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

Final Report

Cottonwood/Grass Creek Watershed Management Plan

Level I Study

Submitted to:

Wyoming Water Development Commission

Submitted by:

Short Elliott Hendrickson Inc.

In association with:

Anderson Consulting Engineers, Inc.
Donald A. Tranas, Range Consultant

October 10, 2007

Cottonwood/Grass Creek Watershed Management Plan
Level I Study

SEH No. A-WWDCO0602.00

October 10, 2007

I hereby certify that this report was prepared by me or under my direct supervision, and that I am a duly Licensed Professional Engineer under the laws of the State of Wyoming.

Douglas M. Yadon, PE

Date: 10/10/07 Reg. No.: PE-4650

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Table of Contents

List of Tables

List of Figures

List of Appendices

Final Report

Cottonwood/Grass Creek Watershed Management Plan Level I Study

Prepared for Wyoming Water Development Commission

1.0 Introduction

1.1 Purpose and Scope

The primary purposes of the Cottonwood Creek Watershed Management Plan, Level I Study are to:

- Inventory all conditions in the watershed relevant to identification and characterization of water resource related issues and opportunities.
- Develop a watershed management and rehabilitation plan describing potential alternative projects and management strategies to address water resource related issues and potential water development opportunities identified in the watershed inventory, including conceptual-level design of major projects (i.e., dams and reservoirs).
- Assess the potential environmental issues or constraints that may affect the projects/strategies identified in the watershed management and rehabilitation plan, and identify and characterize the permits/clearances and any associated environmental studies and/or mitigation that may be required.
- Develop conceptual-level estimates of the costs of the potential projects identified in the watershed management and rehabilitation plan.
- Perform preliminary economic analyses of major project alternatives (i.e., dams and reservoirs), including assessment of project benefits and sponsor ability to pay assuming WWDC financing, and identify and describe potential funding sources for all potential project types identified in the watershed management and rehabilitation plan.

The scope of this study addresses each of the above primary purposes in turn, and is fully responsive to the Scope of Services in Exhibit "A" of the Consultant Contract for Services.

1.2 Responsibility

This project was authorized by the Consultant Contract for Services effective June 16, 2006 between the Wyoming Water Development Commission (WWDC) and Short Elliott Hendrickson Inc. (SEH). The official contractual representative for the WWDC was Lawrence M. Besson, Director of the Wyoming Water Development

Office (WWDO). Ron Vore served as the WWDO Project Manager and primary point of contact for SEH on both technical and administrative matters.

SEH's Project Manager for this study was Douglas M. Yadon, Wyoming PE No. 4650, and all engineering work on the project was performed under his responsible charge. Except as described herein, the work for this project was performed by Mr. Yadon and other selected SEH staff including William R. Kelly, PE, Alan C. Jewell, PE, Aaron S. Ritter, EIT, Brian Kennedy, Christopher Wichmann, and Amber Leyba. Anderson Consulting Engineers, Inc. (ACE) of Fort Collins, Colorado performed the stream geomorphology and irrigation inventory and rehabilitation plan tasks, reviewed and utilized the existing Wind/Big Horn Basin plan model, assisted in the remainder of the surface water hydrology task, and developed the project GIS and geodatabase. The work by ACE was led by Jay Schug under the direction of Brad Anderson, PE. Don Tranas of Greybull, Wyoming performed the assessment of range and related vegetation conditions, and assisted in the development of potential wildlife/stock watering projects and range management practices.

Numerous landowners, irrigators and ranchers, staff of the Hot Springs and Washakie County Conservation Districts, Hot Springs and Washakie County Weed and Pest, Wyoming Department of Agriculture, Thermopolis and Worland offices of the NRCS, Worland office of the BLM, and employees of Merit Energy Company, Rocky Mountain Pipeline Company, Marathon Oil and Pipeline Companies, High Plains Power, and Rocky Mountain Power all provided valuable information and assistance throughout the project. This included but was not limited to: supporting acquisition of site access as necessary; accompanying study team members during numerous site reconnaissance visits; providing information on a wide range of topics, including especially irrigation practices and needs in the study area; and assisting in developing and screening potential alternative storage concepts/sites and other watershed management and rehabilitation measures.

1.3 Review of Background Information

A substantial effort was made to identify and collect relevant and applicable background information on all of the key topics and tasks of this Level I study. This included, but was not necessarily limited to, seeking information from the following sources:

- U.S. Bureau of Land Management (BLM)
- U.S. Forest Service (USFS), U.S. Geological Survey (USGS)
- U.S. Department of Agriculture/Natural Resources Conservation Service (NRCS)
- U.S. Department of Agriculture/Farm Service Agency (FSA)
- U.S. Environmental Protection Agency (EPA)
- U.S. Fish and Wildlife Service (FWS)
- U.S. Bureau of Reclamation (USBR)
- Wyoming Water Development Commission (WWDC)
- Wyoming Department of Environmental Quality (WDEQ)
- Wyoming Game and Fish Department (WGFD)
- Wyoming State Engineer's Office (WSEO)

- Wyoming Oil and Gas Conservation Commission (WOGCC)
- Wyoming State Geological Survey (WSGS)
- Wyoming Board of Land Commissioners/State Lands and Investments Board (WBLC/SLIB)
- Wyoming Wildlife and Natural Resources Trust (WWNRT)
- Wyoming Geographic Information Science Center (WyGISC)
- Hot Springs County Assessor's Office
- Hot Springs Conservation District
- Hot Springs County Weed and Pest District
- Washakie County Assessor's Office
- Washakie County Conservation District
- Washakie County Weed and Pest District
- Merit Energy Company
- Rocky Mountain Pipeline Company
- Marathon Oil Company/Marathon Pipeline Company
- High Plains Power, Inc.
- Rocky Mountain Power
- The Nature Conservancy
- National Fish and Wildlife Foundation
- Ducks Unlimited
- Trout Unlimited

Information was acquired from these agencies and entities by one or more of the following methods: download from their internet site, acquisition of published materials from the agency/entity or libraries, telephone/email contacts, and personal visits.

Knowledgeable landowners, ranchers, irrigators and other individuals in the project area were also contacted for information on a variety of topics including but not limited to: irrigation practices and shortages, potential dam and reservoir sites, potential spring developments, existing wildlife/livestock watering systems, and the history of Hamilton Dome water discharges.

The information gathered through these efforts formed the basis for the watershed description and inventory presented in Section 2.0 below, as well as all subsequent tasks.

1.4 Project Geographic Information System (GIS)

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

One of the primary objectives of this GIS was to utilize as much of the previously available information pertaining to this area as practical and to combine it with new GIS data generated within this project. A vast amount of spatial data and imagery is available free of charge for download via the Internet from various federal, state, and local agency websites. Sources include:

- Wyoming Water Resources Data System (WRDS),
- Wyoming Geographic Information Science Center (WyGISC), and
- Natural Resources Conservation Service's (NRCS) Spatial Data Gateway.

Information collected from these sources and incorporated into the project GIS included spatial data such as roads, hydrography, public lands survey (PLSS) and background mapping (color infrared photography, topographic mapping, etc.). These sources were accessed early in the study and a preliminary GIS was constructed upon which all information collected or generated during the investigation was added.

Additional agencies contacted that provided spatial data incorporated into the geodatabase include:

- United States Bureau of Land Management – Worland Field Office
- Natural Resources Conservation Service (Thermopolis)
- United States Geological Survey
- Wyoming Water Development Commission
- Wyoming Department of Environmental Quality
- Washakie County
- Hot Springs County

In addition, data collected during the completion of field and office efforts were incorporated into the geodatabase where appropriate. These data sets include, but are not limited to, the following:

- Irrigation system evaluation: field inventory data, digitized irrigated acres, and ditch alignments;
- Geomorphic investigation: field investigation sites and stream classification results;
- Storage opportunities: Potential reservoir locations; and
- Proposed watershed improvement district boundaries.

Appendix M – GIS Coverages contains a list of coverages included in the project GIS and their source.

The project GIS was not intended to be a complete and comprehensive collation of all available spatial data. Only those available themes deemed pertinent to the watershed planning process and agricultural community were incorporated in an effort to keep the size of the project from overwhelming PC capabilities and resources. For example, publicly available spatial data pertaining to information such as hospitals, cemeteries, courthouses, demographics, etc., were not included. Should the project sponsors desire additional information in the future, it can easily be incorporated at that time at their discretion.

Certain GIS themes covering areas larger than the immediate study area were "clipped" to the extent of the study area in an effort to minimize computer requirements and maximize performance of the GIS. All of the spatial data was incorporated into a single geodatabase. The geodatabase is a relational database that contains geographic information stored in feature classes (analogous to shapefiles), as well as tables that contain additional attributes. A geodatabase was chosen to house the majority of the data for efficient transfer of information, simple file management, and to facilitate incorporation into customized tools developed during the course of this project.

In order to transform three-dimensional real-world data into a two-dimensional space, a projected coordinate system was used. This allows for visual enhancement of the data, as well as accurate measurement of distance and area. The Universal Transverse Mercator System (UTM), Zone 12 North was used as the coordinate system for the majority of the data. The UTM coordinate system is typically the most accepted coordinate system for GIS products in the region. Consequently, the data will be able to be readily incorporated without conflict.

1.5 Overview of Study Area and Key Issues

The Cottonwood/Grass Creek watershed is located in Hot Springs and Washakie Counties as shown on Figure 1.5-1 – Study Area Location. The watershed is comprised of the combined drainage basins of Cottonwood Creek and its main tributary, Grass Creek. Lower Cottonwood Creek drains to the Bighorn River at Winchester, approximately four (4) miles north of Kirby. The watershed ranges from sagebrush dominated dissected hills in the east to forested lands in the Shoshone National Forest to the west.

The economy of the watershed is based on agriculture (primarily cattle ranching and associated forage production) and oil and limited natural gas extraction at two larger (Hamilton Dome and Grass Creek) and a number of smaller still active fields. A small open-cut coal mine and several small aggregate pits are also operated within the watershed. Recreation is an integral part of the local economy, including commercial horseback riding, use of a 4H lodge facility in upper Grass Creek, and forest access for hiking, picnicking and camping, among other activities. Existing infrastructure includes paved and maintained gravel roads, electric power transmission and distribution lines, telephone lines, and oil and gas pipelines. There are no towns or services available within the watershed, and relatively few full-time residents.

The Cottonwood/Grass Creek Coordinated Resources Management (CRM) group, comprised of a wide array of landowners, ranchers, irrigators, agency and entity staff, and other interested stakeholders, has been active in promoting study, projects and best management practices in the watershed. During the course of this Level I study a group of landowners in the watershed began and are continuing to pursue establishing a watershed improvement district (WID) that would encompass essentially all of the Cottonwood/Grass Creek watershed and some contiguous lands.

These two groups are supported by the local offices/representatives of numerous local, county, state and federal agencies.

These individuals, groups, and agencies have identified a number of key issues that formed the basis of the scope of work for this watershed management and rehabilitation plan study including, but not necessarily limited to, the following:

- Encroachment of juniper and limber/pinyon pine onto the lower slopes and into the valley bottoms of the mid to upper watershed.
- Encroachment of saltcedar (tamarisk) and Russian olive into the lower reach of Cottonwood Creek and locally into the middle portion of the watershed.
- Enhancement of watering opportunities for wildlife and livestock to better use available range land, and to support protection and/or continuing recovery of riparian and aquatic stream habitat.
- Rehabilitation of existing irrigation infrastructure to more efficiently utilize and manage available and potential additional irrigation water supplies.
- Additional surface water storage to address chronic irrigation shortages and provide, to the extent that physically and legally available water supply allows, other multiple-use benefits including, but not necessarily limited to: enhancement/establishment of late-season stream flows to benefit wildlife, riparian and aquatic habitat, and livestock; wildlife/livestock watering; reduction of flooding and improvement of stream channel/bank stability; lake fishery; water quality improvements; and seasonal recreation.
- Potential groundwater development as a source of supply for wildlife and livestock watering, and possibly local irrigation.

The remainder of this report describes the conditions and issues in the watershed in substantial detail, and presents an array of conceptual-level projects and management practices to address the key issues identified above.

2.0 Watershed Description and Inventory

2.1 Land Uses and Management Activities

2.1.1 Land Ownership

The total land area within the Cottonwood/Grass Creek watershed is 266,110 acres. Of the total, 233,068 acres lie within Hot Springs County and the remaining 33,042 acres (located in the northeastern most portion of the watershed) lie within Washakie County. The distribution of land ownership within the watershed is shown on Figure 2.1-1 – Land Ownership and is summarized on Table 2.1-1 – Land Ownership. Note that there is a slight discrepancy (less than one percent) in the totals of private land ownership as reported by both counties compared to values computed from the BLM statewide GIS file used to compute the state and federal land holdings. The BLM totals for private lands are used herein for consistency with the state and federal totals.

Most of the private ownership in the watershed is located along and in the uplands adjacent to the mainstems of Cottonwood and Grass Creeks and their major tributaries (Twenty One Creek, Wagonhound Creek, Prospect Creek, Spring Gulch and Little Grass Creek). State lands occur both as “school sections” and as irregular parcels (particularly in the upper Grass Creek drainage). All of the U.S. Forest

Service lands are located in the high country at the extreme western end of the watershed, and fall within the Shoshone National Forest/Cody District. The BLM lands, which make up the largest percentage of lands within the watershed (at 60 percent), are predominant in the eastern third, common in the middle third, and present locally in the western third of the watershed. All of the BLM lands are administered by the Worland District.

2.1.2 Proposed Watershed Improvement District

A group of landowners in the Cottonwood/Grass Creek watershed is in the process of forming a watershed improvement district (WID) in accordance with WS 41-8-101 to 41-8-126 and related applicable state statutes. At the time of this report filings of the petitions to establish a WID have been made to both counties, hearings on the petitions have been held and the petitions accepted, and a referendum (vote) has been scheduled. The boundary of the proposed WID is shown on Figure 2.1-2 – Proposed Watershed Improvement District. This boundary encompasses all but a very small portion of the hydrologic (watershed) boundary, as well as some lands outside the actual watershed. These additional lands were included to encompass privately owned parcels and/or selected pastures within grazing allotments the remainder of which fall within the hydrologic watershed boundary. A listing of all lands within the proposed WID (down to quarter-quarter section where necessary) is provided as Appendix A – WID Legal Description to this report.

2.1.3 Transportation and Energy Infrastructure

2.1.3.1 <u>Transportation</u>

The primary transportation routes traversing the Cottonwood/Grass Creek watershed are shown on Figure 2.1-3 – Major Roads and Railroads. These major routes and other non-county maintained dirt roads and two tracks are described in the following paragraphs.

Railroads. The only rail access to the watershed is the BNSF mainline which follows the Bighorn River valley. This rail line intersects the very eastern tip of the watershed at Winchester, where a small yard with sidings is located.

Paved and County-Maintained Gravel Roads. The only through-going paved road in the watershed is Wyoming State Highway 120 which connects Thermopolis and Cody. US Highway 20 parallels the BNSF railroad in the Bighorn River valley again at the very eastern edge of the watershed.

State Highway 170 extends from Thermopolis to just inside the watershed at the southern edge of the Hamilton Dome oil field where pavement ends. The route continues as the unpaved but county-maintained Hamilton Dome Road to its intersection with the unpaved Upper Cottonwood Road. The unpaved Lower and Upper Cottonwood Creek Roads together provide county-maintained access from US Highway 20 at Winchester to Putney Flat and then over the Cottonwood Creek/Owl Creek divide to eventually intersect with State Highway 174 (which provides access to return to Thermopolis via the Owl Creek valley).

State Highway 171 connects the Grass Creek oil field with State Highway 120 to the east. Beyond Grass Creek the pavement ends and the road becomes known as the Grass Creek Road. Two unpaved roads (Enos Creek Road and Four Mile Road) provide alternate county-maintained routes from the Grass Creek valley back to State Highway 120. The Grass Creek Road continues up the mainstem valley all the way into the Shoshone National Forest. A short stretch of unpaved county-maintained road diverges from the Grass Creek Road and accesses the lower Little Grass Creek valley. Sand Draw Road provides access from Kirby on the Bighorn River to the Lower Cottonwood Creek Road.

Other Roads and Two-Tracks. In addition to the paved state highways and county-maintained gravel-surfaced roads there are a number of dirt roads and two-tracks traversing various portions of the watershed. These include, but are not necessarily limited to: access up Wagonhound Creek, Prospect Creek, Spring Gulch, and upper Cottonwood Creek to just beyond the Lake Creek confluence; access to Adam Weiss Peak and the Prospect Creek road from Little Grass Creek; 4WD access most of the way up Twentyone Creek. This latter two-track (believed to more or less follow the old Fort Washakie to Meeteetse stage road) would allow dry-weather 4WD access to the Prospect Creek drainage with some minor local repair of headcut gully erosion in a few locations.

2.1.3.2 Energy Infrastructure

Oil and Gas Pipelines. Detailed information on the location of oil and gas pipelines is not generally available to the public in the interests of infrastructure security. The only public-accessible source of pipeline locations in the area found during this study was from a map dated October 2002 from the following Wyoming State Geological Survey (WSGS) website: http://www.wsgs.uwyo.edu/sid/OG/MS53_NW_Basins.sid. Contacts were made as noted below with several representatives of what were believed to be the primary oil pipeline entities in the watershed. During the course of making these contacts it became apparent that determining the current ownership and specific locations of all potentially relevant pipelines and associated facilities was not feasible given the scope of this Level I study. Enough information was, however, collected to recognize and accommodate in conceptual design and costing the overall scope and nature of potential oil and gas infrastructure conflicts with alternative dam and reservoir sites identified during the study.

The very approximate locations of oil and natural gas pipelines traversing the Cottonwood/Grass Creek watershed from the WSGS website are shown on Figure 2.1-4 – Major Pipelines, with the reported owner name, product and size of each pipeline. Based on the contacts noted above, the current owner/operator of the 6-inch oil pipeline extending east from the Grass Creek field is Marathon Pipeline, a subsidiary of Marathon Oil Company. Although not shown on the website figure, Marathon Pipeline indicates that there is also an 8-inch oil pipeline (apparently owned and operated by Marathon Oil Company rather than Marathon Pipeline Company) extending to the east from the Grass Creek field. Finally, Marathon Pipeline's representative said that the 6-inch pipeline traversing the lower Grass Creek valley terminates at some point and that a 10-inch pipeline extends from that point to the southeast. The pipeline following the lower Grass Creek valley identified as "Amoco Crude Oil – 12", and the pipeline initiating at the Hamilton Dome oil field (identified as Marathon Crude Oil – 6"), are owned/operated by Rocky Mountain Pipeline Company. The "Williston Basin Interstate Natural Gas – 6" pipeline is assumed to be owned/operated by "NG Transmission" based on the information on the one gas pipeline "call before you dig" marker found during site reconnaissance. No reliable contact or other information was found regarding this pipeline during the course of the study.

Of the various pipelines apparently traversing the watershed, there are several that appear to pose potentially significant issues relevant to this study. One of these is the Marathon Crude Oil – 6" pipeline extending from the Grass Creek oil field to some point in the lower Grass Creek valley. Based on discussions with Marathon Pipeline's representative and local field reconnaissance following initial identification of potential new dam and reservoir sites (see Section 2.7.4), the presence and approximate alignment of this pipeline in selected reaches were confirmed as indicated on Figure 2.1-4. As noted above, a 10-inch pipeline reportedly extends to the southeast from the termination of this 6-inch pipeline somewhere in the lower Grass Creek valley. Although not observed during the site reconnaissance, it should be assumed that there is also an 8-inch oil pipeline following a generally similar alignment as the 6-inch line in the Grass Creek valley west of Highway 120. These pipelines (and any related oil field infrastructure such as wells, tanks, local piping/valves, etc.) would need to be relocated to mitigate conflicts with any proposed reservoir storage sites in these reaches of Grass Creek.

Another initially identified and potentially significant pipeline is the portion of the Amoco Crude Oil – 12" pipeline traversing the lower reach of the Grass Creek valley. This pipeline, currently owned/operated by Rocky Mountain Pipeline Company, presents similar issues for any proposed storage site in that reach as the Marathon Oil pipelines. Note that the location of this 12-inch pipeline is more accurately known as its route is shown on publicly available U.S. Geological Survey 7.5-minute topographic quadrangle mapping, and was confirmed by hard-copy alignment maps provided by Rocky Mountain Pipeline and locally by field reconnaissance.

The Marathon Crude Oil – 6" pipeline (now owned/operated by Rocky Mountain Pipeline) extending from the Hamilton Dome oil field to Kirby lies mostly outside the watershed boundary. The only other pipeline shown on the WSGS website map that crosses Grass Creek and Cottonwood Creek is the Marathon Crude Oil – 6" pipeline interconnecting with the Grass Creek – Winchester and the Hamilton Dome – Kirby pipelines. Neither of these pipelines appears to pose any potential conflicts for any of the potential alternative dam and reservoir sites identified during this study.

The location of the Williston Basin Interstate Natural Gas – 6" pipeline shown on Figure 2.1-4 is again known only very approximately. It appears that this alignment mostly traverses uplands with only one crossing each of Grass Creek and Cottonwood Creek. Field reconnaissance and review of aerial imagery in the vicinity of the Grass Creek crossing suggest that this pipeline may follow the Grass Creek Valley for up to one to two miles upstream of the known single-point location shown on Figure 2.4-1.

It is recommended that contact be made with the owner/operators of any pipelines or other oil or gas field infrastructure that may be affected by any water-resources related projects pursued in the watershed. The contacts at the time this report was prepared are Michael J. Good for Marathon Oil (307.867.2311, x223 – office, 307.250.3772 – cell, mjgood@marathonoil.com and Gabriel F. Trevino (713.205.6384 – cell; gftrevino@marathonpetroleum.com) for Marathon Pipeline. The Rocky Mountain Pipeline contact is Charles Ferree (307.864.5593 – office, 307.921.1052 – cell; ccferree@paalp.com). As noted previously, no reliable contact for NG Transmission could be found. Records dated 2006 from the U.S. Department of Transportation, Office of Pipeline Safety website indicate the following contact name and address: Gordon Newmann/NG Transmission, P.O Box 541, 101 Division Street, Worland, Wyoming 82401. However, no telephone listing was found for either Gordon Newmann or NG Transmission in Worland or the surrounding area.

Electric Power Service. Electric power service in the Cottonwood/Grass Creek watershed and surrounding areas is provided primarily by High Plains Power Inc./Thermopolis Division (Kerr, 2007). Service to Marathon Oil Company's Grass Creek field is provided by Rocky Mountain Power (a subsidiary of PacifiCorp). Rocky Mountain Power also has a 230 kV transmission line between Thermopolis and Cody that passes through the watershed. Finally, Western Area Power Administration (WAPA) and Mid-States each have a transmission line also passing through the watershed approximately parallel to and east of the Rocky Mountain Power transmission line. The WAPA line is 230 kV and the Mid-States line is 115 kV. The locations of the High Plains power lines, substations and service locations, the Rocky Mountain Power distribution and transmission line, and the WAPA and Mid-States transmission lines are shown on Figure 2.1-5 – Electric Power Service. Most of the existing High Plains distribution lines are located along the major paved and county-maintained gravel roads in the watershed, providing service to much of the oil and gas industry and private residences/ranches. Industry served includes: the Hamilton Dome oil field; various small oil producers on Wagonhound Bench, in lower Prospect Creek and off of State Highway 120 between lowermost Prospect and Grass Creeks; the Grass Creek coal mine; and a small oil field in the Little Grass Creek drainage. The three transmission lines pass through the watershed in a north-northwest trending corridor more or less parallel to State Highway 120.

Available service from High Plains Power within the watershed ranges from single-phase, 7,200 volt to 3-phase, 14,400/24,900 volts. All of the High Plains lines in the watershed are overhead. Order-of-magnitude costs for adding new overhead service to reasonably accessible locations in the watershed are as follows:

- Single-phase: $25,000-27,000/mi (in-house); assume 15-20 percent surcharge if work is subcontracted
- 3-phase: $40,000/mi; assume 25 percent surcharge if work is subcontracted

Costs would increase if the new service is over rough terrain requiring the use of tracked equipment and/or if poles need to be set in rock. Costs for relocation of existing lines (including RMP's distribution line to Marathon Oil's Grass Creek field) would be generally comparable, but may be somewhat less if existing materials/equipment can be re-used. The order of magnitude cost for relocation of any one of the transmission lines is estimated as $150,000-$200,000/mi.

2.1.4 Irrigation

Irrigated agriculture is a key element of the local economy in the Cottonwood/Grass Creek watershed. Hot Springs County (2005) recognizes agriculture (including livestock grazing as discussed in the following subsection) as "*integral to this community's ability to remain viable with a diverse, sustainable economy*". Agricultural lands (including both irrigated lands and rangeland) provide a wide range of existing and potential values directly or indirectly relevant to watershed function and health, including:

- Protection of critical wildlife habitat;

- Preservation of open space;
- Stabilization of soils and protection of water quality; and
- Recreational opportunities (stream/lake fishing, hunting, sightseeing).

The irrigated agriculture in the Cottonwood/Grass Creek watershed contributing to these values is discussed in the following paragraphs, including: the lands currently being irrigated; the current and potential future cropping pattern; and the irrigation methods used.

Note that evaluation of the potential for developing new irrigated lands was not included in the scope of this Level I study as discussed further in Section 2.7 below. This is not to say, however, that additional lands suitable for irrigation are not present in the watershed. For example, local landowners/irrigators have pointed out that the soils and topography at Putney Flat in the mid to upper Cottonwood Creek basin is ideally suited to highly productive alfalfa and/or hay production if there was adequate water available.

Irrigated Lands Mapping. An estimate of the total amount of irrigated lands within the Cottonwood/Grass Creek watershed was developed as part of this study. This began with review of the most recent comprehensive mapping of irrigated lands undertaken as part of the Wind/Bighorn Basin Plan (BRS, et al., 2003). The lands identified during that study were those that were being irrigated based on examination of black and white aerial photography that was reportedly from 2000 and/or 2001 and color infrared (CIR) satellite imagery from 1999. In reviewing the metadata for the aerial photography used in the Basin Plan, however, it appears that the black and white coverage used was actually flown in 1994. It is not known if any of the mapped irrigated lands within the Cottonwood/Grass Creek watershed were included in the selected field verifications conducted as part of the Basin Plan study. The total amount of irrigated lands identified in the Basin Plan in the Cottonwood/Grass Creek watershed was 3,474 acres. As would be expected, essentially all of the irrigated lands in the watershed are located in the overbanks and flanking terraces along the mid to lower reaches of Cottonwood Creek and Grass Creek.

The irrigated lands identified in the Basin Plan study were digitally overlain on digital orthophoto quarter quadrangle (DOQQ) CIR photography flown in July 2001 which is the latest available coverage suitable for this purpose. These more recent photos were then examined to identify any other irrigated lands in addition to those identified in the Basin Plan. Characteristics taken to indicate irrigated lands included an appropriate combination of: red color on the CIR imagery (indicated the presence of growing vegetation); location and topographic position in the Cottonwood and Grass Creek valleys; shape of the area; and/or apparent texture of the ground. An attempt was made to include lands that appeared to have been cultivated in the recent past even if they did not appear to have been irrigated at the time the available imagery was acquired. This effort identified an additional 333 acres that appeared to have been irrigated in July 2001 but that were not included in the Basin Plan mapping. Thus, a total of 3,807 acres appear to have been irrigated at one time or another during the period 1994-2001.

It is interesting to note that during the updating of irrigated acreage mapping as described above, it appeared that approximately 1,000 acres that were reported as being irrigated in the Basin Plan were not being irrigated in July 2001. This is believed to be a result of the severe water shortages being experienced in the watershed as a result of the ongoing drought (see related discussion in Section 2.2.1 below). These acres are still included in the total estimated irrigated acreage as it is assumed that they will be irrigated again when more normal water supplies are available.

At this level of study it was not feasible to conduct a thorough reconnaissance to further ground-check the irrigated lands mapping. Instead, the updated irrigated lands mapping was sent to local landowner/irrigator Dee Hillberry for review and comment. This brief review concluded that the mapped acreages appeared generally reliable.

Cropping Patterns. The Wind/Bighorn Basin Plan (BRS, et al., 2003) utilized the following typical cropping pattern as representative of the irrigated agricultural practices in the smaller, tributary basins of the overall Bighorn Basin:

- Alfalfa – 60 percent
- Grass hay – 30 percent
- Spring grains – 8 percent
- Beans – 2 percent

These estimates were reviewed by landowner/irrigator Dee Hillberry (2007) and Jim Mischke/NRCS (2007) and found to be a reasonable representation of what irrigators would likely grow with a fully adequate water supply under otherwise current conditions. At present, with less than adequate water supply, Mischke estimates that the cropping pattern is closer to 40 percent alfalfa, 55 percent grass hay and 5 percent small grains.

Irrigation Methods. Most of the irrigation in the Cottonwood/Grass Creek watershed is accomplished by traditional flood methods. The second most common method used is gated pipe. At present there is one center pivot operating at the very eastern end of the watershed, with a second being considered on that place. An estimate of the distribution of irrigation practices provided by Jim Mischke/NRCS (2007) and generally confirmed by other irrigators in the watershed is as follows:

- Flood – 70-80 percent
- Gated pipe – 20-30 percent
- Pivot – <2 percent

Several irrigators have commented informally during the course of this study that consideration would be given to more gated pipe and/or pivot irrigation in the watershed if a more reliable supply of water could be provided.

2.1.5 Range Conditions/Grazing Practices

For purposes of this study "rangeland" is defined as: *"Land on which the native vegetation (climax or natural potential) is predominantly grasses, grass-like plants, forbs, or shrubs. This includes lands revegetated naturally or artificially when routine management of that vegetation is accomplished mainly through manipulation of grazing. Rangelands include natural grasslands, savannas, shrublands, most deserts, tundra, alpine communities, coastal marshes, and wet meadows."* (BLM, 2007)

The term "watershed" implies runoff or the shedding of water. If this runoff occurs too rapidly, water is difficult to put to beneficial use. Soil erosion, flooding, and downstream damage can occur. Properly applied range management principles can be used to slow the runoff of water and allow it to be absorbed into the ground for prolonged release and later use.

Excessive bare ground results in rapid runoff and accelerated soil erosion. A raindrop falling on bare ground splashes, moving soil, which rapidly seals off the soil surface. This decreases the water infiltration rate of the soil. A healthy rangeland has much less bare ground, and more of the precipitation falls on plants and plant litter. This can greatly increase the amount of water entering the soil. More water entering the soil results in increased desirable plant growth, which benefits livestock and wildlife grazing. It can also improve the groundwater resource and increases spring and stream flows.

Livestock grazing on rangelands as defined above comprises the most widespread land use within the Cottonwood/Grass Creek watershed. Nearly all of the approximately 266,000 acres within the watershed are used or available for grazing, although the current suitability of the land for grazing varies. The existing grazing allotments that are wholly or partially located within the watershed are discussed in Section 2.1.5.1. The basis for evaluating existing rangeland conditions is discussed in Section 2.1.5.2. Then overall existing range conditions and the interrelated watershed issues are summarized and the need for alternative management practices and improvements is discussed in Section 2.1.5.3.

2.1.5.1 Grazing Allotments/Leases

Federal Grazing Allotments. Grazing allotments administered by the Bureau of Land Management (BLM) Worland District encompass essentially all of the land within the watershed (see Figure 2.1-7 – Grazing Allotments). Only 13,450 acres (or about 5 percent) of the land within the watershed is not included in an active BLM allotment (areas designated as "OUT" on Figure 2.1-7). The allotment numbers, names and acreages are provided on Table 2.1-2 – BLM Grazing Allotments.

The BLM-administered allotments typically include intermingled private, state, and federally-administered lands used for grazing. In addition, all of the Shoshone National Forest lands within the watershed are administered under a single grazing allotment by the U.S. Forest Service (USFS). The private (deeded) lands and much of the state land within the designated allotments are used extensively for grazing especially in the central and western portions of the watershed (see additional discussion below regarding grazing on state and private lands).

Under the Record of Decision and Approved Resource Management Plan for the Grass Creek Planning Area (BLM, 1998) livestock grazing permittees are required to implement management actions (e.g., grazing systems, land treatments, and range improvements) appropriate to the allotment category (i.e., "C" – Custodial, "M" – Maintain, or "I" – Improve). Grazing on BLM lands to meet these requirements is managed under the Standards for Healthy Rangelands and Guidelines for Livestock Grazing Management for the Public Lands Administered by the BLM in the State of Wyoming (BLM, 2007). Among the full suite of grazing management guidelines, those most applicable to this watershed study are summarized as follows:

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

A set of six standards have been established to meet the above guidelines (BLM, 2007). Each standard sets a specific objective, explains the function and importance of the objective, and provides indicators to assess the attainment of the objective.

Implementation of appropriate range management practices and/or improvements is carried out under an activity or implementation plan, including allotment management plans (AMPs). AMPs have been completed for the following allotments in the Cottonwood/Grass Creek watershed (Appendix 5 in BLM, 1998) as of 1998:

- 00516 – Blue Creek
- 00521 – Lower Cottonwood
- 00522 – Grass Creek
- 00524 – Cottonwood
- 00596 – Wagonhound
- 00604 – LU
- 00613 – Putney Flat
- 00616 – Home
- 00620 – Prospect
- 00633 – Upper Pastures
- 00634 – Lower Pastures
- 00637 – Adam Weiss Peak
- 00678 – South Grass Creek

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

Grazing on Private Lands. Grazing practices on private lands are established by the landowner, often with technical assistance from the local NRCS staff and/or a range consultant. Range improvement projects implemented under an NRCS program (e.g., EQIP or PL566 – see Section 6.4) follow the guidelines established in the plan of operations developed for the property and/or applicable NRCS technical guidelines as adapted for local conditions (see Section 2.1.5.2 following).

2.1.5.2 Ecological Site Descriptions

Information relevant to the conditions and suitability of rangelands for grazing is included in the NRCS Electronic Field Office Technical Guides (eFOTGs) for Hot Springs and Washakie Counties. These eFOTGs are available on-line at the following website: http://www.nrcs.usda.gov/technical/efotg/.

Of most direct relevance to grazing conditions are the Ecological Site Descriptions (ESDs). ESDs are classified by precipitation zones; the most applicable zones for the Cottonwood/Grass Creek watershed are Zone 5 – Big Horn Basin, Zone 6 – Foothills and Mountains East (15-19 E), and Zone 7 – Foothills and Basins East (10-14 E). The westernmost, high elevation portion of the watershed is Zone 1 – Mountains (20+ M), but this represents only a very small percentage of the rangeland in the watershed. Note that 10-14, 15-19 and 20+ in the zone names refer to average annual precipitation zones in inches. There are a total of 47 ESDs potentially applicable to the watershed within the three predominant zones. As an example, a copy of one of the applicable ESDs for the Cottonwood/Grass Creek watershed (Site Type: Rangeland, Site Name: Loamy (Ly) 5-9" Big Horn Basin Precipitation Zone) is included in Appendix B – Ecological Site Description. The ESD addresses the full range of physiographic and climatic features, influencing water features, representative soil features, plant communities, wildlife interpretations, grazing interpretations, hydrology functions, recreational uses and other information relevant to the site type. NRCS staff in Thermopolis and Worland can assist in identifying the applicable ESDs to a given area; these ESDs can then be easily downloaded in pdf format from the previously cited website.

According to the above referenced NRCS Ecological Site Descriptions, the Cottonwood/Grass Creek watershed includes the following Precipitation Zones: 5"-9", 10"-14", 15"-19" and 20+". Precipitation generally increases with elevation. The type and amount of vegetation varies in each of these Precipitation Zones. The NRCS Ecological Site Descriptions can be used to compare what is growing on the rangeland with what each site is capable of growing. By comparing the present vegetative composition to the potential composition, the relative health of the range resource can be evaluated. Production of each site is closely related to the ecological condition of the site. Watershed values are also tied to the condition class. For example, areas with reduced ground cover have the greatest potential for reduced infiltration and increased runoff; and soils with reduced organic content also hold less water.

Range conditions and features on approximately 50,000 acres of the Cottonwood/Grass Creek watershed have been mapped at 1:24,000 scale (1 inch = 2000 feet) for private landowners by Mr. Don Tranas, Range Consultant utilizing the NRCS ESD methodology. This mapping is available to those landowners and the agencies they are working with to plan and implement various range improvements.

The existing vegetation (ecological site) inventory for non-woodland/forest lands utilized by BLM is determined as described above by comparison to the potential plant community as indicated by the NRCS range condition guide for the site. Four classes are used by BLM to express the degree to which the existing plant community reflects its potential natural community: 76-100 percent – seral; 51-75 percent – late seral; 26-50 percent – mid seral; and 0-25 percent – early seral. Range management practices and improvements are intended to improve the class of the allotment under consideration, ideally to seral class.

2.1.5.3 Range Conditions and Needs

The Cottonwood/Grass Creek watershed was heavily grazed by domestic livestock (both cattle and sheep) in the late 1800's, and the rangeland suffered significant degradation and damage during that time. Some of the areas have substantially recovered, while others are still significantly degraded. In general, the lower precipitation zones recover more slowly than higher precipitation areas (see Section 2.2.1 for a discussion of climatic conditions in the watershed). Generally, range conditions are in "high fair" to "good" ecological condition. Range trends are generally stable to slightly upward overall.

Many riparian areas continue to be heavily relied upon for their wildlife and livestock water, feed values, and cover. This inhibits recovery of many of these ecologically important areas, including contributing at least locally to geomorphic stream instability. The shortage of reliable, well distributed wildlife and livestock water in much of the watershed results in less than desirable use of available upland rangelands, and correspondingly more need for wildlife and livestock to overuse the locally impacted riparian areas.

The single most important factor needed to facilitate improved grazing management and thereby achieve the associated benefits to the watershed is well distributed, reliable livestock water. Good grazing systems control both the time (amount of time spent in an area), and the timing (the time of the year) that the livestock spend in a pasture. Grasses and other plants need to recover from the last grazing event before being grazed again. This is because food reserves in the roots must be utilized for new plant growth. If they do not get to replace these root reserves, the plants are weakened and may eventually die. Less desirable plants eventually take over and plant densities decrease. Without well distributed livestock water, areas near water (frequently riparian areas) are grazed heavily while many other areas are under utilized. Livestock water must also be reliable so that each pasture can be used as needed in a grazing rotation. Otherwise, the same pastures with reliable water get grazed repeatedly at the same crucial time of the year.

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

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

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

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

Alternatives to address the need for additional wildlife/livestock watering sites are presented in Section 3.2 below. Potential management practices and improvements to address other rangeland/grazing related issues are included in Section 3.5. It is important to consider that to be cost-effective any range improvement practices/facilities that may be implemented must be followed up with a good grazing system. Otherwise, any short term gains will be lost, and often made worse. Since the key to any good grazing system is usually a good, reliable livestock water system, this usually is the most cost effective practice to begin with. The best value for the dollar usually occurs on the more productive land. Land that is too steep or shallow can only show limited returns on investments. Finally, to work in the long run, any change in range management must be supported by the land user.

2.1.6 Oil and Gas Production and Resources

Oil production began in the period 1910-1920 at the Grass Creek, Hamilton Dome and Golden Eagle fields in the Cottonwood/Grass Creek watershed. All of these fields still produce oil today, as do a number of other small fields and individual wells in the watershed. The locations of all active wells were acquired from records available on the Wyoming Oil and Gas Conservation Commission (WOGCC) website: http://wogcc.state.wy.us/FieldMenu2.cfm?Skip='Y'&oops=49.

All reportedly active oil wells and the approximate location and extent of known oil and gas fields within the watershed are shown on Figure 2.1-8 – Oil and Gas Wells/Fields. Table 2.1-3 – Annual Oil and Gas Production for 2006 summarizes the oil and gas production by field, or shows the last year of any production for the five fields that recorded no production of oil or gas in 2006. Total oil production was nearly 2,300,000 barrels of which 99 percent was from the Hamilton Dome field owned and operated by Merit Energy Company (MEC) and the Grass Creek field owned and operated by Marathon Oil Company (Marathon). Minor natural gas production totaling about 185,000 million cubic feet (mcf) was recorded in two fields, with Grass Creek accounting for 99 percent of the total.

In addition to the oil production, a very significant amount of water is produced at the Hamilton Dome oil field. Much of this produced water is released to Cottonwood Creek after separation of the hydrocarbon fraction. The balance of the produced water is reinjected in the field for secondary recovery of oil. This topic is discussed and analyzed in detail in Section 2.3.5 below.

2.1.7 Mining and Mineral Resources

The only active mining and mineral production in the Cottonwood/Grass Creek watershed involves coal at one small mine and sand and gravel at four small pits. These mining operations contribute only a very minor amount to the economy of the watershed area, and affect only a very small total land area. Some other historic coal mining has occurred in the Grass Creek basin and at four other sites in the Cottonwood Creek basin. The active and historic mining and minerals potential in the watershed are briefly discussed in the following paragraphs.

Coal. The only non-aggregate mineral commodity that has been mined in economic quantities in the Cottonwood/Grass Creek watershed is coal. As shown on Figure 2.1-9 – Active and Historic Coal Mine and Resource Potential, about half of the total land area of the watershed is underlain by geologic units with moderate potential for yielding mining-grade coal. The areas shown as having high coal potential comprise the Grass Creek Coal Field which includes the currently active surface Grass Creek Coal Mine. Closed and/or abandoned mines in this portion of the field include the underground Grass Creek, Dickie No. 1, and Dickie No. 2 Mines as well as another unnamed mine, and the Spring Gulch surface (strip) mine. Cumulative production from these mines through 1974 was reported by Glass, et al. (1975) as only 67,337 tons as compared to 11,032,114 tons produced over the same time from the 13 mines in the Gebo Coal Field located southeast of the Cottonwood/Grass Creek watershed (the other high potential area shown just east of Kirby on Figure 2.1-9).

A preliminary estimate of the reserves of high quality, low sulfur coal remaining in the Grass Creek field was made by Stewart (1975). Based on the somewhat sparse data available to him, Stewart estimated that a total reserve of about 15,000,000 tons of coal was present in the Mayfield and Gwynn seams of the Tertiary Fort Union formation. He estimated stripping depths as averaging about 100 feet with a maximum depth to coal of about 200 feet. At a rate of 700,000 to 1,000,000 tons/year (as proposed by an entity considering opening a mine in 1975), the life of mine would be about 15-20 years. Given that only very modest mining has occurred in this field since 1975 during a period when coal mining in Wyoming elsewhere has steadily increased in response to high and growing demand and prices, it is believed unlikely that major new activity will occur in this field anytime soon (if ever). Two factors that weigh heavily against economical mining in this field are the stripping depths and the distance to the nearest railhead (approximately 40 miles by road to Kirby).

Other small coal mines in the watershed include the Putney and Berry Brothers Prospect mines in the Cottonwood basin upstream of Hamilton Dome and the Wright (or Cottonwood #1) and Ferelli (or Cottonwood Creek) mines near and below the Prospect Creek confluence with Cottonwood Creek (Glass, et al., 1975). No information was found regarding the history or production from these mines, but it is believed that they were very small mines or prospects.

Sand and Gravel. There are four actively permitted sand and gravel pits within the Cottonwood/Grass Creek watershed. As shown on Figure 2.1-10 – Other Mine Sites and Mineral Potential, two of these pits are located on Cottonwood Creek between the confluences of Prospect and Grass Creeks, one is located on lower Wagonhound Creek, and the fourth is located on Grass Creek above the confluence of Spring Gulch. These pits produce sand and gravel if/as needed mainly for state and county road construction and maintenance. Production history and quantities are not known, but are believed to be minor.

Other Minerals. As shown on Figure 2.1-10 there are several areas where potential for uranium, sulfur and bentonite have been mapped within the Cottonwood/Grass Creek watershed. However, the likelihood of commercial-scale mining of these deposits is judged low to very low on the basis that no known activity has occurred to date and there are other areas in the state with significant historic and active mining of these resources.

Issues. Given the small number and scale of intermittently active mining operations in the watershed, the potential for any significant impacts to water resources and related values are judged minor. All of these operations hold active surface water discharge and/or stormwater permits with the Wyoming Department of Environmental Quality (WDEQ). The discharge limits and/or BMPs required under these permits should continue to protect the watershed from any significant contaminant releases from these sites. In the unlikely event that significantly expanded coal mining ever did occur in the Grass Creek field, stringent requirements to protect water quality would be incorporated in the required permits for such an operation. (See related discussion in Section 2.6.)

2.2 Natural Environment

2.2.1 Climate

Overview. The climate of the Cottonwood/Grass Creek watershed is classified as semiarid. The definition of semiarid adopted herein is a climatic zone with annual precipitation between 10 and 20 inches, and where the predominant vegetation is drought-resistant short grasses and the area is especially susceptible to severe droughts (Thornthwaite, 1931). The climate in the watershed is strongly influenced by the presence of the Absaroka and Owl Creek Mountains to the northwest, west and southwest, and the Bighorn Mountains to the east. The downslope movement of air masses into the watershed results in warming of the air (estimated at 5-6 °F per 1000 feet of descent) and an accompanying reduction in humidity (Iiams, 1983). During the winter months shallow cold air masses from the north are largely blocked by the Bighorn Mountains, but some cold air still does spill into the Bighorn basin and can become trapped resulting in periods of severe cold that can last for several days. Moisture from the Pacific Coast is largely blocked from the watershed by the intervening mountain chains (including locally the Absaroka Mountains which receive average annual precipitation in excess of 40 inches).

Drought. The Cottonwood/Grass Creek watershed lies within a larger area that has been experiencing severe drought conditions since the summer of 2000. At the time of writing of this report the Cottonwood/Grass Creek watershed was at drought intensity D2 – severe as reported on the US Drought Monitor for Wyoming: http://drought.unl.edu/dm/DM_state.htm?WY,W.

During June 2007 the western half of the watershed received less than 50 percent of its normal precipitation for the month and the eastern half received less than 25 percent (Gray, 2007). The outlook according to NOAA (as reported in Gray, 2007) is for drought conditions in this part of Wyoming to persist or intensify.

Weather Stations and Records. As shown on Figure 2.2-1 – Weather Stations there are three locations in or near the Cottonwood/Grass Creek watershed that have been recording weather conditions for a number of years. These stations have been operating for 46, 56 and 58 years. Annual precipitation records for these three stations are summarized on Table 2.2-1 – Period of Record General Climate Summary – Precipitation. Mean annual precipitation at the Grass Creek station (480228) over the 58 years of record is 10 inches; Anchor Dam (480228) received 15 inches on average over the last 56 years; and a station on South Fork Owl Creek below Anchor Dam and above the North Fork confluence received an average of 12 inches over its 46 year history. Mean annual snowfall at these three stations was 27, 37, and 56 inches, respectively. Temperature data at the three stations is summarized on Table 2.2-2 - Period of Record General Climate Summary – Temperature. The mean monthly average temperature recorded at all three stations was about 41-44 °F, with a maximum monthly average of about 56-59 °F and a minimum monthly average of about 27-29 °F. More complete climate data for these three stations as well as for the station at the Town of Thermopolis are presented in Appendix C – Climate Data.

Precipitation Zones. Isohyetals of mean annual precipitation are shown on Figure 2.2-2 – Precipitation which was derived from NRCS (2007). Comparison of these contours of precipitation with the mean annual values summarized in Table 2.2-1 shows relatively good correlation. Most of the eastern half of the watershed receives about 10 inches of precipitation, while the highest elevations at the western end of the watershed receive about 20 inches. This range of precipitation fits exactly the common definition of a semiarid climatic zone presented previously.

2.2.2 Vegetation and Land Cover

2.2.2.1 Overview

Vegetation in the Cottonwood/Grass Creek watershed is most broadly classified as forestland vegetation in the westernmost, higher elevation areas and rangeland vegetation in the remainder of the watershed. The transition between these two major classifications occurs between the 12- and 14-inch precipitation isohyetals shown on Figure 2.2-2. Existing vegetation and non-vegetative land cover types as classified by the Wyoming Gap Analysis program are shown on Figure 2.2-3 – Land Cover/Vegetation. Information on the Wyoming Gap Analysis program and the various relevant work products produced to date is available at the following website: http://www.wygisc.uwyo.edu/wbn/gap.html.

The classification scheme in the GAP program "*organizes vegetation communities into a hierarchical structure with **classes** based on gross physiognomy at the coarsest level (also referred to as **level 1**), and **community types** based on dominant species composition at the finest level (**level 6**).*"

Review of Figure 2.2-3 shows that the most common vegetation class in the watershed is Wyoming big sagebrush (which is also the dominant class for the entire state), and that this classification is typically intermixed with desert shrub. These classifications are only absent at the highest elevations in the western end of the watershed where forestland classes are predominant and at the eastern end where saltbrush fans and flats are most prevalent.

The classifications in the forestland in the western portion of the watershed generally vary with elevation from juniper woodland at the moderate elevations, grading to limber pine and woodland at higher elevations, and then to Douglas fir at the highest elevations. A small area of subalpine meadow is mapped on the flanks of

Cottonwood Peak at the westernmost end of the watershed. Mountain big sagebrush occurs at intermediate elevations in the upper Grass Creek drainage above its confluence with Little Grass Creek. As shown on Figure 2.2-4 – Wildfires, only some very small areas in the middle reach of the Grass Creek basin have experienced natural fires in recent decades. BLM (1996) noted that "*along the upper part of Grass Creek, woodland canopy cover increased by about 210 percent between 1953 and 1989, probably because of a lack of fire.*" (page 109) An aggressive and reportedly very successful response to this condition by controlled burning is discussed later in Section 3.5.3 below.

The valley bottom of Cottonwood Creek below its confluence with Prospect Creek is classified as forest-dominated riparian, while the central reach of Grass Creek is mapped as shrub-dominated riparian. Only two areas are mapped as basin-exposed rock/soil (Hamilton Dome and a northwest trending high cliff northeast of the lower reaches of Grass Creek.

2.2.2.2 Targeted Vegetation

Certain classes and/or species of vegetation were identified in the scope of work for this study for special attention due to their known or inferred more significant effects on the water-resource related functions and values of the watershed. These include limber pine and juniper encroaching from forestlands to transitional zones and rangelands, big sagebrush in the transitional zones and rangelands, saltcedar (tamarisk) and Russian olive in the lower elevation rangeland areas, and noxious weeds throughout the watershed. This is not to say that other vegetation classes and/or species are not important to watershed character and function, but that the targeted vegetation is believed to play a greater proportionate role.

Limber Pine and Juniper. In their natural state, juniper and limber pine prefer to grow in areas of shallow soil in the 10-14 inch precipitation zone, are often widely spaced, and tend to have sparse understories. In the absence of fire (or other controls), these species have historically invaded areas of deeper soils on lower slopes and even onto the terraces and overbanks in stream valleys, especially in the Grass Creek basin and in the headwaters of Prospect and Twentyone Creeks. The resulting canopy limits undergrowth of desirable grasses, resulting in excessive runoff and erosion. An increase in grazing-resistant plants, including especially big sagebrush, also tends to occur. When present at excessive densities, these plants compete with more desirable rangeland plants for water, space, and nutrients.

As an example of the relative impact that encroachment of these plants can have on the watershed, Owen and Ansley (1997) reported that a monitored juniper population in Texas transpired an average of 1.4 acre-feet/year in an ungrazed pasture, 0.97 acre-feet/year in a lightly grazed pasture, and 0.34 acre-feet/year in a heavily browsed pasture. This suggests a net savings of water on the order of at least 30 to more than 100 percent with recovery of adequate to high value rangeland and good grazing management.

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

The consumptive use of moderate to dense stands of saltcedar has been estimated to be as much as 3-5 acre-feet/acre/year (USBR, 2007; Hart, 2004; Lacher, 1994). Large individual saltcedar plants can transpire at least 200 gallons per plant each per day (Tranas, 2007). Davenport and others (1982) found that moderately dense stands of saltcedar used about 3 times as much water as sparse stands, and that dense stands used about 2½ times as much water as moderate stands. Russian olive is estimated to use on the order of about 70 percent as much water per year as saltcedar for comparable plant density scientific (Hart, 2004). Based on the extensive scientific literature (some of which is cited above) and observation by local landowners/irrigators in the watershed, it is clear that saltcedar (and locally Russian olive) stands can greatly reduce stream flows, which limits water availability for the riparian environment, aquatic and terrestrial wildlife, livestock and irrigation.

Noxious Weeds. Noxious weeds such as Canada thistle and Russian knapweed are already widespread in the Cottonwood/Grass Creek watershed. These and other noxious weeds and undesirable plants prefer the better watered and/or irrigated lands. As a result, they tend to invade riparian areas, big game winter ranges, high production grazing lands, and irrigated croplands first and most aggressively. Noxious weeds can produce major negative effects on overall watershed health by replacing more natural plant communities that support and are compatible with desirable watershed function.

2.2.3 Soils

A detailed (1:24,000 scale) printed soil survey has been prepared and released for Washakie County (NRCS, 1983). Both tabular and spatial data are available for the county from the NRCS Soil Survey Geographic (SSURGO) Data Base accessible at: http://www.ncgc.nrcs.usda.gov/products/datasets/ssurgo/index.html. The spatial soils mapping data for Washakie County is shown on Figure 2.2-5A - SSURGO Soils Map – Washakie County. The Hot Springs County tabular SSURGO data is also available but the spatial (map) data is still in preparation. The release date for the Hot Springs County spatial data depends on available funding and staffing and is unknown as of the date of this report. Hand-drafted soils mapping for Hot Springs County is available for inspection at the discretion of the NRCS staff in Thermopolis.

The Washakie County soil survey and the Washakie and Hot Springs Counties SSURGO tabular data include the following key information on the soils within the study area:

- Soil unit characteristics:
  - particle size distribution
  - soil reaction
  - bulk density
  - salinity
  - available water capacity
  - organic matter
- Relevant related conditions:

- flooding
- depth to bedrock
- water table depth
- soil subsidence

- Use and management data:
  - sanitary facilities
  - construction material
  - building site development
  - crops
  - recreational development
  - woodland suitability
  - water management
  - wildlife habitat suitability
  - rangeland potential

Provisional soils mapping by BLM (2007) for the entire Cottonwood/Grass Creek watershed is shown on Figure 2.2-5B – Provisional BLM Soils Map. The following qualifications for this mapping were provided by BLM:

Soil Survey Data
Source and Disclaimer Statement

Soils data for Big Horn, Hot Springs and Park Counties are the results of inventory efforts conducted in the late-1970s through the mid-1980s by the Bureau of Land Management (BLM) and Soil Conservation Service (SCS) personnel. This effort was* ***not*** *correlated by the SCS. Map units are based on preliminary mapping that was transferred to mylar topographic and orthophoto quads in the mid-1980s.*

In Hot Springs County the data source for the attribute data was a soil survey titled "Soil Inventory Grass Creek Area Wyoming" prepared for BLM by Soil and Land Use Technology, Inc. (SALUT) and soil survey handbooks and legends. In Big Horn and Park and Park Counties the source of the attribute data was soil survey handbooks and legends and the National Soil Information System (NASIS) maintained by the National Resource Conservation Service (NRCS).

No warranty is made by the BLM as to the accuracy, reliability, or completeness of these data. This product was developed through digital means and may be updated without notification. Original data were compiled from various sources discussed above. Maps and tabular data may not meet National Cooperative Soil Survey Standards.

The soil types in the Cottonwood/Grass Creek watershed are highly variable as a result of the differences and interactions among the primary factors that influence soil formation and character: parent material, topography, vegetation, climate and time. Soils tend to be lighter colored in the lower elevation portions of the watershed reflecting the relative scarcity of organic matter as compared to the typically darker soils at higher elevation. Shallow soils (less than 20 inches deep) are common in the watershed, especially in the 10-14 inch precipitation zone in upland locations underlain by the prevalent sandstone and shale bedrock in the watershed. These soils often are also high in salts (and sometimes gypsum) content especially at lower elevations.

Soil productivity generally varies strongly with elevation (and thus precipitation) and salt content, with the higher rangeland soils in the central and western portion of the watershed notably more productive than in the low easternmost area. The generally deeper soils formed on alluvial deposits in the mid to lower Grass Creek and Cottonwood Creek drainages are also productive where irrigated and adequately drained to minimize salt accumulation. Productivity of soils in the watershed under natural (non-irrigated) conditions ranges from as little as 200 lbs/acre in the extreme eastern end of the watershed (in the 5-9 inch precipitation zone) to more than 2300 lbs/acre in healthy riparian areas (BLM, 1996).

Rates of sheet and rill erosion for upland range sites in the Grass Creek Planning Area (which includes the Cottonwood/Grass Creek watershed) have been estimated by BLM (1996) to vary from about 0.1 to 2.0 tons/ac/yr. It is estimated that in areas of relatively shallow loamy and saline upland soils in the 10-14 inch precipitation zone the erosional loss of soil may be exceeding the rate of soil formation in some portions of the Grass Creek Planning Area. The quantitative loss of soil within the watershed by gully and stream erosion is not known, but was found to represent up to ¾ of the total sediment load in the Bighorn River, with only ¼ derived from sheet/rill erosion (BLM, 1996). See related discussion regarding stream geomorphology in Section 2.4.

2.2.4 Geology

The geology of the Cottonwood/Grass Creek watershed is described in the following subsections on surficial and bedrock units, geologic structure, slope stability (landsliding), and seismotectonics (faults and earthquakes). Geologic conditions most relevant to potential surface water storage alternatives are further discussed in Section 3.3.2.3 below.

2.2.4.1 Surficial Units

The distribution of surficial geologic deposits in the Cottonwood/Grass Creek watershed is shown on Figure 2.2-6 – Surficial Geology. Nearly all the watershed is covered to some depth with surficial deposits with only local exposures of outcropping bedrock. These are the geologic units on which the soils described in Section 2.2.3 above have formed. These surficial units and their overlying soils represent an important source of borrow materials for earth construction, and locally may require removal or improvement to serve as foundations for large structures (e.g., earth or possibly concrete dams). In addition to surficial deposits, Figure 2.2-6 also shows the location of distinctive geomorphic features such as alluvial plains and benches, some of which are noticeably dissected (eroded).

Outcropping bedrock is generally confined to locally steeper terrain including: the slopes flanking lower Cottonwood Creek below the Grass Creek confluence; the bluff at the northern boundary of the watershed north of lower Grass Creek; slopes on the divides between the mainstem creeks and major tributaries in the central part of the watershed; and the slopes above Grass Creek and Little Grass Creek in the area just below and for some distance above their confluence.

Most of the watershed is covered to varying depths estimated as from a few feet to a few tens of feet by a variety of surficial deposits, depending primarily on the nature of the underlying bedrock and the slope inclination and aspect. These deposits include colluvium, slopewash, older alluvium and terraces, and residuum (deeply weathered in-place bedrock).

Various combinations of alluvium, alluvial fan, alluvial terrace, slopewash, and residuum deposits are typically present in the mainstem and mid to lower tributary valleys and their adjacent lower slopes. The depths of these deposits are estimated as typically a few tens to as much as 100 feet for alluvium, alluvial fan and alluvial terrace deposits, and a few feet to a few tens of feet for slopewash and residuum.

Landslide deposits are present in the western-most portion of the watershed as shown on Figure 2.2-6. Further discussion of landsliding and a more detailed landslide map are presented in Section 2.2.4.3 below.

2.2.4.2 Bedrock Units

The bedrock geology exposed at or near the surface and underlying the Cottonwood/Grass Creek watershed to great depths spans a very substantial portion of geologic time from at least the Ordovician period to the present (±400 million years). Figure 2.2-7 – Bedrock Geology shows the distribution of outcropping or near surface bedrock (and the major surficial geologic units) within the watershed. In order of their age from youngest to oldest, these bedrock units include:

- Wiggins formation
- Teepee Trail formation
- Aycross formation
- Fort Union formation
- Lance formation
- Meeteetse formation
- Mesaverde formation
- Cody Shale
- Frontier formation

These units will have the most direct effects on the watershed because they are at or near the surface. As noted previously, these bedrock units very strongly influence the nature and distribution of surficial geologic units, which in turn strongly influence soil development. Surface water quality is also influenced by these bedrock units as discussed later in Section 2.6. As discussed further in Section 3.3.2.3 below, some of these units will form the foundation at alternative dam sites and/or provide a resource of earth or rockfill for dam construction.

Table 2.2-3 – Geologic Unit Descriptions (derived from Plafcan and Ogle, 1994) provides a summary description of all of the major surficial and bedrock units present within Hot Springs County. Most, but not necessarily all, of these units underlie the Cottonwood/Grass Creek watershed at some depth. Units believed not present at depth include the: Wagon Bed formation, Wind River formation, possibly the Tatman formation, Nugget Sandstone, and Darby formation.

The distribution of outcropping and near surface bedrock in the watershed is controlled by the geologic structure (folding) discussed in the following subsection. The result of the folding and subsequent overall regional uplift and erosion is that the oldest outcropping/shallow bedrock occurs in a northwest-southeast trending band through the central portion of the watershed. The oldest of these rocks are the Frontier formation that crops out at Hamilton Dome and in the crest of the anticlinal fold that extends from the dome to the southeast. The oldest unit near surface in the synclinal fold that includes the Grass Creek basin is the Cody Shale. The Mesozoic Mesaverde and Lance/Meeteetse formations and the Cenozoic Fort Union formation are present in the flanks of the anticline/syncline fold belt in the central portion of the watershed.

The older rocks described are covered by the younger Absaroka Volcanics in both the eastern and western portions of the watershed. These rocks (including the Aycross, Teepee Trail and Wiggins formations) formed after the major episode of folding that affected the older rocks. In this area, these formations are mainly comprised of water-reworked and deposited volcanic rocks that originally formed as extrusive deposits (pyroclastic tuffs and ash falls and some lava flows). As a result, they originally blanketed the upturned older units. These older rocks are now exposed (or are near surface) only where erosion has removed the younger reworked volcanic sedimentary rocks. As seen on Figure 2.2-7, the older Aycross rocks occur in the western portion of the watershed, where they are exposed by erosion of the overlying Teepee Trail rocks. The youngest of the Absaroka Volcanics (the Wiggins formation) crops out (or is near surface) locally along the eastern edge of the Aycross/Teepee Trail outcrops in the western portion of the watershed and in the northeastern-most portion of the watershed where they unconformably overlie the Fort Union formation.

The deeper, older bedrock units are only relevant to this watershed study in terms of their potential as sources of groundwater as discussed in more detail in Section 2.2.5.3 below. These rocks are relevant to a lesser degree due to the presence of oil and some natural gas in some of the units (especially the Frontier, Phosphoria and Tensleep, and to a lesser degree the Nugget, Chugwater, Amsden, Madison and Bighorn).

2.2.4.3 Structure

The Cottonwood/Grass Creek watershed is located in the southwestern portion of the Bighorn basin, a large structural (as well as topographic) basin. The watershed occupies the boundary portion of the Bighorn basin (defined by the Absaroka Mountains to the west and the Owl Creek Mountains to the south) and the generally northeast sloping flank of the basin. It does not extend into the deeper portion of the Bighorn basin.

The structural deformations that resulted in the initial formation of the Bighorn basin and bounding mountain ranges began and were most extensive during what is called the Laramide period (40-65 million years before present). Regional crustal shortening in a north-northeast direction resulted in areas of high uplift and adjacent deep downwarp. The areas between uplifts and downwarps are often characterized by local folding and faulting of the basement (Pre-Cambrian) and overlying younger rocks. The folds and faults of the Hamilton Dome and the Grass Creek basin are examples of this deformation. The Laramide period of intense structural deformation (tectonism) was followed in the Late Eocene (around 40 million years ago) by extensive volcanic activity. This was the time that the Absaroka Volcanics described previously were formed in the watershed. Around 10 million years ago (during the Cenozoic era) a period of broad regional uplift began that continues to present, resulting in significant erosion exposing rocks as old as the Cretaceous Frontier formation in the watershed (and very old Pre-Cambrian rocks in the Wind River Canyon).

Structure in most of the Cottonwood/Grass Creek watershed generally follows a west-northwest trend reflecting its position on the southwest flank of the Bighorn basin and the adjoining Owl Creek Mountains to the south/southwest. The older, larger scale fold structures are interpreted as having resulted from basement thrust faulting that often did not extend to the ground surface (Bown, 1982). Structural contours on the top of the Tensleep Sandstone clearly define the elongate uplift of Hamilton Dome and the en echelon downwarp of the Grass Creek basin (see Lowry, et al., 1976). This local structure on the flank of the Bighorn basin has resulted in hydrocarbon accumulations tapped by the Hamilton Dome oil field and the Grass Creek oil and gas field. Smaller structures subsidiary to the main dome and basin support other local, smaller scale oil (and some minor gas) extraction. Local faults are present both perpendicular to and paralleling the axes of the larger folds. These faults are of limited extent and offset.

An unusual type of structure is present locally in the Absaroka Volcanics in the westernmost portion of the watershed. These structures are remnant masses called klippen of what are believed to be large scale detachment faults of gravity rather than tectonic origin (Bown, 1982). Numerous klippens are mapped within the Absaroka Volcanics present in the headwaters of Grass and Cottonwood Creeks and their major tributaries. These features are typically characterized by intensely deformed rocks that lie on top of much more gently folded older rocks (i.e., the intense deformation is not the result of deeper structural deformation). Furthermore, the deformation in one klippen does not appear to bear any relation to that in adjacent klippens. Normal and thrust faults of very local extent, minor offset and apparently random orientation are common in the klippens.

2.2.4.4 Slope Stability

Landsliding of significant scale and density of occurrence is largely confined to the westernmost portion of the Cottonwood/Grass Creek watershed as shown on Figure 2.2-8 – Landslides. Nearly all of these mapped landslides occur within the predominantly volcaniclastic sedimentary rocks of the Aycross, Teepee Trail and Wiggins formations described previously. A few landslides occur locally in the Fort Union and Lance formations in the middle Grass Creek and Spring Gulch/Prospect Creek drainages. The depth, age of original movement, and degree of recent or current activity for the mapped landslides is unknown. It is possible that the larger landslide complexes such as those present on the south slope above upper Grass Creek and at the Lake Creek Dam site in the upper Cottonwood Creek drainage were originally activated under much wetter climatic conditions accompanying one or more interglacial periods during the late Pleistocene (perhaps a few tens of thousands of years ago) or possibly more recently during a cycle of much higher precipitation (e.g., sometime before or after the "little ice age" of the northern Rocky Mountains lasting from about 1550 to 1860).

Very localized slope failures are common along the banks of the active channels of Grass and Cottonwood Creeks and their tributaries. These form in response to undercutting and erosion accompanying seasonal high spring flows and intense thunderstorm runoff events.

Potential triggering mechanisms to accelerate or reactivate existing landslides in the watershed include loading the head or unloading (undercutting) the toe by grading or natural erosion, periods of intense and/or sustained precipitation, and/or strong ground shaking from nearby earthquakes (as discussed further in the next subsection). These mechanisms can also result in new landsliding where none was present before.

2.2.4.5 Seismotectonics

The Cottonwood/Grass Creek watershed is an area of minor historic seismicity. A total of only thirteen earthquakes have been recorded in or near Hot Springs County with magnitude greater than 3.0. The largest recorded earthquake was a magnitude 4.7 event in 1967 with its epicenter located approximately 32 miles southwest of Thermopolis. No damage was reported anywhere in Hot Springs County as a result of this earthquake. The only historic earthquake known to have occurred in or near the watershed was an event in 1950 of Modified Mercalli intensity V that reportedly caused houses to shake and dishes to rattle at Hamilton Dome. (Case, et al., 2002)

There are no mapped active or potentially active faults in the Cottonwood/Grass Creek watershed or in Hot Springs County. The closest mapped potentially active fault is the Stagner Creek fault located approximately 20-25 miles south of Kirby immediately downstream of Boysen Dam. There is reportedly evidence of recurrent latest Quaternary activity (i.e., within the past approximately 15,000 years) based on detailed mapping and morphometric studies of the fault zone. The apparent slip rate of this fault is relatively low (<0.2 mm/yr). An estimate of the recurrence interval for earthquakes on the Stagner Creek fault is 8,000-22,000 years. The maximum credible earthquake for this fault has been estimated as M6.75. This size event has been estimated to be capable of producing a peak horizontal ground acceleration of approximately 0.06g at Hamilton Dome and 0.057g at Kirby. The next closest potentially active structure is a portion of the Cedar Ridge/Dry Fork fault zone located over 80 miles to the west of the Stagner Creek fault. If it is conservatively assumed that the entire fault zone is active, a M7.1 earthquake could occur. Such an event would result in ground shaking of about 0.029g at Hamilton Dome and 0.05g at Kirby. Lower accelerations than any of these estimates would be predicted in the Cottonwood/Grass Creek watershed. (Case, et al., 2002) These levels of ground shaking would not result in any significant damage to well designed and constructed reservoir storage dams, irrigation facilities, or wildlife/livestock watering systems.

Because fairly large earthquakes can and do occur where no known source structure (e.g., an active fault or fold) is known to be present, it is prudent to design critical structures such as high hazard dams assuming that a “floating or random” earthquake could occur near the facility. A previous study related to Boysen Dam recommended that a M6.25 event be assumed at a distance of 15 km to address this potential in the seismotectonic province that includes the Cottonwood/Grass Creek watershed. Such an event would result in peak horizontal accelerations on the order of 0.15g. (Case, et al., 2002) This level of shaking could result in some effects such as triggering metastable landslides or weakening loose, saturated silty to sandy soils. Again, well designed facilities on adequate foundations should not experience significant damage under this level of ground shaking.

The U.S. Geological Survey has developed an interactive program that predicts probabilistic levels of ground shaking in a given area based on the presence of the surrounding known or suspected active earthquake generating structures and the potential for a floating or random earthquake event. This program can be accessed at: http://earthquake.usgs.gov/research/hazmaps/products_data/2002/wus2002.php. For the purposes of this study, a map of the predicted peak horizontal ground accelerations within the Cottonwood/Grass Creek watershed with an annual probability of 2 percent of not being exceeded within any 50-year period was generated (see Figure 2.2-9 – Estimated Peak Horizontal Ground Acceleration). Maximum predicted accelerations in all but the southeastern-most portion of the watershed are in the range of 0.14-0.16g (coincident with the estimated acceleration with an assumed floating or random earthquake as discussed above.) Slightly higher accelerations are predicted for the southeast portion of the watershed (0.16-0.18g).

2.2.5 Groundwater

Groundwater in the Cottonwood/Grass Creek watershed occurs in both shallow (alluvial) and deeper (bedrock) aquifers, and in some locations discharges directly to the ground surface as springs. The quantity and to a large degree the quality of these groundwater sources are directly related to the physical properties and geologic history of the various geologic units comprising the aquifers, and to the current climate of the area (relative to recharge). Each of these three sources of groundwater is described in turn in the subsections that follow. Groundwater quality is addressed in Section 2.6 below.

2.2.5.1 Springs

Springs occur where the groundwater table intersects the ground surface. This can occur as a result of various combinations of geologic and topographic conditions that result in groundwater discharging directly to the ground surface. For example, where a sufficiently permeable geologic unit (e.g., uncemented sandstone or conglomerate) crops out in a swale or on a hillside at an elevation below the ambient groundwater table in the bedrock unit at that location, a spring will occur. Similarly, a permeable geologic structure (e.g., an open joint, fracture or fault zone) may intersect the ground surface and serve as a conduit for the discharge of groundwater.

Spring flows vary widely due to the nature of the aquifer/structure discharging, the amount of seasonal recharge from snowmelt and rainfall, depletion of storage during periods of drought, and even evaporation and evapotranspiration at the site of the spring. The flows can be concentrated or diffuse, again depending on the nature of the geologic conditions causing the spring. Spring flows in the Cottonwood/Grass Creek watershed generally appear to range from less than a gallon/minute (gpm) to at most a few tens of gallons/minute. This is generally consistent with the range of reported spring flows in Hot Springs County as tabulated by Plafcan and Ogle (1994). As noted previously in Section 2.2.1, many springs in the watershed have reportedly dried up or their flows have significantly reduced due to the ongoing multi-year drought in this part of Wyoming.

The locations of springs in the watershed are shown on Figure 2.2-10 – Springs. These locations are compiled from several sources including: a BLM GIS file (see project geodatabase); prior range mapping and field reconnaissance for this study by consultant Don Tranas; input from several landowners in the watershed; and review of available topographic mapping and digital orthophoto quarter quadrangle (DOQQ) color infrared (CIR) photography. Those springs estimated to have at least seasonally sustained flows greater than about 2 gpm are identified on Figure 2.2-10.

2.2.5.2 Alluvial Aquifers

Alluvial aquifers with some development potential occur within the alluvium and alluvial terrace deposits that have formed in the valleys of Cottonwood Creek and Grass Creek. These deposits are comprised of unconsolidated mixtures of clay, silt, sand, gravel and cobbles. In general, the alluvial deposits tend to be coarser higher in the watershed and/or where their source is comprised of more competent bedrock. The source of groundwater in these alluvial aquifers includes flows from locally discharging bedrock aquifers, surface water flows in the stream channels and overbanks, and in some cases both. The thickness of alluvium deposits in the watershed is not known with any certainty but is estimated to range from a few feet on small tributaries to as much as 100 feet or more in the Bighorn River valley, with a more typical range of a few tens of feet in the mainstem valleys of Cottonwood and Grass Creeks. The thickness of alluvial terrace deposits is also estimated to be in the few tens of feet.

The number of wells completed in alluvium and alluvial terrace deposits within the watershed is unknown as the unit in which the wells are completed is not specified in the Wyoming State Engineer's Office (WSEO) database of permitted water wells (see Appendix D - Permitted Wells and Figure 2.2-11 – Groundwater Wells). Although not known with certainty, it is possible that wells with reported depths and/or static water levels less than a few tens of feet are completed in alluvium or alluvial terrace deposits. The yield for well depths less than 30 feet (and thus static water levels also less than 30 feet) range from 3-25 gpm.

The depth of alluvial wells throughout Hot Springs County reportedly ranges from 12 to 90 feet, averaging 41 feet. The yield of five of these wells ranges from 1 to 140 gpm, with four of the five less than or equal to 3 gpm. Depths of wells completed in alluvial terrace deposits in Hot Springs County range from 5 to 64 feet, averaging 32 feet. Yields from three of these wells are reported as 5, 16 and 400 gpm. (Plafcan and Ogle, 1994)

2.2.5.3 Bedrock Aquifers

Groundwater occurs in many of the bedrock units underlying the Cottonwood/Grass Creek watershed. In general, groundwater in the major bedrock aquifers tends to flow toward the east-northeast structurally down-dip toward the center of the overall Bighorn structural basin. Locally groundwater occurrence and flow is controlled or influenced by faulting and fracturing associated with the structural deformation that occurred during the formation of the Bighorn basin and the surrounding uplifts.

Table 2.2-4 – Bedrock Aquifers summarizes information on the bedrock aquifers relevant to the watershed based on information compiled from Lowry, et al. (1976) and Libra, et al. (1981). Figure 2.2-11 shows the locations of wells within the Cottonwood/Grass Creek watershed including those completed in bedrock units.

BLM (1996) had reportedly developed 63 wells in the Fort Union, Mesaverde, Lance and Willwood formations within the Grass Creek Planning Area. The wells originally produced from 5 to more than 20 gpm of water suitable for use by livestock and wildlife, but many are no longer functioning due to deterioration over time. It is inferred that some of the domestic, and most of the domestic/stock and stock use wells included in the WSEO database (Appendix D) are also completed in one or the other of these formations given their depths and the distribution of bedrock units in the watershed. The average depths of wells greater than 30 feet deep that are designated for domestic or domestic/stock use is 115 feet (with a range of 45.5-205 feet); the static water level in these wells averages 37 feet (ranging from 12-100 feet); and the yields of these wells average 13 gpm (with a range of 8-25 gpm). The wells designated only for stock use are an average of 248 feet deep (ranging from 81-380 feet); static water level averages 105 feet (with a range of 10-280 feet); and yields average 6 gpm (with a range of 4-12 gpm). There is only one well in the extreme eastern end of the watershed designated for irrigation use. This well (designated the Pitz Irr #1 in Appendix D) is reportedly 340 feet deep yielding 10 gpm from a static water level of 40 feet.

As shown in Table 2.2-3 the major, most productive aquifers in terms of potential yield are in the older, much deeper bedrock units including the Tensleep Sandstone, Madison formation, Bighorn Dolomite, and Flathead Sandstone. Given the depths of domestic, stock and irrigation wells in the Cottonwood/Grass Creek watershed, it appears that none of the existing wells are completed in any of these units, presumably due to the very high cost to develop, pump and maintain wells in these deep units.

2.3 Watershed Hydrology

2.3.1 Hydrologic Regions and Stream Types

The study area comprises the combined drainage basins of Cottonwood Creek and its primary tributary Grass Creek, referred to herein as the Cottonwood/Grass Creek watershed. The location and extent of the watershed, the mainstem creeks, significant tributaries, and existing reservoirs are shown on Figure 2.3-1 – Watershed Hydrologic Features.

The Cottonwood/Grass Creek watershed falls within the Mountainous and Plains hydrologic regions as defined by Lowham (1988) and applied to Hot Springs County in Plafcan and Ogle (1994). The boundary between these regions (as shown on Figure 2.3-1) is approximately located just upstream of the confluence of Little Grass Creek with Grass Creek and between the confluences of Twentyone Creek and Lake Creek with Cottonwood Creek. Elevations in the Mountainous region range from approximately 6,700 feet to a high of 10,919 feet at Cottonwood Peak. The Plains region extends to the east end of the watershed at the confluence with the Bighorn River at elevation 4,190 feet.

Streamflows in the Mountainous region are dominated by snowmelt runoff in the spring and early summer. Discharges from springs and seeps and summer rainfall events dominate flows in the summer and fall. Flows are lowest in the winter. As a result of these sources, streamflows in the Mountainous region are typically characterized by relatively small peak flows but higher annual runoff. In the Plains region, streamflow occurs primarily due to rainfall events, and is sometimes sustained locally and/or seasonally by discharges from springs and seeps (especially in the higher elevation reaches of this region). This results in typically relatively large peak flows that are highly variable in location and from year-to-year. Annual runoff is typically low.

The portions of the mainstems (Cottonwood and Grass Creeks) and their larger tributaries located in the Mountainous region tend to be perennial to intermittent streams, while reaches and streams in the Plains region are intermittent to ephemeral. The perennial stream reaches in the watershed (including the uppermost reaches of Cottonwood and Grass Creeks and their high elevation tributaries) are the result of higher precipitation (including greater snowpack) and greater groundwater recharge that, in turn, result in higher spring time runoff flows and sustain seep and spring discharge to these stream reaches through the summer and fall. As noted by local ranchers and other stakeholders in the watershed, the extent of the upper watershed perennial stream reaches has declined significantly over the course of the current drought, with many smaller springs ceasing to flow and greatly reduced flows in larger springs. The lower reach of Cottonwood Creek below the Hamilton Dome oil field is a perennial reach due to discharges of produced water from the oil extraction operations (see additional discussion in Section 2.3.4 below).

The stream reaches and tributaries in the Plains region of the watershed typically range from intermittent in the mid-elevations to ephemeral in the lower elevation (eastern) portion of the watershed. Ephemeral streams are defined herein 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. Typical intermittent streams include Prospect Creek and Wagonhound Creek; ephemeral streams include Boulder Gulch, Spring Gulch, Lester Draw and Chimney Gulch, all tributary to lower Cottonwood Creek below the Grass Creek confluence. (Note that there is another Spring Gulch tributary to Grass Creek; that stream is perennial to intermittent.)

2.3.2 Existing Lakes and Reservoirs

There are no natural lakes of any significance within the Cottonwood/Grass Creek watershed. There are only two small active non-stock reservoirs, Lake Creek Reservoir and Wales Reservoir, and one inactive, breached reservoir (Phelps Reservoir) in the watershed (see Figure 2.3-1). These existing facilities and a road fill (causeway) crossing the Grass Creek valley are described in Section 2.7.2; the potential to reconstruct and/or enlarge these reservoirs or the causeway is discussed in Section 3.3.

2.3.3 Gaging/Sampling Stations

As shown on Figure 2.3-2 – Gaging Stations and Streamflow/Sampling Sites and Table 2.3-1 – Gaging Stations and Streamflow Sites, two U.S. Geological Survey (USGS) gaging stations (one historic and one active) and 22 other miscellaneous streamflow/sampling sites and/or temporary gages are reported in the watershed (Plafcan and Ogle, 1994; http://waterdata.usgs.gov/nwis/si).

Gage 06265337. The only currently active gage in the combined Cottonwood/Grass Creeks watershed is on Cottonwood Creek above Hamilton Dome near the Cottonwood Creek crossing of Upper Cottonwood Creek Road. The drainage area reporting to this gage is 81.4 mi^2. The only known factors affecting flow at this gage are the relatively minor diversions and return flows associated with irrigation in the valley bottom at the old Rhodes Ranch site. This gage has operated continuously since April 1993 (i.e., for 14 years). According to Dee Hillberry (2007) Lake Creek Reservoir has not stored any water during this period and should not have affected the gage record. Complete flow and water quality data for this gage are available at: http://waterdata.usgs.gov/nwis/inventory/?site_no=06265337&amp.

Gage 06265500. This gage was located on Cottonwood Creek just above the confluence with the Bighorn River near Winchester (just north of Kirby). The contributing drainage area above this gage site is 416 mi^2. In addition to the non-natural factors noted for Gage 0626337 above, flows at this gage were also affected by substantially more irrigation diversions and return flows, the operation of Wales Reservoir, and possibly some amount of groundwater discharge from the Hamilton Dome oil field (see additional discussion in Section 2.3.4 below). This gage operated more or less continuously for only four years (from July 1941 to June 1945). This site was also sampled once each in 1965, 1966 and 1976, and gaged/sampled a total of 11 times during 1977-78. Complete flow and water quality data for this site are available at the following websites:

http://waterdata.usgs.gov/nwis/inventory/?site_no=06265500&

http://nwis.waterdata.usgs.gov/nwis/nwisman/?site_no=435146108091000&agency_cd=USGS

The miscellaneous streamflow/sampling sites listed in Table 2.3-1 and shown on Figure 2.3-2 were monitored/sampled only for brief periods in 1970, 1976, 1977-78, 1990 and/or 2000 as part of special studies in the watershed. All measured streamflows and field and laboratory water quality data for these sites can be found by starting at the following website, entering the site number where indicated, and selecting the appropriate choices and/or filling in whatever other necessary information is required: http://waterdata.usgs.gov/nwis/si.

2.3.4 Streamflow Characteristics

Analysis of Gage Data. Quantitative characterization of gaged streamflows within the Cottonwood/Grass Creeks watershed is limited to Cottonwood Creek at the two gaging stations discussed above. Given the relatively short record for both of these gages and the disparity in the recorded period between the two records, caution must be exercised both in interpreting the data for each gage independently and in comparing the two sets of data. Given these precautions, it is useful to examine the mean and peak annual and mean monthly flows for these two gages to gain at least a sense of the behavior of Cottonwood Creek and the overall watershed over time.

Gage 06265337. Mean monthly discharge at the upstream Gage 06265337 (at High Island Ranch above Hamilton Dome) is plotted on Figures 2.3-3 – Mean Monthly Discharge (cfs) – Cottonwood Creek at USGS Gage 06265337 and 2.3.-4 – Mean Monthly Discharge (ac-ft/month) – Cottonwood Creek at USGS Gage 06265337. Note that monthly discharges in May and June together represent more than 60 percent of the total mean annual flow at this gage, with April through July flows accounting for more than 80 percent of the total.

Mean annual flows at this gage are plotted on Figures 2.3-5 – Mean Annual Discharge (cfs) – Cottonwood Creek at USGS Gage 06265337 and 2.3.-6 – Mean Annual Discharge (ac-ft/year) – Cottonwood Creek at USGS Gage 06265337. The impact of the ongoing drought in the Bighorn basin is strikingly apparent in the very low mean annual discharges since 2000. These flows average about 2,500 ac-ft/year which is only 23 percent of the pre-2000 average annual flow of 10,600 ac-ft/year. If the lower flows in 1994 and 1996 are excluded, the average annual flows during the ongoing drought are only 18 percent of the four wetter years in the record.

Annual peak flows recorded at Gage 06265337 are plotted on Figure 2.3-7 – Peak Gaged Streamflow – Cottonwood Creek Gage 06265337. It is interesting to note that peak gaged flows range over two orders of magnitude (from a low of 34 cfs to a high of 3410 cfs) and occur in six different months (March through August). Most of the annual peak flows were well under 1000 cfs, while higher (flood) peak flows occurred during June 1997 and July 2001 (the latter peak having occurred during the sustained drought that began in 2000). These two highest peak flows were likely due to very intense rainfall events. This overall evaluation is a qualitative indication that although the record is not long, this gage does appear to have recorded a wide range of hydrologic conditions in the upper Cottonwood Creek basin.

Gage 06265500. Mean monthly discharge at the downstream Gage 06265500 (located at the confluence of Cottonwood Creek with the Bighorn River at Winchester) is plotted on Figures 2.3-8 – Mean Monthly Discharge (cfs) – Cottonwood Creek at USGS Gage 06265500 and 2.3-9 – Mean Monthly Discharge (ac-ft/month) – Cottonwood Creek at USGS Gage 06265500. Essentially the same percentages of mean annual flow occur during the May/June and April-July runoff periods as for the upstream Gage 06265337.

Mean annual flows for four complete years of record for the lower gage are plotted on Figures 2.3-10 – Mean Annual Discharge (cfs) – Cottonwood Creek at USGS Gage 06265500 and 2.3-11 – Mean Annual Discharge (ac-ft/year) – Cottonwood Creek at USGS Gage 06265500. An evaluation of the monthly flow data for the five years of record at this gage concluded that three of the five years were wet years and the other two years normal years as defined for the Wind/Bighorn Basin Plan model (see Section 2.71.1 below). A comparison was made of the average gaged flow hydrograph for 1942-1943 with the normal year model hydrograph and the averaged 1941-1944-1945 gaged hydrograph with the wet year model hydrograph for this node. The wet year correlation is very strong and the normal year correlation is fair. This evaluation also included analysis of precipitation records from the weather stations at Worland and Cody. Values of total annual precipitation for all years of record at these two weather stations were ranked from high to low and then percentile ranges were determined corresponding to those for wet, normal and dry year hydrologic conditions as defined in the Wind/Bighorn Basin Plan model. The precipitation totals for 1941, 1944 and 1945 all fell within the upper 80th-100th percentile range indicating wet years; 1942 and 1943 fell within the middle 21st-80th percentile range indicating normal years.

It is significant to note that the mean annual discharge at this gage at the mouth of Cottonwood Creek was 20,600 ac-ft/year (with a range of 7,500 to 30,300 ac-ft/year) even with the historic diversions and associated net consumptive irrigation losses assumed to have been present in the watershed during those years. As discussed further in Section 2.7, this is consistent with the conclusion that there are flows physically available for storage in the watershed at least during normal and wet years that could be stored to address at least some of the existing late season normal year and chronic dry year irrigation shortages. Note, however, that this conclusion would need to be tempered somewhat if information not found to date were to indicate that significant Hamilton Dome oil field discharges to lower Cottonwood Creek were occurring during this time period (see discussion in Section 2.3.4 below).

Annual peak streamflows are plotted on Figure 2.3-12 – Peak Gaged Streamflow – Cottonwood Creek Gage 06265500. As might be expected from the behavior at the upstream gage, peak flows at this gage again range over more than two orders of magnitude (195 cfs to 4,120 cfs) and occur during five different months (March and May through August).

Modeled Streamflows. Table 2.3-2 – Headwaters Subbasin Characteristics and Table 2.3-3 – Modeled Natural and Gaged Flows derived from the Wind/Bighorn Basin Plan (BRS, et al., 2003) provide subbasin characteristics and estimates of annual streamflows for dry and normal year conditions for the modeled headwaters of the mainstems and several tributary streams/areas in the watershed. Note that the model estimates from Table 2.3-3 of normal (6 out of 10 years) headwater unit runoff appear generally reasonable on a comparative basis (even though the absolute values of the estimates are only approximate at best - see discussion in Section 2.7.1 regarding model limitations). For example, the estimated unit runoff of 486 ac-ft/mi^2 from the Lake Creek subbasin with a mean elevation of nearly 7,900 feet is in the same order of magnitude as for Grass Creek at 316 ac-ft/mi^2 (with a mean basin elevation of about 7,500 feet). Although similar in terms of mean elevation, a substantially greater portion of the much smaller Lake Creek basin is higher than the mean elevation as compared to the larger Grass Creek headwaters basin. With generally similar solar exposures, this difference in predominant basin elevation would lead to an expectation of greater unit runoff in the Lake Creek headwaters basin as predicted by the model. Similarly, the model prediction that the higher Grass Creek headwaters basin yields approximately three (3) times the unit runoff of 149 ac-ft/mi^2 from the similar size and exposure Spring Gulch ("Mayfield Wells") subbasin (with a mean elevation of about 6,200 feet) does not seem unreasonable.

As a further check on the order of magnitude reasonableness of the modeled headwaters streamflows (or basin runoff), the gaged unit runoff for the upper portions of the nearby North and South Fork Owl Creek drainages was calculated and compared to the modeled Cottonwood and Grass Creek runoff estimates. Based on 14 years of data for Gage 06262300 in the upper North Fork Owl Creek, the average annual streamflow is approximately 9,800 ac-ft/year (13.6 cfs) resulting in 161 ac-ft/mi^2 of runoff. The comparable values for upper South Fork Owl Creek (at Gage 06260000) above Anchor Reservoir) are 24,800 ac-ft/year (34.3 cfs) and 285 ac-ft/mi^2, respectively, based on 31 years of gage data. That the yield for South Fork Owl Creek is nearly twice that for the North Fork is most likely due to the fact that the average elevations in the South Fork headwaters are significantly higher than in the North Fork headwaters, including a substantially greater percentage of the South Fork at elevations greater than about 8,000 feet as compared to the North Fork. This comparison in the Owl Creek watershed is comparable to that described above between Lake Creek and Grass Creek headwaters in the Cottonwood/Grass Creek watershed.

Although relative unit runoff between differing portions of the headwaters of both watersheds appears reasonably comparable as discussed above, comparison of the absolute values of the Owl Creek runoff estimates based on gaged flow to the Cottonwood/Grass Creek model estimates suggests that the model may be over-predicting natural runoff in the Cottonwood/Grass Creek watershed. For example, given the overall higher elevations in the South Fork Owl Creek headwaters as compared to the upper Cottonwood Creek or upper Grass Creek headwaters, it would not be unreasonable to expect to see higher unit runoff from the South Fork Owl Creek headwaters. Rather, the unit runoffs predicted in the Cottonwood/Grass Creek headwaters range from 316 to 329 ac-ft/mi^2 (excluding the very localized Lake Creek subbasin), exceeding the 285 ac-ft/mi^2 gage-based runoff calculated for South Fork Owl Creek. The Cottonwood/Grass Creek estimates exceed by an even greater margin the gage-based unit runoff of 161 ac-ft/mi^2 calculated for the North Fork Owl Creek headwaters basin. This is the case even though the elevations in the North Fork Owl Creek headwaters are at least as high or are higher than in the Cottonwood/Grass Creek headwaters.

In conclusion, it appears that the areal variations of headwaters unit runoffs (and resulting streamflows) predicted by the Wind/Bighorn Basin Plan model in the Cottonwood/Grass Creek watershed are reasonable, but that the absolute values may be somewhat higher than actual yields. Note, however, that these conclusions are based only on the semi-quantitative evaluations discussed above and that more detailed analyses beyond the scope of this Level I study would be required to further substantiate or modify them. As discussed in Section 2.7 below, it is also important to consider the inherent limitations of this portion of the Wind/Bighorn Basin Plan model and the resulting precision/accuracy of the model results.

Summary. The large majority of annual runoff in the Cottonwood/Grass Creek watershed is from the Mountainous region. As described above, it is estimated that the average annual runoff from the Mountainous (headwaters) areas of the watershed is most likely not greater than 150-300 ac-ft/mi^2. In general, annual average runoff in the Mountainous region of Hot Springs County is estimated to be on the order of 10-20 times the runoff from the Plains region (Plafcan and Ogle, 1994). Based on this ratio, annual runoff for the lower Plains portions of the watershed would be anticipated to be on the order of 7.5-30 ac-ft/mi^2.

Peterson, et al. (1987) estimated that the overall average annual runoff for the entire Cottonwood/Grass Creek watershed was in the range of 20-49.9 ac-ft/mi^2 reportedly based on available gage records throughout hydrologically similar areas in the Bighorn basin. The average annual runoff measured at Gage 0626337 at the mouth of the Cottonwood/Grass Creek watershed was evaluated as a check on this overall estimate of runoff. Unit runoff at this gage ranged from 18-73 ac-ft/mi^2 and averaged 50 ac-ft/mi^2 during what was a normal to wet period of record in the 1940s. This gaged runoff appears to be a reasonably good match with the Peterson, et al. (1987) estimate, considering that the gage record covers a generally wetter period than average. Note, however, that this gage record probably does not accurately reflect natural runoff over the basin (i.e., runoff not influenced by man's activities). For example, some net consumptive losses due to irrigation are assumed to have occurred during the period of record. Given that the gaged period was normal to wetter than normal, these losses were likely significantly less than would have been the case in dry years. This is due to natural precipitation providing a greater portion of the required crop moisture resulting in less need to irrigate with diverted streamflows. Any such loss of streamflows attributable to irrigation diversions and accompanying net consumptive evapotranspiration would have to be added back into the gaged flow to arrive at a more accurate estimate of natural runoff.

2.3.5 Hamilton Dome Discharges

Discharges from the Hamilton Dome oil field to Cottonwood Creek represent a very substantial portion of the total annual flow downstream, and provide substantial benefits to irrigators, livestock, wildlife, aquatic life and the riparian environment throughout the year. An analysis by SWWRC (2003) concluded on the basis of water balance analyses and interviews with local stakeholders that "*even with the MEC* *discharges, Cottonwood Creek frequently runs dry prior to its confluence with the Big Horn River.*" (p. 16) As a result, considerable effort was expended during this Level I study to gather and evaluate information and data on the current and historical discharges of produced water from the Hamilton Dome oil field to Cottonwood Creek as a basis for better understanding their potential role in future water development in the watershed.

Oil Field Background. The first oil well at the Hamilton Dome field was completed in 1918 in the Tensleep formation. Most of the historic and current oil production is from the Tensleep with the next most significant contribution from the Phosphoria formation. Production zones in both of these formations occur in an interval of about 2500-3400 feet below ground surface (bgs), well below historic and current static groundwater levels on the order of 1500 feet bgs (Georgius, 2007). In general, it would be expected that water production from a field of this type would have been absent or very low initially and possibly well into the life of the field (Van Kirk, 2007; Sharma, 2007). Low water production tends to occur when there is still sufficient oil in the producing zone(s) to be "pushed or pulled" into the wells (depending on whether the well is artesian or pumped) ahead of (hydraulically above) the more dense groundwater. At some point, depending on extraction rates and resulting reservoir pressures, water would typically begin to be extracted along with the oil. As oil production continues, the "water cut" (the ratio of water volume to the total water and oil volume produced) would generally be expected to increase. The overall rate of water production from a given well or field over time would depend on the rate of the combined oil and water extraction. The net rate of water discharged off-site would equal the total rate of water produced less the rate of re-injection (if any).

Interviews. In an attempt to learn more about historic conditions in the Cottonwood Creek basin relative to discharges of produced water from the Hamilton Dome oil field, especially prior to the period of available records, contacts were made and interviews conducted with several local, long-time residents. These individuals were identified and phone numbers provided by Mr. Bob Georgius of Merit Energy Company (MEC), the current owner/operator of the field. The key information provided by these individuals is summarized in the following paragraphs.

The earliest firm indication found during these interviews of water discharges being made from Hamilton Dome to Cottonwood Creek is the account of Mr. Bill Deromedi of Thermopolis (Deromedi, 2007). Mr. Deromedi went to work at Hamilton Dome in March of 1955. He stated that produced water was definitely being discharged to Cottonwood Creek at that time, that discharges occurred essentially continuously since that time, and that the water cut in the wells generally increased over time during his more than 30 years at the field. Furthermore, it is his belief that flows had been occurring for some time before 1955, but he was not aware of any actual data as to how much earlier or at what rates of discharge. It is his opinion that it is possible that water was being discharged during the 1940s when Gage 02625337 was operable.

Mr. Joe Shaffer of Thermopolis was interviewed based on his extensive familiarity with the Cottonwood Creek drainage both prior to and especially after going to work at Hamilton Dome in 1959 (Shaffer, 2007). Mr. Shaffer stated that there were discharges to Cottonwood Creek when he went to work at Hamilton Dome, but that they were relatively small at that time. He observed that these discharges were fully diverted for irrigation and/or otherwise lost (presumably due to seepage and evapotranspiration) long before reaching the confluence with the Bighorn River. Then in the early 1960s, he recalls that one of the several operators at the field at that time installed new, much higher capacity pumps in a number of wells to increase oil production. The result was a significant increase in discharge of produced water to Cottonwood Creek. Other operators then also added higher capacity pumps and production of water and oil increased more. He also noted that secondary recovery at Hamilton Dome began sometime in the 1970s by water flooding with a portion of the produced water, but that discharges to the creek were still much greater than the amounts re-injected.

Mr. Frank Rhodes of Thermopolis, a long-time prior resident (rancher and irrigator) in the Cottonwood basin (Rhodes, 2007) was also interviewed for his recollections of discharges from Hamilton Dome. Mr. Rhodes stated that he lived in the Cottonwood Creek basin since 1948 above Hamilton Dome until his family moved to a ranch just downstream of the Dome (the "Irwin place") in 1959. His strong recollection is that there were no releases from Hamilton Dome that fall/winter (i.e., Cottonwood Creek was dry), but that there definitely were flows during the winter of 1960-61 and thereafter. Mr. Rhodes also stated in an affidavit that "*Prior to produced water being discharged, Cottonwood Creek would only flow from approximately March to July or August, and would sometimes be dry as early as June. For the rest of the year, Cottonwood Creek was dry with the exception of intermittent flows of rain or snow melt.*" (SWWRC, 2003)

WOGCC Data. Data on oil and water production for the Hamilton Dome oil field is available from the Wyoming Oil and Gas Conservation Commission (WOGCC) at: http://wogcc.state.wy.us/FieldMenu2.cfm?Skip='Y'&oops=49.

Note that compiled data on this website is only available since 1978. Archival monthly production records back to 1958 are available at the WOGCC offices in Casper. Records prior to 1958 were not found. Monthly water production data for 1958, 1960, 1965, 1970, and 1975 were acquired and compiled for this study. These data were selected to investigate long-term trends; acquiring and compiling all of the voluminous available archived data from 1958 through 1977 was beyond the scope of this study and not necessary for the purposes at hand. Note that data on re-injection of produced water were not found in the WOGCC records.

Available data on water production over time at Hamilton Dome is plotted on Figure 2.3-13 – Hamilton Dome Water Production. During the period of record the total annual water production has varied from about 300 to 17,000 ac-ft. There is a clear trend of increasing water production over time, but with a significantly lower rate of increase and increasing scatter about the trend over time. The scatter in the data reflects variations in the pumping rates of various wells and the addition and/or shutting-in of wells over time. It is important to note that these total water production values are not necessarily the amount of water discharged to Cottonwood Creek. As discussed above under Interviews, re-injection reportedly began sometime in the 1970s. Available data on the net discharge of produced water to the creek is discussed under WDEQ Data below.

The expected long-term trend of increasing water cut described above is clearly evident in the data plotted on Figure 2.3-14 – Hamilton Dome Water Cut Over Time. Note that at the current water cut of about 98.5-99.0 percent, less than 1.5 percent of the total volume of fluid extracted from Hamilton Dome is oil, with the remainder water. The power costs to sustain the pumping of these very significant volumes of water (and the associated very small volume of oil) are substantial.

WDEQ Data. As addressed further in Section 2.6, a portion of the total produced water from the Hamilton Dome oil field is discharged to Cottonwood Creek at two WDEQ-permitted locations, one just above and the other just below the field. Data on total water discharged from these two sites is available for 2002, 2005 and the first half of 2006 (WDEQ, 2007). These data are summarized in Table 2.3-4 – Hamilton Dome Production Water Discharge to Cottonwood Creek. These discharges are the difference between the total amount of water extracted along with the oil (see Figure 2.3-13) and the amount of water being re-injected into the producing zones for secondary recovery. The average annual discharge to Cottonwood Creek since 2002 has been about 9,000 ac-ft (or about 750 ac-ft/month, 25 ac-ft/day or 12.5 cfs). Discharges are relatively constant throughout the year. Table 2.3-4 also shows that in recent years an average of 70 percent of the total water produced from the field is discharged to the creek, with the remaining 30 percent re-injected into the producing zones. Based on the sparse data available, it is clear that the ratio of water discharged is variable (between 61 and 76 percent). Due to the many factors that influence this ratio, it is not possible to predict how it may vary in the future.

Summary. Figure 2.3-15 – Hamilton Dome Oil Production shows the general long-term decline of oil production over the more recent 28-year period of record available in digital format. The plot also shows that the rate of decline in production has decreased in the past several years and that a slight increase was experienced from 2005 to 2006, presumably as a result of higher crude oil prices supporting more aggressive recovery. It is not possible to predict how much longer oil and the associated significant volumes of water will continue to be produced from this 89-year old field, or at what rate. However, it is important to realize that an end to production at Hamilton Dome has been predicted numerous times over its life (as is the case for many of the older northern Rocky Mountain oil fields), but the field continues to produce in response to higher crude oil prices and advances in recovery technology.

Based on the review of available data and the interviews and affidavit summarized above, the history of water discharges from the Hamilton Dome oil field to Cottonwood Creek prior to 1958 is still somewhat uncertain. For the purposes of this study, it is assumed that some discharges from Hamilton Dome to Cottonwood Creek were occurring at least as early as 1955 and continuously thereafter. Until or unless additional data is discovered, it appears reasonable to assume that any water discharges occurring during the period of record of Gage 06265337 (1941-45) were minor (likely only a few hundred acre-feet per year at most based on the above interviews and the 1958 WOGCC data discussed above).

No water discharges from the Grass Creek oil field are shown in production data for 1979 to present available on the WOGCC website. Review of archival records at the WOGCC offices determined that total annual water production at the Grass Creek field during the years 1941-45 varied from a high of 34.8 ac-ft to a low of 13.0 ac-ft. Even if all of this produced water had been discharged to Grass Creek, these minor flows (0.018-0.048 cfs) would have had no discernible effect on the flows recorded at Gage 06265337 at the mouth of Cottonwood Creek.

2.4 Stream Geomorphology

2.4.1 General

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

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

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

Impairments to geomorphic function reflect a significant loss of the functional potential of the green channel segment. These impairments are typically described in general, qualitative terms, and any rehabilitation of impaired channel segments requires a more thorough, site-specific assessment of impacts, impairments, and feasible remedies.

2.4.2 Rosgen Classification System

The literature presents descriptions of numerous systems for classifying and evaluating stream systems. Of these, perhaps the most widely used today is the Rosgen classification system (Rosgen, 1996). This system, based upon the stream’s existing channel morphology, was utilized in this study. Parameters such as the sinuosity, slope, width/depth ratio, and size of channel materials are evaluated and used to classify the stream into one of the various "types" included in the system. There are four levels of classification in the Rosgen system, each being more detailed than the previous level. Figure 2.4-1 – Hierarchy of the Rosgen Classification System displays the hierarchy of the assessment levels and the general nature of effort associated with each.

Much of the Level I geomorphic characterization is qualitative and utilizes aerial photography and topographic maps. Streams are divided into eight (8) broad types on the basis of their channel and floodplain geometry. Rosgen’s classification system stream types can be thought of in their relative location within the watershed, from their headwaters through lowlands. The major stream types reflect their location in the watershed. For example, “A” type streams are located in headwaters, “C” & “E” stream types are located in meandering lowlands, etc.

The Level II effort provides a more detailed description of the stream using measurements at selected locations. Stream types are further subdivided into 94 subtypes based upon degree of entrenchment, width-to-depth ratio, water surface slope, streambed materials, and sinuosity (Figure 2.4-2 – Rosgen Classification Matrix). 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 Cottonwood/Grass Creek watershed study included Rosgen Level I and Level II assessments of channel conditions.

The Cottonwood Creek Watershed Study included Level I evaluation of Cottonwood Creek, Grass Creek, and their major tributaries (Twentyone Creek, Wagonhound Creek, Prospect Creek and Spring Gulch). Following completion of the Level I effort, a Level II investigation was completed on Prospect Creek, Wagonhound Creek, and to a limited extent, Spring Gulch. These channels were initially identified as impaired during the Level I assessment.

2.4.3 Cottonwood/Grass Creek Level I Classification

2.4.3.1 Level I Methods

The purpose of the Level I geomorphic classification is to provide an inventory of the Cottonwood/Grass Creek watershed’s overall stream morphology, character, and condition.

It is intended to serve as an initial assessment for use in more detailed assessments and to determine the location and approximate percentage of stream types within the basin. The results of the Level I classification can be integrated directly into the project Geographic Information System (GIS) providing a graphical “snapshot” of the basin. Based upon this initial effort, potential stream reference reaches can be identified for further study in the Level II classification effort. The end product of the Level I classification is the determination of the major stream types, A through G. Table 2.4-1 – Summary of Rosgen Stream Type Characteristics presents a brief summary of the different stream types found within the Rosgen system and Figure 2.4-3 – Major Stream Types with the Rosgen Classification System shows the relative locations of these types within a typical watershed. Brief descriptions of the various stream types encountered in the Cottonwood/Grass Creek watershed are presented in the following paragraphs.

A-Type Channels are relatively steep channels that form in headwater areas as well as within bedrock canyons (Figure 2.4-4 – Grass Creek Headwaters (Type A Channel)). 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 (Figure 2.4-5 – Upper Wagonhound Creek (Type B Channel)). B-channels are characterized by moderate slopes, moderate entrenchment, and stable channel boundaries. Due to the relatively steep channel slopes and stable channel boundaries, B-channels are moderately resistant to human impacts, although, their reduced slopes relative to headwater areas can make them prone to sediment deposition and subsequent adjustment following a large sediment transport event such as an upstream landslide, debris flow, or flood.

C-Type Channels are typically characterized by relatively low slopes, meandering planforms (i.e., the shape one would see if viewing from above, as on a map or aerial photo), and pool/riffle sequences (Figure 2.4-6 – Cottonwood Creek above Wagonhound Creek (Type C Channel)). The channels tend to occur in broad alluvial valleys, and they are typically associated with broad floodplain areas. C-channels tend to be relatively sinuous, as they follow a meandering course within a single channel thread. In stream systems in which the boundaries of C-type channels are composed of alluvial sediments, channels tend to be dynamic in nature, and susceptible to rapid adjustment in response to disturbance.

E-Type Channels are somewhat similar to C channels, as they form as single threads with defined, accessible floodplain areas (Figure 2.4-7 – Grass Creek above Little Grass Creek (Type E Channel)). However, E channels are different in that they tend to have fine-grained channel margins, which provide cohesion and support dense bankline vegetation. The fine-grained, vegetation-reinforced banklines allow for the development of steep banks, very sinuous planforms, and relatively deep, U-shaped channel cross sections. E-type channels commonly form in low gradient areas with fine-grained source areas, mountain meadows, and in beaver-dominated environments. E-channels tend to have very stable planforms, and efficient sediment transport capacities due to low width/depth ratios.

F-Type Channels typically have relatively low slopes (<2%), similar to C and E channel types. The primary difference between C/E channels and F channels is with respect to entrenchment. F channels are entrenched, which means that the floodplain is quite narrow relative to the channel width. The entrenchment of alluvial F-type channels typically is an indicator of an historic downcutting event. F-type channels may form in resistant boundary materials (e.g., U-shaped bedrock canyons), and relatively erodible alluvial materials (e.g., arroyos). When the boundary materials are erodible, the steep valley walls are prone to instability, and channel widening commonly occurs within the entrenched channel cross section (Figure 2.4-8 – Upper Wagonhound Creek (Type F Channel)).

G-Type Channels are narrow, steep entrenched gullies. G-Type channels typically have high bank erosion rates and a high sediment supply. Channel degradation and sideslope rejuvenation processes are typical. Figure 2.4-9 – Prospect Creek Tributary (Type G Channel) displays a typical G-Type channel within the Cottonwood/Grass Creek watershed.

The Level I classification effort was conducted primarily using existing information incorporated into the project GIS. Several analytical tools were developed and integrated into the GIS which allowed the evaluation of various geomorphic parameters (sinuosity, slope, stream station determination). The data collated and incorporated in the Geomorphology GIS include digital aerial photography, USGS topographic maps, Landsat color infrared imagery, a digital elevation model (DEM), and digitized hydrography information.

Each reach was evaluated in light of the characteristics required at the Level I classification. These parameters, as indicated in Figure 2.4-1 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. These parameters are quantified and the Level I assessments verified during the Level II effort.

2.4.3.2 Level I Classification Results

Results of the Level I classification effort are presented in Figure 2.4-10 – Rosgen Level I Geomorphic Classification. This figure displays a map of the Cottonwood Creek watershed depicting the various stream types. Table 2.4-2 – Summary of Level I Geomorphic Data presents a summary of the Level I geomorphic parameters used in this characterization.

Cottonwood Creek and Grass Creek originate in the steep eastern foothills of the Absaroka Range. Within the mountainous areas, the channels are steep and bounded by very coarse, resistant materials that include hillslope colluvium, glacial deposits, and bedrock. As a result, the channels are laterally stable, and geomorphically resilient with respect to human impacts. Channel change in these upper subreaches typically results from punctuated hillslope processes rather than gradual channel migration. The channels are A-type or B-type channels (Table 2.4-2), which reflects their steep slope and stable boundaries.

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

Based upon field observations and information provided by landowners, Cottonwood Creek has experienced a degradation period in the past. This is evidenced by terraces and abandoned floodplains within its lower reaches. Today, it appears the channel has re-formed a broad floodplain within the confines of the valley slopes. The stream displays a relatively large degree of variability. However, for the most part the channel appears to be vertically stable and have adequate connection to its floodplain and would not be considered to be entrenched. Consequently, Cottonwood Creek can be considered to be a C-Type channel throughout most of its reach. Sinuosity of Cottonwood Creek in its mid to lower reaches ranges from 1.7 to 2.2. Figure 2.4-11 – Cottonwood Creek near the Confluence with the Bighorn River (Type C4 Channel) displays a photograph of Cottonwood Creek near its confluence with the Bighorn River.

Lateral migration of Cottonwood Creek has caused the formation of vertical banks where the channel impinges upon the valley sideslopes. The tendency of the stream to migrate has also resulted in the abandonment of several irrigation diversions.

Irrigators have resorted to utilizing concrete barriers in the channel to restore flow conditions necessary to divert water. Portions of Cottonwood Creek would be classified as more entrenched F-Type channels. In the vicinity of Putney Flats the channel is entrenched, has vertical banks, and displays little connection to its floodplain.

Whereas the larger Cottonwood Creek emerges into the basin as a meandering C channel, relatively fine-grained, sinuous, E-type channels dominate the smaller Grass Creek (Figure 2.4-12 – Grass Creek near Little Grass Creek (Type E Channel)). The fine-grained, vegetated upper banks of these channels tend to result in the formation of overhanging upper banks where the bank toe undercuts the upper bank, creating a cantilever bank cross section. In general, these streams are moderately resistant to changes in hydrology or sediment load; however, they are prone to rapid destabilization due to gravitational bank failure, which can be caused by loss of vegetative reinforcement.

Many of the first-order tributaries in the basin can be classified as G-Type channels, or gullies. These channels are highly erosive, generate high sediment volumes, and can result in the loss of productive lands and destabilize upland conditions (Figure 2.4.-13 – Tributary to Wagonhound Creek – (Type G Channel)). Observation of many of these channels indicates that while the major stream channels appear to have achieved a level of stability, the upper reaches of the watershed are still suffering a level of destabilization. These channels could be forming in response to one or more of numerous stimuli including but not necessarily limited to: road and culvert construction, range management practices, or base-level lowering associated with main channel incision.

2.4.4 Cottonwood/Grass Creek Level II Classification

2.4.4.1 Level II Methods

The purpose of the Level II classification was to obtain more detailed morphological description of the Wagonhound Creek, Prospect Creek, and Spring Gulch subwatersheds. These areas were identified during the initial Level I investigation as potentially being impaired and being locations of potential watershed improvement projects. The results of the Level I classification were reviewed prior to initiation of the Level II classification. Representative reaches were selected for Level II classification based upon the Level I stream type and field observations of channel conditions. An effort was made to identify "reference reaches" for specific channel types that could be utilized in future restoration efforts. The intent was to identify unimpaired, "ideal" channel segments of a given channel type that could be replicated within impaired reaches of similar type to improve channel stability and/or function. However, due to the inherent variability in the system and the fact that the system has been historically disturbed by various land use practices, the application of a broad "reference reach" approach to channel restoration is likely inappropriate. Such an approach could potentially be applied on a smaller scale, with the direct application of reference reach characteristics to an adjacent impaired reach, rather than a broad replication of a general reference reach to an entire extent of a given channel type. Furthermore, ongoing impacts within the system such as flow diversions, wildlife and livestock grazing and road construction indicate that restoration efforts should include the assessment of existing and anticipated future conditions of hydrology and sediment supply, and thus be based on fundamental processes of channel hydraulics and sediment transport. Consequently, numerous cross sections were measured at reaches determined to be representative of the stream in question in an effort to ascertain the processes occurring within the watershed.

At each of the cross section locations, numerous tasks were completed. Several geomorphic parameters were evaluated including channel slope, channel shape, channel patterns, valley morphology, entrenchment ratio, width depth ratio, and channel materials. The Rosgen classification system is heavily reliant upon the determination of bankfull stage. Bankfull stage corresponds to "the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends or meanders, and generally doing work that results in the average morphologic characteristics of channels" (Dunne and Leopold, 1978). Consequently, the channel-forming discharge is typically associated with the 1.5 to 2 year event. Identification of bankfull stage in ephemeral channels such as Prospect and Wagonhound Creeks can be problematic. Typically, key indicators include the presence of a floodplain, depositional features, vegetative indicators, staining on rocks, etc. With channels formed during the 'flashy' high-intensity, short duration runoff event, these indicators may be more obscure or subtle. Channels can be greatly 'reworked' during each event.

2.4.4.2 Level II Classification Results

This section contains a summary of channel classification results by subreach, as well as a description of observed impairments and potential approaches to channel rehabilitation. These summaries are derived from quantitative data from individual cross sections, coupled with supplementary field observations. Table 2.4-3 – Summary of Level II Geomorphic Characterization presents a tabulation of geomorphic parameters obtained at each of the cross sections. Figure 2.4-14 – Rosgen Level II Geomorphic Classification Cross Section Locations displays the results of the Level I and II investigations graphically.

Prospect Creek. The upper reaches of Prospect Creek in the vicinity of Cow Camp were classified as B5a- to B5-Type channels. The channels are moderately entrenched within steep valley sideslopes. The steep channel slope in the upper portion of the reach gives cross section PC-10 its B5a classification indicating the channel tends toward an A-Type channel. A series of localized small headcuts may be associated with past and/or ongoing wildlife and livestock grazing. Upstream of Cow Camp mature pines are located within the channel indicating channel stability. Bedrock outcrops in the channel will likely serve as base level control and upstream migration of the headcutting is not anticipated.

Downstream from Cow Camp, the channel transitions into a stable C-Type channel at cross section PC-8 (Figure 2.4-15 – Prospect Creek at Cross Section PC-08 (Type C4b Channel)). Approximately 3.0 miles downstream from Cow Camp, the channel abruptly changes to a deeply entrenched F-Type channel. Channel incision has migrated upstream to this location and has been arrested by a 6-ft diameter culvert. The channel has incised approximately four feet below the culvert invert indicating the culvert has protected the upper portions of the watershed from significant degradation. Figure 2.4-16 – Prospect Creek at Cross Section PC-07 (Type F4c Channel) displays a photograph of Prospect Creek downstream of the culvert as a contrast to Figure 2.4-15 which was taken approximately 0.6 miles upstream. The F-Type channel classification continues for approximately 2.5 miles downstream.

An aggradational reach exists near the confluence of Prospect Creek and Little Prospect Creek. Sediment transported from upstream is deposited where the Prospect Creek slope is reduced. A dense stand of willows has formed within the reach which tends to retard flows and further contribute to the depositional nature of the reach.

The remainder of the Prospect Creek channel appears to be relatively stable and either a C-Type or B-Type classification. Throughout the remainder of its course, Prospect Creek displays local bank erosion of varying degree where the meandering channel impinges upon the valley sideslopes. However, the channel appears to be relatively stable vertically.

Legal access to the lowermost portions of Prospect Creek was not obtained during the course of this study. However, based upon evaluation of aerial photographs and the results of the Level I investigation, the channel appears to be re-entrenched and is classified as an F-Type channel.

Wagonhound Creek. Wagonhound Creek displays many of the features encountered on Prospect Creek. However, based upon visual evidence, the majority of Wagonhound Creek appears to be in a stage of recovery from previous channel degradation. The upper reaches of Wagonhound Creek, however, are steep, entrenched, and actively degrading. Consequently, this portion of the stream channel was classified as a G4-Type channel at cross section WH-06 (Figure 2.4-17 – Wagonhound Creek at Cross Section WH-06 (Type G4 Channel)). This area is experiencing active channel degradation and widening. The channel then transitions to an F-Type channel for a limited extent. Within the F-Type channel there are cottonwood trees up to approximately 10-inches in diameter growing at bed-level on the banks indicating the channel is relatively stable (Figure 2.4-18 – Wagonhound Creek at Cross Section WH-04 (Type F4b Channel)).

The remainder and majority of Wagonhound Creek was classified as either a B4c-Type or E5-Type channel. These channels are relatively stable and resilient to hydrologic changes. However, similar to Prospect Creek, localized bank erosion was evident in varying magnitude at locations where the channel has migrated laterally and become impinged upon the valley sideslope.

Spring Gulch. The upper reaches of Spring Gulch were classified as A-Type channels. The Spring Gulch channel appeared to be relatively stable, however, numerous G-Type gullies were encountered. Stockpond projects have been completed in the upper Spring Gulch watershed which may contribute to channel stability simply by reducing available streamflows.

Downstream of the stockponds, Spring Gulch appears to be relatively stable and was classified as a B4-Type channel for the majority of its extent. A small headcut was noted, however, approximately 2.0 miles upstream of the confluence with Grass Creek (Figure 2.4-19 – Headcut Located on Spring Gulch). This small headcut appears to have formed in response to wildlife and livestock grazing in this spring-fed reach. Downstream of the headcut the channel appears to have recovered and there is not extensive channel degradation. It appears, however, that this headcut is tending to migrate upstream and potentially result in more extensive channel degradation and erosion.

2.4.5 Impairments

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

- Channel degradation/incision;
- Bank erosion associated with channel migration and/or widening; and
- Effects of historic and current range management practices.

Table 2.4-4 – Summary of Geomorphic Impairments presents an overview of these impairments by stream as noted during the office and field investigations conducted as part of the Level I and Level II geomorphic studies.

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

The consequences of the incised channel evolution process can be severe. Large-scale bank instability results in extensive bank failure and sediment production. As the groundwater table drops with the channel bed, the depth to groundwater from the original floodplain surface increases, commonly to the point where pre-incision vegetation patterns are not sustainable. Eventually, however, a new equilibrium condition will be achieved, as the channel develops a new equilibrium profile, and flood energies are dispersed on the new incised floodplain surface.

Multiple approaches to restoration can be applied to incised river channels (Rotar and Boyd, 1999). Common objectives in such restoration efforts are to promote channel stability, as well as to connect the channel to its historic floodplain. The reconnection of the channel to its historic floodplain requires raising the channel bed, which can be achieved through grade controls and channel infilling, or even reconstruction of a new channel. These approaches can have difficult and costly challenges, however, such as tying in the project end points to the incised channel grade, or preventing post-project channel relocation (avulsion). Another approach to incised channel stabilization is to completely armor the channel banks and add grade control structures. This process will reduce sediment inputs, but will not provide a dynamic, functional channel configuration. Perhaps the most geomorphically beneficial approach to incised channel restoration is to promote the natural recovery process of channel widening and incised floodplain development. This can be achieved by encouraging the development of a new floodplain surface adjacent to the channel to provide an area for flood energy dissipation and new riparian corridor establishment. Any work in incised channel restoration requires an assessment of the status of the current channel stability, so that the potential for further downcutting is known and accommodated for in the channel restoration design.

As discussed previously in Section 2.1.5.3, historic range management practices have had significant impacts upon riparian habitat and stream channel stability, especially in the central portion of the watershed. More recent practices in some of these areas are resulting in significantly improving range, riparian and stream geomorphic conditions. However, these improving areas and especially other areas still showing locally significant instability and degradation would benefit by one or a combination of the potential management measures and improvement projects as discussed in Sections 3.2, 3.5.2 and 3.5.5.

2.5 Irrigation Inventory

2.5.1 Overview

Irrigation systems within the Cottonwood/Grass Creek study area can generally be characterized as small, privately owned systems. Many of the systems are old, with some predating statehood. Based upon a review of tabulated water rights, there are over 30 individual irrigation ditches with adjudicated water rights on Cottonwood Creek, Grass Creek, and their tributaries (see Appendix E – Water Rights). (Note: for current status and more detailed information on direct flow, ditch and storage rights it is recommended that the State Engineers Office database be accessed at http://seo.state.wy.us/wrdb/index.aspx) They range in size from ditches irrigating less than 20 acres to systems as large as several hundred acres.

Ditch owners/managers were contacted by mail and invited to participate at project meetings and a list of willing participants was generated. Consequently, the ditch systems inventoried included the following:

- Alm Ditch Nos. 1, 2 and 3 (Hugh Dickie No. 1 and No. 2)
- Berry Ditch
- Butterfield Ditch
- Caledonia Ditch
- Earl Ditch North and South (Permitted Name Uncertain)
- Hillberry North Ditch (Permitted Name Uncertain)
- Kirby Ditch
- Little John Ditch (Gillies Ditch)
- LU Ranch Ditch
- Putney Ditch
- Robbins Ditch
- Wales Ditch
- Wilson Ditch

The above list references the names the ditches are locally referred to by and the name permitted by the Wyoming State Engineer's Office if different.

Figure 2.5-1 – General Location of Inventoried Irrigation Ditches displays the general location of the ditches, their headgates, and their locations in relation to their sources. Figures displaying each of the individual ditches are included as Appendix F – Irrigation Inventory. Each figure displays:

- The general location of the ditch and its alignment;
- Its water source;
- Primary laterals;
- Key structures (headgates, measurement devices, flumes, siphons, liners, etc); and
- Noteworthy observations (seepage sites, erosion sites, hillslope instability, etc.).

The ditch systems were inventoried in an effort to evaluate system integrity and determine potential rehabilitation improvements that would facilitate greater irrigation efficiency. Potential improvements included rehabilitation or replacement of existing infrastructure, conversion of open ditches to pipelines, lining of open ditches, etc. Many components of the ditch systems are suffering from age and deterioration. Several ditches were built prior to statehood and have been nursed along over the years through the efforts of irrigators. None of the ditches inventoried are managed by ditch companies; all are privately owned and managed.

Given the magnitude of the use of water for irrigation in relation to its availability, and the range in condition of irrigation infrastructure, there is significant opportunity for water conservation through improvement of existing conveyance systems, management, measurement, and water application. In an effort to identify these opportunities, a field inventory of participating ditch systems was conducted. This effort included:

- Interviewing ditch representatives and irrigators;
- Field inventory of hydraulic structures;
- Inventory of ditch conditions;
- Assessment of the hydraulic efficiency of the structures;
- Photographic documentation of the structures and their condition;
- Location of the structures using GPS technology, and
- Incorporation of data into the project GIS.

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

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

2.5.2 Ditch Characterization

2.5.2.1 Alm Ditch Nos. 1, 2 and 3

The Jewell LLC owns the Alm Ditches. The Alm family recently purchased the property. The Alm property is irrigated by one diversion from Cottonwood Creek and two from Grass Creek (Appendix F).

Alm #1 Ditch (Permitted Name – Hugh Dickie No. 1). This ditch diverts flow from Grass Creek upstream of its confluence with Cottonwood Creek. The ditch is approximately 0.8 miles long and services a small irrigated area at the Cottonwood/Grass Creek confluence. The following general observations were noted:

- The upper portion of the current open ditch system needs cleaning.
- A 2-ft Parshall flume is located near the headgate. It appears to be in fair condition and fully functional.

Alm #2 Ditch (Permitted Name - Hugh Dickie No. 2). In addition to being a means of irrigating several parcels, this ditch is used to convey Cottonwood Creek flows to Grass Creek for diversion downstream by the Alm #3 ditch. The ditch is approximately 0.8 miles long. The following general observations were noted:

- The rock diversion structure in the creek is in good condition, seems to be stable and is working well.
- The headgate has heavy sedimentation and is in need of cleaning.
- A 3-ft Parshall flume is located near the headgate. It appears to be in fair condition and fully functional.

Alm #3 Ditch (Permitted Name – Hugh Dickie No. 2). This ditch is located on Grass Creek and re-diverts flows diverted from Grass Creek via the Alm #2 Ditch. The ditch is approximately 3.3 miles long and services irrigated acres on Cottonwood Creek downstream of the Cottonwood/Grass Creek confluence. The following general observations were noted:

- The diversion structure in the creek unstable and the headgate is silted in.
- The ditch crosses over a local drainage in a suspended corrugated metal pipe (CMP). The structural support of the suspended CMP is in very poor condition. The downstream abutment supporting the pipe and the cable system is failing (Figure 2.5-2 – Drainage Crossing at Alm #3 Ditch).
- The ditch has also breached just downstream of a siphon.
- No measurement device was encountered on the Alm #3 ditch.

2.5.2.2 Berry Ditch

The Berry Ditch headgate is located on Cottonwood Creek upstream of its confluence with Wagonhound Creek near the Caledonia Ditch headgate. The ditch is approximately 0.9 miles long and irrigates approximately 200 acres of irrigated lands on the south side of Cottonwood Creek (Appendix F). Review of State Engineer's Office water rights tabulations indicates the Berry Ditch has original water rights dating to 1908 with enlargements in 1910. Total adjudicated water rights amount to 5.44 cfs. The following general observations were noted:

- The headgate is in fair condition, however there is some bank erosion on the creek.
- A 2-ft Parshall flume is located on the ditch near the headgate. The flume was noted to be poor condition.

2.5.2.3 Butterfield Ditch

The Butterfield Ditch (permitted name uncertain) is located in the lower reaches of Cottonwood Creek near the confluence with the Bighorn River. The ditch has one diversion that feeds a center pivot and continues in a pipe to gated pipe. The following general observations were noted:

- There is not a stable diversion structure in the creek and the owner has placed concrete rubble to check Cottonwood Creek streamflows.
- The head gate is in fair condition but needs a system for flushing sediment.
- Currently the headgate captures a large amount of sediment, which ends up depositing in the pond used by the center pivot.
- A pipe leads out of the center pivot and crosses over Cottonwood Creek. The pipeline is supported by a cable system which is problematic for the owner.
- The center pivot was recently installed and a second is planned.

2.5.2.4 Caledonia Ditch

The Caledonia Ditch headgate is located on Cottonwood Creek upstream of its confluence with Wagonhound Creek. The ditch irrigates approximately 700 acres of irrigated lands on the north side of Cottonwood Creek. The ditch is approximately 1.9 miles long. Approximately 110 acres are irrigated under the ditch. Review of State Engineer's Office water rights tabulations indicates the Caledonia Ditch has original water rights dating to 1907 with enlargements as recent as 1930. Total adjudicated water rights amount to 12.68 cfs. The following general observations were noted:

- The diversion consists of a rock structure in the creek and a Waterman 42-inch rectangular headgate. The diversion structure is in fair condition.
- Minor scour is evident on the downstream side of the rock structure and headgate as well as downstream at the sediment trap/wasteway.
- In the summer of 2006 the ditch conveyance was reported to be significantly restricted by algae, which is suspected to be a consequence of warmer deep groundwater discharge from the Hamilton Dome oil field entering Cottonwood Creek upstream.
- There are several splitter structures along the ditch delivering flow to various parcels. Although they are functional, the splitter structures are in poor condition and in need of updating (Figure 2.5-3 – Splitter Structure in Caledonia Ditch).
- At several locations along the ditch, flow is diverted onto fields by breaching the ditch banks.

- A 4-ft Parshall flume is located on the ditch near the headgate. The flume was noted to be poor condition

2.5.2.5 Earl Ditch North and South

The Earl Ditch North and South headgates are located on Grass Creek at the Leroux property. The north ditch is approximately 1.3 miles long and serves approximately 66 acres. The south ditch is approximately 0.3 miles long and serves approximately 14 acres (Appendix F). The following general observations were noted:

- The north ditch and headgate diversion structure are in good condition.
- The north headgate consists of a fabricated steel box welded to a steel culvert conveying Grass Creek flows under the county road.
- Measurement devices are in place on both ditches. A 2-ft Parshall flume is located on the north ditch and a 1-ft Parshall flume is located on the south ditch. Both appear to be in good condition and fully functional.
- On the north ditch, scour is occurring at the most upstream culvert and measurement device. Most of the 66 acres are flood irrigated and the remainder utilizes gated pipe.
- The south ditch diversion structure on Grass Creek was built in 2001. The structure appears to be in good condition and fully functional.
- Overall, the north and south ditch system appear to be in fair to good condition.

2.5.2.6 Hillberry North Ditch (Permitted Name Unknown)

The Hillberry North Ditch is located on Grass Creek upstream of its confluence with Spring Gulch (Appendix F). The ditch is approximately 1.2 miles long and services irrigated acreage on the north side of Grass Creek. The following general observations were noted:

- The diversion and headgate are in poor condition. The diversion consists of a rock structure and debris in the creek (Figure 2.5-4 – Hillberry North Headgate).
- Bank erosion occurring on the upstream side of the diversion may cause flow to bypass the rock check structure.
- Downstream of the rock structure the creek is degrading and a scour hole has formed.
- The Waterman 24-inch headgate does not have a solid headwall and scour has occurred around the gate. Sheets of steel have been placed on the right bank to protect against erosion.
- The ditch is relatively small and extends only approximately ¼ mile and its capacity is limited.
- The wasteway/sandtrap gate was in fair condition, however, there has been severe scouring at the outlet exposing the CMP.
- At the time of the field visit flow in the ditch, which was frozen, had overtopped the ditch banks in two locations.
- A splitter structure divides the ditch at the point where on-farm diversion begins. The splitter structure was in fair condition.

- A 2-ft Parshall flume is used to measure ditch flow. The flume appears to be in good condition and fully functional.

2.5.2.7 Kirby Ditch

The Kirby Ditch diverts from Cottonwood Creek and is utilized by the Alm, Swing, and Ward property owners. The ditch is approximately 1.6 miles long and services approximately 570 acres on the south side of Cottonwood Creek upstream of its confluence with Grass Creek (Appendix F). Review of State Engineer's Office water rights tabulations indicates the Caledonia Ditch has original water rights dating to 1910 with adjudicated water rights totaling 6.28 cfs. The following general observations were noted:

- The headgate is located on the outer portion of a large migrating bend on Cottonwood Creek. Severe bank erosion is occurring at the diversion (Figure 2.5-5 – Kirby Ditch Diversion).
- The headgate and headwall are in poor condition and in danger of failing due to scour and bank erosion.
- The upper portion of the Kirby Ditch is perched above the creek; several locations were noted which appear to be experiencing severe seepage. According to ditch representatives, the ditch has historically breached at several locations within this reach.
- A 3-ft Parshall flume is located approximately 0.9 miles downstream of the ditch headgate. The flume appears to be in fair condition and fully functional.

2.5.2.8 Little John Ditch (Permitted Name – Gillies Ditch)

This ditch is located on Grass Creek upstream of the confluence with Spring Gulch. The ditch is approximately 1.8 miles long (Appendix F). The following general observations pertaining to the ditch were made:

- The diversion and headgate are in poor condition (Figure 2.5-6 – Little John Ditch Diversion). A wooden check weir is located in Grass Creek and is supported with steel pipe. The pipe structure is in fair condition, however, scour and bank erosion is occurring upstream and downstream of the weir.
- Concrete rubble has been place up and downstream of the weir.
- The ditch headgate consists of a Waterman circular 36-inch slide gate with no headwall. Severe erosion and scour is occurring around the headgate. It is our understanding that during most of the year the headgate remains open diverting Grass Creek to the ditch. Grass Creek flow is then diverted back to the creek through a wasteway/sandtrap structure located downstream of the headgate. As a result, Grass Creek has a considerable amount of debris in the channel from the diversion downstream to the waste flow return.
- The wasteway/sandtrap gate was also in poor condition and in need of a headwall to mitigate scour.
- There were also several locations along the upper portion of the ditch that had obvious signs of significant seepage occurring.
- The farm turnouts on the upper portion of the ditch included slide gates diverting flow to gated pipe. The lower portion of the ditch is in need of more permanent check structures and turnouts.

- There are numerous culverts located on the ditch that are used to check up the flow to spill into an on-farm ditch earthen ditch often resulting in parallel ditches (Figure 2.5-7 – Parallel Ditches on Little John Ditch).
- A 30-inch Parshall flume is located approximately 0.2 miles downstream of the ditch headgate. The flume appears to be in fair condition and fully functional.

2.5.2.9 LU Ditch

This ditch is the most upstream diversion on Grass Creek and provides water for a portion of the LU Ranch property north of the ditch. The ditch is approximately 1.0 miles long and services approximately 310 acres on the north side of Grass Creek downstream of the Grass Creek/Little Grass Creek confluence (Appendix F). The ditch conveys flow from the point of diversion approximately 1 mile to gated pipe. Review of State Engineer's Office water rights tabulations indicates these LU Ranch rights are among the most senior in the basin with a priority of 1883. Total adjudicated water rights amount to 1.26 cfs. The following general observations pertaining to the LU Ditch were made:

- The diversion and headgate are in good condition and are not in need of any improvements.
- The ditch has heavy sedimentation and a low capacity for conveyance.
- There is currently no wasteway/sandtrap structure to facilitate evacuation of diverted sediment.
- There were some signs of seepage along the ditch.
- An 18-inch Parshall flume is located near the ditch headgate. The flume appears to be in fair condition and fully functional.

2.5.2.10 Putney Ditch

The Putney Ditch headgate is located in the upper reaches of Cottonwood Creek upstream of its confluence with Twentyone Creek (Appendix F). The ditch irrigates the Putney (old Rhodes Ranch) place owned by Dee Hillberry. The ditch is approximately 0.3 miles long and services approximately 110 acres on the south side of Cottonwood Creek upstream of the confluence with Twentyone Creek. Review of State Engineer's Office water rights tabulations indicates the Putney Ditch has original water rights with priority of 1902. Total adjudicated water rights amount to 2.05 cfs. The following general observations were noted:

- The existing headgate is in fair condition, however, the creek has experienced degradation making it difficult to divert water.
- The channel invert is approximately three feet lower than the headgate invert and there is no means of efficiently checking Cottonwood Creek to provide an adequate head for diversion.
- Concrete barriers have been placed in Cottonwood Creek in an effort to train the channel towards the headgate and to check flows to an elevation that can be diverted (Figure 2.5-8 – Putney Ditch Diversion). It is our understanding that these structures require re-establishment annually.
- A 2-ft Parshall flume is located near the ditch headgate. The flume appears to be in fair condition and fully functional.

2.5.2.11 Robbins Ditch

The Robbins Ditch is located in the upper reaches of Grass Creek (Appendix F). Review of State Engineer's Office water rights tabulations indicates the Robbins Ditch has original water rights with priority of 1915 to 1916. Total adjudicated water rights amount to 0.9 cfs. The following general observations pertaining to the Robbins Ditch were made:

- A sandtrap wastewater structure was built in 2005 by the NRCS and appears to be in good condition and fully functional. During operation the headgate is left fully open and the wasteway/sandtrap is used to regulate the flow diverted from Grass Creek as well as flush any sediment.

2.5.2.12 Wales Ditch

The Wales Ditch is located south of Cottonwood Creek upstream of its confluence with Wagonhound Creek. The ditch is approximately 2.8 miles long and services irrigated acres on the south side of Cottonwood Creek in the vicinity of Wales Reservoir (Appendix F). The ditch carries flow diverted from Cottonwood Creek as well as Hamilton Dome produced water discharges captured by the ditch. The Wales Ditch also conveys flow into the 200 acre-foot Wales Reservoir. Review of State Engineer's Office water rights tabulations indicates the Wales Ditch has original water rights with priority of 1908. Total adjudicated water rights amount to 1.56 cfs. The following general observations were noted:

- The ditch headgate is in good condition, however, it is reportedly difficult to check up the flow in Cottonwood Creek to an adequate elevation to facilitate diversion.
- There is currently no structure in the stream channel to train the channel or to facilitate diversion.
- Local surface runoff flowing into the ditch just downstream of the headgate is causing severe gully erosion (Figure 2.5-9 – Severe Gully Erosion at Wales Ditch). The upper portion of the ditch in the vicinity of the wasteway/sand trap and measurement structure is poorly defined.
- Produced water discharges from the Hamilton Dome oil field are captured and diverted for use in the Wales Ditch and Berry Ditch. Capturing the discharge is difficult due to lack of a defined channel. Just downstream of a culvert conveying the produced water discharge to the north, the discharge is spread out onto a low gradient depositional area and lacks a clearly defined channel. At this location there is a diversion structure to capture and divert the discharge to the Wales Ditch and Berry Ditch. Due to the unconfined flow over the depositional area, it is difficult to capture the produced water discharge for irrigation. Hillberry states that the produced water discharge is an extremely important supplemental source of water and in recent years they have lost use of a lot of the flow due to the uncontrolled situation.
- An 18-inch Parshall flume is located near the ditch headgate. The flume appears to be in fair condition and fully functional.

2.5.2.13 Wilson Ditch

The Wilson Ditch headgate is located in the upper reaches of Cottonwood Creek upstream of its confluence with Twentyone Creek. The ditch irrigates the Putney (old Rhodes Ranch) Place owned by Dee Hillberry. The ditch is approximately 0.2

miles long and serves approximately 75 acres (Appendix F). Review of State Engineer's Office water rights tabulations indicates the Wilson Ditch has original water rights with priority of 1907. Total adjudicated water rights amount to 3.54 cfs. The following general observations were noted:

- The Wilson Ditch headgate is located downstream of the Putney Ditch diversion on the north side of the creek (Figure 2.5-10 – Wilson Ditch Diversion). Here, the creek is also exhibiting degradation. Hillberry has placed concrete barriers at the Wilson Ditch headgate in a similar configuration as the Putney Ditch in an effort to check flows to facilitate diversion. The barriers reportedly need to be adjusted following annual peak discharges.
- The ditch downstream of the measurement device is not clearly defined and conveyance capacity has been reduced due to sedimentation and encroachment of vegetation.
- A 2-ft Parshall flume is located near the ditch headgate. The flume appears to be in fair condition and fully functional.

2.6 Water Quality

2.6.1 Suitability for Agricultural Use

Water Quality Criteria. The objectives of the water quality evaluations conducted for this Level I study of the Cottonwood/Grass Creek watershed are to compile available surface and groundwater quality data and assess the suitability of those waters for agricultural uses (i.e., irrigation and livestock watering). Available water quality data for WDEQ-permitted discharges is also presented for informational purposes. Evaluation of these data relative to permit conditions is not included in the scope of this study.

Criteria for suitability of water for irrigation and livestock watering were compiled from several sources and are shown on Table 2.6-1 – Water Quality Criteria for Agricultural Uses. The criteria shown on Table 2.6-1 were selected from the source documents to be as applicable as practical to the crops (primarily alfalfa and grass hay, with some spring grains and potentially beans) and livestock (primarily cattle and potentially some sheep) present in the watershed. Although they are believed to be generally applicable, some of the criteria may be somewhat conservative for these crops and livestock.

Surface Water. The locations of surface water quality sampling of Cottonwood Creek and of Grass Creek and some of its tributaries are shown on Figure 2.3-2 and the dates and data counts for the sampling events are listed on Table 2.3-1. All of the surface water quality sampling summarized in this report was performed by the U.S. Geological Survey (Plafcan and Ogle, 1994; http://waterdata.usgs.gov/nwis/qw). Data count is the number of sampling events at the given site on the given date or during the period of record noted. The number of parameters analyzed for a sample from a given site may vary from one sampling event to another. As seen on Table 2.3-1 and Figure 2.3-2, two main sampling episodes have occurred in the Cottonwood/Grass Creek watershed, one between April 1977 and July 1978 and the other during September 1990. Two locations at and just downstream of the Hamilton Dome oil field were sampled one time in 1970, and three other locations (one each on Cottonwood and Grass Creeks just above their confluence, and the other at the confluence with the Bighorn River) were sampled once or twice during 1976.

Sampling for suspended sediments was conducted twice during 1965 on Cottonwood Creek at the confluence with the Bighorn River.

The 1977-78 water quality sampling episode involved sampling five (5) sites between 7 and 11 times each. The sites were located to provide data on Grass Creek above and below the Grass Creek oil field, on Cottonwood Creek above and below the Hamilton Dome oil field, and just above the confluence of Cottonwood Creek with the Bighorn River at Winchester. Sampling of Grass Creek and several of its tributaries was conducted at 13 sites over a three day period from September 11-13, 1990 (Plafcan and Ogle, 1994). Sampling locations on the mainstem of Grass Creek ranged from the headwaters at the Shoshone National Forest boundary to a point downstream of the Grass Creek oil field just above Highway 120. Samples were also taken in several of the tributaries to Grass Creek just above their confluences, including on Little Grass Creek.

All available water quality data for the above sites can be accessed at the following U.S. Geological Survey website: http://waterdata.usgs.gov/nwis/qw.

Data for the 1977-78 data are also tabulated and discussed in Plafcan and Ogle (1994). In general, the surface waters of both Cottonwood Creek and Grass Creek are dominated by sodium as the main cation through most of their reaches; potassium is the major cation at the confluence of Cottonwood Creek and the Bighorn River. Both creeks are characterized by bicarbonate as the principal anion in their upper reaches, but change to sulfate in the middle and lower reaches. Some of the trace metals showed a trend increasing downstream (e.g., barium and boron on Grass Creek), while others decreased (e.g., iron and aluminum on Grass Creek). Although a detailed analysis is beyond the scope of this Level I study, it is noted that the bedrock geology is different in the upper watershed (predominantly extrusive igneous and igneous-derived fluvial deposits of the Aycross and Teepee Trail formations) versus the middle and lower watershed (characterized by Cretaceous- and Tertiary-age sedimentary units). The predominant groundwater type associated with the igneous rocks is calcium bicarbonate, while sodium sulfate (with lesser sodium bicarbonate) is the dominant groundwater type in the sedimentary rocks (Lowry, et al., 1976). It is reasonable that the surface water quality type reflects to some degree the dominant bedrock mineralogy and its associated groundwater quality.

The results of the surface water quality sampling described above relative to suitability for agricultural uses are summarized on Table 2.6-2 – Surface Water Suitability. Note that analytical results that exceed one or more of the criteria presented on Table 2.6-1 are highlighted on Table 2.6-2. As suggested above, the fact of an exceedance does not necessarily mean that the water is not suitable for the intended use. It does indicate that less tolerant plants (e.g., early growth or growth in otherwise less than ideal soils) or livestock (e.g., calves, nursing cows) may be less productive than they might otherwise be. The most widespread and persistent exceedances on both Cottonwood Creek and Grass Creek are for the irrigation use criteria for sulfate and specific conductance. The TDS criterion for irrigation is slightly exceeded for some of the measurements on Grass Creek. The pH criteria for both irrigation and livestock watering are sometimes slightly exceeded (associated with the reaches of bicarbonate-dominant water higher in the drainages). A recent study by Raisbeck, et al. (undated) suggests that the current WDEQ criterion for pH for livestock water is excessively conservative, at least on the acidic side, but that data are not sufficient to offer an alternative criterion. Slight to modest exceedances of irrigation criteria for chloride and fluoride occur on Cottonwood Creek below the Hamilton Dome oil field (see related discussion in Section 2.6.3). The WDEQ criterion for mercury in livestock water is exceeded slightly to moderately in some of the measurements available for Grass Creek.

Groundwater. Plafcan and Ogle (1994) provide groundwater sampling locations and analytical results for Hot Springs County, in the Cottonwood/Grass Creek watershed. The locations of wells and springs sampled for groundwater quality by others as reported by Plafcan and Ogle (1994) are shown on Figure 2.6-1 – Groundwater Quality Sample Locations. Detailed summaries of groundwater quality data in Hot Springs County as reported in Plafcan and Ogle (1994) are presented in Appendix G – Groundwater Data.

Groundwater quality is a result of the chemistry of meteoric (original in situ) pore water and the chemical changes of recharge water from the surface as it moves from the point of recharge to the point of withdrawal in a well or spring. Groundwater quality thus varies significantly with the nature, lithology and geochemistry of the aquifer within which it occurs and through which it has passed. A summary discussion of groundwater quality in each of the sampled aquifers in the Cottonwood/Grass Creek watershed is presented as follows:

- *Alluvium and Alluvial Terraces. W*ater quality data are available from sampling of one alluvial aquifer location and one alluvial terrace location in the Grass Creek drainage and one alluvial aquifer location in the Prospect Creek drainage. Site number Qa8 is located in upper Grass Creek well above the confluence of Little Grass Creek. This water is characterized as sodium bicarbonate water with moderately high pH and low total dissolved solids (TDS). Sample Qt7 located just downstream of the Grass Creek townsite classifies as a sodium sulfate-bicarbonate water with moderate pH and moderately high TDS. Sample Qa8 was taken in Prospect Creek alluvium in the middle stream reach. This sample is intermediate in classification between the other two alluvial samples described here, with intermediate pH and TDS values. Most trace element concentrations in all three samples are low. Boron values are somewhat elevated, with the concentrations ranging from 40 µg/l at the most upstream location (Qa8) to 610 µg/l at the most downstream location (Qt7).
- *Tertiary Absaroka Volcanics (Aycross and Teepee Trail Formations).* Two springs, one in the Prospect/Little Grass Creeks divide (Tav3) and the other in the Cottonwood/North Fork Owl Creeks divide (Tav1), represent groundwater in the volcaniclastic units of the Absaroka Volcanics. Tav3 is sodium-bicarbonate water with moderately high pH and low TDS. Tav1 is sodium bicarbonate water with close to neutral pH and low TDS. Trace elements are generally very low in both samples, although aluminum and iron are slightly elevated in Tav3.
- *Tertiary Fort Union Formation.* Fort Union formation groundwater is represented by a spring sample taken in the lower Prospect Creek drainage (Tfu2) and a well sample just below the confluence of Grass Creek and Cottonwood Creek (Tfu1). Tfu1 is a dominantly sodium sulfate water with neutral pH and high TDS. Boron is elevated at nearly 1000 µg/l. Tfu2 is magnesium sulfate-bicarbonate water with slightly elevated pH and moderately high TDS; trace element concentrations are all very low to low.

- *Upper Cretaceous Meeteetse Formation.* Meeteetse formation groundwater has been sampled in a well located in the Grass Creek valley just above Highway 120 (Km 1) and in a well on the Grass Creek/Prospect Creek divide (Km2). Water from Km1 classifies as sodium bicarbonate-sulfate with high pH and moderately high TDS. Km2 groundwater is magnesium-calcium sulfate type with near neutral pH and moderate TDS. Boron is slightly elevated in Km 1 and zinc is somewhat elevated in Km2. All other trace element concentrations are low to very low.

- *Upper Cretaceous Mesaverde Formation.* Groundwater in the Mesaverde formation has been sampled at seven locations in the middle to lower portions of the Cottonwood/Grass Creek watershed (see Figure 2.6-1). In general, the Mesaverde groundwater samples tend to be mixed but typically sodium dominant sulfate-bicarbonate waters with moderate pH. TDS concentrations vary from 688 to 5,510 µg/l, generally increasing lower in the watershed. The two samples with the highest TDS (Kmv5 and Kmv6) also have the highest sulfate concentrations at 1,940 and 5,510 µg/l.

- *Upper Cretaceous Cody Shale.* The Cody Shale is sampled at only one location in the watershed in a well located in the Grass Creek valley downstream of the old Grass Creek townsite (Kc3). This sample is mixed sodium sulfate dominant type with near neutral pH and high TDS at 2,720 µg/l. Boron is elevated at 1,000 µg/l.

- *Paleozoic (Mississippian-Devonian) Madison Formation.* A groundwater sample from a well completed in the Madison formation is available from a well located just downstream of the old Grass Creek townsite (MDm1). This sample is mixed calcium dominant bicarbonate-sulfate water with neutral pH and high TDS at 3,390 µg/l. Boron concentration was very low; no other trace elements were analyzed.

- *Paleozoic (Oligocene) Bighorn Dolomite Formation.* A well located just upstream of the old Grass Creek townsite was sampled in the Bighorn Dolomite formation (Ob6). This sample showed very similar water quality to the Madison formation sample described immediately above, except that boron was elevated at 1,500 µg/l. This is likely a result of the mixing of groundwater between these two aquifers via extensive, interconnected fracture systems.

- *Other Major Aquifers.* No results for samples of groundwater from the Tensleep formation or Flathead Sandstone were encountered within the Cottonwood/Grass Creek watershed. In other portions of the Bighorn basin the Tensleep groundwater varies in quality, generally being higher quality near its outcrop areas. Where overlain by the Park City formation the Tensleep can have high concentrations of sulfate. Also, the abundant oil and gas in the Tensleep can locally impact its water quality. Where sampled in the Bighorn basin, the Flathead Sandstone has shown low TDS (less than 500 µg/l) and is otherwise of good quality.

The suitability of groundwater for agricultural uses within the Cottonwood/Grass Creek watershed is summarized in Table 2.6-3 – Groundwater Suitability. The suitability criteria are the same as presented previously on Table 2.6-1 for surface water. At least some exceedances of one or more of the criteria on Table 2.6-1 are present in groundwater from each of the sampled geologic units except for the Absaroka Volcanics (Aycross and Teepee Trail formations).

Exceedances of boron irrigation water criteria are relatively minor and only occur in a few of the geologic units sampled. Chloride exceedances of irrigation water criteria are limited to the older geologic units - mostly minor and only occasional in the Mesaverde formation and somewhat greater in the Cody Shale, Madison formation and Big Horn Dolomite. The irrigation and/or livestock watering criteria for fluoride are exceeded in about a third of the samples analyzed; the samples span the full range of geologic units except for the Absaroka Volcanics. Note, however, that fluoride is neutralized by neutral to alkaline soils that are typical in the watershed. The manganese criterion for livestock is exceeded in four of the Mesaverde formation samples; one of those samples also exceeds the irrigation criteria. The more stringent WDEQ (1980) criterion for mercury in livestock water is exceeded in 6 samples – one each from the Fort Union and Meeteetse formations and the other four from the Mesaverde formation. None of these samples exceed the more recent and less stringent Ayers and Westcot (1994) criterion. The criterion for sulfate in irrigation water is exceeded in 12 of the 19 samples, with only the Absaroka Volcanics without at least one sample exceedance. Only one of the 12 samples also slightly exceeded the livestock watering criterion. Five samples exceeded the less stringent WDEQ (1980) sulfate criterion for irrigation water; and one of those also slightly exceeded the livestock water criterion. An additional 11 samples fell within the criterion range for sulfate in irrigation water by Ayers and Westcot (1994). The pH criteria are only slightly exceeded in one sample. Both of the SAR criteria for irrigation water are exceeded in three samples; one other sample only slightly exceeds one of the two criteria. Seven samples exceed both irrigation water criteria for specific conductance, and an additional 9 samples fall in the criterion range of Bauder, et al. (2006).

Overall, groundwater for agricultural uses appears most suitable in the Quaternary alluvium and alluvial terrace deposits and the Tertiary Absaroka Volcanics (Aycross and Teepee Trail formations). The least suitable water is from the Cody Shale, Madison formation and Big Horn Dolomite. The Tertiary Fort Union and Upper Cretaceous Meeteetse and Mesaverde formations all have exceedances of various criteria, but may still prove suitable depending on the specific uses intended. As noted previously for surface water, the criteria presented on Table 2.6-1 are intended to be generally applicable to conditions in the Cottonwood/Grass Creek watershed, but are believed to be somewhat conservative in some cases. The most significant water quality issue for groundwater use in the watershed appears to be the potential for salt impacts to less resistant species and salt accumulation in inadequately drained soils. These potentials are related to the relatively high levels of sulfate, TDS and specific conductance present in many of the samples summarized in Table 2.6-3.

2.6.2 Stream Classifications

All streams named on the U.S. Geological Survey 1:500,000 scale hydrologic map of Wyoming and other selected streams have been classified for protection of one or more designated uses by the Water Quality Division of the WDEQ. The stream classifications applicable to the Cottonwood/Grass Creek watershed as noted in the latest Wyoming Surface Water Classification List (WDEQ, 2001) are shown on Figure 2.6-2 – WDEQ Stream Classifications. The definitions of the stream classes applicable to the watershed are quoted from the Water Quality Rules and Regulations, Chapter 1, Wyoming Surface Water Quality Standards (WDEQ, 2007) as follows:

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

- *Class 2B waters are those known to support or have the potential to support game fish populations or spawning and nursery areas at least seasonally and all their perennial tributaries and adjacent wetlands and where it has been shown that drinking water uses are not attainable pursuant to the provisions of Section 33. Class 2B waters include permanent and seasonal game fisheries and can be either "cold water" or "warm water" depending upon the predominance of cold water or warm water species present. All Class 2B waters are designated as cold water game fisheries unless identified as a warm water game fishery by a "ww" notation in the "Wyoming Surface Water Classification List". Uses designated on Class 2B waters include game and nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture and scenic value…*
- *Class 2C waters are those known to support or have the potential to support only nongame fish populations or spawning and nursery areas at least seasonally including their perennial tributaries and adjacent wetlands. Class 2C waters include all permanent and seasonal nongame fisheries and are considered "warm water". Uses designated on Class 2C waters include nongame fisheries, fish consumption, aquatic life other than fish, recreation, wildlife, industry, agriculture, and scenic value…*
- *Class 3B waters are tributary waters including adjacent wetlands that are not known to support fish populations or drinking water supplies and where those uses are not attainable. Class 3B waters are intermittent and ephemeral streams with sufficient hydrology to normally support and sustain communities of aquatic life including invertebrates, amphibians, or other flora and fauna which inhabit waters of the state at some stage of their life cycles. In general, 3B waters are characterized by frequent linear wetland occurrences or impoundments within or adjacent to the stream channel over its entire length. Such characteristics will be a primary indicator used in identifying Class 3B waters."*

All of Grass Creek and Cottonwood Creek above Hamilton Dome are classified 2AB which means that they are protected for all uses. Below Hamilton Dome Cottonwood Creek is classified 2C. The only non-protected uses on this reach are drinking water and game fish. Spring Gulch, Prospect Creek, Wagonhound Creek and Twentyone Creek are all classified 3B. All uses except drinking water, game fish, non-game fish and fish consumption are protected on these tributary streams. Other unlisted streams in the watershed (including Little Grass Creek) are classified in accordance with the applicable provisions in the Wyoming Surface Water Classification List.

The stream classifications described above control the allowable effluent limits for point source discharges and the best management practices (BMPs) for non-point discharges to these streams.

2.6.3 NPDES Permitted Discharges

A total of 14 active National Pollution Discharge Elimination System (NPDES) permitted discharges are present within the Cottonwood/Grass Creek watershed. The locations of these discharges are shown on Figure 2.6-3 – NPDES Permitted Discharges. Six of these permits are for stormwater discharges and the remaining eight are for point-source discharges. The stormwater permits are not further considered here due to the absence of any data and the relatively low potential for significant impacts to the watershed assuming that the applicable BMPs and other controls contained in the permits are being implemented.

Available water quality data obtained from WDEQ for the point-source discharges is summarized on Table 2.6-4 – NPDES Water Quality Data. As indicated on the table and based on other indications in the file information provided by WDEQ, only the Hamilton Dome discharges are significant in terms of the quantity of water discharged. As shown, data were only available on the Hamilton Dome discharges for 2002, 2005 and the first half of 2006. A detailed analysis of the flow rates of these discharges over time was presented in Section 2.3.5 previously. The effect of these discharges on the water quality in lower Cottonwood Creek is briefly addressed below in Section 2.6.4. Flows for the other three permitted discharges shown in Table 2.6-4 average about 7, 4 and 4 gpm, respectively. An evaluation of the effects on the quality of the receiving streams (Grass Creek and Cottonwood Creek) and/or underlying groundwater was beyond the scope of this Level I study. However, there was no indication in the WDEQ files reviewed of any of the discharges violating the applicable discharge standards.

Two of the permitted discharges (WY0041891 and WY0039390) are for settling ponds at oil wells. No flows and thus no water quality data are available for these discharges. Permit WY0030317 is still listed on the WDEQ website as an active point-source discharge permit. However, review of file information indicates that this permit is currently only active for stormwater discharges from the 4B Settling Pond at the Grass Creek Coal Mine. No data on flows or water quality of discharges are available in the WDEQ files for this permit.

2.6.4 Waters Requiring TMDLs

Cottonwood Creek below the Hamilton Dome oil field to its confluence with the Bighorn River is included on Table A: 2006 303(d) Waters with Water Quality Impairments as published by WDEQ (2006). Table A indicates that this reach of Cottonwood Creek is classified as 2AB; discussion with WDEQ staff (Hargett, 2007) suggests that this is a typographical error and that the classification should be shown as 2C as on the Wyoming Surface Water Classification List dated June 21, 2001. This reach was first included on the 303(d) list in 2004. Impairments of protected uses identified include cold water fish, aquatic life and wildlife, and the causes of impairment are listed as chloride and selenium concentrations resulting from point source discharges from the Hamilton Dome oil field. The priority for TMDL development is indicated as low on the 2006 303(d) list. This reach of Cottonwood Creek was the subject of a Beneficial Use Reconnaissance Monitoring and Assessment Report (WDEQ, undated) and a Use Attainability Analysis (UAA) first submitted in December 2002 and later resubmitted with revised recommendations in

February 2003 (States West Water Resources Corporation, et al., 2003). Based on the UAA, site-specific standards for chloride and selenium on the lower reach of Cottonwood Creek were revised to 860 mg/L and 43 µg/L, respectively (WDEQ, 2007). It is assumed that the 303(d) list will be revised if/as appropriate to reflect these recently adopted site-specific stream standards.

2.7 Water Storage and Retention

Identification and evaluation of opportunities to develop additional surface water storage in the Cottonwood/Grass Creek watershed is a key objective of this Level I study. This objective is stated in the Project Description of the Contract Scope of Services and was reiterated by the Cottonwood/Grass Creek CRM and other stakeholders at the Scoping Meeting and all subsequent project meetings during the course of the study. The need for additional storage to address existing irrigation shortages in the watershed has been clearly established as discussed below in Section 2.7.1.

In addition to meeting these present irrigation needs, a number of other potential benefits of additional storage have been identified during the course of this study and are recommended for more detailed evaluation should a storage project(s) advance to the next level of study. These potential benefits include the following:

- Enhancement/establishment of late-season stream flows to benefit aquatic and wildlife species, riparian habitat, and livestock
- Provision of additional direct wildlife/livestock watering opportunities and potential to serve gravity-fed watering systems
- Reduction of flooding impacts to the aquatic and riparian habitats downstream
- Improvement of stream bank/channel conditions
- Establishment of a lake fishery
- Improvement of water quality both in the Cottonwood/Grass Creek watershed and (at least incrementally) in the Bighorn River
- Provision of seasonal recreational opportunities (consistent with meeting other needs and achieving other benefits)

It is important to note that the degree to which any one or some combination of these other benefits could be attained would depend on the results of the more detailed evaluations recommended later in this section, especially the amount and location of streamflows physically and legally available to store within the watershed.

In order to preliminarily evaluate the potential for surface water storage it is first necessary to assess the order of magnitude of the needs for storage and the physical/legal availability of water to store. This evaluation is presented in Section 2.7.1. Next a description of the existing reservoirs in the watershed is presented in Section 2.7.2. In Section 2.7.3 the potential for reconstruction of the breached Phelps Dam, enlargement of the existing Wales Reservoir, rehabilitation (possibly with enlargement) of Lake Creek Reservoir, and development of new storage in the Cottonwood and/or Grass Creek drainages (including at the existing Grass Creek causeway) is addressed. This includes identifying a number of alternative storage projects to address at a preliminary level the needs and potential benefits summarized above. The objective(s), location, potential size, and key characteristics of these sites are described. Preliminary screening of these alternative sites is also discussed.

Conceptual level layout and sizing of selected storage alternatives is presented below in Section 3.3; cost estimates for and economic analyses of these alternatives are presented and discussed in Section 5.0 and Section 6.0, respectively.

2.7.1 Surface Water Availability and Shortages

The evaluation of flows available for potential storage projects and of irrigation shortages within the Cottonwood/Grass Creek watershed was based upon results of the Wyoming Water Development Commission (WWDC) basin planning model developed for the Wind/Bighorn River watershed (BRS, et al., 2003). This section summarizes key aspects of that effort. Much of the discussion of the model, assumptions inherent to it, and its limitations was extracted from previous reports and modified with information pertinent to this study. It is included herein to provide the background necessary to interpret model results.

The primary quantifiable need for storage in the Cottonwood/Grass Creek watershed is for supplemental irrigation supply to address to the degree possible existing shortages known to be experienced during normal and dry years. As noted previously in Section 2.1.4, the total of 3,807 acres of irrigated land estimated in this study is about 10 percent greater than the Basin Plan estimate of 3,474 acres. At this level of study it was not feasible to update the Basin Plan model to account for this difference. Although the effect of this difference cannot be quantified at this level of study, it is judged not so great as to significantly impact the results of the Basin Plan hydrologic model discussed below in Section 2.7.1. If anything, it is most likely that updating the model for this one factor would result in somewhat greater shortages than currently estimated.

Based on input from the project sponsor and direction from WWDC's project manager, this study did not evaluate the potential to bring new (i.e., never previously irrigated) lands under production. This decision was made based primarily on the apparent limitations of supply (in terms of amount and/or location) relative to the existing irrigation needs. If a storage project advances to the next level of study, this decision should be reevaluated based on more detailed watershed modeling that was beyond the scope of this Level I study.

2.7.1.1 Wind/Bighorn River Basin Model

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

For the purposes of this study, the spreadsheet model developed during completion of the Wind/Bighorn River Basin Planning Study was utilized without significant modification. The Wind/Bighorn River model consists of ten individual spreadsheet models, each representing a specific subbasin of the watershed. The Cottonwood Creek/Grass Creek watershed is tributary to the Bighorn River within the limits of the Upper Bighorn River subbasin model.

The individual spreadsheet models are linked to enable data generated in one model to be "passed along" to subsequent models. Furthermore, models were generated to reflect each of three hydrologic conditions: dry, normal, and wet year water supply.

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

To mathematically represent the Bighorn River system subbasins, each basin was first divided into reaches based primarily upon the location of USGS gaging stations. Each reach was then sub-divided by identifying a series of individual nodes representing locations where diversions occur, basin imports are added, tributaries converge, or other significant water resource features are located. Figure 2.7-1 – Model Nodes and Reaches Schematic shows these model elements for the Cottonwood/Grass Creek portion of the Upper Bighorn model.

At each node, a water budget computation is completed to determine the amount of water that flows out of the node. Total flow into the node and diversions or other losses from the node are calculated. The difference between total inflow and diversions/losses is the amount of flow available to the next node downstream. Mass balance, or water budget calculations, are repeated for all nodes in a reach, with the outflow of the last node being the inflow to the beginning node in the next reach. Figure 2.7-2 – Diagram of Model Water Budget Computations 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.

Based on the information and discussion presented previously in Section 2.3.5, it is apparent that the historic and still ongoing discharges of produced water from the Hamilton Dome oil field to Cottonwood Creek are a very important resource to the environment and irrigators downstream. Note, however, that the existing model does not include these discharges as imported flows. This choice by the modelers was presumably to avoid the potential for planning decisions being made on a source that was not under the control of likely users of the water, and to recognize that this source could be shut off if economic or other factors demanded.

2.7.1.2 Model Limitations

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

- The spreadsheet model does not explicitly account for diversions from the river in accordance with Wyoming water law and is not operated on these legal principals. Simply stated, this means that the model cannot forego a diversion to an upstream junior water appropriator to satisfy a downstream senior water right. The basin planning model was originally developed under the assumption that if this situation occurred historically, the diversion data would reflect this occurrence and the junior appropriator would incur a shortage.

- The model does not incorporate reservoir operational rules for release or storage of water. For each simulation condition (normal-, dry- and wet-year conditions), reservoir releases do not deviate from historic releases. For example, releases from Boysen Reservoir remain consistent with historic patterns despite changes to reservoir inflow and storage. The implication of this limitation is that Boysen Reservoir behaves as a "buffer" between the upper and lower portions of the basin.

- The spreadsheet model does not contain logic to evaluate impacts upon the state's obligations under the Yellowstone River Compact (Compact). The Yellowstone River Compact between Montana, North Dakota and Wyoming was signed in 1950. The compact outlines allocations for several rivers in northern Wyoming, including the Bighorn River. On the Bighorn River, water is to be allocated 80 percent to Wyoming and 20 percent to Montana. Pre-1950 water rights are guaranteed. The Compact does not affect Native American rights to Yellowstone River water. Consequently, all estimates of available flows presented in this report do not include consideration of the Yellowstone River Compact.

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

  - *Calibration (Historical):* This mode simulates the historical diversions where data are available. This mode is typically used for model calibration because historic diversion data are utilized.

  - *Full Supply for Existing Irrigated Lands:* This mode reflects full supply diversions, based on computed diversion requirements for existing irrigated lands (lands presently irrigated and mapped during the planning process).

  - *Full Supply for Existing Irrigated Lands and Futures Projects:* This mode simulates full supply, based on computed diversion requirements, for existing irrigated lands and Tribal futures projects. Within the Cottonwood/Grass Creek portions of the model, there were no Tribal Futures projects; consequently, there were no local impacts of their potential implementation. The "Futures" version of the model was used, however, because Tribal Futures will impact availability of the Bighorn River downstream of the confluence with Cottonwood Creek, which could ultimately affect availability of flows within the Cottonwood/Grass Creek watershed.

2.7.1.3 Available Flows Analysis

To determine how much of the physical supply is actually available for storage at any given model node, "available water" was defined as that portion of the physically available streamflow that could be stored without causing a shortage to existing water users in any downstream river reach on Cottonwood Creek or the Bighorn River. In other words, the water available at any node was determined as the minimum of the physically available flow at that point or the minimum available flow at any node downstream in the system (including the Bighorn River). As noted previously, this evaluation is made on a water budget basis (inherent to the Basin Plan model) and does not directly incorporate individual water rights (see Section 2.7.1.4 for additional related discussion).

Results. Results of the availability analyses indicate that there is flow available for storage without incurring a shortage in downstream reaches as summarized in Table 2.7-1 – Available Flow at Modeled Reach Outflows for modeled stream reaches within the study area or downstream on the Bighorn River. The total annual available flow for the entire Cottonwood/Grass Creek watershed (represented by Reach No. 460) is estimated in the model as about 21,000 ac-ft for a normal (6 out of 10 years) condition and 7,300 ac-ft for a dry (2 out of 10 years) condition. The model results show that the large majority of available flows occur in April, May and June as would be expected in this hydrologic setting and consistent with the pattern of gaged flows as previously described in Section 2.3.4. The results also indicate that nearly three-quarters of the total annual available flows in the watershed occur on Grass Creek under normal-year conditions and nearly half during dry-year conditions. This result is consistent with the modeled headwaters inflows and unit runoff for both mainstem creeks being similar (see discussion in Section 2.3.4) and the modeled current irrigation demands on Grass Creek being much less than on Cottonwood Creek.

As discussed above in Section 2.3, evaluation of available gage data (including comparison to gage records in the nearby Owl Creek watershed) and the experience of long-time residents and irrigators suggest that these model predictions of available flow may be on the high side. However, the results are believed to be within order-of-magnitude of the actual values. Given the model estimates to date, we conclude that there is sufficient physically/legally available flow for storage during normal and wet years (including carry-over storage) to significantly mitigate existing normal and dry year irrigation shortages and thus justify more detailed study at Level II.

2.7.1.4 Recommendations for Future Hydrologic Studies

Consideration was given to attempting to refine the existing spreadsheet model during this Level I study, but it was decided (with the concurrence of the project sponsors and WWDC’s project manager) that a better course of action is to perform more detailed watershed hydrology, water rights, and reservoir operations studies should a storage project advance to Level II.

It is recommended that consideration be given to development of a StateMod (or equivalent) hydrologic model for the watershed during Level II so that appropriate exercise of water rights and reservoir operations can be included in the more detailed evaluations. It is recommended that natural headwaters inflows estimated in the current model using regression methods (based on the work of Lowham, 1988) be reevaluated and consideration be given to making these estimates by correlation with nearby gaged streams (including especially the upstream-most gages on the North and South Forks of Owl Creek). Although natural flows generated in most of the intermittent drainages in the central portion of the watershed are small relative to the yield of the higher elevation headwaters, it is recommended that these flows also be estimated and incorporated in a Level II model. Given the paucity of historical gage data in the watershed, it is recommended that the five years of record for Gage 0626550 at the mouth of Cottonwood Creek be incorporated in a Level II model to at least incrementally improve the calibration of the overall model. Finally, the imported flows from Hamilton Dome oil field should be included in the model so that current conditions can be more accurately defined and "what-if" scenarios can be run to investigate the effects of potential decrease or loss of these flows sometime in the future.

It is also important to note that the results of the availability analyses for the Tribal Futures Condition Scenario from the existing Wind/Bighorn Basin Plan model used for this Level I study were identical to those of the Existing Condition Scenario. The reason for this reflects the method in which Boysen Reservoir releases are computed within the model. As previously discussed, the model does not adjust reservoir releases; releases are based on historically calibrated data regardless of the inflows to the reservoir. The modeling simulation does indicate that the reservoir incurs a reduction in storage with the Tribal Futures Condition compared to the Existing Condition Scenario. This issue would best be further addressed by utilizing a StateMod (or comparable) model approach should a storage project advance to Level II.

2.7.2 Existing Reservoirs

As noted above in Section 2.3.2 there are two existing and one breached reservoirs and a causeway in the Cottonwood/Grass Creek watershed (see Figure 2.3-1). These facilities are described here in their existing condition, and evaluated as potential sites for additional, regained or new storage in Section 2.7.4.

Lake Creek Reservoir. Lake Creek Reservoir has a normal storage capacity of 1373 ac-ft under two storage permits:

- *Permit No. 4638R/Approriator: Lake Creek Irrigation District/Priority: 10-01-1935/Use: Irrigation/1,240.30 ac-ft*
- *Permit No. 4639R/Approriator: Lake Creek Irrigation District/Priority: 10-31-1936/Use: Irrigation/132.70 ac-ft*

According to the dams database of the Wyoming State Engineer's Office, Surface Water Division, Safety of Dams Program (WSEO, 2003) Lake Creek Dam is 45 feet high with an overall crest length of 778 feet. This is generally consistent with the "Map of Amended Application" included in Appendix H – Existing Dams; the source of this map was: http://seo.state.wy.us/wrdb/index.aspx. Note, however, that the overall dam is comprised of three adjacent embankments to fill the ground between local highs along the dam centerline alignment. The total length of these three embankments and the high ground is 655 feet (versus the 778 feet reported on the WSEO database – that dimension appears to include existing higher ground between the north embankment and the natural spillway). The main (south or right) embankment is 45 feet high with a crest length of only about 280 feet. The volume of the main embankment is reported as 28,850 cy. The other two embankments are much smaller (with the larger north or left embankment only 15 feet high with a 195-foot crest length).

Releases from Lake Creek Reservoir are made via a 30-inch reinforced concrete outlet pipe. Control is from the crest of the dam by a manually operated gate on a gate stem installed in a 4'3" square vertical concrete shaft at the dam centerline. An unlined saddle at the north (left) end of the dam serves as the spillway. The overflow section is indicated as 118 feet wide on the permit application drawing and 200 feet wide on the most recent WSEO (2005a) inspection report (see copy in Appendix H). The maximum spillway head is five (5) feet to top of dam.

Lake Creek Dam has a low hazard rating (WSEO, 2003; see also Appendix H) which indicates that it would be a Class III dam in accordance with the Requirements for Dams and Diversion Systems Falling Under the Safety of Dams Law. This means that no loss of life is expected in the event of a clear-weather breach of the dam, and that failure would not render uninhabitable or inoperable structures where people generally live, work or recreate. The dam was last inspected by WSEO on September 7, 2005. At the time of the inspection the water level in the reservoir was reported as 35 feet below the dam crest. The volume of water stored at that elevation was approximately 80 ac-ft. The only negative findings during the inspection were that the outlet control was "STUCK, BROKEN or EXCESSIVELY CORRODED", and that the "Road to the dam is almost impassable in a truck." The dam owner (Dee Hillberry, 2007) stated that the outlet gate has been stuck in the open position since he acquired the dam in the early 1990s, and that there was debris at the bottom of the vertical outlet shaft (and likely sediment build-up at the inlet to the conduit) that is presumably partially blocking the outlet. According to Hillberry, water has not been intentionally stored since at least the early 1990s (and likely not for some time before that). Given the storage volume reported in 2005, it appears that some minor unintentional storage occurs when inflows are greater than the available outlet capacity considering the existing inferred blockages.

Wales Reservoir. Wales Reservoir has a normal storage capacity of 200 acre feet under the following storage permit:

- *Permit No. 1209R/Approriator: Fred Wales/Priority: 02-13-1908/Use: Domestic, Irrigation/200.00 ac-ft*

Releases from Wales Reservoir are made as necessary to provide supplemental irrigation of hay fields located just to the north/northwest along Cottonwood Creek.

Wales Dam is reportedly 14 feet high with a crest length of 750 feet (http://seo.state.wy.us/wrdb/index.aspx). The embankment appears to have been constructed of earth fill excavated from the reservoir area. Releases are via a 12-inch diameter steel outlet pipe manually controlled from a vertical gate operator located on the inlet end of the pipe. The gate operator is accessed by a walkway extending from the dam crest. The outlet end of the conduit is extended some distance downstream with clay tile pipe. An unlined spillway is located at the site. The spillway dimensions are reported as 200 feet wide, 5 feet of head (to crest of dam), and a crest width of 15 feet (http://seo.state.wy.us/wrdb/index.aspx).

The hazard rating for Wales Dam is low (Class III); the dam was last inspected on April 14, 2005 (WSEO, 2005b, 2003; see also Appendix H). The only negative results of the inspection were that the slopes of the dam needed to be cleared of brush and trees that locally inhibited visual inspection of the dam. At the time of the inspection the water level was 10 feet below the dam crest which meant the reservoir was essentially empty.

Grass Creek (Phelps) Reservoir. The WSEO water rights tabulation includes the following permit entry:

- *Permit No. P1202R/Applicant: L.G. Phelps/Priority: 12-30-1907/Use: Irrigation/293.8 ac-ft*

The location of this reservoir in the water rights database is T45N, R99W, Sections 6 and 7 and T45N, R100W, Section 12 (quarter and quarter/quarter locations omitted here). Based on this location the dam and reservoir would appear to have been permitted immediately below the confluence of Little Grass Creek with Grass Creek with the reservoir extending a small distance up each stream above the confluence. The WSEO (2003) dams database also has an entry for this same permit number. The dam name is given as Grass Creek with L. G. Phelps as the owner. The location in the dams database is given as T45N, R100W, SWSW of Section 6. This location entry appears to be in error as that location would put the dam well out of the Grass Creek valley. If the correct range is 99W then the location would coincide with the observed remnant of an earth dam present in the Grass Creek valley just above the confluence of Little Grass Creek (hereinafter referred to as the Phelps Dam).

All but the portion of Phelps Dam southwest (right) of the original maximum section at the Grass Creek channel and a minor remnant at the northeast (left) abutment has been completely eroded away. There is no trace of what is assumed would have been an outlet pipe in or near the stream channel, nor any remaining fill in the valley bottom north of the stream. The remaining embankment is comprised of silty to fine sandy fill presumably excavated from the reservoir area and/or lower valley slopes in the immediate vicinity of the dam. It appears that the fill was placed as an essentially homogeneous section with no apparent internal filter or drainage zones. It also appears that the fill was placed in quite thick lifts more or less parallel to the slopes, rather than in relatively thin, horizontal lifts as would be required in current practice. Given the apparent age of the dam, it is also very likely that the fill received little if any moisture conditioning or compaction. All of these conditions are consistent with a hypothesis that Phelps Dam failed by internal erosion (piping) along the outlet conduit, although it is also possible that the dam was overtopped during a flood and failed by erosion during release of the reservoir water.

Grass Creek Causeway. There is a road fill (causeway) crossing the full width of the Grass Creek valley approximately three-quarters of a mile downstream of the confluence of Little Grass Creek. This fill section is mostly on the order of 10-15 feet high, with an estimated maximum height of about 20 feet at the stream channel. A large diameter culvert carries the flow of Grass Creek under the causeway. It is of interest to note that there was a storage permit issued for a reservoir at approximately this location that has since been cancelled. Permit number P1204R was issued to Grass Creek Reservoir & Ditch Company for 150 acre-feet of storage with a priority date of 07-02-1906. It is not known if the causeway fill originally functioned as a dam at this site.

2.7.3 Previous Storage Site Investigations

The only previous study encountered that identified a potential new storage reservoir site within the Cottonwood/Grass Creek watershed is the Kirby Area Water Supply Level I Study (Anderson Consulting Engineers, Inc. (ACE), 2005). A reservoir site with a capacity of 74,390 ac-ft was identified in Section 12, T45N, R95W on lower Cottonwood Creek about 3.5 miles upstream of the confluence with the Bighorn

River. This alternative was intended to provide storage of Bighorn River water in an "off-mainstem channel" site to benefit a majority of the water users in the Kirby project study area. This site was eliminated in the ACE (2005) study during site screening due mainly to the high cost/ac-ft of storage which was driven largely by the need for a pumping plant with a 270-foot lift to supply the site from the Bighorn River.

2.7.4 Alternatives for New Surface Water Storage

2.7.4.1 <u>Alternative Storage Concepts</u>

As part of the overall site identification, characterization and screening process, several alternative storage concepts were developed based on the various known and potential needs and opportunities for surface water storage summarized in the introduction to this Section 2.7. These concepts are described as follows:

- *Supplemental Irrigation by Direct Release Only* – Under this concept only the amount of water judged necessary to address existing downstream irrigation shortages amenable to direct release and gravity delivery would be stored at a given site. The site(s) must be located upstream of the irrigated lands they are intended to serve, and sufficiently downstream of the headwaters to capture the necessary amount of available flow to serve the identified need. Sites located and sized under this concept may be able to provide some degree of other benefits (depending on actual storable (i.e., available) flows), such as seasonal recreation/lake fishery and/or local/temporary stream flow enhancement, but operation to realize these benefits would be secondary to meeting irrigation demands. Potential sites under this concept would be located either on- or off-mainstem on reaches of both Cottonwood and Grass Creeks as necessary to match available flows to downstream shortages. Given the model estimates of available flow and shortages, at least one site on Grass Creek and two sites on Cottonwood Creek would be needed under this concept.

- *Supplemental Irrigation by Exchange* – In this concept, the primary function of the storage site(s) would be to capture as much of the available flow as possible at a location where releases could be made to satisfy normal downstream diversions or calls during times of shortage in exchange for out-of-priority diversions upstream on reaches which otherwise would still suffer shortages. Given the locations of the greatest modeled available flows versus the greatest apparent irrigation shortages, storage sites on the mid to lower reaches of Grass Creek would likely be considered under this concept. Sites would be sized to address any shortages that could be served by exchange, as well as those that could be served by direct release. As for the previous concept, some other benefits may derive under this concept consistent with the primary objective of storing and operating in a manner that best serves irrigation shortages.

- *Multipurpose Storage and Operation* – Here the concept would be to store as much of the available flow in the watershed as reasonably possible at a location that could best serve the widest array of potential needs and achieve the most benefits. If the preliminary, order of magnitude available flows and shortages from the Basin Plan model discussed previously are shown by more detailed analyses to be correct, then a reservoir under this concept would ideally: 1) address a significant share of existing irrigation shortages (by exchange and possibly by direct release); 2) maintain a recreation and fishery pool; and 3) provide low-flow releases to enhance the aquatic/riparian environment downstream. Assuming again that available flows were adequate, a large reservoir under this concept might also provide, together with or in place of some of the benefits noted above, some degree of flood protection and periodic flushing flows, both of which would be helpful to preserve or improve stream geomorphic stability and habitat downstream. It is important to stress, however, that the ability to provide some or all of one or more of these multiple additional benefits depends entirely on the actual physically and legally available flows as would be determined in recommended more detailed studies.

All of these concepts would also provide direct wildlife and stock watering, and could serve one or multiple pipeline/tank watering systems downgradient of the site.

These concepts are meant to provide a basis for identifying a suite of alternative surface water storage sites/sizes in this Level I study that would merit more detailed and refined analysis should this aspect of the study advance to the next level (Level II assuming application is made to WWDC). A Level II study would begin with a much more rigorous evaluation of available flows and shortages (as recommended previously in Section 2.7.1.4). It could also look in substantially more detail at the potential for significant exchanges within the watershed and the associated physical, legal and stakeholder issues involved. Finally, a Level II study could examine in as quantitative a manner as feasible the potential for multipurpose operation of a moderate to large reservoir both to achieve the associated benefits and as a potential means to attract broader-based and higher levels of funding and in-kind support for a storage project.

2.7.4.2 Identification of Potential Sites

The identification of potential sites for additional or new surface water storage in the Cottonwood/Grass Creek watershed involved the following sometimes iterative steps:

- Interview locally knowledgeable stakeholders
- Review Wyoming State Engineers Office (WSEO) dams database
- Locate areas of irrigation shortage
- Identify stream reaches with potentially significant available flows
- Characterize other potential benefits (including relative size and location of storage appropriate to realize those benefits)
- Review topographic mapping and digital aerial photography
- Conduct initial reconnaissance of potential alternative sites

Discussions with local stakeholders identified the existing Wales Reservoir as a possible candidate for enlargement, the Lake Creek Reservoir as a candidate for rehabilitation and possibly enlargement, the Grass Creek causeway as a potential site for construction of a new reservoir, and reconstruction of Phelps Reservoir to at least regain its originally permitted storage capacity. In addition to these “existing” sites, Mr. Dee Hillberry (2007) identified a potential site on upper Cottonwood Creek in the box canyon reach below the confluence with Dugout Draw (downstream of the old Rhodes Ranch homestead).

The WSEO (2003) dams database was reviewed to determine if any currently or previously permitted dams and reservoirs were listed within the study area beyond those previously identified during stakeholder interviews.

Areas of existing and apparent historic irrigated lands were identified as described previously in Section 2.1.4. For purposes of preliminary siting of potential storage reservoirs, it was assumed that all of these irrigated lands could benefit from supplemental irrigation water. Those irrigated lands with diversions in stream reaches identified as having significant normal- or dry-year shortages received particular attention. However, other irrigated lands were also included in the siting evaluations due to the unavoidable uncertainties associated with the model-predicted shortages at this level of study, the potential to provide supplemental water for dry periods more severe than the modeled 2 out of 10 year dry periods, and local irrigators' input as to their experience with shortages. In regard to the last point, every irrigator interviewed during the course of this study described the chronic seasonal (as well as dry year or drought period) shortages they have experienced in the watershed. This includes reaches for which the model predicts no (or minimal) shortages even for the dry-year condition. The other condition considered in regard to irrigated lands along Cottonwood Creek below Hamilton Dome is the possibility that there may come a time when produced water discharges to the creek are significantly reduced or cease due to economic conditions in the oil industry.

Stream reaches with apparent available flows to store were identified from the Wind/Bighorn Basin Plan model as described above in Section 2.7.1. For purposes of site identification and characterization, it is assumed that these modeled available flows are maximums and that actual available flows may be less.

Other potential benefits (as initially identified at the beginning of Section 2.7 above) were also considered in terms of site identification based on the following factors:

- Preferences or constraints on location (if any) to realize the envisioned benefit(s)
- Approximate amount of storage desirable/necessary to best provide for benefit(s)
- Any special considerations associated with the intended benefit(s)

Digital U.S. Geological Survey (USGS) 7.5-minute topographic mapping was reviewed as part of initial site identification utilizing DeLorme XMap® 5.0 GIS Editor software. Digital orthophoto quarter quadrangle (DOQQ) color infrared (CIR) aerial photography was also reviewed. Potentially favorable dam sites were identified where stream valleys were locally relatively narrow and then widened upstream, below confluences with major tributaries, and where valley floor gradients were relatively low.

Potential reservoir sites identified during interviews and in the office utilizing topographic mapping and aerial photography were then viewed in the field during one or more site visits to ground-truth the site identification process.

2.7.4.3 Preliminary Characterization and Screening of Alternatives

A "long list" of 31 potential surface water storage sites was initially compiled by implementing the methodology described above. These sites are listed in Table 2.7-2 – Potential Surface Water Storage Sites and shown on Figure 2.7-3 – Potential Surface Water Storage Sites.

The long list includes 16 permitted sites from the WSEO (2003) dams database. In general, reservoirs in the database with permitted storage capacities less than or equal to 10 ac-ft were disregarded. This eliminated a significant number of permitted stock ponds which were judged not likely to yield potential dam and reservoir sites relevant to this study. Sites with State ID numbers 8096R, 8097R, and 8098R are listed with storage capacities of 3, 2, and 1 acre-feet, respectively, but were permitted to heights ranging from 28 to 36 feet and lengths from 90 to 120 feet. The dam dimensions, locations, and owner/applicant for these three dams (Northwestern Resources) suggest that they may have been intended for containment or treatment of runoff associated with existing or potential future mining activities in the Grass Creek coal field. Given their locations and sizes these sites were not considered further in this study.

All but one of the other sites on the WSEO dams database were judged too small to address any significant portion of the overall shortages in the watershed. However, a number of these general site locations were adopted for the new sites identified during this study. These include the sites on the upper reaches of Grass Creek above and below the confluence with Little Grass Creek (including the breached Phelps Reservoir), Wales Reservoir, and the sites on Cottonwood Creek between the confluences of Prospect and Grass Creeks.

Sites 0201R and 1760R were not carried further in this study due to the anticipated relatively low available flows in Spring Gulch and Wagonhound Creek as compared to the apparent downstream shortages, the generally more difficult and expensive access as compared to mainstem sites, and the potentially greater conveyance losses with relatively small releases on intermittent tributaries as compared to larger releases from mainstem sites. Sites such as these may have a place if a concept of multiple small reservoirs constructed to serve individual landowner needs, or constructed over a relatively long time frame to eventually address the overall shortages in the watershed, was of interest to the local irrigators and other stakeholders.

The Cottonwood Creek Reservoir site identified in the ACE (2005) study was not carried further in this study as it would not be able to serve the existing irrigation shortages or provide for other potential benefits in the Cottonwood/Grass Creek watershed.

2.7.4.4 Selected Alternative Surface Water Storage Sites

Short-List Sites. Based on the above rationales and screening, a total of ten "short-list" sites were advanced for further evaluation in Section 3.3. These sites are referred to as the selected alternative surface water storage sites. Following is a summary of which storage concepts are intended to be addressed by each of the alternative new storage sites:

- *Supplemental Irrigation by Direct Release Only* – Site 1 – Grass Creek Causeway (small), Site 2 – Putney Flat, and Site 5 – Wagonhound or an appropriately sized Site 4 – Wales Reservoir Expansion.
- *Supplemental Irrigation by Exchange* – Appropriately sized Site 1A – Grass Creek Causeway (large), Site 7 – Spring Gulch, Site 9 – Lower Grass Creek or Site 11 – Prospect.

- *Multipurpose Storage and Operation* – Maximum sized Site 1A – Grass Creek Causeway, Site 7 – Spring Gulch or Site 9 – Lower Grass Creek.

The three existing dam and reservoir sites were selected for further evaluation based on the following rationales:

- Site 4 - Wales Reservoir – This site represents a potentially attractive off-channel site that is already served by an existing ditch and which is well positioned to capture and store some of the year-round discharges from the Hamilton Dome oil field should that prove desirable.
- Site 12 - Phelps Reservoir – Reconstruction of this dam and reservoir was selected as a surrogate to examine the relative cost per acre-foot of providing small capacity storage in the watershed.
- Site 13 - Lake Creek Reservoir – It was assumed that the cost to regain operational use of existing storage at this site would be relatively less expensive per acre-foot of developed water as compared to any other alternative for storage considered.

Site 14 – Dvarishkis was identified as a potential substitute for either or both a rehabilitated Lake Creek Reservoir and a new Putney Creek Site. However, this site was not carried forward at this level of study in part due to anticipated greater costs for access, greater conveyance losses than would be experienced from releases from the Putney site to shortages on Cottonwood Creek, and the general proximity of numerous landslides (although none are mapped directly at the site).

Availability and Shortages. For each selected alternative reservoir site, the closest hydrologic model node located upstream of the dam site was used as the upstream end of an availability analysis (see Section 2.7.1 above). Availability was quantified as the minimum of 1) the flow physically available at that node and 2) the minimum flow among all nodes downstream, including the Bighorn River reaches. Shortages below each site were taken from the model results for the nodes downstream of each given dam site.

Table 2.7-3 – Alternative Storage Sites - Annual Available Flows and Shortages summarizes the results of this exercise on an annual basis. Table 2.7-4 – Alternative Storage Sites - Available Flows By Month provides a more detailed monthly breakdown of the modeled available flows. These results are displayed graphically in Figures 2.7-4A – 2.7-4I – Alternative Storage Sites - Available Flow By Month. Note that available flows for Site 4 - Wales Reservoir Expansion could not be estimated using the basin planning model as this is an offstream site, and that natural inflows are shown for Site 13 – Lake Creek Reservoir as the modeled available flows are believed incorrect due to invalid assumptions regarding reservoir operations during the modeled time period.

These model-generated values of availability and shortages serve as the basis for conceptual-level sizing of the appropriate storage capacity and estimating the yield of the selected alternative storage sites as described in Section 3.3 below.

3.0 Watershed Management and Rehabilitation Plan

3.1 Irrigation Supply Systems

3.1.1 General

In this section, conceptual rehabilitation plans are presented for each of the ditches inventoried. The rehabilitation plans represent the integration of individual measures to mitigate problems identified in the inventory phase of the project. Specifically, the improvements that comprise each rehabilitation plan focus on:

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

The alternatives were developed based upon information obtained from: (a) the project meetings; (b) discussions with ditch representatives; and (c) the evaluation of field inventory data. The improvements discussed in this section also include recommendations from previous investigations conducted by the NRCS where appropriate.

For each of the irrigation systems inventoried, an individual rehabilitation plan was developed. A total of sixteen (16) systems were inventoried. The full extent of the Robbins Ditch was not inventoried, nor were rehabilitation plans developed at the request of the owner. The Earl North and Earl South Ditches were also deemed in good condition and no recommendations provided. Consequently, ditch improvements were generated for 13 individual systems.

These plans are intended to provide the ditch owners an overall assessment of conditions associated with the ditches and their associated hydraulic structures. They are not all-inclusive as the entire extent of each ditch was not examined. For the purposes of this Level I investigation, the rehabilitation plans offer potential solutions to the primary issues and problems associated with each system. The irrigators can use these plans as a "resource or wish list" from which they can select projects for future Small Water Project Program or Water Development Program Level II investigations and ultimately Level III design and construction, if they desire to follow through with WWDC funding. Alternatively, this information will also support application for NRCS and/or other funding as appropriate.

3.1.2 Ditch Rehabilitation Plans

Based upon the results of the field inventories, the conceptual rehabilitation plans were developed and are presented in Table 3.1-1 – Irrigation System Rehabilitation Plan. This table includes the general description of the improvements and the estimated cost of construction. In an effort to assist the ditch representatives in prioritizing potential improvements to each ditch, relative priorities were defined as follows:

- *Priority 1*: These improvements replace or rehabilitate a potential failure in ditch operation, provide improved water management by providing measurement capabilities, or mitigate significant seepage losses.
- *Priority 2*: These improvements improve the overall condition of the ditch system by replacing or rehabilitating aging structures.
- *Priority 3:* These improvements provide for reduced operation and maintenance costs and provide additional long-term improvements to ditch infrastructure.

The improvements identified and described here are based on extensive experience by team member ACE with the planning, design, and construction oversight for numerous other projects in Wyoming with similar rehabilitation measures and system upgrades.

3.2 Wildlife/Livestock Watering

As discussed previously in Section 2.1.5, providing additional wildlife and livestock watering opportunities is the single most important action that can be taken to restore, improve and/or maintain watershed function and values affected by grazing. Existing watering opportunities are first discussed in Section 3.2.1, followed by discussion of potential new and/or enhanced opportunities in Section 3.2.2.

3.2.1 Existing/Planned Watering Sites

3.2.1.1 Undeveloped and Over/Under Utilized Sites

Perennial and Intermittent Streams. The perennial and intermittent reaches of the existing mainstem streams (Cottonwood and Grass Creeks) and their main tributaries were historically a primary source of wildlife and livestock watering. In some areas this is still the case today. Given the severe drought conditions over the past several years and during the course of this Level I study, it was not possible to delineate the extent of perennial versus intermittent stream reaches in the watershed applicable to more typical runoff conditions. Based on discussions with long-time ranchers and residents, it appears that perennial flows on Grass Creek are not uncommon to at least the confluence of Little Grass Creek. Perennial flows on Cottonwood Creek appear to be limited to the reaches generally above the confluence of Twentyone Creek. Most of the tributaries to Cottonwood and Grass Creeks reportedly only exhibit perennial flows in their upper reaches where they are spring-fed during normal to wetter years. Occasional and/or localized use of these perennial stream reaches (and intermittent reaches when flowing) for watering of big game and livestock can be appropriate and not result in significant impacts to the riparian environment and water quality. Livestock use of a riparian area should be under an appropriate planned grazing system to avoid overuse that can result in locally severe impacts.

Springs. Numerous existing springs have been identified as discussed previously in Section 2.2 and as shown on Figure 2.2-10. All of these springs provide at least some opportunity for wildlife and livestock watering when they are flowing. However, where these springs are used in their existing (undeveloped) state, damage to the spring can occur resulting in less use and value (especially where flows are lower). This usually includes damage to local riparian values associated with the spring. Those springs that were preliminarily identified as producing more than about two (2) gallons per minute (gpm) on a reasonably sustained (at least seasonal) basis are considered as candidates for further development as described later in this section.

Ponds. Many small ponds are present in the Cottonwood/Grass Creek watershed as shown on Figure 3.2-1 – Stock/Wildlife Ponds. These ponds and their locations were compiled from a: 1) a BLM GIS shapefile; 2) review during this study of U.S. Geological Survey 7.5-minute topographic mapping; and 3) observations during several site reconnaissance visits. In addition, stock ponds permitted by the Wyoming State Engineer's Office were checked to ensure that they were already accounted for by the other sources. It was not feasible to inspect each of these sites at this level of study, but many of them were observed at least briefly during site visits. Based on these observations and the comments of various landowners and BLM staff, it appears that many of these existing ponds need to be to be cleaned of accumulated sediment, repaired, or rebuilt to regain their original functionality. Even when fully functional, these ponds require periodic precipitation/runoff to refill/refresh the stored water, and maintenance to remove sediment and/or repair breaches caused by high runoff.

3.2.1.2 Existing/Planned Higher Value Sites

Existing and planned watering sites that are judged to have generally higher value than the sites discussed in Section 3.2.1.1 above were identified during this study as shown on Figure 3.2-2 - Existing Wildlife/Livestock Watering Sites. Each site shown on Figure 3.2-2 represents a one-half mile radius area around an existing or actively planned individual watering site (see qualifications in the following discussion). The half-mile radius is conservatively estimated as the nominal maximum distance that livestock will travel for water in moderately rough terrain assuming that no other opportunities are present closer.

Pipeline/Tank Systems. The existing/planned sites include tanks on well-designed and highly functional water systems involving spring developments or wells that supply several miles of pipeline feeding multiple tanks (labeled as "Existing" or "Proposed/Planned Pipeline/Tank Service" on Figure 3.2-2). These systems have been installed (or are actively being planned/designed) by several ranchers in the watershed, with the technical assistance of NRCS staff and individual consultants. The specific existing or planned locations/alignments of the individual components comprising these systems are included in the project geodatabase.

Ponds. The existing ponds judged adequately functional as wildlife and livestock watering sites are shown on Figure 3.2-2. Note that due to limitations on field reconnaissance time at this level of study there may be some functional ponds that are inadvertently not included on Figure 3.2-2. Subsequent on-farm conservation planning will provide for future development of these water facilities.

Guzzlers. There are three known guzzlers in the watershed as shown on Figure 3.2-2. These watering systems rely on local direct precipitation (as described further below in Section 3.2.1.3); thus, their functionality depends on the frequency of use versus the frequency and amount of direct precipitation.

Wells. Those wells in the Wyoming State Engineer's Office (WSEO) database with active permits and at least one of their uses identified as for stock watering are also shown on Figure 3.2-2. It is important to note that only a few of these wells were observed in the field and confirmed as currently providing a wildlife/livestock watering opportunity. Given the substantial number of wells fitting the criteria that suggest they are currently used for this purpose, a more detailed field verification/clarification effort is recommended. It is possible (if not likely) that at least some (and perhaps many) of these wells indicating more than one beneficial use are not in fact currently used for wildlife/livestock watering. It is also possible that the WSEO database is not fully up to date and that some of the permitted wells have either not actually been installed or have been abandoned. Given these uncertainties, the wells are shown with an open circle in Figure 3.2-2 to reflect that they may not be providing as much existing watering opportunity as their numbers and locations would otherwise suggest.

Summary of Needs. Discounting to some degree the "active groundwater wells" on Figure 3.2-2 (for the reasons discussed above under Wells), it is apparent that major areas of the watershed are currently underserved in terms of efficient and effective wildlife and livestock watering. Even if all of the wells are in fact existing, functional watering sites (which is doubtful), the need for infill watering opportunities is apparent. This is especially true in the lower precipitation, eastern half to third of the watershed.

3.2.2 Alternative New Watering Opportunities

As discussed previously in Section 2.1.5, providing additional upland range water developments at appropriate locations for use by both wildlife and livestock will result in significant benefits to the watershed, including but not necessarily limited to the following:

- Soil erosion and resulting sediment loading to streams from currently over-utilized upland rangeland near existing water sources will be reduced. This reduction will result from development of more sustainable forage and desirable associated vegetation in currently under-utilized upland range which will allow for recovery and ongoing health of the currently over-utilized areas.
- The need for wildlife and livestock to water in streams will be minimized by providing water in upland areas where adequate and more suitable forage is available. This will promote ongoing recovery of riparian areas that have historically been over-utilized.
- Stream stability will be enhanced in those areas where over-utilization of streambank and overbank vegetation by wildlife and livestock has historically occurred. Healthy riparian and associated vegetation in the stream corridor is a key factor in avoiding excessive erosion and bank failure with the resultant sediment overloading of the downstream reaches (see related discussion in Section 3.5.5).
- Stable stream conditions and healthy riparian habitat will help control the establishment and spread of undesirable plants (e.g., saltcedar and Russian olive) and noxious weeds (see related discussions in Sections 3.5.2 and 3.5.4).
- All of the above benefits taken together contribute to healthier and more sustainable riparian and aquatic environments and compatible agricultural uses (including grazing and irrigation of hay and alfalfa) that will in turn produce direct and indirect economic/socioeconomic benefits for the watershed.

Opportunities to provide additional and/or more efficient and effective wildlife and livestock watering opportunities within the Cottonwood/Grass Creek watershed are substantial as shown on Figure 3.2-3 – Alternative Wildlife/Livestock Watering Opportunities. This figure shows currently undeveloped springs with estimated reasonably sustained flows greater than about 2 gpm, existing but currently non-or low-functional ponds, and reportedly permitted active wells with stock watering as an allowed beneficial use. It also shows the existing electric power distribution system relative to these potential water sources. The springs and wells represent a major portion of the potential water sources available to develop as individual watering sites or to use to feed multiple sites utilizing a pipeline/tank system. Certain of the existing non- or low-functional ponds may be located in areas that are not technically and/or economically feasible for individual spring or pipeline/tank system development. The potential appears to exist to provide at least seasonal watering at such sites that could open underutilized range lands to more productive use. In addition to the opportunities called out on Figure 3.2-3, the perennial reaches of higher elevation streams and any future storage reservoir(s) that may be constructed (see Section 3.3 below) could also serve as sources of water to feed pipeline/tank systems.

Detailed mapping of riparian areas was beyond the scope of this Level I study, but a first-order approximation of these areas can be gained by considering the mapped areas/reaches of NWI wetlands shown on Figure 4.3.6 as a surrogate for riparian areas. Comparing Figures 3.2-2 and 3.2-3 to Figure 2.4-10 and Figure 4.3.6 shows that existing, planned, proposed and potential future wildlife/livestock water developments in the central portion of the watershed are generally well situated to help maintain or restore healthy conditions in riparian areas and less stable stream reaches (Types F and G).

Various alternative types of watering improvements/developments are described in more detail in the following subsections. Note that alternative watering tanks applicable to use with essentially any of the water sources are addressed in Section 3.2.2.4. Options for power where pumping is required are discussed in Section 3.2.2.8. A number of currently planned and potential wildlife and livestock water development projects within the watershed are presented and discussed in Section 3.2.2.9. Finally, the potential for development of larger-scale, cooperative water development projects is discussed in Section 3.2.2.10.

3.2.2.1 Spring Developments

An individual spring (or close-by set of springs or seep area) can be developed as a local watering site or to feed a pipeline conveying the flow to multiple tanks (see discussion on Pipeline/Tank Systems following). The specific method(s) used to develop a spring or seep area depend on the site-specific conditions. In general, the following factors and recommendations should be considered and implemented/adopted as appropriate:

- Carefully examine the spring/seep to determine the source (or "eye"), and to determine if there any known or potential sources of contamination.
- Observe the rate of flow (estimated or measured) during a dry season or the season of intended use to determine if flow rate will be sufficient or to guide design of the spring development.
- Remove obstructions to spring flow (fine grained soils, surficial deposits, dense vegetation, etc.).
- Remove phreatophytic vegetation that can significantly reduce the amount of spring flow via transpiration (in accordance with any necessary environmental analysis, permitting and mitigation).

- Collect the available flow by appropriate means/methods (perforated pipe; ditching; drainage trench/gallery; etc.).
- Construct a means to settle sediment, protect the spring flow from external debris or contaminants, and facilitate maintenance of the spring (e.g., a spring box).
- Consider lowering the outlet elevation of the spring to increase the head at the discharge and thereby increase the flow.
- Use of explosives for spring development is discouraged as this practice can result in lower instead of higher flows and is dangerous unless performed by fully qualified personnel.
- Protect the spring development from washout or sediment burial during periods of flooding by diking and ditching as appropriate.
- Construct and maintain fencing or other barrier around the source to minimize impact to the source by wildlife or livestock.

Detailed information on the occurrence and characteristics of springs and the design of spring development, collection and protection is included in Chapter 12 – Springs and Wells of the Engineering Field Handbook (NRCS, 1983). This reference may be downloaded at the following website: http://www.info.usda.gov/CED/ftp/CED/EFH-Ch12.pdf.

Alternative guidance for the design, construction and maintenance of spring developments as published by USAID (1982) is available at the following website: http://www.lifewater.org/resources/rural_water_supply.html.

Figure 3.2-4 – Spring Development Schematics shows several typical spring development schemes abstracted from these two references.

3.2.2.2 Conventional Windmills, Wind Turbines and Combined Solar/Wind Systems

Conventional Windmills. Windmills are a traditional method used to collect groundwater by means of a conventional well equipped with a mechanical pump powered by the wind-driven rotation of a set of high-torque, low-speed gears. Windmills are most typically used where: distance to power lines is greater than about a mile; reliability of supply is not crucial; high pumping rates are not required; ease of maintenance is important or desirable (i.e., no electrical and associated control components); and where cost per gallon of water produced needs to be low compared to other alternatives.

Modern windmills are capable of pumping from depths up to about 1000 feet if needed (at low pumping rates); however, most applications are where relatively shallow groundwater is available (typically less than a few hundred feet). Pumping rates from shallow depths typically range from a few tens to as much as several thousand gallons per hour (gph) under favorable conditions. Mechanical single-action piston pumps are most commonly used. Performance parameters for a high efficiency, modern-era Oasis 3 windmill manufactured by WINDTech International, LLC are presented on Figure 3.2.5 – Windmill Performance Curves.

Wind speeds necessary to drive modern windmills may be as low as about 5 miles per hour (mph) for highly efficient designs; more typically winds of at least 12 mph are needed, with efficiency increasing notably at wind speeds greater than about 18 mph. The life of a windmill is usually on the order of 20 years under a normal range of operating and environmental conditions.

A windmill would normally fill a local tank and serve as a single point source of wildlife and livestock watering. A typical mechanical windmill set-up is shown schematically on Figure 3.2-6 – Windmill Schematic.

Wind Turbines. A wind turbine can be used as an alternate source of power for a conventional pump installed in a groundwater well. In this type of system a wind turbine is mounted on a tower either at the site of the groundwater well or a more wind-suitable site near the well. The turbine converts wind energy to electrical energy through a generator or alternator that in turn powers a conventional submersible pump. If desired, storage batteries could be included in the system so that pumping could continue during times when the wind velocities are not sufficient. Information about wind turbines in a water pumping application is available from the U.S. Department of Energy Efficiency and Renewable Energy (EERE) website at: http://www.eere.energy.gov/consumer/your_home/electricity/index.cfm/mytopic=10890. Information on commercial wind water pumping systems utilizing a Bergey wind turbine and Grundfos submersible pumps are available from Bitterroot Solar at: http://www.bitterrootsolar.com/pumping/windpump.htm. These particular systems range from 4,800 to 40,000 gal/day production with an 11 mph wind and a pumping head of 100 feet. Additional technical and cost information for these systems is available at: http://www.bergey.com/Products/XL1.html.

Combined Solar/Wind Powered Systems. An alternative to a conventional windmill or a wind turbine powered pumping system is a combined system that includes both a wind turbine and solar panels as power sources for a generator and conventional submersible water pump. This system allows the pump to be operated by solar power alone, wind power alone, or a combination of both sources depending on environmental conditions at the site at any given time. Although more expensive to install and maintain, this system provides more reliable power for stock water pumping than either single source alone. A commercially available source of this type of system is produced by Grundfos; information on this system is available at: http://net.grundfos.com/doc/webnet/sqflex/home.htm.

3.2.2.3 Wells

Wells are a potential source of water for wildlife and livestock watering. Because of the cost of drilling and completing a well and the unavoidable uncertainty as to the production that will be achieved (without very expensive prior site-specific exploration), a new well would usually only be considered as a source where no other more practical and cost-effective options are available. On the other hand, conversion of an existing well to serve as a source of wildlife/livestock watering may be very cost-effective. For this to be the case, some or all of the following conditions should be met:

- Located near an area in need of additional watering opportunities
- Sufficient capacity to serve this and any other existing uses (or potential to increase well yield through re-conditioning or possibly deepening)
- Capable of operation by wind or solar power (unless already served by a power line)

It may be possible to convert a dormant oil (or gas) well to water production; however, there are a number of factors that may render this impractical. First, the well must be open to at least the depth of the target aquifers(s). If open deeper, it may be necessary to plug the hole up to or for some distance below the base of the lowest target aquifer to minimize pumping residual oil and/or natural gas. Depending on the nature of the aquifer(s) (hydrocarbon content) it may be necessary to install a "treater" or "skimmer" at the surface to separate the hydrocarbons from the water. If the well is cased across the producing zone(s), it will have to be perforated, and depending on formation properties, protection against piping of the sidewall provided by some means. Unless conditions are generally favorable, the cost of conversion of an existing oil well may end up exceeding the cost of drilling and completing a new well. This is not to say that such opportunities do not exist or are always impractical. An oil well on Wagonhound Bench was reportedly successfully converted and serves a year-round watering installation. Any such conversion opportunities should be carefully evaluated on a case-by-case basis.

Conditions most advantageous to use of a new well are summarized as follows:

- Shallow depth to aquifer(s) with adequate transmissivity to meet projected needs
- Located where hydrogeologic conditions are reasonably well known from prior drilling and/or well installation
- Either close to existing power lines or suitable for wind or solar operation
- Location upgradient of an area or areas of significant wildlife/livestock watering shortage

If a new well is planned, it is recommended that a water well driller with substantial experience in the local area be utilized to take best advantage of prior experience with the relevant geologic units and conditions. Depending on the size (depth and anticipated yield) of the well, it may be worthwhile to consult a groundwater geologist with experience in this or similar geologic settings prior to finalizing a decision as to drilling a new well.

Information on the planning, design, drilling, completion, development of groundwater wells is available from many sources. One source of such information is available from the NRCS (1983) Engineering Field Handbook at the following website: http://www.info.usda.gov/CED/ftp/CED/EFH-Ch12.pdf.

3.2.2.4 Pipeline/Tank Systems

Pipeline/tank systems are generally considered to be the best method for conveyance of flows from any suitable source of water, since they can put the water where it is needed (at multiple locations), when it is needed. These systems can operate by gravity, be fed by a pumped source, or combine both gravity and pumping reaches (usually with a surge/storage tank in the system). Sources of water may include any of those described in this section, including a groundwater well, developed spring, pond, reservoir, or stream diversion.

Considerations in the layout and design of a pipeline/tank system include, but are not limited to the following:

- *Location of the source relative to the points of use* – ideally the water source will be located upgradient of the points of use so that all delivery can be by gravity

- *Temporary storage* - if necessary, one or more locations for temporary storage of pumped supply can be provided that then feed the remainder of the system by gravity; typically a 2-3 day supply for the wildlife and livestock using the system is provided
- *Terrain* – an alignment with some variation in grade is desirable to minimize problems with air-locking by installation of air relief valves at appropriate locations; very rugged terrain is less desirable due to the higher installation costs
- *Geologic conditions* – ideally pipeline alignments will be located where rock excavation and/or adverse soils conditions are avoided or minimized to the degree practical (adverse soils conditions may include landslides, areas of significant active erosion, etc.)
- *System length/size* – the longer the system and the more tanks planned or desired, the greater the flow capacity from the source required; friction losses in the pipe and through the fittings can be significant over long distances relative to the available energy of the source water
- *Property ownership* – systems may be designed to serve a single landowner; alternatively, there may be opportunities for cooperative projects in which the system is designed to serve two or more entities (see additional discussion later in this subsection)
- *Environmental conditions/issues* – it is necessary, to the extent feasible, to avoid impacts to the environment including but not limited to wetlands, riparian zones, high value sage grouse habitat, and cultural resources

Several landowners in the Cottonwood/Grass Creek watershed, in cooperation with NRCS, have planned, designed and/or installed a number of pipeline/tank systems (see Figure 3.2-2 for areas of watering coverage provided by these systems). A new pipeline/tank system to serve the Little Grass Creek area is currently in planning and preliminary design (see Figure 3.2-7 – Little Grass Creek Pipeline/Tanks Layout with permission of the landowners). This is an example of a project involving a cooperative effort between two landowners to their mutual benefit in terms of overall system efficiency and cost-effectiveness, with the technical assistance of the NRCS.

Taken together, the pipeline/tank systems planned and/or installed already in the watershed include some or all of the following elements/components:

- Spring development or well as water source
- HDPE piping
- Air release vents/valves
- Pipeline drains
- Tanks (with pressure reducing valves, rescue ladders, gate or ball valves, float valves, air and vacuum release or pressure relief valves, overflow piping, and pump manifold gages, valves and fittings)

There is a wide array of different wildlife/livestock watering tanks that can be used in a pipeline/tank system or with any of the other water sources described in this section. At present, converted heavy equipment tires appear to be the preferred tank type in the watershed. This is due to their relative availability, comparative cost-effectiveness, durability, freeze-resistance, long-life, and ease of installation (with the proper equipment available). A typical 12-foot by 2.5-foot tire tank holds on the order of 1500 gallons when full. Other types of tanks that could be considered on a case-by-case basis include, but are not necessarily limited to:

- Cast-in-place or precast concrete tank or trough
- Bottomless corrugated metal tanks
- Pit/pond (sealed or lined where necessary)
- Fiberglass or galvanized tanks

The larger pipeline/tank systems planned and/or installed in the watershed are designed to fill the tanks automatically as the contents are drawn down. There is provision for taking individual tanks out of service when necessary for maintenance or repair. Overflow drainage is provided in the event of malfunction. The design plans for one of these pipeline/tank systems are provided in Appendix I – Pipeline/Tank System (with the landowner's permission) as an excellent example of a comprehensive, efficient and cost-effective wildlife/livestock watering system. This system includes a 15,000 gallon storage tank filled from a well source which in turn feeds the pipeline/tanks by gravity. A number of other currently planned and potential pipeline/tank systems are included in the wildlife/livestock water development projects addressed in Section 3.2.2.9.

3.2.2.5 Ponds

Small ponds can provide seasonal watering opportunities to both wildlife and livestock. Watering can occur directly from the pond, or a pipeline can be fed from the pond to deliver water to one or more tanks downgradient.

For purposes of this study, a watering ("stock") pond is defined as a reservoir or pit/dugout (excavation below original grade) with a maximum capacity of less than 20 acre-feet and a dam height less than 20 feet. Reservoirs/pits of this size qualify for application to the State Engineer's Office as "stock reservoirs" and thereby avoid the more restrictive and costly administrative, design, and construction requirements associated with permitting under the standard reservoir regulations.

A pond is typically created by excavation of soils in the pond area and placing the excavated soil as embankment fill to create a dam. This approach is most cost-effective initially; however, it may be more cost-effective in the long run to secure soils from areas near but not immediately at the reservoir site depending on the properties of the soils. In particular, clay soils with dispersive properties or with significant percentages of soluble salts should not be used for embankment fill if other more suitable soils are available nearby. Embankment fill should be placed in relatively thin horizontal lifts, compacted with rubber-tired (versus tracked) equipment, and not placed too wet or too dry. This will result in a more erosion resistant embankment.

An overflow earthen spillway should be provided for ponds constructed in ephemeral or intermittent drainages and in swales with relatively large drainage areas. If possible, the spillway section should be excavated in or to rock. If this is not feasible, the spillway should be constructed with as broad a crest and as shallow a discharge channel as practical to lower flow velocities and thereby limit erosion during times of use. Revegetating the spillway with grasses will also increase its erosional resistance.

The arrangement of the spillway relative to the dam embankment and the general configuration of the spillway are shown by the centerline profiles shown in Figure 3.2.8 – Pond Embankment and Spillway Profile Schematics.

An outlet pipe is usually only included in this type of pond if it is needed to feed one or more tanks downgradient (supply pipe) or if there is enough spring-fed flow or intermittent runoff events to cause excessive use of the overflow spillway ("trickle tube"). A supply pipe is placed with its inlet near but not at the lowest point of the foundation (to allow for some sediment accumulation). Flow is controlled by a downstream valve (e.g., a float valve regulated by water level in the downgradient tank or pipeline/tank system being supplied). The trickle tube is an appropriately-sized open pipe installed through the embankment dam at an elevation slightly lower than the overflow crest elevation of the spillway.

If direct watering is intended (which allows for watering more animals at a time), then it is recommended that protection of the dam embankment, spillway (and outlet if present) be considered to reduce the need for and cost of future maintenance. Although initially more costly, consideration should also be given to armoring of the pond rim to lessen erosion and excessive sedimentation. This decision should be based on the site soils conditions, planned usage, and estimated cost of future maintenance in the absence of such protection. One alternative on larger ponds may be to selectively armor only portions of the rim and fence the remainder to exclude use by wildlife and livestock. If armoring is used it should consist of reasonably durable gravel (over larger rock if necessary) to encourage use by wildlife/livestock and minimize sloughing and erosion of the pond banks.

Information on the planning, design and construction of small ponds is available from the NRCS at: http://www.info.usda.gov/CED/ftp/CED/EFH-Ch11.pdf. The local NRCS staff in Thermopolis and Worland (and other staff they may contact) may also be able to provide technical assistance for projects to be constructed under an NRCS program (see Section 6.4 below).

3.2.2.6 Reservoirs

A new surface water storage reservoir (as described in Section 3.3 following) could serve as a source of supply to a wildlife/livestock watering system. This could involve direct gravity to one or more pipeline/tank systems arrayed downgradient of the reservoir. Alternatively, the reservoir could serve as the source for pumping water to one or more pipeline/tank systems.

Any new reservoir would also serve as a direct source of wildlife and livestock watering. Depending on the location of the reservoir relative to grazing locations, it may be appropriate to include one or several watering access sites around the reservoir rim. These sites should be sized to accommodate the anticipated or desired use, and designed with appropriate grades to and in the near-shore pool to facilitate watering. The access ramps and watering areas should be adequately armored as described above in Section 3.2.2.5.

3.2.2.7 Guzzlers

A guzzler is a wildlife watering system utilizing direct precipitation as a source of supply, with a storage tank of capacity suitable to the watering need, and designed to discourage use and protect from damage by livestock. A complete guzzler system is comprised of the following components:

- Catchment apron – typically made of textured HDPE; secured with rocks placed on a suitable grid spacing, and protected by suitable fencing from trampling by wildlife or livestock
- Catchment outlet - pipe boot, clamps and well screen section
- HDPE pipe – typically 1.5-2-inch, 160 psi, SDR 11
- Catchment tank – HDPE tank sized to accommodate wildlife or livestock watering needs, with integral drinker (ideally with no float valve required), small animal escape ladder and overflow adapter (1800-gallon tank with patented features is available from Boss Tanks and Elko Bighorns Unlimited, Elko, Nevada)
- Overflow pipe – with erosion protection at discharge

The guzzler operates by intercepting direct rainfall or snowmelt on the catchment, routing the captured water via a pipe to the tank, and controlling the tank level via a simple overflow outlet pipe. Figure 3.2-9 – Guzzler Schematic shows a typical set up with dual catchments and tanks. Information on a commercially available system compatible with the design described above is available from Boss Tanks and Elkhorn Bighorns Unlimited at: http://www.bosstanks.com/guzzler.htm. A self-contained guzzler is available from Wildlife Water Guzzler; information on this product line is available at: http://www.wildlifewaterguzzler.com/.

3.2.2.8 Power Sources

Conventional Electrical Service. As noted in Section 2.1.3 and shown on Figures 2.1-5 and 3.2-3, there is overhead power along much of central and lower Cottonwood Creek and most of Grass Creek. This system is operated by High Plains Power Inc., Thermopolis Division. In most cases the cost to bring overhead power to a single well or lift station site for wildlife/livestock watering would probably be prohibitive. This option should normally be considered only when the point of power use is close to existing service (usually less than about ¼ to ½ mile) or the power demands are higher than can be feasibly supplied by other sources (wind, solar).

Portable/Remote Generator. Although possible, the use of portable or remotely installed gasoline or diesel powered generators is generally not an economically feasible alternative to operate pumps to supply wildlife/livestock water. This type of power is usually only considered in temporary or emergency conditions. If used, special care is required to ensure safe transport, storage and use of fuel to prevent accidental fires and/or releases of fuel to the environment.

Solar Water Pump. Solar power can be an appropriate, efficient and long-term cost-effective means to power a pump used to extract groundwater from a well or to convey water upgradient from another source of supply (pond, spring, storage tank, etc.) to temporary storage or point of use (watering tank or pipeline/tanks system). This type of system is best suited to remote locations with sufficient sunlight, typical of conditions where additional wildlife/livestock watering is needed in the Cottonwood/Grass Creek watershed.

Solar water pump systems are typically comprised of one or more photovoltaic (PV) panels, sometimes a set of storage batteries, and a DC-capable pump. Figure 3.2-10 – Solar Water Pump Schematics shows two typical set-ups, one with storage batteries and direct delivery to the watering tank(s) and the other with a storage tank set above the watering tank(s) and without storage batteries. Other arrangements are also possible. Batteries are used where pumping during low-light and nighttime periods is necessary or desirable (e.g., to fill a storage tank or refill a watering tank overnight when watering demands are low).

Overall, solar water pump systems are relatively easy to install and maintain. However, the solar panels are relatively fragile and need to be mounted in a suitable location and well-secured against wind and livestock damage. The other components in the system (pump, controller, switches and possibly batteries) also need to be properly installed, protected from weather and incidental damage, and require some periodic maintenance and/or replacement.

Solar water pumps are specially designed to work efficiently with DC solar power, including during low-light (reduced voltage) conditions. Many different types of pumps can be used depending on the pumping head and flow rates for the particular application. These include positive displacement types (piston and jack pumps, diaphragm, vane and screw pumps) that maintain lift capacity at slow, varying speeds resulting from changing light conditions. In low-lift and/or high-volume applications, centrifugal-type pumps are often used. The pumping rates that can be achieved vary with the lift (head) from the pump to storage or point of use and the amount of power supplied by the solar system. At relatively low heads (say less than 100 feet) and with modest power (say less than 150 watts), pumping rates on the order of 150-200 gph (3.0-3.5 gpm) are possible. With greater available power at low heads (50-100 feet), pumping rates up to several thousand gph (25-75 gpm) are possible with centrifugal pumps. For high lifts (say 400-500 feet) and sufficient power, pumping rates of several hundred gph are attainable with helical rotor pumps.

Flyers from several solar water pump suppliers are included in Appendix J – Solar Water Pumps; manufactures should be contacted for more current and detailed information and technical assistance in determining the best system for a particular application. Also included in Appendix J is a copy of a presentation that provides background information, discussion of applications and issues, design guidance and cost analysis for solar water pump systems.

(Note that any references to any proprietary products in this report are for informational purposes only and do not imply any endorsement or guarantee of the products.)

3.2.2.9 Wildlife/Livestock Water Development Projects

Information on a total of 25 proposed and potential projects to develop new wildlife/livestock watering opportunities in the Cottonwood/Grass Creek watershed has been compiled during this Level I study. These projects were identified through interviews with a number of ranchers during the course of this Level I study. Many of these projects are being developed with the assistance of the local NRCS office in Thermopolis. The status of these projects ranges from those for which final designs have been submitted to BLM for environmental clearances to very preliminary concepts still in the early planning stage. Additional water developments would be beneficial to the watershed as described previously, and may be proposed and implemented at any time (see related discussion in Section 3.2.2.10 below).

Information on the projects compiled during this study is summarized on Table 3.2-1 – Wildlife/Livestock Watering Projects Plan. Each project is assigned a project number and name and the projects are grouped by the stream drainage (either mainstem or tributary) within which they are located. Key information on the water source and associated infrastructure for each project is presented. This information provides the basis for the estimated costs shown for each project. Additional information on costing of these projects is presented in Section 5.2. Potential funding sources applicable to these projects are discussed in Section 6.4.

3.2.2.10 Cooperative Effort

There appears to be significant potential in the Cottonwood/Grass Creek watershed for larger-scale, broader-based cooperative projects than have been planned to date to increase wildlife/livestock watering opportunities. Given the “patchwork” of land ownership overlaid on the areas of rangeland that could substantially benefit from additional water, it is recommended that local stakeholders including at least interested private landowners (and/or the existing CRM and WID currently being formed), NRCS, and BLM convene a meeting to discuss the potential for one or more larger-scale projects to provide additional watering opportunities. If such a meeting results in strong interest, a committee with an appropriate range of interests and skills should be formed to further pursue this potential. It is believed that such a cooperative effort would be considered favorably by a number of the potential funding entities described in Section 6.4 below.

3.3 Surface Water Storage

The sites selected in Section 2.7.4.4 for further consideration are addressed in this section. First, a wide array of information about these sites is compiled and assessed in Section 3.3.1. Conceptual design of these alternatives is then presented in Section 3.3.2. Note that preferred alternatives among the full range of selected alternatives are identified and discussed in Section 7.0.

3.3.1 Site Characterization

A wide array of relevant information about the ten selected alternative storage sites was compiled from the results of the watershed inventory described in Sections 2.1 and 2.2, from information on environmental issues identified as part of the work documented in Sections 4.3 and 4.4, and from conceptual-level modeling of the sites as described later in this Section 3.3. This information is compiled on Table 3.3-1 – Alternative Surface Water Storage Sites and the sites are shown on Figure 3.3-1 – Alternative Surface Water Storage Sites. A comparative ranking of selected parameters/conditions for each of the alternative sites is shown by the color-coding on Table 3.3-1. Because these sites have been selected to address a number of different storage concepts, it is not necessarily intended that the comparative ranking be used to further screen these sites. Rather, the coding shows the relative degree to which each site may be impacted by various factors or how well the sites are suited to their roles. Table 3.3.1 is derived from an Excel spreadsheet that links the compiled site information to a number of equations and algorithms that support the conceptual design and costing described in the remainder of this section and in Section 5.0.

3.3.2 Conceptual Design of Alternatives

3.3.2.1 Overview

A conceptual design was prepared for each of the selected dam and reservoir sites identified in Section 3.3.1. These concept designs are based on information developed throughout the project under various work tasks and significant prior experience in the planning, design and/or construction oversight of numerous dam and reservoir projects in Wyoming over the past 25 years.

Key factors influencing conceptual design (and estimated cost) include reservoir capacity and dam size, anticipated geological conditions, flood hydrology and the associated spillway sizing, and permitting and environmental considerations and mitigation. The first three of these factors are discussed in the following subsections. Permitting and environmental considerations are discussed in Section 4.0 below.

A series of figures is presented illustrating the general dam and reservoir layout for each of the alternative dam and reservoir sites relative to local site topography (Figures 3.3-2A through 3.3-2J – Dam and Reservoir Site Layouts). Figures 3.3-3A through 3.3-3I – Photographs of Alternative Dam and Reservoir Sites show photographs of the dam sites.

3.3.2.2 Alternative Reservoir Sizing

Each alternative was initially selected for consideration because of a variety of factors as described in Section 2.7.4 above. Alternatives that were retained for conceptual design and cost estimating were selected in order to provide options for achieving various potential objectives in terms of reservoir location and size. Reservoir capacities were selected that were consistent with both “available” water and downstream “irrigation shortage” that could be served from the reservoir location (see discussion on available flows and irrigation shortages in Section 2.7.1 above).

Reservoir capacity for Alternatives 1A, 7, and 9 was maximized for the given site and modeled normal year available flows regardless of modeled irrigation shortages. Those alternatives could be considered for maximizing potential multipurpose use and irrigation exchange with users below the confluence of Grass Creek and Cottonwood Creek. Table 3.3-2 - Reservoir Capacity and Yield lists, for each site, estimated annual “available” water and “irrigation shortage” for both dry and normal years. Assumed yield from each reservoir is also listed in Table 3.3-2. For Alternatives 1, 4, 5, 10, and 11 yield was established as the shortage below the site for both normal and dry years. For Alternatives 2 and 13, yield was based on the available normal year flow (normal year yield), and as 50 percent of the combined reservoir capacity and dry year available flow for dry year yield. For Alternative 12, yield was limited to reservoir capacity.

3.3.2.3 Anticipated Geological Conditions

The overall surficial and bedrock geologic and seismotectonic conditions in the study area were presented in Section 2.2.4 above. Relevant information for the selected alternative dam and reservoir sites from the available geologic mapping and reports is summarized in Table 3.3-1. This information was used to assess the relative effects, both positive and negative, that site geology might have on foundation conditions and borrow availability and quality at each site.

All of the sites except Site 9 – Lower Grass Creek, Site 10 – LU Cow Camp and Site 13 – Lake Creek Reservoir Expansion are underlain by Cretaceous-age sedimentary rocks of the Cody, Mesa Verde and Lance/Meeteetse formations. All of these units are comprised mostly of moderately competent interbeds of claystone, mudstone, siltstone and sandstone in varying proportions and thicknesses. In general, the Cody rocks tend to be predominantly claystone and mudstone (“shale”); the Mesa Verde is predominantly sandstone and siltstone in typically comparable proportions (with lesser claystone and mudstone); and the Lance/Meeteetse are comprised mainly of sandstone (Lance) or claystone and mudstone (Meeteetse), but with locally significant siltstone and sandstone beds. The competence of foundations in any of these units will depend largely on the depth and degree of weathering of the near surface rock and the relative proportion of claystone/mudstone versus siltstone/sandstone. It is not possible to further assess site-specific conditions given the surficial reconnaissance carried out at this level of study. It should be noted that there is some potential for interbeds of relatively weak claystone, bentonite (altered volcanic ash), and/or coal in all of these units that, if present, could influence overall foundation strength depending on their depth and orientation at a given dam site. However, no extraordinary foundation treatments were assumed at any of these sites in the absence of specific knowledge of the presence of these potentially detrimental conditions.

Site 9 – Lower Grass Creek is underlain by the Tertiary (Paleocene) Fort Union formation. This unit is typically comprised of a heterogeneous interbedding of sedimentary lithologies from claystone to sandstone. Given that it is considerably younger than the Cretaceous-age units described above, it should be anticipated that the overall strength and competence of these sedimentary rocks would be somewhat less. The Fort Union could also contain relatively weaker claystone, bentonite and/or coal beds as for the older units.

Foundation rock at Site 10 – LU Cow Camp is underlain on the north (left) by the Cretaceous-age Mesa Verde and by the much younger Tertiary (Eocene) Wiggins formation on the south (right). The Wiggins formation, in terms of typical geologic and geotechnical conditions, is expected to be generally of lower strength and higher compressibility than the older bedrock units in the watershed. There is also potential for relatively weaker discontinuities (small faults, joints) that could influence foundation stability and seepage potential.

Finally, Site 13 – Lake Creek Reservoir is underlain at some depth by the Tepee Trail and Aycross formations. These Tertiary (Eocene) units are comprised of a wide range of mixed pyroclastic (explosive air-deposited volcanic) and volcanic-derived sedimentary units, including in approximate order of abundance: volcanic sandstones, volcanic mudstones, volcanic pebble and roundstone conglomerates, shale, arkose, tuff and breccia. The Tepee Trail formation sometimes also includes thin volcanic flows and/or flow breccias not normally found in the Aycross formation. Given their mixed origins and highly heterogeneous character foundation conditions in these units are very difficult to assess without site-specific exploration. Small scale structural features as described above for the Wiggins formation at Site 10 should also be anticipated.

All of the selected dam and reservoir sites are underlain to some depth by Quaternary- to Holocene-age alluvial deposits in the stream valley bottoms and in the flanking alluvial fans and terraces. In general, the larger the stream and the further downstream the site, the greater depth of alluvium would be expected. Based on experience with similar sites, it is not anticipated that depths of valley bottom alluvium would exceed a few tens of feet at most. The gradation of the valley bottom alluvial deposits where visible during site reconnaissance was typically from fine-medium sand to silt or locally clay. Some gravel deposits are present locally in all of the larger drainages, and are sometimes more common in smaller drainages where erosive forces during their deposition were less and the clasts traveled only short distances from their source. The composition of the Quaternary terrace and fan deposits is generally somewhat coarser on average than the Holocene alluvium, but is also highly variable. Many, if not most, of the alluvial and terrace deposits in the site areas appear to have a relatively high percentage of silty to clayey fines. Valley slopes will also be mantled by colluvium or slopewash to depths likely ranging from as little as a few feet to few tens of feet (except where bedrock crops out). All of these deposits are typically loose, compressible and relatively permeable and would most likely need to be removed from the dam footprint for use as fill if suitable.

Site 13 – Lake Creek Reservoir is shown constructed on a large landslide mass on Figure 2.2-7. More detailed mapping by Bown (1982) shows the entire dam and reservoir area and much of the surrounding terrain to be comprised of landslide deposits. These landslide deposits formed in the relatively weak and heterogeneous mixed sedimentary/volcaniclastic rocks of the Aycross and Tepee Trail formations. The age and current degree of activity (if any) of these deposits is unknown. Site-specific subsurface exploration would be required to evaluate the degree of risk (if any) that these deposits pose to the Lake Creek Dam and Reservoir (especially if it were to be filled and function as originally intended). It is of interest to note that the original topographically favorable damsite at this location is interpreted to have resulted from the local breaching of a natural landslide dam. Numerous similar sites are present in Wyoming where early irrigators constructed relatively small dams in breaches of larger landslide dams to achieve an attractive ratio of storage capacity to dam fill. Some of these sites are adequately stable and experience relatively little seepage, while others have experienced potentially damaging movements and/or significant seepage losses. For purposes of this Level I study, it is cautioned that these potentially detrimental conditions may be present at the Lake Creek site. However, the optimistic assumption was made in the conceptual design and costing of this site that the landslide materials provide an adequate foundation for the existing dam. This was done intentionally to provide a lower-end estimate to the potential cost of rehabilitating Lake Creek Dam. If in fact conditions are much less stable than assumed, the presence of the landslide deposits could result in significantly higher rehabilitation costs or pose a fatal flaw at this site.

3.3.2.4 Flood Hydrology and Spillway Sizing

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

- A "Class I" dam is a dam for which loss of human life is expected in the event of the failure of the dam.
- A "Class II" dam is a dam for which significant damage is expected to occur, but no loss of human life is expected in the event of failure of the dam. Significant damage is defined as damage to structures where people generally live, work, or recreate, or public or private facilities exclusive of non-primary roads and picnic areas. Damage means rendering the structures uninhabitable or inoperable.

- A “Class III” dam is a dam for which loss of human life is not expected, and damage to structures and public facilities as defined for a “Class II” dam is not expected in the event of failure of the dam.
- A “Class IV” dam is a dam for which no loss of human life is expected, and for which damage will occur only to the dam owner’s property in the event of failure of the dam.

Conceptual-Level Hazard Classification. Hazard classification requires determination of the potential for inundation of existing structures, recreational areas or primary roads. Completing such an analysis requires dam break analysis and routing of flood waters and is beyond the scope of this Level I study. Accordingly, judgment has been used to “select” hazard classifications and provide an initial basis for sizing the IDF and thereby the conceptual spillway type and size. In general, sparsely populated areas with structures well out of the flood plain and/or significantly downstream from the reservoir (enabling dissipation of a flood wave), and/or small reservoirs which would provide minimal impacts on failure offer a reduced threat to property and human life.

Based on this concept and a review of topographic mapping downstream from each site, the alternative dam sites were preliminarily classified. At this level of study, Sites 1, 1A, 2, 4, 5, 7, 9, 10, and 11 are being considered as either Class I or Class II, while sites 12 and 13 are being assumed to be Class III or Class IV due to their relatively small size and/or location.

Inflow Design Flood Determination. The required IDF for both Class I and II dams is the Probable Maximum Flood (PMF), unless an incremental damage/loss of life analysis (IDA) demonstrates that a lesser IDF is applicable. The IDF for a Class III dam is the 100-year flood, and no spillway is required for a Class IV dam.

At this level of study it is not practicable to perform a detailed and fully defensible IDA. Accordingly, the IDF was conservatively assumed to be the PMF for assumed Class I and II dams. Because the consequences of the potentially significant conservatism inherent in this assumption can be substantial in terms of the cost of the spillway capacity required, it would be appropriate to evaluate the IDF further in a subsequent study if the alternative is otherwise found to be favorable.

Probable Maximum Flood Estimation. At this level of study it is not warranted to perform the extensive and detailed analyses necessary to most accurately determine the characteristics of a PMF at each site. Instead, estimates of PMF peak flows were made from correlations of peak flow versus drainage area based on past studies of other sites in Wyoming. Initially, data on a total of 27 dam sites for which previous estimates of PMF peak flow had been made by others were compiled and evaluated. The source of the data for these previous PMF study results was the U.S. Bureau of Reclamation and other projects completed for WWDC. Correlations of peak flow versus drainage area were investigated using this complete data set and various subsets of the data to determine if a reasonably reliable correlation could be derived.

Reasonable correlations (i.e., with relatively high R^2 values) were found once obvious outliers were excluded from the data set, leaving 23 data points with areas ranging from 1.3 sq miles to nearly 20,000 sq miles. Because the majority of sites on this project were relatively small (i.e., less than 200 square miles) the analysis was limited to sites with similar areas, leaving 14 data points for which the following regression equation was determined:

$Q_{PMF} = 5755(A^{0..58})$, where Q is peak PMF discharge in cfs and A is drainage area in mi^2

100-Year Flood Estimation. Peak 100-year flood discharges were estimated for Site 11 – Phelps Dam and Site 13 – Lake Creek for use as the IDF based on the presumed hazard classification of these sites. These estimates were made using the methodology of Lowham (1988). This methodology is based on regression equations using data from gaged sites in the "mountainous" regions of Wyoming as applicable to these two sites. The regression equations used for this study were those requiring input of the drainage area above the site of interest and the average annual precipitation over the drainage area. The resulting estimated peak flows are 800 cfs for Site 11 and 200 cfs for Site 13 as shown in Table 3.3-1.

Inflow Design Floods. The results of the IDF evaluations described above are summarized in Table 3.3-3 – Inflow Design Floods for Selected Dam and Reservoir Sites. As shown on the table, PMF IDF peak flows range from 13,000 cfs at the off-channel Site 4 – Wales Reservoir to 123,000 cfs at Site 11 – Prospect located relatively low in the Cottonwood Creek basin. The 100-year IDF peak flows for Site 11- Phelps Dam and Site 13 – Lake Creek Reservoir are more than an order of magnitude less than even the off-channel PMF for Site 4 – Wales Reservoir. As noted previously, it will be necessary to evaluate IDF flows at a significantly greater level of detail (likely including an IDA study) should any of the storage projects advance to the next level of study.

3.3.2.5 Conceptual Dam and Appurtenances Design

The bases for establishing conceptual-level dam and reservoir size and spillway capacity for each of the Phase II alternatives have been described previously in this subsection. These parameters and others relevant to the conceptual design and cost estimating of the alternative projects are among the information summarized on Table 3.3-1. It is important to note, however, that these parameters will have to be appropriately modified should further studies regarding needs, reservoir operations, and site-specific hydrologic and geologic/geotechnical conditions be undertaken.

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

Earth Dam/Abutment Spillway Concept. The approach to the conceptual design of the dams, spillways and outlet works for this Level I study involved first establishing a "typical design" representative of the concept which is assumed to be a zoned earth dam with an abutment spillway. The typical design was then applied to each alternative site as appropriate.

For this approach to be appropriate site topography needs to be generally favorable to construction of an abutment or reservoir rim emergency spillway. This means that a "saddle" (a low swale in the reservoir rim relative to the flood pool elevation), a gradually sloping abutment, or a relatively low abutment as compared to the flood pool (or spillway crest) elevation must be present at the sites. Otherwise, the excavation necessary to make room for the spillway could result in the required volume of excavation greatly exceeding the volume of fill that could be productively used in construction of an earth embankment. Site topography was reviewed to confirm that this is generally the case at the alternative sites. As seen on Figures 3.3-2A through 3.3-2E, a somewhat more detailed evaluation of spillway potential was performed for these sites that were ultimately identified as the preferred alternatives (see Section 7.0). However, as any given site is being considered for various potential storage capacities, such conditions should be confirmed for the capacity ultimately selected. Otherwise, an alternative spillway concept would be required.

In the typical design, an emergency spillway would be constructed by excavation into the abutment of the dam, with the excavated material used (to the extent feasible) in construction of the earth dam in the valley section. The emergency spillway is assumed to incorporate a concrete cutoff at its crest, and to be cut in natural earth or rock in the entrance and tailrace channels. The service spillway is assumed to be a concrete chute-type spillway located in one of the abutments with an ogee crest and stilling basin. Service spillway capacity was assumed at 10% of the estimated PMF inflow and emergency spillway capacity was assumed at 90 % of the estimated PMF inflow. No attempt to route the inflow flood was made at this level of study.

A low-level outlet works is assumed to be a cut-and-cover low-level pipe outlet with gate control. The outlet works is assumed to be located on one side or the other of the valley section, founded on rock or otherwise competent material.

A typical zoned earthfill dam section used in estimating earthwork quantities is shown on Figure 3.3-4 – Typical Zoned Earthfill Dam. This typical dam section assumed a zoned embankment with a 3:1 upstream slope, 2.5:1 downstream slope, 20-foot crest width, and a nominal 15 ft foundation cutoff excavation. Freeboard, which allowed for the PMF discharge head, was added to the normal storage pool volume to set the dam crest elevation.

The dam design would incorporate an impervious core zone/core trench founded on competent foundation, internal filters and drains to control seepage and prevent internal erosion/piping, and upstream slope protection (either riprap or RCC/soil cement depending on material availability and cost). If needed, a grout curtain (or possibly a relief well system) would be installed to control seepage and pore pressures in the deeper foundation. Note that it may be feasible at many of the alternative sites to design a homogeneous versus a zoned embankment. The only real difference with the homogeneous design would be that the core and shell materials would be the same material or materials with similar key geotechnical properties (shear strength, permeability and compressibility). That material would be sufficiently impervious to act as the waterstop in the dam. All other features would be essentially the same.

Alternative Designs. As discussed previously, there are substantial unavoidable uncertainties regarding the appropriate number, specific location and size of dam and reservoir(s) to best meet some or all of the existing and potential future needs and opportunities for this project. As a result, it was determined that preparation of detailed, site-specific conceptual layouts and designs for each alternative was premature and cost-inefficient. Instead, the base designs described above were used as the basis to appropriately scale and adjust estimated costs for each alternative as described in Section 5.0.

Consideration was given early in the conceptual design process to the potential for construction of concrete or roller-compacted concrete (RCC) dams at some of the selected alternative sites because of the potential for significant spillway cost savings. These types of dams can typically be designed to incorporate the spillway in the dam section at less cost per unit of capacity than constructing a separate spillway(s). However, given the anticipated foundation conditions at most of the selected alternative sites evaluated above, it is judged unlikely that a concrete or RCC dam would be feasible. Possible exceptions are Site 2 - Putney Flat and to a lesser degree Site 10 – LU Cow Camp depending on the depth of surficial deposits and the particular lithology and physical condition of the shallow bedrock. Subsurface investigation would be required to further assess this potential at these or any other site.

3.4 Groundwater Development

Shallow Groundwater. The use of relatively shallow groundwater as a source of water for wildlife/livestock watering was discussed in Sections 3.2.2.2 and 3.2.2.3 above in the context of windmills and wells, respectively. Based on the information summarized in Section 2.2.5 above, it appears that groundwater can be developed from alluvial and/or alluvial terrace aquifers with wells typically less than 30 feet deep yielding up to as much as 25 gpm, but more typically in the range of 5-10 gpm, or from relatively shallow bedrock wells typically less than 250 feet deep yielding essentially the same range of flow as for the alluvial wells. The potential for achieving these kinds of results depends on the specific conditions at the well site selected. In general, the chances of bringing in an adequate well increase if a qualified, locally knowledgeable groundwater professional and/or locally experienced and capable driller are used to site and complete the well.

The potential for use of alluvial/alluvial terrace or relatively shallow bedrock aquifers for high capacity irrigation supply is limited primarily by the typically low yields anticipated (5-10 gpm or .01-.02 cfs). Also, alluvial and alluvial terrace wells are most likely hydraulically connected to the surface water system and thus subject to surface water rights constraints. Only very localized irrigation needs appear potentially feasible to address using shallow groundwater.

Deep Groundwater. The major bedrock aquifers previously identified in Section 2.2.5 all have the potential to support development of irrigation supply wells if the appropriate water-yielding zones (e.g., highly permeable lithologies, open fractures, karst, etc.) are encountered and properly developed. However, the cost to drill and complete deep wells (several thousand feet) in these units and then to operate the deep well pumps required is judged too great relative to the returns anticipated. Furthermore, even if the high end of the anticipated yield for a single well is obtained (200-500 gpm or 0.4-1.1 cfs), it may take several wells depending on the irrigation need to be satisfied. Finally, the potential is relatively high that the desired yields in any given well will not be realized due to the variability in geologic conditions in these units. If deep groundwater is to be considered as a possible source of irrigation water it is recommended that a detailed study of the potential for successful well development be conducted first.

3.5 Other Management Practices and Improvements

Potential alternative practices and improvements relevant to range conditions (other than the wildlife/livestock watering already covered above), targeted vegetation, and noxious weeds are addressed in the following subsections. Given the nature of these issues and the scope of this Level I study, the alternatives offered here are more general in nature and aimed primarily at practices, improvements and treatments that are focused on water-resource issues.

3.5.1 Grazing Management

Appropriate grazing management practices can have substantial positive effects on essentially all of the water-related issues in the Cottonwood/Grass Creek watershed. In fact, for any targeted vegetation and noxious weed practices and/or improvements (treatments) and their benefits to last, improved grazing management must follow the treatment.

Grazing management aims to control the location, duration and intensity of livestock grazing. The ultimate objective of these practices is to achieve maximum sustainable use of the available rangeland in a manner that is protective of the directly interrelated functions and values of the watershed (i.e., soil stability and productivity, stream stability, riparian habitat health, water quality, aquatic and terrestrial wildlife habitat and health, etc.).

3.5.2 Saltcedar Treatment

Problem Assessment. As previously discussed in Section 2.2.2, saltcedar (tamarisk) has invaded the Cottonwood/Grass Creek watershed and become well established in the lower reaches of Cottonwood Creek. Limited field reconnaissance and brief review of available DOQQ CIR aerial photography were used during this Level I study to preliminarily assess the approximate distribution of saltcedar densities in the watershed. Densities are defined for purposes of this study as follows:

- Heavy - $\geq$ 50 percent occurrence
- Moderate – 25-50 percent occurrence
- Light – 0-25 percent occurrence

where percent occurrence is the estimated proportion of the total canopy area within the riparian corridor that is comprised of saltcedar. The estimated densities of saltcedar from this very preliminary reconnaissance-level examination are shown on Figure 3.5-1 – Selected Plant Communities. Densities are highest in the lowermost portion of Cottonwood Creek where in some areas the saltcedar is completely dominant in the riparian zone. Moderate densities were noted further up Cottonwood Creek to nearly the confluence of Wagonhound Creek. Densities on Cottonwood Creek above Wagonhound Creek and on all but the lowest reach of Grass Creek were classified as light. It is important to understand that these classifications and the locations of the boundaries between density classes are very preliminary and should not be used as other than a generalized basis for planning or conducting any control or eradication efforts.

Recognizing the substantial limitations of the preliminary mapping of saltcedar occurrence in the watershed, an attempt was still made to estimate the order of magnitude of total and net transpiration loss due to this species. The methodology used to make this estimate is summarized as follows:

1) Calculate the approximate area of the riparian zone vegetation in appropriate reaches along the creek from measurements taken on DOQQ CIR photos;
2) Select an appropriate percent occurrence of saltcedar based on the reach classifications mapped on Figure 3.5-1.; and then
3) Calculate the estimated total saltcedar water use for the given reach by multiplying the total riparian zone area for the reach by the percent occurrence of saltcedar and then by the estimated water use rate for the percent occurrence (i.e., saltcedar density).

Applying this methodology with a reasonably broad range assigned to the estimated areas and percent occurrences and using 4 ac-ft/yr as the estimated water use rate for heavy occurrence of saltcedar and 3 ac-ft/yr for moderate occurrence yields a total estimated saltcedar water loss for the watershed of about 400-1600 ac-ft/yr. Next, an assumption was made that the portion of the riparian zone area that is not saltcedar has a water use rate one-half that of saltcedar (e.g., willow dominant), and a similar methodology was applied to estimate the loss from the remainder of the riparian zone in the reaches of interest. The combined total estimated loss from the riparian zone in the reaches of interest was on the order of 800-2200 ac-ft/yr. Finally, if it is assumed that all of the saltcedar was eradicated and that a natural riparian community was reestablished with a water use rate of one-half that of saltcedar, the net gain of water to the watershed would be on the order of 200-700 ac-ft/yr. If a healthy natural riparian corridor is assumed to have only half the plant density assumed for the impaired condition, then the water gain would be on the order of 400-1400 ac-ft/yr.

Based on the very approximate estimates described above, it appears that aggressive eradication of saltcedar in the Cottonwood/Grass Creek watershed with reestablishment of a more natural and healthy riparian vegetative community could result in a net gain (salvage) of 1000 ac-ft/yr or more of water to support riparian habitat, aquatic life, wildlife and livestock watering, and/or irrigation.

Treatment Methods. Saltcedar treatment and control can include a number of different methods and strategies, including but not necessarily limited to:

- Prevention – seed disturbed or reclaimed areas with native species
- Prescribed burning – reducing biomass prior to chemical treatment
- Flooding – requires sustained submergence for 2 years or more
- Manual/mechanical removal – root plowing and cutting, bulldozing, hand pulling (seedling stage), mowing, chain sawing (followed by spot chemical treatment); deep root removal necessary for permanent eradication without chemical treatment
- Chemical treatment - Habitat®+Rodeo®, Pathfinder II®, RoundupPro®, Arsenal®, Garlon 3A®, Garlon4®, etc. as foliar spray or spot application as appropriate to chemical being used
- Biologic treatment - *Diorhabda elongata deserticola Chen* (tamarisk leaf beetle)

The appropriate treatment strategy and method(s) depends on a large number of factors including especially: maturity stage of the infestation; density of the stand(s); predominance of saltcedar versus more desirable native species; location in the floodplain/overbank; accessibility; season/weather; etc. It is important to implement appropriate management practices to encourage development of healthy riparian and related vegetation in any areas in which saltcedar and/or Russian olive have been removed to prevent invasion by other noxious weeds and undesirable plant species. See applicable additional discussion in Section 3.5.4 below.

3.5.3 Prescribed Fire

The BLM has used prescribed fire (sometimes called pyric treatment) on a substantial portion of the "limber pine and woodland" (Figure 3.5-1) vegetation in the upper Grass Creek and Little Grass Creek drainages with very favorable results of improving range conditions. Figure 3.5-2 – Pyric Treatments shows the areas already treated over the past 20 years by BLM. The Rocky Mountain Elk Foundation has also conducted prescribed burns in the Grass Creek drainage (K2/ABC, 2006). As a result of these treatments production of desirable forage has significantly increased, benefiting both livestock and wildlife. Watershed values have been greatly improved overall by decreasing bare ground, decreasing runoff, and improving infiltration, again to the benefit of wildlife and stock. And base flows in both creeks are sustained by groundwater discharges later into the summer, benefiting the riparian environment and aquatic habitat in these reaches. BLM is actively planning additional prescribed fire treatments, including 2,000 acres in the upper Grass Creek watershed near the H Diamond W 4-H Camp in the near future (BLM, 2006). Given the success to date with the treatment of mixed limber pine, juniper and big sagebrush in the Grass Creek drainage, similar treatment of the juniper dominated woodland in the upper drainages of Cottonwood, Twentyone and Prospect Creeks is recommended (see Figure 3.5-1).

3.5.4 Noxious Weed and Undesirable Plant Control.

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

3.5.5 Stream Channel Condition and Stability

The general condition of the principal stream channels and primary tributaries were evaluated during the geomorphic investigation. Results of that study are presented in Section 2.4 above. During the evaluation of existing channel conditions, several impaired reaches were identified and three general classes of impairments noted. The impairments were classified as indicated below:

- Channel degradation/incision;
- Bank erosion associated with channel migration and/or widening; and
- Effects of historic and current range management practices.

Various approaches can be taken during channel restoration and stabilization efforts, including both "hard" engineering and "soft" approaches and combinations of the two. Examples of "hard" approaches would include construction of channel structures or reconstruction of channels themselves. For instance, methods of restoring incised channels may include construction of gradient restoration facilities (i.e., drop structures) within the incised channel. Another option, where there is sufficient space available, could be the design and construction of a new geomorphically stable channel within the existing floodplain and abandoning the previous alignment.

Examples of "soft" approaches include a variety of Best Management Practices (BMPs). Examples of potentially applicable BMPs designed for channel restoration activities include those that result in reducing or where necessary and appropriate excluding at least temporarily wildlife and livestock from accessing designated riparian zones, establishment of riparian buffers, etc. The proposed and potential wildlife/livestock water developments discussed previously in Sections 3.2 and 3.2.2.9 (and others that may be identified in the future) can be considered elements of a range management BMP that will help restore over time those areas of channel impairment related to historic or current grazing practices that have resulted in over-utilization of riparian areas or adjacent upland range. In particular, projects identified previously on Table 3.2-1 in the Prospect Creek, Wagonhound Creek, and to a lesser degree Spring Gulch drainages are expected to be very beneficial to currently impaired stream channel conditions.

These examples of "hard" and "soft" approaches represent both extremes of the continuum of channel restoration strategies that exist. In practice, it must be kept in mind that it is generally a combination of strategies, integrated into a cohesive plan that provides the most effective solution. Table 3.5.1 presents a summary of some of these channel restoration strategies which can be employed during future restoration efforts. Development of more specific projects and BMPs was beyond the scope of this Level I study. Such projects can be identified and developed on the basis of more detailed geomorphic analysis of impaired stream reaches, perhaps associated with the watershed-wide environmental assessment recommended in Section 4.2.2 below. If further study of reservoir storage is planned within the watershed, the potential effects of such storage on stream stability/geomorphic conditions should be evaluated in appropriate detail as part of those studies. This may also result in identification of further opportunities not only to minimize impacts of any such new storage, but to improve stream conditions with proper reservoir operations management and implementation of appropriate “hard” and/or “soft” measures as described above.

4.0 Permits

The following discussion presents the results of an early regulatory process analysis for the types of alternative projects that have been identified in Section 3.0 above. The purpose of this analysis is to characterize the known and likely environmental processes, permits and related requirements and conditions associated with the alternative projects, including identification of environmental documentation, permits, agency clearances and approvals, and agency coordination steps that would be required for implementation of the proposed actions and alternatives.

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

NEPA compliance and documentation is presented in Section 4.1, permitting and approvals are discussed in Section 4.2, and environmental issues are discussed in Section 4.3. Cultural resources are addressed in Section 4.4 and mitigation is discussed in Section 4.5. These discussions are based upon various assumptions about the proposed actions and alternatives. These assumptions may change as project planning progresses from this Level I study. Ultimately, the applicability of the individual federal and Wyoming permits, clearances and approvals to the project(s) will depend upon the alternative(s) selected and their implications.

4.1 NEPA Compliance And Documentation

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

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

4.1.1 NEPA for Reservoir Storage Projects

The following discussion characterizes the basic steps of the NEPA process applicable to a reservoir storage project. A separate discussion in Section 4.1.2 addresses other potential watershed rehabilitation or improvement projects.

Prepare a Purpose and Need Statement for the Project. It is important to develop an accurate and defensible Purpose and Need statement for the project as one of the first steps in the NEPA process. The Purpose and Need statement provides an overall or basic purpose for the proposed action and presents details supporting various needs for the project. The Purpose and Need statement should provide enough information to develop and support a “reasonable range” of alternatives. More specifically, the Purpose and Need statement guides the alternative development and screening process. With the COE as the lead agency, the Purpose and Need would include a reference to finding the “least damaging practicable alternative.” This reference relates to the Clean Water Act Section 404 requirements that are under the jurisdiction of the COE and is an important part of the NEPA process for a reservoir storage project. Additional details about the Section 404 process are provided in

Section 4.2. The project sponsor, WWDC, other project participants, and the public should all be part of the process of defining the Purpose and Need statement.

Develop Project Alternatives and NEPA Documentation Determination. The NEPA process requires analysis of the No Action alternative and a reasonable range of alternatives that fully address the project's purpose and need. The reasonable range of alternatives may include one or more "build" alternatives, depending on the nature and extent of anticipated project impacts and level of NEPA documentation to be provided.

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

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

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

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

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

Many NEPA analyses relate to compliance with various laws and regulations. Integrating the NEPA, National Historic Preservation Act, Endangered Species Act and other compliance processes will reduce overall permitting timeframes and costs, and streamline agency decision-making. These issues are discussed in Section 4.2.

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

4.1.2 NEPA for Other Project Types

The applicability of NEPA to projects other than major (non-stock pond) reservoir storage must be determined on a case-by-case basis. For example, proposed new wildlife/livestock watering developments, including especially tank/pipeline systems that cross and/or serve federal or state rangeland will require that an appropriate NEPA process be followed. In this case, and for many of the lesser potential impact projects (e.g., a well, stock/wildlife pond, guzzler, etc.), it is possible if not likely that an EA process will be found appropriate rather than a full EIS (see related discussion in Section 4.1 above).

BLM. Under current practice, NEPA evaluations and processes for both reservoir storage projects and other types of projects that may be proposed where BLM is the lead federal agency will be performed by BLM staff or qualified, independent third-party experts responsible to BLM. These experts may include specialists from other federal and/or state agencies working under memoranda of understanding (MOU) or other appropriate arrangement(s). Compliance with NEPA will be guided in large part by the Record of Decision (ROD) and Approved Resource Management Plan for the Grass Creek Planning Area (Plan) (BLM, 1998) and any subsequent new or additional guidance and/or updates. The ROD and Plan were developed on the basis of a NEPA-compliant Environmental Impact Statement (EIS) (BLM, 1996). All BLM-led NEPA-related processes and studies are administered by the Worland District office staff, with the assistance if/as necessary and appropriate of BLM state office staff.

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

Watershed-Wide Environmental Analysis. Given the significant number of planned and potential wildlife/livestock water development projects identified in Section 3.2.2.9 and the opportunity for larger-scale, cooperative projects as discussed in Section 3.2.2.10, it is recommended that serious consideration be given to the potential benefits of conducting a comprehensive “watershed-wide” environmental analysis for these and other potential water-resources related improvement projects. A key benefit of this approach would be developing a single baseline characterization and impacts assessment of the relevant environmental issues associated with these types of projects rather than repetitively for many similar individual projects. This should, in turn, substantially reduce the overall resources and time necessary to conduct the required environmental permitting (including especially NEPA compliance) for these projects. If necessary, the overall environmental analysis could be supplemented on a case-by-case basis for a particular issue in a focused, time and resource efficient manner.

4.2 Permitting/Clearances/Approvals

4.2.1 Dam and Reservoir Construction

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

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

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

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

Fish and Wildlife Coordination Act. The Fish and Wildlife Coordination Act requires federal agencies involved in actions that will result in the control or structural modification of any natural stream or body of water for any purpose to take action to protect the fish and wildlife resources which may be affected by the action.

It requires federal agencies or applicants to first consult with state and federal wildlife agencies to prevent, mitigate and compensate for project-caused losses of wildlife resources, as well as to enhance those resources.

Laws and Regulations Addressing Cultural Resources. Because federal approvals are likely involved with any of the identified alternatives, a consideration of effects on cultural resources must be undertaken (Section 106 consultation), as required under the following laws and regulations: the National Historic Preservation Act (NHPA) of 1966 (16 U.S.C. § 470 et seq.); the National Environmental Policy Act (NEPA) of 1969 (42 U.S.C., § 4321); the Archaeological Resources Protection Act (ARPA) of 1979 (16 U.S.C. § 470aa et seq.); the National Park Services (NPS) procedures concerning the National Register of Historic Places (NR) (36 CFR Part 60); the Advisory Council on Historic Preservation's Procedures for the Protection of Cultural Properties (36 CFR Part 800); the Treatment of Archaeological Properties of 1980: Determination of Eligibility for Inclusion in the NR (36 CFR 63); the Secretary of Interior’s Standards and Guidelines for Archaeological Historical Preservation of 1983; Reservoir Salvage Act of 1960; and the l974 Amendment to the Reservoir Salvage Act of 1960. The State of Wyoming Historic Preservation Office (SHPO) coordinates with federal agencies in determining the significance of cultural resources potentially affected by ground disturbing activities.

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

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

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

Wyoming State Engineer’s Office Permit to Construct/Dam Safety Review. The Wyoming Dam Safety Law (W.S. 41-3) requires that any persons, public company, government entity or private company who proposes to construct a dam which is greater than 20 feet high or which will impound more than 50 acre-feet of water, or a diversion system which will carry more than 50 cubic feet of water per second, must obtain approval for construction of the dam or ditch from the Wyoming State Engineer's Office. The approval by the State Engineer's Office of a dam's construction is contingent upon the Office's review and approval of all dam plans and specifications, which must be prepared by a registered professional engineer licensed in Wyoming. Design, construction, and operation of jurisdictional dams must also comply with dam safety regulations promulgated pursuant to the Dam Safety Act. At present, these regulations are in final draft form and formal issuance is anticipated in the not distant future.

Wyoming State Engineer's Office Ditch Enlargement Permit. In addition to the permits and clearances that will be required for reservoir construction, the use of the Wales Ditch to supply an enlarged Wales reservoir would require an enlargement filing with the Wyoming SEO. Even if physical enlargement of the existing ditch was found to not be required, the enlargement filing would be a legal formality as a water right requirement.

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

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

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

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

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

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

4.2.2 Other Project Types

Permits, clearances and approvals for projects other than major dams and storage reservoirs will depend on the specific nature and location of the project. Various of the permits and clearances discussed above in Section 4.2.1 may also apply to other types of projects. The specific permits and clearances necessary for a particular project should be determined early in the planning stages of the project to ensure compliance with applicable laws and regulations, and to avoid possible delays, increased costs and possibly re-design later during project implementation.

4.3 Environmental Considerations

4.3.1 General Habitat Description

The project area is located in Hot Springs and Washakie Counties, Wyoming in the drainage basins of Cottonwood Creek and its main tributary Grass Creek; Cottonwood Creek is tributary to the Bighorn River. The study area consists of a variety of habitats including: mixed–grass prairie, pinyon pine, junipers, irrigated and dry-land crops, sage brush, riparian habitats, minor open water, and local oil and gas operations. Elevations range from approximately 5,000 to 10,000 feet. See Section 2.2 for a more complete description of the natural environment in the study area.

4.3.2 Animal and Plant Resources

Proposed, Threatened and Endangered Species. The following species have the potential to occur within the proposed project areas: bald eagle (Haliaeetus leucocephalus), and the Ute Ladies' Tresses Orchid (Spiranthes diluvialis) (Wyoming Natural Diversity Database [WYNDD], 2007).

<u>Bald Eagle (Threatened – Proposed for De-listing)</u>

Bald eagles are known as year round residents of Wyoming. Their main food source is fish, carrion, and small to medium sized mammals. They tend to be associated with riparian areas, lakes and reservoirs where mature trees provide roosting opportunities. Winter roosting occurs in areas with high density of large mature trees that protect them from the prevailing winds. If the proposed project or identified dam and reservoir site contains suitable habitat, a bald eagle survey may be needed prior to any construction activities occurring.

<u>Ute Ladies'-tresses Orchid (Threatened)</u>

Ute ladies'-tresses orchids are considered to be a perennial wetland plant that occurs in wet meadow areas adjacent to perennial streams. The orchid is found in elevations of 5,100 – 6,850 feet. If disturbances occur in suitable habitat, a Ute ladies'-tresses orchid survey may be required.

Other Animal Species of Concern. The Wyoming Natural Diversity Database (WYNDD) lists several other species of concern existing within and adjacent to the project area sites:

- *Birds* - common loon (Gavia immer), ferruginous hawk (Buteo regalis), Harlequin duck (Historionicus historinonicus), Greater sage grouse (Centrocercus urophasianus), burrowing owl (Athene cunicularia), black-billed cuckoo (Coccyzus erythropthalmus), short-eared owl (Asio flammeus), American three-toed woodpecker (Picoides dorsalis), white-faced ibis (Plegadis chihi), loggerhead shrike (Lanius ludovicianus), sage sparrow (Amphispiza belli)
- *Mammals* - river otter (Lontra canadensis), spotted bat (Euderma maculatum), Townsend's big-eared bat (Corynorhinus townsendii), pallid bat (Antrzous pallidus); (Herptiles) northern leopard frog (Rana pipiens)
- *Fish* - Yellowstone cutthroat trout (Oncorhyncus clarki lewisi), and Western silvery minnow (Hybognathus argyritis)

The potential exists for some of these species to occur within appropriate habitats within the study area. For example, some known raptor nesting areas are shown on Figure 4.3-1 – Raptor Nesting Areas and known sage grouse leks (with a 2-mile radius buffer zone) are shown on Figure 4.3-2 – Sage Grouse Leks. Although none of these species receive federal or state protection, sage grouse are identified as a sensitive species/species of concern and merit special attention as discussed in some detail in the following paragraphs.

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

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

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

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

Rare Plant Species of Concern. The WYNDD has 13 known sensitive plant species of concern located in the study area: sweet-flowered rock-jasmine (Androsace chamaejasme), Evert's wafer parsnip (Cymopterus evertii), Porsild's whitlow-grass (Draba porsildii), Kirkpatrick's ipomopsis (Ipomopsis spicata), Nevada sweetpea (Lathyrus lanszwertii), Watson's prickly-phlox (Linanthus watsonii), Tree-like oxytheca (Oxytheca dendroidea), woolly twinpod (Physaria dornii), Rocky mountain twinpod (Physaria saximontana), twin leaf cinquefoil (Potentilla subjuga), One-leaf cinquefoil (Potenilla uniflora), Shoshonea (Shoshonea pulvinata), and King campion (Silene kingii). The potential exists for some of these species to occur within appropriate habitats within the project area. However, none of these species receive federal or state protection.

Big Game. The Cottonwood/Grass Creek watershed contains portions of crucial big game habitat for antelope, mule deer, elk and moose (see Figure 4.3-3 – Crucial Big Game Habitats) managed by the Wyoming Game and Fish Department (WGFD) and big game (elk and moose) parturition (birthing) sites (see Figure 4.3-4 – Big Game Parturition). The WGFD maps the seasonal ranges by herd unit for each big game species and makes special note of areas listed as crucial habitat. Crucial habitat or range is defined as those seasonal ranges or habitats (mostly winter range) that have been documented as the determining factor in a population's ability to maintain itself at a certain level over a long period of time. The alternative dam and reservoir project sites are all located in delineated big game seasonal ranges. However, no significant impacts (or seasonal impacts that cannot be mitigated) are anticipated to occur to big game seasonal ranges within or in the vicinity of the project area. The project may, in fact, create positive impacts by providing additional water sources to the various wildlife species in the general vicinity of the dam sites (see related discussion in Section 3.2.2.6 above). Coordination with WGFD will need to occur to fully assess and evaluate potential impacts and mitigation measures for crucial big game habitat/range. None of the selected alternative dam and reservoir projects identified to date would impact the big game birthing areas shown on Figure 4.3-4.

Fisheries. All of the alternative reservoir sites are located on tributaries that are considered intermittent streams and have the potential to contain viable fisheries resources. As shown on Figure 4.3-5 – WGFD Stream Classifications, WGFD classifies a portion of Cottonwood Creek and the majority of its tributaries as Class IV Streams while the mainstem of Grass Creek is listed as a Class III Stream with its tributaries classified as Class IV Streams (WGFD, 1987). Class III streams are described as "*important trout waters – fisheries of regional importance.*" Class IV streams are described as "*low production trout waters – fisheries frequently of local importance, but generally incapable of sustaining substantial fishing pressure.*" Impacts to the various streams and associated fishery resources will occur with any of the alternative dam and reservoir storage alternatives and should be considered during further environmental evaluation of these sites as discussed further below under mitigation in Section 4.5.

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

The wetland habitats inferred to be present within the project area based on NWI mapping are shown on Figure 4.3-6 – NWI Wetlands. The total acreage of wetlands within the preliminary footprint of each of the dam and reservoir storage project alternatives has been calculated and is presented in Table 3.3-1.

Some of the areas identified on the NWI maps as wetlands may in fact not qualify as jurisdictional wetlands upon subsequent detailed examination in the field. This is due to inherent limitations in the aerial photography-based methodology used to prepare the NWI maps. In general, estimates of wetland acreage based on the NWI maps tend to be conservative and actual acreage of jurisdictional wetlands may be less.

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

4.4 Cultural Resources

Cultural resources in this context include prehistoric and historic cultural resources, paleontological resources, and natural history resources. The two known cultural resources of some significance within the Cottonwood/Grass Creek watershed are the Fort Washakie to Meeteetse stage road and the Legend Rock Petroglyph Site as shown on Figure 4.4-1 – Cultural Resources. The Legend Rock Petroglyph Site is included on the National Register of Historic Places and thereby protected from any future disturbance. Although a class I cultural resources survey was not included in the scope of this Level I study, it is very likely that other cultural resources will be found in the watershed, possibly at potential project sites or along potential project alignments. This is due to the fossils found in various of the bedrock geologic units, prehistoric use of the area by various Native American tribes, and historic ranching and oil and gas development.

4.5 Mitigation

Based on prior experience, mitigation could be required at any of the identified alternative dam and reservoir sites to address impacts to wetlands, riparian vegetation, stream channel habitat, cultural resources, fish and game resources, and possibly threatened or endangered species. A variety of potentially applicable mitigation measures are presented in Appendix 3 – Mitigation for Surface-Disturbing and Disruptive Activities of the ROD and Plan for the Grass Creek Planning Area (BLM, 1998). As noted previously, it is preferred to avoid the need for mitigation of a potentially significant impact by relocation and/or "self-mitigating" design if technically and economically feasible.

Detailed mitigation plans would need to be prepared and approved to replace any lost wetlands identified and quantified by formal wetlands delineation, and riparian vegetation communities. However, given the relatively small acreages of wetlands at the alternative dam and reservoir sites (ranging from 1 to 39 acres), it is anticipated that mitigation of this resource will be possible at any of the sites by constructing additional wetlands nearby, ideally in the same mainstem stream and/or in a close-by tributary.

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

Additional cultural and historic resource fieldwork would need to be completed to identify and document any such resources that would be inundated or otherwise impacted as a result of constructing any one (or more) of the alternative dams and reservoirs or other potential projects described in Section 3.0 above. This would include, in turn, a class I (literature search) survey, a class II (reconnaissance inventory) survey, and if needed, a class III (intensive inventory) survey. Ultimately, a mitigation plan for cultural resources would be developed which would culminate in a Memorandum of Agreement (MOA) between the Wyoming SHPO and the lead federal agency with concurrence by the project sponsor(s), and possibly affected Native American tribes. The agreement would require approval from the Advisory Council on Historic Preservation.

5.0 Cost Estimates

Conceptual-level costs have been developed for each of the alternative potential projects identified and described in Section 3.0 above. The bases for these costs are described in the following subsections for each of the overall project types.

5.1 Irrigation Infrastructure

Costing for the recommended potential irrigation infrastructure rehabilitation measures and system upgrades identified in Section 3.1 is based on extensive prior experience by team member ACE in the planning, design, costing and construction oversight of similar project elements throughout Wyoming, including in the Bighorn basin. These costs are included in Table 3.1-1.

5.2 Wildlife/Stock Watering

The cost for the various types of wildlife/livestock watering projects described in Section 3.2.2 above are highly dependent on local site conditions and the type of system and components used. Some order-of-magnitude estimated costs for selected components and operations are presented here for general reference:

- *Spring Developments* - $1,000-$5,000 depending on size and yield; use $3,000 if site specific conditions are unknown
- *Conventional Windmills* - $5,000-$10,000 for windmill, mechanical pump, tank pad, and tank depending on well yield and tank size; estimated amortized cost assuming 20-year life is <$100/month (includes annual maintenance, replacement parts, etc.); add cost of well (less pump)
- *Wind Turbine/Tower* - $5,000 for 1kW, 24 VDC turbine, controller, and 80-foot tilt-up tower and erector; add cost of well and conventional submersible pump for complete system
- *Wells* - $10,000-$15,000 (see discussion in Section 5.4 below)
- *Pipeline/Tank Systems* – Assume $2.25/lineal foot of pipeline for typical pipe size and depth of burial (some shallower where frost protection is less necessary and some deeper where more protection is required); assume $2,600 for a typical watering tank (rubber-tire type as described in Section 3.2.2.4); assume $7.50/cu-ft for a water storage tank
- *Ponds* - $10,000-$20,000 for 5-10 acre-foot capacity; assume 3000 cy dike fill, piping/fittings/controls, 12-foot tire tank
- *Guzzlers* - $10,000 for 2250 ft^2 catchment area feeding 1800 gal BOSS tank
- *Solar Water Pump* – Equipment cost: small system - $2,500, medium system - $4,000-$5,000, large system - $7,000-$8,5000 (see Appendix J for additional information); add cost of well (less pump) for single watering site or supply to tank/pipeline system if/as appropriate

More detailed and current site-specific costs may be obtained for a given watering project by consulting an appropriately qualified consultant, local staff of the NRCS and/or BLM, local contractors experienced with the applicable site conditions, and various suppliers for materials/equipment costs.

5.3 Surface Water Storage

Conceptual level estimates for each of the surface water storage alternatives identified in Section 3.3 were prepared by use of a similar approach. This approach first involved estimation of construction costs for each of the major project components (i.e., dam, spillway and outlet works), miscellaneous items (e.g., mobilization, clearing, fencing, etc.), and known interferences from existing infrastructure such as road/highway or pipeline relocation. Indirect costs (i.e., construction engineering and contingency) were then added as a percentage of the construction cost estimate.

The construction cost estimating approach included preparation of a conceptual layout of a potential dam and spillway at the subject alternative site on USGS topographic mapping (at either 20 ft or 40 ft contour interval depending on the site). See Section 3.3.2 for additional information on the typical layouts used in the conceptual designs on which cost estimates are based. Volumes of earthwork and storage capacity were then calculated at various dam heights (using multiple sections) to provide an approximate curve of dam height versus storage capacity and excavation/fill requirements. The overall dam volume was apportioned based on dam geometry (i.e., average dam height and length) to estimate various materials requirements such as riprap, core, shell, drain, etc.

The estimated construction cost for the service spillway was based on a formula used to estimate the approximate concrete volume considering dam height, head on the spillway, slope of abutment, and spillway width. The derived formula was then checked against prior dam construction projects. The emergency spillway cost was based on construction of a concrete crest (cutoff wall) and open cut rock/earth spillway in one of the abutments. If estimated earthwork cut volumes for the spillway exceeded that required for construction of the dam embankment, an additional cost was added to cover hauling this material to a local waste fill assumed to be within the reservoir area or immediate vicinity of the dam and reservoir.

The outlet works estimate for new reservoirs was based on a formula which related outlet works size to storage volume (and associated dam safety drawdown requirements) and height of dam (which is related to conduit diameter and length). The generalized formula was then checked for reasonableness against costs from prior projects.

Costs were also included on a case by case basis to provide an allowance for other items such as instrumentation, revegetation, site access, supply canal and/or wetlands mitigation, as appropriate.

Costs for the non-project component items (i.e., preparation of final design and specifications, construction engineering, contingency, legal fees, acquisition of access and rights of way, and environmental permitting and mitigation) were included as a percent of construction cost based on average percentages of these costs on prior project estimated and actual costs, or based on WWDC contract-designated percentages where appropriate.

The conceptual-level estimated project costs for each of the Level I alternatives are presented in Tables 5.3-1 through 5.3-11 – Conceptual Cost Estimate – Site 1 through Site 13. These estimates are in the contract-required WWDC format and are based on 2008 dollars.

Costs for Alternative 12 (Phelps Reconstruction) and Alternative 13 (Lake Creek Reservoir Rehabilitation) assume reduced spillway protection – approximately 100-year flood capacity. Lake Creek Reservoir Rehabilitation assumes existing embankment and riprap are adequate but that a new outlet gate and service spillway would be required.

Table 5.3-12- Alternative Projects Cost Summary presents a summary of the total project cost for each alternative as well as the estimated cost per acre-foot of storage. Cost curves of total project cost versus reservoir capacity for each of the sites are included in Appendix K – Storage Site Cost Curves. These curves were derived from the model used to estimate costs at the capacity included in Tables 5.3-1 through 5.3-11 and are provided to illustrate how cost may vary with reservoir size should alternative sizes at any of the sites be considered in the future.

It is important to understand that these opinions of cost are very preliminary, and that a number of potentially significant factors must be further investigated to support refinement of these costs. Among these factors, probably the most significant involve storage capacity, site topographic mapping, foundation design/improvement requirements and spillway sizing/locations. At this level of study, the opinions of cost are, at best, estimated to be within +50 to –30 percent of the actual costs.

5.4 Groundwater Development

The cost of planning, drilling, completing and developing a groundwater well is dependent on a large number of site-specific factors. Before deciding to proceed with drilling a groundwater well it is recommended that an estimate be obtained from a qualified engineer or groundwater geologist, locally knowledgeable staff of the NRCS or BLM, and/or an experienced local water well driller.

An order-of-magnitude estimate of the cost per foot to drill, case, complete, and develop a typical wildlife/stock watering well is $35-50/ft. Thus, a 250 foot deep well would be expected to cost on the order of $8,750-$12,500. A pump (installed with all fittings and controls) capable of delivering up to 25 gpm from 100 feet static water level is estimated to cost on the order of $750-$1,000. Thus, the total construction cost of a typical well with pump is estimated to be in the range of $10,000-$13,000.

5.5 Other Management Practices and Improvements

The costs of other potential management practices and improvements such as range/grazing management, prescribed burning, and removal/control of invasive plants and noxious weeds are very project and site dependent. Normally, all but some of the range/grazing management practices or improvements would be implemented by the appropriate agency (NRCS, BLM, Weed and Pest Districts, etc.). Local staff of those agencies should be consulted regarding the costs of these practices and improvements. The cost of range/grazing practices and improvements (other than wildlife/livestock watering addressed in Section 5.2 above) mostly involve the rancher’s time for planning, herding, salting, noxious weed and plant control/removal (where not otherwise covered by cooperative efforts managed by the Weed and Pest Districts), and possibly installation of local fencing in critical areas.

Relatively recent estimates of the cost per acre-foot of added (salvaged) water for saltcedar (tamarisk) removal and control were compiled by Hart (2004). These costs for treated sites in Texas ranged from about $16 to $111 per acre-foot, averaging about $55/acre-foot. Compared to the total capital cost of constructing new or rehabilitating/enlarging existing surface water storage reservoirs (ranging from $643 to $4,000/acre-foot as presented in Section 5.0 above), this is clearly an extremely cost-effective method of developing “new” water for use in the watershed.

6.0 Economic Analysis and Project Financing

This section analyses the order-of-magnitude economics of and considers potential funding scenarios for the selected surface water storage project alternatives identified in Section 3.3 above. The economic analyses are based on the direct and indirect benefits of using stored water for supplemental irrigation of existing irrigated lands. The funding scenarios assume WWDC grant/loan funding of an eligible local project sponsor in accordance with the contract scope of work. The economic and financing analyses address the following key elements:

- Benefits associated with the alternative projects;
- The ability-to-pay of local irrigators;
- The minimum cost of water to irrigators under current WWDC guidelines; and
- The sponsor’s ability-to-pay under different grant/loan scenarios.

Economic and financing analyses of the other project types described in Section 3.0 (irrigation infrastructure rehabilitation/upgrade, wildlife/stock watering, and other watershed rehabilitation, protection and/or enhancement efforts) was outside the scope of this Level I study.

Potential sources of funding for the alternative surface water storage projects, as well as the other project types, are identified and described below in Section 6.4. In regard to funding of surface water storage projects, other potential funding sources than just WWDC may be identified and quantified if more detailed study proceeds with one or more project alternatives. Given the scope of this Level I study, it was not feasible to quantitatively assess the magnitude of any such other funding and the effects it may have on project economics. However, none of the other potential funding sources discussed in Section 6.4 below appear likely to be able to provide a significant additional monetary contribution to these dam and reservoir projects.

6.1 Benefits Analysis

The economic benefits of supplemental irrigation water are measured by the marginal increase in farm income that would be generated by a given amount of additional water. This section develops an estimate of the marginal increase in farm income attributable to an additional acre-foot of water for a typical irrigated operation in the Cottonwood/Grass Creek watershed. To develop this estimate, several variables must be known or estimated, including:

- The efficiency with which the additional water would be utilized by the crop or crops under consideration;
- The yield response of the crop or crops to the application of the additional water;
- The market value of the additional yield that would be generated; and
- The marginal production costs that would be incurred in harvesting the additional yield.

Estimates of this type are typically developed through crop enterprise budget analyses. These analyses can consist of developing site-specific estimates of all relevant variables through exhaustive studies of local agronomic conditions and farm production practices. They can also be generated by adapting estimates developed for other areas with similar characteristics. Due to the conceptual level of this study, the latter approach was used.

Estimates of irrigation efficiency were adapted from the Wind/Bighorn Basin Plan, (BRS, et al., 2003). That plan estimates overall annual average irrigation efficiency at 28 percent for small watersheds generally comparable to the Cottonwood/Grass Creek watershed. Irrigation efficiency was assumed to vary during the irrigation season, however, from a low of 19 percent in April to a high of 42 percent in July. Because supplemental water presumably would be used later in the irrigation season, an efficiency estimate of 40 percent was used in developing the benefit estimates described in this report.

Estimates of the crop yield response to additional irrigation water were adapted from studies undertaken for the North Platte River Basin in eastern Wyoming near Torrington (Pochop, et. al, 1992). Those studies indicate that an assumed crop mix of 50 percent alfalfa and 50 percent grass hay would have a yield response averaging 1.48 tons per acre-foot of consumptively used irrigation water. Studies by the

University of Wyoming indicate that the average growing season in the Cottonwood/Grass Creek area is approximately ten percent shorter than in the Torrington area (Pochop, et. al, 1992). Assuming that changes in the yield response to irrigation water are proportional to changes in the growing season results in an estimated yield response of 1.33 tons per acre-foot of consumptively used irrigation water.[1]

The market value of the additional yield that would be generated from an acre-foot of additional irrigation water is dependent upon crop prices. For the past four years (2003 – 2006) the market price of alfalfa hay in Wyoming has averaged $80.12 per ton. The corresponding average price for grass hay has been $75.50.[2] Because hay production along the Cottonwood/Grass Creek Watershed is estimated as about twice as much alfalfa as grass, an average price of $78.58 per ton was used to derive the benefit estimates described in this report.

The final piece of data needed to arrive at an estimate of the marginal value of supplemental irrigation water is an estimate of the marginal increase in production costs that would be incurred to harvest the incremental yield. In the case of hay production, these marginal costs consist primarily of increased costs for irrigation, baling, loading, and stacking activities. A study of these costs for North Platte River irrigators resulted in an estimated cost increase of $26.12 per ton in 1995 dollars (Watts and Brookshire, 2000). Updating these costs to 2006 dollars (consistent with other cost data and estimates herein) results in a marginal production cost estimate of $30.24 per ton[3].

The information described above can be used to estimate the economic benefits of an acre-foot of supplemental irrigation water as follows. One acre-foot of water at an irrigation diversion point applied with 40 percent efficiency will result in an estimated increase in hay production of 0.40 X 1.33 = 0.53 tons. At an average market price of $78.58 per ton, the estimated value of the increased production is $41.65. Subtracting a marginal production cost increase of 0.53 X $30.24 = $16.03 results in a net benefit estimate of $25.62 for each acre-foot of supplemental irrigation water available for diversion when and where it is needed.

6.1.1 Indirect Irrigation Benefits

Indirect benefits, sometimes referred to as secondary benefits, stem from the economic multiplier effect of increases in income in a regional economy. For example, if irrigators' incomes increase because of a new irrigation project, some of that income will be spent locally, resulting in additional income increases in other sectors of the Wyoming economy. Thus, the total economic benefits associated with an irrigation project can be larger than direct income increases to irrigators alone.

Some economists argue that it is inappropriate to include indirect benefits in project evaluations because building an irrigation project in one part of Wyoming may result

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[1] The growing season for northeast Wyoming was estimated as the average of the Moorcroft and Colony growing seasons, or 191 days. The average growing season for the Torrington area is 201 days.

[2] http://www.nass.usda.gov/Statistics_by_State/Wyoming/index.asp

[3] Costs were updated using the index of production costs paid by Wyoming farmers and ranchers available from the Wyoming Office of the National Agricultural Statistics Service at the following website: http://www.nass.usda.gov/Statistics_by_State/Wyoming/index.asp

in economic losses elsewhere in the state. For example, in a report prepared for the U.S. Environmental Protection Agency, Huszar (1990) argued that indirect benefits should not be considered in an economic evaluation of the Sandstone Project. His reasoning was that funding for the project came from taxes on Wyoming citizens, and that without the project, taxes could be lowered with an equally large stimulating effect on the Wyoming economy. Although the logic of this argument is sound, the facts are incorrect. WWDC construction funds are derived from minerals severance taxes, not taxes on Wyoming citizens. If minerals severance taxes were lowered, the likely result would be a benefit to out-of-state users of Wyoming's coal or out-of-state shareholders of energy companies doing business in Wyoming, not Wyoming residents. For this reason, it is appropriate to consider indirect benefits in evaluating projects funded largely by minerals severance taxes.

The Bureau of Economic Analysis of the U.S. Department of Commerce (USDOC) produces periodic estimates of indirect income multipliers for Wyoming's agricultural sector. Their latest published estimate of this multiplier is 3.36 (USDOC, 1992); meaning that for each dollar of additional farm income, total income in Wyoming increases by $3.36. The $3.36 is comprised of $1.00 of farm income and $2.36 of indirect income, which can be an indirect benefit of new irrigation projects.

6.2 Ability to Pay Analysis

An irrigator's ability to pay for irrigation water is bounded by the magnitude of direct irrigation benefits that would be generated by the additional water. For example, the analysis used in Section 6.1 is based on the estimate that supplemental irrigation water will generate a direct benefit of $25.62 per acre-foot. The benefit estimate reflects the market value of additional crop production minus the costs associated with producing the additional crop. Table 6.2-1 – Summary of Maximum Potential Benefits of Project Alternatives presents an analysis of maximum potential benefits of the various project alternatives based on estimated normal and dry-year shortages, available yield, and project benefits for each of the alternatives. The column labeled "Maximum Potential Annual Benefits From Supplemental Irrigation Only" is based on the estimated direct benefit of $25.62 per acre-foot of water utilized. The next to last column in the table is the "Present Value" of those benefits based on an interest rate of 4.0% and a loan period of 50 years. Numbers in that column could be compared to the capital cost of an alternative which would represent a break even project cost if no grant money was provided and if a loan of 4.0% for a 50-year period was received. The final column represents the total estimated value of the increased benefit of the project to the state economy based on a ratio of 3.36 total benefit to increased direct farm income.

The above figure represents an upper bound on ability to pay because they are estimates of the total additional farm income that could be generated from additional storage. If irrigators were required to forfeit all of the additional income to repay project expenditures, however, they would have no incentive to participate in the project. Thus, ability-to-pay studies assume that ability to pay is some reasonable fraction of direct project benefits. For purposes of this analysis, ability to pay is assumed to be 50 percent of the additional income that could be generated from new storage, or $12.81 per acre foot. It is important to understand that the ability to pay numbers are based on the very preliminary values for shortage, available flow and associated yield from this Level I study.

6.3 Financing Under WWDC Guidelines

The current WWDC project financing default standard is 67 percent grant with the remaining 33 percent of project costs to be repaid by the project sponsor. Repayment can be financed over 50 years at the State Loan Board interest rate, which is currently four (4) percent. See Section 6.4 for additional discussion regarding the WWDC program. The implications of applying these funding criteria to the project surface water storage alternatives can be seen in the results in Table 6.3-1A – Summary of Ability to Pay for Project Alternatives – 67% Grant. For comparison, additional funding scenarios of 75% Grant/ 25% Loan and 90% Grant/ 10% Loan are presented in Table 6.3-1B and Table 6.3-1C, respectively. Each of these three tables show the estimated Level III cost of each alternative (column 3), the project sponsor's share of those costs based on the assumed grant (column 4), and the sponsor's annual repayment amount assuming a 50-year loan at four percent interest (column 5). The estimated Level III cost is the estimated total project cost less the estimated Level II/ Phase III costs, except for alternative 12 and possibly alternative 13.

Alternative 12 involving the reconstruction of the breached Phelps Dam falls well short of the requirement to develop at least 1000 acre-feet of additional storage or 2000 acre-feet of new storage necessary to be eligible for WWDC Level II, Phase III funding of permitting and engineering design costs. Alternative 13 may or may not be eligible for Level II, Phase III funding. It is believed that the approximately 1,400 acre-feet of storage originally envisioned for this site has not been functional for at least 15 years (and possibly since the early 1960s) (Hillberry, 2007). Thus, it might be argued that rehabilitation of the existing facilities will result in an enlarged storage capacity of greater than 1000 acre-feet and the project should be eligible for the Phase II, Level III full funding by WWDC. This matter would have to be addressed by WWDC should this alternative project advance to more detailed study. Given the uncertainty, the economic and financing analyses for alternative 13 have assumed that Phase II, Level III funding is not available.

The remaining two columns of the table show estimates of the maximum amount irrigators could repay each year based upon an ability-to-pay rate of $12.81 per acre-foot of storage. These amounts are substantially less than would be required to fund any of the alternatives under current WWDC guidelines for sponsored projects.

The last column of the tables presents ability to pay as a percentage of a sponsor's share of total project costs, for the assumed funding percentage, interest rate and loan period. These results indicate a limited ability for project sponsors to repay estimated project costs without substantial additional state assistance in the form of a much higher than average grant or some other source(s) of significant funding.

Table 6.3-2 – Annual Costs by Alternative Storage Site presents the recurring annual cost over the life of a 50-year loan (i.e., the amortized non-grant share of total project cost) per irrigated area served and per acre-ft of available yield. The annual cost in Table 6.3-2 is the sponsor's share of the total project cost based on the three assumed funding scenarios of 67%, 75% and 90% grant.

The "irrigated land served" is assumed to be the sum of all irrigated lands located downstream of a given reservoir site to the confluence with the Bighorn River. Pending more refined modeling in a subsequent study, all irrigated lands below a given site are assumed to benefit equally from release of stored water. If in fact some of the irrigated lands are not experiencing a shortage, and thus would not benefit from the storage, the unit cost to those lands that are benefited would increase proportionately. The results presented in Table 6.3-2 range from a low of $1.50/per acre to a high of $746/acre, depending on site location and cost, acreage served, and percent grant funding assumed. This wide range is due in large part to the size/cost of the reservoir relative to the acreage potentially served by that reservoir. A small, low cost reservoir serving a large need at the most favorable grant percentage results in a low cost/acre; the opposite scenario yields a high result.

The "annual yield" used in the calculations in Table 6.3-2 is the "dry-year yield" developed as described previously in Section 3.3.2.2. The cost to the sponsor per acre-foot of yield on this basis ranges from a low of $5.59/ac-ft to a high of $210.72 per ac-ft. The reasons for this wide range of annual cost/acre-foot are the same as described above for the annual cost/acre.

6.4 Project Funding Sources

Funding is clearly a critical factor in the implementation of the alternative projects identified in Section 3.0. Potential sources of funding are identified and discussed in general terms by project type (storage reservoirs, irrigation infrastructure improvements, wildlife/stock watering, stream/riparian corridor rehabilitation, and "other" water-resource related project types) and the key agencies/entities providing and/or administering the funding potentially applicable to those projects.

It is important to understand that the potential sources identified herein are not necessarily exhaustive of the resources that may be available, that existing programs change and sometimes disappear over time, new programs arise, funding levels vary year to year, and competition for many of the programs is significant. Also, contact information for various programs and key people can also change.

Key local contacts for current information on funding sources relevant to watershed protection, restoration and conservation, wildlife/stock watering, and irrigation infrastructure improvements include, but are not limited to the following:

- Hot Springs Conservation District (307.864.3488)
- Washakie County Conservation District (307.347.2456)
- NRCS/Thermopolis and Worland Offices (307.864.3488; 307.347.2456)
- Bureau of Land Management/Worland District Office (307.347.5100)

In addition to these local contacts, there are two key websites that provide a wealth of information on grant, loan and in-kind support for watershed related projects. The first site leads to the Water Management & Conservation Assistance Programs Directory (WWDC, 2005) first compiled by the Wyoming State Engineer's Office and now maintained by the Wyoming Water Development Commission at the following website: http://wwdc.state.wy.us/wconsprog/WtrMgntConsDirectory.html.

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

The Habitat Extension Services program of the Wyoming Game and Fish Department published Habitat Extension Bulletin No. 50 – Fisheries and Wildlife Habitat Cost-

Share Programs and Grants. Bulletin No. 50 provides a very comprehensive listing of potential funding sources for fisheries and wildlife habitat projects. A copy of Bulletin 50 dated February 2007 is included as Appendix L - Funding Sources, Note that this bulletin was not available on the WGFD website at the time of this study, but may be made available in the future.

Key aspects and information about the primary funding programs identified are discussed in the following sections and summarized in a matrix format (Table 6.4-1 – Primary Potential Funding Sources).

6.4.1 Local Agencies

6.4.1.1 Worland Grazing District/Taylor Grazing Act Funds

The Hot Springs and Washakie County treasurers hold monies received from federal Taylor Grazing Act grazing fees on behalf of the Worland Grazing District (District). Hot Springs County receives 15.93 percent and Washakie County 31.80 percent of the fees allocated to the Worland Grazing District. These fees are credited to a special Range Improvement Fund (Fund) for the District. The District is administered by the Wyoming State Grazing Board of the Worland District (Board) which is comprised of 5 to 9 permittees who hold Taylor Act permits and graze livestock on public lands within the District. Meetings may be held by the Board at any time to conduct the business of the Board, but must be held at least twice each year.

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

6.4.1.2 Hot Springs and Washakie Conservation Districts

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

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

The HSCD and WCCD would implement the grant program being developed by the Wyoming Association of Conservation Districts (WACD) to address locally driven watershed efforts.

6.4.1.3 Hot Springs/Washakie County Weed and Pest Districts

The Hot Springs and Washakie County Weed and Pest Districts mission is to "*Maintain healthy ecosystems with desirable, sustainable vegetation consistent with* *the land management goals of affected agencies, organizations, and individuals.*" (Franklin, 2006) This mission is achieved by implementing the following key goals:

- Develop cooperative relationships and agreements to foster resource sharing using the CRM model;
- Remove barriers to managing noxious weeds between agency jurisdictions and private lands;
- Prevent the introduction and reintroduction of noxious weeds into Wyoming; and
- Improve education and awareness programs that provide training and educational opportunities for professional weed managers and land owners/managers.

As part of implanting the above goals, the Weed and Pest Districts provide in-kind support to landowners and other agencies/entities including, but not necessarily limited to:

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

6.4.2 State Agencies

6.4.2.1 Wyoming Department of Environmental Quality

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

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

6.4.2.2 Wyoming Game and Fish Department

The following summary of funding assistance available from the Wyoming Game and Fish Department (WGFD) is quoted from the Water Management & Conservation Assistance Program Directory (WWDC, 2005):

"The Wyoming Game and Fish Department offers a funding program to help landowners, conservation groups, institutions, land managers, government agencies, industry and non-profit organizations develop and/or maintain water sources for fish and wildlife. This program also provides funding for the improvement and/or protection of riparian/wetland areas for fish and wildlife resources in Wyoming. Applications for projects are accepted any time with approval on January 1 and August 1 of each year.

Riparian Habitat Improvement Grant. *The purpose of this program is to improve or maintain riparian and wetland resources. Fencing, herding, stock water development, streambank stabilization, small damming projects and beaver transplanting are a few examples of efforts that qualify under this program. Permits, NEPA compliance, construction, maintenance, access and management planning are all grantee responsibilities. There is $10,000/project maximum available with 50% cash or in-kind required from grantee.*

Water Development/Maintenance Habitat Project Grant. *The purpose of this program is to develop or maintain water for fish and wildlife. Spring development, windmills, guzzlers, water protection and pumping payments are examples of the extent of this program. Permits, NEPA compliance, maintenance, access and water rights are responsibilities of the grantee. There is a maximum of $10,000/project and 50% cash or in-kind contribution required from the grantee.*

Upland Development Grant. *The purpose of this program is to develop upland wildlife habitat. Example project include management, grazing systems, prescribed burning, wildlife food plots such as oat, millet or corn plantings, range pitting and range seeding. Permits, NEPA compliance, maintenance, access and management planning are responsibilities of the grantee. There is a maximum of $10,000/project and 50% cash or in-kind contribution required from the grantee.*

Fish Wyoming. *The purpose of this program is to develop public fishing opportunities. Examples of projects within this effort are boat ramps and fishing access. This program provides a 50% match of funding which is channeled through a private organization or municipality."*

- **Wyoming Sage Grouse Conservation Fund.** WGFD also administers the Wyoming Sage-Grouse Conservation Fund (WSGCF); http://gf.state.wy.us). The WSGCF is a special fund established by the Wyoming State Legislature to support the efforts of Local Sage-Grouse Working Groups (LWGs). The applicable LWG for the Cottonwood/Grass Creek watershed is the Big Horn Basin Sage-Grouse Local Working Group (BHLWG). The WSGCF funding is intended to promote conservation of sage grouse populations and habitat (sagebrush ecosystems), including socio-economic and human use of the habitat. The BHLWG has recently completed the Sage-grouse Conservation Plan for the Big Horn Basin (BHLWG, 2007) to identify and guide implementation of these objectives.

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

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

Additional sage grouse conservation funding opportunities are presented in Section 6.4.5 below.

6.4.2.3 Wyoming Office of State Lands and Investments

As the administrative advisory arm of the Board of Land Commissioners and State Loan and Investment Board, the Office of State Lands and Investments (OSLI) administers Regular Farm Loans and Small Water Development Project Loans that may be applicable to certain of the potential projects identified in Section 3.0.

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 3, purchasing, constructing or installing equipment and/or improvements necessary to maintain or improve the earning capacity of the farming operation. Eligible applicants include individuals whose primary residence is in Wyoming and legal entities with a majority of the ownership meeting the individual residency requirements. Single loans or combinations of loans cannot exceed an outstanding principal balance of $600,000. Loan rates are 8 percent for loans up to 50 percent of the appraised value of the security land and improvements and 9 percent for loans between 50 and 60 percent of the security. The term of a given loan is limited to 30 years.

Small Water Development Project Loans. These loans are authorized for projects for development and use of water upon agricultural lands for agricultural purposes. These projects may convert dry land into irrigated land or lead to more efficient use of water and/or increased crop or forage production.

Eligible recipients may include court approved water districts, agencies of state and local government, persons, corporations, associations, and other legal entities recognized under state law.

Individual loans up to $150,000 may be made. Interest is currently set at 6 percent and the maximum term of loans is 40 years.

6.4.2.4 Wyoming Water Development Commission

The mission of the Wyoming Water Development Commission (WWDC) as defined in the enabling legislation is to:

"provide, through the commission, procedures and policies for the planning, selection, financing, construction, acquisition and operation of projects and facilities

for the conservation, storage, distribution and use of water, necessary in the public interest to develop and preserve Wyoming's water and related land resources. The program shall encourage development of water facilities for irrigation...for abatement of pollution, for preservation and development of fish and wildlife resources…and shall help make available the waters of the state for all beneficial uses…" (W.S. 41-2-112(a))

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

Wyoming Water Development Program

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

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

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

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

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

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

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

Key Criteria and Procedures. An application for funding under either the New Development or Rehabilitation Program must meet the following key criteria most applicable to potential projects as identified in Section 3.0 above:

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

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

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

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

- *"For projects that enlarge existing storage projects by 1,000 acre-feet or greater or for proposed new dam and reservoirs with a capacity of 2,000 acre-feet or greater, expenses associated with final engineering design and required National Environmental Policy Act reviews, including but not limited to environmental assessments and environmental impact statements, are eligible components of a Water Development Program Level II, Phase III Study Project."*
- *"For dam and reservoir projects, the Commission may waive sponsor eligibility requirements through Level II, Phase II. However. the eligible entity requirements shall be met prior to initiation of Level II, Phase III activities described herein."*

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

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

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

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

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

Small Water Project Program

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

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

- Small reservoirs and stock watering ponds (up to 20 feet high and 20 acre-feet capacity)

- Wells
- Pipelines and conveyance facilities
- Spring developments
- Windmills
- Wetland developments

Irrigation works/projects may be eligible if they are already documented in a conservation district's existing watershed plan or a resource management plan or environmental evaluation prepared by a state or federal agency. These types of projects are only eligible if they cannot be addressed by the Water Development Program.

Benefits associated with SWPP projects may include, but are not necessarily limited to:

- Improved water quality;
- Habitat and water for fish and wildlife;
- Improved riparian habitat; and
- Increased recreational opportunities.

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

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

Application, Evaluation and Administration. Details of the application and evaluation process and program administrative procedures are provided in the Small Water Project Program Operating Criteria available online as noted previously. Some key aspects of the process and procedures applicable to the potential projects identified in Section 3.0 include the following:

- Applications are received by March 1, June 1 and September 1 for consideration at the May, August, and November/December WWDC regular meetings, respectively.
- Proposed projects must be in accord with the sponsoring entity's long-range management plan for the watershed.
- Sufficient benefit must accrue to the public to comply with applicable state law, and projects may only be constructed on private lands where such "public benefits" are adequately documented.
- The sponsoring entity is responsible for ensuring that all required permits and clearances are obtained prior to construction of the project; costs for technical assistance in obtaining permits and clearances may be included in the SWPP funding within the overall limits noted previously.

- Higher priority will be given by WWDC to projects located on public land managed by a federal agency where that agency provides matching cash or in-kind contributions.

6.4.2.5 Wyoming Wildlife and Natural Resource Trust

The Wyoming Wildlife and Natural Resource Trust (WWNRT) was formed by the state legislature in 2005 to preserve and enhance Wyoming's wildlife and natural resources. Projects funded by WWNRT must provide a public benefit such as continued agricultural production to maintain open space and healthy ecosystems, enhancements to water quality, and maintenance or enhancement of wildlife habitat. Allowable projects under this program that are potentially relevant to this watershed management plan study include:

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

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

6.4.3 Federal Agencies

6.4.3.1 Bureau of Land Management

The Bureau of Land Management (BLM) administers the **Riparian Habitat Management Program**. The goals of this program are to maintain, restore, improve, protect and expand riparian-wetland areas to achieve *"proper functioning condition for their productivity, biological diversity, and sustainability."* Funding is available (subject to budget allocations) for projects which include partnering with non-BLM interests.

BLM also administers rangeland improvement projects on their lands under a **Cooperative Agreement for Range Improvements**. Range improvement projects can include development of water through the construction of reservoirs, pits, springs developments, and wells including any associated distribution pipelines. BLM's share of funding comes from their range improvement fund which is generated from grazing fees and to a lesser degree from general rangeland management appropriations. Participation by livestock operators generally is in-kind labor and sometimes a portion of material costs. Monetary support sometimes is available from conservation/environmental interests.

As noted previously, BLM also participates in the implementation of a number of section 319 watershed plans statewide.

6.4.3.2 Bureau of Reclamation

The Bureau of Reclamation (BOR) administers the **Water 2025 Challenge Grant Program**. This program provides funding on a competitive basis for projects focused on water conservation, efficiency and water marketing. Preference is given to projects that can be completed within 24 months that will help to prevent crises over water in areas identified as "hot spots" where potential for conflict is judged to be moderate to highly likely by 2025. Because the Cottonwood/Grass Creek watershed is not located in or near a BOR-defined "hot spot", it would appear that the chances of successfully competing for a grant under this program are slim.

6.4.3.3 Environmental Protection Agency

The Targeted Watershed Grants Program administered by the Environmental Protection Agency (EPA) "*encourages watershed practitioners to examine local water related problems in the context of the larger watershed in which they exist, to develop solutions to those problems by creatively applying the full array of available tools, including general, state and local programs, to restore and preserve water resources through strategic planning and coordinated project management that draw in public and private sector partners...*" as described in the following program website: http://www.epa.gov/twg/2006/2006faq.html#intro.

Organizations eligible for funding include nonprofits, tribes, and local governments. The assistance provided consists of grants for up to 75 percent of the total project costs. A match of at least 25 percent is required. The typical median amount awarded is $700,000 with a typical range of $300,000 to $900,000. It is important to note that application must be made by the governor, and that the competition for these grants is keen.

6.4.3.4 Farm Service Agency

The Farm Service Agency (FSA) administers three different programs that may be applicable to some of the alternative projects identified in Section 3.0. Technical assistance for the FSA programs is provided by NRCS. Each of these three programs is briefly discussed below.

Conservation Reserve Program (CRP). This is a voluntary program under which eligible highly erodible cropland is removed from production in return for annual rental payments and cost share assistance by FSA over a 10-15 year period. The producer is required to establish long-term conservation practices on the erodible, environmentally sensitive lands taken out of production.

Continuous Sign-Up for High Priority Conservation Practices. Under this program farmers and ranchers implement certain high-priority conservation practices on their eligible CRP lands. These practices may include: riparian buffers, filter strips, grass waterways, shelter belts, field windbreaks, living snow fences, contour grass strips, salt tolerant vegetation, and shallow water areas for wildlife.

This cost share program offers rental rates for the CRP lands based on the average value of dryland cash rent with an additional financial incentive of up to 20 percent of the soil rental rate for selected practices. Establishing permanent cover merits up to a 50 percent cost share.

Emergency Conservation Program (ECP). This program provides emergency funding and technical assistance for implementing emergency livestock watering conservation measures during periods of severe drought and rehabilitating farmland damaged during natural disasters. Cost share assistance up to 75 percent of the cost to implement the emergency measure(s) is available.

6.4.3.5 Fish and Wildlife Service

Technical and financial assistance are available to private landowners, profit or non-profit entities, public agencies and public-private partnerships under several programs addressing the management, conservation, restoration or enhancement of wildlife and aquatic habitat (including riparian areas, streams, wetlands and grasslands). These programs include, but are not necessarily limited to:

- **Partners for Wildlife Habitat Restoration** – technical and financial assistance to private landowners through Wildlife Extension Agreements (WEA) to implement and maintain restoration projects while the landowner retains full control of the land.
- **North American Wetlands Conservation Act Grant Program** – grant program promoting long-term conservation of wetlands ecosystems and the species that depend on them; requires cost-share partners to provide non-federal matching funds at least equal to the grant amount. Small Grants are typically for $50,000.
- **Landowner Incentive Program (Non-Tribal).** This program provides funding directly to the lead state wildlife service agency (WGFD in Wyoming) for programs addressing the issues noted previously.

6.4.3.6 Natural Resources Conservation Service

The Natural Resources Conservation Service (NRCS) administers a number of funding and technical assistance programs applicable to many of the alternative projects identified in Section 3.0. These programs are briefly described below and summarized in Table 6.4-1. Additional information on these programs is included in Appendix J.

Environmental Quality Incentives Program. The Environmental Quality Incentives Program (EQIP) is a voluntary program available to agricultural producers that provides technical assistance, cost sharing and incentive payments for projects and practices that improve water quality, enhance grazing lands, and/or increase water conservation. Current priorities used by NRCS in allocating EQIP funds that are applicable to the Cottonwood/Grass Creek watershed include reduction of non-point source pollution of surface waters, reduction in soil erosion and sedimentation from agricultural lands, and promotion of at-risk species habitat conservation.

Non-federal landowners (including American Indian tribes) that engage in livestock operations or agricultural production are eligible for funding. Eligible land includes cropland, rangeland, pasture, forestland, and other farm and ranch lands. Eligibility also requires that the applicant develop an EQIP plan of operations that becomes the basis of the cost-sharing agreement between NRCS and the participant.

Funding assistance may include cost-sharing, incentive payments and technical assistance. Cost-sharing can provide up to 75 percent of the costs of eligible conservation practices important to improving and maintaining the health of natural resources in the area. The term of cost-sharing contracts is from one (1) to ten (10) years. Incentive payments may be made for up to three (3) years to encourage land, integrated pest, irrigation, and/or wildlife management practices. The maximum aggregate limit of cost-sharing and incentive payments to an individual or entity is $450,000 for all contracts entered into during FY 2002-2007.

Detailed information about the EQIP program is available at the following website: http://www.nrcs.usda.gov/PROGRAMS/EQIP/.

Watershed Protection and Flood Prevention Program. Also known as the "Small Watershed Program" or the "PL 566 Program," this program provides technical and financial assistance to address resource and related economic problems on a watershed basis. Projects related to watershed protection, flood prevention, water supply, water quality, erosion and sediment control, wetland creation and restoration, fish and wildlife habitat enhancement, and public recreation are eligible for assistance. Technical and financial assistance is also available for planning and installation of works of improvement to protect, develop, and use land and water resources in small watersheds.

Applicants eligible for funding through this program that are potentially relevant to the Cottonwood/Grass Creek watershed include: local or state agencies, counties, conservation districts, or other subunits of state government (e.g., watershed improvement, water conservancy and irrigation districts) with the authority and capacity to carry out, operate, and maintain installed works of improvement. Projects are limited to watersheds containing less than 250,000 acres.

The assistance provided consists of technical assistance and cost sharing (amount varies) for implementation of NRCS-authorized watershed plans. Technical assistance is provided on watershed surveys and planning. Although projects vary significantly in scope and complexity, projects receiving $3.5 million to $5 million in federal financial assistance are not uncommon.

Other NRCS Programs. Other programs administered through NRCS that may be relevant to certain of the alternative projects discussed in Section 3.0 include, but are not necessarily limited to the following:

- Wildlife Habitat Incentives Program (WHIP)
- Wetlands Reserve Program (WRP)
- Grassland Reserve Program (GRP)
- Conservation Security Program (CSP)
- Farm and Ranchlands Protection Program (FRPP)
- Emergency Watershed Protection (ERP)
- Small Watershed Rehabilitation Program
- Sage Grouse Restoration Project (SGRP)
- Grazing Lands Conservation Initiative (GLCI) Grants
- Cooperative Conservation Partnership Initiative (CCPI)

Information on all NRCS programs is available from the local contacts listed at the beginning of this Section 6.4.

6.4.4 Non-Profit and Other Organizations

6.4.4.1 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.

6.4.4.2 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 Cottonwood/Grass Creek watershed include, but are not limited to the following:

- **Pulling Together Initiative -** provides support on a competitive basis for the formation of local Weed Management Area (WMA) partnerships that engage federal resource agencies, state and local governments, private landowners, and other interested parties in developing long-term weed management projects within the scope of an integrated pest management strategy; minimum 1:1 non-federal match is required.
- **Native Plant Conservation Initiative** – funding preference for "on-the-ground" projects that involve local communities and citizen volunteers in the restoration of native plant communities.
- **Bring Back the Natives Grant Program** – funds to restore damaged or degraded riverine habitats and their native aquatic species provided by BLM, Bureau of Reclamation, FWS, Forest Service, and NFWF; minimum 2:1 non-federal match required.
- **Five-Star Restoration Program -** provides modest financial assistance on a competitive basis to support community-based wetland, riparian, and coastal habitat restoration projects that build diverse partnerships and foster local natural resource stewardship through education, outreach and training activities; average grant is $13,000.

Information about all of these and other NFWF grants/programs is available at their website: http://nfwf.org/.

6.4.4.3 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.

6.4.5 Funding Opportunities for Sage Grouse Conservation Efforts

Sage grouse habitat is of special significance in the Cottonwood/Grass Creek watershed relative to both potential opportunities such as wildlife/livestock watering development and potential permitting issues and mitigation measures for reservoir storage. Funding for conservation of sage grouse habitat consistent with appropriate range management and water resource development is available from a wide array of governmental agency and non-governmental entity programs. A list of potential funding sources compiled by the Wyoming Game and Fish Department (WGFD) with brief program descriptions and website contact information follows:

State of Wyoming Sources:

- **Wyoming Wildlife and Natural Resource Trust Account -** Created by legislative action in 2005 for the purposes of preserving and enhancing Wyoming's wildlife and natural resources. Income from the trust account is used to fund a wide variety of conservation programs. http://wwnrt.state.wy.us
- **Wyoming Game and Fish Department (WGFD) Trust Fund -** Matching grants program for riparian or upland habitat improvement, water development, and industrial water projects. http://gf.state.wy.us
- **WGFD/U.S. Fish & Wildlife Service – Landowner Incentive Program (LIP)** - Provides Federal funds to enhance habitats for sensitive fish and wildlife species on private lands. Priorities in Wyoming are grassland, sagebrush and prairie watersheds. Matching funds, goods or services are required. http://gf.state.wy.us
- **Wyoming Animal Damage Management Board (ADMB) -** Provides funding for the purposes of mitigating damage caused to livestock, wildlife and crops by predatory animals, predacious birds and depredating animals or for the protection of human health and safety. http://www.wyadmb.com

Federal Sources:

U.S. Fish and Wildlife Service http://www.fws.gov

- **Partners for Fish and Wildlife Program** – Provides assistance to private landowners who want to restore or improve habitat on their property. The landowner is reimbursed based on the cost sharing formula in the agreement, after project completion.
- **Private Stewardship Program** – Provides grants or other assistance to individuals and groups engaged in private conservation efforts that benefits species listed or proposed as endangered or threatened under the Endangered Species Act, candidate species, or other at-risk species on private lands. Maximum Federal share is 90%.
- **Cooperative Conservation Initiative -** Supports efforts to restore natural resources and establish or expand wildlife habitat. Maximum Federal share is 50%.
- **Multistate Conservation Grant Program** - Supports sport fish and wildlife restoration projects identified by the International Association of Fish and Wildlife Agencies. Maximum Federal share is 100%.
- **Conservation Grants -** Provides financial assistance to States to implement wildlife conservation projects such as habitat restoration, species status surveys, public education and outreach, captive propagation and reintroduction, nesting surveys, genetic studies and development of management plans. Maximum Federal share is 75% for a single state or 90% for two or more states implementing a joint project.

Farm Service Agency (FSA) http://www.fsa.usda.gov/pas/

- **Conservation Reserve Program (CRP) -** A voluntary program for agricultural landowners. Through CRP, you can receive annual rental payments and cost-share assistance to establish long-term, resource conserving covers and enhance wildlife habitat on eligible agricultural land.

Natural Resource Conservation Service (NRCS) http://www.wy.nrcs.usda.gov

- **Conservation Innovation Grants (CIG)** - CIG is a voluntary program that enables the NRCS to work with public and private entities to accelerate the development and adoption of innovative conservation approaches and technologies in conjunction with agricultural production.
- **Conservation Technical Assistance (CTA)** - Provides voluntary conservation technical assistance to land-users, communities, units of state and local government, and other Federal agencies in planning and implementing conservation systems. This assistance is for planning and implementing conservation practices that address natural resource issues.
- **Environmental Quality Incentives Program (EQIP) -** Provides a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible goals. EQIP offers financial and technical help to assist eligible participants install or implement structural and management practices on eligible agricultural land.
- **Wildlife Habitat Incentives Program (WHIP)** – Provides a voluntary program to develop and improve wildlife habitat primarily on private land by providing both technical assistance and up to 75% cost-share assistance to establish and/or improve fish and wildlife habitat.
- **Sage-Grouse Restoration Project (SGRP) –** Cooperative effort involving private landowners, agencies, organizations and universities in a process to evaluate and document, through research and demonstration areas, the effects of NRCS conservation practices in restoring sage-grouse habitat and populations.
- **Grazing Land Conservation Initiative (GLCI) grants** - A nationwide collaborative process of individuals and organizations working to maintain and improve the management, productivity, and health of the Nation's privately owned grazing land. This process has formed coalitions that actively seek sources to increase technical assistance and public awareness activities that maintain or enhance grazing land resources.
- **Cooperative Conservation Partnership Initiative (CCPI)** - A voluntary program established to foster conservation partnerships that focus technical and financial resources on conservation priorities in watersheds and airsheds of special significance. Under CCPI, funds are awarded to State and local governments and agencies; Indian tribes; and non-governmental organizations that have a history of working with agricultural producers.
- **Conservation Security Program (CSP)** - A unique program that goes beyond the past approach of installing conservation practices. Instead, CSP offers rewards to those who have been good stewards of the soil and water resources on their working agricultural land. It also offers incentives for those who wish to exceed the minimum levels of resource protection and enhance the natural resources on the land they manage. The program is available in designated watersheds.

Bureau of Land Management http://www.blm.gov

- **Challenge Cost Share** – This program is designed to leverage funds with partners to monitor and inventory resources; implement habitat improvement projects; develop recovery plans; protect or document cultural resources; provide enhanced recreational experiences; and to better manage wild horse and burro populations. Matching funds, goods or services are required.
- **Cooperative Conservation Initiative (CCI)** – CCI was designed to remove barriers to citizen participation in the stewardship of our natural resources and to help people take conservation into their own hands by undertaking projects at the local level. Projects must seek to achieve the actual restoration of natural resources and/or the establishment or expansion of habitat for wildlife. Matching funds, goods or services are required.

Forest Service http://www.fs.fed.us

- **Cooperative project funding –** Contact local U.S. Forest Service staff for information about opportunities to develop partnerships in projects involving National Forests or National Grasslands.
- **Partnership Resource Center -** The Partnership Resource Center of the National Forest Foundation (NFF) and the USDA - Forest Service (FS) provides partnering organizations and FS staff with the information to enhance working relationships. Partnerships expand opportunities for obtaining grants. Many funding sources prefer or require them because projects involving partnerships are viewed as having an increased potential for success over single entity projects. http://www.partnershipresourcecenter.org

Other potential funding sources include but are not limited to:

- **Wildlife Heritage Foundation of Wyoming** - The Wyoming Wildlife Heritage Foundation is an independent, charitable organization whose purpose is to provide financial support, through philanthropy, to critical wildlife conservation efforts in Wyoming. http://whfw.org
- **Wyoming Governor's Big Game License Coalition** - Funding generated from the sale of Governor's licenses placed in five accounts: bighorn sheep, moose, elk, mule deer and general wildlife. Funds administered by the Wildlife Heritage Foundation of Wyoming. http://whfw.org
- **National Fish and Wildlife Foundation (NFWF) - General Matching Grant Program** - Provides matching grants to priority projects that address fish and wildlife conservation and the habitats on which they depend, work proactively to involve other conservation and community interests, leverage NFWF funding, and evaluate project outcomes. Government agencies, educational institutions, and nonprofit organizations may apply. Grants typically range from $10,000-$150,000. http://www.nfwf.org
- **National Fish and Wildlife Foundation - Native Plant Conservation Initiative (NPCI)** - NPCI grants of federal dollars are provided to non-profit organizations and agencies for conservation of native plants. NPCI grants range from $5,000 to $40,000, averaging $15,000. Non-Federal matching funds, goods or services are required. There is a strong preference for "on-the-ground" projects

that involve local communities and citizen volunteers in the restoration of native plant communities. http://www.nfwf.org/programs/npci.cfm

- **National Fish and Wildlife Foundation - Pulling Together Initiative (PTI) -** Provides support for the formation of local Weed Management Area (WMA) partnerships. These partnerships engage federal resource agencies, state and local governments, private landowners, and others in developing weed management projects within an integrated pest management strategy. Non-Federal matching funds, goods or services are required. http://www.nfwf.org/programs/pti.cfm
- **Intermountain West Joint Venture (IWJV) - Joint Venture Cost-Share -** Habitats within the IWJV area support nearly 100% of the range of all high priority sagebrush steppe landbird species, such as: Sage Sparrow, Sage Thrasher, Sage-Grouse and Brewer's Sparrow. The purpose of Cost-Share is long-term conservation of bird habitat through partnerships. http://iwjv.org/costshare.htm
- **The Nature Conservancy (TNC)** - TNC works with conservation supporters and partner organizations to create funding for conservation worldwide using a variety of creative methods. http://nature.org
- **Tom Thorne Sage-Grouse Conservation Fund –** Provides grants for the conservation of sage-grouse in the Upper Green River Basin. The fund was created by Shell Exploration & Production Co. and managed by a board overseen by the Wyoming Community Foundation (WCF). Although not currently applicable to the Bighorn Basin, similar WCF programs may become available in the future. www.wycf.com
- **Rocky Mountain Elk Foundation (RMEF) -** RMEF is a wildlife conservation organization with an emphasis on elk. It advocates sustainable, ethical use of resources and seeks common ground among stakeholders. RMEF funds habitat restoration and improvement projects, acquires land or conservation easements. http://www.rmef.org
- **Mule Deer Foundation (MDF) -** MDF's goals center on restoring, improving and protecting mule deer habitat. MDF achieves its goals through partnering with state and federal wildlife agencies, conservation groups, businesses and individuals to fund and implement habitat enhancement projects on both public and private lands. http://www.muledeer.org
- **One Shot Antelope Foundation -Water for Wildlife -** Water for Wildlife is a conservation program designed to benefit wildlife and the environment in arid regions of the West. Emphasis focuses on the development of supplemental water resources in areas where both the habitat and wildlife are being impaired by lack of this vital resource. http://www.waterforwildlife.com
- **North American Grouse Partnership (NAGP) -** Promotes the conservation of prairie grouse and the habitats necessary for their survival and reproduction. http://www.grousepartners.org
- **Pheasants Forever (PF)** – Some sage-grouse populations in Wyoming occur within areas that have a local PF chapter. Local chapters determine how their funds are spent. Game birds other than pheasants may be eligible for funding. http://www.pheasantsforever.org/chapters/

7.0 Conclusions and Recommendations

Summary conclusions and recommendations are presented below relative to the major conditions and issues identified in the Cottonwood/Grass Creek watershed.

7.1 Conclusions

Watershed Description and Inventory

Land Uses and Management Activities

- ***Land Ownership*** **-** The spatial distribution of the multiple land ownership (private, state and federal) within the watershed presents both opportunities and challenges to the potential implementation of larger scope/scale water resources related management practices and rehabilitation/improvement projects.
- ***Infrastructure*** - Existing transportation and electric power infrastructure are generally adequate to support the recommended rehabilitation/improvement projects recommended in this Level I study. However, in some instances this infrastructure and existing oil/gas infrastructure may affect the siting/alignment of new facilities or require relocation of the existing infrastructure.
- ***Irrigated Lands*** **-** Existing irrigated lands (primarily forage crops) are adequate to support the current scale of livestock operations assuming that adequate irrigation water is available. If additional reliable water supplies beyond current needs were available, it is possible that some new lands would be brought into production.
- ***Rangelands*** **-** Range conditions within the watershed are variable, but judged overall “high fair” to “good”, with trends generally stable to slightly upward overall. Conditions are generally less favorable in the lower precipitation eastern portion of the watershed and in some riparian areas that are heavily utilized by wildlife and livestock for watering and forage. Wildlife and livestock watering opportunities in the upland rangelands are locally adequate, but insufficient to best utilize the available range in much of the watershed.
- ***Energy and Mining*** – Oil and some natural gas production have been occurring since the early 1900s. Although overall average annual production has been declining for some time, the rate of decline has been slowed over time by implementation of enhanced recovery technologies and recent substantial increases in crude oil prices. Existing production of coal and aggregate is small, and it is not anticipated that significant expansion in production of these or other mineral resources in the watershed will occur in the foreseeable future.

Natural Environment

- ***Climate*** **-** The climate of the Cottonwood/Grass Creek watershed is classified as semiarid, with average annual precipitation ranging from about 10-20 inches from the lower hills in the east to the mountains in the west. The drier eastern portion of the watershed receiving less than 10 inches of precipitation is marginal in terms of supporting high quality range. The watershed has been experiencing overall severe drought since 2000, with current outlooks for continuing to intensifying drought.
- ***Vegetation and Land Cover*** – Most of the watershed is broadly classified as rangeland, transitioning in the west through the 12-14 inch precipitation zone to

forestland. Limber pine and juniper (and often sagebrush) have encroached on lower slopes and locally terraces and valley bottoms in the middle to higher elevations in the watershed. This encroachment has resulted in more rapid runoff accompanied by lower late season stream and spring flows and poorer quality rangeland for wildlife and livestock. Prescribed burns in the Grass Creek basin have substantially improved conditions where implemented. Saltcedar and Russian olive have invaded the riparian and adjacent lands in the lower watershed resulting in excess evapotranspiration estimated as on the order of 1,000 acre-feet/year over healthy riparian conditions. Various noxious and other undesirable weeds have also invaded the watershed resulting in locally diminished habitat and rangeland values.

- ***Soils*** – Soil types vary over the watershed in response to parent material, climate and topography. Soil productivity varies strongly with elevation (and thus precipitation) from as little as 200 lbs/acre in the lowest precipitation zone in the eastern-most watershed to as much as 2,300 lbs/acre in healthy riparian areas. Soils in the valley bottoms and alluvial terraces are well suited to irrigation of forage crops (alfalfa and grass hay).

- ***Geology*** – Geologic conditions in the watershed appear generally suitable for construction of dams in terms of foundation conditions and borrow material availability, and do not appear to present major challenges to construction of other improvements (e.g., irrigation system rehabilitation, wildlife/livestock watering systems, etc.). There are local bedrock and surficial deposit conditions that may affect siting and/or design of dams and other facilities including, but not necessarily limited to: low strength (e.g., bentonite beds, coal seams, fine-grained alluvium); higher seepage potential (e.g., joints, fractures and faults in bedrock; coarse-grained alluvial deposits); and high compressibility (e.g., loose alluvial, colluvial and slopewash deposits).

  Landsliding is common in the younger sedimentary rocks of volcanic origin in the higher precipitation western third of the watershed, and essentially absent elsewhere.

  No active faults are present in the watershed and ground shaking from earthquakes is judged not to present a hazard to dams or other facilities that cannot be fairly readily mitigated.

- ***Groundwater*** – Groundwater occurs both in shallow alluvium/alluvial terraces and deeper bedrock aquifers. In general, production from wells developed in the alluvial aquifers ranges from a few to as much as 25 gallons/minute (gpm), with most less than 5-10 gpm. Wells in the shallower bedrock units vary widely in production, ranging again from about 5-25 gpm. Two wells have produced 140 gpm and 400 gpm, but these are judged not typical. Very deep aquifers underlying the watershed are estimated as being able to yield in the range of 50-500 gpm.

Watershed Hydrology

- ***Gaged Streamflow*** – Gage records in the watershed are sparse; a gage on Cottonwood Creek above Hamilton Dome has continuous records over the past 14 years, while a gage at Winchester at the confluence with the Bighorn River only operated for four years (from mid-1941 through mid-1945). Average annual flows at the upper gage range from 10,600 acre-feet/year prior to the beginning of the drought in 2000 to 2,500 acre-feet/year during the ongoing drought.

Average annual flow at the lower gage (during a period of more normal precipitation) was 20,600 acre-feet/year (ranging from 7,500 to 30,300 acre-feet/year).

- ***Hamilton Dome Discharges*** - Discharges of treated water from the Hamilton Dome oil field to lower Cottonwood Creek apparently began at least by 1955, but were relatively minor until sometime in the early 1960s when larger pumps began to be installed in the field. Current annual discharges to the creek average about 9,000 acre-feet/year (12.5 cfs). Water production from the field has stabilized in the past 25 years, but the duration and amount of future discharges is unknown.

Stream Geomorphology

- Stream channels in the western portion of the watershed (on the lower slopes of the Absaroka Mountains) are generally laterally stable and geomorphically resilient to external impacts.
- Cottonwood Creek displays a relatively large degree of channel variability, but for the most part appears to be vertically stable with adequate connection to its floodplain. Although some reaches are more entrenched F-Type channels, Cottonwood Creek is considered a C-Type channel throughout most of its reach.
- The smaller Grass Creek channel is dominated by sinuous, finer-grained E-Type channels that are moderately resistant to changes in hydrology or sediment load, but prone to local, rapid destabilization due to bank failure triggered by loss of vegetation.
- Many of the first-order tributaries in the watershed can be classified as G-Type channels or gullies. These channels are highly erosive and generate high sediment volumes. These characteristics can lead to loss of productive land and destabilization of upland conditions.
- Impairments to stream channels in the watershed fall into three broad categories: 1) channel degradation/incision; 2) bank erosion associated with channel migration and/or widening; and 3) effects of historic and current range management practices.

Irrigation Inventory

- Irrigation systems in the watershed are generally small, privately owned and managed, and typically old (some predating statehood). They range in size from ditches serving less than 20 acres to systems irrigating several hundred acres. Although most of the systems are still generally functional, many components of various of the ditches are suffering from age and deterioration.
- More efficient water management (resulting in significant water savings) could be achieved by targeted rehabilitation (e.g., sediment removal, rehabilitation or replacement of diversion structures, conversion of open ditch to pipeline, lining or open ditches, replacement or repair of headgates, repair and/or reinforcement of breached or overtopped banks, etc.).

Water Quality

- ***Surface Water*** – Although surface water in the Cottonwood/Grass Creek watershed is generally suitable for agricultural uses (irrigation and livestock watering), there are some exceedances of published criteria for these uses. The most prevalent exceedances are for sulfate and specific conductance which are interpreted to be largely an unavoidable result of the natural geologic conditions in the watershed. Adequate drainage of irrigated lands using water with high specific conductance (indicating high salts content) is necessary to minimize the build-up of salts in the soils. The other lesser exceedances of criteria (e.g., locally TDS, pH, chloride and fluoride) are not judged as presenting a significant impediment to the use of these waters based in large part on the fact they have been used without apparent serious consequence for over 100 years.

- ***Groundwater*** – Groundwater is generally not used for irrigation in the watershed at present. If more use of groundwater for irrigation was envisioned, the relatively common exceedances of sulfate, specific conductance and TDS in many of the aquifers would require the same attention as some of the surface waters to adequate drainage to mitigate salt buildup in soils.
- ***Permitted Discharges and TMDLs*** – Currently permitted and active discharges are present in the watershed, but only the two treated water discharges from the Hamilton Dome oil field are significant in terms of volume. All of these discharges appear to meet their permitted limits in terms of water quality (including the Hamilton Dome discharges given the recent adoption of site-specific standards for chloride and selenium in lower Cottonwood Creek). It is assumed that the current (2006) listing of lower Cottonwood Creek on the 303(d) list of impaired waters will be removed during the next update given the new stream standards for this reach.

Water Storage and Retention

- Based on the results of prior modeling under the Wind/Bighorn Basin Plan study, it appears that there are physically and legally available flows that could be stored within the Cottonwood/Grass Creek watershed. The Basin Plan model estimates that a total of 21,000 acre-feet are available during a normal (6 out of 10) year basis and 7,300 acre-feet on a dry (2 out of 10) year basis. These estimates are believed to be somewhat high, but within order of magnitude.
- Modeled irrigation shortages in the Cottonwood Creek drainage are approximately 5,200 acre-feet/year for the dry-year case and 2,400 acre-feet for the normal year case. In the Grass Creek drainage the comparable estimates are 1,800 acre-feet and 800 acre-feet, respectively. Actual shortages are believed to be greater than these model estimates.
- Given these estimated available flows and irrigation shortages, it appears that there is significant opportunity to mitigate at least a substantial portion of the irrigation shortages and provide some other multiple use benefits by building new storage at one or more locations identified within the watershed. A total of ten alternative sites were selected for more detailed evaluation to meet one or more of three storage concepts (supplemental irrigation by direct release only, supplemental irrigation by exchange, and multipurpose storage and operation).

Permitting and Environmental Considerations

- The primary environmental considerations in the Cottonwood/Grass Creek watershed in relation to permitting of dam and reservoir sites (and to a lesser degree other types of projects) appear to include: wetlands, sage grouse habitat (including especially leks), and crucial big game habitat. This is not to say that other considerations are not important or may not significantly influence the ability to permit a project.

- It is considered most likely that permitting of a dam and reservoir site would require that a full EIS process be followed under the lead of either the BLM or the COE, or possibly under their joint lead.

Costs and Financing of Dam and Reservoir Projects

- The estimated costs for development of reservoir storage vary substantially depending mainly on the size and overall efficiency of the dam and reservoir site. The total project cost of the ten selected alternatives studied in more detail range from about $900,000-$1,000,000 for the rehabilitation of the existing Lake Creek Dam or reconstruction of the breached Phelps Dam to $31,000,000-$53,000,000 for sites intentionally maximized to capture as much as possible of the estimated total available flow in the watershed and thereby provide the most potential for multiple uses and benefits. The capital costs for storage projects sized primarily to address existing irrigation shortages are in the range of $10,000,000-$22,000,000.
- The estimated costs per acre-foot of storage on a capital cost basis for the ten projects studied in more detail range from about $600 to $5,000. Costs per cubic yard of fill for these projects (again on a capital cost basis) range from about $12 to $24.
- Annual costs per acre of irrigated lands served range from about $2 to over $200 (assuming 90 percent grant funding) and $5 to over $700 (assuming 67 percent grant funding). The ranges of annual costs per acre-foot of yield under the same assumptions of grant funding are $5-$76 and $17-$250.
- The estimated maximum potential present value of direct and indirect irrigation benefits for the project alternatives evaluated ranges from approximately $1,300,000 to $2,100,000 except for the Phelps Reservoir Reconstruction. That project yields only about $300,000 in total benefits due to its very small yield. These costs can be compared to the total project costs above to gain some sense of the order of magnitude cost to irrigation benefit ratio.
- Under the most favorable assumption of a 90 percent grant and the WWDC's standard loan terms for the remainder of the cost, the estimated sponsor's ability to pay (as a percentage of the sponsor's annual payment obligation) ranges from 230 percent for the Lake Creek Rehabilitation project to 8 percent for the Prospect project. The ability to pay percentages assuming 67 percent grant for the same projects are estimated as 70 percent and 2 percent.

7.2 Recommendations

Watershed Management and Rehabilitation Plan

<u>Irrigation Supply Systems</u>

- Potential solutions to the primary issues and problems for a total of 13 individual ditch systems were identified and conceptual-level costs estimated. Individual actions recommended range from sediment removal at a cost of approximately $500 to lining of nearly a mile of ditch at a cost of about $170,000.

- The recommended solutions for any system can be implemented individually, in combination, or as a complete package depending on the needs, preferences and financial ability of the owner. Funding assistance is available from a number of sources, especially the WWDC Small Water Project Program and various programs administered by NRCS.

Wildlife/Livestock Watering

- Providing additional facilities for wildlife and livestock watering at appropriate locations is recommended as the highest priority and best value means to improve rangeland condition and use and to maintain and/or support continuing recovery of riparian and associated aquatic habitat and stream channel stability in the watershed. These watershed values are significantly improved by decreases in bare ground, decreasing runoff and improved infiltration that result from the range management (grazing) practices made possible with adequate upland watering. It is important that any such improvements and practices be fully implemented and maintained by the landowner to gain the maximum overall benefits to the watershed.
- Pipeline/tank systems appear to offer the most efficient and cost-effective means to provide adequate watering to large areas of rangeland. Water sources for these systems will depend on the location of the rangeland to be served and the available alternative sources. The most likely sources are wells or spring developments, although in some cases direct stream diversions or a diversion from a reservoir or pond may prove workable.
- Where gravity supply is not feasible or providing commercial electric service is not cost effective, solar powered pumping systems appear to offer an efficient, cost-effective means to supply water directly to a tank or pipeline system (or to a storage tank that in turn supplies water by gravity). In some cases wind turbines or existing electrical power may prove more feasible.
- Other types of watering facilities should be considered for smaller or more isolated service areas, where less frequent use is envisioned, or where the cost is prohibitive or the conditions otherwise make a pipeline/tank system impractical. Alternative facilities can include individual wells (with a solar- or wind turbine-powered pump or a conventional mechanical windmill-driven pump), single gravity-type spring/tank developments, ponds, or guzzlers.
- A total of 25 planned and potential wildlife/livestock watering developments were identified during the course of the project, and there are opportunities for many more such projects including possibly one or more larger-scale cooperative projects. The currently identified projects include spring developments with one watering tank and spring or well supplied pipeline/tank systems with up to six tanks fed from a single water source.

Surface Water Storage

- ***Additional Study*** - Based on the results of existing modeling of available flows and irrigation shortages and careful evaluation of those results during this study, more detailed study of the potential for development of surface water storage in the Cottonwood/Grass Creek watershed is justified and recommended. Such a study would best be performed under the WWDC's Water Development Program as a Level II, Phase I study. The study should include, but not be limited to, more detailed hydrologic, water rights and reservoir operations modeling using the StateMod or an equivalently robust model to support refinement of the existing irrigation needs, available flows in the watershed, and opportunities to achieve multiple uses and benefits from one or more reservoirs.

- ***Recommended Sites*** **-** Based on the results of this Level I study, it is recommended that a Level II study focus on four of the selected alternative dam and reservoir sites evaluated herein. These include:
  - *Site 1 - Grass Creek Causeway* as a means to address all existing irrigation shortages on Grass Creek, and potentially as much as feasible of any additional shortages that may be identified on Cottonwood Creek below the confluence of Grass Creek;
  - *Site 2 – Putney Flat* to capture all available flows from the upper Cottonwood Creek watershed and serve as much of the existing irrigation shortage downstream as possible;
  - *Site 4 – Wales Reservoir Expansion* to store any remaining available flows below Putney Flat (or work in tandem with the Putney Flat reservoir to optimize the size of both reservoirs), and possibly to store any portion of the flows from Hamilton Dome that would not otherwise injure existing downstream uses of these flows; and
  - *Site 13 – Lake Creek Reservoir Rehabilitation* as a means to regain the original permitted storage capacity or as much of the natural flows from its drainage area as could be safely stored to address at least local shortages (if any) at the old Rhodes place above the Putney Flat site; storage in Lake Creek Reservoir would also reduce the required size of the Putney Flat reservoir.

<u>Groundwater Development</u>

- Development of shallow to moderately deep groundwater (up to a few hundred feet) appears feasible as a source of wildlife/livestock watering or small-scale irrigation. Given the unavoidable uncertainties in groundwater development, and the potential for less than desirable water quality from many of the shallower aquifers, it is recommended that site-specific studies be considered before committing to extensive groundwater development.
- Development of deep aquifers where the potential for more reliable, larger flows is present appears infeasible within the Cottonwood/Grass Creek watershed. This is due to the depth of wells necessary and their associated costs (both initial capital costs of drilling and pump purchase and installation and long-term pumping costs).

<u>Other Management Practices and Improvements</u>

- Development and implementation of an effective grazing management plan is strongly recommended to protect and enhance the value and health of both the rangeland and the riparian and aquatic habitat in the watershed. This is especially important to gain the full benefit of wildlife/livestock water developments discussed previously.
- Continued to accelerated removal of saltcedar and Russian olive, and implementation of measures to prevent re-invasion, are highly recommended as a very cost-effective means to increase flows in lower Cottonwood Creek and

avoid the potential for increased losses if these species were to spread higher into the watershed.

- Additional prescribed burns are strongly recommended in the mid to upper reaches of the Grass Creek, Cottonwood Creek and their major tributaries drainages. This measure has proven very effective in Grass Creek where implemented to date in significantly reducing runoff and substantially improving conditions for wildlife, livestock and the riparian and aquatic habitats of the watershed.
- Control of noxious weeds is important to promote the overall health and value of both the rangeland and riparian areas of the watershed.
- Development and implementation of an effective grazing management plan is also critical to the success of the salt cedar removal, prescribed burns, and noxious/undesirable plant control measures recommended above. Without effective management, the benefits of any or all of these measures can be lost.
- Channel restoration and stabilization efforts should be further evaluated and coordinated with planned and proposed upland wildlife/livestock water developments and with any proposed new reservoir storage projects in the basin. In the case of water developments, the project itself and accompanying proper grazing management can promote maintenance or recovery of stable stream conditions. The effects of water storage projects both upstream and downstream of the reservoir site need to be carefully evaluated and accommodated in the design and operation of the project. In some cases it may be necessary and appropriate to implement "hard" engineering approaches to achieve stream stability. Such measures could include, for example, gradient restoration facilities (i.e., drop structures) or design and construction of a new stable channel in the existing floodplain and abandoning the previous alignment.

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Tables

Table 2.1-1
Land Ownership

Class/*Entity*	**Area (acres)**	**Percentage of Total Area**
Federal	166,752	63%
BLM	159,078	60%
USFS	7,674	3%
State	21,523	8%
Private	77,834	29%
Hot Springs County	75,785	28%
Washakie County	2,050	1%
Private	78,151	29%
Hot Springs County	76,109	29%
Washakie County	2,042	1%
Total area (BLM data)	**266,109**	**100%**

Data from BLM (Federal through Private / Washakie County 2,050)

Data from Counties (Private 78,151 through Washakie County 2,042)

Table 2.1- 2
BLM Grazing Allotments

Allotment No.	Allotment Name	Area (ac)
556	21 CREEK	2,358.66
637	ADAM WEISS PEAK	6,178.94
516	BLUE CREEK	5,572.20
685	BRAMAH	1,902.92
558	BUCK CREEK	1,228.12
580	COAL MINE	1,086.60
524	COTTONWOOD CREEK	2,572.20
551	COULEE-MILL IRON	2,673.25
548	D & LM IND	2,011.48
534	EAST COTTONWOOD	6,953.32
522	GRASS CREEK	10,893.19
530	GRASS CREEK BASIN	3,716.00
504	HAMILTON DOME	12,282.76
593	HAMILTON RIM	1,940.54
636	HAYNES	556.06
616	HOME	4,441.22
607	LAKE	6,422.39
680	LAKE CREEK PASTURE	6,098.21
590	LITTLE SAND DRAW	9,161.84
521	LOWER COTTONWOOD	7,357.81
634	LOWER PASTURES	11,017.10
604	LU	54,005.79
604	LU	73,675.33
552	MILK CREEK	1,008.74
665	NELSON	16,222.29
621	NORTH GRASS CREEK	2,990.42
679	NORTH RIM	1,452.61
OUT	OUT	1,058.73
OUT	OUT	2,551.75
OUT	OUT	192.43
OUT	OUT	3.50
OUT	OUT	1,841.56
OUT	OUT	33.76
OUT	OUT	52.24
OUT	OUT	541.74
OUT	OUT	1,109.47
OUT	OUT	645.46
OUT	OUT	3.62
OUT	OUT	615.91
OUT	OUT	1,943.71
OUT	OUT	1,601.68
OUT	OUT	1,252.98
620	PROSPECT	7,783.55
529	PROSPECT COMMON	11,507.73
613	PUTNEY FLAT	2,091.06
720	PUTNEY PLACE	1,586.59
557	RAMUL INDIVIDUAL	331.90
553	RICHMOND	6,496.48
507	SO. GOOSEBERRY GROUP	63,963.61
678	SOUTH GRASS CREEK	12,883.45
622	SOUTH HIGHWAY	8,988.63
681	SPRING CREEK	4,083.62
531	SPRING GULCH	1,981.19
641	SWING INDIVIDUAL	1,053.85
515	UPPER GOOSEBERRY	16,789.68
633	UPPER PASTURES	2,874.55
633	UPPER PASTURES	2,109.72
721	URWIN HOMESTEAD	697.73
608	VASS	1,177.73
596	WAGONHOUND	12,108.90
573	WAGONHOUND BENCH	5,918.63
722	WALES HOMESTEAD	716.30
535	WEST COTTONWOOD	13,875.55
532	WHISKY GULCH	903.66

Table 2.1-3
Annual Oil and Gas Production - 2006

Field	Oil (bbl)	Gas (mcf)	Last Year Any Production
Adam	2748	0	
Aspen Peak	0	0	1994
Baird Peak	1394	0	
Boulder Gulch	626	0	
Dickie	0	0	1985
Golden Eagle	243	2440	
Grass Creek South	0	0	1983
Grass Creek	965979	182150	
Hamilton Dome	1316659	0	
Little Grass Creek	9731	0	
Prospect Creek	0	0	1993
Skelton Dome	0	0	1978
Wagonhound	1482	0	
Totals	**2298862**	**184590**	

Table 2.2-1
Period of Record General Climate Summary - Preciptation

Station Number	Station Name	Period of Record	Precipitation					Total Snowfall		
			Mean	High	Year	Low	Year	Mean	High	Year
480228	Anchor Dam	1961-2006	15.2	20.72	1973	10.87	1969	37.1	54	1971
484036	Grass Creek 1E	1949-2006	10.32	17.3	1962	4.9	1954	27	47.4	1972
488888	Thermopolis 25 WNW	1951-2006	12.15	17.71	1998	7.22	1988	55.8	119.5	1973

Source: http://www.wrcc.dri.edu/summary/Climsmwy.html

Table 2.2-2
Period of Record General Climate Summary - Temperature

Station ID	Station Name	Period of Record	Monthly Averages			Daily Extremes				Monthly Extremes			
			Max	Min	Mean	High	Date	Low	Date	Highest Mean	Year	Lowest Mean	Year
480228	Anchor Dam	1961-2006	55.8	26.8	41.3	98	8/16/1973	-45	1/12/1963	43.1	1966	40.2	1968
484036	Grass Creek 1E	1949-2006	59	29.2	44.1	104	19700716	-49	19831224	46.6	1988	42.3	1982
488888	Thermopolis 25 WNW	1951-2006	58.3	28.2	43.2	100	20020713	-40	19630112	44.1	1963	40.1	1975

Source: http://www.wrcc.dri.edu/summary/Climsmwy.html

Table 2.2-3
Geologic Unit Designation

Erathem	System	Series	Geologic unit	Range of thickness (ft)	Lithology
Cenozoic	Quaternary	Sequence in table does not indicate age relative to other Quaternary entries	Alluvium and colluvium	0-100	Unconsolidated clay, silt, sand, and gravel in floodplains, fans, and terraces. Deposits associated with mountain streams are generally coarser.
Cenozoic	Quaternary	Sequence in table does not indicate age relative to other Quaternary entries	Gravel, pediment, and fan deposits	--	Mostly locally derived clasts (Love and Christiansen, 1985). Terrace deposits.
Cenozoic	Quaternary	Sequence in table does not indicate age relative to other Quaternary entries	Landslide deposits	--	Aggregate of poorly sorted parent material (Lowry and others, 1976).
Cenozoic	Tertiary	Eocene	Intrusive rocks	--	Felsic and mafic igneous bodies; larger bodies are mainly felsic (Love and Christiansen, 1985).
Cenozoic	Tertiary	Eocene	Wagon Bed Formation	--	Green and gray tuffaceous claystone, sandstone, and conglomerate. Some marlstone and bentonitic claystone. Local oil shale (Love and Christiansen, 1985).
Cenozoic	Tertiary	Eocene	Wiggins Formation[1]	--	Light-gray volcanic conglomerate and white tuff, containing clasts of igneous rocks (Love and Christiansen, 1985).
Cenozoic	Tertiary	Eocene	Tepee Trail Formation[1]	--	Green and olive-drab hard and generally well-bedded andesitic conglomerate, sandstone, and claystone (Love and Christiansen, 1985).
Cenozoic	Tertiary	Eocene	Aycross Formation[1]	--	Brightly variegated bentonitic claystone and tuffaceous sandstone, grading laterally into greenish-gray sandstone and claystone (Love and Christiansen, 1985).
Cenozoic	Tertiary	Eocene	Wind River Formation	--	Interbedded siltstone, sandstone, and conglomerate containing some carbonaceous shale and thin coal seams (Whitcomb and Lowry, 1968).
Cenozoic	Tertiary	Eocene	Tatman Formation	375-725	Interbedded claystone, shale, mudstone, marl, sandstone, with minor coal (Lowry and others, 1976). Occurs only in northernmost portion of the county; of limited extent.
Cenozoic	Tertiary	Eocene	Willwood Formation	1,300-2,300	Variegated, interbedded claystone and channel sandstone. Averages about 25 percent sandstone (Lowry and others, 1976).
Cenozoic	Tertiary	Paleocene	Fort Union Formation	600-3,500	Claystone, siltstone, and sandstone with some carbonaceous material. Cliff-forming sandstone near the base. Averages about 25 percent sandstone (Lowry and others, 1976).
Mesozoic	Cretaceous	Upper Cretaceous	Lance Formation	800-1,800	Massive sandstone overlain by interbedded claystone, siltstone, shale, and minor coal seams. Forms resistant ledges (Libra and others, 1981, p. 41).
Mesozoic	Cretaceous	Upper Cretaceous	Meeteetse Formation	650-1,200	Lenticular, poorly indurated fine-grained clayey to silty sandstone interbedded with siltstone, claystone, shale, bentonite, and minor thin coal beds (Libra and others, 1981, p. 42).
Mesozoic	Cretaceous	Upper Cretaceous	Mesaverde Formation	1,100-1,800	Light-colored massive to thin-bedded sandstone, gray sandy shale, and coal beds (Love and Christiansen, 1985).
Mesozoic	Cretaceous	Upper Cretaceous	Cody Shale	2,100-3,000	Lower part dominantly consists of dark gray marine shale, glauconitic sandstone, and thin bentonite beds; whereas, the upper part is interbedded gray, sandy shale and sandstone (Libra and others, 1981, p. 42).
Mesozoic	Cretaceous	Upper Cretaceous	Frontier Formation	450-700	Lenticular fine- to medium-grained sandstone and conglomeratic sandstone beds alternating with shale and lesser amounts of bentonite (Libra and others, 1981, p. 42).
Mesozoic	Cretaceous	Upper Cretaceous	Lance Formation	800-1,800	Massive sandstone overlain by interbedded claystone, siltstone, shale, and minor coal seams. Forms resistant ledges (Libra and others, 1981, p. 41).
Mesozoic	Cretaceous	Upper Cretaceous	Meeteetse Formation	650-1,200	Lenticular, poorly indurated fine-grained clayey to silty sandstone interbedded with siltstone, claystone, shale, bentonite, and minor thin coal beds (Libra and others, 1981, p. 42).
Mesozoic	Cretaceous	Upper Cretaceous	Mesaverde Formation	1,100-1,800	Light-colored massive to thin-bedded sandstone, gray sandy shale, and coal beds (Love and Christiansen, 1985).
Mesozoic	Cretaceous	Upper Cretaceous	Cody Shale	2,100-3,000	Lower part dominantly consists of dark gray marine shale, glauconitic sandstone, and thin bentonite beds; whereas, the upper part is interbedded gray, sandy shale and sandstone (Libra and others, 1981, p. 42).
Mesozoic	Cretaceous	Upper Cretaceous	Frontier Formation	450-700	Lenticular fine- to medium-grained sandstone and conglomeratic sandstone beds alternating with shale and lesser amounts of bentonite (Libra and others, 1981, p. 42).
Mesozoic	Cretaceous	Lower Cretaceous	Mowry Shale	300-400	Siliceous brittle shale with thin beds; sandstone and bentonite beds in the upper part (Libra and others, 1981, p. 42).
Mesozoic	Cretaceous	Lower Cretaceous	Thermopolis Shale	400-600	Soft shale with bentonite beds and sandy and silty zones. The Muddy Sandstone Member, which is about 40 ft thick, occurs about 200 ft above the base (Libra and others, 1981, p. 42).
Mesozoic	Cretaceous	Lower Cretaceous	Cloverly Formation	85-470	Composed of three units; an upper sandstone, a middle shale, and a lower lenticular conglomeratic sandstone (Libra and others, 1981, p. 42).
Mesozoic	Jurassic	Upper Jurassic	Morrison Formation	75-300	Variegated sandy shale and mudstone with lenses of fine-grained sandstone, conglomerate, and limestone.
Mesozoic	Jurassic	Upper and Middle Jurassic	Sundance Formation	200-300	Greenish-gray glauconitic sandstone and shale, underlain by red and gray nonglauconitic sandstone and shale (Love and Christiansen, 1985).
Mesozoic	Jurassic	Middle Jurassic	Gypsum Spring Formation	80-215	Red siltstone and shale with gray to brown limestone beds and massive gypsum beds (Libra and others, 1981, p. 43).
Mesozoic	Jurassic(?)-Triassic(?)		Nugget Sandstone	--	Gray to dull-red massive to coarsely crossbedded quartz sandstone (Love and Christiansen, 1985).
Mesozoic	Triassic	Upper and Lower Triassic	Chugwater Formation	450-1,000	Red very fine-grained sandstone, siltstone, shale, and one thin limestone (Alcova Limestone Member) in the southern part of the Bighorn Basin (Lowry and others, 1976).
Mesozoic	Triassic	Lower Triassic	Dinwoody Formation	0-100	Yellowish siltstone interbedded with gypsum and shales (Lowry and others 1976).
Paleozoic	Permian		Phosphoria Formation and related rocks	100-300	Brown sandstone and dolomite, cherty phosphatic and glauconitic dolomite, phosphatic sandstone and dolomite, greenish-gray to black shale (Love and Christiansen, 1985).
Paleozoic	Pennsylvanian	Upper and Middle Pennsylvanian	Tensleep Sandstone	50-375	Tan to white massive, crossbedded sandstone. Lower part more dolomite with interbedded carbonate beds (Libra and others, 1981, p. 44).
Paleozoic	Pennsylvanian and Mississippian	Middle and Lower Pennsylvanian and Upper Mississippian	Amsden Formation	120-300	Red shale and dolomite with chert and occasional gypsum. Darwin Sandstone Member at base ranges in thickness from 0 to 90 ft (Libra and others, 1981, p. 44).
Paleozoic	Mississippian	Upper and Lower Mississippian	Madison Limestone	300-880	Massive crystalline limestone and dolomite with siltstone and shale zones, cherty in places (Libra and others, 1981, p. 44).
Paleozoic	Devonian	Upper Devonian	Darby Formation	--	Yellow and greenish-gray shale and dolomitic siltstone underlain by fetid brown dolomite and limestone (Love and Christiansen, 1985).
Paleozoic	Ordovician	Upper Ordovician	Bighorn Dolomite	350-450	Massive to thin-bedded dolomite and dolomite limestone. Fine-grained massive sandstone at base. Contains cavernous zones near outcrop areas (Libra and others, 1981, p. 44).
Paleozoic	Cambrian	Upper Cambrian and Lower Ordovician	Gallatin Limestone	400-500	Gray-green calcareous shale and flat-pebble conglomerate (Lowry and others, 1976).
Paleozoic	Cambrian	Upper and Middle Cambrian	Gros Ventre Formation	400-500	Greenish-gray thin-bedded limestone and limestone-pebble conglomerate (Lowry and others, 1976).
Paleozoic	Cambrian	Middle Cambrian	Flathead Sandstone	0-170	Arkosic and quartzitic sandstone with interbedded shale in upper part (Libra and others, 1981, p. 45).
Precambrian			Igneous and metamorphic rocks	--	Metasedimentary and metavolcanic rocks, and granitic rocks of 2,600-Ma age group (Love and Christiansen, 1985).

Table 2.2-4
Bedrock Aquifers

Geologic Unit	Geologic Age	Classification	Well Depth[1] (ft)	Yield (gpm)	Specific Capacity (gpm/ft)
Willwood	Eocene	Discontinous	-	5-20	0.01-1.5
Fort Union	Paleocene	Discontinous	37-375	20	0.16-0.17
Lance/Meteetse	Cretaceous	Discontinous	100-320	-	-
Mesaverde	Cretaceous	Discontinous	120-1180	5-50	0.75-1.8
Frontier	Cretaceous	Minor	40-2910	<100	0.6-30
Cloverly	Cretaceous	Minor	75-559	2	-
Morrison	Jurassic	Minor	-	-	-
Sundance	Jurassic	Minor	-	-	-
Gypsum Springs	Jurassic	Minor	-	-	-
Chugwater	Triassic	Minor	54-400	-	-
Dinwoody	Triassic	Minor	-	-	-
Phosphoria	Permian	Minor	20-6200	-	-
Tensleep Sandstone	Pennsylvanian	Major	>3500	50-200	0.5-5
Amsden	Pennsylvanian/Mississippian	Minor	>3500	-	-
Madison	Mississippian/Devonian	Major	>4000	300-500	low
Bighorn Dolomite	Oligocene	Major	>4500	300	low
Flathead Sandstone	Cambrian	Major	>5600	300-500	unknown

[1] Ranges of depths shown are for wells throughout Hot Springs County included in Plafcan and Ogle (1994); depths in the Cottonwood/Grass Creek watershed will most likely be similar or deeper; depths shown as "greater than" are for the Gooseberry Creek watershed from LRCWE (19**) and are judged generally applicable to the Cottonwood/Grass Creek watershed

Table 2.3-1
Gaging Stations and Streamflow Sites

Site Number	Site Name	Flow Measurement Period of Record	Water Quality Data Period of Record	Water Quality Data Count
06265337	Cottonwood Creek at High Island Ranch/County Bridge, near Hamilton Dome	1993-2007	1977-78, 2000	8
06265350	Cottonwood Creek above Hamilton Dome		1970	1
06265400	Cottonwood Creek below Hamilton Dome		1970	1
06265410	Cottonwood Creek at State Highway 120, near Hamilton Dome		1977-78	11
06265435	Grass Creek above Little Grass Creek, near Grass Creek		1977-78	7
06265492	Grass Creek near mouth, near Hamilton Dome		1977-78	7
06265500	Cottonwood Creek at Winchester, Wyoming	1941-1945	1965,1977-78	13
435030108275300	Cottonwood Creek above Grass Creek, near Hamilton Dome		1976	2
435115108593901	Grass Creek near Anderson Saw Mill, near Grass Creek		1990	1
435135108570201	Hess Creek Draw near Anderson Saw Mill, near Grass Creek		1990	1
435141108553201	Carmichael Draw near LU Cow Camp, near Grass Creek		No Data	
435145108570201	Grass Creek above Hess Creek, near Grass Creek		1990	1
435146108091000	Cottonwood Creek at Mounth at Winchester, Wyoming		1976	1
435155108535501	Grass Creek near LU Cow Camp, near Grass Creek		1990	1
435156108535601	Sanford Draw near LU Cow Camp, near Grass Creek		1990	1
435236108514301	Grass Creek below LU Cow Camp, near Grass Creek		1990	1
435329108470601	Little Grass Creek at mouth, near LU Cow Camp, near Grass Creek		1990	1
435330108470801	Grass Creek above Little Grass Creek, near Grass Creek		1990	1
435439108330201	Grass Creek at Site 12, near Grass Creek		1990	1
435445108291500	Grass Creek near mouth, near Grass Creek		1976	2
435459108314601	Grass Creek at site 13, near Grass Creek		1990	1
435510108452501	Grass Creek at LU Ranch House, near Grass Creek		1990	1
435610108440301	Grass Creek above Gary Kellogg Ranch, near Grass Creek		1990	1
435649108410001	Grass Creek near Grass Creek		1990	1

Table 2.3-2
Headwaters Subbasins Characteristics

Stream/Subbasin	Headwaters Area (mi^2)	Precipitation (in)	Slope (ft/mi)	Relief (ft)	Mean Elevation (ft)
Little Grass Creek	11.6	14.5	1,195	1,972	7,028
Grass Creek	32.2	16.2	1,396	2,792	7,496
Mayfield Wells (Spring Gulch Drainage)	24.3	11.5	1,172	1,916	6,164
Lake Creek	4.5	15.7	1,350	1,348	7,854
Hamilton Dome Well (Local Drainage)	2.7	11	600	751	5,668
Cottonwood Creek	34.8	17	1,488	4,285	8,121

Table 2.3-3
Modeled Natural and Gaged Flows

Stream/Subbasin	Above Model Node	Flow Type	Annual Streamflow (ac-ft)		Normal Year Unit Runoff ($ac\text{-}ft/mi^2$)
			Dry	Normal	
Little Grass Creek	5.0401	Natural	1,166	3,399	293
Grass Creek	5.036	Natural	3,871	10,166	316
Mayfield Wells (Spring Gulch Drainage)	5.0405	Natural	98	3,612	149
Lake Creek	5.0005	Natural	748	2,186	486
COTTONWOOD AT HIGH ISLAND RANCH NEAR HAMILTON DOME (6265337)[1]	5.002	Gaged	4,803	9,188	113
Hamilton Dome Well (Local Drainage)	5.0101	Natural	472	642	238
Cottonwood Creek	5.0001	Natural	4,626	11,462	329

Table 2.3-4
Hamilton Dome Production Water Discharge to Cottonwood Creek

Year	Total Produced Water (ac-ft)	Total Discharged Water (ac-ft)	Ratio of Discharged Water to Produced Water
2002	14,562	8,873	0.61
2005	11,961	9,114	0.76
1st half 2006	6,302	4,548	0.72
	Averages	**9,014**	**0.70**

Table 2.4-1 Summary of Rosgen Stream Type

Stream Type	General Description	Entrenchment Ratio	W/D Ratio	Sinuosity	Slope	Landform/ Soils/Features
Aa+	Very steep, deeply entrenched, debris transport, torrent streams.	<1.4	<12	1.0 to 1.1	>.10	Very high relief. Erosional, bedrock or depositional features; debris flow potential. Deeply entrenched streams. Vertical steps with deep scour pools; waterfalls.
A	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable if bedrock or boulder dominated channel.	<1.4	<12	1.0 to 1.2	.04 to .10	High relief. Erosional or depositional and bedrock forms. Entrenched and confined streams with cascading reaches. Frequently spaced, deep pools in associated step/pool bed morphology.
B	Moderately entrenched, moderate gradient, riffle dominated channel, with infrequently spaced pools. Very stable plan and profile. Stable banks.	1.4 to 2.2	>12	>1.2	.02 to .039	Moderate relief, colluvial deposition, and/or structural. Moderate entrenchment and W/D ratio. Narrow, gently sloping valleys. Rapids predominate w/scour pools.
C	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well defined floodplains.	>2.2	>12	>1.2	<.02	Broad valleys w/terraces, in association with floodplains, alluvial soils. Slightly entrenched with well-defined meandering channels. Riffle/pool bed morphology.
D	Braided channel with longitudinal and transverse bars. Very wide channel with eroding banks.	n/a	>40	n/a	<.04	Broad valleys with alluvium, steeper fans. Glacial debris and depositional features. Active lateral adjustment, w/abundance of sediment supply. Convergence/divergence bed features, aggradational processes, high bedload and bank erosion.
DA	Anastomosing (multiple channels) narrow and deep with extensive, well vegetated floodplains and associated wetlands. Very gentle relief with highly variable sinuosities and width/depth ratios. Very stable streambanks.	>2.2	Highly variable	Highly variable	<.005	Broad, low-gradient valleys with fine alluvium and/or lacustrine soils. Anastomosed (multiple channel) geologic control creating fine deposition w/well-vegetated bars that are laterally stable with broad wetland floodplains. Very low bedload, high wash load sediment.
E	Low gradient, meandering riffle/pool stream with low width/depth ratio and little deposition. Very efficient and stable. High meander width ratio.	>2.2	<12	>1.5	<.02	Broad valley/meadows. Alluvial materials with floodplains. Highly sinuous with stable, well-vegetated banks. Riffle/pool morphology with very low width/depth ratios.
F	Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio.	<1.4	>12	>1.2	<.02	Entrenched in highly weathered material. Gentle gradients, with a high width/depth ratio. Meandering, laterally unstable with high bank erosion rates. Riffle/pool morphology.
G	Entrenched "gully" step/pool and low width/depth ratio on moderate gradients.	<1.4	<12	>1.2	.02 to .039	Gullies, step/pool morphology w/moderate slopes and low width/depth ratio. Narrow valleys, or deeply incised in alluvial or colluvial materials, i.e., fans or deltas. Unstable, with grade control problems and high bank erosion rates.

Table 2.4-2
Summary of Level I Geomorphic

Stream	Reach	Sinuosity	Slope	Entrenchment	Width/Depth Ratio	Level I Type
Cottonwood Creek	above Twentyone Cr.	1.2 to 1.8	0.007 to 0.01	slight >2.2	mod to high >12	C
Cottonwood Creek	below Putney Flat	1.4 to 1.9	0.005 to 0.02	entrenched <1.4	mod to high >12	F
Cottonwood Creek	above Wagonhound Cr.	1.8 to 2.2	0.005 to 0.008	slight >2.2	mod to high >12	C
Cottonwood Creek	Wagonhound Cr. to Prospect Cr.	1.7	0.007	slight >2.2	mod to high >12	C
Cottonwood Creek	Prospect Cr. to Grass Cr.	1.4 to 2.1	0.005 to 0.007	slight >2.2	mod to high >12	C
Cottonwood Creek	below Grass Cr.	1.6 to 2.0	0.004 to 0.006	slight >2.2	mod to high >12	C
Cottonwood Creek	above Bighorn River	1.6	0.005	slight >2.2	mod to high >12	C
Twentyone Creek	headwaters	1.2	0.03	moderate (1.4 to 2.2)	moderate >12	B
Twentyone Creek	lower	1.2 to 1.3	0.015 to 0.016	slight >2.2	mod to high >12	C
Wagonhound Creek	headwaters	1.2	0.03 to 0.07	moderate (1.4 to 2.2)	moderate >12	B
Wagonhound Creek	upper	1.3 to 1.5	0.009 to 0.02	entrenched <1.4	mod to high >12	F
Wagonhound Creek	lower	1.8 to 1.9	0.02 to 0.03	slight >2.2	mod to high >12	C
Prospect Creek	headwaters	1.1	0.05	entrenched <1.4	low <12	A
Prospect Creek	upper	1.2 to 1.5	0.015 to 0.02	entrenched <1.4	mod to high >12	F
Prospect Creek	middle	1.3 to 1.5	0.003 to 0.01	slight >2.2	mod to high >12	C
Prospect Creek	lower	1.2 to 1.9	0.006 to 0.02	entrenched <1.4	mod to high >12	F
Grass Creek	headwaters	1.0	0.13	entrenched <1.4	low <12	A
Grass Creek	above Little Grass Cr.	2.1 to 2.4	0.006 to 0.01	slight >2.2	very low <12	E
Grass Creek	Little Grass Cr. to Spring Gulch	1.8 to 2.2	0.004 to 0.008	slight >2.2	very low <12	E
Grass Creek	Spring Gulch to Cottonwood Cr.	1.4 to 2.0	0.002 to 0.006	slight >2.2	very low <12	E
Spring Gulch	headwaters	1.1	0.05	entrenched <1.4	low <12	A
Spring Gulch	upper	1.2 to 1.3	0.02 to 0.03	moderate (1.4 to 2.2)	moderate >12	B
Spring Gulch	lower	1.3 to 1.4	0.01 to 0.02	entrenched <1.4	mod to high >12	F

Table 2.4-3
Summary of Level II Geomorphic Characterization

Stream	Cross Section	GPS Waypoint	Bankfull Width (ft)	Bankfull Width (ft)	Width/Depth Ratio	Width of Flood Prone (ft)	Entrenchment Ratio	Channel Slope (ft/ft)	Sinuosity	Bed Material (D50-mm)	Stream Type
Prospect Creek	PC-01	36	15.2	1.5	10.1	21.5	1.4	0.005	1.42	45.3	F4
	PC-02	38	14.6	1.2	12.2	20.3	1.4	0.023	1.47	64	F4
	PC-03	39	9.6	2.2	4.4	16	1.7	0.015	1.41	64	B4c
	PC-04	40	13	2.3	5.7	54	4.2	0.008	1.38	2	C5b
	PC-05	56	22.5	1.5	15	40.5	1.8	0.016	1.27	8	C5
	PC-06	53	11.8	0.7	16.9	14.5	1.2	0.013	1.26	11.3	F4
	PC-07	50	4.3	1.1	3.9	10.4	2.4	0.012	1.26	8	F4c
	PC-08	46	13	0.65	20	43	3.3	0.028	1.27	11.3	C4b
	PC-09	43	4	1.3	3.1	16	4	0.03	1.19	5.6	E5b
	PC-10	41	6	2	3	10.5	1.8	0.08	1.15	5.6	B5a
Wagonhound Creek	WH-01	18	7.5	3.3	2.3	27.3	3.6	0.008	1.92	2	E5b
	WH-02	20	26	2.5	10.4	65	2.5	0.008	1.4	2	B4c
	WH-03	21	66	3.3	20	128	1.9	0.01	1.3	11.3	B4c
	WH-04	32	13.8	0.7	19.7	19.4	1.4	0.032	1.34	11.3	F4b
	WH-05	30	17	1.8	9.4	76	4.5	0.039	1.45	11.3	C4b
	WH-06	26	13.6	1.7	8	20	1.5	0.087	1.26	8	G4
Spring Gulch	SG-1	67	6.5	0.88	7.4	13	2	0.012	1.41	16	B4c

Table 2.4-4
Summary of Geomorphic Impairments

Stream	Channel Degradation[1]	Bank Erosion[2]	Range Management[3]
Cottonwood Creek	✔	✔	✔
Grass Creek			✔
Prospect Creek	✔	✔	✔
Wagonhound Creek	✔	✔	✔
Spring Gulch	✔	✔	✔

[1] Channel Degradation: Channel downcutting, headcutting, gully formation

[2] Bank Erosion: Channel widening, channel migration, irrigation diversion abandonment

[3] Range Management: Riparian vegetation, erosion impacts, bank erosion

Table 2.6-1
Water Quality Criteria for Agricultural Uses

Constituent	Units	Irrigation				Livestock Watering		
		Wilcox (1948)	Ayers and Westcot (1994)	WDEQ (2005)	Bauder, et al. (2006)	Ayers and Westcot (1994)	WDEQ (2005)	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	1000-3000[1]	--	750	4100-6000[3]	5000	5000	--
Cadmium	µg/L	--	10	10	--	50	50	--
Chloride	mg/L	--	--	100	141-350[4]	--	2000	--
Chromium	µg/L	--	100	100	--	1000	50	--
Cobalt	µg/L	--	50	50	--	1000	--	--
Copper	µg/L	--	200	200	--	500	500	--
Flouride	µg/L	--	1000	--	--	2000	--	2000
Iron	µg/L	--	5000	5000	--	--	--	--
Lead	µg/L	--	5000	5000	--	100	100	--
Lithium	µg/L	--	2500	2500	--	--	--	--
Magnesium	mg/L	--	--	--	--	250-500	--	--
Manganese	µg/L	--	200	200	--	50	--	--
Mercury	µg/L	--	--	--	--	10	0.05	--
Molybdenum	µg/L	--	10	--	--	10	--	300
Nickel	µg/L	--	200	200	--	200	--	--
Nitrate (NO_3-N)	mg/L	--	--	--	--	--	--	500
Nitrite (NO_2-N)	mg/L	--	--	--	--	--	10	100
(NO_3+NO_2)-N	mg/L	--	5-30[2]	--	--	100	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	--	24000	25000	--
Oil and Grease	mg/L	--	--	10	--	--	10	--
Radium 226 and Radium 228	pCi/L	--	--	5	--	--	5	--
Total Strontium 90	pCi/L	--	--	8	--	--	8	--
Gross alpha particle radioactivity (including Radium 226 but excluding Radon and Uranium)	pCi/L	--	--	15	--	--	15	--
TDS	mg/L	--	450-2000[2]	2000	--	--	5000	--
pH	Standard units	--	--	4.5-9.0	--	--	6.5-8.5	--
Residual Sodium Carbonate (RSC)	meq/L	--	--	1.25	--	--	--	--
SAR	n/a	--	--	8	9	--	--	--
Specific Conductance	µS/cm	2000	--	--	760-2000[5]	5000-8000	--	--

[1] Low value is maximum for sensitive crops; high value is maximum for tolerant crops

[2] Range is for slight to moderate restriction on use; i.e., no restrictions on use for lower values, severe restrictions on use for higher values

[3] Range for which alfalfa is tolerant; wheat requires less than 760-1000 µg/L boron

[4] Range at which moderately tolerant plants show innjury; foliar damage to alfalfa occurs from saline sprinkler water when Cl is in the range of 351-700 mg/L

[5] Lower bound salinity is acceptable for all crops; upper bound salinity requires adequate drainage to mitigate potential salt accumulation in soil

Table 2.6-2
Surface Water Suitability

		Grass Creek (upstream to downstream from left to right)					Cottonwood Creek (upstream to downstream from left to right						
Constituent	**Units**	**435115108593901-435649108410001 Sept 11-13, 1990**	**06265435 1977-78**	**435439108330201-435459108314601 Sept 11-13, 1990**	**435445108291500 1976**	**06265492 1977-78**	**06265337 1977-78 (2000)**	**06265350 Sept 30, 1970**	**06265400 Sept 30, 1970**	**06265410 1977-78**	**435030108275300 1976**	**435146108091000 1976**	**06265500 1977-78**
Aluminum	µg/L	<10-800											
Arsenic	µg/L	<1-2											
Beryllium	µg/L												
Boron	µg/L	30-160	60-70	680-720		130-890	50-130	*1560*	120	310-*1600*			280-*1600*
Cadmium	µg/L	<1		<1									
Chloride	mg/L	1.8-11	1.9-4.1	*130*		16-*380*	1.7-3.5	***420***	33	65-***450***			55-***630***
Chromium	µg/L	<1-1		<1									
Cobalt	µg/L												
Copper	µg/L	1-5		2									
Flouride	µg/L	<100-900	300-700	700-800		500-1000	300-600	*1200*	600	100-***1300***			100-*1100*
Iron	µg/L	8-740	20-370	20-60		80-220	170-1100	160	100	30-400			20-160
Lead	µg/L	<1-9		<1									
Lithium	µg/L												
Magnesium	mg/L	2.7-52	5.6-19	120-130		19-160	1.9-5.9	108	20	26-130			22-210
Manganese	µg/L												
Mercury	µg/L	*<0.1-0.1*		***0.2***									
Molybdenum	µg/L												
Nickel	µg/L												
Nitrate (NO_3-N)	mg/L												
Nitrite (NO_2-N)	mg/L												
(NO_3+NO_2)-N	mg/L	<0.1-0.2	0.01-0.22	<0.1		0.04-0.33							0.02-0.34
Selenium	µg/L	<1-6		2-6									
Sulfate	mg/L	9.3-*280*	18-110	***980-1000***		130-***1400***	16-62	***1400***	*251*	***420-1700***			***380-2900***
Vanadium	µg/L												
Zinc	µg/L	<3-5		<10									
Oil and Grease	mg/L												
Radium 226 and Radium 228	pCi/L												
Total Strontium 90	pCi/L												
Gross alpha particle radioactivity (including Radium 226 but excluding Radon and Uranium)	pCi/L												
TDS	mg/L	135-*839*		*2010-2120*									
pH	Standard units	8.2-***9.6***		*8.6-8.7*			***(9.7)***	8	*8.8*				
Residual Sodium Carbonate (RSC)	meq/L												
SAR	n/a	2-5	2	8		4-***10***	2-4	8	5	4-8			5-***17***
Specific Conductance	µS/cm	202-1320	240-800	***3050***	***2150-3490***	700-***5100***	220-390 (700)	***4140***	972	*1450*-***5000***	*1400*-***4420***	***4820***	*1400*-***7500***

Bold/italics font indicates one or more criteria are exceeded
Italics font indicates one criterion is just exceeded

Table 2.6-3
Groundwater Suitability

		Alluvium and Alluvial Terrace			Absaroka Volcanics		Fort Union Fomration		Meeteetse Formation		Mesaverde Formation							Cody Shale	Madison Formation	Big Horn Dolomite
Constituent	**Units**	**Qa7**	**Qa8**	**Qt7**	**Tav1**	**Tav3**	**Tfu1**	**Tfu2**	**Km1**	**Km2**	**Kmv3**	**Kmv4**	**Kmv5**	**Kmv6**	**Kmv7**	**Kmv8**	**Kmv10**	**Kc3**	**MDm1**	**Ob6**
Aluminum	µg/L		<10	10	200	10	<10	10		10		10	10	10			10			
Arsenic	µg/L		<1	<1	8	2	<1	<1		<1		<1	<1	6			<1			
Beryllium	µg/L																			
Boron	µg/L	130	40	610	70	70	*920*	110	130	60	250	170	*960*	290	260	120	80	*1000*	10	*1000*
Cadmium	µg/L		1	<1	2	<1.0	<1.0	<1.0		<1		1	<1	<1			<1			
Chloride	mg/L	9.8	0.6	24	2.9	3.7	70	21	25	9.9	17	5.9	***420***	42	7.3	*120*	7.8	***510***	***280***	***270***
Chromium	µg/L		<1	2	1	<1	2	2		<1		2	2	<1			<1			
Cobalt	µg/L																			
Copper	µg/L		2	*260*	4	,1	4	<1		1		1	1	1			10			
Flouride	µg/L	*1300*	300	***1800***	300	200	700	700	***1400***	500	*1100*	200	*1100*	1000	900	800	400	600	***3800***	***3400***
Iron	µg/L	9	30	20	250	10	80	10	80	10	40	190	60	1900	20	1100	7			
Lead	µg/L		<1	<1	1	<1	<1	1	<1	1		<1	<1		<1		<1			
Lithium	µg/L																			
Magnesium	mg/L																			
Manganese	µg/L	25	7	3	17	16	17	16	20	<10	***600***	13	***180***	***120***	*86*	39	<1			
Mercury	µg/L		<0.1	<0.1	***2***	<0.1	<0.1	***0.2***	<0.1	***0.2***		***0.2***	***0.3***	***0.2***			<0.1			
Molybdenum	µg/L																			
Nickel	µg/L																			
Nitrate (NO_3-N)	mg/L																			
Nitrite (NO_2-N)	mg/L																			
(NO_3+NO_2)-N	mg/L	0.4	<0.1	0.5	0.2	0.5	2.5	0.1	<0.1		<0.1	0.4	<0.1	<0.1	<0.1	0.5	0.3			
Selenium	µg/L	3	<1	8	7	2	6	<2	6	<2	<2	<2	6	<2	<2	3	2			
Sulfate	mg/L	*260*	24	***460***	36	77	***1700***	***870***	***560***	200	180	*240*	***3200***	***1100***	***540***	190	190	***970***	***1500***	***1400***
Vanadium	µg/L																			
Zinc	µg/L		30	80	3	6	140	<10	140	<10		6	20	10			50			
Oil and Grease	mg/L																			
Radium 226 and Radium 228	pCi/L																			
Total Strontium 90	pCi/L																			
Gross alpha particle radioactivity (including Radium 226 but excluding Radon and Uranium)	pCi/L																			
TDS	mg/L	*684*	181	*1310*	236	265	***3420***	*1730*	*1150*	*938*	*867*	*907*	***5510***	*1940*	*1230*	*688*	*741*	***2720***	***3390***	***3440***
pH	Standard units	7.6	***9.2***	7.9	7.5	8	7.1	7.5	8.4	7.3	7.8	7.8	7.4	7.6	8	7.7	7.6	7.5	7.1	6.8
Residual Sodium Carbonate (RSC)	meq/L																			
SAR	n/a	2	5	*10*	6	3	7	1	5	0.7	***12***	***18***	*9*	6	6	2	2	7	3	3
Specific Conductance	µS/cm	*1060*	331	*1920*	378	412	***4750***	***2450***	*1690*	*1460*	*1350*	*1550*	***6800***	***2590***	*1760*	*1020*	*1210*	***4010***	***4150***	***4210***

Bold/italics font indicates one or more criteria are exceeded

Italics font indicates one criterion is just exceeded

Table 2.6-4
NPDES Water Quality Data

WY0000175 - Hamilton Dome Oil Field[1]

Month	Average Flow (mgd)	Max Flow (mgd)	Min Flow (mgd)	Average Volume (ac-ft)	Average Chlorides (mg/L)	Average Sulfate (mg/L)	Average Conductivity (µmhos/com)	Average pH	Average TDS (mg/L)	Average Selenium (mg/L)	Average Oil & Grease (mg/L)
January	2.62	2.85	2.33	249	No Data	No Data	No Data	No Data	No Data	No Data	No Data
February	2.51	2.68	2.40	216	420	1,190	3,558	7.64	2,639	0.00	4.3
March	2.66	2.83	2.51	253	No Data	No Data	No Data	No Data	No Data	No Data	No Data
April	2.71	3.05	2.34	249	439	1,223	3,555	7.75	1,738	0.00	6.8
May	2.70	2.79	2.59	257	No Data	No Data	No Data	No Data	No Data	No Data	No Data
June	2.78	2.93	2.48	256	446	1,170	3,100	7.95	2,228	0.01	5.4
July	2.47	2.61	2.33	235	No Data	No Data	No Data	No Data	No Data	No Data	No Data
August	2.46	2.61	2.30	234	443	1,223	3,227	7.55	2,292	0.00	4.4
September	2.44	2.44	2.43	224	No Data	No Data	No Data	No Data	No Data	No Data	No Data
October	2.52	2.53	2.51	240	439	1,200	3,240	7.67	2,285	0.00	6.4
November	2.56	2.56	2.56	236	No Data	No Data	No Data	No Data	No Data	No Data	No Data
December	2.58	2.61	2.55	245	413	1,207	3,170	7.63	2,338	0.00	5.3
Maximum=	2.78	3.05	2.59	257	446	1,223	3,558	7.95	2,639	0.01	6.8
Minimum=	2.44	2.44	2.30	216	413	1,170	3,100	7.55	1,738	0.00	4.3
Total=				2,894							

[1] Data for 2002, 2005 and 1st Half 2006

WY0000680 - Hamilton Dome Oil Field[2]

Month	Average Flow (mgd)	Max Flow (mgd)	Min Flow (mgd)	Volume (ac-ft)	Average Chlorides (mg/L)	Average Sulfate (mg/L)	Average Conductivity (umhos/com)	Average pH	Average TDS (mg/L)	Average Selenium (mg/L)	Average Oil & Grease (mg/L)
January	5.49	5.60	5.41	522	No Data	No Data	No Data	No Data	No Data	No Data	No Data
February	5.50	5.60	5.43	473	402	1,041	2,128	7.90	1,548	0.00	4.0
March	5.53	5.71	5.42	526	No Data	No Data	No Data	No Data	No Data	No Data	No Data
April	5.40	5.42	5.38	497	414	1,034	4,363	7.95	2,175	0.00	3.6
May	5.37	5.42	5.34	511	No Data	No Data	No Data	No Data	No Data	No Data	No Data
June	5.46	5.63	5.34	502	400	1,078	4,393	7.92	3,320	0.01	4.1
July	5.43	5.53	5.32	516	No Data	No Data	No Data	No Data	No Data	No Data	No Data
August	5.27	5.34	5.20	501	395	1,037	3,010	7.84	2,125	0.00	2.0
September	5.55	5.56	5.54	511	No Data	No Data	No Data	No Data	No Data	No Data	No Data
October	5.52	5.52	5.52	525	406	1,144	2,870	7.90	1,948	0.00	2.8
November	5.52	5.52	5.52	508	No Data	No Data	No Data	No Data	No Data	No Data	No Data
December	5.52	5.53	5.50	525	390	1,040	2,877	7.96	2,098	0.00	5.6
Maximum=	5.55	5.71	5.54	526	414	1,144	4,393	7.96	3,320	0.01	5.6
Minimum=	5.27	5.34	5.20	473	390	1,034	2,128	7.84	1,548	0.00	2.0
Total=				6,118							

[2] Data for 2002, 2005 and 1st Half 2006

WY0025054 - Wagonhound Field, Christensen #1 Lease

Date	Flow (mgd)	pH	Temperature (°C)	Specific Conductivity (µmhos/com)	T. Rad 226	O&G (mg/L)	Chlorides (mg/L)	SO_4 (mg/L)
9/13/1989	0.014	7.8	19	4120	ND	1	584	
5/10/1989	0.014	7.6	12	3984	ND	1	535	
5/4/1993	0.009	7.79	14.8	5650	52.4	2	ND	
5/5/1994	0.009	7.69	16.9	5680	55.7	1	ND	
8/12/1998	0.008	7.68	20.7	6080	50	6	ND	
4/14/2000	0.009	7.1	8.5	5760	NA	2	ND	1000
2/2/2004	0.009	7.86	2.9	4920	NA	2	547	1527

WY0032042 - Meeteetse 15 Battery

Date	Flow (mgd)	pH	Temperature (°C)	Specific Conductivity (µmhos/com)	T. Rad 226	O&G (mg/L)	Chlorides (mg/L)	SO_4 (mg/L)
Jan-05	0.0058					11	512	
Feb-05	0.0054					7.1		
Mar-05	0.0058					8.1	520	
Apr-05	0.0062					ND		
May-05	0.0066					ND	518	
Jun-05	0.0054				2.6	ND		
Jul-05	0.0057					ND	431	
Aug-05	0.0046					8.7		
Sep-05	0.0072					12	469	
Oct-05	0.0056					3 upstream 5 downstream		
Nov-05	0.0054					12 upstream 36 downstream	499	
Dec-05	0.0054					ND		
	0.0032					14	478	
Feb-06	0.0057					10		
Mar-06	0.0054					6 upstream 7 downstream	486	
Apr-06	0.0061					ND		
May-06	0.0078					4 upstream 5 downstream	485	
Jun-06	0.0061				2.2	ND		

WY00351311 - Ridgely #1 Battery

Date	Flow (mgd)	pH	Temperature (°C)	Specific Conductivity (µmhos/com)	T. Rad 226	O&G (mg/L)	Chlorides (mg/L)	SO_4 (mg/L)
8/11/1998	0	7.23	21.2	9320	9.5	1		
Jan-05	0.0058					ND	507	
Feb-05	0.0049					ND		
Mar-05	0.0051					ND	1320	
Apr-05	0.0051					ND		
May-05	0.0078					ND	1360	
Jun-05	0.0062				6.5	ND		
Jul-05	0.0061					ND	1310	
Aug-05	0.0086					ND		
Sep-05	0.0081					ND	1270	
Oct-05	0.0056					ND		
Nov-05	0.0054					ND	1290	
Dec-05	0.0057					ND		
Jan-07	0.0054					ND	1350	
2/9/2006	0.004	7.26	3.3	7340		12		
Feb-06	0.0057					ND		
Mar-06	0.0054					ND	1340	
Apr-06	0.0061					ND		
May-06	0.0078					ND	1400	
Jun-06	0.0061				4.7	ND		
3/27/2007	0.009	7.46	12.4	7480		25	1138	

Table 2.7-1
Available Flow at Modeled Reach Outflows

Reach No.	Reach Name	Annual Available Flow (ac-ft)	
		Normal Year	Dry Year
460	Cottonwood Creek	21,015	7,275
461	Lake Creek	1,196	418
462	Hamilton Dome Well	441	211
464	Little Grass Creek	3,773	1,533
466	Mayfield Wells	3,952	144
468	Grass Creek	15,274	4,115

Table 2.7-2
Potential Surface Water Storage Sites

State ID or Site Number	Name	Owner/Applicant	Haz	Dam Hgt	Nor Cap	Dam Len	Last Inspect.	Status	Reason
WSEO Dams Database									
2638R	Hardy #1			31	208	0	8/21/1984	Inactive	WO
0201R	Caledonia			23	162	0	11/14/1984	Inactive	NB
0583R	Middle Fork	Russell A. Winchester		14	80	1650	11/13/1980	Inactive	INA
0687R	Lazy Bear	BLM & Prudential Insurance Company		20	91	350	9/9/1985	Inactive	NB
0871R	Cottonwood Irrigation Company			48	1265	0	11/8/1985	Inactive	SLT
1081R	Vallean			19	50	695	9/9/1985	Inactive	NB
1202R	Grass Creek	L.G. Phelps		27	294	0	9/11/1985	Inactive	SLT
1203R	Grass Creek #2	M. Merrill, W & A. Phelps Co.		20	70	0	11/14/1984	Inactive	NF
1204R	Grass Creek #3	M. Merrill & A. Phelps		0	150	0	11/14/1984	Inactive	WO
1205R	Grass Creek #4	Grass Creek Reservoir & Ditch Company		22	45	250	11/14/1984	Inactive	NG
1209R	Wales	Springs Gulch Cattle Company	L	13	200	760	4/14/2005	Active	
1760R	Modoc			24	419	0	9/9/1985	Inactive	TS
4639R	Lake Creek	Legend Rock Ranch & Spring Gulch	L	45	1373	778	9/7/2005	Active	
8096R	Northwestern Resources No. 4B	Northwestern Resources		30	3	120	11/14/1984	Inactive	TS
8097R	Northwestern Resources No. 1A	Northwestern Resources		36	2	100	11/14/1984	Inactive	TS
8098R	Northwestern Resources No. 1B	Northwestern Resources		28	1	90	11/14/1984	Inactive	TS
ACE (2005)									
ACE - 1	Cottonwood Creek				74390				
SEH (this study)									
1	Grass Creek Causeway - Small								
1A	Grass Creek Causeway - Large								
2	Putney Flat A								
3	Putney Flat B								
4	Wales Reservoir Expansion								
5	Wagonhound A								
6	Wagonhound B								
7	Spring Gulch								
8	Seventy Six								
9	Lower Grass Creek								
10	LU Cow Camp								
11	Prospect								
12	Phelps Reservoir Reconstruction								
13	Lake Creek Reservoir Rehabilitation								

Table 2.7-3
Alternative Storage Sites - Annual Available Flows and Shortages

Site Number	Name	Hydrologic Condition	Upstream Node	Total Available (ac-ft)	Downstream Node	Total Shortage (ac-ft)
1	Grass Creek Causeway	Dry Year	5.0402	3,826	5.0403	1,842
		Normal Year		11,893		777
2	Putney Flat	Dry Year	5.0010	1,002	5.0030	4,777
		Normal Year		1,226		2,376
4	Wales Reservoir Expansion	Dry Year	Off-Channel		Off-Channel (5.0030)	1,720
		Normal Year				708
5	Wagonhound	Dry Year	5.025	1,115	5.03	1,720
		Normal Year		2,895		708
7	Spring Gulch	Dry Year	5.0410	3,913	5.0415	168
		Normal Year		15,345		26
9	Lower Grass Creek	Dry Year	5.0415	3,913	5.0430	67
		Normal Year		15,345		-
10	LU Cow Camp	Dry Year	5.0370	3,707	5.0402	1,842
		Normal Year		10,084		777
11	Prospect	Dry Year	5.0300	1,570	5.0350	1,720
		Normal Year		3,569		708
12	Phelps Reservoir Reconstruction	Dry Year	5.0370	3,707	5.0402	1,842
		Normal Year		10,084		777
13	Lake Creek Reservoir Rehabilitation[1]	Dry Year	5.0007	889	5.0008	5,153
		Normal Year		2,247		2,411

[1] Total annual natural inflow is shown instead of total available flow for Lake Creek Reservoir; see text for discussion.

Table 2.7-4
Alternative Storage Sites - Available Flow By Month

Site Number	Name	Upstream Node	Hydrologic Condition	Available Streamflow (ac-ft)												
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	Grass Creek Causeway	5.0402	Dry Year	106	168	241	314	2,000	507	-	-	-	106	221	163	3,826
			Normal Year	199	291	350	913	4,239	4,827	4	-	-	398	379	293	11,893
2	Putney Flat	5.0010	Dry Year	142	135	221	-	115	-	-	-	-	-	228	161	1,002
			Normal Year	165	158	270	-	259	-	-	-	-	-	212	162	1,226
4	Wales Reservoir Expansion	Off-Channel	Dry Year													
			Normal Year													
5	Wagonhound	5.0300	Dry Year	159	142	226	-	115	-	-	-	-	-	281	192	1,115
			Normal Year	189	182	294	-	259	1,494	-	-	-	-	275	202	2,895
7	Spring Gulch	5.0410	Dry Year	105	168	241	314	2,000	507	-	-	-	194	221	163	3,913
			Normal Year	273	426	518	1,212	5,603	5,855	23	-	8	529	508	390	15,345
9	Lower Grass Creek	5.0415	Dry Year	105	168	241	314	2,000	507	-	-	-	194	221	163	3,913
			Normal Year	273	426	518	1,212	5,603	5,855	23	-	8	529	508	390	15,345
10	LU Cow Camp	5.0370	Dry Year	81	129	185	314	2,000	507	-	-	-	194	170	127	3,707
			Normal Year	151	221	268	681	3,573	4,324	4	-	-	349	289	224	10,084
11	Prospect	5.0300	Dry Year	191	156	223	-	115	-	-	-	-	176	434	275	1,570
			Normal Year	249	203	304	-	259	1,494	-	-	-	257	481	322	3,569
12	Phelps Reservoir Reconstruction	5.0307	Dry Year	81	129	185	314	2,000	507	-	-	-	194	170	127	3,707
			Normal Year	151	221	268	681	3,573	4,324	4	-	-	349	289	224	10,084
13	Lake Creek Dam Rehabilitation[1]	5.007	Dry Year	13	21	35	127	406	172	28	8	12	25	26	16	889
			Normal Year	18	32	46	129	833	875	103	30	27	50	72	32	2,247

[1] Inflows rather than available flows are shown for Lake Creek Dam; the Basin Plan model incorrectly assumes seasonal storage in Lake Creek Dam and as a result the available flows are incorrect.

Table 3.1-1
Irrigation System Rehabilitation Plan

Rehabilitation Item Number	Description	Station (feet from headgate)	Priority	Cost
Alm #1, Alm #2, and Alm #3 Ditch System Improvements				
1	Alm #1: Install 4,500 LF of 10” HDPE pipe	0.0 - 4,500	2	$ 160,000
2	Alm #2: Remove sediment at diversion	0.0	3	$ 500
3	Alm #2: Replace wasteway structure	925	2	$ 3,000
4	Alm #2: Install 1 farm turnout structure	2,075	2	$ 2,500
5	Alm #2: Install measurement device (1)	2,075	3	$ 3,000
6	Alm #3: Install measurement device	300	2	$ 3,000
7	Alm #3: Install 30” diameter siphon to replace failing suspended CMP, 75-ft	6,275	1	$ 30,000
8	Alm #3: Repair breached portion of ditch	14,575	1	$ 2,000
Berry Ditch System Improvements				
9	Install check structure in creek at diversion	0	2	$ 30,000
10	Replace 2’ Parshall flume	1,050	2	$ 2,500
11	Increase channel capacity	1,950	2	$ 5,000
Butterfield Ditch System Improvements				
12	Install check structure in creek at diversion	0.0	2	$ 30,000
13	Install sediment trap/shoot at diversion	0.0	2	$ 10,000
14	Repair structural support for suspended pvc pipe crossing creek	9100	1	$ 10,000
Caledonia Ditch System Improvements				
15	Repair minor scour at diversion	0.0	3	$ 5,000
16	Stabilize ditch banks in vicinity of sediment trap/wasteway	1,225	2	$ 5,000
17	Replace 4’ Parshall flume	1,525	2	$ 6,000
18	Remove concrete splitter structure and install check structure and gate	4,860	2	$ 12,000
19	Remove steel splitter structure and install check structure and gate	5,400	1	$ 10,000
20	Re-grade ditches/consolidate parallel ditches, approx 3,000 LF (not parallel lateral)	5,400 - 9,800	2	$ 15,000
21	Install approximately 5 farm turnouts	To Be Determined	2	$ 12,500
22	Install approximately 5 check structures	To Be Determined	2	$ 20,000
23	Install approximately 5 measurement devices	To Be Determined	2	$ 15,000
Earl Ditch North and South				
--	No improvements recommended	--	--	$ -
Hilberry North Ditch System Improvements				
24	Stabilize creek at diversion	0.0	2	
25	Install check structure in creek at diversion	0.0	2	$ 20,000
26	Install headwall on headgate	0.0	2	$ 2,000
27	Stabilize scour hole at outlet of wasteway	2,150	3	$ 1,500
Kirby Ditch System Improvements				
28	Stabilize bank erosion in creek	0.0	1	$ 60,000
29	Replace headgate headwall	0.0	1	$ 5,000
30	Line approximately 5,000 LF of upper portion of ditch (geotextile)	0.0 to 5,000	2	$ 170,000
Little John Ditch System Improvements				
31	Rehabilitate diversion/ restore creek	0.0	2	$ 30,000
32	Replace headgate	0.0	2	$ 2,500
33	Replace sandtrap/wasteway	975	2	$ 10,000
34	Line approximately 1,000 LF of ditch	0.0 to 1,000	2	$ 20,000
35	Install approximately 6 farm turnouts	To Be Determined	2	$ 15,000
36	Install approximately 6 check structures	To Be Determined	2	$ 24,000
36	Install approximately 6 measurement devices	To Be Determined	2	$ 18,000
37	Re-grade ditch to increase capacity/consolidate parallel ditches	5,400 to 12,000	2	$ 60,000
LU Ranch Ditch System Improvements				
38	Install approximately 5,500 LF of 10” HDPE pipe	0.0 to 5,500	3	$ 200,000
Putney Ditch System Improvements.				
39	Install check/diversion structure in creek	0.0	1	$ 55,000
Robbins Ditch Improvement				
--	No improvements recommended	--	--	$ -
Wales Ditch System Improvements				
40	Rehabilitate diversion	0.0	2	$ 55,000
41	Install 30” underdrain culvert/re-grade ditch to repair gully erosion and sedimentation	125	1	$ 40,000
42	Replace 1.5ft Parshall flume	700	2	$ 2,000
43	Install check structure and gate to divert flow to Wales Reservoir	9,550	2	$ 25,000
Wilson Ditch System Improvements.				
44	Install check/diversion structure in creek	0.0	1	$ 55,000

Table 3.2-1
Wildlife/Livestock Watering Projects Plan

Project Number	Project Name	Water Source		Pipeline Length (ft)	Storage Tanks		Water Tanks (number)	Cost
		Springs (number)	Wells[1] (number)		Number	Size (gal)		
Grass Creek								
1	Upper Grass Creek Spirng Developments	5		1,000			5	$30,300
2	Mesaverde Water Supply Well #3 Conversion[2]		1					$39,300
3	Corral Relocation Project (includes new solar pump)[2]		(existing well)	1,700	1	2,200	3	$19,800
4	Grass Creek Spring Development	1		200			1	$6,100
5	NW Corner Grass Creek Basin		(existing well)	8,600			5	$32,400
6	Rankin Basin (includes new solar pump)		(existing well)	19,000	1	10,000	4	$69,200
7	East Basin		(existing well)	23,000			6	$67,400
8	North Ilo		1	10,000	1	8,000	3	$61,800
9	South Ilo	(existing spring)	(existing well)	20,000	1	10,000	5	$68,000
Little Grass Creek								
10	Little Grass Creek	2		23,700			6	$69,000
11	Grass Creek Divide	1		29,600			6	$64,700
Spring Gulch								
12	Adam Weiss North		1	11,000			4	$55,200
13	Adam Weiss North Extension		(existing well)	15,000			3	$41,600
14	Reds and Crook	1		20,800			4	$65,400
15	Spring Gulch and West Spring Gulch		1	17,700	1	10,000	6	$83,500
16	East Spring Gulch and North Spring Gulch		1	14,300			5	$56,700
Upper Cottonwood Creek								
17	Putney School Section	2		21,300			4	$52,900
18	Pats Draw/Putney Flat		1	22,900			5	$63,900
Twentyone Creek								
19	Dickie 21/Bear Creek	2		23,200			6	$68,100
Wagonhound Creek								
20	Wagonhound Extension and Prospect Connection	2		23,000			5	$61,000
21	Prospect Common South	1		23,000			5	$61,900
Prospect Creek								
22	Adam Weiss South		1	11,000			3	$52,600
23	North Prospect Common	3		14,600			5	$58,400
24	Prospect Extension	3		15,700			4	$41,900
25	Urwin/Wales/Otty	3		15,500			4	$41,400

[1] New wells include solar pump installations

[2] Well conversion, solar pump installation and new pipeline will serve both wildlife/livestock watering and irrigation of up to 60 acres

Table 3.3-1
Alternative Surface Water Storage Sites

Site Number	1	1A	2	4	5	7	9	10	11	12	13
Site Name	Grass Creek Causeway - Small	Grass Creek Causeway - Large	Putney Flat	Wales Reservoir Expansion	Wagonhound	Spring Gulch	Lower Grass Creek	LU Cow Camp	Prospect	Phelps Reservoir Reconstruction	Lake Creek Reservoir Rehabilitation
Locational Information											
USGS 7.5-minute Topographic Quadrangle	Adam Weiss Peak	Adam Weiss Peak	Crater Sink/ Twentyone Creek	Hamilton Dome	Hamilton Dome	Red Ridge	Blue Mesa West	Milk Creek/ Twentyone Creek	Gloin Reservoir	Adam Weiss Peak	Milk Creek
Tributary	Grass Creek/ Little Grass Creek	Grass Creek/ Little Grass Creek	Cottonwood Creek	Cottonwood Creek	Cottonwood/ Wagonhound Creek	Grass Creek	Grass Creek	Grass Creek	Cottonwood Creek	Grass Creek	Lake Creek
Onstream / Offstream	Onstream	Onstream	Onstream	Offstream	Onstream	Onstream	Onstream	Onstream	Onstream	Onstream	Onstream
Basin Characteristics and Hydrology											
Drainage Area (square miles)	47	47	72	4	149	100	138	24	197	33	4
Estimated PMF Flood Characteristics											
Estimated Peak Discharge (thousand cfs)	54	54	69	13	105	83	100	36	123	44	13
Estimated Runoff Volume (thousand acre-feet)	24	24	37	2	78	52	72	12	105	16	2
Annual Peak Flow Characteristics											
Region	Plains	Plains	Plains	Plains	Plains	Plains	Plains	Mountainous	Plains	Mountainous	Mountainous
Average Annual Precipitation (in)	14.0	14.0	13.0	10.5	10.5	11.0	10.0	15.0	10.0	14.5	16.0
Reservoir Characteristics and Operation											
Demand											
Dry Year Shortages (ac-ft)	1,800	1,800	4,800	3,000	2,000	200	100	1,800	1,700	1,800	5,200
Normal Year Shortages (ac-ft)	800	800	2,400	1,400	900	30	0	800	700	800	2,400
Normal High Water											
Capacity (acre-feet)	5,000	25,000	3,000	8,000	3,500	25,000	25,000	5,000	10,000	200	1,400
Surface Area (acres)	125	418	106	374	222	591	686	135	377	14	59
Water Surface Elevation	6,279	6,356	5,997	5,203	5,098	5,382	4,889	6,786	4,971	6,287	7,326
Average Water Depth (feet)	40	60	28	21	16	42	36	37	27	14	24
Site Geology											
Geology											
Karst											
Seepage											
Structure											
Liquefaction Potential											
Dispersive/Soluble Soils											
Foundation Strength											
Reservoir Rim Conditions											
Landslide Deposits											
Bedrock Geology Units	Qa, Klm, Kmv	Qa, Klm, Kmv	Qa, Qt, Kmv	Kc	Qa, Qt, Kmv, Kc	Kmv, Kc, Klm	Qa, Tfu	Qa, Kmv, Twl	Qa, Qt, Kmv, Kc	Qa	Qls, Tt, Ta
Surficial Geology Units	at, Rs	at, Rs	at, rsR	at, rsR, rsa	at, t, srR	at, Rsr, rsRa, srR	at, Rsr, t, srR	at, l	at, t, srR	at, Rs	l
Borrow											
Relative apparent availability											
Relative apparent quality											
Site Environmental Conditions											
Environmental Issues											
NWI Wetlands (acres)	17	30	1	6	5	4	3	1	39	1	5
Stream Classification	2AB	2AB	2AB		2C / 3B [3]	2AB	2AB	2AB	2C	2AB	2B
Sage Grouse Leks			x						x		x
Big Game Habitat - Crucial	Mule Deer, Elk	Mule Deer, Elk	Mule Deer	Mule Deer	Mule Deer	Mule Deer	Mule Deer, Antelope	Mule Deer, Elk	Mule Deer, Antelope	Mule Deer, Elk	Mule Deer
Big Game Parturition (Birthing Areas)											
Raptor Nesting Area							x				
Mineral Resources											
Coal Potential	Moderate	Moderate	Moderate/ Low	Low	Moderate/ Low	Moderate/ Low	Moderate	Moderate/ Low	Moderate/ Low	Moderate/ Low	Low
Uranium											
Sulfur											
Bentonite											
Infrastructure and Ownership											
Infrastructure/Utilities Conflicts											
Residences/Facilities	0	0	0	0	0	3	0	2	0	0	0
Highways (miles)	0	0	0	0	0	3	0	0	3.6	0	0
Railroads (miles)	0	0	0	0	0	0	0	0	0		
Pipelines (miles)	0	0	0	0	0	9	4	0	0	0	0
Transmission Lines1 (miles)	0	0	0	0	0	0	0	0	5	0	0
Transmission Lines2 (miles)	0	0	0	0	0	0	0	0	8	0	0
Distribution Lines1 (miles)	1.8	2.6	0	0	0	5.5	0	0	3.2	0	0
Irrigated Lands (acres)	0	0	2	0	21	2	0	0	0	0	0
Energy Resources											
Oil Field						x					
Gas Field											
Land Ownership											
Private	x	x	x	x	x	x	x	x	x	x	x
State	x	x		x		x		x		x	
Federal	x	x		x	x	x	x		x		
Dam Characteristics and Hydraulic Structures											
Dam											
Freeboard/Head on Spillway (ft)	15	15	12	5	15	15	15	15	15	5	5
Crest Elevation (feet)	6,294	6,371	6,009	5,208	5,113	5,397	4,904	6,801	4,986	6,292	7,331
Total Crest Length (feet)	1,291	1,789	1,162	6,630	2,657	3,768	4,454	1,161	2,539	713	640
Crest Width (ft)	20	20	20	20	20	20	20	20	20	18	20
Maximum Dam Height (feet)	98	175	89	77	61	127	119	116	91	32	45
Foundation Excavation Volume (thousand cy)	243	563	161	492	247	739	840	228	404	14	0
Total Earthwork Fill Volume (thousand cy)	999	3,518	602	1,482	736	3,329	3,635	999	1,511	43	36
Storage Efficiency (ac-ft/1000cy)	5.0	7.1	5.0	5.4	4.8	7.5	6.9	5.0	6.6	4.7	38.9
Height Efficiency (feet/thousand ac-ft)	19.6	7.0	29.7	9.6	17.5	5.1	4.8	23.2	9.1	161.0	32.2
Outlet Works											
Proposed Type	Cut/cover conduit	Cut/cover conduit	Cut/cover conduit	Cut/cover conduit	Cut/cover conduit	Cut/cover conduit	Cut/cover conduit	Cut/cover conduit	Cut/cover conduit		
Outlet Elevation (feet)	6,196	6,196	5,920	5,131	5,052	5,270	4,785	6,685	4,895	6,313	7,286
Service Spillway											
Design Capacity (cfs)	5,300	5,300	6,800	1,200	10,400	8,300	10,000	3,600	12,300	800	200
Approximate Width (feet)	24	24	43	28	47	38	45	16	56	19	5
Emergency Spillway											
Design Capacity (cfs)	48,387	48,387	61,955	11,660	94,434	74,887	90,273	32,756	110,966	0	0
Approximate Width (feet)	300	300	600	300	600	340	410	150	500	0	0
Approximate Length (feet)	1,000	1,500	1,100	1,800	2,300	1,300	1,200	1,200	900	0	0
Cut Volume (cy/1000)	800	1,900	200	0	800	1,500[1]	1,500[1]	1,000[1]	1,500[1]	500[1]	500[1]
Supply and Delivery Facilities											
Supply Diversions											
Length (miles)				1.4[2]							
Terrain											
Delivery Canals											
Length (miles)											
Terrain											
Other											
Access											
Cultural Resources			x								
Costing											
Total Project Cost	$ 13,800,000	$ 42,500,000	$ 10,200,000	$ 22,400,000	$ 12,400,000	$ 52,700,000	$ 49,400,000	$ 14,300,000	$ 31,000,000	$ 990,000	$ 850,000
Total Project Cost per cubic yard of fill	$ 13.83	$ 12.09	$ 16.93	$ 15.08	$ 16.82	$ 15.82	$ 13.60	$ 14.29	$ 20.52	$ 23.06	$ 23.59
Total Project Cost per ac-ft of storage	$ 2,765	$ 1,702	$ 3,397	$ 2,794	$ 3,537	$ 2,107	$ 1,978	$ 2,856	$ 3,102	$ 4,943	$ 607

Excellent or more than adequate
Favorable or adequate
Marginal or unfavorable value
Probable fatal flaw or very unfavorable value

[1] Cut volumes estimated
[2] Miles of ditch rehabilitation
[3] 2C - Cottonwood Creek / 3B - Wagonhound Creek

Table 3.3-2
Reservoir Capacity and Yield

Alternative Number	Name	Reservoir Capacity (ac-ft)	In Stream Total Available Dry Year (ac-ft)	"Dry Year" Irrigation Shortage Below Alternative Site (acre-ft)	Assumed Annual Reservoir Yield ¯ Dry Year (ac-ft)	In Stream Total Available Normal Year (ac-ft)	"Normal Year" Irrigation Shortage Below Alternative Site (acre-ft)	Assumed Annual Reservoir Yield ¯ Normal Year (ac-ft)
1	Grass Creek Causeway - Small	5,000	3,826	1,842	1,842	11893	777	777
1A	Grass Creek Causeway - Large	25,000	3,826	1842	Note 1	11893	777	Note 1
2	Putney Flat	3,000	1,002	4,777	2,000	1226	2,376	1,226
4	Wales Reservoir Expansion	8,000	-	1,720	1,720	-	708	708
5	Wagonhound	3,500	1,115	1,720	1,720	2895	708	708
7	Spring Gulch	25,000	3,913	168	Note 1	15345	26	Note 1
9	Lower Grass Creek	25,000	3,913	67	Note 1	15345	0	Note 1
10	LU Cow Camp	5,000	3,707	1,842	1,842	10084	777	777
11	Prospect	10,000	1,570	1,720	1,720	3569	708	708
12	Phelps Reservoir Reconstruction	200	3,707	1,842	200	10084	777	200
13	Lake Creek Reservoir Rehabilitation	1,400	83	5,153	750	958	2,411	950

Note: These projects are assumed to be multiple purpose - and could include exchange of water rights; assigning yield would require additional analysis

Table 3.3-3

Inflow Design Floods for Selected Dam and Reservoir Sites

Site	Site Name	Storage Capacity (ac-ft)	Inflow Design Flood (cfs)	
			PMF	100-yr Flood
1	Grass Creek Causeway - Small	5,000	54,000	
1A	Grass Creek Causeway - Large	25,000	54,000	
2	Putney Flat	3,000	69,000	
4	Wales Reservoir Expansion	8,000	13,000	
5	Wagonhound	3,500	105,000	
7	Spring Gulch	25,000	83,000	
9	Lower Grass Creek	25,000	100,000	
10	LU Cow Camp	5,000	36,000	
11	Prospect	10,000	123,000	
12	Phelps Reservoir Reconstruction	200		800
13	Lake Creek Reservoir Rehabilitation	1,400		200

Table 3.5-1
Potential Channel Restoration Strategies

Impairment	Restoration Strategy
Channel Degradation	Restoration of channel profile
	Structural rehabilitation measures
	Nonstructural rehabilitation measures
Bank Erosion	Structural rehabilitation measures
	Bioengineering rehabilitation solutions
	Nonstructural rehabilitation measures
	Revegetation
Grazing	Alternative water supplies
	Grazing management
	Riparian buffer zones
	Revegetation
	Water gaps

Table 5.3-1
Conceptual-Level Cost Estimate
Site 1 - Grass Creek Causeway (Small)

Cost Item	Cost Estimate	
Preparation of Final Designs and Specifications	$1,188,000	
Permitting	$143,000	
Mitigation	$136,000	
Legal Fees	$48,000	
Acquisition of Access and Rights of Way	$285,000	
Non-Construction Cost Total		***$1,800,000***
Project Components		
Mobilization	$546,000	
Dam	$6,173,000	
Spillway(s)	$1,470,000	
Outlet Works	$706,000	
Other	$611,000	
Construction Cost Subtotal #1		***$9,506,000***
Engineering Costs = CCS#1 x 10%	$950,600	
Subtotal #2		***$10,456,600***
Contigency = Subtotal #2 x 15%	$1,568,490	
Construction Cost Total		***$12,025,000***
Project Cost Total		***$13,825,000***
Less Level II/Phase III Costs [1]	$1,331,000	
Project Cost Used in Ability to Pay Analysis		***$12,494,000***

[1] Preparation of Final Designs and Specifications; and Permitting

Table 5.3-2
Conceptual-Level Cost Estimate
Site 1A - Grass Creek Causeway (Large)

Cost Item	Cost Estimate	
Preparation of Final Designs and Specifications	$3,672,000	
Permitting	$441,000	
Mitigation	$240,000	
Legal Fees	$147,000	
Acquisition of Access and Rights of Way	$881,000	
Non-Construction Cost Total		***$5,381,000***
Project Components		
Mobilization	$1,676,000	
Dam	$22,234,000	
Spillway(s)	$2,025,000	
Outlet Works	$2,430,000	
Other	$1,011,000	
Construction Cost Subtotal #1		***$29,376,000***
Engineering Costs = CCS#1 x 10%	$2,937,600	
Subtotal #2		***$32,313,600***
Contigency = Subtotal #2 x 15%	$4,847,040	
Construction Cost Total		***$37,161,000***
Project Cost Total		***$42,542,000***
Less Level II/Phase III Costs [1]	$4,113,000	
Project Cost Used in Ability to Pay Analysis		***$38,429,000***

[1] Preparation of Final Designs and Specifications; and Permitting

Table 5.3-3
Coneptual-Level Cost Estimate
Site 2 - Putney Flat

Cost Item	Cost Estimate	
Preparation of Final Designs and Specifications	$884,000	
Permitting	$106,000	
Mitigation	$114,000	
Legal Fees	$35,000	
Acquisition of Access and Rights of Way	$212,000	
Non-Construction Cost Total		***$1,351,000***
Project Components		
Mobilization	$401,000	
Dam	$3,793,000	
Spillway(s)	$1,686,000	
Outlet Works	$508,000	
Other	$683,000	
Construction Cost Subtotal #1		***$7,071,000***
Engineering Costs = CCS#1 x 10%	$707,100	
Subtotal #2		***$7,778,100***
Contigency = Subtotal #2 x 15%	$1,166,715	
Construction Cost Total		***$8,945,000***
Project Cost Total		***$10,296,000***
Less Level II/Phase III Costs [1]	$990,000	
Project Cost Used in Ability to Pay Analysis		***$9,306,000***

[1] Preparation of Final Designs and Specifications; and Permitting

Table 5.3-4
Conceptual-Level Cost Estimate
Site 4 - Wales Reservoir Expansion

Cost Item	Cost Estimate	
Preparation of Final Designs and Specifications	$1,936,000	
Permitting	$232,000	
Mitigation	$48,000	
Legal Fees	$77,000	
Acquisition of Access and Rights of Way	$465,000	
Non-Construction Cost Total		***$2,758,000***
<u>Project Components</u>		
Mobilization	$879,000	
Dam	$11,878,000	
Spillway(s)	$548,000	
Outlet Works	$740,000	
Other	$1,443,000	
Construction Cost Subtotal #1		***$15,488,000***
Engineering Costs = CCS#1 x 10%	$1,548,800	
Subtotal #2		***$17,036,800***
Contigency = Subtotal #2 x 15%	$2,555,520	
Construction Cost Total		***$19,592,000***
Project Cost Total		***$22,350,000***
Less Level II/Phase III Costs [1]	$2,168,000	
Project Cost Used in Ability to Pay Analysis		***$20,182,000***

[1] Preparation of Final Designs and Specifications; and Permitting

Table 5.3-5
Conceptual-Level Cost Estimate
Site 5 - Wagonhound

Cost Item	Cost Estimate	
Preparation of Final Designs and Specifications	$1,071,000	
Permitting	$129,000	
Mitigation	$40,000	
Legal Fees	$43,000	
Acquisition of Access and Rights of Way	$257,000	
Non-Construction Cost Total		***$1,540,000***
Project Components		
Mobilization	$487,000	
Dam	$5,096,000	
Spillway(s)	$1,843,000	
Outlet Works	$415,000	
Other	$728,000	
Construction Cost Subtotal #1		***$8,569,000***
Engineering Costs = CCS#1 x 10%	$856,900	
Subtotal #2		***$9,425,900***
Contigency = Subtotal #2 x 15%	$1,413,885	
Construction Cost Total		***$10,840,000***
Project Cost Total		***$12,380,000***
Less Level II/Phase III Costs [1]	$1,200,000	
Project Cost Used in Ability to Pay Analysis		***$11,180,000***

[1] Preparation of Final Designs and Specifications; and Permitting

Table 5.3-6
Conceptual-Level Cost Estimate
Site 7 - Spring Gulch

Cost Item	Cost Estimate	
Preparation of Final Designs and Specifications	$4,570,000	
Permitting	$548,000	
Mitigation	$32,000	
Legal Fees	$183,000	
Acquisition of Access and Rights of Way	$1,097,000	
Non-Construction Cost Total		***$6,430,000***
Project Components		
Mobilization	$2,071,000	
Dam	$24,209,000	
Spillway(s)	$1,968,000	
Outlet Works	$1,914,000	
Other	$6,401,000	
Construction Cost Subtotal #1		***$36,563,000***
Engineering Costs = CCS#1 x 10%	$3,656,300	
Subtotal #2		***$40,219,300***
Contigency = Subtotal #2 x 15%	$6,032,895	
Construction Cost Total		***$46,252,000***
Project Cost Total		***$52,682,000***
Less Level II/Phase III Costs [1]	$5,118,000	
Project Cost Used in Ability to Pay Analysis		***$47,564,000***

[1] Preparation of Final Designs and Specifications; and Permitting

Table 5.3-7
Conceptual-Level Cost Estimate
Site 9 - Lower Grass Creek

Cost Item	Cost Estimate	
Preparation of Final Designs and Specifications	$4,289,000	
Permitting	$515,000	
Mitigation	$24,000	
Legal Fees	$172,000	
Acquisition of Access and Rights of Way	$1,029,000	
Non-Construction Cost Total		***$6,029,000***
Project Components		
Mobilization	$1,944,000	
Dam	$26,766,000	
Spillway(s)	$2,125,000	
Outlet Works	$1,829,000	
Other	$1,652,000	
Construction Cost Subtotal #1		***$34,316,000***
Engineering Costs = CCS#1 x 10%	$3,431,600	
Subtotal #2		***$37,747,600***
Contigency = Subtotal #2 x 15%	$5,662,140	
Construction Cost Total		***$43,410,000***
Project Cost Total		***$49,439,000***
Less Level II/Phase III Costs [1]	$4,804,000	
Project Cost Used in Ability to Pay Analysis		***$44,635,000***

[1] Preparation of Final Designs and Specifications; and Permitting

Table 5.3-8
Conceptual-Level Cost Estimate
Site 10 - LU Cow Camp

Cost Item	Cost Estimate	
Preparation of Final Designs and Specifications	$1,239,000	
Permitting	$149,000	
Mitigation	$8,000	
Legal Fees	$50,000	
Acquisition of Access and Rights of Way	$297,000	
Non-Construction Cost Total		***$1,743,000***
Project Components		
Mobilization	$561,000	
Dam	$6,148,000	
Spillway(s)	$1,273,000	
Outlet Works	$799,000	
Other	$1,129,000	
Construction Cost Subtotal #1		***$9,910,000***
Engineering Costs = CCS#1 x 10%	$991,000	
Subtotal #2		***$10,901,000***
Contigency = Subtotal #2 x 15%	$1,635,150	
Construction Cost Total		***$12,536,000***
Project Cost Total		***$14,279,000***
Less Level II/Phase III Costs [1]	$1,388,000	
Project Cost Used in Ability to Pay Analysis		***$12,891,000***

[1] Preparation of Final Designs and Specifications; and Permitting

Table 5.3-9
Conceptual-Level Cost Estimate
Site 11 - Prospect

Cost Item	Cost Estimate	
Preparation of Final Designs and Specifications	$2,665,000	
Permitting	$320,000	
Mitigation	$312,000	
Legal Fees	$107,000	
Acquisition of Access and Rights of Way	$640,000	
Non-Construction Cost Total		***$4,044,000***
Project Components		
Mobilization	$1,225,000	
Dam	$10,383,000	
Spillway(s)	$2,116,000	
Outlet Works	$944,000	
Other	$6,654,000	
Construction Cost Subtotal #1		***$21,322,000***
Engineering Costs = CCS#1 x 10%	$2,132,200	
Subtotal #2		***$23,454,200***
Contigency = Subtotal #2 x 15%	$3,518,130	
Construction Cost Total		***$26,972,000***
Project Cost Total		***$31,016,000***
Less Level II/Phase III Costs [1]	$2,985,000	
Project Cost Used in Ability to Pay Analysis		***$28,031,000***

[1] Preparation of Final Designs and Specifications; and Permitting

Table 5.3-10
Conceptual-Level Cost Estimate
Site 12 - Phelps Reservoir Reconstruction

Cost Item	Cost Estimate	
Preparation of Final Designs and Specifications	$85,000	
Permitting	$10,000	
Mitigation	$8,000	
Legal Fees	$3,000	
Acquisition of Access and Rights of Way	$20,000	
Non-Construction Cost Total		***$126,000***
Project Components		
Mobilization	$39,000	
Dam	$285,000	
Spillway(s)	$169,000	
Outlet Works	$61,000	
Other	$127,000	
Construction Cost Subtotal #1		***$681,000***
Engineering Costs = CCS#1 x 10%	$68,100	
Subtotal #2		***$749,100***
Contigency = Subtotal #2 x 15%	$112,365	
Construction Cost Total		***$861,000***
Project Cost Total		***$987,000***
Less Level II/Phase III Costs [1]	$95,000	
Project Cost Used in Ability to Pay Analysis		***$892,000***

[1] Preparation of Final Designs and Specifications; and Permitting

Table 5.3-11
Conceptual-Level Cost Estimate
Site 13 - Lake Creek Reservoir Rehabilitation

Cost Item	Cost Estimate	
Preparation of Final Designs and Specifications	$83,000	
Permitting	$8,000	
Mitigation	$40,000	
Legal Fees	$3,000	
Acquisition of Access and Rights of Way	$17,000	
Non-Construction Cost Total		***$151,000***
Project Components		
Mobilization	$34,000	
Dam	$0	
Spillway(s)	$129,000	
Outlet Works	$100,000	
Other	$290,000	
Construction Cost Subtotal #1		***$553,000***
Engineering Costs = CCS#1 x 10%	$55,300	
Subtotal #2		***$608,000***
Contigency = Subtotal #2 x 15%	$91,200	
Construction Cost Total		***$699,000***
Project Cost Total		***$850,000***
Less Level II/Phase III Costs [1]	$91,000	
Project Cost Used in Ability to Pay Analysis		***$759,000***

[1] Preparation of Final Designs and Specifications; and Permitting

Table 5.3-12
Alternative Projects Cost Summary

Site	Site Name	Storage Capacity (ac-ft)	Total Project Cost	Cost/Acre-ft Storage
1	Grass Creek Causeway - Small	5,000	$13,800,000	$2,800
1A	Grass Creek Causeway - Large	25,000	$42,500,000	$1,700
2	Putney Flat Alternative A	3,000	$10,200,000	$3,400
4	Wales Reservoir Expansion	8,000	$22,400,000	$2,800
5	Wagonhound Alternative A	3,500	$12,400,000	$3,500
7	Spring Gulch	25,000	$52,700,000	$2,100
9	Lower Grass Creek	25,000	$49,400,000	$2,000
10	LU Cow Camp	5,000	$14,300,000	$2,900
11	Prospect	10,000	$31,000,000	$3,100
12	Phelps Reservoir Reconstruction	200	$990,000	$5,000
13	Lake Creek Reservoir Rehabilitation	1,400	$850,000	$600

Table 6.2-1
Summary of Maximum Potential Benefits of Project Alternatives

Alternative Number	Name	Reservoir Capacity (ac-ft)	In Stream Total Available Dry Year (ac-ft)	"Dry Year" Irrigation Shortage Below Alternative Site (acre-ft)	Assumed Annual Reservoir Yield - Dry Year (ac-ft)	In Stream Total Available Normal Year (ac-ft)	"Normal Year" Irrigation Shortage Below Alternative Site (acre-ft)	Assumed Annual Reservoir Yield - Normal Year (ac-ft)	Maximum Potential Annual Benefits From Supplemental Irrigation Only ($ per year)	Maximum Potential Present Value of All Direct Irrigation Benefits ($)	Maximum Potential Value of Direct and Indirect Irrigation Benefits ($)
1	Grass Creek Causeway - Small	5000	3,826	1,842	1,842	11,893	777	777	21,400	460,000	1,546,000
1A	Grass Creek Causeway - Large	25000	3,826	1,842	1,842	11,893	777	Note 1	Note 1	Note 1	Note 1
2	Putney Flat	3000	1,002	4,777	2,000	1,226	2,376	1,226	29,100	625,000	2,100,000
4	Wales Reservoir Expansion	8000	-	1,720	1,720	-	708	708	19,700	423,000	1,421,000
5	Wagonhound	3500	1,115	1,720	1,720	2,895	708	708	19,700	423,000	1,421,000
7	Spring Gulch	25000	3,913	168	Note 1	15,345	26	Note 1	Note 1	Note 1	Note 1
9	Lower Grass Creek	25000	3,913	67	Note 1	15,345	0	Note 1	Note 1	Note 1	Note 1
10	LU Cow Camp	5000	3,707	1,842	1,842	10,084	777	777	21,400	460,000	1,546,000
11	Prospect	10000	1,570	1,720	1,720	3,569	708	708	19,700	423,000	1,421,000
12	Phelps Reservoir Reconstruction	200	3,707	1,842	200	10,084	777	200	4,100	88,000	296,000
13	Lake Creek Reservoir Rehabilitation	1400	83	5,153	750	958	2,411	950	18,400	395,000	1,327,000

Note 1 Analysis of associated economic benefits including multi-purpose uses and exchange with users below the confluence of Grass Creek and Cottonwood Creek is beyond the scope of this effort.

Note 2 Analysis assumes no new area placed under irrigation; interest rate of 4.0% assumed, for fifty years

Table 6.3-1A
Summary of Ability to Pay for Project Alternatives - 67 % Grant

Alternative Number	Site	Level III Project Cost ($ Millions)	Sponsor's Share of Project Costs ($ Millions)	Sponsor's Annual Payment ($)	Sponsor's Maximum Ability to Pay ($)	Sponsor's Percentage Ability to Pay (%)
1	Grass Creek Causeway - Small	12.5	4.12	191,900	10,700	5.6
1A	Grass Creek Causeway - Large	38.4	12.68	590,300	Note 1	Note 1
2	Putney Flat	9.3	3.07	143,000	14,600	10.2
4	Wales Reservoir Expansion	20.2	6.66	310,000	9,900	3.2
5	Wagonhound	11.2	3.69	171,700	9,900	5.8
7	Spring Gulch	47.6	15.70	730,700	Note 1	Note 1
9	Lower Grass Creek	44.6	14.73	685,700	Note 1	Note 1
10	LU Cow Camp	12.9	4.25	198,000	10,700	5.4
11	Prospect	28.0	9.25	430,600	9,900	2.3
12	Phelps Reservoir Reconstruction	1.0	0.33	15,200	2,100	13.8
13	Lake Creek Reservoir Rehabilitation	0.9	0.28	13,100	9,200	70.2

Table 6.3-1B
Summary of Ability to Pay for Project Alternatives - 75 % Grant

Alternative Number	Site	Level III Project Cost ($ Millions)	Sponsor's Share of Project Costs ($ Millions)	Sponsor's Annual Payment ($)	Sponsor's Maximum Ability to Pay ($)	Sponsor's Percentage Ability to Pay (%)
1	Grass Creek Causeway - Small	12.5	3.12	145,400	10,700	7.4
1A	Grass Creek Causeway - Large	38.4	9.61	447,200	Note 1	Note 1
2	Putney Flat	9.3	2.33	108,300	14,600	13.5
4	Wales Reservoir Expansion	20.2	5.05	234,900	9,900	4.2
5	Wagonhound	11.2	2.80	130,100	9,900	7.6
7	Spring Gulch	47.6	11.89	553,500	Note 1	Note 1
9	Lower Grass Creek	44.6	11.16	519,400	Note 1	Note 1
10	LU Cow Camp	12.9	3.22	150,000	10,700	7.1
11	Prospect	28.0	7.01	326,200	9,900	3.0
12	Phelps Reservoir Reconstruction	1.0	0.25	11,500	2,100	18.3
13	Lake Creek Reservoir Rehabilitation	0.9	0.21	9,900	9,200	92.9

Table 6.3-1C
Summary of Ability to Pay for Project Alternatives - 90 % Grant

Alternative Number	Site	Level III Project Cost ($ Millions)	Sponsor's Share of Project Costs ($ Millions)	Sponsor's Annual Payment ($)	Sponsor's Maximum Ability to Pay ($)	Sponsor's Percentage Ability to Pay (%)
1	Grass Creek Causeway - Small	12.5	1.25	58,200	10,700	18.4
1A	Grass Creek Causeway - Large	38.4	3.84	178,900	Note 1	Note 1
2	Putney Flat	9.3	0.93	43,300	14,600	33.7
4	Wales Reservoir Expansion	20.2	2.02	93,900	9,900	10.5
5	Wagonhound	11.2	1.12	52,000	9,900	19.0
7	Spring Gulch	47.6	4.76	221,400	Note 1	Note 1
9	Lower Grass Creek	44.6	4.46	207,800	Note 1	Note 1
10	LU Cow Camp	12.9	1.29	60,000	10,700	17.8
11	Prospect	28.0	2.80	130,500	9,900	7.6
12	Phelps Reservoir Reconstruction	1.0	0.10	4,600	2,100	45.7
13	Lake Creek Reservoir Rehabilitation	0.9	0.09	4,000	9,200	230.0

Note 1 — Analysis of associated economic benefits including multi-purpose uses and exchange with users below the confluence of Grass Creek and Cottonwood Creek is beyond the scope of this effort.

Table 6.3-2
Annual Costs by Alternative Storage Sites

Site Number	Site Name	Irrigated Lands Served[1] (ac)	Annual Cost Per Acre Served			Assumed Yield[2] (ac-ft)	Annual Cost Per Acre-Foot Yield		
			With 67 Percent Grant ($/ac)	With 75 Percent Grant ($/ac)	With 90 Percent Grant ($/ac)		With 67 Percent Grant ($/ac-ft)	With 75 Percent Grant ($/ac-ft)	With 90 Percent Grant ($/ac-ft)
1	Grass Creek Causeway - Small	1,948	$99	$75	$30	1,842	$104	$79	$32
1A	Grass Creek Causeway - Large	1,948	$303	$230	$92	Note 1	Note 1	Note 1	Note 1
2	Putney Flat Alternative A	2,526	$57	$43	$17	2,000	$72	$54	$22
4	Wales Reservoir Expansion	1,422	$218	$165	$66	1,720	$180	$137	$55
5	Wagonhound Alternative A	1,226	$140	$106	$42	1,720	$100	$76	$30
7	Spring Gulch	974	$750	$568	$227	Note 1	Note 1	Note 1	Note 1
9	Lower Grass Creek	917	$748	$566	$227	Note 1	Note 1	Note 1	Note 1
10	LU Cow Camp	1,948	$102	$77	$31	1,842	$107	$81	$33
11	Prospect	1,015	$424	$321	$129	1,720	$250	$190	$76
12	Phelps Reservoir Reconstruction	1,948	$8	$6	$2.00	200	$76	$58	$23
13	Lake Creek Reservoir Rehabilitation	2,644	$5	$4	$1.51	750	$17	$13	$5

[1] "Irrigated lands served" is the sum of all existing irrigated lands located downstream from the reservoir to the confluence with the Bighorn River.

[2] The "assumed yield" is the estimated dry-year yield as presented in Table 6.2-1.

Note 1: Analysis of associated economic benefits including multi-purpose uses and exchange with users below the confluence of Grass Creek and Cottonwood Creek is beyond the scope of this effort.

Table 6.4-1

Primary Potential Funding Sources

Agency/Entity	Program Name	Project Type(s)	Internet Site	Telephone	Email
Local					
Hot Springs Conservation District	n/a	Liaison, in-kind administrative and technical assistance, program coordination/partnering	http://www.conservewy.com/wacd/districts/hotsprings.html	307.864.3488	carla.thomas@wy.nacdnet.net
Washakie County Conservation District	n/a	Liaison, in-kind administrative and technical assistance, program coordination/partnering	http://www.conservewy.com/wccd.htm	307.347.2456	
Worland Grazing District	Range Improvement Fund	Range and related improvements			wsgb@wyoming.com
Hot Springs County Weed and Pest District	n/a	Noxious weed and undesirable plant control		307.864.2278	hscwpcd@rtconnect.net
Washakie County Weed and Pest District	n/a	Noxious weed and undesirable plant control	http://www.conservewy.com/wccd.htm	307.347.8582	wcwp@rtconnect.net
State					
Wyoming Department of Environmental Quality	Nonpoint Source Implementation Grants (319 Program)	Water quality BMPs	http://deq.state.wy.us/wqd/watershed/index.asp	307.777.5622	
Wyoming Game and Fish Department	Riparian Habitat Improvement Grant	Stock water development; streambank stabilization; etc.	http://gf.state.wy.us	307.777.4565	gbutle@state.wy.us
	Water Development/Maintenance Habitat Project Grant	Water developments (springs, windmills, guzzlers, pumps, etc.)			
	Upland Development Grant	Range management; prescribed burns			
	Fish Wyoming	Public fishing opportunities			
	Wyoming Sage Grouse Conservation Fund	Sage-grouse habitat protection or improvement			
Wyoming Office of State Lands and Investments	Regular Farm Loans	Projects involving most agricultural purposes	http://slf-web.state.wy.us/admin/slib.aspx	307.777.7331	lboomg@state.wy.us
	Small Water Development Project Loans.	Converson of dry land to irrigated land and/or water use efficiency improvements			
Wyoming Water Development Commission	Wyoming Water Development Program	Planning, design and construciton of new reservoir storage and rehabiliation of existing reservoir storage projects	http://wwdc.state.wy.us/opcrit/final_opcrit.pdf	307.777.7626	jwade@state.wy.us
	Small Water Project Program	Small reservoirs and stock ponds, wells, pipelines/conveyance, spring developments, windmills, wetland developments			rvore@state.wy.us
Wyoming Wildlife and Natural Resource Trust	n/a	Aquatic and wildlife habitat improvement, including water developments, prescribed burns, invasive plant control, etc.	http://wwnrt.state.wy.us/	307.856.4665	
Federal					
Bureau of Land Management	Riparian Habitat Management Program	Projects to maintain, restore, improve, protect and expand riparian/wetland areas	http://www.blm.gov/wy/st/en.html	307.775.6092 (Rick Schuler)	
	Cooperative Agreement for Range Improvements	Reservoirs, pits, spring developments, wells, and associated distribution pipelines	http://www.blm.gov/wy/st/en/field_offices/Worland.html	307.347.5100 (Worland District Office); 307.775.6194 (State Office)	worland_wymail@blm.gov
Bureau of Reclamation	Water 2025 Challenge Grant Program	Water conservation, efficiency and marketing	http://www.doi.gov/water2025/	307.261.5671	jlawson@gp.usbr.gov
Environmental Protection Agency	Targeted Watershed Grants Program	Riparian, wetland, aquatic and upland habitat protection and improvement	http://www.epa.gov/owow/funding/watershedfunding.html		
Farm Service Agency	Conservation Reserve Program (CRP)	Removal of highly erobible lands from production	http://www.fsa.usda.gov/FSA/stateoffapp?mystate=wy&area=home&subject=landing&topic=landing	307.347.2456	james.donahue@wy.usda.gov
	Continuous Sign-Up for High Priority Conservation Practices	Riparian buffers, filter strips, grass waterways, salt tolerant vegetation, shallow water areas for wildlife, etc.			
	Emergency Conservation Program (ECO)	Emergency livestock watering conservation during severe drought			
Fish and Wildlife Service	Partners for Wildlife Habitat Restoration	Various fish and wildlife habitat restoration projects	http://ecos.fws.gov/partners/viewContent.do?viewPage=home	307.332.8719	mark_j_hogan@mail.fws.gov
	North American Wetlands Conservation Act Program	Various wetlands conservation projects	http://www.fws.gov/birdhabitat/Grants/NAWCA/index.shtm		
	Landowner Incentive Program (Non-Tribal)	Funding to WGFD to support above project types			
Natural Resources Conservation Service	Environmental Quality Incentives Program	Conservation planning, range management, irrigation rehabilitation, livestock watering, etc.	http://www.nrcs.usda.gov/PROGRAMS/EQIP	307.864.3488 (Thermopolis) 307.347.2456 (Worland)	jim.mischke@wy.usa.gov rory.karhu@wy.usa.gov
	Watershed Protection and Flood Prevention Program	Water supply, water quality control, erosion and sediment control, wetland creation and restoration, fish and wildlife habitat enhancement, flood control, public recreation, etc.	http://www.nrcs.usda.gov/programs/watershed/index.html		
	Wildlife Habitat Incentives Program (WHIP)	See websites and/or local contacts for detailed information on these programs	http://www.nrcs.usda.gov/programs/whip/		
	Wetlands Reserve Program (WRP)		http://www.nrcs.usda.gov/programs/wrp/		
	Grassland Reserve Program (GRP)		http://www.nrcs.usda.gov/programs/GRP/		
	Conservation Security Program (CSP)		http://www.nrcs.usda.gov/programs/csp/		
	Farm and Ranchlands Protection Program (FRPP)		http://www.nrcs.usda.gov/programs/frpp/		
	Emergency Watershed Protection (ERP)		http://www.nrcs.usda.gov/programs/ewp/		
	Sage Grouse Restoration Project (SGRP)		http://sgrp.usu.edu/		
	Grazing Lands Conservation Initiative (GLCI) Grants		http://www.nrcs.usda.gov/programs/glci/		
Non-Profit and Other Organizations					
Ducks Unlimited	n/a	Waterfowl aquatic and upland habitat protection, restoration and enhancement	http://www.ducks.org/Page1856.aspx	307.472.6980	floyd@trib.com
National Fish and Wildlife Foundation	Pulling Together Initiative	Long-term weed management projects	http://www.nfwf.org/AM/Template.cfm?Section=Grants	202.857.0166	info@nfwf.org
	Native Plant Conservation Initiative	Restoration of native plant communities			
	Bring Back the Natives Grant Program	Riverine habitat and aquatic species restoration projects			
	Five-Star Restoration Program	Wetland and riparian habitat restoration projects			
Trout Unlimited	Watershed Restoration	Erosion control, fish habitat structures, willow and other riparian plantings, etc.	http://www.tu.org/site/c.kkLRJ7MSKtH/b.3083033/k.64AA/Watershed_Restoration.htm	307.733.6991	kbuchner@wyoming.com

Figures

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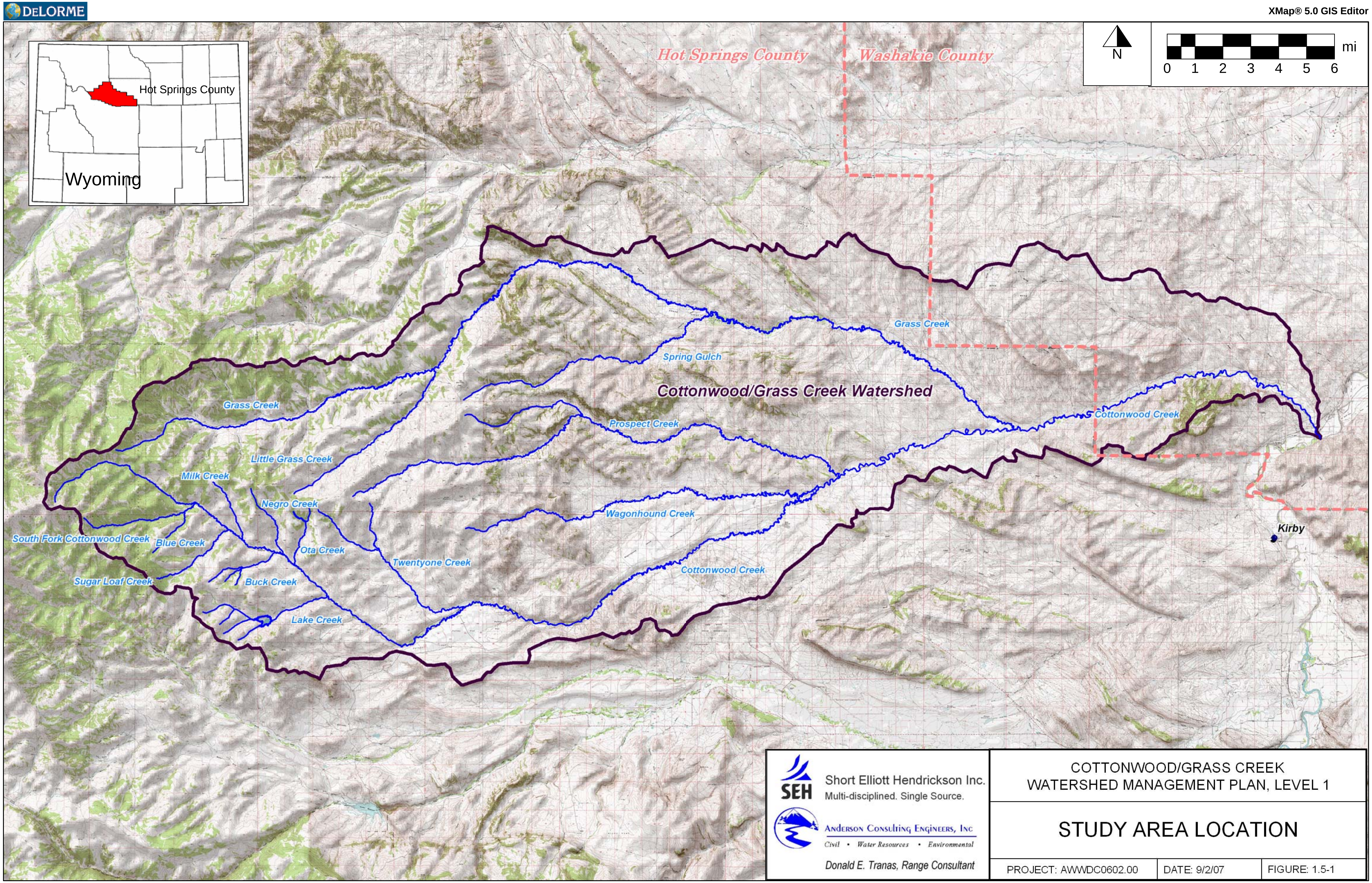

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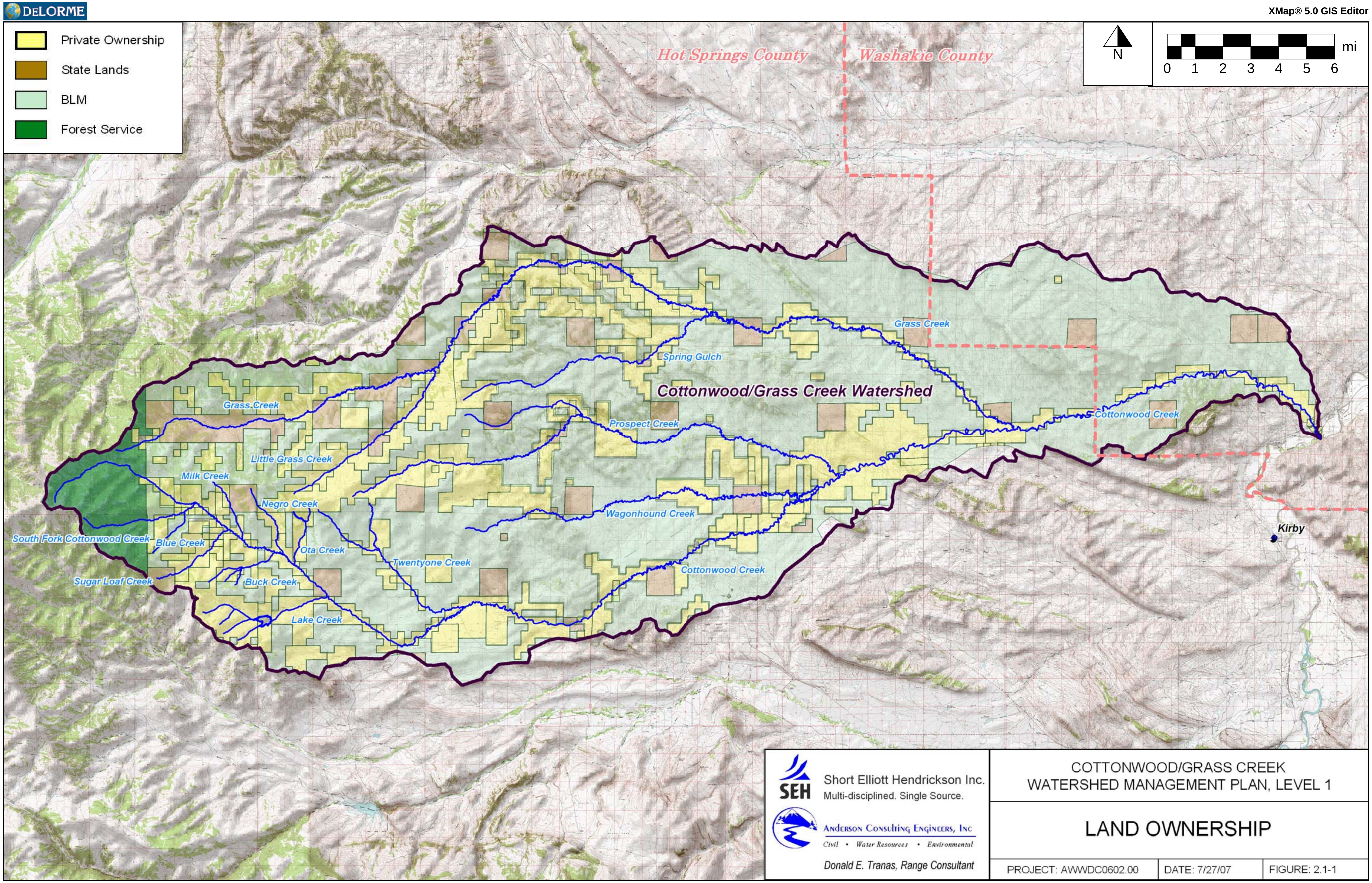
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

STUDY AREA LOCATION

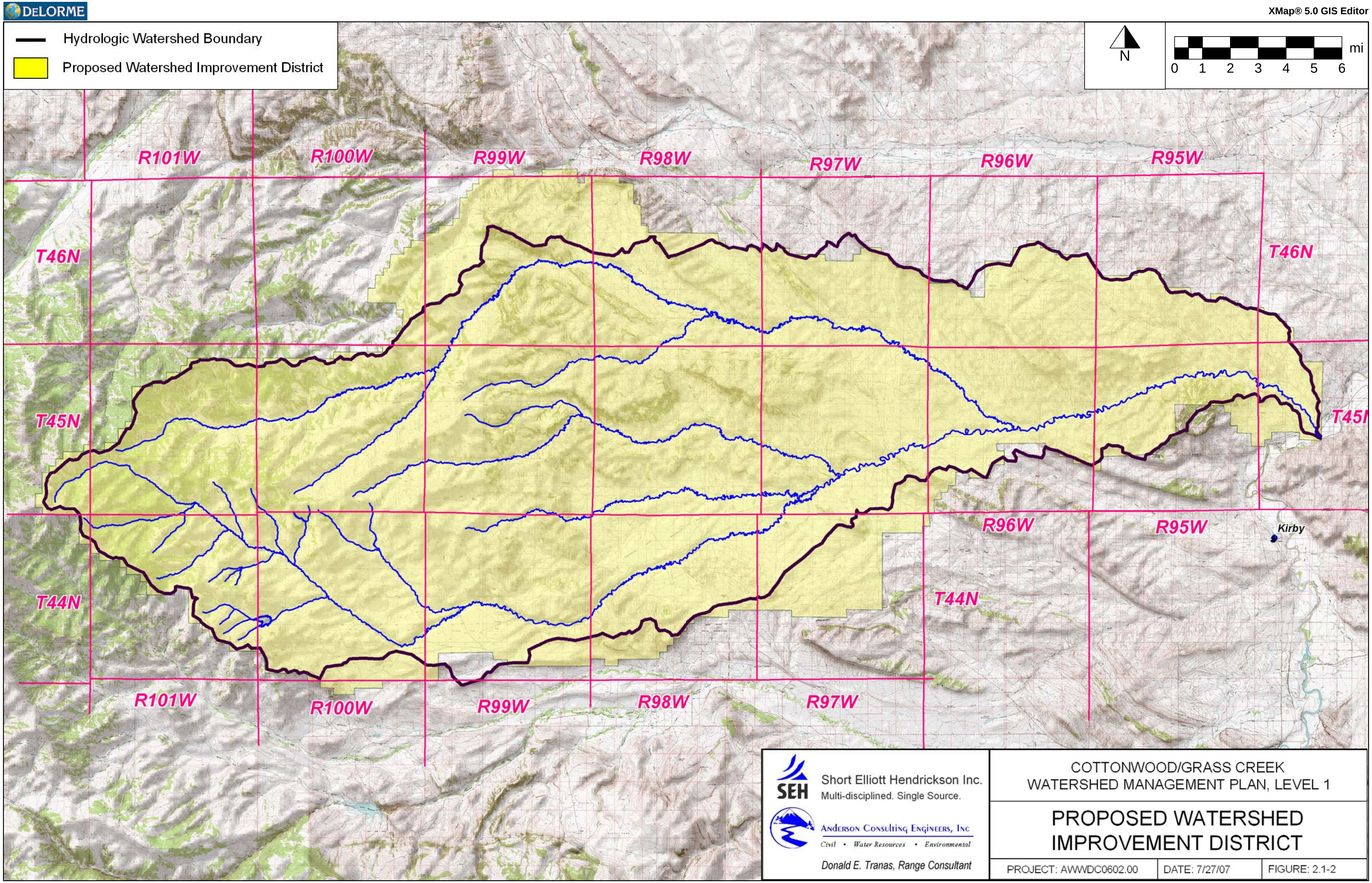
PROJECT: AWWDC0602.00 | DATE: 9/2/07 | FIGURE: 1.5-1



COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

LAND OWNERSHIP

PROJECT: AWWDC0602.00 | DATE: 7/27/07 | FIGURE: 2.1-1


DeLorme
XMap® 5.0 GIS Editor
Hydrologic Watershed Boundary
Proposed Watershed Improvement District
N
0 1 2 3 4 5 6 mi
R101W
R100W
R99W
R98W
R97W
R96W
R95W
T46N
T45N
T44N
Kirby
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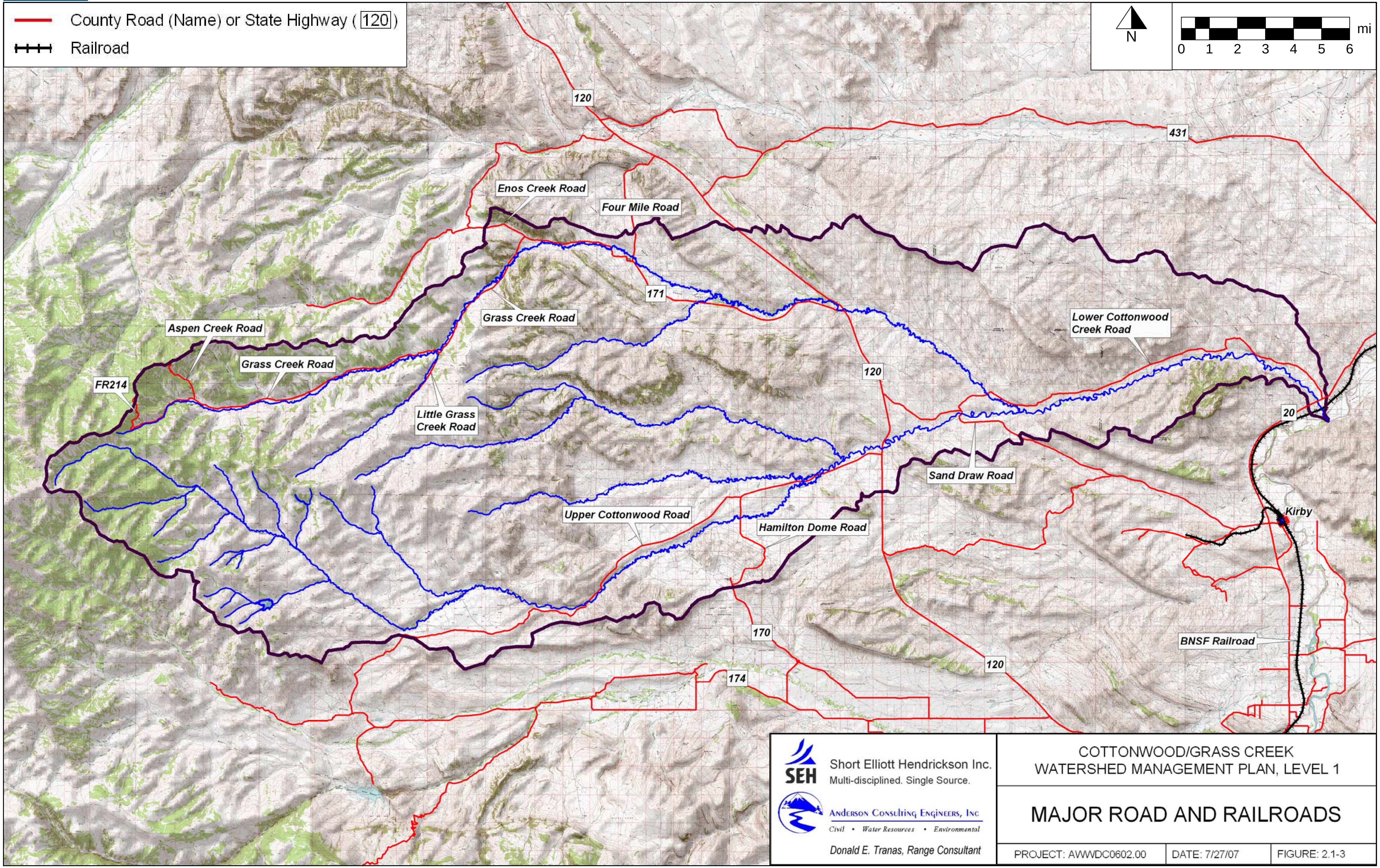
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1
PROPOSED WATERSHED
IMPROVEMENT DISTRICT
PROJECT: AWWDC0602.00
DATE: 7/27/07
FIGURE: 2.1-2

XMap® 5.0 GIS Editor



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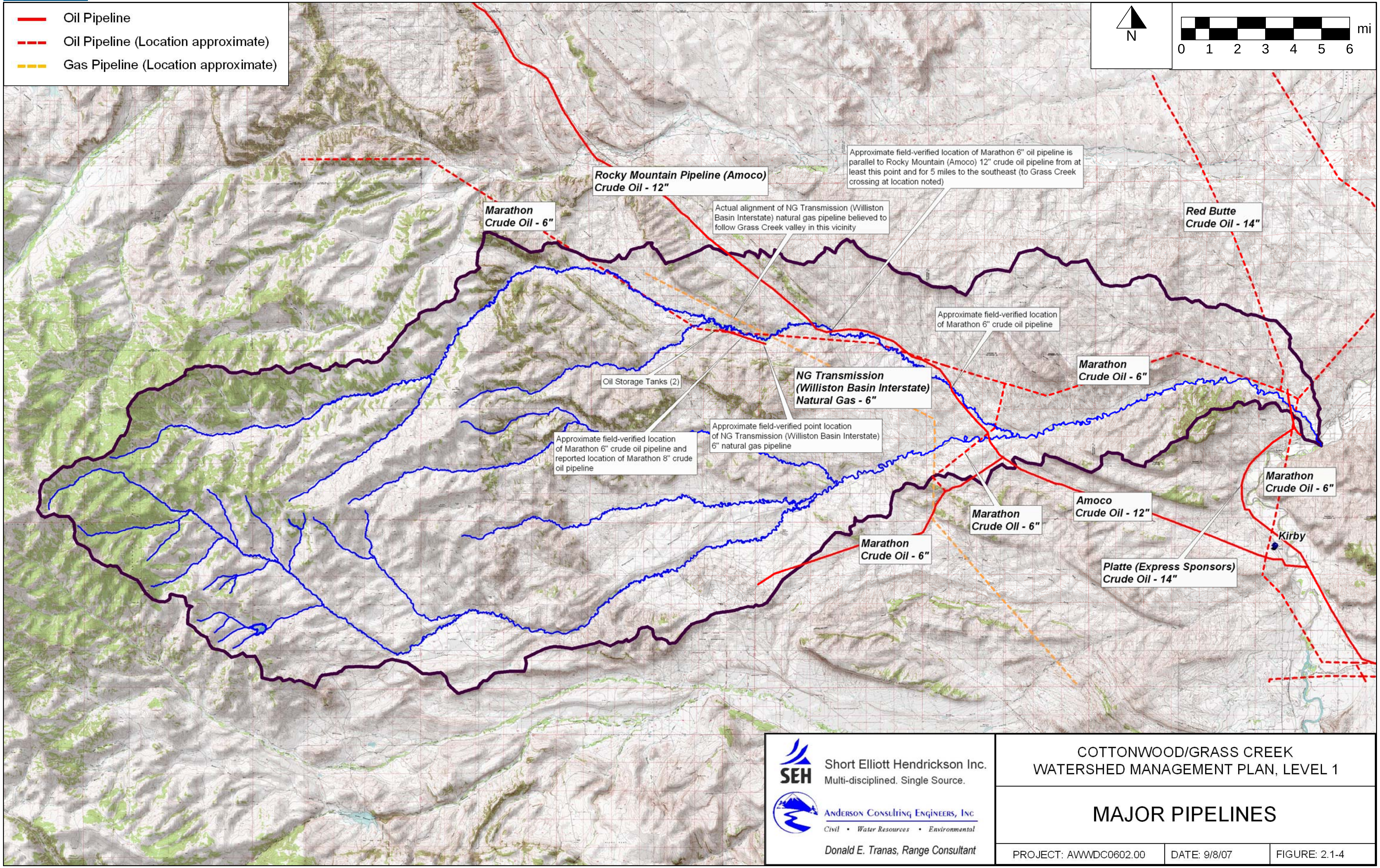
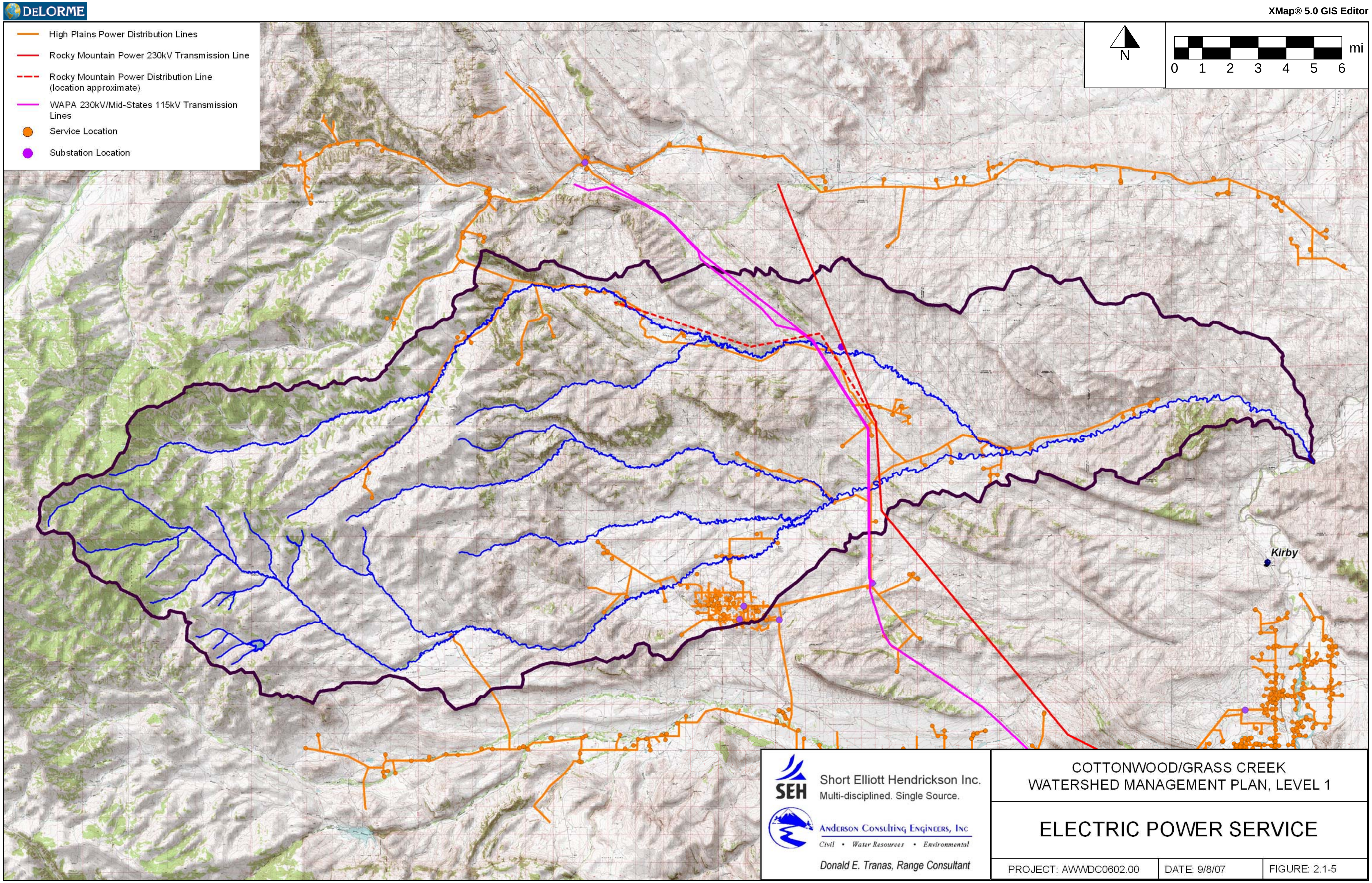
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

MAJOR ROAD AND RAILROADS

PROJECT: AWWDC0602.00 | DATE: 7/27/07 | FIGURE: 2.1-3

XMap® 5.0 GIS Editor





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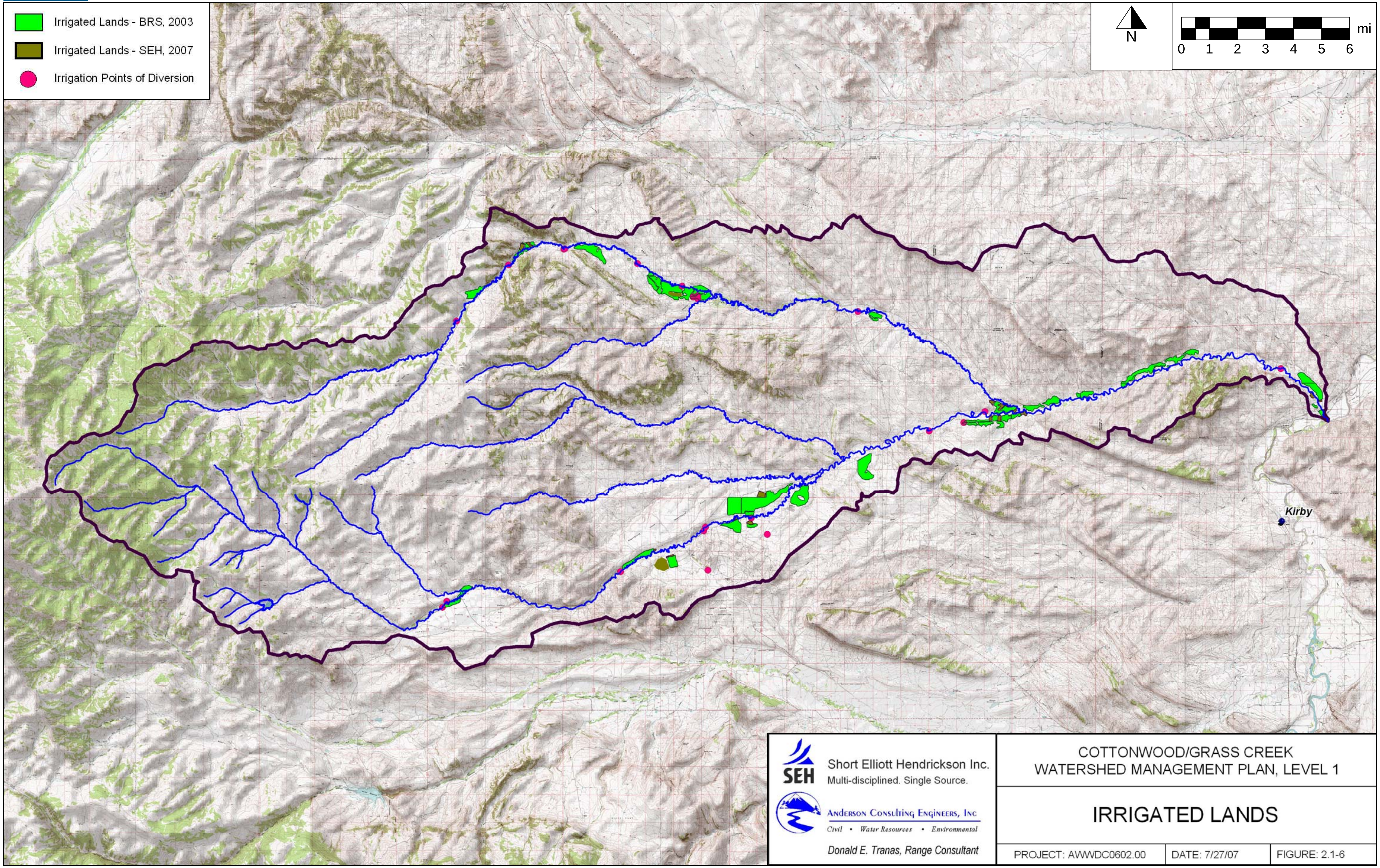
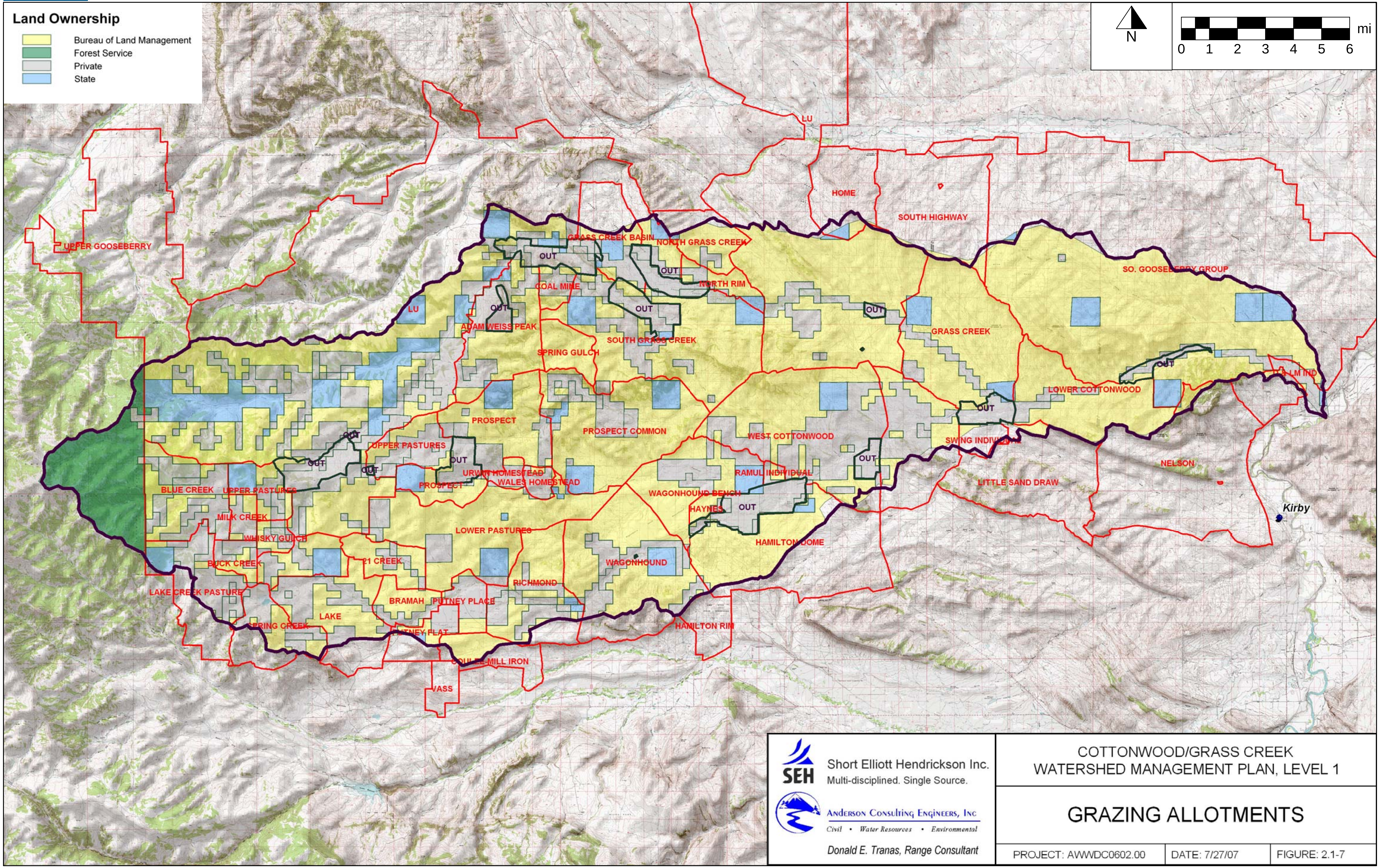
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

ELECTRIC POWER SERVICE

PROJECT: AWWDC0602.00 | DATE: 9/8/07 | FIGURE: 2.1-5

XMap® 5.0 GIS Editor





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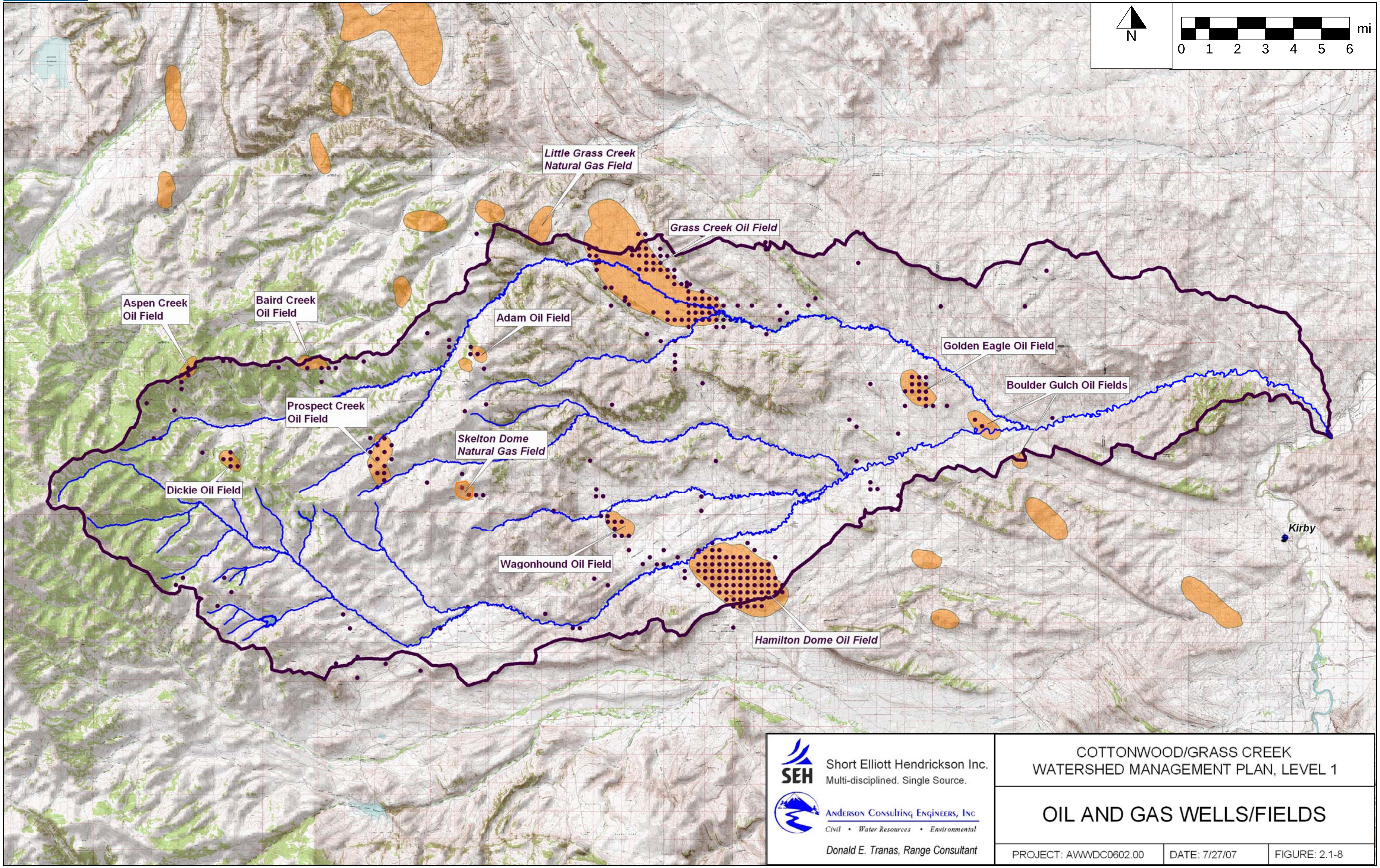
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

GRAZING ALLOTMENTS

PROJECT: AWWDC0602.00 | DATE: 7/27/07 | FIGURE: 2.1-7

XMap® 5.0 GIS Editor



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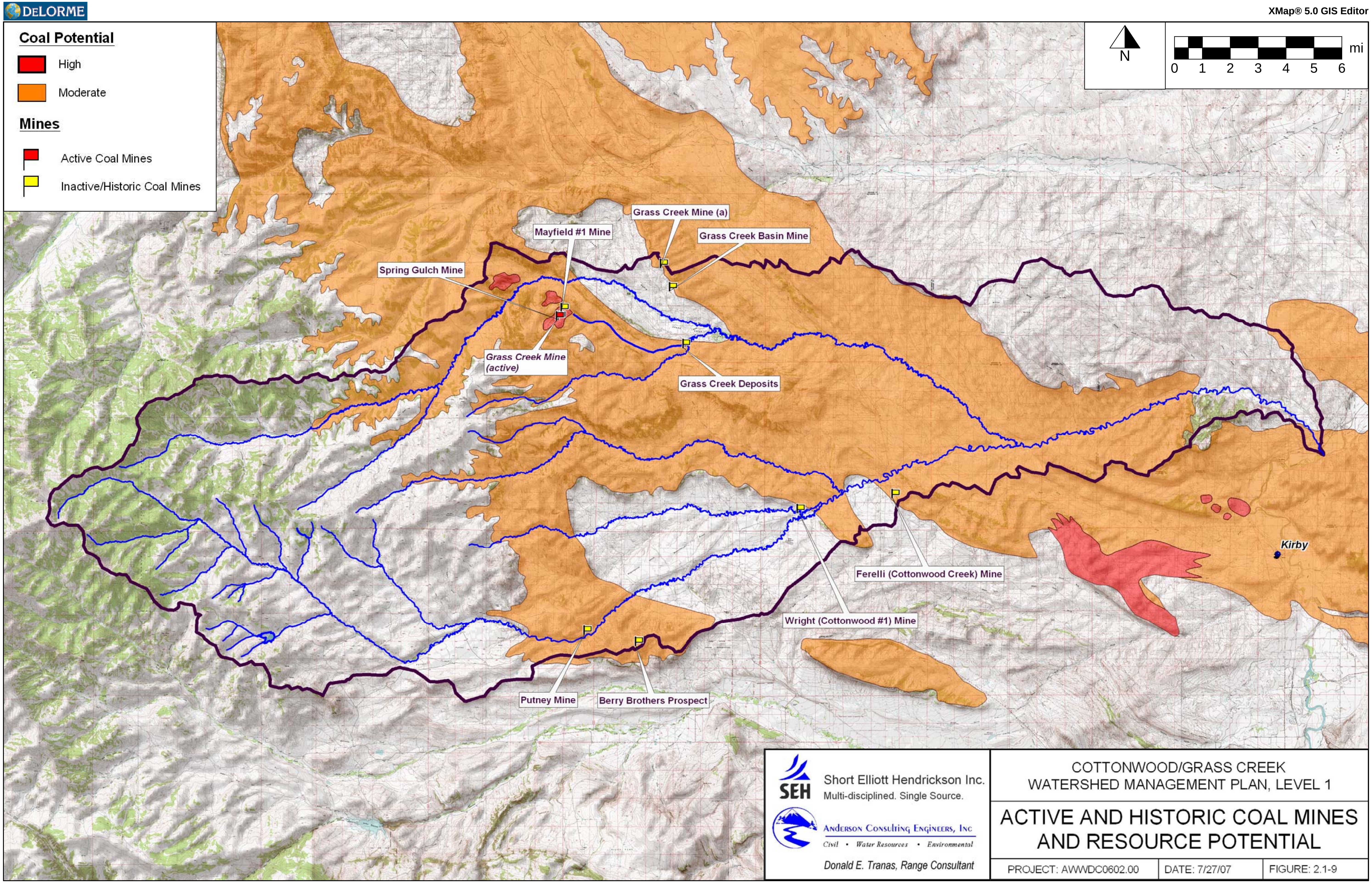
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

OIL AND GAS WELLS/FIELDS

PROJECT: AWWDC0602.00 | DATE: 7/27/07 | FIGURE: 2.1-8


DeLorme
XMap® 5.0 GIS Editor
Coal Potential
High
Moderate
Mines
Active Coal Mines
Inactive/Historic Coal Mines
N
0 1 2 3 4 5 6 mi
Grass Creek Mine (a)
Mayfield #1 Mine
Grass Creek Basin Mine
Spring Gulch Mine
Grass Creek Mine (active)
Grass Creek Deposits
Ferelli (Cottonwood Creek) Mine
Kirby
Wright (Cottonwood #1) Mine
Putney Mine
Berry Brothers Prospect
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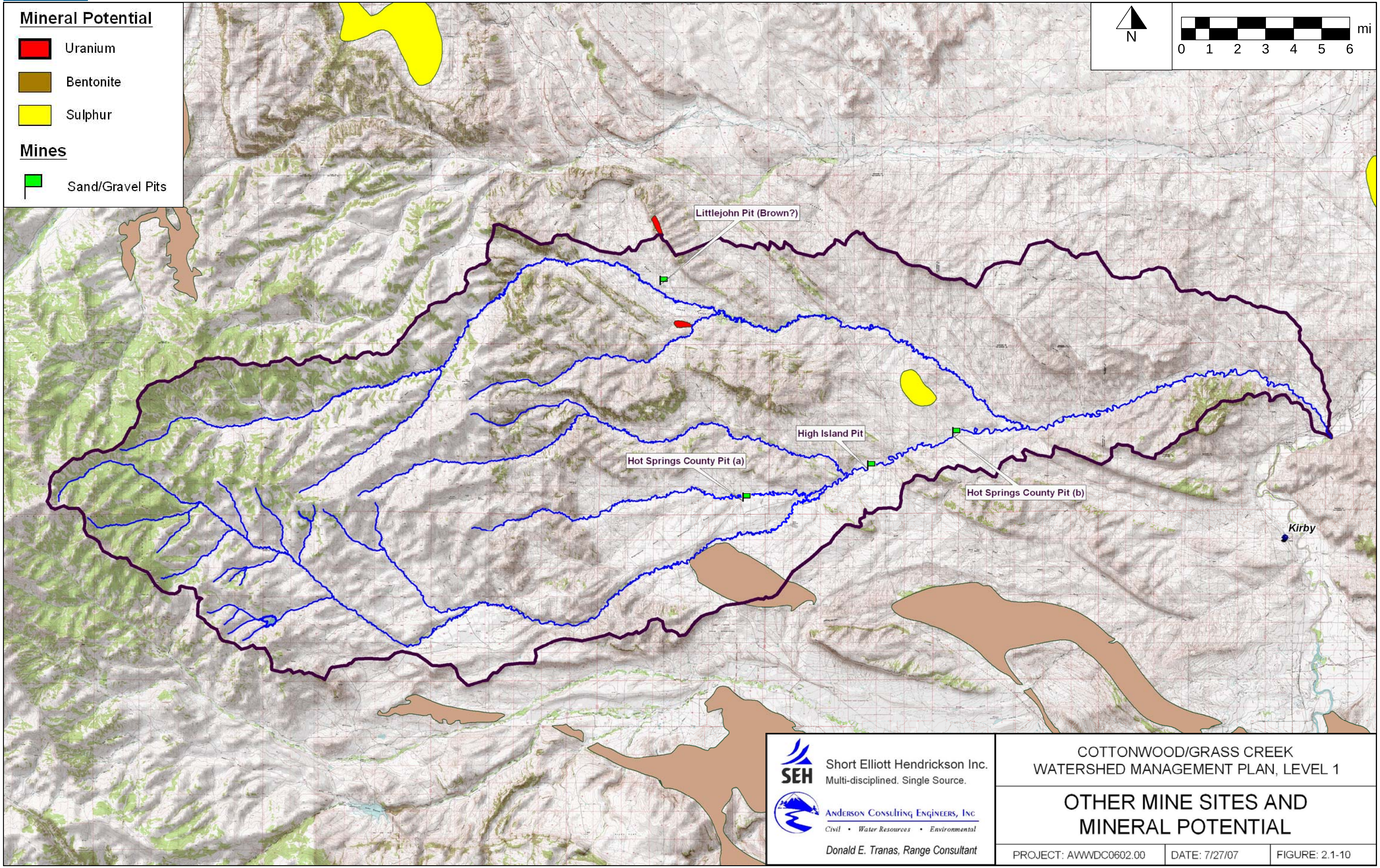
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1
ACTIVE AND HISTORIC COAL MINES AND RESOURCE POTENTIAL
PROJECT: AWWDC0602.00
DATE: 7/27/07
FIGURE: 2.1-9



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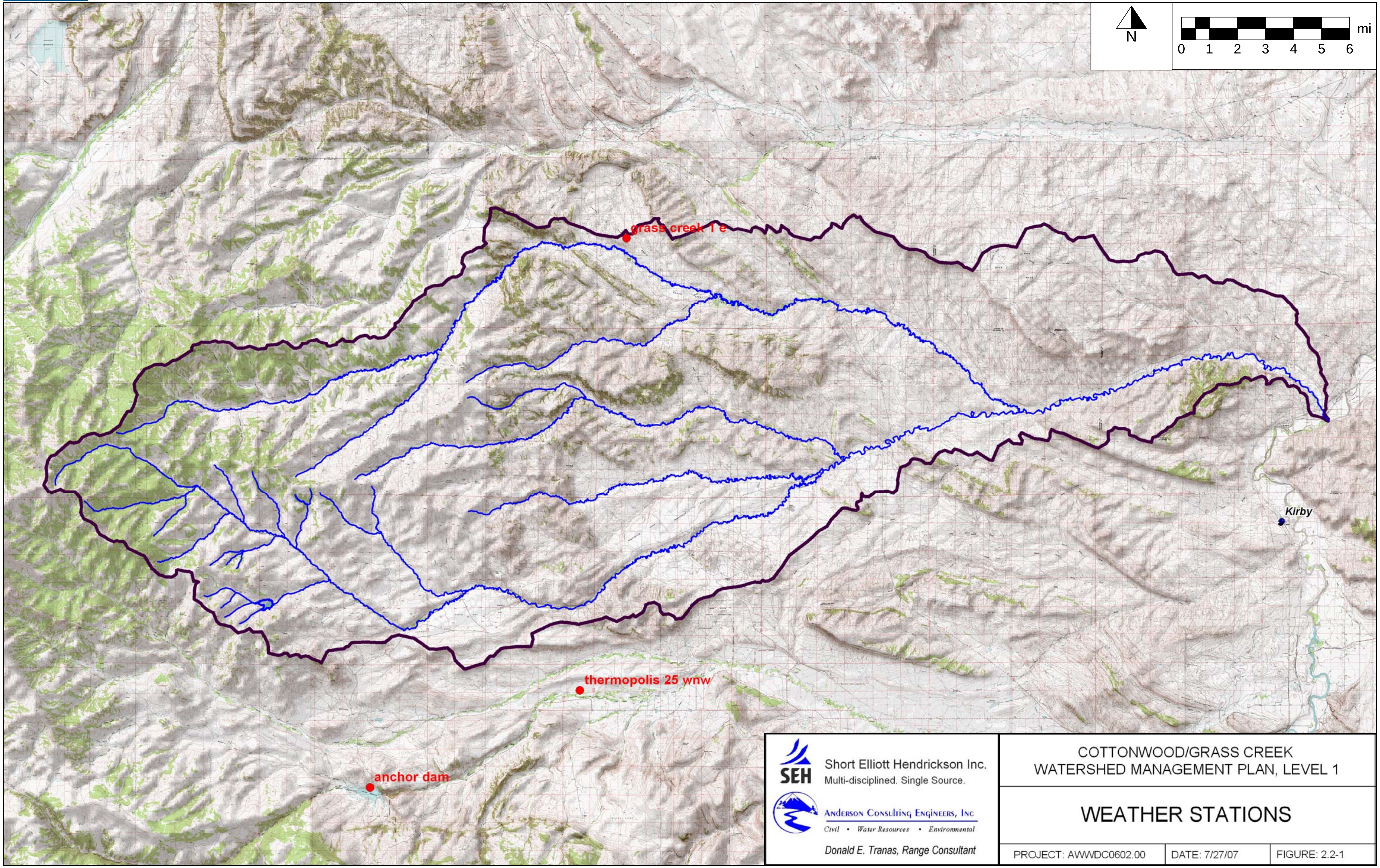
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

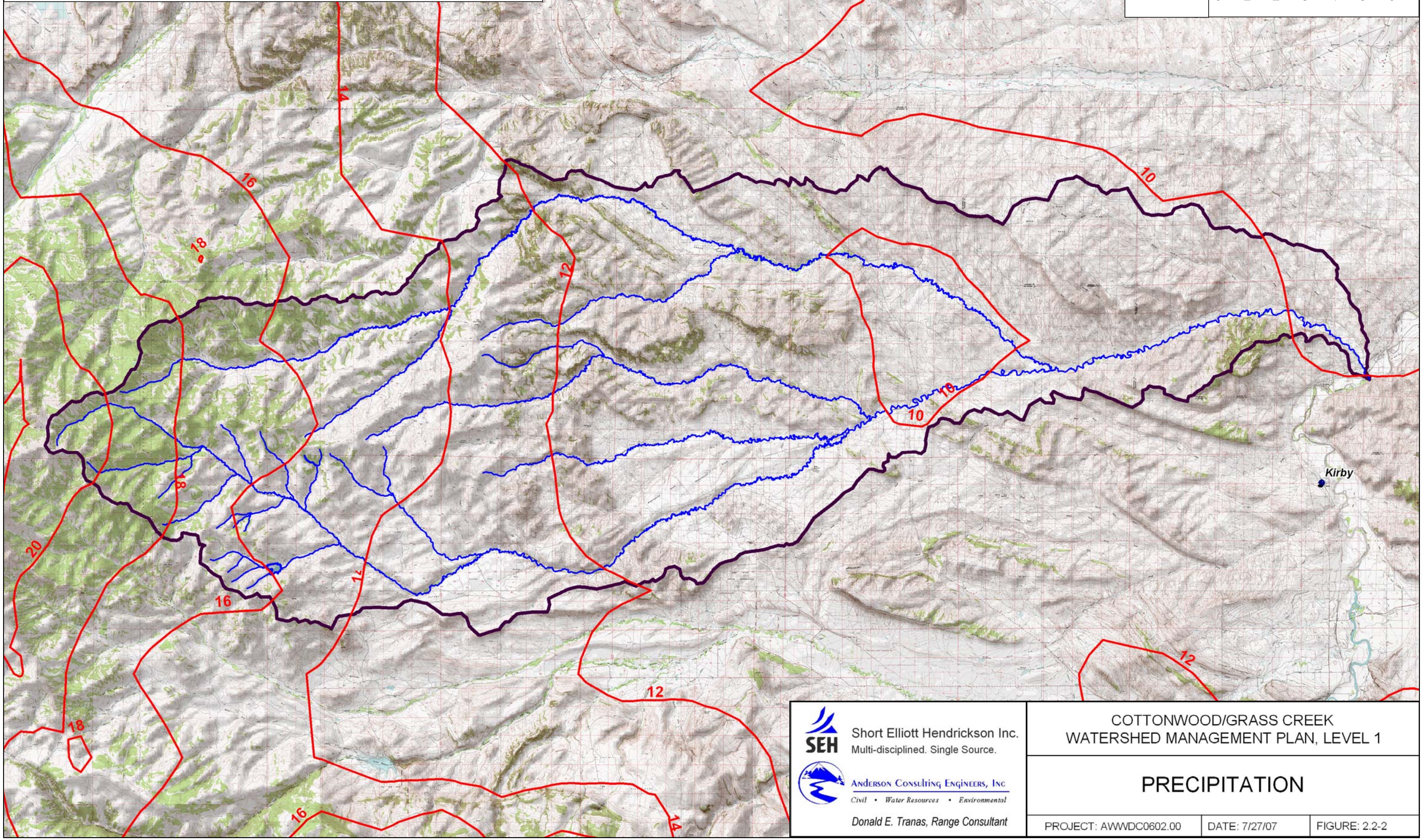
OTHER MINE SITES AND MINERAL POTENTIAL

PROJECT: AWWDC0602.00 | DATE: 7/27/07 | FIGURE: 2.1-10

XMap® 5.0 GIS Editor

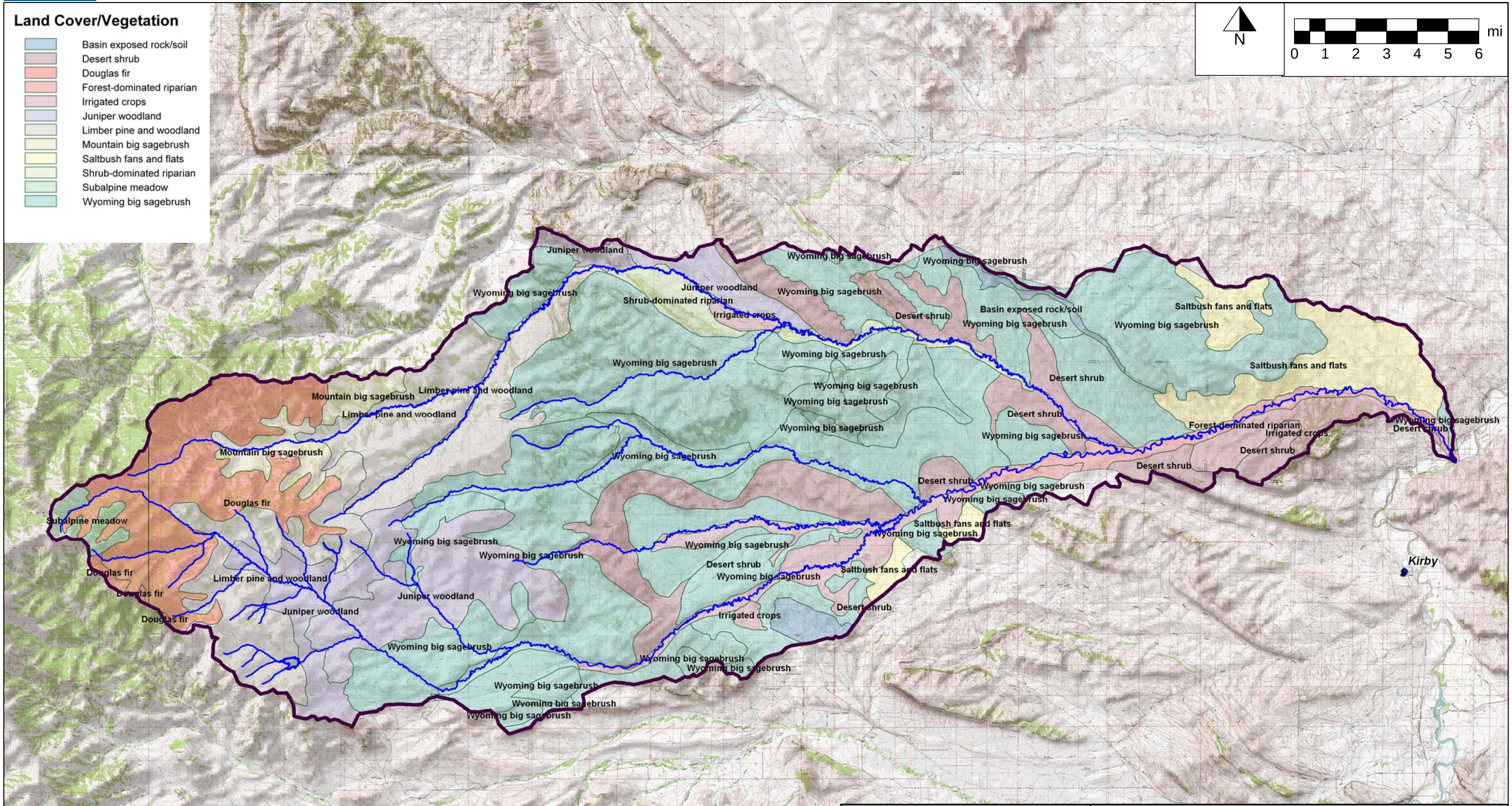


Isohyetals of mean annual precipitation (in.)



DeLORME

XMap® 5.0 GIS Editor



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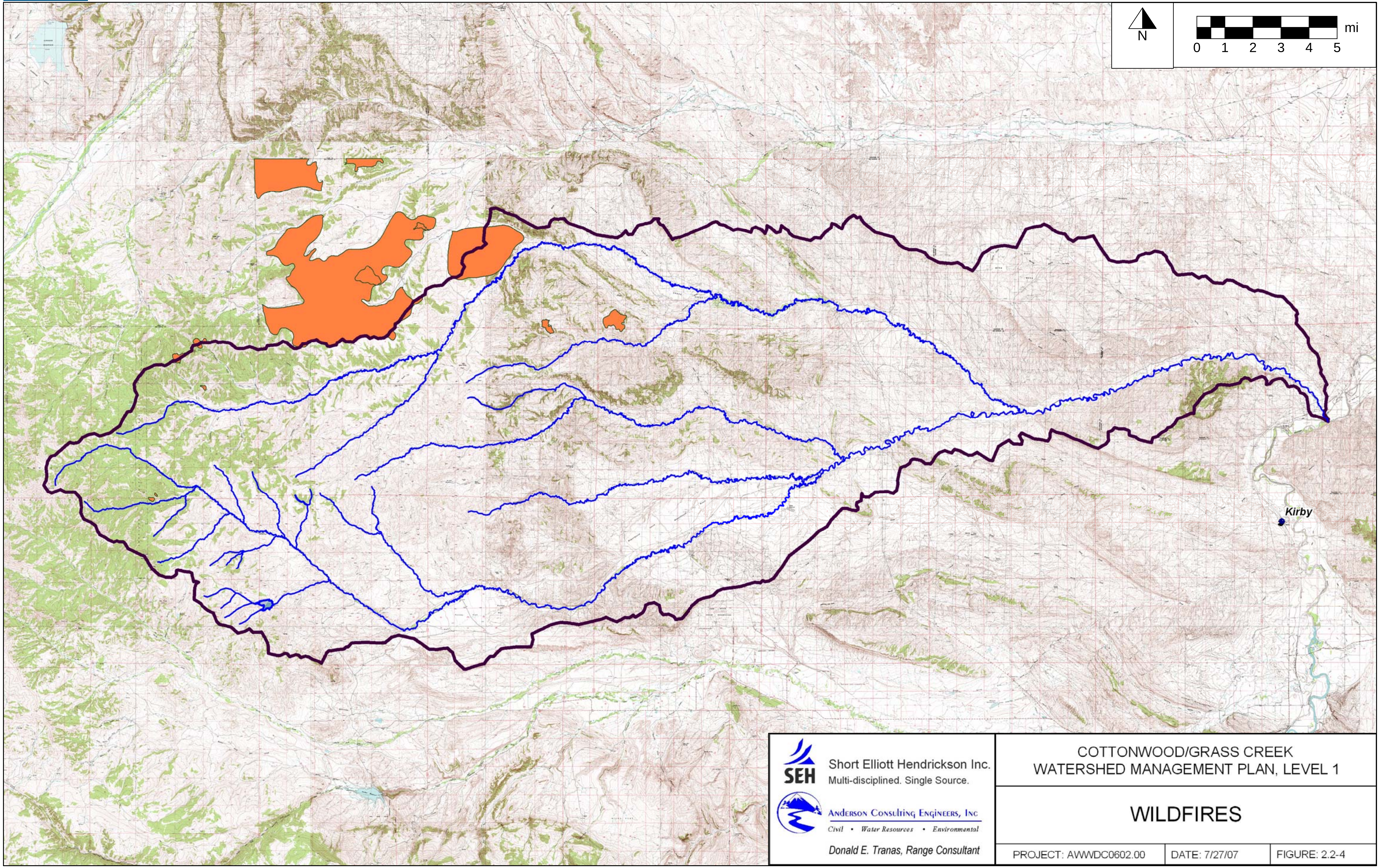
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

LAND COVER/VEGETATION

PROJECT: AWWDC0602.00 | DATE: 7/27/07 | FIGURE: 2.2-3

DeLORME

XMap® 5.0 GIS Editor



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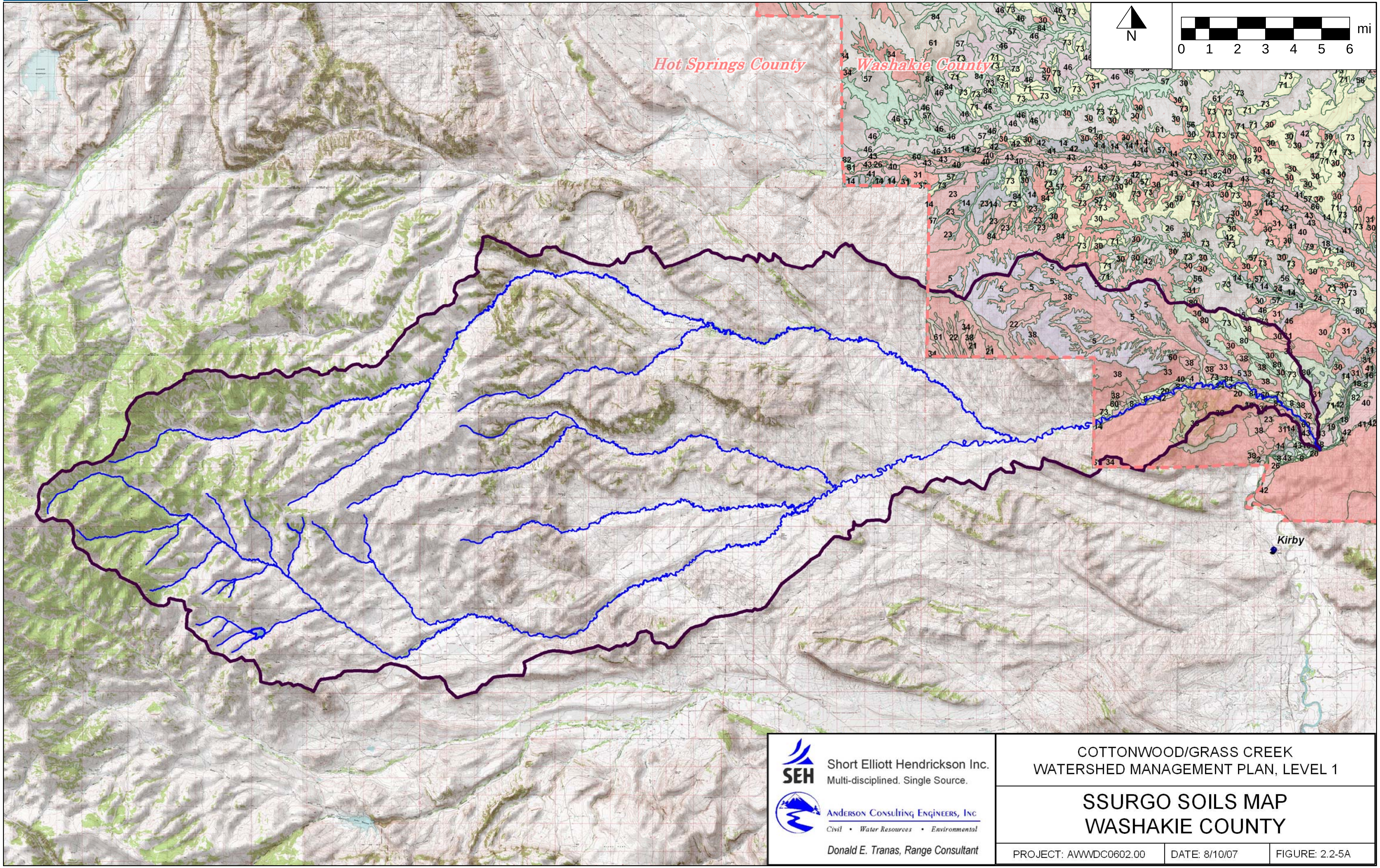
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

WILDFIRES

PROJECT: AWWDC0602.00 | DATE: 7/27/07 | FIGURE: 2.2-4

DeLORME

XMap® 5.0 GIS Editor



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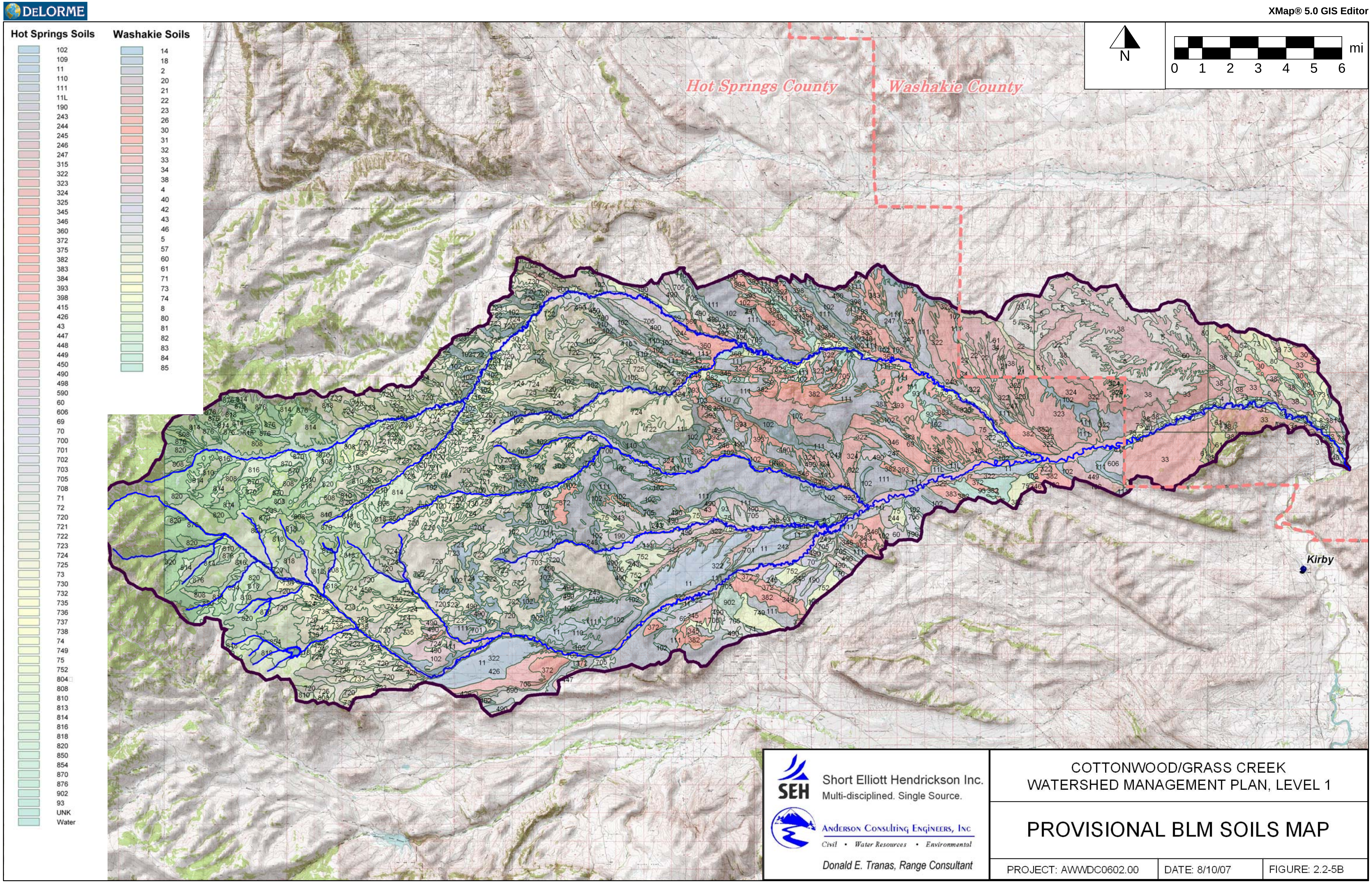
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

SSURGO SOILS MAP
WASHAKIE COUNTY

PROJECT: AWWDC0602.00 | DATE: 8/10/07 | FIGURE: 2.2-5A

Washakie County Soils Key (to accompany Figure 2.2-5A)

Soil Num	Mapunit Name	Surface Texture	MU Slope Range	Slope (low)	Slope (high)	rangesite	Precip. Zone	depth	drainage	Data Source
1	ABSTED(35%)-FORKWOOD(30%)-SHINGLE(10%) ASSOCIATION	vfsl,vfsl,cl	1-25	1	25	Ly,Ly,SwCy	10-14	D	wd	SoilSurvey
10	BURNETTE(35%)-LUCKY STAR(25%)-WALLROCK(15%) ASSOCIATION	l,stvl,sl	2-20	2	20	Ly, Ly, Sb	15-19	D,D,D	wd,wd,sp	SoilSurvey
11	CHITTUM(45%)-ROCK OUTCROP(20%)-BACHUS(10%) ASSOCIATION	grl,ro,l	2-25	2	25	SwLy,RO,Ly	15-19	S,RO,MD	wd,ro,wd	SoilSurvey
12	CLAYBURN(35%)-BACHUS(30%)-INCHAU(15%) ASSOCIATION	l,l,l	2-25	2	25	Ly,Ly,Ly	15-19	D,MD,MD	wd,wd,wd	SoilSurvey
13	CLAYBURN(40%)-WALLROCK(20%)-BURNETTE(15%)ASSOCIATION	l,sl,l	2-25	2	25	Ly,Sb,Ly	15-19	D,D,D	wd,sp,wd	SoilSurvey
14	CLIFTERSON(45%)-PERSAYO(25%)-LOSTWELLS(10%) ASSOCIATION	grscl,l,scl	1-45	1	45	Gr,SU,Ly	5-9	D,S,D	ed,wd,wd	SoilSurvey
15	COUTIS(40%)-GREENMAN(35%)-CHITTUM(10%) ASSOCIATION	fsl,fsl,grl	2-45	2	45	Sy,Sy,SwLy	15-19	D,MD,S	wd,wd,wd	SoilSurvey
16	DOBENT LOAM	l	0-3	0	3	SS	5-9	D	sp	SoilSurvey
17	FINNERTY SILTY CLAY	sic	0-3	0	3	SL	5-9	D	wd	SoilSurvey
18	FINNERTY SILTY CLAY, WET	sic	0-3	0	3	SS	5-9	D	sp	SoilSurvey
19	FLUVAQUENTS	all	0-2	0	2	WL	5-9	D	pd	SoilSurvey
2	APRON SANDY LOAM	sl	0-3	0	3	Sy	5-9	D	wd	SoilSurvey
20	FLUVENTS	all	0-3	0	3	LL	5-9	D	wd,pd	SoilSurvey
21	FORKWOOD(40%)-HAVERDAD(20%)-ARVADA(15%) ASSOCIATION	vfsl,l,l	1-10	1	10	Ly,SL,SU	10-14	D,D,D	wd,wd,wd	SoilSurvey
22	FORKWOOD(45%)-KISHONA(25%)-HAVERDAD(15%) ASSOCIATION	vsl,l,l	1-10	1	10	Ly,Ly,LL	10-14	D,D,D	wd,wd,wd	SoilSurvey
23	FRUITA(30%)-NEIBER(30%)-MUFF(15%) ASSOCIATION	fsl,fsl,fsl	1-30	1	30	Ly,Ly,SU	5-9	D,MD,MD	wd,wd,wd	SoilSurvey
24	GARLAND CLAY LOAM	cl	0-3	0	3	Ly	5-9	D	wd	SoilSurvey
25	GLENTON SANDY LOAM, MODERATELY WET	sl	0-3	0	3	LL	5-9	D	mw	SoilSurvey
26	GLENTON(35%)-BAROID(35%) SANDY LOAMS, WET	l,l	0-3	0	3	SL,SL	5-9	D,D	sp,sp	SoilSurvey
27	GRANILE(50%)-TINE(20%) ASSOCIATION	stvsl,stxsl	2-35	2	35	WL,CU	20+	D,D	wd,se	SoilSurvey
28	GREENMAN(40%)-SPLITRO(25%)-COUTIS(10%) ASSOCIATION	fsl,fsl,fsl	2-25	2	25	Sy,SwSy,Sy	15-19	MD,S,VD	wd,wd,wd	SoilSurvey
29	GREYBULL(40%)-PERSAYO(40%) CLAY LOAMS	cl,cl	3-10	3	10	SU,SU	5-9	MD,S	wd,wd	SoilSurvey
3	APRON(45%)-WORLAND(35%) SANDY LOAMS	sl,sl	0-10	0	10	Sy,Sy	5-9	D,MD	wd,wd	SoilSurvey
30	GREYBULL(40%)-PERSAYO(30%) ASSOCIATION	cl,cl	1-40	1	40	SU,SU	5-9	D,S	wd,wd	SoilSurvey
31	GRIFFY SANDY LOAM	sl	1-10	1	10	Sy	5-9	D	wd	SoilSurvey
32	GRIFFY CLAY LOAM	cl	0-3	0	3	Ly	5-9	D	wd	SoilSurvey
33	HOOT(50%)-ROCK OUTCROP(30%)-PERSAYO(10%) COMPLEX	fsl,ro,cl	3-45	3	45	SwSy,RO,SU	5-9	S,RO,S	wd,ro,wd	SoilSurvey
34	KISHONA(30%)-SHINGLE(30%)-ROCK OUTCROP(15%) ASSOCIATION	l,cl,ro	3-40	3	40	Ly,SwCy,RO	10-14	D,S,RO	wd,wd,ro	SoilSurvey
35	KISHONA(45%)-SHINGLE(35%) ASSOCIATION	cl,cl	6-30	6	30	SU,SwCy	10-14	D,S	wd,wd	SoilSurvey
36	KYLE(35%)-SHINGLE(25%)-BIDMAN(10%) ASSOCIATION	c,cl,fsl	2-40	2	40	Cy,SwCy,Sy	10-14	D,S,D	wd,wd,wd	SoilSurvey
38	LARIM(45%)-OLNEY(30%)-SHINGLE(10%) ASSOCIATION	grvsl,sl,cl	1-40	1	40	Gr,Sy,SwCy	10-14	D,D,S	wd,wd,wd	SoilSurvey
39	LIMBER(40%)-HYATTVILLE(25%)-ROCK OUTCROP(10%) ASSOCIATION	grl,stl,ro	3-40	3	40	WL,WL,RO	20+	MD,MD,RO	wd,wd,ro	SoilSurvey
4	APRON(45%)-WORLAND(30%) SANDY LOAMS	sl,sl	1-12	1	12	Sy,Sy	5-9	D,MD	wd,wd	SoilSurvey
40	LOSTWELLS CLAY LOAM	cl	0-3	0	3	Ly	5-9	D	wd	SoilSurvey
41	LOSTWELLS CLAY LOAM	cl	3-6	3	6	Ly	5-9	D	wd	SoilSurvey
42	LOSTWELLS(40%)-YOUNGSTON(25%)-UFFENS(10%) COMPLEX	scl,sicl,l	1-10	1	10	Ly,SU,SU	5-9	D,D,VD	wd,wd,wd	SoilSurvey
43	LOSTWELLS(30%)-YOUNGSTON(30%)-LOSTWELLS(25%)COMPLEX, WET	cl,sicl,scl	0-6	0	6	SS,SS,Ly	5-9	D,D,D	sp,sp,wd	SoilSurvey
44	LYMANSON(30%)-TURK(30%)-JENKINSON(20%) ASSOCIATION	grl,sicl,cnl	1-30	1	30	Ly,Cy,SwLy	15-19	MD,MD,S	wd,wd,wd	SoilSurvey
45	MEADOWLAKE(50%)-CASTINO VARIANT(20%)-ROCK OUTCROP(15%) ASSOCIATION	flvsl,stvl,ro	5-30	5	30	WL,Ly,RO	20+	MD,MD,RO	wd,wd,ro	SoilSurvey
46	MUFF(40%)-NEIBER(40%) FINE SANDY LOAMS	fsl,fsl	3-30	3	30	SU,Sy	5-9	MD,MD	wd,wd	SoilSurvey
47	MUGHUT(40%)-BONDMAN(25%)-BIDMAN(15%) ASSOCIATION	fsl,sl,fsl	2-25	2	25	Sy,SwSy,Sy	10-14	MD,S,D	wd,wd,wd	SoilSurvey
48	MULGON(40%)-LUCKY STAR(30%) ASSOCIATION	stvl,stvl	6-30	6	30	WL,Ly	20+	D,D	wd,wd	SoilSurvey
49	NATHROP(35%)-STARLEY(30%)-ROCK OUTCRO(10%) ASSOCIATION	grvl,cvl,ro	2-40	2	40	CU,SwLy	15-19	MD,S	wd,wd	SoilSurvey
5	ARVADA(30%)-OLNEY(30%)-RAIRDENT(25%) ASSOCIATION	l,sl,fsl	1-10	1	10	SU,Sy,Ly	10-14	D,D,D	wd,wd,wd	SoilSurvey
50	NEVILLE LOAM	l	0-3	0	3	Ly	10-14	D	wd	SoilSurvey
51	NEVILLE LOAM	l	3-6	3	6	Ly	10-14	D	wd	SoilSurvey
52	NEVILLE LOAM	l	6-10	6	10	Ly	10-14	D	wd	SoilSurvey
53	NEVILLE LOAM, WET	l	0-3	0	3	SS	10-14	D	sp	SoilSurvey
54	NEVILLE(65%)-TENSLEEP(20%) COMPLEX	l,fsl	1-10	1	10	Ly,Ly	10-14	D,D	wd,wd	SoilSurvey
55	NEVILLE(50%)-SPEARFISH(25%)-ROCK OUTCROP(10%) ASSOCIATION	l,l,ro	1-45	1	45	Ly,SwLy,RO	10-14	D,S,RO	wd,wd,ro	SoilSurvey
56	PERSAYO(50%)-MUFF(15%)-ROCK OUTCROP(10%) ASSOCIATION	cl,fsl,ro	1-6	1	6	SU,SU,RO	5-9	S,D,RO	wd,wd,ro	SoilSurvey
57	PERSAYO(40%)-ROCK OUTCROP(40%) ASSOCIATION	cl,ro	15-40	15	40	Sh,RO	5-9	S,RO	wd,ro	SoilSurvey
58	REKOP(40%)-GYSTRUM(30%)-SPEARFISH(10%) ASSOCIATION	l,sil,l	3-60	3	60	ShLy,Ly,SwLy	10-14	S,MD,S	wd,wd,wd	SoilSurvey
59	RENOHILL(35%)-HELDT(30%)-WORF(15%) ASSOCIATION	sicl,sicl,l	1-25	1	25	Cy,Cy,SwLy	10-14	MD,VD,S	wd,wd,wd	SoilSurvey
6	BARNUM LOAM	l	1-3	1	3	LL	10-14	D	wd	SoilSurvey
60	RIVERWASH	all	0-10	0	10	none	5-19	?	?	SoilSurvey
61	ROCK OUTCROP(65%)-PERSAYO(20%) COMPLEX	ro,cl	15-70	15	70	RO,Sh	5-9	RO,S	ro,wd	SoilSurvey
62	ROCK OUTCROP(55%)-SPEARFISH(15%)-NEVILLE(10%) COMPLEX	ro,l,l	1-60	1	60	RO,SwLy,Ly	10-14	RO,S,D	ro,wd,wd	SoilSurvey
63	ROCK OUTCROP(60%)-STARMAN(20%) COMPLEX	ro,grl	6-45	6	45	RO,VS	15-19	RO,S	ro,wd	SoilSurvey
64	SPEARFISH(35%)-TRAVESSILLA(30%)-ROCK OUTCROP(15%) COMPLEX	l,l,ro	10-60	10	60	SwLy,VS,RO	10-14	S,VS,RO	wd,wd,ro	SoilSurvey
65	STUBBS(40%)-TURK(30%)-LYMANSON(15%) ASSOCIATION	l,sicl,grl	1-30	1	30	Ly,Cy,Ly	15-19	MD,MD,MD	wd,wd,wd	SoilSurvey
66	STUTZMAN SILTY CLAY LOAM	sicl	0-3	0	3	SU	5-9	D	wd	SoilSurvey
67	STUTZMAN SILTY CLAY LOAM, WET	sicl	0-3	0	3	SS	5-9	D	sp	SoilSurvey
68	STUTZMAN(30%)-PERSAYO(25%)-YOUNGSTON(20%) ASSOCIATION	sicl,cl,sicl	1-20	1	20	SU,SU,SU	5-9	D,S,D	wd,wd,wd	SoilSurvey
69	TENSLEEP LOAM	l	3-6	3	6	Ly	10-14	D	wd	SoilSurvey
7	BAROID SANDY LOAM	sl	0-3	0	3	LL	5-9	D	mw	SoilSurvey
70	UFFENS(40%)-PERSAYO(30%)-GREYBULL(15%) COMPLEX	l,cl,cl	1-30	1	30	SU,SU,SU	5-9	D,S,MD	wd,wd,wd	SoilSurvey
71	UFFENS(40%)-RAIRDENT(30%)-GRIFFY(10%) COMPLEX	l,fsl,sl	1-10	1	10	SU,Ly, Sy	5-9	D,D,D	wd,wd,wd	SoilSurvey
72	VALE(35%)-TENSLEEP(30%)-SPEARFISH(15%) ASSOCIATION	fsl,vfsl,l	1-40	1	40	Ly,Ly,SwLy	10-14	D,D,S	wd,wd,wd	SoilSurvey
73	WALLSON LOAMY FINE SAND	fsl	1-10	1	10	Sy	5-9	D	wd	SoilSurvey
74	WALLSON SANDY LOAM	sl	3-6	3	6	Sy	5-9	D	wd	SoilSurvey
75	WHALEY(45%)-ROCK OUTCROP(15%)-SPLITRO(15%) COMPLEX	lvfs,ro,fsl	3-60	3	60	SwSy,RO,SwSy	15-19	S,RO,S	ed,ro,wd	SoilSurvey
76	WOOSLEY(45%)-DECROSS(25%)-NATHROP(10%) ASSOCIATION	l,l,cbl	1-25	1	25	Ly,Ly,CU	15-19	MD,D,MD	wd,wd,wd	SoilSurvey
77	WOOSLEY(40%)-MORSET(35%) ASSOCIATION	l,l	2-25	2	25	Ly,Ly	15-19	MD,D	wd,wd	SoilSurvey
78	WOOSLEY(40%)-STARLEY(25%)-ROCK OUTCROP(10%) ASSOCIATION	l,cnvl,ro	2-35	2	35	Ly,SwLy,RO	15-19	MD,S,RO	wd,wd,ro	SoilSurvey
79	WORLAND SANDY LOAM	sl	0-10	0	10	Sy	5-9	MD	wd	SoilSurvey
8	BAROID(40%)-LAS ANIMAS(35%) VARIANT	sl,sl	0-3	0	3	LL,SS	5-9	D,D	mw,sp	SoilSurvey
80	WORLAND(45%)-PERSAYO(20%)-APRON(15%) COMPLEX	sl,cl,sl	3-30	3	30	Sy,SU,Sy	5-9	MD,S,D	wd,wd,wd	SoilSurvey
81	YOUNGSTON CLAY LOAM, MODERATELY WET	cl	0-3	0	3	LL	5-9	D	mw	SoilSurvey
82	YOUNGSTON SILTY CLAY LOAM	sicl	0-3	0	3	SU	5-9	D	wd	SoilSurvey
83	YOUNGSTON(40%)-GLENTON(25%)-LOSTWELLS(15%) COMPLEX	sicl,sl,scl	0-3	0	3	SL,LL,Ly	5-9	D,D,D	wd,wd,wd	SoilSurvey
84	YOUNGSTON(40%)-UFFENS(25%)-LOSTWELLS(15%) COMPLEX	sicl,l,scl	1-10	1	10	SU,SU,Ly	5-9	D,D,D	wd,wd,wd	SoilSurvey
85	WATER	wet	0	0	0	none	5-19	WATER	water	SoilSurvey
86	AGNESTON(35%)-GRANILE(25%)-ROCK OUTCROP(15%) ASSOCIATION	sl,grsl,ro	5-50	5	50			MD,D,RO	wd,wd,ro	NASIS
87	CRYAQUOLLS(100%)		0-5	0	5			VD	vd	NASIS
88	HANSON VARIANT(50%)-STARLEY(25%) ASSOCIATION	grsil,l	10-60	10	60			MD,MD	wd,wd	NASIS
89	ROCK OUTCROP(50%)-CLOUD PEAK (30%)ASSOCIATION	ro,grsil	10-70	10	70		.	RO,MD	ro,wd	NASIS
9	BILLYCREEK(40%)-WETTERHORN(35%) COMPLEX	lfs,stvl	6-60	6	60	WL,WL	15-19	MD,MD	ed,wd	NASIS
90	TONGUE RIVER(40%)-GATEWAY(35%) ASSOCIATION	l,l	2-35	2	35			MD<MD	wd,wd	NASIS



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Donald E. Tranas, Range Consultant

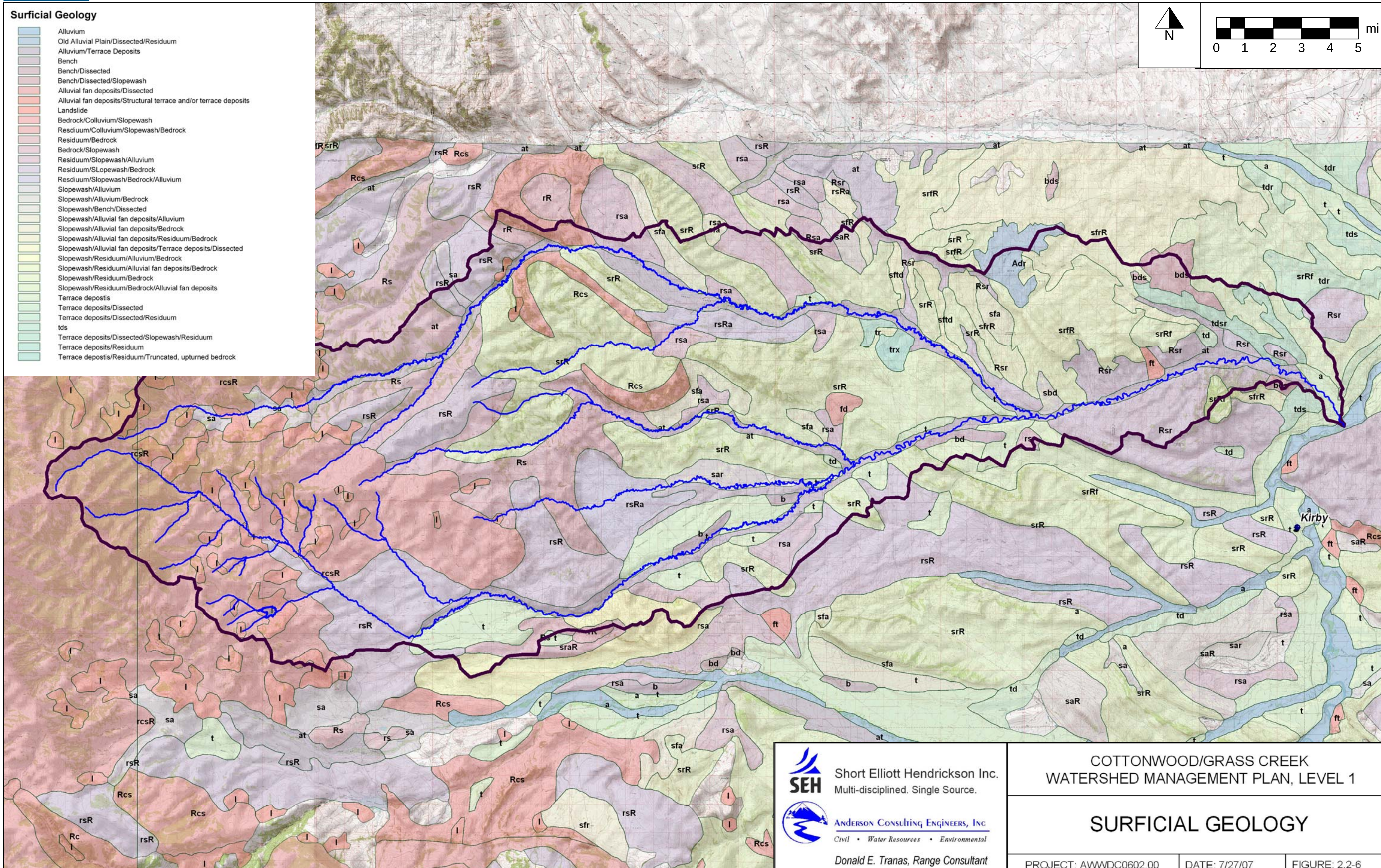
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

PROVISIONAL BLM SOILS MAP

PROJECT: AWWDC0602.00	DATE: 8/10/07	FIGURE: 2.2-5B

Hot Springs County Soils Key (to accompany Figure 2.2-5B)

Soil Num	Mapunit Name	Surface Texture	MU Slope Range	Slope (low)	Slope (high)	Range Site	Precip. Zone	Depth to Bedrock	Drainage Class	Data Source
102	ROCK OUTCROP	ro	0-100	0	100	RO	5-19	RO	ro	SALUT
109	EPSIE(45%)-ROCK OUTCROP(40%) COMPLEX	sic,ro	3-60	3	60	SU,RO	10-14	S,RO	wd,ro	SALUT
11	LARIMER LOAM	l	0-8	0	8	Ly	10-14	D	wd	SALUT
110	SHINGLE(50%)-TASSEL(35%) COMPLEX	l,sl	3-45	3	45	SwLy,SwSy	10-14	S,S	wd,wd	SALUT
111	ROCK OUTCROP(30%)-SHINGLE(25%)-TASSLE(25%) COMPLEX	ro,l,sl	3-60	3	60	RO,SwLy,SwLy	10-14	RO,S,S	ro,wd,wd	SALUT
112	OCEANET(25%)-PERSAYO(25%)-ROCK OUTCROP(25%) COMPLEX	fsl,cl,ro	3-60	3	60	SwSy,SU(SwLy),RO	5-9	S,S,RO	wd,wd,ro	SALUT
11L	LARIMER SANDY LOAM	sl	0-8	0	8	Sy	10-14	D	wd	SALUT
11T	GARLAND(65%)-PREATORSON (25%)COMPLEX	l,grl	0-10	0	10	Ly,Gr	5-9	D,D	wd,wd	SALUT
190	EPSIE(45%)-SHINGLE(30%)-COMPLEX	sic,l	6-45	6	45	SU,SwLy	10-14	S,S	wd,wd	SALUT
192	CADOMA(30%)-SHINGLE(25%)-ROCK OUTCROP(20%) COMPLEX	sicl,l,ro	3-60	3	60	SU,SwLy	10-14	MD,S,RO	wd,wd,ro	SALUT
243	KIM ALKALI(50%)-KIM(30%) LOAMS	l,l	0-6	0	6	SL,Ly(Cy)	10-14	D,D	mw,wd	SALUT
244	KIM ALKALI LOAM	l	0-6	0	6	SL	10-14	D	mw	SALUT
245	ORELLA SILTY CLAY	sic	0-15	0	15	SU	10-14	S	wd	SALUT
246	ORELLA(45%)-EPSIE(25%)-ROCK OUTCROP(20%) COMPLEX	sic,sic,ro	0-45	0	45	SU,SU,RO	10-14	S,S,RO	wd,wd,ro	SALUT
247	TORRIORTHENTS, SEVERELY ERODED	all	0-15	0	15	none	5-19	D	wd	SALUT
315	PERSAYO(50%)-CLIFTERSON(30%) COMPLEX	grcl,grv&c	3-45	3	45	SU(SwLy),Gr	5-9	S,D	wd,wd	SALUT
322	NIHILL(45%)-SHINGLE(30%) GRAVELLY LOAMS	grl,grl	3-45	3	45	Gr,SwLy	10-14	D,S	wd,wd	SALUT
323	NIHILL COBBLY LOAM	cbl	3-45	3	45	Gr	10-14	D	wd	SALUT
324	LARIMER(40%)-NIHILL(40%) COMPLEX	l,grl	3-45	3	45	Ly,Gr	10-14	D,D	wd,wd	SALUT
325	LARIMER(30%)-STONEHAM(30%)-NIHILL(20%) COMPLEX	l,l,grl	3-30	3	30	Ly,Ly,Gr	10-14	D,D,D	wd,wd,wd	SALUT
345	VONA(45%)-OTERO(35%) SANDY LOAMS	sl,sl	3-15	3	15	Sy,Sy	10-14	D,D	wd,wd	SALUT
346	NELSON(30%)-TERRY(30%)-OTERO(20%) COMPLEX	fsl,sl,fsl	3-20	3	20	Sy,Sy,Sy	10-14	MD,MD,D	wd,wd,wd	SALUT
360	STONEHAM(50%)-KIM ASSOCIATION(30%)	l,l	0-6	0	6	Ly,Ly(Cy)	10-14	D,D	wd,wd	SALUT
371	PAVILLION(40%)-PERSAYO(35%) COMPLEX	l,cl	3-45	3	45	Ly,SU	5-9	MD,S	wd,wd	SALUT
372	TASSEL(50%)-NELSON(25%) SANDY LOAMS	sl,sl	3-45	3	45	SwSy,Sy	10-14	S,MD	wd,wd	SALUT
373	NEVILLE(45%)-TENSLEEP(35%) ASSOCIATION	vfsl,vfsl	0-6	0	6	Ly,Ly	10-14	D,D	wd,wd	SALUT
375	BOWBAC(30%)-OLNEY(25%)-ARVADA(25%) COMPLEX	fsl,sl,l	0-15	0	15	Sy,Sy,SU	10-14	MD,D,MD-D	wd,wd,wd	SALUT
382	ROCK OUTCROP(40%)-TASSEL(40%) COMPLEX	ro,l	3-60	3	60	RO,SwSy	10-14	RO,S	ro,wd	SALUT
383	ROCK OUTCROP(30%)-TASSEL(30%)-NELSON(20%) COMPLEX	ro,sl,sl	3-60	3	60	RO,SwSy,Sy	10-14	RO,S,MD	ro,wd,wd	SALUT
389	SPEARFISH(50%)-NEVILLE(30%) ASSOCIATION	vfsl,vfsl	0-6	0	6	SwLy,Ly	10-14	S,D	wd,wd	SALUT
389F	SPEARFISH-NEVILLE ASSOCIATION, VERY STEEP	vfsl,vfsl	45-60	45	60	SwLy,Ly	10-14	S,D	wd,wd	NASIS
393	OLNEY(45%)-BOWBAC(35%) FINE SANDY LOAMS	fsl,fsl	3-15	3	15	SwLy,Ly	10-14	D,MD	wd,wd	SALUT
394	SADDLE(60%)-OCEANET(20%) FINE SANDY LOAMS	fsl,fsl	0-15	0	15	Sy,SwSy	10-14	MD,S	wd,wd	SALUT
398	TASEL(30%)-BOWBAC(30%)-TERRY(25%) COMPLEX	sl,fsl,fsl	3-30	3	30	SwSy,Sy,Sy	10-14	S,MD,MD	wd,wd,wd	SALUT
410	BONDMAN(30%)-WORFKA(25%)-WORF(25%) COMPLEX	fsl,l,l	0-15	0	15	SwSy(Sy),SwLy(SwCy),SwLy	10-14	S,S,S	wd,wd,wd	SALUT
411	BONDMAN(35%)-ROCK OUTCROP(25%)-WORF(20%) COMPLEX	fsl,ro,l	3-45	3	45	SwSy(Sy),RO,SwLy	10-14	S,RO,S	wd,ro,wd	SALUT
426	LARIM(50%)-LARIMER(40%) COMPLEX	grl,l	3-25	3	25	Gr,Ly	10-14	MD,MD	wd,wd	SALUT
440	KISHONA(60%)-TENSLEEP(20%) LOAMS	l,l	0-10	0	10	Ly,Ly	10-14	D,D	wd,wd	10/81legend;1/82leg
445	REKOP(45%)-GYSTRUM(35%) LOAMS	l,l	3-60	3	60	SwLy,Ly	10-14	S,MD	wd,wd	SALUT
446	ROCK OUTCROP(35%)-TRAVESSILLA(25%)-SPEARFISH(20%) COMPLEX	ro,stl,vfsl	3-60	3	60	RO,SwLy,SwLy	10-14	RO,S-VS,S	ro,wd,wd	SALUT
447	TRAVESSILLA STONY LOAM	stl	3-45	3	45	SwLy	10-14	S	wd	SALUT
448	TORRIFLUVENTS, SALINE	none	0-6	0	6	NONE	5-19	D	mw	SALUT
449	TRAVESSILLA(45%)-ROCK OUTCROP(40%) COMPLEX	l,ro	3-60	3	60	VS,RO	10-14	VS,RO	wd,ro	SALUT
45	YOUNGSTON(50%)-LOSTWELLS(25) LOAMS	l,l	0-6	0	6	Ly,Ly	5-9	D,D	wd,wd	SALUT
450	TORRIFLUVENTS(40%)-FLUVAQUENTS(40%) COMPLEX	none	0-6	0	6	NONE	5-19	D,D	mw,pd	SALUT
46	PETRIE(45%)-KIM ALKALI(30%) COMPLEX	sicl,l	3-15	3	15	SU,SL	10-14	D,D	wd,mw	SALUT
47	PETRIE(55%)-CADOMA(25%)-EPSIE(15%) COMPLEX	cl,cl,sic	0-15	0	15	SU,SU,SU	10-14	D,MD,S	wd,wd,wd	SALUT
490	SHINGLE(40%)-THEDALUND(35%) LOAMS	l,l	3-45	3	45	SwLy,Ly	10-14	S,MD	wd,wd	SALUT/NASIS
546	SPEARFISH(35%)-ROCK OUTCROP(30%)-NEVILLE(20%) COMPLEX	vfsl,ro,vfsl	3-60	3	60	SyLy,RO,Ly	10-14	S,RO,D	wd,ro,wd	SALUT
572	WORLAND(50%)-OCEANET(25%) SANDY LOAMS	sl,sl	3-15	3	15	Sy,SwSy	5-9	MD,S	wd,wd	SALUT
590	SHINGLE(50%)-ROCK OUTCROP(30%) COMPLEX	l,ro	3-60	3	60	SwLy,RO	10-14	S,RO	wd,ro	SALUT/NASIS
60	CADOMA(45%)-KIM(45%) COMPLEX	sicl,l	1-10	1	10	SU,Ly(Cy)	10-14	MD,D	wd,wd	SALUT
601	YOUNGSTON(35%)-UFFNES(30%)-LOSTWELLS(20%) COMPLEX	l,vfsl,l	0-10	0	10	Ly,SU,Ly	5-9	D,D,D	wd,wd,wd	SALUT
602	BLINTON(50%)-UFFENS(30%) COMPLEX	l,vfsl	0-10	0	10	SU,SU	5-9	D,D	wd,wd	SALUT
604	EFFINGTON(50%)-EFFINGTON VARIANT(30%) COMPLEX	sil,sicl	0-10	0	10	SU,SU	5-9	D,MD	wd,wd	SALUT
606	HOOT(40%)-ROCK OUTCROP(35%) COMPLEX	cnl,ro	6-60	6	60	SwLy,RO	10-14	S,RO	wd,ro	SALUT
645	MUDRAY(40%)-PERSAYO(25%)-EFFINGTON VARIANT(15%) COMPLEX	vfsl,cl,sicl	3-30	3	30	SU,Sh,SU	5-9	S,S,MD	wd,wd,wd	SALUT
650	MUDRAY CLAY LOAM	cl	0-15	0	15	SU	5-9	S	wd	SALUT
67	CADOMA(40%)-ARCADA(25%)-WORFKA(20%) COMPLEX	sicl,l	0-30	0	30	SU,SU,SwLy(SwCy)	10-14	MD,MD,S	wd,wd,wd	SALUT
671	ROCK OUTCROP(50%)-PERSAYO(35%) COMPLEX	ro,cl	3-60	3	60	RO,Sh	5-9	RO,S	ro,wd	SALUT
675	PAVILLION(40%)-YOUNGSTON(35%) LOAMS	l,l	0-15	0	15	Ly,Ly	5-9	MD,D	wd,wd	SALUT
68	CADOMA(50%)-EPSIE(25%) COMPLEX	sicl,sic	3-45	3	45	SU,SU	10-14	MD,S	wd,wd	SALUT
69	KIM LOAM	l	0-10	0	10	Ly(Cy)	10-14	D	wd	SALUT
70	CADOMA SILTY CLAY LOAM	sicl	1-15	1	15	SU	10-14	MD	wd	SALUT
700	STONEHAM(50%)-CUSHMAN(30%) LOAMS	l,l	3-15	3	15	Ly,Ly	10-14	D,MD	wd,wd	SALUT
701	FORT COLLINS(50%)-KIM(30%) LOAMS	l,l	3-15	3	15	Ly(Cy),Ly(Cy)	10-14	D,D	wd,wd	SALUT
702	ABSTED(45%)-FORT COLLINS(35%) LOAMS	l,l	3-15	3	15	Ly(Cy),Ly(Cy)	10-14	D,D	wd,wd	SALUT
703	FORT COLLINS(50%)-CUSHMAN(30%) COMPLEX	l,l	3-15	3	15	Ly(Cy),Ly(Cy)	10-14	D,MD	wd,wd	SALUT
705	KIM(50%)-THEDALUND(30%) LOAMS	l,l	3-15	3	15	Ly(Cy),Ly	10-14	D,MD	wd,wd	SALUT
706	CUSHMAN(35%)-TERRY(25%)-WORF(20%) COMPLEX	l,sl,l	3-30	3	30	Ly,Sy,SwLy	10-14	MD,MD,S	wd,wd,wd	SALUT
708	RENOHILL(40%)-CUSHMAN(20%)-WORFKA(20%) COMPLEX	cl,l,l	3-30	3	30	Cy(Ly),Ly,SwLy(SwCy)	10-14	MD,MD,S	wd,wd,wd	SALUT
709	RENOHILL(40%)-CADOMA(25%)-WORFKA(20%) COMPLEX	cl,sicl,l	0-20	0	20	Cy(Ly),SU,SwLy(SwCy)	10-14	MD,MD,S	wd,wd,wd	SALUT
71	CADOMA(60%)-SHINGLE(25%) COMPLEX	sicl,l	3-45	3	45	SU,SwLy	10-14	MD,S	wd,wd	SALUT
710	CADOMA(40%)-RENOHILL(25%)-ULM(20%) COMPLEX	sicl,cl,l	3-20	3	20	SU,Cy(Ly),Ly(Cy)	10-14	MD,MD,D	wd,wd,wd	SALUT
72	ABSTED(40%)-ARVADA(35%) COMPLEX	l,fsl	0-10	0	1	Ly,SU	10-14	D,D	wd,wd	SALUT
720	BLAZON(45%)-ROCK OUTCROP(30%) COMPLEX	l,ro	3-60	3	60	SwLy,RO	10-14	S,RO	wd,ro	SALUT
722	BLAZON LOAM	l	3-45	3	45	SwLy	10-14	S	wd	SALUT
723	BLAZON(40%)-DELPHIL(35%)LOAMS	l,l	3-30	3	30	SwLY,Ly(Cy)	10-14	S,MD	wd,wd	SALUT
724	BLAZON(40%)-BROWNSTO(35%) COMPLEX	l,gr&cbl	3-45	3	45	SwLy,SwLy	10-14	S,D	wd,wd	SALUT
725	BLAZON(40%)-DIAMONDVILLE(35%)	l,l	3-30	3	30	SwLy,Ly	10-14	S,MD	wd,wd	SALUT
73	ABSTED(40%)-STONEHAM(30%)-ULM(20%) LOAMS	l,l,l	3-10	3	10	Ly,Ly,Ly(Cy)	10-14	D,D,D	wd,wd,wd	SALUT
730	FORELLE(45%)-DIAMONDVILLE(35%) LOAMS	l,l,	3-15	3	15	Ly,Ly	10-14	D,MD	wd,wd	SALUT
732	THERMOPOLIS(40%)-ROCK OUTCROP(35%) COMPLEX	l,ro	3-45	3	45	SwLy,RO	10-14	S,RO	wd,ro	SALUT
735	PATENT(45%)-FORELLE(35%) ASSOCIATION	l,l	3-15	3	15	Ly,Ly	10-14	D,D	wd,wd	SALUT
736	FORELLE(50%)-PINELLI (30%) LOAMS	l,l	3-15	3	15	Ly,Ly	10-14	D,D	wd,wd	SALUT
737	FORELLE(40%)-ALCOVA (35%) LOAMS	l,l	3-15	3	15	Ly,Ly(Sy)	10-14	D,D	wd,wd	SALUT
74	PETRIE(45%)-ULM(30%) COMPLEX	cl,l	0-15	0	15	SU,Ly(Cy)	10-14	D,D	wd,wd	SALUT
749	RENOHILL(45%)-WORFKA(35%) COMPLEX	cl,l	0-20	0	20	Cy(Ly),SwLy(SwCy)	10-14	MD,S	wd,wd	SALUT
75	ARVADA(40%)-KIM ALKLI(35%) COMPLEX	fsl,l	0-10	0	10	SU,SL	10-14	D,D	wd,mw	SALUT
750	WORFKA(50%)-CUSHMAN(30%) ASSOCIATION	l,l	3-45	3	45	SwLy(SwCy),Ly	10-14	S,MD	wd,wd	SALUT
751	WORFKA(45%)-SHINGLE(20%)-ROCK OUTCROP(15%) COMPLEX	l,l,ro	3-45	3	45	SwLy(SwCy),SwLy,RO	10-14	S,S,RO	wd,wd,ro	SALUT
752	EPSIE SILTY CLAY LAOM	sicl	3-15	3	15	SU	10-14	S	wd	SALUT
753	GAYNOR(40%)-SAMSIL(40%) CLAYS	c,c	3-15	3	15	Cy,SwCy	10-14	MD,S	wd,wd	SALUT
802	ROCK OUTCROP(50%)-STARMAN(40%) COMPLEX	ro,grl	6-60	6	60	RO,VS	15-19	RO,VS	ro,wd	SALUT
804	ROCK OUTCROP(45%)-MERINO(35%) COMPLEX	ro,grscl	6-60	6	60	RO,SwLy,SwCy	15-19	RO,S	ro,wd	SALUT
806	STARLEY(50%)-STARMAN(20%)-ROCK OUTCROP(15%) COMPLEX	l,grl,ro	6-60	6	60	SwLy,VS,RO	15-19	S,VS,RO	wd,wd,ro	SALUT
808	NIELSEN(30%)-ABES(25%)-ROCK OUTCROP(20%) COMPLEX	cnl,cl,ro	6-60	6	60	SwLy,SwCy,RO	15-19	S,S,RO	wd,wd,ro	SALUT
810	GILISPIE(40%)-BACHUS(20%)-NIELSEN(20%) COMPLEX	cbl,l,cnl	3-60	3	60	SwLy(Woodland),Ly,SwLy	15-19	S,MD,S	wd,wd,wd	SALUT
812	BACHUS(50%)-MAYOWORTH(30%) COMPLEX	l,cl	3-45	3	45	Ly,Cy	15-19	MD,MD	wd,wd	SALUT
813	CRYOBOROLLS(70%)-CRYORTHENTS(30%) COMPLEX	rubble	10-60	10	60	NONE	15-19	D,D	wd-sp,wd-sp	SALUT
814	MAYOWORTH(35%)-BURNETTTE(25%)-ABES(20%) COMPLEX	cl,l,cl	3-45	3	45	Cy,Ly,SwCy	15-19	MD,D,S	wd,wd,wd	SALUT
815	BRIDGER(70%)-ABES(15%)-COMPLEX	cbl,cl	3-30	3	30	Cy(Ly),SwCy	15-19	D,S	wd,wd	SALUT
816	NIELSEN(60%)-CLAYBURN(20%) COMPLEX	cnl,l	3-45	3	45	SwLy,Ly	15-19	S,D	wd,wd	SALUT
818	NIESEN(55%)-GILISPIE(25%) COMPLEX	cnl,cbl	3-45	3	45	SwLy,SwLy(Woodland)	15-19	S,S	wd,wd	SALUT
820	BACHUS(40%)-WIX(40%) COMPLEX	l,vfsl	6-45	6	45	Ly,Woodland	15-19	MD,MD	wd,wd	SALUT
822	STARLEY(45%)-BACHUS(20%)-STARMAN(20%) COMPLEX	l,l,grl	6-60	6	60	SwLy,Ly,VS	15-19	S,MD,VS	wd,wd,wd	SALUT
825	BACHUS(50%)-STARLEY(30%) COMPLEX	l,grl	3-20	3	20	Ly,SwLy	15-19	MD,S	wd,wd	BLM-3/81
850	MILLERLAKE(50%)-ADEL(25%) LOAMS	l,l	3-30	3	30	Ly,Ly	15-19	D,D	wd,wd	SALUT
854	BURNETTE(50%)-CLAYBURN(35%) LOAMS	l,l	3-30	3	30	Ly,Ly	15-19	D,D	wd,wd	SALUT
870	WIX(50%)-JUDKINS(25%) COMPLEX	vfsl,stsil	6-60	6	60	Woodland,Woodland	15-19	MD,MD	wd,wd	SALUT
872	BURNETTE(30%)-ABES(25%)-ROCK OUTCROP(20%) COMPLEX	l,l,ro	3-45	3	45	Ly,SwLy,RO	15-19	D,S,RO	wd,wd,ro	SALUT
876	WETTERHORN(40%)-WETTERHORN VARIANT(40%) VARIANT	l,stl	6-60	6	60	Woodland,Woodland	15-19	MD,MD	wd,wd	SALUT
902	SAMSIL(50%)-SHINGLE(20%)-ROCK OUTCROP(15%) COMPLEX	c,l,ro	3-45	3	45	SwCy,SwLy,RO	10-14	S,S,RO	wd,wd,ro	SALUT
90BC	SHINGLE-SAMDAY CLAY LOAMS, 3 TO 10 PERCENT SLOPES	l,	3-10	3	10	SwLy,unk	10-14	S,UNK	wd,unk	NASUS
910	CADOMA(30%)-THEDALUND(25%)-EPSIE(25%) COMPLEX	sicl,l,sic	3-45	3	45	SU,Ly,SU	10-14	MD,MD,S	wd,wd,wd	BLM
920	STONEHAM(25%)-THEDALUND(25%)-ULM(25%) COMPLEX	l,l,l	3-15	3	15	Ly,Ly,Ly	10-14	D,MD,D	wd,wd,wd	BLM
929	RENTSAC(60%)-ROCK OUTCROP(20%) COMPLEX	cnl,ro	10-30	10	30	VS,RO	10-14	S,RO	wd,ro	BLM-5/82
93	VONA(50%)-OLNEY(30%) SANDY LOAMS	sl,sl	0-10	0	10	Sy,Sy	10-14	D,D	wd,wd	SALUT
930	RENTSAC VARIANT(40%)-RENTSAC(30%)-CLAYBURN VARIANT (15%) COMPLEX	l,cnl,l	3-30	3	30	VS,Ly,Ly	10-14	MD,D	wd,wd	BLM-5/82
931	CLAYBURN VARIANT(45%)-RENTSAC VARIANT(35%) COMPLEX	l,l	3-20	3	20	Ly,Ly	10-14	D,MD	wd,wd	BLM-5/82
939	BACHUS VARIANT(35%)-ROCK OUTCROP(30%) COMPLEX	stsl,ro	10-30	10	30	VS,RO	15-19	S,RO	wd,ro	BLM-5/82
940	VONA VARIANT(50%)-BACHUS VARIANT(30%) COMPLEX	fsl,cnvsl	3-30	3	30	VS,VS	15-19	MD,S	wd,wd	BLM-5/82
949	IRIGUL(65%)-ROCK OUTCROP(20%) COMPLEX	grl,ro	10-30	10	30	Ig,RO	15-19	S,RO	wd,ro	BLM-5/82


Surficial Geology
Alluvium
Old Alluvial Plain/Dissected/Residuum
Alluvium/Terrace Deposits
Bench
Bench/Dissected
Bench/Dissected/Slopewash
Alluvial fan deposits/Dissected
Alluvial fan deposits/Structural terrace and/or terrace deposits
Landslide
Bedrock/Colluvium/Slopewash
Resdiuum/Colluvium/Slopewash/Bedrock
Residuum/Bedrock
Bedrock/Slopewash
Residuum/Slopewash/Alluvium
Residuum/SLopewash/Bedrock
Resdiuum/Slopewash/Bedrock/Alluvium
Slopewash/Alluvium
Slopewash/Alluvium/Bedrock
Slopewash/Bench/Dissected
Slopewash/Alluvial fan deposits/Alluvium
Slopewash/Alluvial fan deposits/Bedrock
Slopewash/Alluvial fan deposits/Residuum/Bedrock
Slopewash/Alluvial fan deposits/Terrace deposits/Dissected
Slopewash/Residuum/Alluvium/Bedrock
Slopewash/Residuum/Alluvial fan deposits/Bedrock
Slopewash/Residuum/Bedrock
Slopewash/Residuum/Bedrock/Alluvial fan deposits
Terrace depostis
Terrace deposits/Dissected
Terrace deposits/Dissected/Residuum
tds
Terrace deposits/Dissected/Slopewash/Residuum
Terrace deposits/Residuum
Terrace depostis/Residuum/Truncated, upturned bedrock
N
0 1 2 3 4 5 mi
Kirby
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COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1
SURFICIAL GEOLOGY
PROJECT: AWWDC0602.00
DATE: 7/27/07
FIGURE: 2.2-6

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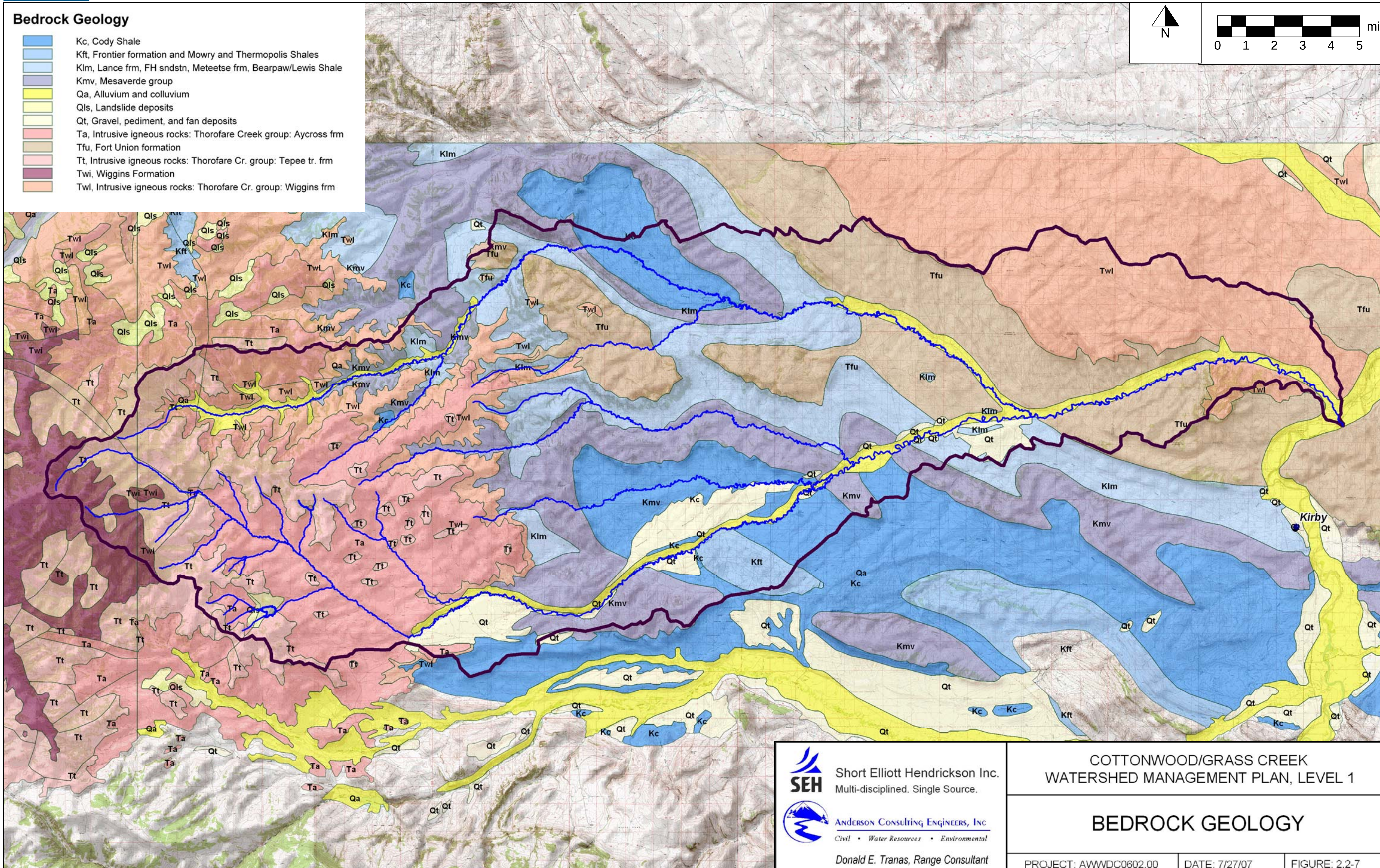
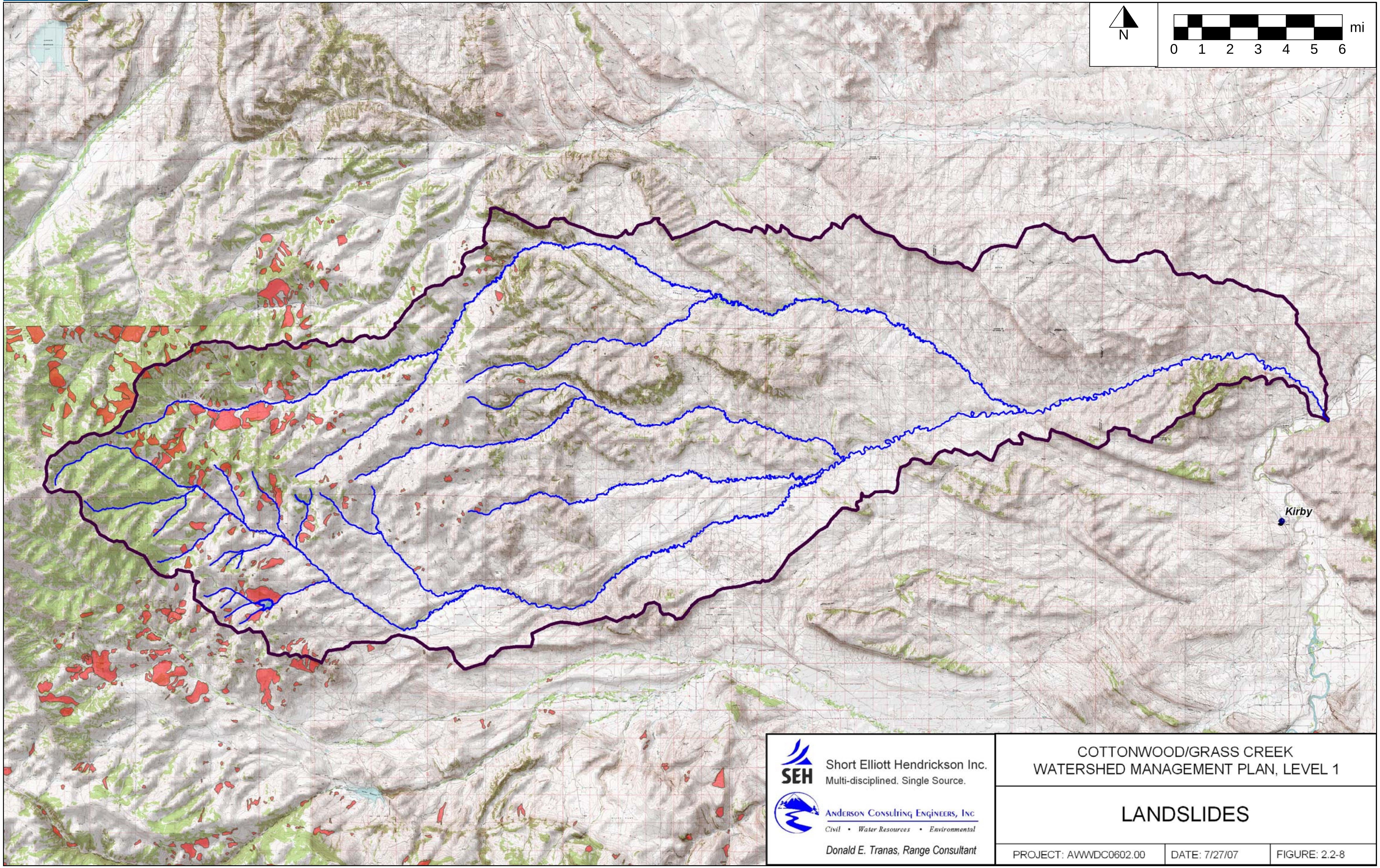


DeLorme

XMap® 5.0 GIS Editor



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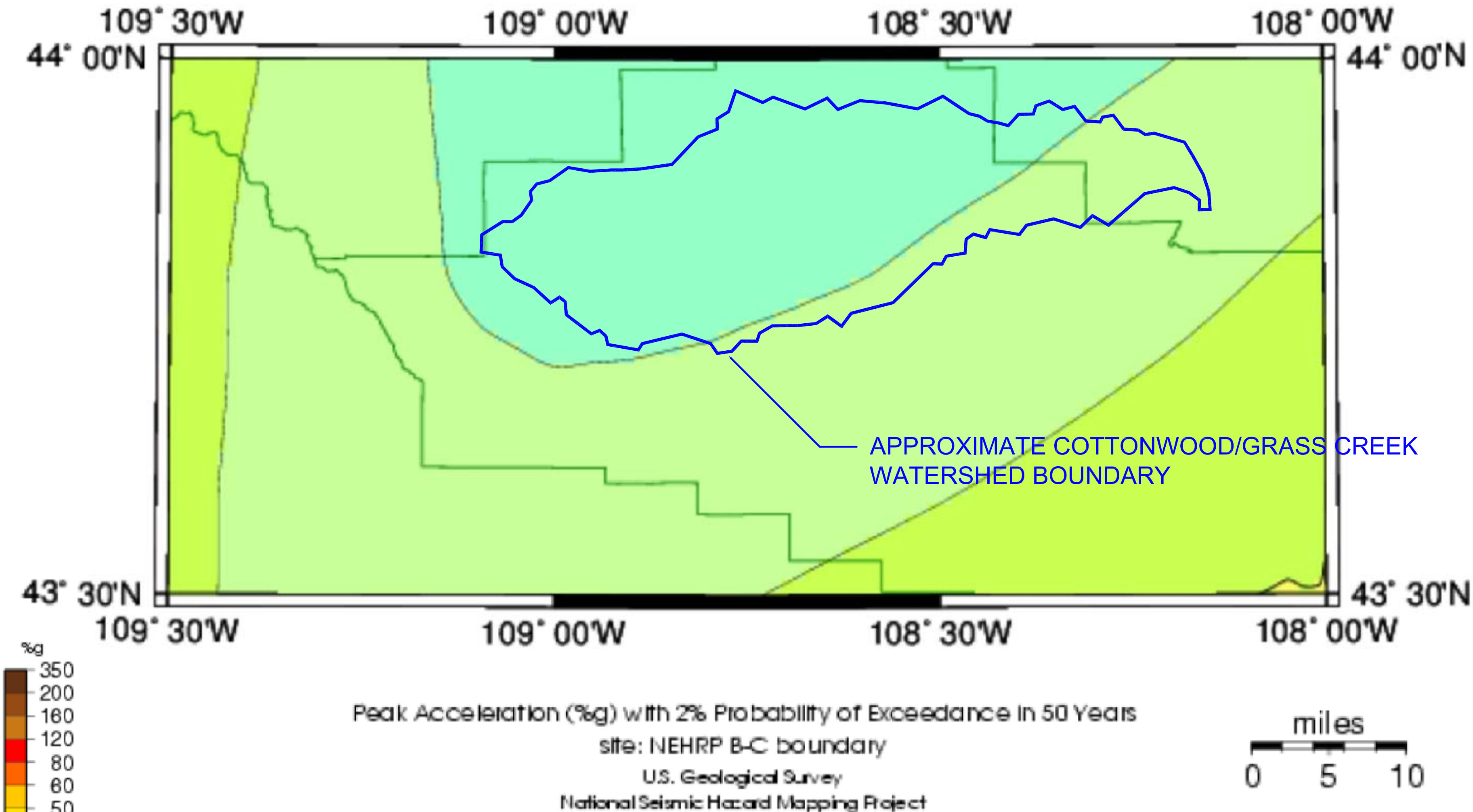
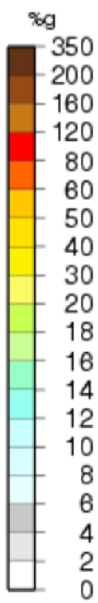
WATERSHED MANAGEMENT PLAN, LEVEL 1

LANDSLIDES

PROJECT: AWWDC0602.00	DATE: 7/27/07	FIGURE: 2.2-8





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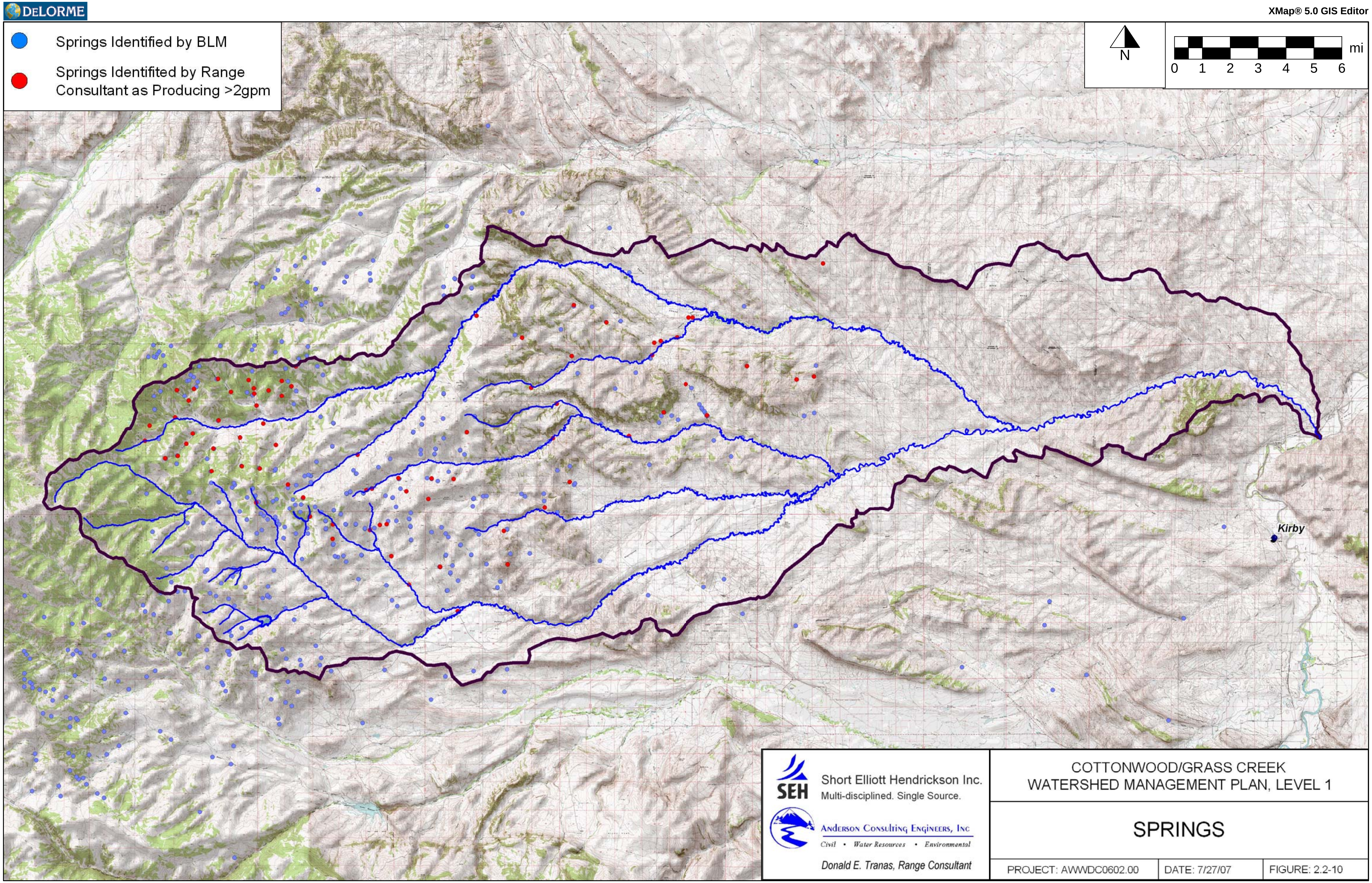
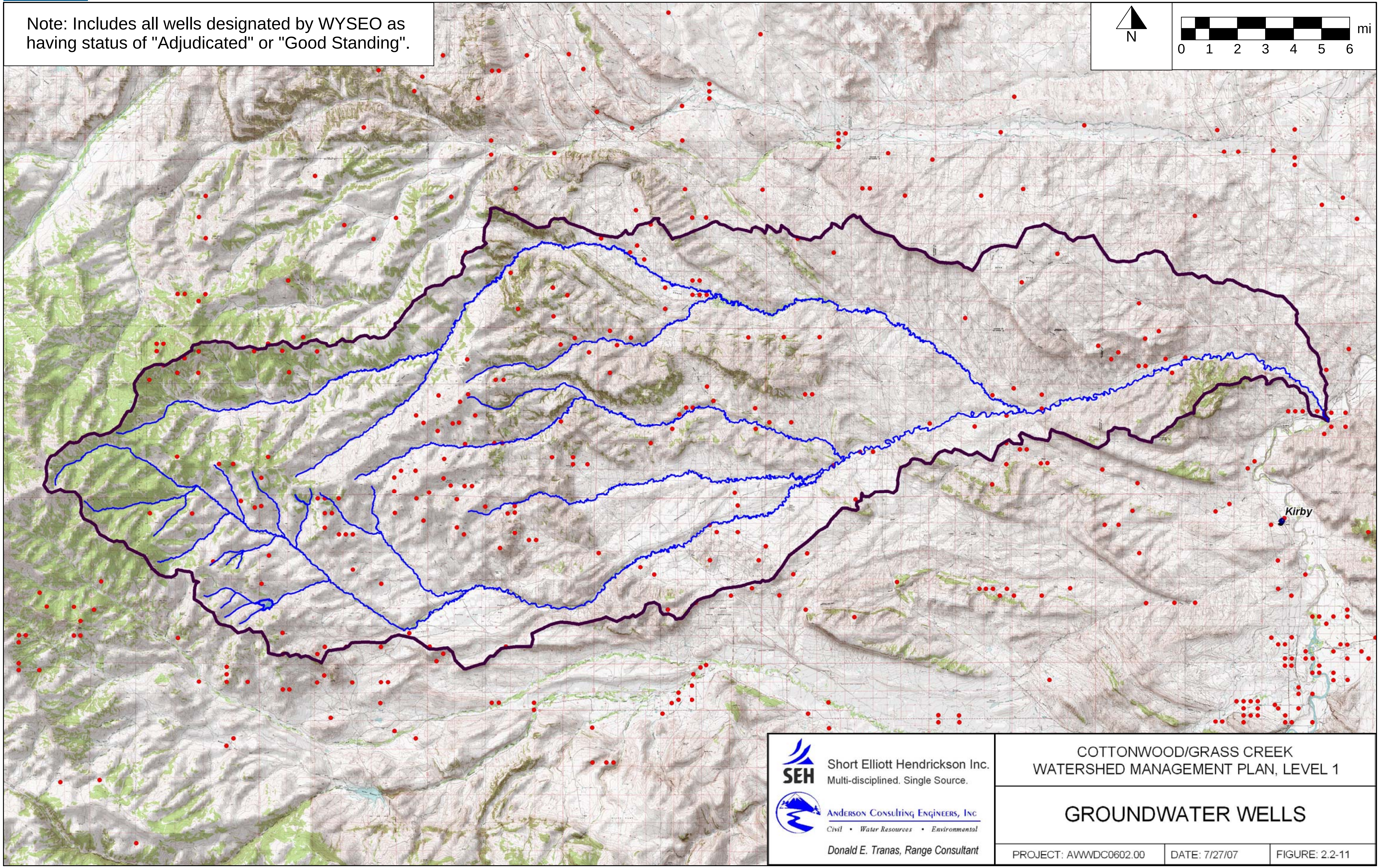
WATERSHED MANAGEMENT PLAN, LEVEL 1

ESTIMATED PEAK HORIZONTAL GROUND ACCELERATION

PROJECT: AWWDC0602.00	DATE: 7/27/07	FIGURE: 2.2-9

XMap® 5.0 GIS Editor




Note: Includes all wells designated by WYSEO as having status of "Adjudicated" or "Good Standing".
N
0 1 2 3 4 5 6 mi
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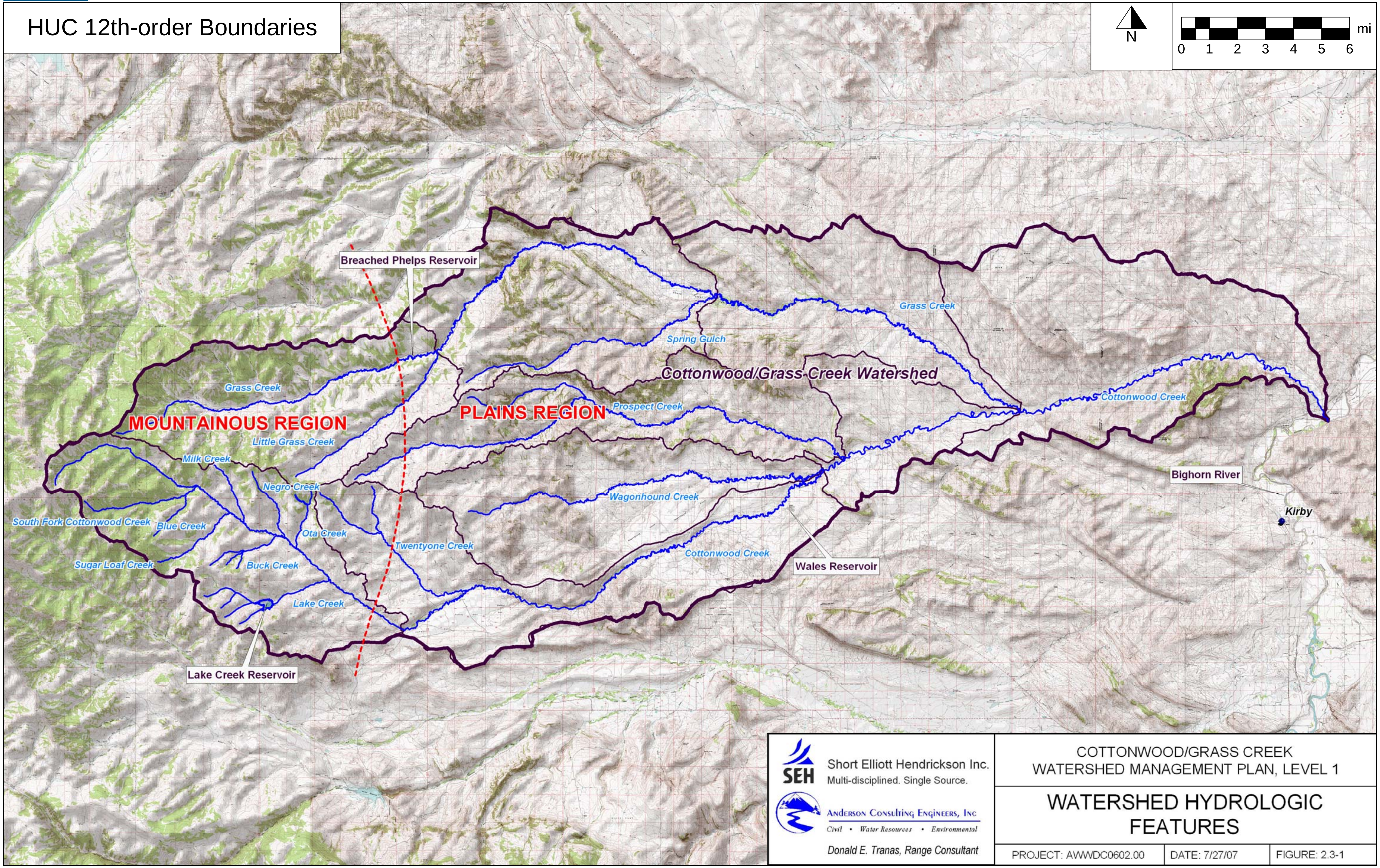
WATERSHED MANAGEMENT PLAN, LEVEL 1
GROUNDWATER WELLS
PROJECT: AWWDC0602.00
DATE: 7/27/07
FIGURE: 2.2-11



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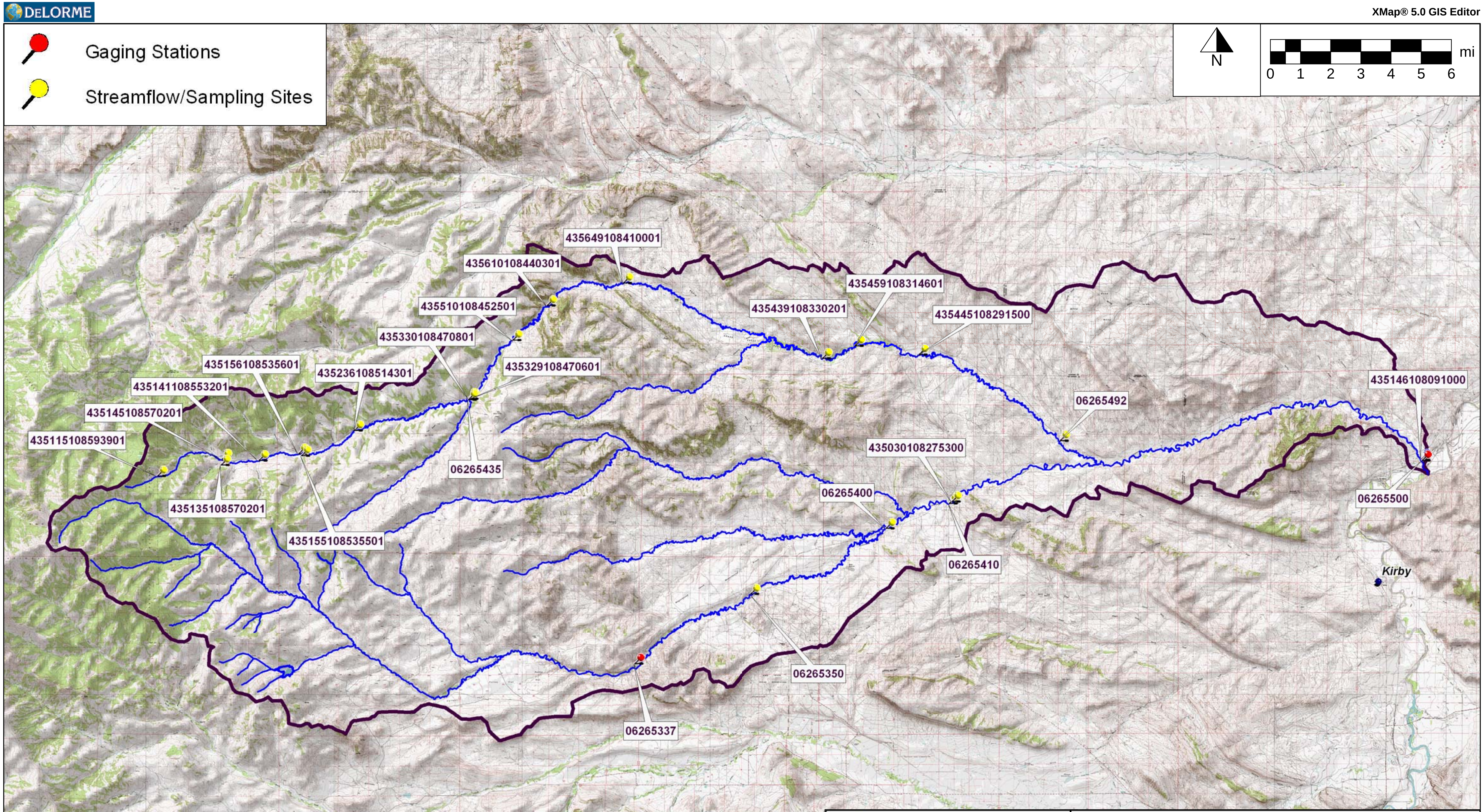
COTTONWOOD/GRASS CREEK WATERSHED MANAGEMENT PLAN, LEVEL 1

WATERSHED HYDROLOGIC FEATURES

PROJECT: AWWDC0602.00 | DATE: 7/27/07 | FIGURE: 2.3-1



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COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

GAGING STATIONS AND STREAMFLOW/SAMPLING SITES

PROJECT: AWWDC0602.00 | DATE: 7/27/07 | FIGURE: 2.3-2

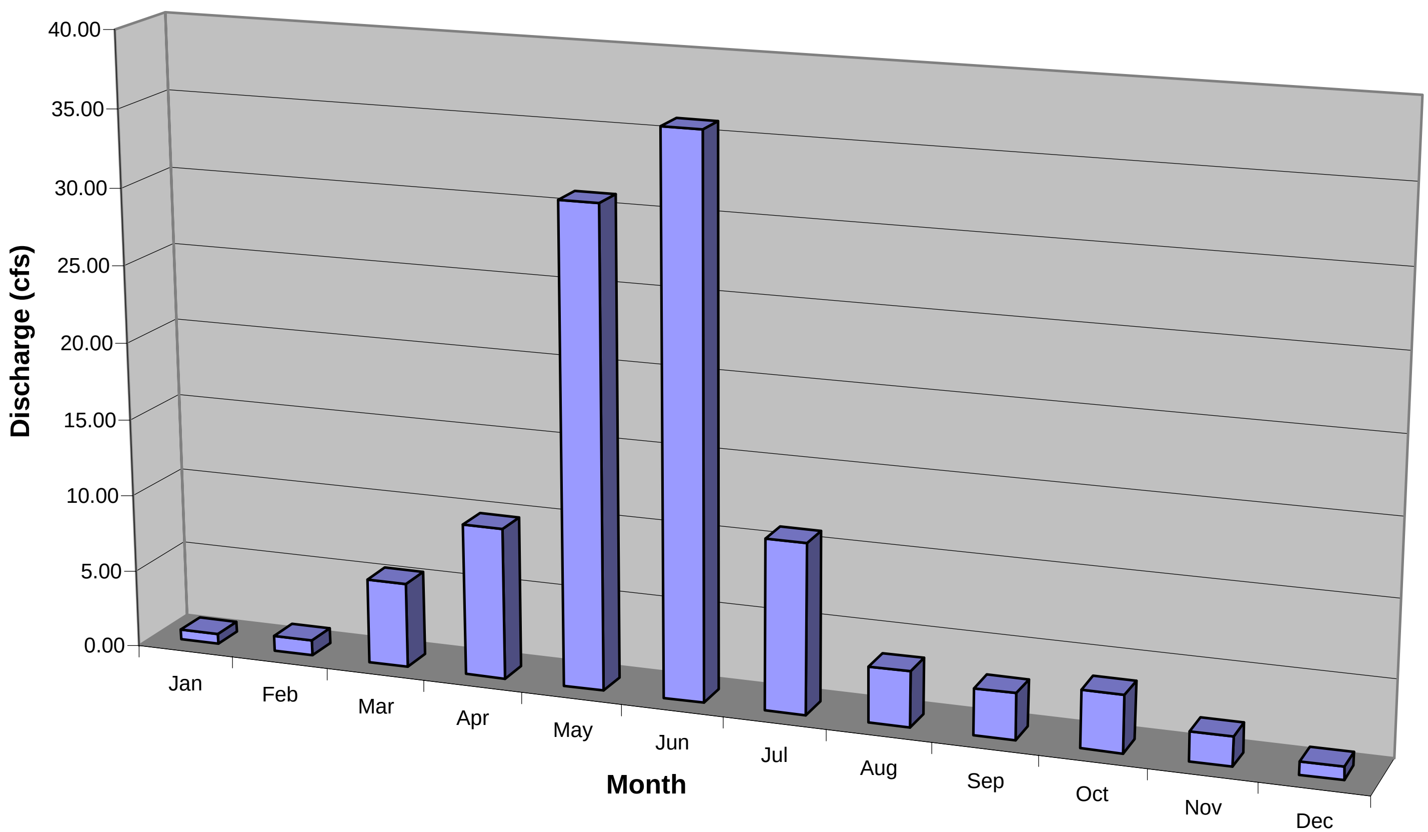


Figure 2.3-3

Mean Monthly Discharge (cfs) - Cottonwood Creek at USGS Gage 06265337

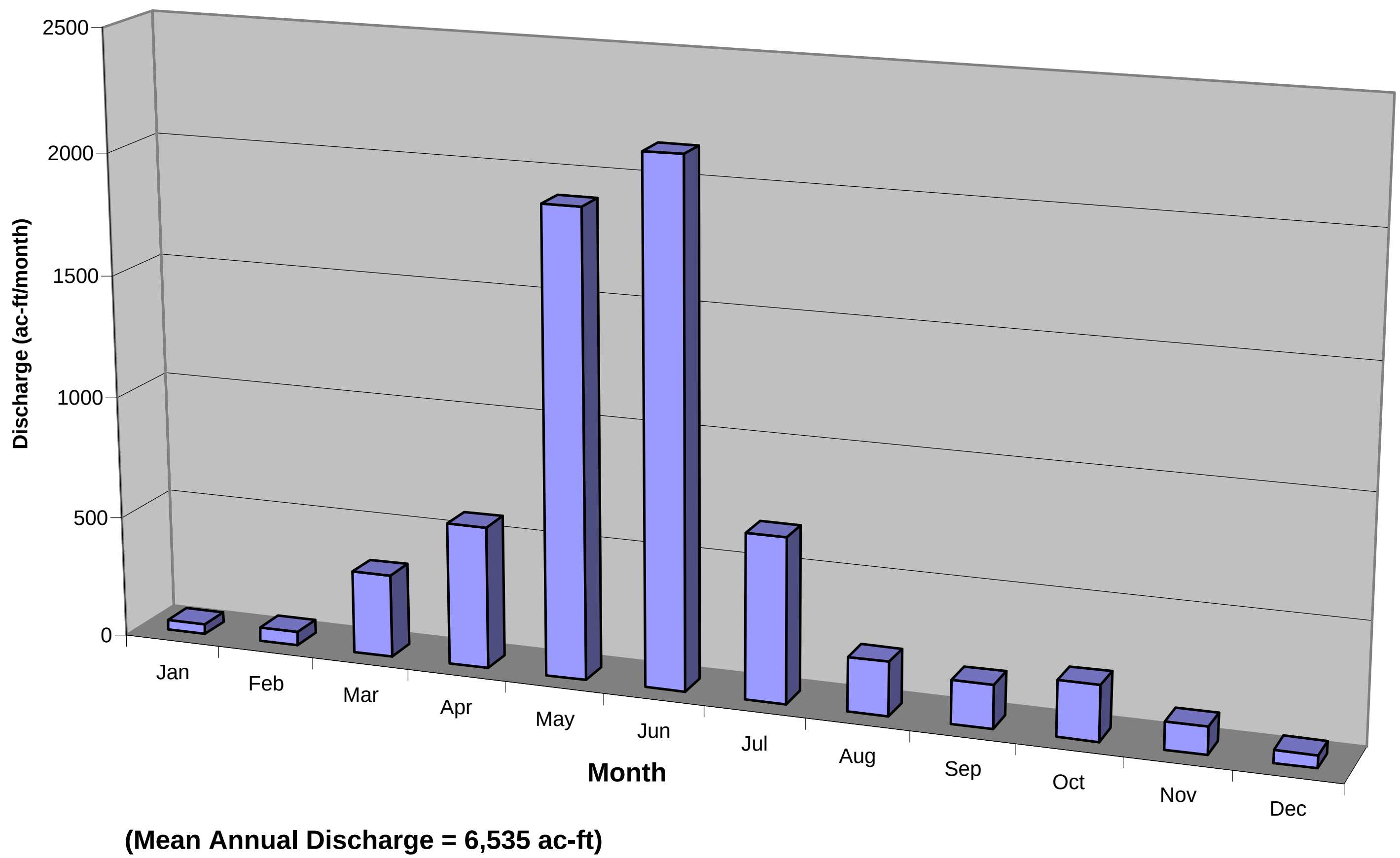


Figure 2.3-4

Mean Monthly Discharge (ac-ft/month) - Cottonwood Creek at USGS Gage 06265337 (near Hamilton Dome)

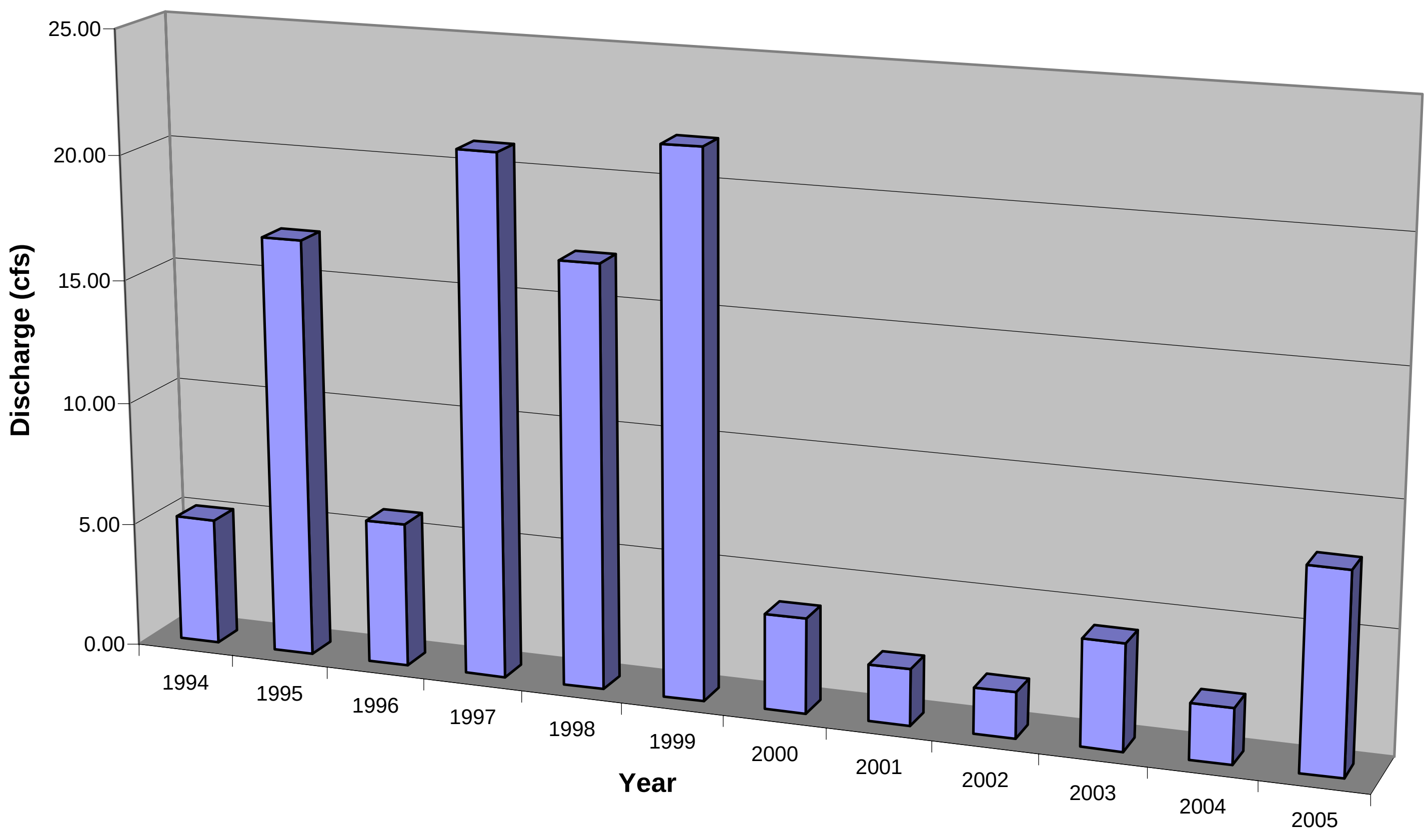
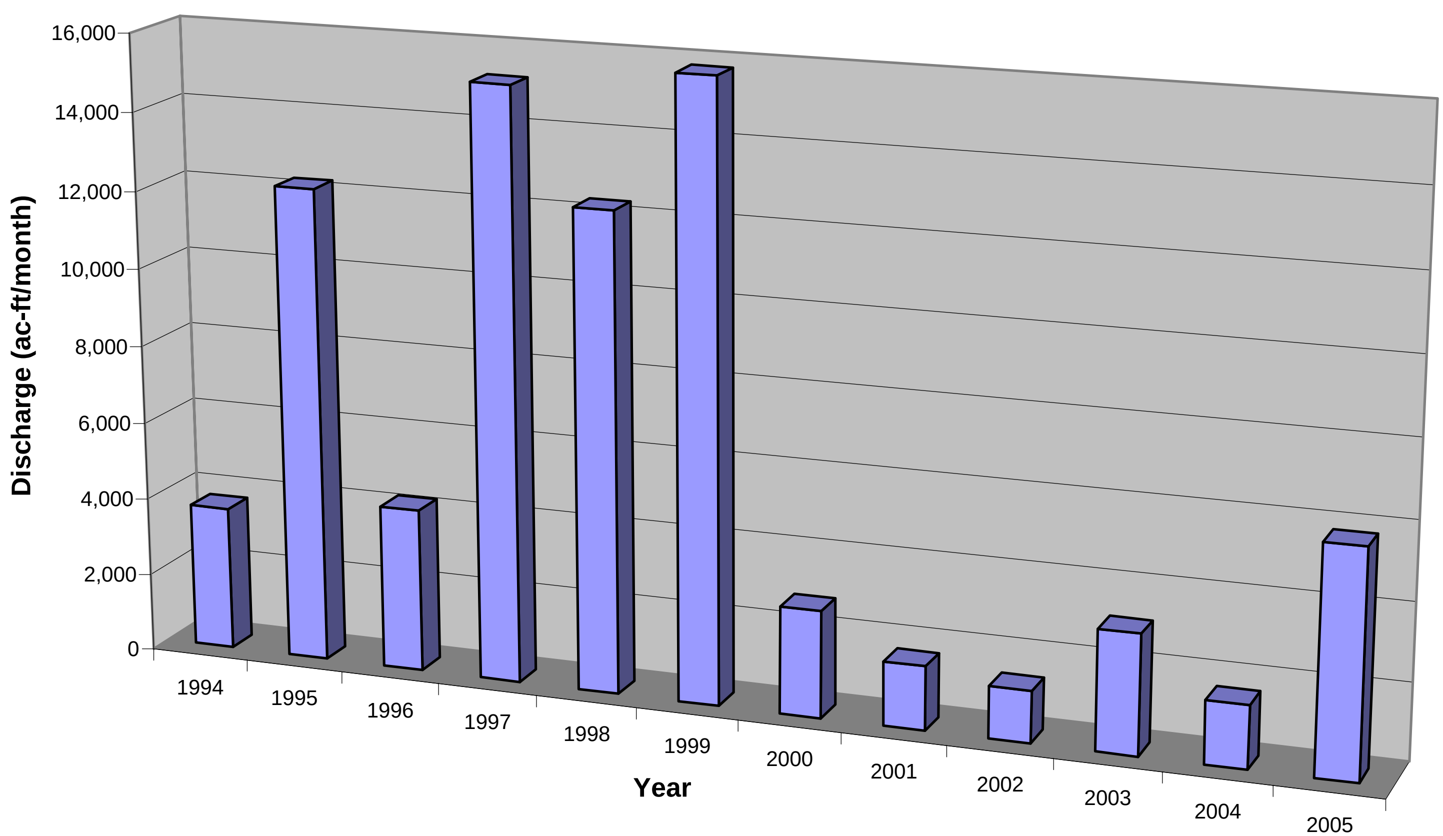


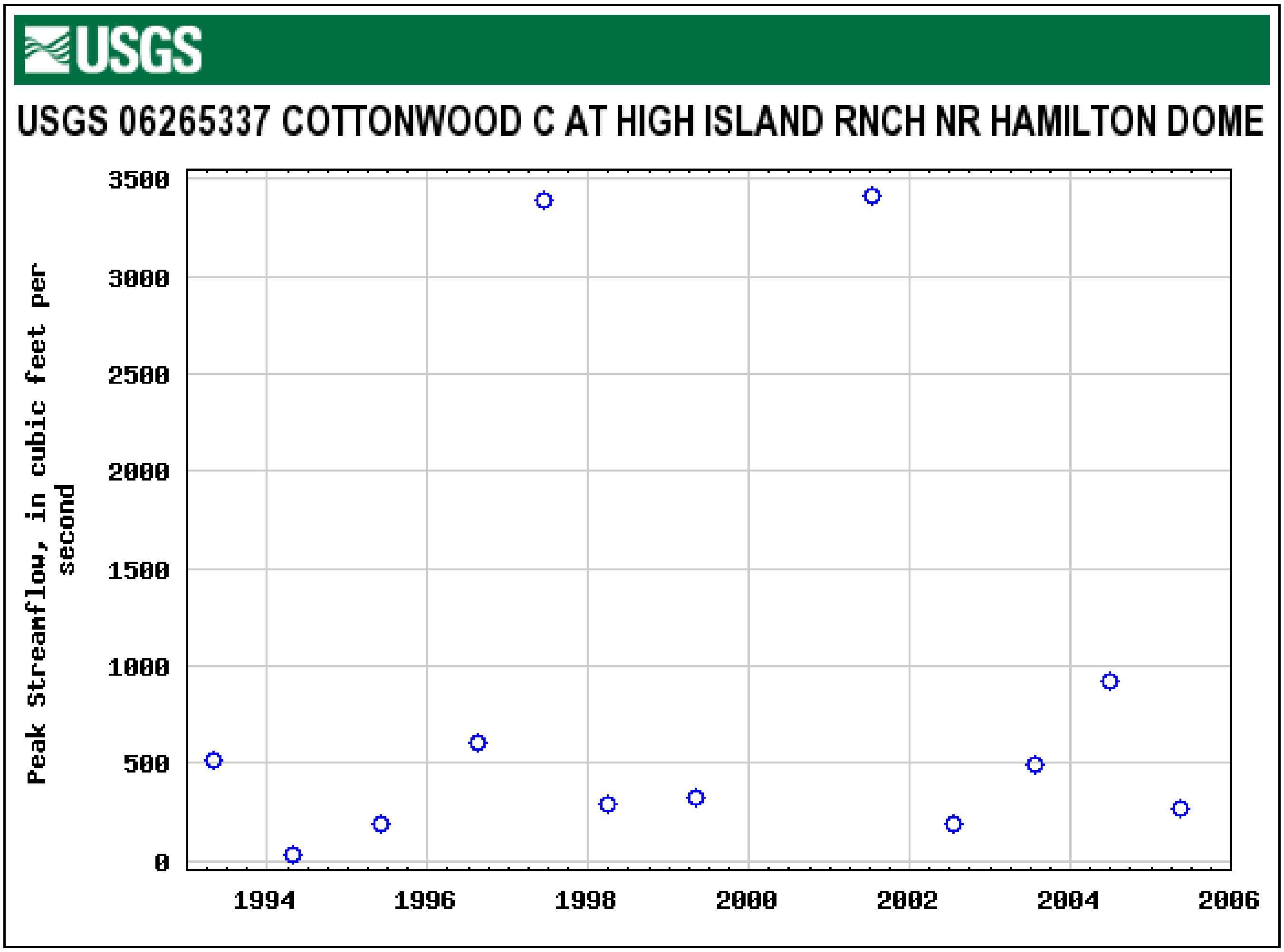
Figure 2.3-5

Mean Annual Discharge (cfs) - Cottonwood Creek at USGS Gage 06265337



(Mean Annual Discharge = 6,216 ac-ft)

Figure 2.3-6
Mean Annual Discharge (ac-ft/year) - Cottonwood Creek at USGS Gage 06265337



Peak Gaged Streamflow – Cottonwood Creek Gage 06265337
Figure 2.3-7

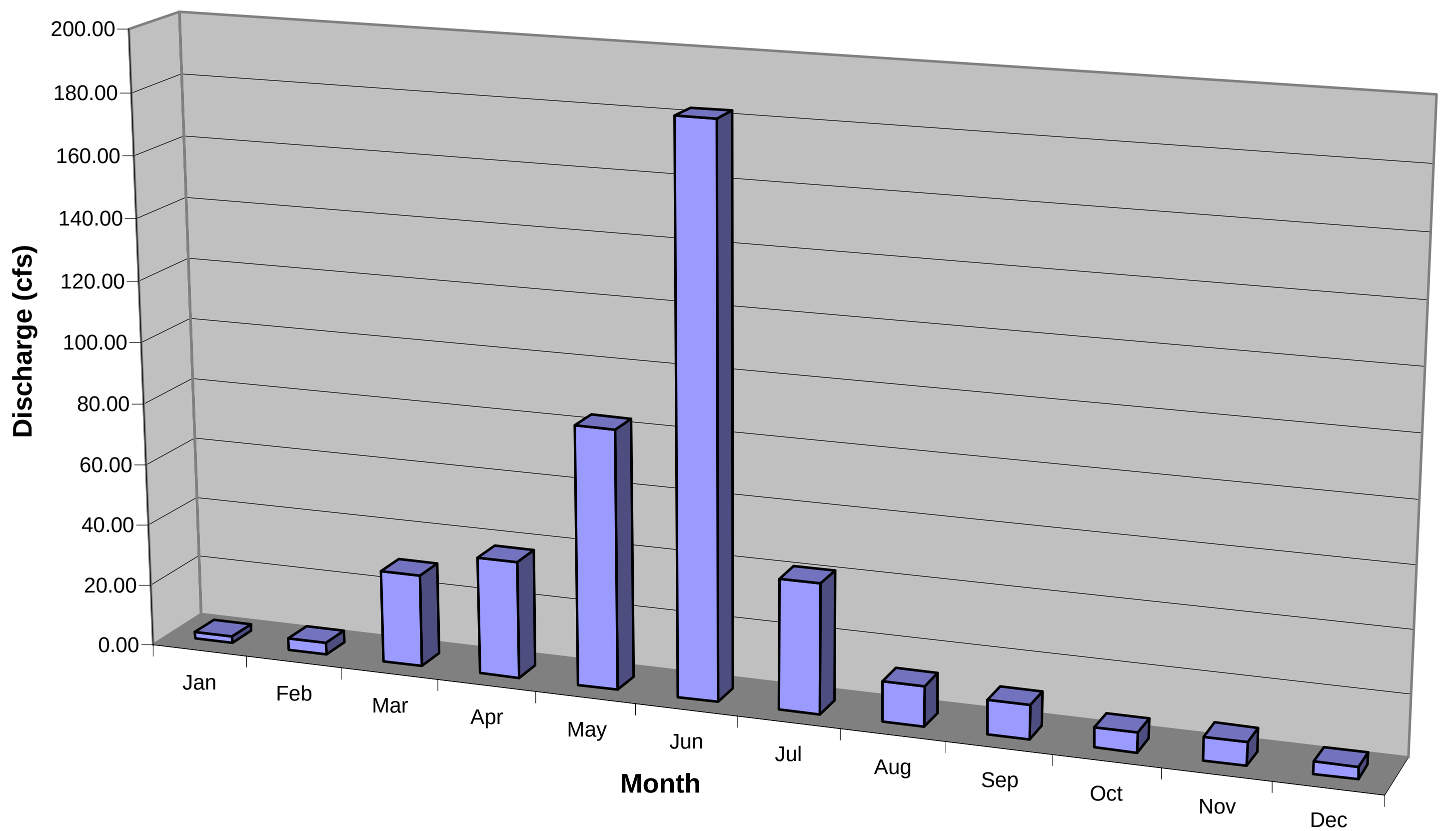
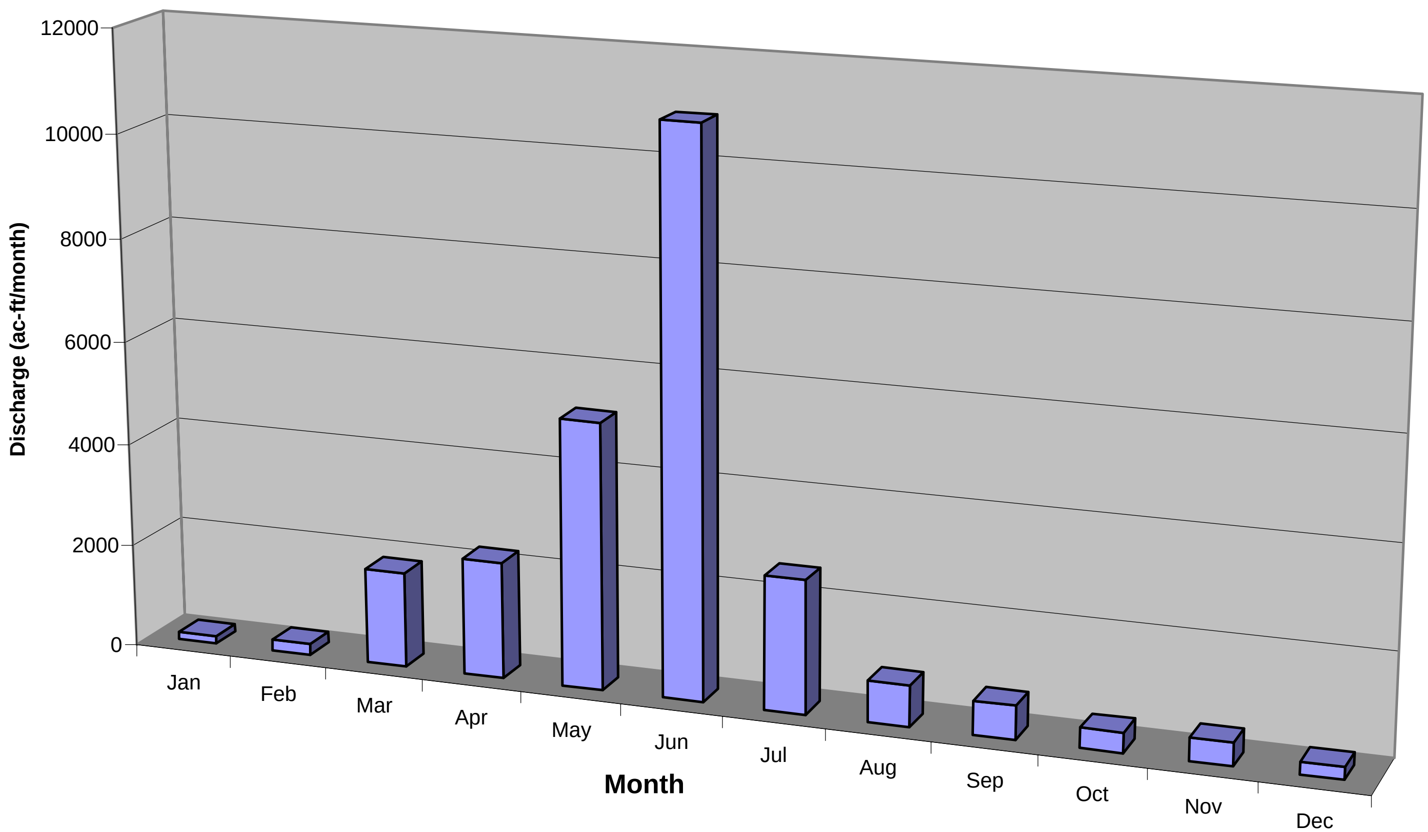


Figure 2.3-8

Mean Monthly Discharge (cfs) - Cottonwood Creek at USGS Gage 06265500 (near Winchester)



(Mean Annual Discharge = 25,628 ac-ft)

Figure 2.3-9

Mean Monthly Discharge (ac-ft/month) - Cottonwood Creek at USGS Gage 06265500 (near Winchester)

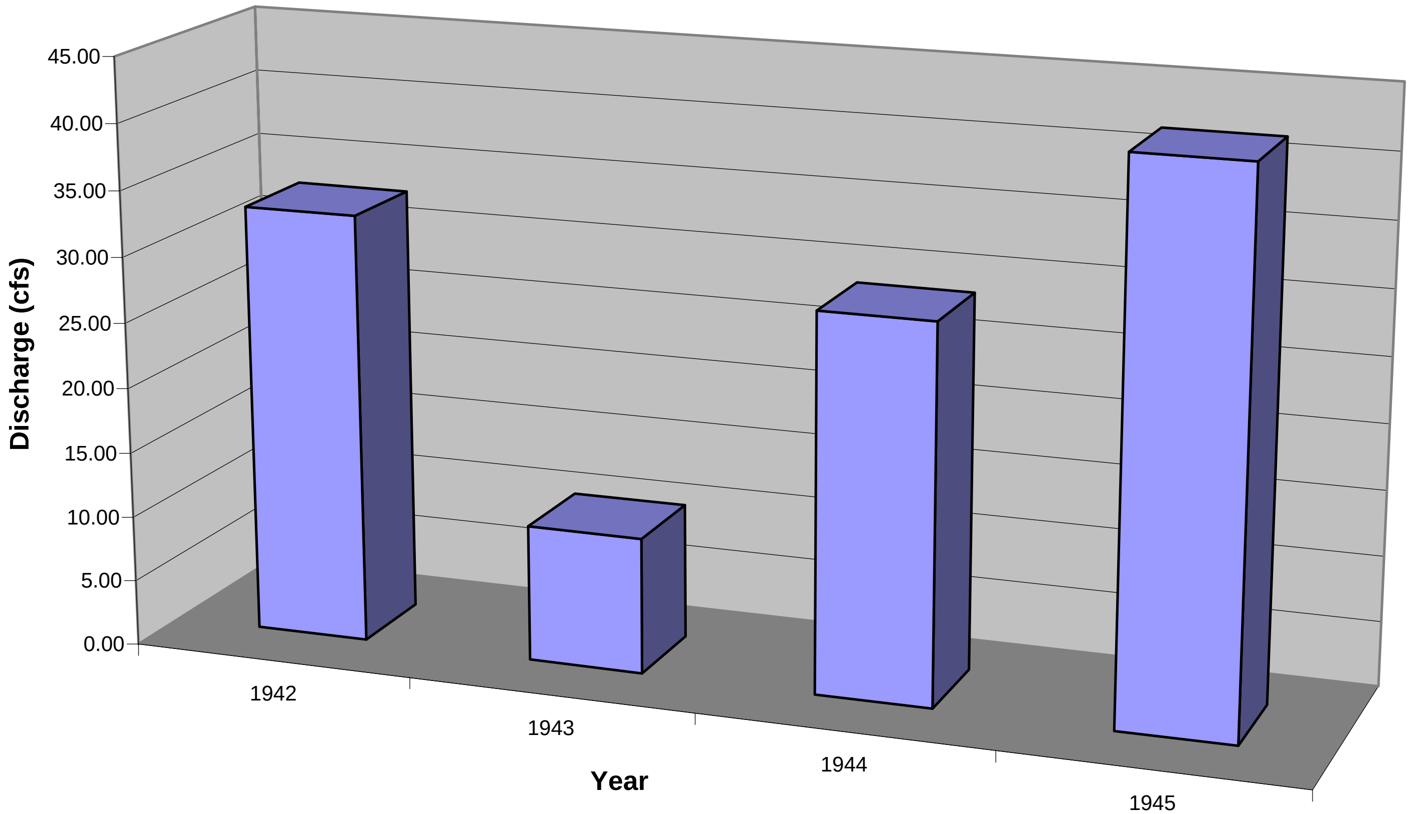


Figure 2.3-10

Mean Annual Discharge (cfs) - Cottonwood Creek at USGS Gage 06265500

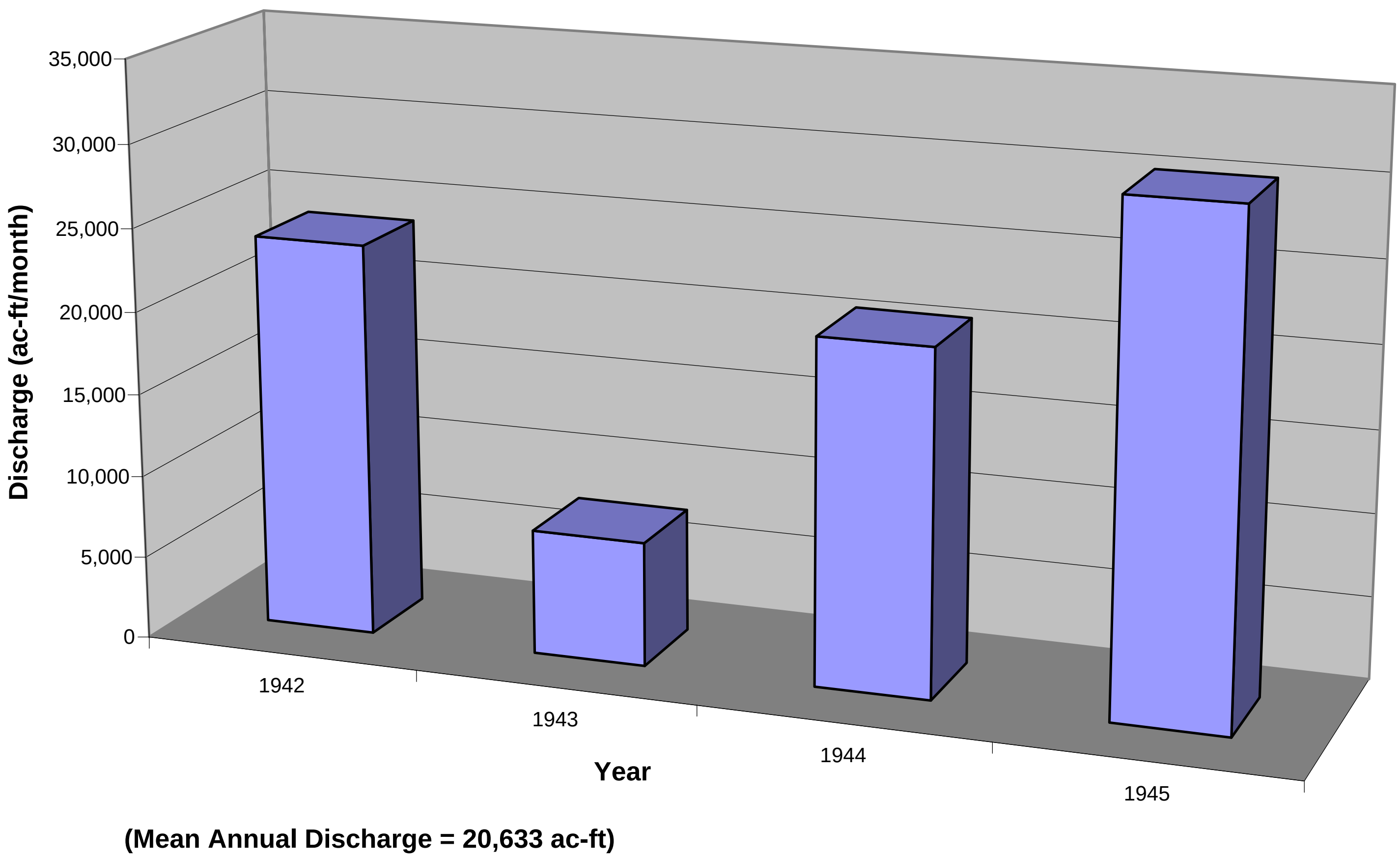
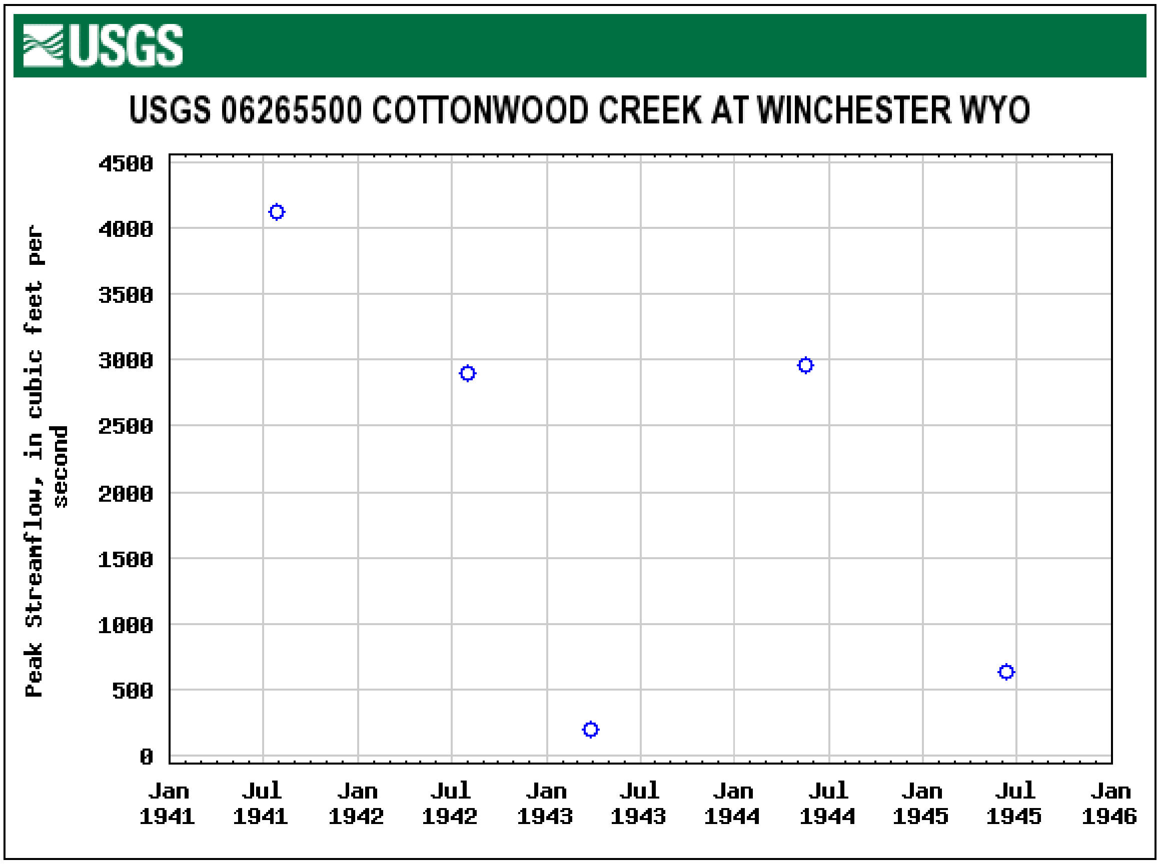
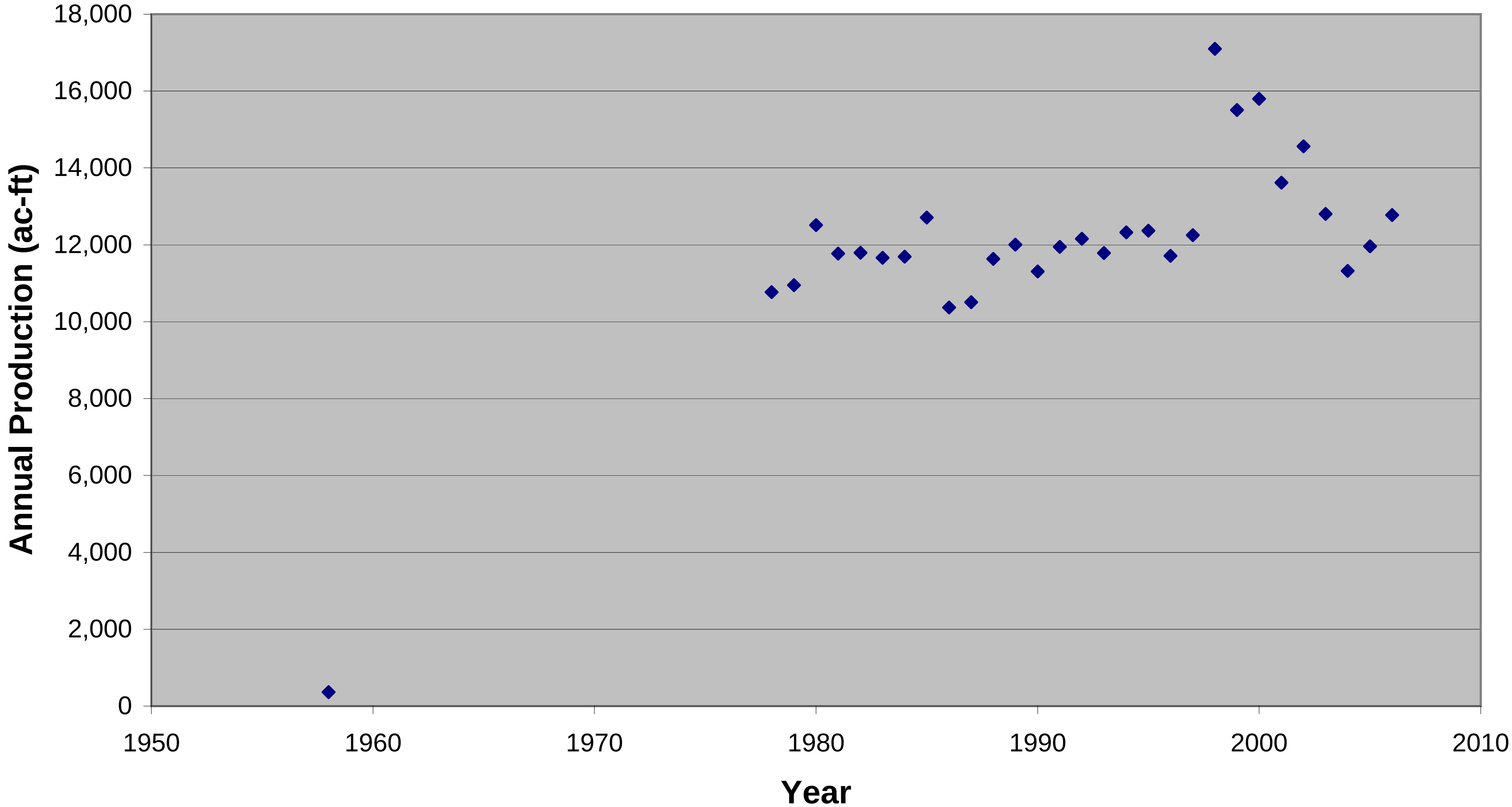


Figure 2.3-11

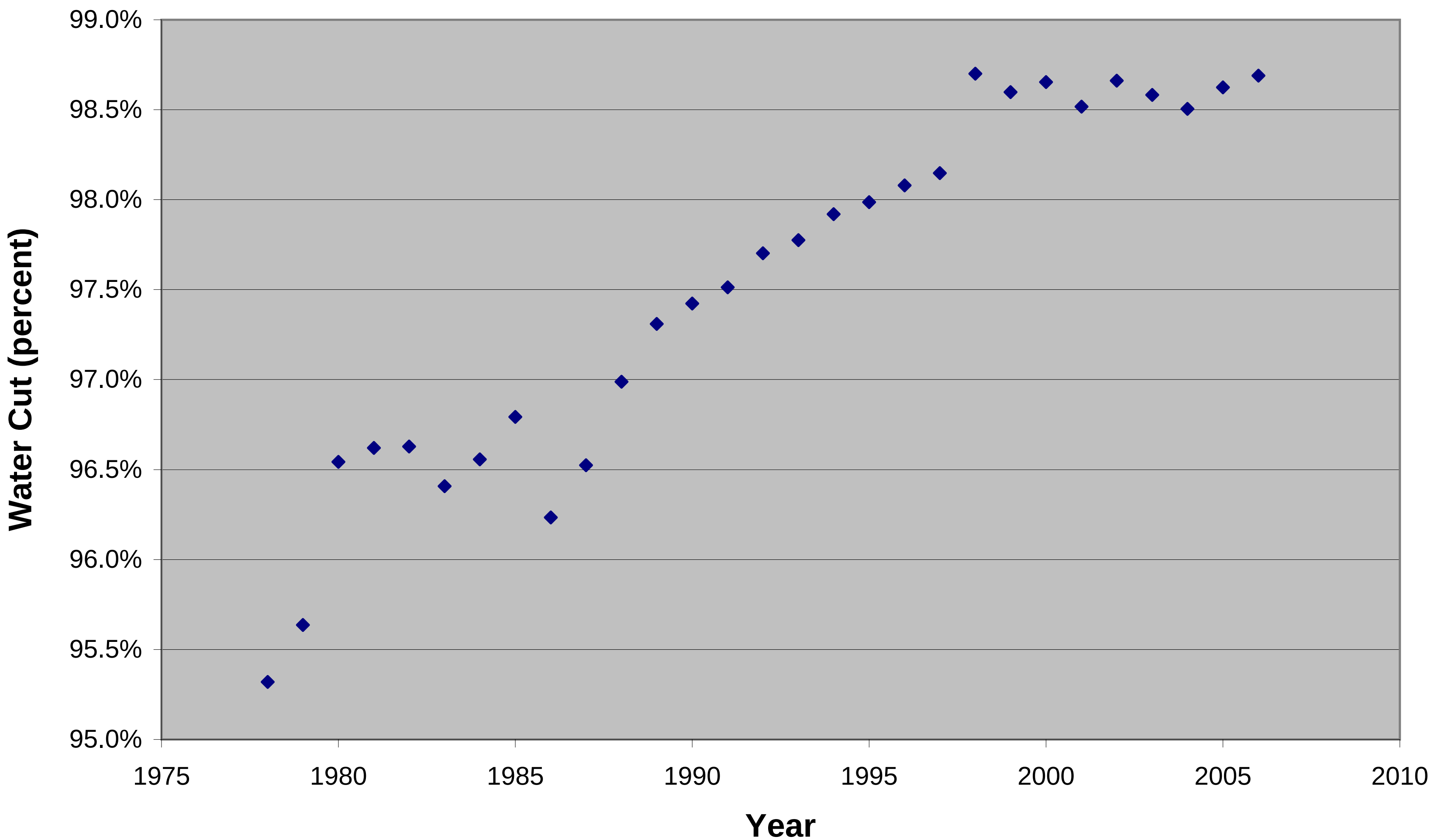
Mean Annual Discharge (ac-ft/year) - Cottonwood Creek at USGS Gage 06265500



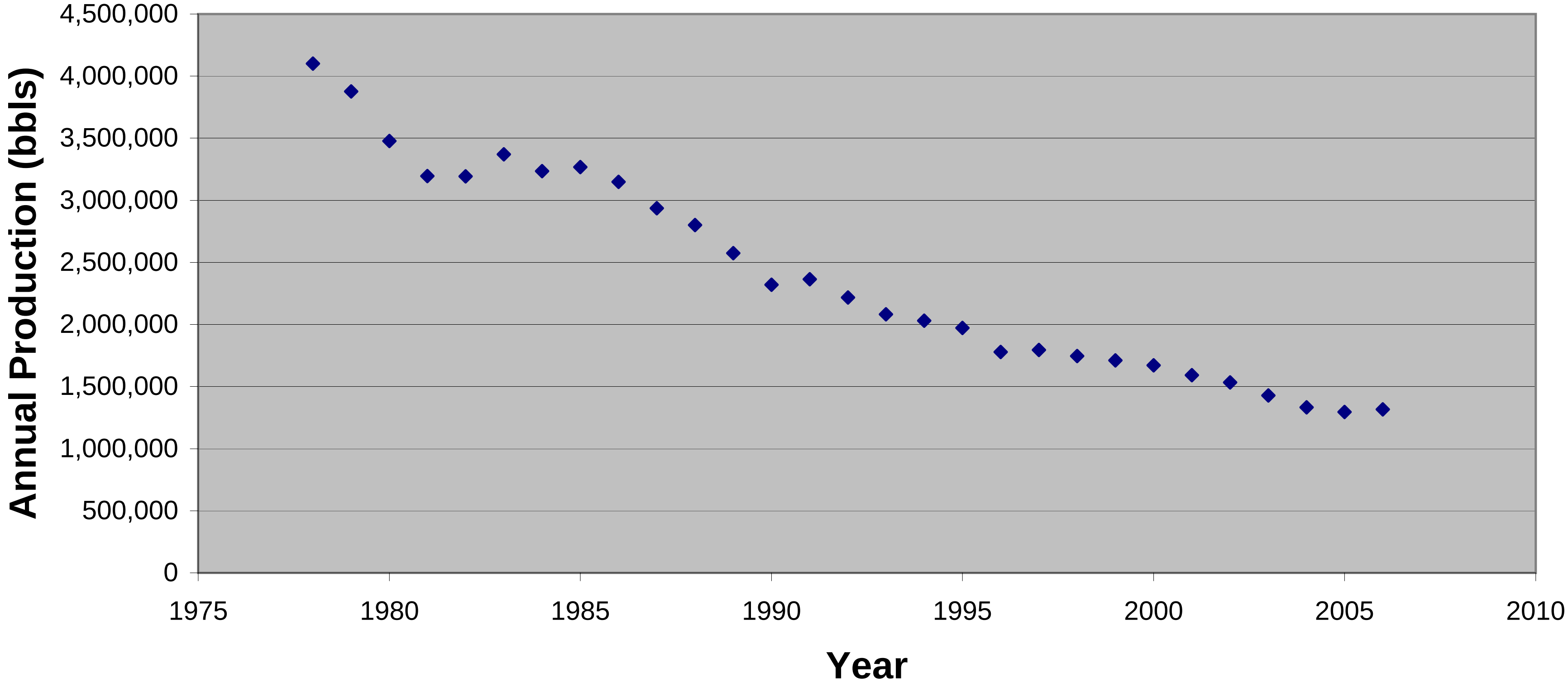
Peak Gaged Streamflow – Cottonwood Creek Gage 06265500
Figure 2.3-12



Hamilton Dome Water Production
Figure 2.3-13



Hamilton Dome Water Cut Over Time
Figure 2.3-14



Hamilton Dome Oil Production
Figure 2.3-15

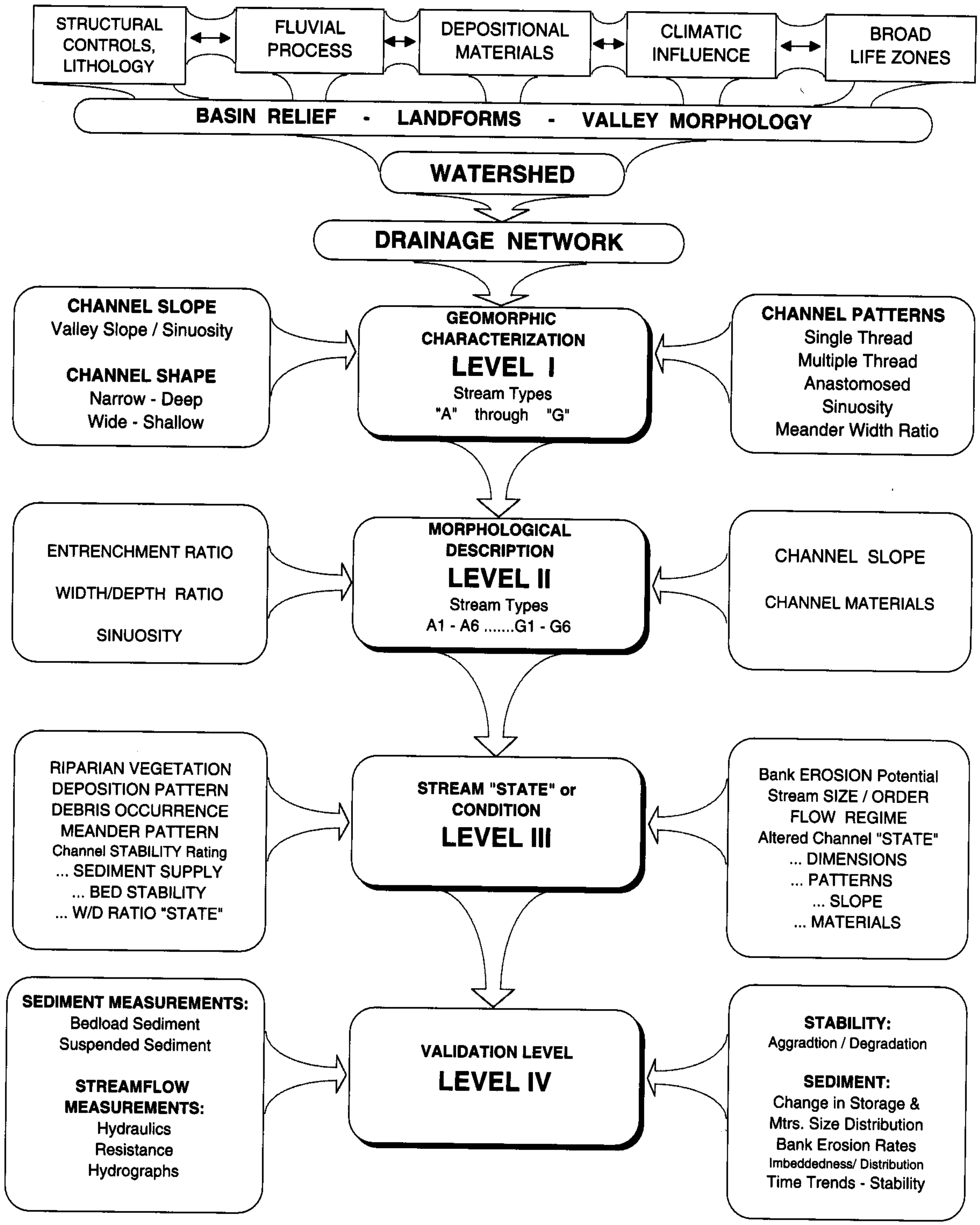


Figure 2.4-1 Hierarchy of the Rosgen Classification System (Rosgen, 1996).

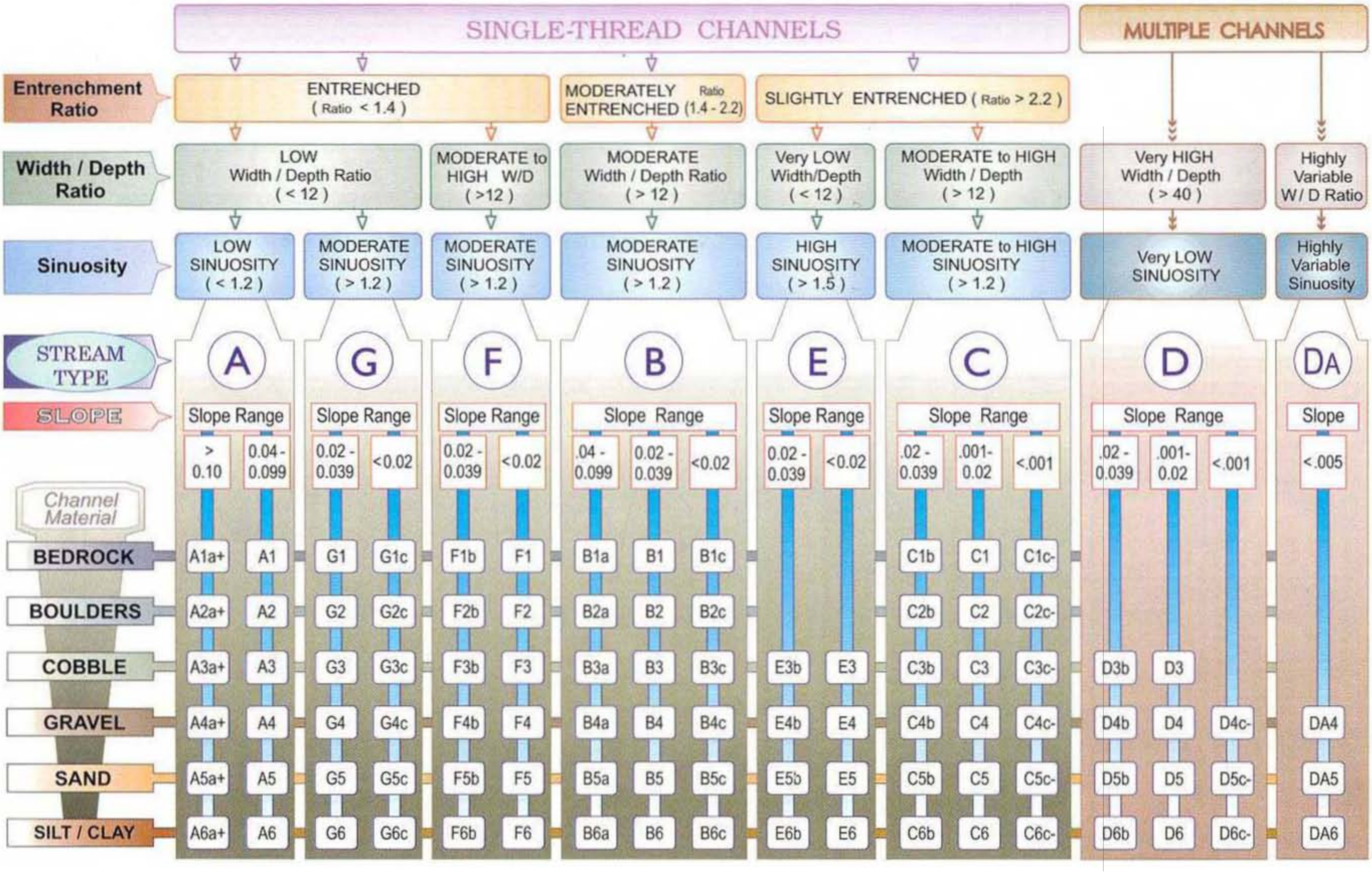


Figure 2.4-2 Rosgen Classification Matrix (Rosgen, 1996).

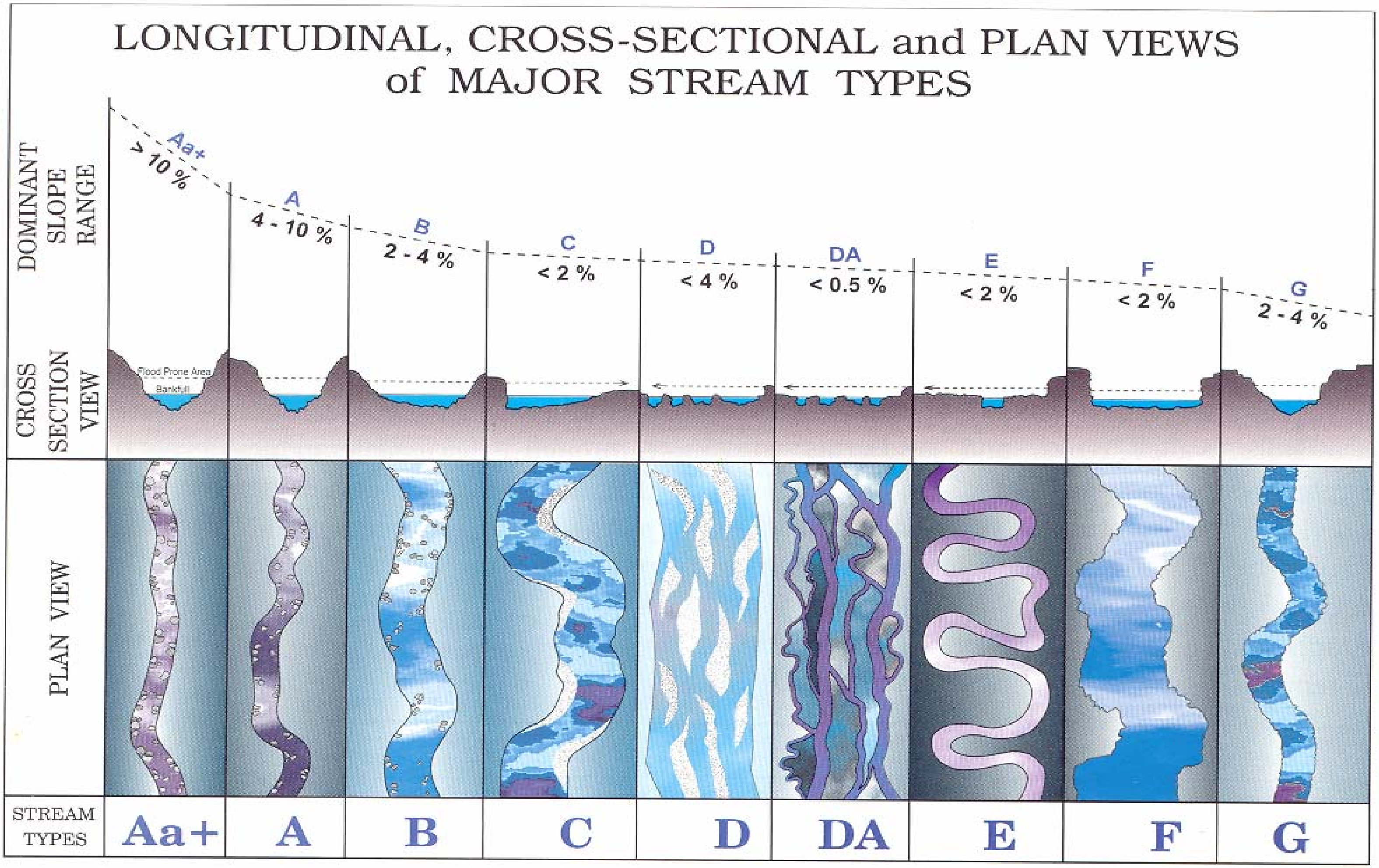


Figure 2.4-3 Major Stream Types within the Rosgen Classification System (Rosgen, 1996).

Figure 2.4-4 Grass Creek Headwaters (Type A)

Figure 2.4-5 Upper Wagonhound Creek (Type B)

Figure 2.4-6 Cottonwood Creek above Wagonhound Creek (Type C).

Figure 2.4-7 Grass Creek above Little Grass Creek (Type E).

Figure 2.4-8 Lower Spring Gulch.

Figure 2.4-9 Prospect Creek Tributary (Type G).

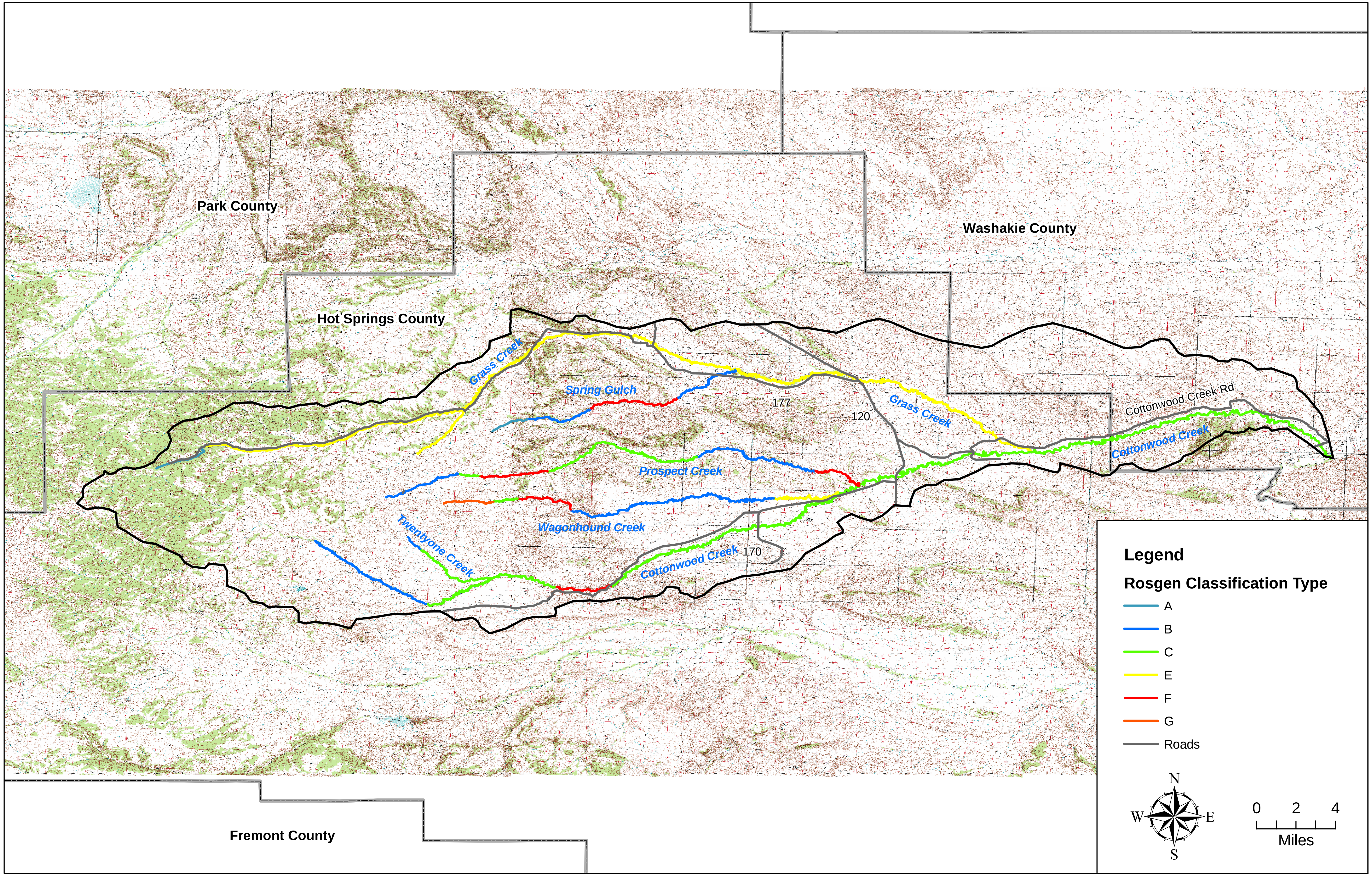


Figure 2.4-10: Rosgen Level I Geomorphic Classification.

Figure 2.4-11 Cottonwood Creek near the Confluence with the Bighorn River. (Type C4 Channel).

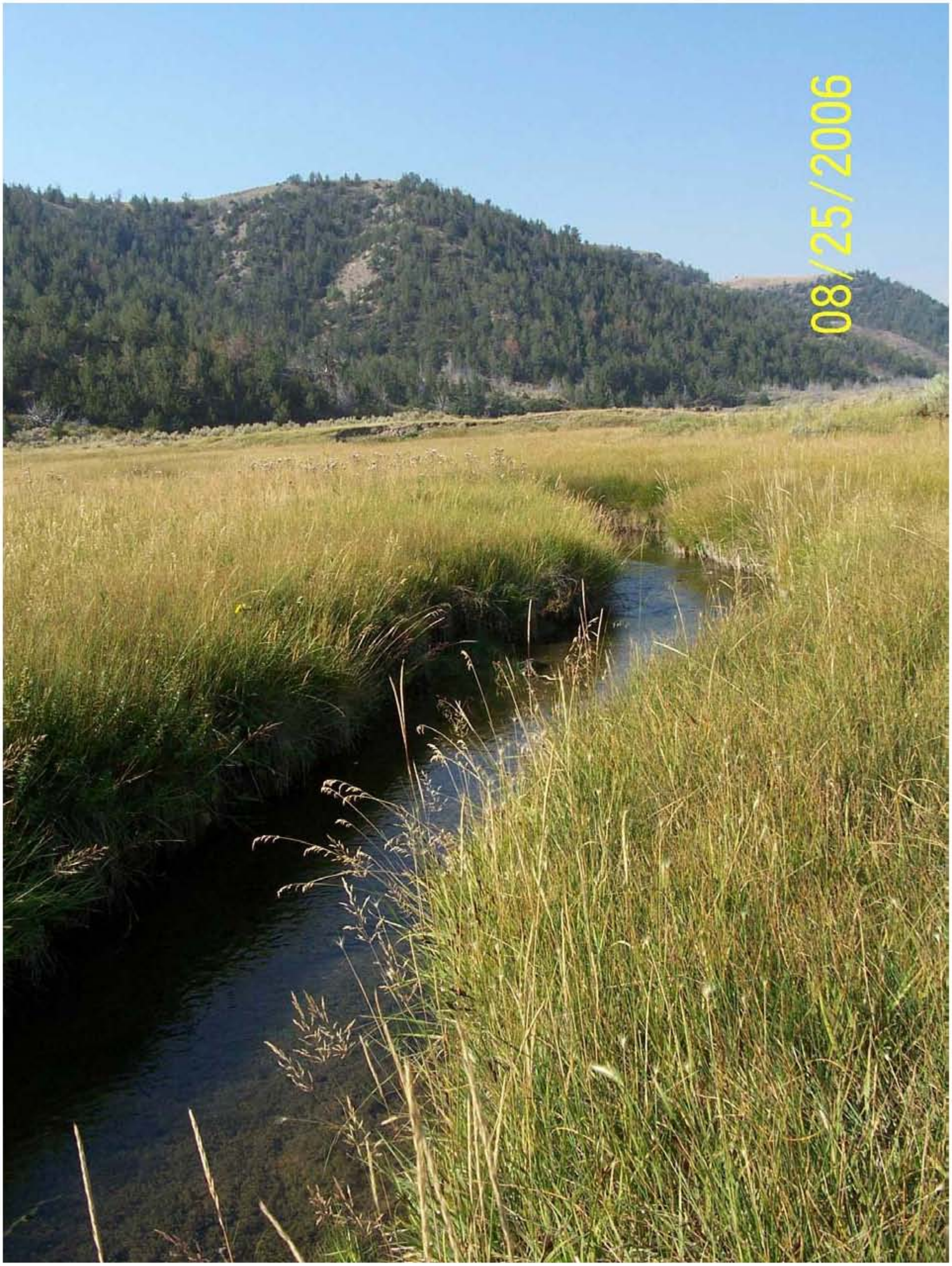


Figure 2.4-12 Grass Creek near Little Grass Creek (Type E Channel).

Figure 2.4-13 Tributary Drainage to Wagonhound Creek (Type G Channel).

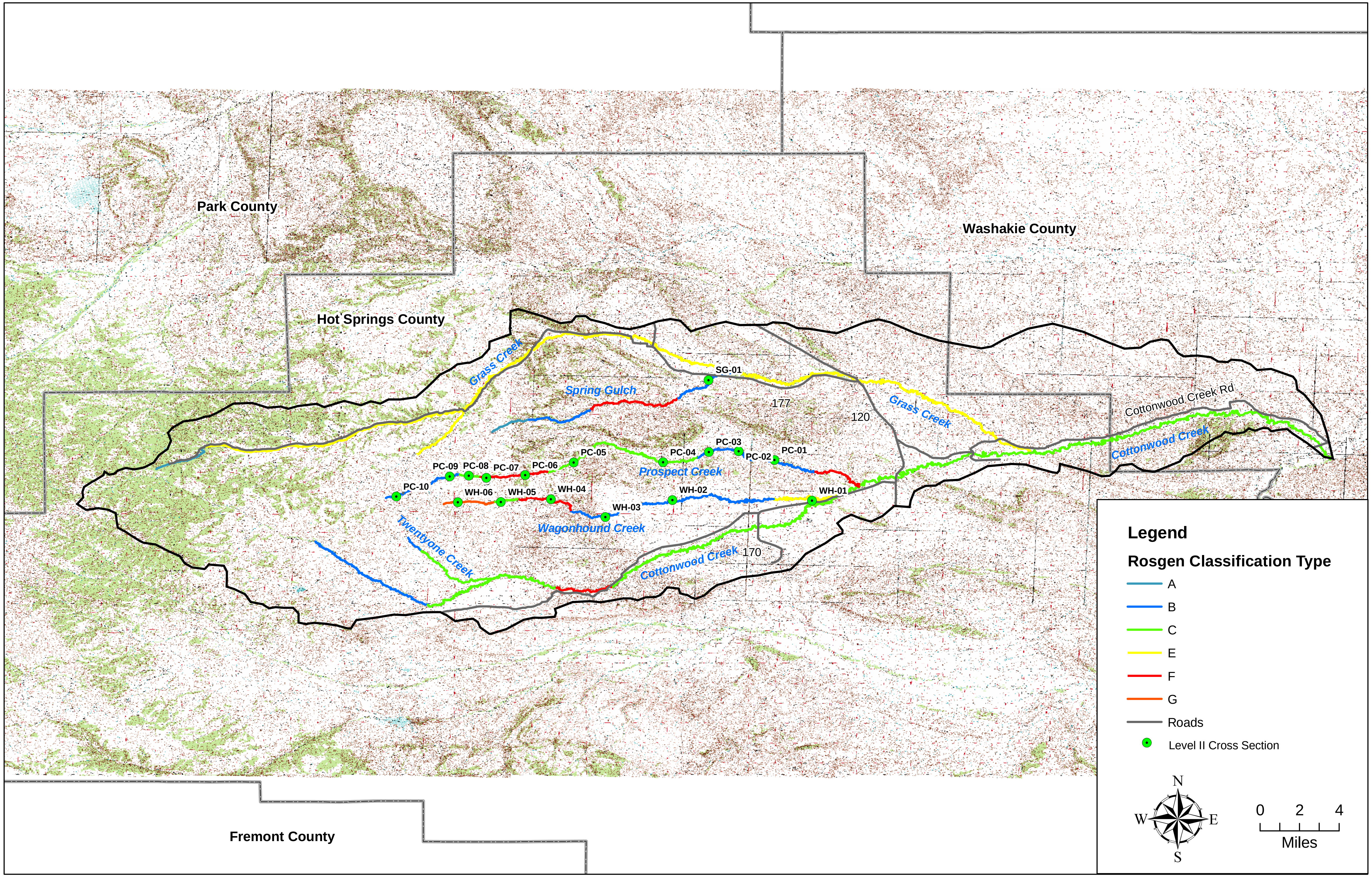


Figure 2.4-14: Rosgen Level II Geomorphic Classification Cross Section Locations

Figure 2.4-15 Prospect Creek at Cross Section PC-08 (Type C4b Channel).

Figure 2.4-16 Prospect Creek at Cross Section PC-07 (Type F4c Channel).

Figure 2.4-17 Wagonhound Creek at Cross Section WH-06 (Type G4 Channel).

Figure 2.4-18 Wagonhound Creek at Cross Section WH-04 (Type F4b Channel).

Figure 2.4-19 Headcut Located on Spring Gulch

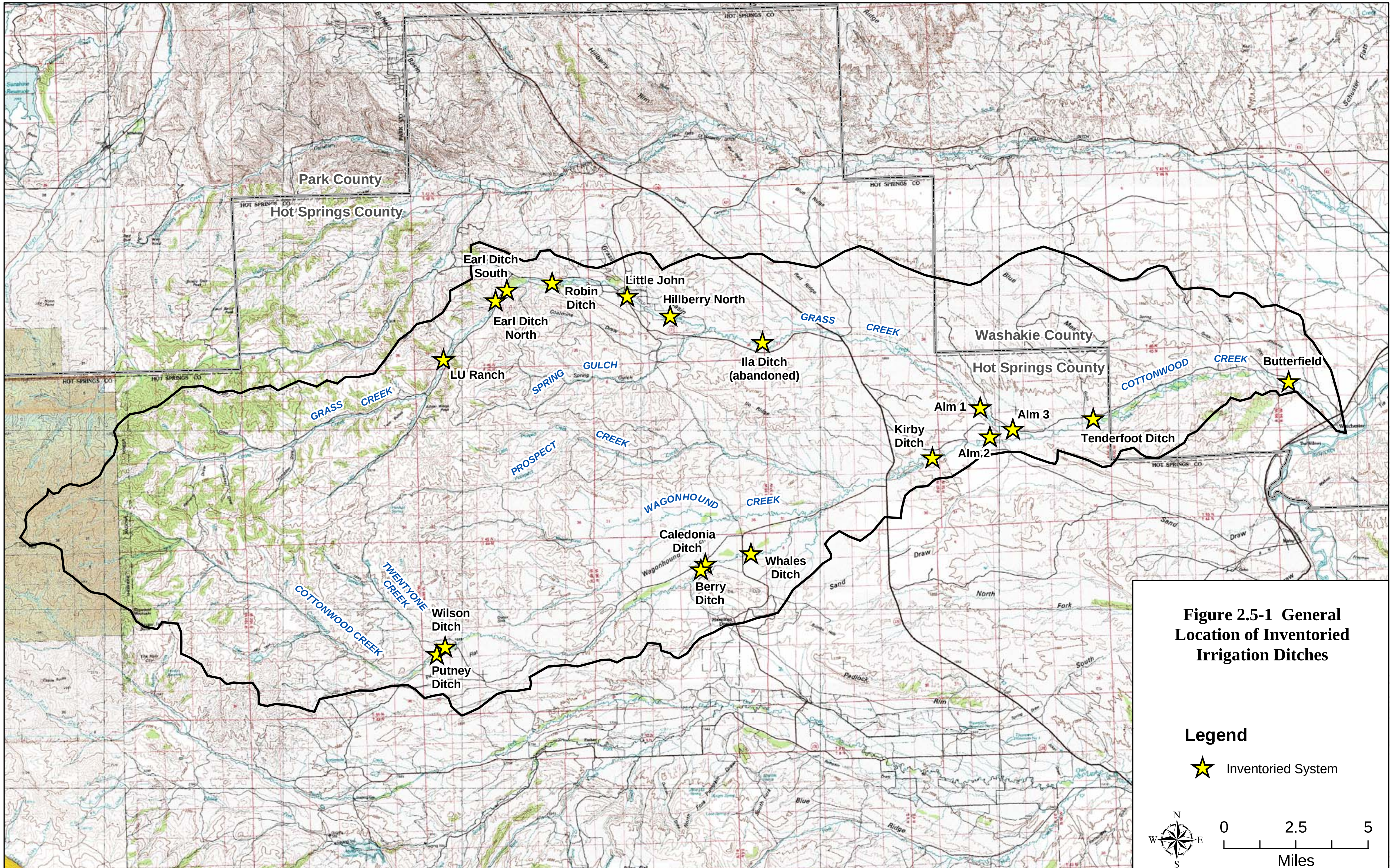


Figure 2.5-1 General Location of Inventoried Irrigation Ditches

Figure 2.5-2 Drainage Crossing on Alm #3 Ditch.

Figure 2.5-3 Splitter Structure in Caledonia Ditch

Figure 2.5-4 Hillberry North Headgate

Figure 2.5-5 Kirby Ditch Diversion

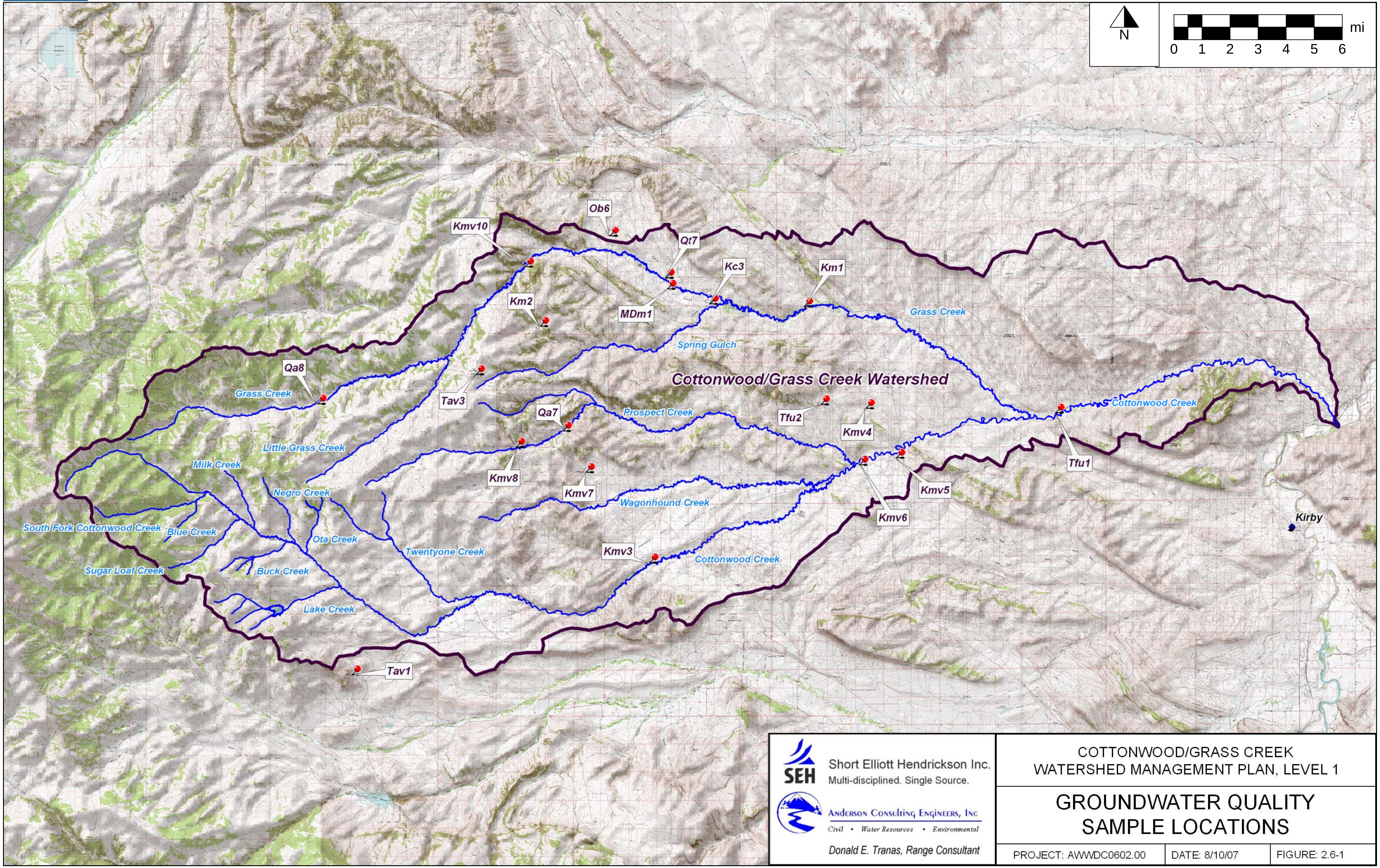
Figure 2.5-6 Little John Ditch Diversion

Figure 2.5-7 Parallel Ditches on Little John Ditch

Figure 2.5-8 Putney Ditch Diversion

Figure 2.5-9 Severe Gully Erosion at Wales Ditch

Figure 2.5-10 Wilson Ditch Diversion



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COTTONWOOD/GRASS CREEK WATERSHED MANAGEMENT PLAN, LEVEL 1

GROUNDWATER QUALITY SAMPLE LOCATIONS

PROJECT: AWWDC0602.00 | DATE: 8/10/07 | FIGURE: 2.6-1

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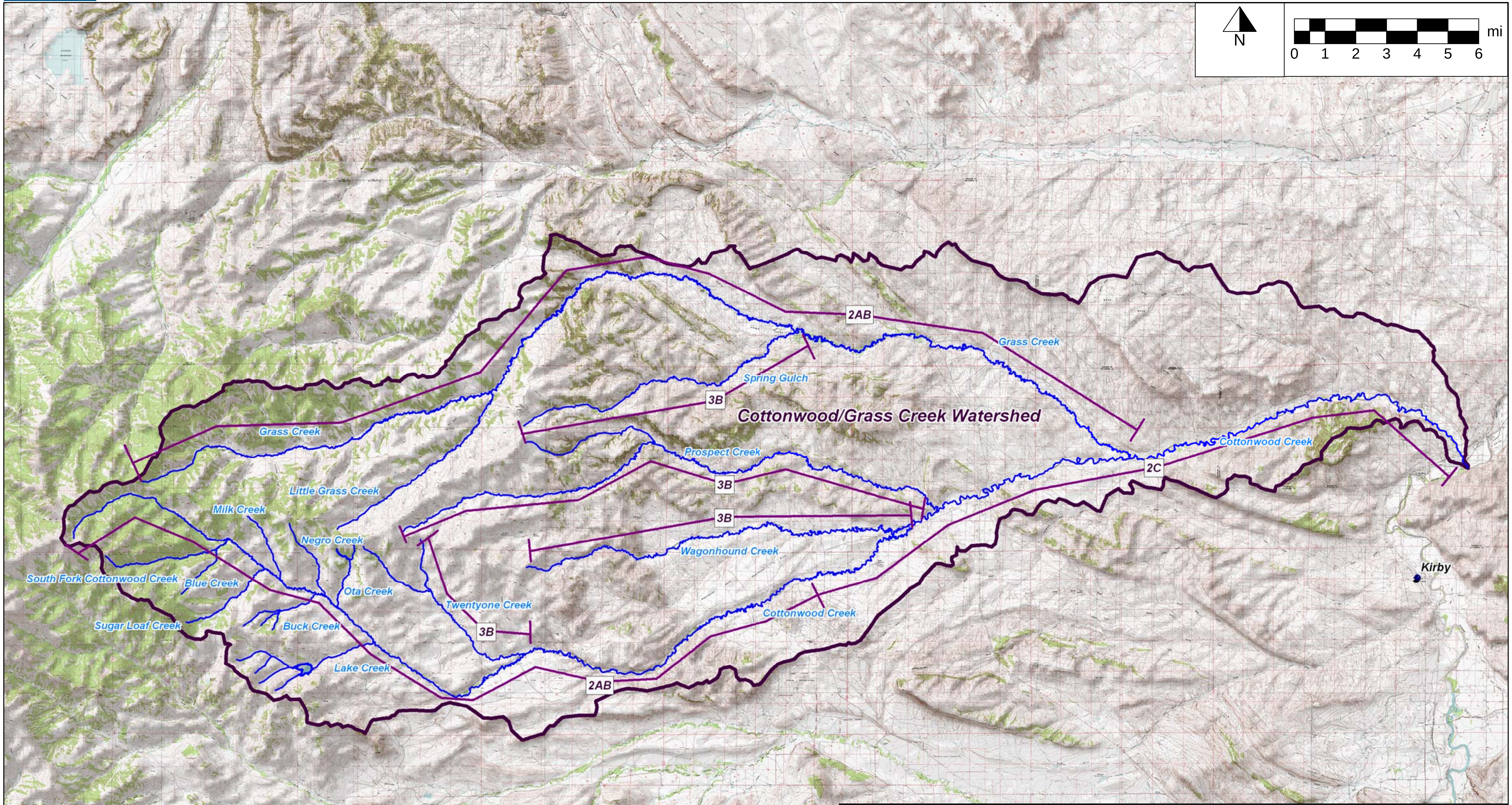

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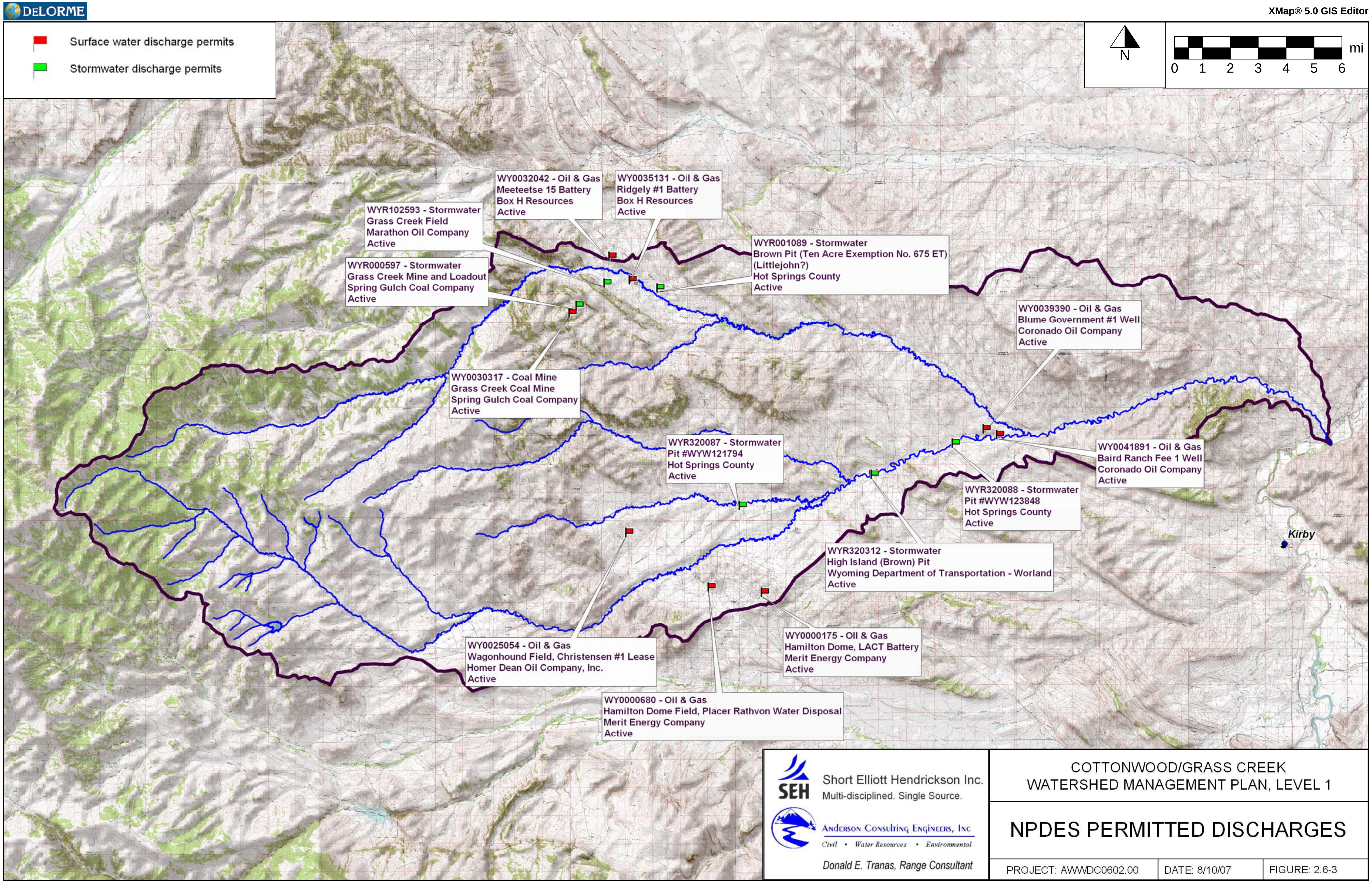
COTTONWOOD/GRASS CREEK WATERSHED MANAGEMENT PLAN, LEVEL 1

WDEQ STREAM CLASSIFICATIONS

PROJECT: AWWDC0602.00 | DATE: 8/10/07 | FIGURE: 2.6-2


DELORME
XMap® 5.0 GIS Editor
Surface water discharge permits
Stormwater discharge permits
N
mi
0 1 2 3 4 5 6
WY0032042 - Oil & Gas
Meeteetse 15 Battery
Box H Resources
Active
WY0035131 - Oil & Gas
Ridgely #1 Battery
Box H Resources
Active
WYR102593 - Stormwater
Grass Creek Field
Marathon Oil Company
Active
WYR001089 - Stormwater
Brown Pit (Ten Acre Exemption No. 675 ET)
(Littlejohn?)
Hot Springs County
Active
WYR000597 - Stormwater
Grass Creek Mine and Loadout
Spring Gulch Coal Company
Active
WY0039390 - Oil & Gas
Blume Government #1 Well
Coronado Oil Company
Active
WY0030317 - Coal Mine
Grass Creek Coal Mine
Spring Gulch Coal Company
Active
WYR320087 - Stormwater
Pit #WYW121794
Hot Springs County
Active
WY0041891 - Oil & Gas
Baird Ranch Fee 1 Well
Coronado Oil Company
Active
WYR320088 - Stormwater
Pit #WYW123848
Hot Springs County
Active
Kirby
WYR320312 - Stormwater
High Island (Brown) Pit
Wyoming Department of Transportation - Worland
Active
WY0000175 - Oil & Gas
Hamilton Dome, LACT Battery
Merit Energy Company
Active
WY0025054 - Oil & Gas
Wagonhound Field, Christensen #1 Lease
Homer Dean Oil Company, Inc.
Active
WY0000680 - Oil & Gas
Hamilton Dome Field, Placer Rathvon Water Disposal
Merit Energy Company
Active
SEH
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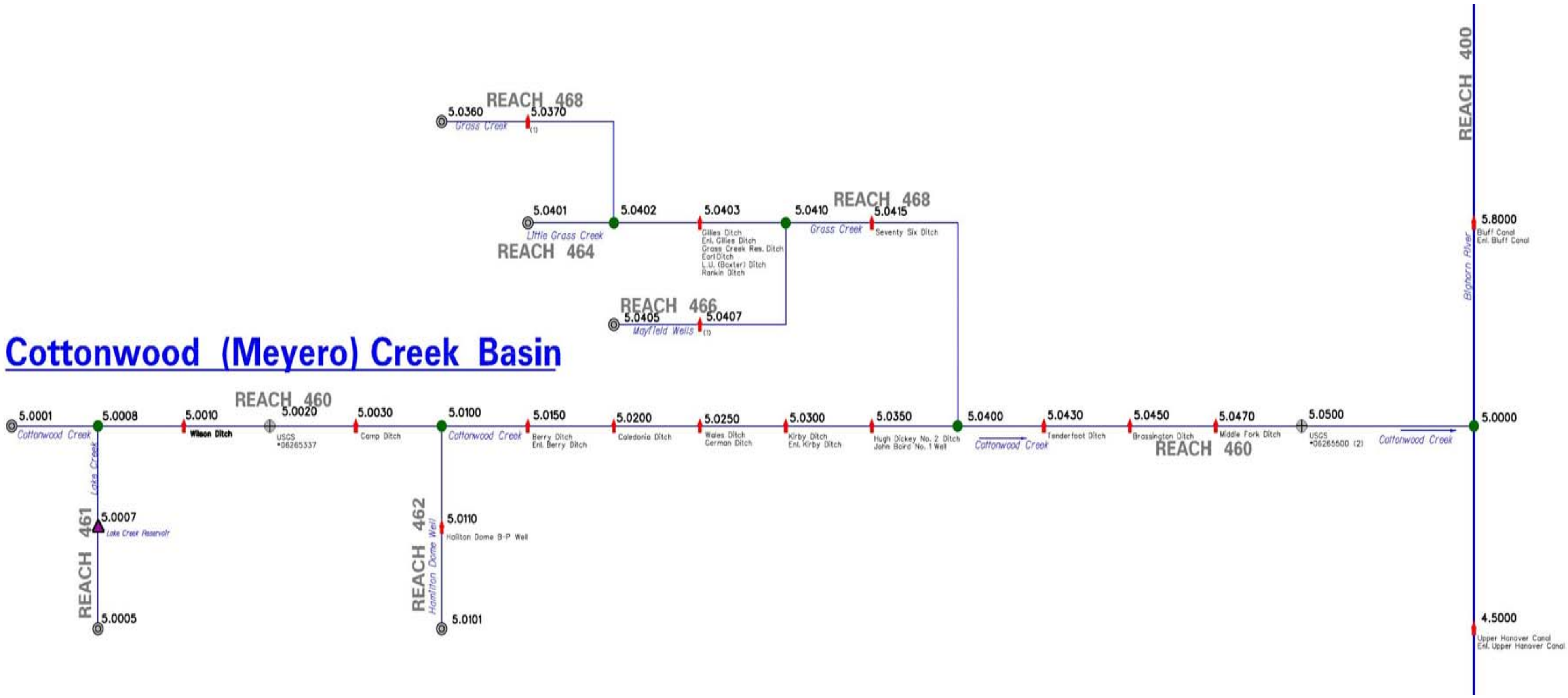
WATERSHED MANAGEMENT PLAN, LEVEL 1
NPDES PERMITTED DISCHARGES
PROJECT: AWWDC0602.00
DATE: 8/10/07
FIGURE: 2.6-3



Model Nodes and Reaches Schematic
Figure 2.7-1

Outflow to
Downstream Node =

Inflow from upstream
+
Irrigation Returns
-
Diversions
+
Tributary Inflow
+/-
Imports/Exports
+/-
Reach Gains/Losses

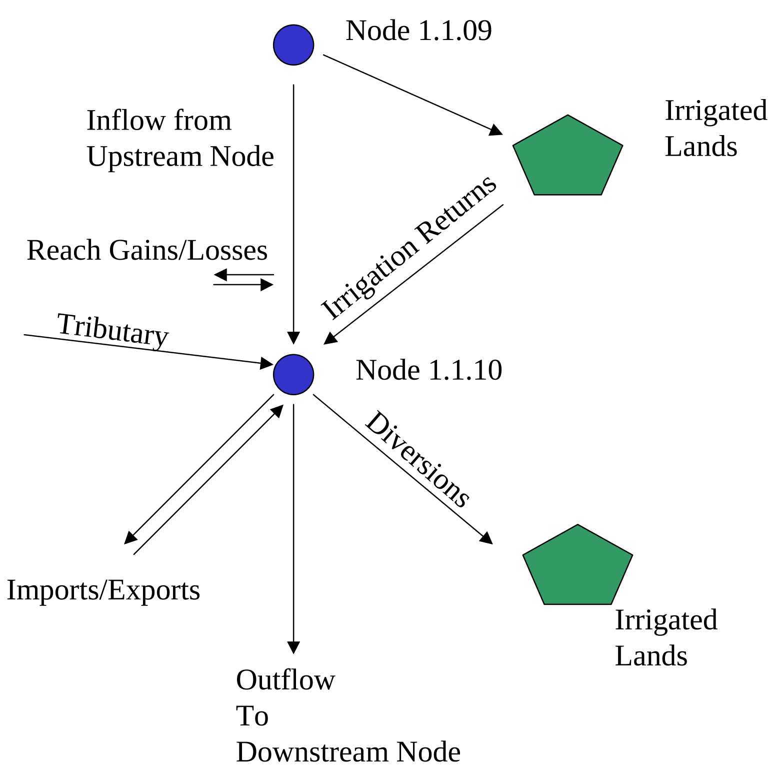
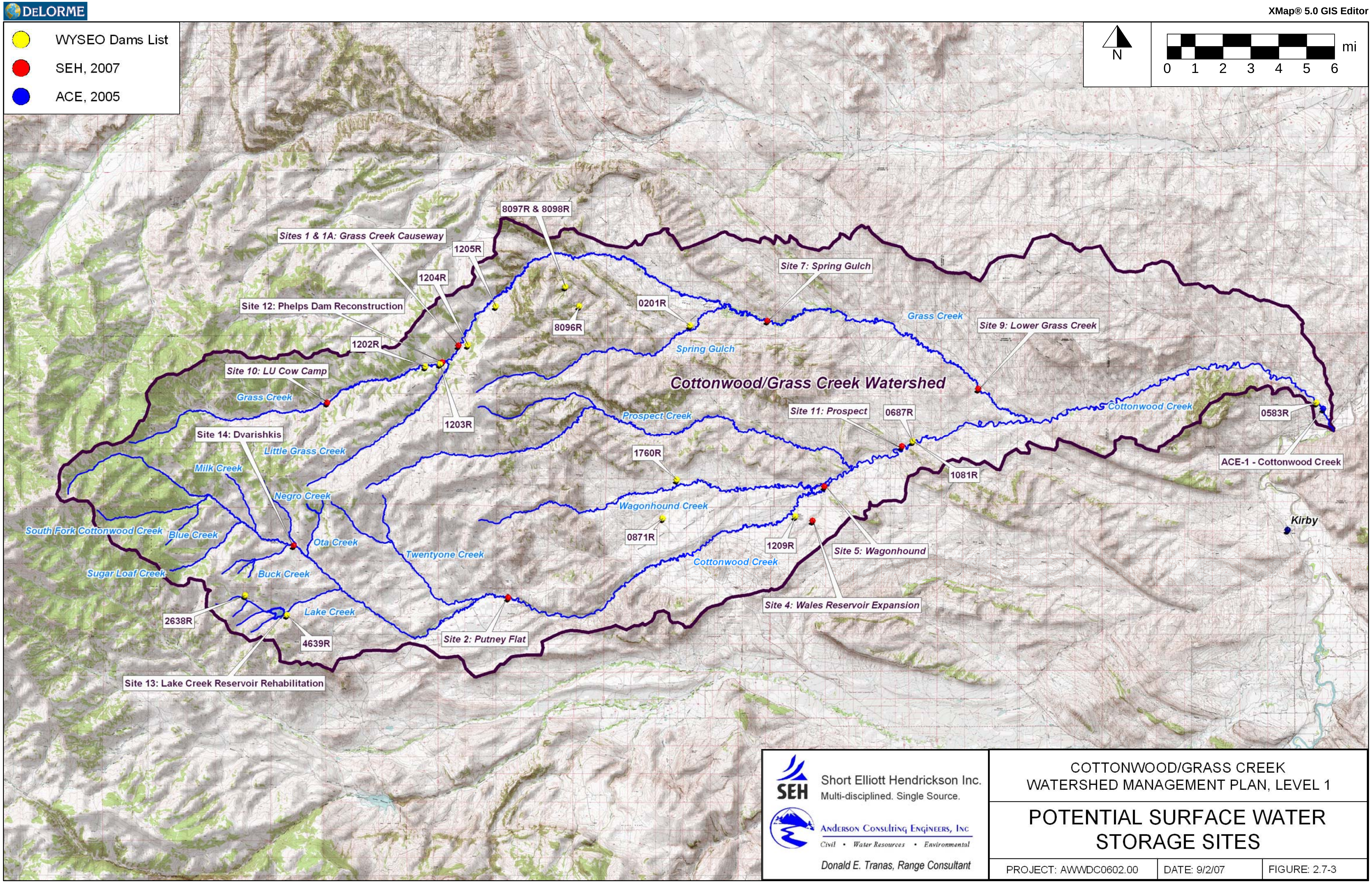


Diagram of Model Water Budget Computations
Figure 2.7-2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XMap® 5.0 GIS Editor
WYSEO Dams List
SEH, 2007
ACE, 2005
N
mi
0 1 2 3 4 5 6
Cottonwood/Grass Creek Watershed
8097R & 8098R
Sites 1 & 1A: Grass Creek Causeway
1205R
1204R
Site 12: Phelps Dam Reconstruction
1202R
Site 10: LU Cow Camp
1203R
8096R
0201R
Site 7: Spring Gulch
Grass Creek
Spring Gulch
Site 9: Lower Grass Creek
Prospect Creek
Site 11: Prospect
0687R
Cottonwood Creek
0583R
ACE-1 - Cottonwood Creek
1081R
Kirby
Site 14: Dvarishkis
Little Grass Creek
Milk Creek
Negro Creek
South Fork Cottonwood Creek
Blue Creek
Ota Creek
Twentyone Creek
Sugar Loaf Creek
Buck Creek
Lake Creek
2638R
4639R
Site 13: Lake Creek Reservoir Rehabilitation
Site 2: Putney Flat
1760R
Wagonhound Creek
0871R
1209R
Site 5: Wagonhound
Cottonwood Creek
Site 4: Wales Reservoir Expansion
SEH
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COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1
POTENTIAL SURFACE WATER
STORAGE SITES
PROJECT: AWWDC0602.00
DATE: 9/2/07
FIGURE: 2.7-3

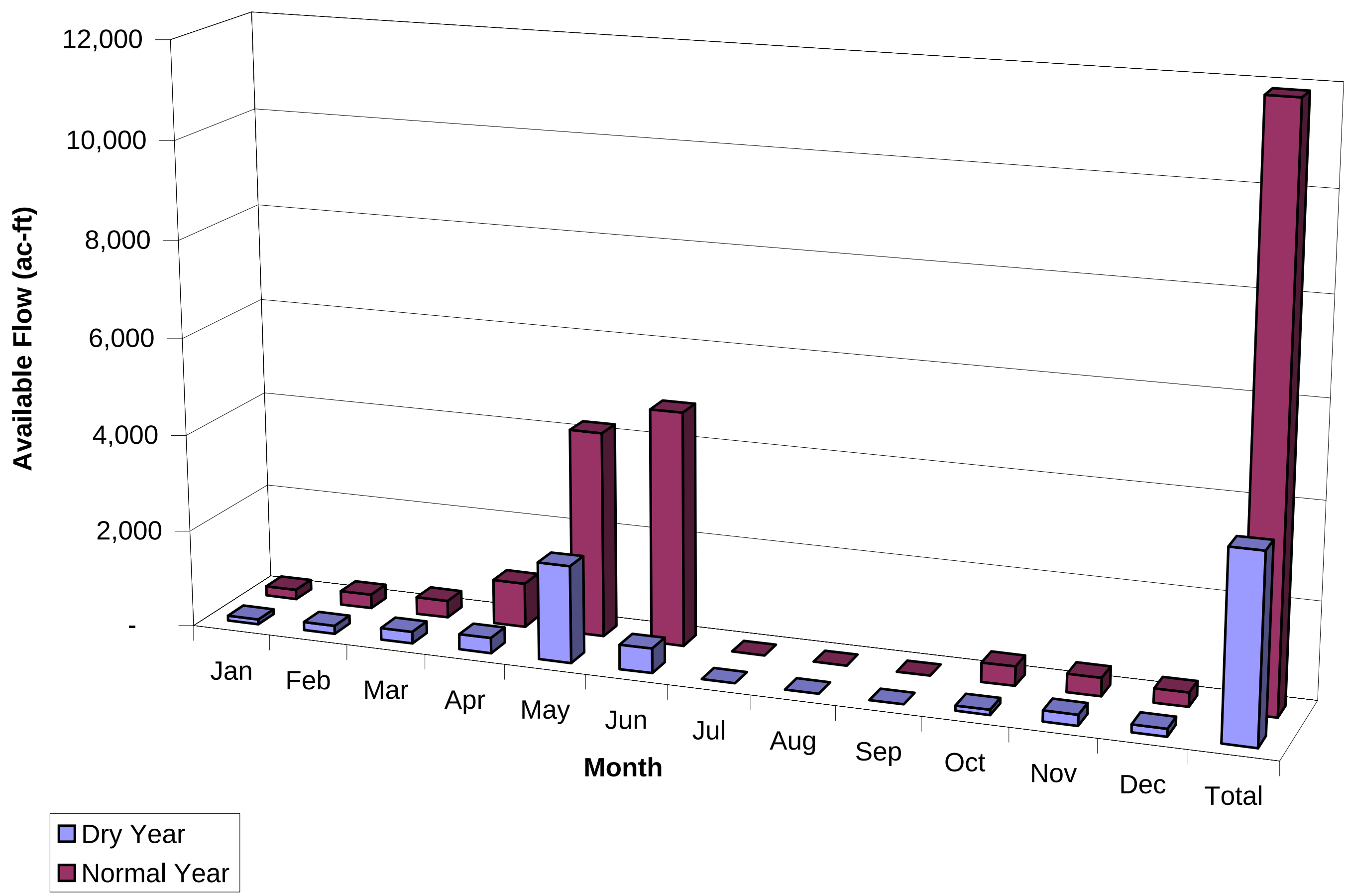

Figure 2.7-4A

Available Flow By Month

Site 1 - Grass Creek Causeway

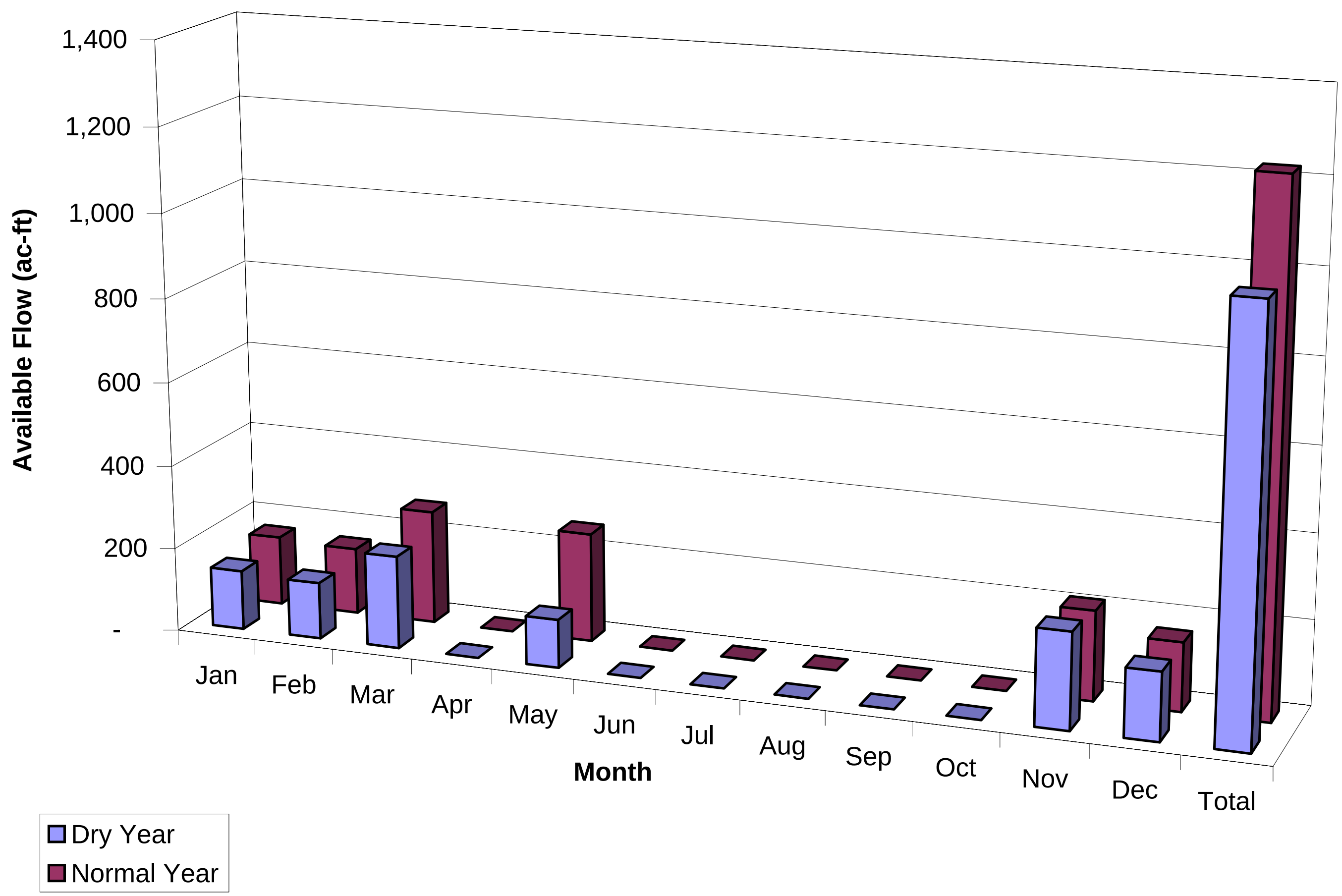

Figure 2.7-4B
Available Flow By Month
Site 2 - Putney Flat

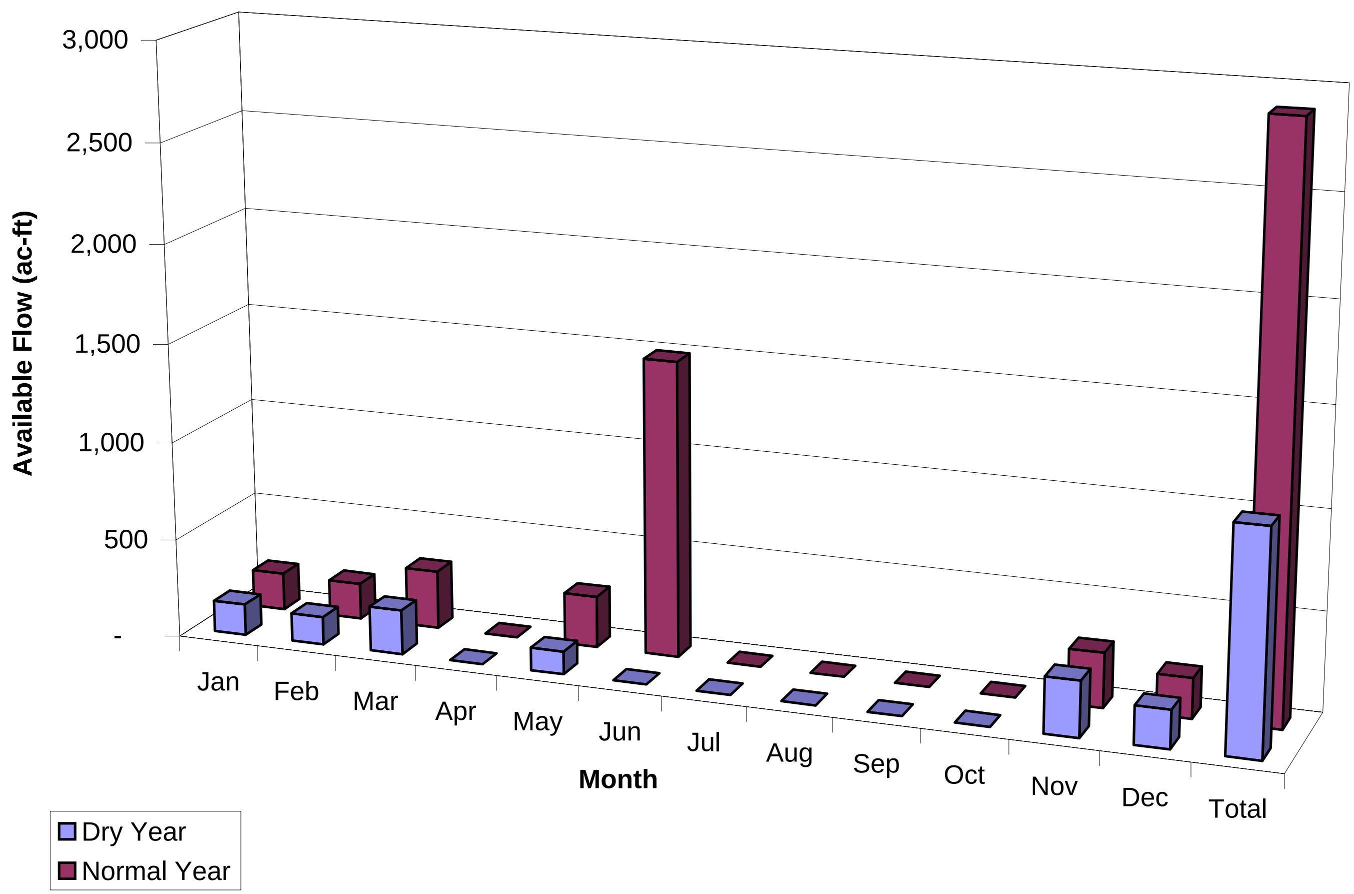

Figure 2.7-4C
Available Flow By Month
Site 5 - Wagonhound

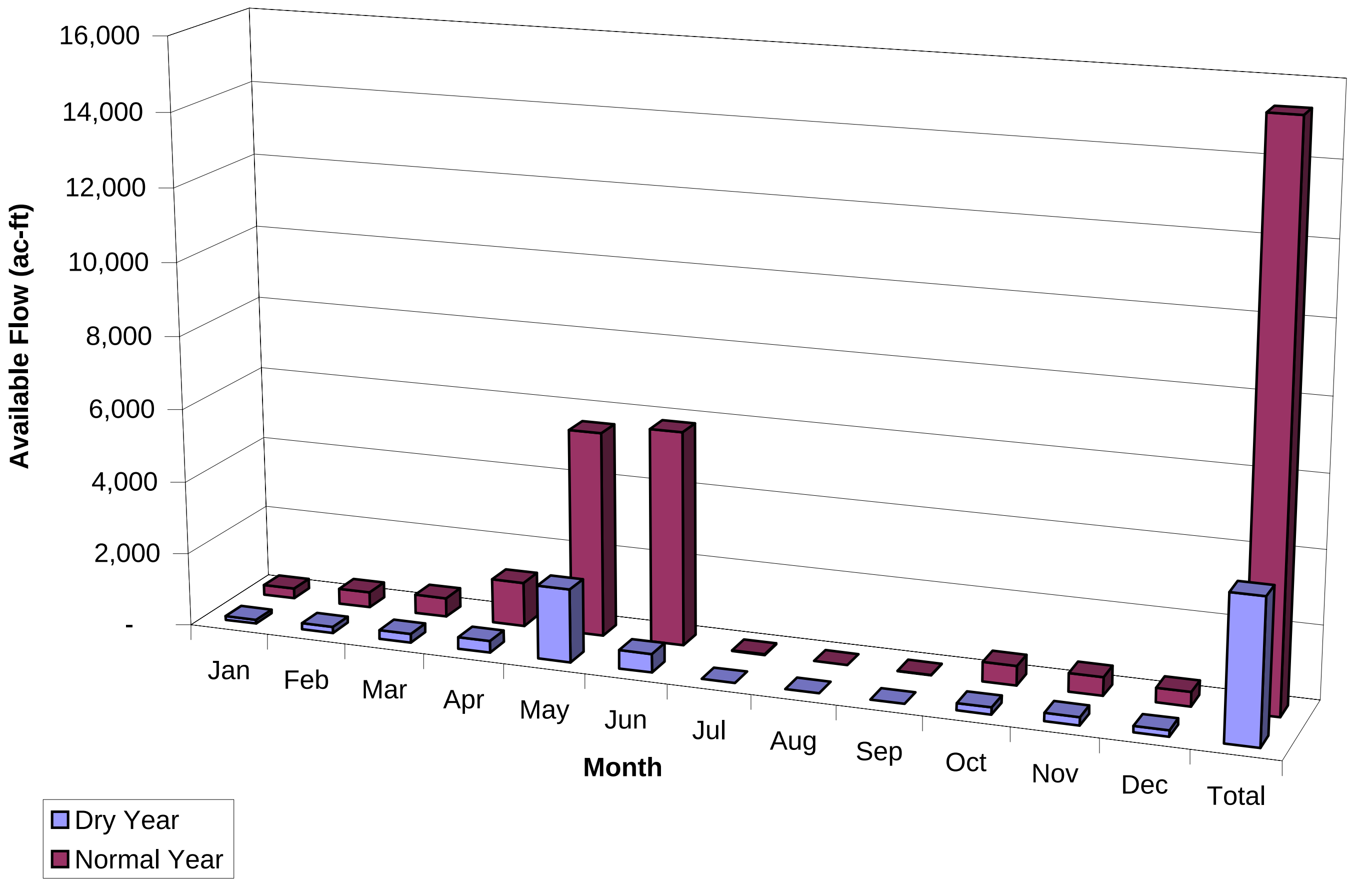

Figure 2.7-4D
Available Flow By Month
Site 7 - Spring Gulch

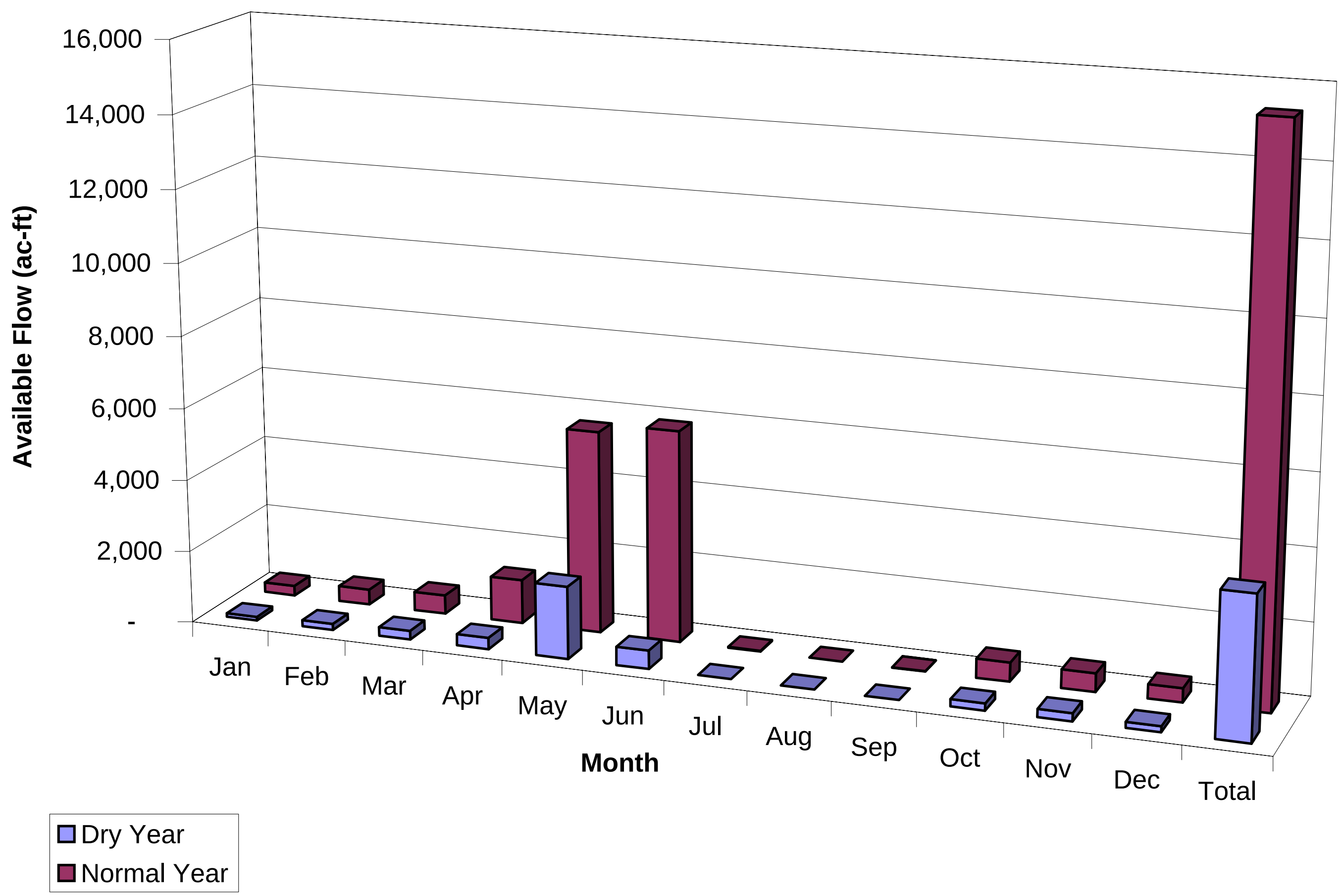

Figure 2.7-4E
Available Flow By Month
Site 9 - Lower Grass Creek

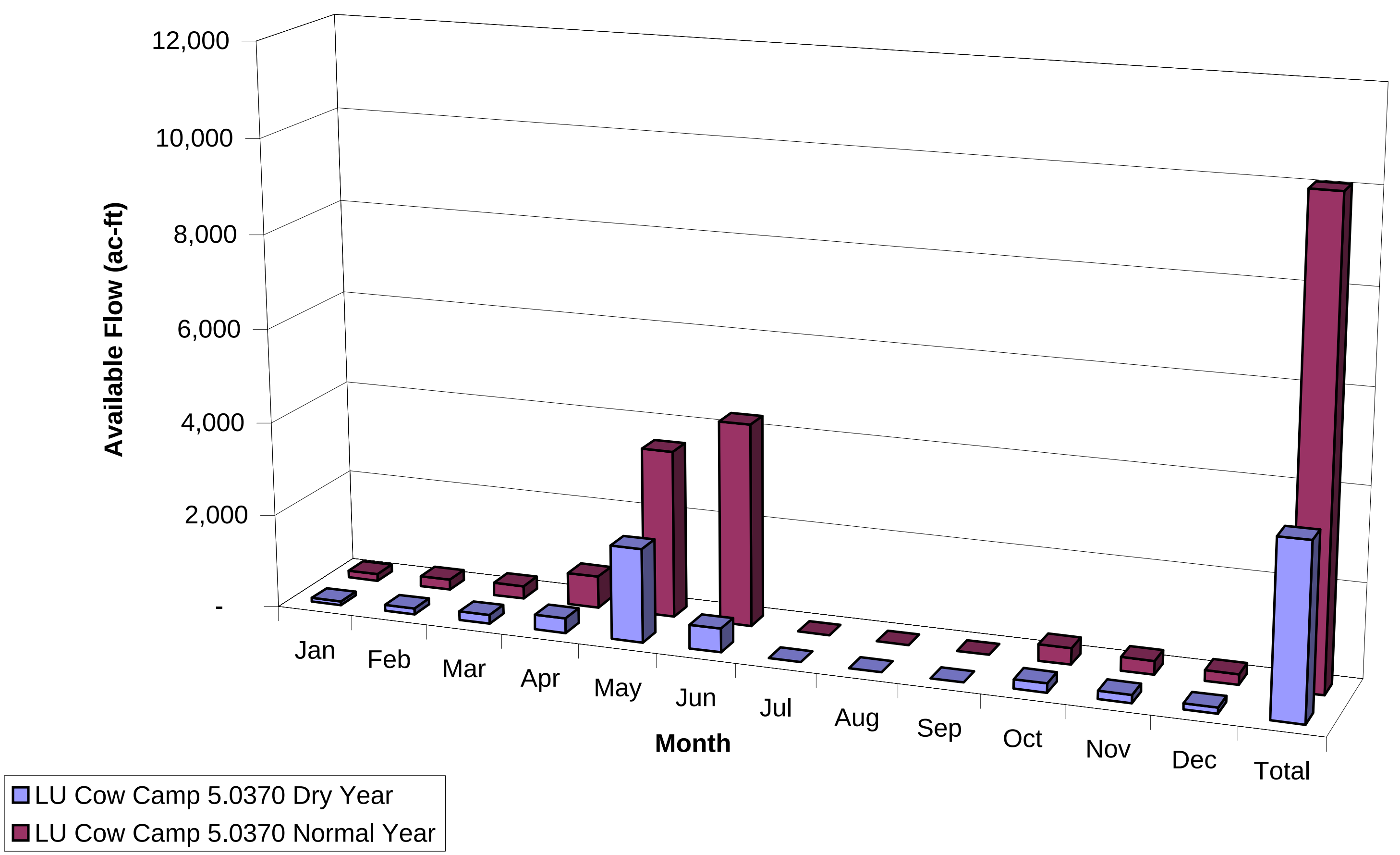

Figure 2.7-4F
Available Flow By Month
Site 10 - LU Cow Camp

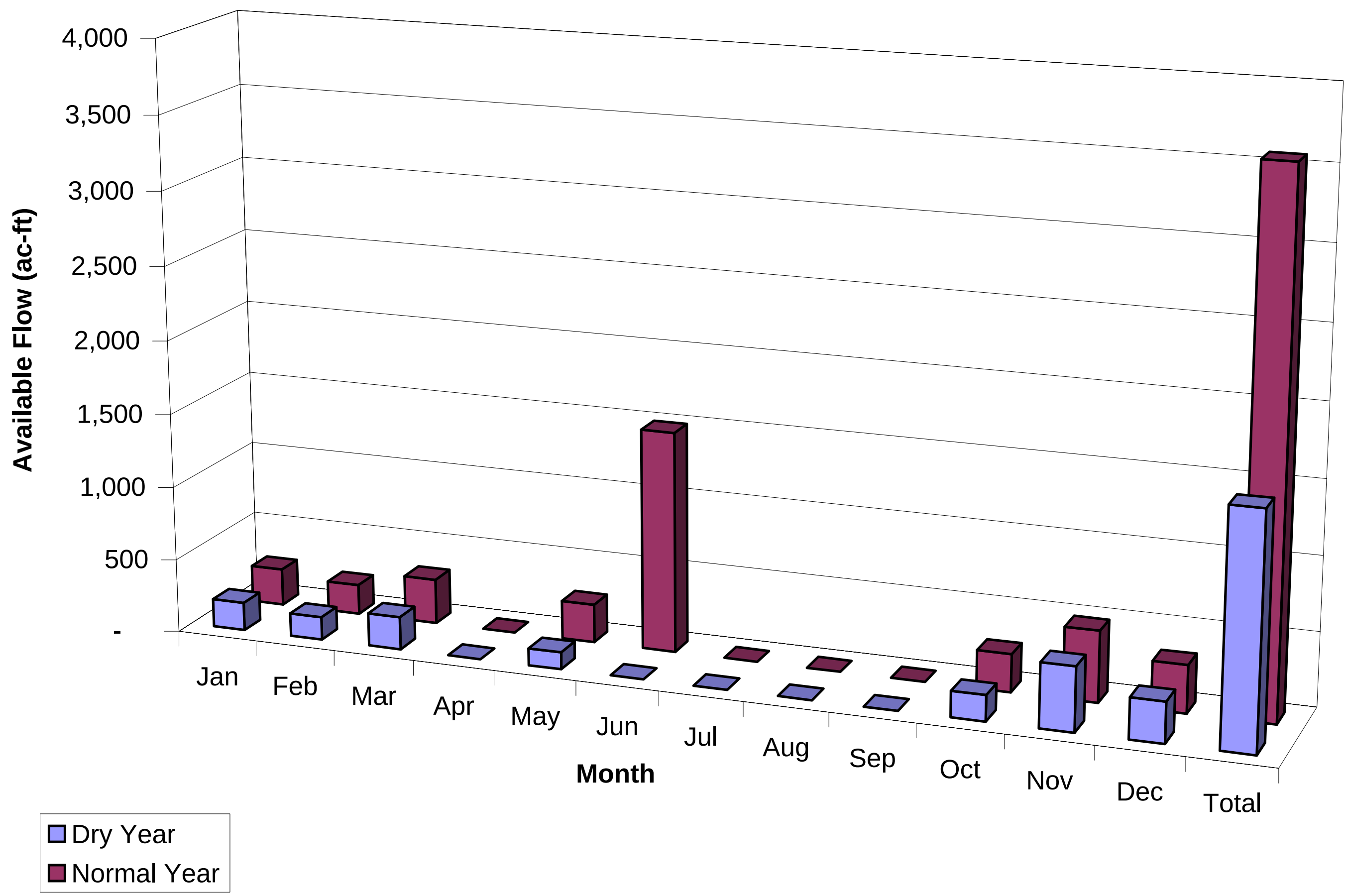

Figure 2.7-4G
Avaiable Flow By Month
Site 11 - Prospect

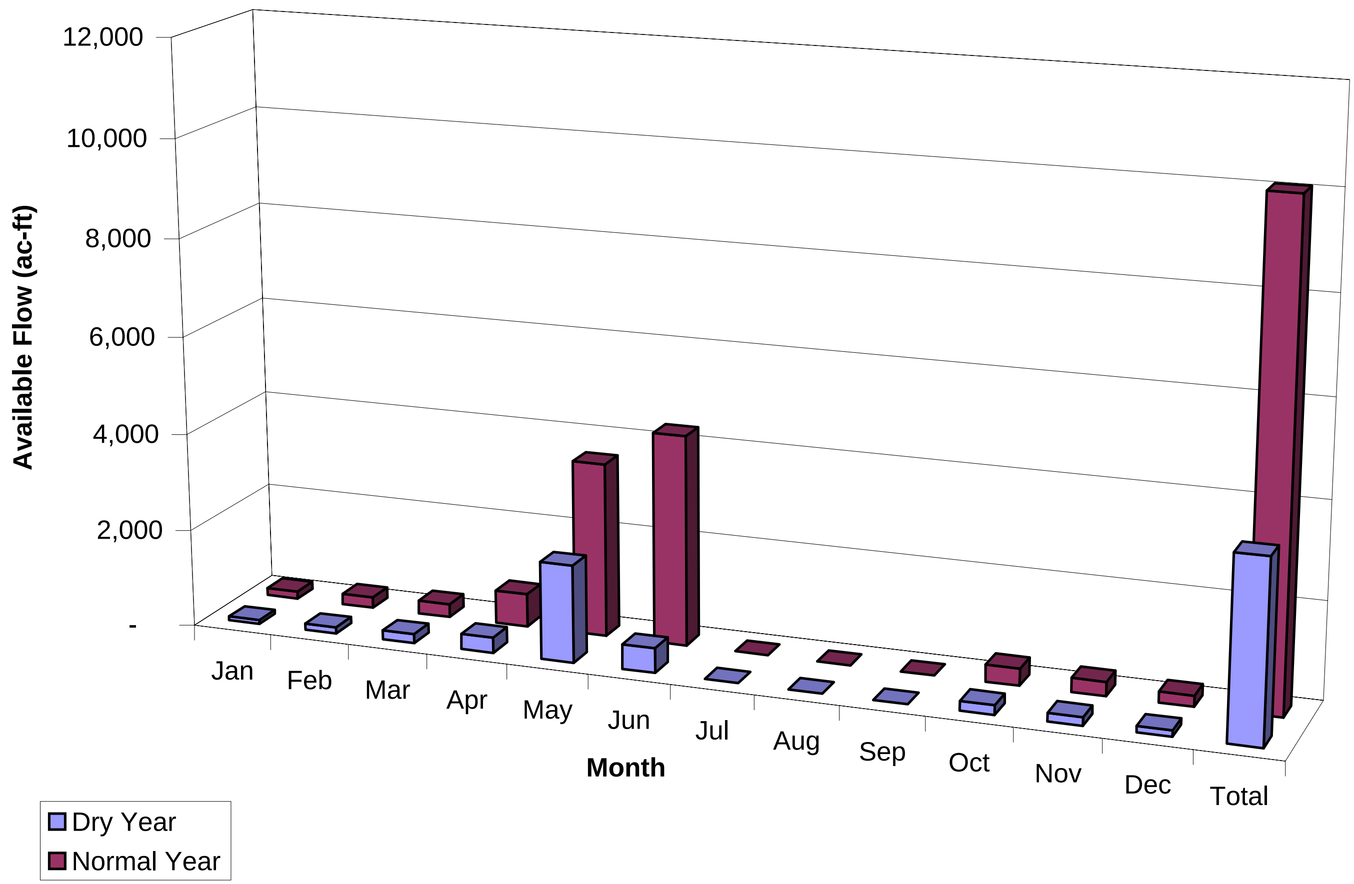

Figure 2.7-4H
Available Flow By Month
Site 12 - Phelps Reservoir Reconstruction

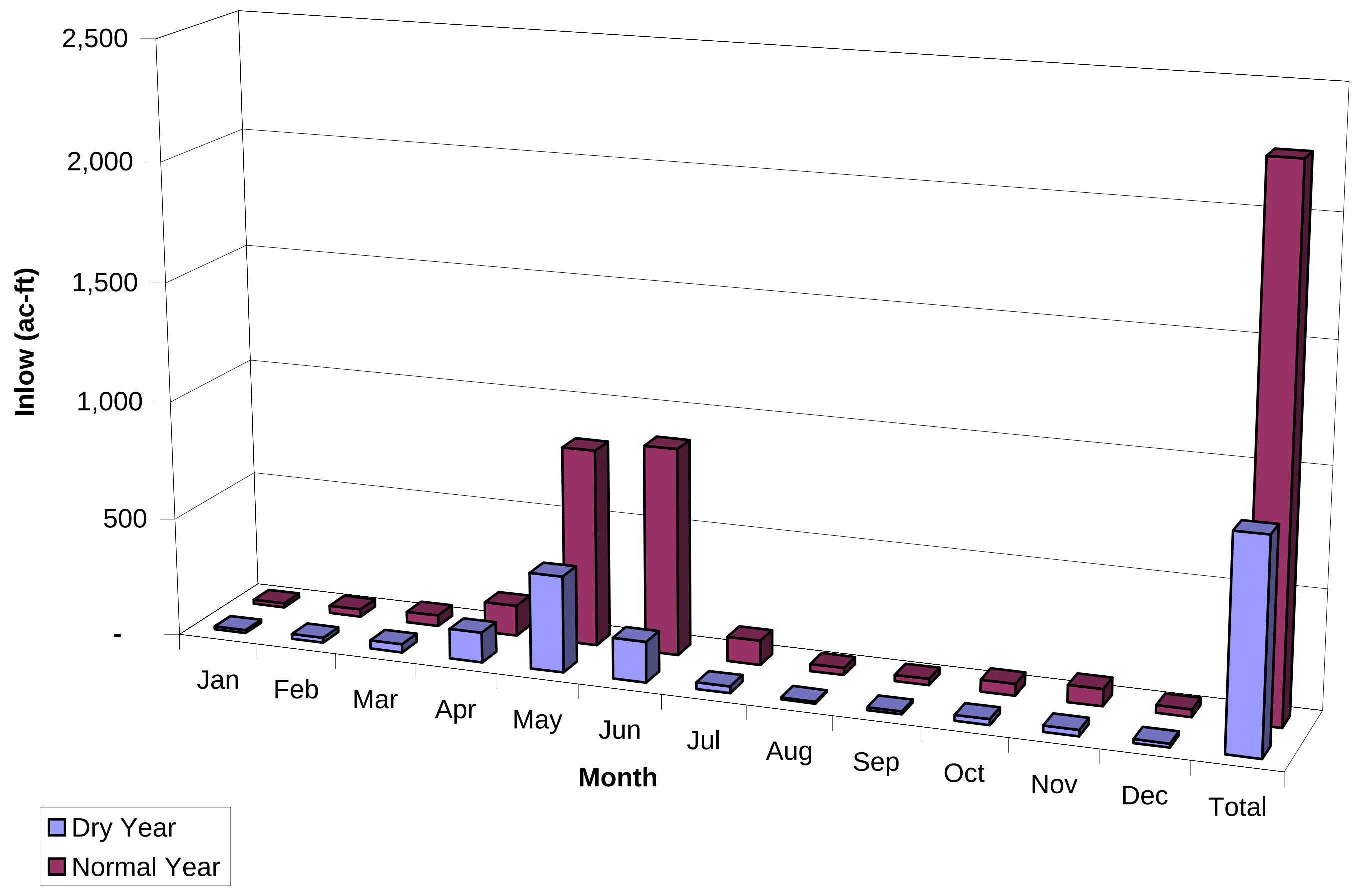

Figure 2.7-4I

Inlow By Month

Site 13 - Lake Creek Dam Rehabilitation

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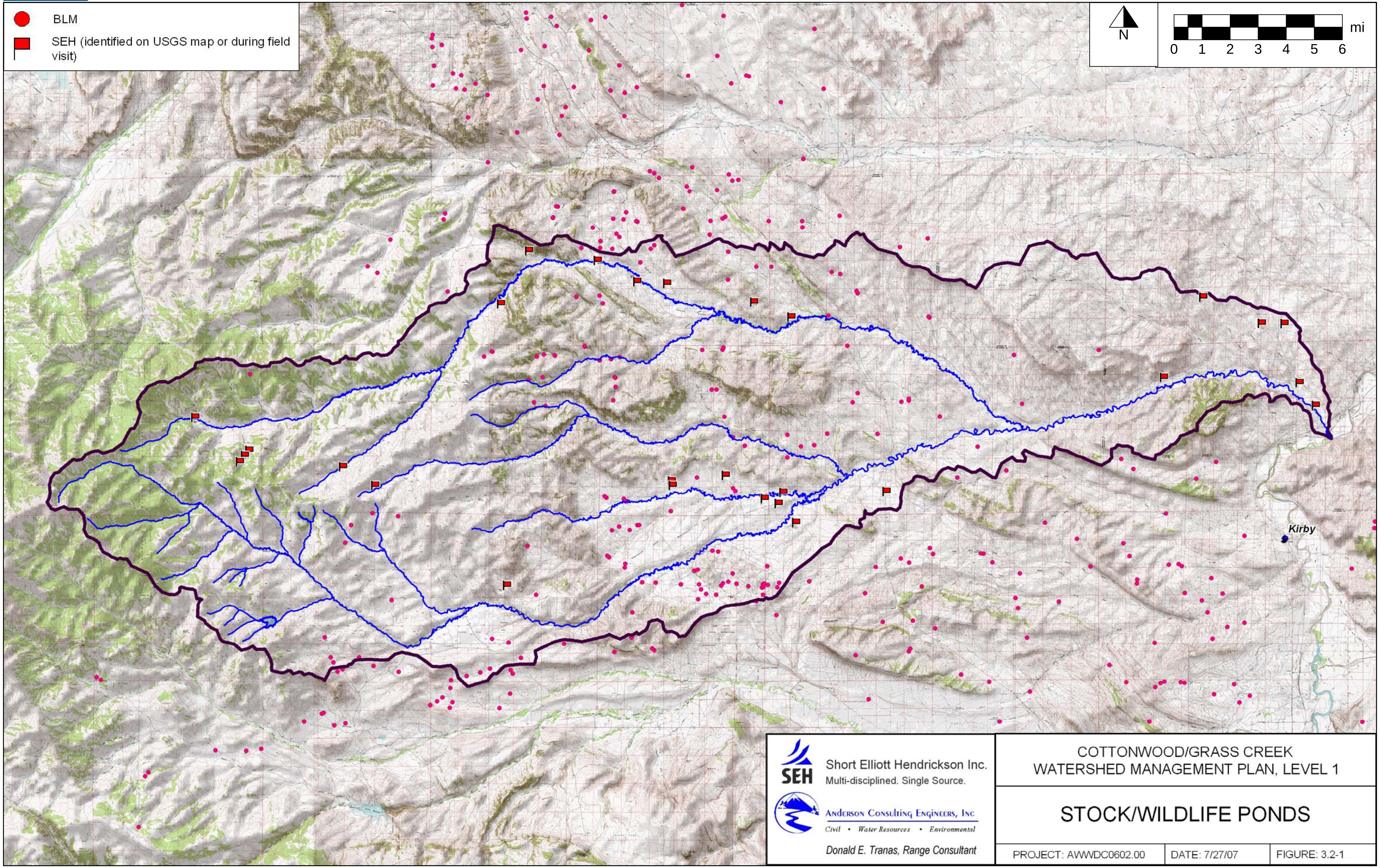

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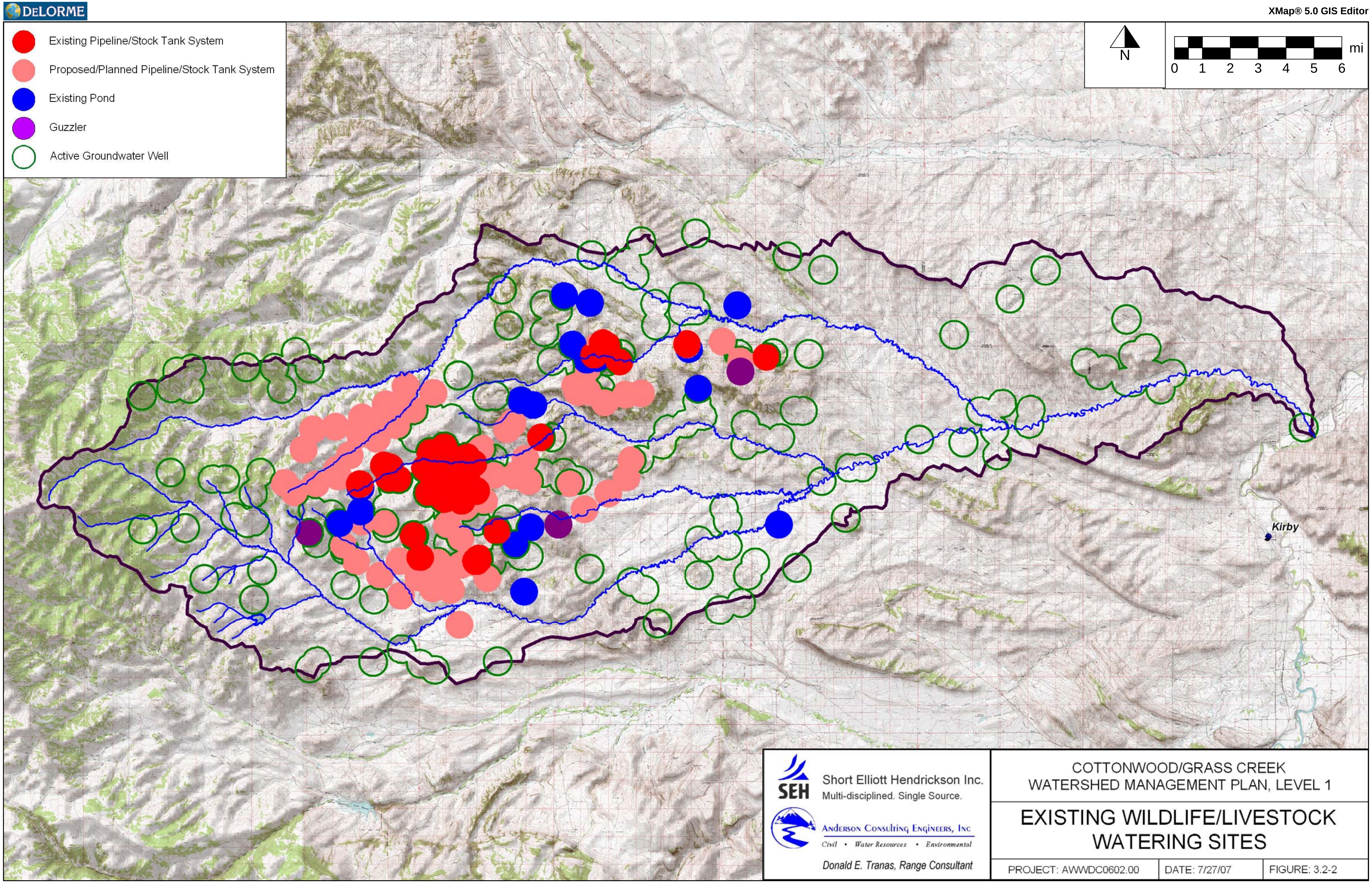

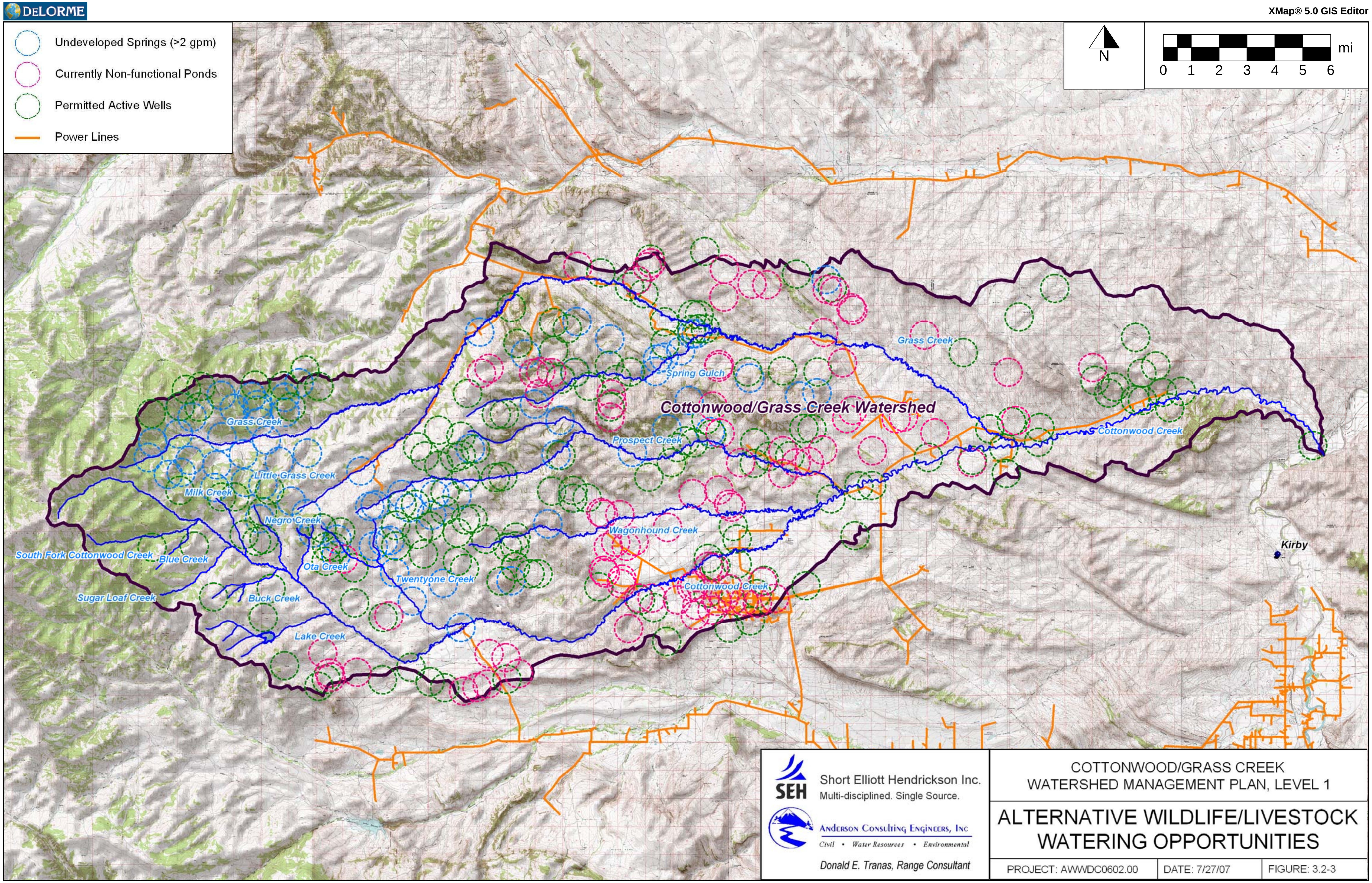

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Undeveloped Springs (>2 gpm)
Currently Non-functional Ponds
Permitted Active Wells
Power Lines
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Cottonwood/Grass Creek Watershed
Grass Creek
Spring Gulch
Prospect Creek
Cottonwood Creek
Little Grass Creek
Milk Creek
Negro Creek
Wagonhound Creek
South Fork Cottonwood Creek
Blue Creek
Ota Creek
Twentyone Creek
Sugar Loaf Creek
Buck Creek
Lake Creek
Kirby
SEH
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COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1
ALTERNATIVE WILDLIFE/LIVESTOCK
WATERING OPPORTUNITIES
PROJECT: AWWDC0602.00
DATE: 7/27/07
FIGURE: 3.2-3

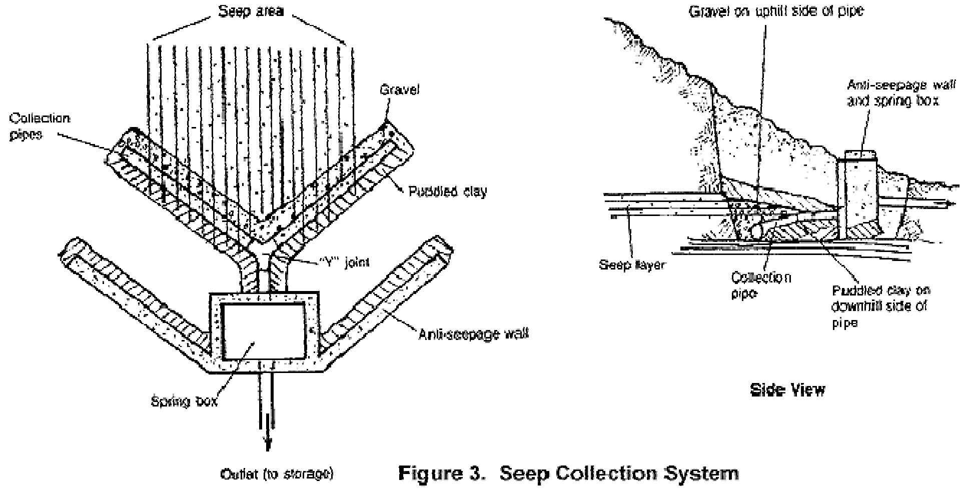


Figure 3. Seep Collection System

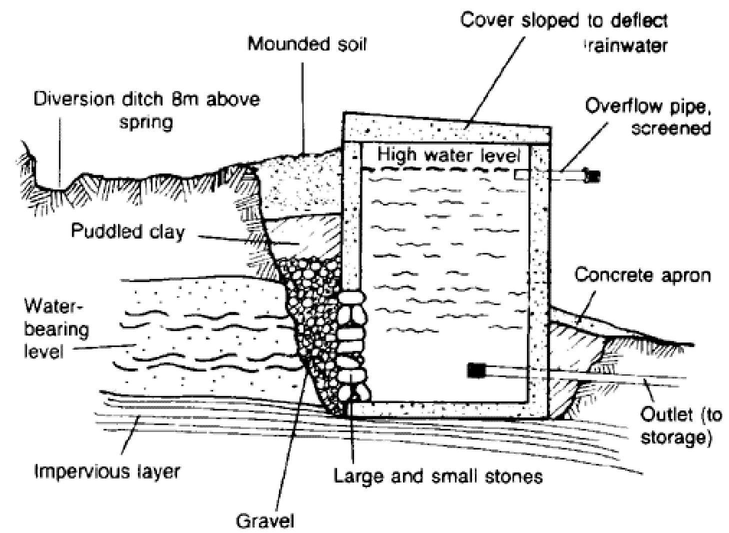


Figure 1. Spring Box with Pervious Side

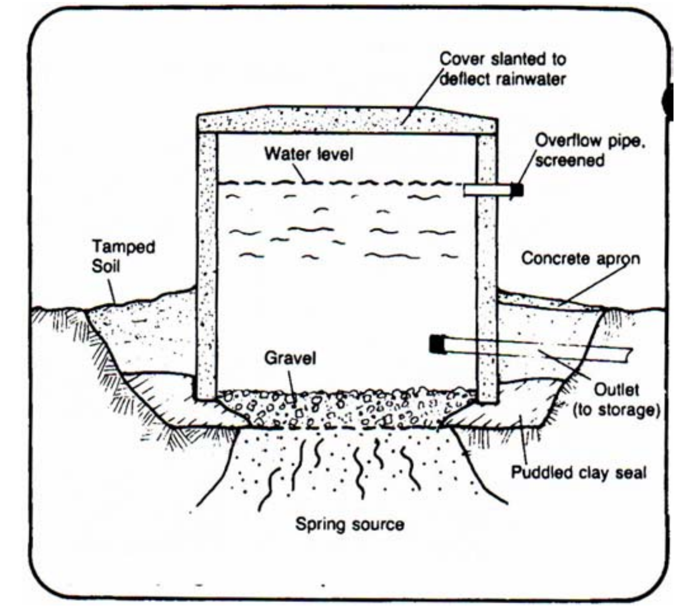


Figure 2: Spring box with permeable bottom for collecting spring water flowing from an opening on level ground (Courtesy of USAID, 1982, available online at www.lifewater.org).

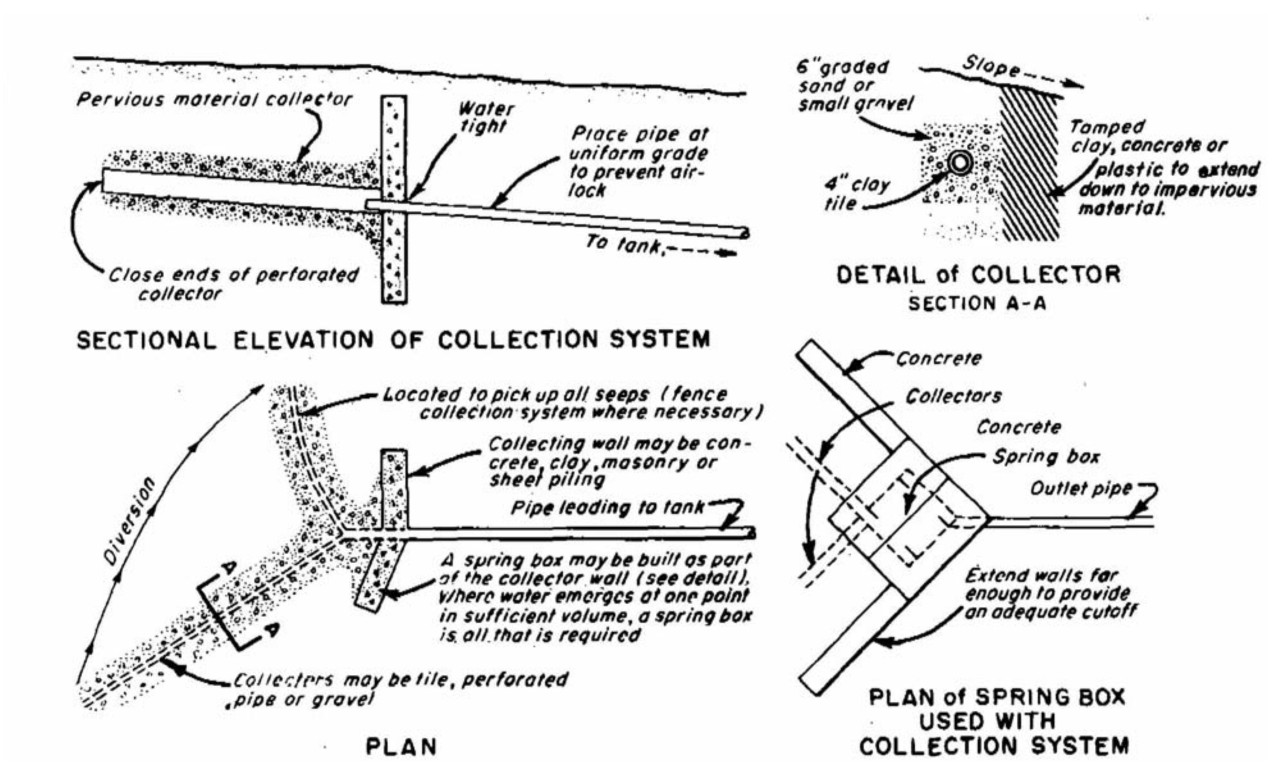
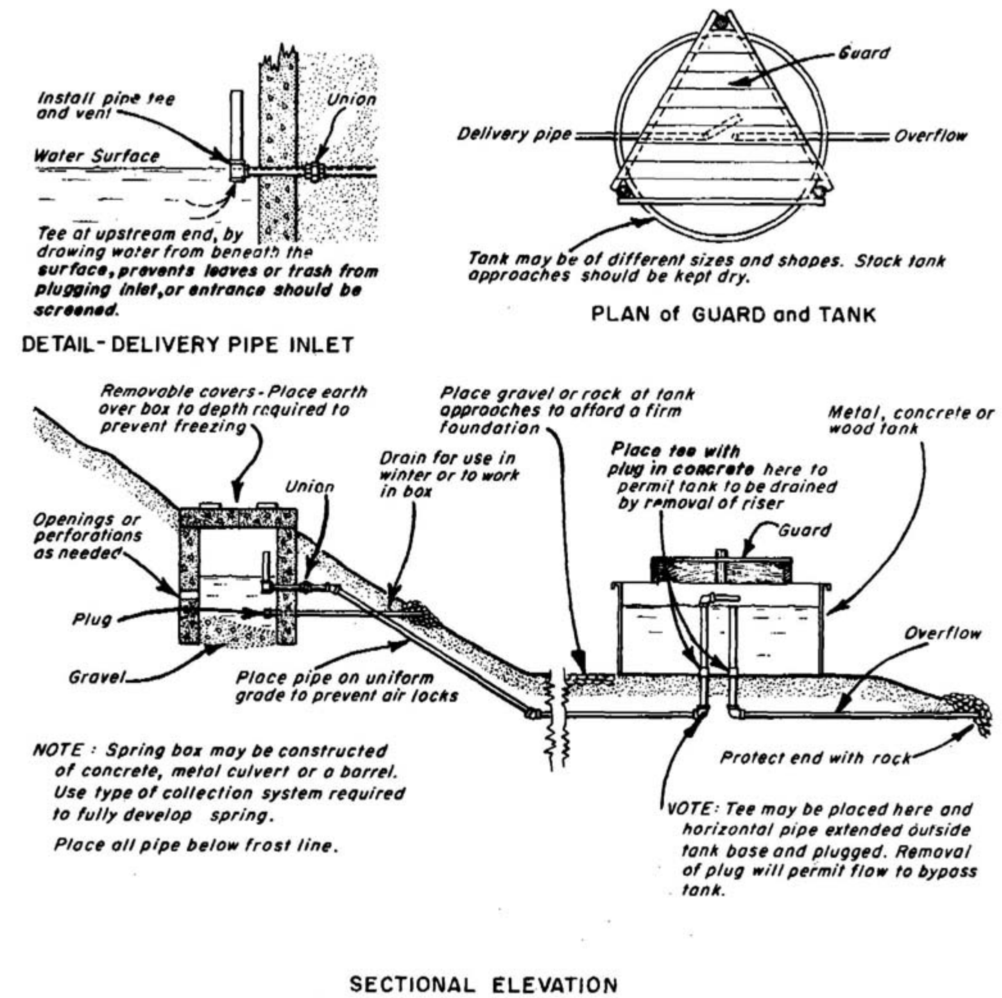
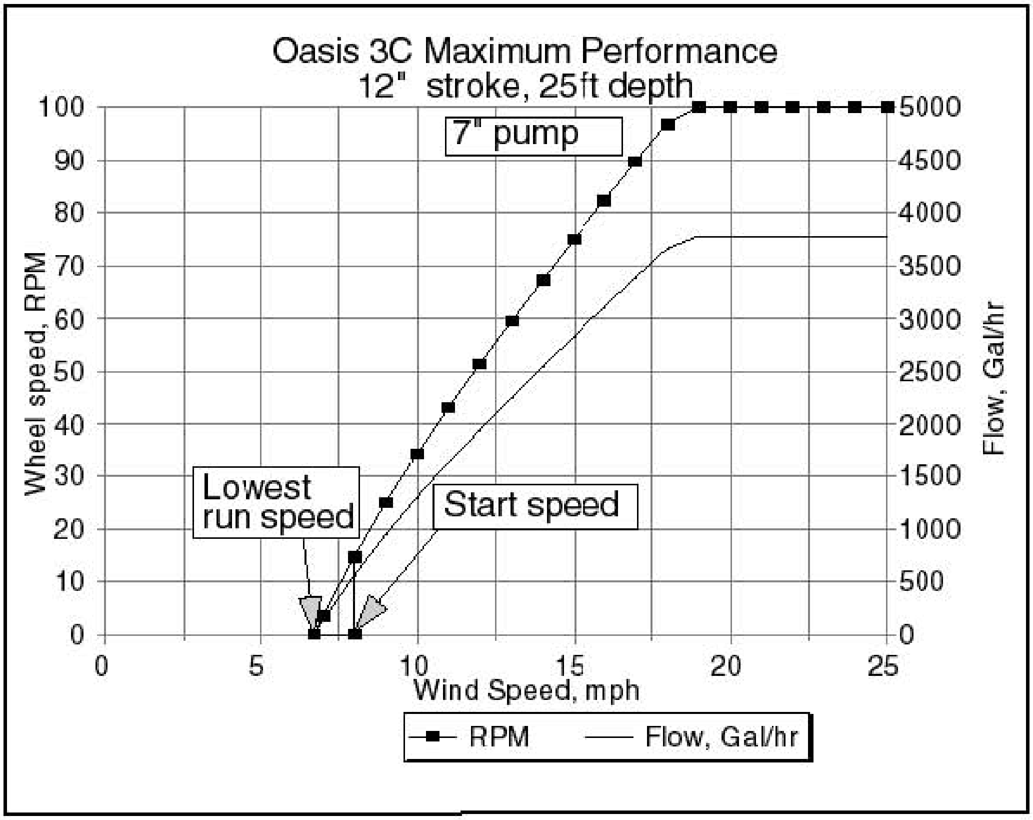


Figure 12-11.—Spring collection system.



igure 12-12.—Spring box and pipe arrangement.

Figure 3.2-4
Spring Development Schematics



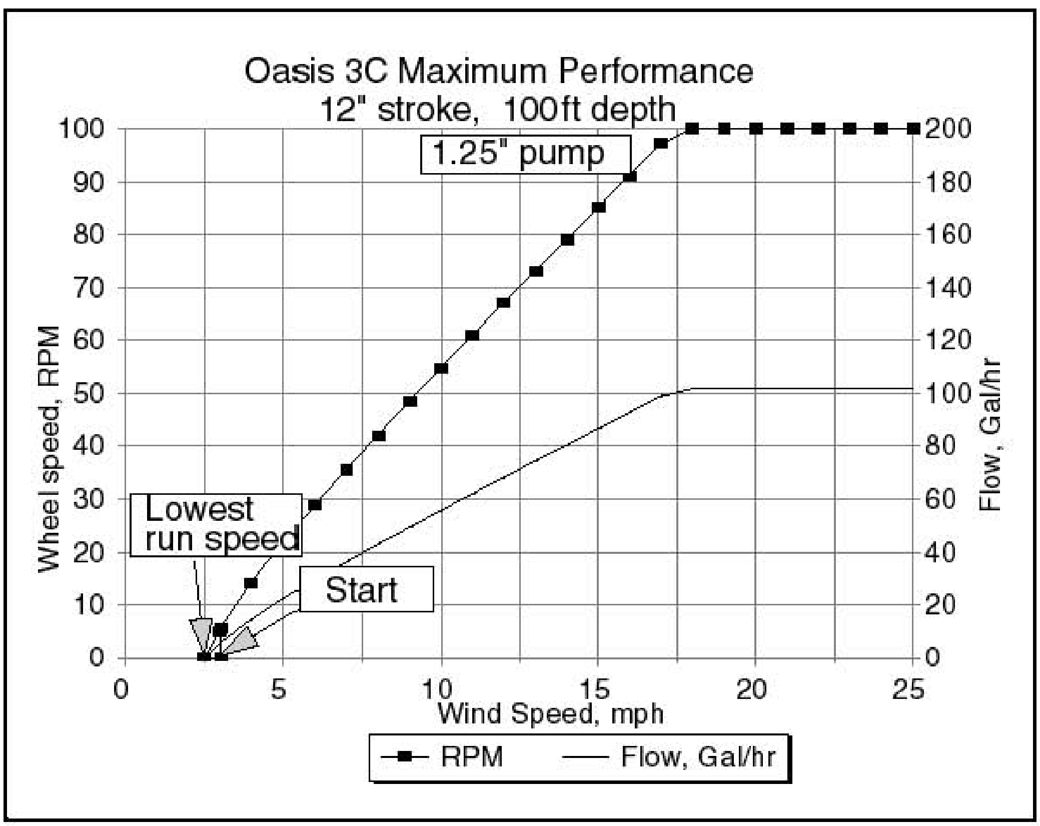


Figure 3.2-5
Windmill Performance Curves

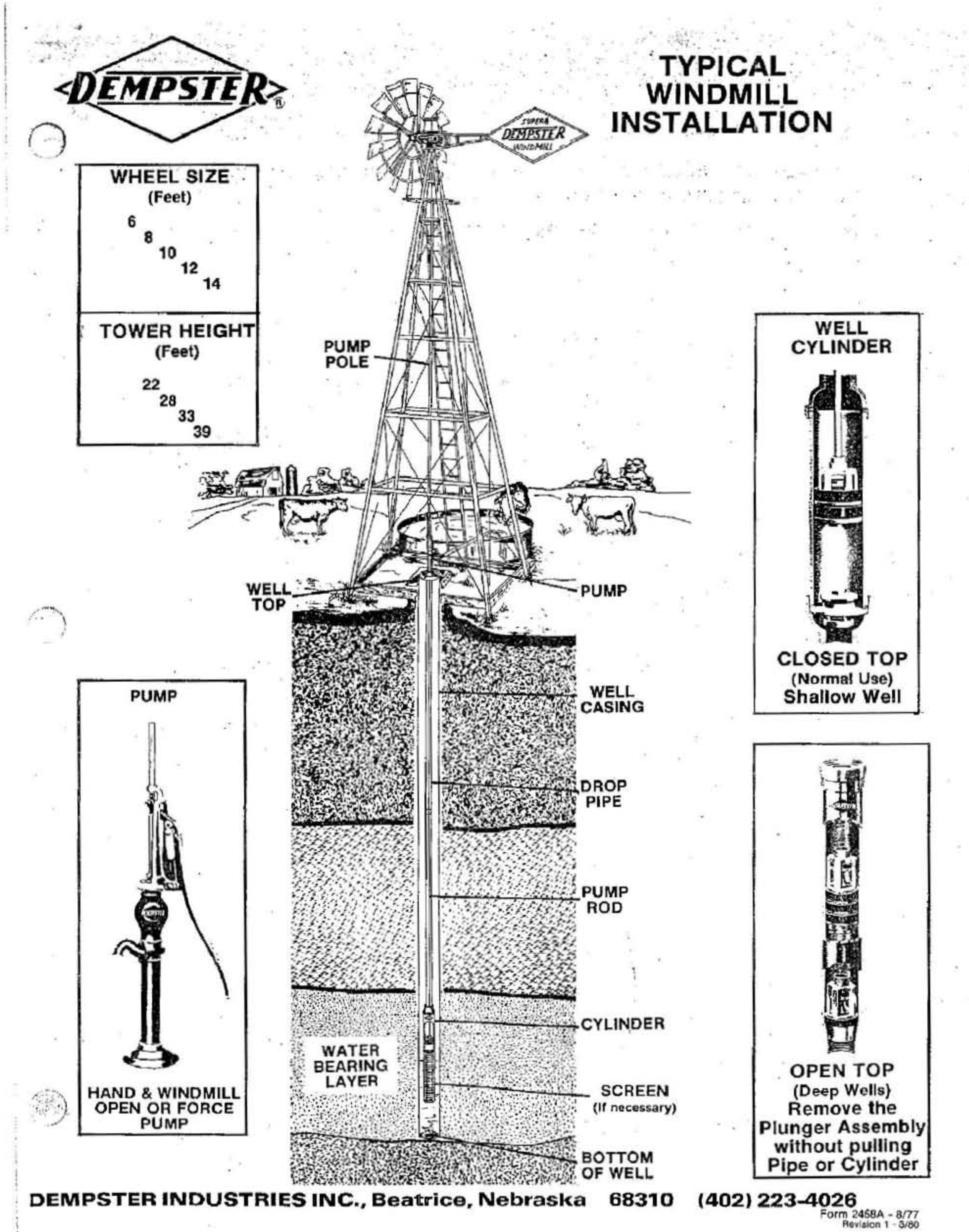


Figure 3.2-6
Windmill Schematic

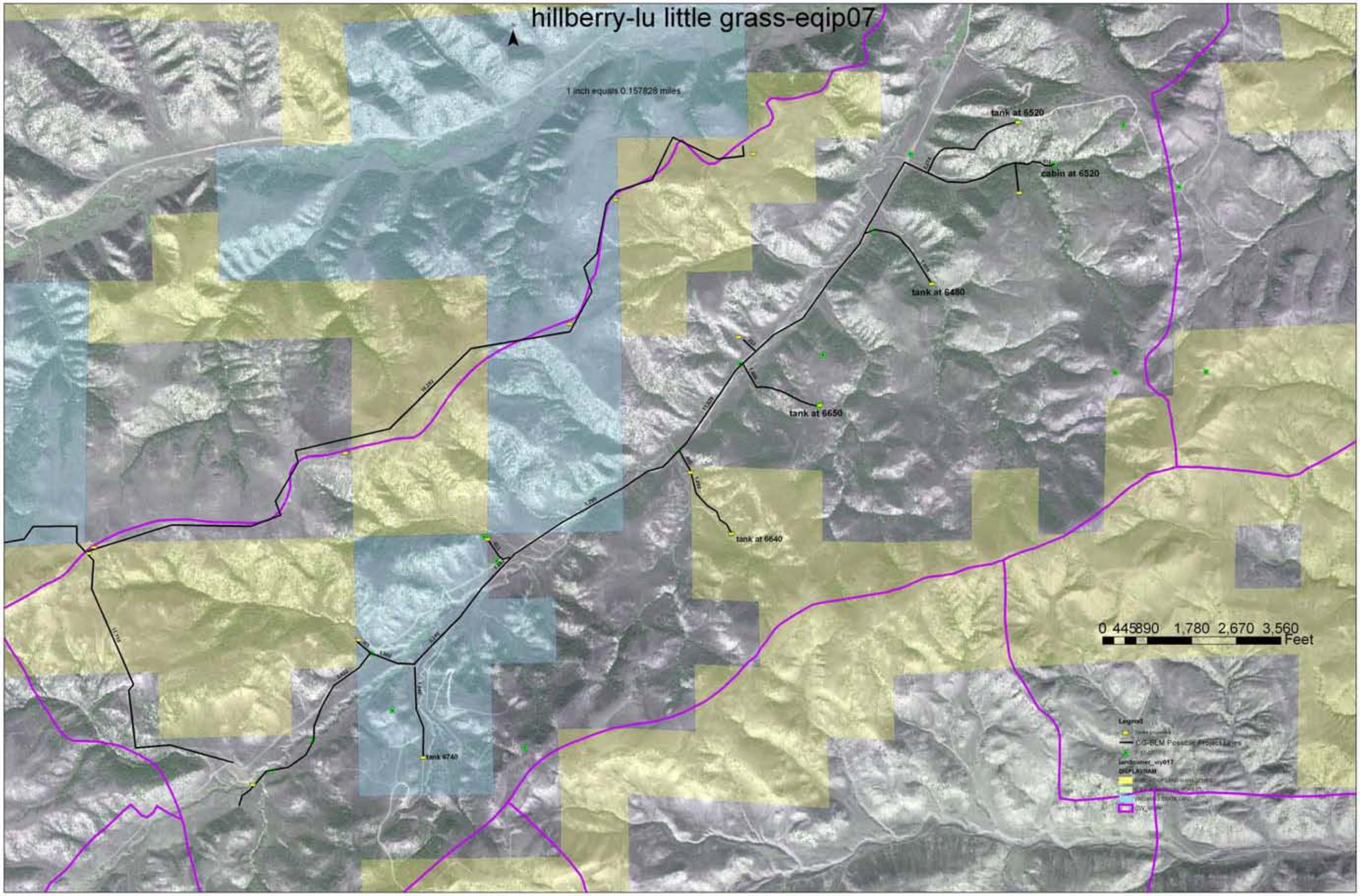


Figure 3.2-7
Little Grass Creek Pipeline/Tanks Layout

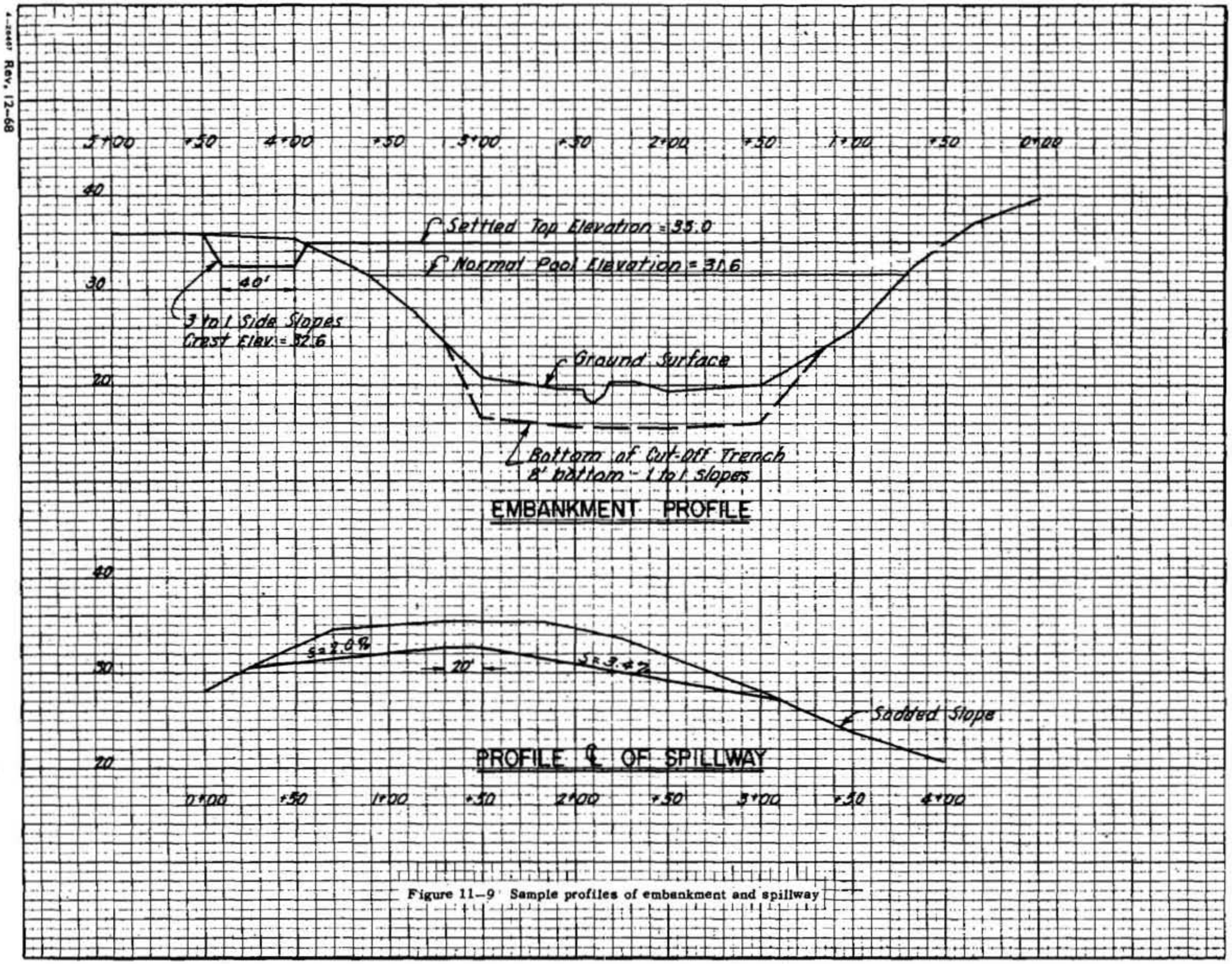


Figure 3.2-8
Pond Embankment and Spillway Profile Schematics

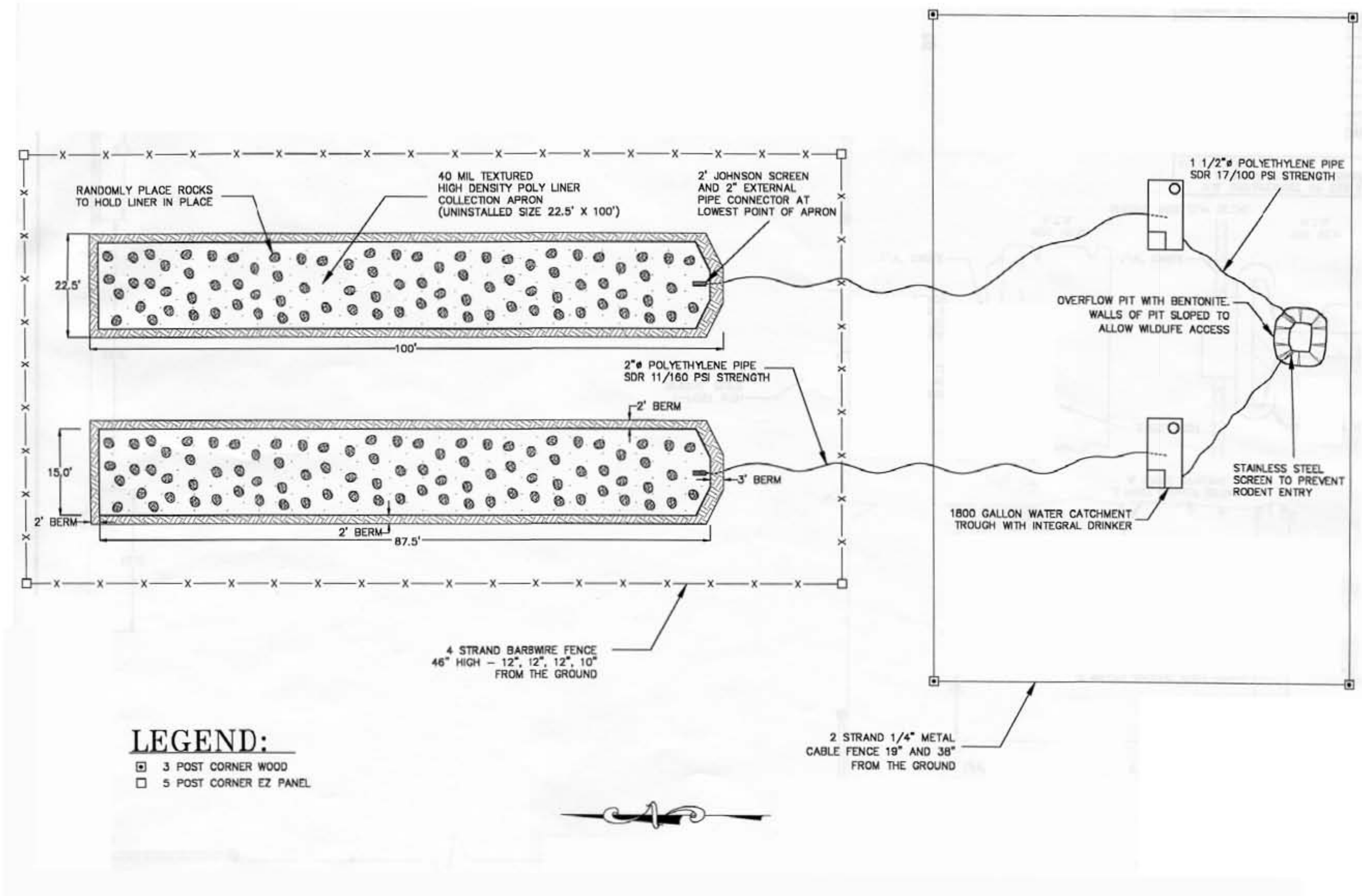


Figure 3.2-9
Guzzler Schematic

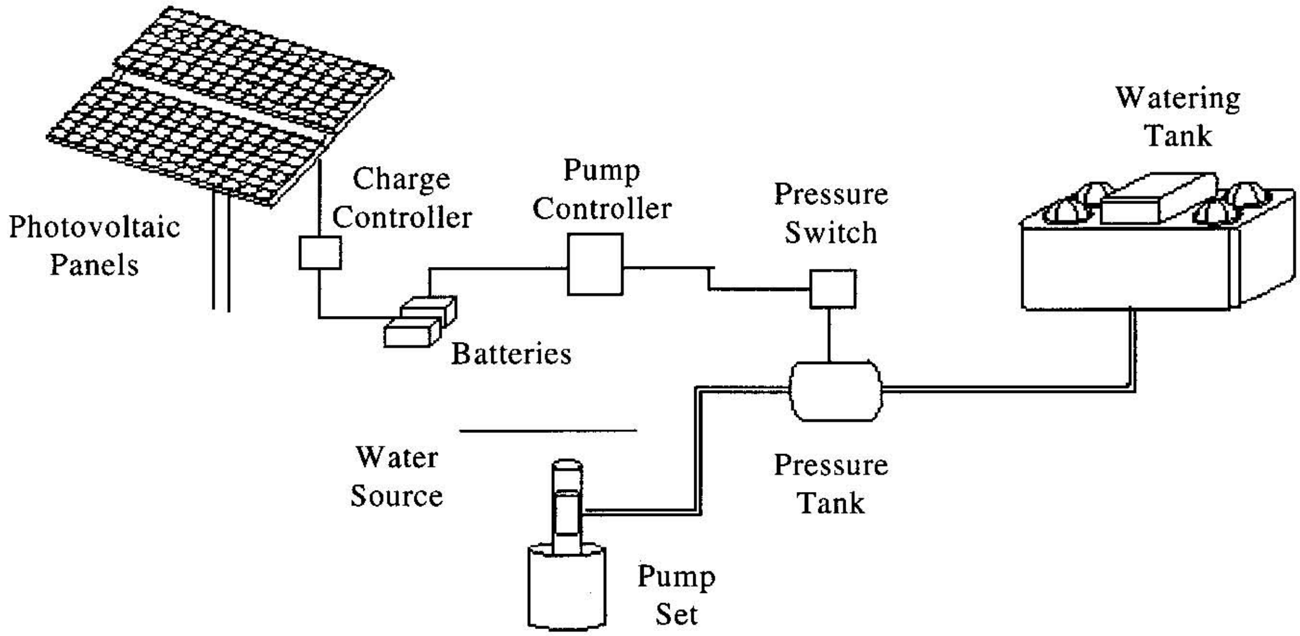


Figure 2. Battery-coupled solar water pumping system.

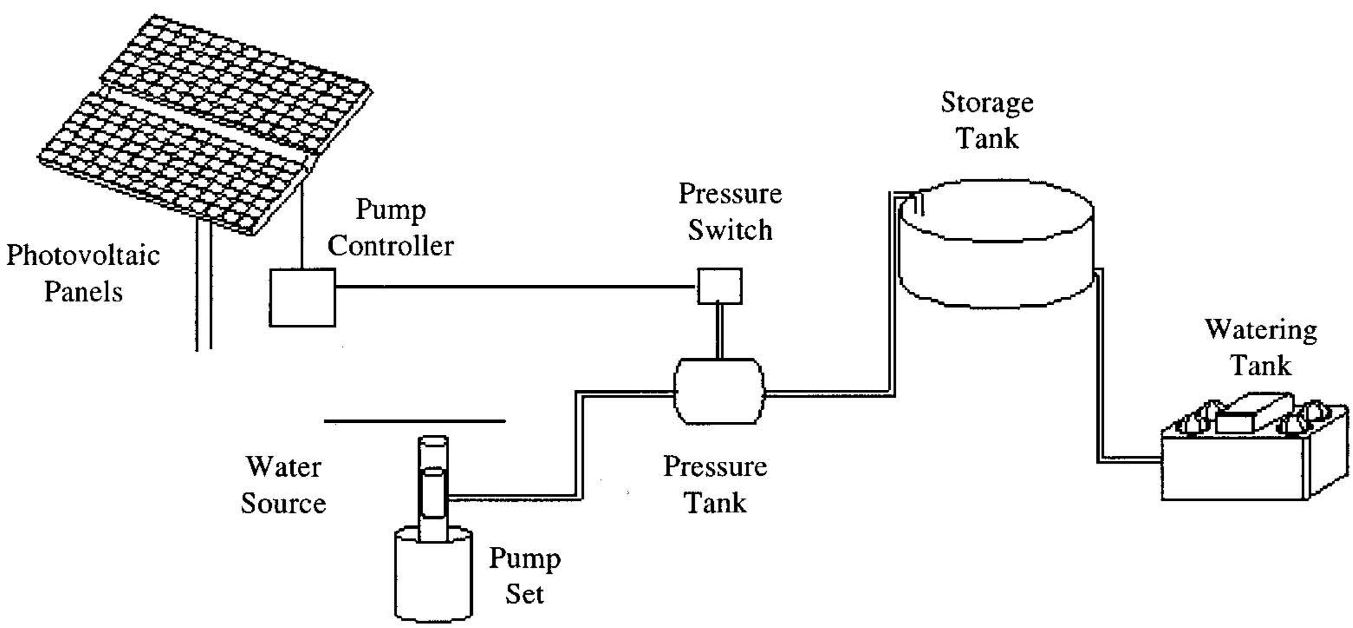
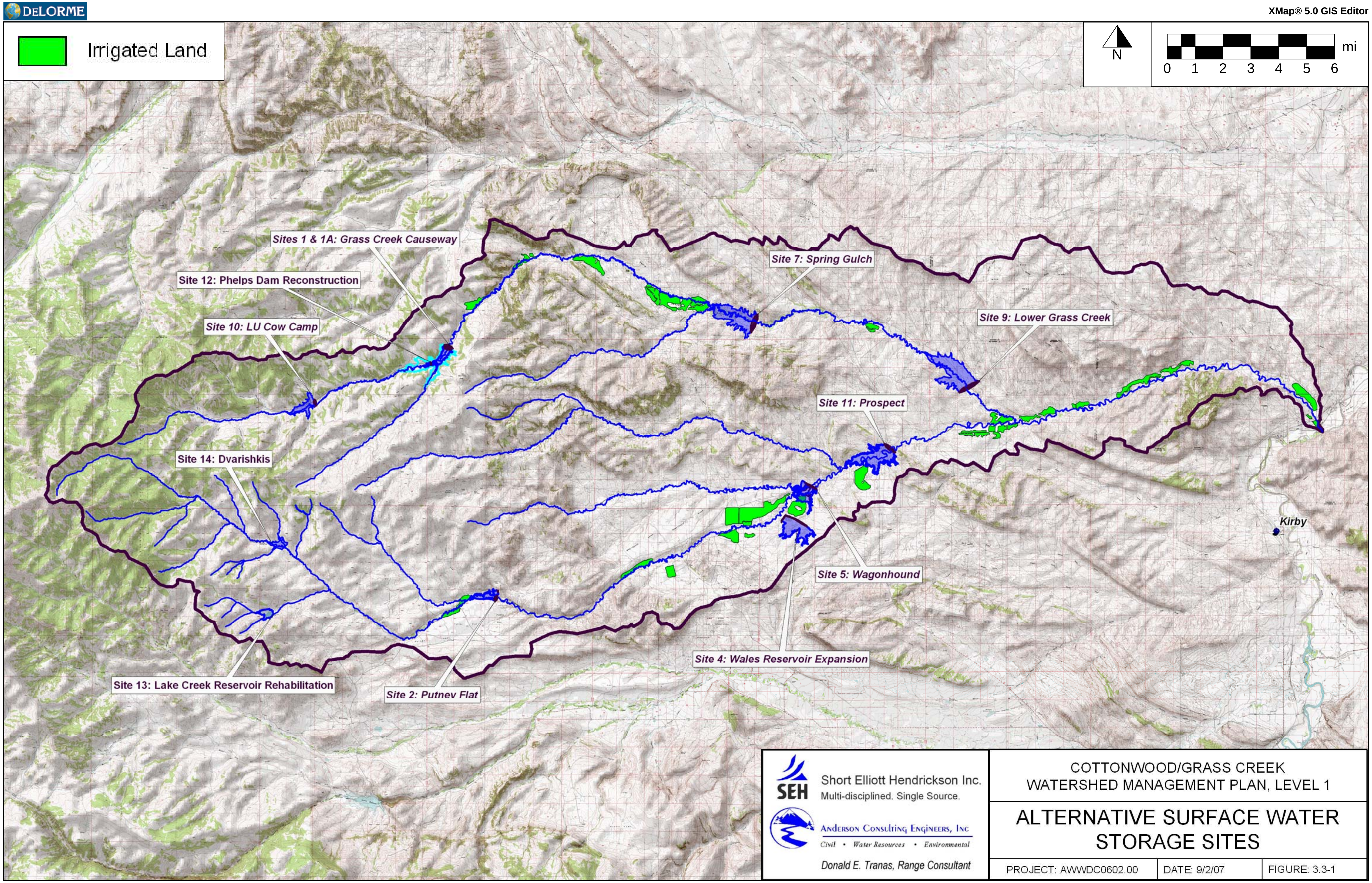


Figure 3. Direct-coupled solar pumping system.

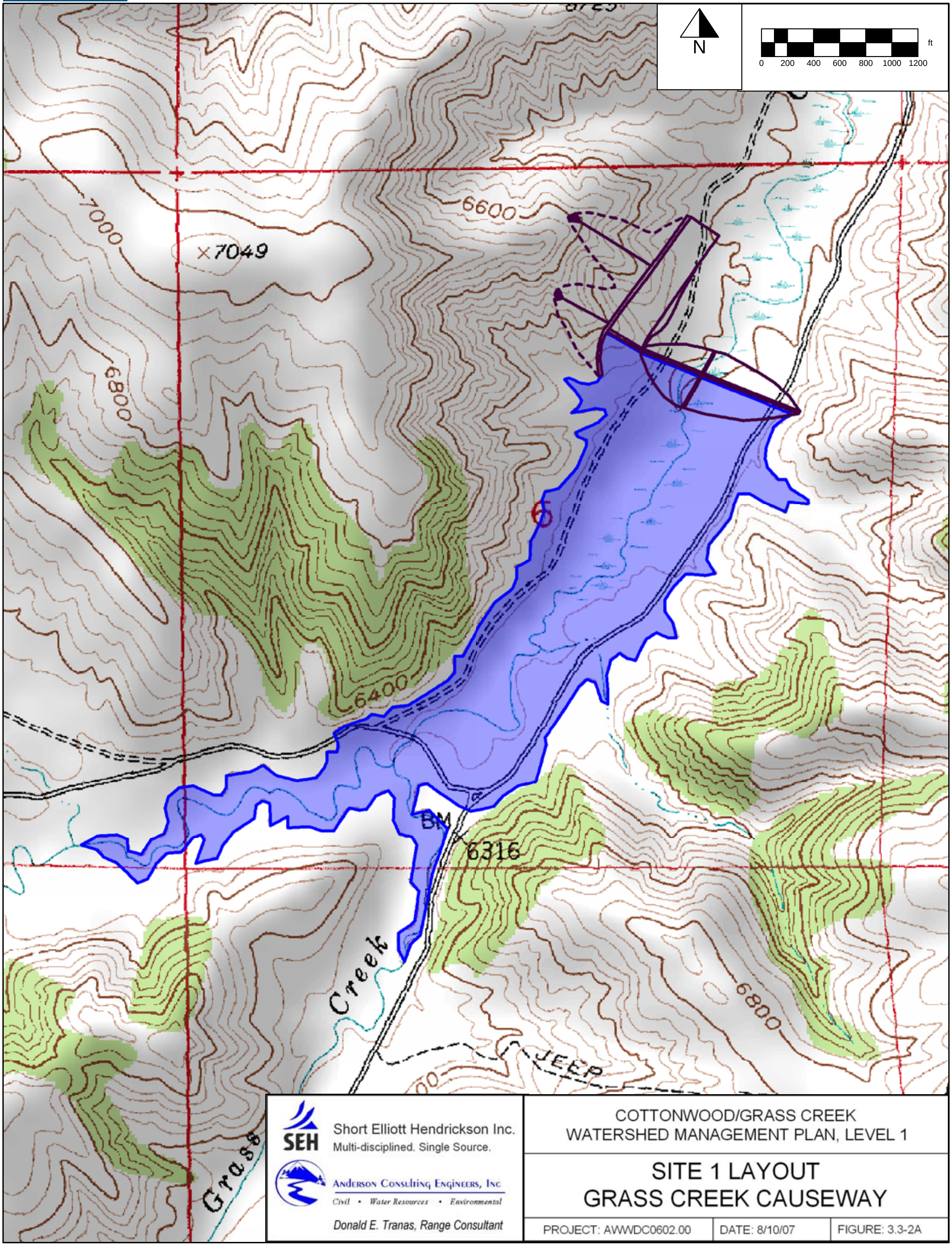
Figure 3.2-10
Solar Water Pump Schematics



COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

ALTERNATIVE SURFACE WATER STORAGE SITES

PROJECT: AWWDC0602.00	DATE: 9/2/07	FIGURE: 3.3-1



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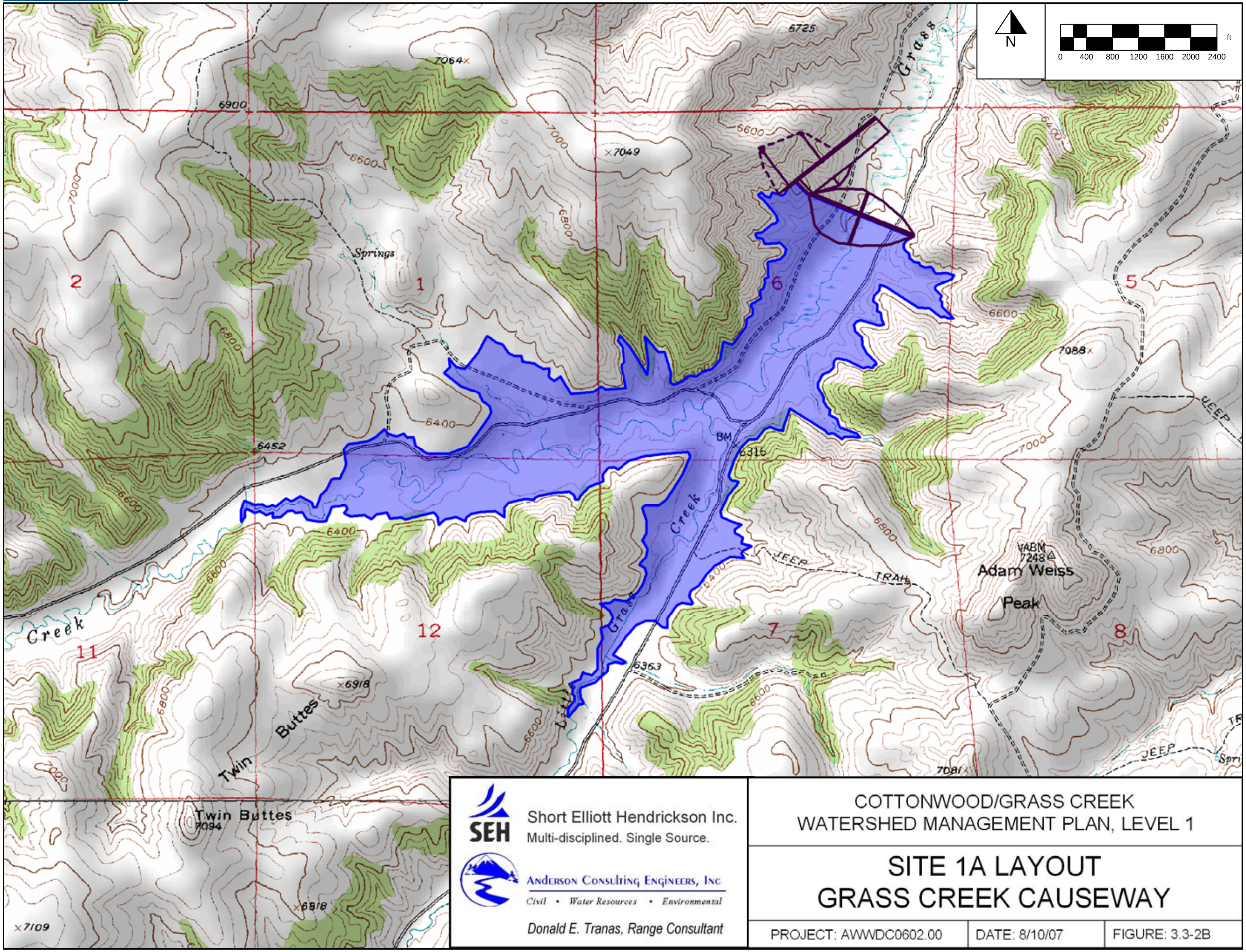
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

SITE 1 LAYOUT
GRASS CREEK CAUSEWAY

PROJECT: AWWDC0602.00	DATE: 8/10/07	FIGURE: 3.3-2A



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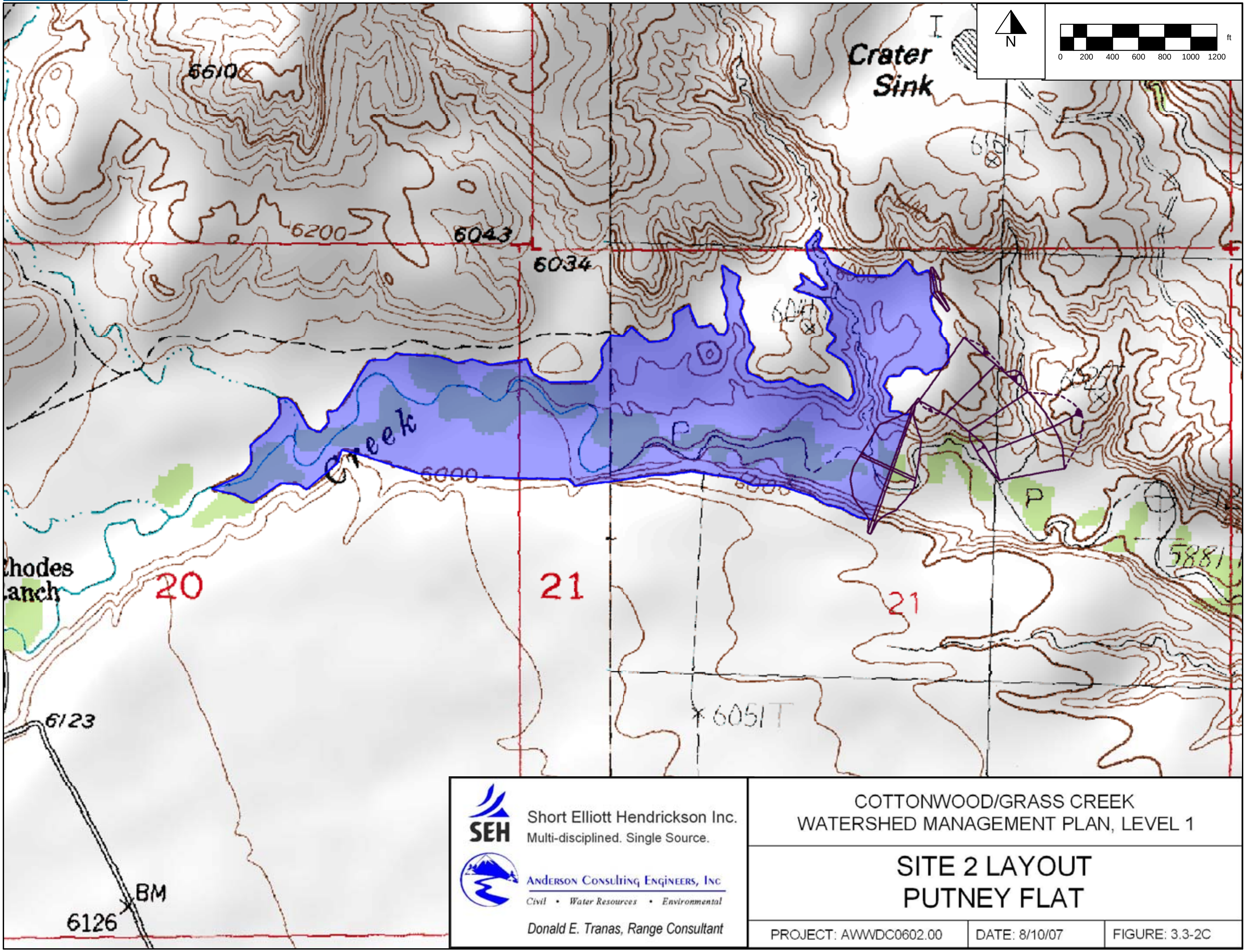
WATERSHED MANAGEMENT PLAN, LEVEL 1

SITE 1A LAYOUT
GRASS CREEK CAUSEWAY

PROJECT: AWWDC0602.00	DATE: 8/10/07	FIGURE: 3.3-2B



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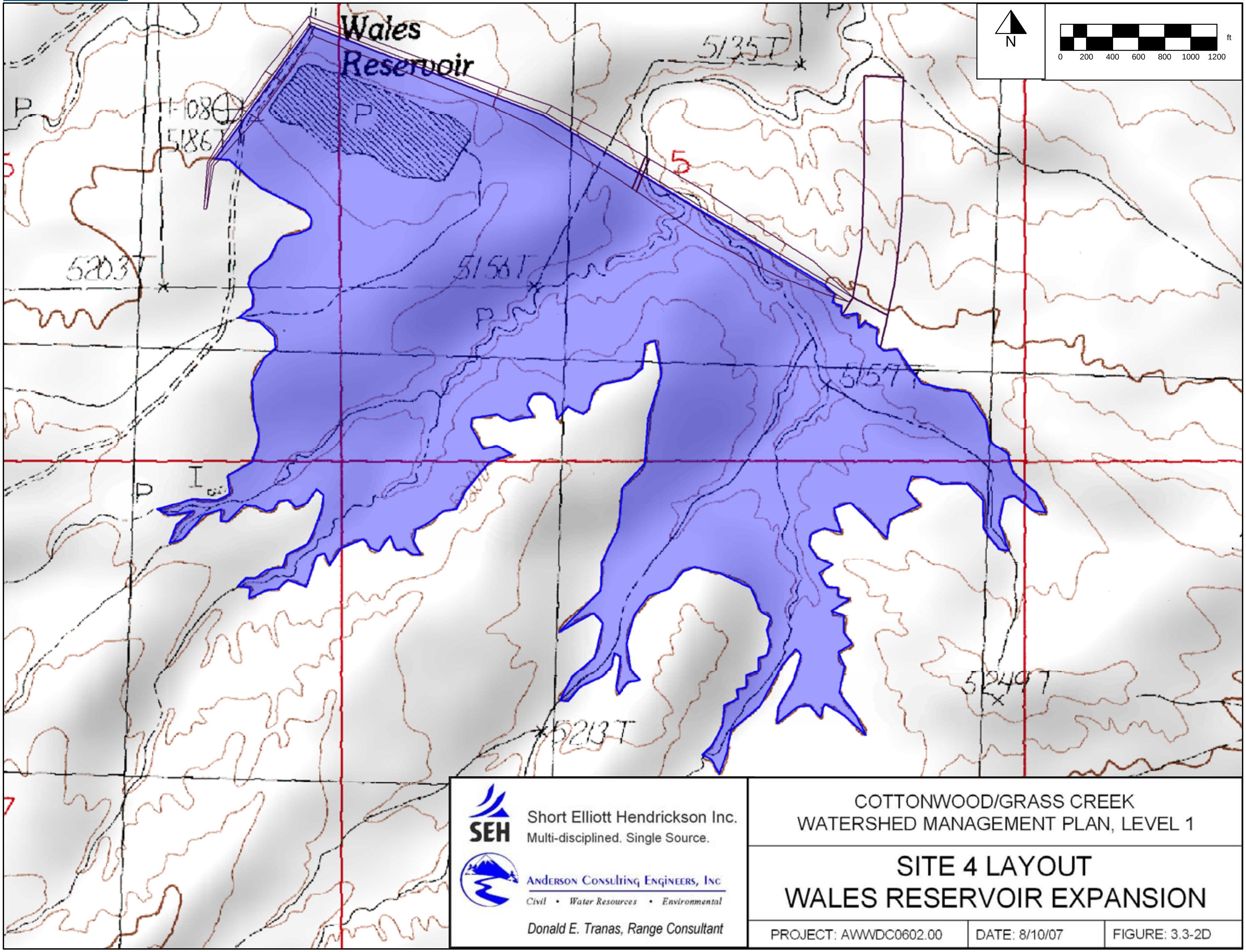
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

SITE 2 LAYOUT
PUTNEY FLAT

PROJECT: AWWDC0602.00 | DATE: 8/10/07 | FIGURE: 3.3-2C



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COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

SITE 4 LAYOUT
WALES RESERVOIR EXPANSION

PROJECT: AWWDC0602.00	DATE: 8/10/07	FIGURE: 3.3-2D

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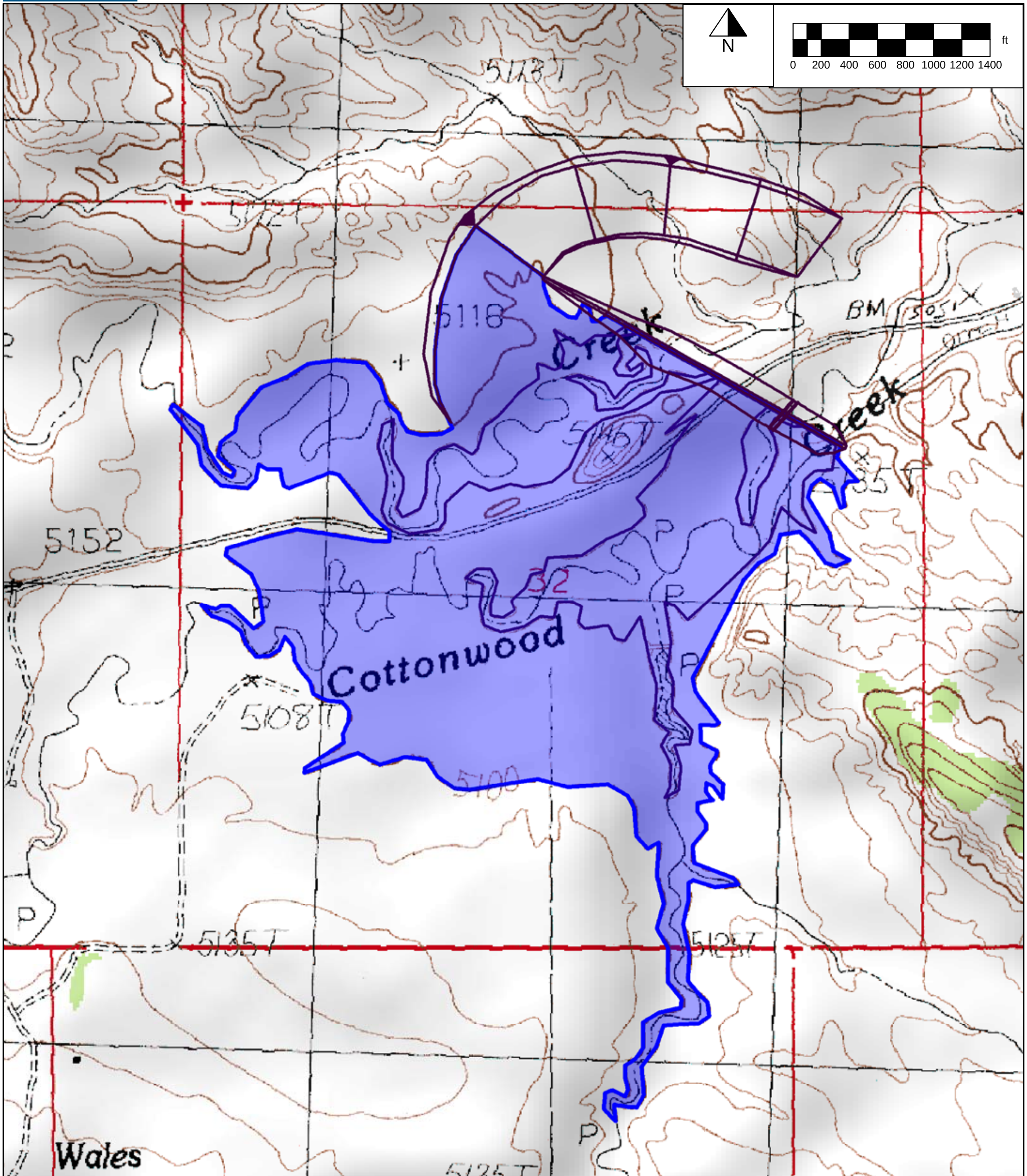

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COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

SITE 5 LAYOUT
WAGONHOUND

PROJECT: AWWDC0602.00 | DATE: 8/10/07 | FIGURE: 3.3-2E

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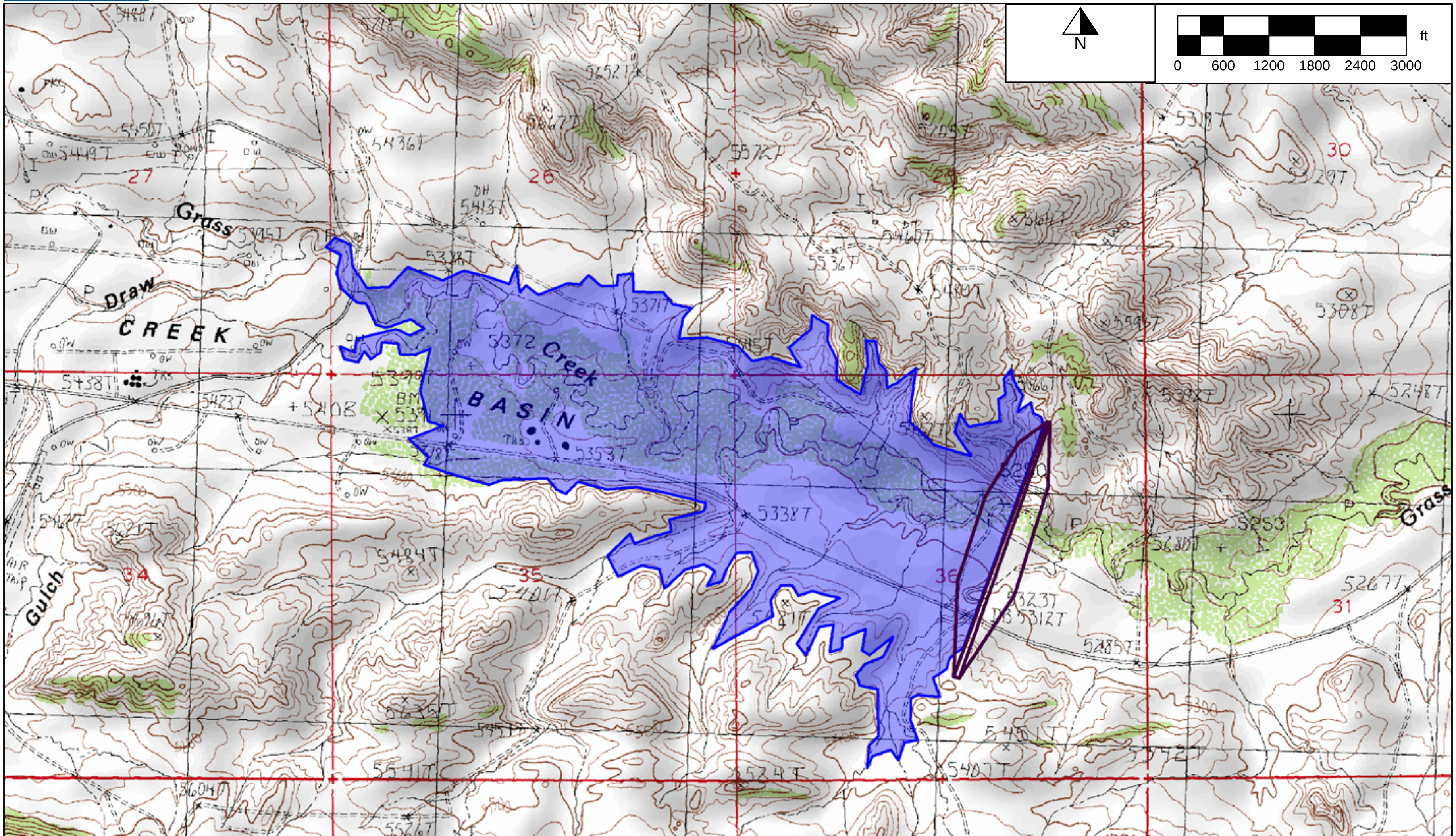

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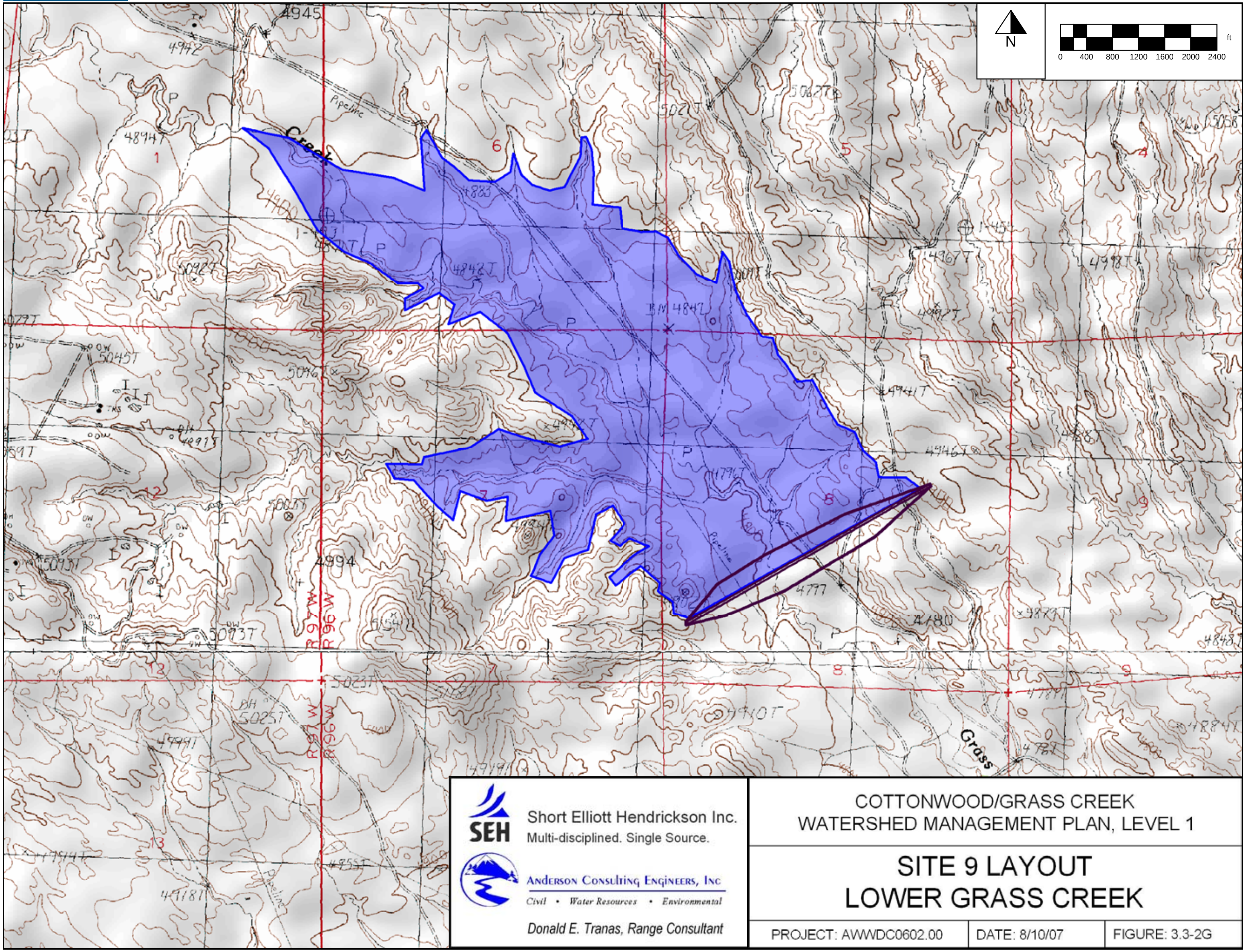
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

SITE 7 LAYOUT
SPRING GULCH

PROJECT: AWWDC0602.00	DATE: 8/10/07	FIGURE: 3.3-2F

XMap® 5.0 GIS Editor



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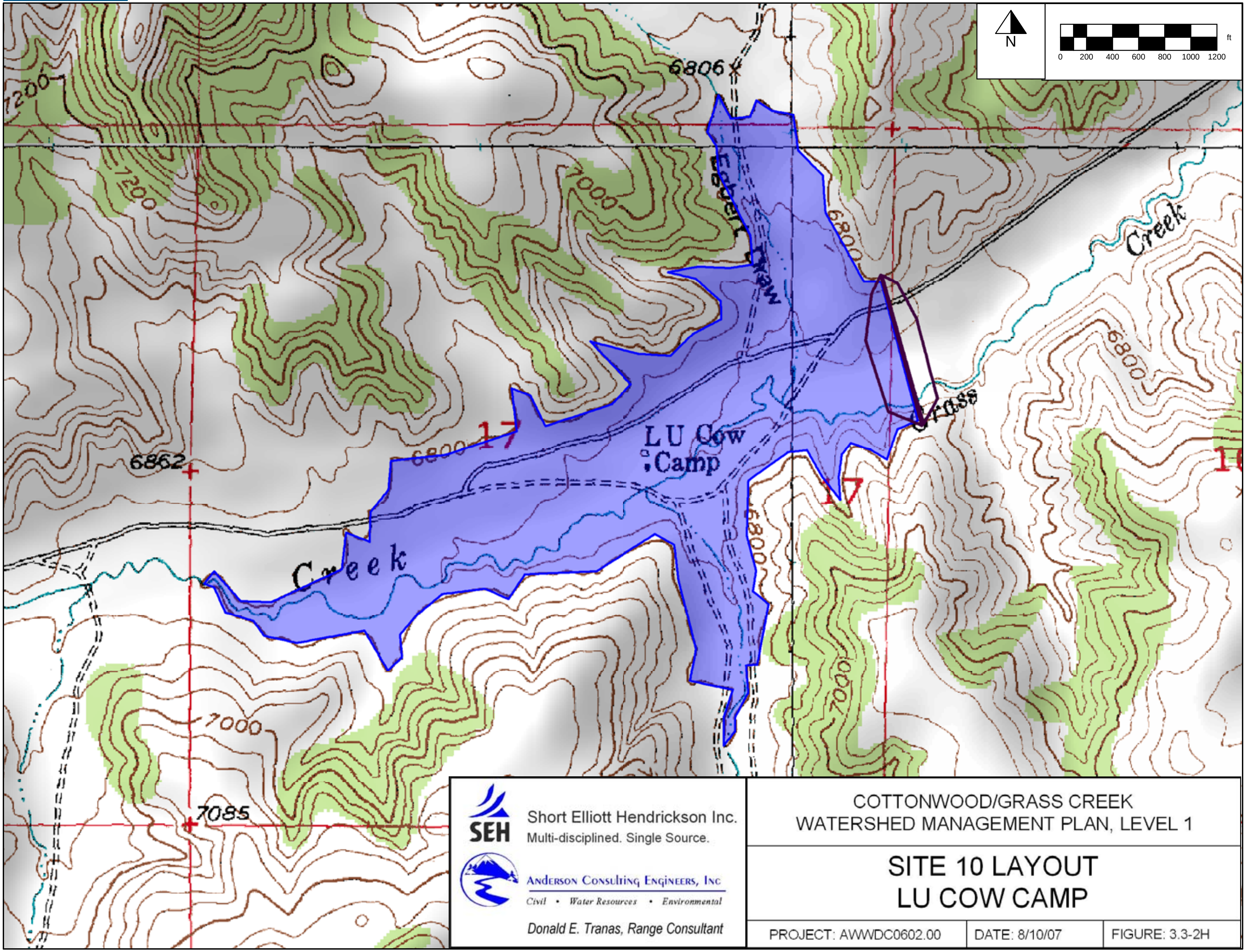

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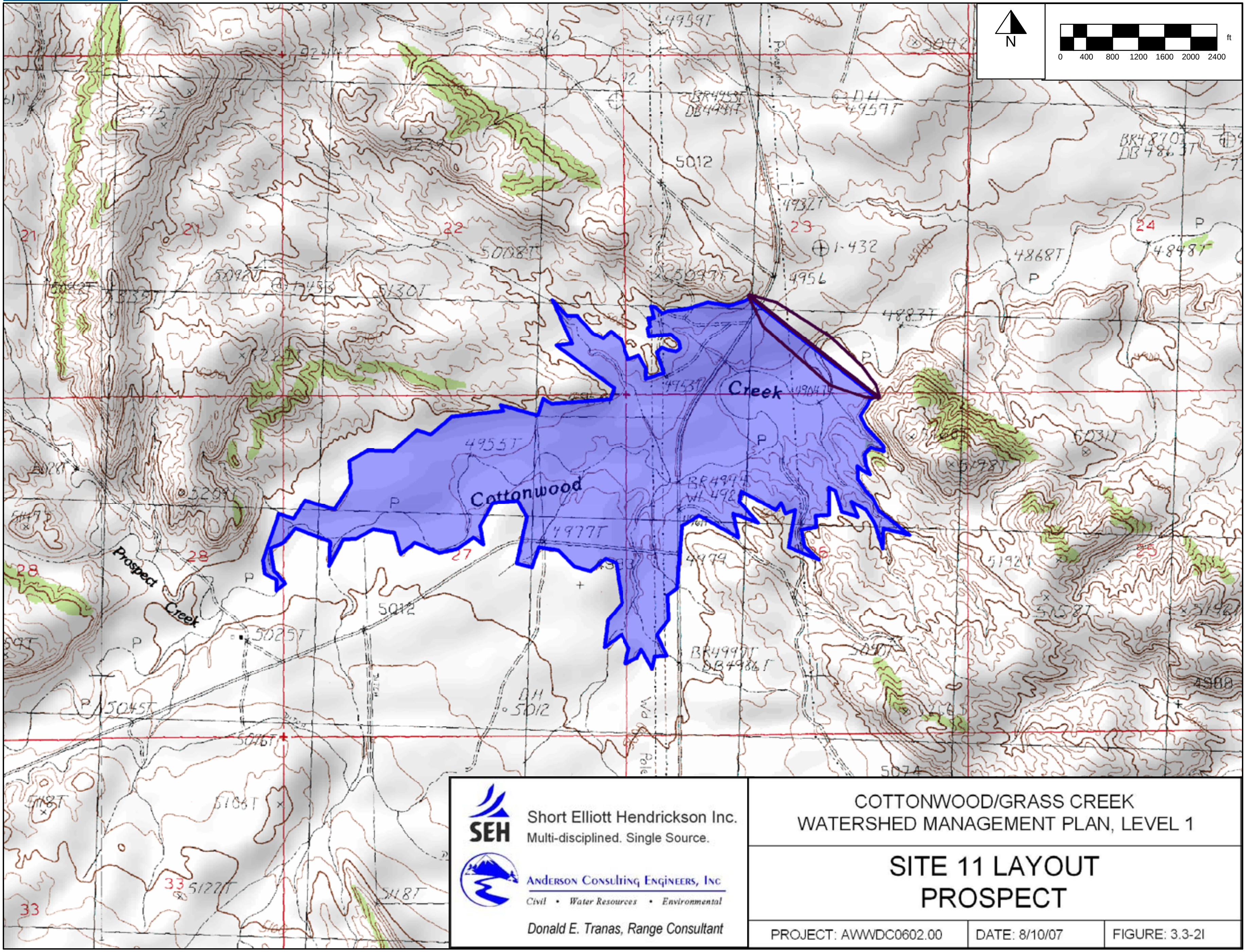

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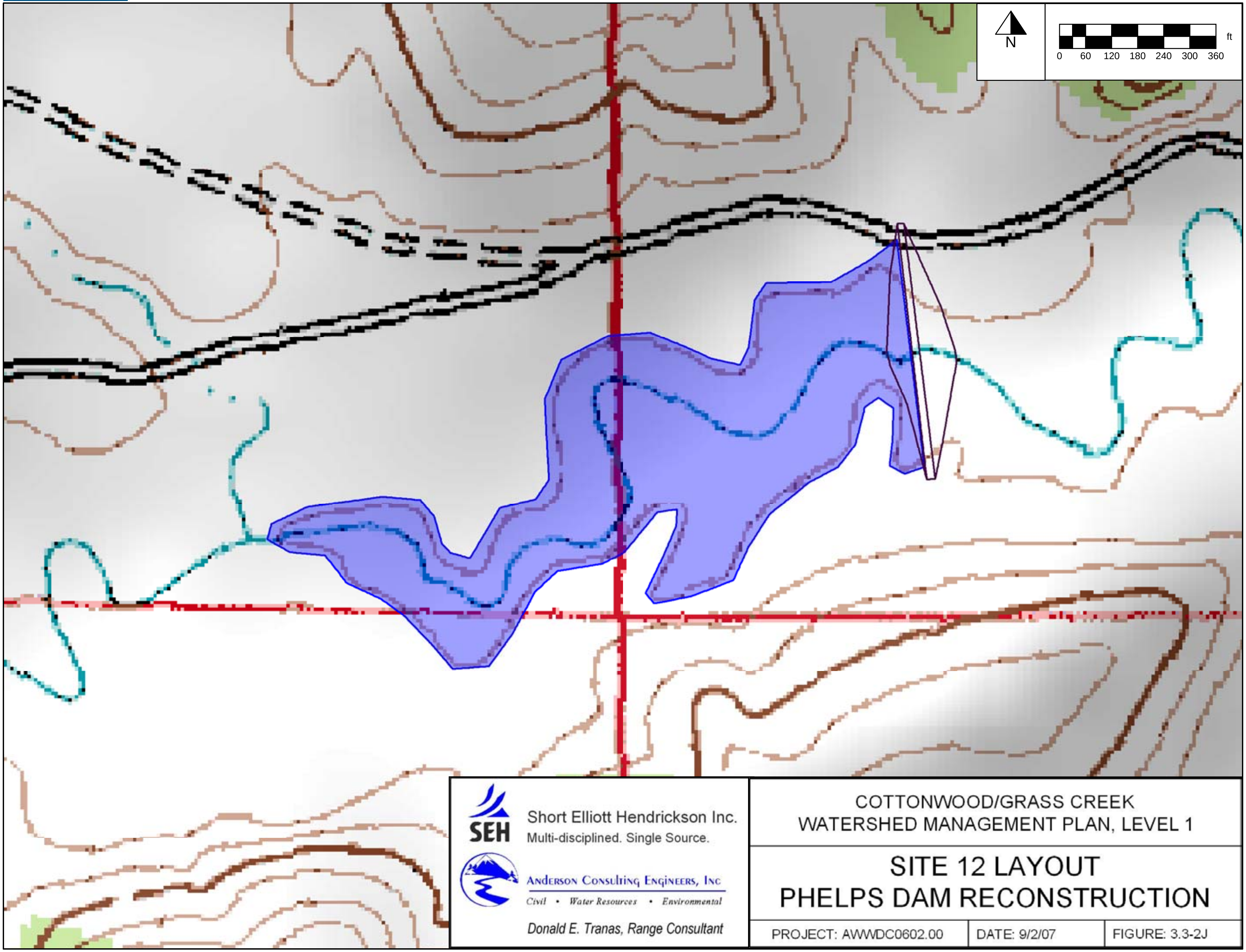
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

SITE 11 LAYOUT
PROSPECT

PROJECT: AWWDC0602.00	DATE: 8/10/07	FIGURE: 3.3-2I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COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1
SITE 12 LAYOUT
PHELPS DAM RECONSTRUCTION
PROJECT: AWWDC0602.00
DATE: 9/2/07
FIGURE: 3.3-2J

Figure 3.3-3A Photographs of Alternative Dam and Reservoir Site 1/1A: Grass Creek Causeway

View of damsite looking upstream; centerline in middle of photo

Right abutment in center of hillside in shadow; note existing causeway in left middle of photo

Close-up of left abutment

Figure 3.3-3B Photographs of Alternative Dam and Reservoir Site 2: Putney Flat

View along dam centerline toward right abutment

Close-up of thick-bedded sandstone in right abutment

View of left abutment

Cottonwood Creek channel at dam centerline

Figure 3.3-3C Photographs of Alternative Dam and Reservoir Site 4: Wales Reservoir Expansion

Existing Wales Reservoir Dam

View toward expanded dam site; dam would extend to right from existing dam at left

Continuation of panorama to right of previous photo; enlarged area in foreground

Treater water discharge from Hamilton Dome; potential source of supply for enlarged reservoir

Figure 3.3-3D Photographs of Alternative Dam and Reservoir Site 5: Wagonhound

View downstream toward dam site; right abutment at sandstone outcrop in right distance; note upper Cottonwood Creek Road through dam and reservoir site

View downstream of dam site; hill in center of valley just upstream of dam centerline; left abutment at far left edge of photo

Sandstone in central hill

Terrace sands and gravels capping lower portions of central hill

Figure 3.3-3E Photographs of Alternative Dam and Reservoir Site 7: Spring Gulch

View along dam centerline toward left abutment

Close-up of left abutment; note bedded sedimentary sequence; note power line and oil pipeline markers in middle ground

View toward right abutment

View of upper reservoir area; note oil storage tanks (and buried pipeline), highway, power line and telephone line are within inundated area

Figure 3.3-3F Photographs of Alternative Dam and Reservoir Site 9: Lower Grass Creek

View along dam centerline toward right abutment

Grass Creek channel at dam centerline

View toward left abutment

Oil pipelines in corridor passing through reservoir area; photo taken northwest of reservoir site

Figure 3.3-3G Photographs of Alternative Dam and Reservoir Site 10: LU Cow Camp

View along dam centerline toward right abutment

Close-up of right abutment

View of left abutment; note interbedded sandstone and siltstone

View upstream of reservoir area

Figure 3.3-3H Photographs of Alternative Dam and Reservoir Site 11: Prospect

View toward dam site from upstream (right abutment at end of ridge in shadow in right distance)

Right abutment and valley section; note transmission line; view looking upstream

Left abutment; note Highway 120; view looking upstream

Open joints and bedding planes in sandstone; upper left abutment

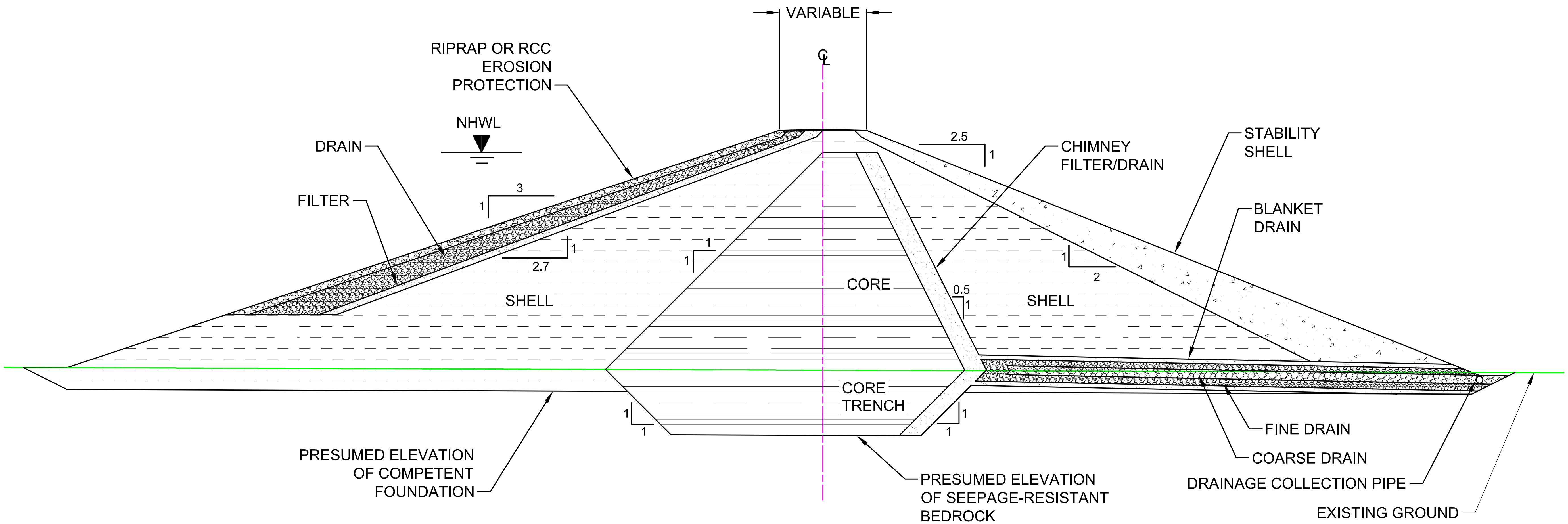
Figure 3.3-3I Photographs of Alternative Dam and Reservoir Site 12: Phelps Dam Reconstruction


View along dam centerline toward right abutment


Close-up of remnant of original dam in right side of valley


View of left abutment area


View upstream of reservoir area



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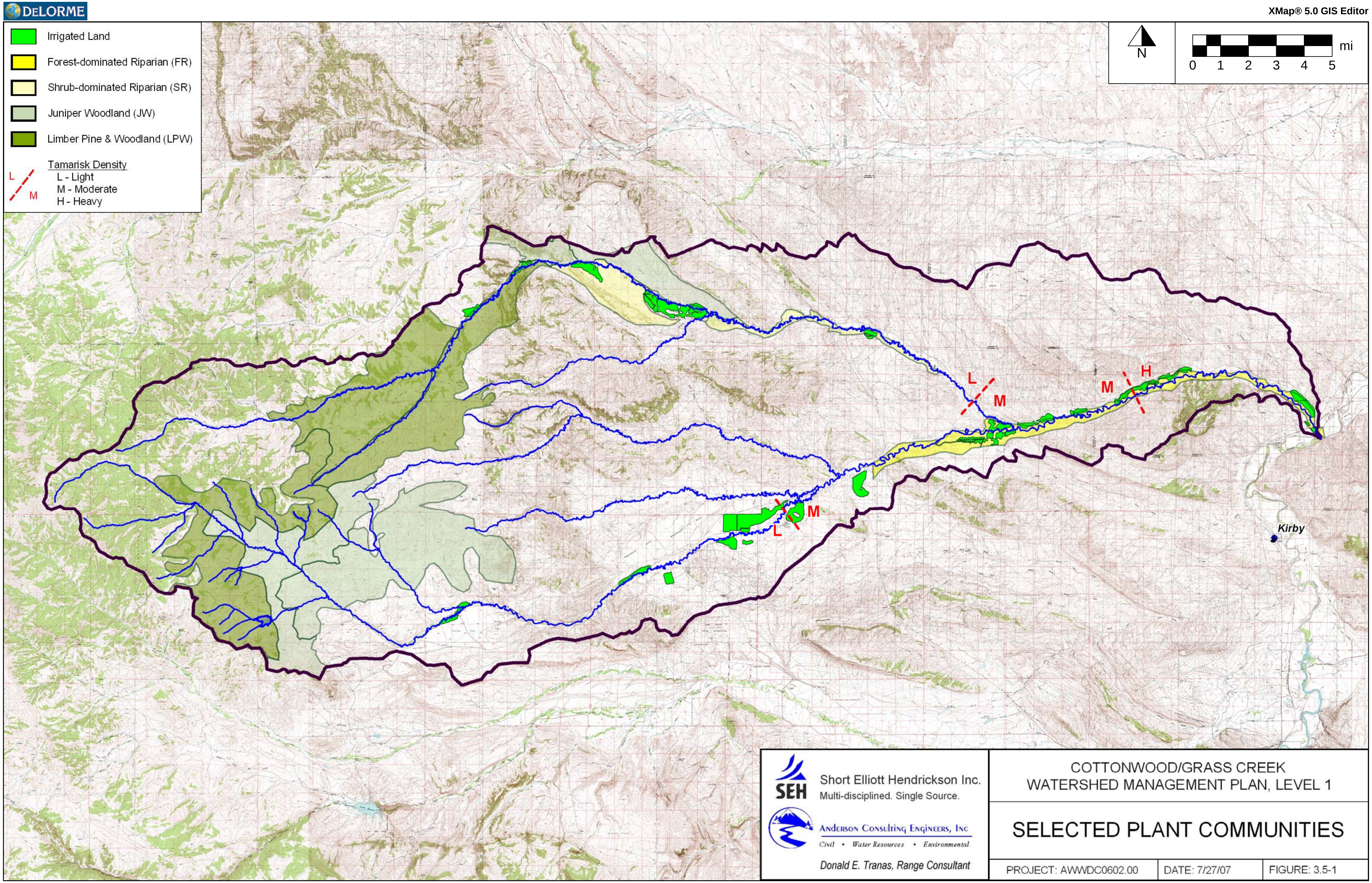
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

TYPICAL ZONED EARTHFILL DAM

PROJECT: AWWDC0602.00	DATE: 7/27/07	FIGURE: 3.3-4



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Irrigated Land
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Shrub-dominated Riparian (SR)
Juniper Woodland (JW)
Limber Pine & Woodland (LPW)
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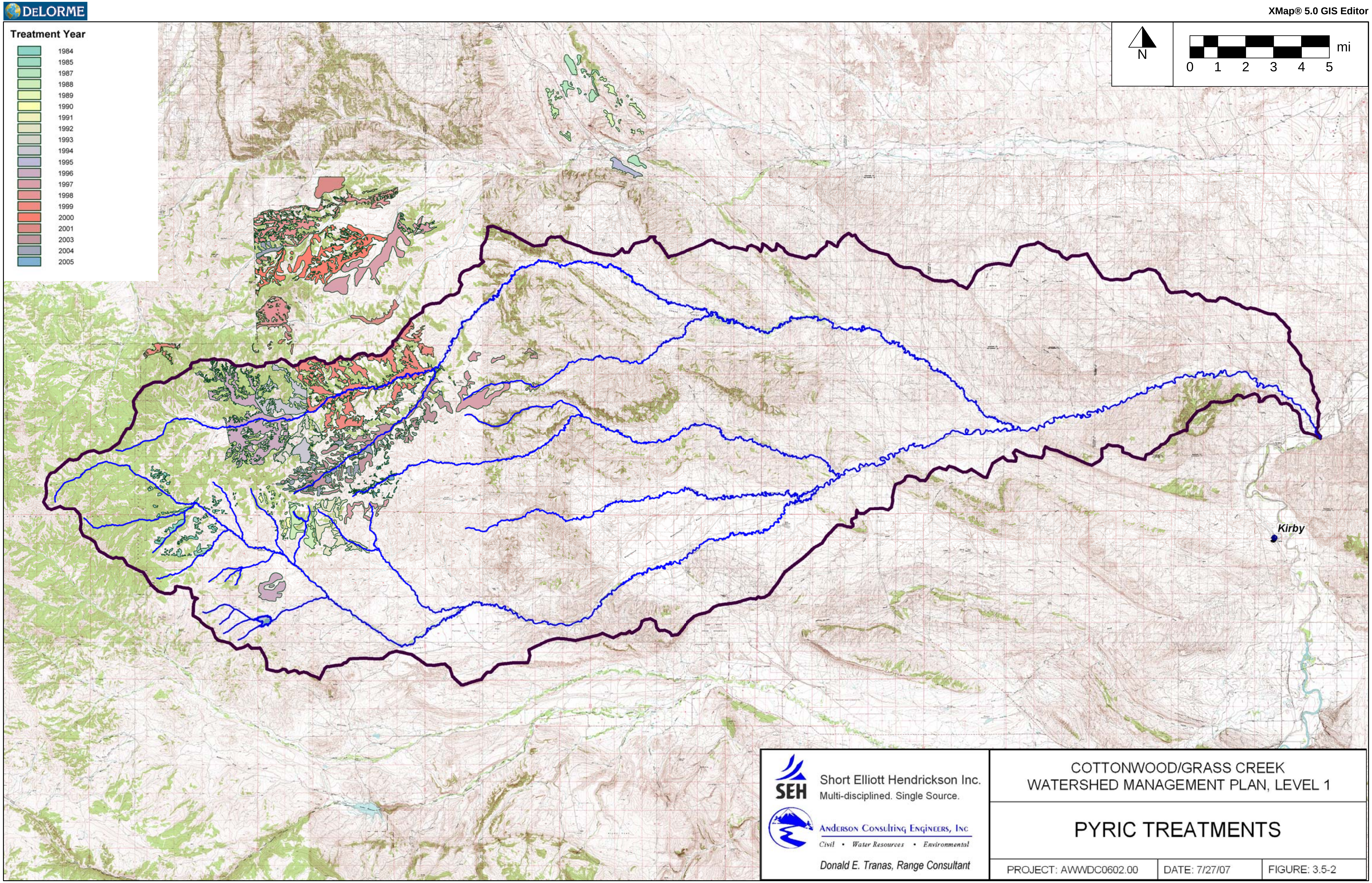
WATERSHED MANAGEMENT PLAN, LEVEL 1
SELECTED PLANT COMMUNITIES
PROJECT: AWWDC0602.00
DATE: 7/27/07
FIGURE: 3.5-1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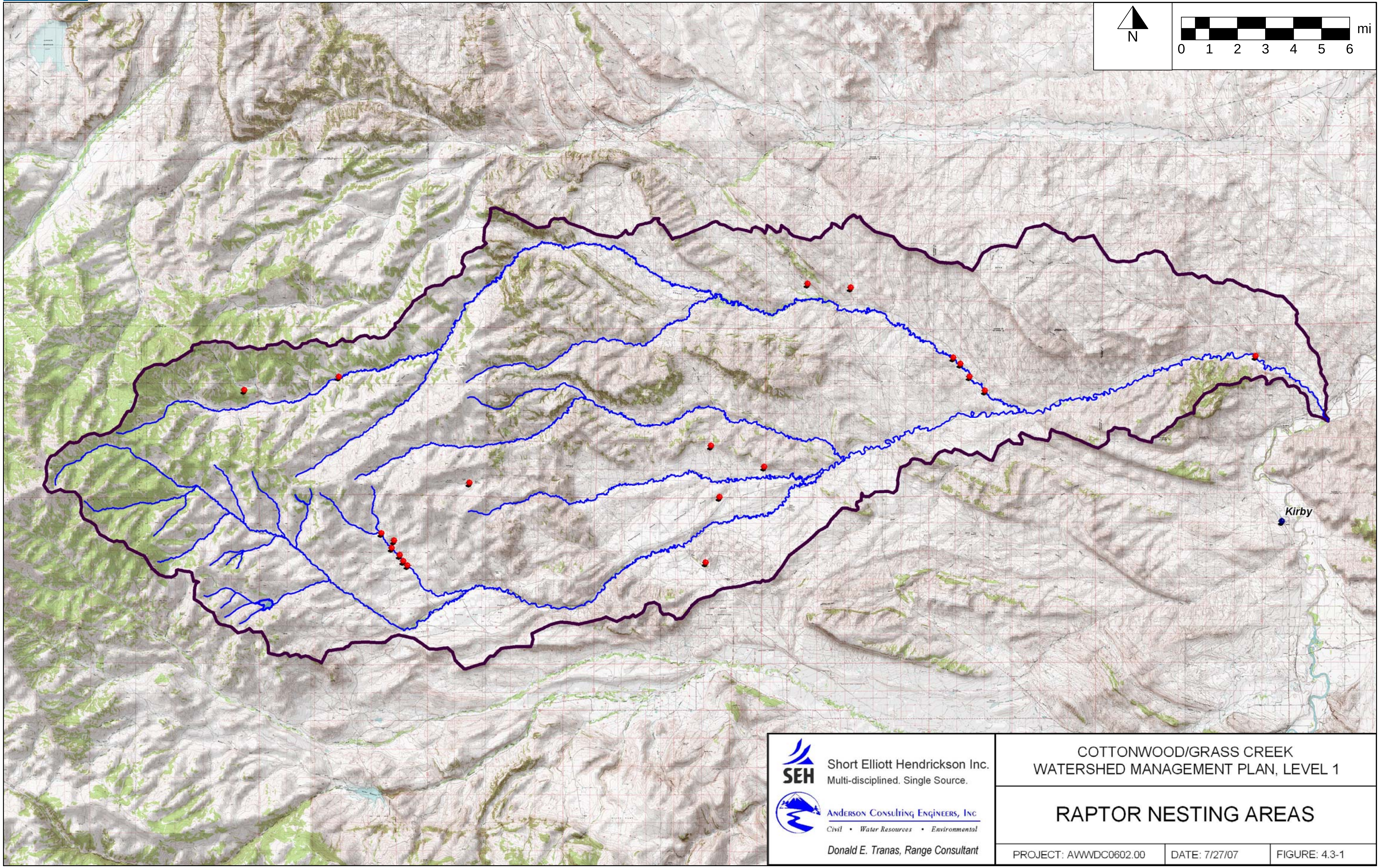
WATERSHED MANAGEMENT PLAN, LEVEL 1
PYRIC TREATMENTS
PROJECT: AWWDC0602.00
DATE: 7/27/07
FIGURE: 3.5-2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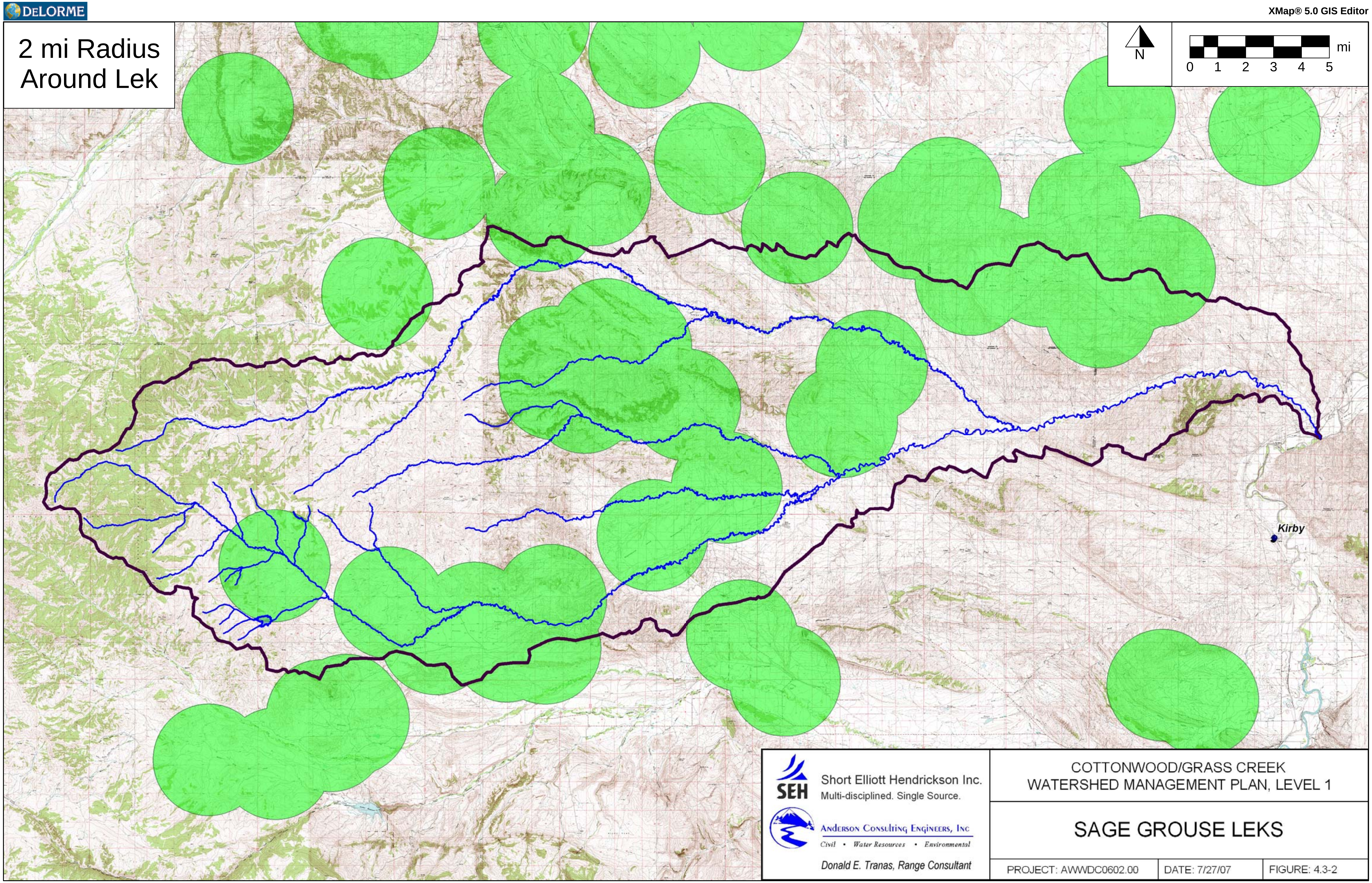
WATERSHED MANAGEMENT PLAN, LEVEL 1
RAPTOR NESTING AREAS
PROJECT: AWWDC0602.00
DATE: 7/27/07
FIGURE: 4.3-1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WATERSHED MANAGEMENT PLAN, LEVEL 1
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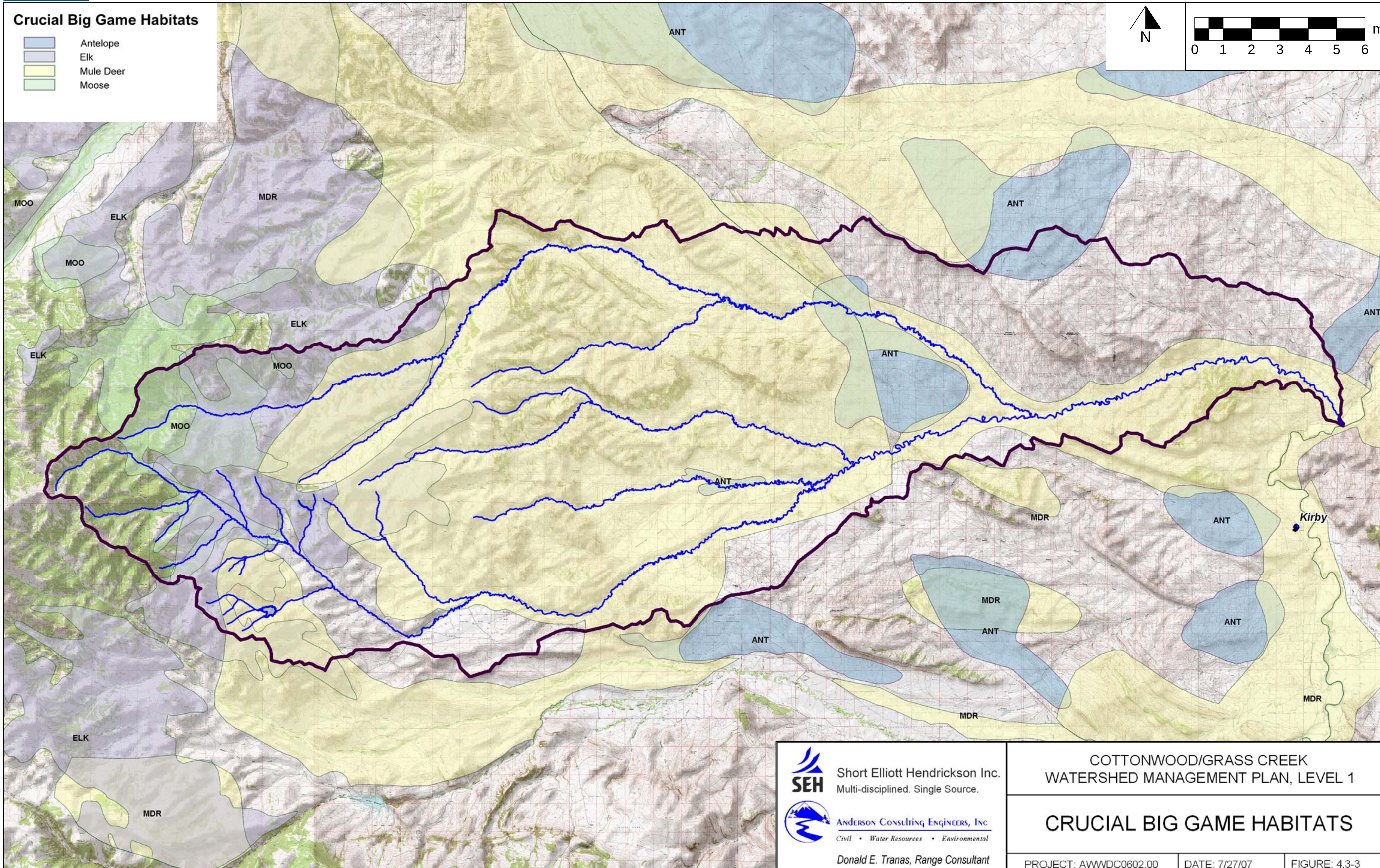
PROJECT: AWWDC0602.00
DATE: 7/27/07
FIGURE: 4.3-2



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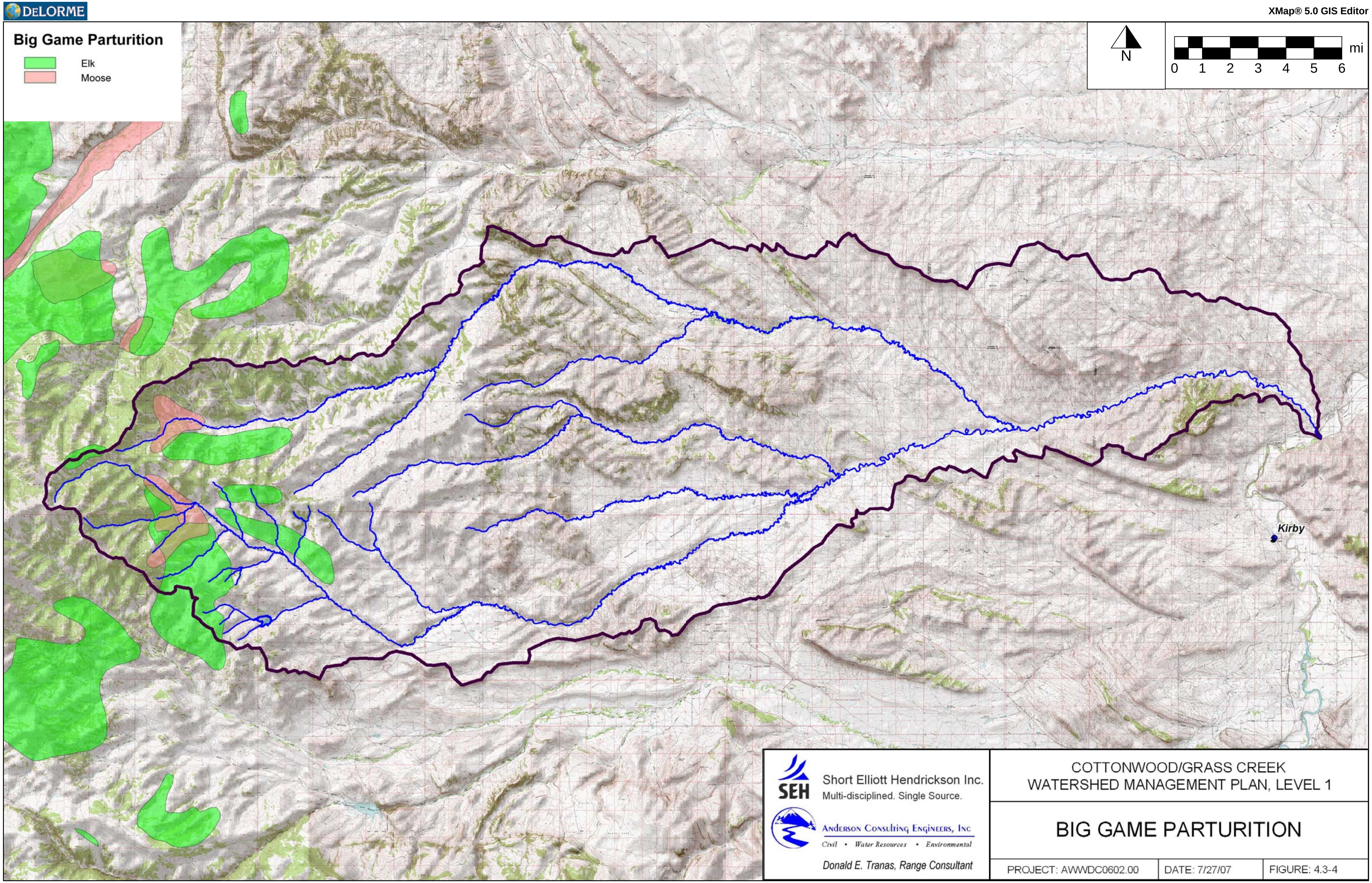
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

CRUCIAL BIG GAME HABITATS

PROJECT: AWWDC0602.00	DATE: 7/27/07	FIGURE: 4.3-3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WATERSHED MANAGEMENT PLAN, LEVEL 1
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PROJECT: AWWDC0602.00
DATE: 7/27/07
FIGURE: 4.3-4

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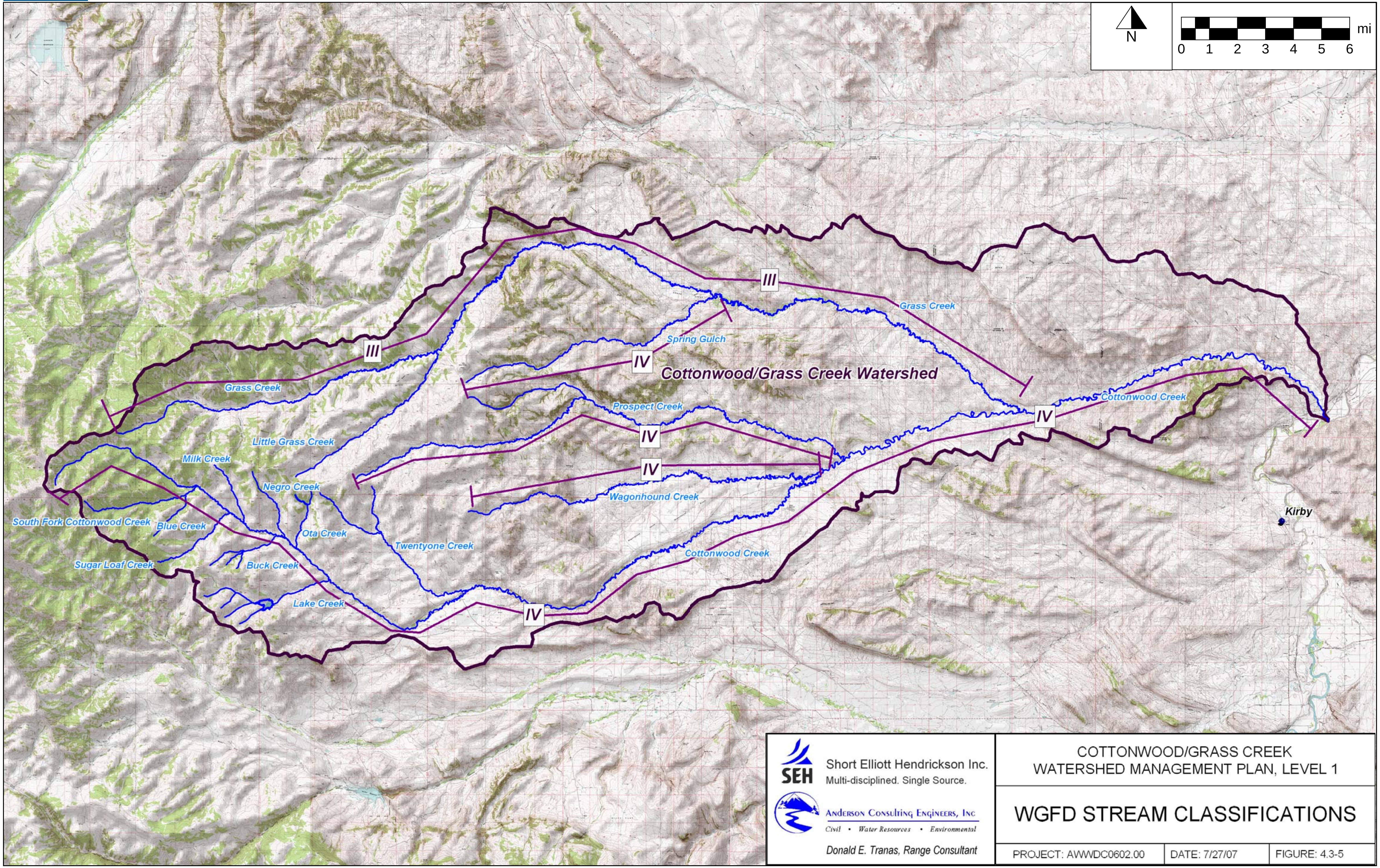

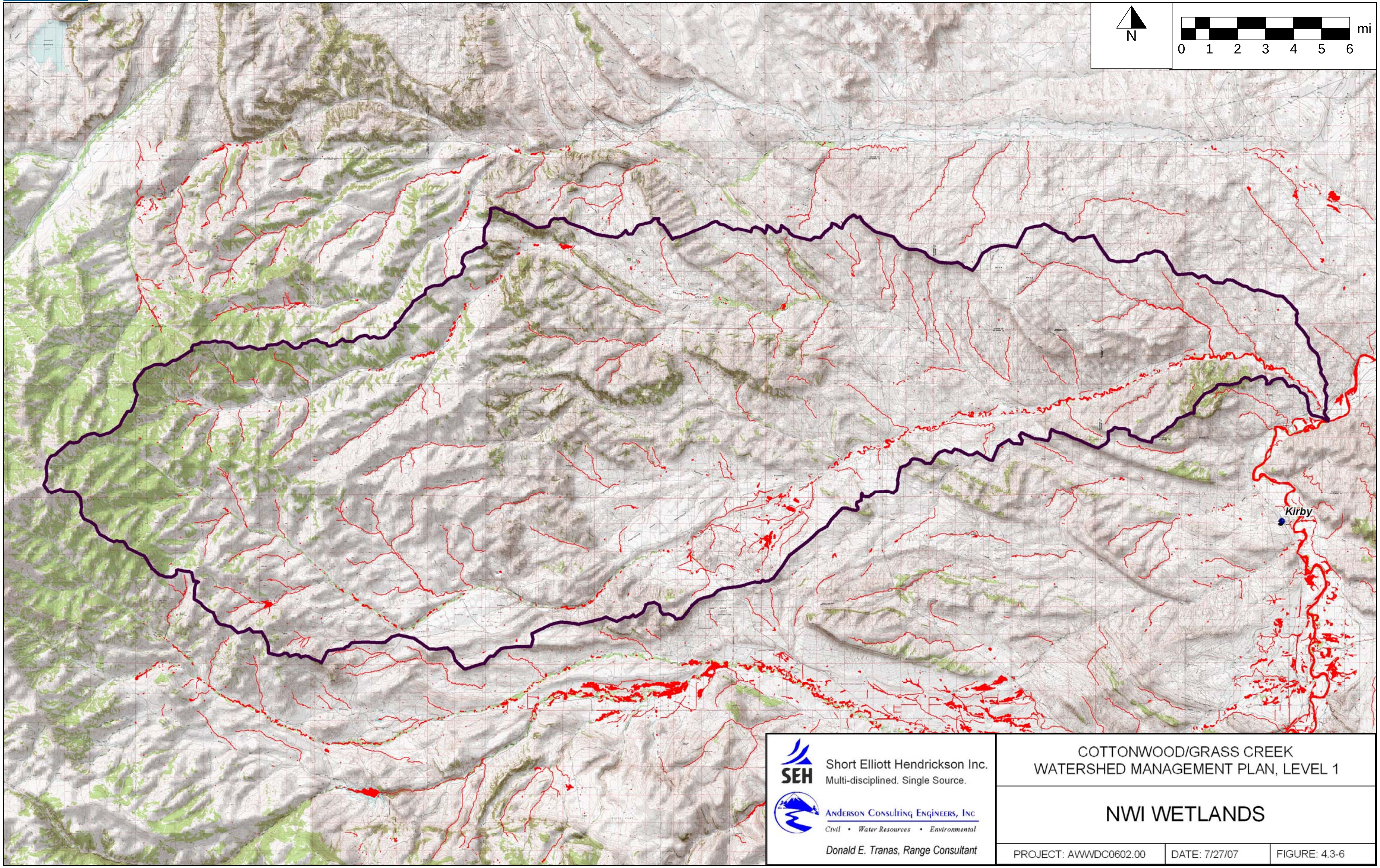

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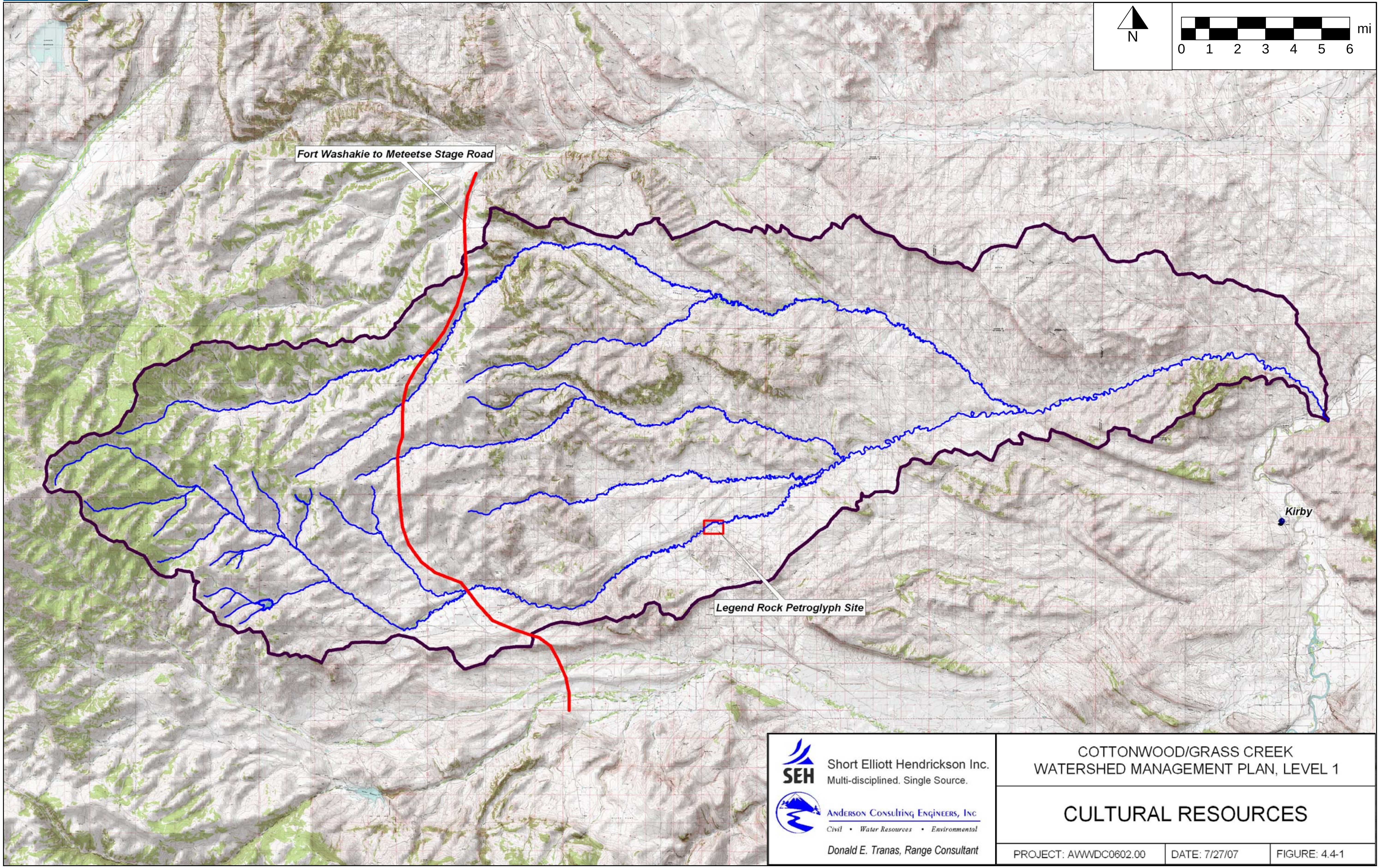
COTTONWOOD/GRASS CREEK
WATERSHED MANAGEMENT PLAN, LEVEL 1

NWI WETLANDS

PROJECT: AWWDC0602.00	DATE: 7/27/07	FIGURE: 4.3-6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Legend Rock Petroglyph Site
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WATERSHED MANAGEMENT PLAN, LEVEL 1
CULTURAL RESOURCES
PROJECT: AWWDC0602.00
DATE: 7/27/07
FIGURE: 4.4-1

Appendix A

WID Legal Description

Cottonwood/Grass Creek Watershed Improvement District

Legal Description of All Lands Within Proposed WID Boundary

Township	Range	Section	Quarter Section	Quarter Quarter Section
43	100	2	NE	NWNE
43	100	2	NW	All
43	100	3	NE	All
43	100	3	NW	All
43	100	4	NW	NENW
43	100	4	NW	NWNW
43	100	4	NW	SENW
43	100	4	NE	All
44	96	6	SW	NESW
44	96	6	SW	NWSW
44	96	6	NW	All
44	97	1	All	All
44	97	2	All	All
44	97	3	All	All
44	97	4	All	All
44	97	5	All	All
44	97	6	All	All
44	97	7	All	All
44	97	8	All	All
44	97	9	All	All
44	97	10	All	All
44	97	11	NE	NWNE
44	97	11	NE	SWNE
44	97	11	SE	NWSE
44	97	11	SE	SWSE
44	97	11	NW	All
44	97	11	SW	All
44	97	14	NE	NWNE
44	97	14	NE	SWNE
44	97	14	SE	NWSE
44	97	14	SE	SWSE
44	97	14	NW	All
44	97	14	SW	All
44	97	15	All	All
44	97	16	All	All
44	97	17	All	All
44	97	18	All	All
44	97	19	SE	NESE
44	97	19	SE	NWSE
44	97	19	SW	NESW
44	97	19	SW	NWSW
44	97	19	NE	All
44	97	19	NW	All
44	97	20	All	All
44	97	21	All	All
44	97	22	SE	NESE
44	97	22	SE	NWSE
44	97	22	SW	NESW
44	97	22	SW	NWSW
44	97	22	SW	SWSW
44	97	22	NE	All
44	97	22	NW	All
44	97	23	NE	NWNE
44	97	23	NE	SWNE
44	97	23	SE	NWSE
44	97	23	SW	NESW
44	97	23	SW	NWSW
44	97	23	NW	All
44	98	1	All	All
44	98	2	All	All
44	98	3	All	All
44	98	4	All	All
44	98	5	All	All
44	98	6	All	All
44	98	7	All	All
44	98	8	All	All
44	98	9	All	All
44	98	10	All	All
44	98	11	All	All
44	98	12	All	All
44	98	13	All	All
44	98	14	All	All
44	98	15	All	All
44	98	16	All	All
44	98	17	All	All
44	98	18	All	All
44	98	19	All	All
44	98	20	All	All
44	98	21	All	All
44	98	22	SE	NESE
44	98	22	SE	NWSE
44	98	22	SE	SWSE
44	98	22	NE	All
44	98	22	NW	All
44	98	22	SW	All
44	98	23	SW	NESW
44	98	23	SW	NWSW
44	98	23	SW	SESW
44	98	23	NE	All

Township	Range	Section	Quarter Section	Quarter Quarter Section
44	98	23	NW	All
44	98	23	SE	All
44	98	24	SE	NESE
44	98	24	SE	NWSE
44	98	24	SW	NESW
44	98	24	SW	NWSW
44	98	24	NE	All
44	98	24	NW	All
44	98	27	SW	NWSW
44	98	27	NW	All
44	98	28	All	All
44	98	29	All	All
44	98	30	All	All
44	98	31	NW	NENW
44	98	31	NW	NWNW
44	98	31	NW	SWNW
44	98	31	SE	NESE
44	98	31	SE	NWSE
44	98	31	NE	All
44	98	32	SW	NWSW
44	98	32	NE	All
44	98	32	NW	All
44	98	33	NE	NENE
44	98	33	NE	NWNE
44	98	33	NW	NENW
44	98	33	NW	NWNW
44	99	1	All	All
44	99	2	All	All
44	99	3	All	All
44	99	4	All	All
44	99	5	All	All
44	99	6	All	All
44	99	7	All	All
44	99	8	All	All
44	99	9	All	All
44	99	10	All	All
44	99	11	All	All
44	99	12	All	All
44	99	13	All	All
44	99	14	All	All
44	99	15	All	All
44	99	16	All	All
44	99	17	All	All
44	99	18	All	All
44	99	19	All	All
44	99	20	All	All
44	99	21	All	All
44	99	22	All	All
44	99	23	All	All
44	99	24	All	All
44	99	25	All	All
44	99	26	All	All
44	99	27	All	All
44	99	28	All	All
44	99	29	All	All
44	99	30	All	All
44	99	31	NE	NENE
44	99	31	NE	NWNE
44	99	31	NE	SWNE
44	99	31	SE	NWSE
44	99	31	SE	SWSE
44	99	31	NW	All
44	99	31	SW	All
44	99	32	NE	NENE
44	99	32	NE	NWNE
44	99	32	NW	NENW
44	99	32	NW	NWNW
44	99	33	NW	NENW
44	99	33	NE	All
44	99	34	NE	All
44	99	34	NW	All
44	99	35	NE	All
44	99	35	NW	All
44	99	36	NE	All
44	99	36	NW	All
44	100	1	All	All
44	100	2	All	All
44	100	3	All	All
44	100	4	All	All
44	100	5	All	All
44	100	6	All	All
44	100	7	All	All
44	100	8	All	All
44	100	9	All	All
44	100	10	All	All
44	100	11	All	All
44	100	12	All	All
44	100	13	All	All
44	100	14	All	All
44	100	15	All	All
44	100	16	All	All
44	100	17	All	All
44	100	18	All	All
44	100	19	All	All
44	100	20	All	All
44	100	21	All	All

Township	Range	Section	Quarter Section	Quarter Quarter Section
44	100	22	All	All
44	100	23	All	All
44	100	24	All	All
44	100	25	All	All
44	100	26	All	All
44	100	27	All	All
44	100	28	All	All
44	100	29	All	All
44	100	30	All	All
44	100	31	SE	NESE
44	100	31	SE	NWSE
44	100	31	SW	NESW
44	100	31	SW	NWSW
44	100	31	NE	All
44	100	31	NW	All
44	100	32	SE	NESE
44	100	32	SE	NWSE
44	100	32	SE	SESE
44	100	32	SW	NESW
44	100	32	SW	NWSW
44	100	32	NE	All
44	100	32	NW	All
44	100	33	All	All
44	100	34	All	All
44	100	35	All	All
44	100	36	All	All
44	101	1	All	All
44	101	2	All	All
44	101	3	All	All
44	101	4	All	All
44	101	5	All	All
44	101	6	All	All
44	101	7	All	All
44	101	8	All	All
44	101	9	All	All
44	101	10	All	All
44	101	11	All	All
44	101	12	All	All
44	101	13	All	All
44	101	14	All	All
44	101	15	All	All
44	101	16	All	All
44	101	17	NW	NENW
44	101	17	NW	NWNW
44	101	17	NW	SENW
44	101	17	SE	NESE
44	101	17	SE	NWSE
44	101	17	SE	SESE
44	101	17	NE	All
44	101	18	NE	NENE
44	101	22	NW	NENW
44	101	22	NW	SENW
44	101	22	SW	NESW
44	101	22	SW	SESW
44	101	22	NE	All
44	101	22	SE	All
44	101	23	All	All
44	101	24	All	All
44	101	25	All	All
44	101	26	SE	NESE
44	101	26	SE	NWSE
44	101	26	SE	SESE
44	101	26	SW	NESW
44	101	26	NE	All
44	101	26	NW	All
44	101	27	NE	NENE
44	101	27	NE	NWNE
44	101	36	NE	NENE
44	102	1	NW	NENW
44	102	1	NW	NWNW
44	102	1	NW	SENW
44	102	1	SW	NESW
44	102	1	SW	SESW
44	102	1	NE	All
44	102	1	SE	All
44	102	2	NE	NENE
44	102	2	NE	NWNE
44	102	2	NW	NENW
44	102	2	NW	NWNW
44	102	12	NE	NENE
44	102	12	NE	NWNE
44	102	12	NE	SENE
44	102	12	NW	NENW
45	94	4	SW	NWSW
45	94	4	SW	SWSW
45	94	5	NW	NWNW
45	94	5	NW	SENW
45	94	5	NW	SWNW
45	94	5	SE	NWSE
45	94	5	SE	SESE
45	94	5	SE	SWSE
45	94	5	SW	All
45	94	6	All	All
45	94	7	All	All
45	94	8	All	All
45	94	9	NW	NWNW

Township	Range	Section	Quarter Section	Quarter Quarter Section
45	94	9	NW	SWNW
45	94	9	SW	NWSW
45	94	9	SW	SWSW
45	94	16	NW	NWNW
45	94	16	NW	SENW
45	94	16	NW	SWNW
45	94	16	SW	All
45	94	17	All	All
45	94	18	All	All
45	94	19	SW	NESW
45	94	19	SW	NWSW
45	94	19	NE	All
45	94	19	NW	All
45	94	20	SE	NESE
45	94	20	SE	NWSE
45	94	20	NE	All
45	94	20	NW	All
45	94	21	NW	NWNW
45	94	21	NW	SWNW
45	94	21	SW	NWSW
45	95	1	All	All
45	95	2	All	All
45	95	3	All	All
45	95	4	All	All
45	95	5	All	All
45	95	6	All	All
45	95	7	All	All
45	95	8	All	All
45	95	9	All	All
45	95	10	All	All
45	95	11	All	All
45	95	12	All	All
45	95	13	All	All
45	95	14	NW	NENW
45	95	14	NW	NWNW
45	95	14	SE	NESE
45	95	14	SE	SESE
45	95	14	NE	All
45	95	15	NE	NENE
45	95	15	NE	NWNE
45	95	15	NW	NENW
45	95	15	NW	NWNW
45	95	16	All	All
45	95	17	All	All
45	95	18	All	All
45	95	19	All	All
45	95	20	All	All
45	95	21	NE	NENE
45	95	21	NE	NWNE
45	95	21	NE	SWNE
45	95	21	SE	NWSE
45	95	21	NW	All
45	95	21	SW	All
45	95	24	NW	NENW
45	95	24	NW	NWNW
45	95	24	NW	SENW
45	95	24	SE	NESE
45	95	24	SE	NWSE
45	95	24	NE	All
45	95	30	SW	NESW
45	95	30	SW	NWSW
45	95	30	NW	All
45	96	1	All	All
45	96	2	All	All
45	96	3	All	All
45	96	4	All	All
45	96	5	All	All
45	96	6	All	All
45	96	7	All	All
45	96	8	All	All
45	96	9	All	All
45	96	10	All	All
45	96	11	All	All
45	96	12	All	All
45	96	13	All	All
45	96	14	All	All
45	96	15	All	All
45	96	16	All	All
45	96	17	All	All
45	96	18	All	All
45	96	19	All	All
45	96	20	All	All
45	96	21	SE	NESE
45	96	21	SE	NWSE
45	96	21	SE	SWSE
45	96	21	NE	All
45	96	21	NW	All
45	96	21	SW	All
45	96	22	SE	NESE
45	96	22	SE	NWSE
45	96	22	SW	NESW
45	96	22	SW	NWSW
45	96	22	NE	All
45	96	22	NW	All
45	96	23	SW	NESW
45	96	23	SW	NWSW

Township	Range	Section	Quarter Section	Quarter Quarter Section
45	96	23	SW	SESW
45	96	23	NE	All
45	96	23	NW	All
45	96	23	SE	All
45	96	24	All	All
45	96	25	NW	NENW
45	96	25	NW	NWNW
45	96	25	NE	All
45	96	28	SW	NESW
45	96	28	SW	NWSW
45	96	28	NE	All
45	96	28	NW	All
45	96	29	SE	NESE
45	96	29	SE	NWSE
45	96	29	SW	NESW
45	96	29	SW	NWSW
45	96	29	NE	All
45	96	29	NW	All
45	96	30	All	All
45	96	31	NE	NENE
45	96	31	NE	NWNE
45	96	31	NE	SWNE
45	96	31	SW	NESW
45	96	31	SW	NWSW
45	96	31	SW	SWSW
45	96	31	NW	All
45	97	All	All	All
45	98	All	All	All
45	99	All	All	All
45	100	1	All	All
45	100	2	All	All
45	100	3	NW	NENW
45	100	3	NW	SENW
45	100	3	NW	SWNW
45	100	3	NE	All
45	100	3	SE	All
45	100	3	SW	All
45	100	4	NE	SENE
45	100	4	NE	SWNE
45	100	4	NW	SENW
45	100	4	NW	SWNW
45	100	4	SE	All
45	100	4	SW	All
45	100	5	NE	SENE
45	100	5	NE	SWNE
45	100	5	NW	SENW
45	100	5	NW	SWNW
45	100	5	SE	All
45	100	5	SW	All
45	100	6	NE	SENE
45	100	6	NE	SWNE
45	100	6	NW	SENW
45	100	6	SE	All
45	100	6	SW	All
45	100	7	All	All
45	100	8	All	All
45	100	9	All	All
45	100	10	All	All
45	100	11	All	All
45	100	12	All	All
45	100	13	All	All
45	100	14	All	All
45	100	15	All	All
45	100	16	All	All
45	100	17	All	All
45	100	18	All	All
45	100	19	All	All
45	100	20	All	All
45	100	21	All	All
45	100	22	All	All
45	100	23	All	All
45	100	24	All	All
45	100	25	All	All
45	100	26	All	All
45	100	27	All	All
45	100	28	All	All
45	100	29	All	All
45	100	30	All	All
45	100	31	All	All
45	100	32	All	All
45	100	33	All	All
45	100	34	All	All
45	100	35	All	All
45	100	36	All	All
45	101	1	NE	SENE
45	101	1	NE	SWNE
45	101	1	NW	SENW
45	101	1	NW	SWNW
45	101	1	SE	All
45	101	1	SW	All
45	101	2	NE	SENE
45	101	2	NE	SWNE
45	101	2	NW	SENW
45	101	2	NW	SWNW
45	101	2	SE	All
45	101	2	SW	All

Township	Range	Section	Quarter Section	Quarter Quarter Section
45	101	3	NE	SENE
45	101	3	NE	SWNE
45	101	3	NW	SENW
45	101	3	SW	NESW
45	101	3	SW	SESW
45	101	3	SW	SWSW
45	101	3	SE	All
45	101	4	SE	SESE
45	101	8	NE	SENE
45	101	8	NE	SWNE
45	101	8	NW	SENW
45	101	8	SW	NESW
45	101	8	SW	SESW
45	101	8	SE	All
45	101	9	NW	SENW
45	101	9	NW	SWNW
45	101	9	NE	All
45	101	9	SE	All
45	101	9	SW	All
45	101	10	All	All
45	101	11	All	All
45	101	12	All	All
45	101	13	All	All
45	101	14	All	All
45	101	15	All	All
45	101	16	All	All
45	101	17	NW	NENW
45	101	17	NW	SENW
45	101	17	NE	All
45	101	17	SE	All
45	101	17	SW	All
45	101	18	SE	SESE
45	101	19	NE	NENE
45	101	19	NE	SENE
45	101	19	NE	SWNE
45	101	19	NW	SENW
45	101	19	SE	All
45	101	19	SW	All
45	101	20	All	All
45	101	21	All	All
45	101	22	All	All
45	101	23	All	All
45	101	24	All	All
45	101	25	All	All
45	101	26	All	All
45	101	27	All	All
45	101	28	All	All
45	101	29	All	All
45	101	30	All	All
45	101	31	All	All
45	101	32	All	All
45	101	33	All	All
45	101	34	All	All
45	101	35	All	All
45	101	36		
45	101	36	SE	SESE
45	101	36	SE	SWSE
45	101	36	SW	SESW
45	101	36	SW	SWSW
45	102	23	SE	NESE
45	102	23	SE	SESE
45	102	23	SE	SWSE
45	102	24	NE	SENE
45	102	24	NE	SWNE
45	102	24	SE	All
45	102	24	SW	All
45	102	25	All	All
45	102	26	NW	NENW
45	102	26	NW	SENW
45	102	26	NW	SWNW
45	102	26	NE	All
45	102	26	SE	All
45	102	26	SW	All
45	102	34	NE	SENE
45	102	34	SE	NESE
45	102	34	SE	SESE
45	102	35	All	All
45	102	36	All	All
46	94	30	SW	NWSW
46	94	30	SW	SESW
46	94	30	SW	SWSW
46	94	31	NE	NWNE
46	94	31	NE	SENE
46	94	31	NE	SWNE
46	94	31	NW	All
46	94	31	SE	All
46	94	31	SW	All
46	94	32	NW	SWNW
46	94	32	SW	NWSW
46	94	32	SW	SWSW
46	95	19	NE	SWNE
46	95	19	NW	NWNW
46	95	19	NW	SENW
46	95	19	NW	SWNW
46	95	19	SE	All
46	95	19	SW	All

Township	Range	Section	Quarter Section	Quarter Quarter Section
46	95	20	NE	SENE
46	95	20	NE	SWNE
46	95	20	NW	SENW
46	95	20	SE	All
46	95	20	SW	All
46	95	21	NW	SENW
46	95	21	NW	SWNW
46	95	21	SE	SESE
46	95	21	SE	SWSE
46	95	21	SW	All
46	95	22	SW	SESW
46	95	22	SW	SWSW
46	95	25	SE	All
46	95	25	SW	All
46	95	26	NE	NWNE
46	95	26	NE	SENE
46	95	26	NE	SWNE
46	95	26	NW	All
46	95	26	SE	All
46	95	26	SW	All
46	95	27	NE	NWNE
46	95	27	NE	SENE
46	95	27	NE	SWNE
46	95	27	NW	All
46	95	27	SE	All
46	95	27	SW	All
46	95	28	All	All
46	95	29	All	All
46	95	30	All	All
46	95	31	All	All
46	95	32	All	All
46	95	33	All	All
46	95	34	All	All
46	95	35	All	All
46	95	36	All	All
46	96	13	SE	SESE
46	96	13	SE	SWSE
46	96	13	SW	NWSW
46	96	13	SW	SESW
46	96	13	SW	SWSW
46	96	14	SE	All
46	96	14	SW	All
46	96	15	NE	SENE
46	96	15	NE	SWNE
46	96	15	NW	SENW
46	96	15	NW	SWNW
46	96	15	SE	All
46	96	15	SW	All
46	96	16	SE	NESE
46	96	16	SE	SESE
46	96	16	SE	SWSE
46	96	16	SW	SESW
46	96	16	SW	SWSW
46	96	17	SE	SESE
46	96	19	SE	SESE
46	96	19	SE	SWSE
46	96	19	SW	NWSW
46	96	19	SW	SESW
46	96	19	SW	SWSW
46	96	20	NE	NENE
46	96	20	SW	SESW
46	96	20	SW	SWSW
46	96	21	All	All
46	96	22	All	All
46	96	23	All	All
46	96	24	All	All
46	96	25	All	All
46	96	26	All	All
46	96	27	All	All
46	96	28	All	All
46	96	29	All	All
46	96	30	All	All
46	96	31	All	All
46	96	32	All	All
46	96	33	All	All
46	96	34	All	All
46	96	35	All	All
46	96	36	All	All
46	97	14	SE	SWSE
46	97	14	SW	All
46	97	15	SW	SESW
46	97	15	SW	SWSW
46	97	15	SE	All
46	97	16	SE	SESE
46	97	16	SE	SWSE
46	97	16	SW	SESW
46	97	16	SW	SWSW
46	97	17	SE	All
46	97	17	SW	All
46	97	18	SE	All
46	97	18	SW	All
46	97	19	All	All
46	97	20	All	All
46	97	21	All	All
46	97	22	All	All
46	97	23	All	All

Township	Range	Section	Quarter Section	Quarter Quarter Section
46	97	24	All	All
46	97	25	All	All
46	97	26	All	All
46	97	27	All	All
46	97	28	All	All
46	97	29	All	All
46	97	30	All	All
46	97	31	All	All
46	97	32	All	All
46	97	33	All	All
46	97	34	All	All
46	97	35	All	All
46	97	36	All	All
46	98	5	NW	SENW
46	98	5	NW	SWNW
46	98	5	SE	SWSE
46	98	5	SW	All
46	98	6	All	All
46	98	7	All	All
46	98	8	NE	NWNE
46	98	8	NE	SWNE
46	98	8	NW	All
46	98	8	SE	All
46	98	8	SW	All
46	98	9	SE	SESE
46	98	9	SE	SWSE
46	98	9	SW	SESW
46	98	9	SW	SWSW
46	98	10	SE	SESE
46	98	10	SE	SWSE
46	98	10	SW	SESW
46	98	10	SW	SWSW
46	98	11	SW	SESW
46	98	11	SW	SWSW
46	98	13	SE	All
46	98	13	SW	All
46	98	14	NE	SWNE
46	98	14	NW	All
46	98	14	SE	All
46	98	14	SW	All
46	98	15	All	All
46	98	16	All	All
46	98	17	All	All
46	98	18	All	All
46	98	19		
46	98	19	SW	SWSW
46	98	20		
46	98	20	NW	SENW
46	98	20	NE	All
46	98	21		
46	98	21	SW	NESW
46	98	21	NE	All
46	98	21	NW	All
46	98	21	SE	All
46	98	22	All	All
46	98	23	All	All
46	98	24	All	All
46	98	25	All	All
46	98	26	All	All
46	98	27	All	All
46	98	28		
46	98	29		
46	98	29	SW	NWSW
46	98	29	SW	SWSW
46	98	30		
46	98	30	NE	SENE
46	98	30	NE	SWNE
46	98	30	NW	All
46	98	30	SE	All
46	98	30	SW	All
46	98	31	All	All
46	98	32	All	All
46	98	33	All	All
46	98	34	All	All
46	98	35	All	All
46	98	36	All	All
46	99	1	All	All
46	99	2	All	All
46	99	3	All	All
46	99	4	All	All
46	99	5	NE	NENE
46	99	5	NE	SENE
46	99	5	NE	SWNE
46	99	5	SW	NESW
46	99	5	SW	SESW
46	99	5	SW	SWSW
46	99	5	SE	All
46	99	7	NE	SENE
46	99	7	SW	SESW
46	99	7	SE	All
46	99	8	All	All
46	99	9	All	All
46	99	10	All	All
46	99	11	All	All
46	99	12	All	All
46	99	13	All	All

Township	Range	Section	Quarter Section	Quarter Quarter Section
46	99	14	All	All
46	99	15	All	All
46	99	16	All	All
46	99	17	All	All
46	99	18	All	All
46	99	19	All	All
46	99	20	All	All
46	99	21	All	All
46	99	22	All	All
46	99	23	All	All
46	99	24	All	All
46	99	25	All	All
46	99	26	All	All
46	99	27	All	All
46	99	28	All	All
46	99	29	All	All
46	99	30	All	All
46	99	31	All	All
46	99	32	All	All
46	99	33	All	All
46	99	34	All	All
46	99	35	All	All
46	99	36	All	All
46	100	13	NE	NENE
46	100	13	NE	SENE
46	100	13	NE	SWNE
46	100	13	NW	SENW
46	100	13	SE	All
46	100	13	SW	All
46	100	14	SE	SESE
46	100	14	SE	SWSE
46	100	22	SE	SESE
46	100	23	NE	All
46	100	23	SE	All
46	100	23	SW	All
46	100	24	All	All
46	100	25	All	All
46	100	26	SE	NESE
46	100	26	SE	NWSE
46	100	26	SW	NESW
46	100	26	SW	NWSW
46	100	26	NE	All
46	100	26	NW	All
46	100	27	NE	NENE
46	100	27	NE	SENE
46	100	27	SE	NESE
46	100	35	NE	SENE
46	100	35	SE	All
46	100	36	All	All
47	98	31	SE	SESE
47	98	31	SE	SWSE
47	99	32	SE	SESE
47	99	33	SE	SESE
47	99	33	SE	SWSE
47	99	33	SW	SESW
47	99	33	SW	SWSW
47	99	34	SE	SESE
47	99	34	SE	SWSE
47	99	34	SW	SESW
47	99	34	SW	SWSW
47	99	35	SE	SESE
47	99	35	SE	SWSE
47	99	35	SW	SESW
47	99	35	SW	SWSW
47	99	36	SW	SESW
47	99	36	SW	SWSW

Appendix B

Ecological Site Description

United States Department of Agriculture
Natural Resources Conservation Service

Ecological Site Description

Site Type: Rangeland

Site Name: Loamy (Ly) 5-9" Big Horn Basin Precipitation Zone,

Site ID: 032XY122WY

Major Land Resource Area: 32 – Northern Intermountain Desertic Basins

Physiographic Features

This site occurs on near level to gently undulating rolling land and on slope generally less than 20%.

Landform: Hillsides, alluvial fans, ridges & stream terraces **Aspect:** N/A

	Minimum	Maximum
Elevation (feet):	3700	6000
Slope (percent):	0	20
Water Table Depth (inches):	None within 60 inches	
Flooding:		
Frequency:	None	None
Duration:	None	None
Ponding:		
Depth (inches):	0	0
Frequency:	None	None
Duration:	None	None
Runoff Class:	negligible	high

Climatic Features

Annual precipitation ranges from 5-9 inches per year. The normal precipitation pattern shows peaks in May and June and a secondary peak in September. This amounts to about 50% of the mean annual precipitation. Much of the moisture that falls in the latter part of the summer is lost by evaporation and much of the moisture that falls during the winter is lost by sublimation. Average snowfall is about 20 inches annually. Wide fluctuations may occur in yearly precipitation and result in more dry years than those with more than normal precipitation.

Temperatures show a wide range between summer and winter and between daily maximums and minimums, due to the high elevation and dry air, which permits rapid incoming and outgoing radiation. Cold air outbreaks from Canada in winter move rapidly from northwest to southeast and account for extreme minimum temperatures. Chinook winds may occur in winter and bring rapid rises in temperature. Extreme storms may occur during the winter, but most severely affect ranch operations during late winter and spring.

High winds are generally blocked from the basin by high mountains, but can occur in conjunction with an occasional thunderstorm.

Growth of native cool-season plants begins about April 1 and continues to about July 1. Cool weather and moisture in September may produce some green up of cool season plants that will continue to late October.

The following information is from the “Emblem” climate station:

	Minimum	Maximum	5 yrs. out of 10 between
Frost-free period (days):	98	171	May 13 – September 19
Freeze-free period (days):	120	184	May 1 – October 5
Mean Annual Precipitation (inches):	3.22	10.97	

Mean annual precipitation: 7.42 inches
Mean annual air temperature: 45.01°F (31.2°F Avg. Min. to 58.7°F Avg. Max.)
For detailed information visit the Natural Resources Conservation Service National Water and Climate Center at http://www.wcc.nrcs.usda.gov/ website. Other climate station(s) representative of this precipitation zone include” Basin”, “Deaver”, “Lovell”, and “Worland”.

Influencing Water Features

Wetland Description:	System	Subsystem	Class	Sub-class
None	None	None	None	None

Stream Type: None

Representative Soil Features

The soils of this site are very deep to moderately deep (greater than 20" to bedrock), moderately well to well-drained & moderately slow to moderate permeable. The soil characteristic having the most influence on plant community is the available moisture and the potential to develop soluble salts near the surface.

Major Soil Series correlated to this site include: Lostwells, Rairdent, Emblem, Fruita, Neiber, Garland, Bowbac, Sharland, and Kinnear.

Other Soil Series correlated to this site in MLRA 32 include:

Parent Material Kind: alluvium and residuum
Parent Material Origin: sandstone, shale
Surface Texture: loam, fine sandy loam, sandy loam
Surface Texture Modifier: none is most common but gravelly may occur
Subsurface Texture Group: loam, sandy clay loam, clay loam, silty clay, sandy loam
Surface Fragments ≤ 3” (% Cover): 0, occasionally up to10
Surface Fragments > 3” (%Cover): 0
Subsurface Fragments ≤ 3” (% Volume): typically 0, occasionally up to 15
Subsurface Fragments > 3” (% Volume): typically 0, occasionally up to 10

	Minimum	Maximum
Drainage Class:	moderately well drained	well drained
Permeability Class:	moderately slow	moderate
Depth (inches):	20	>60
Electrical Conductivity (mmhos/cm) ≤20”:	0	8
Sodium Absorption Ratio ≤20”:	0	13

Soil Reaction (1:1 Water) ≤20":	7.4	9.0
Soil Reaction (0.1M CaCl2) ≤20":	NA	NA
Available Water Capacity (inches) ≤30":	3.0	6.3
Calcium Carbonate Equivalent (percent) ≤20":	0	20

Plant Communities

Ecological Dynamics of the Site:

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

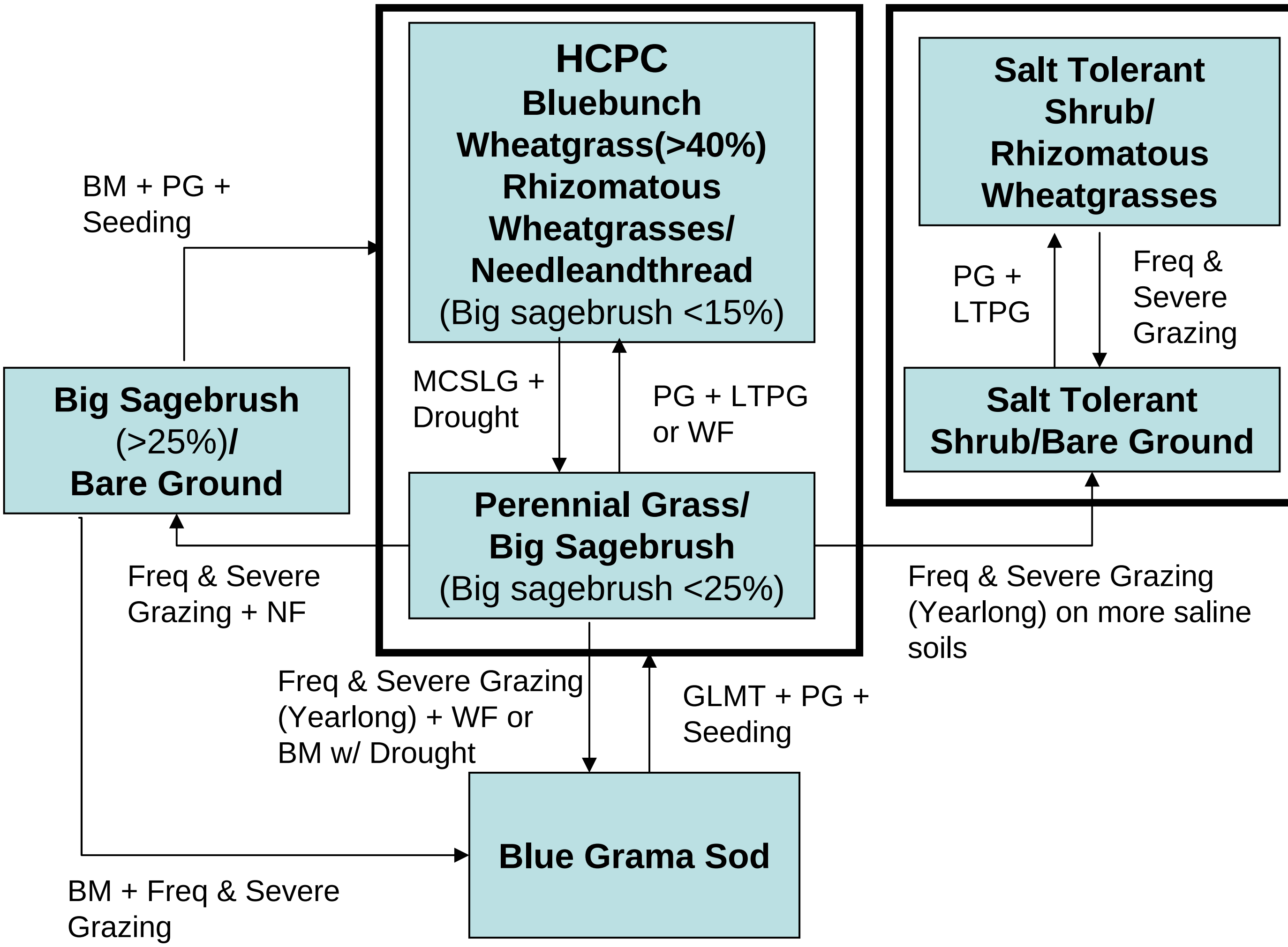
As this site deteriorates species such as blue grama, Sandberg bluegrass, and big sagebrush will increase. Plains pricklypear and weedy annuals will invade. Cool-season grasses such as, bluebunch wheatgrass, rhizomatous wheatgrasses, needleandthread, and Indian ricegrass will decrease in frequency and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

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

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

The Historic Climax Plant Community (description follows the plant community diagram) has been determined by study of rangeland relic areas, or areas protected from excessive disturbance. Trends in plant communities going from heavily grazed areas to lightly grazed areas, seasonal use pastures, and historical accounts have also been used.

The following is a State and Transition Model Diagram that illustrates the common plant communities (states) that can occur on the site and the transitions between these communities. The ecological processes will be discussed in more detail in the plant community narratives following the diagram.



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

Plant Community Composition and Group Annual Production
Reference Plant Community (HCPC)

COMMON NAME/GROUP NAME	SCIENTIFIC NAME	SYMBOL	Annual Production (Normal Year) Total: 400		
			Group	lbs./acre	% Comp.
GRASSES AND GRASS-LIKES					
GRASSES/GRASSLIKES					
Bluebunch wheatgrass	Pseudoroegneria spicata	PSSP6	1	120 - 200	30 - 50
Rhizomatous wheatgrasses			2	40 - 80	10 - 20
Western wheatgrass	Pascopyrum smithii	PASM			
Thickspike wheatgrass	Elymus lanceolatus ssp. lanceolatus	ELLAL			
Streambank wheatgrass	Elymus lanceolatus	ELLA3			
Needleandthread grass	Hesperostipa comata	HEC026	3	40 - 80	10 - 20
Indian ricegrass	Achnatherum hymenoides	ACHY	4	40 - 80	10 - 20
MISC. GRASSES/GRASSLIKES			**5**	0 - 40	**0 - 10**
Blue grama	Bouteloua gracilis	BOGR2	5	0 - 20	0 - 5
Bottlebrush squirreltail	Elymus elymoides	ELELE	5	0 - 20	0 - 5
Prairie junegrass	Koeleria macrantha	KOMA	5	0 - 20	0 - 5
Sandberg bluegrass	Poa secunda	POSE	5	0 - 20	0 - 5
Threadleaf sedge	Carex filifolia	CAFI	5	0 - 20	0 - 5
other perennial grasses (native)		2GP	5	0 - 20	0 - 5
FORBS			**6**	**0 - 60**	**0 - 15**
False carrot	Turgenia spp.	TURGE	6	0 - 20	0 - 5
Fleabane	Erigeron spp.	ERIGE2	6	0 - 20	0 - 5
Larkspur	Delphinium spp.	DELPH	6	0 - 20	0 - 5
Paintbrush	Castilleja spp.	CAST	6	0 - 20	0 - 5
Phlox	Phlox spp.	PHLOX	6	0 - 20	0 - 5
Scarlet globemallow	Sphaeralcea coccinea	SPCO	6	0 - 20	0 - 5
Wild onion	Allium textile	ALTE	6	0 - 20	0 - 5
other perennial forbs (native)		2FP	6	0 - 20	0 - 5
TREES/SHRUBS					
Big sagebrush	Artemisia tridentata	ARTR2	7	20 - 60	5 - 15
Rabbitbrush	Chrysothamnus spp.	CHRYS9	8	0 - 20	0 - 5
Winterfat	Krascheninnikovia lanata	KRAL2	9	0 - 20	0 - 5
other shrubs & half shrubs (native)		2SHRUB	10	0 - 20	0 - 5

This list of plants and their relative proportions are based on near normal years. Fluctuations in species composition and relative production may change from year to year dependent upon precipitation or other climatic factors.

Plant Community Narratives

Following are the narratives for each of the described plant communities. These plant communities may not represent every possibility, but they probably are the most prevalent and repeatable plant communities. The plant composition tables shown above have been developed from the best available knowledge at the time of this revision. As more data is collected, some of these plant communities may be revised or removed, and new ones may be added. None of these plant communities should necessarily be thought of as “Desired Plant Communities”. According to the USDA NRCS National Range and Pasture Handbook, Desired Plant Communities (DPC’s) will be determined by the decision-makers and will meet minimum quality criteria established by the NRCS. The main purpose for including any description of a plant community here is to capture the current knowledge and experience at the time of this revision.

Bluebunch Wheatgrass/Rhizomatous Wheatgrasses/Needleandthread Plant Community
This plant community is the interpretive plant community for this site and is considered to be the Historic Climax Plant Community (HCPC). This state evolved with grazing by large herbivores and periodic fires. The cyclical nature of the fire regime in this community prevented big sagebrush from being the dominant landscape. This plant community can be found on areas that are properly managed with grazing and/or prescribed burning, and on areas receiving occasional short periods of rest. The potential vegetation is about 75% grasses or grass-like plants, 10% forbs, and 15% woody plants. This state is dominated by cool season mid-grasses.

The major grasses include bluebunch wheatgrass, western wheatgrass, needleandthread, and Indian ricegrass. Other grasses occurring in this state include thickspike wheatgrass, and bottlebrush squirreltail. A variety of forbs and half-shrubs also occur, as shown in the preceding table. Big sagebrush is a conspicuous element of this state, occurs in a mosaic pattern, and makes up 5 to 15% of the annual production. Winterfat is a common component found on this site.

The total annual production (air-dry weight) of this state is about 400 lbs/acre, but it can range from about 225 lbs./acre in unfavorable years to about 600 lbs./acre in above average years.

The following is the growth curve of this plant community expected during a normal year:
Growth curve number: WY0501
Growth curve name: 5-9BH, UPLAND SITES
Growth curve description: ALL UPLAND SITES

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	15	50	20	5	0	10	0	0	0

(Monthly percentages of total annual growth)

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

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

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

Perennial Grass/Big Sagebrush Plant Community
Historically, this plant community evolved under grazing by large ungulates and a low fire frequency. Currently, it is found under moderate, season-long grazing by livestock and will be exacerbated by prolonged drought conditions. In addition, the fire regime for this site has been modified and

extended periods without fire is now common. This plant community is still dominated by cool-season grasses, while short warm-season grasses and miscellaneous forbs account for the balance of the understory. Wyoming big sagebrush is now a conspicuous part of the overall production and accounts for the majority of the overstory.

Dominant grasses include western wheatgrass, and needleandthread. Grasses and grass-like species of secondary importance include blue grama, Sandberg bluegrass and threadleaf sedge. Forbs commonly found in this plant community include scarlet globemallow, fringed sagewort, hairy goldaster, and phlox. Sagebrush can make up to 25% of the annual production. The overstory of sagebrush and understory of grass and forbs provide a diverse plant community.

When compared to the Historic Climax Plant Community, big sagebrush and blue grama have increased. Plains pricklypear cactus will also have increased, but occurs only in small patches. Indian ricegrass and bluebunch wheatgrass have decreased and may occur in only trace amounts under the sagebrush canopy or within the patches of pricklypear. In addition, the amount of winterfat may or may not have changed depending on the season of use.

The total annual production (air-dry weight) of this state is about 320 pounds per acre, but it can range from about 180 lbs/acre in unfavorable years to about 480 lbs. /acre in above average years.

The following is the growth curve of this plant community expected during a normal year:
Growth curve number: WY0501
Growth curve name: 5-9BH, UPLAND SITES
Growth curve description: ALL UPLAND SITES

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	15	50	20	5	0	10	0	0	0

(Monthly percentages of total annual growth)

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

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

- Prescribed grazing or possibly long-term prescribed grazing, will convert this plant community to the *HCPC*. The probability of this occurring is high especially if rotational grazing along with short deferred grazing is implemented as part of the prescribed method of use. In addition, the removal of fire suppression will allow a somewhat natural fire regime to reoccur to more easily transition between this plant community and the HCPC. A prescribed fire treatment can be useful to hasten this transition, if desired.

- Frequent and severe grazing plus no fire will convert the plant community to the Big *Sagebrush/Bare Ground Plant Community*. The probability of this occurring is high. This is especially evident on areas with historically higher precipitation and the sagebrush stand is not adversely impacted by drought or heavy browsing.

- Frequent and severe grazing (yearlong grazing) plus wildfire or brush control, will convert the plant community to the *Blue Grama Sod Plant Community.* The probability of this occurring is high, especially if the sagebrush stand has been severely affected by drought or heavy use or has been removed altogether.

- Frequent and severe grazing (yearlong grazing) on more saline soils, will convert the plant community to the *Salt Tolerant Shrub/Bare Ground.* The probability of this occurring is high especially on soils with elevated salts and the sagebrush stand has been severely affected by drought and heavy use or has been removed altogether.

Big Sagebrush/Bare Ground Community
This plant community is the result of frequent and severe grazing and protection from fire. Sagebrush dominates this plant community, as the annual production of sagebrush exceeds 25%. Wyoming big sagebrush is a significant component of the plant community and the preferred cool season grasses have been eliminated or greatly reduced.

The dominant grasses are Sandberg bluegrass and blue grama. Weedy annual species such as cheatgrass may occupy the site if a seed source is available. Cactus and sageworts often increase. Noxious weeds such as Russian knapweed, leafy spurge, or Canada thistle may invade the site if a seed source is available. The interspaces between plants have expanded leaving the amount of bare ground more prevalent. As compared with the HCPC or the Perennial Grass/Big Sagebrush Plant Communities, the annual production is similar, as the shrub production compensates for the decline in the herbaceous production.

The total annual production (air-dry weight) of this state is about 300 pounds per acre, but it can range from about 200 lbs/acre in unfavorable years to about 400 lbs. /acre in above average years.

The following is the growth curve of the plant community expected during a normal year:
Growth curve number: WY0501
Growth curve name: 5-9BH, UPLAND SITES
Growth curve description: ALL UPLAND SITES

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	15	50	20	5	0	10	0	0	0

(Monthly percentages of total annual growth)

This plant community is resistant to change as the stand becomes more decadent. These areas may actually be more resistant to fire as less fine fuels are available and the bare ground between the sagebrush plants is increased. Continued frequent and severe grazing or the removal of grazing does not seem to affect the composition or structure of the plant community. Plant diversity is moderate to poor. The plant vigor is diminished and replacement capabilities are limited due to the reduced number of cool-season grasses. Plant litter is noticeably less when compared to the HCPC.

Soil erosion is accelerated because of increased bare ground. Water flow patterns and pedestalling are obvious. Infiltration is reduced and runoff is increased. Rill channels may be noticeable in the interspaces and gullies may be establishing where rills have concentrated down slope.

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

- Brush management, followed by prescribed grazing, will return this plant community at or near the HCPC. If prescribed fire is used as a means to reduce or remove the shrubs, sufficient fine fuels will need to be present. This may require deferment from grazing prior to treatment. Post management is critical to ensure success. This can range from two or more years of rest to partial growing season deferment, depending on the condition of the understory at the time of treatment and the growing conditions following treatment. In the case of an intense wildfire that occurs when desirable plants are not completely dormant, the length of time required to reach the *HCPC* may be increased and seeding of natives is recommended.

- Brush management, followed by frequent and severe grazing, will convert the plant community to the *Blue Grama Sod Plant Community*.

Blue Grama Sod Plant Community
This plant community is the result of frequent and severe yearlong grazing, which has adversely affected the perennial grasses as well as the addition of other impacts that can affect the shrub component. These factors include drought and wildfires, and human brush control measures. A dense sod of blue grama with patches of threadleaf sedge dominates this state. Pricklypear cactus can become dense enough in patches so that livestock cannot graze forage growing within the cactus clumps. Big sagebrush has been reduced to small patches or in some cases removed.

When compared to the Historic Climax Plant Community, blue grama, threadleaf sedge, and pricklypear have increased. All cool-season mid-grasses, forbs, and most shrubs have been greatly reduced. Production has been significantly decreased.

The total annual production (air-dry weight) of this state is about 100 pounds per acre, but it can range from about 55 lbs/acre in unfavorable years to about 150 lbs. /acre in above average years.

The following is the growth curve of this plant community expected during a normal year:
Growth curve number: WY0501
Growth curve name: 5-9BH, UPLAND SITES
Growth curve description: ALL UPLAND SITES

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	15	50	20	5	0	10	0	0	0

(Monthly percentages of total annual growth)

This sod is extremely resistant to change and continued frequent and severe grazing or the removal of grazing does not seem to affect the plant composition or structure of the plant community. The biotic integrity of this state is not functional and plant diversity is extremely low. The plant vigor is significantly weakened and replacement capabilities are limited due to the reduced number of cool-season grasses.

This sod bound plant community is very resistant to water infiltration. While this sod protects the site itself, off-site areas are affected by excessive runoff that can cause rills and gully erosion. Water flow patterns are obvious in the bare ground areas and pedestalling is apparent along the sod edges. Rill channels are noticeable in the interspaces and down slope. The watershed may or may not be functioning, as runoff may affect adjoining sites.

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

- Grazing land mechanical treatment (chiseling, etc.) and pricklypear cactus control (if needed), followed by prescribed grazing, will return this plant community to near *Historic Climax Plant Community* condition.

Salt Tolerant Shrub/Bare Ground Plant Community
This plant community can occur where states are subjected to continuous yearlong grazing and where soils are influenced by elevated amounts of soluble salts. Salt tolerant shrubs are a significant component of the plant community and the preferred cool season grasses have been eliminated or greatly reduced. Wyoming big sagebrush is still a component of the plant community but may not be the primary overstory species.

This state is dominated by an overstory of shrubs, which can vary widely in composition and production. This variation results from the dissimilarity in quantity of soluble salts present in the soils and the availability of shrubs to occupy the site. The dominant shrubs are greasewood, big sagebrush, rubber rabbitbrush, and a number of different saltbushes.

Perennial cool season mid-grasses have been reduced or removed, leaving mostly patches of blue grama and annuals. Cheatgrass and weedy annual forbs such as halogeton, Russian thistle, and kochia, will occupy the site if a seed source is available. Noxious weeds such as Russian knapweed may also invade this site.

The interspaces between plants have expanded leaving the amount of bare ground more prevalent. Surface salts have increased, especially on sites dominated by greasewood and saltbushes. The leaves of these plants contain high amounts of sodium and other salts, and when shed these soluble salts are transferred to the soils underneath the plants. Consequently, the soil can exhibit wide variations in soluble salts, which can explain the variation in shrub composition.

The total annual production (air-dry weight) of this state is about 225 pounds per acre, but it can range from about 125 lbs/acre in unfavorable years to about 350 lbs. /acre in above average years.

The following is the growth curve of this plant community expected during a normal year:
Growth curve number: WY0501
Growth curve name: 5-9BH, UPLAND SITES
Growth curve description: ALL UPLAND SITES

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	15	50	20	5	0	10	0	0	0

(Monthly percentages of total annual growth)

This plant community is resistant to change. These areas are actually more resistant to fire as less fine fuels are available and the bare ground between the shrubs has increased. Continued frequent and severe grazing does not affect the composition or structure of the plant community. Plant diversity is moderate to poor. The biotic integrity of this state is mostly dysfunctional because of the predominant salt tolerant shrub overstory and absence of perennial cool-season grasses.

Soil erosion is accelerated because of increased bare ground. Water flow patterns and pedestalling are obvious. Infiltration is reduced and runoff is increased. Rill channels may be noticeable in the interspaces and gullies may be establishing where rills have concentrated down slope.

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

- <u>Prescribed grazing or possibly long-term prescribed grazing</u>, will convert this plant community to the *Salt Tolerant Shrub/Rhizomatous Wheatgrass Vegetative State*. Recovery to near *Historic Climax Plant Community* condition is difficult to impossible due to the resistance of these shrubs to herbicides and other brush management techniques. In addition, the increase in surface salts has had accumulated effects on the soil so most of the herbaceous plants associated with the HCPC are no longer suitable for this site. The most notable exceptions are rhizomatous wheatgrasses and bottlebrush squirreltail. Soil remediation to reduce the surface salts is not recommended, as this is mostly ineffective and extremely costly. Seeding more salt-tolerant native grasses and forbs will improve the productivity of the site and increase plant cover.

Salt Tolerant Shrub/Rhizomatous Wheatgrasses Plant Community
This plant community can occur where prescribed grazing management is implemented in the Salt Tolerant Shrub/Bare Ground Plant Community. Salt tolerant shrubs and Wyoming big sagebrush remain a significant component of the plant community but preferred cool season grasses have reestablished.

This site is dominated by an overstory of a variety of shrubs, such as Wyoming big sagebrush rubber rabbitbrush, greasewood, and a variety of saltbushes. Some perennial cool season mid-grasses have once again reestablished such as rhizomatous wheatgrasses and bottlebrush squirreltail. Other important grasses include Sandberg bluegrass and blue grama. Patches of annuals such as cheatgrass and other weedy annual forbs such as halogeton, Russian thistle, and kochia will persist on this site. Noxious weeds such as Russian knapweed may also remain if not treated. The interspaces between plants will have diminished in size. When compared with the HCPC or the Perennial Grass/Big Sagebrush Plant Communities, the annual production is similar, but the plant species are clearly unique.

The total annual production (air-dry weight) of this state is about 300 pounds per acre, but it can range from about 200 lbs/acre in unfavorable years to about 425 lbs. /acre in above average years.

The following is the growth curve of this plant community expected during a normal year:

Growth curve number: WY0501
Growth curve name: 5-9BH, UPLAND SITES
Growth curve description: ALL UPLAND SITES

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
0	0	0	15	50	20	5	0	10	0	0	0

(Monthly percentages of total annual growth)

This plant community is mostly resistant to change, but species composition can be altered through long-term overgrazing. The herbaceous component is stable, but does not include most climax species. Plant vigor and replacement capabilities are sufficient. The biotic community is not intact because of the predominant salt tolerant shrub overstory and lack of climax grass species. Plant diversity is moderate.

Soils are mostly stable and recent soil loss is minimal. This should not be confused with evidence of remnant erosion. Water flow patterns and litter movement is stable but is still occurring on steeper slopes. Incidence of pedestalling is improving. The watershed may or may not be functioning.

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

- Frequent and severe grazing will convert the plant community to the *Salt Tolerant Shrub/Bare Ground Plant Community*.
- Recovery to near *Historic Climax Plant Community* condition is difficult to impossible due to the resistance of these shrubs to herbicides and other brush management techniques. In addition, the increase in surface salts has had accumulated effects on the soil so most of the herbaceous plants associated with the HCPC are no longer suitable for this site. The most

notable exceptions are rhizomatous wheatgrasses and bottlebrush squirreltail. Soil remediation to reduce the surface salts is not recommended, as this is mostly ineffective and extremely costly. Seeding more salt-tolerant grasses and forbs will improve the productivity of the site and plant cover, but will not improve the biotic integrity.

Ecological Site Interpretations

Animal Community – Wildlife Interpretations

Bluebunch Wheatgrass/Rhizomatous Wheatgrasses/Needleandthread (HCPC): The predominance of grasses in this plant community favors grazers and mixed-feeders, such as bison, elk, and antelope. Suitable thermal and escape cover for deer may be limited due to the low quantities of woody plants. However, topographical variations could provide some escape cover. When found adjacent to sagebrush dominated states, this plant community may provide brood rearing/foraging areas for sage grouse, as well as lek sites. Other birds that would frequent this plant community include western meadowlarks, horned larks, and golden eagles. Many grassland obligate small mammals would occur here.

Perennial Grass/Big Sagebrush Plant Community: The combination of an overstory of sagebrush and an understory of grasses and forbs provide a very diverse plant community for wildlife. The crowns of sagebrush tend to break up hard crusted snow on winter ranges, so mule deer and antelope may use this state for foraging and cover year-round, as would cottontail and jack rabbits. It provides important winter, nesting, brood-rearing, and foraging habitat for sage grouse. Brewer's sparrows nest in big sagebrush plants and hosts of other nesting birds utilize stands in the 20-30% cover range.

Big Sagebrush/Bare Ground Plant Community: This plant community can provide important winter foraging for elk, mule deer and antelope, as sagebrush can approach 15% protein and 40-60% digestibility during that time. This community provides excellent escape and thermal cover for large ungulates, as well as nesting habitat for sage grouse. However, it provides little foraging opportunities for upland game birds, as fewer forbs are available. Many grassland obligate small mammals would occur here.

Blue Grama Sod Plant Community: These communities provide limited foraging for antelope and other grazers. They may be used as a foraging site by sage grouse if proximal to woody cover and if the Historic Climax Plant Community or the Perennial Grass/Big Sagebrush/ Plant Community is limiting. Generally, these are not target plant communities for wildlife habitat management.

Salt Tolerant Shrub/Bare Ground Plant Community: This plant community exhibits a low level of plant species diversity due to the accumulation of salts near the soil surface. It does, however, provide thermal and escape cover for both large animals and upland birds. Upland game birds may find little foraging opportunities, as fewer forbs are available. Many grassland obligate small mammals would occur here.

Salt Tolerant Shrub/Rhizomatous Wheatgrasses Plant Community: This plant community can provide winter foraging for elk, mule deer and antelope. This community provides escape and thermal cover for large ungulates, as well as nesting habitat for upland game birds. However, it provides little foraging opportunities for upland game birds, as fewer forbs are available. Many grassland obligate small mammals would occur here.

Animal Preferences (Quarterly - 1,2,3,4) for commonly occuring plants in MLRA 32, 5-9 inch Bighorn Basin

COMMON NAME/ GROUP NAME	SCIENTIFIC NAME	SCIENTIFIC SYMBOL	*Cattle*	*Sheep*	*Horses*	*Deer*	Antelope
GRASSES/GRASSLIKES							
Alkali bluegrass	Poa juncifolia (syn. P. secunda)	POJU (POSE)	DDDD	PPPP	DDDD	PPPP	PPPP
Alkali cordgrass	Spartina gracilis	SPGR	DDDD	UUUU	DDDD	UUUU	UUUU
Alkali sacaton	Sporobolus airoides	SPAI	PPPP	DDDD	PPPP	DDDD	DDDD
Baltic rush	Juncus balticus	JUBA	DDDD	UUUU	DDDD	UUUU	UUUU
Basin wildrye	Leymus cinereus	LECI4	PPPP	PPPP	PPPP	DDDD	DDDD
Beaked sedge	Carex rostrata	CARO6	DDDD	UUUU	DDDD	UUUU	UUUU
Blue grama	Bouteloua gracilis	BOGR2	DDDD	DDDD	DDDD	DDDD	DDDD
Bluebunch wheatgrass	Pseudoroegneria spicata	PSSP6	PPPP	PPPP	PPPP	DDDD	DDDD
Bottlebrush squirreltail	Elymus elymoides	ELEL5	DDDD	DDDD	DDDD	UUUU	DDDD
Canada wildrye	Elymus canadensis	ELCA4	PPPP	PPPP	PPPP	DDDD	DDDD
Golden sedge	Carex aurea	CAAU3	DDDD	DDDD	DDDD	UUUU	UUUU
Indian ricegrass	Achnatherum hymenoides	ACHY	PPPP	PPPP	PPPP	PPPP	PPPP
Inland saltgrass	Distichlis spicata	DISP	UUUU	UUUU	UUUU	UUUU	UUUU
Inland sedge	Carex interior	CAIN11	DDDD	DDDD	DDDD	UUUU	UUUU
Nebraska sedge	Carex nebrascensis	CANE2	PPPP	PPPP	PPPP	DDDD	DDDD
Needleandthread	Hesperostipa comata	HECO26	PPPP	PPPP	PPPP	PPPP	PPPP
Nuttall's alkaligrass	Puccinellia nuttalliana	PUNU2	PPPP	PPPP	PPPP	PPPP	PPPP
Prairie junegrass	Koeleria macrantha	KOMA	DDDD	DDDD	DDDD	DDDD	DDDD
Prairie sandreed	Calamovilfa longifolia	CALO	PPPP	UUUU	PPPP	UUUU	UUUU
Red threeawn	Aristida purpurea	ARPUL	UUUU	UUUU	UUUU	UUUU	UUUU
Sand dropseed	Sporobolus cryptandrus	SPCR	DDDD	DDDD	DDDD	UUUU	UUUU
Sandberg bluegrass	Poa secunda	POSE	DDDD	DDDD	DDDD	DDDD	DDDD
Slender wheatgrass	Elymus trachycaulus	ELTR7	PPPP	DDDD	PPPP	DDDD	DDDD
Streambank wheatgrass	Elymus lanceolatus	ELLA3	DDDD	DDDD	DDDD	DDDD	DDDD
Thickspike wheatgrass	Elymus lanceolatus ssp. lanceolatus	ELLAL	DDDD	DDDD	DDDD	DDDD	DDDD
Threadleaf sedge	Carex filifolia	CAFI	DDDD	DDDD	DDDD	DDDD	DDDD
Threeawns	Aristida spp.	ARIST	UUUU	UUUU	UUUU	UUUU	UUUU
Tufted hairgrass	Deschampsia caespitosa	DECA18	PPPP	PPPP	PPPP	DDDD	DDDD
Upland sedge	Carex spp.	CAREX	DDDD	DDDD	DDDD	DDDD	DDDD
Water sedge	Carex aquatilis	CAAQ	DDDD	UUUU	DDDD	UUUU	UUUU
Western wheatgrass	Pascopyrum smithii	PASM	DDDD	DDDD	DDDD	DDDD	DDDD
FORBS							
Alkali seepweed	Suaeda spp.	AGOSE	UUUU	UUUU	UUUU	UUUU	UUUU
Arrowgrass	Triglochin spp.	TRIGL	TTTT	TTTT	TTTT	TTTT	TTTT
Asters	Eucephalus spp.	EUCEP2	UUUU	UUUU	UUUU	UUUU	UUUU
Biscuitroot	Lomatium spp.	LOMAT	DDDD	DDDD	UUUU	DDDD	DDDD
Blue-eyed grass	Sisyrinchium spp.	SISYR	UUUU	UUUU	UUUU	UUUU	UUUU
Buckwheats	Eripgonum spp.	ERIOG	UUUU	DDDD	UUUU	UUUU	UUUU
Dock	Rumex spp.	RUMEX	UUUU	UUUU	UUUU	UUUU	UUUU
Evening primrose	Oenothera caespitosa	OECA10	UUUU	UUUU	UUUU	UUUU	UUUU
False carrot	Turgenia spp.	TURGE	UUUU	DDDD	UUUU	UUUU	UUUU
Fleabanes	Erigeron spp.	ERIGE2	DDDD	DDDD	DDDD	DDDD	DDDD
Horsetails	Equisetum spp.	EQUIS	UUUU	UUUU	TTTT	UUUU	UUUU
Iris	Iris spp.	IRIS	UUUU	UUUU	UUUU	UUUU	UUUU
Larkspur (poisonous in spring before flowering)	Delphinium spp.	DELPH	DDDD	DDDD	DDDD	DDDD	DDDD
Milkvetch	Astragalus spp.	ASTRA	DDDD	DDDD	DDDD	DDDD	DDDD
Nailwort	Paronychia spp.	PARON	UUUU	UUUU	UUUU	UUUU	UUUU
Paintbrush	Castilleja spp.	CAST	DDDD	DDDD	DDDD	DDDD	DDDD
Penstemons	Penstemon spp.	PENST	PPPP	PPPP	PPPP	PPPP	PPPP
Phlox	Phlox spp.	PHLOX	UUUU	UUUU	UUUU	UUUU	UUUU
Princesplume	Stanleya spp.	STANL	TTTT	TTTT	TTTT	TTTT	TTTT
Pussytoes	Antennaria spp.	ANTEN	UUUU	UUUU	UUUU	UUUU	UUUU
Salsify	Tragopogon porrifolius	TRPO	UUUU	UUUU	UUUU	UUUU	UUUU
Scarlet globemallow	Sphaeralcea coccinea	SPCO	DDDD	DDDD	DDDD	DDDD	DDDD
Stemless hymenoxys	Tetraneuris acaulis	TEACA2	UUUU	UUUU	UUUU	UUUU	UUUU
Stonecrop	Sedum spp.	SEDUM	UUUU	UUUU	UUUU	UUUU	UUUU
Toadflax	Comandra umbellata	COUMP	UUUU	UUUU	UUUU	UUUU	UUUU
Wild onion	Allium textile	ALTE	DDDD	DDDD	DDDD	DDDD	DDDD
Woody aster	Xylorhiza spp.	XYLOR	TTTT	TTTT	TTTT	TTTT	TTTT
TREES, SHRUBS & HALF-SHRUBS							
Big sagebrush	Artemisia tridentata	ARTR2	DDDD	DDDD	UUUU	DDDD	DDDD
Birdfoot sagebrush	Artemisia pedatifida	ARPE6	UUUU	UUUU	UUUU	UUUU	UUUU
Black sagebrush	Artemesia nova	ARNO4	UUUU	PPPP	UUUU	PPPP	PPPP
Bud sagebrush	Picrothamnus desertorum	PIDE4	PPPP	PPPP	DDDD	PPPP	PPPP
Cottonwoods (sprouts)	Populus spp.	POPUL	PPPP	PPPP	PPPP	PPPP	UUUU
Fourwing saltbush	Atriplex canescens	ATCA2	PPPP	PPPP	PPPP	PPPP	PPPP
Gardners saltbush	Atriplex gardneri	ATGA	PPPP	PPPP	DDDD	PPPP	PPPP
Greasewood (toxic in large amounts)	Sarcobatus vermiculatus	SAVE4	DDDD	DDDD	UUUU	DDDD	DDDD
Junipers	Juniperus scopulorum	JUSC2	UUUU	UUUU	UUUU	DDDD	UUUU
Green rabbitbrush	Chrysothamnus viscidiflorus	CHVI8	DDDD	DDDD	UUUU	PPPP	PPPP
Rubber rabbitbrush	Ericameria nauseosa	ERNA10	UUUU	PPPP	UUUU	DDDD	PPPP
Shadscale	Atriplex confertifolia	ATCO	UUUU	UUUU	UUUU	UUUU	UUUU
Silver buffaloberry	Shepherdia argentea	SHAR	UUUU	UUUU	UUUU	UUUU	UUUU
Silver sagebrush	Artemisia cana	ARCA13	DDDD	DDDD	DDDD	PPPP	PPPP
Skunkbush sumac	Rhus trilobata	RHTR	DDDD	DDDD	UUUU	DDDD	DDDD
Spiny hopsage	Grayia spinosa	GRSP	UUUU	UUUU	UUUU	UUUU	UUUU
Wildrose	Rosa woodsii var. woodsii	ROWOW	DDDD	DDDD	UUUU	DDDD	DDDD
Willows	Salix spp.	SALIX	PPPP	PPPP	DDDD	PPPP	UUUU
Winterfat	Krascheninnikovia lanata	KRAL2	PPPP	PPPP	PPPP	PPPP	PPPP
Yucca	Yucca spp.	YUCCA	DDDD	DDDD	UUUU	DDDD	DDDD

N = not used; U = undesirable; D = desirable; P = preferred; T = toxic

Animal Community – Grazing Interpretations

The following table lists suggested stocking rates for cattle under continuous season-long grazing under normal growing conditions. These are conservative estimates that should be used only as guidelines in the initial stages of the conservation planning process. Often, the current plant composition does not entirely match any particular plant community (as described in this ecological site description). Because of this, a field visit is recommended, in all cases, to document plant composition and production. More precise carrying capacity estimates should eventually be calculated using this information along with animal preference data, particularly when grazers other than cattle are involved. Under more intensive grazing management, improved harvest efficiencies can result in an increased carrying capacity. If distribution problems occur, stocking rates must be reduced to maintain plant health and vigor.

Plant Community	Production (lb. /ac)	Carrying Capacity* (AUM/ac)
Bluebunch WG/Rhizomatous WG/Needleandthread	225-600	.20
Perennial Grass/Big Sagebrush	180-480	.16
Big Sagebrush/Bare Ground	200-400	.10
Blue Grama Sod	55-150	.05
Salt Tolerant Shrub/Bare Ground	125-350	.07
Salt Tolerant Shrub/Rhizomatous Wheatgrasses	200-425	.16

* - Continuous, season-long grazing by cattle under average growing conditions.

Grazing by domestic livestock is one of the major income-producing industries in the area. Rangeland in this area may provide yearlong forage for cattle, sheep, or horses. During the dormant period, the forage for livestock use needs to be supplemented with protein because the quality does not meet minimum livestock requirements.

Hydrology Functions

Water is the principal factor limiting forage production on this site. This site is dominated by soils in hydrologic group B and C, with localized areas in hydrologic group D. Infiltration ranges from moderately slow to moderate. Runoff potential for this site varies from low to moderate depending on soil hydrologic group and ground cover. In many cases, areas with greater than 75% ground cover have the greatest potential for high infiltration and lower runoff. An example of an exception would be where short-grasses form a strong sod and dominate the site. Areas where ground cover is less than 50% have the greatest potential to have reduced infiltration and higher runoff (refer to Part 630, NRCS National Engineering Handbook for detailed hydrology information).

Rills and gullies should not typically be present. Water flow patterns should be barely distinguishable if at all present. Pedestals are only slightly present in association with bunchgrasses. Litter typically falls in place, and signs of movement are not common. Chemical and physical crusts are rare to non-existent. Cryptogamic crusts are present, but only cover 1-2% of the soil surface.

Recreational Uses
This site provides hunting opportunities for upland game species. The wide varieties of plants which bloom from spring until fall have an esthetic value that appeals to visitors.

Wood Products
No appreciable wood products are present on the site.

Other Products
None noted.

Supporting Information

Associated Sites

Shallow Loamy	R032XY162WY
Sandy	R032XY150WY
Clayey	R032XY104WY
Lowland	R032XY128WY

Similar Sites
() – Loamy 10-14" Foothills and Basin East P.Z., R032XY322WY has higher production.

Inventory Data References (narrative)
Information presented here has been derived from NRCS inventory data. Field observations from range trained personnel were also used. Other sources used as references include: USDA NRCS Water and Climate Center, USDA NRCS National Range and Pasture Handbook, and USDA NRCS Soil Surveys from various counties.

Inventory Data References

Data Source	Number of Records	Sample Period	State	County
SCS-RANGE-417	19	1965-1986	WY	Park & others

State Correlation
This site occurs entirely within Wyoming.

Type Locality

Field Offices
Cody, Greybull, Lovell, Powell, Thermopolis, Worland

Relationship to Other Established Classifications

Other References

Site Description Approval

______________________________ ______________
State Range Management Specialist Date

Appendix C

Climate Data

ANCHOR DAM, WYOMING

Period of Record General Climate Summary - Precipitation

Station:(480228) ANCHOR DAM

From Year=1961 To Year=2006

	Precipitation											Total Snowfall		
	Mean	High	Year	Low	Year	1 Day Max.		>= 0.01 in.	>= 0.10 in.	>= 0.50 in.	>= 1.00 in.	Mean	High	Year
	in.	in.	-	in.	-	in.	dd/yyyy or yyyymmdd	# Days	# Days	# Days	# Days	in.	in.	-
January	0.51	1.22	1963	0.15	1966	0.5	Dec-72	4	2	0	0	5.5	11.1	1975
February	0.36	0.94	1978	0	1970	0.33	20/1978	4	1	0	0	4	10	1971
March	1.09	2.53	1973	0.36	1978	0.95	18/1968	6	3	0	0	9.4	16.5	1977
April	2.11	4.6	1963	0.75	1976	1.46	27/1963	8	5	2	0	7.8	19	1967
May	2.68	7.21	1978	0.55	1966	1.33	Jun-78	9	6	2	0	0.9	10	1975
June	2.41	6.58	1967	0.2	1971	1.94	Nov-70	9	6	2	1	0	0	1961
July	1.33	3.27	1962	0.22	1970	1.23	26/1962	7	4	1	0	0	0	1961
August	1.2	2.79	1979	0.16	1969	2.16	30/1971	6	3	0	0	0	0	1961
September	1.4	4.66	1973	0.1	1964	1.68	Feb-73	6	3	1	0	0.3	6	1965
October	1.05	3.85	1971	0	1965	1.06	Jan-71	5	3	1	0	2	20	1971
November	0.57	1.57	1972	0.06	1965	0.77	16/1963	4	2	0	0	3.8	14	1972
December	0.48	1.32	1964	0.1	1971	0.77	23/1964	4	2	0	0	3.4	6	1972
Annual	15.2	20.72	1973	10.87	1969	2.16	19710830	72	41	8	2	37.1	54	1971
Winter	1.36	2.85	1965	0.57	1966	0.77	19641223	12	6	0	0	12.9	22.1	1975
Spring	5.88	9.3	1978	3.43	1966	1.46	19630427	23	15	4	1	18.1	28	1975
Summer	4.94	9.43	1967	2.47	1974	2.16	19710830	23	13	3	1	0	0	1961
Fall	3.02	6.94	1973	0.85	1964	1.68	19730902	14	8	2	0	6.1	22	1971

pdated on Apr 23, 2007
nual means, thresholds, and sums
ore missing days are not considered
e missing months are not considered
atological not calendar seasons

Winter = Dec., Jan., and Feb.	Spring = Mar., Apr., and May
Summer = Jun., Jul., and Aug.	Fall = Sep., Oct., and Nov.

Western Regional Climate Center, wrcc@dri.edu

Source: http://www.wrcc.dri.edu/summary/Climsmwy.htm

GRASS CREEK 1 E, WYOMING

Period of Record General Climate Summary - Precipitation

Station:(484036) GRASS CREEK 1 E

From Year=1949 To Year=2006

	Precipitation											Total Snowfall		
	Mean	High	Year	Low	Year	1 Day Max.		>= 0.01 in.	>= 0.10 in.	>= 0.50 in.	>= 1.00 in.	Mean	High	Year
	in.	in.	-	in.	-	in.	dd/yyyy or yyyymmdd	# Days	# Days	# Days	# Days	in.	in.	-
January	0.25	0.95	1962	0	1954	0.46	Aug-62	3	1	0	0	3.4	16.4	1987
February	0.35	2.96	1986	0	1966	2.27	Jul-86	3	1	0	0	4.6	33.7	1987
March	0.45	1.28	1981	0.09	1964	0.75	27/1981	4	2	0	0	4.4	15.5	1980
April	1.12	4.22	1957	0.02	1951	2.47	25/1964	5	3	1	0	2.7	22.5	1983
May	2.1	7.18	1978	0	1960	2.47	18/1978	7	5	1	0	1.5	16	1983
June	1.83	4.91	1958	0.21	1956	2.24	Dec-58	8	4	1	0	0.1	4	1969
July	1.07	7.27	1962	0	1971	4.36	26/1962	5	3	0	0	0	0	1949
August	0.85	5.09	1968	0	1949	1.92	18/1968	5	2	1	0	0	0	1949
September	1.03	5	1961	0	1952	1.8	20/1961	4	2	1	0	0.8	19	1982
October	0.53	2.24	1975	0	1952	1	21/1953	3	2	0	0	1.4	10	1971
November	0.38	1.2	1973	0	1963	1.15	Jul-50	3	1	0	0	3.1	13.8	1988
December	0.34	1.54	1982	0	1954	0.8	29/1972	3	1	0	0	5	35.5	1982
Annual	10.32	17.3	1962	4.9	1954	4.36	19620726	53	27	5	1	27	47.4	1972
Winter	0.94	3.76	1986	0.04	1966	2.27	19860207	9	3	0	0	13	52.8	1987
Spring	3.67	8.84	1964	0.81	1966	2.47	19640425	16	9	2	0	8.6	48	1983
Summer	3.76	11.21	1962	1.51	1970	4.36	19620726	17	9	2	0	0.1	4	1969
Fall	1.95	7.4	1961	0.03	1952	1.8	19610920	10	5	1	0	5.3	23	1982

dated on Apr 23, 2007
nual means, thresholds, and sums:
re missing days are not considered
missing months are not considered
atological not calendar seasons

Winter = Dec., Jan., and Feb.	Spring = Mar., Apr., and May
Summer = Jun., Jul., and Aug.	Fall = Sep., Oct., and Nov.

Western Regional Climate Center, wrcc@dri.edu

Source: http://www.wrcc.dri.edu/summary/Climsmwy.htm

THERMOPOLIS 25 WNW, WYOMING

Period of Record General Climate Summary - Precipitation

Station:(488888) THERMOPOLIS 25 WNW

From Year=1951 To Year=2006

	Precipitation											Total Snowfall		
	Mean	High	Year	Low	Year	1 Day Max.		>= 0.01 in.	>= 0.10 in.	>= 0.50 in.	>= 1.00 in.	Mean	High	Year
	in.	in.	-	in.	-	in.	dd/yyyy or yyyymmdd	# Days	# Days	# Days	# Days	in.	in.	-
January	0.33	1.21	1973	0	1958	0.6	Dec-72	3	1	0	0	6.6	15	1973
February	0.32	1.08	1981	0	1991	0.58	28/2004	3	1	0	0	6.2	19	2004
March	0.68	2.21	1992	0.04	2004	0.95	18/1992	5	2	0	0	9.9	27.5	1998
April	1.39	4.68	1963	0.06	1987	2.07	27/1963	6	4	1	0	10.9	35	1973
May	2.22	6.88	1978	0.05	1984	2.1	Jun-93	8	5	2	0	2.8	22	1965
June	1.99	6.44	1997	0.31	1973	1.75	Mar-93	8	5	1	0	0.1	4	1976
July	1.34	3.76	1965	0.11	1952	2.18	23/1983	7	4	1	0	0	0	1957
August	1.02	2.6	1968	0.06	1969	1.81	30/1971	5	3	0	0	0	0	1957
September	1.26	4.09	1973	0	1964	1.55	Feb-73	5	3	1	0	1.7	18	1984
October	0.83	3.87	1971	0	1958	1.39	18/1971	4	2	0	0	4.9	21	1989
November	0.47	1.25	1987	0	1979	0.8	18/2001	3	2	0	0	6.7	23	1973
December	0.31	1.6	1978	0	1952	0.7	May-78	3	1	0	0	5.9	14	1967
Annual	12.15	17.71	1998	7.22	1988	2.18	19830723	60	34	6	1	55.8	119.5	1973
Winter	0.96	2.15	1998	0.23	1974	0.7	19781205	9	4	0	0	18.7	31	1993
Spring	4.29	9.86	1999	1.29	2001	2.1	19930506	19	12	2	0	23.6	61	1973
Summer	4.35	8.07	1958	1.43	1988	2.18	19830723	21	11	2	1	0.1	4	1976
Fall	2.55	6.1	1973	0.27	1952	1.55	19730902	12	7	1	0	13.3	37	1973

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Winter = Dec., Jan., and Feb.
Spring = Mar., Apr., and May
Summer = Jun., Jul., and Aug.
Fall = Sep., Oct., and Nov.

Western Regional Climate Center, wrcc@dri.edu

Source: http://www.wrcc.dri.edu/summary/Climsmwy.htm

ANCHOR DAM, WYOMING

Period of Record General Climate Summary - Temperature

Station:(480228) ANCHOR DAM

From Year=1961 To Year=2006

	Monthly Averages			Daily Extremes				Monthly Extremes				Max. Temp.		Min. Temp.	
	Max.	Min.	Mean	High	Date	Low	Date	Highest Mean	Year	Lowest Mean	Year	>= 90 F	<= 32 F	<= 32 F	<= 0 F
	F	F	F	F	dd/yyyy or yyyymmdd	F	dd/yyyy or yyyymmdd	F	-	F	-	# Days	# Days	# Days	# Days
January	33.3	5.4	19.4	59	16/1974	-45	Dec-63	26.9	1965	8.1	1979	0	12.8	29.6	11.2
February	39.4	11.3	25.5	60	Apr-63	-25	May-76	31.5	1963	19.2	1964	0	6.1	26.4	4.9
March	42.5	15.8	29.2	71	29/1978	-28	18/1965	37.1	1972	17.7	1965	0	5.3	27.7	4.4
April	51.5	25.3	38.6	75	22/1969	-10	Aug-73	43.5	1977	30.9	1973	0	1.2	23.8	0.5
May	62.6	34.7	48.6	88	28/1966	10	Apr-67	52.7	1966	44.8	1968	0	0.1	12.2	0
June	72	42.7	57.4	93	25/1974	26	30/1968	63.6	1977	52.3	1969	0.4	0	1.8	0
July	81.4	49	65.4	93	21/1964	24	Jan-68	70.5	1966	61.9	1962	1.9	0	0.1	0
August	80.1	47.1	63.6	98	16/1973	27	30/1964	68.8	1971	58.9	1968	2.2	0	0.7	0
September	68.1	37.5	52.8	91	14/1975	8	18/1965	58.8	1963	43.6	1965	0.1	0.1	8.9	0
October	58.4	28.2	43.1	84	Jan-63	-10	30/1971	51.4	1963	32.6	1969	0	0.9	20	0.2
November	43.7	16.8	30.3	69	Apr-65	-27	20/1977	36.7	1965	25	1978	0	4.5	26.8	2.5
December	36.3	8	22.2	63	Apr-65	-38	May-72	27.7	1962	12.5	1978	0	10.1	29.1	8.3
Annual	55.8	26.8	41.3	98	19730816	-45	19630112	43.1	1966	40.2	1968	4.5	40.9	207.1	31.9
Winter	36.3	8.2	22.4	63	19651204	-45	19630112	25.6	1970	15	1979	0	28.9	85.2	24.4
Spring	52.2	25.3	38.8	88	19660528	-28	19650318	41.6	1972	35.5	1973	0	6.6	63.7	4.9
Summer	77.8	46.3	62.1	98	19730816	24	19680701	64.5	1961	59.5	1968	4.4	0	2.6	0
Fall	56.7	27.5	42.1	91	19750914	-27	19771120	48.3	1963	38.8	1970	0.1	5.4	55.7	2.6

ıpdated on Apr 23, 2007
nnual means, thresholds, and sums:
ıore missing days are not considered
e missing months are not considered
natological not calendar seasons

Winter = Dec., Jan., and Feb.	Spring = Mar., Apr., and May
Summer = Jun., Jul., and Aug.	Fall = Sep., Oct., and Nov.

Western Regional Climate Center, wrcc@dri.edu

Source: http://www.wrcc.dri.edu/summary/Climsmwy.htm

GRASS CREEK 1 E, WYOMING

Period of Record General Climate Summary - Temperature

Station:(484036) GRASS CREEK 1 E

From Year=1949 To Year=2006

	Monthly Averages			Daily Extremes				Monthly Extremes				Max. Temp.		Min. Temp.	
	Max.	Min.	Mean	High	Date	Low	Date	Highest Mean	Year	Lowest Mean	Year	>= 90 F	<= 32 F	<= 32 F	<= 0 F
	F	F	F	F	dd/yyyy or yyyymmdd	F	dd/yyyy or yyyymmdd	F	-	F	-	# Days	# Days	# Days	# Days
January	35.8	7.2	21.5	68	16/1974	-41	15/1984	33.5	1981	7.8	1979	0	11	30.4	8.5
February	40.1	12.9	26.5	70	24/1986	-40	Mar-89	33.4	1977	13.7	1989	0	6.2	28.1	4.2
March	48.4	20.5	34.4	74	28/1986	-12	Apr-89	41.3	1986	31	1969	0	2.2	29.1	0.8
April	57.3	28	42.7	84	21/1989	4	14/1986	50.3	1987	36.2	1970	0	0.4	22	0
May	66.2	36.8	51.5	88	27/1969	14	Jan-72	56.5	1987	47.4	1982	0	0	8.4	0
June	77.1	44.9	60.9	98	24/1988	19	Sep-82	70.6	1988	54.3	1975	2.8	0	1.7	0
July	85.1	51.7	68.4	104	16/1970	33	Jan-75	73.1	1966	64.9	1972	7.7	0	0	0
August	83	50.3	66.7	100	May-79	32	18/1974	71.2	1971	62.1	1974	5.3	0	0.1	0
September	73.2	40.9	57	94	Feb-83	12	20/1983	62	1979	52.6	1985	1	0	5	0
October	60.2	30.4	45.3	83	Mar-87	5	13/1969	51.5	1988	38.2	1969	0	0.6	18.5	0
November	44.5	18.1	31.3	71	May-75	-25	23/1985	37.7	1981	16.9	1985	0	4.5	27.8	2.2
December	36.8	9.3	23.4	64	Apr-79	-49	24/1983	33.5	1980	7.3	1983	0	9.9	30.4	5.8
Annual	59	29.2	44.1	104	19700716	-49	19831224	46.6	1988	42.3	1982	16.8	34.8	201.5	21.6
Winter	37.6	9.8	23.8	70	19860224	-49	19831224	31.3	1981	17.4	1984	0	27.1	88.9	18.5
Spring	57.3	28.4	42.9	88	19690527	-12	19890304	46.9	1987	39.9	1983	0	2.6	59.5	0.8
Summer	81.7	49	65.3	104	19700716	19	19820609	70.9	1988	62.4	1975	15.9	0	1.8	0
Fall	59.3	29.8	44.6	94	19830902	-25	19851123	47.3	1987	37.3	1985	1	5.1	51.3	2.2

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Winter = Dec., Jan., and Feb.

Spring = Mar., Apr., and May

Summer = Jun., Jul., and Aug.

Fall = Sep., Oct., and Nov.

Western Regional Climate Center, wrcc@dri.edu

Source: http://www.wrcc.dri.edu/summary/Climsmwy.html

THERMOPOLIS 25 WNW, WYOMING

Period of Record General Climate Summary - Temperature

Station:(488888) THERMOPOLIS 25 WNW

From Year=1951 To Year=2006

	Monthly Averages			Daily Extremes				Monthly Extremes				Max. Temp.		Min. Temp.	
	Max.	Min.	Mean	High	Date	Low	Date	Highest Mean	Year	Lowest Mean	Year	>= 90 F	<= 32 F	<= 32 F	<= 0 F
	F	F	F	F	dd/yyyy or yyyymmdd	F	dd/yyyy or yyyymmdd	F	-	F	-	# Days	# Days	# Days	# Days
January	37.1	7.7	22.4	63	22/1981	-40	Dec-63	32.2	1981	10.8	1963	0	9	29.8	7.8
February	40.1	12.3	26.2	66	24/1986	-40	Mar-89	33.4	1991	12	1989	0	5.9	26.8	4.1
March	47.3	19.2	33.1	73	29/1978	-26	Feb-60	42	1986	20.6	1965	0	2.8	27.9	1.4
April	55.8	27.3	41.5	78	30/1959	-2	Aug-75	47.5	1987	33.1	1975	0	0.5	21.7	0
May	65.3	36.4	50.8	93	29/2003	14	Jan-72	55.7	1994	46.3	1975	0	0	9.4	0
June	74.8	43.6	59.2	95	28/2002	22	Jan-00	66.3	1988	51.7	1993	0.9	0	1.3	0
July	82.7	49.3	66.1	100	13/2002	26	19/1993	73.4	2006	55.5	1993	4.4	0	0.1	0
August	81.7	48.1	64.9	98	Jun-01	20	22/1968	71.2	2003	58.1	1993	2.8	0	0.6	0
September	71	38.3	54.6	92	Aug-74	2	25/1984	61.6	2001	43.9	1965	0.4	0.1	7.3	0
October	59.8	28.7	44.3	87	May-93	-5	29/1971	52.3	1963	38.2	1969	0	0.5	19.9	0.1
November	45.1	16.9	31	70	Apr-65	-26	13/1959	38.3	2001	21.6	2000	0	4	27.4	1.9
December	38.3	10	24.2	69	27/1980	-40	22/1990	33.7	1980	12.9	1990	0	8.1	29.3	5.1
Annual	58.3	28.2	43.2	100	20020713	-40	19630112	44.1	1963	40.1	1975	8.4	30.9	201.5	20.6
Winter	38.5	10	24.3	69	19801227	-40	19630112	30.8	1981	16.7	1993	0	23.1	85.8	17.1
Spring	56.1	27.6	41.8	93	20030529	-26	19600302	45.6	1986	36.5	1975	0	3.2	59	1.5
Summer	79.7	47	63.4	100	20020713	20	19680822	68.2	2001	55.1	1993	8	0	2	0
Fall	58.7	28	43.3	92	19740908	-26	19591113	49.5	1963	39.1	1961	0.4	4.6	54.6	2

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Winter = Dec., Jan., and Feb.
Spring = Mar., Apr., and May
Summer = Jun., Jul., and Aug.
Fall = Sep., Oct., and Nov.

Western Regional Climate Center, wrcc@dri.edu

Source: http://www.wrcc.dri.edu/summary/Climsmwy.html

THERMOPOLIS, WYOMING

Period of Record General Climate Summary - Precipitation

Station:(488875) THERMOPOLIS

From Year=1948 To Year=2006

	Precipitation											Total Snowfall		
								>=	>=	>=	>=			
	Mean	High	Year	Low	Year	1 Day Max.		0.01 in.	0.10 in.	0.50 in.	1.00 in.	Mean	High	Year
	in.	in.	-	in.	-	in.	dd/yyyy or yyyymmdd	# Days	# Days	# Days	# Days	in.	in.	-
January	0.4	2	1995	0	1957	1.43	16/1995	3	1	0	0	5	14.7	1949
February	0.45	1.87	2004	0	1963	0.89	28/2004	3	2	0	0	5.4	26	1955
March	0.8	3.06	1998	0	1997	1.1	Sep-58	4	2	0	0	4.8	37	1998
April	1.47	4.23	1999	0.08	1954	1.2	Sep-04	6	4	1	0	1.6	8	1955
May	2.02	5.01	2005	0.45	2001	1.82	Nov-05	8	5	1	0	0.5	12	1954
June	1.62	5.68	1963	0.02	1954	2	14/1963	7	4	1	0	0	0	1949
July	0.84	2.2	1997	0	1963	0.97	21/1992	5	3	0	0	0	0	1949
August	0.55	1.71	1999	0.05	1961	0.8	Apr-99	5	2	0	0	0	0	1948
September	1.12	3.15	1961	0.06	1956	0.93	20/1950	5	3	1	0	0.2	4.5	2000
October	1.01	3.44	1994	0	1958	1.55	16/1994	4	2	1	0	2.1	14	1991
November	0.7	1.59	1991	0	1949	0.94	13/1994	4	2	0	0	5.1	17	1958
December	0.35	1.65	1997	0.02	1994	0.73	26/2003	3	1	0	0	5.2	20	1997
Annual	11.33	17.4	1998	5.29	1954	2	19630614	57	31	6	1	29.8	61	1955
Winter	1.2	3.38	2004	0.19	1992	1.43	19950116	9	4	0	0	15.7	34	1998
Spring	4.29	8.62	2005	1.07	1960	1.82	20050511	18	11	3	0	6.8	38	1998
Summer	3.01	6.38	1963	0.32	1954	2	19630614	17	9	1	0	0	0	1949
Fall	2.83	6.06	1961	0.66	1952	1.55	19941016	13	8	2	0	7.3	22.8	1991

THERMOPOLIS, WYOMING

Period of Record General Climate Summary - Temperature

Station:(488875) THERMOPOLIS

From Year=1948 To Year=2006

	Monthly Averages			Daily Extremes				Monthly Extremes				Max. Temp.		Min. Temp.	
	Max.	Min.	Mean	High	Date	Low	Date	Highest Mean	Year	Lowest Mean	Year	>= 90 F	<= 32 F	<= 32 F	<= 0 F
	F	F	F	F	dd/yyyy or yyyymmdd	F	dd/yyyy or yyyymmdd	F	-	F	-	# Days	# Days	# Days	# Days
January	36.6	8.7	22.6	67	Sep-53	-39	24/1949	34.7	2006	8.3	1949	0	9.5	30.5	7.6
February	43.1	15.1	29.1	70	Oct-51	-36	13/1949	38	1999	17.1	1949	0	4.8	26.8	3.7
March	51.6	22.3	37	78	31/2004	-17	25/1955	44.4	1992	28.4	1955	0	1.9	26.5	1.3
April	62.6	32.1	47.4	90	13/1952	10	16/1951	51.6	2003	41.8	1953	0	0.2	15.3	0
May	72.2	41.6	56.9	96	29/2003	12	Feb-54	63.4	1958	49.3	1950	0.6	0	3.4	0
June	82.3	48.7	65.5	105	23/1954	24	Mar-51	71.6	1956	57.1	1951	6.9	0	0.4	0
July	91	54.7	72.9	106	13/2005	34	Aug-55	78.1	2002	66.5	1993	20.7	0	0	0
August	90.1	53.6	71.8	103	Nov-57	34	31/1962	77	2003	66.4	1950	18.8	0	0	0
September	79.1	43.7	61.4	99	Mar-50	22	27/1951	67.2	1990	55.4	1951	4.4	0	2.2	0
October	65.7	32.3	49	90	19/2003	4	27/1954	54.9	1963	40.3	1949	0	0.4	15.5	0
November	47.7	19.6	33.7	74	Apr-99	-28	16/1955	45.4	1999	24	2000	0	3.5	27.5	1.8
December	38.7	11.9	25.3	67	Jan-95	-35	21/1990	33.1	1957	14.9	1990	0	7.6	29.8	4.6
Annual	63.4	32	47.7	106	20050713	-39	19490124	50.9	1999	43.9	1955	51.5	27.9	177.8	18.9
Winter	39.5	11.9	25.7	70	19510210	-39	19490124	32.3	2000	15	1949	0	21.9	87	15.9
Spring	62.1	32	47.1	96	20030529	-17	19550325	52.2	1992	42.5	1950	0.7	2	45.2	1.3
Summer	87.8	52.3	70.1	106	20050713	24	19510603	73.6	2001	64.8	1950	46.4	0	0.4	0
Fall	64.2	31.9	48	99	19500903	-28	19551116	52.4	1963	43.4	1961	4.5	3.9	45.2	1.8

Appendix D

Permitted Wells

WSEO Permitted Wells - Cottonwood/Grass Creek Watershed

Permit #	Priority	Status	Tns	Tns Suffix	Rng	Rng Suffix	Section	Qtrqtr	Lots	Applicant	Facility Name	Uses	Yld Act (gpm)	Well Depth[1] (ft)	Static Depth[1] (ft)	Mwbz Top[2] (ft)	Mwbz Bottom[2] (ft)	Well Log	Chemical Analysis	County
P107106W	8/18/1997	GST	45	N	96	W	15	SWSW		BAIRD/SONS INC** BAIRD & SONS INC	BAIRD #6	DOM	10	60	15.8	50	52	Yes	No	Hot Springs
P126309W	6/16/2000	GST	45	N	94	W	21	NWNW		MAURICE T BEHRNES	BEHRNES #2	DOM	10	20	6.5	14	15	Yes	No	Washakie
P84143W	12/17/1990	GST	44	N	101	W	3	NENW		JOHN C. GOETZ	J.G. #1	DOM	3	6	-4	Unknown	Unknown	No	No	Hot Springs
P87489W	3/30/1992	GST	44	N	98	W	17	NWNE		GEORGE NELSON	NELSON #3	DOM	25	30	5	15	20	Yes	No	Hot Springs
P90161W	11/12/1992	GST	45	N	94	W	17	SWSE	L13	FRANK AND ELIZABETH V. KUBIAK	KUBIAK #3	DOM	8	205	100	Unknown	Unknown	No	No	Washakie
P102635W	6/5/1996	GST	46	N	99	W	21	NESE		JOHN F LEROUX	BOX H RANCH #3	DOM,STO	12	80	45	45	75	Yes	No	Hot Springs
P103693W	9/12/1996	GST	46	N	99	W	22	SWNW		JOHN F LEROUX	BOX H RANCH #4	DOM,STO	15	137	50	125	137	Yes	No	Hot Springs
P107560W	9/23/1997	GST	44	N	98	W	1	SWSW		PATHFINDER ENERGY, INC.	PATHFINDER #1	DOM,STO	10	20.5	4.1	5	16	Yes	No	Hot Springs
P107722W	9/29/1997	GST	44	N	98	W	1	SESW		PROSPECT LAND/CATTLE CO, LLC	PROSPECT-BERRY #2	DOM,STO	25	120	20	35	40	Yes	No	Hot Springs
P159218W	5/17/2004	GSE	46	N	98	W	33	SWSE		SPRING GULCH CATTLE COMPANY	REDS #2	DOM,STO						No		Hot Springs
P159219W	5/17/2004	GSE	46	N	98	W	33	SWSW		SPRING GULCH CATTLE COMPANY	REDS #1	DOM,STO						No		Hot Springs
P165210W	1/24/2005	GSI	44	N	98	W	23	NENE		SHAWN I. AND/OR MARGARET I. MCWILLIAMS	MCWILLIAMS #1	DOM,STO						No		Hot Springs
P166829W	4/11/2005	GSI	45	N	94	W	17	NESE		FRANK B & LAJEAN KUBIAK	JUBAR WELL	DOM,STO						No		Washakie
P166830W	4/11/2005	GST	45	N	94	W	17	SESE		FRANK B & LAJEAN KUBIAK	LITTLE ER WELL	DOM,STO	18	4.5	2	2	4	Yes	No	Washakie
P71978W	5/10/1985	GST	46	N	99	W	24	SENE		RONALD E. & CARLA J. BROWN	BROWN #1	DOM,STO	7	55	35	Unknown	Unknown	No	No	Hot Springs
P74722W	5/26/1987	GST	44	N	98	W	17	SENW		HIGH ISLAND RANCH	HIGH ISLAND RANCH #1	DOM,STO	2	203	12	95	96	Yes	No	Hot Springs
P77992W	9/6/1988	GST	45	N	101	W	20	SWNE		TONY & JANICE ABSTETAR	ABSTETAR #1	DOM,STO	1	45.5	18.4	30	32	Yes	No	Hot Springs
P78321W	10/17/1988	GST	46	N	98	W	33	NESE		GILBREATH CATTLE COMPANY	SMITH #2	DOM,STO	25	81	35.5	35	78	Yes	Yes	Hot Springs
P92129W	7/1/1993	GST	45	N	94	W	21	NWNW		CHARLES W. AND LINDA S. SLATTERY	SLATTERY #1	DOM,STO	20	110	20	60	110	Yes	Yes	Washakie
38/1/590W	4/20/2006	UNA	46	N	98	W	32	NWSE		HORSEWORKS WYOMING, LLC	MESAVERDE WATER SUPPLY WELL #3	DOM,STO,IRR						No		
P1130W	1/6/1964		46	N	98	W	18	NWSW		MARATHON OIL COMPANY	FRONTIER UNIT WATER SUPPLY WELL #1	IND	323	5400	1222	4677		Yes		Hot Springs
P1523W	7/30/1965		46	N	99	W	17	NWNE		MARATHON OIL COMPANY	GOVERNMENT #1	IND	29	1648	80	1390	1478	Yes		Hot Springs
P1565W	11/15/1965		46	N	98	W	16	SWSW		MARATHON OIL COMPANY	CURTIS UNIT #51 WATER SUPPLY	IND	166	7000	1250	6084	7000	Yes	No	Hot Springs
P1584W	12/3/1965		46	N	98	W	18	NESE		MARATHON OIL COMPANY	PRE-TENSLEEP UNIT #9 WSW	IND	36	5600	1461	4768	5600	Yes		Hot Springs
P16651W	11/10/1972		44	N	98	W	13	SWSE		INC. ASHLAND OIL	ASHLAND OIL, INC. FEDERAL LEASES-044141-063710	IND	875	-1	-1	Unknown	Unknown	No	No	Hot Springs
P215C	8/5/1935	UNA	46	N	98	W	19	SWSW		THE OHIO OIL CO.	STATE LAND WATER PERMIT #2	IND	10	430	-1	135	147	Yes		Hot Springs
P65154W	7/1/1983	UNA	44	N	98	W	24	NWNW		ARCO OIL AND GAS COMPANY	RATHVON TANK BATTERY #12	IND	94	-1	-1	2700	Unknown	No	Yes	Hot Springs
P66099W	5/10/1983	UNA	44	N	98	W	13	SWSE		USDI, BLM**GRAHAM RESOURCES INC.	PHOSPHORIA UNIT	IND	730	-1	-1	Unknown	Unknown	No	No	Hot Springs
P6616W	10/1/1970		44	N	98	W	14	NWNW		EMPIRE STATE OIL CO.	HORSESHOE LEASE #044177	IND	72	-1	3000	Unknown	Unknown	No	No	Hot Springs
P66354W	1/30/1984	UNA	44	N	98	W	13	SWSE		USDI, BLM**GRAHAM RESOURCES INC.	ENL PHOSPHORIA UNIT	IND	600	-1	-1	Unknown	Unknown	No	No	Hot Springs
P685W	12/18/1961		46	N	98	W	29	NWSE		THE OHIO OIL CO.	CURTIS UNIT WATER SUPPLY WELL #5	IND	235	5880	900	5030		Yes		Hot Springs
P212C	10/1/1935	UNA	46	N	98	W	30	NWNW		THE OHIO OIL CO.	FEDERAL WATER PERMIT #2B	IND,DOM	50	583	-1	535	583	Yes		Hot Springs
P214C	1/20/1934	UNA	46	N	98	W	19	SWSW		THE OHIO OIL CO.	STATE LAND WATER PERMIT #1	IND,DOM	17	200	-1	170	180	Yes		Hot Springs
P2224W	5/8/1968		46	N	99	W	24	SWNW		MARATHON OIL COMPANY	L. B. HORN WATER WELL #1	IND,DOM	63	610	25	280	500	Yes		Hot Springs
P2225W	5/8/1968		46	N	99	W	23	SENE		MARATHON OIL COMPANY	STATE LAND WATER WELL #1	IND,DOM	35	698	15	300	698	Yes		Hot Springs
P318C	7/15/1941	UNA	45	N	96	W	17	NENE		THE OHIO OIL CO.	HAMILTON DOME JUNCTION STATION#1 WATER WELL	IND,DOM	8	25	-1	20	25	No		Hot Springs
P66173W	7/12/1983		46	N	98	W	27	SWSE		MARATHON OIL COMPANY	BATTERY #1 CURTIS UNIT GRASS CREEK FIELD	IND,MIS	151	-1	-1	Unknown	Unknown	No	Yes	Hot Springs
P66180W	7/20/1983		46	N	98	W	19	SWNE		MARATHON OIL COMPANY	FRONTIER BATTERY #2	IND,MIS	269	-1	-1	Unknown	Unknown	No	Yes	Hot Springs
P66181W	7/20/1983		46	N	98	W	20	SWSW		MARATHON OIL COMPANY	FRONTIER 3 TANK BATTERY	IND,MIS	259	-1	-1	Unknown	Unknown	Yes	Yes	Hot Springs
P66182W	7/20/1983		46	N	98	W	20	SWSW		MARATHON OIL COMPANY	MILL IRON BATTERY	IND,MIS	1236	-1	-1	Unknown	Unknown	No	Yes	Hot Springs
P66183W	7/20/1983		46	N	98	W	19	NENW		WY BOARD OF LAND COMMISSIONERS**MARATHON OIL COMPANY	PHOSPHORIA TENSLEEP STATE LAND BATTERY	IND,MIS	508	-1	-1	Unknown	Unknown	No	Yes	Hot Springs
P66184W	7/20/1983		46	N	98	W	19	SENE		WY BOARD OF LAND COMMISSIONERS**MARATHON OIL COMPANY	STATE LAND LAKOTA BATTERY	IND,MIS	846	-1	-1	Unknown	Unknown	No	Yes	Hot Springs
P66185W	10/20/1983		46	N	98	W	18	SESW		MARATHON OIL COMPANY	S L WILEY (LAKOTA BATTERY) GRASS FILED CREEK	IND,MIS	12	-1	-1	Unknown	Unknown	No	Yes	Hot Springs
P66186W	10/20/1983		46	N	98	W	19	NENW		WY BOARD OF LAND COMMISSIONERS**MARATHON OIL COMPANY	PRE TENSLEEP UNIT BATTERY	IND,MIS	204	-1	-1	Unknown	Unknown	No	Yes	Hot Springs
P66188W	10/20/1983		46	N	98	W	19	SWNE		MARATHON OIL COMPANY	CURTIS UNIT BATTERY #3 GRASS CREEK FIELD	IND,MIS	233	-1	-1	Unknown	Unknown	No	Yes	Hot Springs
P79468W	4/10/1989	UNA	46	N	99	W	8	SWNE		MARATHON OIL COMPANY	WALKER DOME TANK BATTERY	IND,MIS	13	5900	-4	Unknown	Unknown	No	No	Hot Springs
P49664W	8/15/1979		45	N	95	W	7	SESE		MERLE PITZ	PITZ IRR #1	IRR	10	340	40	140	240	No	No	Washakie

P144704W	4/10/2002	GST	44	N	98	W	15	NENW		LEGEND ROCK RESOURCES, INC.	WAGNER PIPELINE	IRR,MIS	2500	4	0	Unknown	Unknown	No	No	Hot Springs	
P118801W	9/14/1999	GSM	46	N	98	W	29	NENE		L. U. SHEEP COMPANY	LITTLEJOHN LIVESTOCK #1	MIS	5	32	16	17	27	Yes	No	Hot Springs	
P167429W	5/3/2005	GSI	46	N	98	W	19	SWNE		JOHN F LEROUX dba BOX H RESOURCES** WY STATE BOARD OF LAND COMMISSIONERS	RIDGELY WATER WELL NO. 1	MIS						No		Hot Springs	
P84545W	2/25/1991	UNA	44	N	97	W	7	SWSW		GRAHAM ROYALTY LTD.	GRAHAM ROYALTY TANK BATTERY	MIS	145	0	0	Unknown	Unknown	No	No	Hot Springs	
P86122W	9/19/1991	UNA	44	N	98	W	10	NENE		WYO STATE PARKS & HISTORIC SITES	LEGEND ROCK #1	MIS	3	131	28.8	120	130	Yes	Yes	Hot Springs	
P152343W	6/2/2003	GST	44	N	98	W	15	NENW		LEGEND ROCK RESOURCES, INC.	ENL WAGNER PIPELINE	MIS,RES						No		Hot Springs	
P98211W	1/6/1995	UNA	44	N	98	W	23	SENE		PARKER & PARSLEY PRODUCING, INC.	ENL. #1 LINK	MIS,STO	0	2910	400	2750	Unknown	Yes	No	Hot Springs	
P100988W	12/4/1995	GST	46	N	98	W	19	SESW		MARATHON OIL COMPANY	GC #4	MON	0	55.3	39	46	55	Yes	Yes	Hot Springs	
P126913W	7/13/2000	GST	46	N	98	W	19	SESW	T62	MARATHON OIL COMPANY	GC #5	MON	0	42	38.5	38	42	Yes	Yes	Hot Springs	
P95428W	5/26/1994	GST	46	N	98	W	19	SESW		MARATHON OIL COMPANY	GC #1	MON	0	50.5	31	40	Unknown	Yes	Yes	Hot Springs	
P95429W	5/26/1994	GST	46	N	98	W	19	SESW		MARATHON OIL COMPANY	GC #2	MON	0	60	35	45	Unknown	Yes	Yes	Hot Springs	
P95430W	5/26/1994	GST	46	N	98	W	19	SESW		MARATHON OIL COMPANY	GC #3	MON	0	60.5	52	55	Unknown	Yes	Yes	Hot Springs	
P397W	8/31/1960	UNA	46	N	98	W	28	SWNW		OHIO OIL CO	CURTIS UNIT WATER SUPPLY WELL #4	OIL	274	6000	50	5236		Yes		Hot Springs	
P240W	9/17/1959	UNA	45	N	99	W	17	SWNW		TEXACO PROD. DEPT. INC.	BIGLIN LEASE WATER WELL #1	OIL,DOM,DRI	18	794	400	654		Yes		Hot Springs	
P29572W	4/9/1975		46	N	98	W	20	SWNW		MARATHON OIL CO.	L U SHEEP W S W #1	OIL,IND	350	5900	1583	4942	5900	Yes	No	Hot Springs	
P101813W	3/21/1996	GST	46	N	99	W	32	NENE		JOHN F LEROUX	BOX H RANCH #1	STO	2	220	36	120	126	Yes	No	Hot Springs	
P101814W	3/21/1996	GST	46	N	99	W	23	NESW		JOHN F LEROUX	BOX H RANCH #2	STO	11	140	50	118	140	Yes	No	Hot Springs	
P105983W	5/9/1997	UNA	46	N	98	W	33	NESE		USDI, BLM** SPRING GULCH LAND/CATTLE	ENL SMITH #2	STO	0	81	35.5	35	78	Yes	Yes	Hot Springs	
P123300W	2/11/2000	GST	46	N	99	W	34	SESW		JOHN F LEROUX	Box H Ranch #6	STO	4	315	280	285	310	Yes	No	Hot Springs	
P125148W	4/27/2000	GST	45	N	96	W	21	SENE		GENEVA M. SWING	EAGLE #2	STO	12	360	10	280	360	Yes	No	Hot Springs	
P136955W	7/27/2001	GST	45	N	99	W	10	SWNE		JOHN F. LEROUX** USDI, BUREAU OF LAND MANAGEMENT	ADAM WEISS WELL NO. 7	STO	7	380	130	215	380	Yes	No	Hot Springs	
P144132W	4/29/2002	GST	46	N	99	W	34	SESW		JOHN F. LEROUX	ENL. BOX H RANCH # 6	STO	4	315	280	285	310	Yes	No	Hot Springs	
P150259W	1/22/2003	GSI	45	N	99	W	19	SESW		PROSPECT LAND/CATTLE CO, LLC	SMITH GRANERY	STO						No		Hot Springs	
P155955W	1/21/2004	GSI	45	N	99	W	31	SENW		SPRING GULCH CATTLE CO.** USDI, BUREAU OF LAND MANAGEMENT	CABIN SPRINGS #2	STO						No		Hot Springs	
P160762W	7/13/2004	GSI	45	N	100	W	35	NWNW		PROSPECT LAND & CATTLE CO, LLC	PROSPECT #1	STO						No		Hot Springs	
P160763W	7/13/2004	GSE	45	N	100	W	36	SWNW		SPRING GULCH CATTLE CO** WY STATE BOARD OF LAND COMMISSIONERS	SS #1	STO						No		Hot Springs	
P77922W	8/29/1988	GST	45	N	99	W	9	SENW		GARY V. KELLOGG	KELLOGG #3	STO	5	320	100	308	312	Yes	No	Hot Springs	
P84325W	1/31/1991	UNA	45	N	97	W	34	SENW		ANNE DEBEIXEDON	#1 HAY FIELD JEW PLACE	STO						No		Hot Springs	
P86605W	11/20/1991	GST	44	N	100	W	36	NENW		WYO BOARD OF LAND COMMISSIONERS**PENNOYER AND SON INC.	PUTNEY #4 WELL	STO	6	100	26	Unknown	Unknown	No	No	Hot Springs	

[1] The designation "-1" indicates that the permitted "well" is for the water from an oil well discharged from a "battery" (oil/water separator)

[2] Mwbz = Main water bearing zone

Appendix E

Water Rights

Appendix E
Water Rights

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P29596D		44	N	97	W	2	5	L3		PU	ORI				X	Cottonwood Creek	2/3/1987						WYOMING STATE HIGHWAY DEPARTMENT
P29596D		44	N	97	W	2	9			PU	ORI				X	Cottonwood Creek	2/3/1987						WYOMING STATE HIGHWAY DEPARTMENT
P29596D		44	N	97	W	2	12			PU	ORI				X	Cottonwood Creek	2/3/1987						WYOMING STATE HIGHWAY DEPARTMENT
P29596D		44	N	97	W	2	8			PU	ORI				X	Cottonwood Creek	2/3/1987						WYOMING STATE HIGHWAY DEPARTMENT
P7465E	X	44	N	97	W	4	10		0	UNA	SUP						12/15/2005						Prospect Land & Cattle Co.
C40/137A		44	N	97	W	5	10		8	ADJ	ORI							Nellie L. Wales			Wales Ditch,, Enl.	IRR	
C40/137A		44	N	97	W	5	0	L4	24	ADJ	ORI							Nellie L. Wales	0.34	CFS	Wales Ditch,, Enl.	IRR	
C40/137A		44	N	97	W	5	7		22	ADJ	ORI							Nellie L. Wales			Wales Ditch,, Enl.	IRR	
C40/137A		44	N	97	W	5	0	L3	9	ADJ	ORI							Nellie L. Wales			Wales Ditch,, Enl.	IRR	
C40/514A		44	N	97	W	5	7			PU	ORI				P			Fred Wales			Wales Reservoir	IRR,DOM	
C40/514A		44	N	97	W	5	10			PU	ORI				P			Fred Wales			Wales Reservoir	IRR,DOM	
C71/098A		44	N	97	W	5	10		8	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch	IRR,STO	
C71/098A		44	N	97	W	5	6	L4	24	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch	IRR,STO	
C71/098A		44	N	97	W	5	5	L3	9	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch	IRR,STO	
C71/098A		44	N	97	W	5	7		22	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch	IRR,STO	
P1209R		44	N	97	W	5	7			PU	ORI				P	Cottonwood Creek	2/13/1908						FRED WALES
P1209R		44	N	97	W	5	10			PU	ORI				P	Cottonwood Creek	2/13/1908						FRED WALES
P1859E		44	N	97	W	5	0	L4	10	ADJ	SEC					Cottonwood Creek	4/1/1908						Nellie L. Wales
P1859E		44	N	97	W	5	10		8	ADJ	SEC					Cottonwood Creek	4/1/1908						Nellie L. Wales
P1859E		44	N	97	W	5	0	L3	9	ADJ	SEC				X	Cottonwood Creek	4/1/1908						Nellie L. Wales
P1859E		44	N	97	W	5	0	L4	14	ADJ	SEC					Cottonwood Creek	4/1/1908						Nellie L. Wales
P23400D		44	N	97	W	5	10		8	ADJ	SUP					Wales Draw	10/21/1960						INC. RHODES RANCH
P23400D		44	N	97	W	5	6	L4	24	ADJ	SUP					Wales Draw	10/21/1960						INC. RHODES RANCH
P23400D		44	N	97	W	5	5	L3	9	ADJ	SUP					Wales Draw	10/21/1960						INC. RHODES RANCH
P23400D		44	N	97	W	5	7		22	ADJ	SUP					Wales Draw	10/21/1960						INC. RHODES RANCH
P7267D		44	N	97	W	5	1			DSC	SEC				ALL		7/12/1906						C.D. FARMER**W.P. DUNCAN
C38/795A		44	N	97	W	6	9		10	ADJ	ORI							Jacob Vogel			Vogel Ditch	IRR	
C38/795A		44	N	97	W	6	10		30	ADJ	ORI							Jacob Vogel			Vogel Ditch	IRR	
C38/795A		44	N	97	W	6	3		23	ADJ	ORI							Jacob Vogel			Vogel Ditch	IRR	
C38/798A		44	N	97	W	6	2		25.3	ADJ	ORI							Frank Thomale			Caledonia Ditch	IRR,DOM	
C38/800A		44	N	97	W	6	6		25.3	ADJ	ORI							Jacob Vogel			Caledonia Ditch	IRR,DOM	
C38/800A		44	N	97	W	6	8		40	ADJ	ORI							Jacob Vogel			Caledonia Ditch	IRR,DOM	
C38/800A		44	N	97	W	6	7		40	ADJ	ORI							Jacob Vogel			Caledonia Ditch	IRR,DOM	
C38/800A		44	N	97	W	6	5		25.3	ADJ	ORI							Jacob Vogel			Caledonia Ditch	IRR,DOM	
C40/137A		44	N	97	W	6	13		34	ADJ	ORI							Nellie L. Wales			Wales Ditch,, Enl.	IRR	
C40/137A		44	N	97	W	6	1	L1	10	ADJ	ORI							Nellie L. Wales			Wales Ditch,, Enl.	IRR	
C40/137A		44	N	97	W	6	4		10	ADJ	ORI							Nellie L. Wales			Wales Ditch,, Enl.	IRR	
C40/514A		44	N	97	W	6	4			PU	ORI				P			Fred Wales			Wales Reservoir	IRR,DOM	
C40/514A	X	44	N	97	W	6	4			PUO	ORI							Fred Wales			Wales Reservoir	IRR,DOM	
C40/514A		44	N	97	W	6	13			PU	ORI				P			Fred Wales			Wales Reservoir	IRR,DOM	
C71/098A		44	N	97	W	6	4		10	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch	IRR,STO	
C71/098A		44	N	97	W	6	13		34	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch	IRR,STO	
C71/098A		44	N	97	W	6	1	L1	10	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch	IRR,STO	
P1209R		44	N	97	W	6	4			PU	ORI				P	Cottonwood Creek	2/13/1908						FRED WALES
P1209R	X	44	N	97	W	6	4			PUO	ORI					Cottonwood Creek	2/13/1908						FRED WALES
P1209R		44	N	97	W	6	13			PU	ORI				P	Cottonwood Creek	2/13/1908						FRED WALES
P12500D		44	N	97	W	6	9		10	ADJ	ORI					Cottonwood Creek	6/22/1914						JACOB VOGEL
P12500D		44	N	97	W	6	10		30	ADJ	ORI					Cottonwood Creek	6/22/1914						JACOB VOGEL
P12500D		44	N	97	W	6	3		23	ADJ	ORI					Cottonwood Creek	6/22/1914						JACOB VOGEL
P1859E		44	N	97	W	6	0	L1	10	ADJ	SEC				X	Cottonwood Creek	4/1/1908						Nellie L. Wales
P1859E	X	44	N	97	W	6	4		2	ADJ	SEC					Cottonwood Creek	4/1/1908						Nellie L. Wales
P1859E		44	N	97	W	6	13		34	ADJ	SEC					Cottonwood Creek	4/1/1908						Nellie L. Wales
P2199E		44	N	97	W	6	12		40	ELI	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P2199E		44	N	97	W	6	11	L7	40	ELI	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P23400D		44	N	97	W	6	1	L1	10	ADJ	SUP					Wales Draw	10/21/1960						INC. RHODES RANCH
P23400D		44	N	97	W	6	4		10	ADJ	SUP					Wales Draw	10/21/1960						INC. RHODES RANCH
P23400D		44	N	97	W	6	13		34	ADJ	SUP					Wales Draw	10/21/1960						INC. RHODES RANCH
P7465E		44	N	97	W	6	4		0	UNA	SUP						12/15/2005						Prospect Land & Cattle Co.
P8434D		44	N	97	W	6	7		40	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	97	W	6	2		14.7	ELI	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P8434D		44	N	97	W	6	5		14.7	ELI	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	97	W	6	5		25.3	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	97	W	6	8		40	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	97	W	6	6		12.7	ELI	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	97	W	6	6		25.3	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	97	W	6	2		25.3	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	97	W	6	10		6	ELI	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
C57/192A		44	N	97	W	7	0			PU	ORI				SDX			H. D. Curtis			Empire Pipe Line	STO,DOM,OIL,DRI	
C71/098A	X	44	N	97	W	7	11			PUD	ORI							Rhodes Ranch Inc.			Wales No. 2 Ditch	IRR,STO	
C71/099A	X	44	N	97	W	7	11			PUD	ORI							Rhodes Ranch Inc.			Wales No. 2 Ditch,, Urwin Enlargement of The	IRR	
P15643D		44	N	97	W	7	0			DSC	ORI				XDS	Cottonwood Creek	11/14/1919						H.D. CURTIS
P2199E		44	N	97	W	7	5		40	ELI	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P2199E		44	N	97	W	7	6	L1	40	ELI	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P2199E		44	N	97	W	7	7	L2	40	ELI	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P2199E		44	N	97	W	7	8		40	ELI	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P23400D	X	44	N	97	W	7	11			PUD	ORI					Wales Draw	10/21/1960						INC. RHODES RANCH
P6347E	X	44	N	97	W	7	10	L3		PUH	ORI					Wales Draw	2/1/1965						
P6347E	X	44	N	97	W	7	11			PUD	ORI					Wales Draw	2/1/1965						
P7465E	X	44	N	97	W	7	11		0	UNA	SUP						12/15/2005						Prospect Land & Cattle Co.
C57/192A		44	N	97	W	18	0			PU	ORI				SDX			H. D. Curtis			Empire Pipe Line	STO,DOM,OIL,DRI	
C61/246A		44	N	97	W	18	5			PU	ORI				DX			Westates Petroleum Company			Curtis Pipe Line,, Enl.	DOM,DRI	
C61/246A		44	N	97	W	18	6			PU	ORI				DX			Westates Petroleum Company			Curtis Pipe Line,, Enl.	DOM,DRI	
P15643D		44	N	97	W	18	0			PU	ORI				SDX	Cottonwood Creek	11/14/1919						H.D. CURTIS
P5205E		44	N	97	W	18	5			PU	ORI				DX	Cottonwood Creek	8/19/1939						ITALO PETROLEUM CORPORATION
P5205E		44	N	97	W	18	6			PU	ORI				DX	Cottonwood Creek	8/19/1939						ITALO PETROLEUM CORPORATION
C36/725A		44	N	98	W	1	14		11.7	ADJ	ORI							Frank Haynes			Caledonia Ditch,, Enl.	IRR,DOM	
C36/725A		44	N	98	W	1	9		8.4	ADJ	ORI							Frank Haynes			Caledonia Ditch,, Enl.	IRR,DOM	
C38/796A		44	N	98	W	1	14		28	ADJ	ORI							Aaron Haynes			Caledonia Ditch	IRR,DOM	
C38/796A		44	N	98	W	1	4		40	ADJ	ORI							Aaron Haynes			Caledonia Ditch	IRR,DOM	
C38/796A		44	N	98	W	1	3		40	ADJ	ORI							Aaron Haynes			Caledonia Ditch	IRR,DOM	
C38/797A		44	N	98	W	1	8		40	ADJ	ORI							Manley Gwynn, Admr., By Ralph E. Close			Caledonia Ditch	IRR,DOM	
C38/797A		44	N	98	W	1	2	L2	25.3	ADJ	ORI							Manley Gwynn, Admr., By Ralph E. Close			Caledonia Ditch	IRR,DOM	
C38/797A		44	N	98	W	1	5	L3	25.3	ADJ	ORI							Manley Gwynn, Admr., By Ralph E. Close			Caledonia Ditch	IRR,DOM	
C38/797A		44	N	98	W	1	9		31	ADJ	ORI							Manley Gwynn, Admr., By Ralph E. Close			Caledonia Ditch	IRR,DOM	
C39/418A		44	N	98	W	1	10		33	ADJ	ORI							Frank Haynes			Caledonia Ditch	IRR,DOM	
C39/418A		44	N	98	W	1	6		35	ADJ	ORI							Frank Haynes			Caledonia Ditch	IRR,DOM	
C39/418A		44	N	98	W	1	7		40	ADJ	ORI							Frank Haynes			Caledonia Ditch	IRR,DOM	
C39/419A		44	N	98	W	1	13		30	TRA	ORI							C. A. Koger	0.43	CFS	Berry Ditch,, Enl.	IRR	
C39/419A		44	N	98	W	1	13		30	TRA	ORI							C. A. Koger	0.43	CFS	Berry Ditch,, Enl.	IRR	
C39/419A		44	N	98	W	1	16		5	ADJ	ORI							C. A. Koger			Berry Ditch,, Enl.	IRR	
C39/419A		44	N	98	W	1	13		30	ADJ	ORI							C. A. Koger	0.43	CFS	Berry Ditch,, Enl.	IRR	
C39/419A		44	N	98	W	1	12		20	ADJ	ORI							C. A. Koger			Berry Ditch,, Enl.	IRR	
C39/419A		44	N	98	W	1	13		30	ADJ	ORI							C. A. Koger	0.43	CFS	Berry Ditch,, Enl.	IRR	
C39/419A		44	N	98	W	1	15		5	ADJ	ORI							C. A. Koger			Berry Ditch,, Enl.	IRR	
C40/138A		44	N	98	W	1	12		7	ADJ	ORI							C. A. Koger			Berry Ditch,, Enl.	IRR	
C40/138A		44	N	98	W	1	13		10	TRA	ORI							C. A. Koger	0.14	CFS	Berry Ditch,, Enl.	IRR	
C40/138A		44	N	98	W	1	15		29	ADJ	ORI							C. A. Koger			Berry Ditch,, Enl.	IRR	
C40/138A		44	N	98	W	1	16		35	ADJ	ORI							C. A. Koger			Berry Ditch,, Enl.	IRR	
C40/138A		44	N	98	W	1	13		10	ADJ	ORI							C. A. Koger	0.14	CFS	Berry Ditch,, Enl.	IRR	

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
C42/332A		44	N	98	W	1	11		35	ADJ	ORI							Lee Simonson			Berry Ditch	IRR	
C57/356A		44	N	98	W	1	0	L1	25.3	ADJ	ORI							F. O. Benedict	0.36	CFS	Caledonia Ditch,, Enl.	IRR,DOM	
C71/099A		44	N	98	W	1	15		29	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch,, Urwin Enlargement of The	IRR	
C71/099A		44	N	98	W	1	12		20	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch,, Urwin Enlargement of The	IRR	
C71/099A		44	N	98	W	1	16		35	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch,, Urwin Enlargement of The	IRR	
P2199E		44	N	98	W	1	15		34	ADJ	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P2199E		44	N	98	W	1	12		27	ADJ	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P2199E		44	N	98	W	1	13		40	ADJ	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P2199E		44	N	98	W	1	16		40	ADJ	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P28458D	X	44	N	98	W	1	11			PUD	ORI					Cottonwood Creek	5/7/1984						LARRY L. KING
P2910E		44	N	98	W	1	14		11.7	ADJ	ORI					Cottonwood Creek	1/17/1914						FRANK HAYNES
P2910E		44	N	98	W	1	9		8.4	ADJ	ORI					Cottonwood Creek	1/17/1914						FRANK HAYNES
P2910E		44	N	98	W	1	10		6.4	ELI	ORI					Cottonwood Creek	1/17/1914						FRANK HAYNES
P6347E		44	N	98	W	1	12		20	ADJ	SUP					Wales Draw	2/1/1965						
P6347E		44	N	98	W	1	16		35	ADJ	SUP					Wales Draw	2/1/1965						
P6347E		44	N	98	W	1	15		29	ADJ	SUP					Wales Draw	2/1/1965						
P8220D	X	44	N	98	W	1	15			PUD	ORI					Cottonwood Creek	2/13/1908						FRED WALES
P8346D		44	N	98	W	1	11		35	ADJ	ORI					Cottonwood Creek	4/18/1908						RICHARD D. BERRY
P8434D		44	N	98	W	1	5		14.7	ELI	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	98	W	1	2		14.7	ELI	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	98	W	1	3		40	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	98	W	1	10		33	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	98	W	1	13		21	ELI	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	98	W	1	1		40	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	98	W	1	2		25.3	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	98	W	1	11		40	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	98	W	1	12		40	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	98	W	1	9		31	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	98	W	1	5		25.3	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	98	W	1	14		28	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	98	W	1	6		35	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
C39/418A		44	N	98	W	2	14		15	ADJ	ORI							Frank Haynes			Caledonia Ditch	IRR,DOM	
C39/418A		44	N	98	W	2	13		37	ADJ	ORI							Frank Haynes			Caledonia Ditch	IRR,DOM	

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
C39/418A		44	N	98	W	2	4		22	ADJ	ORI							Frank Haynes			Caledonia Ditch	IRR,DOM	
P2910E		44	N	98	W	2	3		6.9	ELI	ORI					Cottonwood Creek	1/17/1914						FRANK HAYNES
P2910E		44	N	98	W	2	0	L1	25.3	ADJ	ORI					Cottonwood Creek	1/17/1914						FRANK HAYNES
P2910E		44	N	98	W	2	4		18	ELI	ORI					Cottonwood Creek	1/17/1914						FRANK HAYNES
P2910E		44	N	98	W	2	13		2.5	ELI	ORI					Cottonwood Creek	1/17/1914						FRANK HAYNES
P2910E		44	N	98	W	2	0	L1	25.3	ELI	ORI					Cottonwood Creek	1/17/1914						FRANK HAYNES
P4750E	X	44	N	98	W	2	14			PUH	ORI					Cottonwood Creek	11/28/1930						JOE ROMAGNO
P8434D		44	N	98	W	2	13		37	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	98	W	2	8		22	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		44	N	98	W	2	14		15	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P11462R	X	44	N	98	W	5	8		0	ADJ	STR					Blue Draw	11/1/1982						USDI, Bureau of Land Management
P1859E	X	44	N	98	W	5	7		22	ADJ	ORI					Cottonwood Creek	4/1/1908						Nellie L. Wales
P28458D		44	N	98	W	5	10			PU	ORI				X	Cottonwood Creek	5/7/1984						LARRY L. KING
P28458D		44	N	98	W	5	10			DSC	ORI				WAGONHOUND #1	Cottonwood Creek	5/7/1984						LARRY L. KING
P9721D	X	44	N	98	W	5	4			PUD	ORI					Wagonhound Creek	4/18/1910						R. L. MCGIN
P1859E	X	44	N	98	W	6	4		8	ADJ	ORI					Cottonwood Creek	4/1/1908						Nellie L. Wales
P28458D		44	N	98	W	6	2	L2		DSC	ORI				WAGONHOUND #2	Cottonwood Creek	5/7/1984						LARRY L. KING
P28458D		44	N	98	W	6	2			PU	ORI				X	Cottonwood Creek	5/7/1984						LARRY L. KING
CR13/363A	X	44	N	98	W	7	16			ADJ	ORI				P			USDI, Bureau of Land Management; High Island Ranch Inc. (Lessee)			Homestead Stock Reservoir	STO	
P1446S	X	44	N	98	W	7	16			ADJ	ORI				P	Homestead Draw	2/23/1956						USDI, BUREAU OF LAND MANAGEMENT
C39/416A		44	N	98	W	8	16		6	ADJ	ORI							W. J. & May Camp			Camp Ditch	IRR	
P8342D		44	N	98	W	8	16		6	ADJ	ORI					Cottonwood Creek	3/18/1908						W. J. CAMP
C34/066A		44	N	98	W	9	15		29	TRA	ORI							Oscar F. Hurd			Hurd Ditch	IRR	
C34/066A		44	N	98	W	9	0			DSC	ORI				CAMP DITCH			Oscar F. Hurd			Hurd Ditch	IRR	
C34/066A		44	N	98	W	9	16		24	TRA	ORI							Oscar F. Hurd			Hurd Ditch	IRR	
C34/066A		44	N	98	W	9	12		20	TRA	ORI							Oscar F. Hurd			Hurd Ditch	IRR	
C39/417A		44	N	98	W	9	11		14	ADJ	ORI							W. J. Camp	0.2	CFS	Camp Ditch,, Enl.	IRR	
P2661E		44	N	98	W	9	11		14	ADJ	ORI					Cottonwood Creek	3/4/1912						WILLIAM J. CAMP
P8341D		44	N	98	W	9	15		29	ADJ	ORI					Cottonwood Creek	4/1/1908						W. J. CAMP
P8341D		44	N	98	W	9	12		20	ADJ	ORI					Cottonwood Creek	4/1/1908						W. J. CAMP
P8341D	X	44	N	98	W	9	11				ORI					Cottonwood Creek	4/1/1908						W. J. CAMP
P8341D		44	N	98	W	9	16		24	ADJ	ORI					Cottonwood Creek	4/1/1908						W. J. CAMP
C34/066A		44	N	98	W	10	0			DSC	ORI				CAMP DITCH			Oscar F. Hurd			Hurd Ditch	IRR	
C34/066A		44	N	98	W	10	11		9	TRA	ORI							Oscar F. Hurd			Hurd Ditch	IRR	
C39/001A	X	44	N	98	W	10	4			PUD	ORI							T. W. Berry			Berry Ditch,, Enl.	IRR	
C39/419A		44	N	98	W	10	1			DSC	ORI							C. A. Koger			Berry Ditch,, Enl.	IRR	
C39/419A	X	44	N	98	W	10	4			PUD	ORI							C. A. Koger			Berry Ditch,, Enl.	IRR	
C39/419A	X	44	N	98	W	10	1			PUD	ORI							C. A. Koger			Berry Ditch,, Enl.	IRR	
C40/138A	X	44	N	98	W	10	4			PUD	ORI							C. A. Koger			Berry Ditch,, Enl.	IRR	
C41/686A	X	44	N	98	W	10	4			PUD	ORI							T. W. Berry			Berry Ditch,, Enl.	IRR	
C42/332A	X	44	N	98	W	10	4			PUD	ORI							Lee Simonson			Berry Ditch	IRR	
C57/195A	X	44	N	98	W	10	12			PUD	ORI							Argo Oil Corporation			Argo Three Inch Pipe Line	DOM,OIL,DRI	
P15643D	X	44	N	98	W	10	12			PUD	ORI					Cottonwood Creek	11/14/1919						H.D. CURTIS
P15826D	X	44	N	98	W	10	11			PUD	ORI					Cottonwood Creek	8/23/1920						H.D. CURTIS
P15868D	X	44	N	98	W	10	11			PUD	ORI					Cottonwood Creek	11/13/1920						C. R. BUCHANAN
P18836D	X	44	N	98	W	10	11			PUD	ORI					Camp Spring	11/20/1937						ARGO OIL CORP.
P19147D	X	44	N	98	W	10	4			PUD	ORI					Urwin Spring	6/27/1939						ITALO PETROLEUM CORP.
P22474D		44	N	98	W	10	0			DSC	ORI				DESERT LAND ENTRY	Illinois Pipeline Gulch	3/9/1964						CHARLES LAKE**WYO BOARD OF LAND COMMISSIONERS
P2410E	X	44	N	98	W	10	1			PUH	ORI					Cottonwood Creek	2/20/1911						SAMUEL GWYNN
P2410E	X	44	N	98	W	10	1			PUD	ORI					Cottonwood Creek	2/20/1911						SAMUEL GWYNN
P2910E	X	44	N	98	W	10	1			PUH	ORI					Cottonwood Creek	1/17/1914						FRANK HAYNES
P2910E	X	44	N	98	W	10	1			PUD	ORI					Cottonwood Creek	1/17/1914						FRANK HAYNES
P4750E	X	44	N	98	W	10	1			PUD	ORI					Cottonwood Creek	11/28/1930						JOE ROMAGNO
P5206E	X	44	N	98	W	10	1			PUD	ORI					Cottonwood Creek	12/4/1935						JOSEPH ROMAGNO
P7036E	X	44	N	98	W	10	1			UNA	ORI					Cottonwood Creek	4/2/1992						OWL CREEK LAND CO.**WYO LAND COMMISSIONER AND FARM LOANS
P8341D		44	N	98	W	10	11		9	ADJ	ORI					Cottonwood Creek	4/1/1908						W. J. CAMP
C36/725A	X	44	N	98	W	11	6			PUD	ORI							Frank Haynes			Caledonia Ditch,, Enl.	IRR,DOM	
C38/796A	X	44	N	98	W	11	6			PUD	ORI							Aaron Haynes			Caledonia Ditch	IRR,DOM	

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
C38/797A	X	44	N	98	W	11	6			PUD	ORI							Manley Gwynn, Admr., By Ralph E. Close			Caledonia Ditch	IRR,DOM	
C38/798A	X	44	N	98	W	11	6			PUD	ORI							Frank Thomale			Caledonia Ditch	IRR,DOM	
C38/799A	X	44	N	98	W	11	6			PUD	ORI							Frank Thomale			Caledonia Ditch,, Enl.	IRR,DOM	
C38/800A	X	44	N	98	W	11	6			PUD	ORI							Jacob Vogel			Caledonia Ditch	IRR,DOM	
C40/138A		44	N	98	W	11	6			DSC	ORI							C. A. Koger			Berry Ditch,, Enl.	IRR	
C40/138A	X	44	N	98	W	11	6			PUD	ORI							C. A. Koger			Berry Ditch,, Enl.	IRR	
C42/332A		44	N	98	W	11	1		27	ADJ	ORI							Lee Simonson			Berry Ditch	IRR	
C42/332A		44	N	98	W	11	2		18	ADJ	ORI							Lee Simonson			Berry Ditch	IRR	
C57/192A		44	N	98	W	11	0			PU	ORI				SDX			H. D. Curtis			Empire Pipe Line	STO,DOM,OIL,DRI	
C61/245A		44	N	98	W	11	10			PU	ORI				DX			Westates Petroleum Company			Curtis Pipeline,, Enl.	DOM,DRI	
P15034S	X	44	N	98	W	11	6		0	UNA	STR					Wagner Draw	5/19/2003						Legend Rock Resources, Inc.
P15643D		44	N	98	W	11	0			PU	ORI				SDX	Cottonwood Creek	11/14/1919						H.D. CURTIS
P19030D	X	44	N	98	W	11	5			PUD	ORI					Cottonwood Creek	12/4/1935						EMPIRE STATE OIL CO.
P19147D		44	N	98	W	11	10			PU	ORI				DX	Urwin Spring	6/27/1939						ITALO PETROLEUM CORP.
P2199E	X	44	N	98	W	11	1			ADJ	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P2199E	X	44	N	98	W	11	6			ADJ	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P5204E		44	N	98	W	11	10			PU	SUP				X	Cottonwood Creek	8/19/1939						ITALO PETROLEUM CORPORATION
P5204E	X	44	N	98	W	11	5			PUD	SUP					Cottonwood Creek	8/19/1939						ITALO PETROLEUM CORPORATION
P5204E	X	44	N	98	W	11	8			PUH	SUP					Cottonwood Creek	8/19/1939						ITALO PETROLEUM CORPORATION
P5205E	X	44	N	98	W	11	5			PUD	ORI					Cottonwood Creek	8/19/1939						ITALO PETROLEUM CORPORATION
P8346D	X	44	N	98	W	11	6			ADJ	ORI					Cottonwood Creek	4/18/1908						RICHARD D. BERRY
P8434D	X	44	N	98	W	11	1			ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
C39/001A		44	N	98	W	12	8		11	ADJ	ORI							T. W. Berry			Berry Ditch,, Enl.	IRR	
C39/001A		44	N	98	W	12	5		40	ADJ	ORI							T. W. Berry			Berry Ditch,, Enl.	IRR	
C39/001A		44	N	98	W	12	2		40	ADJ	ORI							T. W. Berry			Berry Ditch,, Enl.	IRR	
C39/001A		44	N	98	W	12	3		30	ADJ	ORI							T. W. Berry			Berry Ditch,, Enl.	IRR	
C41/686A		44	N	98	W	12	1		40	ADJ	ORI							T. W. Berry			Berry Ditch,, Enl.	IRR	
C41/686A		44	N	98	W	12	4		40	ADJ	ORI							T. W. Berry			Berry Ditch,, Enl.	IRR	
C42/332A		44	N	98	W	12	6		40	ADJ	ORI							Lee Simonson			Berry Ditch	IRR	
C57/192A		44	N	98	W	12	0			PU	ORI				SDX			H. D. Curtis			Empire Pipe Line	STO,DOM,OIL,DRI	
C71/098A	X	44	N	98	W	12	16			PUD	ORI							Rhodes Ranch Inc.			Wales No. 2 Ditch	IRR,STO	
C71/099A		44	N	98	W	12	2		40	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch,, Urwin Enlargement of The	IRR	
C71/099A	X	44	N	98	W	12	16			PUD	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch,, Urwin Enlargement of The	IRR	
C71/099A		44	N	98	W	12	1		40	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch,, Urwin Enlargement of The	IRR	
C71/099A		44	N	98	W	12	4		30	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch,, Urwin Enlargement of The	IRR	
C71/099A		44	N	98	W	12	3		15	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch,, Urwin Enlargement of The	IRR	
C71/099A		44	N	98	W	12	5		20	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch,, Urwin Enlargement of The	IRR	
P15643D		44	N	98	W	12	0			PU	ORI				SDX	Cottonwood Creek	11/14/1919						H.D. CURTIS
P19456D		44	N	98	W	12	0			BAD D	SEC					SHEEP CREEK,ENL BERRY	10/26/1940						IRA M. DULL
P2199E		44	N	98	W	12	3		30	ADJ	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P2199E		44	N	98	W	12	1		40	ADJ	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P2199E		44	N	98	W	12	8		11	ADJ	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P2199E		44	N	98	W	12	4		40	ADJ	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P2199E		44	N	98	W	12	5		40	ADJ	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P2199E		44	N	98	W	12	2		40	ADJ	ORI					Cottonwood Creek	3/26/1910						J. C. BERRY**T. W. BERRY
P23400D	X	44	N	98	W	12	16			PUD	ORI					Wales Draw	10/21/1960						INC. RHODES RANCH
P6347E		44	N	98	W	12	4		30	ADJ	SUP					Wales Draw	2/1/1965						
P6347E		44	N	98	W	12	5		20	ADJ	SUP					Wales Draw	2/1/1965						
P6347E	X	44	N	98	W	12	16			PUD	SUP					Wales Draw	2/1/1965						
P6347E		44	N	98	W	12	2		40	ADJ	SUP					Wales Draw	2/1/1965						
P6347E		44	N	98	W	12	3		15	ADJ	SUP					Wales Draw	2/1/1965						
P6347E		44	N	98	W	12	1		40	ADJ	SUP					Wales Draw	2/1/1965						
P7465E	X	44	N	98	W	12	16		0	UNA	SUP						12/15/2005						Prospect Land & Cattle Co.
P8346D		44	N	98	W	12	6		40	ADJ	ORI					Cottonwood Creek	4/18/1908						RICHARD D. BERRY
C57/192A		44	N	98	W	13	0			PU	ORI				SDX			H. D. Curtis			Empire Pipe Line	STO,DOM,OIL,DRI	
C57/195A		44	N	98	W	13	10			PU	ORI				DX			Argo Oil Corporation			Argo Three Inch Pipe Line	DOM,OIL,DRI	
C57/195A		44	N	98	W	13	11			PU	ORI				DX			Argo Oil Corporation			Argo Three Inch Pipe Line	DOM,OIL,DRI	
C71/098A	X	44	N	98	W	13	13			PUD	ORI							Rhodes Ranch Inc.			Wales No. 2 Ditch	IRR,STO	
C71/099A	X	44	N	98	W	13	13			PUD	ORI							Rhodes Ranch Inc.			Wales No. 2 Ditch,, Urwin Enlargement of The	IRR	
P15643D		44	N	98	W	13	0			PU	ORI				SDX	Cottonwood Creek	11/14/1919						H.D. CURTIS
P18836D		44	N	98	W	13	11			DSC	ORI				XDX	Camp Spring	11/20/1937						ARGO OIL CORP.
P18836D		44	N	98	W	13	10			DSC	ORI				XDX	Camp Spring	11/20/1937						ARGO OIL CORP.
P23400D	X	44	N	98	W	13	13			PUD	ORI					Wales Draw	10/21/1960						INC. RHODES RANCH
P5205E	X	44	N	98	W	13	14			PUH	ORI					Cottonwood Creek	8/19/1939						ITALO PETROLEUM CORPORATION

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P6347E	X	44	N	98	W	13	13			PUD	ORI					Wales Draw	2/1/1965						
C44/288A		44	N	98	W	14	10			PU	ORI				P			Illinois Pipe Line Co.			Illinois Pipe Line Company Reservoir (HAMILTON DOME)	DOM,BOI,ENG	
C44/288A	X	44	N	98	W	14	10			PUO	ORI							Illinois Pipe Line Co.			Illinois Pipe Line Company Reservoir (HAMILTON DOME)	DOM,BOI,ENG	
C44/288A		44	N	98	W	14	11			PU	ORI				P			Illinois Pipe Line Co.			Illinois Pipe Line Company Reservoir (HAMILTON DOME)	DOM,BOI,ENG	
C44/288A		44	N	98	W	14	12			PU	ORI				P			Illinois Pipe Line Co.			Illinois Pipe Line Company Reservoir (HAMILTON DOME)	DOM,BOI,ENG	
C44/288A		44	N	98	W	14	9			PU	ORI				P			Illinois Pipe Line Co.			Illinois Pipe Line Company Reservoir (HAMILTON DOME)	DOM,BOI,ENG	
C44/289A		44	N	98	W	14	11			PU	SEC				DX			Illinois Pipe Line Co.			Hamilton Dome Station Pipe Line	DOM,BOI,ENG	
C44/289A		44	N	98	W	14	12			PU	SEC				DX			Illinois Pipe Line Co.			Hamilton Dome Station Pipe Line	DOM,BOI,ENG	
C44/289A	X	44	N	98	W	14	10			PUD	SEC							Illinois Pipe Line Co.			Hamilton Dome Station Pipe Line	DOM,BOI,ENG	
C44/289A		44	N	98	W	14	11			DSC	SEC				STEAM PUMP			Illinois Pipe Line Co.			Hamilton Dome Station Pipe Line	DOM,BOI,ENG	
C44/289A	X	44	N	98	W	14	11			PUD	SEC							Illinois Pipe Line Co.			Hamilton Dome Station Pipe Line	DOM,BOI,ENG	
C44/289A		44	N	98	W	14	12			DSC	SEC				STORAGE TANK			Illinois Pipe Line Co.			Hamilton Dome Station Pipe Line	DOM,BOI,ENG	
C57/192A		44	N	98	W	14	0			PU	ORI				SDX			H. D. Curtis			Empire Pipe Line	STO,DOM,OIL,DRI	
C57/193A		44	N	98	W	14	0			PU	ORI				DX			H. D. Curtis			Empire Pipe Line No. 2	DOM,OIL,DRI	
C57/194A		44	N	98	W	14	5			PU	ORI				SDX			Empire State Oil Company			Curtis Pipe Line	STO,DOM,DRI	
C57/195A		44	N	98	W	14	14			PU	ORI				DX			Argo Oil Corporation			Argo Three Inch Pipe Line	DOM,OIL,DRI	
C57/195A		44	N	98	W	14	16			PU	ORI				DX			Argo Oil Corporation			Argo Three Inch Pipe Line	DOM,OIL,DRI	
C57/195A		44	N	98	W	14	13			PU	ORI				DX			Argo Oil Corporation			Argo Three Inch Pipe Line	DOM,OIL,DRI	
C57/195A		44	N	98	W	14	15			PU	ORI				DX			Argo Oil Corporation			Argo Three Inch Pipe Line	DOM,OIL,DRI	
P15643D		44	N	98	W	14	0			PU	ORI				SDX	Cottonwood Creek	11/14/1919						H.D. CURTIS
P15826D		44	N	98	W	14	0			PU	ORI				DX	Cottonwood Creek	8/23/1920						H.D. CURTIS
P15868D		44	N	98	W	14	5			PU	ORI				X	Cottonwood Creek	11/13/1920						C. R. BUCHANAN
P15868D		44	N	98	W	14	9			PU	ORI				DX	Cottonwood Creek	11/13/1920						C. R. BUCHANAN
P16797D	X	44	N	98	W	14	9			PUD	ORI					Dry Gulch	3/19/1924						ILLISNOIS PIPE LINE CO.
P16797D	X	44	N	98	W	14	10			PUD	ORI					Dry Gulch	3/19/1924						ILLISNOIS PIPE LINE CO.
P16797D	X	44	N	98	W	14	11			PUD	ORI					Dry Gulch	3/19/1924						ILLISNOIS PIPE LINE CO.
P16797D	X	44	N	98	W	14	12			PUD	ORI					Dry Gulch	3/19/1924						ILLISNOIS PIPE LINE CO.
P18836D		44	N	98	W	14	15			DSC	ORI				XDX	Camp Spring	11/20/1937						ARGO OIL CORP.
P18836D		44	N	98	W	14	16			DSC	ORI				XDX	Camp Spring	11/20/1937						ARGO OIL CORP.
P18836D		44	N	98	W	14	13			DSC	ORI				XDX	Camp Spring	11/20/1937						ARGO OIL CORP.
P18836D		44	N	98	W	14	14			DSC	ORI				XDX	Camp Spring	11/20/1937						ARGO OIL CORP.
P19030D		44	N	98	W	14	5			DSC	ORI				DS	Cottonwood Creek	12/4/1935						EMPIRE STATE OIL CO.
P22474D	X	44	N	98	W	14	10			PUD	ORI					Illinois Pipeline Gulch	3/9/1964						CHARLES LAKE**WYO BOARD OF LAND COMMISSIONERS
P3951R		44	N	98	W	14	10			PU	ORI				P	Dry Gulch	3/19/1924						ILLINOIS PIPE LINE CO.
P3951R	X	44	N	98	W	14	10			PUO	ORI					Dry Gulch	3/19/1924						ILLINOIS PIPE LINE CO.
P3951R		44	N	98	W	14	11			PU	ORI				P	Dry Gulch	3/19/1924						ILLINOIS PIPE LINE CO.
P3951R		44	N	98	W	14	12			PU	ORI				P	Dry Gulch	3/19/1924						ILLINOIS PIPE LINE CO.
P3951R		44	N	98	W	14	9			PU	ORI				P	Dry Gulch	3/19/1924						ILLINOIS PIPE LINE CO.
P6616E	X	44	N	98	W	14	10			PUD	ORI					Illinois Pipeline Gulch	2/9/1977						CHINOOK COMPANY**WYO BOARD OF LAND COMMISSIONERS
P11479D		44	N	98	W	15	0		160	ELI	ORI					Cottonwood Creek	3/4/1912						WILLIAM J. CAMP**CHARLES B. SHAFFER
P22370D	X	44	N	98	W	15	5			PUD	ORI					Illinois Pipeline Gulch	6/10/1957						RAMUL DVARISHKIS
CR13/042A	X	44	N	98	W	16	12			ADJ	RES				S			George H. Nelson, Jr.			McQueen No. 2 Stock Reservoir	STO	
CR13/045A	X	44	N	98	W	16	7			ADJ	ORI				S			High Island Ranch - Lessee; Wyoming State Board of Land Commissioners - Owner			Little Sand Stock Reservoir	STO	
HIGH	X	44	N	98	W	16	12			ADJ	RES				S								
P1393S	X	44	N	98	W	16	12			ADJ	ORI				S	Butte Draw	1/18/1956						GEORGE NELSON JR. (LESSEE)
P6616E		44	N	98	W	16	4		30.9	UNA	ORI					Illinois Pipeline Gulch	2/9/1977						CHINOOK COMPANY**WYO BOARD OF LAND COMMISSIONERS
P6616E		44	N	98	W	16	2		7.3	UNA	ORI					Illinois Pipeline Gulch	2/9/1977						CHINOOK COMPANY**WYO BOARD OF LAND COMMISSIONERS
P6616E		44	N	98	W	16	1		11.6	UNA	ORI					Illinois Pipeline Gulch	2/9/1977						CHINOOK COMPANY**WYO BOARD OF LAND COMMISSIONERS
P6616E		44	N	98	W	16	14		3.4	UNA	ORI					Illinois Pipeline Gulch	2/9/1977						CHINOOK COMPANY**WYO BOARD OF LAND COMMISSIONERS
P6616E	X	44	N	98	W	16	4			PUH	ORI					Illinois Pipeline Gulch	2/9/1977						CHINOOK COMPANY**WYO BOARD OF LAND COMMISSIONERS
P6616E		44	N	98	W	16	13		8	UNA	ORI					Illinois Pipeline Gulch	2/9/1977						CHINOOK COMPANY**WYO BOARD OF LAND COMMISSIONERS
P6616E		44	N	98	W	16	3		19.9	UNA	ORI					Illinois Pipeline Gulch	2/9/1977						CHINOOK COMPANY**WYO BOARD OF LAND COMMISSIONERS
C39/416A		44	N	98	W	17	2		25	ADJ	ORI							W. J. & May Camp			Camp Ditch	IRR	
C39/416A		44	N	98	W	17	1		28	ADJ	ORI							W. J. & May Camp			Camp Ditch	IRR	
C39/416A		44	N	98	W	17	8		13	ADJ	ORI							W. J. & May Camp			Camp Ditch	IRR	
P8342D		44	N	98	W	17	8		13	ADJ	ORI					Cottonwood Creek	3/18/1908						W. J. CAMP
P8342D		44	N	98	W	17	2		25	ADJ	ORI					Cottonwood Creek	3/18/1908						W. J. CAMP
P8342D		44	N	98	W	17	1		28	ADJ	ORI					Cottonwood Creek	3/18/1908						W. J. CAMP

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
C34/066A	X	44	N	98	W	18	16			PUD	ORI							Oscar F. Hurd			Hurd Ditch	IRR	
C34/066A		44	N	98	W	18	16			DSC	ORI							Oscar F. Hurd			Hurd Ditch	IRR	
C39/416A	X	44	N	98	W	18	16			PUD	ORI							W. J. & May Camp			Camp Ditch	IRR	
C39/417A	X	44	N	98	W	18	16			PUD	ORI							W. J. Camp			Camp Ditch,, Enl.	IRR	
P1446S		44	N	98	W	18	1			ADJ	ORI				P	Homestead Draw	2/23/1956						USDI, BUREAU OF LAND MANAGEMENT
P14502D	X	44	N	98	W	18	13			PUD	ORI					Cottonwood Creek	9/14/1916						C. A. KOGER
P2661E	X	44	N	98	W	18	16			PUD	ORI					Cottonwood Creek	3/4/1912						WILLIAM J. CAMP
P2661E	X	44	N	98	W	18	16			PUH	ORI					Cottonwood Creek	3/4/1912						WILLIAM J. CAMP
P8342D	X	44	N	98	W	18	16				ORI					Cottonwood Creek	3/18/1908						W. J. CAMP
CR12/396A	X	44	N	98	W	19	15	L13		ADJ	ORI				S			George H. Nelson, Jr.			Williams Draw Stock Reservoir	STO	
P11479D	X	44	N	98	W	19	8			PUD	ORI					Cottonwood Creek	3/4/1912						WILLIAM J. CAMP**CHARLES B. SHAFFER
P1447S	X	44	N	98	W	19	15			ADJ	ORI				P	Williams Draw	2/23/1956						GEORGE NELSON, JR.
P3713E	X	44	N	98	W	19	8			PUD	ORI					Cottonwood Creek	8/16/1916						W. J. CAMP
P3713E	X	44	N	98	W	19	8			PUH	ORI					Cottonwood Creek	8/16/1916						W. J. CAMP
P11479D		44	N	98	W	22	2		16	UNA	ORI					Cottonwood Creek	3/4/1912						WILLIAM J. CAMP**CHARLES B. SHAFFER
P11479D		44	N	98	W	22	1		11	UNA	ORI					Cottonwood Creek	3/4/1912						WILLIAM J. CAMP**CHARLES B. SHAFFER
P11479D		44	N	98	W	22	6		9	UNA	ORI					Cottonwood Creek	3/4/1912						WILLIAM J. CAMP**CHARLES B. SHAFFER
P11479D		44	N	98	W	22	5		12	UNA	ORI					Cottonwood Creek	3/4/1912						WILLIAM J. CAMP**CHARLES B. SHAFFER
P2858E		44	N	99	W	0	0	L3		DSC	ORI					Cottonwood Creek	10/2/1913						HENRY FISCHER
P17884D	X	44	N	99	W	7	15			PUD	ORI					Pat Creek	5/22/1931						LAURA E. PUNTENEY
C25/033A		44	N	99	W	19	16		22	ADJ	ORI							Vede Punteney			Punteney Ditch No. 1	IRR	
C37/648A		44	N	99	W	19	15		4	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	19	16		25	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C38/650A		44	N	99	W	19	13		3.7	ADJ	ORI							V. D. Punteney			Wilson Ditch	IRR	
C40/136A		44	N	99	W	19	12		25	ADJ	ORI							John T. Wilson			Wilson Ditch	IRR,STO,DOM	
P12184D		44	N	99	W	19	12		25	ADJ	ORI					Cottonwood Creek	8/4/1913						JOHN T. WILSON
P3872D		44	N	99	W	19	16		22	ADJ	ORI					Cottonwood Creek	5/3/1902						VEDE PUNTENEY
P3872D	X	44	N	99	W	19	15			PUD	ORI					Cottonwood Creek	5/3/1902						VEDE PUNTENEY
C25/033A		44	N	99	W	20	11		20	ADJ	ORI							Vede Punteney			Punteney Ditch No. 1	IRR	
C25/033A		44	N	99	W	20	10		18	ADJ	ORI							Vede Punteney			Punteney Ditch No. 1	IRR	
C25/033A		44	N	99	W	20	9		15	ADJ	ORI							Vede Punteney			Punteney Ditch No. 1	IRR	
C25/034A		44	N	99	W	20	4		18	ADJ	ORI							Clara Punteney			Punteney Ditch No. 2	IRR	
C37/648A		44	N	99	W	20	4		24	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	20	3		13	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	20	9		25	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	20	13		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	20	15		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	20	12		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	20	16		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	20	14		39	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	20	11		20	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C38/650A		44	N	99	W	20	8		29.7	ADJ	ORI							V. D. Punteney			Wilson Ditch	IRR	
C38/650A		44	N	99	W	20	9		2.6	ADJ	ORI							V. D. Punteney			Wilson Ditch	IRR	
C38/650A		44	N	99	W	20	2		20	ADJ	ORI							V. D. Punteney			Wilson Ditch	IRR	
C38/650A		44	N	99	W	20	10		11.2	ADJ	ORI							V. D. Punteney			Wilson Ditch	IRR	
C38/650A		44	N	99	W	20	7		8.3	ADJ	ORI							V. D. Punteney			Wilson Ditch	IRR	
C38/650A		44	N	99	W	20	5		9	ADJ	ORI							V. D. Punteney			Wilson Ditch	IRR	
C38/650A		44	N	99	W	20	3		15.6	ADJ	ORI							V. D. Punteney			Wilson Ditch	IRR	
C38/650A		44	N	99	W	20	1		10	ADJ	ORI							V. D. Punteney			Wilson Ditch	IRR	
P3872D		44	N	99	W	20	11		20	ADJ	ORI					Cottonwood Creek	5/3/1902						VEDE PUNTENEY
P3872D		44	N	99	W	20	9		15	ADJ	ORI					Cottonwood Creek	5/3/1902						VEDE PUNTENEY
P3872D		44	N	99	W	20	10		18	ADJ	ORI					Cottonwood Creek	5/3/1902						VEDE PUNTENEY
P3873D	X	44	N	99	W	20	3			PUD	ORI					Cottonwood Creek	5/3/1902						CLARA PUNTENEY
P3873D		44	N	99	W	20	4		18	ADJ	ORI					Cottonwood Creek	5/3/1902						CLARA PUNTENEY
C25/034A		44	N	99	W	21	7		21	ADJ	ORI							Clara Punteney			Punteney Ditch No. 2	IRR	
C25/034A		44	N	99	W	21	3		10	ADJ	ORI							Clara Punteney			Punteney Ditch No. 2	IRR	
C25/034A		44	N	99	W	21	8		20	ADJ	ORI							Clara Punteney			Punteney Ditch No. 2	IRR	
C37/648A		44	N	99	W	21	8		18	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	21	9		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	21	10		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	21	12		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	21	14		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	21	3		7	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	21	15		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	21	11		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	21	7		20	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
P3873D		44	N	99	W	21	3		10	ADJ	ORI					Cottonwood Creek	5/3/1902						CLARA PUNTENEY
P3873D		44	N	99	W	21	7		21	ADJ	ORI					Cottonwood Creek	5/3/1902						CLARA PUNTENEY
P3873D		44	N	99	W	21	8		20	ADJ	ORI					Cottonwood Creek	5/3/1902						CLARA PUNTENEY

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
C33/073A		44	N	99	W	22	9		4.5	ADJ	ORI							Robert M. Richmond			Sayles Ditch	IRR	
C33/073A		44	N	99	W	22	12		1	ADJ	ORI							Robert M. Richmond			Sayles Ditch	IRR	
C33/073A	X	44	N	99	W	22	9			PUD	ORI							Robert M. Richmond			Sayles Ditch	IRR	
C33/073A		44	N	99	W	22	15		8.5	ADJ	ORI							Robert M. Richmond			Sayles Ditch	IRR	
C34/067A	X	44	N	99	W	22	10			PUD	ORI							Robert M. Richmond			Richmond Ditch	IRR	
P8607D	X	44	N	99	W	22	10			PUD	ORI					Cottonwood Creek	8/5/1908						ROBERT M. RICHMOND
P8608D	X	44	N	99	W	22	9			PUD	ORI					Cottonwood Creek	8/5/1908						ROBERT M. RICHMOND
P11571D	X	44	N	99	W	25	3			PUD	ORI					Cottonwood Creek	11/14/1912						VEDE D. PUNTENEY
P26329D		44	N	99	W	25	5			DSC	ORI				E BREHM #1 KNAPP-STATE	Cottonwood Creek	9/6/1979						C. E. BREHM**WYO BOARD OF LAND COMMISSIONERS
P26329D		44	N	99	W	25	5			PU	ORI				X	Cottonwood Creek	9/6/1979						C. E. BREHM**WYO BOARD OF LAND COMMISSIONERS
P26329D	X	44	N	99	W	25	5			PUD	ORI					Cottonwood Creek	9/6/1979						C. E. BREHM**WYO BOARD OF LAND COMMISSIONERS
P28640D		44	N	99	W	25	6			PU	ORI				X	Cottonwood Creek	9/13/1984						INC. BRAND "X"
P28640D	X	44	N	99	W	25	6			PUD	ORI					Cottonwood Creek	9/13/1984						INC. BRAND "X"
C37/648A		44	N	99	W	28	5		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	28	6		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	28	2		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	29	1		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	29	2		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C37/648A		44	N	99	W	29	6		40	ADJ	ORI							V. D. Punteney			Bullhead Canal	IRR	
C40/136A		44	N	99	W	30	7	L2	1	ADJ	ORI							John T. Wilson			Wilson Ditch	IRR,STO,DOM	
C40/136A		44	N	99	W	30	5		2	ADJ	ORI							John T. Wilson			Wilson Ditch	IRR,STO,DOM	
C40/136A		44	N	99	W	30	6	L1	23	ADJ	ORI							John T. Wilson			Wilson Ditch	IRR,STO,DOM	
P12184D		44	N	99	W	30	5		2	ADJ	ORI					Cottonwood Creek	8/4/1913						JOHN T. WILSON
P12184D		44	N	99	W	30	6	L1	23	ADJ	ORI					Cottonwood Creek	8/4/1913						JOHN T. WILSON
P12184D		44	N	99	W	30	7	L2	1	ADJ	ORI					Cottonwood Creek	8/4/1913						JOHN T. WILSON
P8663D		44	N	99	W	30	0	L1		PU	ORI				X	Cottonwood Creek	9/2/1908						V. D. PUNTENEY**JAMES H. BALDWIN**C. W. FORD
P8663D		44	N	99	W	30	0	L2		PU	ORI				X	Cottonwood Creek	9/2/1908						V. D. PUNTENEY**JAMES H. BALDWIN**C. W. FORD
P12276S	X	44	N	99	W	32	13			ADJ	ORI				P	Little Clark Creek	11/1/1982						USDI BLM
P12276S		44	N	99	W	32	14			ADJ	ORI				P	Little Clark Creek	11/1/1982						USDI BLM
P12270S	X	44	N	99	W	33	10			ADJ	ORI				P	Clarks Pond Draw	11/1/1982						USDI BLM
P13787S	X	44	N	100	W	2	1	L1	0	ADJ	ORI					Malamute Draw	11/1/1982	USDI, Bureau of Land Management	2	AF	Urwin Ed Stock Reservoir	STO	USDI BLM
P15411D	X	44	N	100	W	3	6			PUD	ORI					Maret Spring No. 2	3/19/1919						W.K. MARET
P15410D	X	44	N	100	W	4	1			PUD	ORI					Maret Spring No. 1	3/17/1919						W.K. MARET
P12697D	X	44	N	100	W	12	4			PUD	ORI					Cottonwood Creek	9/17/1914						DAVE FERGUSON
P15510D	X	44	N	100	W	14	14			PUD	ORI					Eagle Spring 1 & 2	6/10/1919						D. LODDER
P15511D	X	44	N	100	W	14	12			PUD	SUP					Eagle Spring 1 & 2	6/10/1919						D. LODDER
27/6/275S	X	44	N	100	W	18	16			UNA	ORI												
C32/077A		44	N	100	W	19	11		17	ADJ	ORI							Warren Martin			Martin Ditch No. 3	IRR	
C32/077A		44	N	100	W	19	12		12	ADJ	ORI							Warren Martin			Martin Ditch No. 3	IRR	
C58/001A		44	N	100	W	19	4		9.4	ADJ	ORI							Harris, A. E.			Harris Ditch No. 2	IRR	
C58/001A		44	N	100	W	19	14		4	ADJ	ORI							Harris, A. E.			Harris Ditch No. 2	IRR	
C58/001A		44	N	100	W	19	1		4.1	ADJ	ORI							Harris, A. E.			Harris Ditch No. 2	IRR	
C58/291A		44	N	100	W	19	4		3.7	ADJ	ORI							Harris, A. E.			Harris Ditch No. 1	IRR	
C58/291A		44	N	100	W	19	13		3.2	ADJ	ORI							Harris, A. E.			Harris Ditch No. 1	IRR	
CR1/323A		44	N	100	W	19	10			PU	ORI				P			Lake Creek Irr. District			Lake Creek Reservoir	IRR	
CR1/323A		44	N	100	W	19	9			PU	ORI				P			Lake Creek Irr. District			Lake Creek Reservoir	IRR	
CR1/323A		44	N	100	W	19	12			PU	ORI				P			Lake Creek Irr. District			Lake Creek Reservoir	IRR	
CR1/323A		44	N	100	W	19	11			PU	ORI				P			Lake Creek Irr. District			Lake Creek Reservoir	IRR	
CR1/323A	X	44	N	100	W	19	12			PUO	ORI							Lake Creek Irr. District			Lake Creek Reservoir	IRR	
CR1/324A		44	N	100	W	19	11			PU	ORI				P			Lake Creek Irr. District			Lake Creek Reservoir,, Enl.	IRR	
CR1/324A	X	44	N	100	W	19	12			PUO	ORI							Lake Creek Irr. District			Lake Creek Reservoir,, Enl.	IRR	
CR1/324A		44	N	100	W	19	10			PU	ORI				P			Lake Creek Irr. District			Lake Creek Reservoir,, Enl.	IRR	
CR1/324A		44	N	100	W	19	9			PU	ORI				P			Lake Creek Irr. District			Lake Creek Reservoir,, Enl.	IRR	
CR1/324A		44	N	100	W	19	12			PU	ORI				P			Lake Creek Irr. District			Lake Creek Reservoir,, Enl.	IRR	
P12874D		44	N	100	W	19	4			PU	SEC				X	Lake Creek	5/26/1913						MOLLY MARTIN
P12874D	X	44	N	100	W	19	13			PUD	SEC					Lake Creek	5/26/1913						MOLLY MARTIN
P19157D	X	44	N	100	W	19	13			PUD	ORI					Lake Creek	10/2/1936						A.E. HARRIS
P19157D		44	N	100	W	19	13		3.2	ADJ	ORI					Lake Creek	10/2/1936						A.E. HARRIS
P19157D		44	N	100	W	19	4		3.7	ADJ	ORI					Lake Creek	10/2/1936						A.E. HARRIS
P19158D		44	N	100	W	19	1		4.1	ADJ	ORI					Lake Creek	10/2/1936						A.E. HARRIS
P19158D		44	N	100	W	19	4		9.4	ADJ	ORI					Lake Creek	10/2/1936						A.E. HARRIS
P19158D	X	44	N	100	W	19	14			PUD	ORI					Lake Creek	10/2/1936						A.E. HARRIS
P19158D		44	N	100	W	19	14		4	ADJ	ORI					Lake Creek	10/2/1936						A.E. HARRIS
P2562R		44	N	100	W	19	14			PU	ORI				P	Lake Creek	5/26/1913						MRS. MOLLY MARTIN
P2562R		44	N	100	W	19	15			PU	ORI				P	Lake Creek	5/26/1913						MRS. MOLLY MARTIN
P2562R	X	44	N	100	W	19	15			PUO	ORI					Lake Creek	5/26/1913						MRS. MOLLY MARTIN
P4638R		44	N	100	W	19	12			PU	ORI				P	Lake Creek	10/1/1935						LAKE CREEK IRRIGATION DISTRICT
P4638R		44	N	100	W	19	10			PU	ORI				P	Lake Creek	10/1/1935						LAKE CREEK IRRIGATION DISTRICT

Permit #	Location	Township	Twn Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P4638R		44	N	100	W	19	11			PU	ORI				P	Lake Creek	10/1/1935						LAKE CREEK IRRIGATION DISTRICT
P4638R	X	44	N	100	W	19	12			PUO	ORI					Lake Creek	10/1/1935						LAKE CREEK IRRIGATION DISTRICT
P4638R		44	N	100	W	19	9			PU	ORI				P	Lake Creek	10/1/1935						LAKE CREEK IRRIGATION DISTRICT
P4639R		44	N	100	W	19	10			PU	ORI				P	Lake Creek	10/31/1936						LAKE CREEK IRRIGATION DISTRICT
P4639R		44	N	100	W	19	9			PU	ORI				P	Lake Creek	10/31/1936						LAKE CREEK IRRIGATION DISTRICT
P4639R		44	N	100	W	19	12			PU	ORI				P	Lake Creek	10/31/1936						LAKE CREEK IRRIGATION DISTRICT
P4639R		44	N	100	W	19	11			PU	ORI				P	Lake Creek	10/31/1936						LAKE CREEK IRRIGATION DISTRICT
P4639R	X	44	N	100	W	19	12			PUO	ORI					Lake Creek	10/31/1936						LAKE CREEK IRRIGATION DISTRICT
P9089D	X	44	N	100	W	19	11			ADJ	ORI					Lake Creek	5/27/1909						WARREN MARTIN
P9089D		44	N	100	W	19	12		12	ADJ	ORI					Lake Creek	5/27/1909						WARREN MARTIN
P9089D		44	N	100	W	19	11		17	ADJ	ORI					Lake Creek	5/27/1909						WARREN MARTIN
C58/001A		44	N	100	W	20	7		4.6	ADJ	ORI							Harris, A. E.			Harris Ditch No. 2	IRR	
C58/291A		44	N	100	W	20	7		11	ADJ	ORI							Harris, A. E.			Harris Ditch No. 1	IRR	
C58/291A		44	N	100	W	20	8		14	ADJ	ORI							Harris, A. E.			Harris Ditch No. 1	IRR	
P12874D		44	N	100	W	20	7			PU	SEC				X	Lake Creek	5/26/1913						MOLLY MARTIN
P12874D		44	N	100	W	20	8			PU	SEC				X	Lake Creek	5/26/1913						MOLLY MARTIN
P19157D		44	N	100	W	20	8		14	ADJ	ORI					Lake Creek	10/2/1936						A.E. HARRIS
P19157D		44	N	100	W	20	7		11	ADJ	ORI					Lake Creek	10/2/1936						A.E. HARRIS
P19158D		44	N	100	W	20	7		4.6	ADJ	ORI					Lake Creek	10/2/1936						A.E. HARRIS
C40/136A	X	44	N	100	W	25	4			PUD	ORI							John T. Wilson			Wilson Ditch	IRR,STO,DOM	
C40/136A		44	N	100	W	25	4		17	ADJ	ORI							John T. Wilson			Wilson Ditch	IRR,STO,DOM	
P12184D		44	N	100	W	25	4		17	ADJ	ORI					Cottonwood Creek	8/4/1913						JOHN T. WILSON
P12184D	X	44	N	100	W	25	4			ADJ	ORI					Cottonwood Creek	8/4/1913						JOHN T. WILSON
C37/648A	X	44	N	100	W	26	14			PUD	ORI							V. D. Punteney			Bullhead Canal	IRR	
P2757E	X	44	N	100	W	26	14			PUD	ORI					Cottonwood Creek	2/7/1913						STELLA HOUSTON
P2757E	X	44	N	100	W	26	14			PUH	ORI					Cottonwood Creek	2/7/1913						STELLA HOUSTON
P2858E	X	44	N	100	W	26	14			PUD	ORI					Cottonwood Creek	10/2/1913						HENRY FISCHER
P8663D	X	44	N	100	W	26	14			PUD	ORI					Cottonwood Creek	9/2/1908						V. D. PUNTENEY**JAMES H. BALDWIN**C. W. FORD
P13788S	X	44	N	100	W	28	7		0	ADJ	ORI					Nighthawk Draw	11/1/1982	USDI, Bureau of Land Management	4.3	AF	Hughie Stock Reservoir	STO	USDI BLM
P12258D	X	44	N	100	W	29	15			PUD	ORI					Spring Gulch	2/19/1914						P. W. DRUMMOND
P15678D	X	44	N	100	W	29	12			PUD	ORI					Spring Gulch	12/22/1919						P. W. DRUMMAND
CR1/323A		44	N	100	W	30	5			PU	ORI				P			Lake Creek Irr. District			Lake Creek Reservoir	IRR	
CR1/323A		44	N	100	W	30	6			PU	ORI				P			Lake Creek Irr. District			Lake Creek Reservoir	IRR	
CR1/324A		44	N	100	W	30	6			PU	ORI				P			Lake Creek Irr. District			Lake Creek Reservoir,, Enl.	IRR	
CR1/324A		44	N	100	W	30	5			PU	ORI				P			Lake Creek Irr. District			Lake Creek Reservoir,, Enl.	IRR	
P4638R		44	N	100	W	30	5			PU	ORI				P	Lake Creek	10/1/1935						LAKE CREEK IRRIGATION DISTRICT
P4638R		44	N	100	W	30	6			PU	ORI				P	Lake Creek	10/1/1935						LAKE CREEK IRRIGATION DISTRICT
P4639R		44	N	100	W	30	5			PU	ORI				P	Lake Creek	10/31/1936						LAKE CREEK IRRIGATION DISTRICT
P4639R		44	N	100	W	30	6			PU	ORI				P	Lake Creek	10/31/1936						LAKE CREEK IRRIGATION DISTRICT
C44/113A		44	N	100	W	32	1		9	ADJ	ORI							W. P. Drummond			Drummand Ditch	IRR	
C44/113A		44	N	100	W	32	2		9.5	ADJ	ORI							W. P. Drummond			Drummand Ditch	IRR	
P15678D		44	N	100	W	32	1		9	ADJ	ORI					Spring Gulch	12/22/1919						P. W. DRUMMAND
P15678D		44	N	100	W	32	2		9.5	ADJ	ORI					Spring Gulch	12/22/1919						P. W. DRUMMAND
P14600D		44	N	101	W	3	0	L3		PU	ORI				SD	Cottonwood/Marsh Creek	12/22/1916						MARIE ADAM
P14600D		44	N	101	W	3	0	L1		DSC	ORI					Cottonwood/Marsh Creek	12/22/1916						MARIE ADAM
C160F	X	44	N	101	W	5	1		0	ADJ	ORI					South Fork Cottonwood Creek	2/9/1983						USDA, FOREST SERVICE
P25910D		44	N	101	W	23	8			DSC	ORI				FED 1-23 WELL	Cottonwood Creek	9/8/1978						MAY PETROLEUM, INC.
P25910D		44	N	101	W	23	8			PU	ORI				X	Cottonwood Creek	9/8/1978						MAY PETROLEUM, INC.
C32/075A		44	N	101	W	24	9		16	ADJ	ORI							Warren Martin			Martin Ditch No. 1	IRR	
C32/075A		44	N	101	W	24	15		2	ADJ	ORI							Warren Martin			Martin Ditch No. 1	IRR	
C32/075A		44	N	101	W	24	14		3.3	ADJ	ORI							Warren Martin			Martin Ditch No. 1	IRR	
C32/075A	X	44	N	101	W	24	5			ADJ	ORI							Warren Martin			Martin Ditch No. 1	IRR	
C32/075A		44	N	101	W	24	10		3	ADJ	ORI							Warren Martin			Martin Ditch No. 1	IRR	
C32/076A		44	N	101	W	24	15		8	ADJ	ORI							Warren Martin			Martin Ditch No. 2	IRR	
C32/076A		44	N	101	W	24	14		1.7	ADJ	ORI							Warren Martin			Martin Ditch No. 2	IRR	
P9087D		44	N	101	W	24	10		3	ADJ	ORI					Lake Creek	10/14/1908						WARREN MARTIN
P9087D		44	N	101	W	24	9		16	ADJ	ORI					Lake Creek	10/14/1908						WARREN MARTIN
P9087D		44	N	101	W	24	15		2	ADJ	ORI					Lake Creek	10/14/1908						WARREN MARTIN
P9087D	X	44	N	101	W	24	7			ADJ	ORI					Lake Creek	10/14/1908						WARREN MARTIN
P9087D		44	N	101	W	24	14		3.3	ADJ	ORI					Lake Creek	10/14/1908						WARREN MARTIN
P9088D		44	N	101	W	24	15		8	ADJ	ORI					Lake Creek	5/27/1909						WARREN MARTIN

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P9088D	X	44	N	101	W	24	9			ADJ	ORI					Lake Creek	5/27/1909						WARREN MARTIN
P9088D		44	N	101	W	24	14		1.7	ADJ	ORI					Lake Creek	5/27/1909						WARREN MARTIN
C33/071A	X	45	N	94	W	7	4			ADJ	ORI							John W. Helvey			Brassington Ditch	IRR,STO,DOM	
C33/300A	X	45	N	94	W	7	4			ADJ	ORI							R. A. Winchester and M. A. Winchester			Brassington Ditch	IRR	
C33/301A		45	N	94	W	7	13		6	ADJ	ORI							George R. Winchester			Brassington Ditch	IRR	
C80/245A	X	45	N	94	W	7	0			ADJ	ORI				(SENE OS)			D. & L. M., Inc.			Brassington Ditch	IRR	
P6320D	X	45	N	94	W	7	4			ADJ	ORI				L11	Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	7	13		6	ADJ	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	7	16	L16	11	ELI	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
C33/071A		45	N	94	W	8	15		5	ADJ	ORI							John W. Helvey			Brassington Ditch	IRR,STO,DOM	
C33/300A		45	N	94	W	8	12		32	ADJ	ORI							R. A. Winchester and M. A. Winchester			Brassington Ditch	IRR	
C33/301A		45	N	94	W	8	11		39	ADJ	ORI							George R. Winchester			Brassington Ditch	IRR	
C33/301A		45	N	94	W	8	10		2	ADJ	ORI							George R. Winchester			Brassington Ditch	IRR	
P6320D		45	N	94	W	8	11		39	ADJ	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	8	10		2	ADJ	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	8	12		32	ADJ	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	8	15		5	ADJ	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
C33/070A		45	N	94	W	17	5		0	ADJ	ORI							John W. Helvey			Middle Fork Ditch	IRR,DOM	
C33/070A	X	45	N	94	W	17	0	L6	0	ADJ	ORI		L6					John W. Helvey			Middle Fork Ditch	IRR,DOM	
C33/070A		45	N	94	W	17	3	L6	15	ADJ	ORI		L6					John W. Helvey	0.21	CFS	Middle Fork Ditch	IRR,DOM	
C33/070A		45	N	94	W	17	3	L6	15	ADJ	ORI		L6					John W. Helvey	0.21	CFS	Middle Fork Ditch	IRR,DOM	
C33/071A		45	N	94	W	17	3		23	ADJ	ORI							John W. Helvey			Brassington Ditch	IRR,STO,DOM	
C33/071A		45	N	94	W	17	4		38	ADJ	ORI							John W. Helvey			Brassington Ditch	IRR,STO,DOM	
C33/071A		45	N	94	W	17	2		36	ADJ	ORI							John W. Helvey			Brassington Ditch	IRR,STO,DOM	
C33/072A	X	45	N	94	W	17	0	L6	0	ADJ	ORI		L6					David R. Russell			Middle Fork Ditch,, Russell Enlargement	IRR,DOM	
C33/072A	X	45	N	94	W	17	5		0	ADJ	ORI							David R. Russell			Middle Fork Ditch,, Russell Enlargement	IRR,DOM	
C33/072A		45	N	94	W	17	14	L8	20	ADJ	ORI							David R. Russell			Middle Fork Ditch,, Russell Enlargement	IRR,DOM	
C33/072A		45	N	94	W	17	15	L13	11.1	ADJ	ORI							David R. Russell			Middle Fork Ditch,, Russell Enlargement	IRR,DOM	
C33/072A		45	N	94	W	17	14		11.1	ADJ	ORI							David R. Russell			Middle Fork Ditch,, Russell Enlargement	IRR,DOM	
C33/072A		45	N	94	W	17	14		20	ADJ	ORI							David R. Russell			Middle Fork Ditch,, Russell Enlargement	IRR,DOM	
C33/299A		45	N	94	W	17	8	L5		AME	ORI							R. A. Winchester and M. A. Winchester			Middle Fork Ditch	IRR	
C33/299A	X	45	N	94	W	17	0	L6	0	ADJ	ORI		L6					R. A. Winchester and M. A. Winchester	-0.0001	AF	Middle Fork Ditch	IRR	
C33/299A		45	N	94	W	17	5			ADJ	ORI				MIDDLE FORK DITCH			R. A. Winchester and M. A. Winchester			Middle Fork Ditch	IRR	
C33/299A	X	45	N	94	W	17	0	L1	0	ADJ	ORI				MIDDLE FORK			R. A. Winchester and M. A. Winchester	-0.0001	AF	Middle Fork Ditch	IRR	
C33/299A		45	N	94	W	17	16		13.99	TRA	ORI				OSBORN PIPE LINE			R. A. Winchester and M. A. Winchester			Middle Fork Ditch	IRR	
C33/299A	X	45	N	94	W	17	0	L6	0	ADJ	ORI		L6					R. A. Winchester and M. A. Winchester	-0.0001	AF	Middle Fork Ditch	IRR	
C33/299A	X	45	N	94	W	17	0	L1	0	ADJ	ORI				MIDDLE FORK			R. A. Winchester and M. A. Winchester	-0.0001	AF	Middle Fork Ditch	IRR	
C33/299A		45	N	94	W	17	13		5	TRA	ORI							R. A. Winchester and M. A. Winchester	0.07	CFS	Middle Fork Ditch	IRR	
C33/300A		45	N	94	W	17	16		10	ADJ	ORI							R. A. Winchester and M. A. Winchester			Brassington Ditch	IRR	
C33/300A		45	N	94	W	17	13		34	ADJ	ORI							R. A. Winchester and M. A. Winchester			Brassington Ditch	IRR	
C33/300A		45	N	94	W	17	5		33	ADJ	ORI							R. A. Winchester and M. A. Winchester			Brassington Ditch	IRR	
C33/302A	X	45	N	94	W	17	5			ADJ	ORI							D. B. Russell			Middle Fork Ditch {Enl. of}	IRR	
C52/393A	X	45	N	94	W	17	5			ADJ	ORI							Casper Potts			Middle Fork Ditch {Enl. of}	IRR	
C52/394A	X	45	N	94	W	17	5			ADJ	ORI							D. R. Russell			Middle Fork Ditch {Enl. of}	IRR	
C80/245A		45	N	94	W	17	6	L3	2	ADJ	ORI							D. & L. M., Inc.	0.03	CFS	Brassington Ditch	IRR	
P1421E	X	45	N	94	W	17	5			ADJ	ORI					Meeyero Creek	8/12/1905						CHARLES F. KERN
P2321E	X	45	N	94	W	17	5			PUD	SEC					Meeyero Creek	10/17/1910						DAVID R. RUSSELL
P2321E		45	N	94	W	17	15	L13	19	ADJ	SEC					Meeyero Creek	10/17/1910						DAVID R. RUSSELL
P2321E	X	45	N	94	W	17	5			PUH	SEC					Meeyero Creek	10/17/1910						DAVID R. RUSSELL
P2321E		45	N	94	W	17	14	L8	20	ADJ	SEC					Meeyero Creek	10/17/1910						DAVID R. RUSSELL
P6318D		45	N	94	W	17	13		5	ADJ	SEC					Meeyero Creek	11/10/1904						RUSSELL A. WINCHESTER
P6318D	X	45	N	94	W	17	5			ADJ	SEC					Meeyero Creek	11/10/1904						RUSSELL A. WINCHESTER

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P6318D		45	N	94	W	17	3		15	ADJ	SEC					Meeyero Creek	11/10/1904						RUSSELL A. WINCHESTER
P6318D		45	N	94	W	17	8		4	ELI	SEC					Meeyero Creek	11/10/1904						RUSSELL A. WINCHESTER
P6318D		45	N	94	W	17	16		29	ADJ	SEC					Meeyero Creek	11/10/1904						RUSSELL A. WINCHESTER
P6320D		45	N	94	W	17	13		34	ADJ	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	17	3		23	ADJ	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	17	6	L3	3	ELI	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	17	8	L5	1	ELI	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	17	6	L3	2	ADJ	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	17	5		4	ELI	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	17	16		10	ADJ	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	17	4		38	ADJ	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	17	2		36	ADJ	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	17	1	L1	5	ELI	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	17	5		33	ADJ	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6322D	X	45	N	94	W	17	15			PUD	ORI					Nowater Creek	11/10/1904						JENNIE TAYLOR**A. M. TAYLOR
P1421E		45	N	94	W	20	2		8	ADJ	ORI					Meeyero Creek	8/12/1905						CHARLES F. KERN
P1421E		45	N	94	W	20	2		10	ELI	ORI					Meeyero Creek	8/12/1905						CHARLES F. KERN
P2321E		45	N	94	W	20	8	L4	14	ADJ	SEC					Meeyero Creek	10/17/1910						DAVID R. RUSSELL
P2321E		45	N	94	W	20	5	L1	30	ADJ	SEC					Meeyero Creek	10/17/1910						DAVID R. RUSSELL
P6318D		45	N	94	W	20	1		40	ADJ	SEC					Meeyero Creek	11/10/1904						RUSSELL A. WINCHESTER
C33/300A		45	N	94	W	21	6		17	ADJ	ORI							R. A. Winchester and M. A. Winchester			Brassington Ditch	IRR	
P1421E		45	N	94	W	21	7		11	ADJ	ORI					Meeyero Creek	8/12/1905						CHARLES F. KERN
P6318D		45	N	94	W	21	6		23	ADJ	SEC					Meeyero Creek	11/10/1904						RUSSELL A. WINCHESTER
P6320D		45	N	94	W	21	5		40	ELI	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
P6320D		45	N	94	W	21	6		17	ADJ	ORI					Meeyero Creek	11/10/1904						D & L. M., INC.
C46/398A		45	N	95	W	1	9		39.5	ADJ	ORI							Charles W. Setty			Dempsey Canal {Enl. of}	IRR	
C46/398A		45	N	95	W	1	14		19	ADJ	ORI							Charles W. Setty			Dempsey Canal {Enl. of}	IRR	
P10037R	X	45	N	95	W	1	2	L6		ADJ	ORI				P	Section 1 Draw	11/1/1982						USDI BLM
P4075E		45	N	95	W	1	0	L12		PU	SUP				X	Wood River	1/2/1920						GOOSEBERRY FARMERS CANAL CO.
P478R		45	N	95	W	2	16			PU	ORI				P	Meeyero Creek	2/13/1904						ELLSWORTH H. JENKENS
C46/198A		45	N	95	W	3	11	L17	15	ADJ	ORI							Chas. B. Schweighart			Tenderfoot Ditch,, The First Enlargement of the	IRR,DOM	
C46/198A		45	N	95	W	3	12	L18	28	ADJ	ORI							Chas. B. Schweighart			Tenderfoot Ditch,, The First Enlargement of the	IRR,DOM	
P3540E		45	N	95	W	3	11	L11	15	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	3	12	L18	28	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P9657D		45	N	95	W	3	12		20	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
C40/140A		45	N	95	W	7	16		22	ADJ	ORI							Joseph Tschigg, & Charles Schweighart			Tenderfoot Ditch	IRR,STO,DOM	
P9657D		45	N	95	W	7	16		22	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
C40/139A		45	N	95	W	8	4		15	ADJ	ORI							Joseph Tschigg			Tenderfoot Ditch,, The First Enlargement of the	IRR	
C40/140A		45	N	95	W	8	13		26	ADJ	ORI							Joseph Tschigg, & Charles Schweighart			Tenderfoot Ditch	IRR,STO,DOM	
C40/140A		45	N	95	W	8	14		27	ADJ	ORI							Joseph Tschigg, & Charles Schweighart			Tenderfoot Ditch	IRR,STO,DOM	
C40/140A		45	N	95	W	8	9		32	ADJ	ORI							Joseph Tschigg, & Charles Schweighart			Tenderfoot Ditch	IRR,STO,DOM	
C40/140A		45	N	95	W	8	10		15	ADJ	ORI							Joseph Tschigg, & Charles Schweighart			Tenderfoot Ditch	IRR,STO,DOM	
C40/140A		45	N	95	W	8	4		17	ADJ	ORI							Joseph Tschigg, & Charles Schweighart			Tenderfoot Ditch	IRR,STO,DOM	
C40/140A		45	N	95	W	8	11		21	ADJ	ORI							Joseph Tschigg, & Charles Schweighart			Tenderfoot Ditch	IRR,STO,DOM	
P3540E		45	N	95	W	8	14	L10	27	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	8	13	L9	26	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART

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P3540E		45	N	95	W	8	14	L10	27	ELI	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	8	13	L9	26	ELI	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	8	4	L8	17	ELI	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	8	4	L8	15	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	8	4	L8	32	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P9657D		45	N	95	W	8	14		32	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
P9657D		45	N	95	W	8	13		37	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
P9657D		45	N	95	W	8	11		22	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
P9657D		45	N	95	W	8	4		17	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
P9657D		45	N	95	W	8	9		32	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
P9657D		45	N	95	W	8	10		16	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
C40/139A		45	N	95	W	9	7		2	ADJ	ORI							Joseph Tschigg			Tenderfoot Ditch,, The First Enlargement of the	IRR	
C40/140A		45	N	95	W	9	7		24	ADJ	ORI							Joseph Tschigg, & Charles Schweighart			Tenderfoot Ditch	IRR,STO,DOM	
C46/198A		45	N	95	W	9	1	L1	26	ADJ	ORI							Chas. B. Schweighart			Tenderfoot Ditch,, The First Enlargement of the	IRR,DOM	
C47/022A		45	N	95	W	9	2	L2	16	ADJ	ORI							Joe Dermodi			Tenderfoot Ditch,, The First Enlargement of the	IRR	
C47/022A		45	N	95	W	9	8	L6	22.4	ADJ	ORI							Joe Dermodi			Tenderfoot Ditch,, The First Enlargement of the	IRR	
C47/022A		45	N	95	W	9	3	L7	10	ADJ	ORI							Joe Dermodi			Tenderfoot Ditch,, The First Enlargement of the	IRR	
C47/022A		45	N	95	W	9	5	L3	8.3	ADJ	ORI							Joe Dermodi			Tenderfoot Ditch,, The First Enlargement of the	IRR	
P13813D	X	45	N	95	W	9	8			PUD	ORI					Meeyero Creek	10/29/1915						LIZZIE L. GREEN
P13813D		45	N	95	W	9	0			PU	ORI				D	Meeyero Creek	10/29/1915						LIZZIE L. GREEN
P3540E		45	N	95	W	9	2	L2	16	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	9	1	L1	26	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	9	5	L3	11	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	9	8	L6	26	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	9	5	L3	8.3	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	9	8	L6	22.4	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	9	7	L5	26	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	9	7	L5	2	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	9	5	L3	2.7	ELI	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	9	8	L6	3.6	ELI	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	9	3	L7	10	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P3540E		45	N	95	W	9	7	L5	24	ELI	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P9657D		45	N	95	W	9	10		12	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER

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P9657D		45	N	95	W	9	9		22	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
P9657D		45	N	95	W	9	1		22	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
P9657D		45	N	95	W	9	7		24	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
P9657D		45	N	95	W	9	3		23	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
P9657D		45	N	95	W	9	8		38	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
C46/198A		45	N	95	W	10	6	L4	19	ADJ	ORI							Chas. B. Schweighart			Tenderfoot Ditch,, The First Enlargement of the	IRR,DOM	
P3540E		45	N	95	W	10	6	L4	19	ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P9657D		45	N	95	W	10	6		22	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
P9657D		45	N	95	W	10	5		13	ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
C42/561A	X	45	N	95	W	11	1			ADJ	ORI							Isabelle O. Leste			Jenkins Ditch	IRR	
P2047R		45	N	95	W	11	4			PU	ORI				P	UNNAMED GULCH	12/15/1910						ELLSWORTH H. JENKINS
P25774D		45	N	95	W	11	0	L3		DSC	ORI					Meeyero Creek	5/22/1978						L. K. TRUCKING
P26018D		45	N	95	W	11	0	L3		DSC	ORI					Meeyero Creek	12/19/1978						TEXACO INC.
P478R		45	N	95	W	11	2			PU	ORI				P	Meeyero Creek	2/13/1904						ELLSWORTH H. JENKENS
P478R		45	N	95	W	11	1			PU	ORI				P	Meeyero Creek	2/13/1904						ELLSWORTH H. JENKENS
P478R	X	45	N	95	W	11	1			PUO	ORI					Meeyero Creek	2/13/1904						ELLSWORTH H. JENKENS
P5839D	X	45	N	95	W	11	1			PUD	ORI					Meeyero Creek	2/13/1904						ELLSWORTH H. JENKINS
C42/561A		45	N	95	W	12	3		20	ADJ	ORI							Isabelle O. Leste			Jenkins Ditch	IRR	
C42/561A		45	N	95	W	12	4		20	ADJ	ORI							Isabelle O. Leste			Jenkins Ditch	IRR	
P1386E	X	45	N	95	W	12	6			PUH	ORI					Meeyero Creek	5/20/1905						AUGUST DEGRENON
P2047R		45	N	95	W	12	7			PU	ORI				P	UNNAMED GULCH	12/15/1910						ELLSWORTH H. JENKINS
P2047R	X	45	N	95	W	12	7			PUO	ORI					UNNAMED GULCH	12/15/1910						ELLSWORTH H. JENKINS
C40/139A	X	45	N	95	W	13	8			ADJ	ORI							Joseph Tschigg			Tenderfoot Ditch,, The First Enlargement of the	IRR	
C40/140A	X	45	N	95	W	13	8	L6		ADJ	ORI							Joseph Tschigg, & Charles Schweighart			Tenderfoot Ditch	IRR,STO,DOM	
C47/022A	X	45	N	95	W	13	8			ADJ	ORI							Joe Dermodi			Tenderfoot Ditch,, The First Enlargement of the	IRR	
C40/140A	X	45	N	95	W	18	6			ADJ	ORI							Joseph Tschigg, & Charles Schweighart			Tenderfoot Ditch	IRR,STO,DOM	
P3540E	X	45	N	95	W	18	6			ADJ	ORI					Meeyero Creek	10/12/1915						JOS. TSCHIGG**CHAS. B. SCHWERGHART
P9657D	X	45	N	95	W	18	6			ADJ	ORI					Meeyero Creek							CHARLES NAGY**JOSEPH TCHIGG**FREDERICK MODCHIEDLER
P10839R	X	45	N	96	W	4	4	L12	0	ADJ	ORI					Windy Draw	11/1/1982						USDI BLM
C33/309A	X	45	N	96	W	8	15			ADJ	ORI							James Dickie			Hugh Dickie Ditch No. 1	IRR	
C66/489A	X	45	N	96	W	8	15			ADJ	ORI							Thomas A Baird			Hugh Dickie Ditch No. 1	IRR,STO,DOM	
P6729D	X	45	N	96	W	8	15			ADJ	ORI					Grass Creek	6/1/1905						THOMAS A. BAIRD
P1386E	X	45	N	96	W	11	1			PUD	ORI					Meeyero Creek	5/20/1905						AUGUST DEGRENON
C46/198A	X	45	N	96	W	13	8	L6		ADJ	ORI							Chas. B. Schweighart			Tenderfoot Ditch,, The First Enlargement of the	IRR,DOM	
C71/319A		45	N	96	W	13	4	L8	22.3	ADJ	ORI							Baird & Sons, Inc.			Hugh Dickie No. 2 Ditch,, Enl.	IRR	
C71/319A		45	N	96	W	13	8	L6	34.8	ADJ	ORI							Baird & Sons, Inc.			Hugh Dickie No. 2 Ditch,, Enl.	IRR	
C71/319A		45	N	96	W	13	7	L5	20	ADJ	ORI							Baird & Sons, Inc.			Hugh Dickie No. 2 Ditch,, Enl.	IRR	
C71/319A		45	N	96	W	13	3	L7	33.4	ADJ	ORI							Baird & Sons, Inc.			Hugh Dickie No. 2 Ditch,, Enl.	IRR	
P15811D		45	N	96	W	13	0			DSC	ORI				HES	Meeyero Creek	7/29/1920						J.H. CORCORAN
P15811D		45	N	96	W	13	0			PU	ORI				SD	Meeyero Creek	7/29/1920						J.H. CORCORAN
P6387E		45	N	96	W	13	4	L8	22.3	ADJ	ORI					Cottonwood Creek	4/1/1971						BAIRD AND SONS INC.
P6387E		45	N	96	W	13	3	L4	33.4	ADJ	ORI					Cottonwood Creek	4/1/1971						BAIRD AND SONS INC.
P6387E		45	N	96	W	13	8	L6	34.8	ADJ	ORI					Cottonwood Creek	4/1/1971						BAIRD AND SONS INC.

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P6387E		45	N	96	W	13	7	L5	20	ADJ	ORI					Cottonwood Creek	4/1/1971						BAIRD AND SONS INC.
C40/135A		45	N	96	W	14	10		28	ADJ	ORI							Ernest O. Akerman			Ackerman Ditch,, Enl.	IRR	
C52/119A		45	N	96	W	14	0	L6	19.5	ADJ	ORI							Ernest O. Ackerman	0.27	CFS	Ackerman Ditch,, Enl.	IRR	
C71/319A		45	N	96	W	14	11		4.6	ADJ	ORI							Baird & Sons, Inc.			Hugh Dickie No. 2 Ditch,, Enl.	IRR	
C71/319A		45	N	96	W	14	9		31.2	ADJ	ORI							Baird & Sons, Inc.			Hugh Dickie No. 2 Ditch,, Enl.	IRR	
C71/319A		45	N	96	W	14	7	L5	2.7	ADJ	ORI							Baird & Sons, Inc.			Hugh Dickie No. 2 Ditch,, Enl.	IRR	
C71/319A		45	N	96	W	14	10	L11	4.3	ADJ	ORI							Baird & Sons, Inc.			Hugh Dickie No. 2 Ditch,, Enl.	IRR	
P15811D	X	45	N	96	W	14	9			PUD	ORI					Meeyero Creek	7/29/1920						J.H. CORCORAN
P2961E		45	N	96	W	14	10		28	ADJ	ORI					Meeyero Creek	5/9/1914						
P4818E		45	N	96	W	14	8	L6	19.5	ADJ	ORI					Meeyero Creek	9/21/1932						ERNEST O. AKERMAN
P4818E	X	45	N	96	W	14	0	L5		PUH	ORI					Meeyero Creek	9/21/1932						ERNEST O. AKERMAN
P6387E		45	N	96	W	14	11		4.6	ADJ	ORI					Cottonwood Creek	4/1/1971						BAIRD AND SONS INC.
P6387E		45	N	96	W	14	9		31.2	ADJ	ORI					Cottonwood Creek	4/1/1971						BAIRD AND SONS INC.
P6387E		45	N	96	W	14	10	L11	4.3	ADJ	ORI					Cottonwood Creek	4/1/1971						BAIRD AND SONS INC.
P6387E		45	N	96	W	14	7	L5	2.7	ADJ	ORI					Cottonwood Creek	4/1/1971						BAIRD AND SONS INC.
P6387E	X	45	N	96	W	14	8	L6		PUH	ORI					Cottonwood Creek	4/1/1971						BAIRD AND SONS INC.
C40/134A		45	N	96	W	15	0	L14	32	TRA	ORI				HUGH DICKIE #2			Ernest O. Akerman			Ackerman Ditch	IRR	
C40/134A		45	N	96	W	15	0	L13	5	TRA	ORI				HUGH DICKIE #2			Ernest O. Akerman			Ackerman Ditch	IRR	
C40/134A		45	N	96	W	15	0	L16	20	TRA	ORI				HUGH DICKIE #2			Ernest O. Akerman			Ackerman Ditch	IRR	
C40/134A		45	N	96	W	15	0	L15	25	TRA	ORI				HUGH DICKIE #2			Ernest O. Akerman			Ackerman Ditch	IRR	
C40/135A		45	N	96	W	15	13		7	ADJ	ORI							Ernest O. Akerman			Ackerman Ditch,, Enl.	IRR	
P11822D		45	N	96	W	15	12		32	UNA	ORI					Meeyero Creek	5/2/1913						ERNEST O. ACKERMAN
P11822D		45	N	96	W	15	15		25	UNA	ORI					Meeyero Creek	5/2/1913						ERNEST O. ACKERMAN
P11822D		45	N	96	W	15	11		5	UNA	ORI					Meeyero Creek	5/2/1913						ERNEST O. ACKERMAN
P11822D		45	N	96	W	15	16		20	UNA	ORI					Meeyero Creek	5/2/1913						ERNEST O. ACKERMAN
P2961E	X	45	N	96	W	15	11			PUD	ORI					Meeyero Creek	5/9/1914						
P2961E	X	45	N	96	W	15	16			PUH	ORI					Meeyero Creek	5/9/1914						
P2961E		45	N	96	W	15	13		7	ADJ	ORI					Meeyero Creek	5/9/1914						
C33/303A		45	N	96	W	16	15		8	ADJ	ORI							James Dickie			Hugh Dickie Ditch No. 2	IRR	
C33/303A		45	N	96	W	16	11		5	ADJ	ORI							James Dickie			Hugh Dickie Ditch No. 2	IRR	
C33/303A		45	N	96	W	16	12		25	ADJ	ORI							James Dickie			Hugh Dickie Ditch No. 2	IRR	
C33/309A		45	N	96	W	16	10		23	ADJ	ORI							James Dickie	0.32	CFS	Hugh Dickie Ditch No. 1	IRR	
C33/309A		45	N	96	W	16	15		8	ADJ	SUP							James Dickie	0	CFS	Hugh Dickie Ditch No. 1	IRR	
C40/134A		45	N	96	W	16	15			DSC	ORI							Ernest O. Akerman			Ackerman Ditch	IRR	
C40/134A	X	45	N	96	W	16	15			PUD	ORI							Ernest O. Akerman			Ackerman Ditch	IRR	
C65/333A		45	N	96	W	16	16		13.8	ADJ	ORI							Thomas A. Baird			Hugh Dickie Ditch No. 2	IRR,STO,DOM	
C65/333A		45	N	96	W	16	15		16.8	ADJ	ORI							Thomas A. Baird			Hugh Dickie Ditch No. 2	IRR,STO,DOM	
C65/333A		45	N	96	W	16	12		6	ADJ	ORI							Thomas A. Baird			Hugh Dickie Ditch No. 2	IRR,STO,DOM	
C66/489A		45	N	96	W	16	9		23	ADJ	ORI							Thomas A Baird			Hugh Dickie Ditch No. 1	IRR,STO,DOM	
C66/489A		45	N	96	W	16	10		5.8	ADJ	ORI							Thomas A Baird			Hugh Dickie Ditch No. 1	IRR,STO,DOM	
C66/489A		45	N	96	W	16	11		2	ADJ	ORI							Thomas A Baird			Hugh Dickie Ditch No. 1	IRR,STO,DOM	
C66/489A		45	N	96	W	16	12		1	ADJ	ORI							Thomas A Baird			Hugh Dickie Ditch No. 1	IRR,STO,DOM	
C70/051A		45	N	96	W	16	14		6	ADJ	ORI							Baird & Sons, Inc. & State Board of Land Commissioners	0.09	CFS	Hugh Dickie Ditch No. 2,, Enl.	IRR	
C80/415A		45	N	96	W	16	9		9	ADJ	SUP							Baird and Sons, Inc.	0	CFS	Hugh Dickie Ditch No. 2	IRR	
C82/106A		45	N	96	W	16	11		4.1	ADJ	ORI							Baird and Sons, Inc.			Kirby Ditch (acipt Hugh Dickie No. 2 Ditch)	IRR	
C82/106A		45	N	96	W	16	16		6.2	ADJ	ORI							Baird and Sons, Inc.			Kirby Ditch (acipt Hugh Dickie No. 2 Ditch)	IRR	
C82/106A		45	N	96	W	16	11		4.1	ADJ	ORI							Baird and Sons, Inc.			Kirby Ditch (acipt Hugh Dickie No. 2 Ditch)	IRR	
C82/106A		45	N	96	W	16	16		6.2	ADJ	ORI							Baird and Sons, Inc.			Kirby Ditch (acipt Hugh Dickie No. 2 Ditch)	IRR	
P11822D	X	45	N	96	W	16	16			PUD	ORI					Meeyero Creek	5/2/1913						ERNEST O. ACKERMAN
P4818E	X	45	N	96	W	16	15			PUD	ORI					Meeyero Creek	9/21/1932						ERNEST O. AKERMAN
P6273E		45	N	96	W	16	14		6	ADJ	ORI					Cottonwood Creek	12/28/1966						GAME & FISH COMM., STATE OF WYOMING** BAIRD & SONS
P6728D		45	N	96	W	16	9		9	ADJ	SUP					Cottonwood Creek	6/1/1905						THOMAS A. BAIRD
P6728D		45	N	96	W	16	15		16.8	ADJ	ORI				C65/333A	Cottonwood Creek	6/1/1905						THOMAS A. BAIRD
P6728D		45	N	96	W	16	15		8	ADJ	ORI				C33/303A	Cottonwood Creek	6/1/1905						THOMAS A. BAIRD
P6728D		45	N	96	W	16					SUP					Cottonwood Creek	6/1/1905						THOMAS A. BAIRD
P6728D		45	N	96	W	16	12		25	ADJ	ORI				C33/303A	Cottonwood Creek	6/1/1905						THOMAS A. BAIRD
P6728D		45	N	96	W	16	9		6	ELI	SUP					Cottonwood Creek	6/1/1905						THOMAS A. BAIRD

Permit #	Location	Township	Twp Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P6728D		45	N	96	W	16	15		15.2	ELI	ORI					Cottonwood Creek	6/1/1905						THOMAS A. BAIRD
P6728D		45	N	96	W	16	12		8	ELI	ORI					Cottonwood Creek	6/1/1905						THOMAS A. BAIRD
P6728D		45	N	96	W	16	16		13.8	ADJ	ORI				C65/333A	Cottonwood Creek	6/1/1905						THOMAS A. BAIRD
P6728D		45	N	96	W	16	11		15	ELI	ORI					Cottonwood Creek	6/1/1905						THOMAS A. BAIRD
P6728D		45	N	96	W	16	16		21.2	ELI	ORI					Cottonwood Creek	6/1/1905						THOMAS A. BAIRD
P6728D		45	N	96	W	16	11		5	ADJ	ORI				C33/303A	Cottonwood Creek	6/1/1905						THOMAS A. BAIRD
P6728D		45	N	96	W	16	12		6	ADJ	ORI				C65/333A	Cottonwood Creek	6/1/1905						THOMAS A. BAIRD
P6729D		45	N	96	W	16	12		39	ELI	SUP					Grass Creek	6/1/1905						THOMAS A. BAIRD
P6729D		45	N	96	W	16	11		2	ADJ	ORI					Grass Creek	6/1/1905						THOMAS A. BAIRD
P6729D		45	N	96	W	16	9		23	ADJ	ORI					Grass Creek	6/1/1905						THOMAS A. BAIRD
P6729D		45	N	96	W	16	9		7	ELI	ORI					Grass Creek	6/1/1905						THOMAS A. BAIRD
P6729D		45	N	96	W	16	9		23	ADJ	SUP					Grass Creek	6/1/1905						THOMAS A. BAIRD
P6729D		45	N	96	W	16	10		23	UNA	ORI					Grass Creek	6/1/1905						THOMAS A. BAIRD
P6729D		45	N	96	W	16	15		8	ADJ	SUP					Grass Creek	6/1/1905						THOMAS A. BAIRD
P6729D		45	N	96	W	16	10		5.8	ADJ	ORI					Grass Creek	6/1/1905						THOMAS A. BAIRD
P6729D		45	N	96	W	16	14		6	ELI	ORI					Grass Creek	6/1/1905						THOMAS A. BAIRD
P6729D		45	N	96	W	16	10		8.2	ELI	ORI					Grass Creek	6/1/1905						THOMAS A. BAIRD
P6729D		45	N	96	W	16	16		35	ELI	SUP					Grass Creek	6/1/1905						THOMAS A. BAIRD
P6729D		45	N	96	W	16	11		20	ELI	SUP					Grass Creek	6/1/1905						THOMAS A. BAIRD
P6729D		45	N	96	W	16	15		32	ELI	SUP					Grass Creek	6/1/1905						THOMAS A. BAIRD
P6729D		45	N	96	W	16	12		1	ADJ	ORI					Grass Creek	6/1/1905						THOMAS A. BAIRD
P6729D		45	N	96	W	16	7		5	ELI	ORI					Grass Creek	6/1/1905						THOMAS A. BAIRD
P32275D	X	45	N	96	W	17	11		0	UNA	ORI					Cottonwood Creek	5/22/2000						HOT SPRINGS COUNTY ROAD & BRIDGE
C41/101A	X	45	N	96	W	19	7	L7		PUD	ORI							Bessie Coleman			Kirby Ditch	IRR,DOM	
C41/685A	X	45	N	96	W	19	7	L7		PUD	ORI							Ole Johnson			Kirby Ditch	IRR	
C47/154A	X	45	N	96	W	19	7			AME	ORI							J. B. Mayfield			Kirby Ditch	IRR	
C47/155A	X	45	N	96	W	19	7			AME	ORI							J. B. Mayfield			Kirby Ditch	IRR	
C47/496A	X	45	N	96	W	19	7			AME	ORI							Ernest O. Ackerman			Kirby Ditch	IRR	
C47/497A	X	45	N	96	W	19	7	L7		AME	ORI							Algot W. Johnson			Kirby Ditch	IRR	
P10447D		45	N	96	W	19	1		32	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D	X	45	N	96	W	19	7	L7		ADJ	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	19	2		12	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P27614D	X	45	N	96	W	19	3			PUD	ORI					Cottonwood Creek	5/13/1982						LARRY L. KING
P4979E	X	45	N	96	W	19	7	L7		UNA	ORI					Cottonwood Creek	1/22/1934						HESTER O. DAVIS
P9727D	X	45	N	96	W	19	10			PUD	ORI					Cottonwood Creek	4/28/1910						L.R. KIRBY**OLE JOHNSON** GUTHERIE Z.C.**DAVID M. RICHMOND
C33/303A	X	45	N	96	W	20	1			ADJ	ORI							James Dickie			Hugh Dickie Ditch No. 2	IRR	
C65/333A	X	45	N	96	W	20	1			ADJ	ORI							Thomas A. Baird			Hugh Dickie Ditch No. 2	IRR,STO,DOM	
C70/051A		45	N	96	W	20	0	L1		DSC	ORI							Baird & Sons, Inc. & State Board of Land Commissioners			Hugh Dickie Ditch No. 2,, Enl.	IRR	
C71/319A	X	45	N	96	W	20	1	L1		PUD	ORI							Baird & Sons, Inc.			Hugh Dickie No. 2 Ditch,, Enl.	IRR	
C76/286A		45	N	96	W	20	0	L8	29	ADJ	ORI							John L. and Virginia A. Baird			Kirby Ditch,, Enl.	IRR	
C76/286A		45	N	96	W	20	0	L7	32	ADJ	ORI							John L. and Virginia A. Baird			Kirby Ditch,, Enl.	IRR	
C76/286A		45	N	96	W	20	0	L5	23	ADJ	ORI							John L. and Virginia A. Baird			Kirby Ditch,, Enl.	IRR	
C76/286A		45	N	96	W	20	0	L6	31.5	ADJ	ORI							John L. and Virginia A. Baird			Kirby Ditch,, Enl.	IRR	
C80/415A	X	45	N	96	W	20	1			ADJ	SUP							Baird and Sons, Inc.			Hugh Dickie Ditch No. 2	IRR	
C82/106A	X	45	N	96	W	20	1	L1	0	ADJ	ORI		L1					Baird and Sons, Inc.			Kirby Ditch (aclpt Hugh Dickie No. 2 Ditch)	IRR	
C82/106A	X	45	N	96	W	20	1	L1	0	ADJ	ORI		L1					Baird and Sons, Inc.			Kirby Ditch (aclpt Hugh Dickie No. 2 Ditch)	IRR	
P10447D		45	N	96	W	20	0	L7	32	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	20	0	L8	29	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P10447D		45	N	96	W	20	0	L6	31.5	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	20	2	L2	23	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	20	16	L16	18	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	20	0	L5	23	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	20	1	L1	23	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	20	6	L4	24	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	20	13	L9	1.5	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	20	5	L3	31	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P6273E	X	45	N	96	W	20	1	L1		PUD	ORI					Cottonwood Creek	12/28/1966						GAME & FISH COMM., STATE OF WYOMING** BAIRD & SONS
P6273E	X	45	N	96	W	20	1	L1		PUH	ORI					Cottonwood Creek	12/28/1966						GAME & FISH COMM., STATE OF WYOMING** BAIRD & SONS
P6387E	X	45	N	96	W	20	1	L1		PUD	ORI					Cottonwood Creek	4/1/1971						BAIRD AND SONS INC.
P6728D	X	45	N	96	W	20	1			ADJ	ORI					Cottonwood Creek	6/1/1905						THOMAS A. BAIRD
P6745E		45	N	96	W	20	0	L6	31.5	ADJ	ORI					Cottonwood Creek	7/6/1976						JOHN BAIRD** BAIRD AND SONS INC.
P6745E		45	N	96	W	20	0	L7	32	ADJ	ORI					Cottonwood Creek	7/6/1976						JOHN BAIRD** BAIRD AND SONS INC.
P6745E		45	N	96	W	20	0	L5	23	ADJ	ORI					Cottonwood Creek	7/6/1976						JOHN BAIRD** BAIRD AND SONS INC.
P6745E		45	N	96	W	20	0	L8	29	ADJ	ORI					Cottonwood Creek	7/6/1976						JOHN BAIRD** BAIRD AND SONS INC.
P7057E		45	N	96	W	20	16	L16	18	UNA	ORI					Cottonwood Creek	4/22/1992						HAROLD B. AND GENEVA M. SWING
P7057E		45	N	96	W	20	13	L9	1.5	UNA	ORI					Cottonwood Creek	4/22/1992						HAROLD B. AND GENEVA M. SWING
C47/155A		45	N	96	W	21	12	L14	40	ADJ	ORI							J. B. Mayfield			Kirby Ditch	IRR	
C47/155A		45	N	96	W	21	11	L13	35	ADJ	ORI							J. B. Mayfield			Kirby Ditch	IRR	
C47/155A		45	N	96	W	21	9	L11	40	ADJ	ORI							J. B. Mayfield			Kirby Ditch	IRR	
C47/496A		45	N	96	W	21	1	L1	38	ADJ	ORI							Ernest O. Ackerman			Kirby Ditch	IRR	
C47/496A		45	N	96	W	21	2	L2	39	ADJ	ORI							Ernest O. Ackerman			Kirby Ditch	IRR	
C47/496A		45	N	96	W	21	3	L7	24	ADJ	ORI							Ernest O. Ackerman			Kirby Ditch	IRR	
C47/497A		45	N	96	W	21	8	L6	39	ADJ	ORI							Algot W. Johnson			Kirby Ditch	IRR	
C47/497A		45	N	96	W	21	7	L5	32	ADJ	ORI							Algot W. Johnson			Kirby Ditch	IRR	
C47/497A		45	N	96	W	21	5	L3	33	ADJ	ORI							Algot W. Johnson			Kirby Ditch	IRR	
C47/497A		45	N	96	W	21	6	L4	37	ADJ	ORI							Algot W. Johnson			Kirby Ditch	IRR	
C82/106A		45	N	96	W	21	1	L1	27.9	ADJ	ORI		L1					Baird and Sons, Inc.			Kirby Ditch (acipt Hugh Dickie No. 2 Ditch)	IRR	
C82/106A		45	N	96	W	21	1	L1	27.9	ADJ	ORI		L1					Baird and Sons, Inc.			Kirby Ditch (acipt Hugh Dickie No. 2 Ditch)	IRR	
C82/106A		45	N	96	W	21	3	L7	23.8	ADJ	ORI		L7					Baird and Sons, Inc.			Kirby Ditch (acipt Hugh Dickie No. 2 Ditch)	IRR	
C82/106A		45	N	96	W	21	2	L2	39	ADJ	ORI		L2					Baird and Sons, Inc.			Kirby Ditch (acipt Hugh Dickie No. 2 Ditch)	IRR	
C82/106A		45	N	96	W	21	2	L2	39	ADJ	ORI		L2					Baird and Sons, Inc.			Kirby Ditch (acipt Hugh Dickie No. 2 Ditch)	IRR	
C82/106A		45	N	96	W	21	3	L7	23.8	ADJ	ORI		L7					Baird and Sons, Inc.			Kirby Ditch (acipt Hugh Dickie No. 2 Ditch)	IRR	
P10447D		45	N	96	W	21	2	L2	39	ADJ	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	21	8	L6	39	ADJ	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P10447D		45	N	96	W	21	7	L5	22	ADJ	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	21	10	L12	22	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	21	7	L5	10	ADJ	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	21	8	L6	1	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	21	12	L14	40	ADJ	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	21	6	L4	37	ADJ	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	21	14	L10	37	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	21	9	L11	40	ADJ	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	21	15	L15	25.5	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	21	11	L13	5	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	21	1	L1	38	ADJ	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	21	5	L3	33	ADJ	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	21	3	L7	24	ADJ	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	21	11	L13	35	ADJ	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P4979E		45	N	96	W	21	14	L10	18	UNA	ORI					Cottonwood Creek	1/22/1934						HESTER O. DAVIS
P4979E		45	N	96	W	21	15	L15	18	UNA	ORI					Cottonwood Creek	1/22/1934						HESTER O. DAVIS
P6804E		45	N	96	W	21	0	L15	25.5	UNA	ORI					Cottonwood Creek	7/11/1985						DARVELL J. & SHARON L. HENRICKS
P6804E		45	N	96	W	21	0	L10	37	UNA	ORI					Cottonwood Creek	7/11/1985						DARVELL J. & SHARON L. HENRICKS
P7057E		45	N	96	W	21	11	L13	5	UNA	ORI					Cottonwood Creek	4/22/1992						HAROLD B. AND GENEVA M. SWING
P7057E		45	N	96	W	21	10	L12	22	UNA	ORI					Cottonwood Creek	4/22/1992						HAROLD B. AND GENEVA M. SWING
P10447D		45	N	96	W	22	6	L4	26	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	22	5	L3	14	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P6745E		45	N	96	W	22	0	L4	26	UNA	ORI					Cottonwood Creek	7/6/1976						JOHN BAIRD** BAIRD AND SONS INC.
P6745E		45	N	96	W	22	0	L3	14	UNA	ORI					Cottonwood Creek	7/6/1976						JOHN BAIRD** BAIRD AND SONS INC.
C82/106A	X	45	N	96	W	24	13		0	ADJ	ORI							Baird and Sons, Inc.			Kirby Ditch (acipt Hugh Dickie No. 2 Ditch)	IRR	
C82/106A	X	45	N	96	W	24	13		0	ADJ	ORI							Baird and Sons, Inc.			Kirby Ditch (acipt Hugh Dickie No. 2 Ditch)	IRR	
C47/154A		45	N	96	W	28	7	L5	32	ADJ	ORI							J. B. Mayfield			Kirby Ditch	IRR	
C47/154A		45	N	96	W	28	10	L12	11.5	ADJ	ORI							J. B. Mayfield			Kirby Ditch	IRR	
C47/155A		45	N	96	W	28	6	L4	36	ADJ	ORI							J. B. Mayfield			Kirby Ditch	IRR	
P10447D		45	N	96	W	28	7	L5	32	ADJ	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P10447D		45	N	96	W	28	0			DSC	ORI				LANDS FROM P9727D	Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	28	6	L4	4	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	28	10	L12	11.5	ADJ	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	28	5	L3	21	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	28	6	L4	36	ADJ	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P27614D		45	N	96	W	28	0	L6		DSC	ORI				WELL #28 10 FED	Cottonwood Creek	5/13/1982						LARRY L. KING
P27614D		45	N	96	W	28	0			PU	ORI				X	Cottonwood Creek	5/13/1982						LARRY L. KING
P4979E	X	45	N	96	W	28	5	L3	21	UNA	ORI					Cottonwood Creek	1/22/1934						HESTER O. DAVIS
P4979E		45	N	96	W	28	2	L2	1	UNA	ORI					Cottonwood Creek	1/22/1934						HESTER O. DAVIS
P6804E		45	N	96	W	28	0	L2	1	UNA	ORI					Cottonwood Creek	7/11/1985						DARVELL J. & SHARON L. HENRICKS
P6804E		45	N	96	W	28	0	L3	21	UNA	ORI					Cottonwood Creek	7/11/1985						DARVELL J. & SHARON L. HENRICKS
P7057E		45	N	96	W	28	6	L4	4	UNA	ORI					Cottonwood Creek	4/22/1992						HAROLD B. AND GENEVA M. SWING
C82/092A		45	N	96	W	29	13	L9	16.6	ADJ	ORI							Harold B. and Geneva M. Swing	0.24	CFS	Kirby Ditch,, Enl.	IRR	
P10447D		45	N	96	W	29	4	L8	9.5	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	29	1	L1	11.5	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	29	4	L8	15	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P10447D		45	N	96	W	29	1	L1	20	ELI	ORI					Cottonwood Creek	12/15/1910						L. R. KIRBY**OLE JOHNSON**Z. C. GUTHRIE**DAVID M. RICHMOND
P6746E		45	N	96	W	29	13	L9	16.6	ADJ	ORI					Cottonwood Creek	6/30/1983						ELLEN S. SANDERLIN
P7057E		45	N	96	W	29	1	L1	31.5	UNA	ORI					Cottonwood Creek	4/22/1992						HAROLD B. AND GENEVA M. SWING
P7057E		45	N	96	W	29	4	L8	24.5	UNA	ORI					Cottonwood Creek	4/22/1992						HAROLD B. AND GENEVA M. SWING
P2130R		45	N	97	W	1	6			PU	ORI				P	Grass Creek	3/27/1911						JAMES DICKIE
P3585D	X	45	N	97	W	1	4			PUD	ORI					Grass Creek	12/16/1901						FRED ZIMMERMAN
P2130R		45	N	97	W	2	1			PU	ORI				P	Grass Creek	3/27/1911						JAMES DICKIE
P28214D		45	N	97	W	16	4			DSC	ORI				STATE 1 16	Cottonwood Creek	10/12/1983						AAA TRUCKING INC.**WYO BOARD OF LAND COMMISSIONERS
P28214D		45	N	97	W	16	4			PU	ORI				X	Cottonwood Creek	10/12/1983						AAA TRUCKING INC.**WYO BOARD OF LAND COMMISSIONERS
P24813D		45	N	97	W	23	2			PU	ORI				X	Cottonwood Creek	8/25/1975						FULTON PRODUCING COMPANY
P687R		45	N	97	W	23	3			PU	ORI				P	Cottonwood Creek	6/5/1905						CHARLES C. RUFF
P687R		45	N	97	W	23	4			PU	ORI				P	Cottonwood Creek	6/5/1905						CHARLES C. RUFF
P687R	X	45	N	97	W	23	4			PUO	ORI					Cottonwood Creek	6/5/1905						CHARLES C. RUFF
P687R		45	N	97	W	23	13			PU	ORI				P	Cottonwood Creek	6/5/1905						CHARLES C. RUFF
P7859D		45	N	97	W	23	12		32.5	ELI	ORI					Cottonwood Creek	6/13/1907						THE COTTONWOOD DITCH CO.
C47/154A	X	45	N	97	W	24	13			ADJ	ORI							J. B. Mayfield			Kirby Ditch	IRR	
C47/155A	X	45	N	97	W	24	13			ADJ	ORI							J. B. Mayfield			Kirby Ditch	IRR	
C47/496A	X	45	N	97	W	24	13			ADJ	ORI							Ernest O. Ackerman			Kirby Ditch	IRR	
C47/497A	X	45	N	97	W	24	13			ADJ	ORI							Algot W. Johnson			Kirby Ditch	IRR	
C76/286A	X	45	N	97	W	24	13			PUD	ORI							John L. and Virginia A. Baird			Kirby Ditch,, Enl.	IRR	
C82/092A	X	45	N	97	W	24	13		0	ADJ	ORI				X			Harold B. and Geneva M. Swing			Kirby Ditch,, Enl.	IRR	
P6745E	X	45	N	97	W	24	13				ORI					Cottonwood Creek	7/6/1976						JOHN BAIRD** BAIRD AND SONS INC.
P6746E	X	45	N	97	W	24	13			ADJ	ORI				X	Cottonwood Creek	6/30/1983						ELLEN S. SANDERLIN
P6746E	X	45	N	97	W	24	13			ADJ	ORI				X	Cottonwood Creek	6/30/1983						ELLEN S. SANDERLIN
P6804E	X	45	N	97	W	24	13			PUD	ORI					Cottonwood Creek	7/11/1985						DARVELL J. & SHARON L. HENRICKS
P6804E	X	45	N	97	W	24	13			PUH	ORI					Cottonwood Creek	7/11/1985						DARVELL J. & SHARON L. HENRICKS

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P7057E	X	45	N	97	W	24	13			UNA	ORI					Cottonwood Creek	4/22/1992						HAROLD B. AND GENEVA M. SWING
P7859D		45	N	97	W	24	3		40	ELI	ORI					Cottonwood Creek	6/13/1907						THE COTTONWOOD DITCH CO.
P7859D		45	N	97	W	24	13		17	ELI	ORI					Cottonwood Creek	6/13/1907						THE COTTONWOOD DITCH CO.
P7859D		45	N	97	W	24	14		14.7	ELI	ORI					Cottonwood Creek	6/13/1907						THE COTTONWOOD DITCH CO.
P7859D		45	N	97	W	24	4		39.5	ELI	ORI					Cottonwood Creek	6/13/1907						THE COTTONWOOD DITCH CO.
P8861D		45	N	97	W	24	14		14	ADJ	ORI					Cottonwood Creek	1/13/1909						FLOYD E. VALLEAU
P8861D	X	45	N	97	W	24	9			ADJ	ORI					Cottonwood Creek	1/13/1909						FLOYD E. VALLEAU
P8861D		45	N	97	W	24	13		18	ADJ	ORI					Cottonwood Creek	1/13/1909						FLOYD E. VALLEAU
P8877D	X	45	N	97	W	24	10			PUD	ORI					Cottonwood Creek	1/13/1909						DAVID M. RICHMOND**CHARLES I. HERBAGE**FLOYD E. VALLEAU
P24813D	X	45	N	97	W	26	7			PUD	ORI					Cottonwood Creek	8/25/1975						FULTON PRODUCING COMPANY
P28214D	X	45	N	97	W	26	7			PUD	ORI					Cottonwood Creek	10/12/1983						AAA TRUCKING INC.**WYO BOARD OF LAND COMMISSIONERS
P29596D		45	N	97	W	26	6			PU	ORI				X	Cottonwood Creek	2/3/1987						WYOMING STATE HIGHWAY DEPARTMENT
P29596D	X	45	N	97	W	26	6			PUD	ORI					Cottonwood Creek	2/3/1987						WYOMING STATE HIGHWAY DEPARTMENT
P29596D		45	N	97	W	26	7			PU	ORI				X	Cottonwood Creek	2/3/1987						WYOMING STATE HIGHWAY DEPARTMENT
P7859D		45	N	97	W	26	6		37	ELI	ORI					Cottonwood Creek	6/13/1907						THE COTTONWOOD DITCH CO.
P7859D		45	N	97	W	26	5		13	ELI	ORI					Cottonwood Creek	6/13/1907						THE COTTONWOOD DITCH CO.
C44/286A		45	N	97	W	27	2		30	ADJ	ORI							Sam Burnstein and Sam Loeb			Cottonwood Ditch	IRR	
C44/286A		45	N	97	W	27	8		17	ADJ	ORI							Sam Burnstein and Sam Loeb			Cottonwood Ditch	IRR	
C44/286A		45	N	97	W	27	3		10	ADJ	ORI							Sam Burnstein and Sam Loeb			Cottonwood Ditch	IRR	
C44/286A		45	N	97	W	27	5		21	ADJ	ORI							Sam Burnstein and Sam Loeb			Cottonwood Ditch	IRR	
C44/287A		45	N	97	W	27	7		9.6	ADJ	ORI							Sam Loeb	0.13	CFS	Cottonwood Ditch,, Enl.	IRR,DOM	
C44/692A		45	N	97	W	27	15		40	ADJ	ORI							Burnstein & Loeb			German Ditch,, Enl.	IRR	
C44/692A		45	N	97	W	27	16		40	ADJ	ORI							Burnstein & Loeb			German Ditch,, Enl.	IRR	
C44/693A		45	N	97	W	27	12		40	ADJ	ORI							Samuel Loeb			German Ditch,, Enl.	IRR	
C44/693A		45	N	97	W	27	14		40	ADJ	ORI							Samuel Loeb			German Ditch,, Enl.	IRR	
C44/693A		45	N	97	W	27	9		40	ADJ	ORI							Samuel Loeb			German Ditch,, Enl.	IRR	
C44/693A		45	N	97	W	27	11		40	ADJ	ORI							Samuel Loeb			German Ditch,, Enl.	IRR	
P2818E		45	N	97	W	27	15		40	ADJ	ORI					Cottonwood Creek	5/31/1913						JOHN A. & AUGUST STIEGELE
P2818E		45	N	97	W	27	16		40	ADJ	ORI					Cottonwood Creek	5/31/1913						JOHN A. & AUGUST STIEGELE
P29596D		45	N	97	W	27	14			PU	ORI				X	Cottonwood Creek	2/3/1987						WYOMING STATE HIGHWAY DEPARTMENT
P29596D		45	N	97	W	27	14			DSC	ORI				PLANT SITE	Cottonwood Creek	2/3/1987						WYOMING STATE HIGHWAY DEPARTMENT
P3016E		45	N	97	W	27	12		40	ADJ	ORI					Cottonwood Creek	8/15/1914						SAMUEL LOEB
P3016E		45	N	97	W	27	14		40	ADJ	ORI					Cottonwood Creek	8/15/1914						SAMUEL LOEB
P3016E		45	N	97	W	27	9		40	ADJ	ORI					Cottonwood Creek	8/15/1914						SAMUEL LOEB
P3016E		45	N	97	W	27	11		40	ADJ	ORI					Cottonwood Creek	8/15/1914						SAMUEL LOEB
P3530E		45	N	97	W	27	7		9.6	ADJ	ORI					Cottonwood Creek	10/12/1915						JOHN WAUGH
P7859D		45	N	97	W	27	3		10	ADJ	ORI					Cottonwood Creek	6/13/1907						THE COTTONWOOD DITCH CO.
P7859D		45	N	97	W	27	8		0.5	ELI	ORI					Cottonwood Creek	6/13/1907						THE COTTONWOOD DITCH CO.
P7859D		45	N	97	W	27	5		21	ADJ	ORI					Cottonwood Creek	6/13/1907						THE COTTONWOOD DITCH CO.
P7859D		45	N	97	W	27	1		26	ELI	ORI					Cottonwood Creek	6/13/1907						THE COTTONWOOD DITCH CO.
P7859D		45	N	97	W	27	8		17	ADJ	ORI					Cottonwood Creek	6/13/1907						THE COTTONWOOD DITCH CO.
P7859D		45	N	97	W	27	2		30	ADJ	ORI					Cottonwood Creek	6/13/1907						THE COTTONWOOD DITCH CO.
C44/286A	X	45	N	97	W	28	4			ADJ	ORI							Sam Burnstein and Sam Loeb			Cottonwood Ditch	IRR	
C44/287A	X	45	N	97	W	28	4			PUD	ORI							Sam Loeb			Cottonwood Ditch,, Enl.	IRR,DOM	
P3530E	X	45	N	97	W	28	4			PUD	ORI					Cottonwood Creek	10/12/1915						JOHN WAUGH
P3803E	X	45	N	97	W	28	4			PUH	ORI					Cottonwood Creek	7/21/1917						JOHN WAUGH
P3803E	X	45	N	97	W	28	4			PUD	ORI					Cottonwood Creek	7/21/1917						JOHN WAUGH
P7859D	X	45	N	97	W	28	4			ADJ	ORI					Cottonwood Creek	6/13/1907						THE COTTONWOOD DITCH CO.
C38/798A		45	N	97	W	31	15		31	ADJ	ORI							Frank Thomale			Caledonia Ditch	IRR,DOM	
C38/798A		45	N	97	W	31	16		8	ADJ	ORI							Frank Thomale			Caledonia Ditch	IRR,DOM	
C38/798A		45	N	97	W	31	12		10	ADJ	ORI							Frank Thomale			Caledonia Ditch	IRR,DOM	
C38/799A		45	N	97	W	31	15		9	ADJ	ORI							Frank Thomale			Caledonia Ditch,, Enl.	IRR,DOM	
C38/799A		45	N	97	W	31	12		30	ADJ	ORI							Frank Thomale			Caledonia Ditch,, Enl.	IRR,DOM	
C57/357A		45	N	97	W	31	11	L4	38	ADJ	ORI							Joseph Romagno	0.54	CFS	Caledonia Ditch,, Enl.	IRR,STO,DOM	
C57/358A		45	N	97	W	31	11	L4	1	ADJ	ORI							Joseph Romagno			Calodonia Ditch,, Enl.	IRR	
C57/358A		45	N	97	W	31	7	L2	36	ADJ	ORI							Joseph Romagno			Calodonia Ditch,, Enl.	IRR	

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
C57/358A		45	N	97	W	31	10	L3	2	ADJ	ORI							Joseph Romagno			Calodonia Ditch,, Enl.	IRR	
P10306D	X	45	N	97	W	31	1			PUD	ORI					Wagonhound Creek	10/10/1910						JOHN A. STIEGELE**AUGUST STIEGELE
P2910E		45	N	97	W	31	15		9	ADJ	ORI					Cottonwood Creek	1/17/1914						FRANK HAYNES
P2910E		45	N	97	W	31	12		30	ADJ	ORI					Cottonwood Creek	1/17/1914						FRANK HAYNES
P4750E		45	N	97	W	31	11	L4	38	ADJ	ORI					Cottonwood Creek	11/28/1930						JOE ROMAGNO
P5206E		45	N	97	W	31	11	L4	1	ADJ	ORI					Cottonwood Creek	12/4/1935						JOSEPH ROMAGNO
P5206E		45	N	97	W	31	10	L3	2	ADJ	ORI					Cottonwood Creek	12/4/1935						JOSEPH ROMAGNO
P5206E		45	N	97	W	31	7	L2	36	ADJ	ORI					Cottonwood Creek	12/4/1935						JOSEPH ROMAGNO
P8434D		45	N	97	W	31	15		31	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		45	N	97	W	31	12		10	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		45	N	97	W	31	16		8	ADJ	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
P8434D		45	N	97	W	31	16		30	ELI	ORI					Cottonwood Creek	10/21/1907						SAMUEL GWYNN**WILLIAM GWYNN**FRANK HAYNES**AARON HAYNES**JACOB VOGLET**FRANK THAMALE
C34/296A		45	N	97	W	32	12		21	ADJ	ORI							Fred Wales			Wales Ditch	IRR,DOM	
C34/296A		45	N	97	W	32	9		34	ADJ	ORI							Fred Wales			Wales Ditch	IRR,DOM	
C34/296A		45	N	97	W	32	10		28	ADJ	ORI							Fred Wales			Wales Ditch	IRR,DOM	
C34/296A		45	N	97	W	32	11		26	ADJ	ORI							Fred Wales			Wales Ditch	IRR,DOM	
C39/002A	X	45	N	97	W	32	4			PUD	ORI							John Stiegele			German Ditch,, Enl.	IRR,DOM	
C44/691A	X	45	N	97	W	32	4			PUD	ORI							Burnstein & Loeb			German Ditch	IRR	
C44/692A	X	45	N	97	W	32	4			PUD	ORI							Burnstein & Loeb			German Ditch,, Enl.	IRR	
C44/693A	X	45	N	97	W	32	4			PUD	ORI							Samuel Loeb			German Ditch,, Enl.	IRR	
C71/098A		45	N	97	W	32	11		26	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch	IRR,STO	
C71/098A		45	N	97	W	32	9		34	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch	IRR,STO	
C71/098A		45	N	97	W	32	10		28	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch	IRR,STO	
C71/098A		45	N	97	W	32	12		21	ADJ	SUP							Rhodes Ranch Inc.			Wales No. 2 Ditch	IRR,STO	
P10306D	X	45	N	97	W	32	4			PUD	ORI					Wagonhound Creek	10/10/1910						JOHN A. STIEGELE**AUGUST STIEGELE
P10307D	X	45	N	97	W	32	4			PUD	ORI					Cottonwood Creek	12/15/1910						JOHN A. & AUGUST STIEGELE
P23400D		45	N	97	W	32	12		21	ADJ	SUP					Wales Draw	10/21/1960						INC. RHODES RANCH
P23400D		45	N	97	W	32	11		26	ADJ	SUP					Wales Draw	10/21/1960						INC. RHODES RANCH
P23400D		45	N	97	W	32	9		34	ADJ	SUP					Wales Draw	10/21/1960						INC. RHODES RANCH
P23400D		45	N	97	W	32	10		28	ADJ	SUP					Wales Draw	10/21/1960						INC. RHODES RANCH
P25193D	X	45	N	97	W	32	1			PUD	ORI					Cottonwood Creek	9/14/1976						WYOMING STATE HIGHWAY DEPARTMENT
P25193D		45	N	97	W	32	7			PU	ORI				X	Cottonwood Creek	9/14/1976						WYOMING STATE HIGHWAY DEPARTMENT
P2818E	X	45	N	97	W	32	4			PUD	ORI					Cottonwood Creek	5/31/1913						JOHN A. & AUGUST STIEGELE
P2818E	X	45	N	97	W	32	4			PUH	ORI					Cottonwood Creek	5/31/1913						JOHN A. & AUGUST STIEGELE
P3016E	X	45	N	97	W	32	4			PUD	ORI					Cottonwood Creek	8/15/1914						SAMUEL LOEB
P3016E	X	45	N	97	W	32	4			PUH	ORI					Cottonwood Creek	8/15/1914						SAMUEL LOEB
P6627E		45	N	97	W	32	1			PU	ORI				X	Cottonwood Creek	2/14/1978						WYOMING STATE HIGHWAY DEPARTMENT
P6627E	X	45	N	97	W	32	1			PUD	ORI					Cottonwood Creek	2/14/1978						WYOMING STATE HIGHWAY DEPARTMENT
P6627E	X	45	N	97	W	32	1			PUH	ORI					Cottonwood Creek	2/14/1978						WYOMING STATE HIGHWAY DEPARTMENT
P8220D		45	N	97	W	32	11		26	ADJ	SEC					Cottonwood Creek	2/13/1908						FRED WALES
P8220D		45	N	97	W	32	9		34	ADJ	SEC					Cottonwood Creek	2/13/1908						FRED WALES
P8220D		45	N	97	W	32	12		21	ADJ	SEC					Cottonwood Creek	2/13/1908						FRED WALES
P8220D		45	N	97	W	32	10		28	ADJ	SEC					Cottonwood Creek	2/13/1908						FRED WALES
P9306D	X	45	N	97	W	32	14			PUD	ORI					Cottonwood Creek	8/6/1909						JOHN STIEGELE
C39/002A		45	N	97	W	34	5		16	ADJ	ORI							John Stiegele			German Ditch,, Enl.	IRR,DOM	
C39/002A		45	N	97	W	34	8		10	ADJ	ORI							John Stiegele			German Ditch,, Enl.	IRR,DOM	
C44/691A		45	N	97	W	34	3		21	ADJ	ORI							Burnstein & Loeb			German Ditch	IRR	

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
C44/691A		45	N	97	W	34	1		40	ADJ	ORI							Burnstein & Loeb			German Ditch	IRR	
C44/691A		45	N	97	W	34	4		32	ADJ	ORI							Burnstein & Loeb			German Ditch	IRR	
C44/692A		45	N	97	W	34	2		40	ADJ	ORI							Burnstein & Loeb			German Ditch,, Enl.	IRR	
P10307D		45	N	97	W	34	4		32	ADJ	SUP					Cottonwood Creek	12/15/1910						JOHN A. & AUGUST STIEGELE
P10307D		45	N	97	W	34	3		21	ADJ	SUP					Cottonwood Creek	12/15/1910						JOHN A. & AUGUST STIEGELE
P10307D		45	N	97	W	34	1		40	ADJ	SUP					Cottonwood Creek	12/15/1910						JOHN A. & AUGUST STIEGELE
P10307D		45	N	97	W	34	6		40	ADJ	SUP					Cottonwood Creek	12/15/1910						JOHN A. & AUGUST STIEGELE
P2818E		45	N	97	W	34	8		10	ADJ	ORI					Cottonwood Creek	5/31/1913						JOHN A. & AUGUST STIEGELE
P2818E		45	N	97	W	34	2		40	ADJ	ORI					Cottonwood Creek	5/31/1913						JOHN A. & AUGUST STIEGELE
P2818E		45	N	97	W	34	5		36	ADJ	ORI					Cottonwood Creek	5/31/1913						JOHN A. & AUGUST STIEGELE
C44/691A		45	N	97	W	35	6		40	ADJ	ORI							Burnstein & Loeb			German Ditch	IRR	
P29596D		45	N	97	W	35	6			PU	ORI				X	Cottonwood Creek	2/3/1987						WYOMING STATE HIGHWAY DEPARTMENT
P29596D		45	N	97	W	35	7			PU	ORI				X	Cottonwood Creek	2/3/1987						WYOMING STATE HIGHWAY DEPARTMENT
P29596D		45	N	97	W	35	10			PU	ORI				X	Cottonwood Creek	2/3/1987						WYOMING STATE HIGHWAY DEPARTMENT
P29596D		45	N	97	W	35	11			PU	ORI				X	Cottonwood Creek	2/3/1987						WYOMING STATE HIGHWAY DEPARTMENT
P13687S	X	45	N	98	W	2	5	L3	0	ADJ	ORI					Gopher Draw	11/1/1982	USDI, Bureau of Land Management	5	AF	35 Stock Reservoir	STO	USDI BLM
P27295D		45	N	98	W	3	5			DSC	ORI				PROSPECT CREEK	Grass Creek	8/17/1981						R & C TRUCKS INC.
P27295D		45	N	98	W	3	5			PU	ORI				X	Grass Creek	8/17/1981						R & C TRUCKS INC.
P13169S	X	45	N	98	W	7	5			ADJ	ORI					Seep Creek	11/1/1982						USDI BLM
P13171S	X	45	N	98	W	7	14			ADJ	ORI					Dredge Creek	11/1/1982						USDI BLM
P10948R	X	45	N	98	W	10	13		0	ADJ	ORI					Bear Draw	11/1/1982	USDI, Bureau of Land Management	5.4	AF	Barazum Reservoir	STO	USDI BLM
P15808D		45	N	98	W	18	0			PU	ORI				SD	Prospect Creek	8/24/1920						HARRY F. MALLON
P3314S		45	N	98	W	28	15			PU	ORI				P	McNeil Draw	7/5/1960						LUKE MCNEIL
P3314S	X	45	N	98	W	28	15			PUO	ORI					McNeil Draw	7/5/1960						LUKE MCNEIL
CR6/099A	X	45	N	98	W	31	13			PUO	ORI							USDI, Bureau of Land Management			R-D Common #1-4107 Stock Reservoir	STO	
CR6/100A		45	N	98	W	31	10	L3		PU	ORI				P			USDI, Bureau of Land Management			R-D Common #2 4108 Stock Reservoir	STO	
CR6/100A		45	N	98	W	31	7	L2		PU	ORI				P			USDI, Bureau of Land Management			R-D Common #2 4108 Stock Reservoir	STO	
CR6/100A		45	N	98	W	31	8			PU	ORI				P			USDI, Bureau of Land Management			R-D Common #2 4108 Stock Reservoir	STO	
CR6/100A	X	45	N	98	W	31	8			PUO	ORI							USDI, Bureau of Land Management			R-D Common #2 4108 Stock Reservoir	STO	
P6812S		45	N	98	W	31	4			PU	ORI				P	Sandy Creek	9/9/1970						USDI, BLM
P6812S		45	N	98	W	31	13			PU	ORI				P	Sandy Creek	9/9/1970						USDI, BLM
P6812S	X	45	N	98	W	31	13			PUO	ORI					Sandy Creek	9/9/1970						USDI, BLM
P6813S		45	N	98	W	31	7	L2		PU	ORI				P	Long Draw	9/9/1970						USDI, BLM
P6813S		45	N	98	W	31	8			PU	ORI				P	Long Draw	9/9/1970						USDI, BLM
P6813S	X	45	N	98	W	31	8			PUO	ORI					Long Draw	9/9/1970						USDI, BLM
P6813S		45	N	98	W	31	10	L3		PU	ORI				P	Long Draw	9/9/1970						USDI, BLM
P17583D		45	N	98	W	33	8			PU	ORI				S	Dry Draw	10/9/1928						RUPERT L. MCGIRR
P17583D	X	45	N	98	W	33	8			PUD	ORI					Dry Draw	10/9/1928						RUPERT L. MCGIRR
P1760R		45	N	98	W	33	3			PU	ORI				P	WAGONHOUND CREEK	4/18/1910						R. L. MCGIN
P1760R		45	N	98	W	33	14			PU	ORI				P	WAGONHOUND CREEK	4/18/1910						R. L. MCGIN
P1760R	X	45	N	98	W	33	3			PUO	ORI					WAGONHOUND CREEK	4/18/1910						R. L. MCGIN
P1760R		45	N	98	W	33	8			PU	ORI				P	WAGONHOUND CREEK	4/18/1910						R. L. MCGIN
P1760R		45	N	98	W	33	9			PU	ORI				P	WAGONHOUND CREEK	4/18/1910						R. L. MCGIN
P9721D		45	N	98	W	33	3			PU	RES				X	Wagonhound Creek	4/18/1910						R. L. MCGIN
P9721D		45	N	98	W	33	8			PU	RES				X	Wagonhound Creek	4/18/1910						R. L. MCGIN
P9721D		45	N	98	W	33	9			PU	RES				X	Wagonhound Creek	4/18/1910						R. L. MCGIN
P9721D		45	N	98	W	33	14			PU	RES				X	Wagonhound Creek	4/18/1910						R. L. MCGIN
P23569D		45	N	98	W	34	3			PU	ORI				X	Cottonwood Creek	5/19/1971						MARATHON OIL COMPANY
P7036E		45	N	98	W	35	15			UNA	ORI				X	Cottonwood Creek	4/2/1992						OWL CREEK LAND CO.**WYO LAND COMMISSIONER AND FARM LOANS
P7036E		45	N	98	W	35	16			UNA	ORI				X	Cottonwood Creek	4/2/1992						OWL CREEK LAND CO.**WYO LAND COMMISSIONER AND FARM LOANS
P5206E	X	45	N	98	W	36	14			PUH	ORI					Cottonwood Creek	12/4/1935						JOSEPH ROMAGNO
P7036E		45	N	98	W	36	11			UNA	ORI				X	Cottonwood Creek	4/2/1992						OWL CREEK LAND CO.**WYO LAND COMMISSIONER AND FARM LOANS

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P7036E		45	N	98	W	36	12			UNA	ORI				X	Cottonwood Creek	4/2/1992						OWL CREEK LAND CO.**WYO LAND COMMISSIONER AND FARM LOANS
P13168S		45	N	99	W	1	4			ADJ	ORI					Spring Gulch	11/1/1982						USDI BLM
P13168S	X	45	N	99	W	1	13			ADJ	ORI					Spring Gulch	11/1/1982						USDI BLM
CR5/447A		45	N	99	W	3	4			PU	ORI				P			USDI, Bureau of Land Management			Kellog Stock Reservoir	STO	
CR5/447A	X	45	N	99	W	3	4			PUO	ORI							USDI, Bureau of Land Management			Kellog Stock Reservoir	STO	
P6583S	X	45	N	99	W	3	4			ADJ	ORI				P	McCoy Creek	12/10/1969						USDI, BLM
P26353D		45	N	99	W	5	3			PU	ORI				X	Grass Creek	10/18/1979						DOME PETROLEUM CORPORATION
P26904D		45	N	99	W	5	9			PU	ORI				X	Grass Creek	12/29/1980						DOME PETROLEUM CORPORATION
P26904D		45	N	99	W	5	9			DSC	ORI				DOME FED 2 5 WELL	Grass Creek	12/29/1980						DOME PETROLEUM CORPORATION
P28239D		45	N	99	W	5	16			PU	ORI				X	Grass Creek	11/3/1983						APACHE CORPORATION**WYO BOARD OF LAND COMMISSIONERS
P1202R		45	N	99	W	6	11			PU	ORI				P	Grass Creek	12/30/1907						L. G. PHELPS
P1202R	X	45	N	99	W	6	11			PUO	ORI					Grass Creek	12/30/1907						L. G. PHELPS
P26353D	X	45	N	99	W	6	12			PUD	ORI					Grass Creek	10/18/1979						DOME PETROLEUM CORPORATION
P26721D		45	N	99	W	6	1	L1		PU	ORI				X	Little Grass Creek	8/14/1980						ELF AQUITAINE INC.
P26721D	X	45	N	99	W	6	1	L1		PUD	ORI					Little Grass Creek	8/14/1980						ELF AQUITAINE INC.
P26904D		45	N	99	W	6	1			PU	ORI				X	Grass Creek	12/29/1980						DOME PETROLEUM CORPORATION
P26904D		45	N	99	W	6	2			PU	ORI				X	Grass Creek	12/29/1980						DOME PETROLEUM CORPORATION
P26904D		45	N	99	W	6	4				?				X	Grass Creek	12/29/1980						DOME PETROLEUM CORPORATION
P27296D	X	45	N	99	W	6	11	L7		PUD	ORI					Grass Creek	8/17/1981						R & C TRUCKS INC.
P27368D	X	45	N	99	W	6	9			PUD	ORI					Grass Creek	10/26/1981						FLORIDA EXPLORATION CO.
P28239D	X	45	N	99	W	6	12			PUD	ORI					Grass Creek	11/3/1983						APACHE CORPORATION**WYO BOARD OF LAND COMMISSIONERS
P6210D	X	45	N	99	W	6	14			PUD	ORI					Grass Creek	9/14/1904						L. G. PHELPS
P1202R		45	N	99	W	7	6			PU	ORI				P	Grass Creek	12/30/1907						L. G. PHELPS
P28117D		45	N	99	W	9	6			DSC	ORI				DOME FEDERAL #1 9	Grass Creek	7/26/1983						DOME PETROLEUM CORPORATION
P28117D		45	N	99	W	9	6			PU	ORI				X	Grass Creek	7/26/1983						DOME PETROLEUM CORPORATION
P15808D	X	45	N	99	W	13	13			PUD	ORI					Prospect Creek	8/24/1920						HARRY F. MALLON
P12824S	X	45	N	99	W	15	1			ADJ	ORI				P	Little Prospect Creek	11/1/1982						USDI BLM
P33707D		45	N	99	W	15	11		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33708D		45	N	99	W	15	11		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P27368D		45	N	99	W	17	4			DSC	ORI				WEISS PEAK FED 1 17	Grass Creek	10/26/1981						FLORIDA EXPLORATION CO.
P27368D		45	N	99	W	17	4			PU	ORI				X	Grass Creek	10/26/1981						FLORIDA EXPLORATION CO.
P33707D		45	N	99	W	19	16		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33707D		45	N	99	W	19	9		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33708D		45	N	99	W	19	9		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33708D		45	N	99	W	19	16		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33707D		45	N	99	W	21	11		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33708D		45	N	99	W	21	11		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33707D		45	N	99	W	22	6		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33708D		45	N	99	W	22	6		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33707D		45	N	99	W	27	16		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33707D		45	N	99	W	27	1		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33708D		45	N	99	W	27	16		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33708D		45	N	99	W	27	1		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
CR8/060A	X	45	N	99	W	28	15			PUO	ORI							Rankine Brothers, Inc.			Rankine Pond Stock Reservoir	STO	
CR8/060A		45	N	99	W	28	14			PU	ORI				P			Rankine Brothers, Inc.			Rankine Pond Stock Reservoir	STO	
CR8/060A		45	N	99	W	28	15			PU	ORI				P			Rankine Brothers, Inc.			Rankine Pond Stock Reservoir	STO	
P33707D		45	N	99	W	28	1		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33707D		45	N	99	W	28	15		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33708D		45	N	99	W	28	1		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33708D		45	N	99	W	28	15		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P7867S	X	45	N	99	W	28	15			PUO	ORI					Rankine Draw	12/16/1974						RANKINE BROTHERS INC.
P7867S		45	N	99	W	28	14			PU	ORI				P	Rankine Draw	12/16/1974						RANKINE BROTHERS INC.
P7867S		45	N	99	W	28	15			PU	ORI				P	Rankine Draw	12/16/1974						RANKINE BROTHERS INC.
P33707D		45	N	99	W	29	4		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33707D		45	N	99	W	29	6		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33707D		45	N	99	W	29	1		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P33708D		45	N	99	W	29	4		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33708D		45	N	99	W	29	1		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33708D		45	N	99	W	29	6		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33707D		45	N	99	W	30	9		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33707D		45	N	99	W	30	1		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33707D	X	45	N	99	W	30	9		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33708D		45	N	99	W	30	9		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33708D		45	N	99	W	30	1		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33708D	X	45	N	99	W	30	9		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
C77/014A	X	45	N	99	W	34	3			ADJ	ORI				S			Rhodes Ranch, Inc.			Gwynn Spring No. 1 Ditch	STO	
P15408D	X	45	N	99	W	34	3			ADJ	ORI				S	Gwynn Spring No. 1	3/17/1919						PROSPER LAROSE
P33707D		45	N	99	W	34	1		0	UNA	ORI					Smith #1 Spring Draw	3/6/2007						Prospect Land & Cattle Co.
P33708D		45	N	99	W	34	1		0	UNA	ORI					Pershal Spring Draw	3/6/2007						Prospect Land & Cattle Co.
C77/011A	X	45	N	99	W	35	10			ADJ	ORI				S			Rhodes Ranch, Inc.			Gwynn Spring No. 2 Ditch	STO	
P15409D	X	45	N	99	W	35	10			ADJ	ORI				S	Gwynn Spring No. 2	3/17/1919						PROSPER LAROSE
P26690D		45	N	100	W	6	15			PU	ORI				X	Grass Creek	7/28/1980						CHANDLER AND ASSOCIATES INC.
P26690D		45	N	100	W	6	15			DSC	ORI				FED #15 6	Grass Creek	7/28/1980						CHANDLER AND ASSOCIATES INC.
P1202R		45	N	100	W	12	1			PU	ORI				P	Grass Creek	12/30/1907						L. G. PHELPS
P26690D	X	45	N	100	W	17	4			PUD	ORI					Grass Creek	7/28/1980						CHANDLER AND ASSOCIATES INC.
P28125D		45	N	100	W	18	13			DSC	ORI					Grass Creek	8/1/1983						DAVIS OIL COMPANY**WYO BOARD OF LAND COMMISSIONERS
P28125D	X	45	N	100	W	18	13			PUD	ORI					Grass Creek	8/1/1983						DAVIS OIL COMPANY**WYO BOARD OF LAND COMMISSIONERS
C43/328A		45	N	100	W	25	10			PU	ORI				SD			Edward Urwin			Urwin Spring No. 3	STO,DOM	
C43/329A		45	N	100	W	25	10			PU	ORI				SD			Edward Urwin			Urwin Spring No. 4	STO,DOM	
P15213D	X	45	N	100	W	25	10			PUD	ORI					Urwin Spring No. 3	8/29/1918						EDWARD URWIN
P15214D	X	45	N	100	W	25	10			PUD	ORI					Urwin Spring No. 4	8/29/1918						EDWARD URWIN
C59/261A		45	N	100	W	27	6		8.2	ADJ	ORI							Alexander Dickie			Little Grass Creek Ditch	IRR,STO,DOM	
C59/261A		45	N	100	W	27	7		5	ADJ	ORI							Alexander Dickie			Little Grass Creek Ditch	IRR,STO,DOM	
P19548D		45	N	100	W	27	6		8.2	ADJ	ORI					Little Grass Creek	5/27/1941						ALEXANDER DICKIE
P19548D		45	N	100	W	27	7		5	ADJ	ORI					Little Grass Creek	5/27/1941						ALEXANDER DICKIE
P19548D	X	45	N	100	W	28	4			PUD	ORI					Little Grass Creek	5/27/1941						ALEXANDER DICKIE
P27296D		45	N	100	W	28	3			PU	ORI				X	Grass Creek	8/17/1981						R & C TRUCKS INC.
P27296D		45	N	100	W	28	3			DSC	ORI				GRASS CREEK	Grass Creek	8/17/1981						R & C TRUCKS INC.
C43/330A		45	N	100	W	34	1			PU	ORI				SD			Edward Urwin			Urwin Spring No. 5	STO,DOM	
C43/331A		45	N	100	W	34	3			ADJ	ORI				SD			Edward Urwin			Urwin Spring No. 6	STO,DOM	
P15215D	X	45	N	100	W	34	1			PUD	ORI					Urwin Spring No. 5	8/29/1918						EDWARD URWIN
P15216D	X	45	N	100	W	34	3			ADJ	ORI				SD	Urwin Spring No. 6	8/29/1918						EDWARD URWIN
C43/326A		45	N	100	W	35	6			PU	ORI				SD			Edward Urwin			Urwin Spring No. 1	STO,DOM	
C43/327A		45	N	100	W	35	6			PU	ORI				SD			Edward Urwin			Urwin Spring No. 2	STO,DOM	
P15211D	X	45	N	100	W	35	6			PUD	ORI					Urwin Spring No. 1	8/29/1918						EDWARD URWIN
P15212D	X	45	N	100	W	35	6			PUD	ORI					Urwin Spring No. 2	8/29/1918						EDWARD URWIN
P15216D	X	45	N	100	W	35	3			PUD	ORI					Urwin Spring No. 6	8/29/1918						EDWARD URWIN
P28125D		45	N	101	W	2	13			PU	ORI				X	Grass Creek	8/1/1983						DAVIS OIL COMPANY**WYO BOARD OF LAND COMMISSIONERS
P27296D		45	N	101	W	11	4			DSC	ORI				WELL MURRAY GOVT #1	Grass Creek	8/17/1981						R & C TRUCKS INC.
P27296D		45	N	101	W	11	4			PU	ORI				X	Grass Creek	8/17/1981						R & C TRUCKS INC.
P26349D	X	45	N	101	W	13	12			PUD	ORI					Grass Creek	10/15/1979						S & H CONSTRUCTION CO.**WYOMING BOARD OF LAND COMM.
P26553D	X	45	N	101	W	13	12			PUD	ORI					Grass Creek	4/24/1980						S & H CONSTRUCTION CO.
P28125D		45	N	101	W	13	12			DSC	ORI					Grass Creek	8/1/1983						DAVIS OIL COMPANY**WYO BOARD OF LAND COMMISSIONERS
P28125D	X	45	N	101	W	13	12			PUD	ORI					Grass Creek	8/1/1983						DAVIS OIL COMPANY**WYO BOARD OF LAND COMMISSIONERS
P28190D	X	45	N	101	W	13	12			PUD	ORI					Grass Creek	9/27/1983						SODY'S INC.**WYO BOARD OF LAND COMMISSIONERS
P28125D	X	45	N	101	W	14	12			PUD	ORI					Grass Creek	8/1/1983						DAVIS OIL COMPANY**WYO BOARD OF LAND COMMISSIONERS
C71/470A		45	N	101	W	15	9			PU	ORI				D			State of Wyoming, Board of Land Commissioners; H-Diamond-W Youth Camp			H-Diamond-W Pipeline 1-B	DOM	

Permit #	Location	Township	Twn Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
C71/470A	X	45	N	101	W	15	7			PUD	ORI							State of Wyoming, Board of Land Commissioners; H-Diamond-W Youth Camp			H-Diamond-W Pipeline 1-B	DOM	
C71/471A		45	N	101	W	15	9			PU	ORI				D			State of Wyoming, Board of Land Commissioners; H-Diamond-W Youth Camp			H-Diamond-W Pipeline 1-C	DOM	
C71/471A	X	45	N	101	W	15	10			PUD	ORI							State of Wyoming, Board of Land Commissioners; H-Diamond-W Youth Camp			H-Diamond-W Pipeline 1-C	DOM	
C71/472A		45	N	101	W	15	9			PU	ORI				D			State of Wyoming, Board of Land Commissioners; H-Diamond-W Youth Camp			H-Diamond-W Pipeline 1-A	DOM	
C71/472A	X	45	N	101	W	15	7			PUD	ORI							State of Wyoming, Board of Land Commissioners; H-Diamond-W Youth Camp			H-Diamond-W Pipeline 1-A	DOM	
C72/128A		45	N	101	W	15	9			PU	ORI				D			State of Wyoming, Board of Land Commissioners; H-Diamond-W Youth			H-Diamond-W Pipeline No. 2	DOM	
C72/128A	X	45	N	101	W	15	10			PUD	ORI							State of Wyoming, Board of Land Commissioners; H-Diamond-W Youth			H-Diamond-W Pipeline No. 2	DOM	
P11641S	X	45	N	101	W	15	9			UNA	ORI				P	H.D.W. Draw	8/11/1992						STATE LAND AND FARM LOAN OFFICE**H DIAMOND W YOUTH CAMP
P11642S	X	45	N	101	W	15	14			UNA	ORI				P	H.D.W. Draw	8/11/1992						STATE LAND AND FARM LOAN OFFICE**H DIAMOND W YOUTH CAMP
P23880D	X	45	N	101	W	15	7			PUD	ORI					H-Diamond-W Spring No. 1	7/12/1972						INC. H-DIAMOND-W YOUTH CAMP
P23880D		45	N	101	W	15	9			PU	ORI				D	H-Diamond-W Spring No. 1	7/12/1972						INC. H-DIAMOND-W YOUTH CAMP
P23881D	X	45	N	101	W	15	10			PUD	ORI					Sawmill Spring	7/12/1972						INC. H-DIAMOND-W YOUTH CAMP
P23881D		45	N	101	W	15	9			PU	ORI				D	Sawmill Spring	7/12/1972						INC. H-DIAMOND-W YOUTH CAMP
P23882D	X	45	N	101	W	15	7			PUD	ORI					H-Diamond-W Spring No. 2	7/12/1972						INC. H-DIAMOND-W YOUTH CAMP
P23882D		45	N	101	W	15	9			PU	ORI				D	H-Diamond-W Spring No. 2	7/12/1972						INC. H-DIAMOND-W YOUTH CAMP
P23883D		45	N	101	W	15	9			PU	ORI				D	H-Diamond-W Spring No. 3	7/12/1972						INC. H-DIAMOND-W YOUTH CAMP
P23883D	X	45	N	101	W	15	10			PUD	ORI					H-Diamond-W Spring No. 3	7/12/1972						INC. H-DIAMOND-W YOUTH CAMP
P28164D	X	45	N	101	W	16	16			PUD	ORI					Grass Creek	9/8/1983						OCONA INC.**WYO BOARD OF LAND COMMISSIONERS
P28164D		45	N	101	W	17	1			PU	ORI				X	Grass Creek	9/8/1983						OCONA INC.**WYO BOARD OF LAND COMMISSIONERS
P27296D		45	N	101	W	21	5			DSC	ORI				ASPEN CREEK	Grass Creek	8/17/1981						R & C TRUCKS INC.
P27296D		45	N	101	W	21	5			PU	ORI				X	Grass Creek	8/17/1981						R & C TRUCKS INC.
P28190D		45	N	101	W	21	8			PU	ORI				X	Grass Creek	9/27/1983						SODY'S INC.**WYO BOARD OF LAND COMMISSIONERS
P26349D		45	N	101	W	25	7			PU	ORI				X	Grass Creek	10/15/1979						S & H CONSTRUCTION CO.**WYOMING BOARD OF LAND COMM.
P26553D		45	N	101	W	26	2			PU	ORI				X	Grass Creek	4/24/1980						S & H CONSTRUCTION CO.
P26553D		45	N	101	W	26	2			DSC	ORI				#16 26 FED WELL	Grass Creek	4/24/1980						S & H CONSTRUCTION CO.
C159F	X	45	N	101	W	29	16		0	ADJ	ORI					Cottonwood Creek	2/9/1983						USDA, FOREST SERVICE
C76/267A	X	45	N	101	W	34	0	L3		ADJ	ORI				D			John C. Goetz and Thomas K. Carpenter			Wallace Pipeline No. 1	DOM	
P27755D	X	45	N	101	W	34	12	L3		ADJ	ORI				D	Blue Creek	8/4/1981						JOHN GOETZ
P26018D		46	N	94	W	30	0	L7		DSC	ORI				TEXACO INC GOVT AN WELL #1	Meeyero Creek	12/19/1978						TEXACO INC.
P26018D		46	N	94	W	30	0			PU	ORI				X	Meeyero Creek	12/19/1978						TEXACO INC.
P12630S	X	46	N	96	W	13	0	L5		ADJ	ORI				P	Deep Draw	11/1/1982						USDI BLM
P10843R	X	46	N	96	W	20	12		0	ADJ	ORI					Blue Ridge Draw	11/1/1982						USDI BLM
P25774D		46	N	96	W	22	0	L2		DSC	ORI				TEXAS OIL WELL CONOCO FEDERAL #11	Meeyero Creek	5/22/1978						L. K. TRUCKING
P25774D		46	N	96	W	22	0			PU	ORI				X	Meeyero Creek	5/22/1978						L. K. TRUCKING
P12473S	X	46	N	96	W	31	11	L17		ADJ	ORI				P	Cobblestone Draw	11/1/1982						USDI BLM
P11475R	X	46	N	96	W	32	0	L15	0	ADJ	STR					River Rock Draw	11/1/1982						USDI, Bureau of Land Management
P12472S	X	46	N	96	W	33	9	L11		ADJ	ORI				P	Mesa Draw	11/1/1982						USDI BLM

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CR6/257A		46	N	97	W	21	7			PU	ORI				P			USDI, Bureau of Land Management			Rusty Can 4074 Reservoir	STO	
CR6/257A	X	46	N	97	W	21	7			PUO	ORI							USDI, Bureau of Land Management			Rusty Can 4074 Reservoir	STO	
P7369R		46	N	97	W	21	7			ADJ	ORI				P	Bedrock Draw	4/6/1971						U.S.DEPT. OF THE INTERIOR
P7370R		46	N	97	W	21	7			PU	ORI				P	C.C. Draw	4/6/1971						U.S.DEPT. OF THE INTERIOR
P7370R	X	46	N	97	W	21	7			PUO	ORI					C.C. Draw	4/6/1971						U.S.DEPT. OF THE INTERIOR
CR4/452A		46	N	97	W	25	15			PU	ORI				P			USDI, Bureau of Land Management			Cobblestone Stock Reservoir	STO	
CR4/452A	X	46	N	97	W	25	15			PUO	ORI							USDI, Bureau of Land Management			Cobblestone Stock Reservoir	STO	
P5855S	X	46	N	97	W	25	15			ADJ	ORI				P	Cobblestone Draw	1/16/1967						USDI, BLM
C33/308A		46	N	97	W	29	11		34	ADJ	ORI							E. L. Gwynn			Ilo Ditch	IRR	
C33/308A		46	N	97	W	29	12		28	ADJ	ORI							E. L. Gwynn			Ilo Ditch	IRR	
C33/308A		46	N	97	W	29	15		35	ADJ	ORI							E. L. Gwynn			Ilo Ditch	IRR	
C33/308A		46	N	97	W	29	16		23	ADJ	ORI							E. L. Gwynn			Ilo Ditch	IRR	
C37/649A		46	N	97	W	29	9		25.5	ADJ	ORI							Edgar L. Gwynn			Ila Ditch (Ilo) (Enl. of)	IRR,DOM	
C37/649A		46	N	97	W	29	14		20.6	ADJ	ORI							Edgar L. Gwynn			Ila Ditch (Ilo) (Enl. of)	IRR,DOM	
C37/650A		46	N	97	W	29	10		14.2	ADJ	ORI							David Dickie			Ila Ditch (Ilo) (Enl. of)	IRR,DOM	
P2103E		46	N	97	W	29	10		14.2	ADJ	ORI					Grass Creek	8/12/1909						EDGAR L. GWYNN
P2103E		46	N	97	W	29	9		25.5	ADJ	ORI					Grass Creek	8/12/1909						EDGAR L. GWYNN
P2103E		46	N	97	W	29	14		20.6	ADJ	ORI					Grass Creek	8/12/1909						EDGAR L. GWYNN
P6570D		46	N	97	W	29	12		28	ADJ	ORI					Grass Creek	3/30/1905						ALFRED L. WILSON
P6570D		46	N	97	W	29	15		35	ADJ	ORI					Grass Creek	3/30/1905						ALFRED L. WILSON
P6570D		46	N	97	W	29	11		34	ADJ	ORI					Grass Creek	3/30/1905						ALFRED L. WILSON
P6570D		46	N	97	W	29	16		23	ADJ	ORI					Grass Creek	3/30/1905						ALFRED L. WILSON
C37/650A		46	N	97	W	30	13		10.1	ADJ	ORI							David Dickie			Ila Ditch (Ilo) (Enl. of)	IRR,DOM	
C37/650A		46	N	97	W	30	16		37.7	ADJ	ORI							David Dickie			Ila Ditch (Ilo) (Enl. of)	IRR,DOM	
P2103E		46	N	97	W	30	13		10.1	ADJ	ORI					Grass Creek	8/12/1909						EDGAR L. GWYNN
P2103E		46	N	97	W	30	16		37.7	ADJ	ORI					Grass Creek	8/12/1909						EDGAR L. GWYNN
C33/308A		46	N	97	W	31	1		32	ADJ	ORI							E. L. Gwynn			Ilo Ditch	IRR	
C33/308A		46	N	97	W	31	2		22	ADJ	ORI							E. L. Gwynn			Ilo Ditch	IRR	
P2103E	X	46	N	97	W	31	8			PUH	ORI					Grass Creek	8/12/1909						EDGAR L. GWYNN
P2103E	X	46	N	97	W	31	8			PUD	ORI					Grass Creek	8/12/1909						EDGAR L. GWYNN
P6570D		46	N	97	W	31	2		22	ADJ	ORI					Grass Creek	3/30/1905						ALFRED L. WILSON
P6570D	X	46	N	97	W	31	7			ADJ	ORI					Grass Creek	3/30/1905						ALFRED L. WILSON
P6570D		46	N	97	W	31	1		32	ADJ	ORI					Grass Creek	3/30/1905						ALFRED L. WILSON
C33/308A		46	N	97	W	32	6		8	ADJ	ORI							E. L. Gwynn			Ilo Ditch	IRR	
P6570D		46	N	97	W	32	6		8	ADJ	ORI					Grass Creek	3/30/1905						ALFRED L. WILSON
C33/310A	X	46	N	97	W	33	4			PUD	ORI							Ella Gwynn			Seventy Six Ditch	IRR	
C33/311A	X	46	N	97	W	33	4			PUD	ORI							M. P. Gwynn			Seventy Six Ditch	IRR	
P8745D	X	46	N	97	W	33	5				ORI					Grass Creek	10/7/1908						MANLY P. & ELLA GWYN
P8746D	X	46	N	97	W	33	4				ORI					Grass Creek	10/7/1908						MANLY P. & ELLA GWYN
C33/310A		46	N	97	W	34	13		40	ADJ	ORI							Ella Gwynn			Seventy Six Ditch	IRR	
C33/310A		46	N	97	W	34	3		16	ADJ	ORI							Ella Gwynn			Seventy Six Ditch	IRR	
C33/310A		46	N	97	W	34	14		24	ADJ	ORI							Ella Gwynn			Seventy Six Ditch	IRR	
C33/311A		46	N	97	W	34	8		15	ADJ	ORI							M. P. Gwynn			Seventy Six Ditch	IRR	
C33/311A		46	N	97	W	34	4		10	ADJ	ORI							M. P. Gwynn			Seventy Six Ditch	IRR	
C33/311A		46	N	97	W	34	7		11	ADJ	ORI							M. P. Gwynn			Seventy Six Ditch	IRR	
P8746D		46	N	97	W	34	13		40	ADJ	ORI					Grass Creek	10/7/1908						MANLY P. & ELLA GWYN
P8746D		46	N	97	W	34	7		11	ADJ	ORI					Grass Creek	10/7/1908						MANLY P. & ELLA GWYN
P8746D		46	N	97	W	34	8		15	ADJ	ORI					Grass Creek	10/7/1908						MANLY P. & ELLA GWYN
P8746D		46	N	97	W	34	3		16	ADJ	ORI					Grass Creek	10/7/1908						MANLY P. & ELLA GWYN
P8746D		46	N	97	W	34	4		10	ADJ	ORI					Grass Creek	10/7/1908						MANLY P. & ELLA GWYN
P8746D		46	N	97	W	34	14		24	ADJ	ORI					Grass Creek	10/7/1908						MANLY P. & ELLA GWYN
C33/311A		46	N	97	W	35	10		25	ADJ	ORI							M. P. Gwynn			Seventy Six Ditch	IRR	
P10618D		46	N	97	W	35	16			PU	ORI				X	Grass Creek	3/27/1911						JAMES DICKIE
P10618D	X	46	N	97	W	35	16			PUD	ORI					Grass Creek	3/27/1911						JAMES DICKIE
P8746D		46	N	97	W	35	10		25	ADJ	ORI					Grass Creek	10/7/1908						MANLY P. & ELLA GWYN
P2130R		46	N	97	W	36	11			PU	ORI				P	Grass Creek	3/27/1911						JAMES DICKIE
C41/684A		46	N	98	W	18	9			PU	ORI				DX			Ohio Oil Company			Grass Creek Pipeline (Enl. of)	DOM,BOI,DRI	
C41/684A		46	N	98	W	18	12			PU	ORI				DX			Ohio Oil Company			Grass Creek Pipeline (Enl. of)	DOM,BOI,DRI	
P2991E		46	N	98	W	18	9			PU	ORI				SDX	Grass Creek	7/13/1914						OHIO OIL COMPANY
P2991E		46	N	98	W	18	12			PU	ORI				SDX	Grass Creek	7/13/1914						OHIO OIL COMPANY
C82/122A		46	N	98	W	19	3		17	ADJ	IRR							Dan Pearce			Grass Creek Reservoir and Ditch	IRR	

Permit #	Location	Township	Twn Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P12982D	X	46	N	98	W	19	4			PUD	ORI					Grass Creek	1/27/1915						J.I. MAYFIELD
P27295D	X	46	N	98	W	19	5			PUD	ORI					Grass Creek	8/17/1981						R & C TRUCKS INC.
P2991E	X	46	N	98	W	19	5			PUD	ORI					Grass Creek	7/13/1914						OHIO OIL COMPANY
P2991E	X	46	N	98	W	19	5			PUH	ORI					Grass Creek	7/13/1914						OHIO OIL COMPANY
P8214D		46	N	98	W	19	7		13	ELI	ELI					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	98	W	19	10		15	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	98	W	19	7		27	ADJ	ORI					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	98	W	19	15		20	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	98	W	19	10		20	ADJ	ORI					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	98	W	19	9		40	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	98	W	19	14		40	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	98	W	19	3		40	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	98	W	19	4		40	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	98	W	19	13		40	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	98	W	19	16		40	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P2745E	X	46	N	98	W	20	9			PUH	ORI					Grass Creek	1/17/1913						QUINTON LITTLEJOHN**WILLIAM D. LITTLEJOHN
P2745E	X	46	N	98	W	20	9			PUD	ORI					Grass Creek	1/17/1913						QUINTON LITTLEJOHN**WILLIAM D. LITTLEJOHN
P5842D	X	46	N	98	W	20	12			ADJ	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	20	15		8	ELI	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P8214D		46	N	98	W	20	10		35	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	98	W	20	11		40	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P12501D	X	46	N	98	W	24	1			PUD	ORI					Grass Creek	6/25/1914						OHIO OIL COMPANY
P12984D		46	N	98	W	26	10		12.5	ELI	ORI				SD	Grass Creek	1/27/1915						JAMES RANKIN
C40/515A		46	N	98	W	27	9		11.5	ADJ	ORI							James Rankine			Rankin Ditch	IRR	
C40/515A		46	N	98	W	27	10		1.8	ADJ	ORI							James Rankine			Rankin Ditch	IRR	
C40/515A		46	N	98	W	27	14		17.9	ADJ	ORI							James Rankine			Rankin Ditch	IRR	
C40/515A		46	N	98	W	27	13		15.8	ADJ	ORI							James Rankine			Rankin Ditch	IRR	
C77/148A		46	N	98	W	27	12		11.5	ADJ	ORI							Gilbreath Cattle Company			Gillies Ditch,, Gilbreath Enlargement of the	IRR	
C77/148A		46	N	98	W	27	11		28.7	ADJ	ORI							Gilbreath Cattle Company			Gillies Ditch,, Gilbreath Enlargement of the	IRR	
C77/148A		46	N	98	W	27	13		1.3	ADJ	ORI							Gilbreath Cattle Company			Gillies Ditch,, Gilbreath Enlargement of the	IRR	
C77/148A		46	N	98	W	27	10		28.3	ADJ	ORI							Gilbreath Cattle Company			Gillies Ditch,, Gilbreath Enlargement of the	IRR	
C77/148A		46	N	98	W	27	15		32.9	ADJ	ORI							Gilbreath Cattle Company			Gillies Ditch,, Gilbreath Enlargement of the	IRR	
C77/148A		46	N	98	W	27	14		4.9	ADJ	ORI							Gilbreath Cattle Company			Gillies Ditch,, Gilbreath Enlargement of the	IRR	
C77/148A		46	N	98	W	27	16		32.7	ADJ	ORI							Gilbreath Cattle Company			Gillies Ditch,, Gilbreath Enlargement of the	IRR	
C77/148A		46	N	98	W	27	9		15.2	ADJ	ORI							Gilbreath Cattle Company			Gillies Ditch,, Gilbreath Enlargement of the	IRR	
P12984D		46	N	98	W	27	9		11.5	ADJ	ORI					Grass Creek	1/27/1915						JAMES RANKIN
P12984D		46	N	98	W	27	14		17.9	ADJ	ORI					Grass Creek	1/27/1915						JAMES RANKIN
P12984D	X	46	N	98	W	27	10		1.8	ADJ	ORI					Grass Creek	1/27/1915						JAMES RANKIN
P12984D		46	N	98	W	27	13		15.8	ADJ	ORI					Grass Creek	1/27/1915						JAMES RANKIN
P6626E		46	N	98	W	27	15		1	ELI	ORI					Grass Creek	3/17/1977						GILBREATH CATTLE COMAPNY
P6626E		46	N	98	W	27	11		11.5	ADJ	ORI					Grass Creek	3/17/1977						GILBREATH CATTLE COMAPNY
P6626E		46	N	98	W	27	14		2	ELI	ORI					Grass Creek	3/17/1977						GILBREATH CATTLE COMAPNY
P6626E		46	N	98	W	27	11		1	ELI	ORI					Grass Creek	3/17/1977						GILBREATH CATTLE COMAPNY
P6626E		46	N	98	W	27	10		28.7	ADJ	ORI					Grass Creek	3/17/1977						GILBREATH CATTLE COMAPNY
P6626E		46	N	98	W	27	8		15.2	ADJ	ORI					Grass Creek	3/17/1977						GILBREATH CATTLE COMAPNY

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P6626E		46	N	98	W	27	9		5	ELI	ORI					Grass Creek	3/17/1977						GILBREATH CATTLE COMAPNY
P6626E		46	N	98	W	27	13		4.9	ADJ	ORI					Grass Creek	3/17/1977						GILBREATH CATTLE COMAPNY
P6626E		46	N	98	W	27	9		28.3	ADJ	ORI					Grass Creek	3/17/1977						GILBREATH CATTLE COMAPNY
P6626E		46	N	98	W	27	15		32.7	ADJ	ORI					Grass Creek	3/17/1977						GILBREATH CATTLE COMAPNY
P6626E		46	N	98	W	27	10		0.5	ELI	ORI					Grass Creek	3/17/1977						GILBREATH CATTLE COMAPNY
P6626E		46	N	98	W	27	12		1.3	ADJ	ORI					Grass Creek	3/17/1977						GILBREATH CATTLE COMAPNY
P6626E		46	N	98	W	27	14		32.9	ADJ	ORI					Grass Creek	3/17/1977						GILBREATH CATTLE COMAPNY
P6626E		46	N	98	W	27	12		20	ELI	ORI					Grass Creek	3/17/1977						GILBREATH CATTLE COMAPNY
C33/307A		46	N	98	W	28	15		29	ADJ	ORI							Quinton Littlejohn			Gillies Ditch	IRR	
C33/307A		46	N	98	W	28	7		40	ADJ	ORI							Quinton Littlejohn			Gillies Ditch	IRR	
C33/307A		46	N	98	W	28	13		20	ADJ	ORI							Quinton Littlejohn			Gillies Ditch	IRR	
C33/307A		46	N	98	W	28	12		8	ADJ	ORI							Quinton Littlejohn			Gillies Ditch	IRR	
C33/307A		46	N	98	W	28	14		20	ADJ	ORI							Quinton Littlejohn			Gillies Ditch	IRR	
C33/307A		46	N	98	W	28	6		20	ADJ	ORI							Quinton Littlejohn			Gillies Ditch	IRR	
C33/307A		46	N	98	W	28	9		20	ADJ	ORI							Quinton Littlejohn			Gillies Ditch	IRR	
C33/307A		46	N	98	W	28	16		35	ADJ	ORI							Quinton Littlejohn			Gillies Ditch	IRR	
C33/307A		46	N	98	W	28	10		34	ADJ	ORI							Quinton Littlejohn			Gillies Ditch	IRR	
C46/281A		46	N	98	W	28	4		6	ADJ	ORI							Meeteetse Oil Co.			Gillies Ditch,, Littlejohn Enlargement	IRR	
C46/281A		46	N	98	W	28	8		32	ADJ	ORI							Meeteetse Oil Co.			Gillies Ditch,, Littlejohn Enlargement	IRR	
C46/281A		46	N	98	W	28	3		13	ADJ	ORI							Meeteetse Oil Co.			Gillies Ditch,, Littlejohn Enlargement	IRR	
C49/469A		46	N	98	W	28	11		5	ADJ	ORI							L. U. Sheep Company			Gillies Ditch,, Littlejohn Enlargement	IRR	
C49/469A		46	N	98	W	28	14		20	ADJ	ORI							L. U. Sheep Company			Gillies Ditch,, Littlejohn Enlargement	IRR	
C49/469A		46	N	98	W	28	16		1	ADJ	ORI							L. U. Sheep Company			Gillies Ditch,, Littlejohn Enlargement	IRR	
C49/469A		46	N	98	W	28	10		2	ADJ	ORI							L. U. Sheep Company			Gillies Ditch,, Littlejohn Enlargement	IRR	
C49/469A		46	N	98	W	28	9		20	ADJ	ORI							L. U. Sheep Company			Gillies Ditch,, Littlejohn Enlargement	IRR	
C49/469A		46	N	98	W	28	12		7	ADJ	ORI							L. U. Sheep Company			Gillies Ditch,, Littlejohn Enlargement	IRR	
C52/120A		46	N	98	W	28	13		20	ADJ	ORI							James Rankine Robert Rankine & Stanolind Oil & Gas	0.28	CFS	Gillies Ditch,, Littlejohn Enlargement	IRR	
P12983D	X	46	N	98	W	28	8			PUD	ORI					Grass Creek	1/27/1915						IRA MAYFIELD**JAMES RANKIN
P2745E		46	N	98	W	28	8		32	ADJ	ORI					Grass Creek	1/17/1913						QUINTON LITTLEJOHN**WILLIAM D. LITTLEJOHN
P2745E		46	N	98	W	28	13		20	ADJ	ORI					Grass Creek	1/17/1913						QUINTON LITTLEJOHN**WILLIAM D. LITTLEJOHN
P2745E		46	N	98	W	28	3		13	ADJ	ORI					Grass Creek	1/17/1913						QUINTON LITTLEJOHN**WILLIAM D. LITTLEJOHN
P2745E		46	N	98	W	28	12		7	ADJ	ORI					Grass Creek	1/17/1913						QUINTON LITTLEJOHN**WILLIAM D. LITTLEJOHN
P2745E		46	N	98	W	28	9		20	ADJ	ORI					Grass Creek	1/17/1913						QUINTON LITTLEJOHN**WILLIAM D. LITTLEJOHN
P2745E		46	N	98	W	28	14		20	ADJ	ORI					Grass Creek	1/17/1913						QUINTON LITTLEJOHN**WILLIAM D. LITTLEJOHN
P2745E		46	N	98	W	28	11		5	ADJ	ORI					Grass Creek	1/17/1913						QUINTON LITTLEJOHN**WILLIAM D. LITTLEJOHN
P2745E		46	N	98	W	28	4		6	ADJ	ORI					Grass Creek	1/17/1913						QUINTON LITTLEJOHN**WILLIAM D. LITTLEJOHN
P2745E		46	N	98	W	28	16		1	ADJ	ORI					Grass Creek	1/17/1913						QUINTON LITTLEJOHN**WILLIAM D. LITTLEJOHN
P2745E		46	N	98	W	28	10		2	ADJ	ORI					Grass Creek	1/17/1913						QUINTON LITTLEJOHN**WILLIAM D. LITTLEJOHN
P5842D		46	N	98	W	28	7		40	ADJ	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	5		4	ELI	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	15		29	ADJ	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	16		35	ADJ	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	15		2	ELI	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	10		34	ADJ	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	4		6	ELI	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	8		32	ELI	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	12		8	ADJ	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	6		20	ADJ	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	9		20	ADJ	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	13		20	ADJ	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	14		20	ADJ	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	3		20	ELI	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	9		20	ELI	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES

Permit #	Location	Township	Twp Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P5842D		46	N	98	W	28	12		7	ELI	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	13		20	ELI	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	28	14		20	ELI	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
C33/307A		46	N	98	W	29	4		28	ADJ	ORI							Quinton Littlejohn			Gillies Ditch	IRR	
C33/307A		46	N	98	W	29	1		32	ADJ	ORI							Quinton Littlejohn			Gillies Ditch	IRR	
C33/307A		46	N	98	W	29	13		5	ADJ	ORI							Quinton Littlejohn			Gillies Ditch	IRR	
C49/469A		46	N	98	W	29	4		2	ADJ	ORI							L. U. Sheep Company			Gillies Ditch,, Littlejohn Enlargement	IRR	
P2745E		46	N	98	W	29	4		2	ADJ	ORI					Grass Creek	1/17/1913						QUINTON LITTLEJOHN**WILLIAM D. LITTLEJOHN
P5842D		46	N	98	W	29	13		5	ADJ	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	29	1		3	ELI	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	29	4		28	ADJ	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P5842D		46	N	98	W	29	1		32	ADJ	ORI					Grass Creek	8/21/1903						DUNCAN D. GILLIES
P8214D		46	N	98	W	29	8		30	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	98	W	29	2		40	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	98	W	29	6		30	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	98	W	29	3		40	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	98	W	29	5		40	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P26554D	X	46	N	98	W	36	3			PUD	ORI					Grass Creek	4/29/1980						DOME PETROLEUM CORPORATION
P26554D	X	46	N	98	W	36	4			PUD	ORI					Grass Creek	4/29/1980						DOME PETROLEUM CORPORATION
P27313D	X	46	N	98	W	36	3			PUD	ORI					Grass Creek	9/21/1981						EXCEL ENERGY CORP.**WYO BOARD OF LAND COMMISSIONERS
P27313D		46	N	98	W	36	8			DSC	ORI				GRASS CREEK WELL 22 36	Grass Creek	9/21/1981						EXCEL ENERGY CORP.**WYO BOARD OF LAND COMMISSIONERS
P27313D		46	N	98	W	36	8			PU	ORI				X	Grass Creek	9/21/1981						EXCEL ENERGY CORP.**WYO BOARD OF LAND COMMISSIONERS
P9569D	X	46	N	98	W	36	4			PUD	ORI					Grass Creek	1/22/1910						A. L. WILSON
P29328D		46	N	99	W	7	14			PU	ORI				X	Blacktail Creek	3/4/1986						CORONADO OIL COMPANY
P14853D		46	N	99	W	10	1			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	10	2			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	10	3			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	10	4			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	10	13			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	10	14			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	10	15			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	10	16			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	11	1			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	11	2			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	11	3			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	11	4			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	11	5			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	11	6			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	11	7			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	11	8			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	11	9			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	11	10			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.

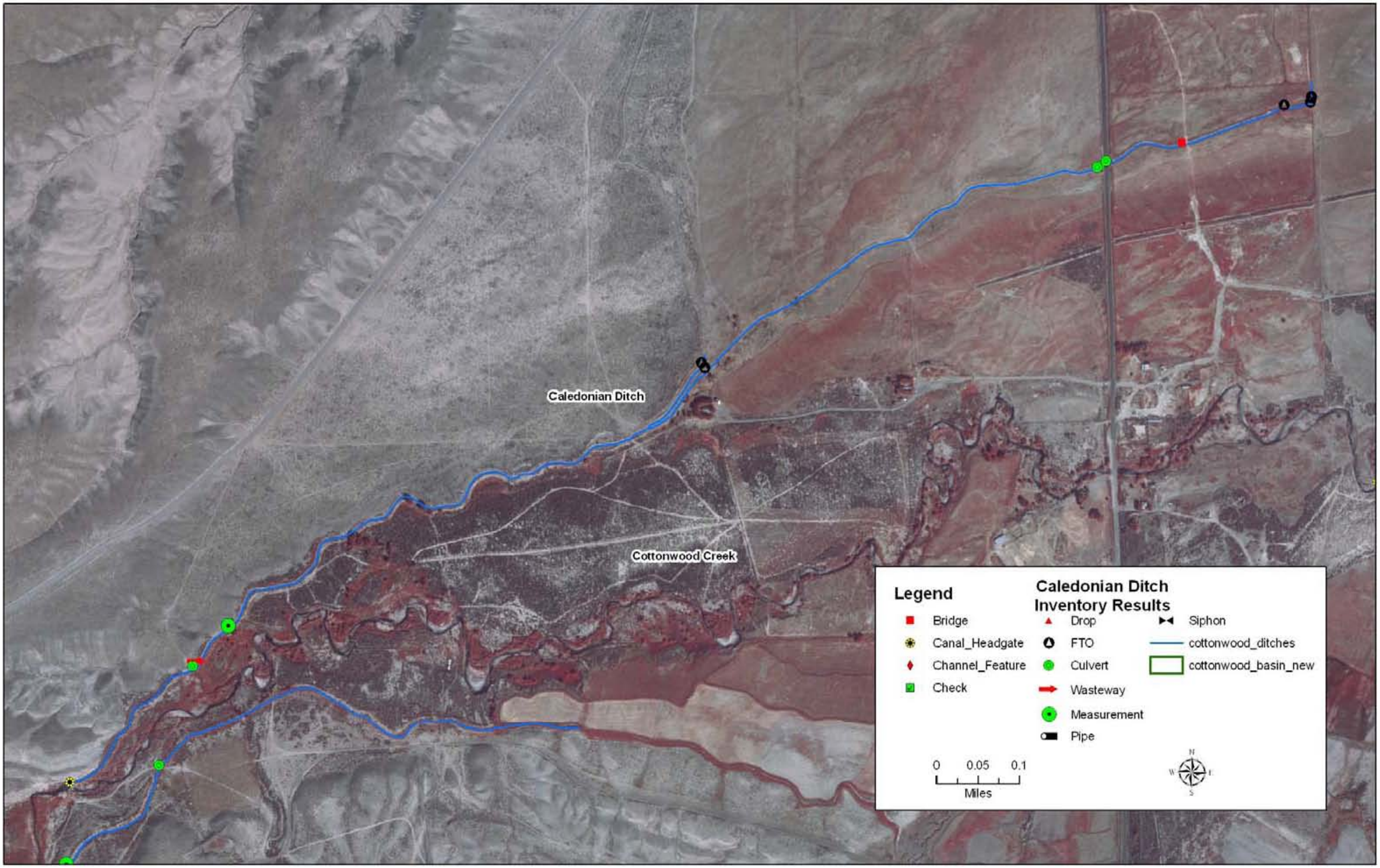
Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P14853D		46	N	99	W	11	11			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	11	12			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	11	13			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	11	14			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	11	15			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P14853D		46	N	99	W	11	16			PU	ORI				SDX	SPRING	9/13/1917						MEXICO-WYOMING PETROLEUM CO.
P12617D		46	N	99	W	12	3			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P12617D		46	N	99	W	12	1			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P12617D		46	N	99	W	12	13			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P12617D		46	N	99	W	12	2			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P12617D		46	N	99	W	12	15			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P12617D		46	N	99	W	12	4			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P12617D		46	N	99	W	12	16			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P12617D	X	46	N	99	W	12	8			PUD	SUP					SPRING	8/14/1914						T.S. HARRISON
P12617D		46	N	99	W	12	14			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P12617D		46	N	99	W	13	2			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P12617D		46	N	99	W	13	3			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P12617D		46	N	99	W	13	13			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P12617D		46	N	99	W	13	14			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P12617D		46	N	99	W	13	1			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P12617D		46	N	99	W	13	16			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P12617D		46	N	99	W	13	4			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P12617D		46	N	99	W	13	15			PU	SUP				SDX	SPRING	8/14/1914						T.S. HARRISON
P8214D		46	N	99	W	13	15		30	ELI	SEC				X	Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	99	W	13	16		30	ELI	SEC				X	Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P5476D		46	N	99	W	15	16		16	ELI	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
C33/306A	X	46	N	99	W	21	16			AME	ORI							J. B. Mayfield			Earl Ditch	IRR	
C81/037A	X	46	N	99	W	21	16			ADJ	ORI							Gary V. Kellogg and Brenda J. Kellogg			Earl Ditch	IRR	
P5476D		46	N	99	W	21	13		3	ELI	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
P5476D	X	46	N	99	W	21	16			ADJ	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
C33/306A		46	N	99	W	22	5		25	AME	ORI							J. B. Mayfield			Earl Ditch	IRR	
C33/306A		46	N	99	W	22	8		5	AME	ORI							J. B. Mayfield			Earl Ditch	IRR	
C33/306A		46	N	99	W	22	2		37	AME	ORI							J. B. Mayfield			Earl Ditch	IRR	
C33/306A		46	N	99	W	22	7		18	AME	ORI							J. B. Mayfield			Earl Ditch	IRR	
C81/037A		46	N	99	W	22	2		32.1	ADJ	ORI							Gary V. Kellogg and Brenda J. Kellogg			Earl Ditch	IRR	
C81/037A		46	N	99	W	22	7		14.2	ADJ	ORI							Gary V. Kellogg and Brenda J. Kellogg			Earl Ditch	IRR	
C81/037A		46	N	99	W	22	10		2.5	ADJ	ORI							Gary V. Kellogg and Brenda J. Kellogg			Earl Ditch	IRR	
C81/037A		46	N	99	W	22	8		9.3	ADJ	ORI							Gary V. Kellogg and Brenda J. Kellogg			Earl Ditch	IRR	
C81/037A		46	N	99	W	22	3		0.2	ADJ	ORI							Gary V. Kellogg and Brenda J. Kellogg			Earl Ditch	IRR	
C81/037A		46	N	99	W	22	5		26.7	ADJ	ORI							Gary V. Kellogg and Brenda J. Kellogg			Earl Ditch	IRR	
C83/239A	X	46	N	99	W	22	8		0	ADJ	ORI							John F. Leroux			Earl Ditch (act Earl No. 2 Ditch)		
C83/239A		46	N	99	W	22	8		9.9	ADJ	ORI							John F. Leroux			Earl Ditch (act Earl No. 2 Ditch)		
C83/239A		46	N	99	W	22	3		3.6	ADJ	ORI							John F. Leroux			Earl Ditch (act Earl No. 2 Ditch)		
C83/239A		46	N	99	W	22	2		0.7	ADJ	ORI							John F. Leroux			Earl Ditch (act Earl No. 2 Ditch)		
C83/239A		46	N	99	W	22	5		0.7	ADJ	ORI							John F. Leroux			Earl Ditch (act Earl No. 2 Ditch)		
P5476D		46	N	99	W	22	1		15	ELI	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
P5476D		46	N	99	W	22	7		18	AME	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
P5476D		46	N	99	W	22	5		26.7	ADJ	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
P5476D		46	N	99	W	22	10		2.5	ADJ	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
P5476D		46	N	99	W	22	5		0.7	AME	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
P5476D		46	N	99	W	22			32.1	ADJ	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
P5476D		46	N	99	W	22	3		3.6	AME	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
P5476D		46	N	99	W	22	5		25	AME	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
P5476D		46	N	99	W	22	8		9.9	AME	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
P5476D		46	N	99	W	22	2		0.7	AME	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD

Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P5476D		46	N	99	W	22	8		9.3	ADJ	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
P5476D		46	N	99	W	22	7		14.2	ADJ	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
P5476D		46	N	99	W	22	3		0.2	ADJ	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
P5476D		46	N	99	W	22	10		3.1	AME	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
P5476D		46	N	99	W	22	8		5	AME	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
P5476D		46	N	99	W	22	2		37	AME	ORI					Grass Creek	5/18/1903						JAY B. MAYFIELD
C82/122A	X	46	N	99	W	23	13		0	ADJ	IRR				X			Dan Pearce			Grass Creek Reservoir and Ditch	IRR	
P14330D	X	46	N	99	W	23	1			PUD	ORI					Grass Creek	6/20/1916						LLOYD ROBBINS
P2645D	X	46	N	99	W	23	6			PUD	ORI					Grass Creek	6/4/1900						LABAN R. HILLBERRY**JOSEPH BENNY**WILLIAM E. BENNY**RHODA J. BENNY
P6015E	X	46	N	99	W	23	1		0	UNA	ORI					Grass Creek	11/23/1960						EUNICE BROWN
P8214D	X	46	N	99	W	23	1		0	ADJ	ORI				X	Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
C45/119A		46	N	99	W	24	4		40	ADJ	ORI							Ralph Robbins	0.57	CFS	Grass Creek Reservoir and Ditch	IRR,STO,DOM	
C45/120A		46	N	99	W	24	3		14	ADJ	ORI							Ralph Robbins	0.2	CFS	Robbins Ditch	IRR,STO,DOM	
C45/121A		46	N	99	W	24	2		20	ADJ	ORI							Lloyd Robbins			Grass Creek Reservoir and Ditch	IRR,STO,DOM	
C45/121A		46	N	99	W	24	5		10	ADJ	ORI							Lloyd Robbins			Grass Creek Reservoir and Ditch	IRR,STO,DOM	
C45/121A		46	N	99	W	24	6		10	ADJ	ORI							Lloyd Robbins			Grass Creek Reservoir and Ditch	IRR,STO,DOM	
C45/122A		46	N	99	W	24	2		20	ADJ	ORI							Lloyd Robbins			Robbins Ditch	IRR,STO,DOM	
C45/122A		46	N	99	W	24	5		4	ADJ	ORI							Lloyd Robbins			Robbins Ditch	IRR,STO,DOM	
C81/421A		46	N	99	W	24	1	L2	25									Ronald and Carla Brown; Daniel and Virginia Pierce	0.36	CFS	Robbins Ditch,, the Brown Enlargement of the	IRR	
P14330D		46	N	99	W	24	1		19.5	ADJ	ORI					Grass Creek	6/20/1916						LLOYD ROBBINS
P14330D		46	N	99	W	24	5		4	ADJ	ORI					Grass Creek	6/20/1916						LLOYD ROBBINS
P14330D		46	N	99	W	24	3		14.3	ADJ	ORI					Grass Creek	6/20/1916						LLOYD ROBBINS
P14330D		46	N	99	W	24	2		20	ADJ	ORI					Grass Creek	6/20/1916						LLOYD ROBBINS
P2645D		46	N	99	W	24	2		38	ELI	ORI					Grass Creek	6/4/1900						LABAN R. HILLBERRY**JOSEPH BENNY**WILLIAM E. BENNY**RHODA J. BENNY
P2645D		46	N	99	W	24	5		23	ELI	ORI					Grass Creek	6/4/1900						LABAN R. HILLBERRY**JOSEPH BENNY**WILLIAM E. BENNY**RHODA J. BENNY
P2645D		46	N	99	W	24	6		12	ELI	ORI					Grass Creek	6/4/1900						LABAN R. HILLBERRY**JOSEPH BENNY**WILLIAM E. BENNY**RHODA J. BENNY
P2645D		46	N	99	W	24	1		40	ELI	ORI					Grass Creek	6/4/1900						LABAN R. HILLBERRY**JOSEPH BENNY**WILLIAM E. BENNY**RHODA J. BENNY
P2888D	X	46	N	99	W	24	2			PUD	ORI					Grass Creek	11/1/1900						FARGNHAR GILLIES
P6015E	X	46	N	99	W	24	6			UNA	ORI					Grass Creek	11/23/1960						EUNICE BROWN
P6015E		46	N	99	W	24	1	L2	2.79	ELI	ORI					Grass Creek	11/23/1960						EUNICE BROWN
P6015E		46	N	99	W	24	1	L2	25	REI	ORI				DESERT LAND ENTRY #03853	Grass Creek	11/23/1960						EUNICE BROWN
P8214D		46	N	99	W	24	0		20	ADJ	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	99	W	24	0		20	ELI	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	99	W	24	0		20	ADJ	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	99	W	24	4		40	ADJ	SEC					Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	99	W	24	1			ADJ	SEC				X	Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	99	W	24	5			ADJ	SEC				X	Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	99	W	24	2			ADJ	SEC				X	Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
P8214D		46	N	99	W	24	6			ADJ	SEC				X	Grass Creek	7/2/1906						W. W. PHELPS**AGNES H. PHELPS**MARY A. MERRILL
CR5/209A		46	N	99	W	26	1			PU	ORI				P			Spring Gulch Coal Company			Coal Draw Number 1 Stock Reservoir	STO	
CR5/209A	X	46	N	99	W	26	1			PUO	ORI							Spring Gulch Coal Company			Coal Draw Number 1 Stock Reservoir	STO	
P10664R	X	46	N	99	W	26	14		0	UNA	ORI				P	Spoilpile Draw	2/27/1998						Spring Gulch Coal Co.
P6200S		46	N	99	W	26	1			PU	ORI				P	Coal Mine Draw	4/9/1968						SPRING GULCH COAL CO.
P6200S	X	46	N	99	W	26	1			PUO	ORI					Coal Mine Draw	4/9/1968						SPRING GULCH COAL CO.
P8096R	X	46	N	99	W	26	13			UNA	ORI				P	Southern Draw	8/28/1979						SPRING GULCH COAL CO.
P8097R	X	46	N	99	W	26	3			UNA	ORI				P	Spoilpile Draw	10/9/1979						SPRING GULCH COAL CO.

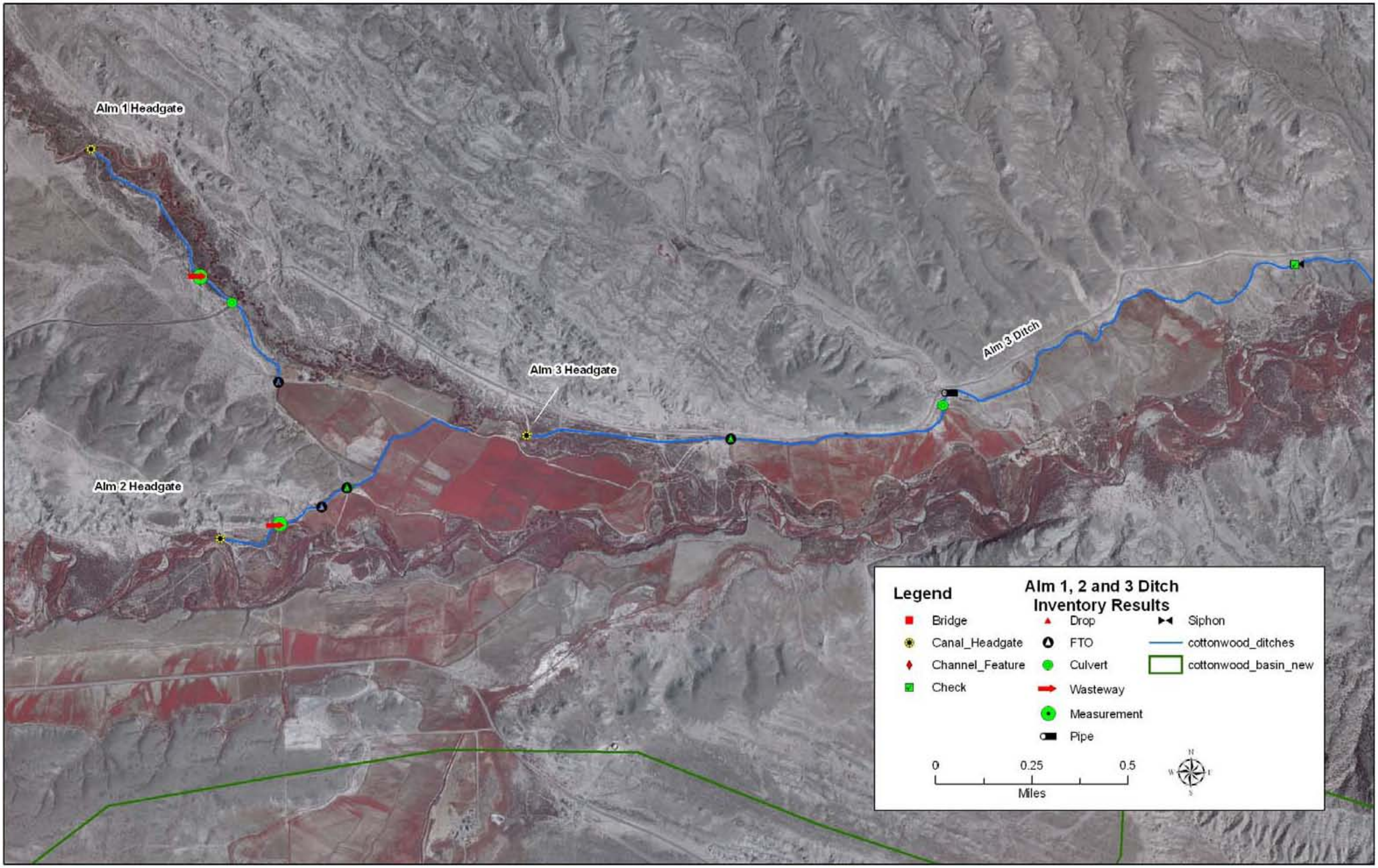
Permit #	Location	Township	Tns Suffix	Range	Rng Suffix	Section	Quarter	Lots	Acres	Status	Supply type	Subdivision	Lot	Block	Additional Description	Source	Priority	Appropriation	Appr Amount	Appr Unit	Facility Name	Uses	Applicant
P8098R	X	46	N	99	W	26	3			UNA	ORI				P	Spoilpile Draw	10/9/1979						SPRING GULCH COAL CO.
P8637R		46	N	99	W	26	3			PU	ORI				P	Coal Mine Draw	7/11/1983						NORTHWESTERN RESOURCES CO.
P8637R	X	46	N	99	W	26	3			PUO	ORI					Coal Mine Draw	7/11/1983						NORTHWESTERN RESOURCES CO.
P8639R	X	46	N	99	W	26	14			UNA	ORI				P	North Branch Southern Draw	7/11/1983						SPRING GULCH COAL CO.
C33/304A		46	N	99	W	29	13		20	ADJ	ORI							Rocky Mountain Cattle Company			L. U. or Baxter Ditch	IRR	
C33/304A		46	N	99	W	29	14		15	ADJ	ORI							Rocky Mountain Cattle Company			L. U. or Baxter Ditch	IRR	
C33/305A		46	N	99	W	29	12		22	ADJ	ORI							L. U. Sheep Co.			L. U. or Baxter Ditch	IRR	
C33/305A		46	N	99	W	29	15		31	ADJ	ORI							L. U. Sheep Co.			L. U. or Baxter Ditch	IRR	
P28117D	X	46	N	99	W	29	15			PUD	ORI					Grass Creek	7/26/1983						DOME PETROLEUM CORPORATION
P17909D		46	N	99	W	34	9			PU	ORI				SD	James Spring	11/10/1931						JOHN F. JAMES
P17909D	X	46	N	99	W	34	10			PUD	ORI					James Spring	11/10/1931						JOHN F. JAMES

Appendix F

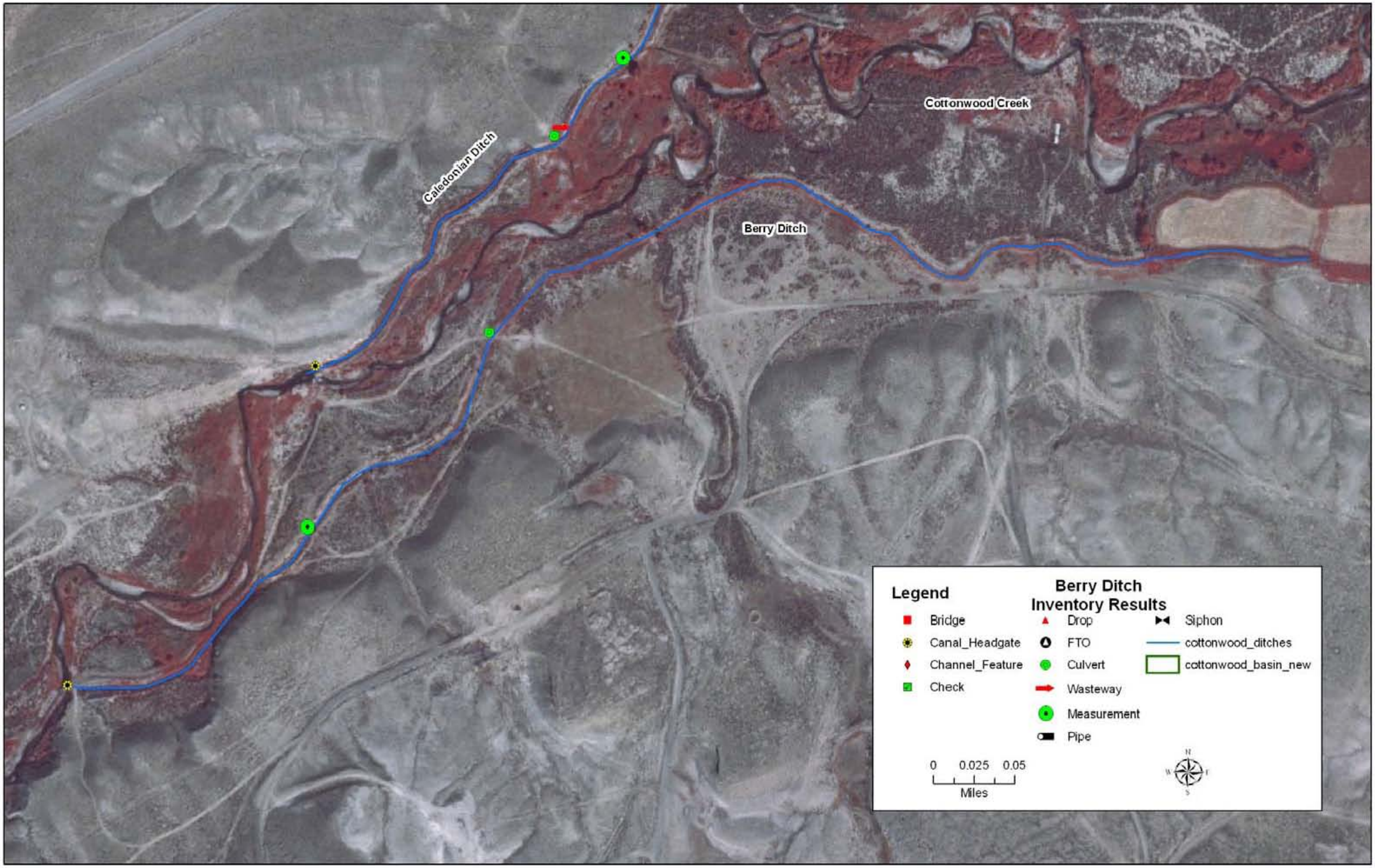
Irrigation Inventory

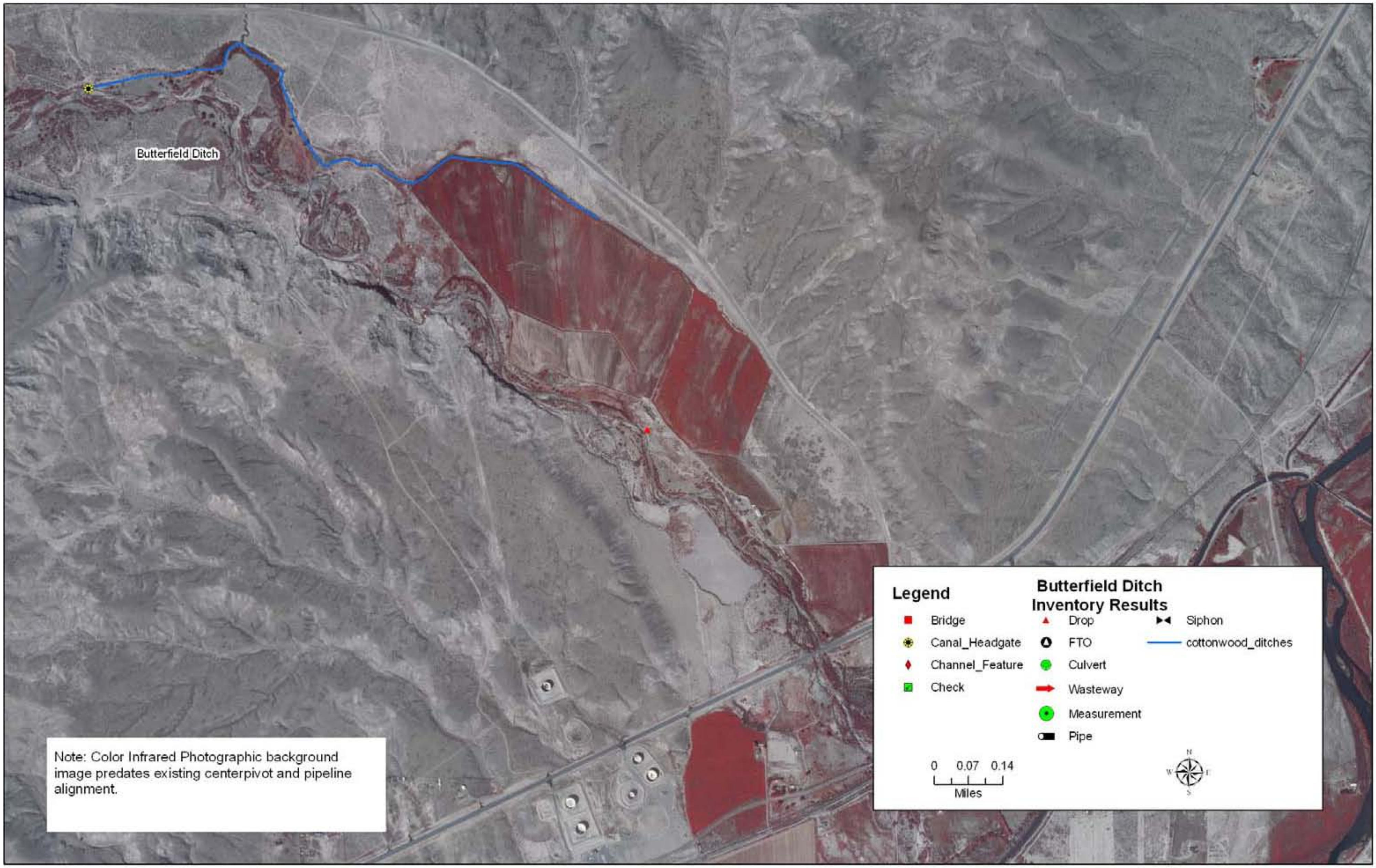


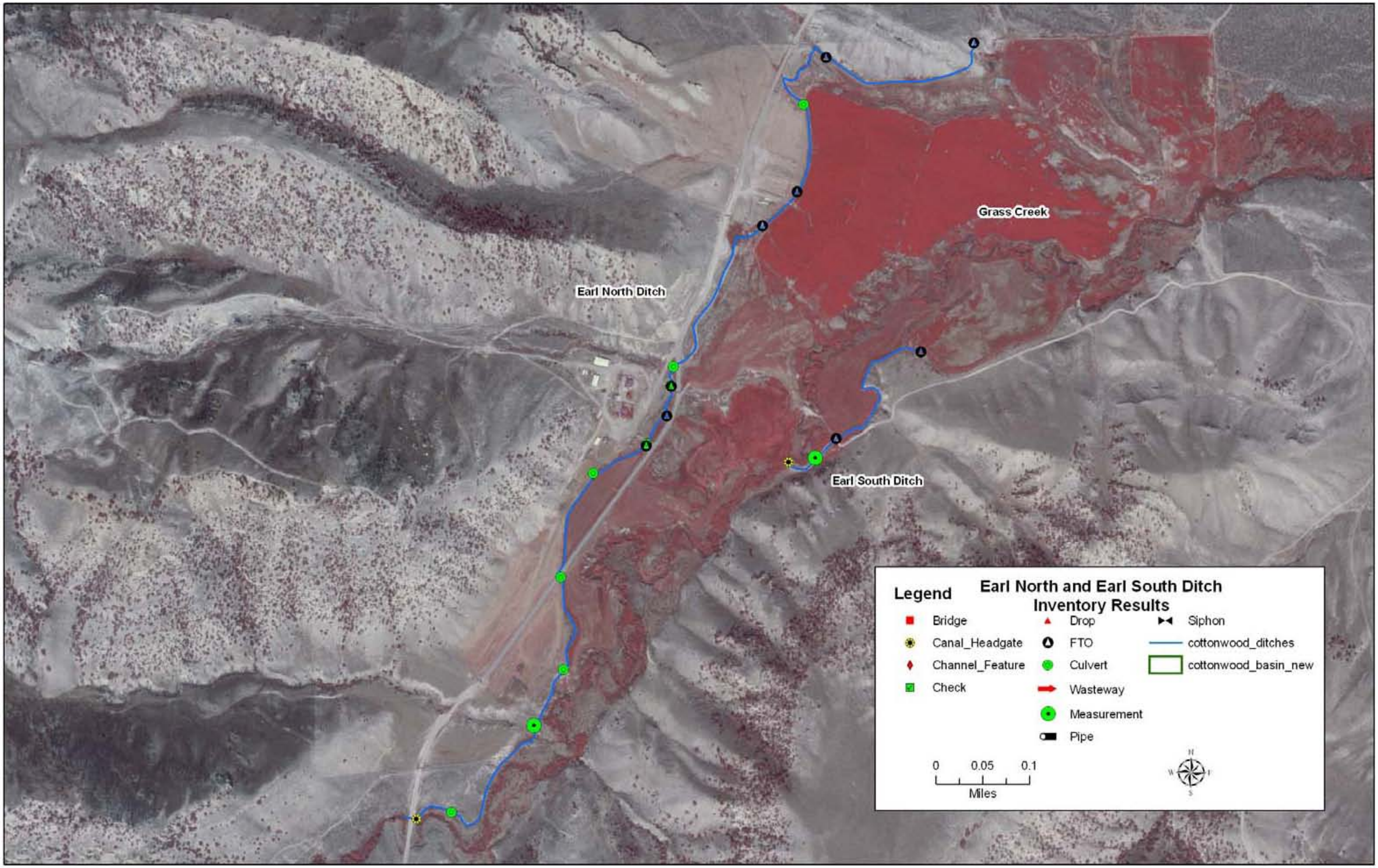
Caledonian Ditch
Cottonwood Creek
Legend
Caledonian Ditch
Inventory Results
Bridge
Canal_Headgate
Channel_Feature
Check
Drop
FTO
Culvert
Wasteway
Measurement
Pipe
Siphon
cottonwood_ditches
cottonwood_basin_new
0
0.05
0.1
Miles

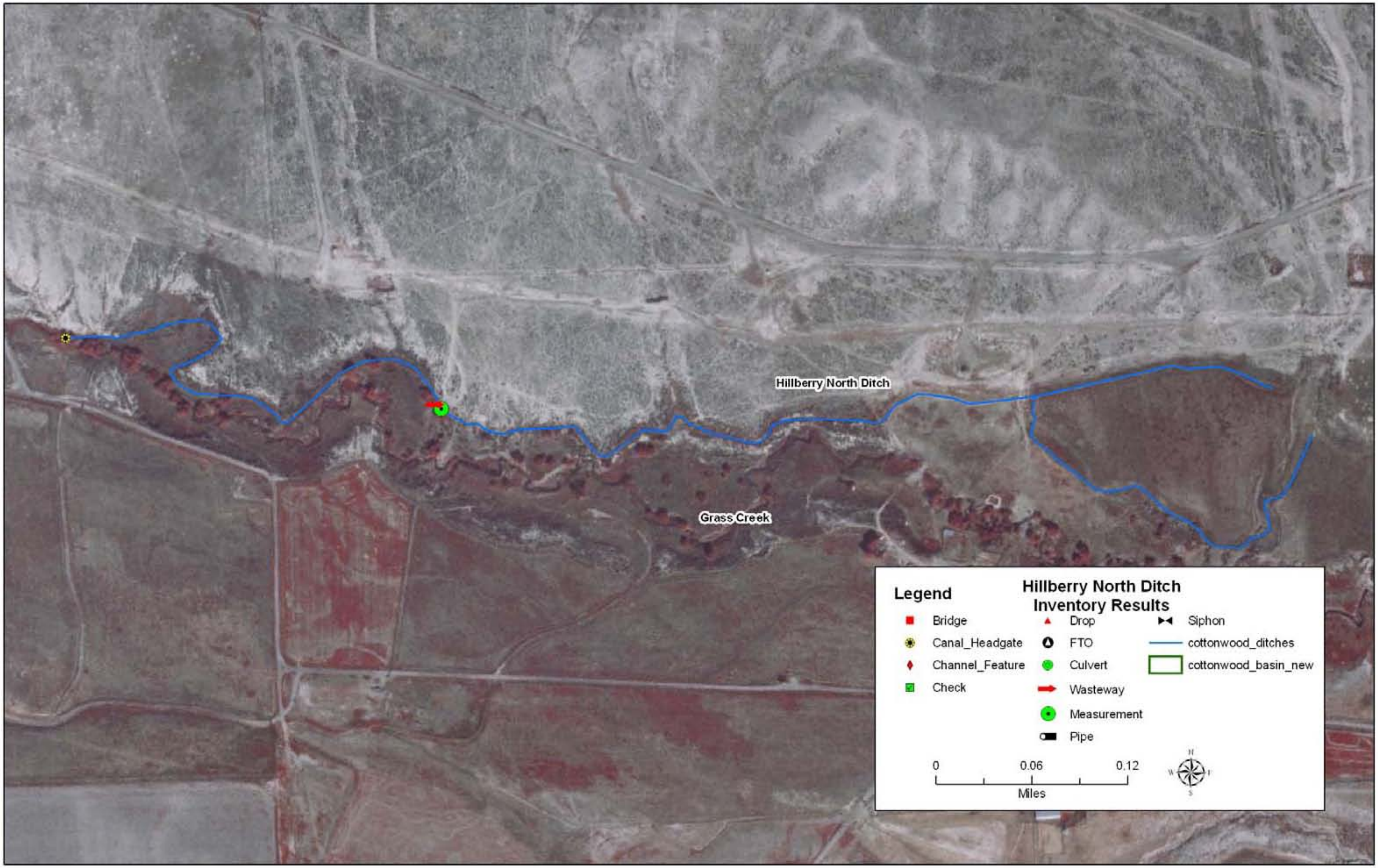


Alm 1 Headgate
Alm 2 Headgate
Alm 3 Headgate
Alm 3 Ditch
Legend
Alm 1, 2 and 3 Ditch
Inventory Results
Bridge
Canal_Headgate
Channel_Feature
Check
Drop
FTO
Culvert
Wasteway
Measurement
Pipe
Siphon
cottonwood_ditches
cottonwood_basin_new
0
0.25
0.5
Miles


Cottonwood Creek
Caledonian Ditch
Berry Ditch
Legend
Berry Ditch
Inventory Results
Bridge
Canal_Headgate
Channel_Feature
Check
Drop
FTO
Culvert
Wasteway
Measurement
Pipe
Siphon
cottonwood_ditches
cottonwood_basin_new
0 0.025 0.05
Miles


Butterfield Ditch
Legend
Butterfield Ditch Inventory Results
Bridge
Canal_Headgate
Channel_Feature
Check
Drop
FTO
Culvert
Wasteway
Measurement
Pipe
Siphon
cottonwood_ditches
0 0.07 0.14
Miles
Note: Color Infrared Photographic background image predates existing centerpivot and pipeline alignment.


Grass Creek
Earl North Ditch
Earl South Ditch
Legend
Earl North and Earl South Ditch
Inventory Results
Bridge
Canal_Headgate
Channel_Feature
Check
Drop
FTO
Culvert
Wasteway
Measurement
Pipe
Siphon
cottonwood_ditches
cottonwood_basin_new
0
0.05
0.1
Miles


Hillberry North Ditch
Grass Creek
Legend
Hillberry North Ditch
Inventory Results
Bridge
Canal_Headgate
Channel_Feature
Check
Drop
FTO
Culvert
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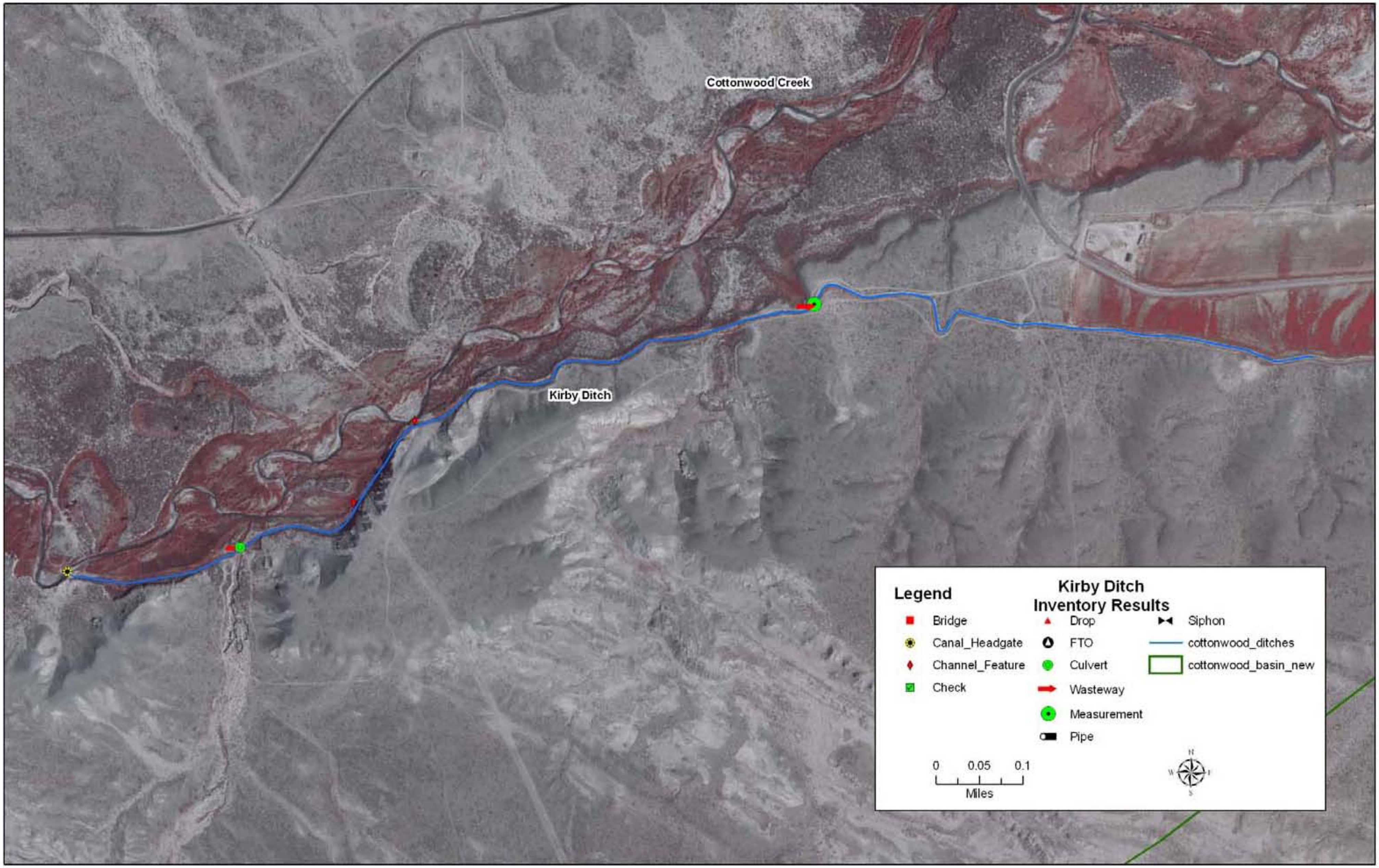
0.06
0.12
Miles


Cottonwood Creek
Kirby Ditch
Legend
Kirby Ditch Inventory Results
Bridge
Canal_Headgate
Channel_Feature
Check
Drop
FTO
Culvert
Wasteway
Measurement
Pipe
Siphon
cottonwood_ditches
cottonwood_basin_new
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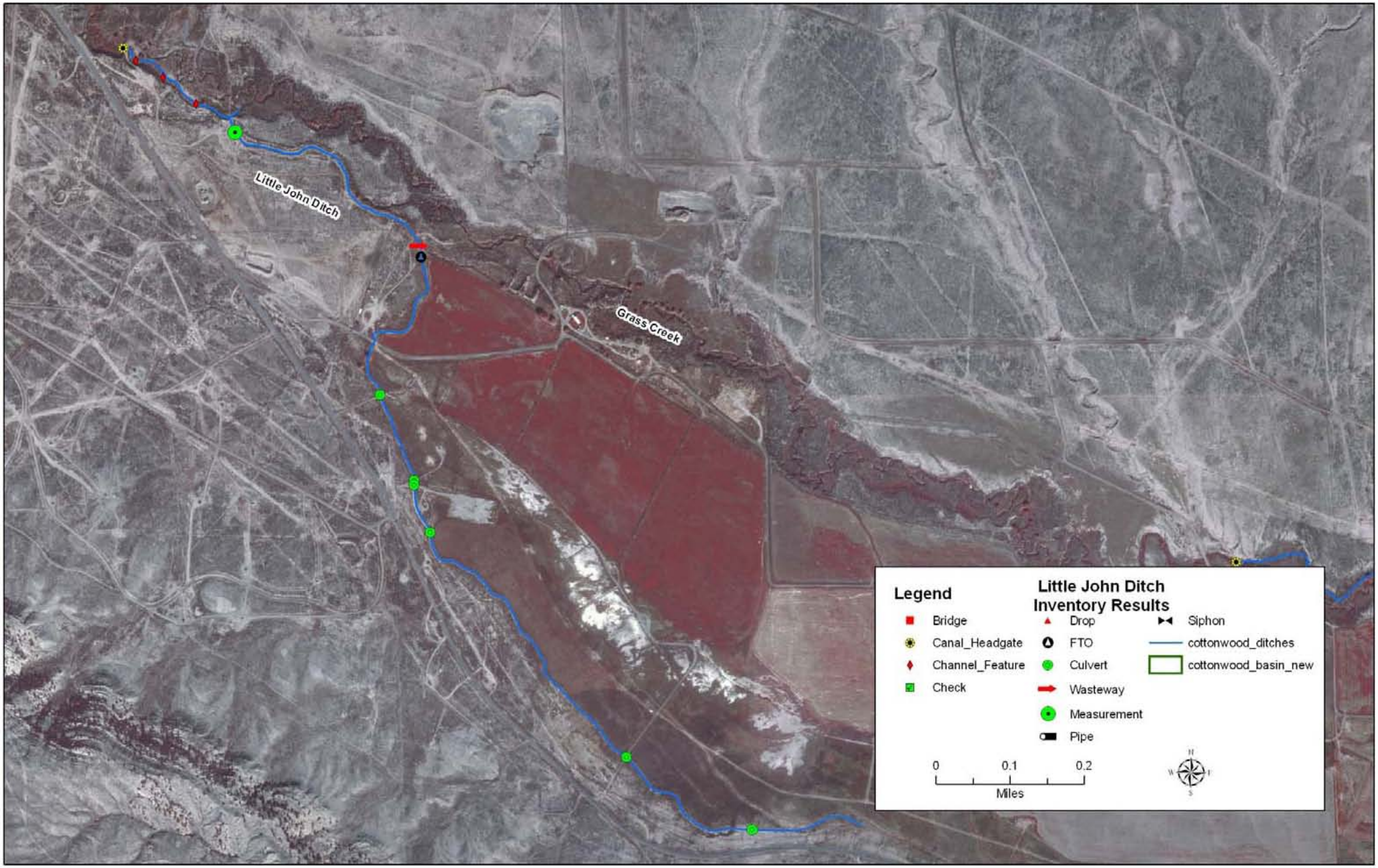
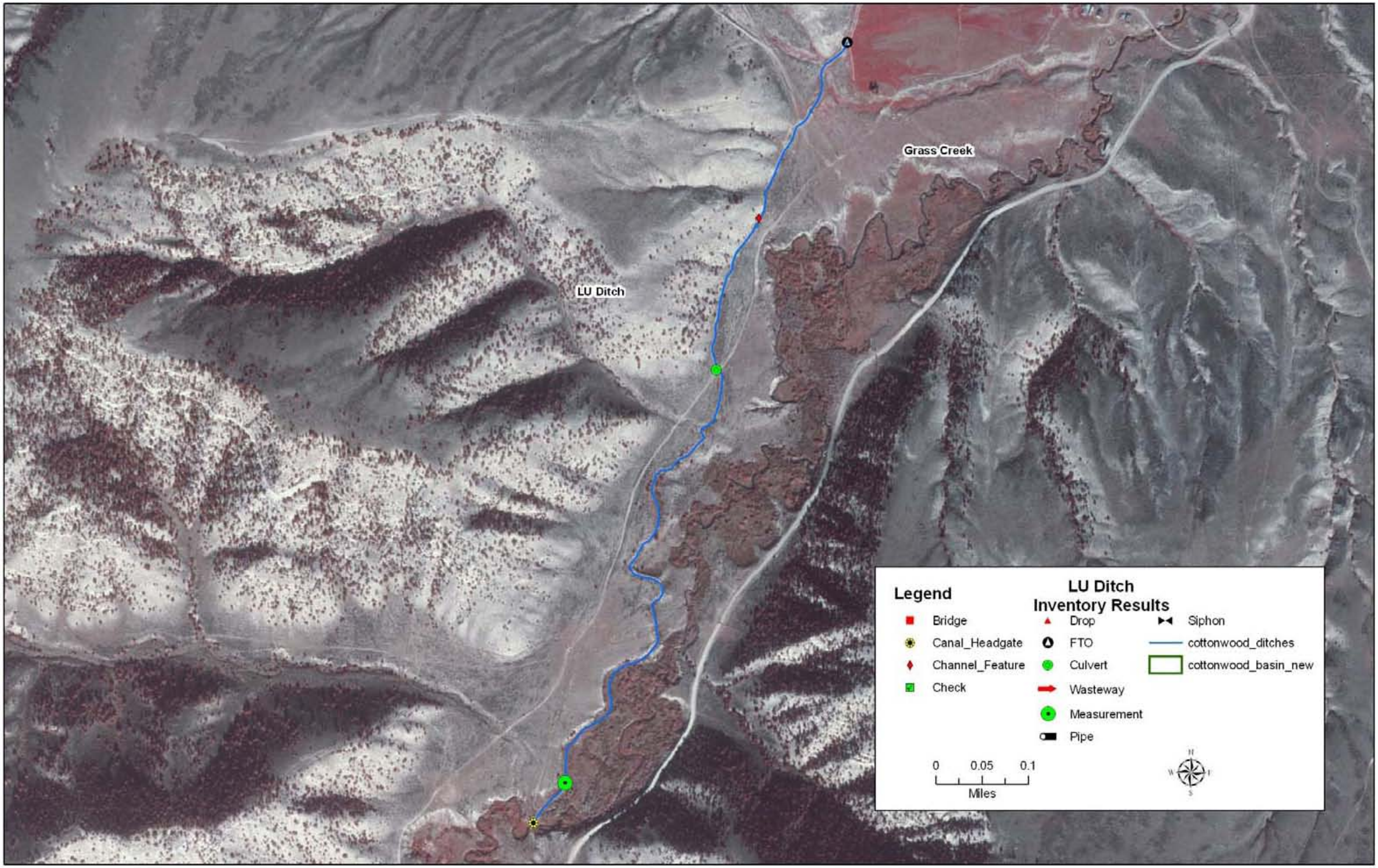
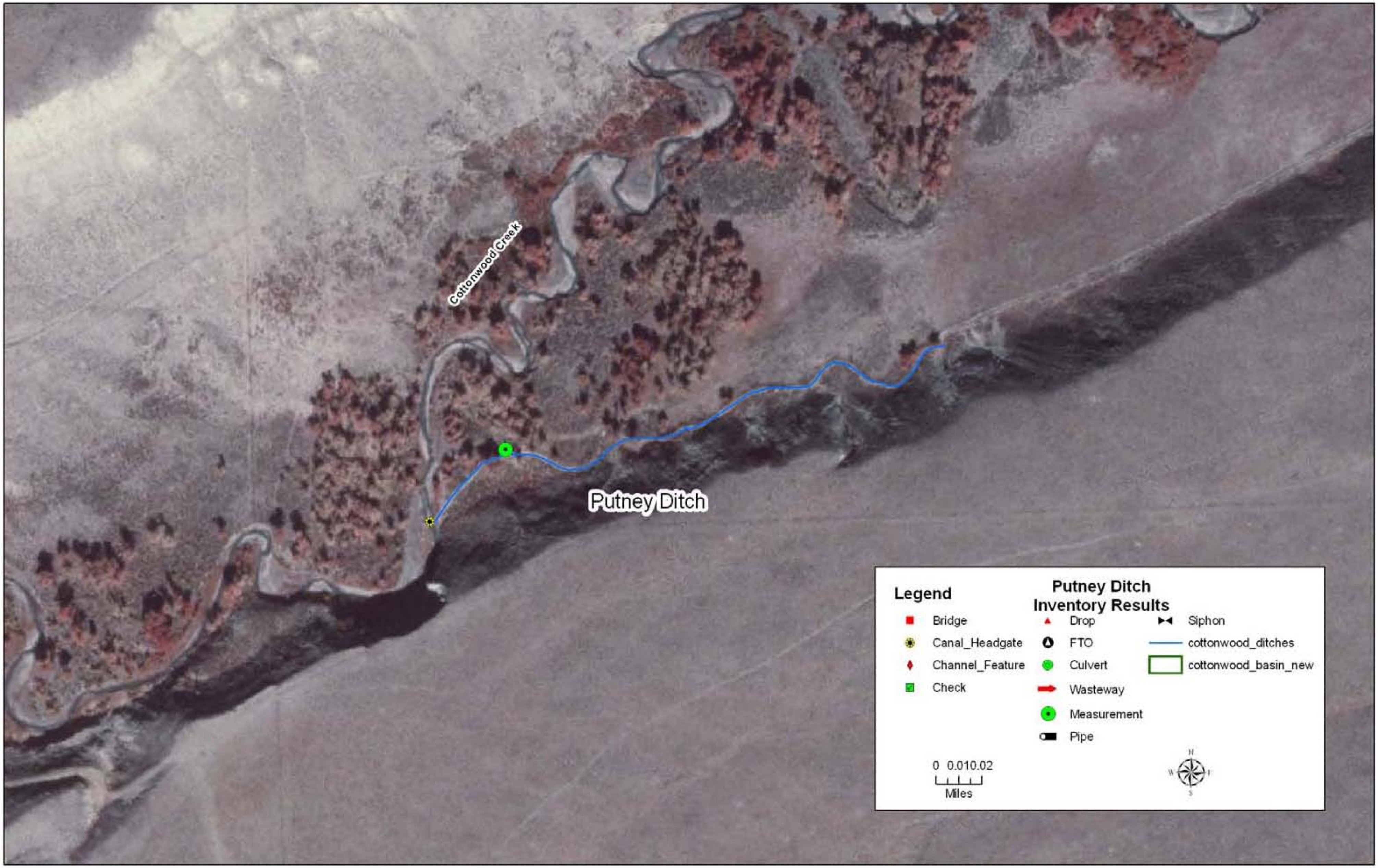
Miles

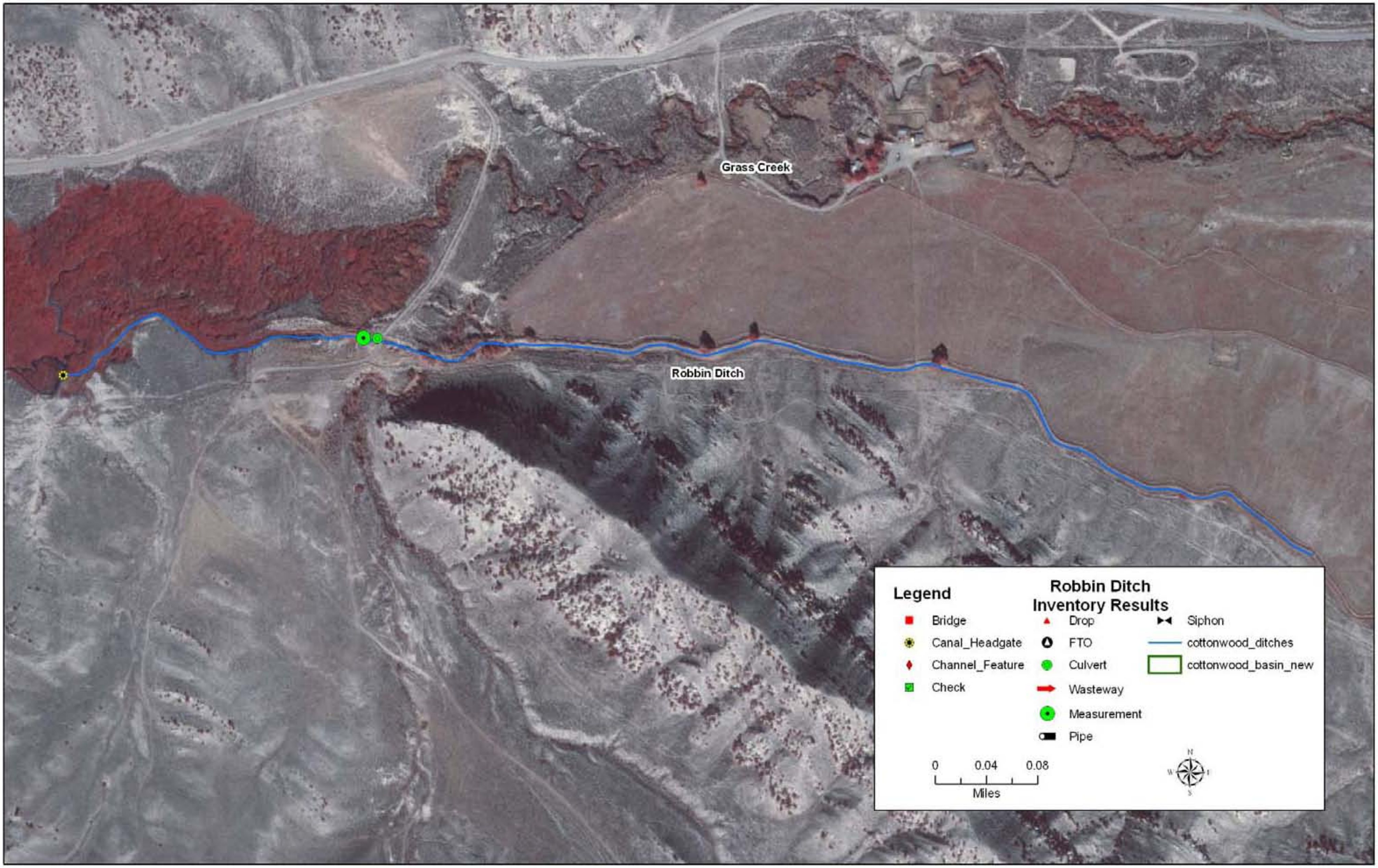


Little John Ditch
Grass Creek
Legend
Little John Ditch
Inventory Results
Bridge
Canal_Headgate
Channel_Feature
Check
Drop
FTO
Culvert
Wasteway
Measurement
Pipe
Siphon
cottonwood_ditches
cottonwood_basin_new
0
0.1
0.2
Miles



Grass Creek
LU Ditch
Legend
LU Ditch
Inventory Results
Bridge
Canal_Headgate
Channel_Feature
Check
Drop
FTO
Culvert
Wasteway
Measurement
Pipe
Siphon
cottonwood_ditches
cottonwood_basin_new
0
0.05
0.1
Miles


Cottonwood Creek
Putney Ditch
Legend
Putney Ditch
Inventory Results
Bridge
Canal_Headgate
Channel_Feature
Check
Drop
FTO
Culvert
Wasteway
Measurement
Pipe
Siphon
cottonwood_ditches
cottonwood_basin_new
0 0.010.02
Miles


Grass Creek
Robbin Ditch
Legend
Robbin Ditch
Inventory Results
Bridge
Canal_Headgate
Channel_Feature
Check
Drop
FTO
Culvert
Wasteway
Measurement
Pipe
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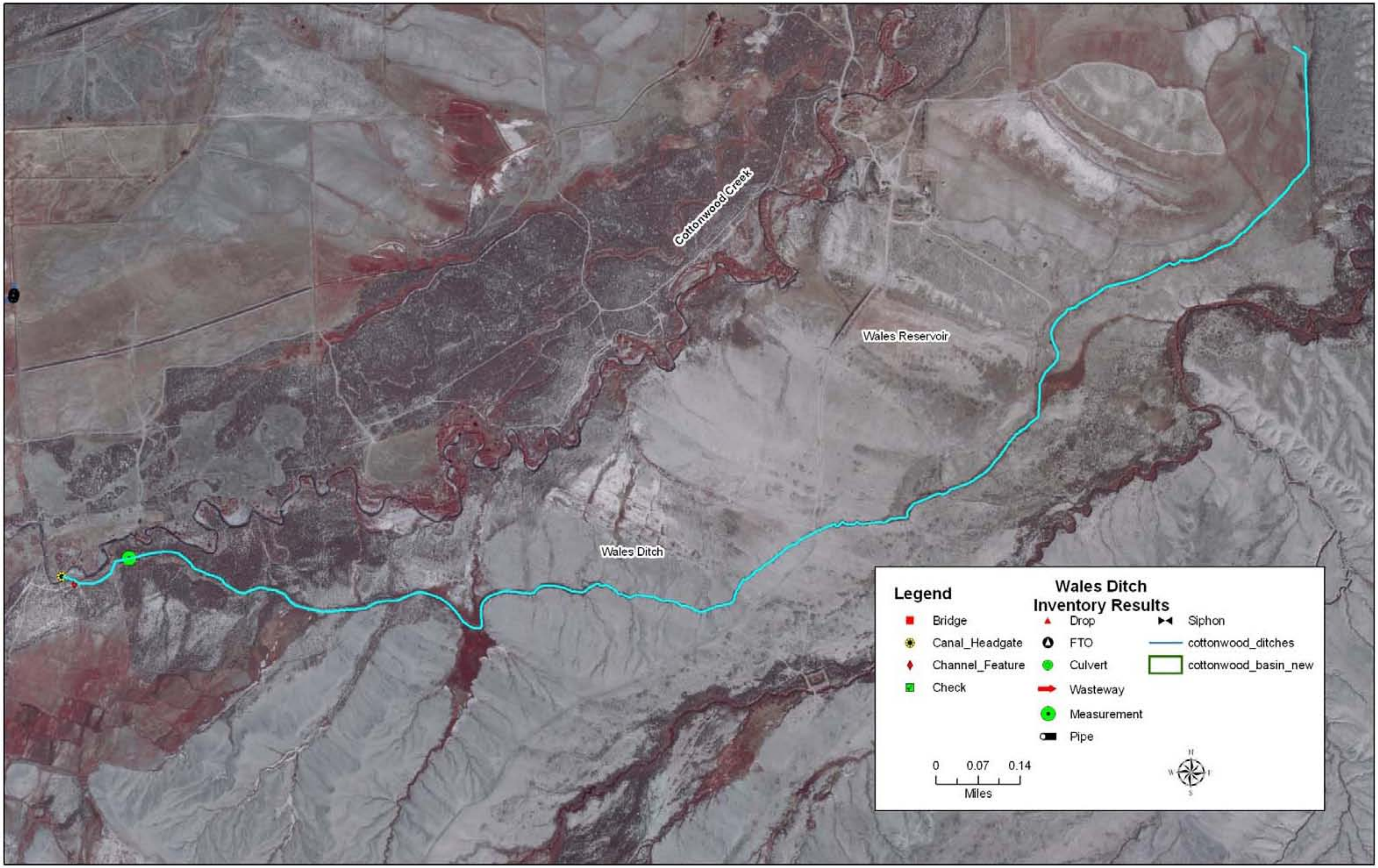
0
0.04
0.08
Miles


Cottonwood Creek
Wales Reservoir
Wales Ditch
Legend
Wales Ditch
Inventory Results
Bridge
Canal_Headgate
Channel_Feature
Check
Drop
FTO
Culvert
Wasteway
Measurement
Pipe
Siphon
cottonwood_ditches
cottonwood_basin_new
0
0.07
0.14
Miles

Appendix G

Groundwater Data

WATER RESOURCES OF HOT SPRINGS COUNTY, WYOMING

By Maria Plafcan and Kathy Muller Ogle

U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 93-4141

Prepared in cooperation with the
WYOMING STATE ENGINEER

Cheyenne, Wyoming

1994

Table 13. *Chemical analyses and physical properties of water samples collected from selected wells and springs in Hot Springs County*

[Site number: Simplified site number used in this report to identify well and spring sampling sites. Local number: See text describing well-numbering system in the section titled Ground-Water. Analytical results in milligrams per liter except as indicated; ft, feet; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; --, no data; <, less than]

Site number (figs. 14-18)	Local number	Date	Well depth (ft)	Specific conductance (µS/cm)	pH	Water temperature (°C)	Hardness ($CaCO_3$)	Calcium, dissolved (Ca)	Magnesium, dissolved (Mg)	Sodium, dissolved (Na)	Sodium adsorption ratio	Potassium, dissolved (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Alkalinity, total (as $CaCO_3$)	Sulfate, dissolved (SO_4)	Chloride, dissolved (Cl)	Fluoride, dissolved (F)	Silica, dissolved (SiO_2)	Dissolved solids, sum of constituents	Nitrogen, NO_2+NO_3, dissolved	Phosphorous, total (P)
Quaternary alluvium																						
Qa1	43-095-16ddc01	07-23-46	42	2,540	7.5	--	980	250	88	--	4	--	280	0	--	1,300	28	0.4	--	2,070	--	--
Qa2	43-097-05bca01	08-19-88	12	2,630	--	13.0	630	120	80	430	7	5.9	--	--	490	920	28	.6	50	1,930	<0.100	0.04
		03-07-89		1,250	7.7	8.5	460	82	62	380	8	7.2	--	--	510	760	16	.7	50	1,670	.16	.22
Qa3	43-097-14bab01	03-07-89	50	2,780	7.4	9.5	820	180	90	390	6	5.8	--	--	480	1,200	24	.5	38	2,210	<.100	.33
Qa4	44-094-08ba 01	10-12-70	15	3,150	8.2	--	800	190	76	450	7	8.1	310	0	--	1,400	90	.2	18	2,390	--	--
Qa5	44-094-20ccc01	07-23-46	42	5,760	7.8	--	2,500	450	340	--	8	--	450	0	--	3,700	87	.8	--	5,710	--	--
Qa6	44-094-33ccb01	06-07-67	15	2,080	7.8	11.0	760	200	65	160	2	9.4	160	0	--	5,800	40	.6	20	1,490	--	--
Qa7	45-099-23cab01	07-25-90	Spring	1,060	7.6	13.0	390	92	38	90	2	4.3	--	--	290	260	9.8	1.3	13	684	.40	.01
Qa8	45-100-17acd01	06-21-90	84	331	9.2	7.0	33	6.7	3.9	60	5	.8	--	--	140	24	.6	.3	1.8	181	<.100	<.01
Qa9	8N-3E-01cda01	09-17-76	40	--	--	--	490	100	58	230	5	3.7	180	0	--	810	15	.6	4.0	1,310	--	<.01
Qa10	8N-3E-02bca01	03-08-89	--	1,250	8.0	8.5	140	36	11	230	9	2.4	--	--	260	380	9.4	.4	8.2	836	.12	<.01
Qa11	8N-3E-02dca01	03-07-89	60	2,710	8.3	12.0	38	9.7	3.3	620	44	2.0	--	--	380	990	15	1.5	9.6	1,880	<.100	.03
Qa12	8N-4E-16aaa01	07-23-46	50	2,440	8.0	--	450	110	41	--	9	--	330	0	--	1,100	30	.8	--	1,860	--	--
Qa13	9N-3E-33adb01	06-23-89	28	1,200	6.9	10.5	450	110	43	89	2	1.1	--	--	240	380	5.9	.7	33	828	5.3	.03
Qa14	9N-3E-33adb02	09-14-76	28	--	--	--	600	150	55	120	2	1.4	470	0	--	470	12	1.0	32	1,070	--	.03
Quaternary terrace deposits																						
Qt1	43-094-08ccc01	07-22-46	36	3,230	8.0	--	1,300	280	150	--	5	--	470	0	--	1,700	26	1.0	--	2,840	--	--
Qt2	43-096-07dbc01	10-28-49	40	3,620	7.4	9.0	1,400	350	130	460	5	5.6	440	0	--	1,900	37	1.2	32	3,120	--	--
		09-03-68		3,720	7.7	--	1,400	300	170	420	5	5.6	610	0	--	1,800	15	2.4	41	3,020	--	--
Qt3	43-096-14bda01	07-25-46	44	11,300	7.9	--	2,000	210	350	--	28	--	500	0	--	7,300	90	1.3	--	11,100	--	--
Qt4	43-096-17bbb03	08-23-65	42	1,890	8.2	9.5	600	120	70	230	4	5.0	450	0	--	680	12	1.4	39	1,380	--	--
Qt5	43-096-18aba01	07-22-46	64	2,460	8.0	--	1,000	240	110	--	4	--	440	0	--	1,100	42	1.3	--	2,020	--	--
Qt6	43-097-03ccd01	07-22-46	--	2,200	7.9	--	790	180	81	--	4	--	570	0	--	800	44	1.1	--	1,720	--	--
Qt7	46-098-28bbb01	06-20-90	28	1,920	7.9	10.0	240	28	42	360	10	2.7	--	--	610	460	24	1.8	17	1,310	.50	<.01
Absaroka Volcanic Supergroup																						
Tav1	43-100-04aad01	07-24-90	Spring	378	7.5	9.0	29	7.5	2.4	76	6	0.4	--	--	150	36	2.9	0.3	18	236	0.20	0.40
Tav2	43-102-15daa01	10-18-89	Spring	202	7.9	7.0	29	7.6	2.4	37	3	.7	--	--	93	13	.8	.2	27	143	.31	.18
Tav3	45-099-08bdc01	06-21-90	Spring	412	8.0	15.0	93	30	4.5	57	3	.6	--	--	140	77	3.7	.2	7.7	265	.50	<.01
Tav4	8N-3W-16add01	10-19-89	Spring	180	7.5	3.0	28	9.6	1.0	30	2	.3	--	--	73	17	.8	.2	22	125	.25	.10
Fort Union Formation																						
Tfu1	45-096-15dda01	09-13-90	100	4,750	7.1	16.5	1,300	270	160	610	7	6.5	--	--	460	1,700	70	.7	16	3,420	2.5	<.01
Tfu2	45-097-17acc01	07-26-90	Spring	2,450	7.5	14.0	1,300	140	220	91	1	14	--	--	610	870	21	.7	11	1,730	.10	<.01
Tfu3	47-097-31cbb01	02-16-68	247	4,320	8.4	--	720	100	110	850	14	9.0	790	8	--	1,800	35	1.7	8.3	3,340	--	--
Tfu4	47-098-28aaa01	06-18-90	200	3,700	8.0	22.0	620	99	90	680	12	7.9	--	--	590	1,300	29	.7	8.6	2,570	<.100	<.01
Tfu5	47-098-34cad01	04-12-66	320	2,350	8.1	--	500	93	65	380	7	13	540	0	--	900	12	.8	7.8	1,730	--	--

Table 13. *Chemical analysis and physical properties of water samples collected from selected wells and springs in Hot Springs County--Continued*

Site number (figs. 14-18)	Local number	Date	Well depth (ft)	Specific conductance (µS/cm)	pH	Water temperature (°C)	Hardness ($CaCO_3$)	Calcium, dissolved (Ca)	Magnesium, dissolved (Mg)	Sodium, dissolved (Na)
Meeteetse Formation										
Km1	46-097-31aaa01	06-07-67	160	1,690	8.4	11.0	430	39	81	230
Km2	46-099-34dcb01	06-21-90	310	1,460	7.3	9.5	790	120	120	43
Km3	46-100-22daa01	06-22-90	100	1,400	7.3	8.0	580	100	81	100
Km4	47-098-32aba01	06-19-90	101	1,840	7.7	11.0	550	80	86	200
Km5	47-099-33cad01	06-19-90	135	2,000	8.1	16.0	380	35	70	310
Mesaverde Formation										
Kmv1	44-095-17bba01	07-16-70	293	3,260	7.9	13.0	1,900	170	360	160
Kmv2	44-097-25cdc01	06-23-70	--	2,330	7.9	14.5	1,400	250	190	67
Kmv3	44-098-17abc01	07-23-90	203	1,350	7.8	12.5	110	28	9.8	290
Kmv4	45-097-15cbd01	07-26-90	260	1,550	7.8	12.0	50	12	4.9	300
Kmv5	45-097-26bcd01	07-24-90	156	6,800	7.4	10.5	2,100	380	280	930
Kmv6	45-097-28dad01	07-23-90	150	2,590	7.6	12.5	650	140	72	350
Kmv7	45-099-25ccd01	07-25-90	Spring	1,760	8.0	9.5	360	66	47	280
Kmv8	45-099-28aba01	07-25-90	120	1,020	7.7	12.0	370	96	31	98
Kmv9	46-098-10bba01	02-06-67	350	2,650	7.0	--	1,200	390	50	250
Kmv10	46-099-22cbc01	06-20-90	Spring	1,210	7.6	9.5	430	80	56	98
Kmv11	47-099-04dab01	06-20-90	215	3,790	8.7	10.0	45	11	4.3	920
Kmv12	47-099-14abc02	09-16-70	1,180	2,260	8.5	16.0	9	2.0	1.0	600
Cody Shale										
Kc1	43-095-12bcc02	07-22-46	53	2,960	7.8	7.0	99	23	10	--
Kc2	43-098-03acd01	06-22-89	60	1,080	7.2	9.5	92	25	7.1	210
Kc3	46-098-27dcc01	09-17-70	80	4,010	7.5	--	1,200	200	170	520
Frontier Formation										
Kf1	41-090-04baa01	09-14-90	Spring	435	8.2	6.0	230	56	21	5.0
~~Kf2~~	~~42-091-35acc01~~	~~09-14-90~~	~~Spring~~	~~2,350~~	~~7.4~~	~~7.0~~	~~1,000~~	~~200~~	~~130~~	~~150~~
Kf3	42-092-02cbb01	07-09-70	600	1,580	8.7	15.0	3	.60	.30	410
		08-22-90		1,580	9.0	14.5	4	1.1	.21	370
Kf4	42-092-08ddd01	07-25-89	254	1,580	9.2	14.5	4	1.4	.12	340
Kf5	42-092-12cda01	08-22-90	381	1,750	8.5	13.0	9	2.8	.45	380
Kf6	43-092-04bda01	08-22-90	--	1,630	9.2	18.0	2	.83	.06	460
Kf7	43-092-22cdb01	08-22-90	--	1,170	9.2	16.0	3	1.1	.07	270
Kf8	44-093-33dac01	08-23-90	1,490	10,300	8.3	15.5	57	10	7.7	3,400
Kf9	44-093-34dcc01	08-23-90	1,390	1,850	9.3	19.5	3	1.1	.16	400
Kf10	8N-2E-11bac01	06-22-89	Spring	2,340	7.3	15.0	740	180	70	270
Kf11	8N-2E-12bcc01	06-21-89	Spring	2,350	7.5	11.5	730	180	69	290

Site number (figs. 14-18)	Sodium adsorption ratio	Potassium, dissolved (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Alkalinity, total (as $CaCO_3$)	Sulfate, dissolved (SO_4)	Chloride, dissolved (Cl)	Fluoride, dissolved (F)	Silica, dissolved (SiO_2)	Dissolved solids, sum of constituents	Nitrogen, NO_2+NO_3, dissolved	Phosphorous, total (P)
Meeteetse Formation												
Km1	5	5.1	370	12	--	560	25	1.4	11	1,150	--	--
Km2	.7	6.8	--	--	710	200	9.9	.5	11	938	<.100	<.01
Km3	2	11	--	--	550	250	43	.1	6.7	936	3.0	<.01
Km4	4	4.0	--	--	440	530	16	.5	14	1,200	<.100	<.01
Km5	7	7.0	--	--	810	470	13	.9	9.7	1,400	<.100	<.01
Mesaverde Formation												
Kmv1	2	21	800	0	--	1,500	30	.5	5.9	2,620	--	--
Kmv2	.8	9.6	810	0	--	840	11	.4	9.8	1,770	--	--
Kmv3	12	2.0	--	--	530	180	17	1.1	20	867	<.100	.01
Kmv4	18	2.5	--	--	550	240	5.9	.2	9.7	907	.40	<.01
Kmv5	9	11	--	--	450	3,200	420	1.1	12	5,510	<.100	<.01
Kmv6	6	6.7	--	--	360	1,100	42	1.0	9.8	1,940	<.100	<.01
Kmv7	6	8.7	--	--	460	540	7.3	.9	10	1,230	<.100	<.01
Kmv8	2	3.2	--	--	230	190	120	.8	9.9	688	.50	<.01
Kmv9	3	15	770	0	--	1,000	21	.7	8.2	2,160	--	--
Kmv10	2	4.2	--	--	480	190	7.8	.4	14	741	.30	<.01
Kmv11	60	4.8	--	--	820	1,000	22	.7	5.8	2,460	<.100	<.01
Kmv12	86	2.5	1,340	22	--	100	36	3.4	7.4	1,430	--	--
Cody Shale												
Kc1	30	--	400	0	--	1,100	46	0.6	--	2,080	--	--
Kc2	10	1.8	--	--	260	290	6.5	.3	9.6	711	0.59	0.01
Kc3	7	6.8	680	0	--	970	510	.6	14	2,720	--	--
Frontier Formation												
Kf1	.1	2.9	--	--	190	65	3.1	.8	18	284	<.100	.03
~~Kf2~~	~~2~~	~~1.7~~	~~--~~	~~--~~	~~330~~	~~1,000~~	~~4.6~~	~~1.1~~	~~31~~	~~1,720~~	~~<.100~~	~~<.01~~
Kf3	110	.8	770	26	--	150	15	3.1	10	998	--	--
	85	.8	--	--	660	170	18	2.9	10	971	.30	.25
Kf4	74	.7	--	--	520	240	11	1.2	8.9	921	.56	.02
Kf5	56	.9	--	--	320	510	2.1	.6	18	1,110	<.100	.19
Kf6	130	.8	--	--	690	280	14	2.8	14	1,190	<.100	.08
Kf7	67	.6	--	--	250	320	2.9	.3	14	758	<.100	.08
Kf8	200	7.4	--	--	570	5,900	280	<.1	11	9,960	<.100	.05
Kf9	94	.7	--	--	400	450	14	.8	16	1,120	.30	.06
Kf10	4	7.9	--	--	180	1,200	3.2	1.5	15	1,860	<.100	.07
Kf11	5	11	--	--	310	1,100	6.3	1.7	18	1,860	<.100	.18

Table 13. *Chemical analysis and physical properties of water samples collected from selected wells and springs in Hot Springs County*--Continued

Site number (figs. 14-18)	Local number	Date	Well depth (ft)	Specific conductance (µS/cm)	pH	Water temperature (°C)	Hardness ($CaCO_3$)	Calcium, dissolved (Ca)	Magnesium, dissolved (Mg)	Sodium, dissolved (Na)
Mowry Shale										
Kmr1	41-091-09cca01	08-23-90	Spring	565	7.9	9.5	75	17	8.0	89
Kmr2	42-092-34bab01	08-11-89	150	1,750	7.2	10.5	400	110	30	220
Kmr3	42-093-07cdc01	07-25-89	Spring	815	7.6	27.0	160	39	16	110
Thermopolis Shale and Muddy Sandstone Member of the Thermopolis Shale										
Kt1	41-092-11abd01	07-27-89	80	965	7.4	15.0	230	57	21	120
Kt2	41-092-11adb01	07-27-89	Spring	1,010	7.4	12.0	250	62	22	120
Kt3	43-091-19daa02	07-13-70	1,240	1,750	9.1	14.0	4	.60	.70	450
Kt4	43-091-36bca01	07-13-70	683	1,100	9.0	17.0	2	.60	.10	250
Mowry and Thermopolis Shales										
Kmt1	8N-2E-13aba01	06-21-89	Spring	1,750	6.8	12.5	480	120	43	91
Kmt2	8N-3E-30bca01	06-21-89	Spring	795	6.5	9.5	380	89	39	17
Kmt3	8N-3E-32abc01	06-21-89	Spring	1,070	6.6	10.0	560	130	56	24
Cloverly Formation										
Kcv1	42-094-07bac01	06-25-70	75	2,960	7.8	10.5	1,700	490	130	140
Kcv2	42-095-03aac01	07-27-90	183	2,240	7.5	12.0	740	170	76	190
Sundance Formation										
Js1	41-091-13cdc01	09-11-89	Spring	590	8.0	9.0	300	75	27	3.2
Gypsum Spring Formation										
Jgs1	41-091-23ddd01	09-13-89	Spring	500	7.9	8.5	250	58	25	5.5
Jgs2	41-091-32aac01	09-13-89	Spring	610	7.9	10.0	140	35	12	87
Jgs3	42-092-18caa01	09-15-89	Spring	2,000	8.0	10.5	940	270	64	84
Jgs4	42-094-15dad01	09-12-89	Spring	2,900	7.3	14.0	1,800	540	110	100
Chugwater Formation										
TRc1	41-091-27dbc01	09-14-89	Spring	880	7.4	9.0	370	89	35	30
TRc2	41-091-27dcc01	09-13-89	Spring	730	7.4	8.5	330	79	32	11
TRc3	41-091-32cad01	09-13-89	68	535	7.7	8.0	220	52	21	39
TRc4	41-092-04bcb01	09-15-89	210	1,300	7.5	10.0	450	84	59	20
TRc5	42-093-14ccb01	07-26-89	127	1,790	7.2	14.0	1,000	320	53	30
TRc6	42-093-21acc01	07-26-89	183	2,680	7.1	14.0	1,700	570	71	24
TRc7	42-094-17ddc01	07-26-89	Spring	2,880	7.3	21.0	1,500	430	95	170
TRc8	42-094-25bdb01	07-25-89	260	3,120	7.1	14.0	1,900	530	130	110
TRc9	43-099-10dba01	07-22-46	400	3,950	8.0	--	160	38	15	--
TRc10	6N-5E-04dcd01	07-28-89	Spring	420	7.8	13.0	200	41	24	13
TRc11	6N-5E-09adb01	07-28-89	Spring	2,430	7.3	15.5	1,600	570	43	11
TRc12	7N-5E-31cda01	07-28-89	Spring	960	7.4	16.0	480	120	44	18

Site number (figs. 14-18)	Sodium adsorption ratio	Potassium, dissolved (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Alkalinity, total (as $CaCO_3$)	Sulfate, dissolved (SO_4)	Chloride, dissolved (Cl)	Fluoride, dissolved (F)	Silica, dissolved (SiO_2)	Dissolved solids, sum of constituents	Nitrogen, NO_2+NO_3, dissolved	Phosphorous, total (P)
Mowry Shale												
Kmr1	4	.6	--	--	170	120	2.3	.5	24	362	.10	.14
Kmr2	5	4.3	--	--	300	590	4.6	.7	11	1,150	<.100	<.01
Kmr3	4	3.3	--	--	180	240	5.1	.7	12	537	1.20	.02
Thermopolis Shale and Muddy Sandstone Member of the Thermopolis Shale												
Kt1	3	3.1	--	--	260	220	3.6	.9	13	599	<.100	.09
Kt2	3	4.4	--	--	280	240	5.7	.4	14	638	.32	.02
Kt3	93	.8	750	79	--	180	9.2	2.3	12	1,100	--	--
Kt4	78	.4	280	31	--	250	1.3	.4	11	683	--	--
Mowry and Thermopolis Shales												
Kmt1	2	6.2	--	--	280	400	3.0	1.0	17	847	<.100	.02
Kmt2	.4	5.4	--	--	110	310	4.3	.9	12	542	<.100	<.01
Kmt3	.4	6.2	--	--	170	440	4.6	1.0	16	779	.24	.04
Cloverly Formation												
Kcv1	1	4.9	120	0	--	1,900	8.6	2.0	20	2,750	--	--
Kcv2	3	5.2	--	--	140	990	12	.5	11	1,540	<.100	<.01
Sundance Formation												
Js1	.1	2.6	--	--	180	1,000	.8	.4	14	331	.50	.02
Gypsum Spring Formation												
Jgs1	.2	2.6	--	--	190	66	1.2	.3	12	287	.30	<.01
Jgs2	3	1.3	--	--	230	87	2.2	.3	18	383	.19	<.01
Jgs3	1	4.8	--	--	120	970	3.1	.8	19	1,490	.58	<.01
Jgs4	1	5.4	--	--	130	1,800	2.6	.7	16	2,650	.80	<.01
Chugwater Formation												
TRc1	.7	1.7	--	--	230	200	1.4	.3	18	514	.50	.06
TRc2	.3	2.7	--	--	170	140	2.6	.3	15	388	.74	<.01
TRc3	1	6.2	--	--	290	12	6.3	.3	9.0	321	<.100	<.01
TRc4	.4	7.0	--	--	210	240	9.6	.9	11	569	2.5	<.01
TRc5	.4	3.0	--	--	240	870	2.5	.3	15	1,450	3.4	<.01
TRc6	.3	4.4	--	--	180	1,500	2.8	.5	11	2,320	7.1	.02
TRc7	2	5.5	--	--	130	1,800	3.3	.6	16	2,600	.63	<.01
TRc8	1	6.9	--	--	140	1,900	6.5	.4	11	2,790	2.5	<.01
TRc9	32	--	230	0	--	1,800	26	1.3	--	2,940	--	<.01
TRc10	.4	1.0	--	--	200	24	4.5	.4	21	251	1.2	.02
TRc11	.1	1.3	--	--	160	1,500	1.8	.6	11	2,240	.14	<.01
TRc12	.4	2.1	--	--	190	320	6.5	.4	19	648	.84	<.01

Table 13. *Chemical analysis and physical properties of water samples collected from selected wells and springs in Hot Springs County*--Continued

Site number (figs. 14-18)	Local number	Date	Well depth (ft)	Specific conductance (µS/cm)	pH	Water temperature (°C)	Hardness ($CaCO_3$)	Calcium, dissolved (Ca)	Magnesium, dissolved (Mg)	Sodium, dissolved (Na)	Sodium adsorption ratio	Potassium, dissolved (K)	Bicarbonate (HCO_3)	Carbonate (CO_3)	Alkalinity, total (as $CaCO_3$)	Sulfate, dissolved (SO_4)	Chloride, dissolved (Cl)	Fluoride, dissolved (F)	Silica, dissolved (SiO_2)	Dissolved solids, sum of constituents	Nitrogen, NO_2+NO_3, dissolved	Phosphorous, total (P)
										Phosphoria	Formation											
Pp1	41-090-29dbc01	09-14-89	Spring	560	7.5	7.0	250	70	19	4.4	.1	2.6	--	--	160	62	1.1	.3	11	268	.28	<.01
Pp2	42-093-29bdb01	07-26-89	627	1,080	7.3	17.0	580	130	62	16	.3	3.7	--	--	180	450	4.4	1.5	9.7	787	.49	.02
Pp3	42-095-25bca01	07-07-70	Spring	1,150	8.0	21.5	570	150	50	41	.7	7.4	380	0	--	280	39	1.2	13	759	--	--
Pp4	42-095-26aad01	07-28-89	20	1,240	6.9	21.0	630	160	55	46	.8	8.1	--	--	290	330	43	1.2	14	832	<.100	<.01
Pp5	46-100-24cca01	09-16-70	6,200	4,730	6.7	--	2,000	530	150	420	4	160	1,330	0	--	1,300	370	4.1	39	3,680	--	--
										Tensleep	Sandstone											
Pt1	41-094-21cda01	08-08-89	Spring	370	7.8	9.0	160	36	16	1.9	.1	.6	--	--	150	8	.7	.1	13	171	.73	.01
Pt2	41-094-27aaa01	08-08-89	Spring	390	8.0	11.0	190	42	21	2.0	.1	.6	--	--	190	9	.6	.1	13	204	.97	.04
Pt3	42-094-26cac01	10-12-70	550	730	8.2	--	400	92	41	10	.2	1.6	300	0	--	170	3.1	2.2	12	478	--	--
Pt4	42-095-13dca01	06-25-70	1,140	2,200	7.8	19.5	1,100	280	86	110	2	22	710	0	--	540	120	2.2	13	1,530	--	--
										Madison	Limestone											
MDm1	46-098-28bcc01	06-07-67	6,000	4,150	7.1	--	1,800	520	130	300	3	170	990	0	--	1,500	280	3.8	30	3,390	--	--
										Bighorn	Dolomite											
Ob1	41-092-17ddd01	09-15-89	Spring	370	9.0	9.5	210	35	30	1.5	.0	1.4	--	--	190	7	.6	.1	7.4	196	.260	<.01
Ob2	41-092-27dac01	08-10-89	Spring	480	7.8	9.0	220	35	32	1.8	.0	1.4	--	--	220	10	1.3	.1	7.2	222	.770	<.01
Ob3	41-092-28aaa01	09-15-89	Spring	530	7.7	7.5	240	36	36	2.0	.1	.8	--	--	240	6	1.3	.2	9.4	237	.500	<.01
Ob4	41-093-21dcb01	08-08-89	Spring	450	7.4	10.0	200	49	19	3.9	.1	2.2	--	--	200	18	1.2	.2	9.8	223	.570	.01
Ob5	41-093-23aad01	07-26-89	Spring	440	7.4	12.0	240	41	34	2.1	.1	1.9	--	--	230	16	1.1	.2	8.8	247	.620	<.01
Ob6	46-098-18cbb01	09-17-70	5,800	4,210	6.8	14.0	2,000	610	120	280	3	160	1,210	0	--	1,400	270	3.4	30	3,440	--	--
										Gallatin	Limestone											
Cg1	6N-6E-15cca01	09-12-89	90	520	7.8	11.0	270	48	36	8.0	.2	2.9	--	--	240	46	1.7	.2	9.7	296	.470	<.01
										Flathead	Sandstone											
Cf1	41-092-33daa01	08-10-89	Spring	155	7.4	12.0	60	18	3	2.5	.1	.8	--	--	50	9	1.3	.2	14	85	.81	.03
Cf2	41-093-25cac01	09-14-89	Spring	70	7.8	8.0	35	9.7	2	2.5	.2	.7	--	--	20	5	3.7	.1	11	58	1.90	<.01
Cf3	41-093-31dcd01	08-09-89	Spring	150	6.7	12.0	61	18	4	2.6	.1	.5	--	--	60	6	.9	.1	15	85	.88	.02

Table 14. *Concentrations of selected trace elements for selected wells and springs in Hot Springs County*

[Site number: Simplified site number used in this report to identify well and spring sampling sites. Local number: See text describing well-numbering system in the section titled Ground-Water Data. Analytical results in micrograms per liter; --no data; <, less than]

Site number (tab. 13)	Local number	Date	Aluminum, dissolved (A1)	Arsenic, dissolved (As)	Barium, dissolved (Ba)	Boron, dissolved (Ba)	Cadmium, dissolved (Cd)	Chromium, dissolved (Cr)	Copper, dissolved (Cu)	Iron, dissolved (Fe)	Lead, dissolved (Pb)	Manganese, dissolved (Mn)	Mercury, dissolved (Hg)	Selenium, dissolved (Se)	Silver, dissolved (Ag)	Zinc, dissolved (Zn)
Quaternary alluvium deposits																
Qa4	44-094-08ba 01	10-12-70	--	--	--	190	--	--	--	--	--	--	--	--	--	--
Qa6	44-094-33ccb01	06-07-67	--	--	--	20	--	--	--	--	--	--	--	--	--	--
Qa7	45-099-23cab01	07-25-90	--	--	--	130	--	--	--	9	--	25	--	3	--	--
Qa8	45-100-17acd01	06-21-90	<10	<1	18	40	1	<1	2	30	<1	7	<0.1	<1	1	30
Quaternary terrace deposits																
Qt2	43-096-07dbc01	10-28-49	--	--	--	530	--	--	--	--	--	--	--	--	--	--
		09-03-68	--	--	--	610	--	--	--	--	--	--	--	--	--	--
Qt4	43-096-17bbb03	08-23-65	--	--	--	300	--	--	--	--	--	--	--	--	--	--
Qt7	46-098-28bbb01	06-20-90	10	<1	11	610	<1.0	2	260	20	<1	3	<.1	8	<1.0	80
Absaroka Volcanic Supergroup																
Tav1	43-100-04aad01	07-24-90	200	8	12	70	2	1	4	250	1	17	.2	7	1	3
Tav3	45-099-08bdc01	06-21-90	10	2	19	70	<1.0	<1	<1	10	<1	16	<.1	2	2	6
Fort Union Formation																
Tfu1	45-096-15dda01	09-13-90	<10	<1	100	920	<1.0	2	16	80	<1	20	<.1	6	<1.0	140
Tfu2	45-097-17acc01	07-26-90	10	<1	<100	110	<1.0	2	2	10	1	<10	.2	<2	<1.0	<10
Tfu3	47-097-31cbb01	02-16-68	--	--	--	250	--	--	--	--	--	--	--	--	--	--
Tfu4	47-098-28aaa01	06-18-90	20	<1	<100	170	<1.0	3	1	20	<1	20	<.1	<1	<1.0	<10
Tfu5	47-098-34cad01	04-12-66	--	--	--	160	--	--	--	--	--	--	--	--	--	--
Meeteetse Formation																
Km1	46-097-31aaa01	06-07-67	--	--	--	130	--	--	--	--	--	--	--	--	--	--
Km2	46-099-34dcb01	06-21-90	10	<1	30	60	<1.0	<1	1	100	1	200	<.1	1	2	150
Km3	46-100-22daa01	06-22-90	<10	<1	19	100	<1.0	1	10	610	<1	16	<.1	<1	2	30
Km4	47-098-32aba01	06-19-90	10	<1	19	110	<1.0	2	1	40	1	130	<.1	<1	1	40
Km5	47-099-33cad01	06-19-90	<10	<1	18	130	<1.0	2	4	10	<1	45	<.1	<1	<1.0	100
Mesaverde Formation																
Kmv1	44-095-17bba01	07-16-70	--	--	--	1,300	--	--	--	--	--	--	--	--	--	--
Kmv2	44-097-25cdc01	06-23-70	--	--	--	160	--	--	--	--	--	--	--	--	--	--
Kmv3	44-098-17abc01	07-23-90	--	--	--	250	--	--	--	40	--	600	--	<2	--	--
Kmv4	45-097-15cbd01	07-26-90	10	<1	12	170	1	2	1	190	<1	13	0.2	<2	<1.0	6
Kmv5	45-097-26bcd01	07-24-90	10	<1	<100	960	<1.0	2	1	60	<1	180	.3	6	<1.0	20
Kmv6	45-097-28dad01	07-23-90	10	6	<100	290	<1.0	<1	1	1,900	<1	120	.2	<2	<1.0	10
Kmv7	45-099-25ccd01	07-25-90	--	--	--	260	--	--	--	20	--	86	--	<2	--	--
Kmv8	45-099-28aba01	07-25-90	--	--	--	120	--	--	--	1,100	--	39	--	3	--	--
Kmv9	46-098-10bba01	02-06-67	--	--	--	350	--	--	--	--	--	--	--	--	--	--
Kmv10	46-099-22cbc01	06-20-90	10	<1	24	80	<1.0	<1	10	7	<1	<1	<.1	2	<1.0	50
Kmv11	47-099-04dab01	06-20-90	10	<1	<100	210	<1.0	1	<1	30	<1	50	<.1	<1	<1.0	<10
Kmv12	47-099-14abc02	09-16-70	--	--	--	290	--	--	--	--	--	--	--	--	--	--

Table 14. *Concentrations of selected trace elements for selected wells and springs in Hot Springs County--Continued*

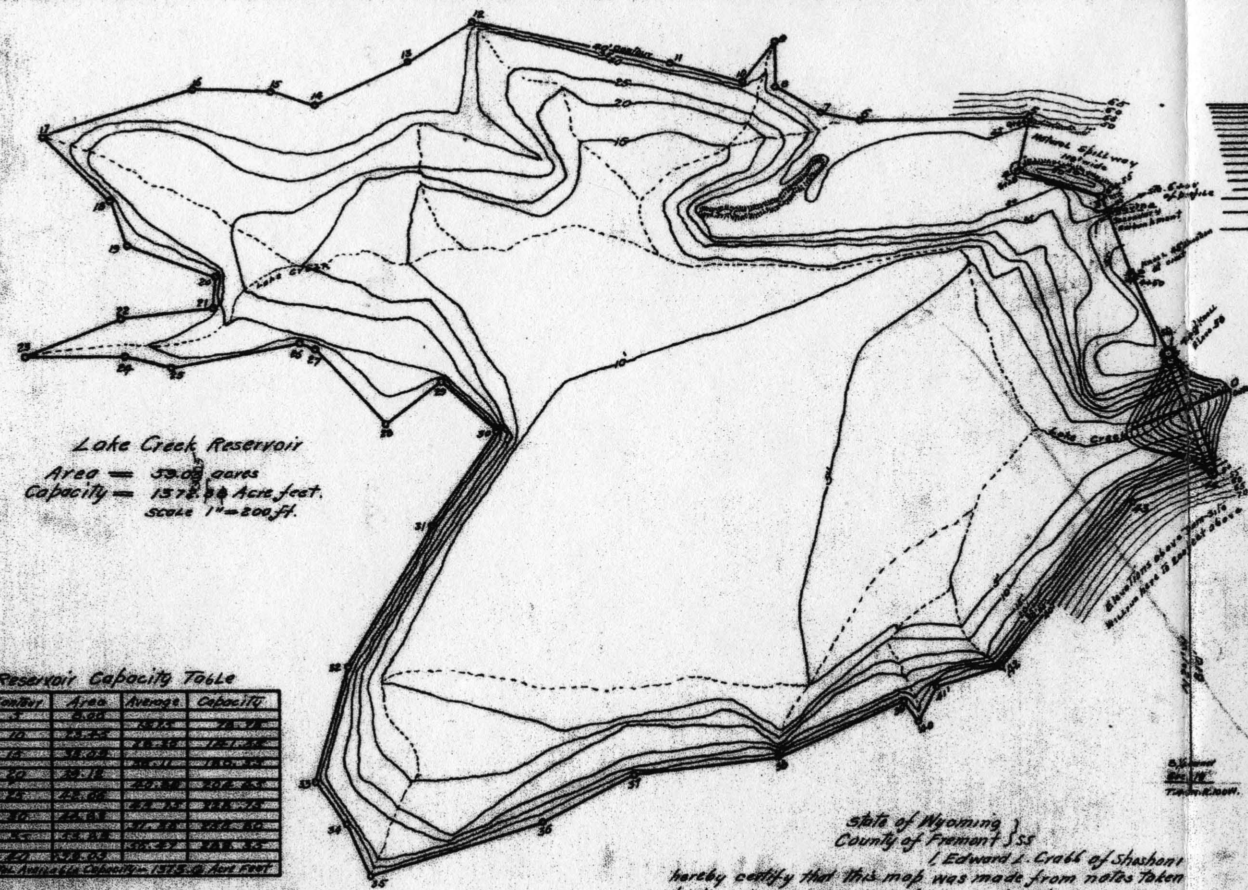
Site number (tab. 13)	Local number	Date	Aluminum, dissolved (A1)	Arsenic, dissolved (As)	Barium, dissolved (Ba)	Boron, dissolved (Ba)	Cadmium, dissolved (Cd)	Chromium, dissolved (Cr)	Copper, dissolved (Cu)	Iron, dissolved (Fe)	Lead, dissolved (Pb)	Manganese, dissolved (Mn)	Mercury, dissolved (Hg)	Selenium, dissolved (Se)	Silver, dissolved (Ag)	Zinc, dissolved (Zn)
Cody Shale																
Kc3	46-098-27dcc01	09-17-70	--	--	--	1,000	--	--	--	--	--	--	--	--	--	--
Frontier Formation																
Kf1	41-090-04baa01	09-14-90	--	--	--	20	--	--	--	<3	--	5	--	<1	--	--
Kf2	42-091-35acc01	09-14-90	<10	<1	<100	70	<1.0	<1	<1	850	<1	190	.2	<1	<1.0	<10
Kf3	42-092-02cbb01	07-09-70	--	--	--	1,400	--	--	--	--	--	--	--	--	--	--
		08-22-90	20	<1	17	1,300	<1.0	1	1	30	<1	6	<.1	<1	<1.0	<3
Kf4	42-092-08ddd01	07-25-89	--	--	--	160	--	--	--	100	--	5	--	<1	--	--
Kf5	42-092-12cda01	08-22-90	<10	<1	12	80	<1.0	1	3	40	<1	21	.1	<1	<1.0	<3
Kf6	43-092-04bda01	08-22-90	--	--	--	1,000	--	--	--	50	--	4	--	<1	--	--
Kf7	43-092-22cdb01	08-22-90	--	--	--	30	--	--	--	20	--	9	--	--	--	--
Kf8	44-093-33dac01	08-23-90	--	--	--	2,400	--	--	--	50	--	120	--	<1	--	--
Kf9	44-093-34dcc01	08-23-90	20	<1	35	180	<1.0	1	<1	40	<1	9	.6	<1	<1.0	<3
Mowry Shale																
Kmr1	41-091-09cca01	08-23-90	30	1	23	20	<1.0	<1	1	20	1	5	<.1	<1	<1.0	<3
Kmr2	42-092-34bab01	08-11-89	--	--	--	370	--	--	--	310	--	96	--	<1	--	--
Kmr3	42-093-07cdc01	07-25-89	--	--	--	140	--	--	--	110	--	4	--	4	--	--
Thermopolis Shale and Muddy Sandstone Member of the Thermopolis Shale																
Kt1	41-092-11abd01	07-27-89	--	--	--	240	--	--	--	520	--	910	--	<1	--	--
Kt2	41-092-11adb01	07-27-89	--	--	--	80	--	--	--	4	--	4	--	--	--	--
Kt3	43-091-19daa02	07-13-70	--	--	--	1,000	--	--	--	--	--	--	--	--	--	--
Kt4	43-091-36bca01	07-13-70	--	--	--	80	--	--	--	--	--	--	--	--	--	--
Cloverly Formation																
Kcv1	42-094-07bac01	06-25-70	--	--	--	500	--	--	--	--	--	--	--	--	--	--
Kcv2	42-095-03aac01	07-27-90	20	1	<100	370	<1.0	3	2	1,700	1	170	0.2	<1	<1.0	40
Sundance Formation																
Js1	41-091-13cdc01	09-11-89	--	--	--	380	--	--	--	8	--	11	--	5	--	--
Gypsum Spring Formation																
Jgs1	41-091-23ddd01	09-13-89	--	--	--	30	--	--	--	20	--	12	--	3	--	--
Jgs2	41-091-32aac01	09-13-89	--	--	--	60	--	--	--	8	--	<1	--	<1	--	--
Jgs3	42-092-18caa01	09-15-89	--	--	--	210	--	--	--	20	--	2	--	3	--	--
Jgs4	42-094-15dad01	09-12-89	--	--	--	50	--	--	--	40	--	10	--	4	--	--
Chugwater Formation																
TRc1	41-091-27dbc01	09-14-89	--	--	--	50	--	--	--	10	--	<1	--	2	--	--
TRc2	41-091-27dcc01	09-13-89	--	--	--	20	--	--	--	7	--	<1	--	8	--	--
TRc3	41-091-32cad01	09-13-89	--	--	--	40	--	--	--	160	--	53	--	<1	--	--
TRc4	41-092-04bcb01	09-15-89	--	--	--	100	--	--	--	10	--	9	--	5	--	--
TRc5	42-093-14ccb01	07-26-89	--	--	--	110	--	--	--	10	--	2	--	--	--	--

Table 14. *Concentrations of selected trace elements for selected wells and springs in Hot Springs County--Continued*

Site number (tab. 13)	Local number	Date	Aluminum, dissolved (Al)	Arsenic, dissolved (As)	Barium, dissolved (Ba)	Boron, dissolved (Ba)	Cadmium, dissolved (Cd)	Chromium, dissolved (Cr)	Copper, dissolved (Cu)	Iron, dissolved (Fe)	Lead, dissolved (Pb)	Manganese, dissolved (Mn)	Mercury, dissolved (Hg)	Selenium, dissolved (Se)	Silver, dissolved (Ag)	Zinc, dissolved (Zn)
Chugwater Formation																
TRc6	42-093-21acc01	07-26-89	--	--	--	220	--	--	--	70	--	20	--	--	--	--
TRc7	42-094-17ddc01	07-26-89	--	--	--	540	--	--	--	8	--	2	--	--	--	--
TRc8	42-094-25bdb01	07-25-89	--	--	--	550	--	--	--	140	--	20	--	--	--	--
TRc10	6N-5E-04dcd01	07-28-89	--	--	--	50	--	--	--	6	--	<1	--	--	--	--
TRc11	6N-5E-09adb01	07-28-89	--	--	--	60	--	--	--	50	--	20	--	--	--	--
TRc12	7N-5E-31cda01	07-28-89	--	--	--	90	--	--	--	5	--	2	--	--	--	--
Phosphoria Formation																
Pp1	41-090-29dbc01	09-14-89	--	--	--	10	--	--	--	9	--	<1	--	2	--	--
Pp2	42-093-29bdb01	07-26-89	--	--	--	60	--	--	--	1,100	--	18	--	--	--	--
Pp3	42-095-25bca01	07-07-70	--	--	--	120	--	--	--	--	--	--	--	--	--	--
Pp4	42-095-26aad01	07-28-89	--	--	--	160	--	--	--	20	--	6	--	--	--	--
Pp5	46-100-24cca01	09-16-70	--	--	--	1,100	--	--	--	--	--	--	--	--	--	--
Tensleep Sandstone																
Pt1	41-094-21cda01	08-08-89	--	--	--	<10	--	--	--	10	--	<1	--	<1	--	--
Pt2	41-094-27aaa01	08-08-89	--	--	--	<10	--	--	--	10	--	2	--	--	--	--
Pt3	42-094-26cac01	10-12-70	--	--	--	0	--	--	--	--	--	--	--	--	--	--
Pt4	42-095-13dca01	06-25-70	--	--	--	410	--	--	--	--	--	--	--	--	--	--
Madison Limestone																
MDm1	46-098-28bcc01	06-07-67	--	--	--	10	--	--	--	--	--	--	--	--	--	--
Bighorn Dolomite																
Ob1	41-092-17ddd01	09-15-89	--	--	--	10	--	--	--	40	--	7	--	<1	--	--
Ob2	41-092-27dac01	08-10-89	--	--	--	<10	--	--	--	10	--	<1	--	--	--	--
Ob3	41-092-28aaa01	09-15-89	--	--	--	10	--	--	--	8	--	<1	--	<1	--	--
Ob4	41-093-21dcb01	08-08-89	--	--	--	20	--	--	--	10	--	<1	--	--	--	--
Ob5	41-093-23aad01	07-26-89	--	--	--	20	--	--	--	40	--	2	--	--	--	--
Ob6	46-098-18cbb01	09-17-70	--	--	--	1,500	--	--	--	--	--	--	--	--	--	--
Gallatin Limestone																
Cg1	6N-6E-15cca01	09-12-89	--	--	--	120	--	--	--	10	--	<1	--	<1	--	--
Flathead Sandstone																
Cf1	41-092-33daa01	08-10-89	--	--	--	10	--	--	--	10	--	<1	--	--	--	--
Cf2	41-093-25cac01	09-14-89	--	--	--	<10	--	--	--	30	--	<1	--	<1	--	--
Cf3	41-093-31dcd01	08-09-89	--	--	--	30	--	--	--	20	--	1	--	--	--	--

Appendix H

Existing Dams



Reservoir Capacity Table

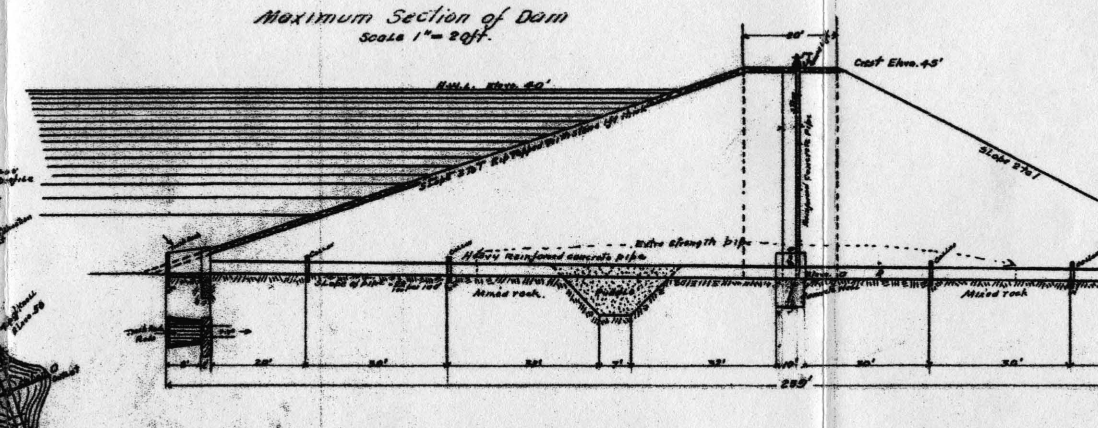
Contour	Area	Average	Capacity
5	8.66		
		[illegible]	[illegible]
10	[illegible]		
		[illegible]	[illegible]
15	[illegible]		
		[illegible]	[illegible]
20	39.12		
		[illegible]	[illegible]
25	42.66		
		[illegible]	[illegible]
30	[illegible]		
		[illegible]	[illegible]
[illegible]	[illegible]		
		[illegible]	[illegible]
[illegible]	[illegible]		
Total Available Capacity = 1375.[illegible] Acre Feet			

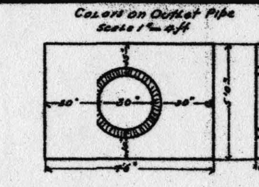
State of Wyoming }
County of Fremont } SS

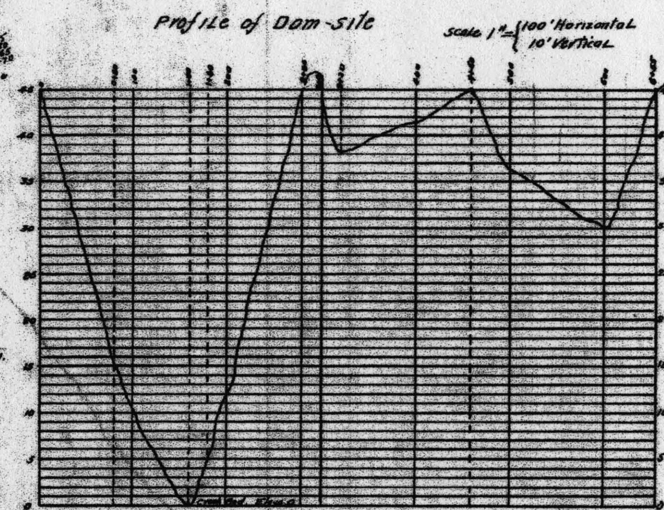
I, Edward L. Crabb of Shoshoni hereby certify that this map was made from notes taken during actual surveys made by me on August 26, 27, 1935; Dec. 7, 8, 9, 10, and 11, 1935; March 13, 14, 15 and 16, 1936 and August 11, 12, 13 and 14, 1936, and that it correctly represents the irrigation works described in the accompanying application together with a meander of streams and shows accurately the location and area of the lands irrigated and adjudicated in Lake Creek Irrigation District.

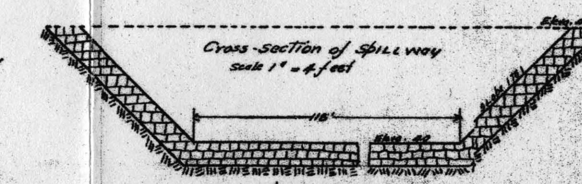
Edward L. Crabb
Surveyor

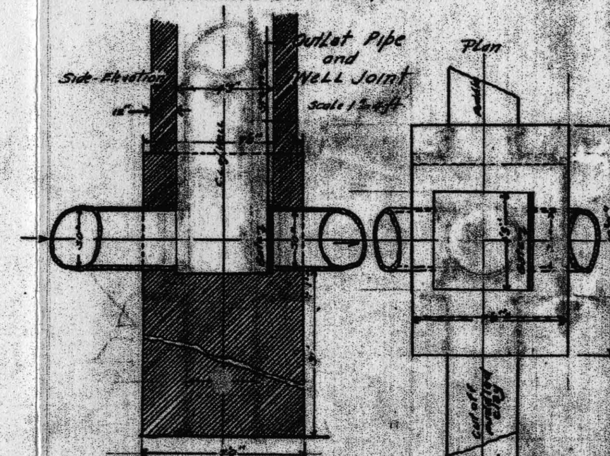
State Registration No 3.











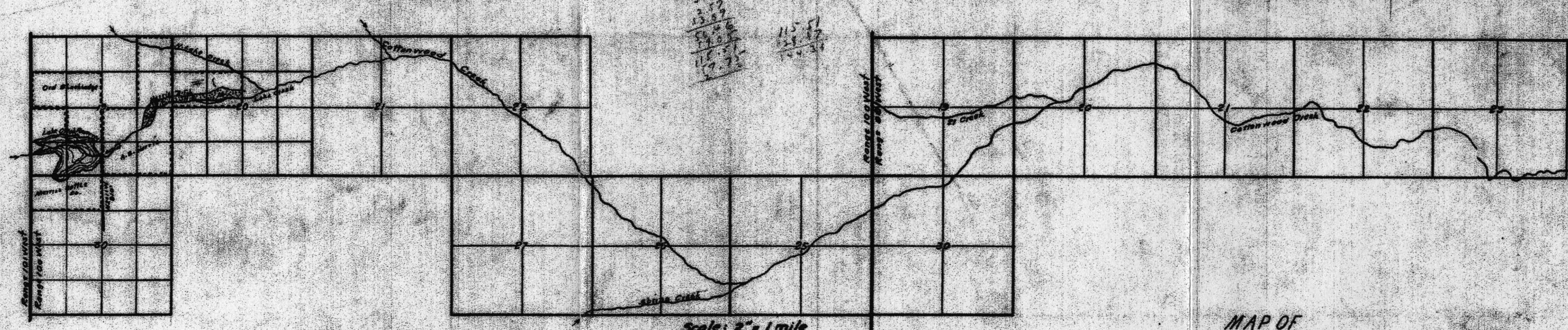
Field Notes of Survey

Station 0 being N 8° 1' W. 810' from the S¼ corner Sec. 19. T. 44 N. R. 100 W.

Stations	Courses	Distance
0 – 1	N 20° 50' W	120
1 – 2	N 24° 46' W	183
2 – 3	N 21° 11' W	180
3 – 4	N 72° 31' W	165
4 – 5	N 11° 55' W	118
5 – 6	S 88° 45' W	362
6 – 7	N 79° 10' W	84
7 – 8	N 60° 45' W	115
8 – 9	North	100
9 – 10	S 38° 45' W	113
10 – 11	N 75° 0' W	157
11 – 12	N 77° 30' W	426
12 – 13	S 57° 45' W	165
13 – 14	S 65° 45' W	220
14 – 15	N 73° 2' W	100
15 – 16	N 88° 20' W	165
16 – 17	S 72° 25' W	332
17 – 18	S 48° 0' E	197
18 – 19	S 19° 48' E	104
19 – 20	S 70° 20' E	203
20 – 21	S 4° 10' W	68
21 – 22	S 83° 2' W	200
22 – 23	S 67° 30' W	217
23 – 24	East	208
24 – 25	S 76° 45' E	102
25 – 26	N 79° 35' E	282
26 – 27	S 69° 58' E	35
27 – 28	S 46° 20' E	221
28 – 29	S 52° 5' E	150
29 – 30	S 47° 15' E	208
30 – 31	S 33° 5' W	245
31 – 32	S 30° 35' W	356
32 – 33	S 15° 35' W	257
33 – 34	S 35° 15' E	112
34 – 35	S 24° 40' E	125
35 – 36	N 72° 15' E	383
36 – 37	N 62° 15' E	220
37 – 38	N 83° 14' E	310
38 – 39	N 64° 45' E	295
39 – 40	S 36° 15' E	55
40 – 41	N 27° 45' E	85
41 – 42	N 72° 40' E	145
42 – 43	N 57° 55' E	454
43 – 44	N 22° 45' E	176
44 – 0	N 20° 50' W	160

T. 44 N. R. 100 W.

T. 44 N. R. 99 W.



Scale: 2" = 1 mile

Yardage in Main Dam = 28650
Rip-rapping Yardage in Main Dam = 3255 sq. yards.

Approved April 9, 1937
John D. Quinn
John D. Quinn, State Engineer

MAP OF
AMENDED APPLICATION

LAKE CREEK RESERVOIR
&
ENLARGEMENT OF LAKE CREEK RESERVOIR

Applicant
LAKE CREEK IRRIGATION DISTRICT
Fred L. Wales, Secretory — Hamilton Dome, Wyoming

4638 Res
4639 Res

No 1

Wyoming Dam Inspection Report

Date 9/7/2005

Name of Dam Lake Creek Water Division # 3 District 14

Permit No(s). 4639 County Hot Springs

Owner Name Spring Gulch Cattle Company

Address Thermopolis Wyoming

Location (1/4 1/4, lot or tract) SESW Section 19 Twnsp 14n 44 Range 100w

GPS - Latitude (DMS) 43 45 72 Longitude (DMS) 108 54 11

Type of Dam : EARTHFILL x ROCKFILL ____ CONCRETE ____ OTHER ____

Hazard Rating : High (1) ____ Significant(2) ____ Low (3) x Non Hazard(4) ____

Height (From Plans) 45' Dam Length (From Plans) ____ Capacity (From Plans) 1373

(Actual) 45' (Actual) 800' (Estimated) 1373

Freeboard (Spillway to Crest) 15' Crest Width 25' Emergency Spillway Width 120'

Outlet Pipe (Size and Type - CMP, STEEL, IRON, CONCRETE, PLASTIC) 36" Concrete

Present Water Level (feet below CREST, PRINCIPAL or EMERGENCY SPILLWAY) 35'

Stream Name (Source of supply) Lake Creek

Use (circle) IRRIGATION, MUNICIPAL, STOCK OTHER Irrigation and Stock

For each item below place an "X" in the yes or no column and circle the word or phrase which applies. Use the back the form to completely describe or explain the conditions that warrant the response below. Fill in all blanks, if unknown enter "UNKN"; if not applicaple - enter "N?A"; if none - enter "NONE".

EVALUATION CRITERIA	YES	NO
1) Are the roads to the dam adequate to allow YEAR ROUND ACCESS and TRAVEL ACROSS the dam by equipment for maintenance and/or repair?		x
2) Is there BRUSH, DEBRIS or OTHER on the upstream slope that inhibits visual inspection of the entire surface?		x
3) Is there BRUSH, DEBRIS or OTHER on the CREST or DOWNSTREAM SLOPE that inhibits visual inspection of the entire surface?		x
4) Are there trees growing on the CREST, UPSTREAM or DOWNSTREAM SLOPE of the embankement?		x
5) Are there CRACKS, SLIDES, SLUMPS, SETTLEMENT or OTHER on the CREST UPSTREAM SLOPE, or DOWNSTREAM SLOPE?		x
6) Are there RODENT HOLES or ERODED GULLIES on the UPSTREAM or DOWNSTREAM SLOPE?		x
7) Is the upstream slope eroded from wave action?		x
8) Is the rip rap DISPLACED, BROKEN DOWN or MISSING ?		x
9) Are there FLOWS of WATER or WET AREAS above the toe of the dam?		x
10) Is there FLOWING WATER, SAND BOILS, or BOGGY AREAS at or below the toe of the dam?		x
11) Are there toe drains?		x
12) Is the water from any LEAKS, TOE DRAINS or in any BOGGY / WET AREAS found to be MUDDY, SANDY or CARRYING any material?		x
13) Is the outlet control easy to get to?	x	
14) Is the OUTLET CONTROL or GATE found to be STUCK, BROKEN or EXCESSIVELY CORRODED?	x	
15) Is the outlet pipe OBSTRUCTED, EXCESSIVELY CORRODED or in OTHERWISE POOR CONDITION?		x
16) Is the released water UNDERCUTTING the OUTLET or ERODING the EMBANKMENT?		x
17) Does the spillway channel show significant EROSION, BACKCUTTING or DETERIORATION?		x
18) Is the spillway obstructed with FLASH BOARDS, TREES, DEBRIS, BRUSH or OTHER material?		x
19) Are spillway WALLS, FLOOR, CONTROL SECTION or ENERGY DISIPATOR in poor condition?		x
20) Are any concrete portions excessively CRACKED, SPALLED or DISPLACED?		x
21) Is there evidence that the dam has been overtopped?		x
22) Is the reservoir usually full year round?		x
23) Do conditions warrant an inspection of this dam by an engineer?		x
24) Were photographs taken and forwarded to the Cheyenne office?		x

Continued on reverse side of sheet

Additional comments and detailed narrative description of problem areas and follow-up action.

The Road to the Dam site is almost not passable in a truck. I would recommend using an ATV to access this dam site in the futur

Sketch (use to show problem area with the dam or related facilities)

Inspected by:

Title: Hydrographer-Commissioner

Return to:
State Engineer's Office
Safety of Dams
Herschler Bldg. 4th Floor East
Cheyenne, WY 82002

File - Wales Res

Wyoming Dam Inspection Report

Date 4/14/2005

Name of Dam Wales Water Division # 3 District 14

Permit No(s). 1209 County Hot Springs

Owner Name Spring Gulch Cattle Co.

Address Thermopolis Wyoming

Location (1/4 1/4, lot or tract) SE NE Section 6 Twnsp 44 Range 97

GPS - Latitude (DMS) 43 48.67 Longitude (DMS) 108 32.04

Type of Dam : EARTHFILL x ROCKFILL ____ CONCRETE ____ OTHER ____

Hazard Rating : High (1) ____ Significant(2) ____ Low (3) x Non Hazard(4) ____

Height (From Plans) 13' Dam Length (From Plans) 760' Capacity (From Plans) 200

(Actual) 14' (Actual) 750' (Estimated) 200

Freeboard (Spillway to Crest) 5' Crest Width 15' Emergency Spillway Width 200'

Outlet Pipe (Size and Type - CMP, STEEL, IRON, CONCRETE, PLASTIC) 12" Steel and Plastic

Present Water Level (feet below CREST, PRINCIPAL or EMERGENCY SPILLWAY) 10'

Stream Name (Source of supply) Cotton Wood Creek, tributary to Big Horn River

Use (circle) IRRIGATION, MUNICIPAL, STOCK OTHER Irrigation

For each item below place an "X" in the yes or no column and circle the word or phrase which applies. Use the back the form to completely describe or explain the conditions that warrant the response below. Fill in all blanks, if unknown enter "UNKN"; if not applicaple - enter "N?A"; if none - enter "NONE".

EVALUATION CRITERIA	YES	NO
1) Are the roads to the dam adequate to allow YEAR ROUND ACCESS and TRAVEL ACROSS the dam by equipment for maintenance and/or repair?	x	
2) Is there BRUSH, DEBRIS or OTHER on the upstream slope that inhibits visual inspection of the entire surface?	x	
3) Is there BRUSH, DEBRIS or OTHER on the CREST or DOWNSTREAM SLOPE that inhibits visual inspection of the entire surface?	x	
4) Are there trees growing on the CREST, UPSTREAM or DOWNSTREAM SLOPE of the embankement?	x	
5) Are there CRACKS, SLIDES, SLUMPS, SETTLEMENT or OTHER on the CREST UPSTREAM SLOPE, or DOWNSTREAM SLOPE?		x
6) Are there RODENT HOLES or ERODED GULLIES on the UPSTREAM or DOWNSTREAM SLOPE?		x
7) Is the upstream slope eroded from wave action?		x
8) Is the rip rap DISPLACED, BROKEN DOWN or MISSING ?		x
9) Are there FLOWS of WATER or WET AREAS above the toe of the dam?		x
10) Is there FLOWING WATER, SAND BOILS, or BOGGY AREAS at or below the toe of the dam?		x
11) Are there toe drains?		x
12) Is the water from any LEAKS, TOE DRAINS or in any BOGGY / WET AREAS found to be MUDDY, SANDY or CARRYING any material?		x
13) Is the outlet control easy to get to?	x	
14) Is the OUTLET CONTROL or GATE found to be STUCK, BROKEN or EXCESSIVELY CORRODED?		x
15) Is the outlet pipe OBSTRUCTED, EXCESSIVELY CORRODED or in OTHERWISE POOR CONDITION?		x
16) Is the released water UNDERCUTTING the OUTLET or ERODING the EMBANKMENT?		x
17) Does the spillway channel show significant EROSION, BACKCUTTING or DETERIORATION?		x
18) Is the spillway obstructed with FLASH BOARDS, TREES, DEBRIS, BRUSH or OTHER material?		x
19) Are spillway WALLS, FLOOR, CONTROL SECTION or ENERGY DISIPATOR in poor condition?		x
20) Are any concrete portions excessively CRACKED, SPALLED or DISPLACED?		x
21) Is there evidence that the dam has been overtopped?		x
22) Is the reservoir usually full year round?		x
23) Do conditions warrant an inspection of this dam by an engineer?		x
24) Were photographs taken and forwarded to the Cheyenne office?		x

Continued on reverse side of sheet

Additional comments and detailed narrative description of problem areas and follow-up action.

Sketch (use to show problem area with the dam or related facilities)

Inspected by: ______________________

Title: Hydrograper-Commissioner

Return to:
State Engineer's Office
Safety of Dams
Herschler Bldg. 4th Floor East
Cheyenne, WY 82002

Appendix I

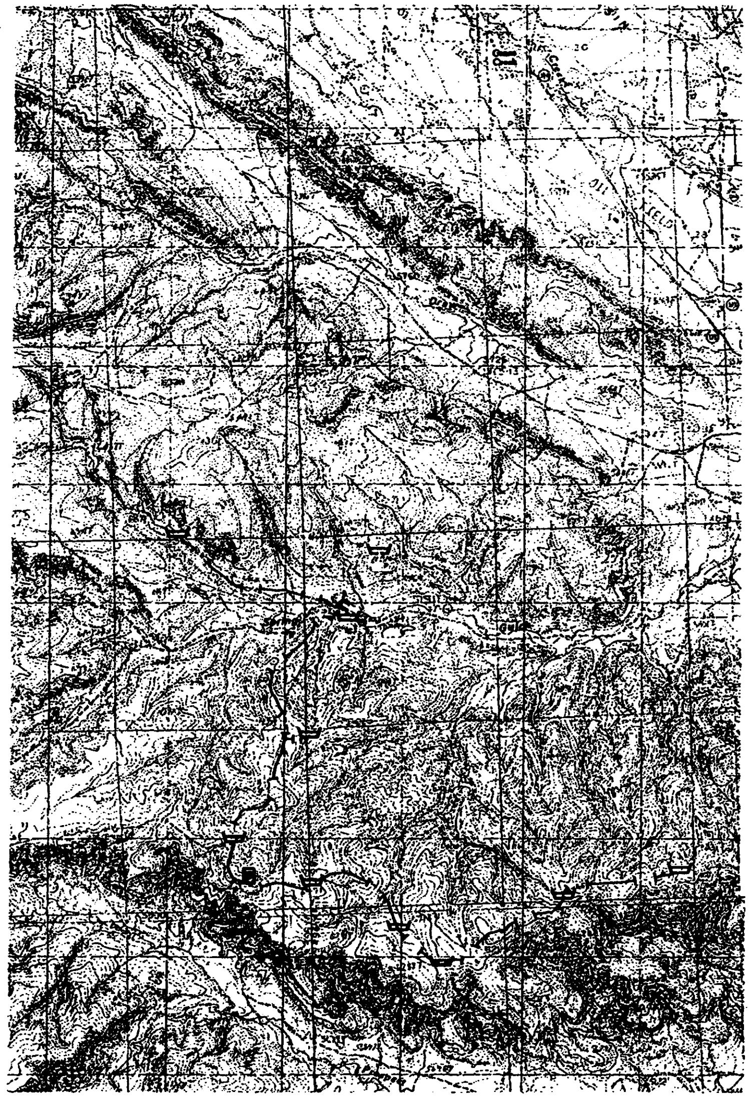
Pipeline/Tank System

HILLBERRY

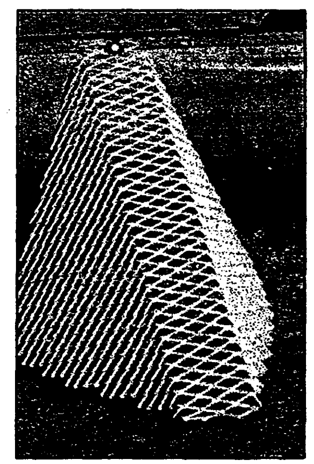
SPRING GULCH STOCKWATER PIPELINE

Hot Springs County, WY.

DESIGNED BY: NATURAL RESOURCES CONSERVATION SERVICE
WORLAND, WYOMING

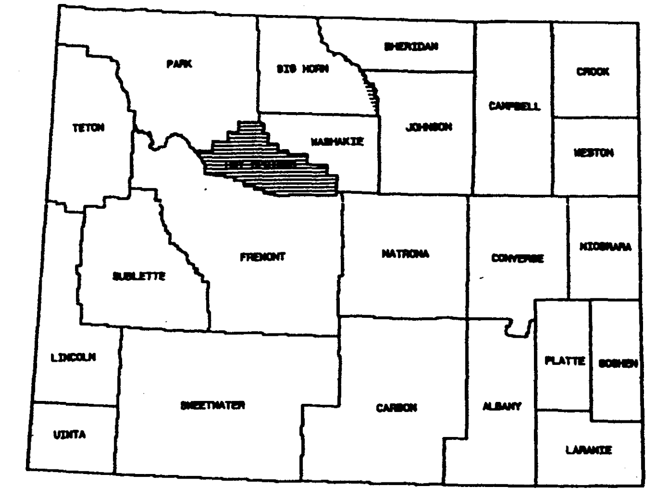


Scale: 1" = 1 mile



STOCK TANK
RESCUE LADDER
No Scale

Rescue ladder constructed of expanded metal and bolted to tank edge



WYOMING

CONSTRUCTION NOTES

1. *The contractor will inspect the construction area for the presence of Utility facilities both surface and subsurface, and notify the Wyoming One Call System 1-800-348-1030 before construction activities begin. The contractor will use extra safety precautions when working near or around pipelines, power lines, power poles, underground cables, or other utility installations.*
2. *Air vent/air vacuum valves shall be Bermad 2" Model 02-ARC or equivalent. Vents to be installed at all summits and no more than one mile apart. Care shall be taken to eliminate grade changes that cause minor high points between air release vavles.*
3. *Individual stock tank Pressure Reducing Valves shall be Watts 3/4" Model U5 or Bermad 3/4" Model 0075-PRV or equivalents, depending on static pressures at individual tanks. Watts standard or heavy duty float valves or equivalents may be used in lieu of pressure reducing valves in instances where static pressures do not exceed the float valve specifications*
4. *Planned depth of cover over pipeline is 18 inches. Drains shall be provided at all low points for seasonal draining.*
5. *In cases where the pipeline cannot be buried due to rocky terrain or other reasons, the engineer shall be contacted to determine if pipe class needs to be increased. Above ground pipe shall be anchored and "snaked" at suffiecient intervals to prevent thermal expansion from causing damage to pipe or adjacent structures.*
6. *If 1 or more acres is expected to be disturbed during this project, the Wyoming Department of Environmental Quality may require the owner or contractor to obtain coverage under a storm water permit for construction activities. Consult the DEQ website at http://deq.state.wy.us/wqd/ or (307) 777-7781 for more information.*

SHEET INDEX

TABLE OF ESTIMATED QUANTITIES

ITEM	UNIT	QUANTITY	AS-BUILT
1-1/2" DIA. HDPE, 160 PSI (SDR 11)	LF	13,186	
1-1/2" DIA. HDPE, 267 PSI (SDR 7)	LF	9,292	
1-1/2" DIA. HDPE, 400 PSI (SDR 5)	LF	10,673	
STORAGE TANK, 15,000 gallon	EA	1	
AIR RELEASE VENTS	EA	14	
PIPELINE DRAINS	EA	15	
12 FT DIAM STOCKWATER TANK	EA	10	

WATER REQUIREMENTS

Animal type: Cattle

Head: 450

Peak gallons/head/day: 15

Total daily water requirement:
450 x 15 = 6,750 gallons per day

Storage: 2 days storage = 13,500 gallons

HYDRAULIC DATA

Materials:
1-1/2" HDPE DR 11 to DR 5
ID 1.55" to 1.14"
Pressure Rating 160 PSI to 400 PSI

Flow Rate 14 gpm max.

Velocity 4 fps max.

PRACTICE STANDARDS

Pipeline (516)
Trough or Tank (614)

Design By: L. STEINKE 06/2006
Checked By:

REVISIONS

DATE	APPROVED	TITLE

Signature:
REVIEWED BY: TITLE JAA 6-06 Date

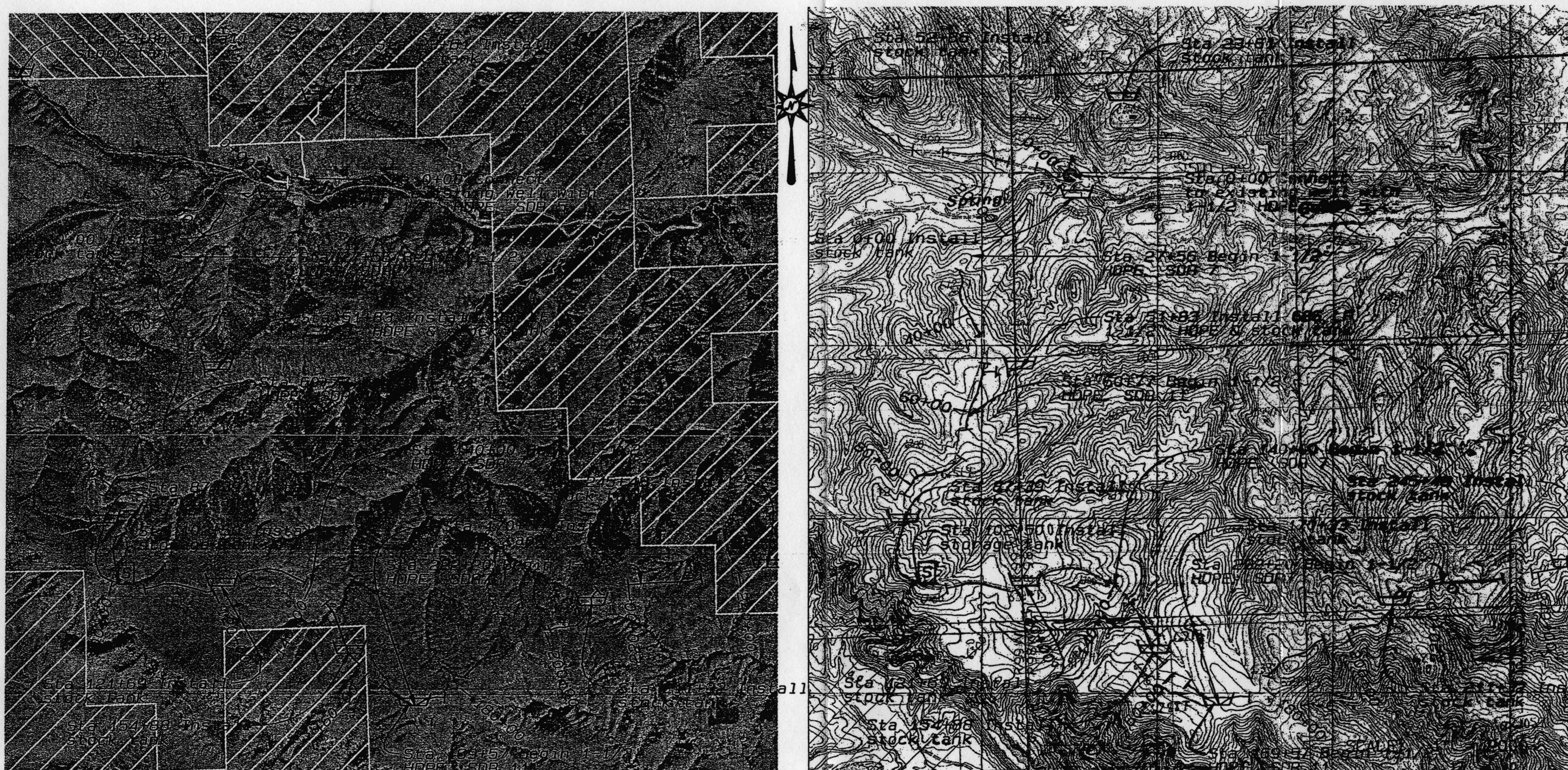
Signature: 6-06

THIS PROJECT IS JOB CLASS V
NRCS INVENTORY SIZED STRUCTURE ☐
DESIGNER'S LEVEL OF JOB APPROVAL AUTHORITY: V

Drawing File:
SHEET NO. 1
TOTAL SHEETS 4

LEGEND

- Proposed Stock Tank
- Proposed Storage Tank
- Existing Well
- Proposed Pipeline
- Private Lands



PLAN VIEWS

Spring Gulch Pipeline1

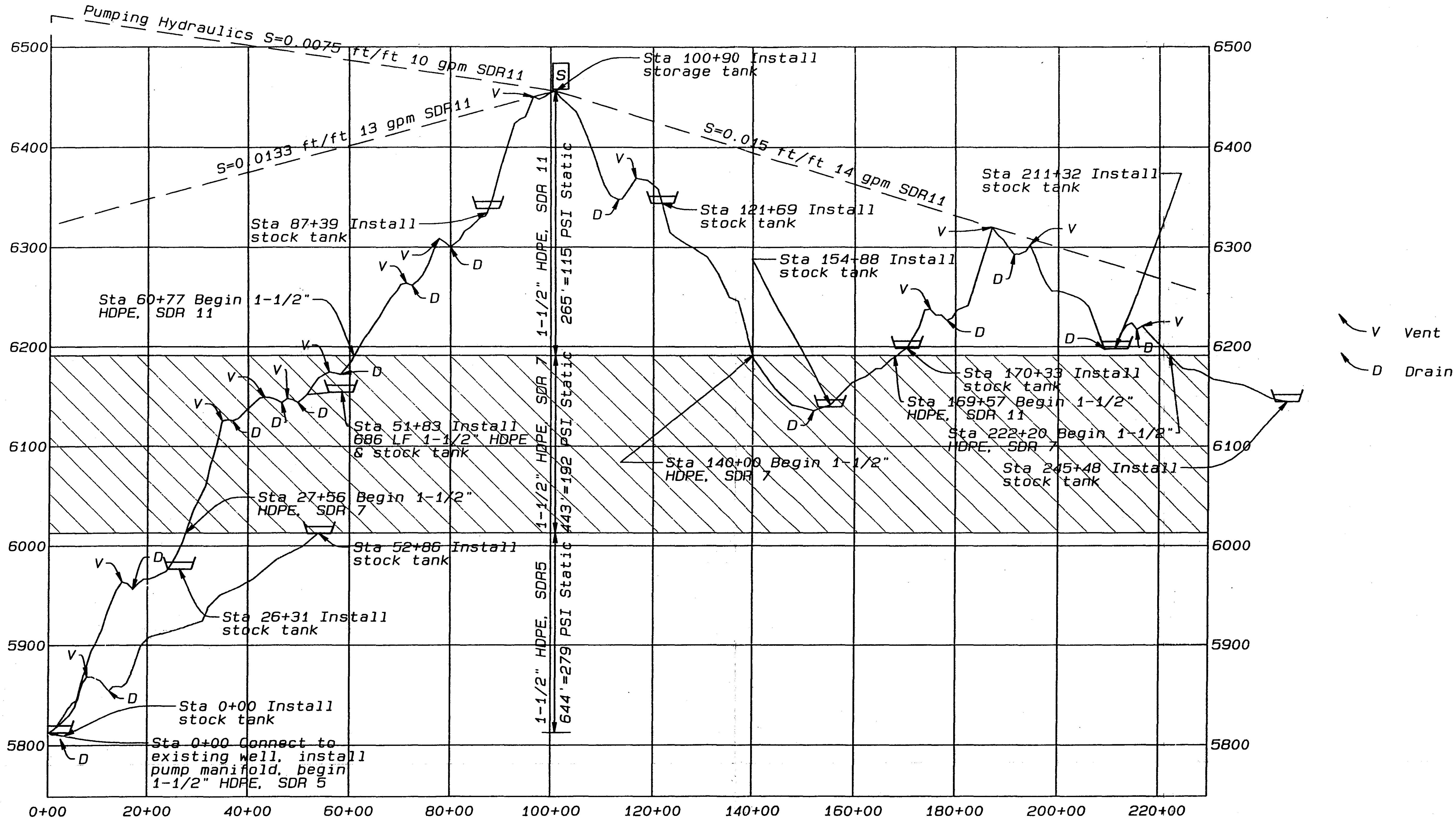
Hot Springs CD   Hot Springs County, WY

Designed	L. STEINKE	Date 06/06
Drawn	L. STEINKE	06/06
Checked		06/06
Approved		06/06

NRCS
Natural Resources Conservation Service

File No.

Drawing No.



MAINLINE PROFILE

SCALE: HORIZ 1" = 2000'
VERT 1" = 100'

Designed	L. STEINKE	Date 06/06
Drawn	L. STEINKE	06/06
Checked		06/06
Approved		06/06

PROFILE VIEW

Spring Gulch Pipeline1

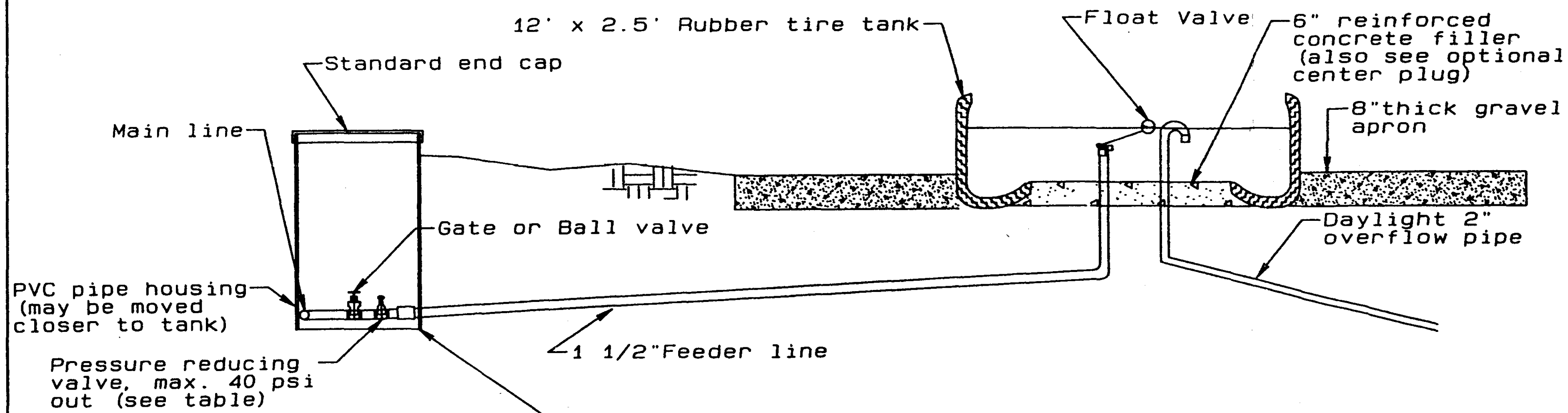
Hot Springs CD Hot Springs County, WY

NRCS Natural Resources Conservation Service

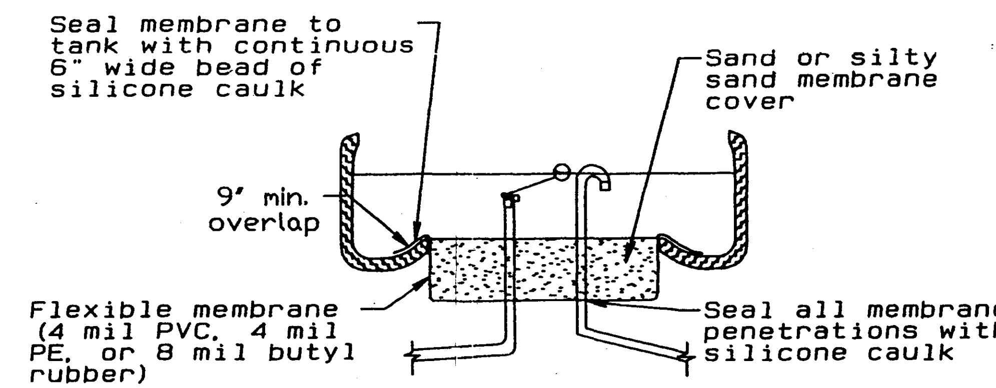
File No.

Drawing No.

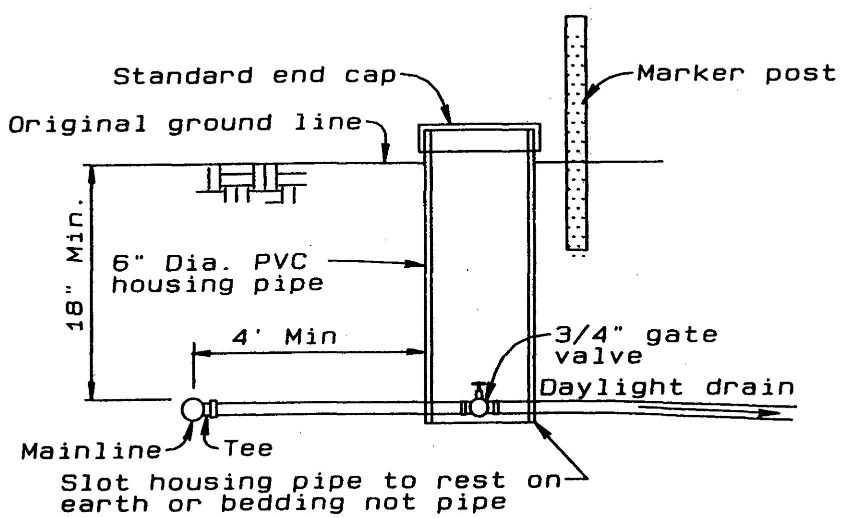
Sheet 3 of 4



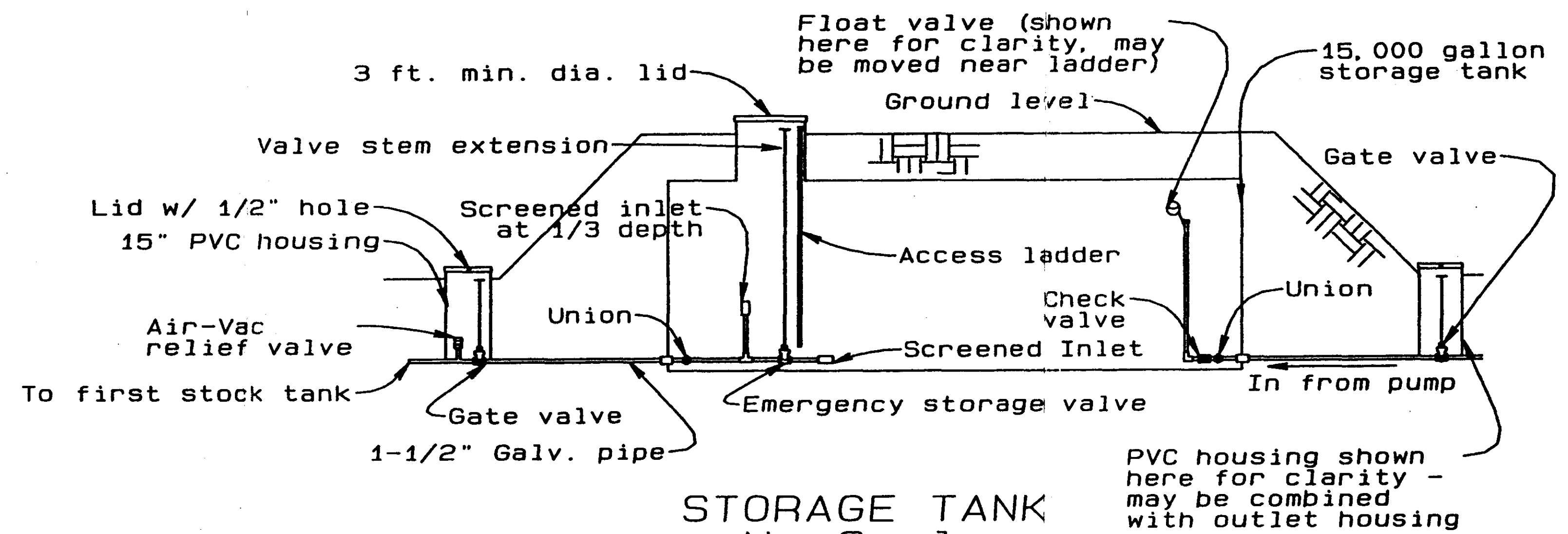
STOCK TANK DETAILS
No Scale



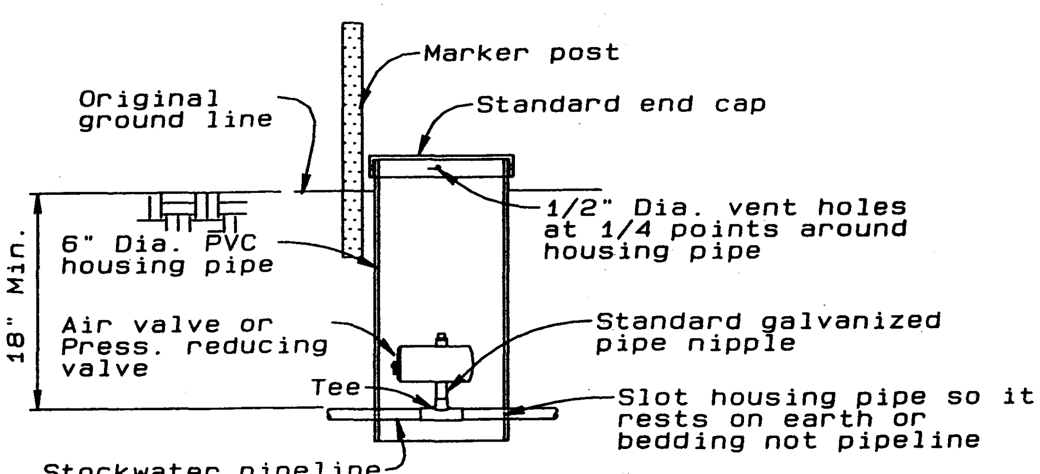
OPTIONAL CENTER PLUG
No Scale



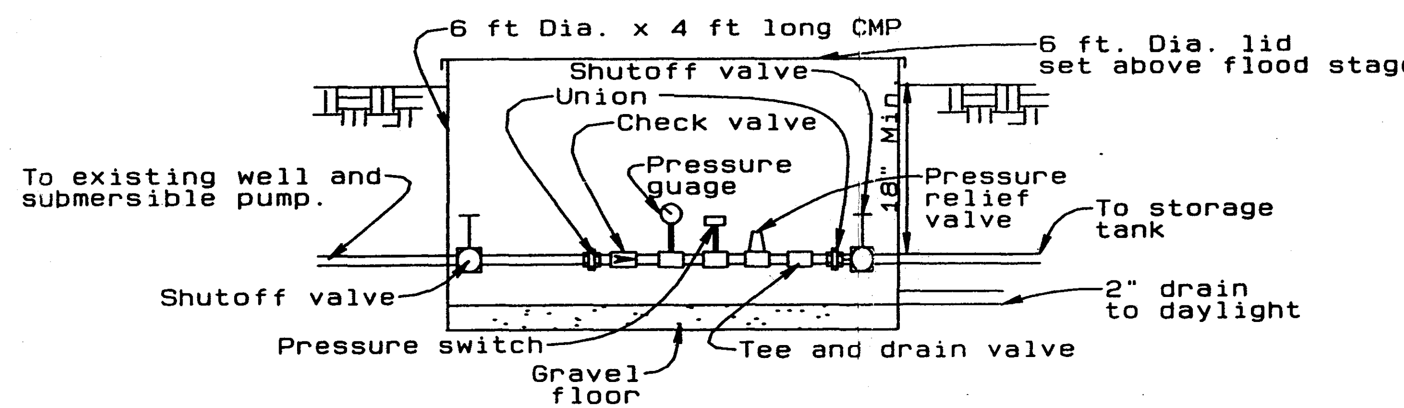
PIPELINE DRAIN
No Scale



STORAGE TANK
No Scale



AIR AND VACUUM RELIEF VALVE
or PRESSURE RELIEF VALVE
No Scale



PUMP MANIFOLD DETAILS
No Scale

Note: Pump/generator to be turned on with timer and shut off with pressure switch.

Pressure switch Shut-off set @ 340 psi

Pressure relief valve set @ 360 psi

Pump T.D.H. (@ 10 gpm) = 745 ft. (~2.5 HP pump)
(assumes 35 well depth)

Pressure guage 0 to 400 psi

	Date
Designed L. STEINKE	06/06
Drawn L. STEINKE	06/06
Checked	06/06
Approved	06/06

APPURTENCES

Spring Gulch Pipeline1

Hot Springs CD Hot Springs County, WY

NRCS Natural Resources Conservation Service

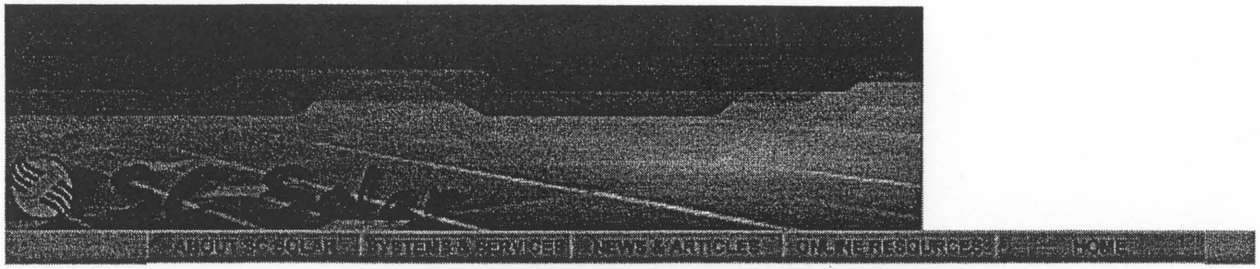
File No.

Drawing No.

Sheet 4 of 4

Appendix J

Solar Water Pumps



- Solar Modules
- Inverters
- Components
- Panel Mounting
- Solargizer
- Wind
- Solar Water Pumps
- Solar Pond Aeration
- Solar Water Heating
- Solar Lighting
- Power Ready Systems
- Standby Power
- Appliances
- Projects

D&B# 784-179-199
CAGE CODE: 1SLJ5
CCR# 1SLJ5

Grundfos Solar Pumps

Grundfos SQ Flex Solar Water Pump

Water, Whenever, Wherever

OUR HOURS OF OPERATION ARE

Mon-Fri 8:00 - 5:30

Phone (803) 980-4320

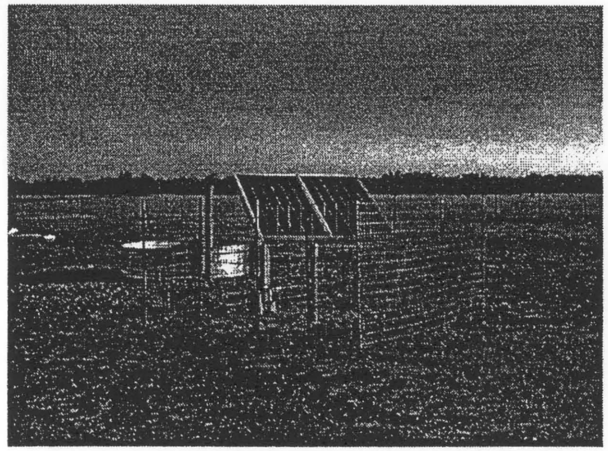
Fax (803) 233-1750

To place an order call us Toll Free at (866) 856-9819

Email Us

SC Solar is now distributing Grundfos SQ Flex solar water pumping systems.

The Grundfos SQFlex solar water pump is the most reliable solar deep well pump we have ever represented. The Grundfos SQ flex solar water pump has two solar pump options helical rotor pumps and centrifugal pumps.



Livestock Watering, Remote Residences, Irrigation, and Village Water Supplies - With the advances in solar pump technology over recent years, areas that would previously have been considered uninhabitable or not supportive of life have become viable and attractive! SC Solar has the experience to provide you with the best solar water pump system available.

The Grundfos SQFlex system is more than just a solar water pump. The SQ Flex is a total concept tailored to any individual water pumping requirements. Our solar water pumping specialists can provide you with a pumping solution to fit any application in any region of the world.

SC Solar needs the following information to design your system:

- Location - Where the Grundfos solar pump is to be located
- The static water level and depth of well
- Recovery rate or how much water does your well produce
- How much water is needed per day
- How far you need to pump the water

With SC Solar you will feel confident in your decision to work with an experienced staff. You have made the right choice and be comfortable in knowing your system was designed to meet or exceed your expectations.

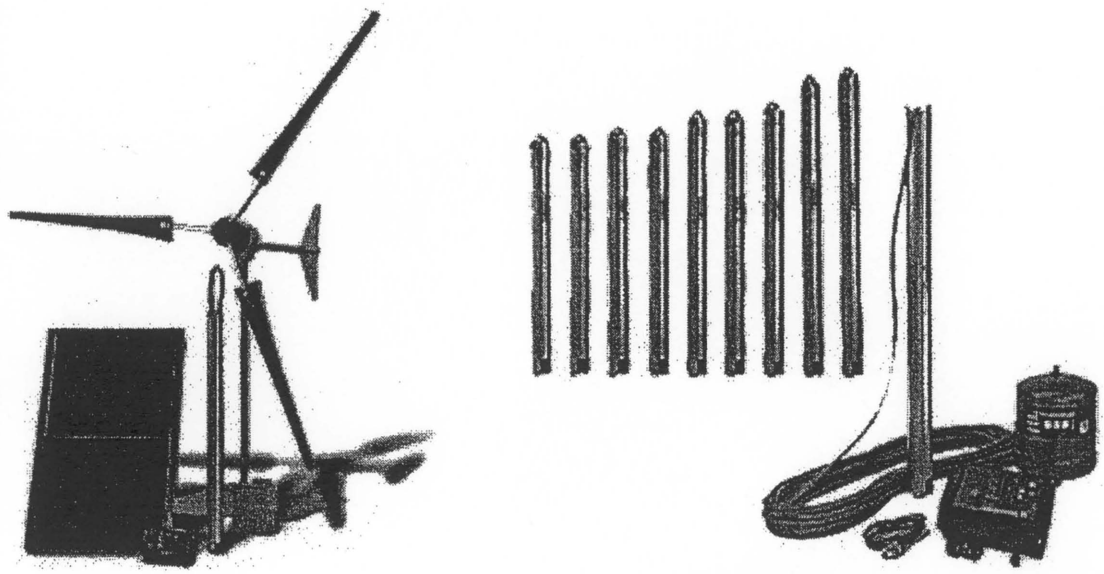
SC Solar has provided the following files to size a Grundfos solar water pump system.

Click here to download the SQ Flex Sizing Chart

Click here to download the SQ Flex Flyer

Click here to download SQ Flex Technical Data

The complete SQFlex pump range consists of 7 different pump sizes: 4 centrifugal and 3 helical rotor pumps. All pumps are fitted with the same size motor which, together with the new sizing tools, makes system sizing simple.



SQ FLEX WIND

Equally cost-effective and easy to install, the SQ Flex Wind is particularly suitable for open fields, valleys and landscapes where the wind blows constantly. The complicated process of converting wind energy to kinetic energy has been made easy and very reliable with the addition of sophisticated components

SQ FLEX SOLAR

Installing the SQ Flex Solar requires no special tools as the Sharp solar modules plug straight into the system. The SQ Flex Solar is inexpensive to operate and virtually maintenance-free.

SQ FLEX PV & Wind

Two energy sources: solar modules for when the sun is shining; a wind turbine for when the wind is blowing. The added benefits of the SQ Flex Combo are even greater reliability and water whenever it's needed.

**Great news for participating CAFTA countries throughout Latin America - tariff free imports on solar water pump solutions and products from SC Solar.

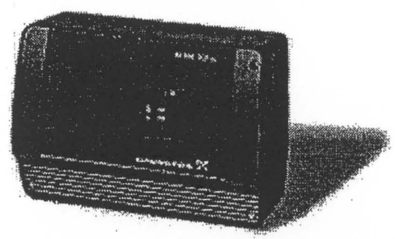
SC Solar exports complete solar water pumping solutions for:

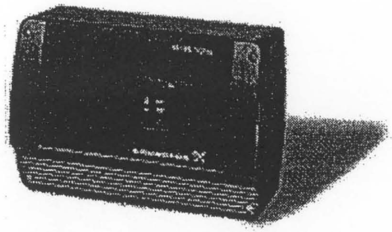
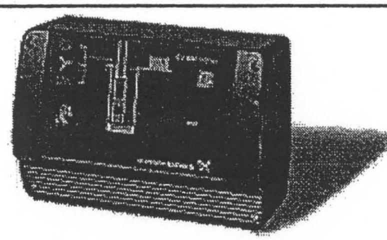
- Farming, Irrigation, and Livestock
- Small municipalities
- Village water demands

SC Solar provides solar water pump installations and projects globally. As a global distributor and installing contractor, SC Solar provides consulting, logistics, project management to the final installation. Providing solutions, covering many regions of the world, for rural development to irrigation projects. SC Solar provides its clients with an experienced staff to assist you with system design and help you locate an installing representative in your area.

Click on a model number below for	
Helical Rotor Solar Pumps	**Centrifugal**
3 SQF-2	25 SQF-3
6 SQF-2	25 SQF-6
11 SQF-2	40 SQF-3
	75 SQF-3

Grundfos SQ Flex	
Model Number	**Price**

3 SQF-2 SQ FLEX Solar Pump	$1575.00
3 SQF-3 SQ FLEX Solar Pump	$1575.00
6 SQF-2 SQ FLEX Solar Pump	$1575.00
11 SQF-2 SQ FLEX Solar Pump	$1575.00
25 SQF-3 SQ FLEX Solar Pump	$1575.00
25 SQF-6 SQ FLEX Solar Pump	$1575.00
40 SQF-3 SQ FLEX Solar Pump	$1575.00
75 SQF-3 SQ FLEX Solar Pump	$1575.00
IO 101 Solar Disconnect, IO 102 Generator Interface, CU200 Controller	
Model	**Retail Price- Wholesale Price**
 Click for the Grundfos IO 100 solar disconnect data	**$163.00** **$105.00**

 Click for the Grundfos IO 101-115V Generator Interface Box	$462.00	$295.00
I/O 102 Solar / Wind Controller	$432.000	$295.00
 Click for CU 200 Flex Control Pump Unit PDF	$365.00	$265.00

SQ Flex Water Level Switch	**Part# 10748**	**$ 25.00**

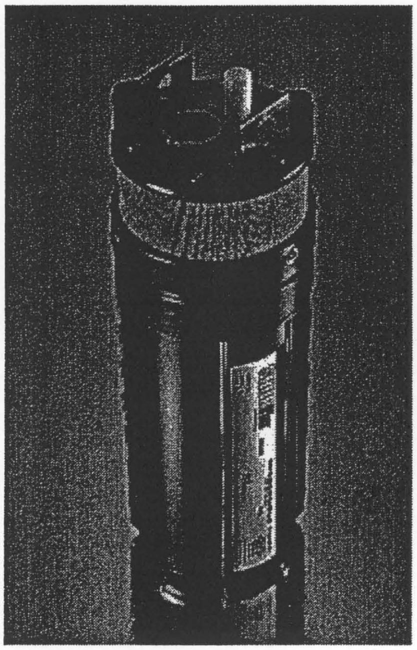
Waterproof Splice Kits Part# DSP-02502 $ 10.00

To place an order call (866) 856-9819

SC Solar

Head (Ft)	Watts:	160 W	270 W	345 W	380 W	450 W	540 W	690 W	805 W	900 W	1150 W
25	Pump Model:	11SQF-2	25SQF-3	25SQF-3	25SQF-3	40SQF-3	40SQF-3	40SQF-3	75SQF-3	75SQF-3	75SQF-3
	Jan Production (GPD)	1500	3500	5000	5400	6700	8300	9100	11400	14400	18500
	April	1800	4100	6000	6600	8000	10000	10900	13500	17400	21700
	July	2000	4300	6100	6800	8300	10300	11100	13800	17900	22500
	October	1700	3800	5400	6000	7300	9100	10100	12200	15900	20300
50	Pump Model:	11SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2	25SQF-6	25SQF-6	25SQF-6	25SQF-6
	Jan Production (GPD)	1000	2400	3200	3300	3800	4200	4500	5600	7300	9500
	April	1300	2900	3700	4000	4500	5000	5200	6700	8800	11200
	July	1400	3000	3800	4200	4700	5200	5400	6800	9000	11600
	October	1200	2700	3400	3700	4100	4500	4800	6100	8100	10400
75	Pump Model:	11SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2	25SQF-6	25SQF-6
	Jan Production	650	1700	2400	2600	3100	3600	3900	4200	4700	6700
	April	850	2100	2900	3100	3700	4300	4500	5000	5700	8000
	July	900	2200	3000	3300	3800	4500	4700	5200	5800	8200
	October	800	2000	2700	2900	3400	3900	4200	4500	5200	7400
100	Pump Model:		11SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2
	Jan Production (GPD)		1100	1700	1900	2300	2800	3100	3600	4100	4500
	April		1300	2000	2300	2800	3400	3700	4300	4800	5300
	July		1400	2100	2400	2900	3500	3800	4400	5000	5500
	October		1200	1900	2100	2600	3100	3400	3900	4400	4800
133	Pump Model:		6 SQF-2	6SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2
	Jan Production (GPD)		800	1100	1200	1600	2000	2250	2850	3450	4000
	April		900	1300	1500	1950	2450	2750	3350	4050	4700
	July		1000	1350	1550	2000	2550	2750	3400	4300	4900
	October		900	1200	1400	1750	2250	2500	3100	3800	4300
166	Pump Model:		3SQF-2	6SQF-2	6SQF-2	6SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2	11SQF-2
	Jan Production (GPD)		600	950	1000	1250	1550	1750	2250	2900	3550
	April		800	1100	1250	1500	1800	2050	2650	3500	4100
	July		800	1100	1300	1550	1900	2100	2700	3600	4350
	October		700	1000	1100	1350	1700	1900	2450	3250	3850
200	Pump Model:		3 SQF-2	3SQF-2	6SQF-2	6SQF-2	6SQF-2	6 SQF-2	6 SQF-2	11SQF-2	11SQF-2
	Jan Production (GPD)		600	750	850	1000	1300	1450	1700	2350	3050
	April		700	900	1000	1250	1600	1750	2000	2850	3700
	July		700	950	1000	1300	1650	1800	2050	2950	3800
	October		600	850	950	1150	1450	1600	1850	2600	3400
233	Pump Model:		3SQF-2	3SQF-2	3SQF-2	6SQF-2	6SQF-2	6 SQF-2	6 SQF-2	11SQF-2	11SQF-2
	Jan Production (GPD)		500	700	700	900	1150	1250	1500	1800	2600
	April		600	850	900	1050	1350	1500	1800	2150	3100
	July		650	850	950	1100	1400	1550	1850	2250	3200
	October		550	750	850	1000	1250	1400	1650	2000	2850
266	Pump Model:		3SQF-2	3SQF-2	3SQF-2	3SQF-2	6SQF-2	6 SQF-2	6 SQF-2	6SQF-2	11SQF-2
	Jan Production (GPD)		450	650	700	800	950	1100	1350	1600	2100
	April		550	750	850	950	1150	1300	1650	1950	2500
	July		550	750	850	1000	1200	1300	1650	2000	2550
	October		500	700	750	850	1050	1150	1500	1800	2300
300	Pump Model:		3SQF-2	3 SQF-2	3SQF-2	3SQF-2	3SQF-2	3SQF-2	6 SQF-2	6SQF-2	6SQF-2
	Jan Production (GPD)		400	550	600	750	850	900	1200	1450	1700
	April		450	700	750	900	1000	1050	1400	1750	2050
	July		500	700	800	900	1050	1100	1450	1850	2150
	October		450	600	700	800	900	950	1250	1600	1900
340	Pump Model:			3SQF-2	3SQF-2	3SQF-2	3SQF-2	3SQF-2	6SQF-2	6SQF-2	6SQF-2
	Jan Production (GPD)			500	550	650	750	800	1000	1300	1600
	April			600	650	800	950	950	1150	1600	1900
	July			600	700	800	950	1000	1200	1650	1950
	October			500	600	750	850	900	1050	1450	1750
390	Pump Model:					3SQF-2	3SQF-2	3SQF-2	3SQF-2	6SQF-2	6SQF-2
	Jan Production (GPD)					550	650	750	850	1100	1450
	April					650	800	850	950	1300	1700
	July					700	850	900	1000	1350	1750
	October					600	750	800	900	1200	1550

9300 Series Submersible 24 VDC Pump



Features:

- Long -life 24 VDC operation
- For 4" wells or larger
- Quick disconnect with "Watertite-Gland" Design Pat Pend
- Corrosion-proof housing with stainless-steel fasteners
- Runs dry without damage
- 50 mesh stainless steel inlet screen
- State of the art solid diaphragm

The solution to your remote water pumping needs. This pump is rugged, durable and built to last. The 9300 delivers a steady 112 GPH (422 LPH) at its maximum depth of 230 feet (70M) when supplied with 24 VDC. Its unique water-tight power connector stops water wicking and prevents potential condensation problems. Great for livestock watering, irrigation, pond areation, remote homes and cabins.

Note: Do not use any SHURflo pump for petrol gasoline, petroleum products, solvents, thinners or any other flammable liquid with a flash point below 82 C (180 F). Not for use where flammable vapors are present.

Model	Description
9325-043-101	24 VDC Submersible Pump for potable water wells, 1/2" Hose Barb discharge port, 50 mesh SS inlet screen

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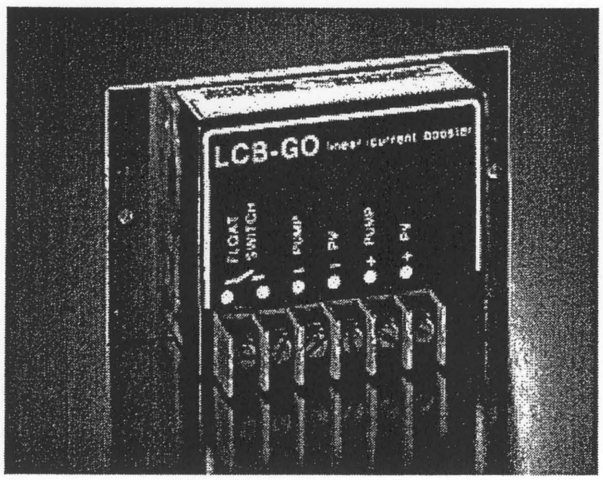
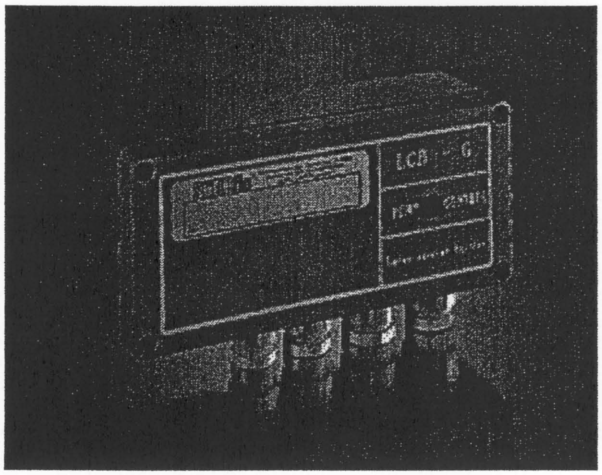
902-100 Features

- Operates on 24 VDC
- Increases daily water output up to 30%
- System starts pumping earlier in the morning
- System stops pumping later in the evening
- Protects pump from low or high voltage conditions
- Terminals for float switch



Boost your DC solar pumps performance by up to 30%. Controller optimizes your solar water pumping system by translating the current and voltage available from your photovoltaic panels, into a combination that is better matched to that needed by the pump. With the optional float switch installed, the controller will automatically stop pumping when the reservoir is full.



902-200 Features:

Includes all 902-100 features plus:

- Switch selectable for 12 VDC or 24 VDC operation
- Pump On / Off switch
- Water tight enclosure and cable inlets
- Includes water level monitor mode with probes and cable

The versatile 902-200 has all the features of the 902-100 and more. This controller is switch selectable for 12 VDC or 24 VDC operation and includes a manual on/off switch for easy pump maintenance. The controller comes with high / low water level sensors so the pump will not run when the well water is too low. Weather proof enclosure.

902- 100 / 200 Specifications:

- Maximum power output 150 Watts
- Over temperature shutdown 176^{o}F (80^{o}C)
- Ambient temperature 14^{o}F (-10^{o}C) to 113^{o}F

(45°C)

Model	Description
902-100 (LCB-GO)	**9300 DC Pump Controller**
902-200 (LCB-G)	**9300 DC Pump Controller**

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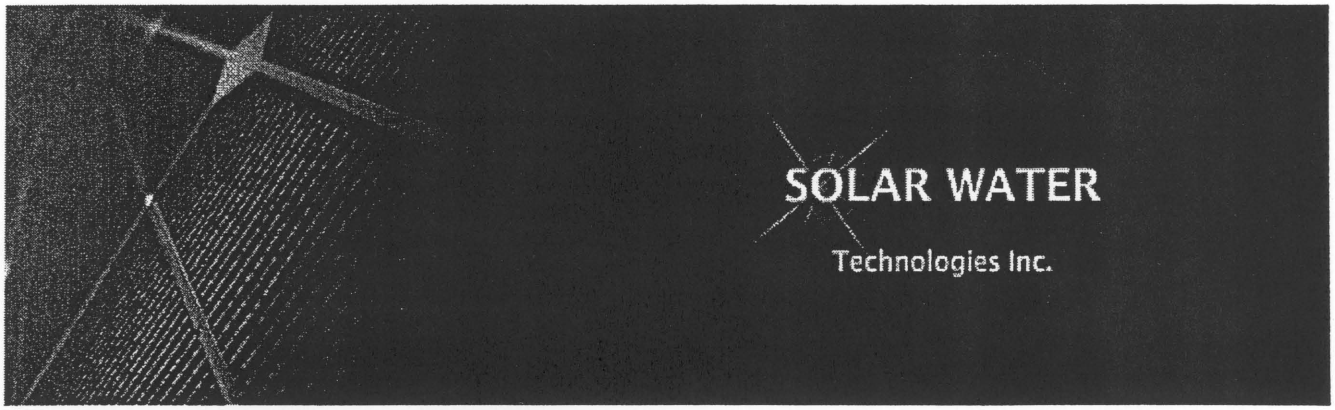

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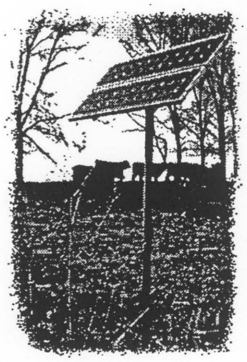

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PRODUCT LINE

Solar Water Technologies Inc.™ offers five different Systems sized to a user's needs depending on water depth, required production, application and daily hours of sunlight. **SWT™ Pumps** operate in surface water or a 4 inch [10.17 cm] well (borehole) casing size or larger.

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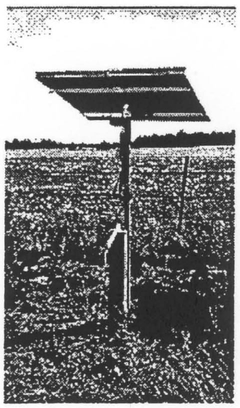
CHOOSE THE SYSTEM WHICH BEST SUITS YOUR NEEDS FROM OUR AVAILABLE SIZES...

SWT-150 SYSTEM

Most Popular Size ~ SWT-150 System Is Powered By Two 75 Watt Panels [150 Watts]. Delivers Up To 1500 Gallons Per Day [5675 Liters] And Lifts From 200 Feet [60 Meters].

SWT-100 SYSTEM



Excellent Combination Of Production And Affordability. Runs Off Two 50 Watt Panels [100 Watts]. Ideally Suited To Pump From 100 Feet [30 Meters] Or Shallower.

SWT-75 SYSTEM

One Of The Lowest Cost Solar Powered Pumping Systems Available In Its Class ~ Powered From One 75 Watt Panel. Suited To Pump From 75 Feet [22.5 Meters] Or Shallower.

SWT-180 SYSTEM

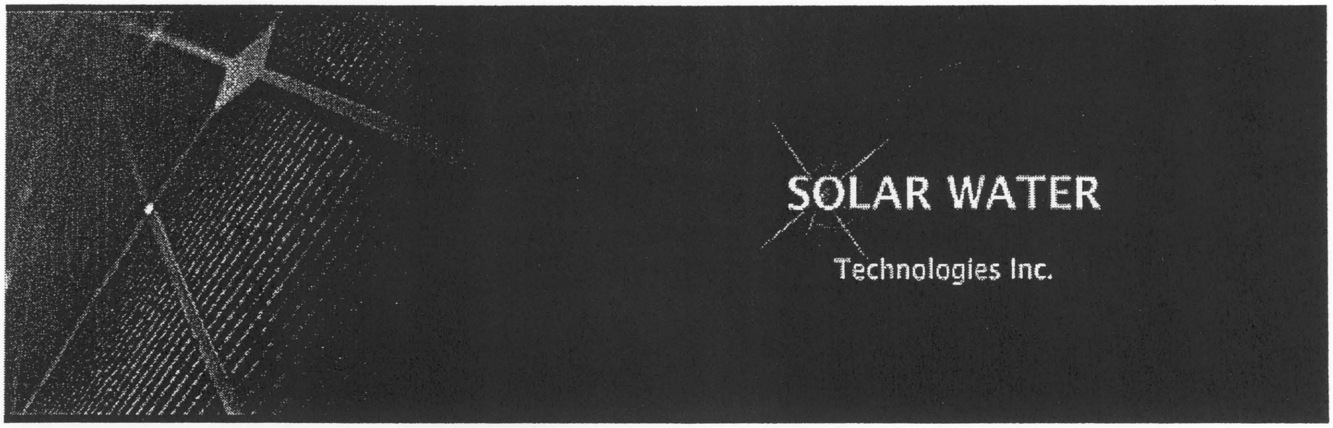
Used On Dual Or Triple Pump Setups To Increase Output With The Same Solar Panel & Controller Array. Utilizes two 90 Watt Panels [180 Watts total].

SYSTEM COMPONENTS

Purchase Of An SWT™ System Includes The Following Components:

- ***SWT Pump*** With Factory Installed Wire: Available In Lengths Of 50 - 100 - 150 or 200 Feet [15-30-45 or 60 Meters] To Match Depth Of Water Source.
- ***SWT Controller*** With Automatic Water Shutoff
- ***Solar Panel (s)*** Which Comes Pre-Wired From The Factory ~ Ready To Plug Into The Controller!
- ***Aluminum Panel Mounts*** And Hardware.

See Our Components *Section For Additional Details On Each Part Of The SWT™ System*



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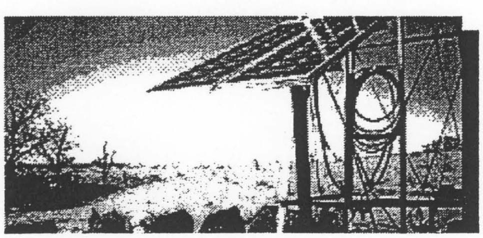
Call Conta Informa Specific A We'll A Selectin System (Match

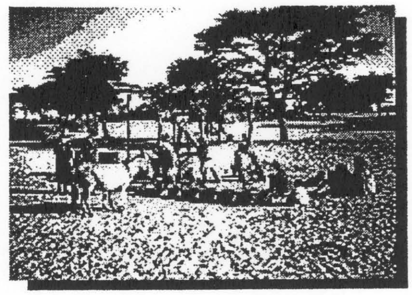
APPLICATION INFORMATION

SWT™ Systems are ideal for use in a wide range of applications. From Livestock Watering to Remote Home or Village Water Supply, they are well suited to meet your water pumping needs! Below are examples of the most common usages.

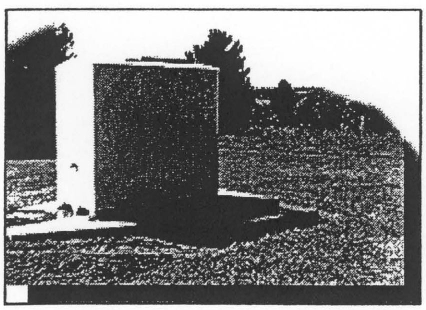
APPLICATION:
Livestock Watering: Cattle - Sheep - Poultry - Exotics



APPLICATION:
Remote Village Water Supply
In West Africa [Senegal]



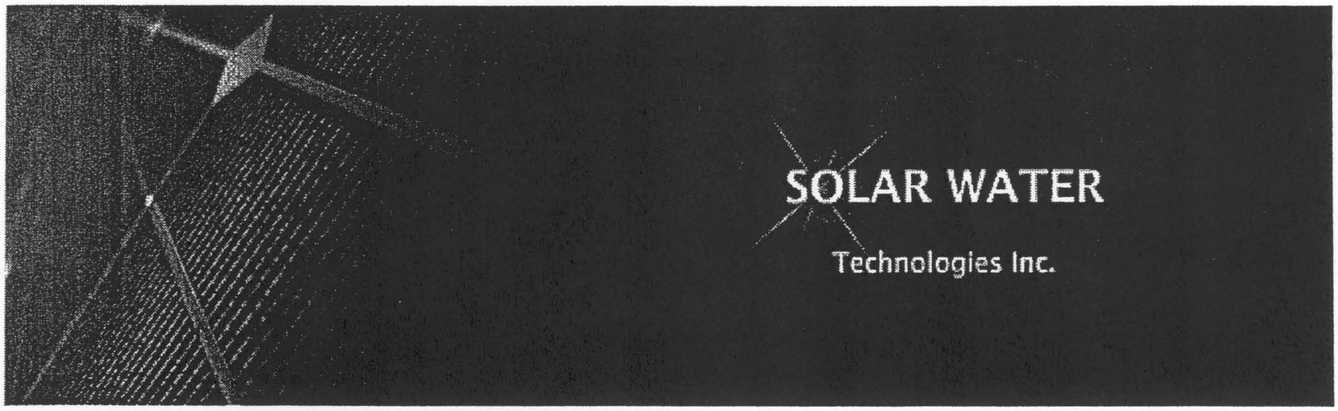
APPLICATION:
Remote Chlorination System



In addition to these, SWT™ Systems have been used for pumping in:

- ***Irrigation (both small-scale Traditional and Drip)***
- ***Orchard and Tree Nursery Watering***
- ***Fish Ponds***
- ***Pollution Monitoring and Remediation Wells***
- ***Wildlife Water Supply***
- ***Year 2000 (Y2K) Backup Systems***

Back Home Next



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PUMPING PRODUCTION CHARTS

The amount of water which an SWT™ System will pump over a given period of time (usually measured in Gallons Or Liters Per Minute (GPM/LPM) or Per Hour (GPH/LPH) is based on the pressure against which the unit has to work.

Pressure is determined by Total Vertical Pumping Distance referred to simply as "Head" or Total Dynamic Head "TDH". It is roughly equal to an increase of 1 PSI (Pound per Square Inch) for every 2.31 Feet of TDH. Thus a vertical pumping distance of 231 feet (~70 Meters) equates to a pressure of 100 PSI.

Simply put, the greater vertical pumping distance, the less water which will be pumped.
Therefore, as the Charts below show, the greater TDH, the lower the GPH/LPH.

SWT Single Panel Systems: Models SWT 50 and SWT 75

Total Vertical Lift * Flow Rate Per Hour * Solar Panel Output

Feet	Meters	Gallons	Liters	Amps	Volts	Watts
0	0	76.0	287.7	1.10	17	19
20	6	74.0	280.1	1.40	17	24
40	12	60.0	227.1	1.7	17	29

60	18	54.0	204.4	2.05	17	35
80	24	48.0	181.7	2.30	17	39
100	30	45.0	170.3	2.55	17	43
120	37	39.0	147.6	2.80	17	48
140	43	36.0	136.3	2.95	17	50
160	49	35.0	132.5	3.05	17	52
180	55	32.0	121.1	3.20	17	54
200	60	25.0	94.6	3.50	17	60

SWT Dual Panel Systems: Models SWT 100 - SWT 150 and SWT 180

Total Vertical Lift * Flow Rate Per Hour * Solar Panel Output

Feet	Meters	Gallons	Liters	Amps	Volts	Watts
0	0	126.0	476.9	1.68	30	50
20	6	120.0	454.2	1.80	30	54
40	12	111.0	420.2	2.00	30	60
60	18	105.0	397.5	2.35	30	71
80	24	99.0	374.7	2.65	30	80
100	30	93.0	352.0	3.00	30	90
120	37	90.0	340.7	3.20	30	96
140	43	87.0	329.3	3.40	30	102
160	49	84.0	318.0	3.45	30	104
180	55	81.0	306.6	3.55	30	107
200	60	50.0	189.3	3.65	30	110

Note: Production Data Is A Representative Sample. Actual Performance May Vary According To Environmental Conditions.

All Shown For Systems Using One Pump...

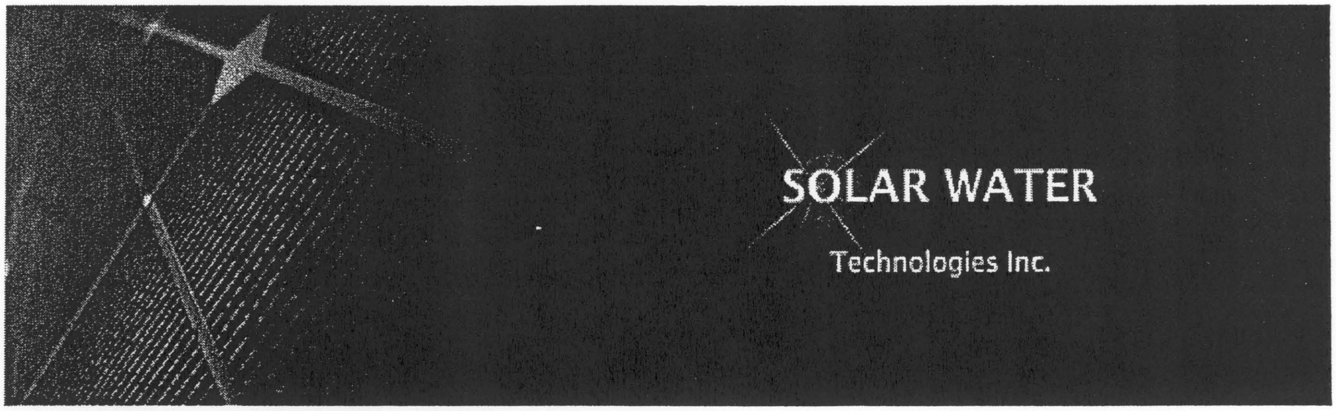
DOUBLING OR TRIPLING OF FLOW MAY BE OBTAINED BY ADDING A 2ND (up to 100'/30m) OR 3RD PUMP (up to 50'/15m)!!!

Maximum Pumping Depth:

SWT™ Systems utilize a Pressure Relief Valve which engages at 85 PSI. This added feature prevents damage which could be caused by excessive pressure build up from a constriction in the pipe (e.g. if the pipe becomes clogged or livestock stands on the pipeline).
85 PSI equates to a depth of 196.3 feet (~ 60 meters). Therefore, when Total Vertical Pumping Distance

begins to exceed 195 feet, pumping output will drop off as the Valve is engaged.
If you need to pump at Heads in excess of 200 feet, contact us for information about other water pumping options. We have systems suited to deeper wells (all the way up to 4500' / 1370 meters)!

Back Home Next



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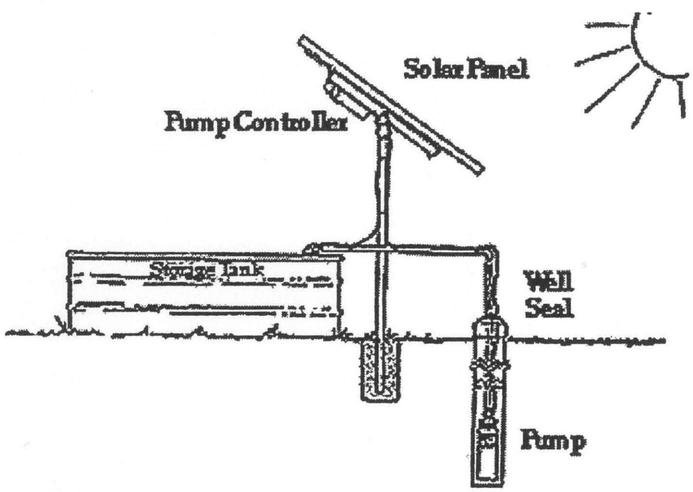
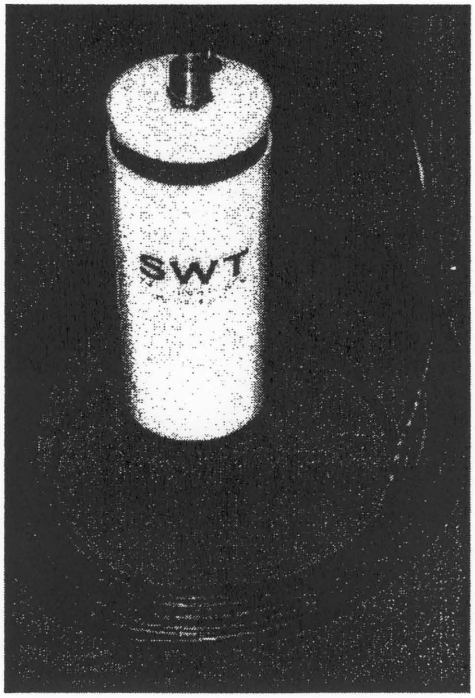
SYSTEMS COMPONENTS



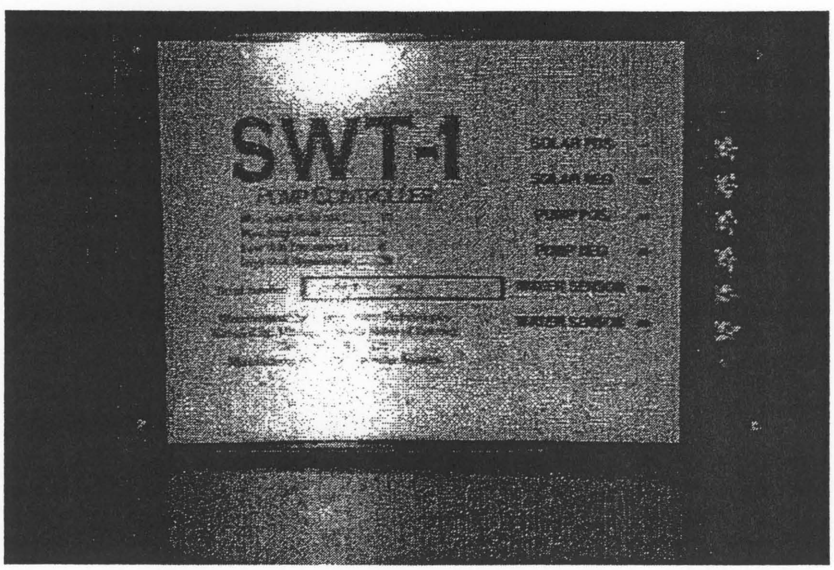
SWT PUMP
The SWT™ Pump Is A Submersible Positive Displacement Diaphragm Pump.

- Operates At 12 To 30 Volts Of Direct Current Supplied From Solar Panels [Can Also Be Connected To Battery Power]
- Produces Pressures Of Up To 85 PSI Or Lifts From 200 Feet [60 Meters] Deep And Flows To 2.1 GPM [7.95 LPM]
- Pump Comes Pre-Wired From The Factory And Features 1/2" [12.7 mm] Stainless Steel Connector For Drop Pipe
- One Year Warranty And 8000 Hour Average Operating Life



SWT CONTROLLER
The SWT Controller Is A Microprocessor Used To Monitor Power Between SWT Pump And Solar Panels, Forming An Integral Part Of The SWT System.

- Automatically And Continuously Adjusts Voltage And Amperage To Obtain Optimum Power Matching As Panel Production Varies Throughout The Solar Day
- Boosts Power In Low Light Conditions To Increase Output
- Includes Simple Reliable Automatic Water Sensor Shut-Off
- Capable Of Running 2nd Pump For Higher Production Needs

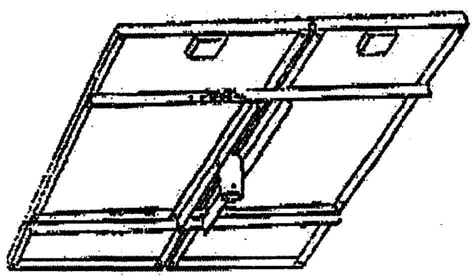


BP SOLAR PANELS
Manufactured By Industry Leader BP (British Petroleum) Solar, Inc.

- Backed By 10 Year (50 watt panels) or 20 Year (75 & 90 watt panels) Product Warranty
- Highly Resistant To Hail And Other Environmental Factors
- Superior Efficiency And Durability

OPTIONAL EQUIPMENT
Balance of System Packages Are Available

- Include All Items Required To Complete Installation And Begin Pumping
- Contact Us For A Customized Quotation To Match Your Application Needs

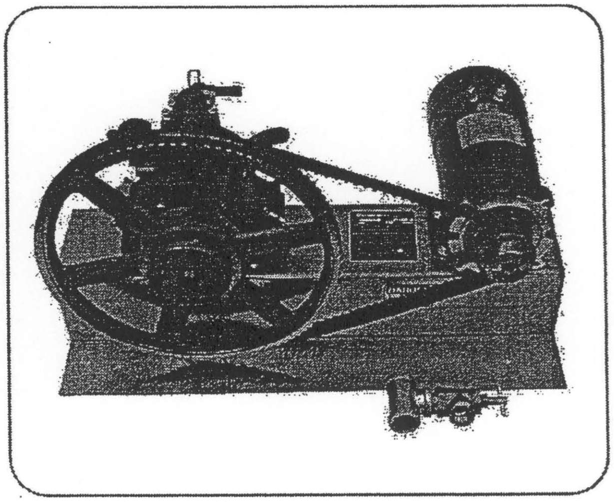


Solar pumps surface | Technical data

Conergy Solaram Surface Pump

conergy

The Conergy Solaram Surface Pump draws water from a shallow well, spring, pond, river or tank. It can push water uphill and over long distances for home, village, irrigation or livestock uses. It can use power directly from a photovoltaic array to fill a storage tank.



Ultra-efficient
- Uses less power than any other pump in its range, starts pumping in low light conditions

Economical
- Reduces power system cost by 25-75 % compared to centrifugal or AC pumps

Rugged and Reliable
- Proven design with a 20 year life expectancy

Simple to Maintain

Dirt-tolerant

Dry Run-tolerant

Easy-to-install

High Lift and Flow

Suction Capacity

25 vertical feet (7.6 m) at sea level. Subtract 1 ft for every 1,000 ft elevation (1 m for every 1,000 m). Suction capacity may be further limited by intake pipe friction or gases in water. For best reliability, place the pump as close to the water source as possible.

Construction
- Multiple diaphragm industrial design
- Cast aluminum pump body
- Neoprene diaphragms backed by pistons
- Non-toxic oil-filled crankcase
- Massive ball bearings
- Permanent Magnet DC Motor
- Gear (timing) belt drive
- Pressure relief valve include

Power System Requirements
- Solar (PV) array: Chart indicates power (W) required at the pump. For solar array-direct (non-battery) systems, the rated power of the PV array must exceed the pump watts by 25 % or more.
- 120 V models: Use 10 x 12 V or 5 x 24 V modules in series.
- Linear Current Booster (pump controller) is required to facilitate starting and to prevent stalling in low-light conditions.
- Solar tracker: Optional, to increase daily yield (typically 30%).

Accessories
- 1¼" (31.2 mm) Foot Valve (Item #DSP-11044) if pump is placed higher than water source
- Float Switch (Item #DSP-11003) for remote shut-off of the pump when tank fills
- Diaphragm and Oil Kit (Item #DSP-08503): Supplies for regular preventive maintenance
- Long-term Parts Kit: (Item #DSP-08504) Three Diaphragm and Oil Kits, plus a gearbelt and a motor brush set

Fittings
- Intake: 1-1¼" (25.4-31.2 mm) male pipe thread
- Outlet: 1" (25.4 mm) female pipe thread

Dimensions
- 28" W x 16.5" H x 16" D (710 x 420 x 410 mm)
- Weight, max. 150 lbs (68 kg)

Warranty
- 1 year against defects in materials and workmanship

SOLAR PUMPS

Conergy Solaram Surface Pump

conergy

Reading the Chart
Use the chart to determine a four-digit model number. Make note of the voltage indicated.

Total Lift = vertical distance from surface of the water source to the pipe outlet or top of storage tank, plus pipeline friction loss

gpm = U.S. gallons per minute

lpm = liters per minute

Technical data Conergy Solaram Surface Pump:

Total Lift		Model #[1] __21			Model #[1] __22			Model #[1] __23			Model #[2]
ft	m	gpm	lpm	W	gpm	lpm	W	gpm	lpm	W	V
0-80	24	3.0	11.4	170	3.7	14.0	207	4.6	17.4	285	
120	37	2.9	11.0	197	3.7	14.0	238	4.5	17.1	319	
160	49	2.9	11.0	225	3.6	13.6	268	4.5	17.1	352	
200	61	2.9	11.0	247	3.6	13.6	296	4.5	17.1	388	
240	73	2.8	10.6	265	3.6	13.6	327	4.5	17.1	427	
280	85	2.8	10.6	286	3.6	13.6	356	4.4	16.7	466	81__
320	98	2.8	10.6	315	3.5	13.3	388	4.4	16.7	496	24 V
360	110	2.8	10.6	342	3.5	13.3	416	4.4	16.7	536	
400	122	2.7	10.6	363	3.4	12.9	450	4.4	16.7	572	
480	146	2.7	10.2	416	3.4	12.9	505	4.3	16.3	649	
560	171	2.7	10.2	456	3.3	12.5	570	4.3	16.3	693	
640	195	2.7	10.2	502	3.3	12.5	623	[illegible]	[illegible]	[illegible]	
720	220	2.6	10.2	551	3.2	12.1	690	[illegible]	[illegible]	[illegible]	82__
800	244	2.6	9.9	589	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24 V
880	268	2.6	9.9	647	[illegible]	[illegible]	[illegible]	4.0	15.2	1,082	83__
960	293	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4.0	15.2	1,190	120 V

Total Lift		Model #[1] __41			Model #[1] __42			Model #[1] __43			Model #[2]
ft	m	gpm	lpm	W	gpm	lpm	W	gpm	lpm	W	V
0-80	24	6.2	23.5	258	7.5	28.4	339	9.4	35.6	465	
120	37	6.0	22.7	305	7.3	27.7	396	9.1	34.5	539	81__
160	49	5.8	22.0	354	7.2	27.3	453	8.9	33.7	619	24 V
200	61	5.7	21.6	400	7.1	26.9	513	8.9	33.7	693	
240	73	5.6	21.2	453	7.0	26.5	572	[illegible]	[illegible]	[illegible]	
280	85	5.5	20.8	499	6.9	26.2	628	[illegible]	[illegible]	[illegible]	82__
320	98	5.4	20.5	548	6.8	25.8	686	[illegible]	[illegible]	[illegible]	24 V
360	110	5.4	20.5	592	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
400	122	5.3	20.1	649	[illegible]	[illegible]	[illegible]	8.7	33.0	1,122	
480	146	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8.5	32.2	1,265	83__
560	171	[illegible]	[illegible]	[illegible]	6.5	24.6	1,045	8.4	31.8	1,397	120 V
640	195	[illegible]	[illegible]	[illegible]	6.5	24.6	1,116	[illegible]	[illegible]	[illegible]	
720	220	5.1	19.3	1,031	6.4	24.3	1,287	[illegible]	[illegible]	[illegible]	[illegible]
800	244	5.1	19.3	1,114	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	120 V
880	268	5.1	19.3	1,206	[illegible]	[illegible]	[illegible]	8.0	30.3	1,958	85__
960	293	5.0	18.9	1,289	[illegible]	[illegible]	[illegible]	8.0	30.3	2,145	120 V

Performance may vary +/- 10 %

[1] Second two model number digits
[2] First two model number digits

Available from:

Solaram-TD-USA-0508

For further information: www.conergy.us
Subject to technical changes

Presentation

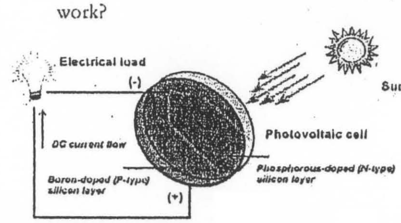
- Solar Energy Overview
- Solar Power Usage In US
- Solar Pumping – Finally a Mature Technology
- Environmental issues
- Designing a solar pumping system
- Why solar pumping is the most cost effective solution for remote pumping
- Wind Power

Demonstration

- Solar Pumping Equipment
- Solar Panels
- Constructing a solar pumping system
- Different Manufacturers and Models
- Demonstration of different solar pumping systems

Solar Energy Overview

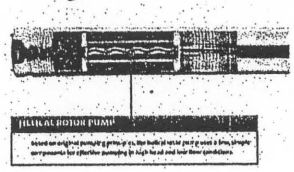
- Solar Photovoltaic Panels – How do they work?

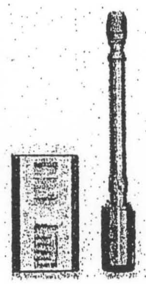


Source: www.fsec.ucf.edu/pvt/pvbasics/

Mature Technology: Helical Rotor Pumps

Grundfos SQ Flex (below) and Lorentz HR (right) both use the Helical Rotor Design to pump water and a brushless motor design.





Environmental Issues

- All kinds of weather can affect a solar pumping system; however the extreme wind of Wyoming can cause significant damage if not properly planned for.
- This means a sturdy frame for the solar panels, adequate gap between panels to allow for wind to pass and No Trackers!

Designing a Solar Pumping System

Water Information

- Information about the well
  - Static Water Level
  - Draw Down Water Level and at what Flowrate
  - Well Casing Size
  - Depth of Well
- Pipeline Information
  - Pipeline Size
  - Total length of line and elevation change

Water Information

- Amount of Water Required by Livestock – What we estimate in our designs
  - Cow-calf pair
    - Summer 15-20 gallons per day (GPD)
    - Winter 10-12 GPD
  - Yearling
    - Summer 12-15 GPD
    - Winter 10-12 GPD
  - Sheep
    - Summer 2-4 GPD
    - Winter 1-2 GPD
  - Horse about same as cow/calf pair

Now you have all you need!

- How to read the pump charts
- Grundfos SQ Flex Chart
- Lorentz PS600/PS1200 Chart

Design Example 1

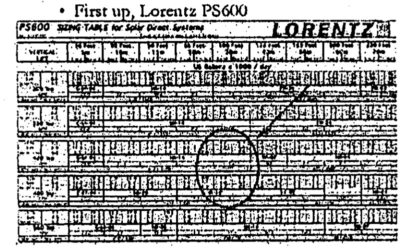
- Old windmill, produces ~10 GPM
- Has a 4" steel casing
- 100' deep, static water level at 40'
- 200 Pairs water at this location
- Well empties to open tank at well head

Design Example 1

- Total water needed:
  - 200 X 20 = 4000 GPD summer
  - 200 X 12 = 2400 GPD winter
- Drawdown is unknown, so assume the pump will be at 95'. Therefore maximum head will be ~92' due to the low water sensor protection.
- Pump is limited to 10 GPM flowrate

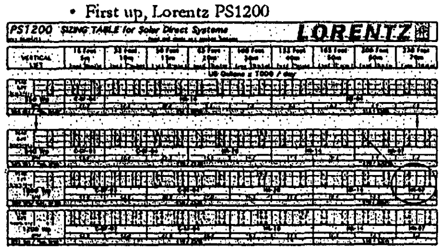
Design Example 1

- Time to go to the Pump Charts:
  - First up, Lorentz PS600



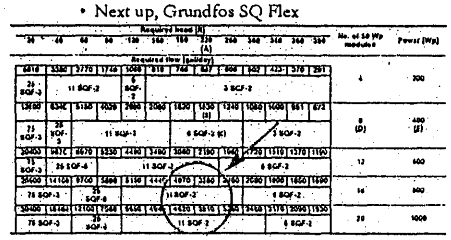
Design Example 2

- Time to go to the Pump Charts:
  - First up, Lorentz PS1200



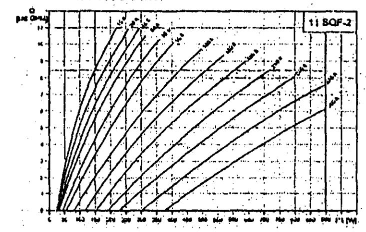
Design Example 2

- Time to go to the Pump Charts:
  - Next up, Grundfos SQ Flex



Design Example 2

- What will the 11 SQF 2 produce in the winter sun?



8.5 GPM X 4.5 Hr X 60 min/HR

=

2295 GPD

Design Example 2

- In this case the SQF Produces more water in the summer, however at a higher flow rate. The 11 SQF will pump more than the well can produce.
- The PS1200 HR-07 will produce enough water in both winter and summer while not overloading the well.
- Again, both systems use the same size of solar array.

Design Example 2

- Lorentz HR-14 Pump
- PS1200 Controller
- 1000 Watt Array – 72-96 Volts DC
  - 6 X 165-170 Watt Panels
  - 8 X 125 Watt Panels
  - 10 X 100 Watt Panels
- Rack for Mounting Panels
- 3 Wire with ground Submersible Pump Cable, Pipe, Safety Rope and 2 wire sensor cable

Optional
  - AC Power Pack Generator Converter

Solar Pumping Systems
Approximate Equipment Cost

- Small System - $2,500
  - 100' Lift – 1,200 GPD, 3 GPM
  - 50' Lift – 2,200 GPD, 5 GPM
- Medium System - $4,000-$5,000
  - 400' Lift – 1,000 GPD, 2.6 GPM
  - 200' Lift – 2,500 GPD, 5 GPM
  - 50' Lift – 5,000 GPD, 10 GPM
- Large System - $7,500-$8,500
  - 600' Lift – 1,000 GPD, 1.8 GPM
  - 300' Lift – 2,600 GPD, 5 GPM
  - 100' Lift – 8,000 GPD, 14 GPM
- Gallons per Minute Numbers are Peak Flow

Solar, AC Line & AC Gen vs. Miles from Power Line

- AC Pump - $600 est.
  - 10 GPM
  - 1 HP Single Phase Franklin 4" Pump Motor
  - Motor Starter
- Cost of Gasoline - $2.50 / gallon
- Line Extension Cost - $20,000 / mile
- Cost of AC Power - $0.06 / kW-hr
- Line Connection Charge - $10.00 / month
- Generator – Honda EB5000
  - $2,483 MSRP
  - Specs from hondapowerequipment.com

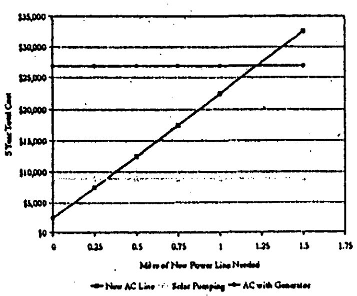
Solar, AC Line & AC Gen vs. Miles from Power Line

- Lorentz PS1200, HR-14 Pump - $1800 est.
- 1000 Watt Solar Array $5000 est.
- System will pump, with 165' lift:
  - 5500 gpd summer
  - 4800 gpd fall/spring
  - 4000 gpd winter
  - 10 gpm maximum pump rate
- In order to compare with this solar system, the cost for the AC systems are calculated using these production quantities.

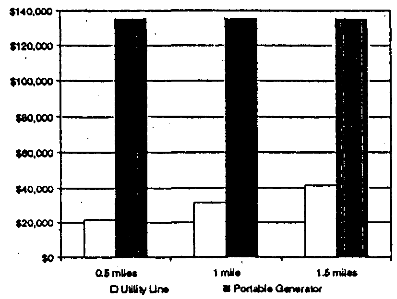
Solar, AC Line & AC Gen vs. Miles from Power Line

- 10 Mile Round Trip to Check on Well
  - 7 days a week for generator (fueling)
  - 1 day a week for utility line powered
  - 4 days a week for solar system
  - Assume your truck gets 15 mpg
- At 165' lift, the AC pump will have 60 psi of pressure at outlet in order to limit the flowrate to 10 gpm.

Solar, AC Line & AC Gen vs. Miles from Power Line



25 Operation Cost Comparison

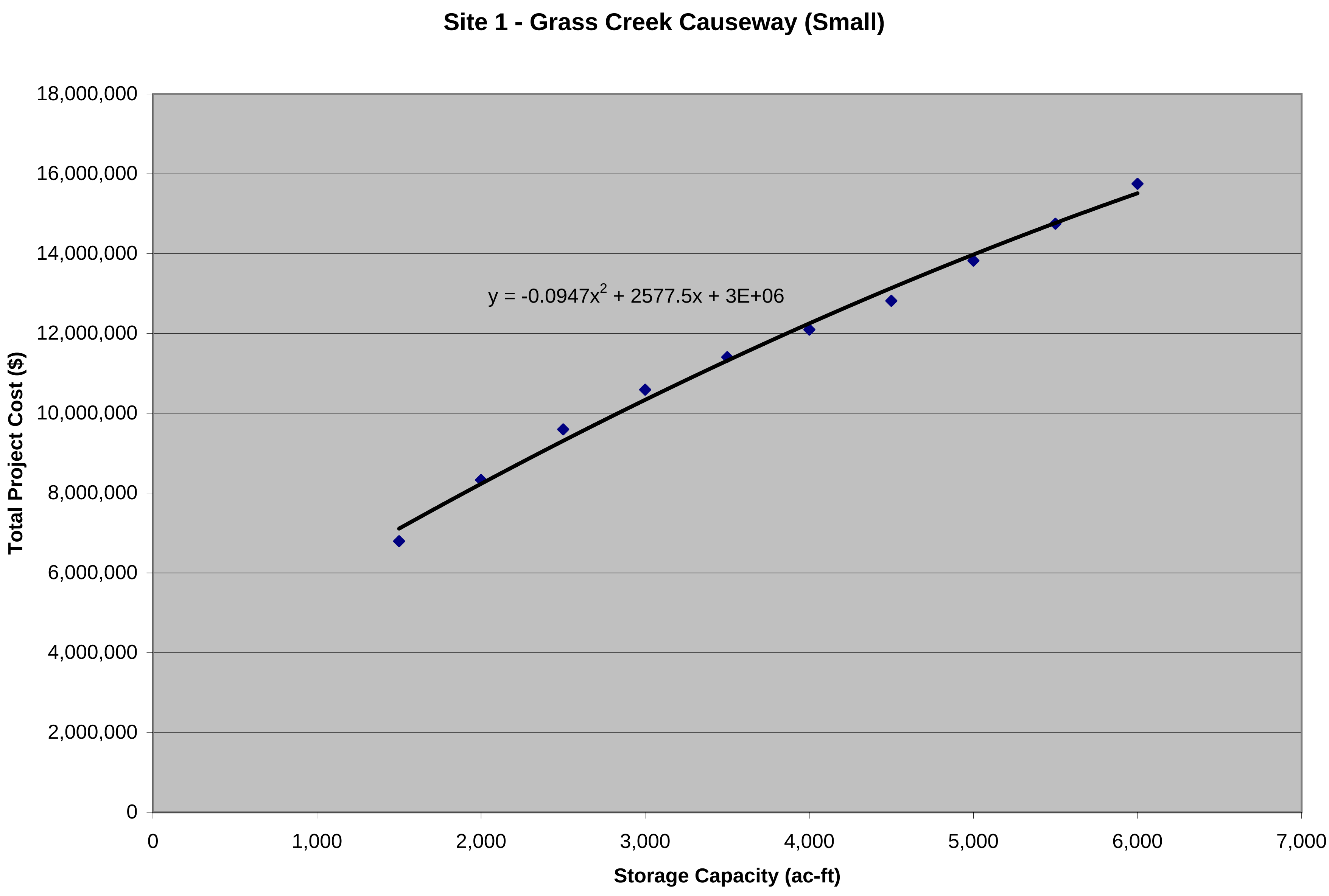


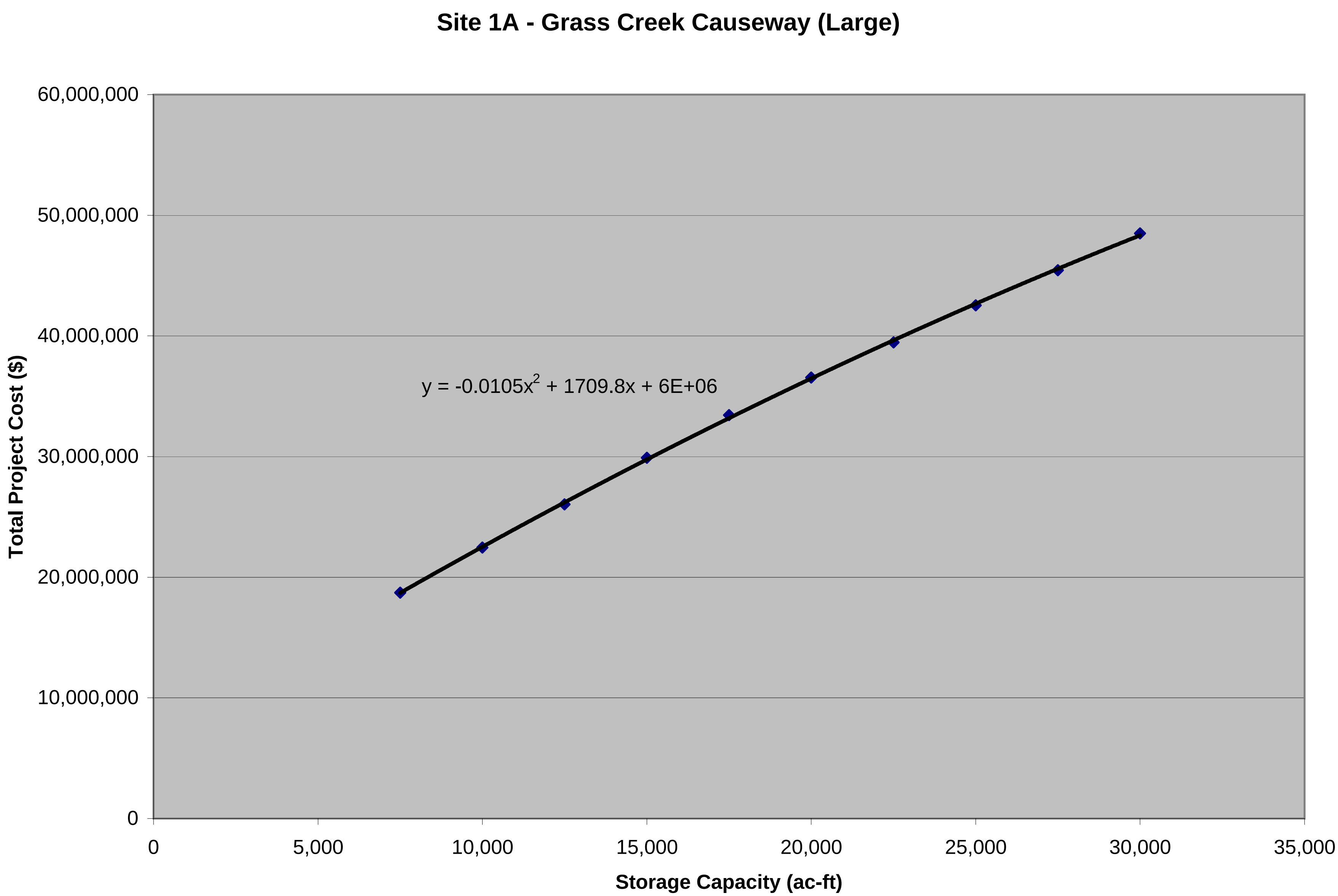
Wind Power

- More economical than Solar PV
  - PV – Approximately $4.25/watt
  - Wind – Whisper 200 $2.15/watt
- More Maintenance and problems with Wyoming Wind
- Allows for pumping during low light daytime conditions and at night
- Grundfos SQ Flex IO 102 Switch Box is designed to power the SQ Flex pump with Solar Panels and a Wind Generator
- Lorentz pumps have no wind generation options available

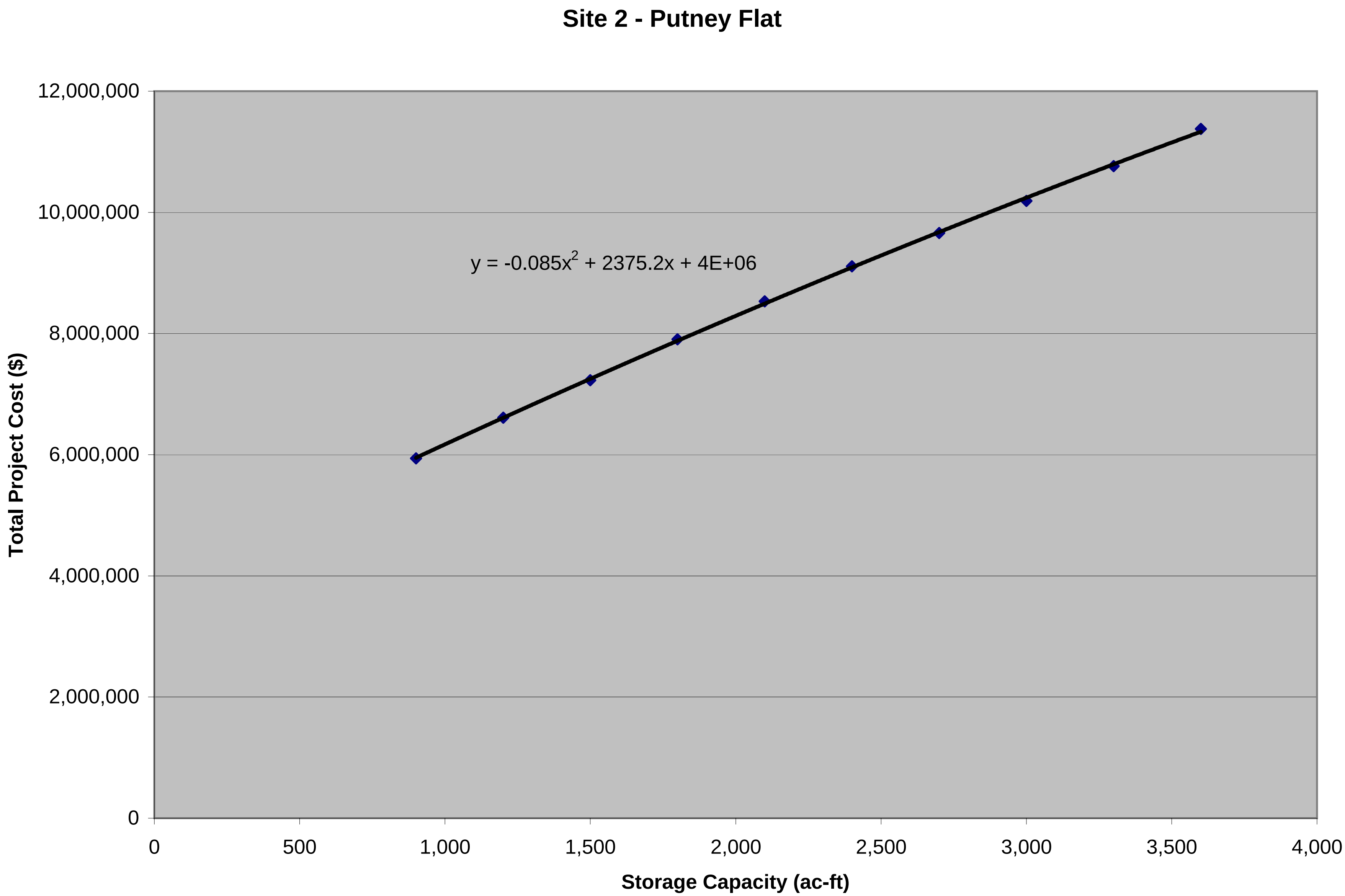
Appendix K

Storage Site Cost Curves

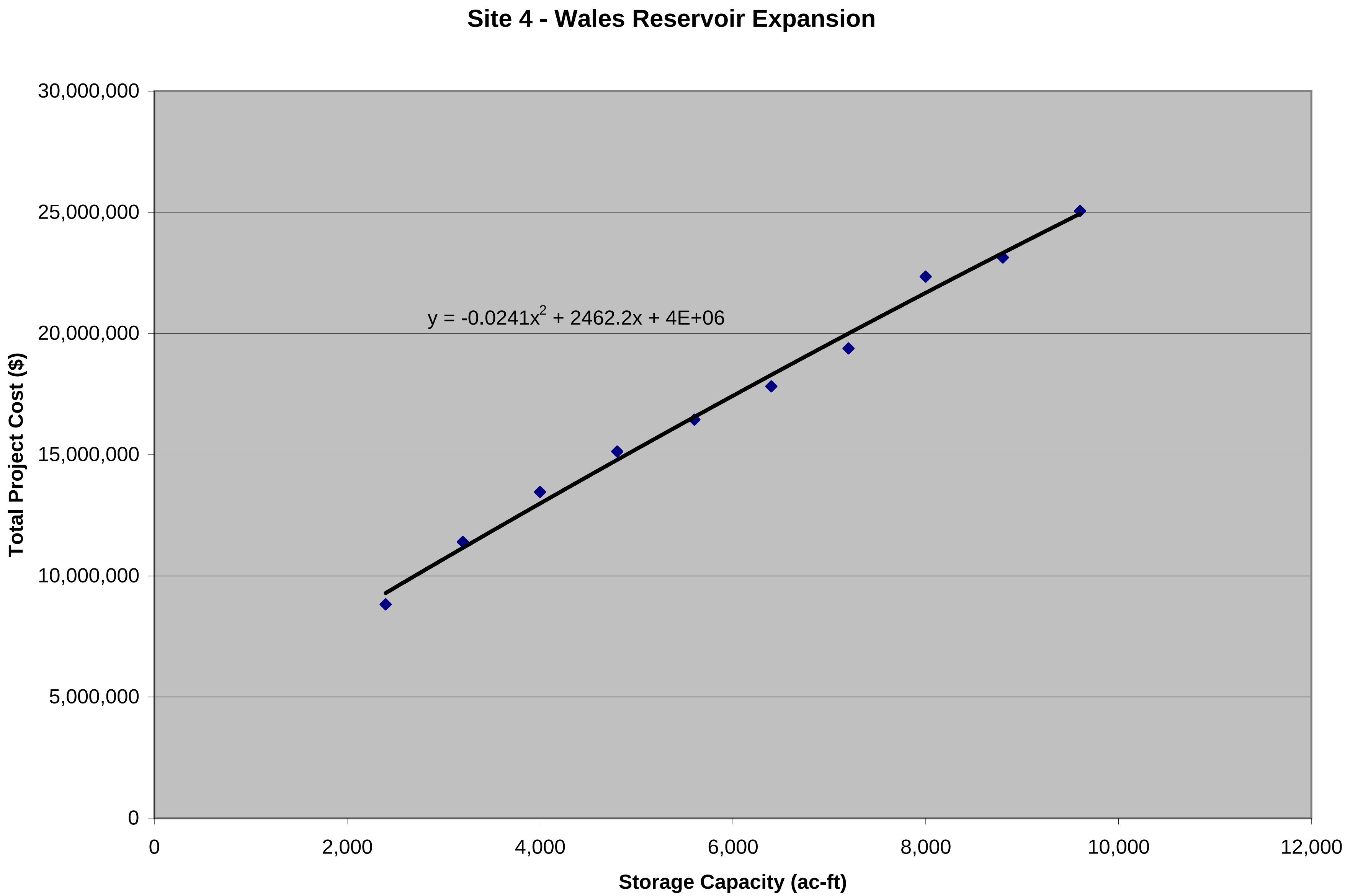

Site 1 - Grass Creek Causeway (Small)
y = -0.0947x2 + 2577.5x + 3E+06
Total Project Cost ($)
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
Storage Capacity (ac-ft)

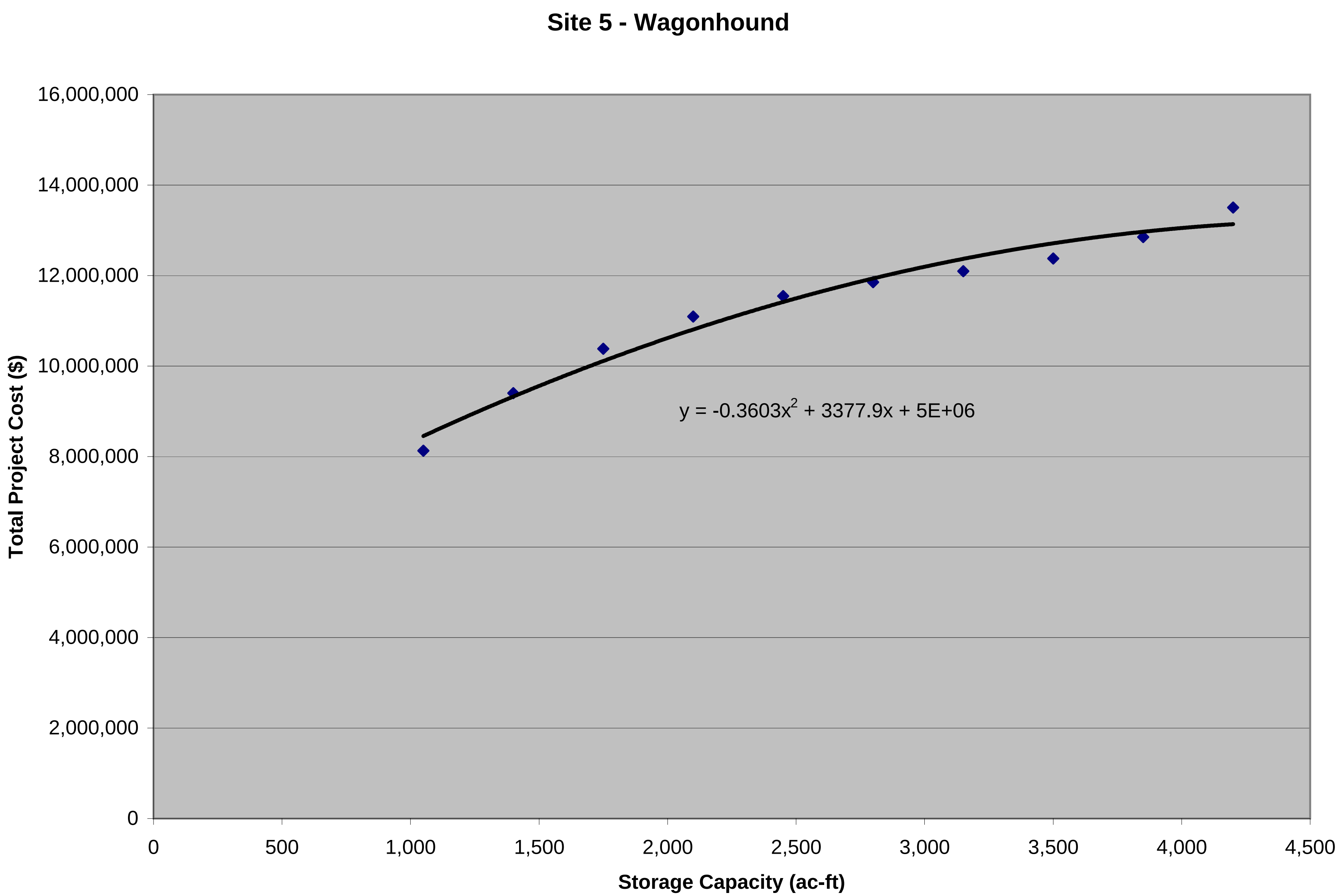


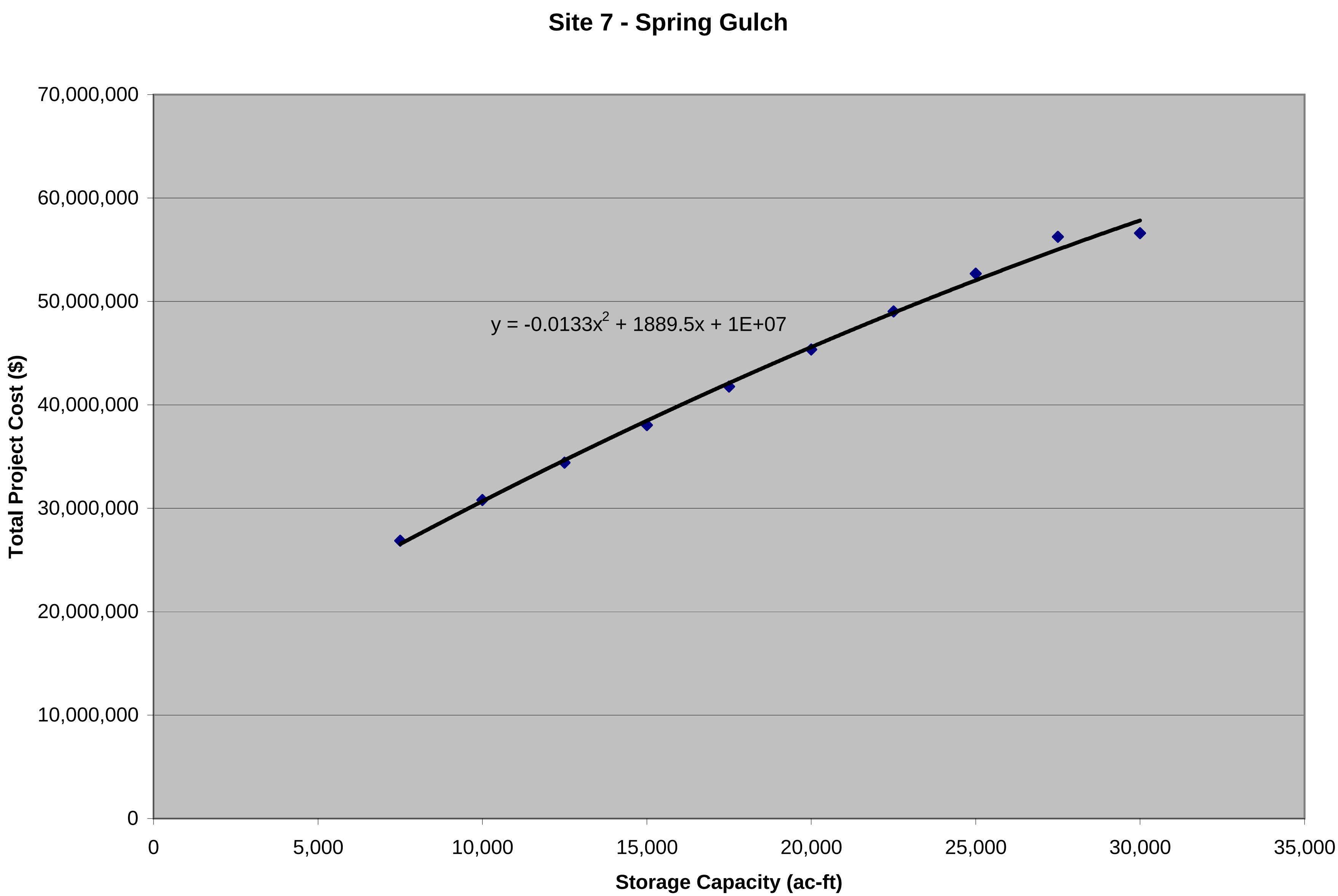
Site 1A - Grass Creek Causeway (Large)
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
Total Project Cost ($)
y = -0.0105x2 + 1709.8x + 6E+06
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
Storage Capacity (ac-ft)

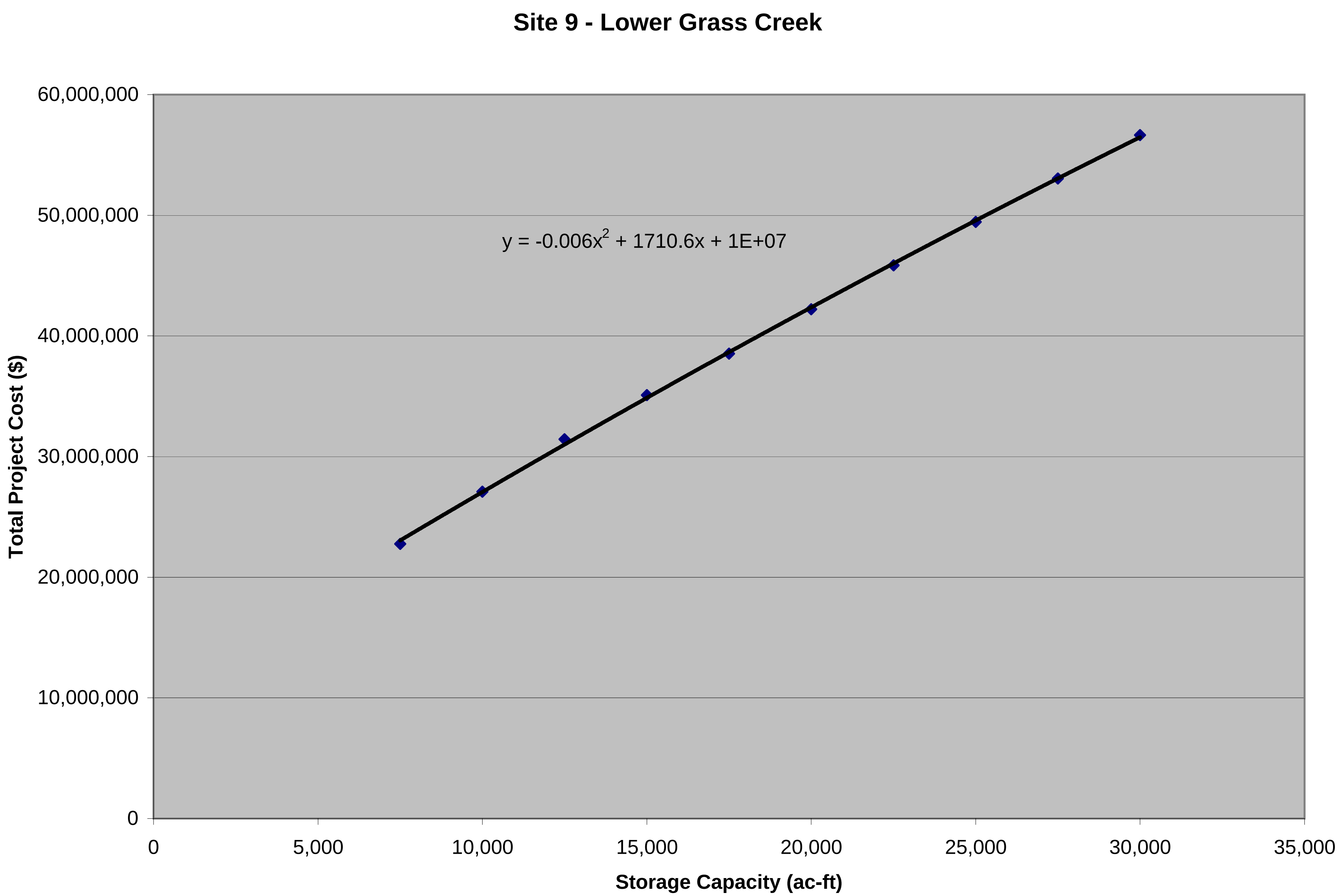


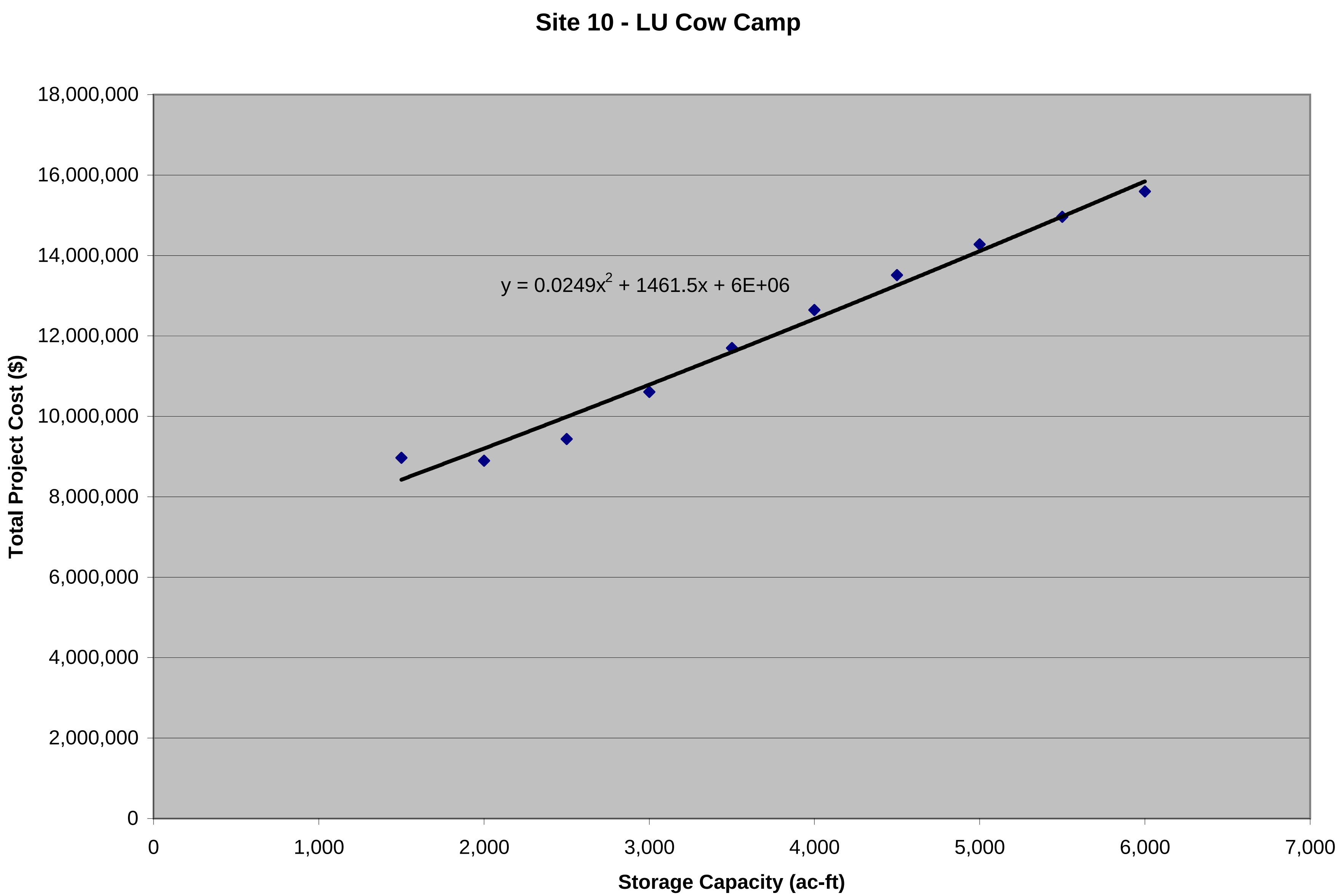
Site 2 - Putney Flat
y = -0.085x2 + 2375.2x + 4E+06
Total Project Cost ($)
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
Storage Capacity (ac-ft)


Site 4 - Wales Reservoir Expansion
y = -0.0241x2 + 2462.2x + 4E+06
Total Project Cost ($)
30,000,000
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
0
2,000
4,000
6,000
8,000
10,000
12,000
Storage Capacity (ac-ft)

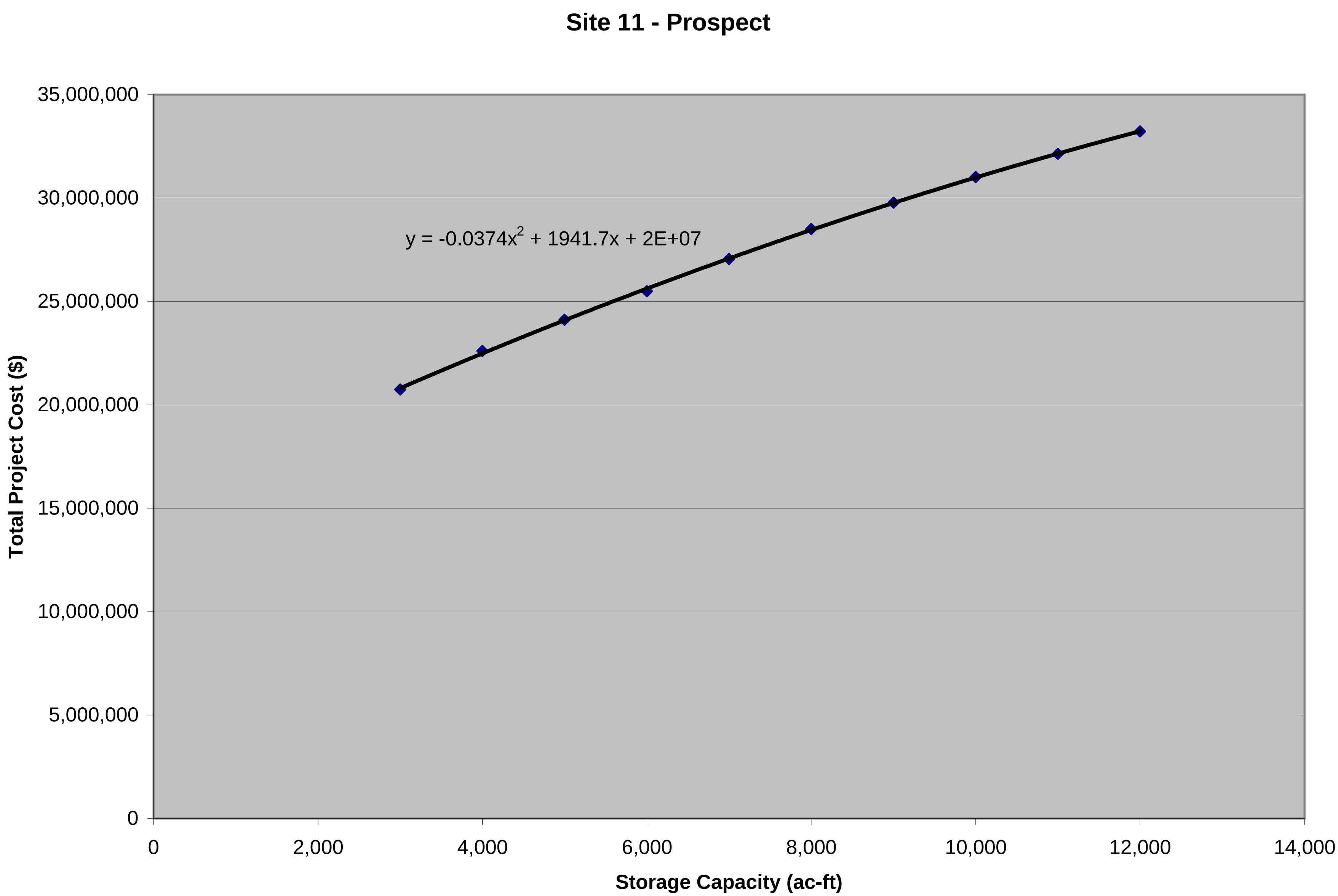

Site 5 - Wagonhound
Total Project Cost ($)
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
y = -0.3603x2 + 3377.9x + 5E+06
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
Storage Capacity (ac-ft)


Site 7 - Spring Gulch
70,000,000
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
Total Project Cost ($)
y = -0.0133x2 + 1889.5x + 1E+07
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
Storage Capacity (ac-ft)


Site 9 - Lower Grass Creek
y = -0.006x2 + 1710.6x + 1E+07
Total Project Cost ($)
60,000,000
50,000,000
40,000,000
30,000,000
20,000,000
10,000,000
0
0
5,000
10,000
15,000
20,000
25,000
30,000
35,000
Storage Capacity (ac-ft)



Site 10 - LU Cow Camp
y = 0.0249x2 + 1461.5x + 6E+06
Total Project Cost ($)
Storage Capacity (ac-ft)
18,000,000
16,000,000
14,000,000
12,000,000
10,000,000
8,000,000
6,000,000
4,000,000
2,000,000
0
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000


Site 11 - Prospect
y = -0.0374x2 + 1941.7x + 2E+07
Total Project Cost ($)
35,000,000
30,000,000
25,000,000
20,000,000
15,000,000
10,000,000
5,000,000
0
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
Storage Capacity (ac-ft)

Appendix L

Funding Sources

Fisheries and Wildlife Habitat Cost-Share Programs and Grants

Habitat Extension Bulletin No. 50

This extension bulletin provides information on cost-share programs and grants available through a number of different agencies and organizations for fisheries and wildlife habitat projects. Many of these programs provide technical and/or financial aid to agricultural producers, private landowners, various land management agencies, and other organizations for implementation of various activities that benefit wildlife and natural resources. Some of the activities that could be implemented include: various best management practices, such as livestock grazing; developing livestock and wildlife water sources; enhancing fisheries, improvement of floodplain and riparian function; groundwater projects; invasive species management; point and non-point source pollution and pollution prevention projects such as restoration, source water protection, storm and waste water management, water conservation, watershed management, and wetland and wildlife habitat enhancements or developments.

Funding sources are arranged alphabetically by federal agency, state agency, and private organization. Specific information regarding any of the programs should be obtained from the agency or organization's regional or local office listed under the Contact heading.

The funding sources contained in this bulletin are by no means an all-encompassing list of opportunities. Many additional opportunities exist, though the programs listed in this bulletin are those that have been routinely used by Wyoming Game and Fish Department personnel and other resource management agencies to help fund private and public wildlife and natural resource related projects. Those listed have been found most applicable and used in the State of Wyoming or those that have the most potential for becoming useful in Wyoming. For more information regarding the listed funding opportunities or additional opportunities please contact your local Wyoming Game and Fish Department employee, Habitat Extension Biologist, regional Game and Fish office, Natural Resource Conservation Service office, or other land management agency offices around the State.

FEDERAL AGENCIES

Agency Name	Program Assistance Available	Contact
1. Environmental Protection Agency (EPA)	A. Clean Water Program (financial and technical) B. Pollution Program (financial and technical) C. Non-Point Source Implementation Grants (319 Program) (financial and technical) D. Pesticide Environmental Stewardship Grants (PESP) (financial) E. Superfund Technical Assistance Grants for Citizen Groups at Priority States (financial and technical) F. Brownsfields Assessment and Cleanup Cooperative Agreements (addresses hazardous substance, pollutants, and contaminants) (financial) G. Brownsfields Job Training and Development Cooperative Agreements (EPA training program) H. Wetlands Program Development Grants (financial and technical)	EPA Region 8 Office US EPA Region 8 1595 Wynkoop Street Denver, CO 80202-1129 EPA Operations Office Federal Building 10 W 15th Street, Suite 3200 Helena, MT 59626 Environmental Quality, Department of 122 W 25th St, Herschler Bldg. Cheyenne, WY 82002
2. Cooperative State Research, Education, and Extension Service (CSREES, USDA)	A. Watershed Process and Water Resources Program (research)	University of Wyoming Dept. 3354 1000 E. University Ave. Laramie, WY 82071

FEDERAL AGENCIES

Agency Name	Program Assistance Available	Contact
3. Farm Service Agency (FSA, USDA)	A. 2002 Farm Bill Conservation Reserve Program (CRP) and Continuous Conservation Reserve Program (CCRP) (financial and technical) B. Direct and Counter Cyclical Program (DCP) (financial) C. Emergency Conservation Program (ECP) (financial) D. Conservation Reserve Enhancement Program (CREP) (financial and technical) E. Farmable Wetland Program (FWP) (financial and technical) F. Source Water Protection Program (SWPP) (financial and technical) G. 2002 Farm Bill conservation easements, leases and loan debt-reconstructioning program (financial)	Wyoming State FSA Office 951 Werner Ct. Ste 130 Casper WY 82601-1307 *County FSA Offices located in:* Afton, Buffalo, Casper, Cheyenne, Driggs, ID, Douglas, Ft. Washakie, Gillette, Greybull, Laramie, Lusk, Lyman, New Castle, Powell, Riverton, Rock Springs, Saratoga, Sheridan, Sundance, Torrington, Wheatland, Worland
4. Forest Service (USFS, USDA)	A. Challenge Cost-Share Program (financial and technical) B. Range Betterment Funds (financial and technical) C. KV Funds (financial) D. Cooperative Forest Assistance (technical) E. Forest Legacy Program (FLP) (financial and technical)	USDA Forest Service Intermountain Region 324 25th Street Ogden, UT 84401 USDA Forest Service Rocky Mountain Region 740 Simms St Golden, CO 80401 Ashley NF 355 North Vernal Ave Vernal, UT 84078 Bighorn NF 2013 Eastside 2nd Street Sheridan, WY 82801 Bridger-Teton NF P.O. Box 1888 Jackson, WY 83001 Caribou-Targhee NF 1405 Hollipark Dr Idaho Falls, ID 83401 Medicine Bow-Routt NF Thunder Basin NG 2468 Jackson Street Laramie, WY 82070 Shoshone NF 808 Meadow Lane Cody, WY 82414 Wasatch-Cache NF 125 South State Street Salt Lake City, UT 84138

FEDERAL AGENCIES

Agency Name	Program Assistance Available	Contact
5. Natural Resource Conservation Service (NRCS, USDA)	A. Environmental Quality Incentives Program (EQIP) 1. Forestry Health Initiative (financial and technical) 2. Wyoming Grazing Land Initiative (financial and technical) 3. Livestock Waste (financial and technical) 4. Wildlife Habitat Conservation (financial and technical) 5. Drought Mitigation (financial and technical) B. Wildlife Habitat Incentive Program (WHIP) (financial and technical) C. Wetland Reserve Program (WRP) (financial and technical) D. Conservation Security Program (CSP) (financial and technical) E. Farm and Ranch Protection Program (FRPP) (financial and technical) F. Colorado River Salinity Control (financial and technical) G. Plant Materials Center Program (commercial nurseries and seed producer assistance) H. Resource Conservation and Development (financial and technical) I. Rural Abandoned Mine Program (financial and technical) J. Watershed Protection and Flood Prevention Program (PL566) (technical and loans) K. Emergency Watershed Protection (EWP) program (financial and technical) L. Small Watershed Rehabilitation Program (financial and technical) M. Conservation Innovation Grants (CIG) (financial and technical) N. Conservation Technical Assistance (CTA) (technical) O. Sage Grouse Restoration Project (SGRP) (financial and technical) P. Grazing Lands Conservation Initiative (GLCI) Grants (financial and technical) Q. Cooperative Conservation Partnership Initiative (CCPI) (financial and technical)	NRCS State Office Federal Building P.O. Box 33124 100 East B Street, 3rd Floor Casper, Wyoming 82602-5011 Casper NRCS Field Office Habitat Extension Biologist 5880 Enterprise Drive, Ste. 100 Casper, WY 82609 Gillette NRCS Field Office Habitat Extension Biologist 601 4J Court, Suite C Gillette, Wyoming 82716 Greybull NRCS Field Office Habitat Extension Biologist 408 Greybull Ave. Greybull, WY 82426-2037 Wheatland NRCS Field Office Habitat Extension Biologist 1502 Progress Ct. Wheatland, WY 82201-3211
6. Federal Emergency Management Agency (FEMA, USDHS)	A. Hazard Mitigation Grant Program (HMGP) (reduce potential hazards) B. Flood Mitigation Assistance (FMA) program (financial and technical)	Federal Emergency Management Agency P.O. Box 10055 Hyattsville, MD 20782-7055
7. Bureau of Land Management (BLM, USDI)	A. Challenge Cost-Share Program (financial and technical) B. Range Improvement (8100) Funds) (financial and technical) C. Sikes Act (financial and technical) D. Cooperative Conservation Initiative (CCI) (financial and technical)	State BLM Office 2515 Warren Ave. P.O. Box 1828 Cheyenne, WY 82003 *BLM Resource Area Offices Located in:* Buffalo Casper Cody Kemmerer Lander New Castle Pinedale Rawlins Rock Springs Worland

FEDERAL AGENCIES

Agency Name	Program Assistance Available	Contact
8. U.S. Fish and Wildlife Service (USFWS, USDI)	A. 2002 Farm Bill Conservation Easements and Leases (financial and technical) B. Small Wetland Acquisition Program (SWAP) (financial and technical) C. Farm fish pond management (financial and technical) D. North American Wetland Conservation Act Grants Program (financial) E. Partners for Fish and Wildlife Program (financial and technical) F. Private Stewardship Grants Program (PSGP) (financial and technical) G. State Wildlife Grant (SWG) program (funds go to state wildlife agencies for various projects) H. Cooperative Conservation Initiative (CCI) (financial and technical) I. Multi-State Conservation Grant Program (financial and technical) J. Tribal Landowner Incentives Program (financial and technical) K. Tribal Wildlife Grants (financial and technical) L. Conservation Grants (financial and technical) M. Cooperative Endangered Species Conservation Funds (work with state agencies for funding) 1. Conservation Grants 2. Habitat Conservation Planning Assistance Grants 3. Habitat Conservation Plan Land Acquisition Grants 4. Recovery Land Acquisition Grants	Ecological Services Field Office Mountain-Prairie Region (6) 5353 Yellowstone Rd. Suite 308A Cheyenne, WY 82009-4178 Lander Fish and Wildlife Management Assistance Office 170 North 1st St. Lander, WY 82520-2836

STATE AGENCIES

Agency Name	Program Assistance Available	Contact
1. Wyoming Animal Damage Management Board (ADMB)	Funding for mitigating damage caused to livestock, wildlife, and crops	Animal Damage Mgmt. Board 2219 Carey Ave. Cheyenne, WY 82002-0100
2. Wyoming Legislature	Wyoming Wildlife and Natural Resource Trust Fund	Wyoming Wildlife and Natural Resource Trust 500 East Fremont Riverton, Wyoming 82501
3. Wyoming State Forestry	A. Forest Land Enhancement Program (FLEP) (financial and technical) B. Forest Incentive Program (FIP) (financial and technical)	State Lands & Investments Wyoming State Forestry Division 1100 W. 22nd Cheyenne, WY 82002 Wyoming State Forestry Division, District 3 305 S. Smith Rd. Riverton, WY 82501
4. Wyoming Water Development Commission (WWDC)	Small Water Project Program (SWPP) (financial and technical)	Wyoming Water Development 6920 Yellowtail Road Cheyenne, WY 82002

PRIVATE ORGANIZATIONS

Agency Name		Program Assistance Available	Contact
3.	Ducks Unlimited, Inc.	Matching Aid to Restore States Habitat (MARSH) (financial)	*Main Office* Ducks Unlimited, Inc. One Waterfowl Way Memphis, Tennessee 38120 *Western Regional Office* 3074 Gold Canal Drive Rancho Cordova, CA 95670
4.	The Forest Guild	Land Trust Services (financial)	The Forest Guild P.O. Box 519 Santa Fe, NM 87504
5.	Wyoming Chapter Foundation for North American Wild Sheep	A. Wild Sheep Habitat Program (financial) B. Funds Available for Wildlife Now (financial and hay)	FNAWS Headquarters 720 Allen Ave. Cody, WY 82414-3402
6.	Game Conservation International	Protection of Habitat (financial)	Game Conservation International P.O. Box 17444 San Antonio, TX 78217
7.	Intermountain West Joint Venture (IWJV)	Joint Venture Cost-Share (financial)	Intermountain West Joint Venture 120 State Avenue NE, #1457 Olympia, WA 98501-8212 Andrea Cerovski WY Game & Fish Department 260 Buena Vista Lander, WY 82520
8.	Izaak Walton League of America Endowment	Land Acquisition Program	*Endowment Executive Secretary* Shirley A. Freeman 106 Maple Circle Waverly, Iowa - 50677-4383
9.	Mule Deer Foundation	Mule deer habitat and conservation (financial)	*Main Office* The Mule Deer Foundation 404 East 4500 South, Suite B-10 Salt Lake City, UT 84107 *Northern Wyoming* Brandon Mason 928 N. 16th St. Bismarck, ND 58501
10.	National Association of Conservation Districts (NACD)	Natural Resources Conservation and Development Program (financial and technical)	NACD 509 Capitol Ct. NE Washington , D.C. 20002
11.	National Audubon Society	Sanctuary Program (financial)	Audubon Wyoming 101 Garden Creek Road Casper, WY 82604

ADDITIONAL RESOURCES AND CONTACTS

Max McGraw Wildlife Foundation P.O. Box 9 Dundee, IL 60118	National Institute for Urban Wildlife 10921 Trotting Ridge Way Columbia, MD 21044	National Wildlife Refuge 10824 Fox Hunt Lane Potomac MD 20854	North American Wildlife Foundation 102 Wilmot Rd., Suite 410 Deerfield, IL 60015
North American Wildlife Park Foundation Wolf Park Battle Ground, IN 47920	Safari Club International Foundation 4800 W. Gates Pass Rd. Tucson, AZ 85745	Society for Conservation Biology Dept of Wildlife Ecology University of Wisconsin Madison, WI 53706	Welder Wildlife Foundation P.O. Drawer 1400 Sintonj, TX 7838
Wilderness Inquiry 1313 Fifth St. SE, Box 84 Minneapolis, MN 55414	The Wilderness Society 900 Seventeenth St., NW Washington, DC 20006	Wildlife Conservation International New York Zoological Society 185th St. & Southern Blvd. Bronx, NY 10460	Wildlife Habitat Enhancement Council 1010 Wayne Ave., Suite 1240 Silver Spring, MD 20910
Wildlife Management Institute 1101 14th St., NW, Suite 725 Washington, DC 20005	Wildlife Preservation Trust International 3400 West Girard Ave. Philadelphia, PA 19104	The Wildlife Society 5410 Grosvenor Lane Bethesda, MD 20814	Woodswomen 25 W. Diamond Lake Rd. Minneapolis, MN 55419

Written by Erin Smith, Habitat Extension Biologist, Wyoming Game and Fish Department

This publication is one in a series of Habitat Extension Bulletins produced by the Wyoming Game and Fish Department. Call (307) 777-4600 for additional information or assistance.

Habitat Extension Services
WYOMING GAME AND FISH DEPARTMENT

Appendix M

GIS Data Summary

Appendix M

GIS Data Summary

Theme	Filename
BLM Data	
PLSS - Township and Range	WID_PLSS_twn_rng.shp
PLSS - Sections	WID_PLSS_section.shp
PLSS - Quarter Quarter Sections	WID_PLSS_qq.shp
Allotments/Pasture Boundaries	BLM_ALLOTMENTS.shp
Hot Springs County Soils	HotSpg_Soil.shp
Oil and Gas Well Locations	Cottonwood__OilGas_Wells_NEW.shp
Hot Springs County Reservoirs	HSC_RESERVOIRS.shp
Hot Springs County Springs	HSC_SPRINGS.shp
Washakie County Soils	Wash_Soil.shp
Soils	Cottonwood_Soils.shp
Roads	HSC_GPSED_ROADS.shp
Land Management Fiduciaries	HSC_LAND_MANAGEMENT_FIDUCIARIES.shp
Mechanical Treatments	HSC_MECHANICAL_TREATMENTS.shp
Reservoirs	HSC_RESERVOIRS.shp
Seeding Treatments	HSC_SEEDING_TREATMENTS.shp
Springs	HSC_SPRINGS.shp
Weeds	HSC_WEEDS.shp
Wildfire	HSC_WILDFIRE.shp
GLeks	GFleks2006 1327
WFO Leks	WFO_leks
County Roads	HSC_GPSED_ROADS.shp
Allotments	BLM_ALLOTMENTS.shp
Pyric Treatments	HSC_PYRIC_TREATMENTS.shp
NRCS Data	
Tanks (existing)	existing-tanks.shp
Tanks (planned)	tank-planned.shp
Tanks (proposed)	Tanks proposed.shp, Proposed-tanks.shp
Springs (existing)	spring-exists.shp
Springs (proposed)	Proposed-springs.shp
Pipeline (proposed)	Proposed-Pipeline.shp, pipelin proposedlu.shp
Pipeline (planned)	pipeline-planned.shp
Pipeline (existing)	CG/BLM/NRCS
PowerCompany Data	
Capacitor	Capacitor.shp
Fuse	Fuse.shp
OpenPoint	OpenPoint.shp
Pedestal	Pedestal.shp
Pole	Pole.shp
Reclose	Reclose.shp
Sectionalizer	Sectionalizer.shp
substation	substation.shp
switch	switch.shp
transformer	transformer.shp
primaryLine	primaryLine.shp
SecondaryLine	SecondaryLine.shp
Tanks - Existing	existing-tanks
Tanks - proposed	Proposed-tanks
Tanks proposed NEW	Tanks proposed_new
Tanks - Planned	tank-planned
Tanks - proposed	Tanks proposed
Springs - Proposed	Proposed-springs
Springs - Existing	spring-exists
Pipelines - Existing	Existing-pipelines
Pipelines - planned	Plan gravity pipeline
Pipelines - Proposed - LU	pipeline proposedlu
Pipelines - Proposed	Proposed-Pipeline
Pipelines - Proposed	pipeline proposed
Geodatabase Items	
Raster Catalog - Color Infrared Photos	WYGISC-cirs raster catalog
Raster Catalog - USGS 7.5' Quadrangles (1:24,000)	WYGISC-topos raster catalog
Raster Catalog - UGSG Quadrangles (1:100,000)	WYGISC-topos_100k raster catalog
WyGISC Data	
30m Digital Elevation Model (DEM)	DEM
Geology	cottonwood_bedrock_geology.shp
Land cover (mostly vegetation types), gap analysis	cottonwood_GAP.shp
Lakes, Hydrographic features	cottonwood_lake.shp
Land ownership	cottonwood_public_land.shp
Quadrangle boundries, USGS, 24k	cottonwood_quad_index.shp
Roads	cottonwood_road100k.shp
Streams, Hydrography	cottonwood_stream.shp
Surficial, geology	cottonwood_surficial_geology.shp
Drought Palmer Index - population, society, economy, environment, etc.	drought_palmer_index.shp
Wyoming Cities	wy_cities.shp
Wyoming Counties	wy_counties.shp
Weather stations, precipitation, climate	wy_precip_stations.shp
USGS Data	
Reservoirs	Reservoirs-Potential_USGS Topo_Cottonwood.shp
Sampling Sites	Gage Stations_Sampling Sites.shp
GW Sampling Sites	GW Quality Sampling Locations.shp
WDEQ Data	
Active NPDES Permits	NPDES Permits_Active.shp
Inactive NPDES Permits	NPDES Permits_Inactive.shp
WWDC Data	
Hydrography	wbhhydro.shp
Irrigated Parcels	WBHirrag.shp
Point of diversion	wbhpod.shp
Groundwater, wells, aquifer, water-table	wbhwells.shp
Project Generated	
Geomorphology of the Study Area	ACE_Geromorphology_Fieldwork.shp
Rosgen Level I classification	ACE_Rosgen_Classification_Type.shp
Rosgen Level II cross sections	ACE_Cross_Sections_Level_2.shp
Irrigation Structures in Study Area	ACE_Irrigation_Fieldwork.shp
Base Map of the Study Area	Cottonwood_AOI.shp
Base Map of the Irrigation Ditches in the Study Area	cottonwood_ditches.shp
Cottonwood/Greass Creek Basin	cottonwood_grass_creek_basin.shp
Irrigated Lands/Irrigated Agriculture	cottonwood_Irrigated_parcels.shp
Photo Hotlinks - Channel Photos	ACE_Channel_Photos.shp
Photo Hotlinks - Geomorphology evaluation Photos	ACE_Rosgen Level II Waypoints.shp
Photo Hotlinks - Irrigation Inventory Photos	ACE_Irrigation_Photos.shp
Privated Irrigated Lands	cottonwood_irrigated_private_land.shp
Potential Reservoir Site 1 Grass Creek Causeway	Site 1 - Grass Creek Causeway
Potential Reservoir Site 1 Grass Creek Causeway Large	Site 1 - Grass Creek Causeway_Large
Potential Reservoir Site 10 LU Cow Camp	Site 10 - LU Cow Camp.shp
Potential Reservoir Site 11 Prospect	Site 11 - Prospect.shp
Potential Reservoir Site 2 Putney Flat	Site 2 - Putney Flat.shp
Potential Reservoir Site Wales Expansion	Site 4 - Wales Expansion.shp
Potential Reservoir Site 5 Wagonhound	Site 5 - Wagonhound.shp
Potential Reservoir Site Spring Gulch	Site 7 - Spring Gulch.shp
Potential Reservoir Site Lower Grass Creek	Site 9 - Lower Grass Creek.shp
Public Irrigated Lands	cottonwood_irrigated_public_land.shp
Private Lands	cottonwood_private_ownership.shp
Springs	cottonwood_springs_SEH.shp
Ditch location	Ditch Diversion Labels Points.shp
Streams, digitized for sinuousity evaluation	streams_Ace_digitized.shp
Database of potential and existing water sources	Water_Sources_Database.shp
Buffers about existing/potential water sources (0.5 miles)	Existing_buffer_pt5mi
Database of potential and existing pipeline projects	Pipeline_Database.shp
Watershed Improvement District (WID) Boundary	WID_Boundary.shp
MISC Data	
Mines	mines_trainweb.shp
Soils (SSURGO)	soils_washakie_county.shp
U.S. State Plane Zones (Nad 1983)	state_plane_zones.shp
World UTM Zones	utm_zones.shp
Precipitation using the Prism Model	wy-prism-precip.shp
Coordinate System - State Plane Zones	ESRI
Coordinate System - UTM Zones	ESRI
National Wetlands Inventory	NWI_Polyline
National Wetlands Inventory	NWI_Polygon