (small) 12"	12	CY	$110	$1,320
Reclamation	LS	LS	$200	$200

Total Component Cost (Subtotal #2)	$7,670	
Construction Engineering Cost (Subtotal #2 x 10%)	$767	
Components and Engineering Costs (Subtotal #3)	$8,437	
Contingency (Subtotal #3 x 15%)	$1,266	
Construction Cost Total (Subtotal #4)		$9,703
Total Project Cost (Subtotal #1 + Subtotal #4)		$11,470



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Project Name: Alliance Lateral Ditch Turnout 1

Project ID:	**ISI-BG-ALL-19**	**Structure Type:**	**Turnout**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Replace existing turnout to small stockwater reservoir located in the Soldier Creek drainage (to the north), check dam, culvert crossing, and 12" culvert that extends beneath Alliance Lateral Ditch bank.		
Project Benefits:	Increasing and extending irrigation water availability.		

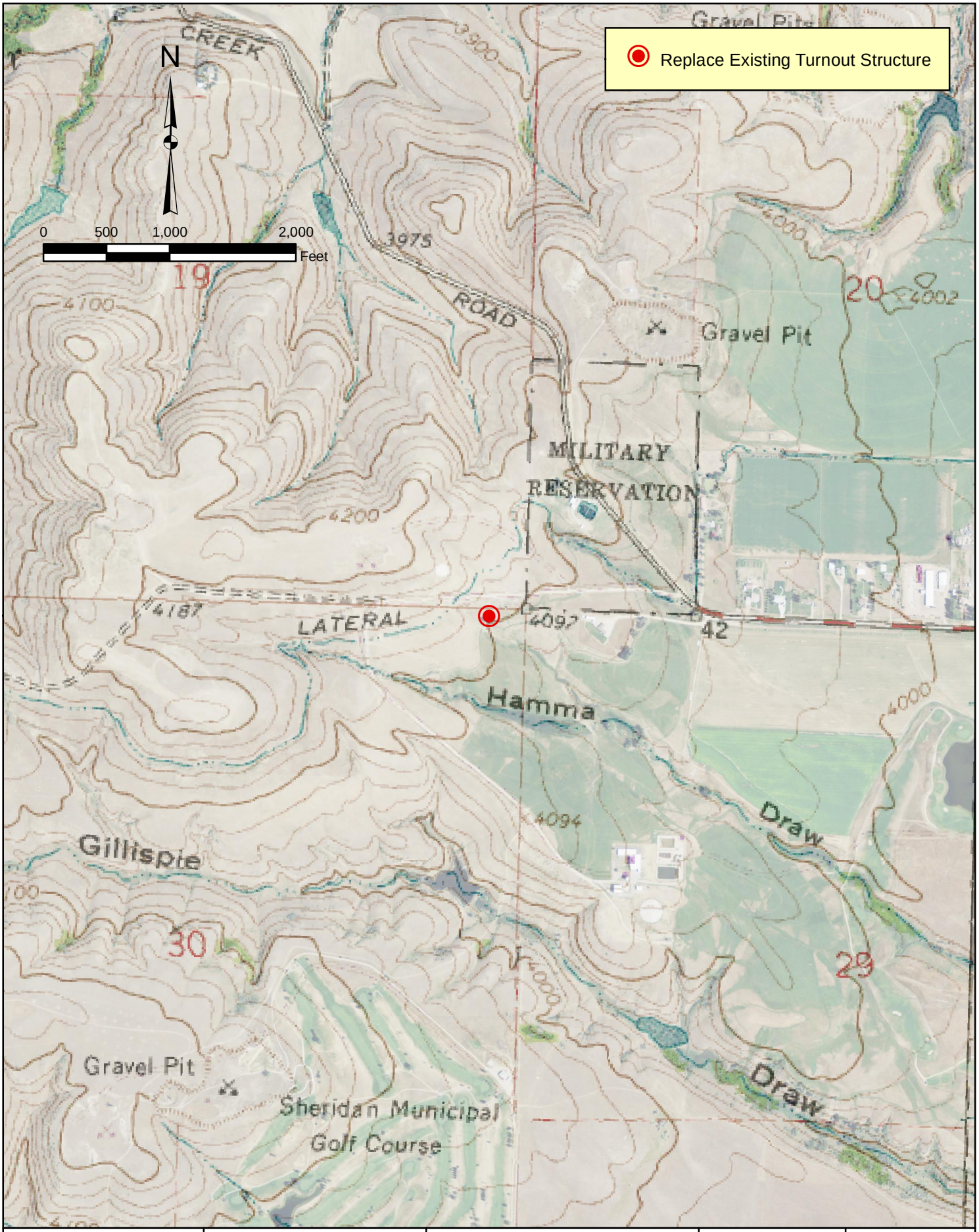
Project Costs

Preparation of Final Design and Specifications	$2,138	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$2,138

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$2,000	$2,000
Check Dam	6	CY	$1,500	$9,000
Headgate - 12"	1	EA	$900	$900
Precast Turnout	1	EA	$5,300	$5,300
Corr. HDPE Culvert - 12"	50	LF	$18	$900
Corr. HDPE Culvert - 36"	20	LF	$51	$1,020
Culvert FE Sect - 12"	3	EA	$620	$1,860
Culvert FE Sect - 36"	1	EA	$400	$400

Total Component Cost (Subtotal #2)	$21,380	
Construction Engineering Cost (Subtotal #2 x 10%)	$2,138	
Components and Engineering Costs (Subtotal #3)	$23,518	
Contingency (Subtotal #3 x 15%)	$3,528	
Construction Cost Total (Subtotal #4)		$27,046
Total Project Cost (Subtotal #1 + Subtotal #4)		$29,184



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Project Name: Alliance Lateral Ditch Turnout 2

Project ID:	**ISI-BG-ALL-20**	**Structure Type:**	**Turnout**
Ditch Name:	Alliance Lateral Ditch	Coordinates:	44.806450, -107.015590
Contact Persons:	Don Roberts/Brett Bateman, Alliance Lateral Ditch Company		
Description:	Replace existing turnout structure.		
Project Benefits:	Increasing and extending irrigation water availability.		

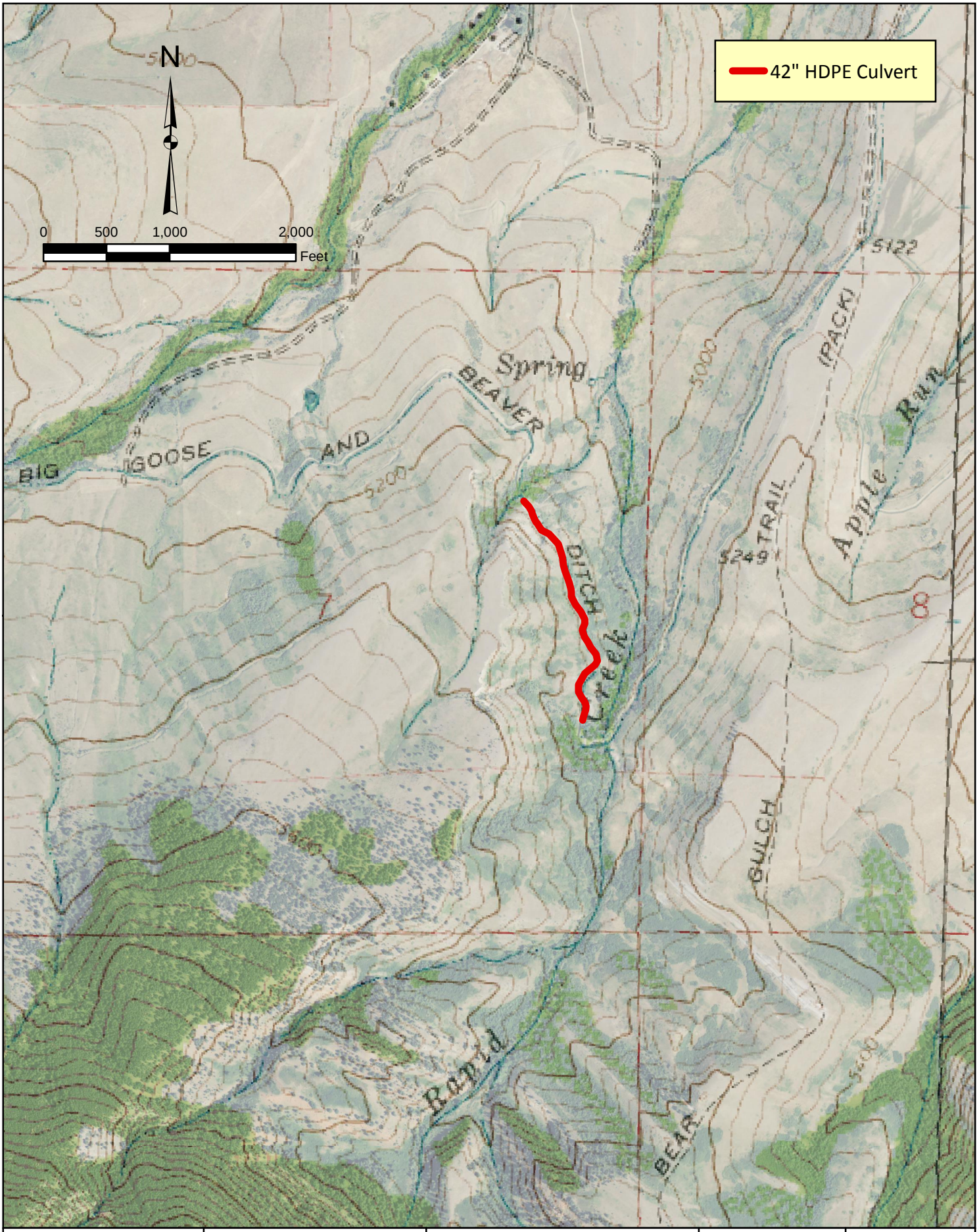
Project Costs

Preparation of Final Design and Specifications	$2,917	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$2,917

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$2,700	$2,700
Structure	6	CY	$1,500	$9,000
Drop Structure	10	CY	$1,500	$15,000
Headgate - 12"	1	EA	$900	$900
Corr. HDPE Culvert - 12"	25	LF	$18	$450
Culvert FE Section - 12"	1	EA	$620	$620
Rip Rap - 24"	4	CY	$125	$500

Total Component Cost (Subtotal #2)	$29,170	
Construction Engineering Cost (Subtotal #2 x 10%)	$2,917	
Components and Engineering Costs (Subtotal #3)	$32,087	
Contingency (Subtotal #3 x 15%)	$4,814	
Construction Cost Total (Subtotal #4)		$36,901
Total Project Cost (Subtotal #1 + Subtotal #4)		$39,818



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Project Name: Big Goose Beaver Ditch Culvert Installation

Project ID:	**ISI-BG-BGB-01**	**Structure Type:**	**Culvert Installation**
Ditch Name:	Big Goose Beaver Ditch	Coordinates:	44.669401, -107.138317
Contact Persons:	Jim Ankney, Big Goose Beaver Ditch Co.		
Description:	Install 2,000 LF of 42" culvert in the section of the ditch just upstream of where it makes a 180 degree turn at Little Rapid Creek. Within this area, there are two areas where the banks are sloughing. One section of sloughing that is occurring is approximately 300' long and is 200' up the bank from the ditch.		
Project Benefits:	Increasing and extending irrigation water availability.		

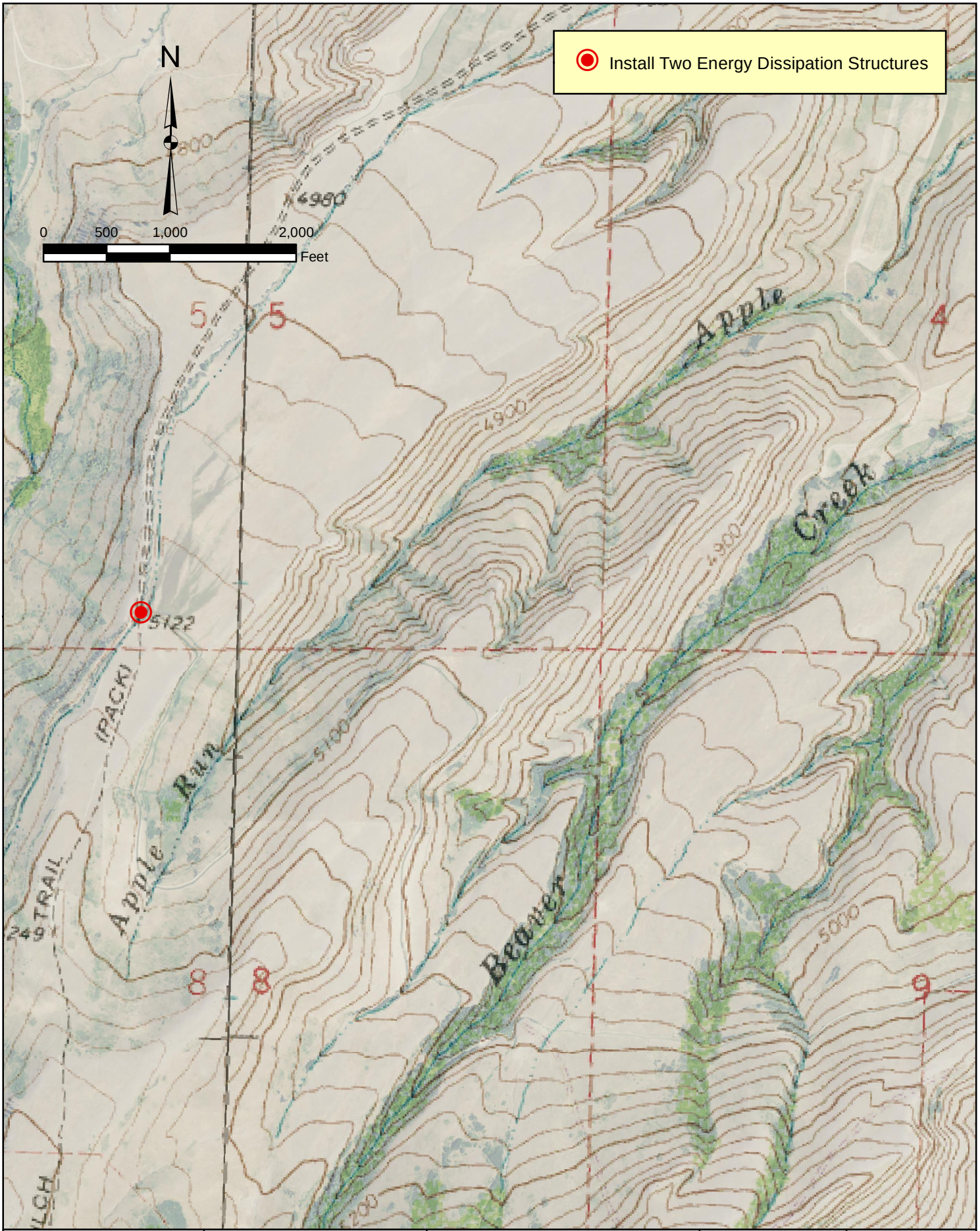
Project Costs

Preparation of Final Design and Specifications	$13,544	
Permitting and Mitigation	$1,000	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$15,544

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$12,400	$12,400
Corr. HDPE Culvert - 42 in	2,000	LF	$57	$114,000
Culvert Flared End Section - 42 in	2	EA	$470	$940
Trash Guard 42 in	1	EA	$2,500	$2,500
Seeding	5,600	SY	$1	$5,600

Total Component Cost (Subtotal #2)	$135,440	
Construction Engineering Cost (Subtotal #2 x 10%)	$13,544	
Components and Engineering Costs (Subtotal #3)	$148,984	
Contingency (Subtotal #3 x 15%)	$22,348	
Construction Cost Total (Subtotal #4)		$171,332
Total Project Cost (Subtotal #1 + Subtotal #4)		$186,876



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Project Name:	Big Goose Beaver Ditch Energy Dissipation Structures		
Project ID:	**ISI-BG-BGB-02**	**Structure Type:**	**Energy Dissipation Structures**
Ditch Name:	Big Goose Beaver Ditch	Coordinates:	44.675803, -107.128565
Contact Persons:	Jim Ankney, Big Goose Beaver Ditch Co.		
Description:	Install two energy dissipation structures just downstream of the Doenz and Widener diversion points. There is considerable erosion along the ditch banks due to the large elevation drop that currently exists in the ditch at this location. This project would construct energy dissipation structures and perform bank stabilization.		
Project Benefits:	Increasing and extending irrigation water availability.		

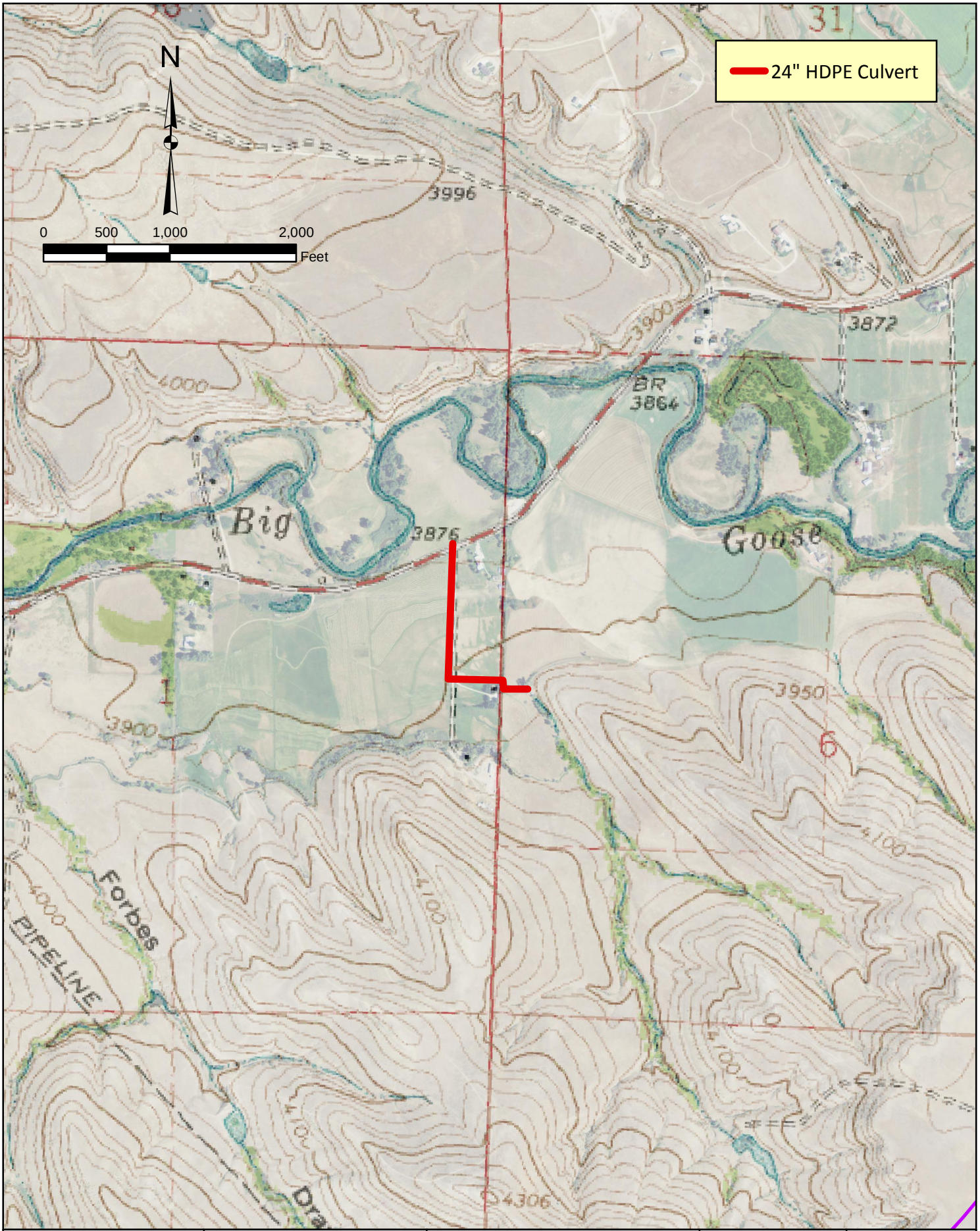
Project Costs

Preparation of Final Design and Specifications	$2,518	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$2,518

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$2,500	$2,500
30 in	EA	2	$280	$560
Trash Guard - 30 in	EA	2	$1,900	$3,800
RCP Culvert - 30 in	LF	50	$57	$2,850
Manhole Type C	EA	2	$5,900	$11,800
Machine-placed Riprap	CY	9	$130	$1,170
Misc. earthwork	LS	LS	$5,000	$5,000

Total Component Cost (Subtotal #2)	$25,180	
Construction Engineering Cost (Subtotal #2 x 10%)	$2,518	
Components and Engineering Costs (Subtotal #3)	$27,698	
Contingency (Subtotal #3 x 15%)	$4,155	
Construction Cost Total (Subtotal #4)		$31,853
Total Project Cost (Subtotal #1 + Subtotal #4)		$34,371



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Project Name: Daisy Ditch Wasteway Installation

Project ID:	**ISI-BG-DA-01**	**Structure Type:**	**Wasteway**
Ditch Name:	Daisy Ditch	Coordinates:	44.769787, -107.032869
Contact Persons:	Dave Barkan		
Description:	Install 1300 LF of 24" culvert and 100 LF of 24" bored pipe for highway crossing. The wasteway for returning Daisy Ditch water to Big Goose Creek has been blocked since approximately 2008, resulting in flooding of adjacent properties. Flooding results on the Barkan property to the north. This project will efficiently return this water to Big Goose Creek.		
Project Benefits:	Increasing and extending irrigation water availability.		

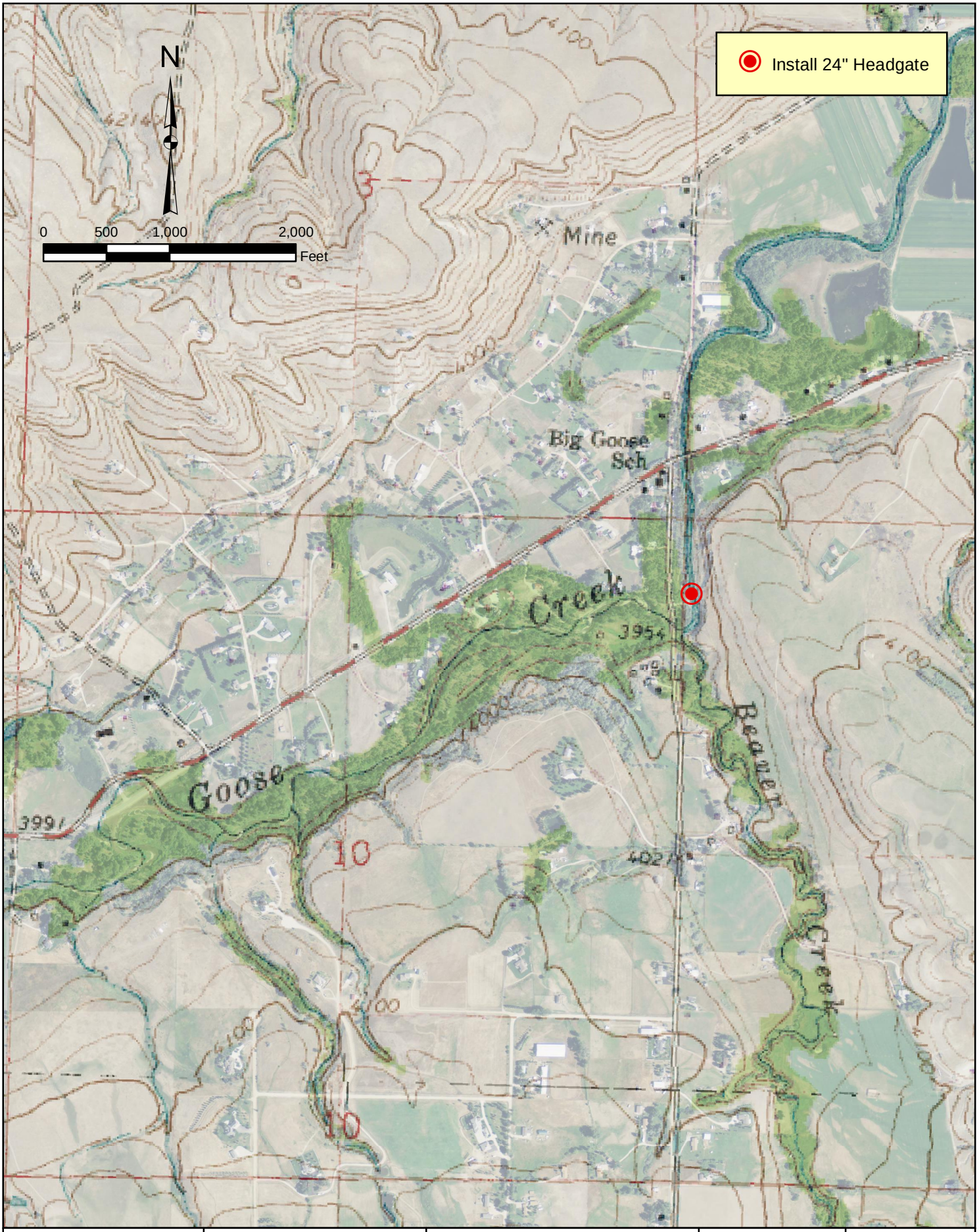
Project Costs

Preparation of Final Design and Specifications	$9,424	
Permitting and Mitigation	$2,000	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$2,000	
Pre-Construction Costs (Subtotal #1)		$13,424

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$8,600	$8,600
Corr. HDPE Culvert - 24 in	1,650	LF	$38	$62,700
Culvert Flared End Section - 24 in	4	EA	$260	$1,040
Bore 24" Pipe	100	LF	$150	$15,000
Trash Guard 24 in	2	EA	$1,600	$3,200
Seeding	3,700	SY	$1	$3,700

Total Component Cost (Subtotal #2)	$94,240	
Construction Engineering Cost (Subtotal #2 x 10%)	$9,424	
Components and Engineering Costs (Subtotal #3)	$103,664	
Contingency (Subtotal #3 x 15%)	$15,550	
Construction Cost Total (Subtotal #4)		$119,214
Total Project Cost (Subtotal #1 + Subtotal #4)		$132,638



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Project Name: Daisy Ditch Headgate Replacement

Project ID:	**ISI-BG-DA-02**	**Structure Type:**	**Headgate**
Ditch Name:	Daisy Ditch	Coordinates:	44.760750, -107.073783
Contact Persons:	Dave Barkan		
Description:	Replace existing 24" headgate at the Daisy Ditch diversion on Big Goose Creek. The existing headgate is old, in poor condition and leaks.		
Project Benefits:	Increasing and extending irrigation water availability.		

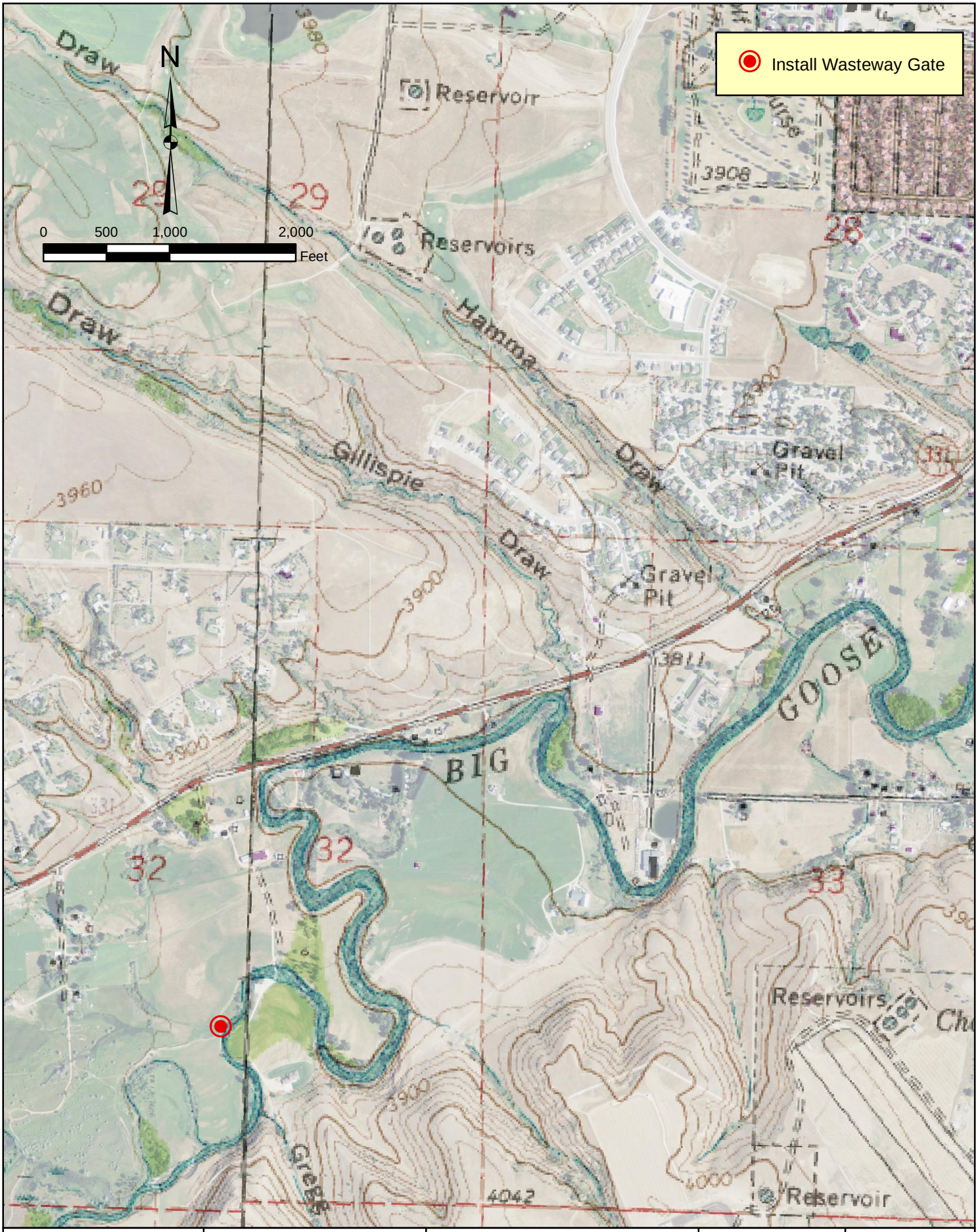
Project Costs

Preparation of Final Design and Specifications	$1,040	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$1,040

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$1,000	$1,000
Headgate - 24"	1	EA	$1,700	$1,700
Precast Turnout	1	EA	$5,300	$5,300
Trash Rack - 24"	1	EA	$1,600	$1,600
Diversion Dam	1	LS	$800	$800

Total Component Cost (Subtotal #2)	$10,400	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,040	
Components and Engineering Costs (Subtotal #3)	$11,440	
Contingency (Subtotal #3 x 15%)	$1,716	
Construction Cost Total (Subtotal #4)		$13,156
Total Project Cost (Subtotal #1 + Subtotal #4)		$14,196



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Project Name: Flume Ditch Wasteway Gate Replacement

Project ID:	**ISI-BG-FL-01**	**Structure Type:**	**Wasteway**
Ditch Name:	Flume Ditch	Coordinates:	44.781037, -107.001445
Contact Persons:	Corey Jost		
Description:	The wasteway gate is in poor condition and is need of replacement.		
Project Benefits:	Increasing and extending irrigation water availability.		

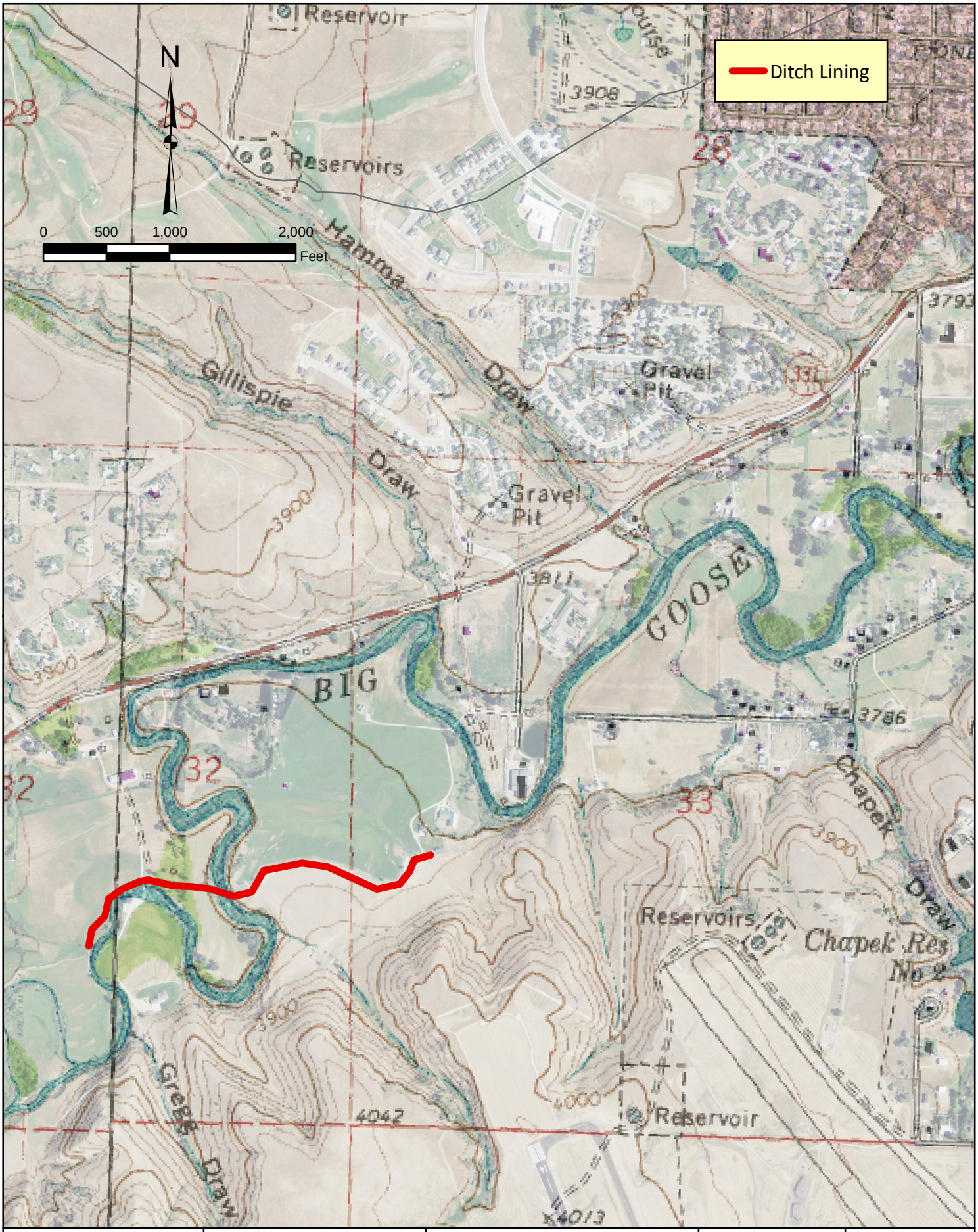
Project Costs

Preparation of Final Design and Specifications	$374	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$374

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	340	340
Remove existing headgate	LS	LS	500	500
Install concrete headwall	1	CY	$1,500	$1,500
12" headgate	1	EA	$900	$900
12" trash rack	1	EA	$500	$500

Total Component Cost (Subtotal #2)	$3,740	
Construction Engineering Cost (Subtotal #2 x 10%)	$374	
Components and Engineering Costs (Subtotal #3)	$4,114	
Contingency (Subtotal #3 x 15%)	$618	
Construction Cost Total (Subtotal #4)		$4,732
Total Project Cost (Subtotal #1 + Subtotal #4)		$5,106



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Project Name: Flume Ditch Seepage

Project ID:	**ISI-BG-FL-02**	**Structure Type:**	**Ditch Lining**
Ditch Name:	Flume Ditch	Coordinates:	44.783953, -106.994219
Contact Persons:	Corey Jost		
Description:	Bentonite existing unlined ditch throughout its entire length in order to reduce seepage. The proposed project assumes a trapezoidal cross-section of 3-foot sideslopes and 3-foot bottom width, and a total ditch length of 3,300'.		
Project Benefits:	Increasing and extending irrigation water availability.		

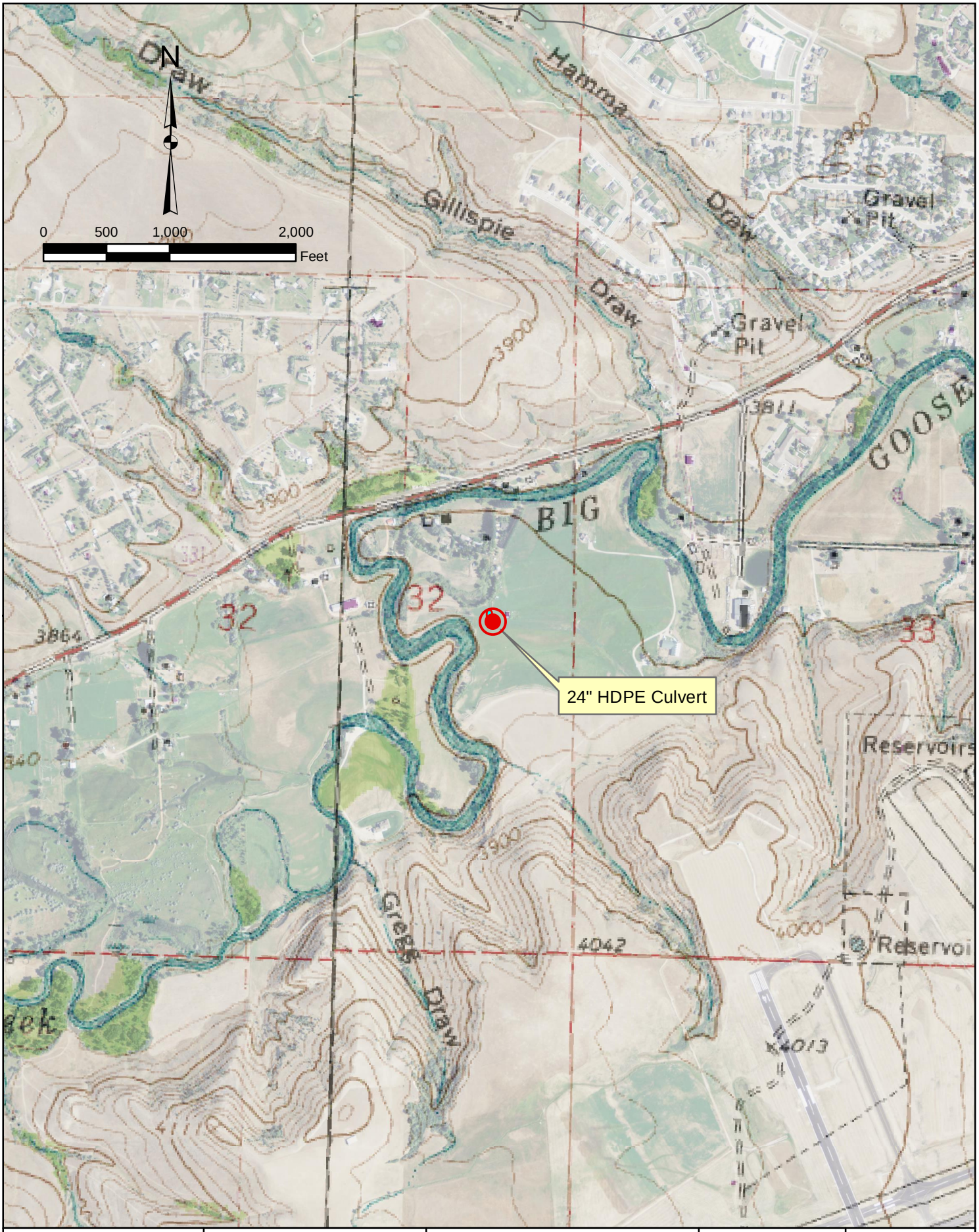
Project Costs

Preparation of Final Design and Specifications	$15,911	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$15,911

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$14,465	$14,465
Remove vegetation in existing ditch	86	CY	$18	$1,548
Bentonite liner	47,700	SF	$3	$143,100

Total Component Cost (Subtotal #2)	$159,113	
Construction Engineering Cost (Subtotal #2 x 10%)	$15,911	
Components and Engineering Costs (Subtotal #3)	$175,024	
Contingency (Subtotal #3 x 15%)	$26,254	
Construction Cost Total (Subtotal #4)		$201,278
Total Project Cost (Subtotal #1 + Subtotal #4)		$217,189



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Project Name: Flume Ditch Culverts

Project ID:	**ISI-BG-FL-03**	**Structure Type:**	**Culvert Installation**
Ditch Name:	Flume Ditch	Coordinates:	44.783620, -106.996607
Contact Persons:	Corey Jost		
Description:	Install culverts at three fence line crossing locations to minimize livestock impacts as the ditch crosses beneath the fence.		
Project Benefits:	Increasing and extending irrigation water availability.		

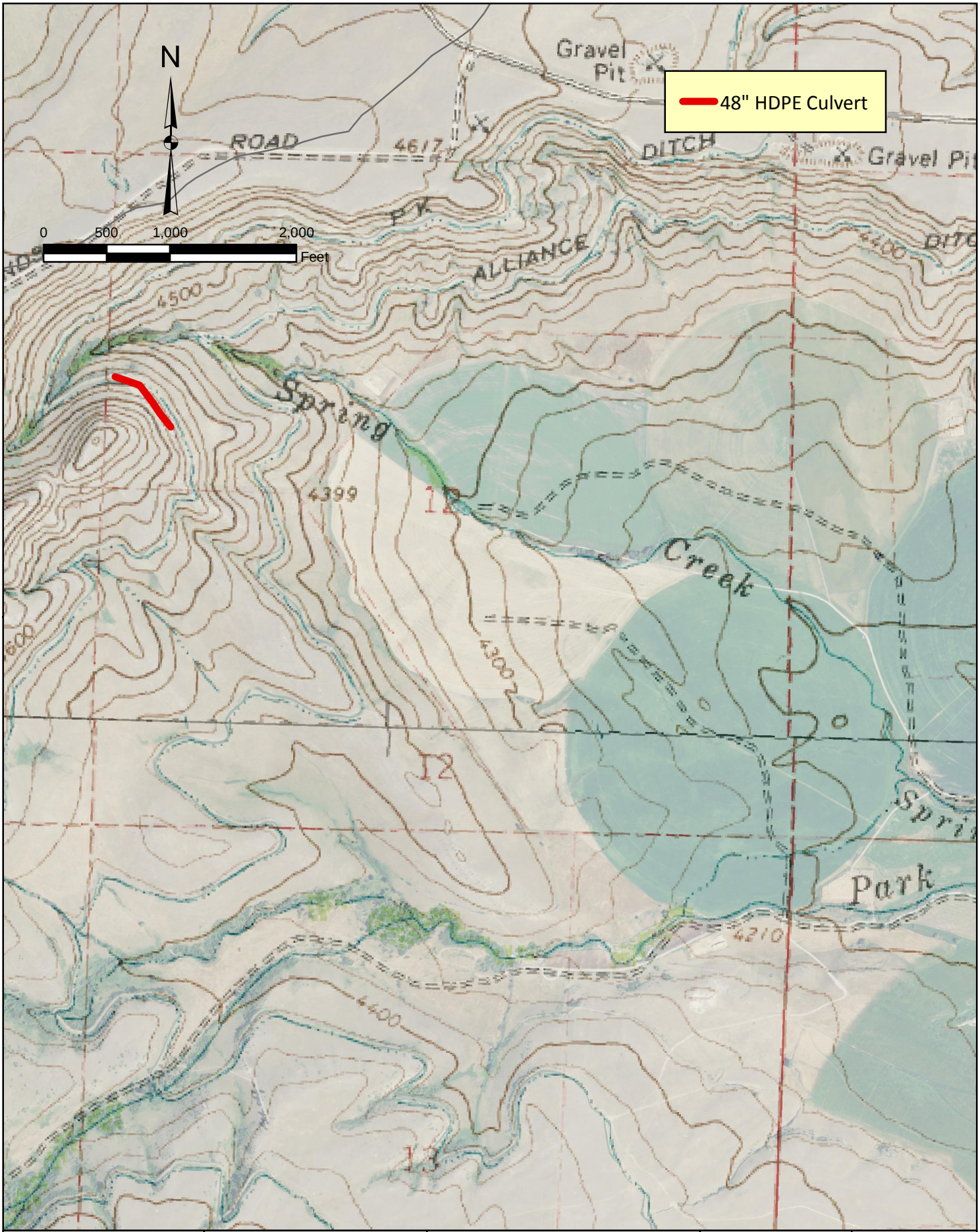
Project Costs

Preparation of Final Design and Specifications	$161	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$161

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$146	$146
Install 24" HDPE Culvert	48	LF	$18	$864
Remove and reinstall 4-wire barbed wire fence	60	LF	$10	$600

Total Component Cost (Subtotal #2)	$1,610	
Construction Engineering Cost (Subtotal #2 x 10%)	$161	
Components and Engineering Costs (Subtotal #3)	$1,771	
Contingency (Subtotal #3 x 15%)	$266	
Construction Cost Total (Subtotal #4)		$2,037
Total Project Cost (Subtotal #1 + Subtotal #4)		$2,198



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Project Name: PK Ditch Culvert Replacement

Project ID:	**ISI-BG-PK-01**	**Structure Type:**	**Culvert Replacement**
Ditch Name:	PK Ditch	Coordinates:	44.756577, -107.174452
Contact Persons:	Dennis Elchlinger, PK Ditch Company		
Description:	.Install 600 LF of 48" culvert installed in the ditch around 2008 because of major sloughing of the hillside above the west ditch bank. Sloughing has continued and may have caused the pipe to settle, causing an adverse slope. The ditch slope downstream of this pipe is already very flat. The pipe needs to be replaced with the proper slope and the bank above the ditch stabilized.		
Project Benefits:	Increasing and extending irrigation water availability.		

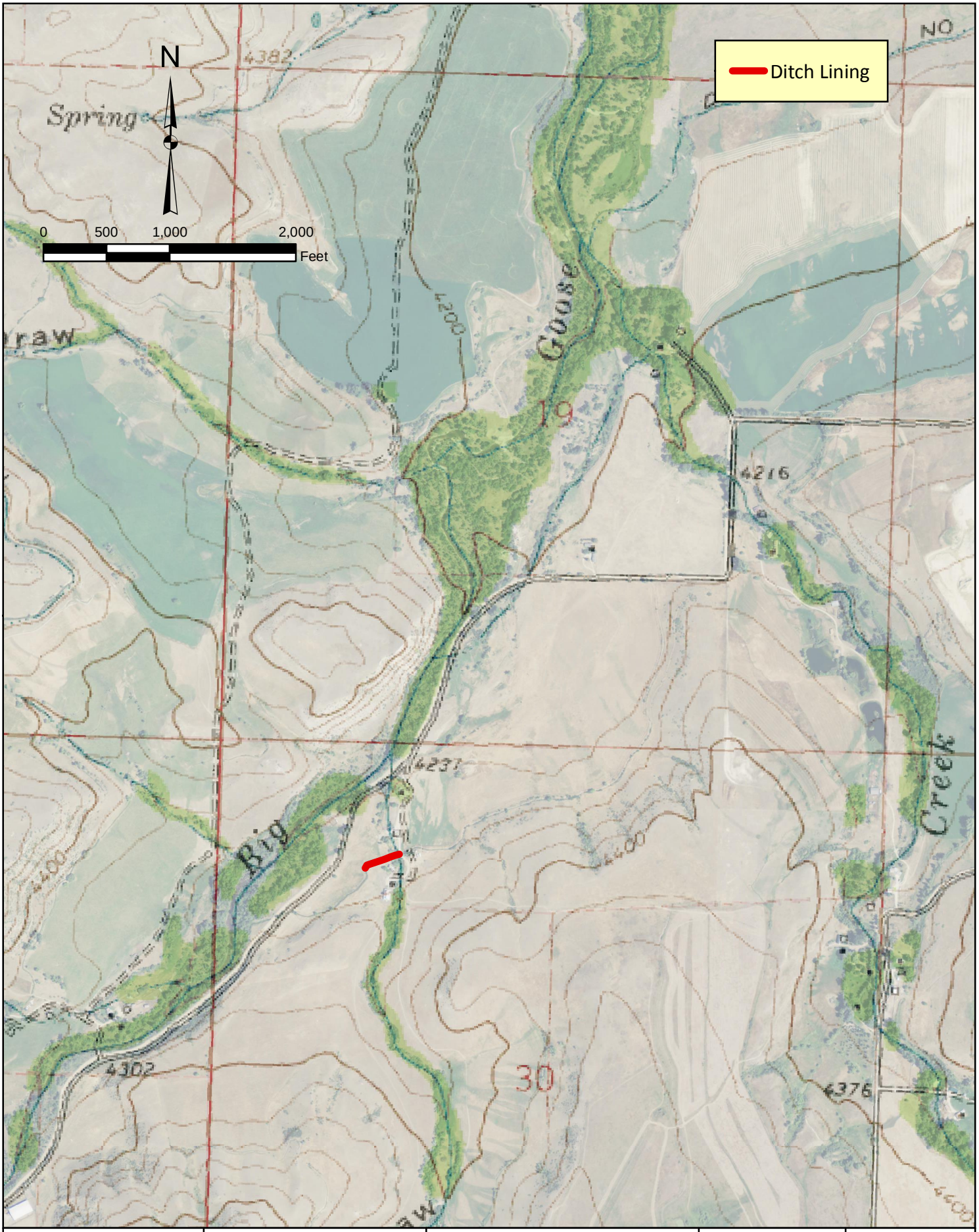
Project Costs

Preparation of Final Design and Specifications	$5,220	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$6,220

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$4,800	$4,800
Corr. HDPE Culvert 48"	600	LF	$69	$41,400
Culvert FE Sect. 48"	2	EA	$600	$1,200
Trash Guard 48 in	1	EA	$3,200	$3,200
Seeding	1600	SY	$1	$1,600

Total Component Cost (Subtotal #2)	$52,200	
Construction Engineering Cost (Subtotal #2 x 10%)	$5,220	
Components and Engineering Costs (Subtotal #3)	$57,420	
Contingency (Subtotal #3 x 15%)	$8,613	
Construction Cost Total (Subtotal #4)		$66,033
Total Project Cost (Subtotal #1 + Subtotal #4)		$72,253



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Project Name: Rocky Ditch Seepage Rehabilitation

Project ID:	**ISI-BG-RO-01**	**Structure Type:**	**Ditch Lining**
Ditch Name:	Rocky	Coordinates:	44.716252, -107.150108
Contact Persons:	Renny Burke		
Description:	Install 300 LF of ditch liner in seepage area.		
Project Benefits:	More efficient use of available flows.		

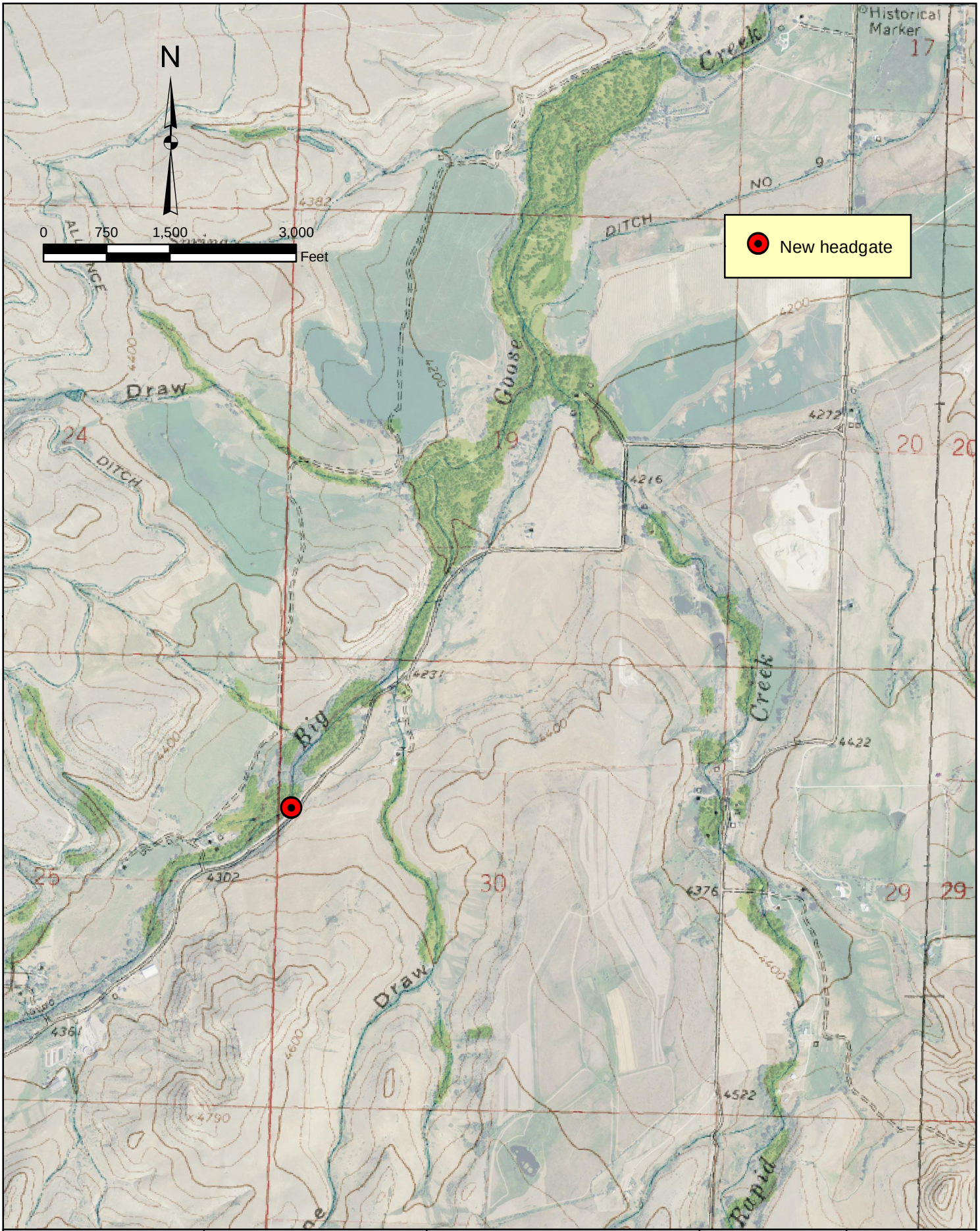
Project Costs

Preparation of Final Design and Specifications				$900	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$0	
			Pre-Construction Costs (Subtotal #1)		$900

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	900	900
Geomembrane Lining	2700	SF	$3	$8,100

Total Component Cost (Subtotal #2)	$9,000	
Construction Engineering Cost (Subtotal #2 x 10%)	$900	
Components and Engineering Costs (Subtotal #3)	$9,900	
Contingency (Subtotal #3 x 15%)	$1,485	
Construction Cost Total (Subtotal #4)		$11,385
Total Project Cost (Subtotal #1 + Subtotal #4)		$12,285



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Project Name: Rocky Ditch Headgate Replacement

Project ID:	**ISI-BG-RO-02**	**Structure Type:**	**Headgate**
Ditch Name:	Rocky	Coordinates:	44.713888, -107.154717
Contact Persons:	Renny Burke		
Description:	Replace existing 24" headgate on Big Goose Creek. The existing headgate is antiquated and in need of replacement.		
Project Benefits:	Increasing and extending irrigation water availability.		

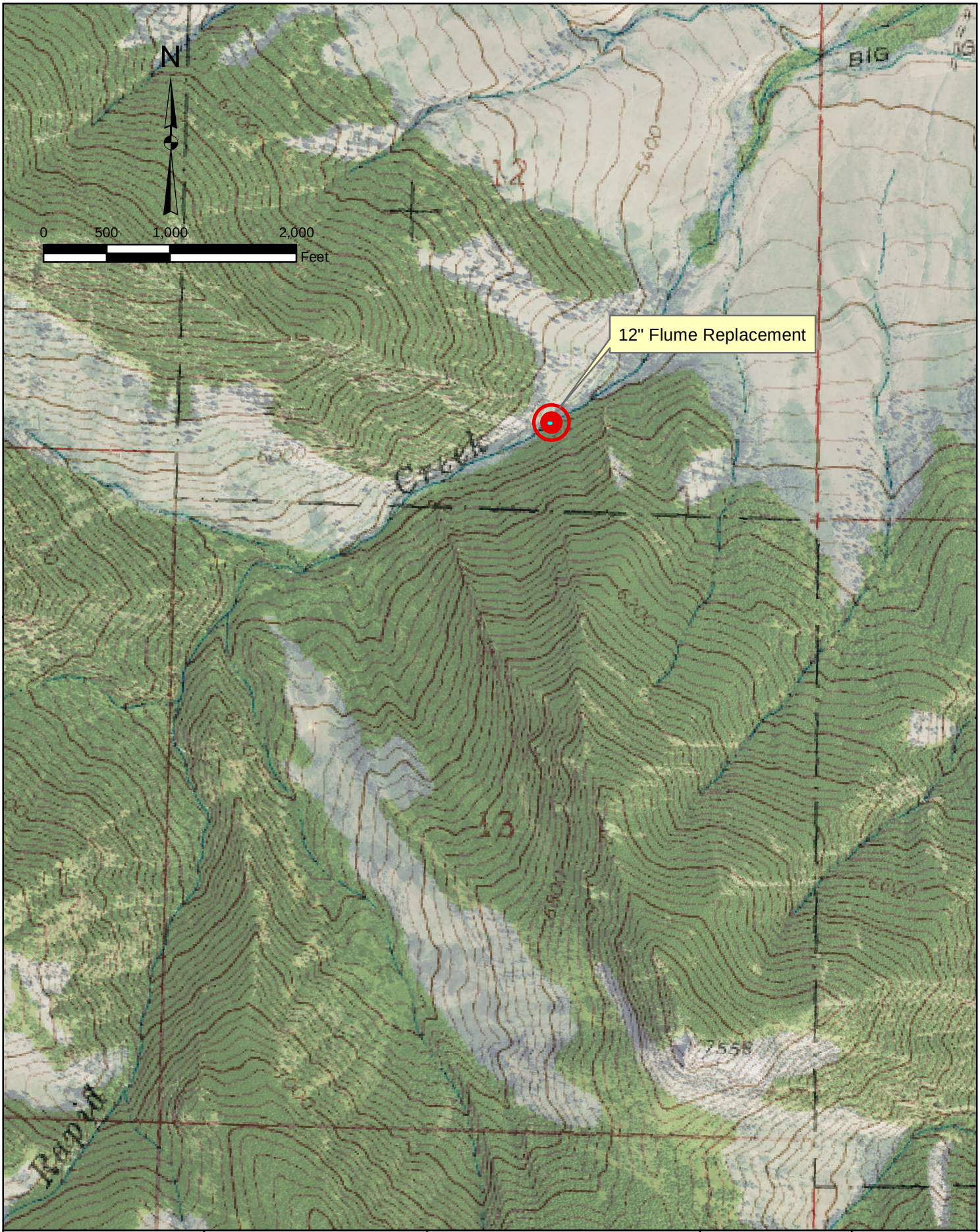
Project Costs

Preparation of Final Design and Specifications	$910	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$910

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	900	900
Clearing & Grubbing	1	LS	$400	$400
Headgate - 24"	1	EA	$1,700	$1,700
Precast Turnout	1	EA	$5,300	$5,300
Diversion Dam	1	LS	$800	$800

Total Component Cost (Subtotal #2)	$9,100	
Construction Engineering Cost (Subtotal #2 x 10%)	$910	
Components and Engineering Costs (Subtotal #3)	$10,010	
Contingency (Subtotal #3 x 15%)	$1,502	
Construction Cost Total (Subtotal #4)		$11,512
Total Project Cost (Subtotal #1 + Subtotal #4)		$12,422



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Project Name: Snively Ditch Flume Replacement

Project ID:	**ISI-BG-SN-01**	**Structure Type:**	**Flume Replacement**
Ditch Name:	Big Goose Beaver Ditch	Coordinates:	44.662057, -107.162884
Contact Persons:	Clint Pickerl, Big Goose Beaver Ditch water user		
Description:	Install 40 LF of Snively Ditch flume that crosses Rapid Creek immediately upstream of Big Goose Beaver Ditch diversion point from Rapid Creek. At the present time, this CMP flume is inoperable due to it freezing and breaking several years back.		
Project Benefits:	Increasing and extending irrigation water availability.		

Replace Flume

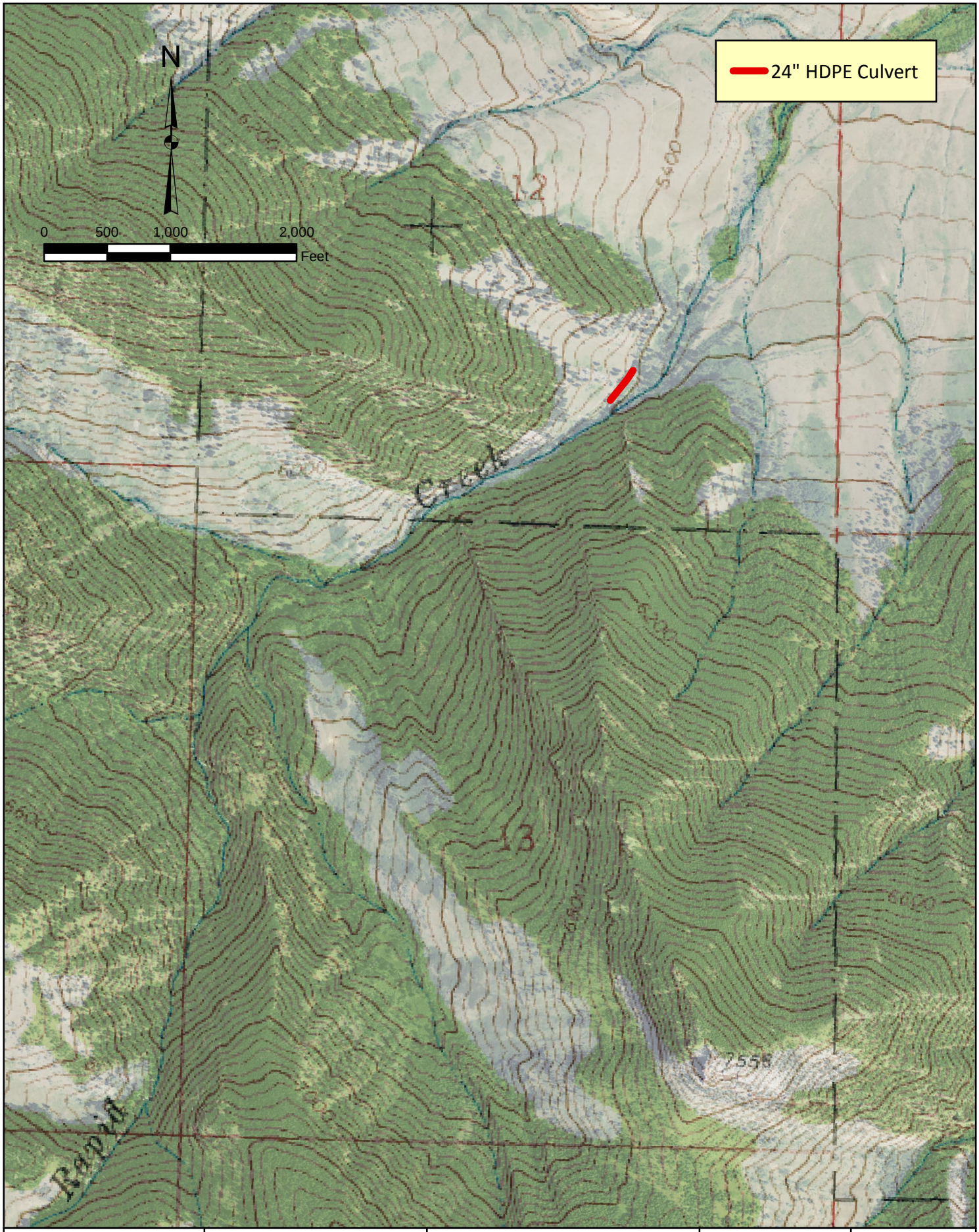
Project Costs

Preparation of Final Design and Specifications	$2,190	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$2,190

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$2,000	$2,000
Concrete Ditch Lining	200	SF	$9	$1,800
Check Dam	3	CY	$1,500	$4,500
Headgate - 12"	1	EA	$900	$900
Headgate - 18"	1	EA	$1,300	$1,300
Precast Turnout	2	EA	$5,300	$10,600
Corr. HDPE Culvert - 12"	10	LF	$18	$180
Culvert FE Sect - 12"	1	EA	$620	$620

Total Component Cost (Subtotal #2)	$21,900	
Construction Engineering Cost (Subtotal #2 x 10%)	$2,190	
Components and Engineering Costs (Subtotal #3)	$24,090	
Contingency (Subtotal #3 x 15%)	$3,614	
Construction Cost Total (Subtotal #4)		$27,704
Total Project Cost (Subtotal #1 + Subtotal #4)		$29,894



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Project Name: Snively Ditch Culvert Installation

Project ID:	**ISI-BG-SN-02**	**Structure Type:**	**Culvert Installation**
Ditch Name:	Big Goose Beaver Ditch	Coordinates:	44.663001, -107.161566
Contact Persons:	Clint Pickerl, Big Goose Beaver Ditch water user		
Description:	Install 300 LF of 24" culvert in area along Snively Ditch (north side) where there is a gravel seam where irrigation water is lost due to percolation. The Snively Ditch is located immediately upstream of the point of diversion from Rapid Creek for the Big Goose Beaver Ditch.		
Project Benefits:	Increasing and extending irrigation water availability.		

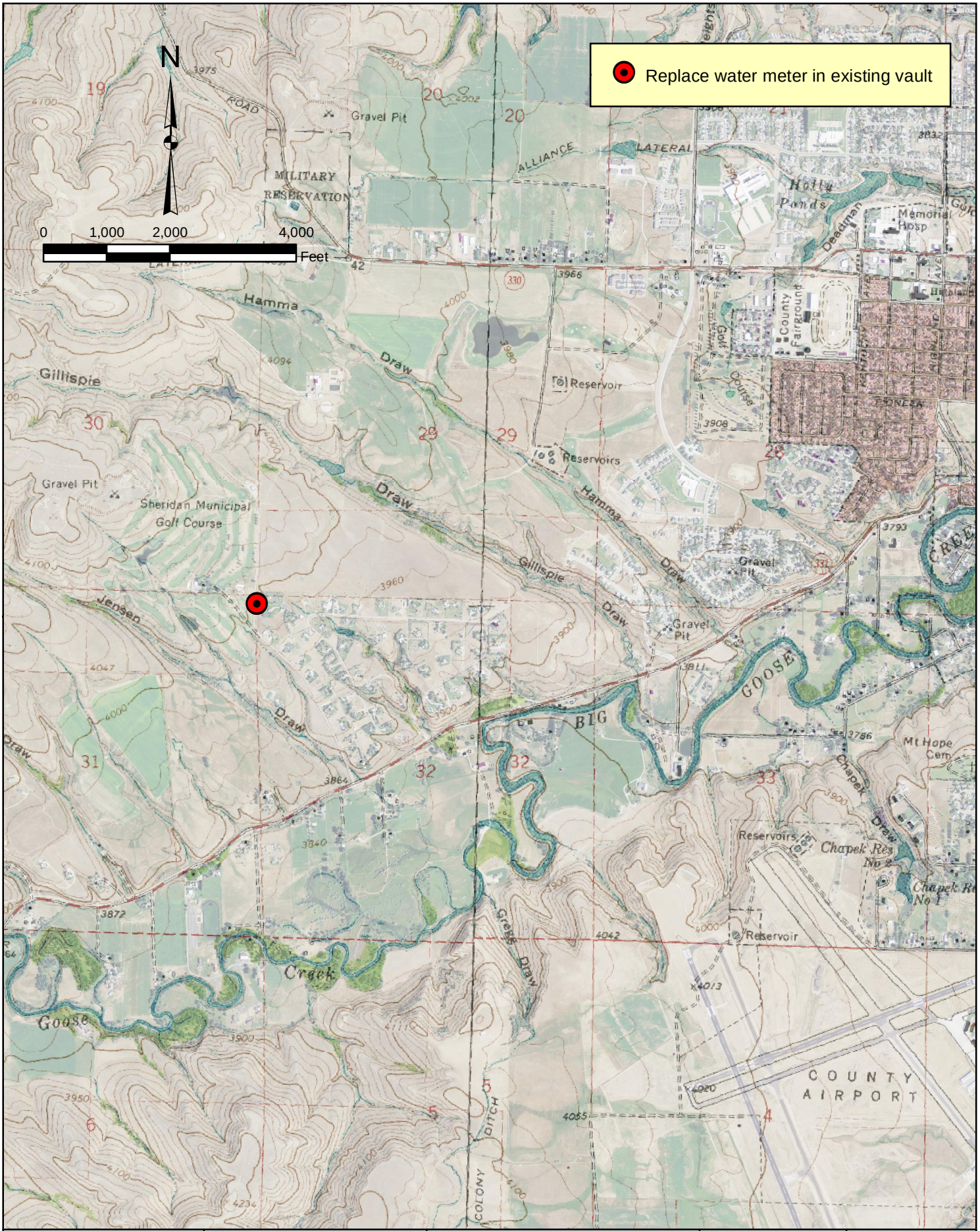
Project Costs

Preparation of Final Design and Specifications	$1,586	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$1,586

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$1,500	$1,500
Corr. HDPE Culvert - 24 in	300	LF	$38	$11,400
Culvert Flared End Section - 24 in	2	EA	$260	$520
Trash Guard - 24 in	1	EA	$1,600	$1,600
Seeding	840	SY	$1	$840

Total Component Cost (Subtotal #2)	$15,860	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,586	
Components and Engineering Costs (Subtotal #3)	$17,446	
Contingency (Subtotal #3 x 15%)	$2,617	
Construction Cost Total (Subtotal #4)		$20,063
Total Project Cost (Subtotal #1 + Subtotal #4)		$21,649



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Project Name: Wild Rose Meter Replacement

Project ID:	**ISI-BG-WR-01**	**Structure Type:**	**Meter**
Ditch Name:	Wild Rose Water System	Coordinates:	44.791493, -107.014373
Contact Persons:	Ed Fack, Bill Shupe, Bruce Tomsovic, Bernie Spielman: Wild Rose I&S District		
Description:	Replace 6" master meter in vault at entry point into distribution system.		
Project Benefits:	More efficient use of available flows.		

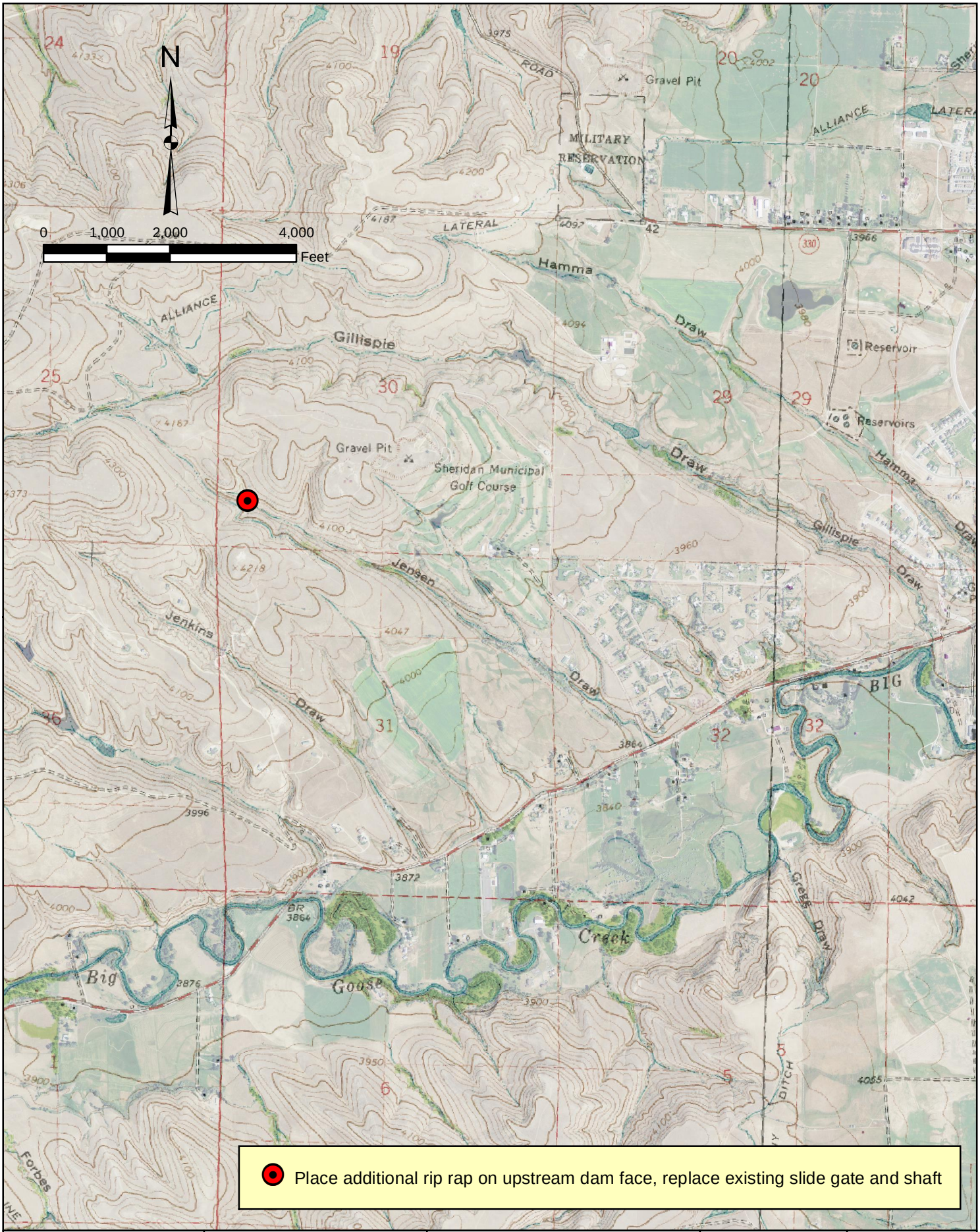
Project Costs

Preparation of Final Design and Specifications	$170	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$170

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	200	200
Replace 6" Master Meter	1	EA	$1,500	$1,500

Total Component Cost (Subtotal #2)	$1,700	
Construction Engineering Cost (Subtotal #2 x 10%)	$170	
Components and Engineering Costs (Subtotal #3)	$1,870	
Contingency (Subtotal #3 x 15%)	$281	
Construction Cost Total (Subtotal #4)		$2,151
Total Project Cost (Subtotal #1 + Subtotal #4)		$2,321



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	**GOOSE CREEK WATERSHED LEVEL I STUDY**	**IRRIGATION SYSTEM INFRASTRUCTURE REHABILITATION AND IMPROVEMENTS**	**ISI-BG-WR-02**

Project Name: Wild Rose Dam Improvements

Project ID:	**ISI-BG-WR-02**	**Structure Type:**	**Dam Improvements**
Ditch Name:	Wild Rose Ditch	Coordinates:	44.794056, -107.032958
Contact Persons:	Ed Fack, Bill Shupe, Bruce Tomsovic, Bernie Spielman: Wild Rose I&S District		
Description:	Install riprap on upstream face of storage dam due to considerable erosion on this upstream face attributed primarily to cattle intrusion. Replace existing slide gate and shaft.		
Project Benefits:	Increasing and extending irrigation water availability.		

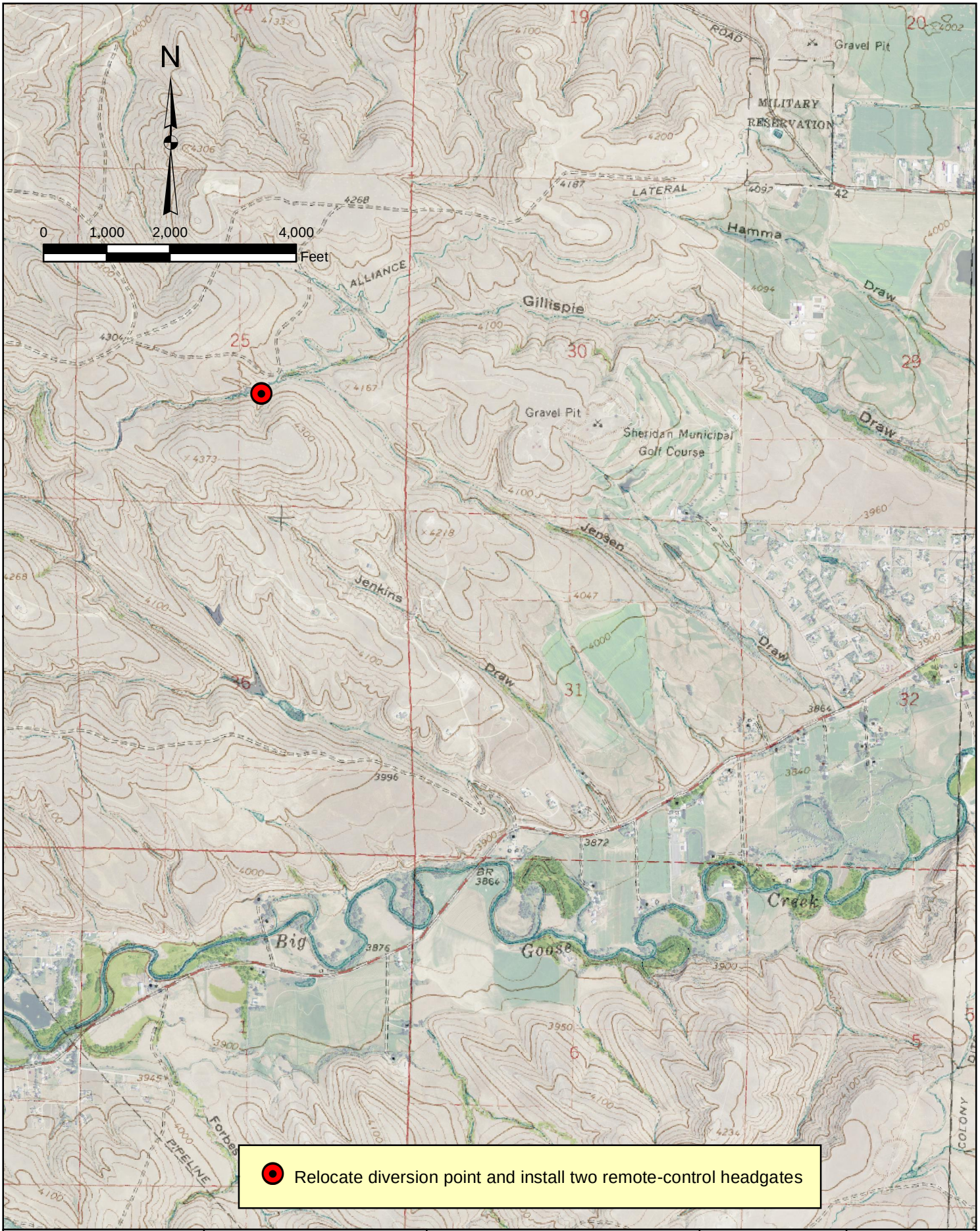
Project Costs

Preparation of Final Design and Specifications	$11,046	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$11,046

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$10,100	$10,100
Rip Rap (large) 36"	660	CY	$140	$92,400
Select backfill (Large Structure)	80	CY	$37	$2,960
Replace slide gate and shaft	1	LS	$5,000	$5,000

Total Component Cost (Subtotal #2)	$110,460	
Construction Engineering Cost (Subtotal #2 x 10%)	$11,046	
Components and Engineering Costs (Subtotal #3)	$121,506	
Contingency (Subtotal #3 x 15%)	$18,226	
Construction Cost Total (Subtotal #4)		$139,732
Total Project Cost (Subtotal #1 + Subtotal #4)		$150,778



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Project Name: Wild Rose Headgate Improvements

Project ID:	**ISI-BG-WR-03**	**Structure Type:**	**Turnout**
Ditch Name:	Wild Rose Ditch	Coordinates:	44.796984, -107.043760
Contact Persons:	Ed Fack, Bill Shupe, Bruce Tomsovic, Bernie Spielman: Wild Rose I&S District		
Description:	Relocate the existing point of diversion for the Wild Rose I&S District downstream onto the Big Goose Ditch and construct both a headgate and check structure on this ditch. The existing diversion and intake structure on the Alliance Lateral Ditch fills with debris and silt, with the silt due in large part to upstream erosion within the Alliance Lateral Ditch. The silt accumulates at this location due to a reduction in velocity of the Alliance Lateral Ditch water. The current situation creates a large maintenance burden to keep the intake structure free and operational. The proposed relocation point has been used occasionally in the past and has shown to be an effective method of avoiding many of the debris accumulation and silting problems. The Alliance Lateral Ditch at the existing diversion point into the Big Goose Ditch will still require periodic dredging in order to maintain flow into the Big Goose Ditch. This project also includes: 1) automatic operation of the proposed turnout on the Big Goose Ditch, and 2) addressing the issue of the Wild Rose's water right being 0.2 cfs, yet the minimum release from Park Reservoir (site of Wild Rose's stored water) being only 0.5 cfs.		
Project Benefits:	Increasing and extending irrigation water availability.		

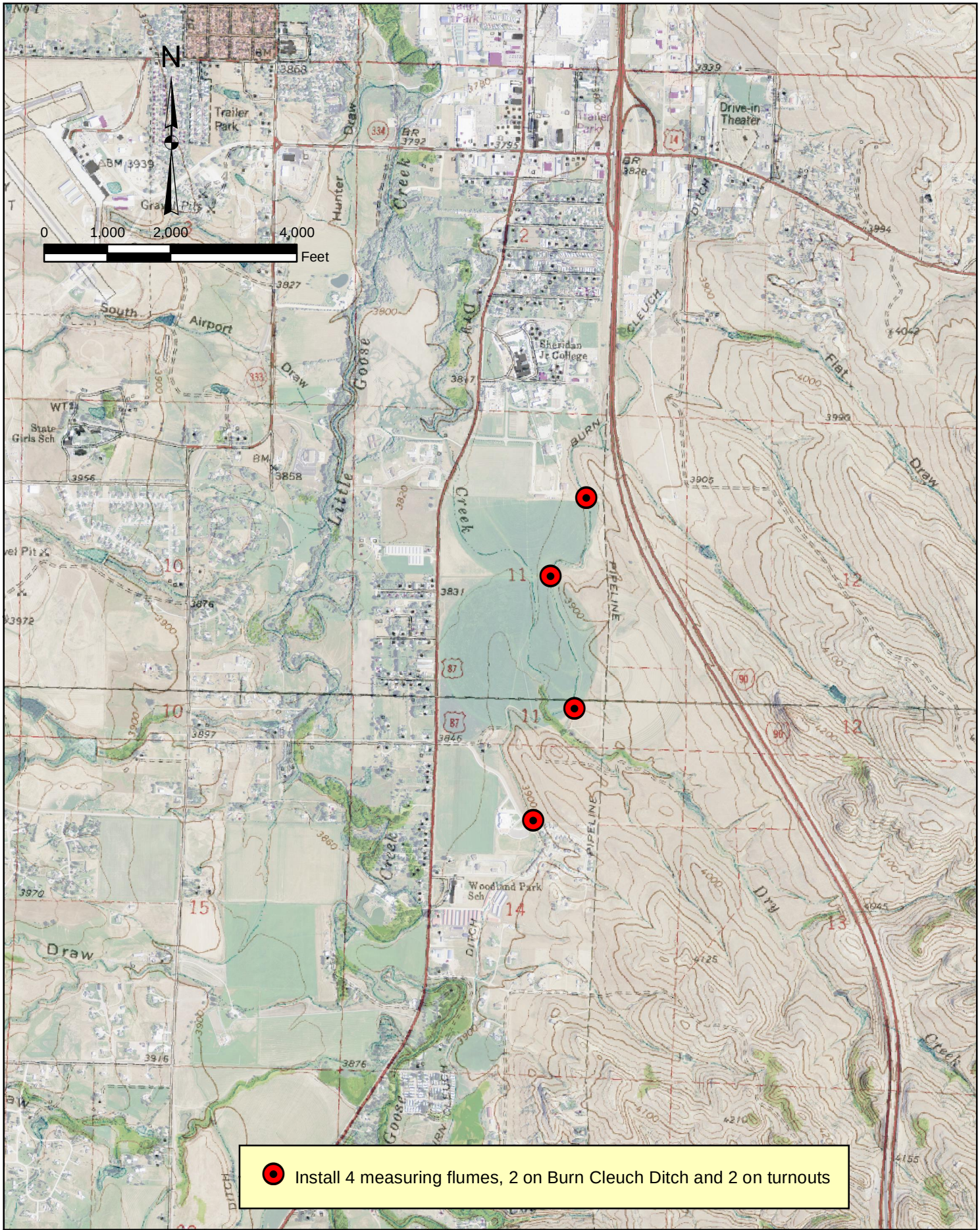
Project Costs

Preparation of Final Design and Specifications	$3,830	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$3,830

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$4,000	$4,000
Headgate 12"	2	EA	$900	$1,800
Reinforced Concrete Structure < 25 CY	1	CY	$1,500	$1,500
Automatic control mechanism for headgate (including solar power)	LS	LS	$35,000	$35,000

Total Component Cost (Subtotal #2)	$38,300	
Construction Engineering Cost (Subtotal #2 x 10%)	$3,830	
Components and Engineering Costs (Subtotal #3)	$42,130	
Contingency (Subtotal #3 x 15%)	$6,320	
Construction Cost Total (Subtotal #4)		$48,450
Total Project Cost (Subtotal #1 + Subtotal #4)		$52,280



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Project Name: Burn-Cleuch Ditch Measuring Flumes

Project ID:	**ISI-LG-BU-01**	**Structure Type:**	**Measuring Device**
Ditch Name:	Burn-Cleuch Ditch	Coordinates:	44.744700, -106.940960
Contact Persons:	Brian Mealor, University of Wyoming		
Description:	Install four new measuring flumes (Parshall or cutthroat) to measure: 1) Burn-Cleuch Ditch flow entering Adams Ranch property, 2) two turnouts delivering water to offsite locations, and 3) Burn-Cleuch Ditch flow exiting the Adams Ranch property.		
Project Benefits:	Increasing and extending irrigation water availability.		

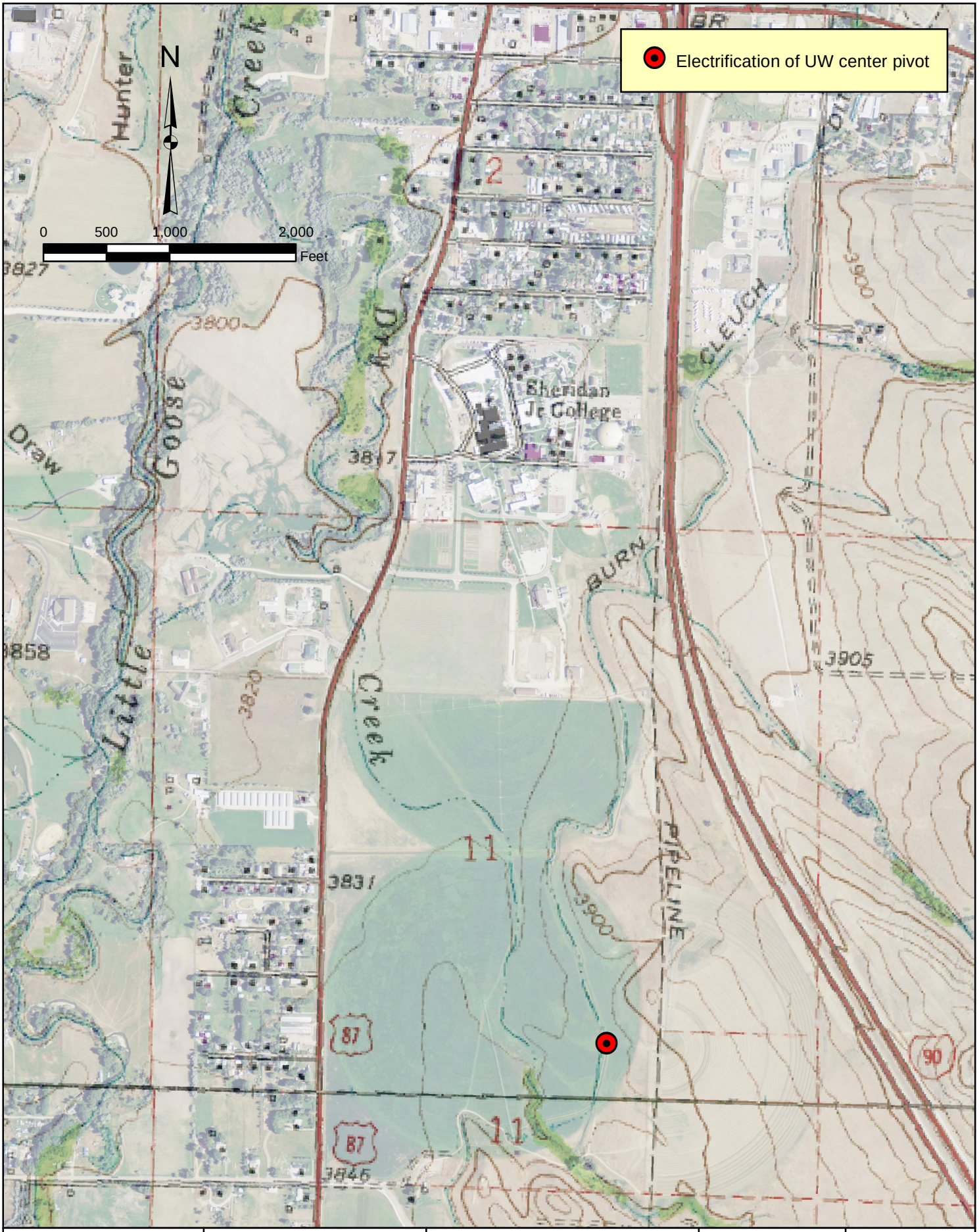
Project Costs

Preparation of Final Design and Specifications	$930	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$930

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$900	$900
Parshall Flume - 12"	2	EA	$1,200	$2,400
Parshall Flume - 60"	2	EA	$3,000	$6,000

Total Component Cost (Subtotal #2)	$9,300	
Construction Engineering Cost (Subtotal #2 x 10%)	$930	
Components and Engineering Costs (Subtotal #3)	$10,230	
Contingency (Subtotal #3 x 15%)	$1,535	
Construction Cost Total (Subtotal #4)		$11,765
Total Project Cost (Subtotal #1 + Subtotal #4)		$12,695



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Project Name: Burn-Cleuch Ditch UW Center Pivot Electrification

Project ID:	**ISI-LG-BU-02**	**Structure Type:**	**Center Pivot**
Ditch Name:	Burn-Cleuch Ditch	Coordinates:	44.751163, -106.938309
Contact Persons:	Oscar Rucki, Burn-Cleuch Ditch		
Description:	Convert means of power for existing center pivot irrigating lands east of the Burn-Cleuch Ditch from diesel to electric. This system is owned and operated by the University of Wyoming.		
Project Benefits:	Economic stability for the State's agricultural sector.		

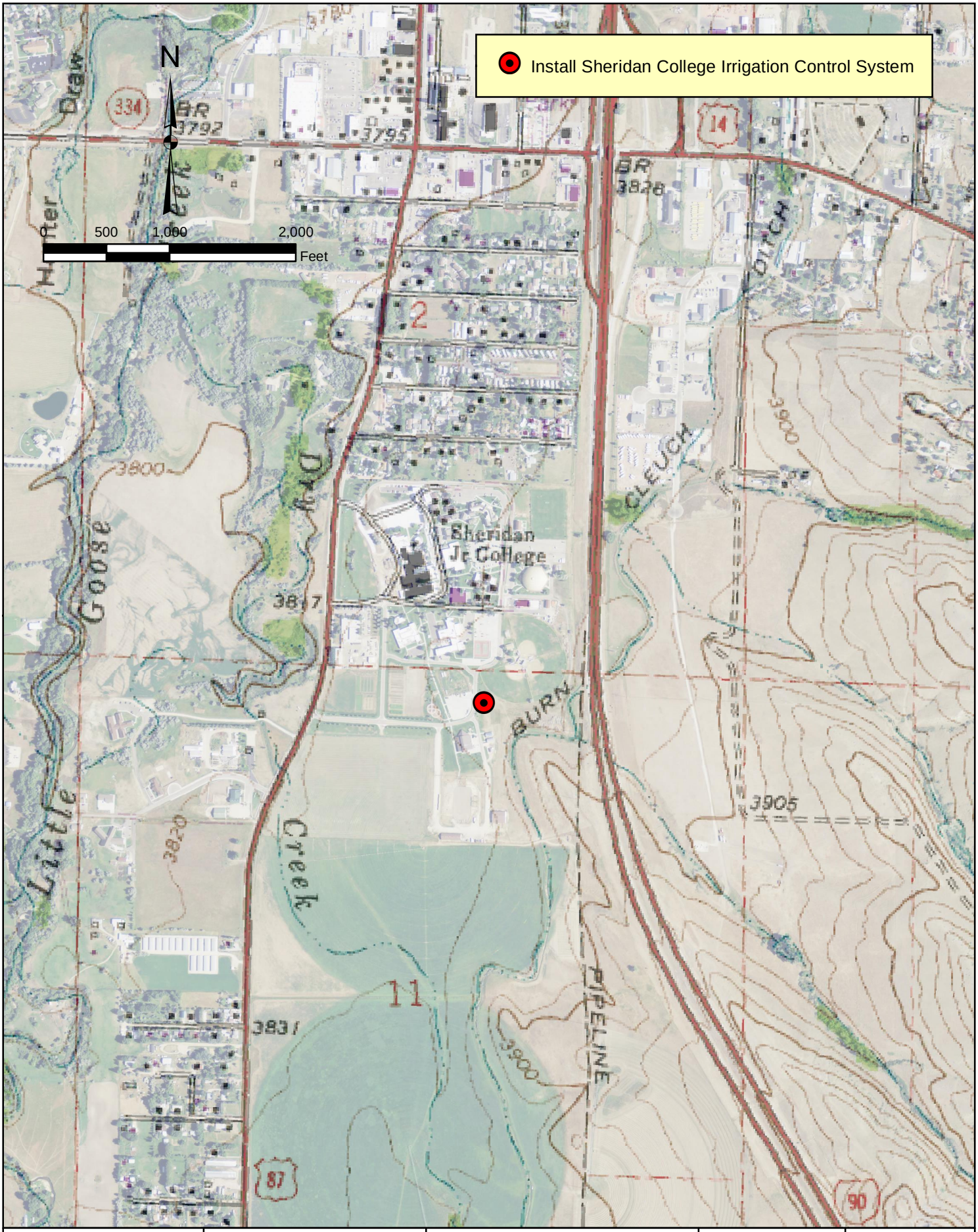
Project Costs

Preparation of Final Design and Specifications	$5,850	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$5,850

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$6,000	$6,000
Extend power from Woodland Park Road	LS	LS	$40,000	$40,000
Motor, switches, fuses, misc. electrical gear	LS	LS	$5,000	$5,000
Concrete pad	2	CY	$1,500	$3,000
Metal roof enclosure	LS	LS	$3,000	$3,000
Furnish and install fence paneling with gate	60	LF	$25	$1,500

Total Component Cost (Subtotal #2)	$58,500	
Construction Engineering Cost (Subtotal #2 x 10%)	$5,850	
Components and Engineering Costs (Subtotal #3)	$64,350	
Contingency (Subtotal #3 x 15%)	$9,653	
Construction Cost Total (Subtotal #4)		$74,003
Total Project Cost (Subtotal #1 + Subtotal #4)		$79,853



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Project Name: Burn-Cleuch Ditch SC Control System

Project ID:	**ISI-LG-BU-03**	**Structure Type:**	**Irrigation Control System**
Ditch Name:	Burn-Cleuch Ditch	Coordinates:	44.761663, -106.940121
Contact Persons:	Oscar Rucki, Burn-Cleuch Ditch Company		
Description:	Upgrade the control system for Sheridan College's existing irrigation system. At the present time, there are numerous separate controllers scattered throughout the campus. The project would link each controller to the campus ethernet system with the objective of coordinating system use throughout the entire campus. In so doing, pipeline usage can be maximized and friction loss minimized.		
Project Benefits:	More efficient use of available flows.		

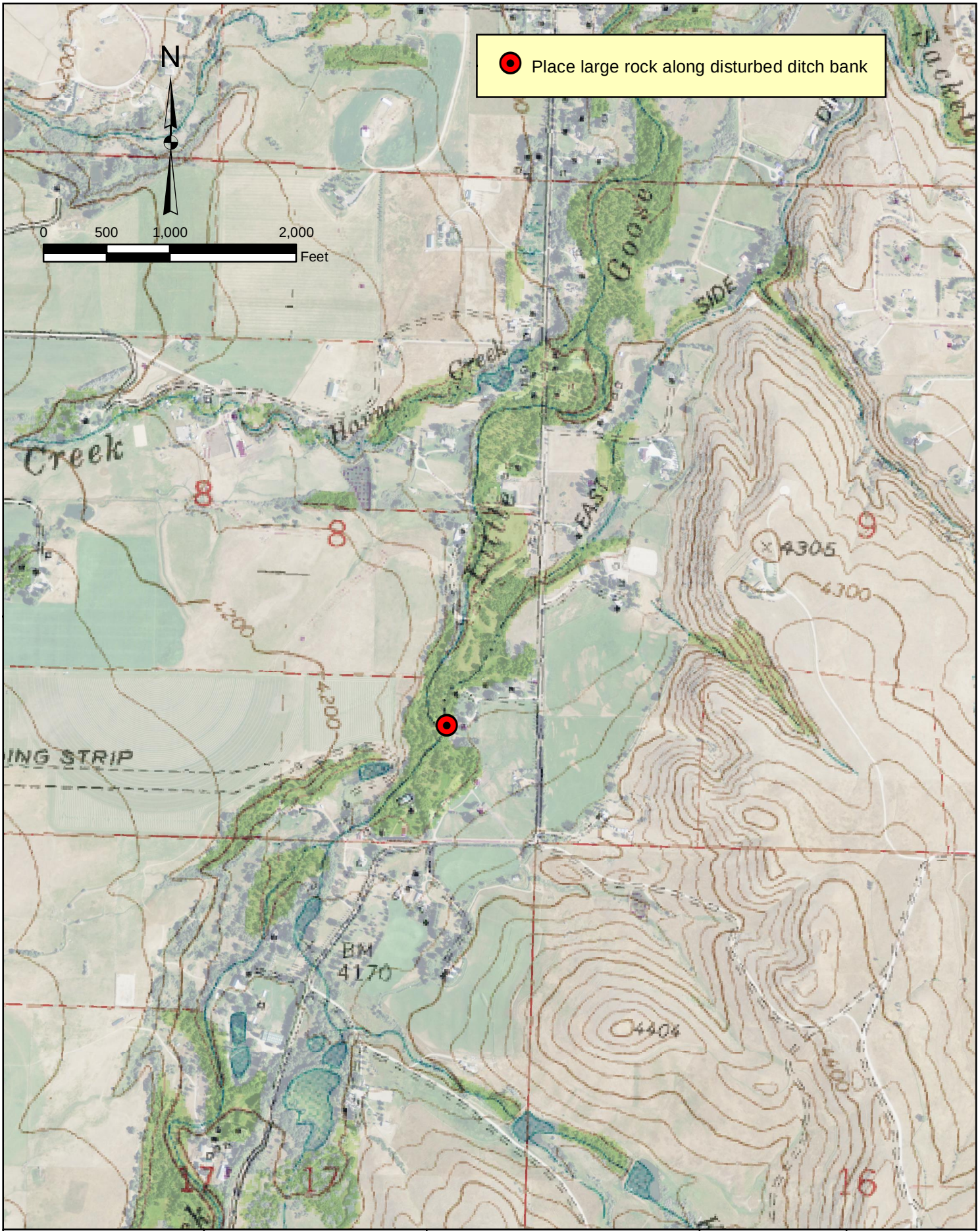
Project Costs

Preparation of Final Design and Specifications				$1,500	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$0	
			Pre-Construction Costs (Subtotal #1)		$1,500

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Control System (Houck, 2017)	LS	LS	$15,000	$15,000

Total Component Cost (Subtotal #2)	$15,000	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,500	
Components and Engineering Costs (Subtotal #3)	$16,500	
Contingency (Subtotal #3 x 15%)	$2,475	
Construction Cost Total (Subtotal #4)		$18,975
Total Project Cost (Subtotal #1 + Subtotal #4)		$20,475



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Project Name: East Side Ditch Diversion Rehabilitation

Project ID:	**ISI-LG-ES-01**	**Structure Type:**	**Erosion Control Improvements**
Ditch Name:	East Side Ditch	Coordinates:	44.663431, -106.995627
Contact Persons:	Steve Pattison, East Side Ditch Company		
Description:	Place additional large rock along east ditch bank just upstream of headgate. This area was damaged during 2015 springtime flooding.		
Project Benefits:	Increasing and extending irrigation water availability.		

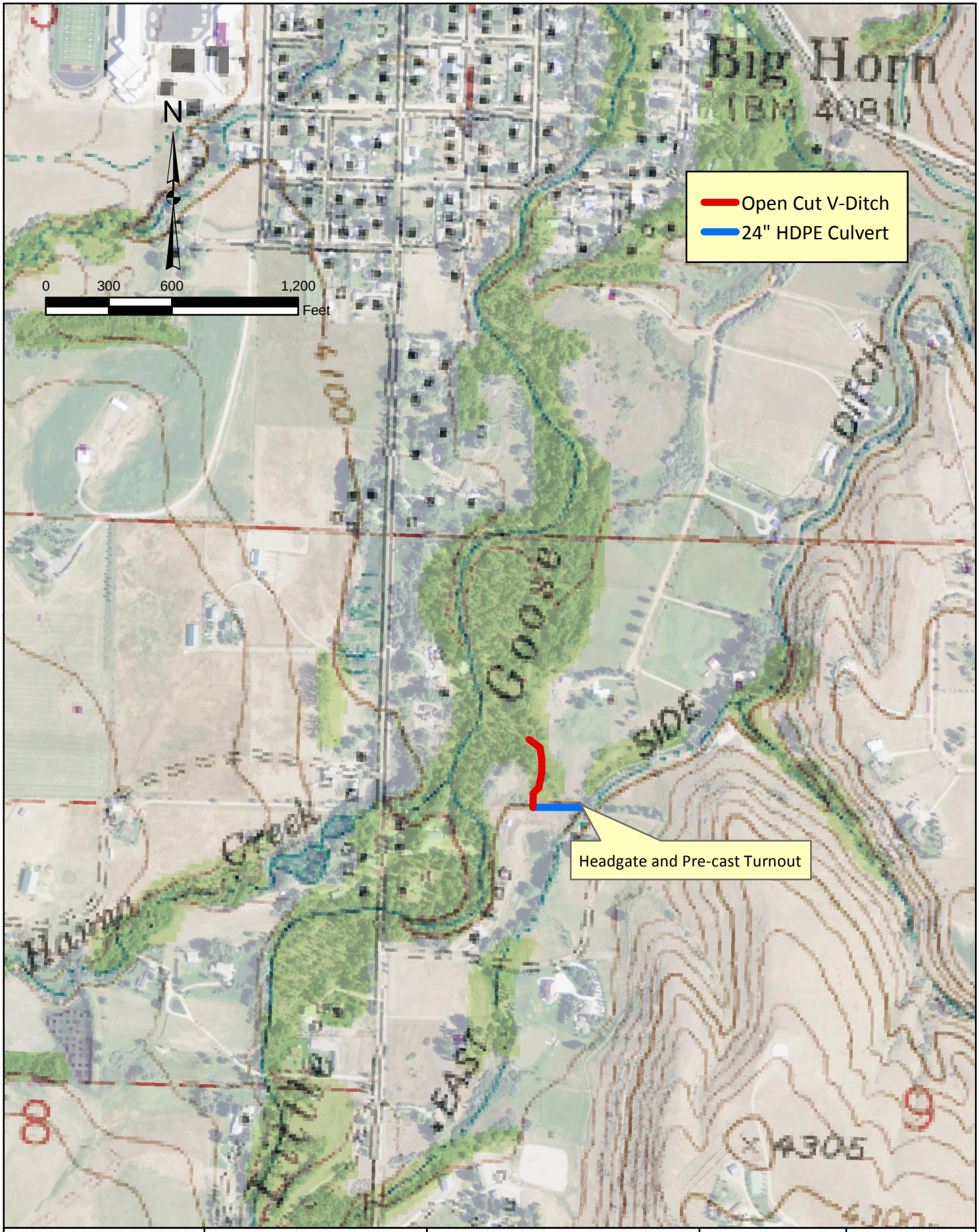
Project Costs

Preparation of Final Design and Specifications	$488	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$488

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	500	500
Rip Rap 24"	35	CY	$125	$4,375

Total Component Cost (Subtotal #2)	$4,875	
Construction Engineering Cost (Subtotal #2 x 10%)	$488	
Components and Engineering Costs (Subtotal #3)	$5,363	
Contingency (Subtotal #3 x 15%)	$805	
Construction Cost Total (Subtotal #4)		$6,168
Total Project Cost (Subtotal #1 + Subtotal #4)		$6,655



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Project Name: East Side Ditch Wasteway

Project ID:	**ISI-LG-ES-02**	**Structure Type:**	**Wasteway**
Ditch Name:	East Side Ditch	Coordinates:	44.671741, -106.989278
Contact Persons:	Steve Pattison, East Side Ditch Company		
Description:	Replace turnout and install new pipe to allow wastewater from East Side Ditch and Muskrat Ditch to flow back directly to Little Goose Creek. By so doing, this wastewater will not have to continue to flow down the ditch.		
Project Benefits:	Increasing and extending irrigation water availability.		

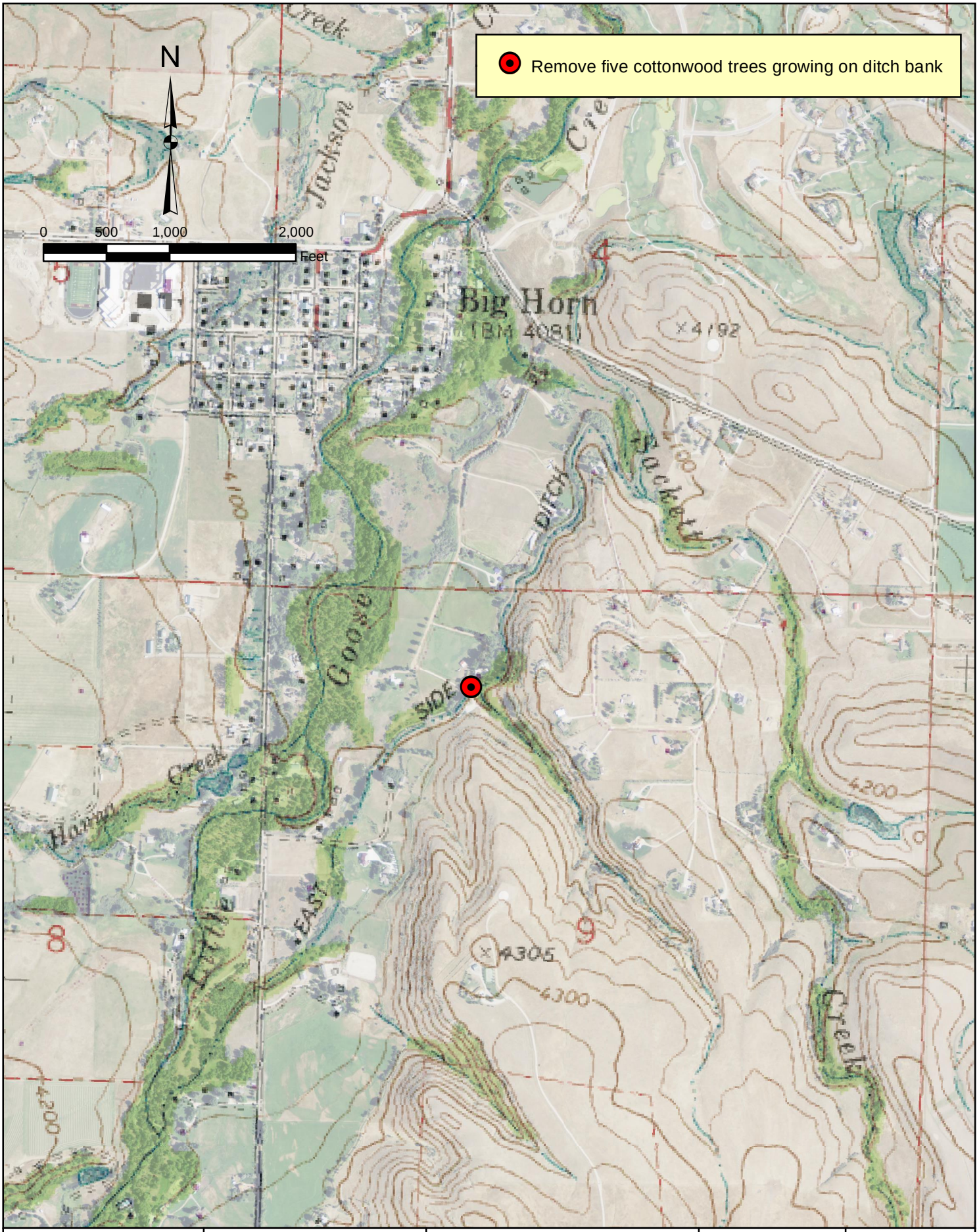
Project Costs

Preparation of Final Design and Specifications	$1,924	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$1,924

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$1,800	$1,800
Headgate - 24"	1	EA	$1,700	$1,700
Precast Turnout	1	EA	$5,300	$5,300
Corr. HDPE Culvert - 24"	230	LF	$38	$8,740
Culvert FE Sect - 24"	1	EA	$260	$260
Open Cut V Ditch	360	LF	$4	$1,440

Total Component Cost (Subtotal #2)	$19,240	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,924	
Components and Engineering Costs (Subtotal #3)	$21,164	
Contingency (Subtotal #3 x 15%)	$3,175	
Construction Cost Total (Subtotal #4)		$24,339
Total Project Cost (Subtotal #1 + Subtotal #4)		$26,263



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Project Name: East Side Ditch Improvements

Project ID:	**ISI-LG-ES-03**	**Structure Type:**	**Misc. Ditch Improvements**
Ditch Name:	East Side Ditch	Coordinates:	44.673210, -106.986672
Contact Persons:	Steve Pattison, East Side Ditch Company		
Description:	Remove the five cottonwood trees growing on the inside ditch bank (where ditch water is undercutting these trees' roots) and replace ditch in disturbed areas.		
Project Benefits:	Increasing and extending irrigation water availability.		

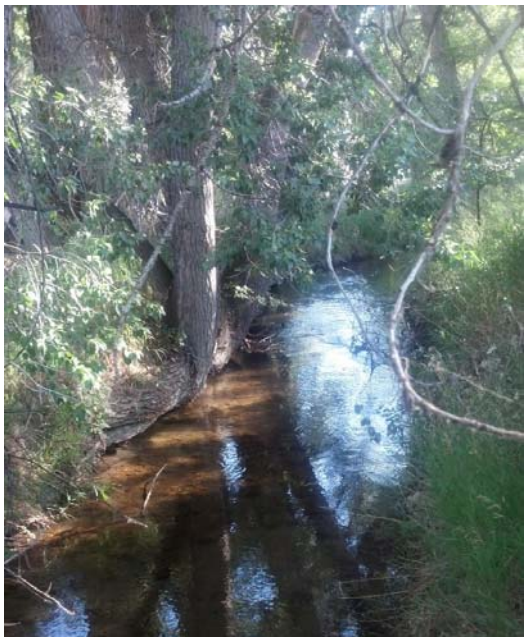
Project Costs

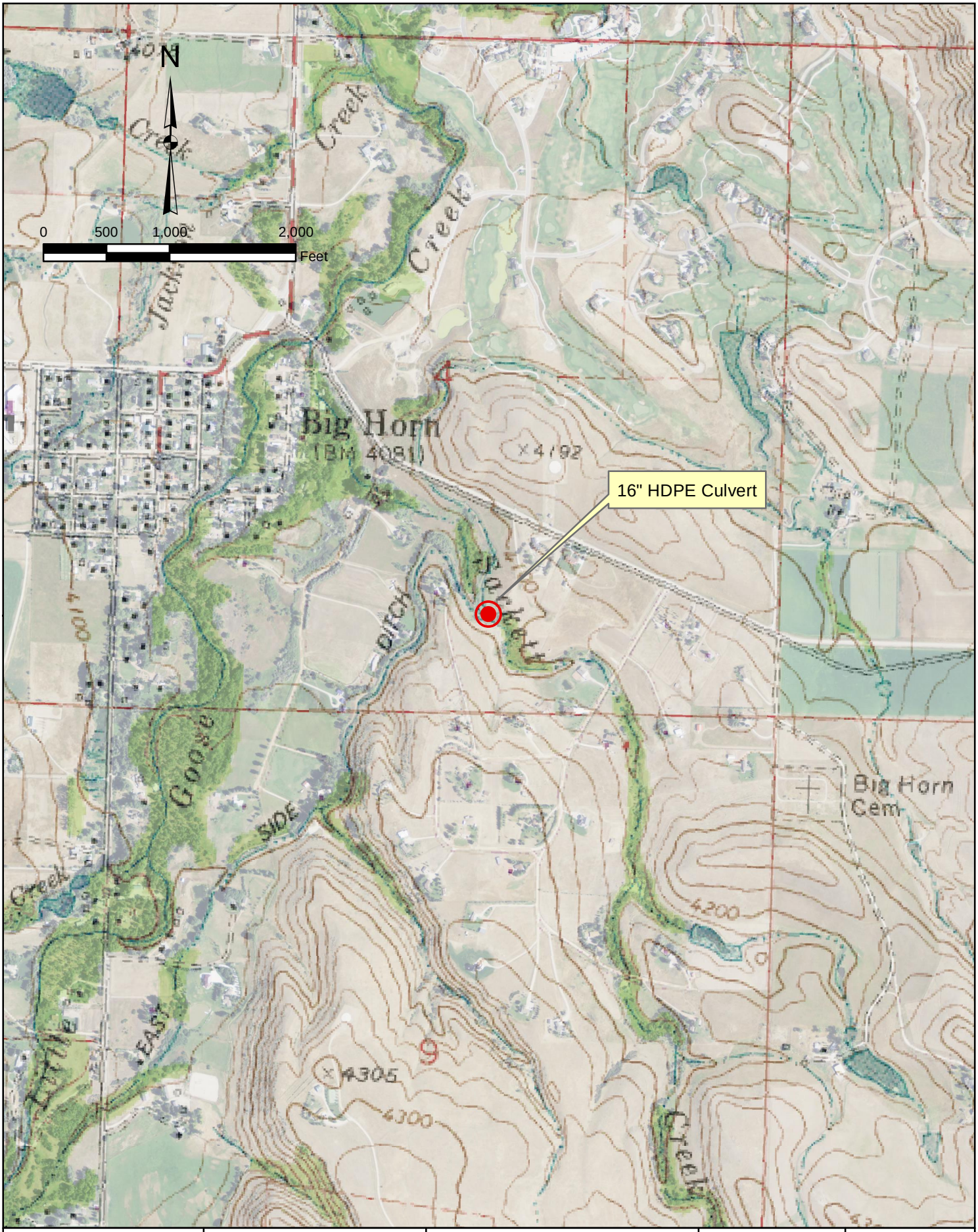
Preparation of Final Design and Specifications	$1,997	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$1,997

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$1,900	$1,900
Remove cottonwood tree (25" - 48" DIA)	5	EA	$3,600	$18,000
Cleaning/Reshaping Canal	67	SY	$1	$67

Total Component Cost (Subtotal #2)	$19,967	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,997	
Components and Engineering Costs (Subtotal #3)	$21,964	
Contingency (Subtotal #3 x 15%)	$3,295	
Construction Cost Total (Subtotal #4)		$25,259
Total Project Cost (Subtotal #1 + Subtotal #4)		$27,255





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Project Name: East Side Ditch Culvert Installation 1

Project ID:	**ISI-LG-ES-04**	**Structure Type:**	**Culvert Replacement**
Ditch Name:	East Side Ditch	Coordinates:	44.677478, -106.981501
Contact Persons:	Steve Pattison, East Side Ditch Company		
Description:	Line existing 18" CMP (which runs Sackett Creek water beneath the ES Ditch) with a 16" liner. Sackett Creek water must be able to flow into the East Side Ditch during lower flows, as this return water helps sustain the ditch flow.		
Project Benefits:	Increasing and extending irrigation water availability.		

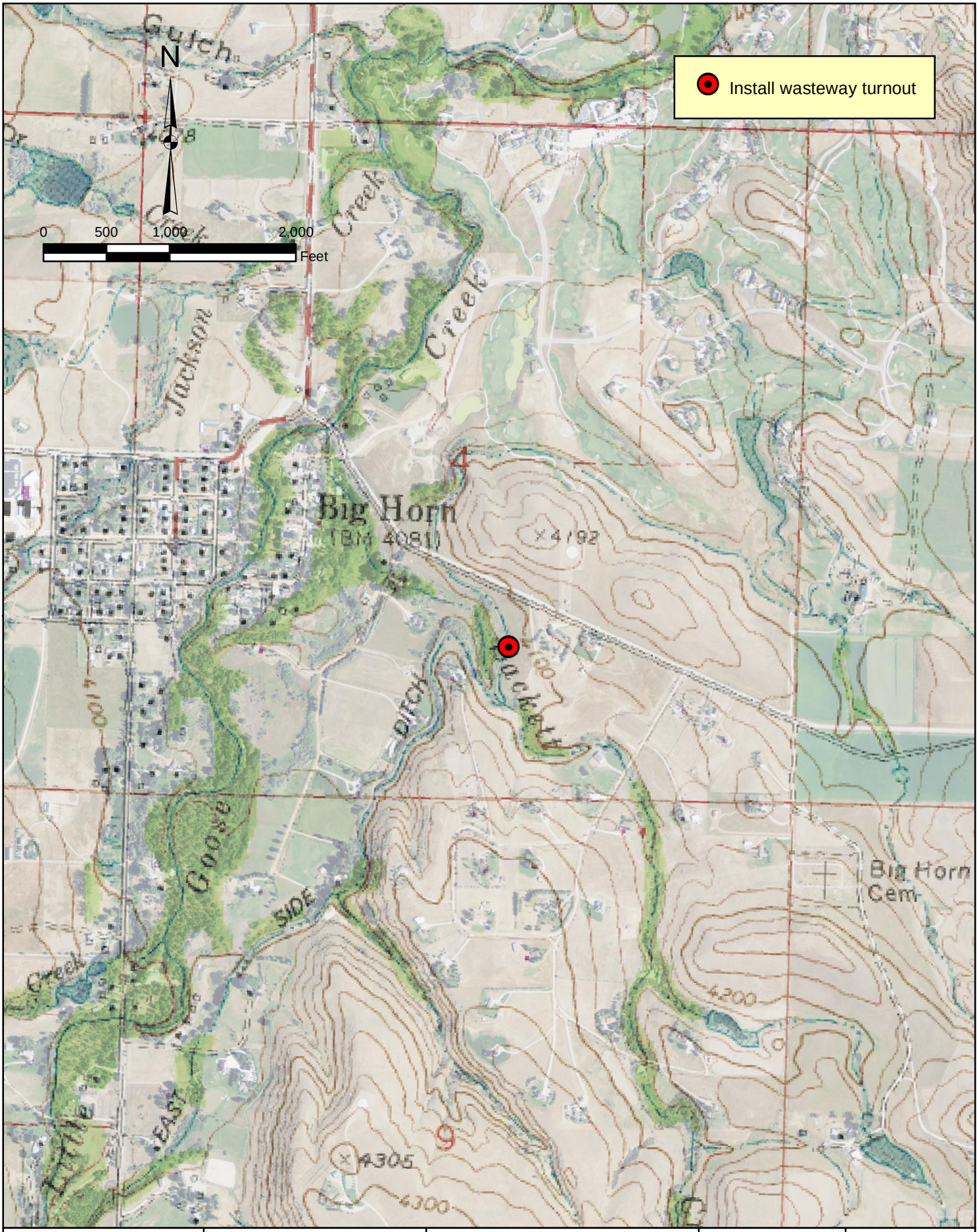
Project Costs

Preparation of Final Design and Specifications				$400	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$1,000	
			Pre-Construction Costs (Subtotal #1)		$1,400

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	400	400
HDPE Liner Pipe 16 in.	60	LF	$60	$3,600

Total Component Cost (Subtotal #2)	$4,000	
Construction Engineering Cost (Subtotal #2 x 10%)	$400	
Components and Engineering Costs (Subtotal #3)	$4,400	
Contingency (Subtotal #3 x 15%)	$660	
Construction Cost Total (Subtotal #4)		$5,060
Total Project Cost (Subtotal #1 + Subtotal #4)		$6,460



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Project Name: East Side Ditch Sackett Creek Wasteway

Project ID:	**ISI-LG-ES-05**	**Structure Type:**	**Wasteway**
Ditch Name:	East Side Ditch	Coordinates:	44.678662, -106.981410
Contact Persons:	Steve Pattison, East Side Ditch Company		
Description:	Install new turnout to improve existing wasteway that allows for ditch water to return to Sackett Creek.		
Project Benefits:	Increasing and extending irrigation water availability.		

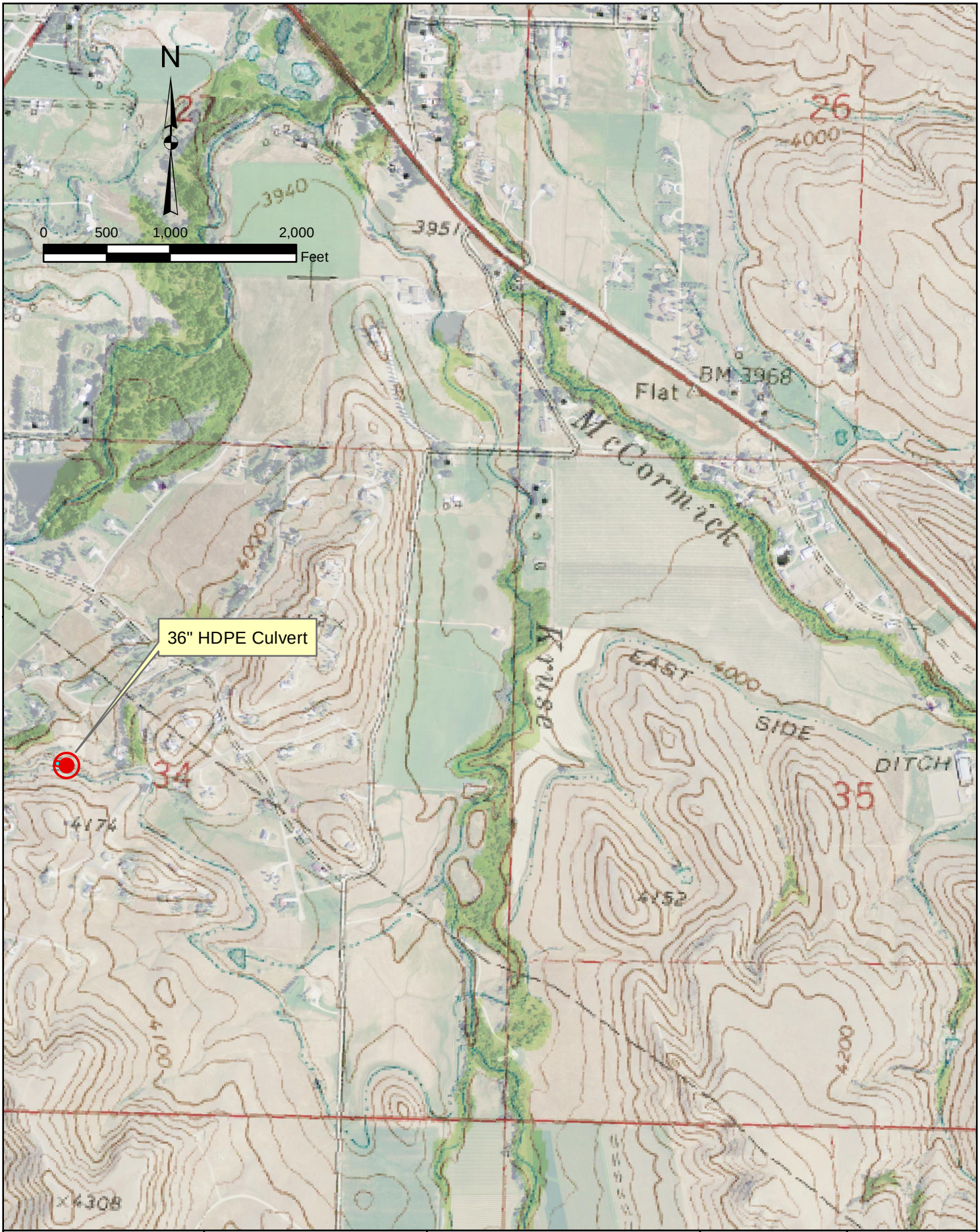
Project Costs

Preparation of Final Design and Specifications	$770	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$770

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$700	$700
Headgate - 24"	1	EA	$1,700	$1,700
Precast Turnout	1	EA	$5,300	$5,300

Total Component Cost (Subtotal #2)	$7,700	
Construction Engineering Cost (Subtotal #2 x 10%)	$770	
Components and Engineering Costs (Subtotal #3)	$8,470	
Contingency (Subtotal #3 x 15%)	$1,271	
Construction Cost Total (Subtotal #4)		$9,741
Total Project Cost (Subtotal #1 + Subtotal #4)		$10,511



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Project Name: East Side Ditch Culvert Installation 2

Project ID:	**ISI-LG-ES-06**	**Structure Type:**	**Culvert Installation**
Ditch Name:	East Side Ditch	Coordinates:	44.6974672, -106.966268
Contact Persons:	Steve Pattison		
Description:	Install 100 LF of 36" culvert in area where hillside is caving off in SE corner of Knode Ranch Subdivision. This is in an area where the downstream ditch bank sloughed in the spring of 2017. Sloughing could result in breach of the ditch, with ditch water then potentially inundating a residence directly below this site.		
Project Benefits:	Safety of local residents, increasing and extending irrigation water availability.		

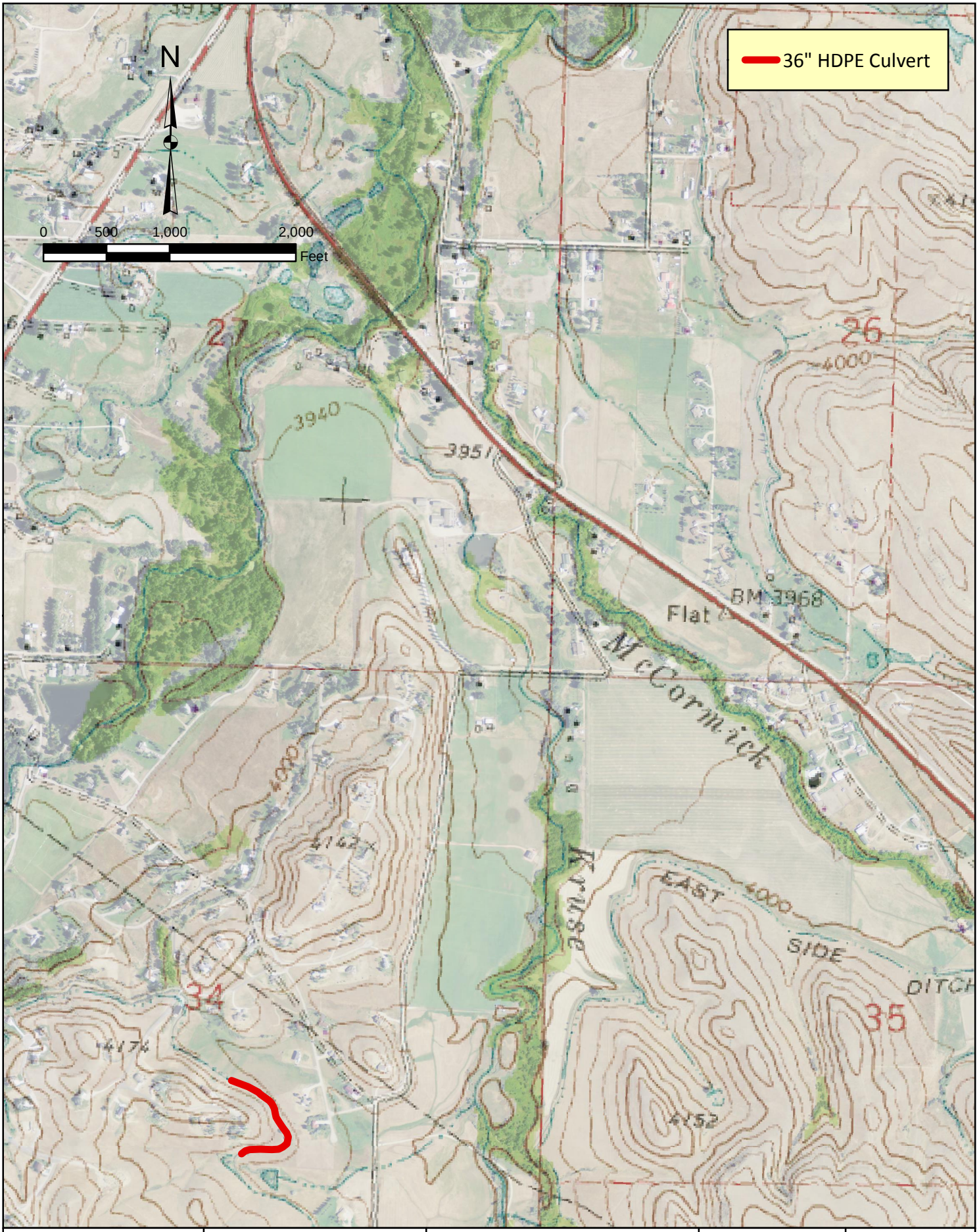
Project Costs

Preparation of Final Design and Specifications	$920	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$2,000	
Pre-Construction Costs (Subtotal #1)		$2,920

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$900	$900
Corr. HDPE Culvert - 36 in	100	LF	$51	$5,100
Culvert Flared End Section - 36 in	2	EA	$400	$800
Trash Guard 36 in	1	EA	$2,100	$2,100
Seeding	300	SY	$1	$300

Total Component Cost (Subtotal #2)	$9,200	
Construction Engineering Cost (Subtotal #2 x 10%)	$920	
Components and Engineering Costs (Subtotal #3)	$10,120	
Contingency (Subtotal #3 x 15%)	$1,518	
Construction Cost Total (Subtotal #4)		$11,638
Total Project Cost (Subtotal #1 + Subtotal #4)		$14,558



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Project Name: East Side Ditch Culvert Installation 3

Project ID:	**ISI-LG-ES-07**	**Structure Type:**	**Culvert Installation**
Ditch Name:	East Side Ditch	Coordinates:	44.694365, -106.960298
Contact Persons:	Steve Pattison, East Side Ditch Company		
Description:	Install 1100 LF of 36" culvert in area where hillside is caving off in SE corner of Knode Ranch Subdivision. There is a deep (25') cut through the hillside in this area (just north of Goldeneye Drive), and sloughing into the ditch occurs.		
Project Benefits:	Safety of local residents, increasing and extending irrigation water availability.		

Project Costs

Preparation of Final Design and Specifications	$6,770	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$2,000	
Pre-Construction Costs (Subtotal #1)		$8,770

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$6,200	$6,200
Corr. HDPE Culvert - 36 in	1100	LF	$51	$56,100
Culvert Flared End Section - 36 in	2	EA	$400	$800
Trash Guard 36 in	1	EA	$2,100	$2,100
Seeding	2500	SY	$1	$2,500

Total Component Cost (Subtotal #2)	$67,700	
Construction Engineering Cost (Subtotal #2 x 10%)	$6,770	
Components and Engineering Costs (Subtotal #3)	$74,470	
Contingency (Subtotal #3 x 15%)	$11,171	
Construction Cost Total (Subtotal #4)		$85,641
Total Project Cost (Subtotal #1 + Subtotal #4)		$94,411

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Project Name: East Side Ditch Garber Measuring Device

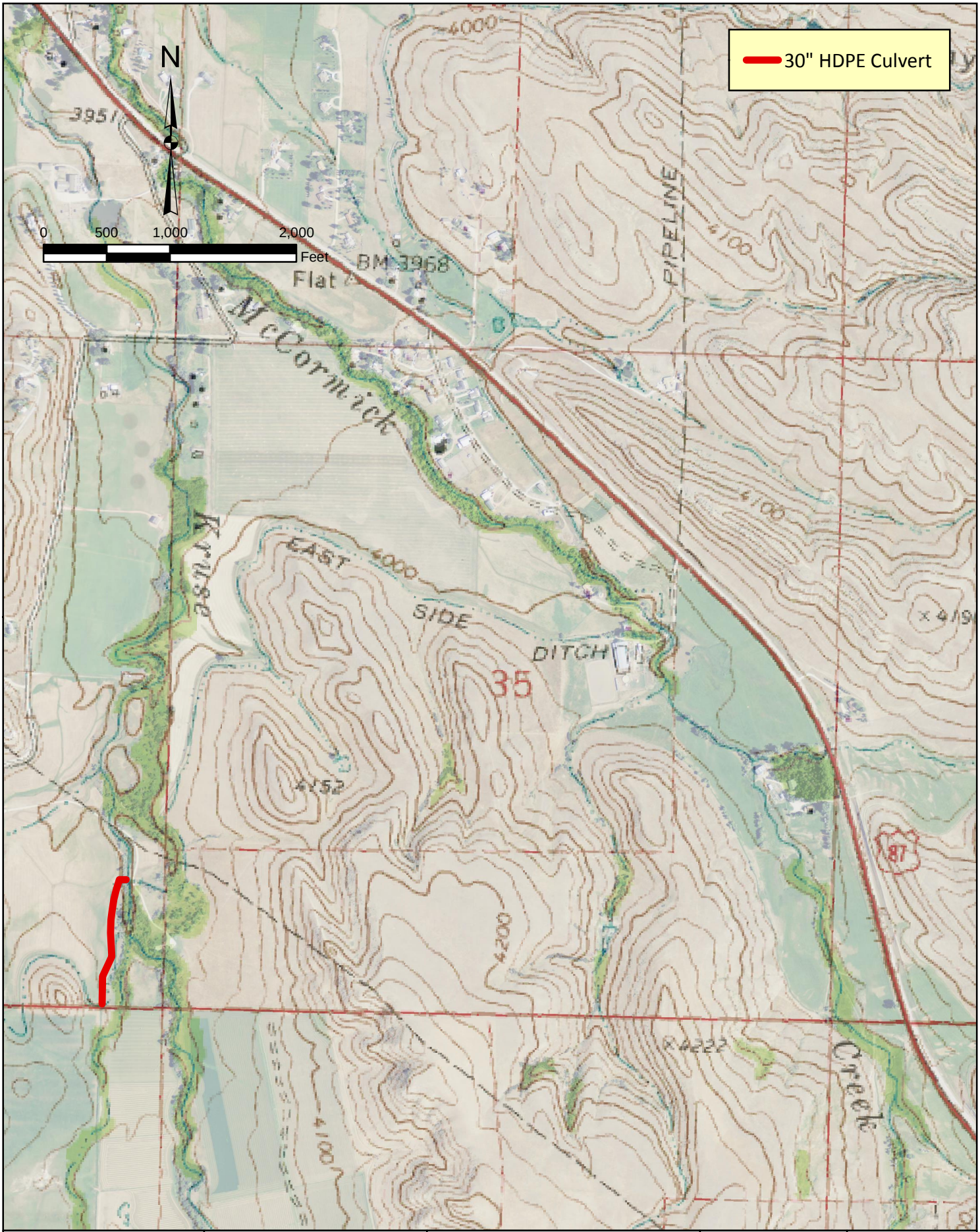
Project ID:	**ISI-LG-ES-08**	**Structure Type:**	**Measuring Device**
Ditch Name:	East Side Ditch	Coordinates:	44.689828, -106.957443
Contact Persons:	Steve Pattison, East Side Ditch Company		
Description:	Install 2'-wide Parshall measuring flume on a wasteway that comes off the East Side Ditch. The Garbers currently pump water from Lee Creek just north of Kruse Creek Road and east of McCormick Road, in order to irrigate meadows along McCormick Road. The water that they pump is likely wastewater from the Last Chance Ditch that has found its way into Lee Creek. The Garber pump has a junior water right, hence they need to replenish flows in Lee Creek in order to satisfy downstream users along Kruse Creek and Little Goose Creek. The Garbers have historically performed this replenishment by having the East Side Ditch convey a portion of the Garbers' Cross Creek Reservoir stored water to the point where the East Side Ditch crosses beneath McCormick Road, at which point the Cross Creek Reservoir water is released back to Lee Creek. A measurimg flume is needed at this locaiton to record these flows going back into Lee Creek.		
Project Benefits:	Increasing and extending irrigation water availability.		

Project Costs

Preparation of Final Design and Specifications				$250	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$1,000	
			Pre-Construction Costs (Subtotal #1)		$1,250

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price	
Mobilization	1	LS	$300	$300	
Parshall Flume - 12"	1	EA	$1,200	$1,200	
Misc. excavation	1	LS	$1,000	$1,000	
			Total Component Cost (Subtotal #2)	$2,500	
			Construction Engineering Cost (Subtotal #2 x 10%)	$250	
			Components and Engineering Costs (Subtotal #3)	$2,750	
			Contingency (Subtotal #3 x 15%)	$413	
			Construction Cost Total (Subtotal #4)		$3,163
			Total Project Cost (Subtotal #1 + Subtotal #4)		$4,413



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Project Name: East Side Ditch Concrete Ditch Replacement

Project ID:	**ISI-LG-ES-09**	**Structure Type:**	**Ditch Lining**
Ditch Name:	East Side Ditch	Coordinates:	44.690815, -106.954435
Contact Persons:	Steve Pattison, East Side Ditch Company		
Description:	Replace 1050 LF of existing concrete ditch section just west of Kruse Creek with new concrete lining.		
Project Benefits:	Increasing and extending irrigation water availability.		

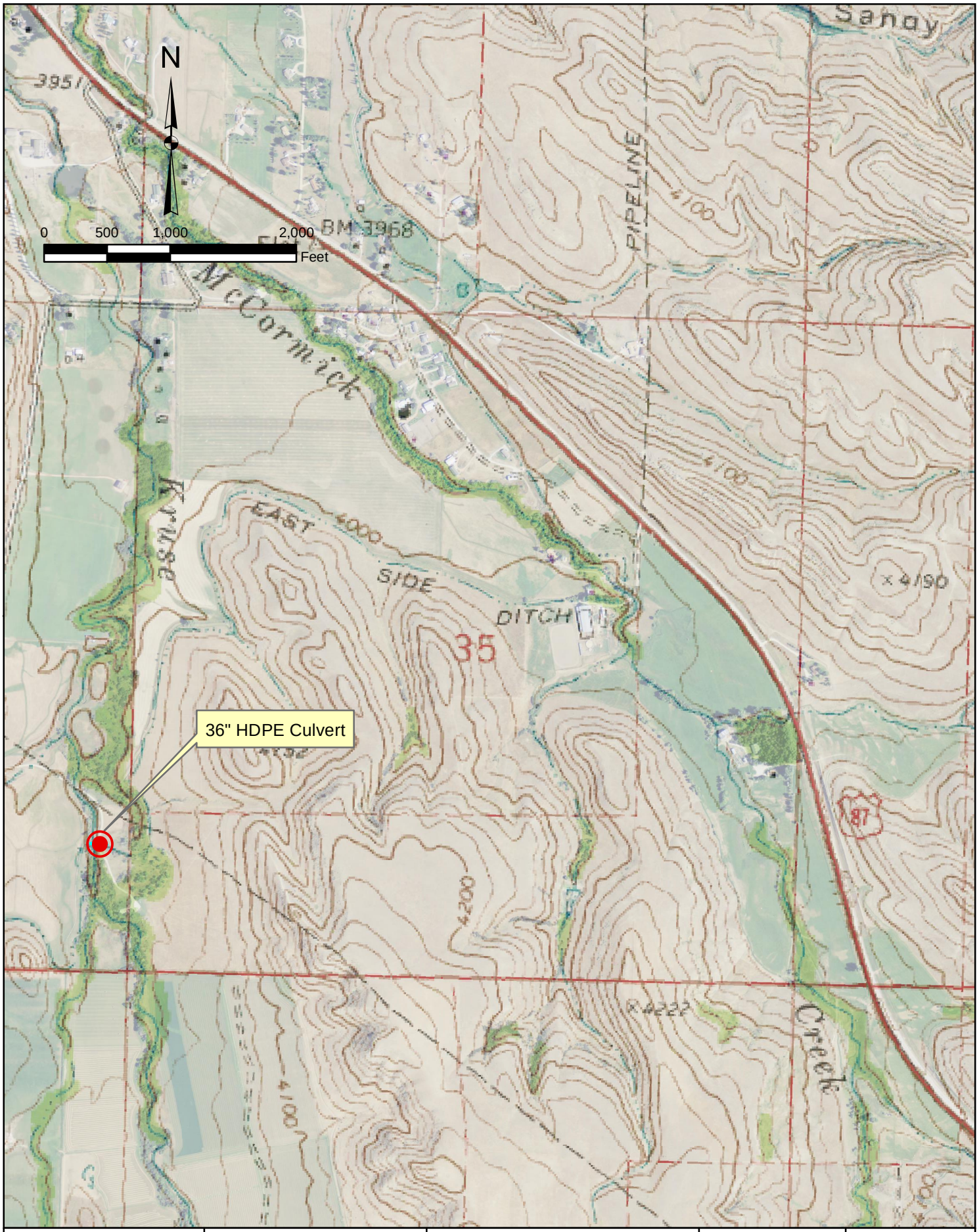
Project Costs

Preparation of Final Design and Specifications	$13,860	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$13,860

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$12,600	$12,600
Concrete lining	10500	SF	$3	$31,500
Concrete Lining	10,500	SF	$9	$94,500

Total Component Cost (Subtotal #2)	$138,600	
Construction Engineering Cost (Subtotal #2 x 10%)	$13,860	
Components and Engineering Costs (Subtotal #3)	$152,460	
Contingency (Subtotal #3 x 15%)	$22,869	
Construction Cost Total (Subtotal #4)		$175,329
Total Project Cost (Subtotal #1 + Subtotal #4)		$189,189



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Project Name: East Side Ditch Siphon

Project ID:	**ISI-LG-ES-10**	**Structure Type:**	**Siphon**
Ditch Name:	East Side Ditch	Coordinates:	44.692819, -106.953685
Contact Persons:	Steve Pattison, East Side Ditch Company		
Description:	Replace existing siphon beneath Kruse Creek with a new concrete pipe siphon.		
Project Benefits:	Increasing and extending irrigation water availability.		

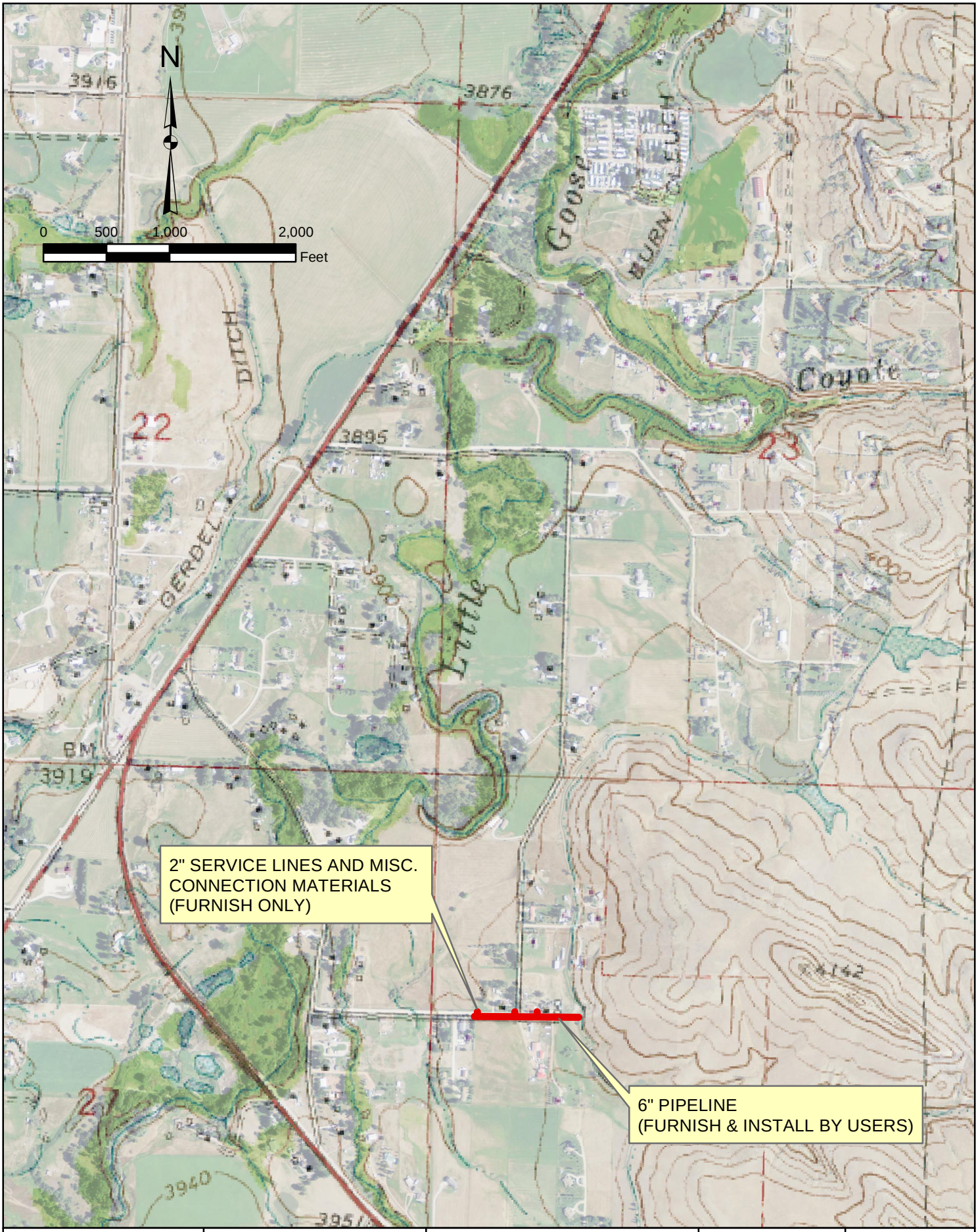
Project Costs

Preparation of Final Design and Specifications	$3,608	
Permitting and Mitigation	$1,500	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$5,108

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$3,300	$3,300
Demo/remove Existing Diversion Dam	2	CY	$1,100	$2,200
Reinforced Concrete Structure < 25 CY	10	CY	$1,500	$15,000
RCP Culvert - 36 in	125	LF	$79	$9,875
Trash Guard - 36 in	2	EA	$2,100	$4,200
Reclamation	1	LS	$1,500	$1,500

Total Component Cost (Subtotal #2)	$36,075	
Construction Engineering Cost (Subtotal #2 x 10%)	$3,608	
Components and Engineering Costs (Subtotal #3)	$39,683	
Contingency (Subtotal #3 x 15%)	$5,953	
Construction Cost Total (Subtotal #4)		$45,636
Total Project Cost (Subtotal #1 + Subtotal #4)		$50,743



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Project Name:	East Side Ditch Maverick Lane Pipeline Installation		
Project ID:	**ISI-LG-ES-11**	**Structure Type:**	**Pipeline**
Ditch Name:	East Side	Coordinates:	44.713926, -106.948001
Contact Persons:	Steve Pattison, David Odekoven: East Side Ditch Company		
Description:	East Side Ditch users in this area have requested that portions of their lateral be replaced with a pressure pipeline. Replacing existing unlined ditch sections with pipe would not only improve water conveyance, but also create the opportunity for pressurized irrigation systems along the ditch. The landowners are providing the 6" pipeline material at their own cost, and they will provide all labor for the project.		
Project Benefits:	Increasing and extending irrigation water availability.		

Project Costs

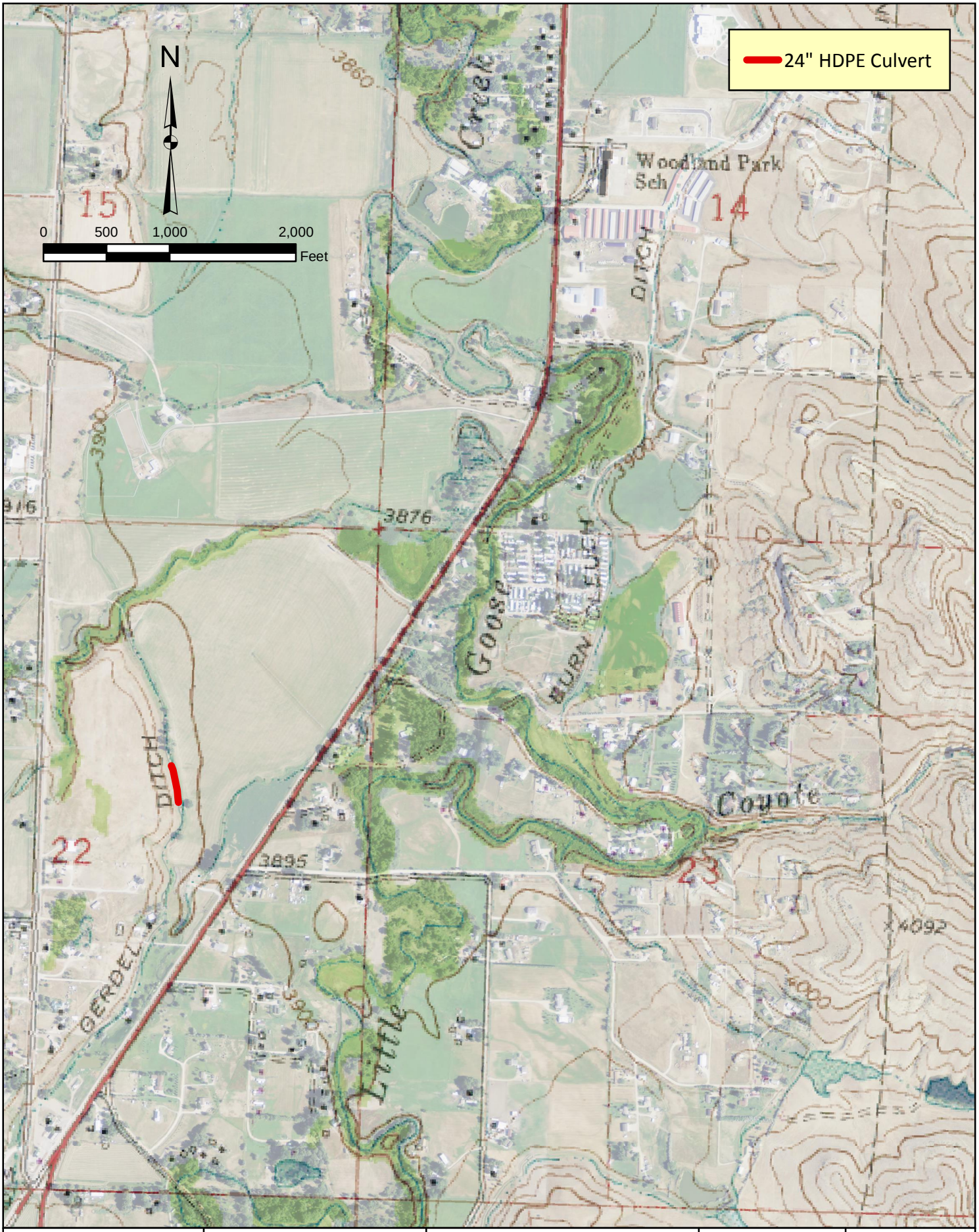
Preparation of Final Design and Specifications	$1,697	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$2,697

Cost of Project Components

All costs except reclamation are furnish only, as owners will install.

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$600	$600
Headwall (Concrete)	2	CY	$420	$840
6" valve	1	EA	$500	$500
2' x 3' concrete box with lid (	1	LS	$500	$500
2" Riser	4	EA	$300	$1,200
2" HDPE service lines	100	LF	$5	$500
6" Fitting (45-degree, plug)	3	EA	$300	$900
2" Corp stop	4	EA	$200	$800
2" Curb stop	5	EA	$150	$750
6" Meter	1	EA	$800	$800
4' Manhole for Meter	2	EA	$3,000	$6,000
Gravel restoration	50	CY	$36	$1,800
Seeding	1,780	SY	$1	$1,780

Total Component Cost (Subtotal #2)	$16,970	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,697	
Components and Engineering Costs (Subtotal #3)	$18,667	
Contingency (Subtotal #3 x 15%)	$2,801	
Construction Cost Total (Subtotal #4)		$21,468
Total Project Cost (Subtotal #1 + Subtotal #4)		$24,165



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Project Name: Gerdel Ditch Seepage Rehabilitation

Project ID:	**ISI-LG-GE-01**	**Structure Type:**	**Culvert Installation**
Ditch Name:	Gerdel	Coordinates:	44.727716, -106.958183
Contact Persons:	Steve Washut, Gerdel Ditch Co.		
Description:	Install 300 LF of 24" culvert. The Gerdel Ditch on the Elmer DeTavernier property has a stretch with several leaks that cause water to flow into the field, preventing him from haying the meadows in this area. Bentonite lining was placed in 2015 as an attempted remedy for these areas, but the leakage persists.		
Project Benefits:	Increasing and extending irrigation water availability.		

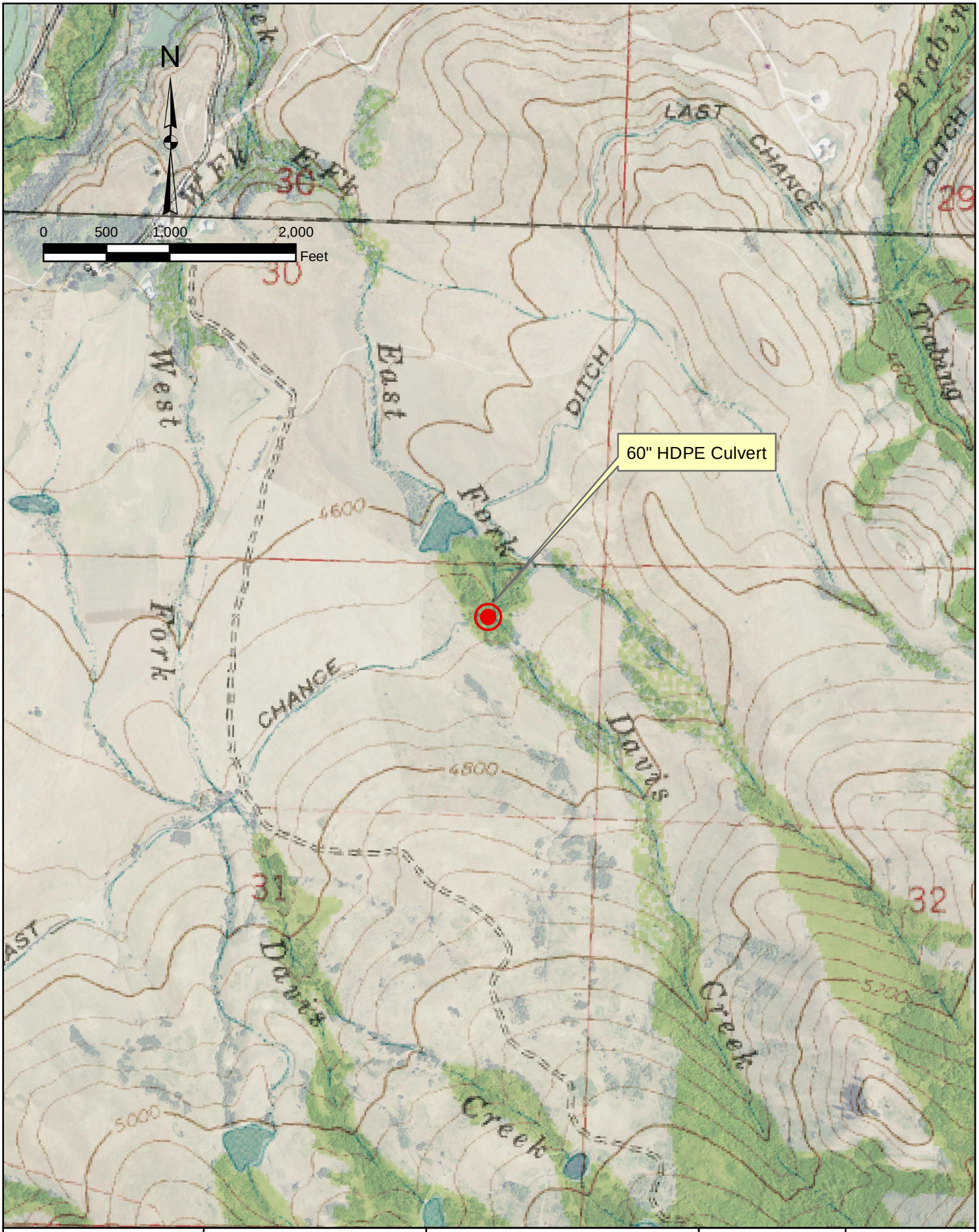
Project Costs

Preparation of Final Design and Specifications				$1,569	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$0	
			Pre-Construction Costs (Subtotal #1)		$1,569

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$1,500	$1,500
Corr. HDPE Culvert - 24 in	300	LF	$38	$11,400
Culvert Flared End Section - 24 in	2	EA	$260	$520
Trash Guard 24 in	1	EA	$1,600	$1,600
Seeding	670	SY	$1	$670

Total Component Cost (Subtotal #2)	$15,690	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,569	
Components and Engineering Costs (Subtotal #3)	$17,259	
Contingency (Subtotal #3 x 15%)	$2,589	
Construction Cost Total (Subtotal #4)		$19,848
Total Project Cost (Subtotal #1 + Subtotal #4)		$21,417



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Project Name:	Last Chance Ditch Flume Replacement at East Fork Davis Creek		
Project ID:	**ISI-LG-LC-01**	**Structure Type:**	**Flume**
Ditch Name:	Last Chance Ditch	Coordinates:	44.616401, -107.016755
Contact Persons:	Lance Baker, Martin McCarty: Flying H Ranch		
Description:	Replace existing flume over East Fork of Davis Creek. Existing flume consists of an approximate 5'-wide half pipe extending over the creek channel that is lined with hypalon material.		
Project Benefits:	Increasing and extending irrigation water availability.		

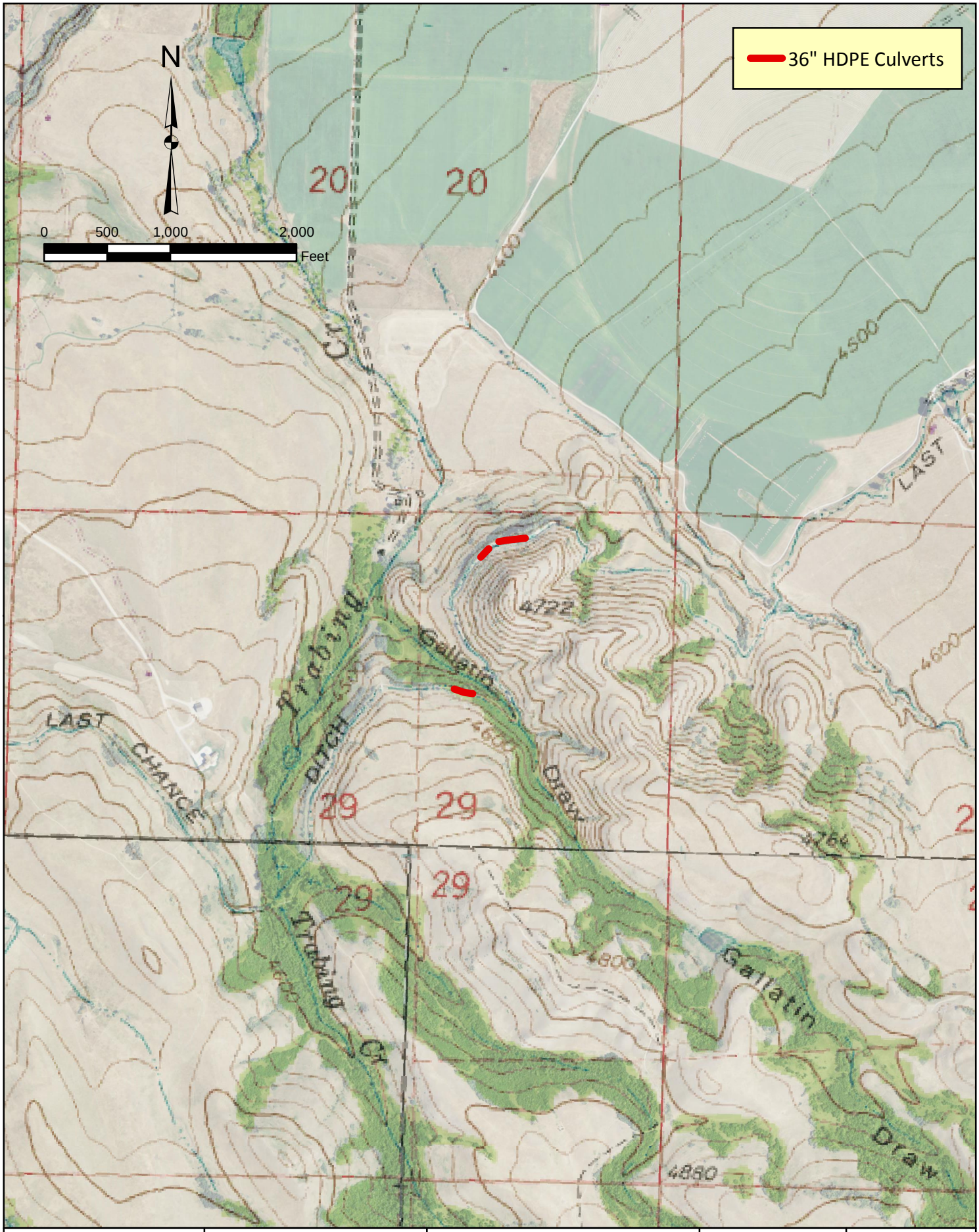
Project Costs

Preparation of Final Design and Specifications				$1,358	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$0	
			Pre-Construction Costs (Subtotal #1)		$1,358

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$1,300	$1,300
Removal of Pipe	20	LF	$14	$280
60" Flume structure w/half pipe	20	LF	$200	$4,000
Abutment	2	EA	$1,000	$2,000
Reinforced Concrete Structure < 25 CY	4	CY	$1,500	$6,000

Total Component Cost (Subtotal #2)	$13,580	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,358	
Components and Engineering Costs (Subtotal #3)	$14,938	
Contingency (Subtotal #3 x 15%)	$2,241	
Construction Cost Total (Subtotal #4)		$17,179
Total Project Cost (Subtotal #1 + Subtotal #4)		$18,537



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Project Name: Last Chance Ditch Culvert Installation 1

Project ID:	**ISI-LG-LC-02**	**Structure Type:**	**Culvert Installation**
Ditch Name:	Last Chance Ditch	Coordinates:	44.628239, -106.999126
Contact Persons:	Lance Baker, Martin McCarty: Flying H Ranch		
Description:	Install 450 LF of 36 inch culvert in three ditch sections where sloughing has occurred on upstream side of ditch.		
Project Benefits:	Increasing and extending irrigation water availability.		

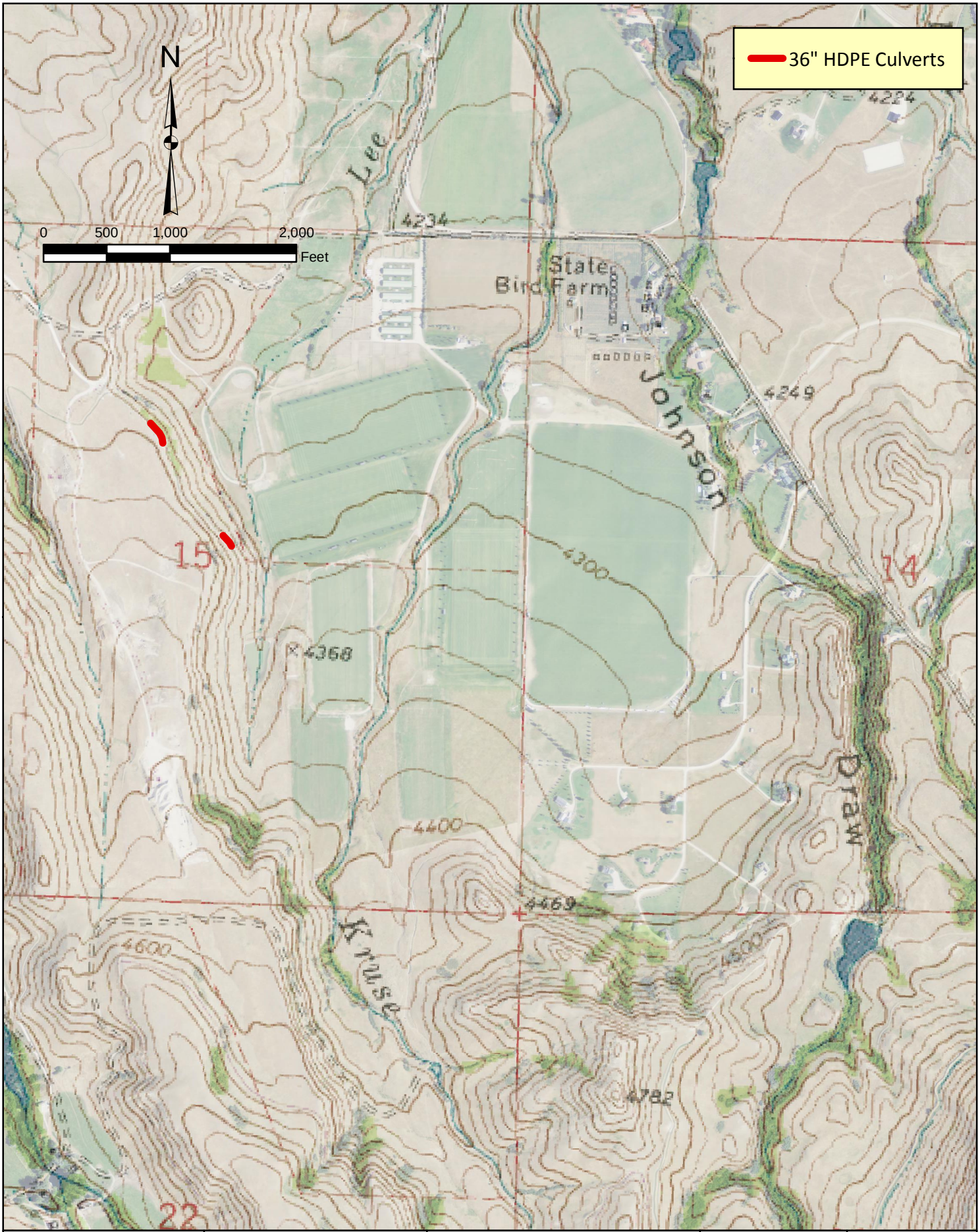
Project Costs

Preparation of Final Design and Specifications	$3,595	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$3,595

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$3,300	$3,300
Corr. HDPE Culvert - 36 in	450	LF	$51	$22,950
Culvert Flared End Section - 36 in	6	EA	$400	$2,400
Trash Guard 36 in	3	EA	$2,100	$6,300
Seeding	1000	SY	$1	$1,000

Total Component Cost (Subtotal #2)	$35,950	
Construction Engineering Cost (Subtotal #2 x 10%)	$3,595	
Components and Engineering Costs (Subtotal #3)	$39,545	
Contingency (Subtotal #3 x 15%)	$5,932	
Construction Cost Total (Subtotal #4)		$45,477
Total Project Cost (Subtotal #1 + Subtotal #4)		$49,072



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Project Name: Last Chance Ditch Culvert Installation 2

Project ID:	ISI-LG-LC-03	Structure Type:	Culvert Installation
Ditch Name:	Last Chance Ditch	Coordinates:	44.656437, -106.963773
Contact Persons:	Lance Baker, Martin McCarty: Flying H Ranch		
Description:	Install 300 LF of 36 inch culvert in two ditch sections where sloughing has occurred on upstream side of ditch.		
Project Benefits:	Increasing and extending irrigation water availability.		

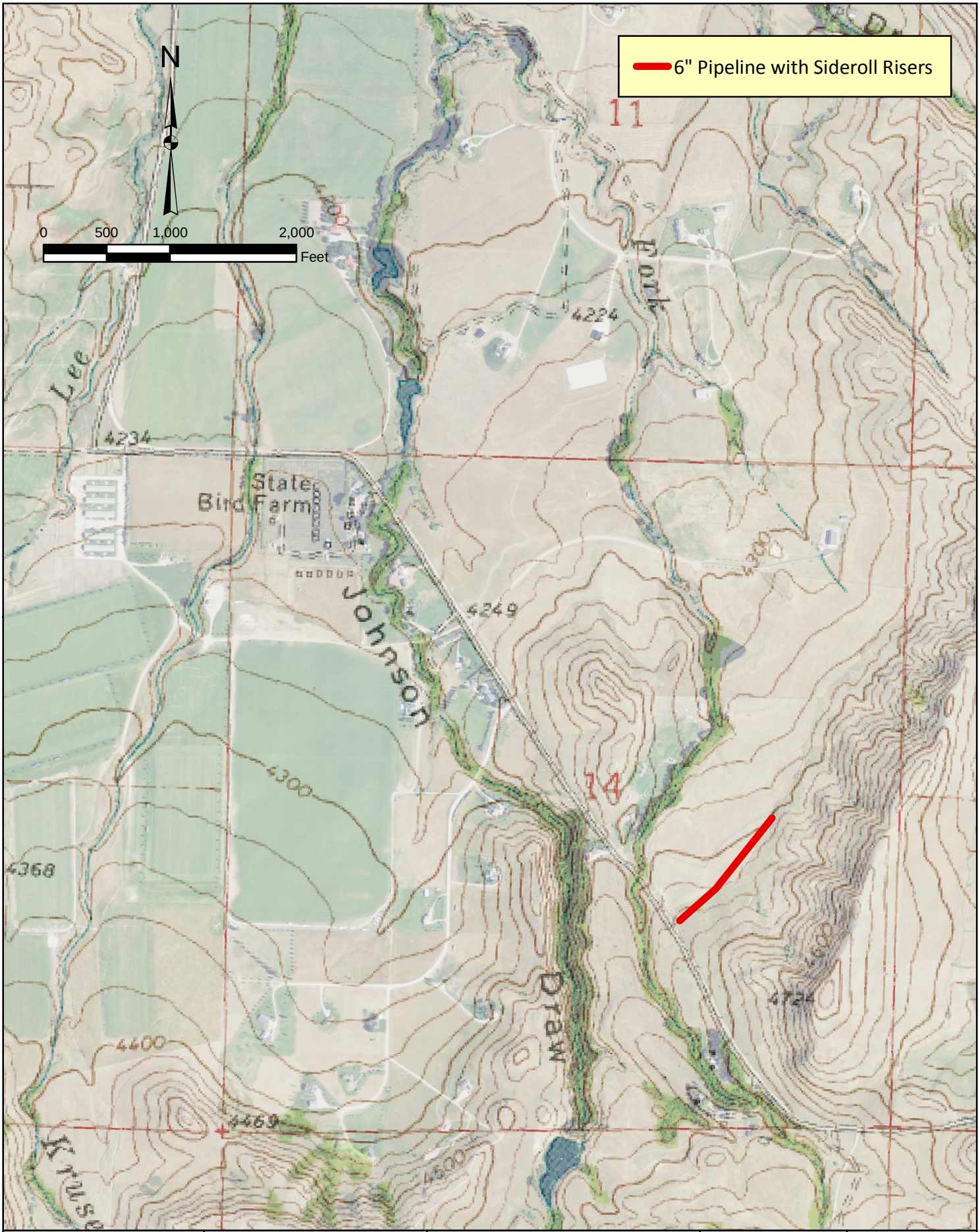
Project Costs

Preparation of Final Design and Specifications	$2,397	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$3,397

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$2,200	$2,200
Corr. HDPE Culvert - 36 in	300	LF	$51	$15,300
Culvert Flared End Section - 36 in	4	EA	$400	$1,600
Trash Guard 36 in	2	EA	$2,100	$4,200
Seeding	670	SY	$1	$670

Total Component Cost (Subtotal #2)	$23,970	
Construction Engineering Cost (Subtotal #2 x 10%)	$2,397	
Components and Engineering Costs (Subtotal #3)	$26,367	
Contingency (Subtotal #3 x 15%)	$3,956	
Construction Cost Total (Subtotal #4)		$30,323
Total Project Cost (Subtotal #1 + Subtotal #4)		$33,720



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Project Name: Kruse Creek Sideroll Irrigation Sytem

Project ID:	**ISI-LG-MC-01**	**Structure Type:**	**Sideroll Irrigation System**
Ditch Name:	Meade Coffeen Ditch	Coordinates:	44.646539, -106.924413
Contact Persons:	Jim Roach, Meade Coffeen Ditch Company Board Member and Manager		
Description:	Install pumping and sideroll system for lands adjacent to the East Fork of Kruse Creek below the Meade Coffeen Ditch.		
Project Benefits:	Increasing and extending irrigation water availability.		

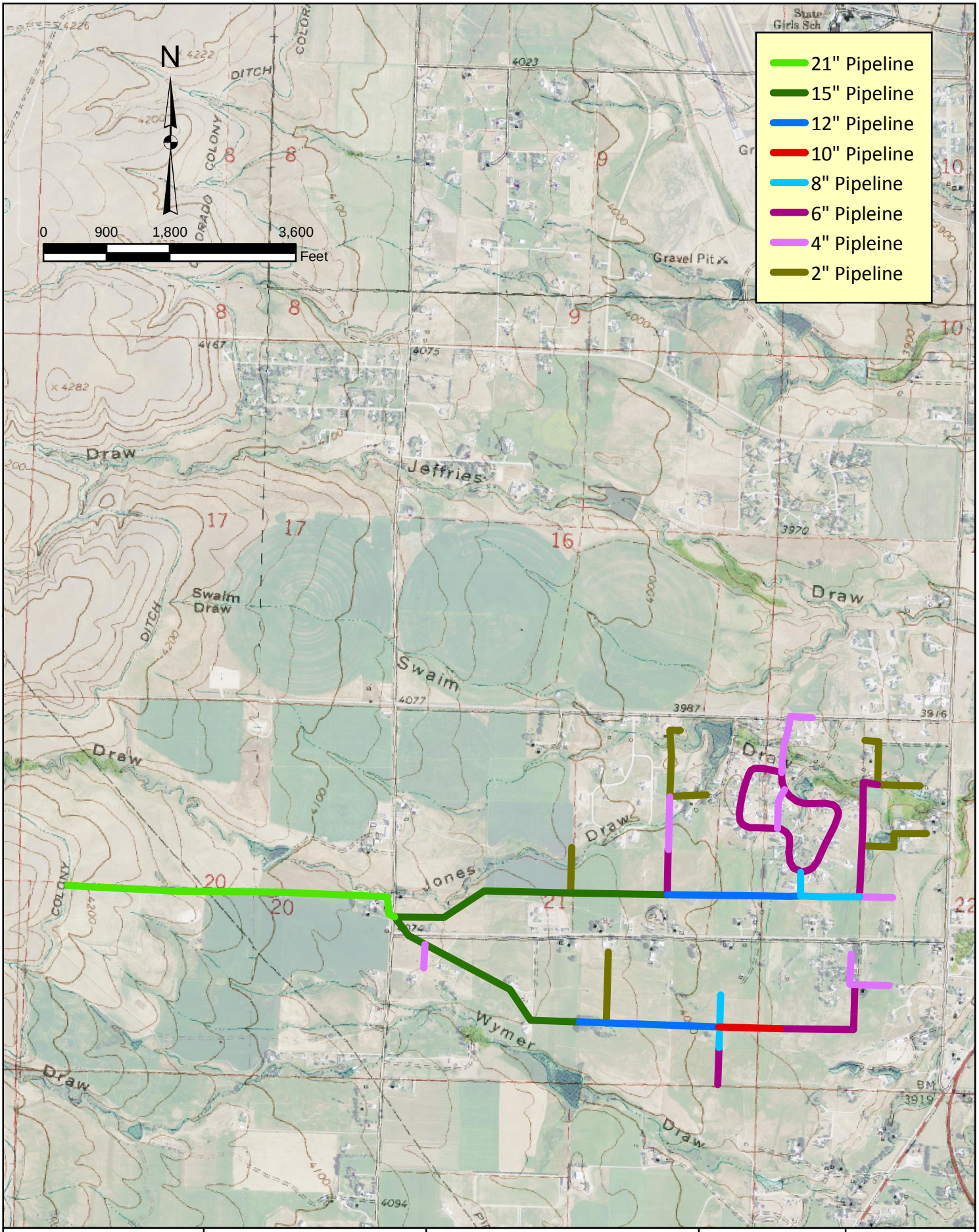
Project Costs

Preparation of Final Design and Specifications				$4,967	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$0	
			Pre-Construction Costs (Subtotal #1)		$4,967

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$4,600	$4,600
Precast Turnout	1	EA	$5,300	$5,300
Pump and Motor	1	EA	$5,000	$5,000
Power Extension	LS	LS	$5,000	$5,000
Underground 6" pipeline	1100	LF	$15	$16,500
Risers	22	EA	$300	$6,600
Sideroll	400	LF	$15	$6,000
Seeding	670	SY	$1	$670

Total Component Cost (Subtotal #2)	$49,670	
Construction Engineering Cost (Subtotal #2 x 10%)	$4,967	
Components and Engineering Costs (Subtotal #3)	$54,637	
Contingency (Subtotal #3 x 15%)	$8,196	
Construction Cost Total (Subtotal #4)		$62,833
Total Project Cost (Subtotal #1 + Subtotal #4)		$67,800



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Project Name: Metz Ditch Pipeline Installation

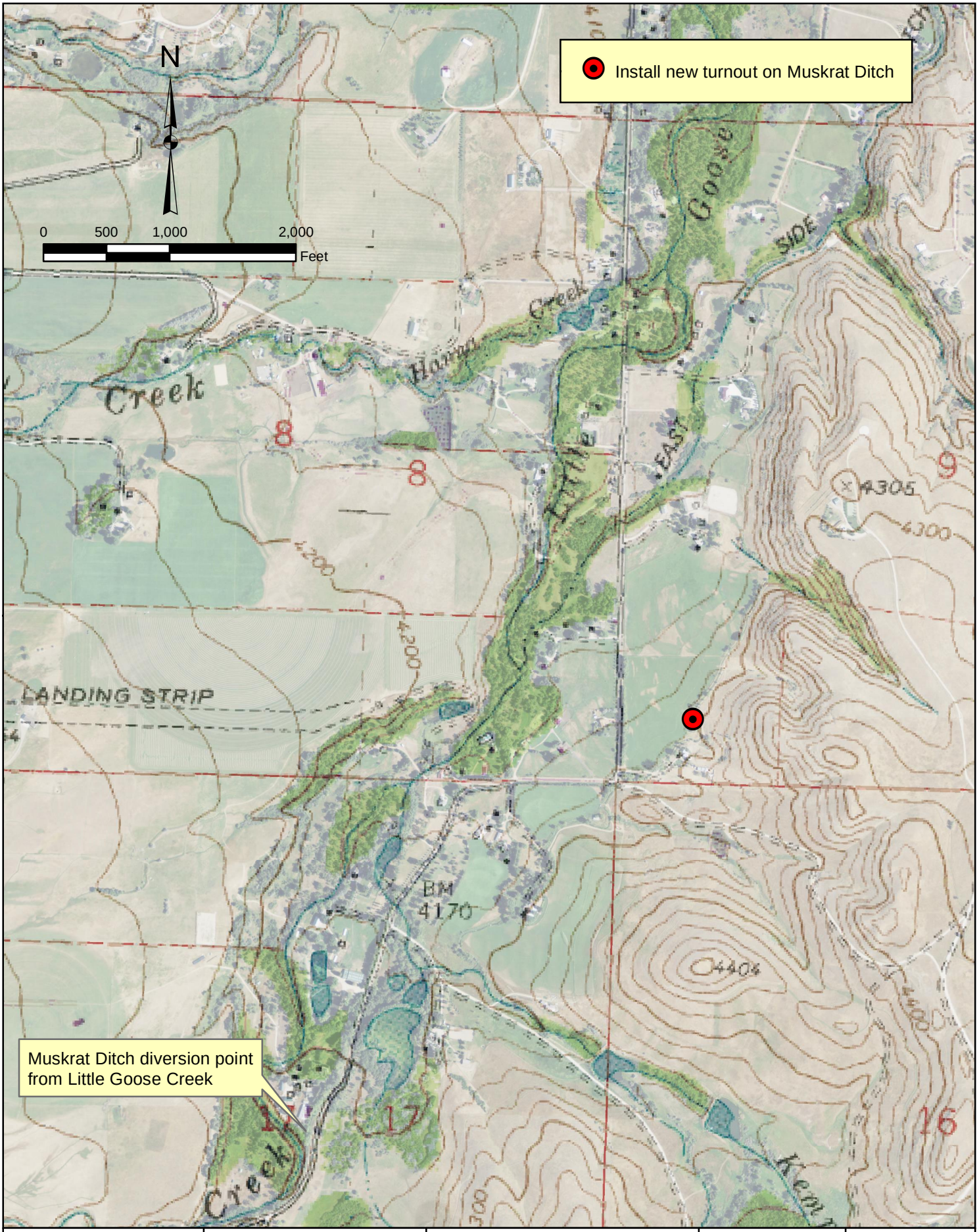
Project ID:	**ISI-LG-ME-01**	**Structure Type:**	**Pipeline**
Ditch Name:	Metz	Coordinates:	44.726371, -107.008161
Contact Persons:	John & Joe Wesnitzer, Doug Harbel, Metz Ditch Co.		
Description:	The concrete-lined ditch that lines the majority of the Metz Ditch is deteriorating, is in poor condition (due primarily to longitudinal cracking and growth of vegetation therein), and voids have been created beneath the concrete from burrowing animals. Replacing these concrete-lined ditch sections with pipe would not only improve water conveyance, but also create the opportunity for pressurized irrigation systems along the ditch.		
Project Benefits:	Increasing and extending irrigation water availability.		

Preparation of Final Design and Specifications	$78,174	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$10,000	
Pre-Construction Costs (Subtotal #1)		$88,174

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$71,100	$71,100
PVC Pressure Pipe 24"	40	LF	$40	$1,600
PVC Pressure Pipe 21"	4,920	LF	$28	$137,760
PVC Pressure Pipe 15"	7,122	LF	$24	$170,928
PVC Pressure Pipe 12"	3,936	LF	$22	$86,592
PVC Pressure Pipe 10"	936	LF	$20	$18,720
PVC Pressure Pipe 8"	1,964	LF	$17	$33,388
PVC Pressure Pipe 6"	8,671	LF	$13	$112,723
PVC Pressure Pipe 4"	3,650	LF	$10	$36,500
PVC Pressure Pipe 3"	810	LF	$9	$7,290
PVC Pressure Pipe 2"	4,143	LF	$7	$29,001
Fittings and Risers	LS	LS	$76,140	$76,140

Total Component Cost (Subtotal #2)	$781,742	
Construction Engineering Cost (Subtotal #2 x 10%)	$78,174	
Components and Engineering Costs (Subtotal #3)	$859,916	
Contingency (Subtotal #3 x 15%)	$128,988	
Construction Cost Total (Subtotal #4)		$988,904
Total Project Cost (Subtotal #1 + Subtotal #4)		$1,077,079



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Project Name: Muskrat Ditch Turnout

Project ID:	**ISI-LG-MU-01**	**Structure Type:**	**Turnout**
Ditch Name:	Muskrat	Coordinates:	44.662326, -106.990531
Contact Person(s):	Pam Hubbard, Bill Valdez, Muskrat Ditch Company		
Description:	Install new turnout on main Muskrat Ditch, to be used for the Valdez property. Installing this turnout would aid in irrigation of the property below the ditch.		
Project Benefits:	Increasing and extending irrigation water availability.		

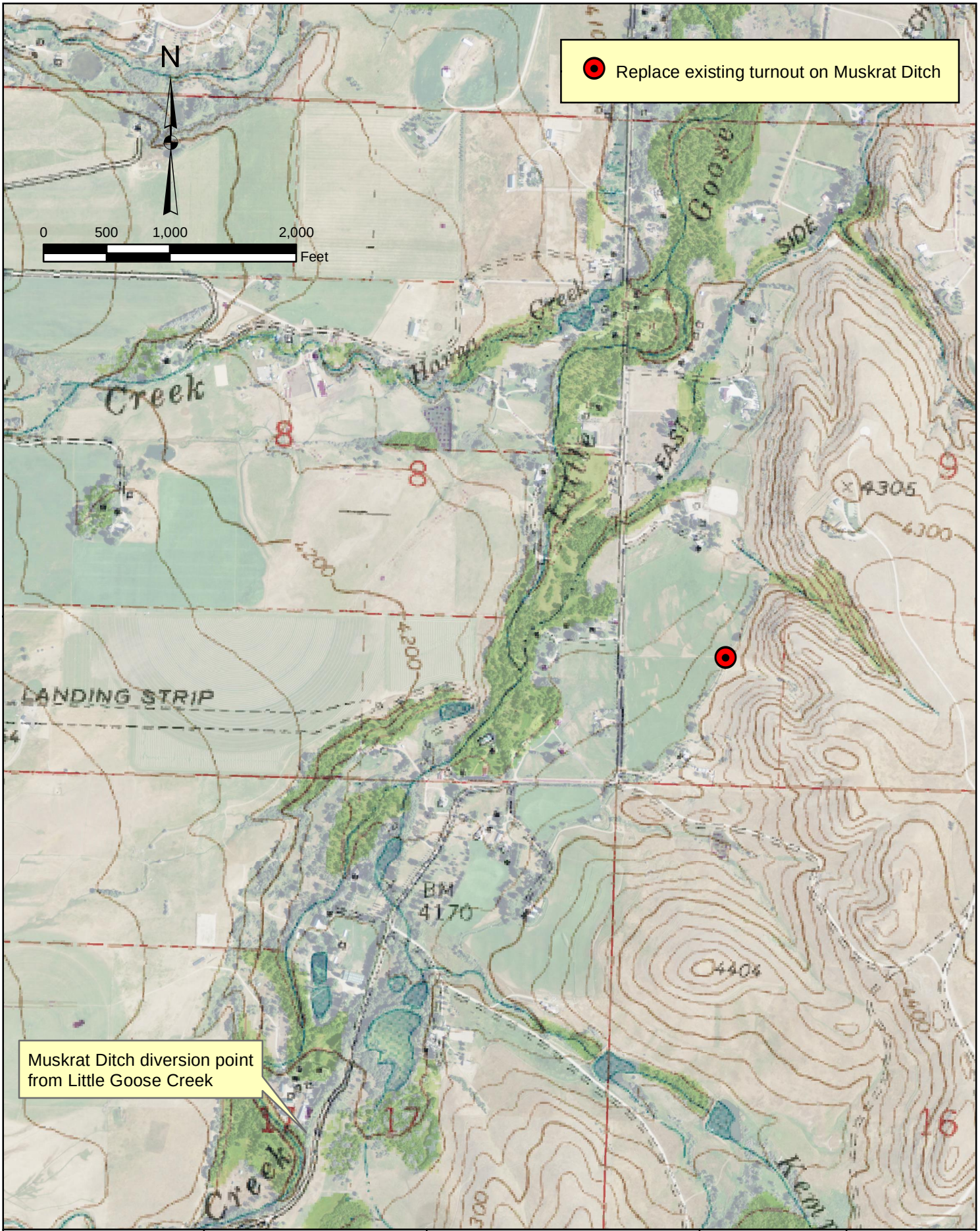
Project Costs

Preparation of Final Design and Specifications	$770	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$770

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$700	$700
Headgate - 12"	1	EA	$900	$900
Precast Turnout	1	EA	$5,300	$5,300
Corr. HDPE Culvert - 12"	10	LF	$18	$180
Culvert FE Sect - 12"	1	EA	$620	$620

Total Component Cost (Subtotal #2)	$7,700	
Construction Engineering Cost (Subtotal #2 x 10%)	$770	
Components and Engineering Costs (Subtotal #3)	$8,470	
Contingency (Subtotal #3 x 15%)	$1,271	
Construction Cost Total (Subtotal #4)		$9,741
Total Project Cost (Subtotal #1 + Subtotal #4)		$10,511



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Project Name: Muskrat Ditch Turnout Replacement

Project ID:	**ISI-LG-MU-02**	**Structure Type:**	**Turnout**
Ditch Name:	Muskrat	Coordinates:	44.663708, -106.989599
Contact Person(s):	Pam Hubbard, Muskrat Ditch Company		
Description:	The existing turnout leaks under the slide gate and concrete channel that lines the small ditch between the main Muskrat Ditch and the slide gate. This project will replace this existing structure.		
Project Benefits:	Increasing and extending irrigation water availability.		

Project Costs

Preparation of Final Design and Specifications	$2,190	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$2,190

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$2,000	$2,000
Concrete Ditch Lining	200	SF	$9	$1,800
Check Dam	3	CY	$1,500	$4,500
Headgate - 12"	1	EA	$900	$900
Headgate - 18"	1	EA	$1,300	$1,300
Precast Turnout	2	EA	$5,300	$10,600
Corr. HDPE Culvert - 12"	10	LF	$18	$180
Culvert FE Sect - 12"	1	EA	$620	$620

Total Component Cost (Subtotal #2)	$21,900	
Construction Engineering Cost (Subtotal #2 x 10%)	$2,190	
Components and Engineering Costs (Subtotal #3)	$24,090	
Contingency (Subtotal #3 x 15%)	$3,614	
Construction Cost Total (Subtotal #4)		$27,704
Total Project Cost (Subtotal #1 + Subtotal #4)		$29,894

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Project Name: Negro John Ditch Diversion Dam

Project ID:	**ISI-LG-NE-01**	**Structure Type:**	**Diversion Dam and Pipeline**
Ditch Name:	Negro John Ditch	Coordinates:	44.675391, -107.005555
Contact Persons:	Bob Whyard		
Description:	Jackson Creek has moved on its own and is now approximately 50' away from a previous point of diversion for this ditch. This project would build a new diversion dam on Jackson and install 50 LF of pipe to the existing point of diversion.		
Project Benefits:	Increasing and extending irrigation water availability.		

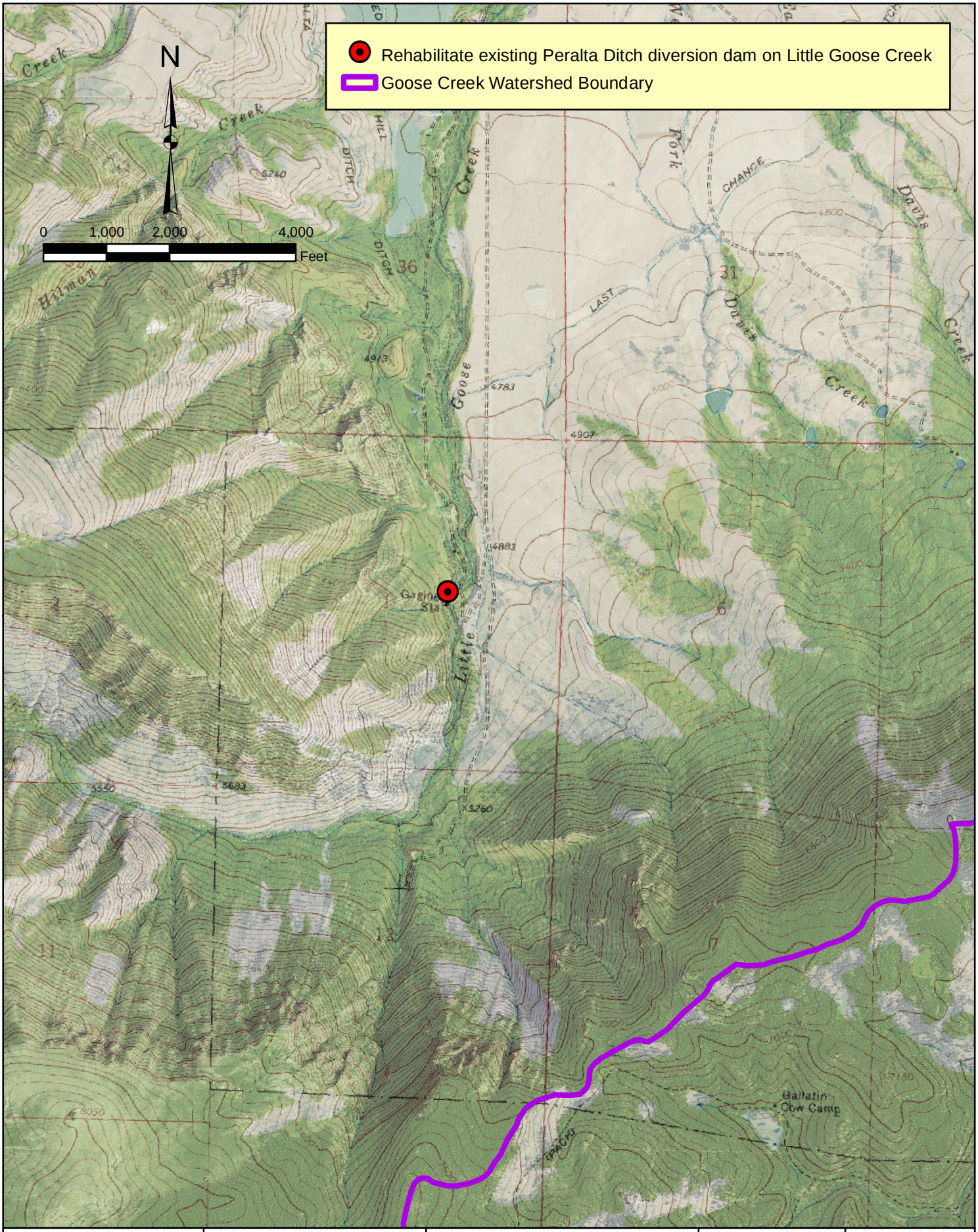
Project Costs

Preparation of Final Design and Specifications				$3,845	
Permitting and Mitigation				$1,000	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$0	
			Pre-Construction Costs (Subtotal #1)		$4,845

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$3,500	$3,500
Corr. HDPE Culvert - 24 in	50	LF	$38	$1,900
Unclassified Excavation	20	CY	$9	$180
Clean Gravel - 1"	10	CY	$75	$750
Reinforced Concrete Structure < 25 CY	20	CY	$1,500	$30,000
Connect to existing headgate	LS	LS	$2,000	$2,000
Seeding	120	SY	$1	$120

Total Component Cost (Subtotal #2)	$38,450	
Construction Engineering Cost (Subtotal #2 x 10%)	$3,845	
Components and Engineering Costs (Subtotal #3)	$42,295	
Contingency (Subtotal #3 x 15%)	$6,345	
Construction Cost Total (Subtotal #4)		$48,640
Total Project Cost (Subtotal #1 + Subtotal #4)		$53,485



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Project Name: Peralta Ditch Headgate Rehabilitation

Project ID:	**ISI-LG-PE-01**	**Structure Type:**	**Headgate**
Ditch Name:	Peralta Ditch	Coordinates:	44.596242, -107.039784
Contact Persons:	David Garber, Peralta Ditch Company Board Member		
Description:	Pressure grout voids beneath the existing concrete diversion dam and the existing concrete foundation supporting the headgates. There is a leak around the west side of the diversion dam and beneath the headgates. Because of these leaks and the proximity of the headgates to the diversion dam, they cannot completely shut off irrigation water flowing into the ditch.		
Project Benefits:	Increasing and extending irrigation water availability.		

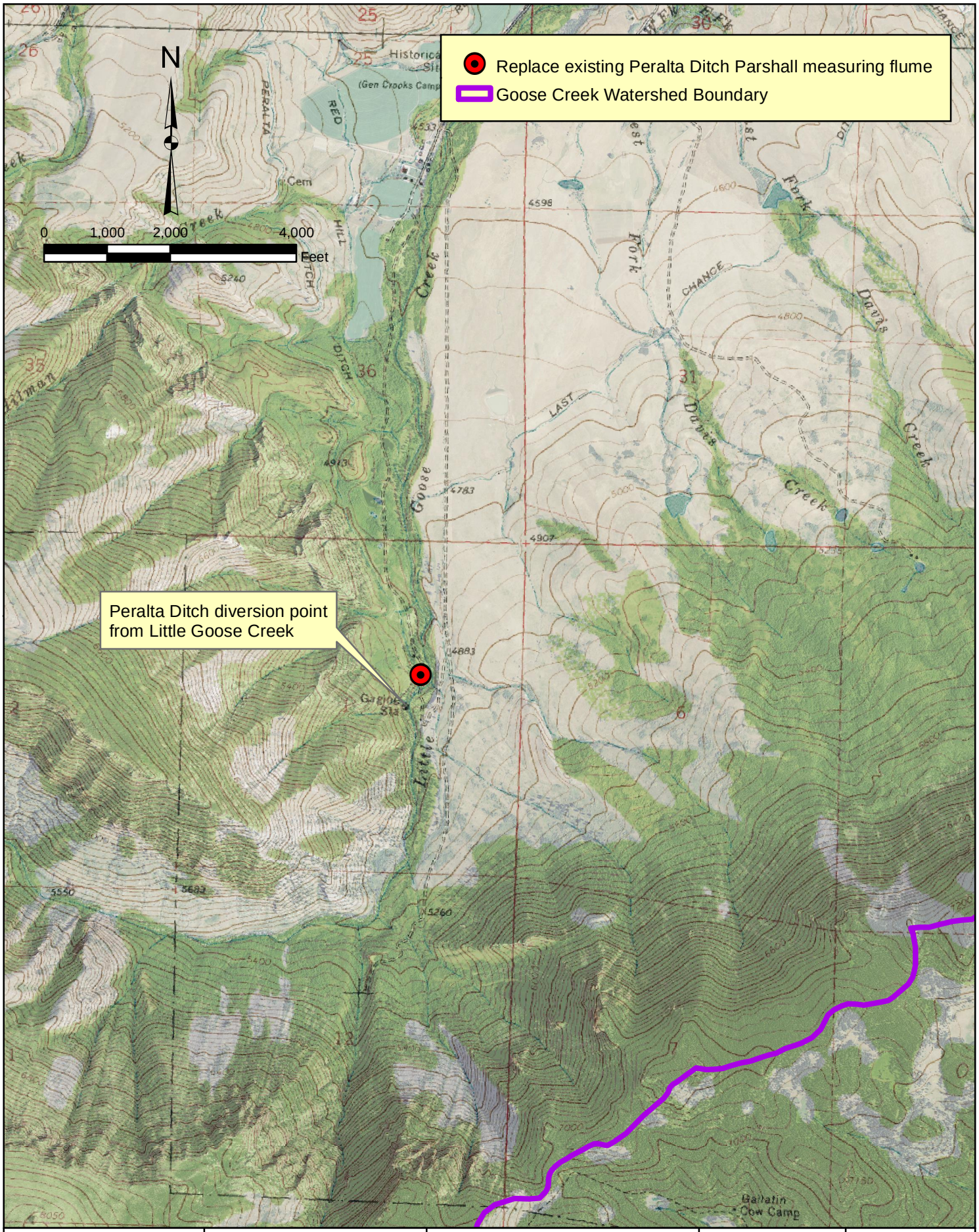
Project Costs

Preparation of Final Design and Specifications	$1,650	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$1,650

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$1,500	$1,500
Road Improvements for Access	LS	LS	$5,000	$5,000
Pressure Grout	500	CF	$20	$10,000

Total Component Cost (Subtotal #2)	$16,500	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,650	
Components and Engineering Costs (Subtotal #3)	$18,150	
Contingency (Subtotal #3 x 15%)	$2,723	
Construction Cost Total (Subtotal #4)		$20,873
Total Project Cost (Subtotal #1 + Subtotal #4)		$22,523



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Project Name: Peralta Ditch Measuring Flume

Project ID:	**ISI-LG-PE-02**	**Structure Type:**	**Measuring Device**
Ditch Name:	Peralta Ditch	Coordinates:	44.597174, -107.039010
Contact Persons:	David Garber, Peralta Ditch Company Board Member		
Description:	Replace the existing 6'-wide Parshall flume. The existing flume is rusted out and in need of replacement.		
Project Benefits:	Increasing and extending irrigation water availability.		

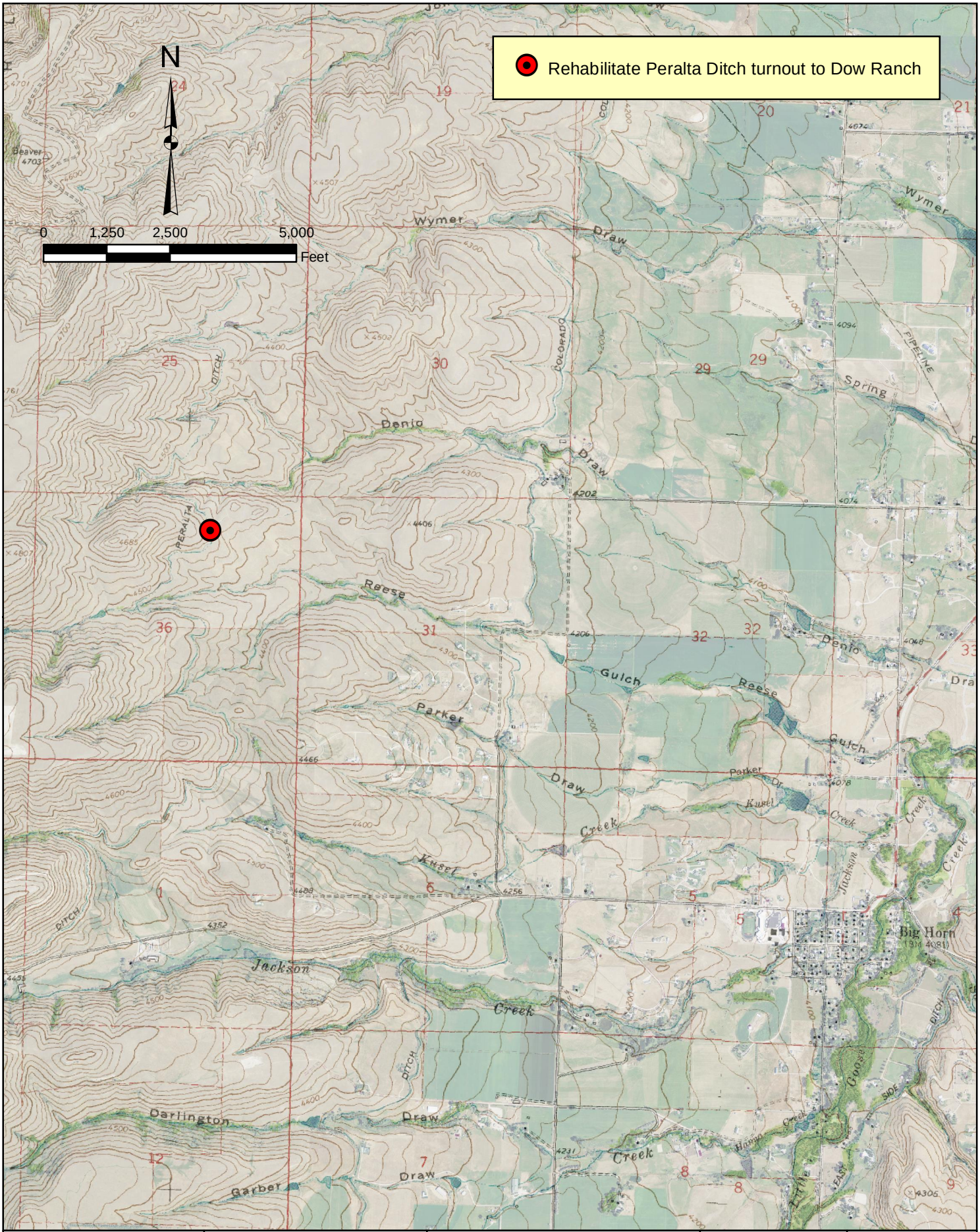
Project Costs

Preparation of Final Design and Specifications	$1,283	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$1,283

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$1,200	$1,200
Headgate - 18"	1	EA	$1,300	$1,300
Corr. HDPE Culvert - 18"	80	LF	$26	$2,080
Install 18"x45° Bend with Straps and Thrust Block	1	EA	$2,000	$2,000
Rip Rap - 24"	20	CY	$125	$2,500
Parshall Flume - 72"	1	EA	$3,750	$3,750

Total Component Cost (Subtotal #2)	$12,830	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,283	
Components and Engineering Costs (Subtotal #3)	$14,113	
Contingency (Subtotal #3 x 15%)	$2,117	
Construction Cost Total (Subtotal #4)		$16,230
Total Project Cost (Subtotal #1 + Subtotal #4)		$17,513



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Project Name: Peralta Ditch Dow Ranch Turnout Rehabilitation

Project ID:	**ISI-LG-PE-03**	**Structure Type:**	**Turnout**
Ditch Name:	Peralta Ditch	Coordinates:	44.704416, -107.045552
Contact Persons:	David Garber, Peralta Ditch Company Board Member		
Description:	Install a new 18" headgate, replace the existing pipe with 20' of new pipe laid on a very flat grade, place a 45-degree bend on the flat pipe, then extend new pipe a distance of approximately 100' to a point where riprap could be installed to dissipate the energy at this point. This project addresses a collapsed pipe for the turnout that serves the Dow Ranch. Irrigation water cannot flow through the collapsed pipe, and thus it is currently eroding a hillside immediately below the turnout.		
Project Benefits:	Increasing and extending irrigation water availability.		

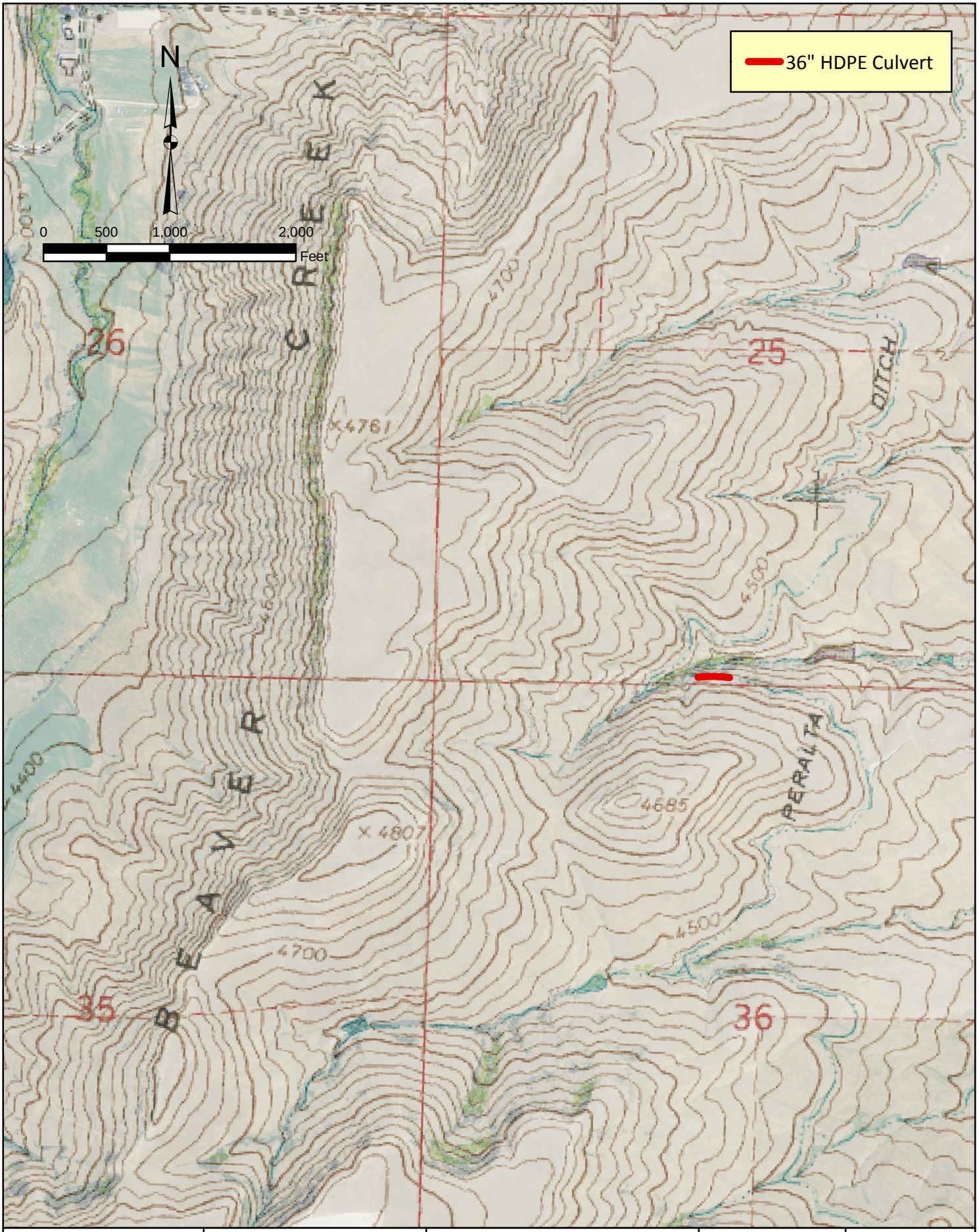
Project Costs

Preparation of Final Design and Specifications	$1,157	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$1,157

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$1,100	$1,100
Headgate - 18"	1	EA	$1,300	$1,300
Precast Turnout	1	EA	$5,300	$5,300
Corr. HDPE Culvert - 18"	120	LF	$26	$3,120
Culvert FE Sect - 18"	1	EA	$200	$200
45° Bend - 18"	1	EA	$300	$300
Rip Rap - 24"	2	CY	$125	$250

Total Component Cost (Subtotal #2)	$11,570	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,157	
Components and Engineering Costs (Subtotal #3)	$12,727	
Contingency (Subtotal #3 x 15%)	$1,910	
Construction Cost Total (Subtotal #4)		$14,637
Total Project Cost (Subtotal #1 + Subtotal #4)		$15,794



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Project Name: Peralta Ditch Breach Restoration

Project ID:	**ISI-LG-PE-04**	**Structure Type:**	**Culvert Installation**
Ditch Name:	Peralta Ditch	Coordinates:	44.704416, -107.045552
Contact Persons:	David Garber, Peralta Ditch Company Board Member		
Description:	Install 250' of 36" culvert in area where ditch has been breached.		
Project Benefits:	Increasing and extending irrigation water availability.		

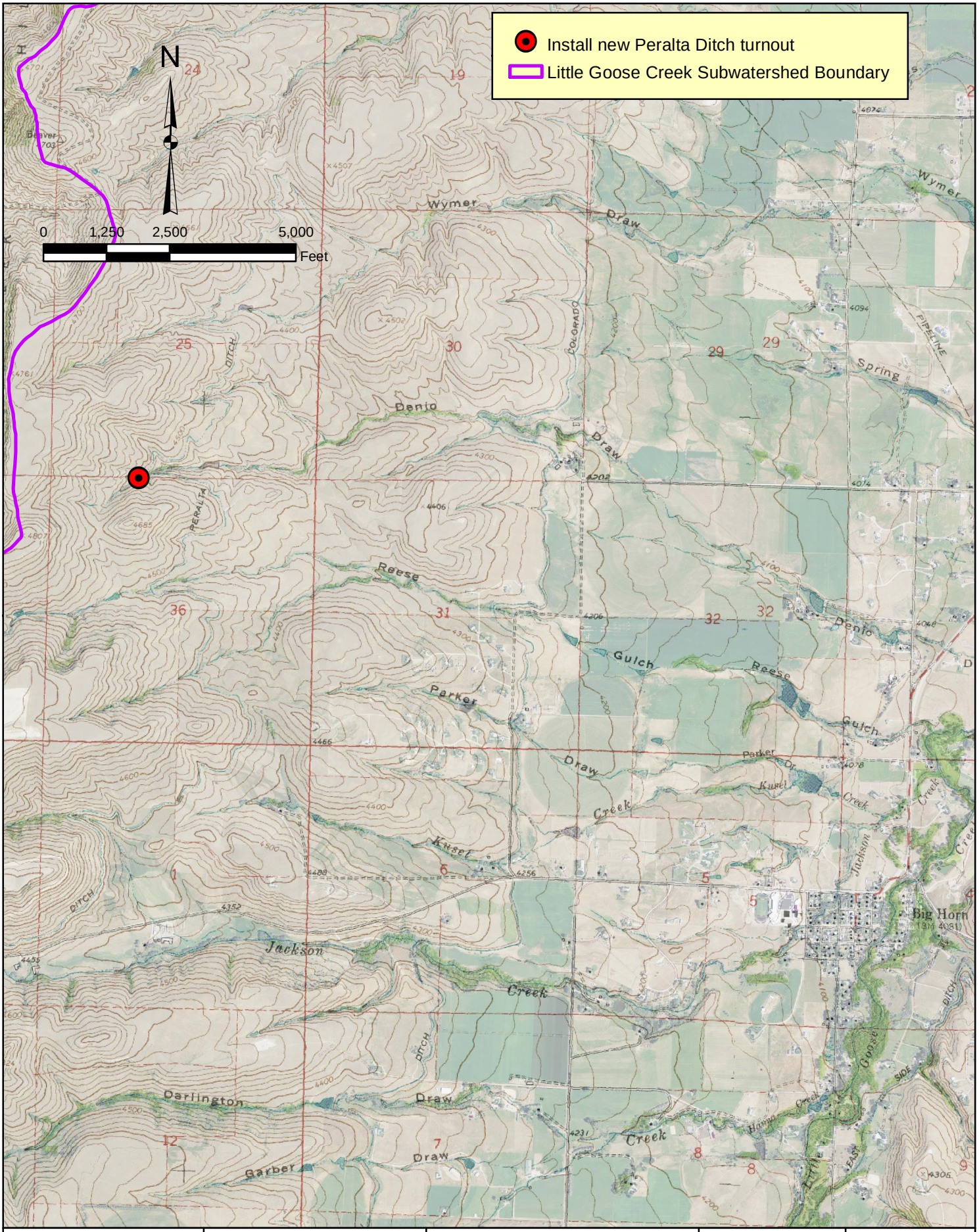
Project Costs

Preparation of Final Design and Specifications	$1,791	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$2,000	
Pre-Construction Costs (Subtotal #1)		$3,791

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$1,700	$1,700
Corr. HDPE Culvert - 36 in	250	LF	$51	$12,750
Culvert Flared End Section - 36 in	2	EA	$400	$800
Trash Guard 36 in	1	EA	$2,100	$2,100
Seeding	560	SY	$1	$560

Total Component Cost (Subtotal #2)	$17,910	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,791	
Components and Engineering Costs (Subtotal #3)	$19,701	
Contingency (Subtotal #3 x 15%)	$2,956	
Construction Cost Total (Subtotal #4)		$22,657
Total Project Cost (Subtotal #1 + Subtotal #4)		$26,448



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Project Name: Peralta Ditch Turnout Installation

Project ID:	**ISI-LG-PE-05**	**Structure Type:**	**Turnout Installation**
Ditch Name:	Peralta Ditch	Coordinates:	44.7041766, -107.047089
Contact Persons:	David Garber, Peralta Ditch Company Board Member		
Description:	Install 12" headgate turnout along main ditch in order to allow filling of Denio Draw Stock Reservoir located in Denio Draw Ditch. This project will require approval by the Board of Control.		
Project Benefits:	Increasing and extending irrigation water availability.		

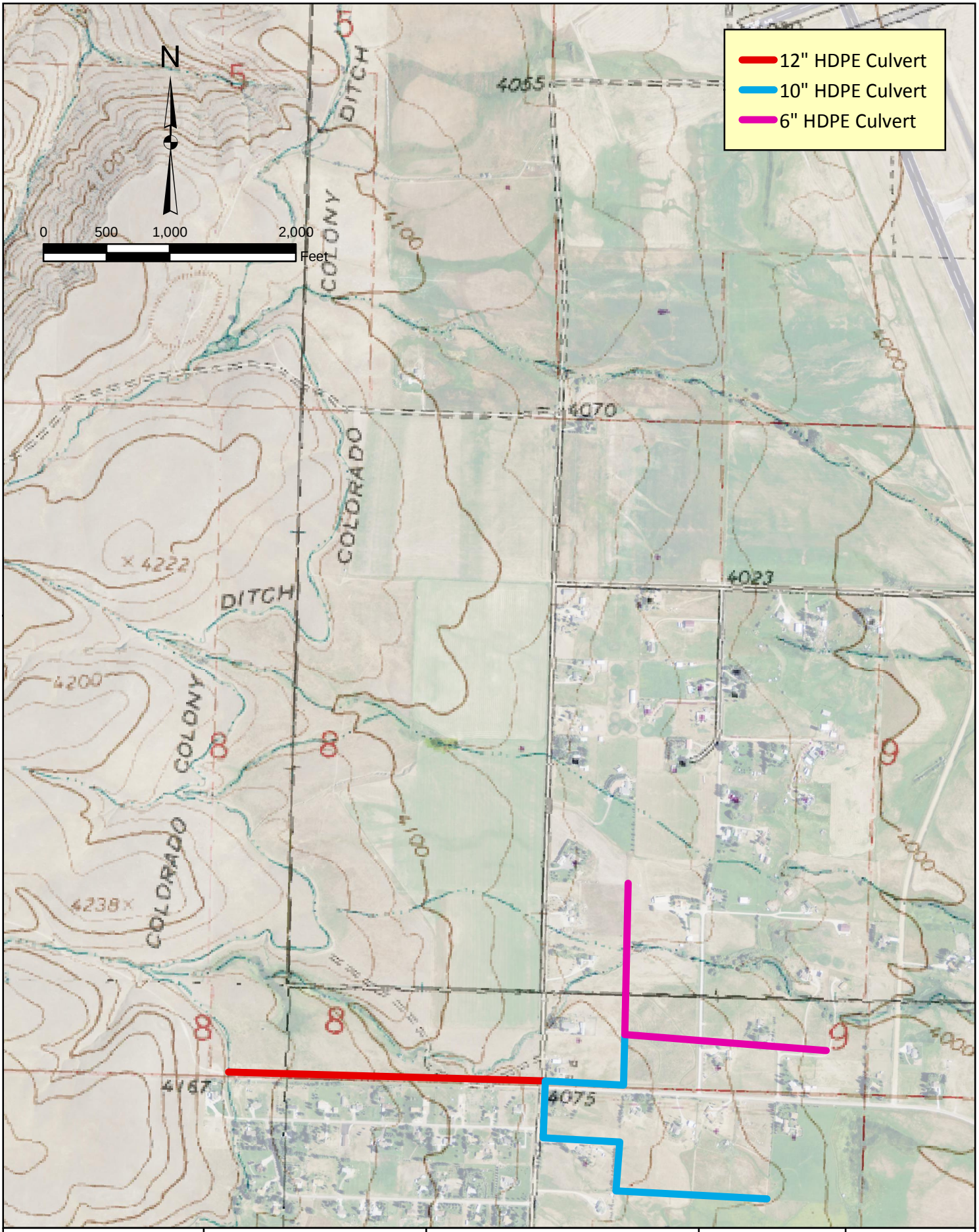
Project Costs

Preparation of Final Design and Specifications	$740	
Permitting and Mitigation	$3,000	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$4,740

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$700	$700
Precast Turnout	EA	1	$5,300	$5,300
Headgate 12"	EA	1	$900	$900
Reclamation	LS	LS	$500	$500

Total Component Cost (Subtotal #2)	$7,400	
Construction Engineering Cost (Subtotal #2 x 10%)	$740	
Components and Engineering Costs (Subtotal #3)	$8,140	
Contingency (Subtotal #3 x 15%)	$1,221	
Construction Cost Total (Subtotal #4)		$9,361
Total Project Cost (Subtotal #1 + Subtotal #4)		$14,101



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Project Name: South Paradise Park Pipeline

Project ID:	**ISI-LG-PP-01**	**Structure Type:**	**Pipeline**
Ditch Name:	N/A	Coordinates:	44.745699, -107.001655
Contact Persons:	Jack Landon, Paradise Park South Homeowners Association		
Description:	Replace approximately 8900 LF of existing ditch with new 8" pipeline to reduce water conveyance losses and provide for pressurized sprinkler system.		
Project Benefits:	Increasing and extending irrigation water availability.		

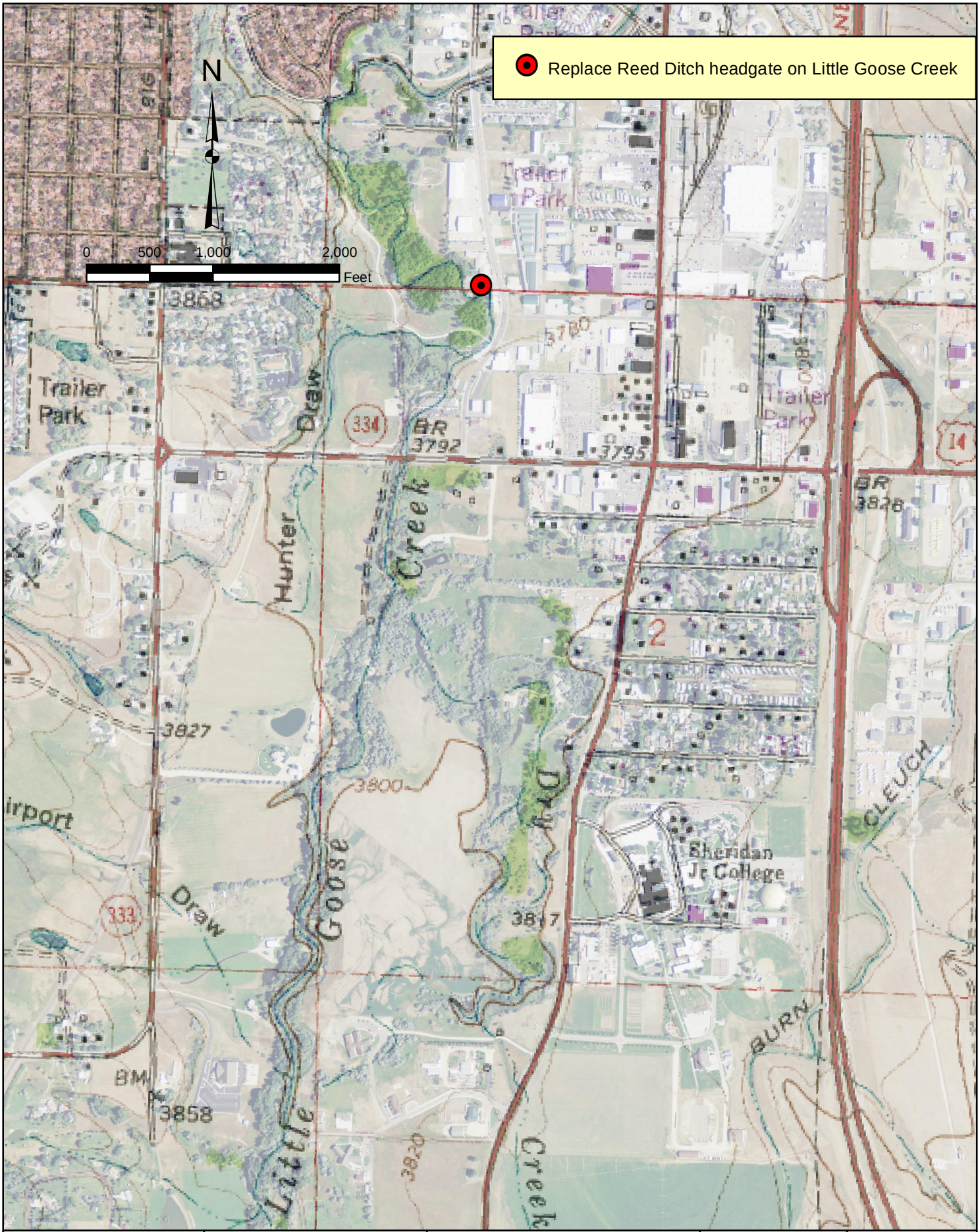
Project Costs

Preparation of Final Design and Specifications				$19,972	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$5,000	
			Pre-Construction Costs (Subtotal #1)		$24,972

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$18,200	$18,200
PVC Pressure Pipe 12"	2350	LF	$22	$51,700
PVC Pressure Pipe 10"	3670	LF	$20	$73,400
PVC Pressure Pipe 6"	2844	LF	$13	$36,972
Fittings and Risers	LS	LS	$19,449	$19,449

Total Component Cost (Subtotal #2)	$199,721	
Construction Engineering Cost (Subtotal #2 x 10%)	$19,972	
Components and Engineering Costs (Subtotal #3)	$219,693	
Contingency (Subtotal #3 x 15%)	$32,954	
Construction Cost Total (Subtotal #4)		$252,647
Total Project Cost (Subtotal #1 + Subtotal #4)		$277,619



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Project Name: Reed Ditch Headgate Replacement

Project ID:	**ISI-LG-RE-01**	**Structure Type:**	**Headgate**
Ditch Name:	Reed	Coordinates:	44.777463, -106.948004
Contact Persons:	Rolland Culligan, Jerry Burgess: Reed Ditch Company		
Description:	Replace existing headgate damaged approximately five years ago during stream rehabilitation projects. This headgate now leaks.		
Project Benefits:	Increasing and extending irrigation water availability.		

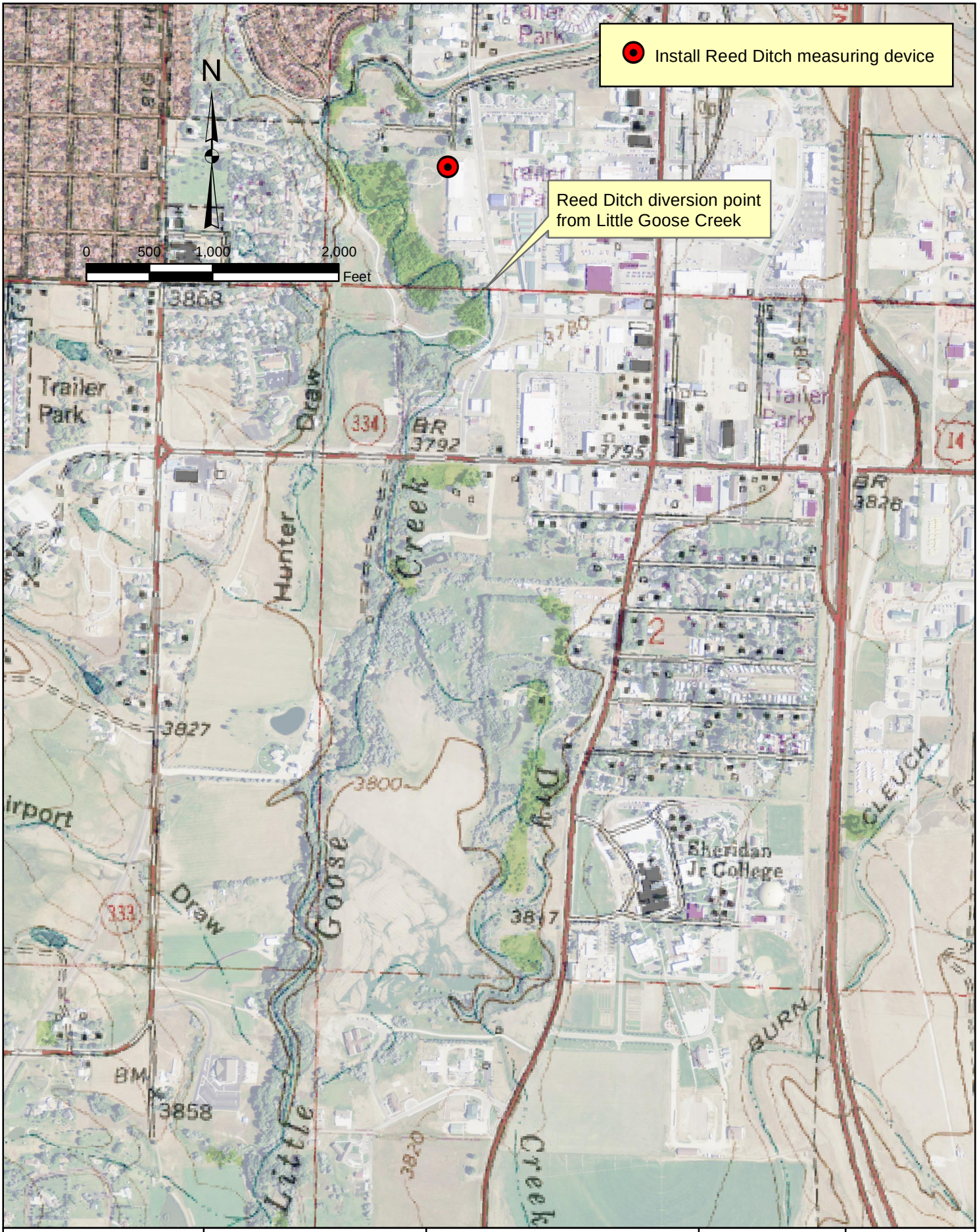
Project Costs

Preparation of Final Design and Specifications	$410	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$410

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$400	$400
Clearing & Grubbing	1	LS	$400	$400
Headgate - 24"	1	EA	$1,700	$1,700
Trash Rack - 24"	1	EA	$1,600	$1,600

Total Component Cost (Subtotal #2)	$4,100	
Construction Engineering Cost (Subtotal #2 x 10%)	$410	
Components and Engineering Costs (Subtotal #3)	$4,510	
Contingency (Subtotal #3 x 15%)	$677	
Construction Cost Total (Subtotal #4)		$5,187
Total Project Cost (Subtotal #1 + Subtotal #4)		$5,597



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Project Name: Reed Ditch Measuring Device

Project ID:	**ISI-LG-RE-02**	**Structure Type:**	**Measuring Device**
Ditch Name:	Reed	Coordinates:	44.780001, -106.949074
Contact Persons:	Rolland Culligan, Jerry Burgess: Reed Ditch Company		
Description:	Install 2'-width Parshall flume on main ditch. Currently, there is no measurement device on the ditch, presumably because this is the last diversion on Little Goose Creek. Due to the Montana v. Wyoming Yellowstone River Compact lawsuit decisions, it will be necessary to measure the amount of flow through this diversion.		
Project Benefits:	Increasing and extending irrigation water availability.		

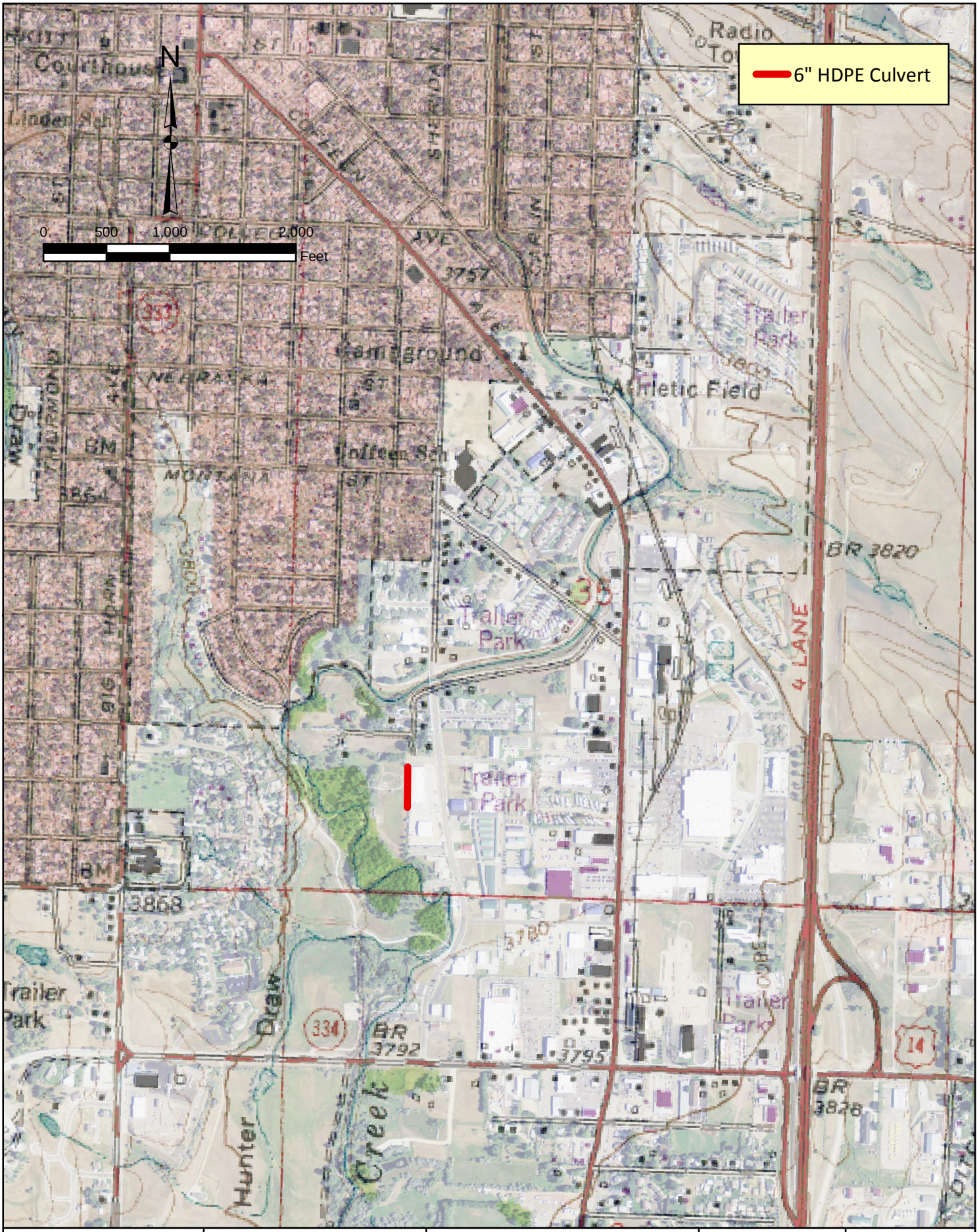
Project Costs

Preparation of Final Design and Specifications	$150	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$150

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	200	200
Parshall Flume - 18"	1	EA	$1,300	$1,300

Total Component Cost (Subtotal #2)	$1,500	
Construction Engineering Cost (Subtotal #2 x 10%)	$150	
Components and Engineering Costs (Subtotal #3)	$1,650	
Contingency (Subtotal #3 x 15%)	$248	
Construction Cost Total (Subtotal #4)		$1,898
Total Project Cost (Subtotal #1 + Subtotal #4)		$2,048



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Project Name: Reed Ditch Knecht Drainage

Project ID:	**ISI-LG-RE-03**	**Structure Type:**	**Drainage Improvements**
Ditch Name:	Reed	Coordinates:	44.779996, -106.94908
Contact Persons:	Rolland Culligan, Jerry Burgess: Reed Ditch Company		
Description:	Reroute Knecht building drainage to prevent runoff from roof flowing into ditch during storm events.		
Project Benefits:	Increasing and extending irrigation water availability.		

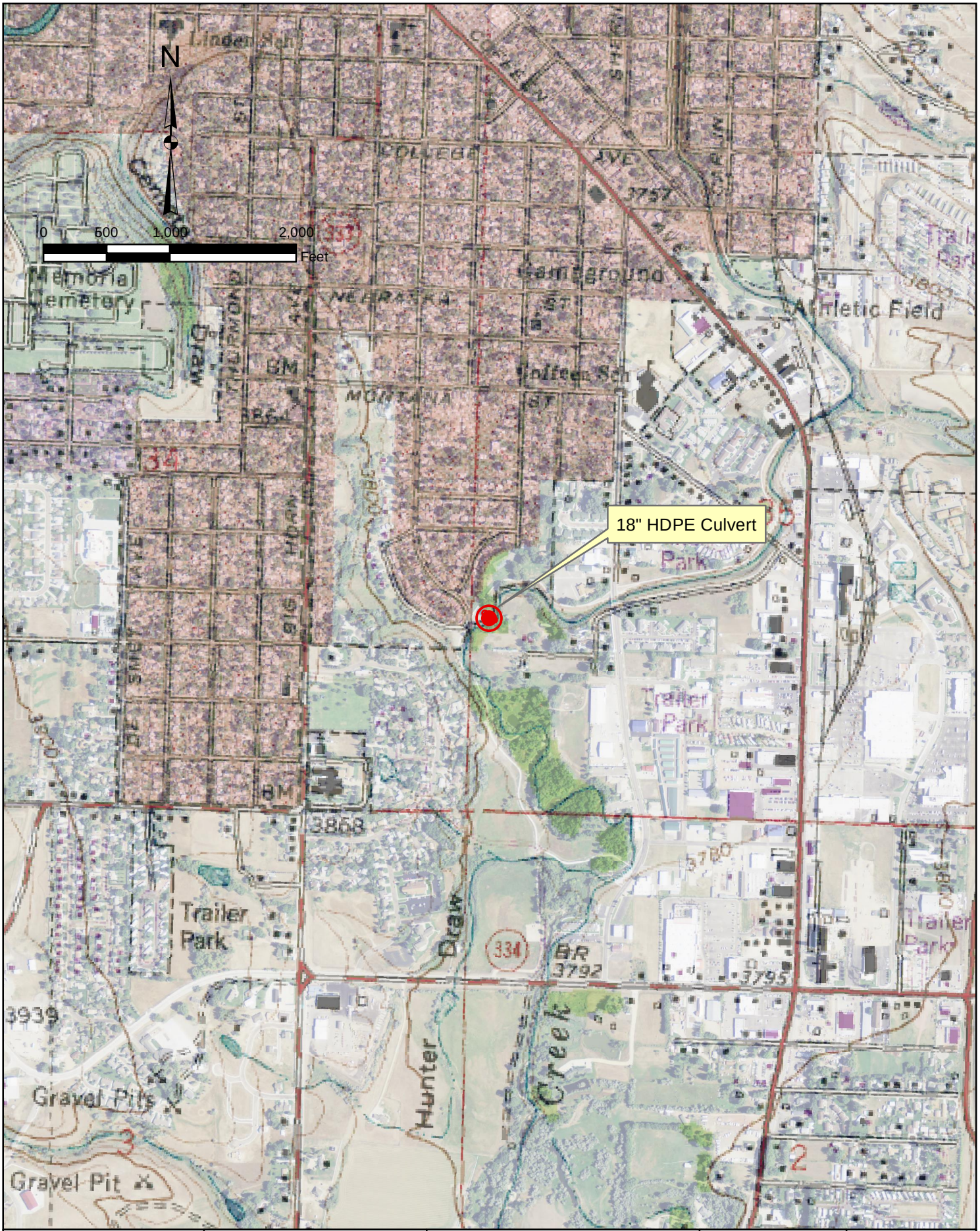
Project Costs

Preparation of Final Design and Specifications	$490	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$490

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	500	500
Gutter Installation	320	LF	10	3200
Gutter connection to downspouts	4	EA	$300	$1,200

Total Component Cost (Subtotal #2)	$4,900	
Construction Engineering Cost (Subtotal #2 x 10%)	$490	
Components and Engineering Costs (Subtotal #3)	$5,390	
Contingency (Subtotal #3 x 15%)	$809	
Construction Cost Total (Subtotal #4)		$6,199
Total Project Cost (Subtotal #1 + Subtotal #4)		$6,689



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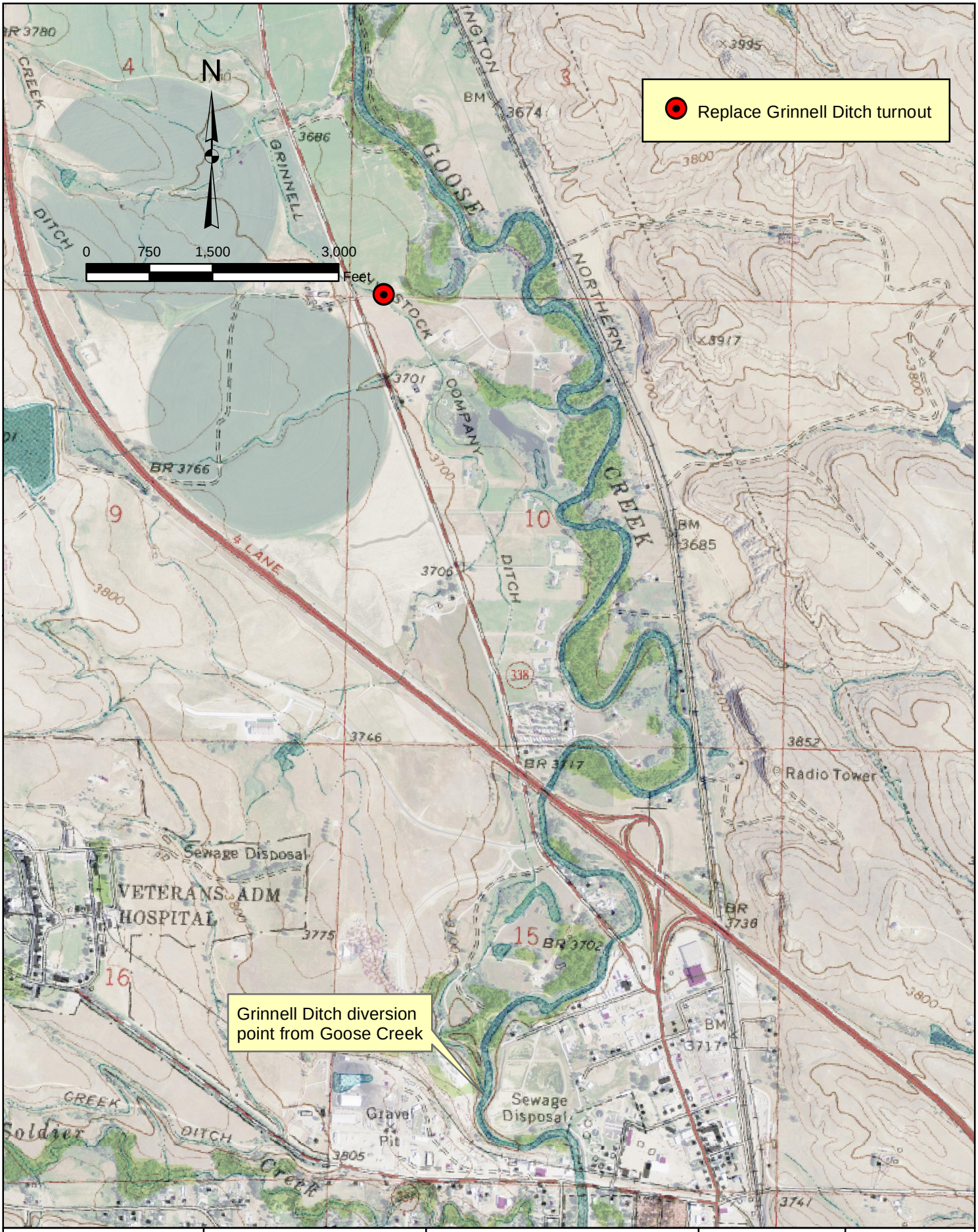
Project Name: Reed Ditch Flume Structure Replacement

Project ID:	**ISI-LG-RE-04**	**Structure Type:**	**Flume Structure**
Ditch Name:	Reed	Coordinates:	44.781553, -106.952053
Contact Persons:	Rolland Culligan, Jerry Burgess: Reed Ditch Company		
Description:	Replace bridge structure that supports a flume that crosses Little Goose Creek. The flume pipeline was replaced in the fall of 2017. However, the bridge structure is in need of replacement.		
Project Benefits:	Increasing and extending irrigation water availability.		

Project Costs

Preparation of Final Design and Specifications				$3,507	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$0	
			Pre-Construction Costs (Subtotal #1)		$3,507
Cost of Project Components					
Item Description	Quantity	Unit	Unit Cost	Extended Price	
Mobilization	1	LS	$3,200	3200	
Existing Structure Demolition	1	LS	$2,500	$2,500	
18" CMP Carrier Pipe	90	LF	$35	$3,150	
18" FE Section	1	EA	$210	$210	
6" Steel Pipe Support Spans	189	LF	$40	$7,560	
8" Steel Pipe Support Columns	210	LF	$65	$13,650	
Concrete Support Column Encasement	20	CY	$180	$3,600	
Cable Support System	1	LS	$1,200	$1,200	
			Total Component Cost (Subtotal #2)	$35,070	
			Construction Engineering Cost (Subtotal #2 x 10%)	$3,507	
			Components and Engineering Costs (Subtotal #3)	$38,577	
			Contingency (Subtotal #3 x 15%)	$5,787	
			Construction Cost Total (Subtotal #4)		$44,364
			Total Project Cost (Subtotal #1 + Subtotal #4)		$47,871



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	***GOOSE CREEK WATERSHED LEVEL I STUDY***	***IRRIGATION SYSTEM INFRASTRUCTURE REHABILITATION AND IMPROVEMENTS***	***ISI-LoG-GR-01***

Project Name: Grinnell Ditch Turnout Replacement

Project ID:	**ISI-LoG-GR-01**	**Structure Type:**	**Turnout**
Ditch Name:	Grinnell Ditch	Coordinates:	44.849811, -106.971688
Contact Persons:	Butch Jellis, Ginnell Ditch Company		
Description:	Replace two existing turnouts on Grinnell Ditch located east of Decker Highway.		
Project Benefits:	Increasing and extending irrigation water availability.		

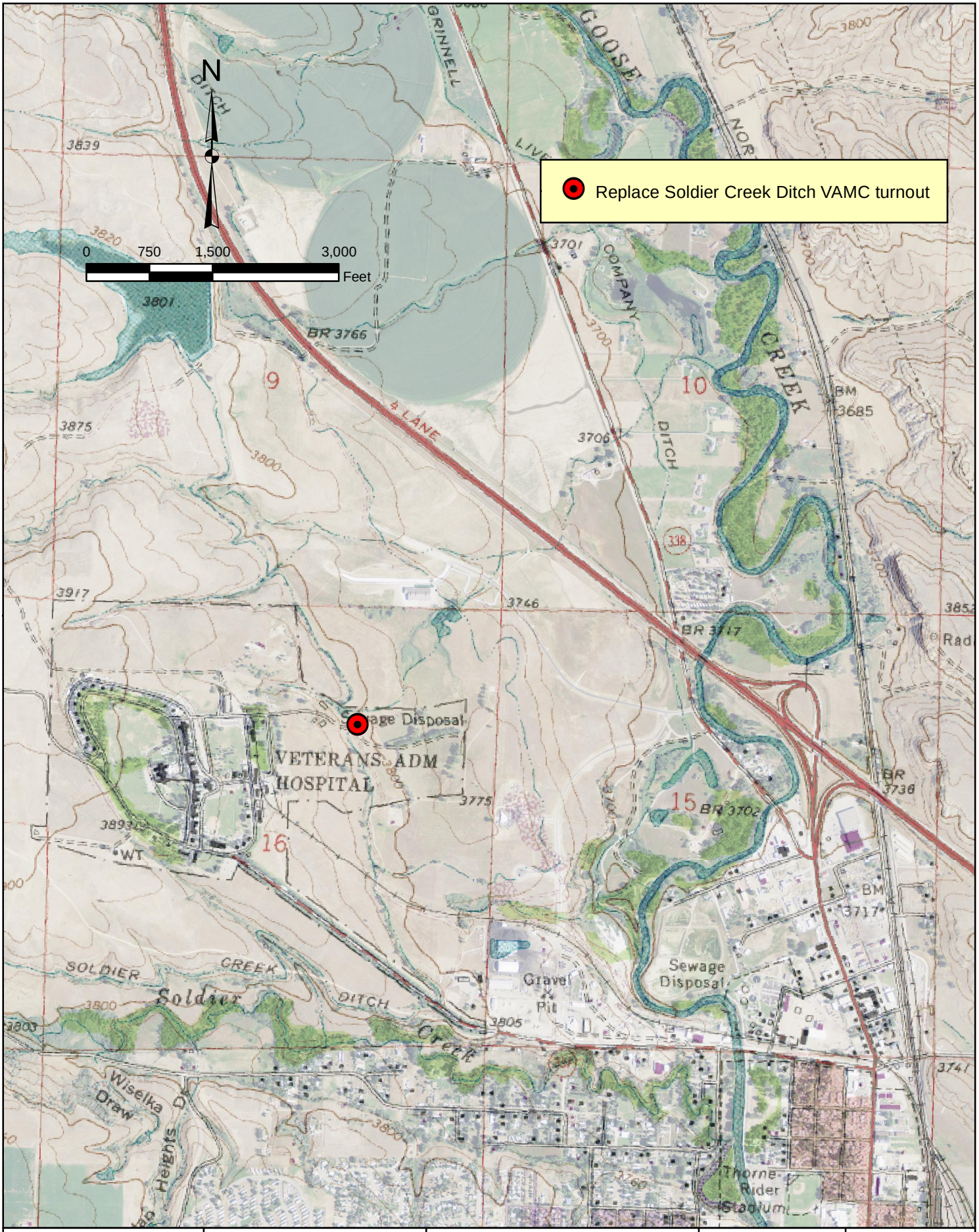
Project Costs

Preparation of Final Design and Specifications	$1,512	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$1,512

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$1,400	$1,400
Headgate - 18"	2	EA	$1,300	$2,600
Precast Turnout	2	EA	$5,300	$10,600
Corr. HDPE Culvert - 18"	20	LF	$26	$520

Total Component Cost (Subtotal #2)	$15,120	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,512	
Components and Engineering Costs (Subtotal #3)	$16,632	
Contingency (Subtotal #3 x 15%)	$2,495	
Construction Cost Total (Subtotal #4)		$19,127
Total Project Cost (Subtotal #1 + Subtotal #4)		$20,639



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	**GOOSE CREEK WATERSHED LEVEL I STUDY**	**IRRIGATION SYSTEM INFRASTRUCTURE REHABILITATION AND IMPROVEMENTS**	**ISI-LoG-SC-01**

Project Name: Soldier Creek Ditch VAMC Turnout Replacement

Project ID:	**ISI-LoG-SC-01**	**Structure Type:**	**Turnout**
Ditch Name:	Soldier Creek Ditch	Coordinates:	44.831298, -106.979465
Contact Persons:	Butch Jellis, Soldier Ditch Company		
Description:	Replace existing turnout located on VAMC property. This turnout was previously used to irrigate the US Forest Service's "Remount Pasture", and has since been removed from the ditch bank. This project will require VAMC approval.		
Project Benefits:	Increasing and extending irrigation water availability.		

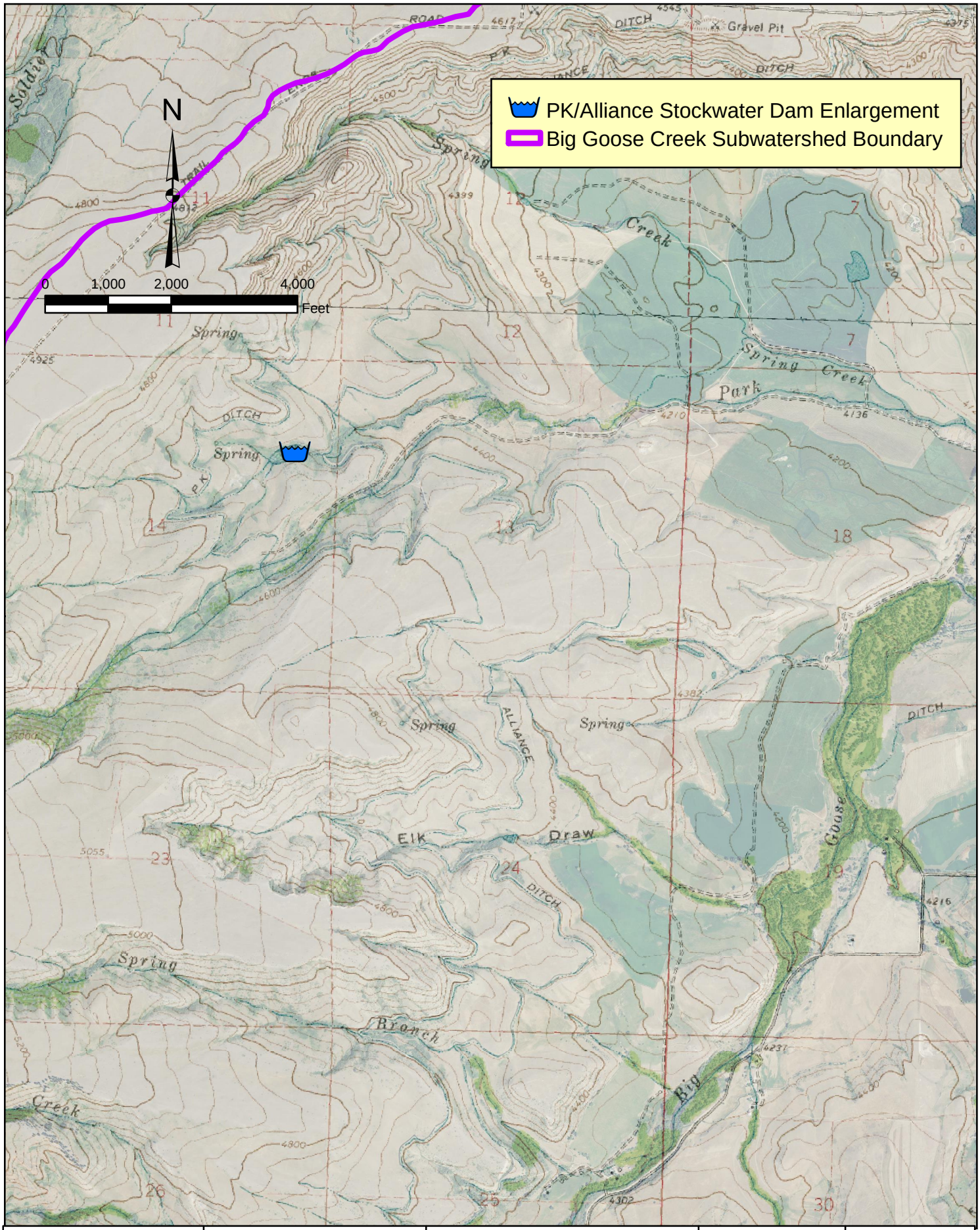
Project Costs

Preparation of Final Design and Specifications	$926	
Permitting and Mitigation	$2,000	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$2,926

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$900	$900
Headgate - 18"	1	EA	$1,300	$1,300
Precast Turnout	1	EA	$5,300	$5,300
Corr. HDPE Culvert - 18"	60	LF	$26	$1,560
Culvert FE Sect - 18"	1	EA	$200	$200

Total Component Cost (Subtotal #2)	$9,260	
Construction Engineering Cost (Subtotal #2 x 10%)	$926	
Components and Engineering Costs (Subtotal #3)	$10,186	
Contingency (Subtotal #3 x 15%)	$1,528	
Construction Cost Total (Subtotal #4)		$11,714
Total Project Cost (Subtotal #1 + Subtotal #4)		$14,640



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	**GOOSE CREEK WATERSHED LEVEL I STUDY**	**SURFACE WATER STORAGE OPPORTUNITIES**	**SWSO-01**

Project Name: PK/Alliance Stockwater Dam Enlargement

Project ID:	**SWSO-01**	**Structure Type:**	**Stockwater Dam**
		Coordinates:	44.743690, -107.178804
Contact Person:	Cam Forbes, Alliance Ditch Co.		
Description:	Enlarge existing stockwater dam and reservoir. PK Ditch, located above the Alliance Ditch, has considerable leakage. Enlargement of the existing dam would provide for a larger reservoir for stockwatering purposes.		
Project Benefits:	Additional water supply for stock made available by storage.		

Project Costs

Preparation of Final Design and Specifications	$17,484	
Permitting and Mitigation	$2,000	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$19,484

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$16,000	$16,000
Clearing and Grubbing	LS	LS	$10,000	$10,000
Unclassified Excavation	10,400	CY	$9	$93,600
Extend 18" outlet pipe (RCP)	400	LF	$96	$38,400
Flared End Section - 18"	1	EA	$200	$200
Emergency spillway excavation	1,200	CY	$9	$10,800
Rip rap	6	CY	$140	$840
Reclamation	LS	LS	$5,000	$5,000

Total Component Cost (Subtotal #2)	$174,840	
Construction Engineering Cost (Subtotal #2 x 10%)	$17,484	
Components and Engineering Costs (Subtotal #3)	$192,324	
Contingency (Subtotal #3 x 15%)	$28,849	
Construction Cost Total (Subtotal #4)		$221,173
Total Project Cost (Subtotal #1 + Subtotal #4)		$240,657

Project Name: Gillispie Draw Dam and Reservoir

Project ID:	**SWSO-02**	**Structure Type:**	**Municipal Supply Dam and Reservoir**
		Coordinates:	44.800195, -107.015818
Contact Person:	Dan Roberts, City of Sheridan		
Description:	Construct new 2,660 ac-ft in Gillispie Draw (a tributary of Big Goose Creek) immediately upstream of the Sheridan city limits. The reservoir will be filled with up to 26 cfs of Big Goose Creek water diverted at the City's intake at the mouth of Big Goose Creek canyon and conveyed to the reservoir site via the City's existing 30" raw water transmission main. Water will then be pumped to the Sheridan WTP.		
Project Benefits:	Additional water supply for City of Sheridan and Sheridan Area Water Supply JPB.		

Project Costs

Preparation of Final Design and Specifications	$1,488,749	
Permitting and Mitigation	$800,000	
Legal Fees	$110,000	
Acquisition of Access and Rights-of-Way	$1,500,000	
Pre-Construction Costs (Subtotal #1)		$3,898,749

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	1	$1,354,000	$1,354,000
Clearing and Grubbing	SY	126540	$1	$126,540
Reclamation	AC	19	$3,300	$62,700
Soil Excavation	CY	31080	$1	$31,080
Bedrock Excavation	CY	12210	$5	$61,050
Embankment Core Fill Placement	CY	143000	$5	$715,000
Embankment Shell Fill Placement	CY	1141080	$3	$3,423,240
Drain Sand Placement	CY	46620	$38	$1,771,560
Drain Gravel Placement	CY	15540	$33	$512,820
Riprap Slope Protection	CY	39960	$50	$1,998,000
Road Base	CY	700	$45	$31,500
Grout Curtain Holes	LF	20000	$55	$1,100,000
Outlet Works/Pump Station	LS	1	$2,500,000	$2,500,000
Emergency Spillway	LS	1	$110,000	$110,000
Pipeline Relocation	LS	1	$650,000	$650,000
Wetland Mitigation	AC	20	$22,000	$440,000

Total Component Cost (Subtotal #2)	$14,887,490	
Construction Engineering Cost (Subtotal #2 x 10%)	$1,488,749	
Components and Engineering Costs (Subtotal #3)	$16,376,239	
Contingency (Subtotal #3 x 15%)	$2,456,436	
Construction Cost Total (Subtotal #4)		$18,832,675
Total Project Cost (Subtotal #1 + Subtotal #4)		$22,731,424

Project Name:	**Lake DeSmet Reservoir Transbasin Diversion - Municipal Water Source**

Project ID:	**SWSO-03**	**Structure Type:**	**Water Supply Transbasin Diversion Project**
		Coordinates:	44.516972, -106.78249
Contact Person:	Bill Novotny - Chairman, Johnson County Commissioners		
Description:	Deliver treated water to the Sheridan Area Water Supply Joint Powers Board's system just east of the community of Big Horn. The project would include a water treatment, pump station and 16" and 20" transmission mains, and would provide up to 4 MGD of water.		
Project Benefits:	Augmentation of the treated water supply to the Sheridan regional area with the Lake DeSmet supply that is currently available.		

Project Costs		
Preparation of Final Design and Specifications	$4,476,800	
Permitting and Mitigation	$478,000	
Legal Fees	$120,000	
Acquisition of Access and Rights-of-Way	$1,195,000	
Pre-Construction Costs (Subtotal #1)		$6,269,800
Cost of Project Components		
Pumping Intake & 6,000' to WTP	$1,733,000	
Water Treatment Plant	$19,600,000	
Reduction	$7,529,000	
Route A Pipeline		
11 miles of 16" Pipeline	$5,772,000	
6 miles of 20" Pipeline	$4,338,000	
2 Tanks (At Story and Bird Farm Road)	$2,988,000	
Pump Station on Piney Creek	$717,000	
2 PRV Stations & Miscellaneous	$896,000	
Surfacing Allowance	$1,195,000	
Total Component Cost (Subtotal #2)	$44,768,000	
Construction Engineering Cost (Subtotal #2 x 10%)	$4,476,800	
Components and Engineering Costs (Subtotal #3)	$49,244,800	
Contingency (Subtotal #3 x 15%)	$7,386,720	
Construction Cost Total (Subtotal #4)		$56,631,520
Total Project Cost (Subtotal #1 + Subtotal #4)		$62,901,320

Project Name:	**Lake DeSmet Reservoir Transbasin Diversion - Irrigation Water Source**
Project ID:	**SWSO-04**
Structure Type:	**Water Supply Transbasin Diversion Project**
	Coordinates: 44.516972, -106.78249
Contact Person:	Bill Novotny - Chairman, Johnson County Commissioners
Description:	Deliver irrigation water from Lake DeSmet to Little Goose Creek immediately upstream of the Colorado Colony Ditch diversion. Using this water and an exchange program with Big Horn Reservoir, approximately 6,800 A-F of Park Reservoir water (which has been historically used in the Little Goose Creek valley) could be freed up for use in both the Big Goose and Little Goose valleys. This concept would allow the City of Sheridan and Sheridan Area Water Supply Joint Powers Board to utilize additional Park Reservoir water within their systems, which have water treatment plants located in the Big Goose Creek valley. The project would include a pump station and 42" transmission main, and would provide up to 35 CFS to Little Goose Creek, which has been the histrocial peak-day usage of Park Reservoir water in the Little Goose Creek valley.
Project Benefits:	Additional water provided in the Little Goose Creek valley would "free up" Park Reservoir water for use in the Big Goose Creek valley by municipal water suppliers.

Project Costs

Preparation of Final Design and Specifications				$4,350,030	
Permitting and Mitigation				$200,000	
Legal Fees				$50,000	
Acquisition of Access and Rights-of-Way				$312,000	
				Pre-Construction Costs (Subtotal #1)	$4,912,030

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price	
Quality Control Testing	LS	1	$194,800	$194,800	
Mobilization	LS	1	$1,168,700	$1,168,700	
Insurance & Bonds	LS	1	$389,600	$389,600	
Traffic Control	LS	1	$194,800	$194,800	
Compliance with WYDEQ Stormwater Permit	LS	1	$78,000	$78,000	
Trench Stabilization Material	TON	11600	$35	$406,000	
Underground Utility Line Crossing (less than 18")	EA	50	$1,000	$50,000	
Underground Utility Line Crossing (18" or greater)	EA	20	$2,000	$40,000	
42-inch Waterline and Appurtenances - Restrained	LF	41530	$300	$12,459,000	
42-inch Waterline and Appurtenances - Unrestrained	LF	62290	$290	$18,064,100	
42-inch Butterfly Valve and Vault	EA	6.6	$150,000	$990,000	
42-inch Air Release / Vacuum Valve and Vault	EA	30	$35,000	$1,050,000	
Transmission Main Blow Off Assembly	EA	30	$25,000	$750,000	
60" Bored Steel Casing	LF	2440	$1,600	$3,904,000	
Asphalt Surface Restoration - 42-inch Pipeline	LF	290	$200	$58,000	
Gravel Surface Restoration - 42-inch Pipeline	LF	1280	$35	$44,800	
Rip Rap Erosion Protection	SF	500	$12	$6,000	
Seeding and Restoration	LF	105000	$3	$262,500	
Cathodic Protection System	LS	1	$150,000	$150,000	
Pressure Reducing Station (42" main line)	EA	2	$360,000	$720,000	
Pump Station	LS	1	$2,520,000	$2,520,000	
			Total Component Cost (Subtotal #2)	$43,500,300	
			Construction Engineering Cost (Subtotal #2 x 10%)	$4,350,030	
			Components and Engineering Costs (Subtotal #3)	$47,850,330	
			Contingency (Subtotal #3 x 15%)	$7,177,550	
				Construction Cost Total (Subtotal #4)	$55,027,880
				Total Project Cost (Subtotal #1 + Subtotal #4)	$59,939,910

Project Name:	**Lake DeSmet Reservoir Transbasin Diversion - Watershed Supplemental Supply Source**
Project ID:	**SWSO-05**
Structure Type:	**Water Supply Transbasin Diversion Project**
	Coordinates: 44.516972, -106.78249
Contact Person:	Bill Novotny - Chairman, Johnson County Commissioners
Description:	Deliver water from Lake DeSmet to Prairie Dog Creek via a 48" pipeline at a flow rate of 60 CFS for an approximate three-month period, which would constitute a volume of approximately 9,400 acre-feet. This water would be used to offset the post-1950 storage rights of Park Reservoir, Sawmill Reservoir, Cross Creek Reservoir, Twin Lakes Reservoir, Dome Lake Reservoir and Big Horn Reservoir in the Watershed, thereby allowing them to fill during times of water shortages and calls being placed upon Wyoming water by the State of Montana.
Project Benefits:	Provide for post-1950 storage rights located in the Big Goose Creek valley to be utilized during times of drought by fulfilling release requirements imposed by the State of Montana per the Yellowstone River Compact.

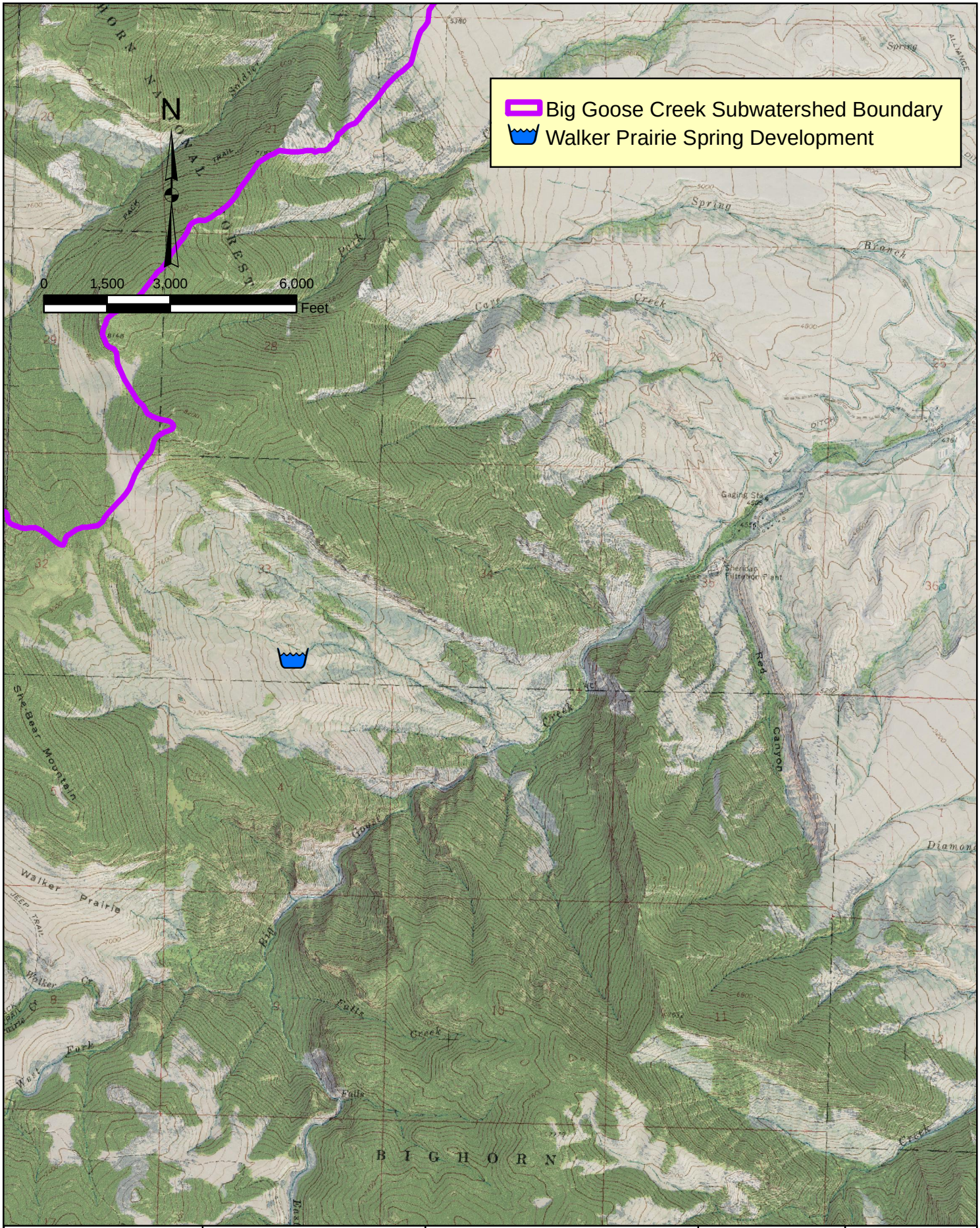
Project Costs

Preparation of Final Design and Specifications	$2,553,095	
Permitting and Mitigation	$150,000	
Legal Fees	$30,000	
Acquisition of Access and Rights-of-Way	$180,000	
Pre-Construction Costs (Subtotal #1)		$2,913,095

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Quality Control Testing	LS	1	$109,700	$109,700
Mobilization	LS	1	$658,100	$658,100
Insurance & Bonds	LS	1	$219,400	$219,400
Traffic Control	LS	1	$43,900	$43,900
Compliance with WYDEQ Stormwater Permit	LS	1	$43,900	$43,900
Trench Stabilization Material	TON	6600	$35	$231,000
Underground Utility Line Crossing (less than 18")	EA	30	$1,000	$30,000
Underground Utility Line Crossing (18" or greater)	EA	10	$2,000	$20,000
48-inch Waterline and Appurtenances	LF	59140	$320	$18,924,800
48-inch Butterfly Valve and Vault	EA	3.7	$160,000	$592,000
48-inch Air Release / Vacuum Valve and Vault	EA	20	$38,000	$760,000
Transmission Main Blow Off Assembly	EA	20	$25,000	$500,000
60" Bored Steel Casing	LF	350	$1,600	$560,000
Gravel Surface Restoration - 48-inch Pipeline	LF	240	$35	$8,400
Rip Rap Erosion Protection	SF	500	$12	$6,000
Seeding and Restoration	LF	61500	$3	$153,750
Cathodic Protection System	LS	1	$150,000	$150,000
Pump Station	LS	1	$2,520,000	$2,520,000

Total Component Cost (Subtotal #2)	$25,530,950	
Construction Engineering Cost (Subtotal #2 x 10%)	$2,553,095	
Components and Engineering Costs (Subtotal #3)	$28,084,045	
Contingency (Subtotal #3 x 15%)	$4,212,607	
Construction Cost Total (Subtotal #4)		$32,296,652
Total Project Cost (Subtotal #1 + Subtotal #4)		$35,209,747



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	***GOOSE CREEK WATERSHED LEVEL I STUDY***	***UPLAND WATER DEVELOPMENT OPPORTUNITY***	***UWDO-01***

Project Name: Walker Prairie Spring Development

Project ID:	**UWDO-01**	**Structure Type:**	**Spring Development**
		Coordinates:	44.691081, -107.224045
Contact Persons:	Dan Reinke		
Description:	Install stockwater tank and piping. The proposed site is on land that Dan Reinke leases for grazing that is owned by Renny Burke and the Beverly Kane Trust, which is adjacent to the Bighorn National Forest in the Walker Prairie area. Spring development would be the water source for the stockwater tank.		
Project Benefits:	Development of existing water supplies.		

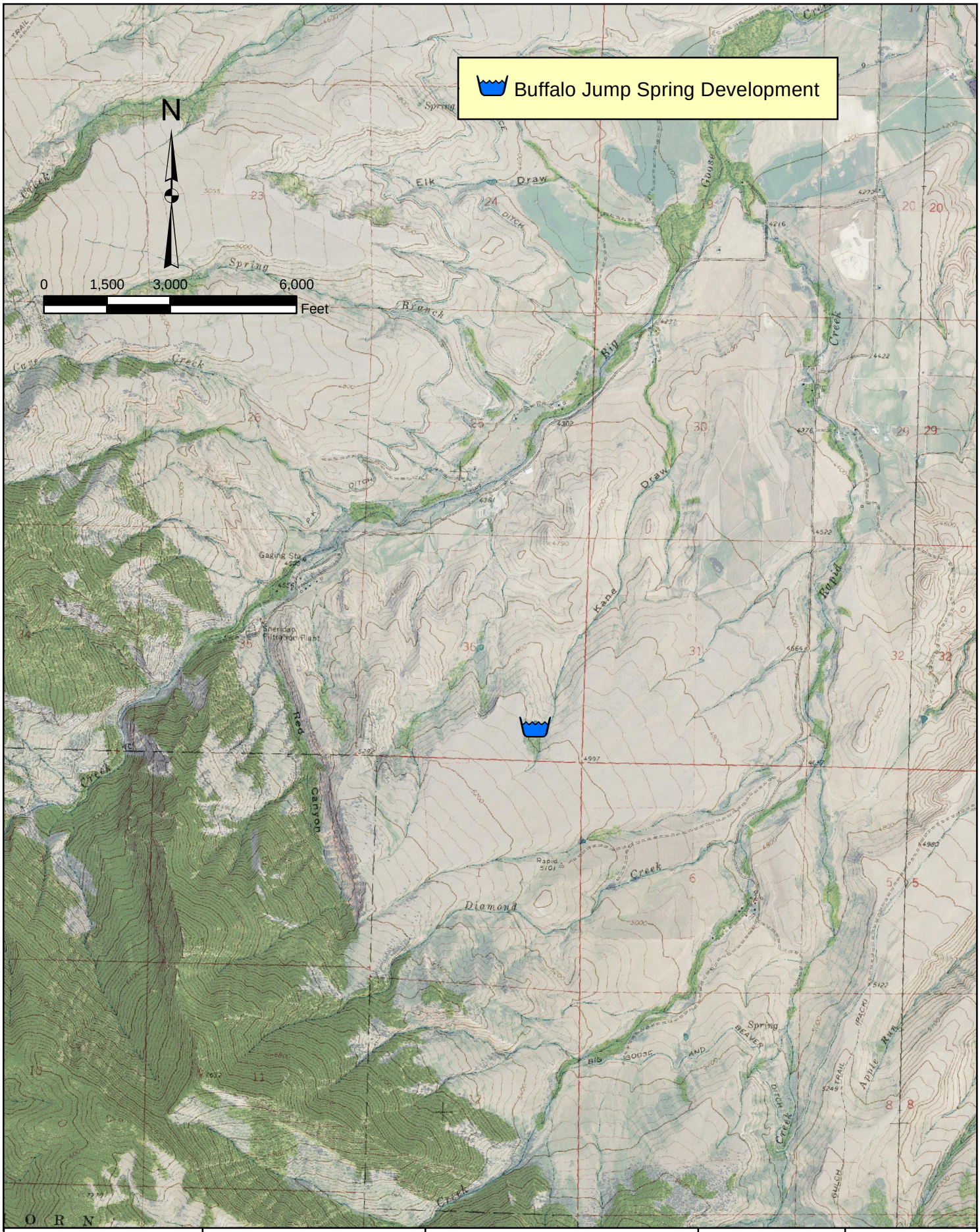
Project Costs

Preparation of Final Design and Specifications	$600	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$500	
Pre-Construction Costs (Subtotal #1)		$1,100

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$600	$600
2" Waterline and appurtenances	100	LF	$20	$2,000
Stock tank	1	EA	$3,100	$3,100
Seeding	300	SY	$1	$300

Total Component Cost (Subtotal #2)	$6,000	
Construction Engineering Cost (Subtotal #2 x 10%)	$600	
Components and Engineering Costs (Subtotal #3)	$6,600	
Contingency (Subtotal #3 x 15%)	$990	
Construction Cost Total (Subtotal #4)		$7,590
Total Project Cost (Subtotal #1 + Subtotal #4)		$8,690


Buffalo Jump Spring Development
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Creek

Project Name: Buffalo Jump Spring Development

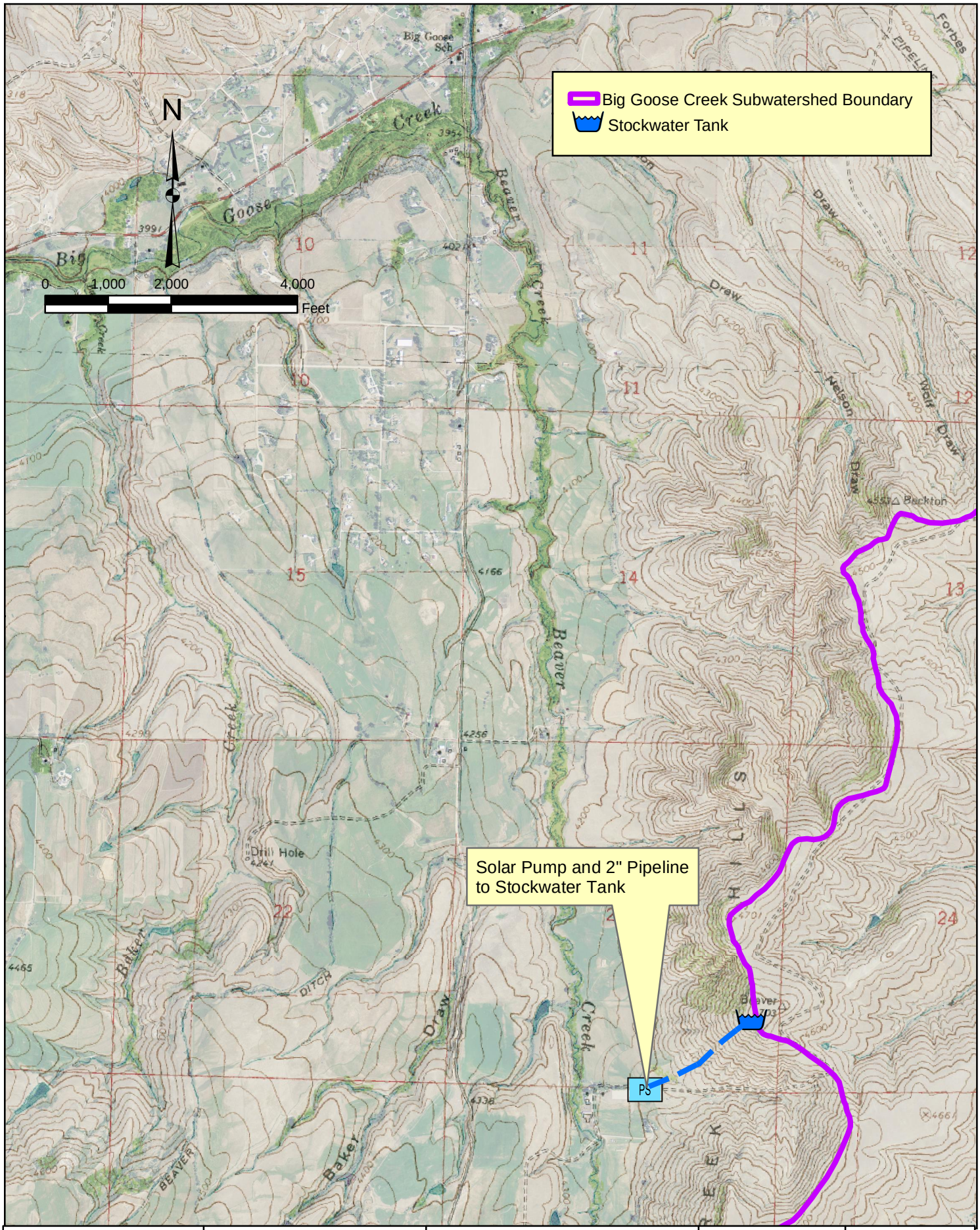
Project ID:	**UWDO-02**	**Structure Type:**	**Spring Development**
		Coordinates:	44.691081, -107.224045
Contact Persons:	Dan Reinke		
Description:	Install stockwater tank and piping. Dan Reinke leases land for grazing from the State of Wyoming, which is immediately south of the site of the Big Goose water treatment plant. Spring development would be the water source for the stockwater tank.		
Project Benefits:	Development of existing water supplies.		

Project Costs

Preparation of Final Design and Specifications				$600	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$1,000	
			Pre-Construction Costs (Subtotal #1)		$1,600

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price	
Mobilization	LS	LS	$600	$600	
2" Waterline and appurtenances	100	LF	$20	$2,000	
Stock tank	1	EA	$3,100	$3,100	
Seeding	300	SY	$1	$300	
			Total Component Cost (Subtotal #2)	$6,000	
			Construction Engineering Cost (Subtotal #2 x 10%)	$600	
			Components and Engineering Costs (Subtotal #3)	$6,600	
			Contingency (Subtotal #3 x 15%)	$990	
			Construction Cost Total (Subtotal #4)		$7,590
			Total Project Cost (Subtotal #1 + Subtotal #4)		$9,190



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	**GOOSE CREEK WATERSHED LEVEL I STUDY**	**UPLAND WATER DEVELOPMENT OPPORTUNITY**	**UWDO-03**

Project Name: Beaver Creek Hills Upland Water Development

Project ID:	**UWDO-03**	**Structure Type:**	**Solar Pump, Pipeline and Stockwater Tank**
		Coordinates:	44.721772, -107.055516 (tank site)
Contact Persons:	Orrin Connell, RC Ranch		
Description:	Install solar pump, stockwater tank and piping. The proposed tank site is on land owned by the JC Ranch at the top of the Beaver Creek Hills. The water source would be an irrigation ditch that diverts out of Beaver Creek at approximately the west quarter corner of Section 35, T55N, R85W. The solar pump would pump water out of the irrigation ditch to the tank.		
Project Benefits:	Development of existing water supplies.		

Project Costs

Preparation of Final Design and Specifications	$5,460	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$5,460

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$5,000	$5,000
Solar Pumping System, including submersible pump, photovoltaic panels, batteries, wiring	1	EA	$3,300	$3,300
2" Waterline and appurtenances	2500	LF	$15	$37,500
Stock tank	1	EA	$3,200	$3,200
Seeding	5600	SY	$1	$5,600

Total Component Cost (Subtotal #2)	$54,600	
Construction Engineering Cost (Subtotal #2 x 10%)	$5,460	
Components and Engineering Costs (Subtotal #3)	$60,060	
Contingency (Subtotal #3 x 15%)	$9,009	
Construction Cost Total (Subtotal #4)		$69,069
Total Project Cost (Subtotal #1 + Subtotal #4)		$74,529

EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	**GOOSE CREEK WATERSHED LEVEL I STUDY**	**UPLAND WATER DEVELOPMENT OPPORTUNITY**	**UWDO-04**

Project Name: Tepee Upland Water Development

Project ID:	**UWDO-04**	**Structure Type:**	**Solar Pump, Pipeline and Stockwater Tank**
		Coordinates:	44.622505, -107.124959 (tank site)
Contact Persons:	Orrin Connell, RC Ranch		
Description:	Install solar pump, 3,000 gallon stockwater tank and piping. The proposed site is on the Bighorn National Forest. The JC Ranch holds a grazing lease from the BNF at this location. The water source would be an existing spring, which would fill a new cistern. The solar pump would pump water out of the cistern up to the new storage tank.		
Project Benefits:	Development of existing water supplies.		

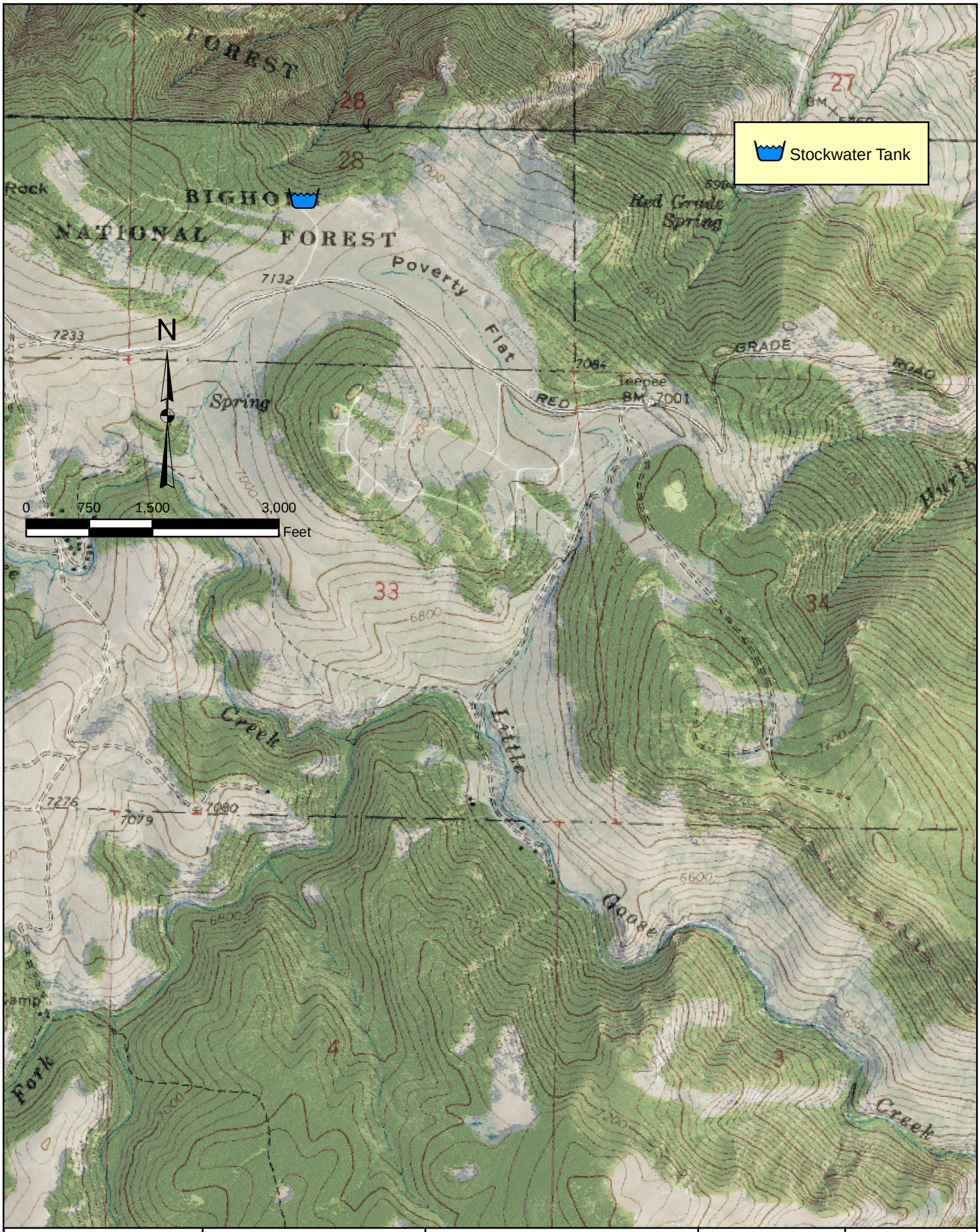
Project Costs

Preparation of Final Design and Specifications	$3,920	
Permitting and Mitigation	$2,000	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$5,920

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$3,600	$3,600
Solar Pumping System, including submersible pump, photovoltaic panels, batteries, wiring	1	EA	$3,300	$3,300
Cistern - 1,000 Gal	LS	LS	$5,000	$5,000
2" Waterline and appurtenances	800	LF	$20	$16,000
Stock tank - 3,000 Gal	LS	LS	$5,000	$5,000
Concrete stock tank foundation	3	CY	$1,500	$4,500
Seeding	1800	SY	$1	$1,800

Total Component Cost (Subtotal #2)	$39,200	
Construction Engineering Cost (Subtotal #2 x 10%)	$3,920	
Components and Engineering Costs (Subtotal #3)	$43,120	
Contingency (Subtotal #3 x 15%)	$6,468	
Construction Cost Total (Subtotal #4)		$49,588
Total Project Cost (Subtotal #1 + Subtotal #4)		$55,508



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	**GOOSE CREEK WATERSHED LEVEL I STUDY**	**UPLAND WATER DEVELOPMENT OPPORTUNITY**	**UWDO-05**

Project Name: Poverty Flat Upland Water Development

Project ID:	**UWDO-05**	**Structure Type:**	**Stockwater Tank Enlargement**
		Coordinates:	44.622535, -107.106347
Contact Persons:	Orrin Connell, RC Ranch		
Description:	Install 12,000 gallon storage tank and watering trough to replace two 12' diameter existing stockwater tanks. The proposed site is on the Bighorn National Forest. The JC Ranch holds a grazing lease from the BNF at this location. The source of water would continue to be the same source as that used by the Blacktooth Subdivision. In late summer, there is a limited supply available due to use by the subdivision homeowners, thus the need for the larger-sized tank.		
Project Benefits:	Development of existing water supplies.		

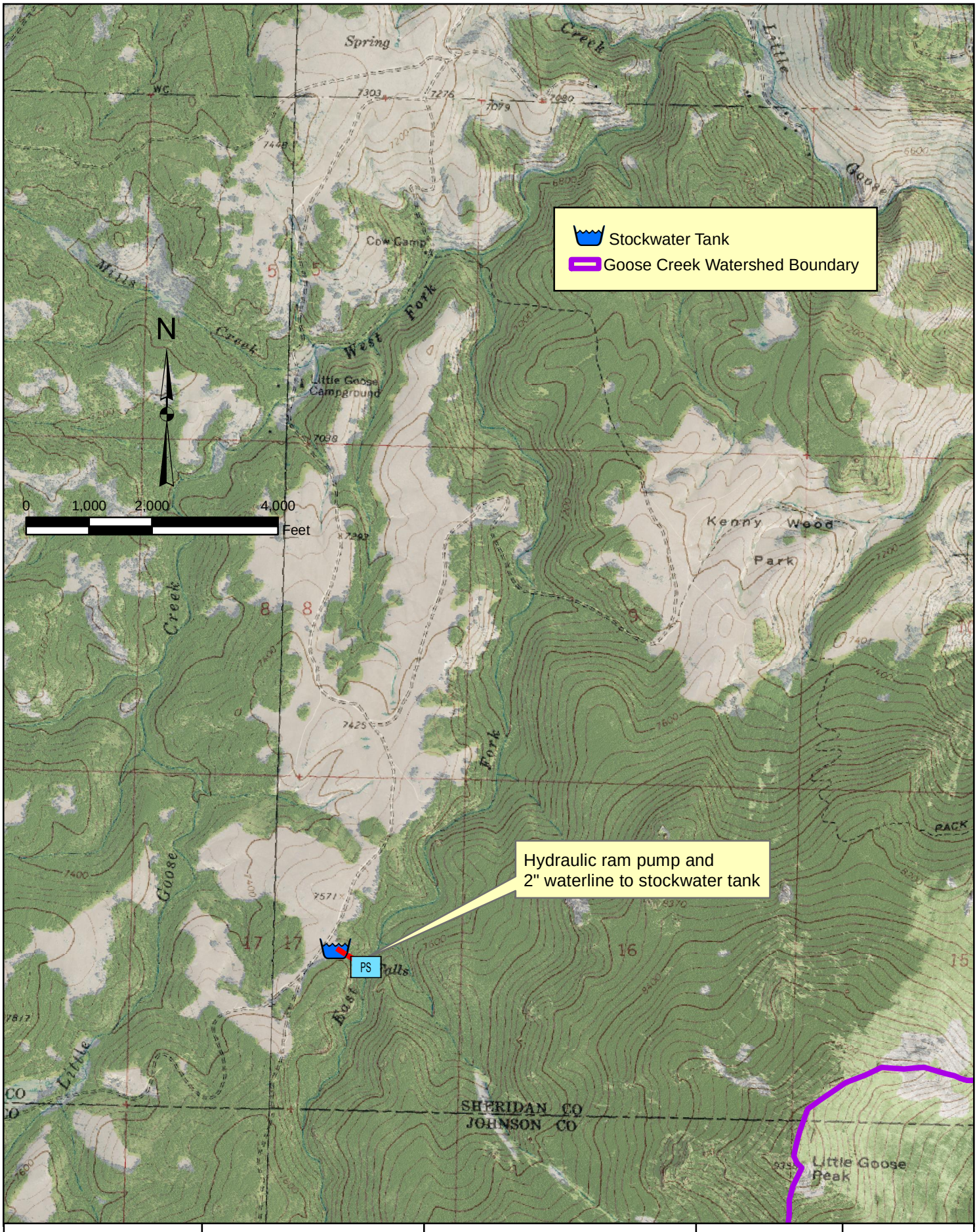
Project Costs

Preparation of Final Design and Specifications	$3,170	
Permitting and Mitigation	$2,000	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$5,170

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$3,000	$3,000
Demo existing tank system	LS	LS	$1,000	$1,000
Miscellaneous piping to connect new stockwater tank	LS	LS	$1,000	$1,000
Stock tank - 12,000 Gal	1	EA	$15,000	$15,000
Concrete tank foundation	7	CY	$1,500	$10,500
Tank Bolt-down system	LS	LS	$1,000	$1,000
Seeding	LS	LS	$200	$200

Total Component Cost (Subtotal #2)	$31,700	
Construction Engineering Cost (Subtotal #2 x 10%)	$3,170	
Components and Engineering Costs (Subtotal #3)	$34,870	
Contingency (Subtotal #3 x 15%)	$5,231	
Construction Cost Total (Subtotal #4)		$40,101
Total Project Cost (Subtotal #1 + Subtotal #4)		$45,271



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	**GOOSE CREEK WATERSHED LEVEL I STUDY**	**UPLAND WATER DEVELOPMENT OPPORTUNITY**	**UWDO-06**

Project Name: East Fork Little Goose Creek Upland Water Development

Project ID:	**UWDO-06**	**Structure Type:**	**Hydraulic Ram Pump, Pipeline and Stockwater Tank**
		Coordinates:	44.564270, -107.120054
Contact Persons:	Orrin Connell, RC Ranch		
Description:	Install hydraulic ram pump, pipeline and stockwater tank. The proposed site is on the Bighorn National Forest. The JC Ranch holds a grazing lease from the BNF at this location. The water source would be Little Goose Creek. The hydraulic ram pump is proposed for use due to lack of electric power and lack of applicable sunlight along the creek.		
Project Benefits:	Development of existing water supplies.		

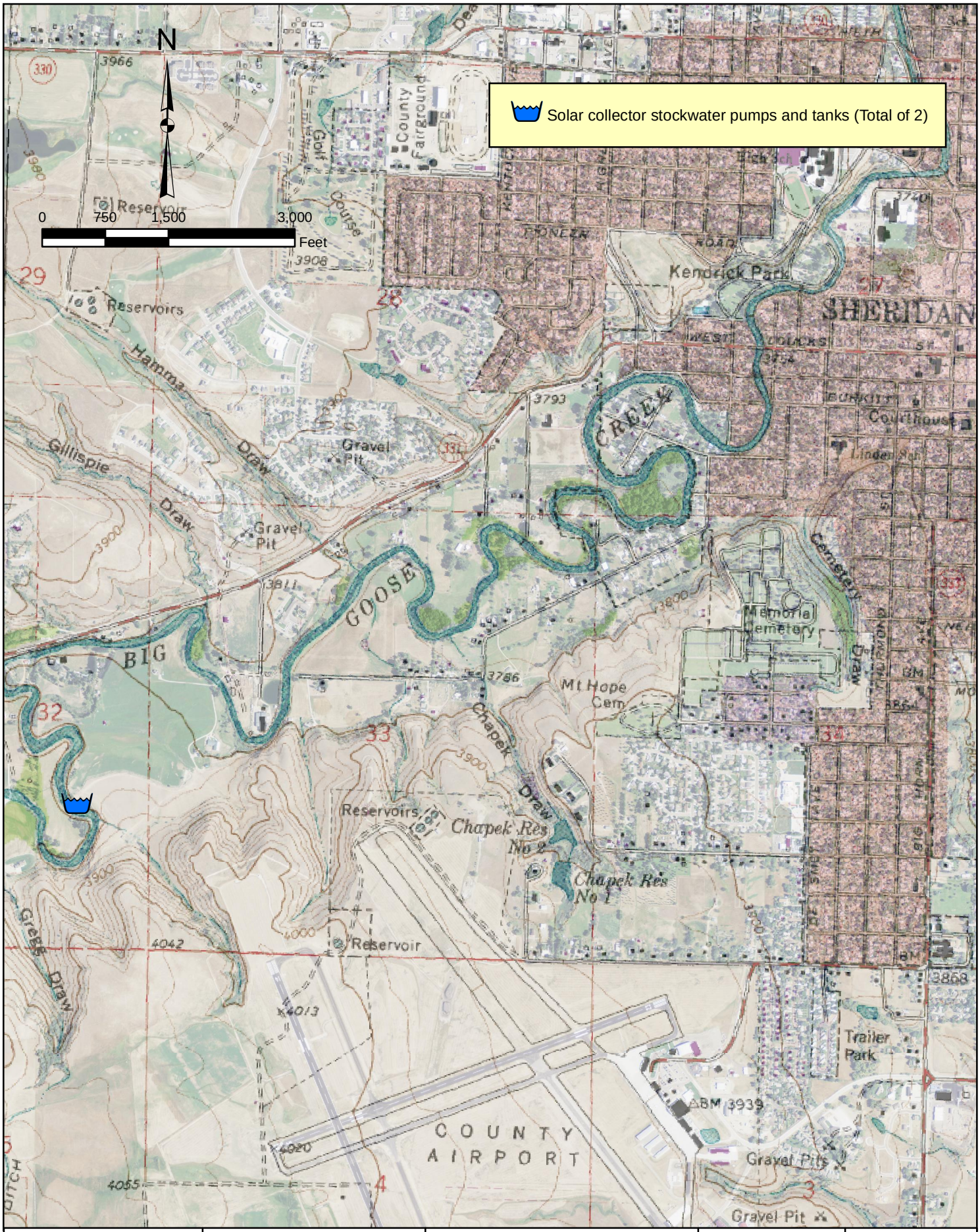
Project Costs

Preparation of Final Design and Specifications				$2,190	
Permitting and Mitigation				$1,000	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$2,000	
			Pre-Construction Costs (Subtotal #1)		$5,190

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$2,000	$2,000
Solar Pumping System, including submersible pump, photovoltaic panels, batteries, wiring	1	EA	$3,300	$3,300
2" Waterline and appurtenances	600	LF	$20	$12,000
Stock tank	1	EA	$3,200	$3,200
Seeding	1400	SY	$1	$1,400

Total Component Cost (Subtotal #2)	$21,900	
Construction Engineering Cost (Subtotal #2 x 10%)	$2,190	
Components and Engineering Costs (Subtotal #3)	$24,090	
Contingency (Subtotal #3 x 15%)	$3,614	
Construction Cost Total (Subtotal #4)		$27,704
Total Project Cost (Subtotal #1 + Subtotal #4)		$32,894



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	**GOOSE CREEK WATERSHED LEVEL I STUDY**	**UPLAND WATER DEVELOPMENT OPPORTUNITY**	**UWDO-07**

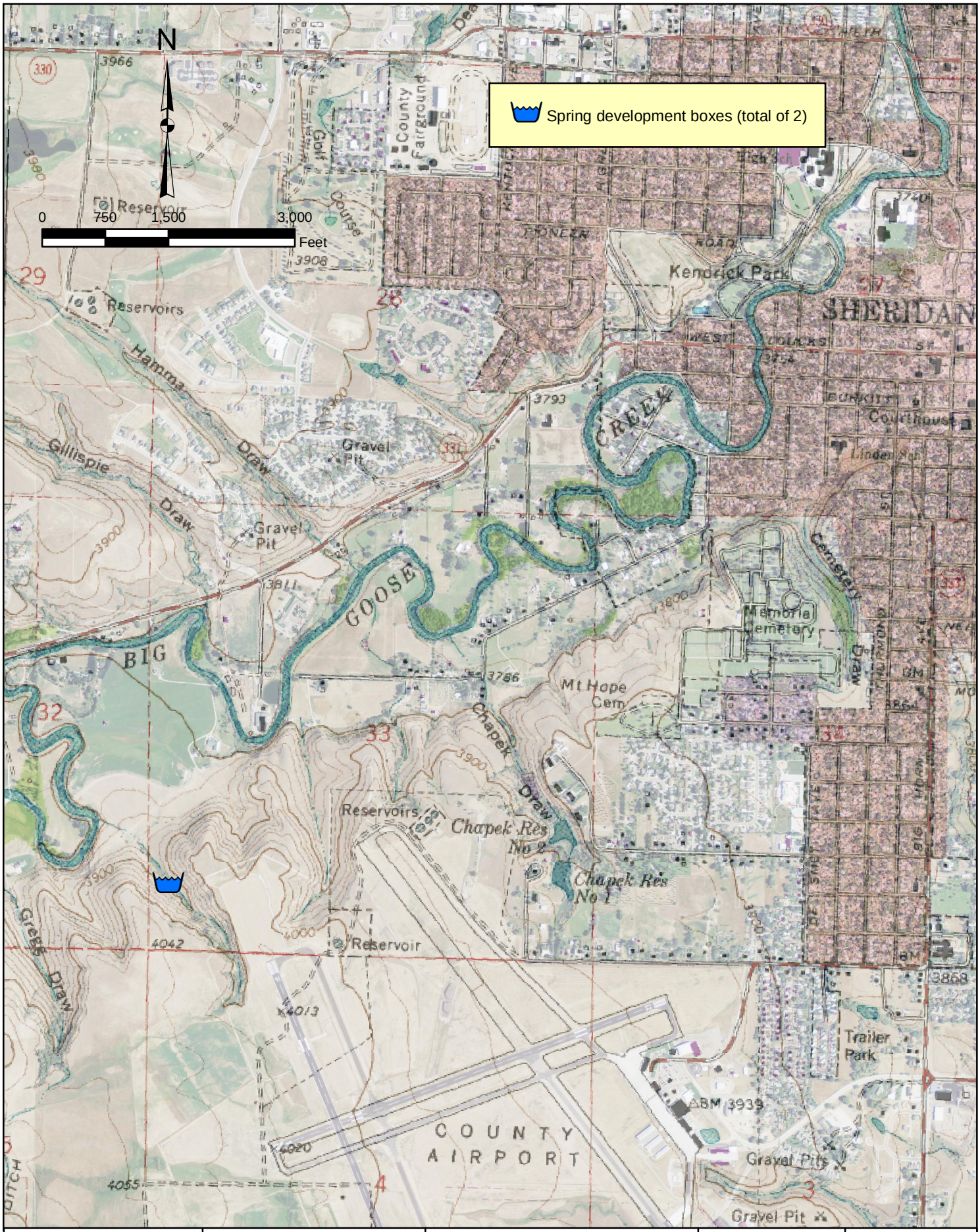
Project Name:	Flume Ditch Solar Collector Stockwater Pumping Systems		
Project ID:	**UWDO-07**	**Structure Type:**	**Solar Collector Stockwater Pumping Systems**
Ditch Name:	Flume Ditch	Coordinates:	44.781979, -106.99674
Contact Persons:	Corey Jost		
Description:	Install two solar collector stockwater pumping systems. These pumping systems will utilize available shallow groundwater to provide stockwater, including during the winter months when it is currently required to chip ice on Big Goose Creek to provide stockwater.		
Project Benefits:	Development of existing water supplies.		

Project Costs

Preparation of Final Design and Specifications				$1,705	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$0	
			Pre-Construction Costs (Subtotal #1)		$1,705

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price	
Mobilization	LS	LS	$1,550	$1,550	
Solar Pumping System, including submersible pump, photovoltaic panels, batteries, wiring	2	EA	$3,300	$6,600	
2" Waterlines and appurtenances	100	LF	$20	$2,000	
Stock tank	2	EA	$3,200	$6,400	
Reclamation	LS	LS	$500	$500	
			Total Component Cost (Subtotal #2)	$17,050	
			Construction Engineering Cost (Subtotal #2 x 10%)	$1,705	
			Components and Engineering Costs (Subtotal #3)	$18,755	
			Contingency (Subtotal #3 x 15%)	$2,814	
			Construction Cost Total (Subtotal #4)		$21,569
					$23,274



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	***GOOSE CREEK WATERSHED LEVEL I STUDY***	***UPLAND WATER DEVELOPMENT OPPORTUNITY***	***UWDO-08***

Project Name: Flume Ditch Spring Development

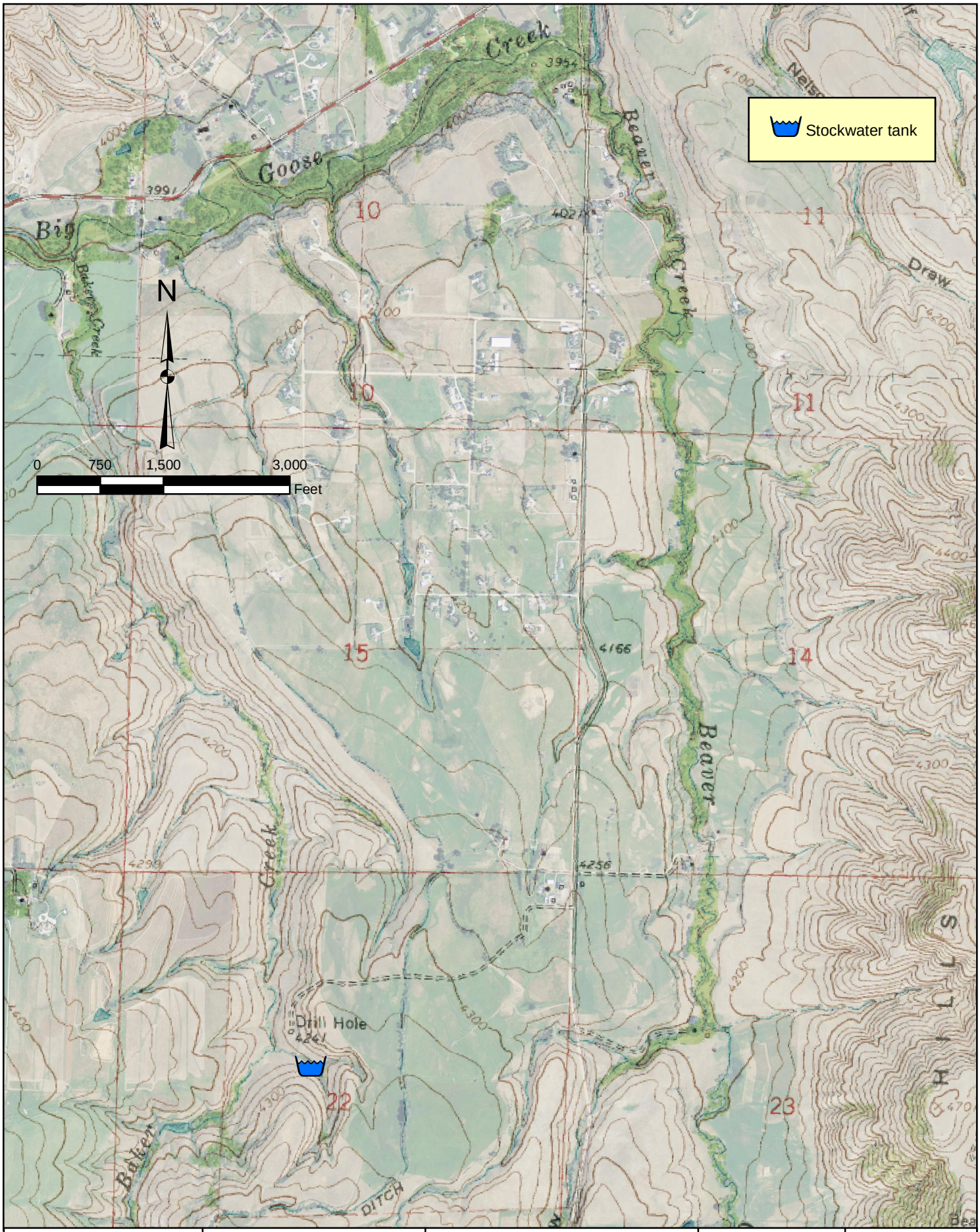
Project ID:	**UWDO-08**	**Structure Type:**	**Spring Development**
Ditch Name:	Flume Ditch	Coordinates:	44.779484, -106.992487
Contact Persons:	Corey Jost		
Description:	Develop two springs resulting from seeps coming from the hillside along the north edge of the Airport. (The springs may be seepage coming from the Colorado Colony Ditch.)		
Project Benefits:	Increasing and extending irrigation water availability.		

Project Costs

Preparation of Final Design and Specifications				$1,312	
Permitting and Mitigation				$0	
Legal Fees				$0	
Acquisition of Access and Rights-of-Way				$0	
				Pre-Construction Costs (Subtotal #1)	$1,312

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price	
Mobilization	LS	LS	$1,193	$1,193	
Spring box (4' diameter concrete manhole with lid)	2	EA	$4,000	$8,000	
4" Perforated Collector Pipe	50	LF	$15	$750	
Gravel pack	15	CY	$45	$675	
2" Supply Pipe	100	LF	$20	$2,000	
Reclamation	LS	LS	$500	$500	
			Total Component Cost (Subtotal #2)	$13,118	
			Construction Engineering Cost (Subtotal #2 x 10%)	$1,312	
			Components and Engineering Costs (Subtotal #3)	$14,429	
			Contingency (Subtotal #3 x 15%)	$2,164	
			Construction Cost Total (Subtotal #4)		$16,594
			Total Project Cost (Subtotal #1 + Subtotal #4)		$17,905



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	**GOOSE CREEK WATERSHED LEVEL I STUDY**	**UPLAND WATER DEVELOPMENT OPPORTUNITY**	**UWDO-09**

Project Name: Clark Upland Water Development

Project ID:	**UWDO-09**	**Structure Type:**	**Spring Development**
		Coordinates:	44.727119, -107.085558
Contact Persons:	Dan Reinke		
Description:	Install stockwater tank and piping. Dan Reinke leases land from Jane Clark along Beaver Creek. He winters cattle in that area, and would like to have a pipeline conveying water from a water source (Beaver Creek or springs) that would be piped underground, then daylight at a tank. Water being conveyed via pipe will be warmer (because it has been underground) and would thus less prone to freezing. It is proposed to be a gravity system.		
Project Benefits:	Development of existing water supplies.		

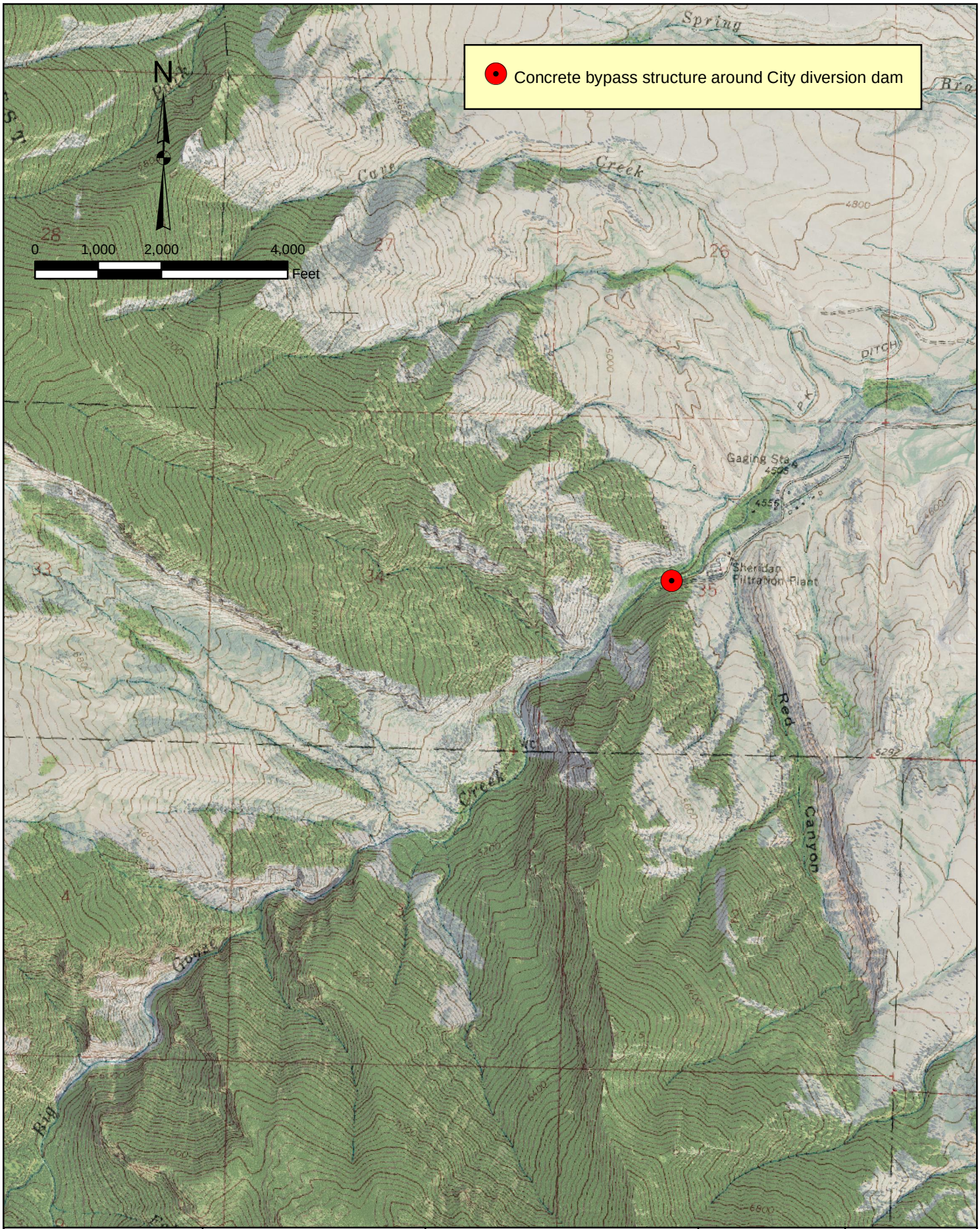
Project Costs

Preparation of Final Design and Specifications	$627	
Permitting and Mitigation	$0	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$0	
Pre-Construction Costs (Subtotal #1)		$627

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$570	$570
2" Waterlines and appurtenances	100	LF	$20	$2,000
Stock tank	1	EA	$3,200	$3,200
Reclamation	LS	LS	$500	$500

Total Component Cost (Subtotal #2)	$6,270	
Construction Engineering Cost (Subtotal #2 x 10%)	$627	
Components and Engineering Costs (Subtotal #3)	$6,897	
Contingency (Subtotal #3 x 15%)	$1,035	
Construction Cost Total (Subtotal #4)		$7,932
Total Project Cost (Subtotal #1 + Subtotal #4)		$8,559



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	**GOOSE CREEK WATERSHED LEVEL I STUDY**	**FISHERIES MITIGATION PROJECT**	**FM-BG-CS-01**

Project Name: City of Sheridan Intake Diversion Dam Fish Ladder

Project ID:	**FM-BG-CS-01**	**Structure Type:**	**Fish Ladder**
Ditch Name:	Sheridan Raw Water Pipelines	Coordinates:	44.697177, -107.188601
Contact Persons:	Dan Roberts, City of Sheridan Utilities Division Manager		
Description:	The existing City of Sheridan diversion dam diverts raw water into pipelines which deliver water to its two treatment plants, the Kendrick Golf Course and the VA Medical Center. This diversion dam is a large concrete structure approximately 10' high that spans Big Goose Creek. This dam height inhibits fish passage up Big Goose Creek, and therefore should be modified to accommodate fish passage. The proposal is to install a fish ladder along the north side of the diversion dam to allow for this passage.		
Project Benefits:	Improve fish habitat by allowing migration around existing diversion dam.		

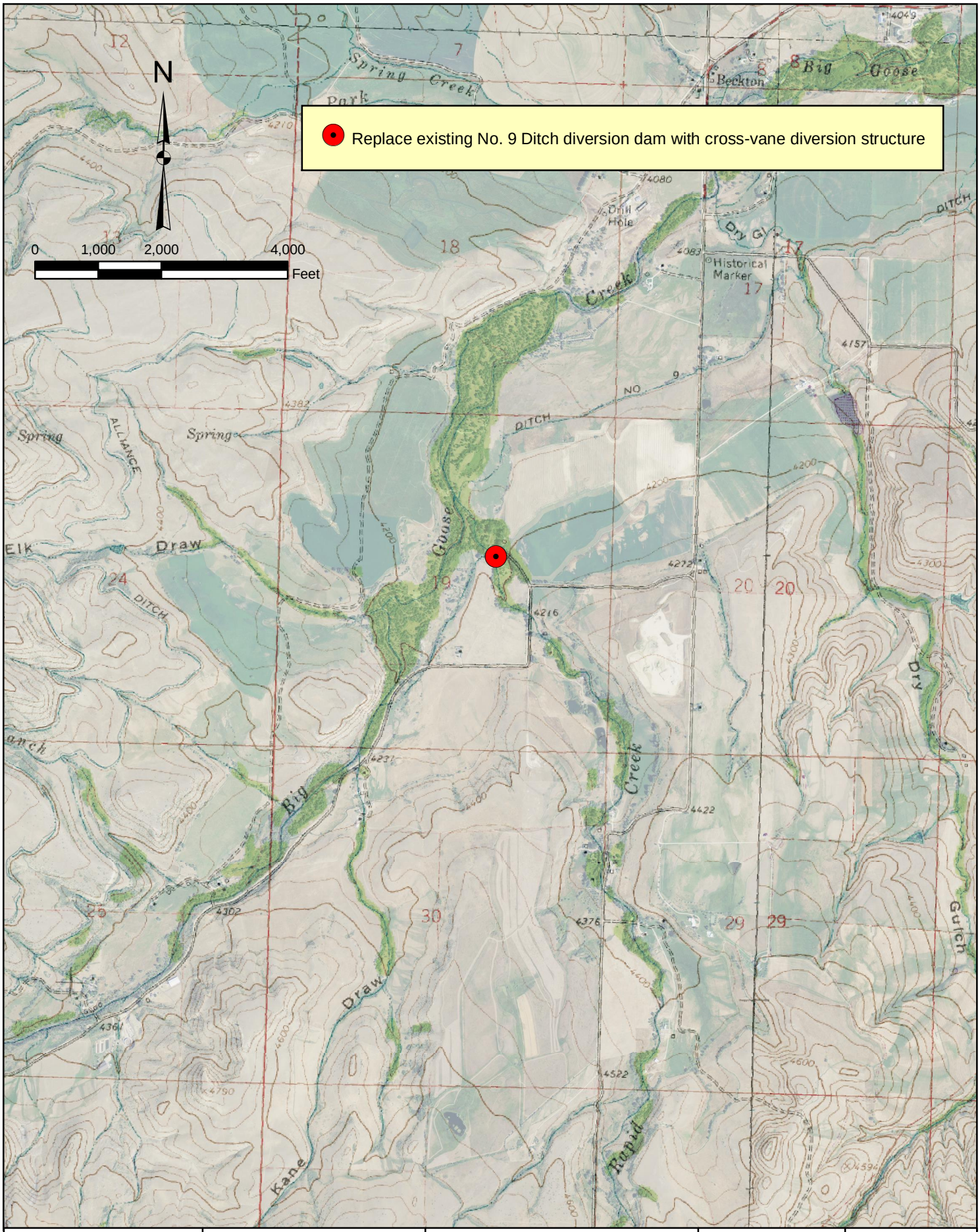
Project Costs

Preparation of Final Design and Specifications	$21,430	
Permitting and Mitigation	$3,000	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$2,000	
Pre-Construction Costs (Subtotal #1)		$26,430

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$15,000	$15,000
Clearing and Grubbing	1	LS	$50,000	$50,000
Reinforced Concrete Structure > 25 CY	150	CY	$750	$112,500
Rock; Diam. >3'	10	EA	$270	$2,700
Excavation (Small Structure)	500	CY	$34	$17,000
Rip Rap (large) 36"	100	CY	$140	$14,000
Headgate 36"	1	EA	$3,100	$3,100

Total Component Cost (Subtotal #2)	$214,300	
Construction Engineering Cost (Subtotal #2 x 10%)	$21,430	
Components and Engineering Costs (Subtotal #3)	$235,730	
Contingency (Subtotal #3 x 15%)	$35,360	
Construction Cost Total (Subtotal #4)		$271,090
Total Project Cost (Subtotal #1 + Subtotal #4)		$297,520



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	**GOOSE CREEK WATERSHED LEVEL I STUDY**	**FISHERIES MITIGATION PROJECT**	**FM-BG-N9-01**

Project Name: No. 9 Ditch Diversion Dam Replacement

Project ID:	**FM-BG-N9-01**	**Structure Type:**	**Diversion Dam**
Ditch Name:	#9 Ditch	Coordinates:	44.729181, -107.144091
Contact Persons:	Jim Spell, Dan Reinke		
Description:	Replace existing diversion dam on Rapid Creek. The existing diversion dam is an old Civilian Conservation Corps concrete structure that is in poor condition. It is often necessary to place plastic tarps in the stream in order to check the water up enough to get it into the ditch.The proposed solution is a cross-vane type of diversion dam to improve flow into the ditch while accommodating fish passage through the structure.		
Project Benefits:	Increasing and extending irrigation water availability, accommodating fish habitat by allowing for migration through diversion facilities.		

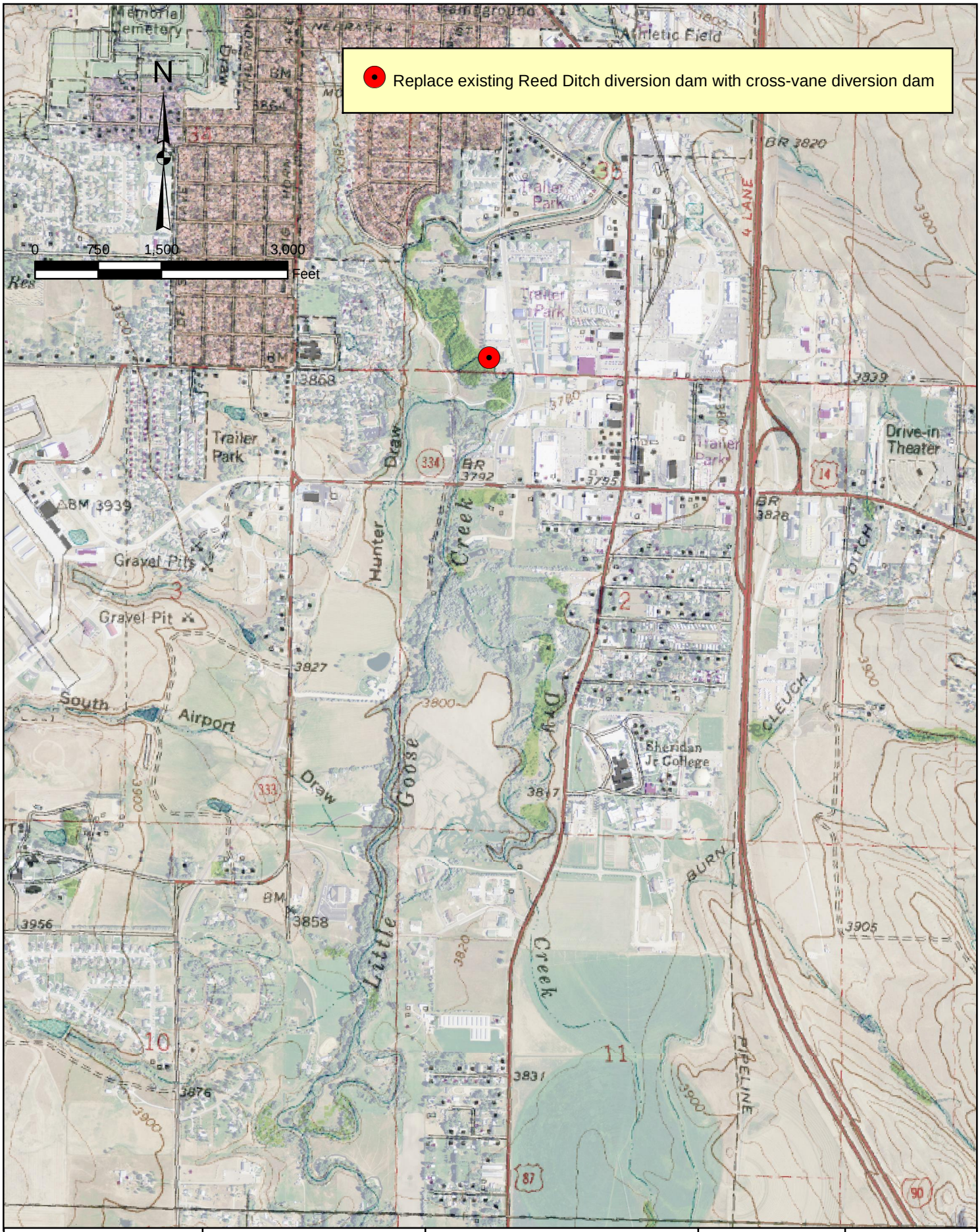
Project Costs

Preparation of Final Design and Specifications	$12,615	
Permitting and Mitigation	$2,000	
Legal Fees	$1,000	
Acquisition of Access and Rights-of-Way	$2,000	
Pre-Construction Costs (Subtotal #1)		$17,615

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$11,500	$11,500
Demo/remove Existing Diversion Dam	1	CY	$1,100	$1,100
Unclassified Excavation	1,000	CY	$9	$9,000
Embankment Fill (Large Structure)	1,250	CY	$6	$7,500
Controlled Density Fill	10	CY	$125	$1,250
Concrete Block: 5' x 2.5' x 2.5'	140	EA	$300	$42,000
Geotextile Fabric	100	SY	$9	$900
Aggregate, 2" Minus	270	CY	$150	$40,500
Rock; Diam. >3'	20	EA	$270	$5,400
Reclamation	1	LS	$7,000	$7,000

Total Component Cost (Subtotal #2)	$126,150	
Construction Engineering Cost (Subtotal #2 x 10%)	$12,615	
Components and Engineering Costs (Subtotal #3)	$138,765	
Contingency (Subtotal #3 x 15%)	$20,815	
Construction Cost Total (Subtotal #4)		$159,580
Total Project Cost (Subtotal #1 + Subtotal #4)		$177,195



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	**GOOSE CREEK WATERSHED LEVEL I STUDY**	**FISHERIES MITIGATION PROJECT**	**FM-LG-RE-01**

Project Name: Reed Ditch Diversion Dam Rehabilitation

Project ID:	**FM-LG-RE-01**	**Structure Type:**	**Diversion Dam**
Ditch Name:	Reed	Coordinates:	44.777374, -106.948075
Contact Persons:	Rolland Culligan, Jerry Burgess		
Description:	This cross-vane diversion dam was installed approximately five years ago during the Little Goose stream improvements project. Since being built, too much water flows through the structure, which prevents enough water from being checked up and into the ditch. This project would provide a means to seal the structure to improve flow into the ditch.		
Project Benefits:	Increasing and extending irrigation water availability, improve fish habitat by allowing for migration through diversion facilities.		

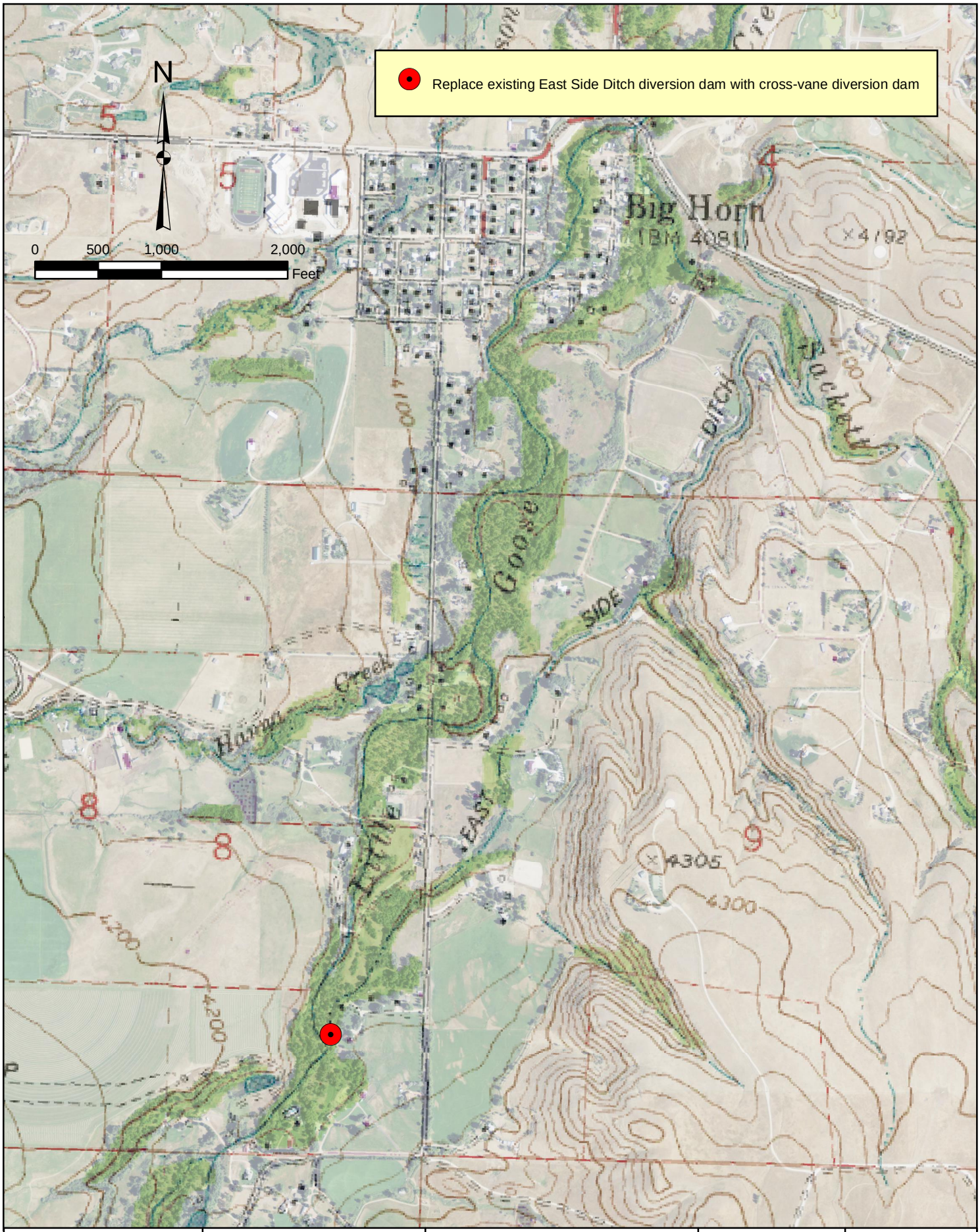
Project Costs

Preparation of Final Design and Specifications	$2,454	
Permitting and Mitigation	$2,000	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$1,000	
Pre-Construction Costs (Subtotal #1)		$5,454

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$3,000	$3,000
Unclassified Excavation	60	CY	$7	$420
Geotextile Fabric	80	SY	$8	$640
Aggregate, 2' Minus	60	CY	$150	$9,000
Rock; Diam. >3'	24	EA	$270	$6,480
Reclamation	LS	LS	$5,000	$5,000

Total Component Cost (Subtotal #2)	$24,540	
Construction Engineering Cost (Subtotal #2 x 10%)	$2,454	
Components and Engineering Costs (Subtotal #3)	$26,994	
Contingency (Subtotal #3 x 15%)	$4,050	
Construction Cost Total (Subtotal #4)		$31,044
Total Project Cost (Subtotal #1 + Subtotal #4)		$36,498



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	**GOOSE CREEK WATERSHED LEVEL I STUDY**	**FISHERIES MITIGATION PROJECT**	**FM-LG-ES-01**

Project Name: East Side Ditch Diversion Dam Replacement

Project ID:	**FM-LG-ES-01**	**Structure Type:**	**Diversion Dam**
Ditch Name:	East Side Ditch	Coordinates:	44.663473, -106.995688
Contact Persons:	Steve Pattison, East Side Ditch Company		
Description:	Replace existing rock diversion dam with a new cross-vane diversion dam.		
Project Benefits:	Increasing and extending irrigation water availability, improve fish habitat by allowing for migration through diversion facilities.		

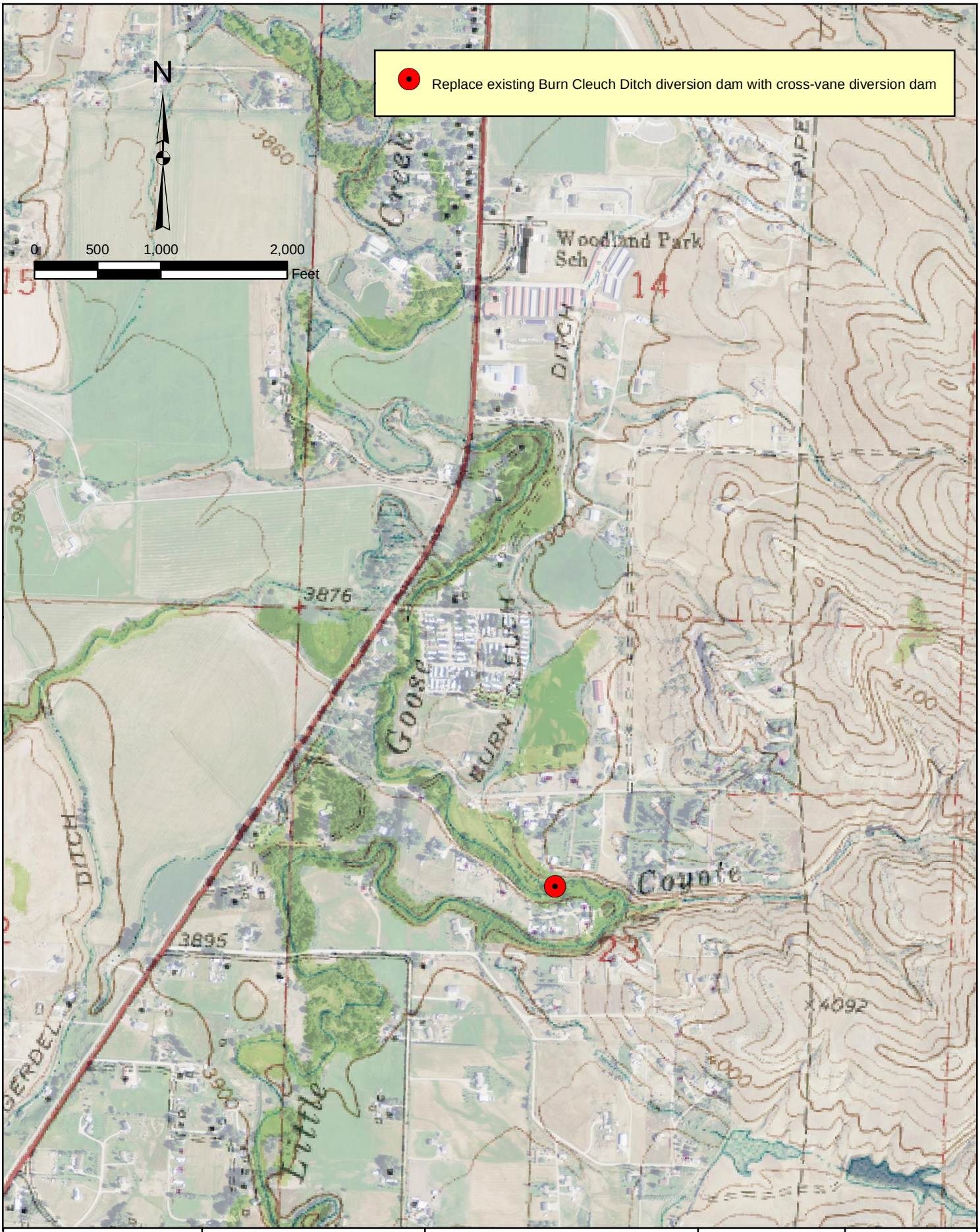
Project Costs

Preparation of Final Design and Specifications	$16,991	
Permitting and Mitigation	$2,000	
Legal Fees	$0	
Acquisition of Access and Rights-of-Way	$2,000	
Pre-Construction Costs (Subtotal #1)		$20,991

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	1	LS	$15,500	$15,500
Demo/remove Existing Diversion Dam	1	CY	$1,100	$1,100
Unclassified Excavation	1,400	CY	$9	$12,600
Embankment Fill (Large Structure)	1,700	CY	$6	$10,200
Controlled Density Fill	14	CY	$125	$1,750
Concrete Block: 5' x 2.5' x 2.5'	190	EA	$300	$57,000
Geotextile Fabric	140	SY	$9	$1,260
Aggregate, 2" Minus	360	CY	$150	$54,000
Rock; Diam. >3'	30	EA	$270	$8,100
Reclamation	1	LS	$8,400	$8,400

Total Component Cost (Subtotal #2)	$169,910	
Construction Engineering Cost (Subtotal #2 x 10%)	$16,991	
Components and Engineering Costs (Subtotal #3)	$186,901	
Contingency (Subtotal #3 x 15%)	$28,036	
Construction Cost Total (Subtotal #4)		$214,937
Total Project Cost (Subtotal #1 + Subtotal #4)		$235,928



EnTech Inc. Professional Engineers	SWCA Anderson Consulting Engineers, Inc. Civil • Water Resources • Environmental	**GOOSE CREEK WATERSHED LEVEL I STUDY**	**FISHERIES MITIGATION PROJECT**	**FM-LG-BU-01**

Project Name: Burn-Cleuch Ditch Diversion Dam

Project ID:	**FM-LG-BU-01**	**Structure Type:**	**Diversion Dam**
Ditch Name:	Burn-Cleuch Ditch	Coordinates:	44.727582, -106.944356
Contact Persons:	Oscar Rucki, Burn-Cleuch Ditch Company		
Description:	Install new diversion dam in order to alleviate existing problem of placement of checkboards into concrete slots within existing diversion dam in Little Goose Creek. The new diversion dam would also provide for fish passage through the diversion structure.		
Project Benefits:	Increasing and extending irrigation water availability, improve fish habitat by allowing for migration through diversion facilities.		

Project Costs

Preparation of Final Design and Specifications	$24,530	
Permitting and Mitigation	$2,000	
Legal Fees	$1,000	
Acquisition of Access and Rights-of-Way	$2,000	
Pre-Construction Costs (Subtotal #1)		$29,530

Cost of Project Components

Item Description	Quantity	Unit	Unit Cost	Extended Price
Mobilization	LS	LS	$23,000	$23,000
Unclassified Excavation	2,000	CY	$7	$14,000
Fill	2,500	CY	$8	$20,000
Controlled Density Fill	20	CY	$125	$2,500
Concrete Block: 5' x 2.5' x 2.5'	280	EA	$280	$78,400
Geotextile Fabric	200	SY	$8	$1,600
Aggregate, 2' Minus	540	CY	$150	$81,000
Rock; Diam. >3'	40	EA	$270	$10,800
Reclamation	LS	LS	$14,000	$14,000

Total Component Cost (Subtotal #2)	$245,300	
Construction Engineering Cost (Subtotal #2 x 10%)	$24,530	
Components and Engineering Costs (Subtotal #3)	$269,830	
Contingency (Subtotal #3 x 15%)	$40,475	
Construction Cost Total (Subtotal #4)		$310,305
Total Project Cost (Subtotal #1 + Subtotal #4)		$339,835