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WYOMING WATER DEVELOPMENT COMMISSION

KIRBY CREEK WATERSHED PLAN
LEVEL I STUDY

September 12, 2005

SUNRISE ENGINEERING, INC.
Afton, WY

IN ASSOCIATION WITH:

NORTH WIND, INC.
Cody, WY

ECI, INC.
Greenwood Village, CO

SUNRISE ENGINEERING INC.

KIRBY CREEK WATERSHED PLAN
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Funded By:

The Wyoming Water Development Commission

September 12, 2005

Prepared By:

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TABLE OF CONTENTS

FIGURES

TABLES

EXHIBITS

APPENDICES

1.0 INTRODUCTION

1.1 PURPOSE AND SCOPE

The Wyoming Water Development Commission (WWDC) authorized Sunrise Engineering, Inc. to complete a Level I reconnaissance study of the Kirby Creek Watershed. The Kirby Creek Coordinated Resource Management (CRM) group, working through the Hot Springs Conservation District, was seeking to evaluate the conditions of the drainage ways and creeks in the Kirby Watershed including main-stem head cutting, also to provide an assessment of the existing rangeland and riparian areas of the watershed. The information contained in this Study is intended to "baseline information" from which the District can continue to expand upon and begin implementation of the management practices discussed. The results of this study will be used to further prioritize, plan, and implement projects that will improve the condition of the watershed. Future basin improvement projects will address erosion, water quality, wildlife habitat, rangeland resources, and irrigation supply.

One of the main concerns of the sponsors is the head cutting that has been occurring on Kirby Creek. Early historical accounts suggest that the watershed was once a productive meadow on the valley floor and Kirby Creek was not eroded like it is today. One could cross the creek on horseback at almost any location (Milek 2001). Today, the creek has vertical walls of 30 feet or more in some places. The cutting of the creek has also dropped the water table and where once meadow grass and hay were common, now greasewood and bush can be found.

Erosion is a severe problem throughout much of the Kirby Creek Watershed. Consequently, one of the objectives of the Kirby Creek CRM is to use the WWDC Level 1 Study to assess possible restoration projects and opportunities. Specifically, this watershed assessment will help the Kirby Creek CRM:

- Identify natural features and processes important in restoring the watershed.
- Determine how biotic and abiotic processes are influencing the watershed.
- Understand how human activities may have influenced soil erosion and stream morphology.
- Evaluate the cumulative effects of past land management practices.
- Prioritize problem areas and develop general plans for remediation.

As part of the Study, Sunrise Engineering, Inc. was required to gather, review, and compile existing background information available through previously completed studies in the watershed.

1.2 LOCATION

The Kirby Creek Watershed is located north and east of Thermopolis in Hot Springs County. The watershed catchment consists of approximately 128,500 acres of hilly grassland and flat valley bottom. Its headwater is Guffy Peak at the top of West Kirby Creek. It falls almost 4,000 feet to the Big Horn River over a distance of approximately 32 miles. Numerous tributaries drain into Kirby Creek, including Rock Springs Draw, Blue Springs Draw, Alkali Creek (Olson Draw, Major Basin Draw), West Kirby Creek (Dry Fork, Reed Creek), and East Kirby Creek (Little V-H Draw, Ackles Fork). Lake Creek is a primary tributary flowing from the east into Kirby Creek. Lake Creek includes Cottonwood, Gardner, and Packsaddle Creeks as shown in **Figure I-1**. The Lake Creek Watershed was not included in this study. The Kirby Creek Watershed is part of the Upper Bighorn River Watershed (USGS Cataloging Unit 10080007), a sub-basin to the larger Yellowstone River Watershed. The Yellowstone River Watershed consists of 70,271 square miles (mi^2) and its major tributaries include the Clarks Fork of the Yellowstone, Wind/Bighorn, Tongue, and Powder Rivers.

1.3 HISTORY

Historical information on the Kirby Creek area is limited. A description of the watershed is provided in Kirby Creek Country (Milek 2001). This document provides insight into the region's first native inhabitants and describes the subsequent settlement and development of the watershed for livestock and farming. Prior to the development of a road through the Wind River Canyon, the Kirby Creek Watershed was used as a travel route into the Big Horn Basin from the south. The watershed was named for a Texas cowboy named Kris Kirby, who first brought cattle into the watershed around 1878. Several other families homesteaded the area shortly thereafter such as the Hayes and Reed families. Descendants of these families still live in the area today.

A fundamental factor in determining where settlement occurred in the Big Horn Basin was water. Livestock grazing, irrigated farming, and homesteading depended on the location and quantity of water. In the Kirby Creek Watershed, those with a "territorial" right had the most control of where development was to occur. After 1890, water rights were obtained and secured by a permit filed with the Wyoming State Engineer and are based on the "doctrine of prior appropriation."

Irrigated farming was more common in the early 1900s than it is today. It is unclear if Kirby Creek flowed year-round in the late 1800s and early 1900s. In the upper portion of Ackles Fork, old irrigation ditches can still be found, indicating that flowing water may have been more common in the early days of settlement. Irrigation ditches are also found in other parts of the watershed, indicating the complexity and importance of irrigated agriculture.

Another important factor in the development of Kirby Creek was oil. The first oil drilled in the watershed was at the C.W. Anderson farm in 1914 (Milek 2001). Subsequently, oil fields such as Murphy Dome, Red Hole, Zimmerman Butte, Lake Creek, Black

Mountain, and Walker Dome were developed early in the twentieth century. The drilling of oil required the construction of roads which made the watershed more accessible.

Early photographs of Kirby Creek indicate that stream morphology was remarkably different than it is today. Undercut banks were uncommon and settlers indicated that they "could cross the creek on horseback at almost any location" (Milek 2001). This is not the case today, as the creek has downcut 30 or more feet in places.

Sometime between 1915 and 1920, drought struck the region. In the early to mid 1920s, severe erosion started to commence along Kirby Creek. Drought coupled with the catastrophic flooding of the early 1920s, and subsequent flooding likely contributed to the deterioration of Kirby Creek.

2.0 WATERSHED DESCRIPTION AND INVENTORY

2. 1 TOPOGRAPHY AND DRAINAGES

Topographic relief of the study area is composed primarily of hills, hogbacks, anticlines, synclines, alluvial valleys and floodplains, stream channels and meadows. Elevations in the watershed range from about 4260 ft., at the confluence with the Big Horn River to Guffy Peak, at elevation 8,046 ft. above sea level. East and West Kirby creeks converge at about 4890 feet above sea level, and the channel then becomes the main stem Kirby Creek. Lake Creek enters Kirby Creek at approximately 4560 ft. Kirby Creek then flows in a westerly direction to the confluence with the Big Horn River.

Upper sections of East Kirby Creek have some trees and in many place a well-established riparian zone. Beaver activities are noted in this portion of East Kirby Creek. Upper East Kirby Creek is fed by springs and seeps, as well as run-off from a large expansive drainage. Several perennial wetlands and riparian areas are also found along East Kirby Creek. There are, however, in the lower reaches of East Kirby Creek areas that are experiencing aggressive head-cutting.

West Kirby Creek has a similarly well established riparian corridor, but with fewer trees and beaver activity. It is also experiencing progressive head-cutting.

Numerous small stock reservoirs are also scattered throughout the watershed, in many of the ephemeral draws and tributaries to catch and store water during times of run-off. Several of these water storage facilities are no longer functioning properly due sedimentation and low or no maintenance.

There are three on-channel reservoirs located on the main stem of Kirby Creek. One located approximately 8 miles from the Bighorn River confluence, and the other two approximately 20 and 23 miles upstream of the confluence. Two of the three dams are in need of maintenance and stabilization. Along the main stem of Kirby Creek some areas have 30-ft. vertical banks which are causing progressive head cutting of its tributaries.

2. 2 GEOMORPHOLOGY

The Kirby Creek Watershed contains typical physiography of high mountains and lowland basins. The Upper Bighorn River basin is part of the Middle Rocky Mountains province (Zelt et al. 1999). The upper basin, including the eastern Owl Creek Mountains and Copper Mountain region, contain Precambrian rocks that are flanked by Paleozoic and Mesozoic sedimentary rocks. Tertiary deposits, partially covered by Quaternary alluvium, are common in the lowland basins (USGS 2004).

Much of the Kirby Creek basin is dominated by fractured bedrock ridges and uplifts. Resistant rock beds form the high ridges that have escarpments on the open faces and sloping back slopes parallel to the tilted bedrock. Stream pattern and geomorphology generally conforms and sometimes cuts though these ridges forming the characteristic smaller canyons of the upper Kirby Creek area. The larger tributaries form wide floodplains and low stream terraces with narrow, downcut channels. Erosional gravel beds form benches and terraces along both upland and lowland channels (BLM 1978).

Bedrock in the lower half of the watershed is mostly shale. Sandstone shale carbonates of the Mesozoic and Paleozoic dominate the upper half of the watershed, including upper East and West Kirby Creek and the Copper Mountain region. Clay of the lower half of the watershed is rich in sodium, and other salts. Resistant sandstone and siltstone layers are intermittent with less resistant shale and often form ridge crests. In the Red Hole area of lower Kirby Creek, red shale beds, thick sandstone beds, and highly gypsiferous beds crop out (BLM 1978, Snoke et al. 1993). The basin geology is shown in **Figure II-1**.

2. 3 LAND USES

Land ownership of the watershed is divided among the Bureau of Land Management (BLM), approximately 65 percent, State lands, approximately 15 percent, and private ownership, approximately 20%. **Figure II-2** shows the general land ownership of the watershed.

The primary surface land use of the watershed is rangeland agriculture. The BLM provides livestock rangeland leases. **Figure II-2** shows the allotment data for the Kirby Creek Watershed.

Irrigated farming was more prevalent during the early history of the area than it is today. Old irrigation ditches can be found throughout the watershed. More intensive agriculture may have been more common in the early 1900's. The majority of the land now is non-irrigated pasture.

Oil drilling and exploration is another land use found in the Kirby Creek watershed. The first oil was drilled in 1914 at the C.W. Anderson farm (Milek 2001). The watershed now includes the Murphy Dome, Red Hole, Zimmerman Butte, Lake Creek, Black Mountain oil fields which have produced over 75 million barrels of oil. The watershed was more accessible after the oil drilling began due to the roads which were constructed.

Other land uses include gas production, mining for bentonite, sand, and gravel, residential living, and recreation. Several species of big game roam the watershed and hunting of mule deer, elk, and antelope is a popular fall recreational pursuit.

2. 4 OIL AND GAS, MINING AND PIPELINES

There are 56 active oil and gas wells located in the Kirby Creed watershed. Most of these are located near the area where Kirby Creek and Lake Creek come together. Table 2.4

shows a list of the companies that own and operate active wells in the watershed and the number of wells they own. There are 225 inactive oil and gas wells, most of which have a Permanently Abandoned status. They are scattered throughout the watershed but the majority are near the active wells.

TABLE 2.4 - ACTIVE WELLS

Company	# of Wells	Status
Carol-Holly Oil Corporation	3	PO
Coronado Oil Company	2	PO
DOW	1	O
Gas Ventures L.L.C.	5	2 - AI 3 - PO
H.D. Oil Company	1	PO
Petroleum Resource Management	1	PO
Thorofare Resources Inc.	27	12 - AI 15 - PO
Ute Oil Company	1	PO
Voyage Exploration Inc.	15	PO

AI=Active Injector PO=Producing Oil Well

Five main pipelines pass through the watershed. These pipelines are owned by Amoco, Colorado Interstate Gas, Express Sponsors, and Williston Basin Interstate. Cenex owns a smaller pipeline in the watershed. These pipelines range in size from four to 16 inches and follow East Kirby Creek and Kirby Creek to the Bighorn River. **Figure II-3** shows the active gas and oil wells in the watershed as well as the pipelines.

2. 5 CONSERVATION RESERVE

The USDA Farm Service Agency's (FSA) Continuous Conservation Reserve Program (CCRP) is a voluntary program available to agricultural producers to help them safeguard environmentally sensitive land. Those enrolled in CCRP plant long-term, resource-conserving crops that improve water quality, control soil erosion, and enhance wildlife habitat. To those enrolled in the program, the FSA provides participants with rental payments and cost-share assistance. Contracts are normally between 10 to 15 years. Producers can offer land for CRP during designated sign-up periods, or environmentally desirable land may be enrolled at any time under CRP continuous sign-up.

To be eligible for placement in CCRP, land must either be cropland that is planted or considered planted to an agricultural commodity 4 of the pervious 6 crop years and which is physically and legally capable of being planted, or certain marginal pastureland that is enrolled in the Water Bank Program or suitable for use as a riparian buffer or for similar water quality purposes.

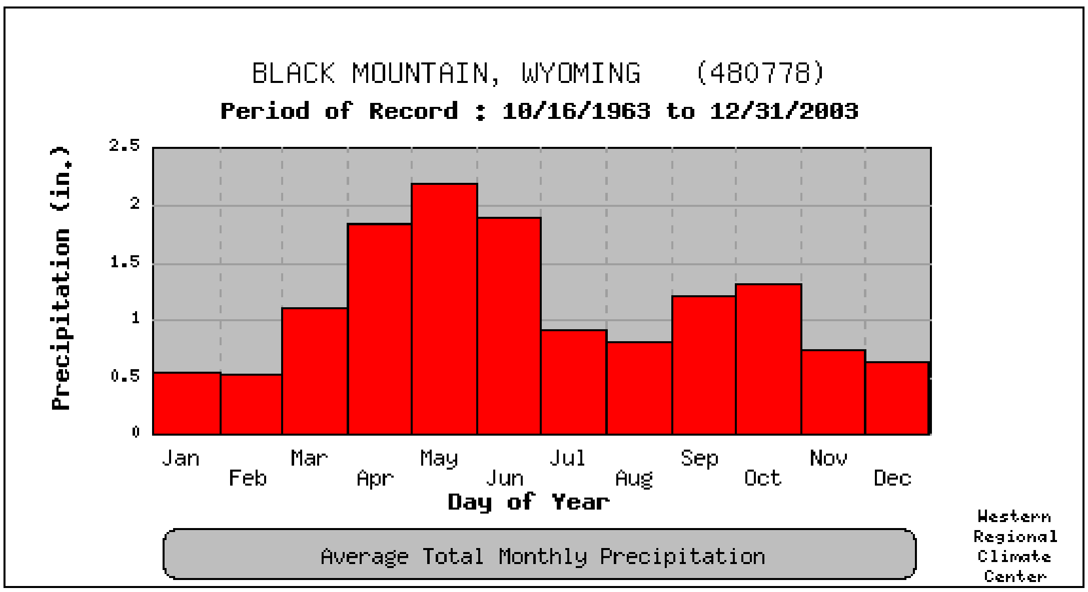
In return for establishing long-term, resource-conserving covers, the FSA provides annual rental payments. These payments are based on the average dryland cash rent or cash-rent equivalent. The maximum rental rates are calculated for each CCRP area prior to enrollment. The FSA also provides cost-share assistance of up to 50 percent of the cost in establishing approved practices.

Currently, the Kirby Creek Watershed has 200 acres enrolled in CCRP. These areas are fenced riparian areas to enhance the vegetation and water quality of the existing streams, and assist in controlling erosion. **Figure II-4** shows the areas currently enrolled in CCRP.

2. 6 CLIMATE

The weather station closest to the Kirby Creek Watershed is the Black Mountain station. It is located east of Lake Creek and will most closely represent the Kirby Creek area. The Watershed is considered to be semiarid. The Black Mountain Climate Station showed that it received 11.10 inches of precipitation in 2002. The precipitation received in 2003 was 16.10 inches, a substantial increase from the year before, most of which was received March through June. The chart below shows the average precipitation for the Black Mountain area:

EXHIBIT 2.6 - BLACK MOUNTAIN CLIMATE RECORD



The precipitation zones of the Watershed are shown in **Figure II-5**. This map shows the area along the lowest elevation of the Watershed with 10-12 inches of precipitation extending up to 18-20 inches at the highest elevation. It is recommended that the CRM pursue placing a climate station somewhere within the Kirby Creek Watershed, or possibly several rain gauges placed in strategic areas of the Watershed.

The average annual temperature for 2003 in the Black Mountain area was 47.44ºF, up almost 2ºF from the 40 year average of 45.7ºF, but almost 2ºF lower than the high of 49.12ºF in 1999. The months with the highest average temperature were July and August with an average of 77.45ºF and 75.87ºF. The lowest was December with an average of 28.95ºF. (Western Regional Climate Center, 2003)

2. 7 LAND COVER

The Kirby Creek Watershed has one main class of vegetative cover and several lesser classes. The main vegetative classification as provided by the Spatial Data and Visualization Center at the University of Wyoming is Wyoming Big Sagebrush. This classification covers approximately 70% of the watershed. It is present in all areas of the watershed but is most prominent in the middle and lower regions. The second largest vegetative classification is Juniper Woodland, covering 12% of the watershed. It is present in the headwaters region. Desert Shrub is located on the north edge of the watershed along the main confluence of Kirby Creek and comprises approximately 8% of the vegetative cover. Mixed Grass Prairie and Dry Land Crops each account for 4% of the vegetation cover and are located sporadically in the upper and middle regions of the watershed. Limber Pine Woodland covers a very small area at the headwaters of West Kirby Creek.

It should be noted that Tamarisk has begun to invade the watershed. Tamarisk can be found along the riparian corridor of Kirby Creek from the confluence with the Big Horn River to just down stream of the confluence of Lake Creek and Kirby Creek. Also, the invasive species cheat grass was found in the upland range transects. The vegetative cover will be discussed more in-depth in Section 2.16. **Figure II-6** shows the vegetative cover for the Kirby Creek Watershed.

2. 8 WILDLIFE

Several species of big game are found within the Watershed. Mule deer and antelope are in abundance. The Watershed is also home to some white tail deer and elk. Several species of birds and rodents, as well as predators such as coyotes and badgers inhabit the Watershed. Beaver activity has been seen in areas of Kirby Creek. Beaver ponds have contributed to the rehabilitation of riparian areas. The affects of beavers and the role they play in rehabilitation will be discussed later in Section 6. The Watershed is also in part of the waterfowl migration corridor.

2. 9 IRRIGATION DIVERSIONS AND RESERVOIRS

The irrigation diversions located in the Kirby Creek watershed are located in the middle and upper regions. Twelve irrigation diversions have been identified in the Kirby Creek Watershed. Eight of these diversions are used for irrigation, two are used for irrigation and domestic purposes, and two are used for irrigation and stock purposes. The priority dates on these diversions range from 1897 to 1918.

In the Lake Creek area of the watershed there are six irrigation diversions, all of which are used for irrigation. A permitted total of 0.44 cfs of water can be diverted. Four diversions are located on West Kirby Creek, three in the middle region and one in the lower region. These diversions are permitted to a total of 4.29 cfs of water for irrigation, stock, and domestic use. Two diversions are located in the upper region of East Kirby Creek and are permitted for 0.91 cfs of water for irrigation and stock use.

The West Kirby diversions are in relatively good condition. The Reed family has a ditch used for irrigation and stock purposes, and the Mishurda Mountain Ranches LLC diversion is also in good condition. Most of the other irrigation ditches are no longer useable due to the down-cutting of the stream. New ditches would have to be constructed with the point of diversion moved up-stream a significant distance in order to take water from the down-cut channel.

In addition to irrigation diversions, there is a dam located on Kirby Creek on the Jones Ranch. It is privately owned, produces a reservoir used for stock watering and irrigation, but the dam is in need of repair. It is approximately 670 feet wide and produces a reservoir 2,700 feet long and has 70 acre-ft. of water right. There are also 62 stock reservoirs and 2 detention basins in the watershed as shown in **Figure II-7**. A data base of these reservoirs is in **Appendix A**. Some reservoirs appear to be in good working condition, while several others are in need of repair.

2. 10 NPDES PERMITS

There are currently nine NPDES permits on file with the Wyoming Department of Environmental Quality within the Kirby Creek watershed. These permits have been filed by county government, communications companies, and oil and gas companies. The facilities being served by these permits are stormwater facilities and oil and gas production units. Table 2.10 shows a list of the permit holders and the number and status of these permits.

TABLE 2.10 - NPDES PERMITS IN KIRBY CREEK WATERSHED

Name	# of Permits	Status/Notes	Location			
			Township	Range	Section	QQ
Hot Springs County	3	1 Active, Stormwater	43N	92W	17	SESE (2) NWSW (1)
RT Communications, Inc.	1	Active, Stormwater	38-42N	90-95W	Various	
Petroleum Resource Management	1	Active	43N	93W	21	SWSE
Citation Oil and Gas Management	1	Inactive	43N	92W	14	
Holly Oil	1	Active	43N	92W	21	NE
Texaco Exploration and Production, Inc.	1	Inactive	43N	92W	11	
Gas Ventures of Casper, WY	1	Active	43N	91W	34	

2. 11 Roads

The Kirby Creek watershed has two main road types, county roads and two-track roads. Black Mountain Road is the only county road in the watershed and is 20 miles long. It follows the course of Kirby Creek and Lake Creek. The two-track roads are less traveled than county roads but more traveled than jeep trails. In the watershed there are 320 miles of two-track roads. These roads cover all areas of the watershed and most follow the streams which are tributary to Kirby Creek. **Figure II-7** shows the roads in the Kirby Creek Watershed.

2. 12 Water Wells

Sixty-nine wells are located in the Kirby Creek watershed. Table 2.12 shows the types and number of wells. The majority of wells are used for stock watering. Priority dates for the wells range from 1916 to 1998 with 60% of the wells having a priority date of 1970 or later. The deepest wells are over 4,000 feet deep and are used for industrial and stock watering. The shallowest well is 15 feet deep. The well locations are shown in **Figure II-8** and Appendix F contains the attribute data for the wells.

Table 2.12 – Water Well Type and Quantity

Well Type	# of Wells	Notes
Stock	43	Deep = 4,319 ft Shallow = 15 ft
Stock, Domestic	18	Deep = 3,719 ft Shallow = 28 ft
Domestic	5	Deep = 381 ft Shallow = 52 ft
Industrial	2	Deep = 4,099 ft
Monitoring	1	Depth = 2,963 ft

2. 13 Wetlands

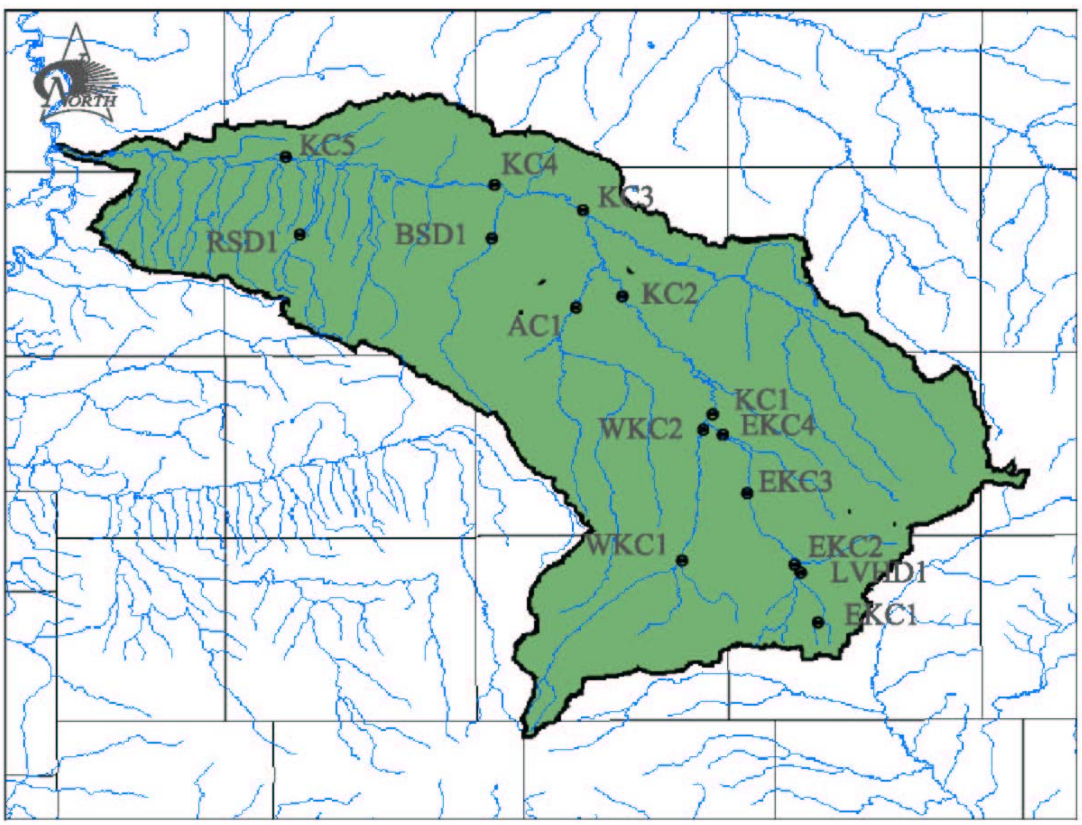
The Kirby Creek Watershed has little area considered to be wetlands as compared to the overall area of the entire watershed. This may be attributed in part to the down cutting of the stream channels. As the channels continue to down cut, the ground water continues to drop as well. Areas where ground water was once a few feet deep now may be as much as 30 feet deep. The Spatial Data and Visualization Center at the University of Wyoming provides data on wetlands throughout the State. The areas considered wetlands can be seen in **Figure II-9**. For the most part, wetlands are confined to reservoirs and along the stream channels. There are however some off channel wetlands due to seeps throughout the watershed.

2. 14 WATER QUALITY

The Kirby Creek watershed was tested in 2002 for physical, chemical, and biological parameters to determine the water quality. This testing was conducted from April 2002 to October 2002 as part of a study conducted by Hurley Geological Consulting in cooperation with Hot Springs Conservation District and was funded through the Wyoming Non-Point Source Task Force and the Wyoming Department of Environmental Quality. Information from that study was summarized in this report. For a more comprehensive look at the water quality parameters for the Watershed, one should look in the 205j final report.

During testing for the previously mentioned report the Kirby Creek watershed was experiencing a drought. Some locations along Kirby Creek did not have water flowing in them during parts of the year. This affected some of the test results, and is discussed in later sections. **Exhibit 2.14** is a location map showing 205j report test locations.

EXHIBIT 2.14 - TEST LOCATION MAP



2.14.1 Physical Parameters

Physical parameters are associated with the physical characteristics of the water. The physical parameters that were tested are temperature, specific conductance, and turbidity and total suspended solids (TSS). No formal flow measurements were performed but visual inspection estimated the flows to vary from 0 to 4 cubic feet per second (cfs) based on approximate stream cross-sections and stream velocity.

Temperature

Water temperature can change from day to day and even from hour to hour. Water temperature is important because it affects the amount of dissolved oxygen (DO) in the water, which is one of the measurements of water quality. Cooler temperatures allow more oxygen to be dissolved in the water, while warmer temperatures promote activity in the water which reduces the amount of oxygen.

The water temperature in Kirby Creek was measured and recorded at 12 different locations. During the sampling periods the water temperatures were coolest in April and October and warmest in May, June, and August. Table 2.14.1 shows the water temperatures that were recorded during the sampling period. This table shows that the temperatures varied from a high of 26.6°C in June 2002 at the Kirby Creek 4 site to a low of 1.6°C in October at the East Kirby Creek 1 site.

TABLE 2.14.1 – TEMPERATURE DATA

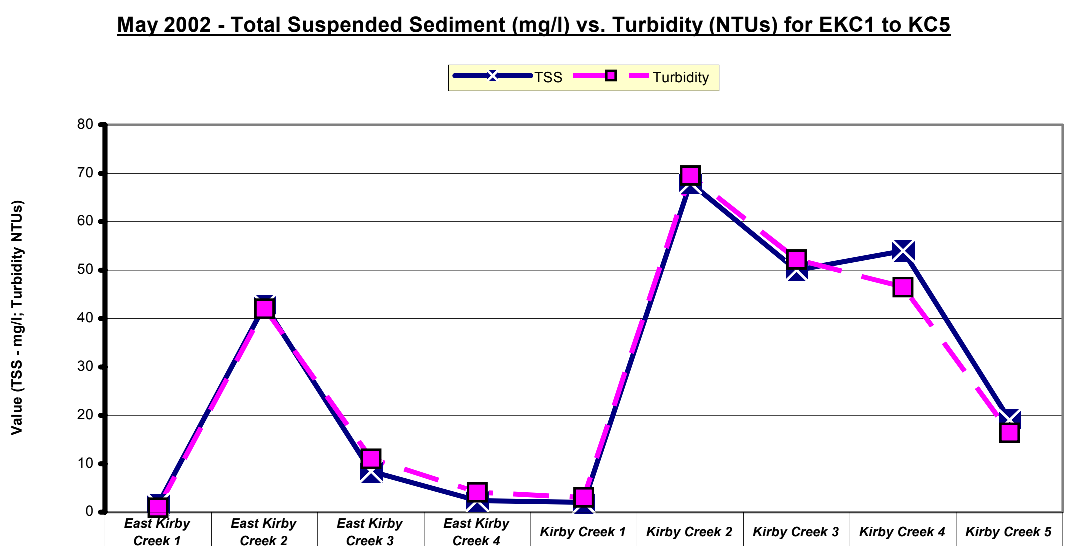
Sample Location	Average Temperature per Month (°C)						
	April	May	June	July	August	September	October
East Kirby Creek 1	6.8	9.8	18.5		24.7	9.2	1.6
East Kirby Creek 2	9.5	13.4	23.1		23.8	10.9	4.6
East Kirby Creek 3	11.5	15.1	23.2				
East Kirby Creek 4	12.1	16.1					
West Kirby Creek 1			16.4				
West Kirby Creek 2	15.7	16	25.2				3.9
Kirby Creek 1		7.6					
Kirby Creek 2		9.8					4.4
Kirby Creek 3		9.5					2.5
Kirby Creek 4		10.8	26.6				1.7
Kirby Creek 5	6	11.3					
Red Spring Draw 1	6.5	13.6					

Turbidity and Total Suspended Solids (TSS)

Turbidity is a measure of the relative clarity of water. Turbidity tests can indicate the presence of clay, silt, or other particulate matter. The higher the test result number, the greater the number of particles present in the water. In an area such as Kirby Creek turbidity levels can indicate eroded material being transported by the stream. This eroded material can enter the stream through storm events, livestock activity, or erosion caused by the flowing water. Testing performed for turbidity showed discrepancies between the filed test results and the lab test results. For this reason the lab test results were considered accurate for this study.

Results of turbidity and TSS testing conducted in May 2002 showed that the major contributor to turbidity was an increased amount of sediment. This sediment entered the water through storm events or livestock activity. Exhibit 2.14.1 shows a comparison of total suspended sediment (TSS) and turbidity from site EKC1 to site KC5 for May 21 and 22, 2002. This figure shows that the values for TSS and turbidity are closely linked. The EKC2 site and the KC2-KC4 sites produced the highest values. The EKC2 site was influenced by active grazing upstream and nearby and the KC2-KC4 sites were influenced by very low stream velocities which allowed for partial stagnation of the water throughout the year.

EXHIBIT 2.14.1 – VALUES OF TSS AND TURBIDITY



	East Kirby Creek 1	East Kirby Creek 2	East Kirby Creek 3	East Kirby Creek 4	Kirby Creek 1	Kirby Creek 2	Kirby Creek 3	Kirby Creek 4	Kirby Creek 5
TSS	1.6	42.7	8.4	2.4	2	68	50	54	19
Turbidity	0.91	42	11	4.09	3.07	69.5	52.2	46.5	16.4

(Hurley, 2003)

In addition to the testing performed on May 21 and 22, 2002, the average values for TSS and turbidity were studied. The highest average value for TSS was 46.7 mg/L at site KC4. The two lowest average values for TSS were 2.0 mg/L and 2.4 mg/L at sites KC1 and KC4, respectively. The highest average turbidity value for the testing period was 67.2 NTUs at site KC2. The lowest average value for the testing period was 3.07 NTU at site KC1. These results show a dramatic increase in turbidity from the KC1 to KC2 sites. The 205j report refers to this increase as the KC2 spike. The very high turbidity values may be due to stagnation of flows at this site, or other factors.

2.14.2 Chemical Parameters

Chemical parameters are usually not visible. They relate to the chemical make-up of the water and the chemical reactions that occur. The chemical parameters that were tested are pH, Total Dissolved Solids (TDS), and Dissolved Oxygen (DO), and cations and anions.

pH

pH is a measurement of the Hydrogen ion concentration in the water. When the pH is above 7, the water is basic or alkaline. When the pH is below 7, the water is acidic. A range of 6.8 to 8.7 will produce the highest diversity of aquatic life in a stream.

During the 2002 testing period 12 sites were tested for pH. Test results showed that the pH values in the stream do not vary significantly and range from 8.0 to 8.65. These values indicate that the water in Kirby Creek becomes slightly more alkaline as it travels downstream. There are two possible reasons for this increase in alkalinity in the water: 1) oil field waters being discharged into the creek and 2) alkaline constituents from geologic formations being absorbed in the water. These two features will increase the alkalinity of the water.

Total Dissolved Solids (TDS)

A dissolved solid is one which is homogeneously dispersed in the water. It cannot be removed by filtration, sedimentation, or other physical methods but requires a phase change for removal (reverse osmosis). Water with a high specific conductance is likely to have a high level of TDS.

Test results for specific conductance and total dissolved solids (TDS) follow the same pattern, with specific conductance results slightly higher than TDS results. The highest values in the entire creek for TDS occurred in May 2002, during the highest runoff, and the lowest values in the entire creek occurred during October 2002. The low average lab TDS value was 442 mg/l at site EKC1 and the high average lab TDS value was 5282 mg/l at site KC5, with a general increase in TDS values from upstream points to downstream points (see Exhibit 2.14, Test Location Map, for site locations)

Dissolved Oxygen (DO)

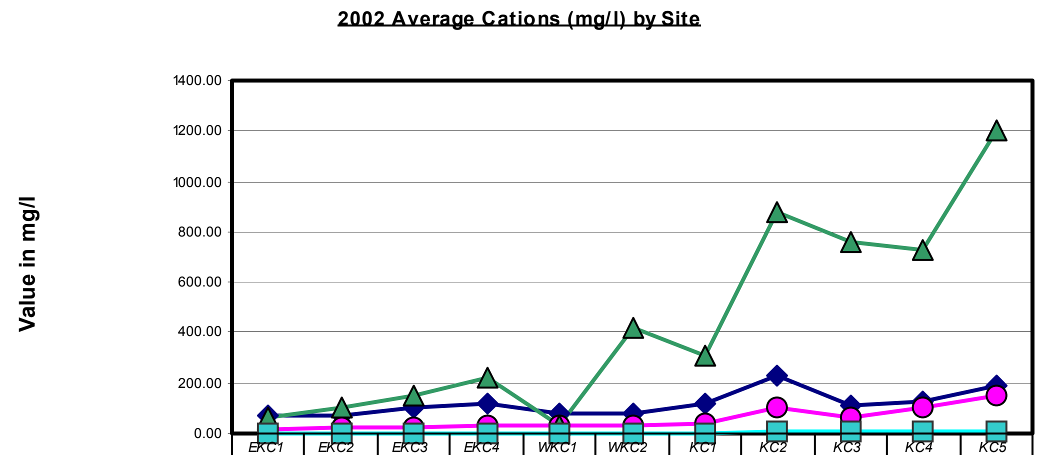
The level of dissolved oxygen in a body of water is an indicator of general health and water quality. Dissolved oxygen is required for plant and animal life. If the level of dissolved oxygen decreases below 4 to 5 mg/l, game fish will be driven out. Dissolved oxygen is affected by water temperature, stream flows, and photosynthesis activity. Lower water temperatures result in higher levels of dissolved oxygen.

The test results showed that East Kirby Creek appears to be losing dissolved oxygen downstream with values ranging from 10.85 to 4.39 mg/l. West Kirby and the main stem of Kirby Creek ranged from 10.55 to 12.32 mg/l.

Cations and Anions

Cations are positively charged elements in the water and anions are negatively charged elements in the water. Testing for cations and anions was performed at the Wyoming Department of Agriculture Laboratory for samples taken during 2002. The cations that were detected were calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K). The anions that were detected were carbonate (CO_3), bicarbonate (HCO_3), chloride (Cl), fluoride (F), nitrate as N (NO_3), nitrate as N (NO_2), orthophosphate as P, and sulfate (SO_4). For a more detailed description of the cations and anions please see the 205j report. Exhibits 2.14.2 and 2.14.3 show the per site average for cations and anions, respectively.

EXHIBIT 2.14.2 – AVERAGE CATIONS BY SITE

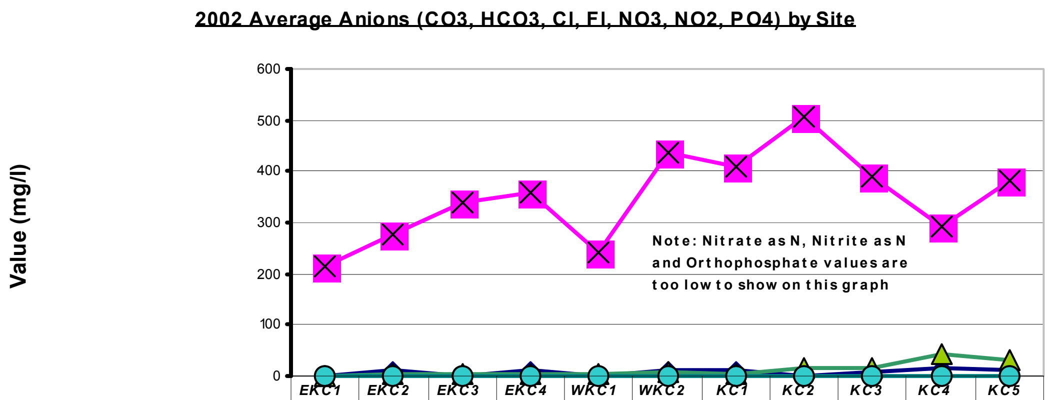


	EKC1	EKC2	EKC3	EKC4	WKC1	WKC2	KC1	KC2	KC3	KC4	KC5
Avg Calcium	72.50	73.50	100.00	120.00	78.00	75.70	120.00	230.00	110.00	128.00	190.00
Avg Magnesium	14.50	23.50	27.00	35.00	33.00	31.70	38.00	101.50	64.00	102.00	150.00
Avg Sodium	60.50	102.30	150.00	220.00	35.00	417.00	310.00	875.00	760.00	730.00	1200.00
Avg Potassium	1.90	2.40	3.40	3.40	3.30	2.60	3.00	7.70	4.55	9.70	10.00

Site number

(Hurley, 2003)

EXHIBIT 2.14.3 – AVERAGE ANIONS BY SITE



	EKC1	EKC2	EKC3	EKC4	WKC1	WKC2	KC1	KC2	KC3	KC4	KC5
Avg Carbonate	0	12.75	0	13	0	13.3	12	0	7	14	12
Avg Bicarbonate	215	275	340	360	240	437	410	505	390	293	380
Avg Chloride	1.9	1.95	2.3	3	2.6	6.1	4.5	15.4	14.5	44	33
Avg Fluoride	0.2	0.45	0.7	0.7	0.3	0.63	0.7	0.25	0.2	0.6	0
Avg Nitrate as N	0.08	0	0	0	0.2	0	0	0	0	0	0
Avg Nitrite as N	0	0	0	0	0	0	0	0	0	0	0
Avg Orthophosphate	0	0.025	0	0	0	0	0	0	0	0	0

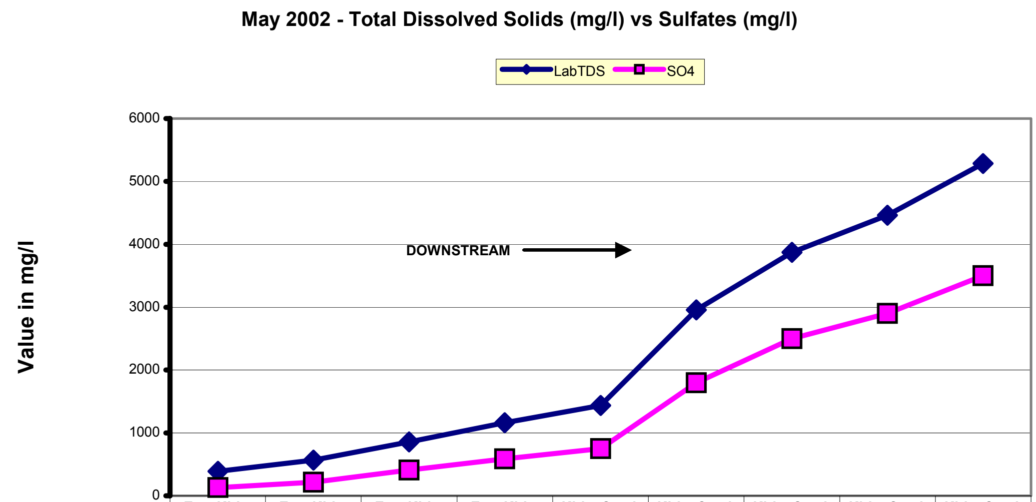
Site number

(Hurley, 2003)

Exhibit 2.14.2 shows that the most dominant cation in the waters of Kirby Creek is sodium, followed by calcium, magnesium, and potassium. The presence of cations generally increases from upstream to down stream, with the same KC2 spike that was visible in testing for TSS and turbidity.

Exhibit 2.14.3 shows that the most dominant anion in the waters of Kirby Creek is bicarbonate, followed by carbonate, chloride, fluoride, orthophosphate, and nitrate. In addition to the anions shown in Exhibit 2.14.3, sulfate is extremely common in the water in Kirby Creek. Exhibit 2.14.4 shows that a majority of the dissolved solids in the waters of the Kirby Creek watershed are sulfate.

EXHIBIT 2.14.4 – TOTAL DISSOLVED SOLIDS (mg/l) VS. SULFATE (mg/l)

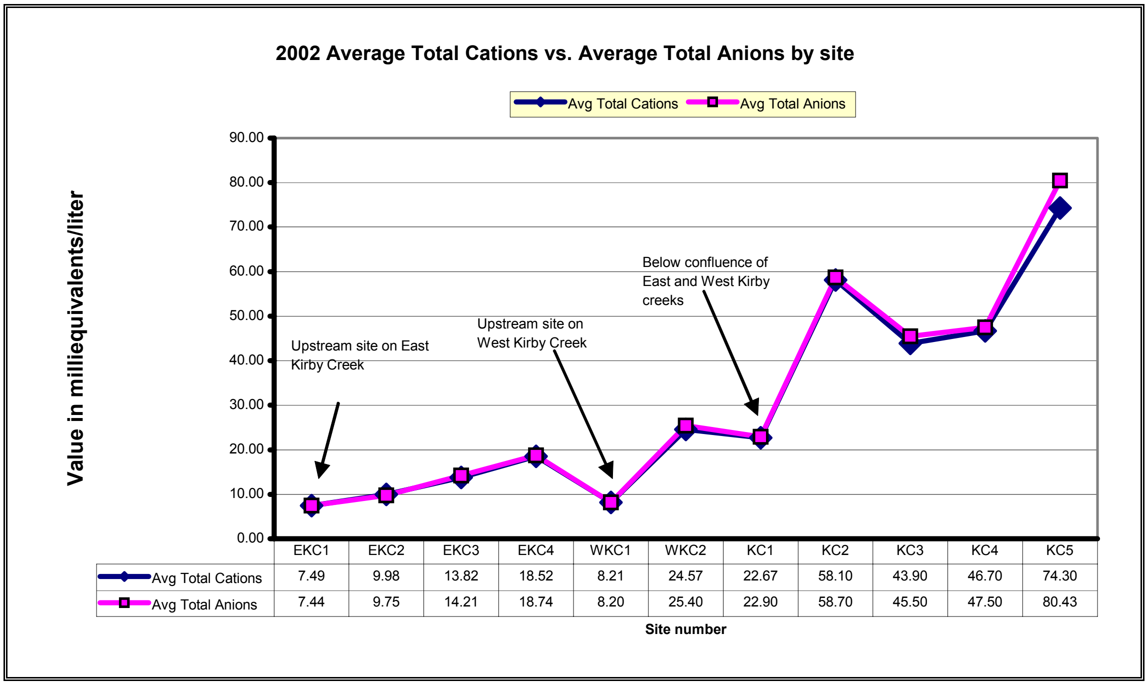


	East Kirby Creek 1	East Kirby Creek 2	East Kirby Creek 3	East Kirby Creek 4	Kirby Creek 1	Kirby Creek 2	Kirby Creek 3	Kirby Creek 4	Kirby Creek 5
LabTDS	391	567	861	1162	1440	2956	3870	4461	5282
SO4	130	220	410	590	750	1800	2500	2900	3500

(Hurley, 2003)

Exhibit 2.14.5 shows the average total cations per site vs. the average total anions per site for the sites sampled. This graph shows that the cations and anions closely match each other at each site, with a steady increase in concentration from upstream to downstream sites.

EXHIBIT 2.14.5 – AVERAGE TOTAL CATIONS/ANIONS



(Hurley, 2003)

2.14.3 Biological Parameters

Biological parameters may or may not be visible in the stream. They are parameters which affect the stream on a biological level. The parameters that were observed were fecal coliform bacteria and for the ability of the stream to support wildlife, namely fish.

Fecal Coliform Bacteria

Fecal coliform can enter the water directly through discharge or indirectly through runoff, septic system leakage, or other similar means. The presence of fecal coliform may indicate the presence of other, more dangerous bacteria and or viruses. Testing was performed in 1999, 2000, and 2002 for fecal coliform in Kirby Creek.

Table 2.14.2 shows the test results from the 2002 testing. The testing performed in 1999 and 2000 had high levels of fecal coliform while the testing performed in 2002 had much lower levels.

TABLE 2.14.2 – 2004 FECAL COLIFORM RESULTS (COLONIES/100ml)

Kirby Creek Watershed

Site #	May	June	August	September	October	November
EKC1	0	0	--	19	93	--
EKC2	72	0	--	31	0	17
EKC3	200	62	--	--	--	--
EKC4	10	--	--	--	--	--
WKC1	--	0	--	--	0	--
WKC2	89	0	--	--	--	--
AC1	--	--	--	--	--	--
RDS1	145	--	--	--	--	--
BSD1	--	--	--	--	--	--
LVHD1	--	--	--	553	--	--
KC1	0	--	--	--	--	--
KC2	0	--	--	--	0	--
KC3	0	--	--	--	2	--
KC4	0	0	--	--	0	--
KC5	0	--	--	--	--	--

Hurley, 2003

Fisheries

Kirby Creek has been classified as a Class 2C water by WDEQ. A Class 2C water supports or has the potential to support only non-game fish populations. These waters can be permanent or seasonal and are considered warm water. The uses for this class of water include non-game fisheries, fish consumption, aquatic life other than fish, primary contact recreation, wildlife, industry, agriculture, and scenic value. Table 2.14.3 obtained from WDEQ shows the Wyoming surface water classes and use designations. Further information on surface water classifications can be found in Chapter 1 of the Wyoming Water Quality Rules and Regulations – Surface Water Standards.

TABLE 2.14.3 - SURFACE WATER CLASSES AND USE DESIGNATIONS

	Drinking Water	Game Fish	Non-Game Fish	Fish consumption	Other Aquatic Life	Recreation	Wildlife	Agriculture	Industry	Scenic Value
1*	*Yes*	*Yes*	*Yes*	*Yes*	Yes	Yes	Yes	Yes	Yes	Yes
2AB	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

2A	Yes	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
2B	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2C	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3A	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3B	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
3C	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes
4A	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4B	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes
4C	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes

WDEQ Water Quality Division, Surface Water Standards, June 2001

During the 2002 sampling period, three different locations on Kirby Creek were electro-shocked by the Wyoming Game and Fish Department (WGFD). Location #1 is on East Kirby Creek, location #2 is on West Kirby Creek, and location #3 is on the main stem of Kirby Creek. During the electro-shocking four different types of fish were observed, as well as Northern Leopard frogs. Table 2.14.4 shows the number of fish that were observed and their locations. This table shows that while wildlife is present in the form of fish and frogs.

TABLE 2.14.4 – ELECTRO-SHOCK LOCATIONS AND OBSERVATIONS

Site	Lake Chub	Long Nose Dace	Mountain Sucker	White Sucker	Notes
East Kirby Creek	0	25	13	0	heavily grazed, hard bottom w/ pooled silt, abundant frogs, suffers from intense grazing, temps too high for game fish
West Kirby Creek	3	90	52	0	heavily grazed and downcut, abundant frogs
Kirby Creek	32	79	11	11	heavily silted bottom, few woody plants, abundant frogs

2. 15 SOILS

Soils in the watershed are derived from Cretaceous through Triassic shales and sandstones. Soils have formed in residual deposits and weathered from shale or sandstone bedrock, colluvium, alluvium, aeolian material, and gravel deposits (BLM 1978). Soils are generally shallow in the uplands, ranging in thickness from zero to 20 inches. Soils are high in exchangeable salts, including gypsum, calcium, and sodium. Soils are relatively deep in the bottomlands and consist of mostly clay, clay loam, or silty clay. The soils of the Kirby Creek Watershed are shown in **Figure II-10**. The corresponding reference description can be found in **Appendix B**. More detailed soil descriptions can be obtained from the BLM Worland Office.

Soils in the watershed help determine the class and species of surface vegetation. Soils are highly variable throughout the basin, and vegetation type generally conforms to soil type. For example, black sagebrush (*Artemisia nova*) is found in shallow, gravelly soils, whereas Threetip sagebrush (*Artemisia tripartida*) is found on deep, sandy soils. Both species are found at the same elevation and precipitation zone, however, their growth is dependent on soil texture.

At the time this report was written, there was no published soil survey for Hot Springs County and the Kirby Creek Watershed. Soils data is currently available in unpublished format from the BLM's Worland Field Office. Also, a soils map for Hot Springs County by Jack Iiams (date unknown). This map shows the various soil types that are found within the Kirby Creek Watershed. The base for these maps is a composite of the Thermopolis and Cody sheets of the U.S. Geological Survey 1:250,000 scale topographic map series.

Soils within the Kirby Creek Watershed can be grouped into the following categories based on local climate and topographic position: 1) Soils of Flood Plains, 2) Soils of the Warmest and Dryest Zone, 3) Soils of the Warmest Zone, Intermediate Moisture Status, and 4) Soils of the Intermediate Temperature and Moisture Zone.

Soils of Flood Plains. These soils include the following two groups:

1) Deep, nearly level, strongly to very alkaline, and well to somewhat poorly drained, loamy soils over stream alluvium. These soils include Typic and Ustic Torrifluvents, and Typic and Ustic Torriorthents. Desert shrub vegetation, primarily greasewood (*Sarcobatus vermiculatus*), dominates these soils. These soils are typical of the lower Kirby Creek Watershed.

2) Deep, nearly level, neutral to moderately alkaline, well to somewhat poorly drained loamy and clayey soils over stream and fan alluvium. These soils include Ustic and Aquic Torrifluvents, Aeric and Typic Fluvaquents, Borollic Haplargids, Borollic Calciorthids, and Typic and Argic Cryoborolls. Desert shrub grassland, primarily basin big sagebrush (*Artemisia tridentata* ssp. *tridentata*), dominates these soils. Representative soils include Forelle, Adel, Clayburn, and Burnette. These soils are typical of both the lower and middle Kirby Creek Watershed.

Soils of the Warmest and Dryest Zone. These soils include the following two groups:

1) Deep, nearly level to sloping, moderately to strongly alkaline, well drained, loamy and clayey soils over alluvium, shale, or sandstone. These soils include Typic Torrifluvents,

Typic Torriorthents, and Typic Natrargids. Desert shrub vegetation, primarily saltbush (*Atriplex* spp.) and/or basin big sagebrush, dominates these soils. This group also includes smaller amounts of shallow and moderately deep, sloping, and steep soils. Representative soils include Binton, Effington, Youngston, and Persayo. These soils are typical of the middle and upper Kirby Creek Watershed.

2) Shallow, sloping to steep, moderately alkaline, well drained, loamy soils over sandstone. These soils include Typic Haplargids. Shrub grasslands, including black sagebrush (*Artemisia nova*), Wyoming big sagebrush (*Artemisia tridentata* spp. *wyomingensis*), and juniper (*Juniperus scopulorum*), dominate these soils. These soils are typical of the middle and upper Kirby Creek Watershed.

Soils of the Warmest Zone, Intermediate Moisture Status. These soils include the following four groups:

1) Deep and moderately deep, nearly level to sloping, moderately to very strongly alkaline, well drained loamy soils over alluvial fill or outwash gravel. These soils include Ustic Torriorthents, Ustollic Haplargids, and Ustollic Natrargids. Shrub grasslands, including Wyoming big sagebrush and saltbush, dominate these soils. Representative soils include Kim, Fort Collins, Cushman, and Larimer. These soils are typical of the middle and upper Kirby Creek Watershed.

2) Shallow to deep, gently sloping to steep, moderately to very strongly alkaline, well drained, loamy and clayey soils over shale or sandstone. These soils include Ustic Torriorthents, Ustollic Haplargids, Ustollic Natrargids, and Ustollic Camborthids. Shrub grassland or desert shrub vegetation, primarily saltbush, big sagebrush, or black sagebrush, dominate these soils. Representative soils include Epsie, Cadoma, Shingle, Tassel, Cushman, and Fort Collins.

3) Deep, gently sloping to steep, mildly to moderately alkaline, well drained, loamy and gravelly soils over gravelly deposits. These soils include Ustic Torriorthents and Ustollic Haplargids. Shrub grassland vegetation, primarily black sagebrush and Wyoming big sagebrush, dominates these soils. Representative soils include Nihill and Larimer.

4) Shallow to deep, nearly level to steep, mildly to moderately alkaline, well drained, loamy soils over red shale, sandstone, or gypsiferous shale. These soils include Ustic and Lithic Torriorthents and Ustollic Camborthids. Shrub grassland, primarily big sagebrush, black sagebrush, or juniper, dominates these soils. Representative soils include Spearfish, Neville, Travessilla, Rekop, and Gystrum.

Soils of the Intermediate Temperature and Moisture Zone. These soils include the following group:

1) Shallow to deep, gently sloping to steep, mildly to moderately alkaline, well drained, loamy soils over sandstone or shale. These soils include Ustic Torriorthents, Borollic Haplargids, and Borollic Calciorthids. Shrub grassland vegetation, including low

sagebrush (*Artemisia arbuscula*), Wyoming big sagebrush, and juniper, dominates these soils. Common soil types include Blazon, Diamondville, and Forelle.

2. 16 VEGETATION

The identification and description of vegetation is an important component of the Kirby Creek Level 1 Watershed Assessment. The Kirby Creek upland range vegetation has been aggregated into "cover types" based on current plant assemblages present within the basin Society of Range Management (SRM 1994). These cover types were observed during the 2003 field survey, however, they have not been mapped. Cover types are defined as "the existing vegetation of an area" (SRM 1994).

Cover types are named for the dominant plant species with no more than three species per type. Common names are used in the cover type name, with Latin or scientific names used in the text of the description. In addition, a numbering system was used to designate the geographic location of cover types. For example, plant cover types in the Kirby Creek Watershed were placed into three ecoregions: Northern Rocky Mountains (300 series), Great Basin (400 series), and Northern Great Plains (600 series).

Below is the summary of plant cover types found within the Kirby Creek Watershed. These cover types were observed during the Level 1 watershed assessment and are based on *Rangeland Cover Types of the United States* (SRM 1994).

SRM 302: Bluebunch Wheatgrass - Sandberg Bluegrass.

Description: Bluebunch wheatgrass (*Pseudoroegnaria spicata*) is the dominant plant species of this cover type, with lesser amounts of Sandberg bluegrass (*Poa secunda*) and prairie junegrass (*Koeleria pyramidata*). Needle-and-thread (*Hesperostipa comata*) is often common and co-dominant with bluebunch wheatgrass. Forb composition varies, both in species and cover. Arrowleaf balsamroot (*Balsamorhiza sagittata*) may be abundant, particularly in the spring and on steep, high elevation, south-facing slopes.

Ecology: Soils are derived from shale or sandstone, and are usually loamy to loamy sands, and may be shallow and rocky. They are often susceptible to the effects of overgrazing. Precipitation ranges from 10 to 14 inches per year.

Management: Bluebunch wheatgrass decreases rapidly with excessive grazing. Sandberg bluegrass and arrowleaf balsamroot may either increase or decrease, depending on the grazing animals involved. Fringed sagewort (*Artemisia frigida*) and broom snakeweed (*Gutierrezia sarothrae*) often increase under disturbance. This cover type may eventually become a shrubland through increases in big sagebrush (*Artemisia tridentata*) and rabbitbrush (*Chrysothamnus* spp.). Cheatgrass (*Bromus tectorum*) and knapweeds (*Centaurea* spp.) may increase with continued disturbance and/or excessive grazing.

SRM 303: Bluebunch Wheatgrass - Western Wheatgrass.

Description: This cover type is characterized by a strong dominance of bluebunch wheatgrass, associated with western wheatgrass (*Pascopyrum smithii*), a rhizomatous species, and or thickspike wheatgrass (*Agropyron dasystachyum*). Other key grasses are prairie junegrass, needle-and-thread, and sandberg bluegrass. Forbs are not common, but relatively diverse in composition. They include: Hood's phlox (*Phlox hoodii*), scarlet globemallow (*Sphaeralcea coccinea*), hairy goldenaster (*Chrysopsis villosa*), and salsify (*Tragopogon dubius*). Fringed sagewort and broom snakeweed are often present. On steeper slopes, green needlegrass (*Stipa viridula*) is common.

Ecology: Annual precipitation is 12-14 inches. This cover type is often interspersed with a shrub steppe type dominated by big sagebrush, with a bluebunch and western wheatgrass understory.

Management: Under excessive grazing, bluebunch wheatgrass is replaced by needle-and-thread and rhizomatous wheatgrasses. Other heavy grazing indicator plants include hairy goldenaster, Hood's phlox, fringed sagewort, pricklypear cactus (*Opuntia polyacantha*), and broom snakeweed. Shrub species, such as big sagebrush and rabbitbrush, assume dominance from grazing-induced plant succession.

SRM 304: Idaho Fescue - Bluebunch Wheatgrass.

Description: Idaho fescue (*Festuca idahoensis*) is the dominant plant species in this cover type. Bluebunch wheatgrass is present and is the co-dominant plant. Other wheatgrass species are much less dominant. Associated grasses include prairie junegrass, Sandberg bluegrass, and needlegrasses. Forb composition is both high in species composition and abundance. Woody shrubs are rare except following disturbance.

Ecology: This cover type is common on intermediate slopes and elevations, mostly in the 15 to 19 inch precipitation zone. Soils vary, but usually are deep and well-drained. This cover type provides important habitat for wildlife and forage for domestic livestock.

Management: A green needlegrass phase occurs at high elevations and steep slopes. With excessive grazing, Idaho fescue may replace bluebunch wheatgrass. Red three-awn (*Aristida longiseta*), bluegrasses, fringed sagewort, and other forbs may replace Idaho fescue with heavy grazing.

SRM 309: Idaho Fescue – Western Wheatgrass.

Description: Idaho fescue is the dominant grass in this cover type. Rhizomatous wheatgrasses, such as thickspike and western wheatgrass, are subdominant. Rough fescue (*Festuca scabrella*) and bluebunch wheatgrass is rare or absent. Sandberg bluegrass may increase in cover, particularly on disturbed sites. Forbs and shrubs are a minor component of this cover type.

Ecology: This cover type is found on relatively dry sites. Precipitation ranges from 10 to 14 inches per year. Soils are derived from shale or sandstone. Since co-dominant grasses are mostly rhizomatous, bare soil is common.

Management: This cover type is relatively uniform in species composition and cover. On overgrazed sites, Idaho fescue is replaced by rhizomatous wheatgrasses. Wheatgrasses may eventually succumb to increaser species such as cheatgrass, Sandberg bluegrass, western yarrow, and fringed sagewort.

SRM 313: Tufted Hairgrass – Sedge.

Description: This cover type is found in, adjacent to, or within riparian habitat. The dominant species of this cover type is tufted hairgrass (*Deschampsia caespitosa*). Various sedges (*Carex* spp.) are almost always found with tufted hairgrass. Bentgrasses (*Agrostis* spp.) and rushes (*Juncus* spp.) are also common. Wheatgrasses, fescues, forbs, and shrubs are uncommon.

Ecology: The primary ecological influence on this cover type is the intermittent or semi-permanent presence of a high water table during some or all of the growing season. Soils are deep and moisture-rich, however, are often high in salts, which limits plant growth and species composition.

Management: Excessive grazing causes tufted hairgrass to decline, being replaced by sedges, rushes, Kentucky bluegrass (*Poa pratensis*), dandelion (*Taraxacum officianale*), and redtop (*Agrostis gigantea*).

SRM 314: Big Sagebrush – Bluebunch Wheatgrass.

Description: This cover type is dominated equally by big sagebrush and bluebunch wheatgrass. This type is one of the most common in the Kirby Creek Watershed. Three subspecies of sagebrush may be found, including: Wyoming big sagebrush (*Artemisia tridentata* ssp. *wyomingensis*), mountain big sagebrush (*A .tridentata* ssp. *vaseyana*) and Basin big sagebrush (*A. tridentata* ssp. *tridentata*). The latter is found in deep soils of swales or drainages.

Ecology: This cover type usually exists within the 12 to 16 inch precipitation zone at higher elevations. This type is located on shallow to moderately deep soils derived from shale and sandstone.

Management: Under excessive grazing, shrubs will increase. Associated shrubs include rabbitbrush, fringed sagewort, broom snakeweed, and gray horsebrush (*Tetradymia canescens*). Other increaser plants include prairie junegrass, Sandberg bluegrass, needle-and-thread, and blue grama (*Bouteloua gracilis*). Arrowleaf balsamroot and western yarrow is the most common forb in this cover type. Bluebunch wheatgrass is highly susceptible to excessive grazing.

SRM 315: Big Sagebrush – Idaho Fescue.

Description: Mountain big sagebrush and Idaho fescue dominate this cover type. Wyoming big sagebrush is also common at lower elevations. Bluebunch wheatgrass and prairie junegrass are often associated with Idaho fescue. Forbs are common, especially on wetter microsites. Other plants include prairie smoke (*Geum triflorum*), rubber rabbitbrush, green rabbitbrush, and fringed sagewort.

Ecology: This cover type is located in the 16 inch or greater annual precipitation zone. Soils are well-developed and deep. This type is located on steep slopes and higher elevations.

Management: This cover type is particularly susceptible to overgrazing. Excessive grazing will cause an increase in big sagebrush, green rabbitbrush, prairie smoke, and western yarrow. Sandberg bluegrass, slender wheatgrass, and green needlegrass may increase as well.

SRM 320: Black Sagebrush – Bluebunch Wheatgrass.

Description: The primary plant species of this cover type is black sagebrush (*Artemisia nova*). Bluebunch wheatgrass is very common and grows in the interspaces. Other common understory species include prairie junegrass and Sandberg bluegrass. Forbs are not common in this cover type. Big sagebrush may be common in the deeper soils of swales and drainages.

Ecology: The total annual precipitation of this cover type is generally less than 12 inches. Soils are dry and rocky, with large amounts of bare soil and limestone rock outcrops. This type is more common on steep hillslopes.

Management: With excessive grazing, bluebunch wheatgrass may decrease dramatically. Other species that may decrease with grazing include Indian ricegrass (*Oryzopsis hymenoides*), winterfat (*Krascheninnikovia lanata*), needle-and-thread, and prairie junegrass. Excessive sheep grazing may cause a decline in black sagebrush cover. Needle-and-thread may dominate in sandier soils. Broom snakeweed and fringed sagewort may increase as well.

SRM 324: Threetip Sagebrush – Idaho Fescue.

Description: The dominant plants of this cover type include threetip sagebrush (*Artemisia tripartida*) and Idaho fescue. Finged sagewort, green rabbitbrush (*Chrysothamnus vicidiflorus*), and gray horsebrush are common. Other grasses include prairie junegrass and plains reedgrass (*Calamagrostis montanensis*). Hood's phlox, rose pussytoes (*Antennaria rosea*), and silky lupine (*Lupinus sericeus*) are the dominant forbs.

Ecology: This cover type lies in the 10 to 14 inch precipitation zone. Soils are shallow and rocky, however bare soil is uncommon.

Management: The number of grasses in this type is higher than in the big sagebrush – Idaho fescue cover type. Excessive grazing usually causes an increase in threetip sagebrush, green rabbitbrush, gray horsebrush, broom snakeweed, and fringed sagewort. Idaho fescue will decrease with an increase in grazing disturbance. Forbs may totally dominate the site with continued, excessive grazing.

SRM 401: Basin Sagebrush.

Description: The dominant overstory of this cover type is basin big sagebrush. Basin big sagebrush is very tall, often growing more than 40 inches high. The understory consists of a variety of forbs and perennial grasses. Sagebrush is often accompanied by smaller amounts of rubber and green rabbitbrush, antelope bitterbrush (*Purshia tridentata*), and gray horsebrush. Dominant grasses include bluebunch wheatgrass, Sandberg bluegrass, Idaho fescue, bottlebrush squirreltail (*Elymus hystrix*), needle-and-thread, and western wheatgrass. Cheatgrass may be dense in some areas. Common forbs include western yarrow, rose pussytoes, milkvetch (*Astragalus* spp.), arrowleaf balsamroot, hawksbeard (*Crepis acuminata*), and lupine (*Lupinus* spp).

Ecology: This cover type occurs in areas of very low precipitation, usually in the 8 to 10 inch range, and on deep, well-drained soils. Soils of this type are often saline. Soil water storage aids big sagebrush growth. This sagebrush type may also be found adjacent to Wyoming big sagebrush and mountain big sagebrush.

Management: Since this cover type is located in low-lying areas, it is particularly susceptible to the influences of overgrazing. Excessive grazing may completely eliminate the grass component, and often opens the site for the invasion of cheatgrass and greasewood (*Sarcobatus vermiculatus*).

This cover type is particularly susceptible to fire. Competition from cheatgrass, greasewood, and other invasive plants makes reclamation of these sites with native plants difficult.

SRM 402: Mountain Big Sagebrush.

Description: This cover type is dominated by mountain big sagebrush and by a well-developed understory of forbs and perennial grasses. Antelope bitterbrush, green rabbitbrush, and gray horsebrush are also common. Mountain snowberry (*Symphoricarpos albus*) is common on moist sites. The principal grasses include Idaho fescue, bluebunch wheatgrass, Sandberg bluegrass, prairie junegrass, and western wheatgrass. Dominant forbs include western yarrow, milkvetch, arrowleaf balsamroot, hawksbeard, buckwheat (*Eriogonum* spp.), biscuitroot (*Lomatium* spp.), silky lupine, phlox (*Phlox* spp.), and groundsel (*Senecio* spp.).

Ecology: This is the wettest of the big sagebrush types, occurring at higher elevations with a mean annual precipitation of 14 to 18 inches. Soils are moderately deep, well-drained, and coarse. This type occurs at the upper end of the sagebrush growth zone, often bordering taller shrubs or forest vegetation. On sites of variable soil depth, mountain big sagebrush is often found with low sagebrush (*Artemisia arbuscula*).

Management: Palatable grasses and forbs will decrease rapidly with excessive grazing, while sagebrush becomes more dense. Cheatgrass may dominate disturbed sites, but not to the extent of dryer sites. Mountain big sagebrush reestablishes from seed quickly from fire. Green rabbitbrush and gray horsebrush, both sprouters, increase with repeated burning. This cover type is particularly susceptible to erosion, since steep and rugged topography is common, particularly at higher elevations.

SRM 403: Wyoming Big Sagebrush

Description: This cover type is characterized by the prevalence of Wyoming big sagebrush, with an understory of perennial grasses and forbs. Shrub height is relatively low (16 to 22 inches) and shrub cover ranges from 13 to 18 percent. Green rabbitbrush may be co-dominant with sagebrush. Understory species include bluebunch wheatgrass, Sandberg bluegrass, bottlebrush squirreltail, green needlegrass, needle-and-thread, Indian ricegrass, and western wheatgrass. Forbs include milkvetch, pussytoes, aster (*Aster* spp.), phlox, and fleabanes (*Erigeron* spp.). Arrowleaf balsamroot, hawksbeard, and lupine are common in the wetter portions of this cover type. Prickly pear cactus and globe mallow (*Sphaeralcea* spp.) occur on the dryer sites.

Ecology: This is the driest of the big sagebrush cover types, often occurring on sites that receive less than 10 inches of annual precipitation. Soils are moderate to shallow in depth, low in organic matter, and rocky. On this cover type's xeric edge, black sagebrush or saltbush (*Atriplex* spp.) dominates. At higher and wetter elevations, this cover types merges with mountain big sagebrush.

Management: With excessive grazing, palatable grasses and forbs decline rapidly. Continued heavy grazing generally results in increased shrub density and longevity, a sparse herbaceous layer, consisting of Sandberg bluegrass and annuals such as cheatgrass, and higher rates of soil erosion. If fire is present, the sagebrush will quickly be killed, and the site may become dominated by cheatgrass. Cheatgrass, an annual grass, is highly flammable and is perpetuated by fire unless revegetation with perennial grasses occurs. Bottlebrush squirreltail may naturally reseed and is often found on previously burned sites.

SRM 404: Threetip Sagebrush.

Description: This cover type is characterized by the dominance of threetip sagebrush and a well-developed grass and forb component. Threetip sagebrush is low is stature (rarely exceeds 12 inches) and is usually shorter than surrounding bunchgrasses. In the Kirby Creek area, this species is found as the subspecies *Artemisia tridentata* ssp. *rupicola*, and is generally confined to thin, sandy soils. Surrounding herbaceous cover is sparse. Ground cover is high in litter and bare ground and low is surface rock. Green rabbitbrush and gray horsebrush are also common. Grasses include Idaho fescue, bluebunch wheatgrass, Sandberg bluegrass, prairie junegrass, needle-and-thread, green needlegrass, and western wheatgrass. The presence of Kentucky bluegrass indicates relatively mesic conditions. Perennial forbs include pussytoes, milkvetch, Indian paintbrush (*Castilleja angustifolia*), hawksbeard, fleabane, biscuitroot, lupine, various phloxes, and death camas (*Zigadenus venenosus*).

Ecology: This cover type is found at relatively high elevations with an annual precipitation of 12 to 16 inches. It prefers cool and moderately moist sites. Edaphic (soil-related) factors play an important role in the distribution of this cover type. Threetip sagebrush prefers sites similar to those occupied by mountain or basin big sagebrush, but on shallower and sandy soils.

Management: Threetip sagebrush sprouts from shallow lateral roots. Thus, this shrub regenerates rapidly following fire or other disturbances. With excessive grazing, shrub density may increase considerably and desirable perennial grasses and forbs are replaced by annuals and less palatable forbs.

SRM 405: Black Sagebrush.

Description: This cover type is characterized by the dominance of black sagebrush (*Artemisia nova*), with a herbaceous layer of grasses and forbs in the interspaces. Black sagebrush is low in height (less than 12 inches). Percent bare ground is very high (up to 70 percent) and litter is sparse. Green rabbitbrush, winterfat, and buckwheat (*Eriogonum* spp.) are the co-dominant plants. Bluebunch wheatgrass is the most common grass, and Sandberg bluegrass, bottlebrush squirreltail, Indian ricegrass, needle-and-thread, green needlegrass, and Idaho fescue are also present. Forbs likely to occur are milkvetch, Indian paintbrush, fleabane, lomatium (*Lomatium* spp.), phlox, prickly pear, and hawksbeard.

Ecology: This cover type occurs at middle to high elevations with an annual precipitation of 8 to 10 inches. This cover type overlaps the precipitation and elevation range of big sagebrush, however, its occurrence is primarily due to edaphic factors. Black sagebrush typically grows on poorly developed, low moisture, and coarse soils. On fine-grained soils, black sagebrush often merges with threetip, Wyoming or basin big sagebrush. On coarse, xeric soils, black sagebrush merges with saltbush cover types. Black sagebrush is morphologically similar to low sagebrush. Often the two species are difficult to distinguish.

Management: Continued heavy grazing may reduce the grass and forb component, particularly Idaho fescue and bluebunch wheatgrass. Sandberg bluegrass is unaffected, and may dominate the forb layer. Black sagebrush is particularly susceptible to sheep grazing, however, is not affected by cattle or deer. Fire is uncommon in this cover type due to low quantities of fuel. Cheatgrass is not as common here as in other sagebrush types.

SRM 414: Salt Desert Shrub.

Description: This cover type is common in lower Kirby Creek and is dominated by Shadscale saltbush (*Atriplex confertifolia*), four-wing saltbush (*Atriplex canascens*), greasewood, winterfat, and halogeton (*Halogeton glomeratus*). Natural vegetative cover is extremely low (less than 10 percent). Grasses include Indian ricegrass, saltgrass (*Distichlis spicatum*), squirreltail, alkali sacaton (*Sporobolus airoides*), and great basin wildrye (*Elymus cinereus*). Forbs are inconspicuous. They include globe mallow, halogeton, and Russian thistle (*Salsola kali*). Cheatgrass may be common in some areas.

Ecology: The salt desert shrub type is commonly found in low laying areas, such as alluvial terraces, playas, and salt flats. Soils are water stressed and root penetration may not occur below saline soil layers. On sites where the water table reaches the soil surface, salinity will generally decrease with depth. Annual precipitation is generally less than 8 inches.

The soils on which this cover type is found are unique. They are generally soils with natric (high sodium) properties. Natric soils are characterized by the following two features: 1) the existence of a dense columnar structure forming the B2 horizon, and 2) the presence of "slickspots" or "panspots" on the soil surface. These soils contain no A horizon. Slickspots are common throughout the watershed and may help to identify SRM 414. The spots are sparsely vegetated and are shallow pits from a couple of inches to a foot deep, ranging in area from a few to 100 square feet.

Management: This cover type is particularly susceptible to the effects of grazing because of the high percentage of bare ground, low ratio of palatable herbaceous plants versus shrubs, and prevalence of cheatgrass and invader plants. Kochia (*Kochia americana*), cheatgrass, and halogeton will increase with excessive grazing. A high salt content limits plant growth and reduces overall plant species composition. This is the dominant cover type in the lower portion of the basin. Livestock forage quantity and quality in this area is poor.

SRM 422: Riparian.

Description: This is a very broad cover type that includes all vegetation located adjacent to lentic (still water) and lotic (moving water) water bodies. It also includes sites where water is present in the upper soil layers, at least for part of the growing season. These may include playas, stock ponds, reservoirs, or irrigation canals. Predominance of moisture in the upper soil layers results in the growth of hydrophytic plants. This cover type represents only a small portion of the Kirby Creek Watershed, however, is more productive in terms of both plant and animal species' diversity and biomass than adjacent uplands.

Dominant grass genera of this cover type include *Calamagrostis*, *Glycera*, *Poa*, *Phalaris*, and *Distichlis* species. Grass-like graminoids include members of the genera *Carex*, *Juncus*, *Eleocharis*, and *Scirpus*. Typical woody plant genera include *Picea*, *Abies*, *Populus*, *Alnus*, *Betula*, and *Acer*.

Ecology: The riparian cover type covers less than 5 percent of the total land area of the Kirby Creek Watershed. In the steep country of the upper watershed, riparian habitat is confined to the bottoms of canyons and drainages, while on the gentle, lower terrain of lower Kirby Creek riparian vegetation is more extensive.

The cover and growth of riparian vegetation depends on the balance between the soil, water, and vegetation resources. On high gradient stretches (>3 to 4%), rocks, boulders, and/or large trees slow moving water. On shallow gradients (<5%), deep-rooted grasses, sedges, and rushes buffer high-flow events and help protect streambanks from erosion.

Many drainages within the Kirby Creek Watershed are intermittent or ephemeral. Intermittent streams flow typically during spring runoff. Ephemeral streams are streams where surface water flows only after precipitation events. It is difficult to determine the status of drainages that only flow for part of the year. The drainage is normally not considered riparian if the soils do not show the presence of persistent water and the vegetation is not significantly different from the surrounding upland plant community.

Management: This cover type is highly susceptible to the influences of excessive grazing and other activities. Grazing animals prefer riparian areas due to the presence of water, lush forage, and shade. Any activity that compacts the soil, removes stabilizing plants, or alters the channel gradient may cause stream downcutting, a lower water table, and a loss of riparian vegetation.

SRM 607: Wheatgrass – Needlegrass.

Description: This cover type is common throughout the entire Kirby Creek Watershed. It consists of a mid- and short-grass component, where the mid-grass component dominates in cover and aerial extent. Dominant grasses include western wheatgrass, thickspike wheatgrass, needle-and-thread, green needlegrass, prairie junegrass, and plains reedgrass (*Calamagrostis montanensis*). Other less-dominant grasses include prairie sandreed (*Calamovilfa longifolia*) and purple threeawn (*Aristida purpurea*). The primary shortgrasses include blue grama, Sandberg bluegrass, and buffalograss (*Buchloe dactyloides*). Sandberg bluegrass and blue grama are very common, while buffalograss is inconspicuous over much of the range. Needleleaf sedge (*Carex eleocharis*) and threadleaf sedge (*Carex filifolia*) can be found as well.

Forbs are common and species composition is similar to adjacent cover types. They include fringed sage, golden aster (*Chrysopsis villosa*), scurf-pea (*Cullen* spp.), globemallow, locoweeds (*Oxytropis* spp.), wild onion (*Allium textile*), and prickly pear. Common shrubs include big sagebrush, green rabbitbrush, and broom snakeweed.

Ecology: This cover type exists in the 11 to 16 inch annual precipitation range. The dominant topography ranges from flat to rolling and is generally not found on very steep slopes. Soils are medium in texture and areas of saline and alkaline soils are common. Big sagebrush may dominate in some parts of this cover type converting it to a sagebrush-grass type.

Management: Under excessive grazing the mixed-grass component may become sub-dominant to the short-grass component. This cover type provides abundant forage for both domestic livestock and wildlife.

SRM 608: Wheatgrass - Grama – Needlegrass.

Description: This cover type is similar to SRM 608, except the shortgrass component, primarily blue grama, is more common. This type is abundant throughout the uplands of lower Kirby Creek. On many sites, the shortgrass component, consisting of blue grama, Sandberg bluegrass, threadleaf sedge, and buffalograss, becomes dominant. On particularly dry sites, the mid-grasses are significantly reduced in cover.

The major forbs in this cover type include prickly pear, fringed sage, pussytoes (*Antennaria* spp.), scurf pea (*Cullen* spp.), milkvetch, globemallow, wild onion, golden aster, broom snakeweed (a sub-shrub), curly-cup gumweed (*Grindelia squarrosa*), western yarrow, phlox, cinquefoils (*Potentilla* spp.), goldenrods (S*olidago* spp.), and skeletonweed.

Ecology: This cover type is found in the 11 to 15 inches per year precipitation zone. Precipitation falls in the spring and early summer and by mid-July vegetation growth has slowed and grasses become cured. Soils are mixed in texture, well drained, and have moderate profile development. Saline soils occur throughout this cover type and support salt tolerant species such as inland saltgrass and shadscale saltbush.

Management: Blue grama and buffalograss will increase with excessive grazing. Sagebrush may increase in cover as well, reducing herbaceous plant growth and subsequent forage production. Cheatgrass and/or Japanese brome (*Bromus japonicus*), if present, may dominate deteriorated range sites.

SRM 609: Wheatgrass – Grama

Description: This cover type is common throughout the Kirby Creek Watershed and consists of a mixed grass type with an overstory of western wheatgrass and green needlegrass and an understory of blue grama, buffalograss, and dryland sedges. Thickspike wheatgrass, needle-and-thread, and purple threeawn are common as well.

This cover type is more common throughout the northwestern Great Plains, but is found at low- to mid-elevations in the Kirby Creek area. It is associated with heavy soils derived from the clayey and silty Cody shale formation. This cover type is found on long and gradual exposures with gentle to steep slopes intersected by badland formations.

Common forbs include fringed sage, prickly pear, globemallow, scurf-peas, prairie vetch (*Vicia americana*), purple coneflower (*Echinacea angustifolia*), wild onion, wild parsley, and curly cup gumweed. Silver sagebrush (*Artemisia cana*) is the most common shrub.

Ecology: Precipitation ranges from 12 to 16 inches per year. In the Kirby Creek area, this type is most commonly found on fine-textured soils derived from cretaceous shales. Cover types SRM 607 and 608 are variants of this type and intermix on many sites.

Management: Blue grama and buffalograss will increase with excessive grazing. Sagebrush may increase in cover as well, reducing herbaceous plant growth and subsequent forage production. Cheatgrass and/or Japanese brome (*Bromus japonicus*), if present, may dominate deteriorated range sites.

SRM 610: Wheatgrass

Description: This cover type is dominated by western wheatgrass and occurs as a sub-type to SRM 607, 608, and 609. It is composed primarily of western wheatgrass, with lesser amounts of green needlegrass, and sandberg bluegrass. The shortgrass component, primarily blue grama and sedge, is nearly absent.

Common plants within this cover type include thickspike wheatgrass, bluebunch wheatgrass, wild onion, wild parsley, scarlet globemallow, prairie vetch, golden pea, western yarrow, and prickly pear.

Ecology: This cover type is generally restricted to clay soils underlain by Cody shale. Most of the land area of this type is native grass because the extremely dense nature of the soil makes it unsuitable for cultivation. This cover type is restricted to clay soils due to the swelling and shrinking of the soils. This limits the growth of the fine roots of blue grama and sedge.

Management: This cover type provides ample forage for wildlife and livestock and is relatively resistant to moderate grazing levels. Western wheatgrass will decline with excessive grazing and sandberg bluegrass may dominate. Shortgrasses will generally not increase due to soil limitations.

SRM 614: Crested Wheatgrass

Description: Crested wheatgrass (*Agropyron cristatum*), as a cover type within the Kirby Creek watershed, came into existence during the 1930s when large areas of abandoned cropland were seeded to this grass. It is unknown how many acres within the watershed were originally reseeded to this species, but many dense stands can be found in the lower portion of the drainage. Crested wheatgrass is native to Russia and is relative hardy, allowing it to persist over time without reseeding.

This plant is a cool-season, perennial bunchgrass of moderate height, which produces an abundance of tough and wiry stems at maturity. Dense, comb-like seed heads appear to be "crested", hence the plant's common name. The grasses' resilience and longevity along with its high drought and cold tolerance have allowed this plant to be common throughout Wyoming and the Kirby Creek watershed. Crested wheatgrass also maintains primary dominance when grasses, forbs, and shrubs invade. Other plants that are subdominant to crested wheatgrass include Sandberg bluegrass, western wheatgrass, scarlet globemallow, wild buckwheat, fringed sage, and curly-cup gumweed.

Ecology: Crested wheatgrass is primarily found on dry, upland soils in areas with annual precipitation ranging from 9 to 15 inches. This cover type is found on a variety of soil types, but grows best on medium textured soils, such as sandy loams and clay loams. It is not found on coarse, gravelly or sandy soils and its growth is restricted on heavy clays.

Management: This cover type is extremely resistant to grazing. Research has shown that long-term grazing of crested wheatgrass does not reduce the plant's longevity. Many of the stands seeded in the 1930s may persist indefinitely.

SRM 615: Wheatgrass – Saltgrass – Grama

This cover type is found on upland saline-alkali soils throughout the major drainages of the Kirby Creek watershed. It typically occupies lowland bottoms, salt flats, and playas. The distinguishing plant of this cover type is inland saltgrass (*Distichlis spicata*). Other grasses include alkali sacaton, redtop, blue grama, thickspike wheatgrass, western wheatgrass, sandberg bluegrass, Kentucky bluegrass, green needlegrass, bottlebrush squirreltail, basin wildrye, prairie junegrass, cordgrass (*Spartina pectinata*), and tumblegrass (*Schedonnardus paniculatus*). Sedges include needleleaf sedge, threadleaf sedge, and penn sedge (*Carex pensylvanica*). Common shrubs include basin big sagebrush, silver sagebrush, saltbush, shadscale, rabbitbrush, and greasewood. Common forbs include globemallow, poverty weed (*Iva axillaris*), curly-cup gumweed, wild buckwheat, white aster (*Aster ericoides*), wild onion, scurf-peas, and prickly pear.

Ecology: The soils on which this cover type is found are unique. They are generally soils with natric (high sodium) properties. Natric soils are characterized by the following two features: 1) the existence of a dense columnar structure forming the B2 horizon, and 2) the presence of "slickspots" or "panspots" on the soil surface. These soils contain no A horizon. Slickspots are common throughout the watershed and may help to identify SRM 615. The spots are sparsely vegetated and are shallow pits from a couple of inches to a foot deep, ranging in area from a few to 100 square feet.

The upper soil layers are fine-textured, and the saline-alkali complex is usually associated with clay soils. Since sodium concentrations and soil conditions are highly irregular, vegetative cover may be extremely variable over any given site.

Management: Since this cover type often lies adjacent to riparian or wetland areas, they may be more susceptible to the influences of cattle, which tend to congregate in such areas. "Pucks" or "hummocks" are commonly found, which result from livestock hoof action and trampling of the moist, clay-rich soils. The forage production of this cover type is limited by the high salt content of the soil; therefore, grazing value is low. Soil erosion may be problematic on this cover type due to steep banks and poorly developed sodium-rich soils with little or no structure.

3.0 UPLAND RANGE AND RIPARIAN METHODOLOGY

3.1 INTRODUCTION

By examining the vegetation, soils, geomorphology, and climate of the Kirby Creek Watershed, the Kirby Creek CRM can target and better understand the sources of degradation. The purpose of the inventory portion of the Level I Watershed Assessment was to describe, characterize, and quantify upland and riparian vegetation through the systematic acquisition and analysis of field data. This chapter presents the techniques used to complete the 2003 assessment.

As might be expected, data for many different vegetation and stream attributes can be collected. Inventories are used not only for mapping and describing the watershed as a whole, but also for determining the status of specific sites within the watershed, assessing the distribution and abundance of native, introduced, and invasive plants, active sediment, and establishing baseline data for future monitoring and trend studies.

Vegetation attributes are quantitative features or characteristics of vegetation that describe how many, how much, or what kinds of plant species are present. An interagency steering committee formed from the BLM, Game and Fish, Kirby Creek CRM, and consultants determined what attributes would be studied, and how the data would be collected. The attributes examined with this study include:

Native Plant Cover	Functional Groups
Litter Amount	Invasive Plant Cover
Bare Ground	Lichen Cover

3.2 WATERSHED ASSESSMENT

A watershed assessment is a process or methodology for examining how well a watershed maintains desired functions, such as proper water flow, minimal soil erosion, and ample wildlife habitat. This is a complex process and involves steps for identifying erosion and grazing issues, examining the history of the watershed, describing its primary features (abiotic and biotic), and evaluating the key resources within the watershed.

The fundamental goal of conducting a watershed assessment is to characterize a basin in such a way as to be able to identify the primary cause of degradation. A concern with the Kirby Creek Watershed is soil erosion. In order to determine where soil erosion exists and what is causing it, the watershed as a whole must be examined for its abiotic and biotic attributes. This assessment will help the Kirby Creek (CRM) group determine which of these attributes meets their goals and objectives.

The objective of this Section is to examine the biotic aspects of the Kirby Creek Watershed, chiefly upland rangeland vegetation and riparian vegetation. Abiotic aspects, such as basin geomorphology, soils, and climate, are described as well. Both abiotic and biotic aspects need to be examined in order to determine their effect on soil erosion within the watershed.

3.3 KEY AREAS

Proper selection of data collection points is critical to the success of a monitoring program. Errors in making these selections can result in irrelevant data and inappropriate management decisions.

The inventory methods outlined below were used to collect the data necessary to adequately characterize and describe the upland range and riparian condition of the Kirby Creek Watershed. The methods were carefully selected by the Coordinated Resource Management (CRM) technical committee in June 2003.

Ninety-four (94) upland range and seventy-two (72) riparian points were located in *key areas* of the Kirby Creek Watershed. Key areas are indicator areas that reflect what is happening on a larger scale as a result of on-the-ground management actions. A key area should be a representative sample of a large stratum, such as a pasture, grazing allotment, wildlife habitat area, area of reseeding, etc.

The following criteria were considered in selecting key areas within the Kirby Creek Watershed:

- Representative of the entire management unit in which it is located.
- Located within a single ecological site and plant community.
- Contained the key plant species of interest.
- Capable of and likely to show a response to management actions.

Some of the site characteristics and other information that were considered in the selection of key areas were:

- Soil Type
- Vegetation (kinds and distribution of plants)
- Ecological sites
- Seral stage
- Topography
- Location of water, fences, and natural barriers
- Size of pasture
- Kind and/or class of forage animals – livestock and wildlife
- Habits of the grazing animals, including foraging behavior and distribution
- Areas of animal concentration
- Location and extent of critical areas

- Sources of erosion
- Threatened, endangered, and sensitive plant species
- Period of animal use
- Grazing history
- Location of salt, mineral, or protein supplements
- Location of livestock or wildlife trails and access routes

A Note on Critical Areas
Critical areas are areas that should be evaluated separately from the remainder of a management unit because they contain special or unique values. Critical areas could include soils susceptible to erosion, sage grouse nesting grounds, riparian areas, unstable stream segments, etc. Critical areas were *not* examined in this assessment.

A Note on Reference Areas
Reference areas are rangelands where natural, biological, and physical processes are functioning normally. Reference areas serve as benchmarks for comparing management actions on rangelands. References areas are *not* key areas. Reference areas differ from key areas in that they represent rangelands where impacts are minimal. Reference areas are found in grazing exclosures, natural areas, or areas that receive minimal grazing impacts. Reference areas may or may not be better ecologically than areas that receive livestock grazing. Reference areas were not used as part of this assessment.

3.4 PERMANENT MONITORING POINTS

The key feature of this study was the installation of permanent monitoring points. These points are shown in **Figure III-1**. A *transect* approach was used to inventory the upland range and riparian points. Transects were established by stretching a meter tape between two, permanent wooden stakes labeled “A” and “B”, respectively. Stake “A” was located at the pre-selected point. Eighteen-inch wooden stakes were hammered into the ground at each point and GPS coordinates were recorded so that they could be located for future range monitoring studies.

The wooden stakes were labeled to be easily identified. Stakes were labeled by project (“K1” for Kirby Creek Level 1 assessment), point type (“U” for upland or “R” for riparian, point number (001), and point location (“A” or “B”). An example point would be recorded as “K1R001A”. Upland range transects were aligned south (point “A”) to north (point “B”). Riparian transects were aligned perpendicular to the stream.

3.5 ASSESSMENT METHODS

For each data type, three inventory methods were used. These are outlined below:

1. Upland Rangeland
    a. Rangeland Health Survey
    b. Vegetation Transects
    c. Digital Photographs

2. Riparian
    a. Proper Functioning Condition (PFC) Survey
    b. Riparian Transects
    c. Digital Photographs

3.6 UPLAND RANGE

Ninety-four (94) upland rangeland points (including rangeland health, vegetation transects, and digital photographs) were located on *key sites* throughout the watershed. Points were located on all types of ownership (i.e. private, state, BLM), rangeland cover types, and topography. Most points can be driven to, either via two-track roads or cross-country, and located via GPS coordinates.

A diversity of points was chosen so that the entire watershed could be represented. These points serve two purposes. First, they provide a "snapshot" of current conditions. Current conditions may be related to recent weather, current grazing management, or historical influences (i.e. tillage, irrigation, or seeding). The upland rangeland data is not intended to indicate vegetation trend (i.e. whether or not the plant community is moving towards or away from a desired condition).

Rangeland Health

This approach is a qualitative assessment which provides a preliminary evaluation of soil/site stability, hydrologic function, and integrity of the biologic community on upland range sites. Rangeland health data should assist the BLM and landowners identify areas that are at potential risk of degradation, provide early warnings of potential problems, and identify management opportunities. This procedure is repeatable and can be used by both the BLM and landowners.

Typically, rangeland health assessments are completed by comparing the area of interest to a reference ecological site. This project was unique in that rangeland health data were collected for the entire watershed. As such, it was not possible to use a reference site within the watershed for comparison. Since reference ecological sites in surrounding watersheds (i.e., Lake Creek, Nowood River) were substantially different than those in the Kirby Creek drainage, they could not be used as comparison sites. As such, the rangeland health surveys in the Kirby Creek Watershed were completed by estimating what the theoretical reference site would be. Although this technique differs from that used by the BLM and is very subjective, it was the most efficient and accurate method to collect a large volume of data within a single watershed.

Location: Key Areas, BLM and Private
Number: 94 Points
Inventory Method: BLM Field Checksheet
Data Collected: Soil/Site Stability,
    Hydrologic Function, Biotic
    Integrity (For further information on these three attributes, see
    http://www.blm.gov/nstc/library/pdf/1734-6.pdf

Vegetation Transects

Ground cover classes were assessed at one meter-intervals along 100-meter transects stretched between points "A" and "B". The same transects were used for the rangeland health surveys. Cover classes include the following nine categories: warm season grass, cool season grass, weed, woody, forb, soil, lichen, rock, and litter.

Location: Key Areas, BLM and Private
Number: 94 Points
Inventory Method: Field Checksheet
Data Collected: Cover type – 9 classes

Digital Photographs

Digital photographs were taken looking north down the transect line from point "A" at each rangeland health survey and vegetation transect. Photographs provided a visual site characterization. They may also be used as permanent photopoints to furnish visual evidence of vegetation and soil changes over time.

Location: Key Areas on BLM and Private
Collection Method: Digital Camera
Data Collected: Visual Appraisal

3.7 RIPARIAN

Seventy-two (72) riparian monitoring points (including PFC, riparian transects, and digital photographs) were located on key stream segments throughout the watershed. Points were located on all types of ownership (i.e. private, state, and BLM), riparian habitat types, and topography. Most points can be driven to, either via two-track roads or cross-country, and located via GPS coordinates.

Riparian points were located on each major tributary to Kirby Creek. Many points were located on dry, ephemeral drainages to monitor the presence or absence of riparian vegetation where the water table is low or absent. Many of the points coincide with the BLM's Riparian/Aquatic Information Data Summary (RAIDS) segments where previous PVC assessments have occurred. In addition, key points are also in close proximity to water quality monitoring points established from the recent Kirby Creek 205(j) study (Hurley, 2003).

Proper Functioning Condition

(adopted from BLM Technical Report 1737-15)

Proper Functioning Condition (PFC) is a riparian inventory method developed and used by the BLM for qualitatively assessing the condition of riparian-wetland areas. Hydrologic, vegetative, and erosional attributes are examined. The term PFC is used for both the assessment process and the condition of a riparian-wetland area.

A checklist was used for the PFC assessment which synthesizes information in determining the overall health of a riparian-wetland system. Yes, no, or N/A categories are marked on the checklist for various hydrology, vegetation, and erosion/deposition attributes.

Location: Riparian Key Areas – BLM and
Private
Number: 72 Points
Collection Method: Field Checksheet
Data Collected: Qualitative assessment of
hydrology, vegetation, erosion

Riparian Transect

(adopted from RMRS-GTR-47)
Each riparian complex is usually composed of a mix of stands of six to 12 plant community types. This procedure is designed to quantify the percent of each community type in a particular complex. Collection of future data may be used to indicate how much change has occurred in a particular complex or how closely the cover types in that area represents a desired condition.

For this procedure, a transect was established perpendicular to the stream grade in a riparian complex. The entire riparian area was crossed, upland to upland. The length of the transect varied depending on the distance from upland to upland. Seventy-two points were located and named with wooden stakes, similar to the upland range methodology. Points were objectively located in key stream reaches throughout the watershed. Cover type composition was obtained by taking the linear distance, in meters, encountered for each type (upland shrub, wet meadow grass, sedge-rush, willow, cottonwood, upland soil, bank, rock, and water) and dividing that by the total length of the transect. PFC was examined at the same location.

Location: Riparian Key Areas –
BLM/Private
Number: 72 Points
Collection Method: Field Checksheet
Data Collected: Cover type – 9 classes

Digital Photographs

Digital photographs were taken parallel to each riparian transect. In cases where the channel was deeply incised, a downstream photo was taken perpendicular to the transect. Photographs were taken to provide a visual site characterization. They may also be used as permanent photopoints to furnish visual evidence of riparian vegetation and stream morphology changes over time.

Location: Key Areas on BLM and Private
Collection Method: Digital Camera
Data Collected: Visual Appraisal

4.0 FIELD SURVEY RESULTS AND DISCUSSION

4.1 SUMMARY

Upland Rangeland

The upland rangeland surveys were completed from July to September 2003. Rangeland health and vegetation transect form templates can be found in **Appendix C**. Copies of the actual field sheets can be obtained upon request.

Riparian Assessment

The riparian surveys were conducted concurrent with the upland rangeland survey from July to September 2003. Proper functioning condition (PFC) and riparian transect form templates can be found in **Appendix D**. Copies of the actual field sheets can be obtained upon request.

4.2 DATA INTERPRETATION

The field data sheets present the findings of the Level 1 assessment. These data may used to estimate the condition of the entire pasture, allotment, or drainage since they are located in key areas throughout the watershed. There is likely some heterogeneity in upland rangeland and riparian condition across key areas. As such, management decisions for large land units should not be solely based on data from a single point.

4.3 GENERAL FINDINGS

Upland Rangeland – Upper Watershed

Considerable variation exists between upper and lower Kirby Creek. Rangeland health within upper Kirby Creek, including East Kirby Creek, West Kirby Creek, Ackles Fork, and Little V-H Draw, rates as "None to Slight" or "Slight to Moderate" deviation from the desired condition. Overall, the vegetative transects in the upper basin show adequate native plant cover in most areas and very few weedy or otherwise "undesirable" plant species.

Problem areas do exist in the upper watershed. For example, areas of dense cheatgrass have invaded many of the draws, particularly the bottomlands where excessive grazing has occurred. Heavily grazed spots were observed around many of the watering areas, mineral licks, high ridgetops, and fencelines of the upper basin. Heavily grazed areas were observed in the Reed Creek drainage.

A buildup of standing dead litter and biomass was observed in the West Kirby Creek pastures. These sites included an overabundance of green needlegrass, bluebunch wheatgrass, and Sandberg bluegrass. These sites rated poorly on the rangeland health scale due to unnaturally high vegetative cover. Limited grazing and fire suppression has led to the buildup of hazardous wildfire fuel conditions. Wildfire risk should be mitigated in order to prevent soil erosion and the spread of invasive species. **Figure IV-1** shows the above mentioned area determined to be a high risk for wildfire.

Upland Rangeland – Lower Watershed

Rangeland conditions within lower Kirby Creek are considerably poorer than in the upper basin. These areas are typical of the desert shrubland communities found in Wyoming's Big Horn Basin. Many sites are dominated by greasewood, saltbush, halogeton, and cheatgrass, indicating both excessive grazing and poor quality soils. Many rangeland health points were rated as "Moderate" to "Extreme." Historical evidence suggests that these sites once supported a higher percentage of native plants and greater plant cover than exist today. Rills and water flow paths, which indicate excessive erosion, are common in many of the pastures adjacent to Kirby Creek. High sedimentation was observed along Alkali Creek, Major Basin Draw, Rock Spring Draw, and Red Hole Road.

Several of the rangeland health surveys in the uplands within the lower basin rated as "None to Slight" to "Moderate." Excessive grazing and invasive weeds appear to be problematic near water sources, mineral blocks, fencelines, and ridgetops.

Badland formations are common in the lower basin. These areas are likely naturally caused.

Upper and Lower Watershed Rangeland Results

Upland Rangeland Results for both the upper and lower watershed are summarized below in Table 4.3.1

TABLE 4.3.1 RANGE LAND RESULTS

%	Extreme	Moderate to Extreme	Moderate	Slight to Moderate	Non to Slight
Soil Site Stability	0	11	24	37	28
Hydrologic Function	0	9	24	33	34
Biotic Integrity	6	14	28	30	22

Riparian Condition – Upper Watershed

The riparian condition of stream segments in the upper watershed is generally functional. Few points rated as "Non Functional." Many points rated as "Functioning At Risk" due to channel downcutting, a lack of coarse woody debris, and a lack of bank stabilizing plants. There is an adequate supply of hydrophytic plants in most locations; however, sedges and rushes are absent in many ephemeral draws.

Large, coarse woody debris is inadequate in most locations. It is unknown whether or not cottonwood and willows were naturally absent in the tributaries of Kirby Creek. Where present, these trees are old and decadent, indicating little to no reproduction.

Evidence of past erosion and channel alteration exists throughout the upper basin. Headcuts, many of which are now stabilized, indicate that severe erosion has occurred. Off-channel water diversions, such as irrigation ditches, are common. Many reservoirs have deteriorated through time, either through sedimentation or dam failure. Breached dams have caused severe stream deterioration in several locations.

Road erosion and livestock grazing have caused severe degradation along Reed Creek. Cattle use the creek bottom as a trail through most of Reed Creek canyon. Overgrazing of riparian vegetation is severe. In addition, the county road has channelized the creek. Consequently, stream flow has increased in Reed Creek, causing excessive erosion and an unnatural, altered channel morphology.

Riparian Condition – Lower Watershed

Most PFC points in the lower watershed were rated as “Functional At Risk” with either an “Upward” or “Downward” trend. Many points were “Not Functional.” Stream downcutting, invasive plants, bank sloughing, lack of coarse woody debris, the absence of hydrophytic plants, piping, road erosion, and channelization were common problems noted along lower Kirby Creek, Alkali Creek, Major Basin Draw, and Red Hole Road.

The general state of lower Kirby Creek is that of a degraded system. Past erosion has been severe to extreme. Many banks along Kirby Creek are greater than 20 to 30 feet tall. The mainstem of Kirby Creek is substantially downcut along most of its length from the junction of Lake Creek to its confluence with the Big Horn River. The water table is too low in most reaches to support riparian vegetation (including sedges, rushes, shrubs, and trees). In most locations, the water table is 10 to 15 feet below the surrounding floodplain.

Remnants of the historical Kirby Creek channel were observed in areas below the confluence of East and West Kirby Creek towards the junction with Lake Creek. The current channel is 8 to 10 feet lower than the historical channel, providing evidence of severe downcutting through time.

The unnamed ephemeral drainages which flow into Kirby Creek are generally in good condition. Although riparian vegetation is absent in many of these draws, they do not exhibit the same level of erosion, stream downcutting, and altered channel morphology that is found within Kirby Creek itself.

Upper and Lower Watershed Riparian Results

Riparian results for both the upper and lower watershed are summarized below in Table 4.3.2.

TABLE 4.3.2 – RIPARIAN RESULTS

Proper Functioning Condition	Functioning At Risk	Non Functional
33%	49%	18%

Figure IV-2 shows which points were determined to be proper functioning condition, functioning at risk, and non functional.

4.4 CONCLUSIONS

Although the results of the upland rangeland and riparian assessment described in this report are based upon a site-specific inventory of *key areas*, they can be applied at a pasture, allotment, ranch, or watershed basis with the understanding that heterogeneity may preclude averaging the data across a larger scale. If it is found that larger land units are relatively uniform both temporally and spatially, then data from a single field point can be used to infer the rangeland health or PFC of larger areas.

Tools to help apply these data to larger land units outside of the *key areas* include the use of topographic maps, grazing distribution maps, soil survey data, other data such as the BLM's RAIDS or upland rangeland monitoring information, or most importantly, local knowledge. Areas in the same pasture or allotment with the same rangeland health or PFC ratings may be mapped and consolidated together. Additional studies or information may be necessary to validate the extrapolation of information gathered in this assessment to larger areas.

The establishment of 94 upland rangeland and 72 riparian data collection points should be considered a "starting point" for future monitoring studies. The qualitative information, gathered from the rangeland health and PFC surveys, combined with the quantitative data gathered from the upland rangeland transects and riparian transects, provide a substantial base of information for the Kirby Creek CRM group to identify problem areas and track management changes through time.

5.0 STREAM MORPHOLOGY

5.1 INTRODUCTION

This section reports the conditions of the drainage ways and creeks in the Kirby Watershed, a rangeland catchment in central Wyoming. The recommendations are based on field reconnaissance, studies of geology and topographic maps and review of the Kirby Creek Riparian Field Forms completed by the rangeland specialists Aaron Maier and George Ivory, of the transects on the creeks at 72 locations, Figure III-1. For each transect, the cross section was sketched and dimensioned, the vegetation described, and the conditions of the stream noted. Reference is made to some of these transects in this section.

The scope of services called for a Rosgen (1996 Applied *River Morphology*) Level I Assessment of the stream conditions. This has been provided in the following text. However, because the main valley floor is either stable or gullied, the streams fall under either the Rosgen G classification, the Rosgen E classification or are grassed waterways which are not defined by the Rosgen Method. For more information on the types of stream processes ongoing in the Kirby catchment, the book *Incised Channels* by Schumm et al. (1984) is recommended. Schumm's book is not a method; it is about knowledge gathered on incised streams (gullies included) mostly in the Western US. Rosgen's book is heavily based on his experiences with the Forest Service in the mountainous Western US.

In a Level II Assessment, more information is added to what is collected at Level I. The information on the Level II is in the field notes of Maier and Ivory and in the figures presented in this text. There are no streamflow records for the catchment, nor rainfall records, only anecdotal information on runoff. Moreover, where there are gullies, issues such as floodplain morphology are not applicable. Therefore, the Level II assessment is necessarily abbreviated. There is a summary in this report. One must keep in mind that stream types can and do change in short distances. A gully may be downcutting on one side of the road and filling in on the other. The stream slope can flatten and change the stream type for a short section, not discernable on 20-foot contour maps. Transects are not the complete assessment. That can be obtained by walking all drainage ways in the catchment.

Rosgen's method of stream analyses is to classify streams into a number of categories, identified by letters and numbers, for example G6 ('G' denotes gully and '6' of clay bed). The classification is based on a wide number of hydrologic, geomorphic, and topographic features, with one classification grading into the next (see Exhibit 5.1.1). In the Level I assessment, the Rosgen method uses slope, sinuosity, width to depth ratio, and entrenchment ratio to classify streams into one of nine general stream types. The major channels within the Kirby Creek watershed were classified by field observations and by measuring or calculating each of the four parameters at each stream point. The results are

EXHIBIT 5.1.1 – ROSGEN GEOMORPHIC CHARACTERIZATION

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
Aa+	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with depositional soils. Very stable is bedrock or boulder dominated channel.	<1.4	<12	1.0 to 1.2	0.04 to 0.10	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	>1.4	<0.02 to 0.039	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	>1.4	<0.02	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	<0.04	Broad valleys with alluvium, steeper fans. Glacial debris and sepositional features. Active lateral adjustement, 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	<0.005	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 waste
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	<0.02	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	>1.4	<0.02	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	0.02 to 0.039	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.

Rosgen, 1996

shown on Figure V-2 and are summarized in a table in Appendix D. Generally, channels lower in the watershed were classified as type E due to the lower channel slopes, higher sinuosity, and higher entrenchment ratio. Type G streams, with higher slopes, were found higher in the watershed. Some of the stream sections located near the drainage divide lacked a defined bed and bank channels. These sections were classified as swales, a stream type not found in the Rosgen classification system. It should be noted that not all of the stream points fell neatly into a single Rosgen stream type. Therefore, preference was given to field observations (photos) and channel slope in making a classification.

The Kirby catchment does not lend itself well to the Rosgen-type analysis because of the lack of hydrologic, hydraulic, and more precise slope information. Yet this is not a problem. The Rosgen method calls for the classification so that a body of information, obtained from many other similar streams in other places, can be brought to bear on the stream under consideration. Why does the stream look like it does? What can be done to change it?

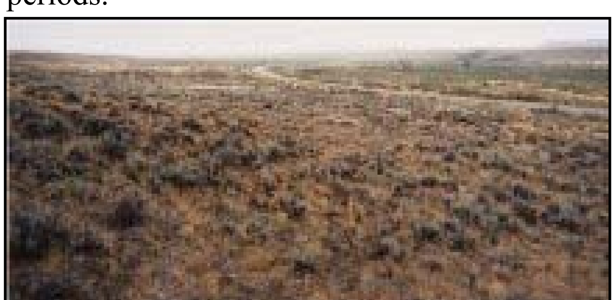
The stream morphology study covers three streams in detail: Kirby Creek, West Kirby Creek, and Alkali Creek. Lake Creek is another major tributary in the catchment, but is not included as there is no interest in this study by the people living or using the Lake Creek catchment.

In Milek's history of Kirby Creek (2001), there is often reference to East Kirby Creek. The US Geological Survey topographic map (1957) has no named East Kirby Creek, instead extending Kirby Creek past its confluence with West Kirby Creek to the headwaters. In this report, only Kirby Creek is used.

5.2 CATCHMENT

The entire Kirby Creek catchment covers 200 square miles of hilly grassland and flat valley bottom: this study is concerned with only 150 square miles. Its headwater is Guffy Peak, at elevation 8,046 (feet) at the top of West Kirby Creek. It falls almost 4,000 feet to the Big Horn River in a distance of approximately 32 miles.

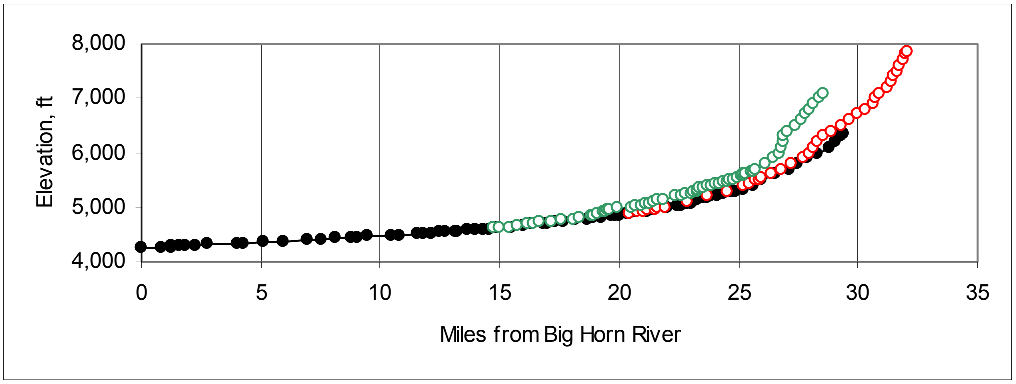
The valley profiles of the three creeks are very similar (Exhibit 5.2.1). Stationing begins at the Black Mountain Road Bridge over the Big Horn River (Mile 0.0). From the Big Horn River to the confluence of Alkali Creek, Kirby Creek is slight sinuous, running in a broad alluvial valley (Photograph 1) filled with sediment from past geological erosion periods.



Photograph 1. View of the lower Kirby Creek Valley looking down-stream towards the Big Horn River 12 miles away. The creek is to left of the road where the vegetation appears greener.

Valley profile of Kirby Creek (black), West Kirby Creek (red) and Alkali Creek (green). The Alkali confluence is at Mile 14.7; the West Kirby is at Mile 20.5. The contour interval on the 1-to-24,000 scale topographic maps used here is 20 feet.

EXHIBIT 5.2.1 – VALLEY PROFILE



From the confluence of Kirby and Alkali Creeks to the Big Horn the valley slope is 0.45 percent. The Alkali confluence is 14.7 miles upstream. Between Alkali and West Kirby, the Kirby Creek valley narrows up and the slope doubles to 0.9 percent. The West Kirby Creek confluence is 20.5 miles upstream from the Big Horn. In the headwaters, all three creeks have valley slopes of approximately 15 percent.

5.3 GEOLOGY

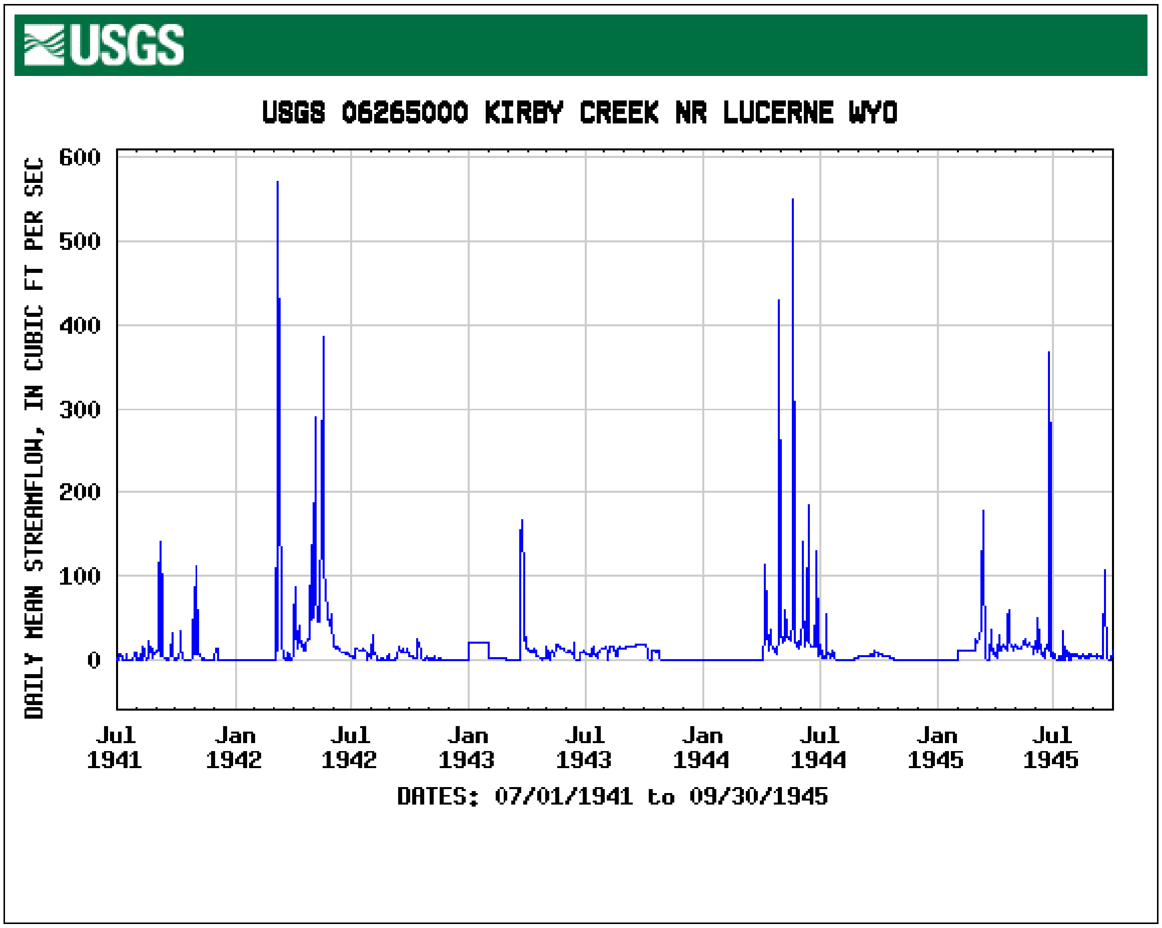
As was stated in Section 2.2, Cody Shale is the major geological unit of the catchment. It lies in the lower part of the catchment and covers approximately half of the study area (See map attached). In the upper catchment, the major formations are the Frontier, the Mowry and Thermopolis formations (Cretaceous)(shales), and the Wagon Bed (Tertiary).

The Cody Shale in the lower catchment is susceptible to erosion, especially in areas of little or no vegetation. Almost all the gullying occurs in the lower catchment in slope wash mixed with residuum of the Cody Shale formation and alluvial deposits. The deposits extend up Kirby Creek to about 2 miles upstream from the West Kirby Creek confluence and up Alkali Creek for about 2.5 miles. In the flat lower valley, gullying continues from Kirby Creek up some of its small tributaries. In streams of the upper catchment, headcutting and gullying are is observed in relatively few locations as compared to the lower catchment. This is due to the change in the bedrock geology. Change stream morphology follows the change in geology.

5.4 HYDROLOGY

There are no current stream-gauging stations or precipitation gages in the catchment. Historical data was researched and a stream-gauging station was present on Kirby Creek from 1941 to 1945. This data showed stream flow to be as little as 0 cfs up to as high as 570 cfs. The data is shown on the USGS graph below, Exhibit 5.4.

EXHIBIT 5.4 - STREAM FLOW (CFS)



The Wyoming Water Development Commission recently had a basin plan completed for the Wind/Bighorn River Basin. In the plan, models were generated using flow estimates for all tributaries in the basin for wet, normal, and dry year flows. The water flows from Kirby Creek used in the Basin Plan are shown below in Table 5.4.1.

TABLE 5.4.1 – KIRBY CREEK AVAILABLE STREAM FLOW (ac-ft)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Dry Year	887	853	1,354	2,650	3,042	614	64	31	122	796	772	620	11,807
Normal Year	1,205	1,307	1,675	42,052	7,344	7,032	310	97	255	1,297	1,169	893	26,786
Wet Year	1,761	1,579	2,222	6,903	13,204	14,300	1,257	155	316	2,060	1,681	1,327	46,764

The available stream flow varies a great deal from a dry year to a wet year with the wet year flows approximately 4 times the dry year flows.

The USGS recently published a report for the State of Wyoming which provides equations that can be used to calculate flood events for the different regions throughout the State. The report is titled "Peak-Flow Characteristics of Wyoming Streams" Water-Resources Investigations Report 03-4107. The information in this report can be used when sizing reservoirs or used in other projects in which peak flows from flood events are required.

5.5 HISTORY

The following are statements and paraphrases extracted from Dorothy G. Milek's (2001) history of Kirby Creek County that relate to the morphology of the streams.

- In the **early part of the century**, the creek was approximately two feet deep and twenty feet wide.
- In the spring or during a flash flood it was often almost a mile wide. One could cross on horseback at almost any location. The creek didn't have the cut banks it has now.
- One could step across any place up to the head of the creek.
- In some years it dried up completely and other years it flowed fairly well all year.
- Massive numbers of sheep came in around **1910**.
- By **1915**, the creek started to erode for it was approximately four feet deep and twenty feet wide.
- Drought hit Hot Springs County in **1919**. Floods were common after that.
- The vegetation began to deteriorate after the disastrous 1919 year.
- Cloudburst hit the region in the summer of **1923** causing severe flooding. Walls of water were high enough to gather brush and push it ahead of the water, causing scouring in the channel, and cutting deep gullies in it. The creek started to wash badly in 1923.
- On the Allard place, a cut was started on the lower end of the hay field around **1935** and by the **1990s** it was fourteen feet deep.
- In the spring of **1978**, the water was running so high it was going over the bridge on the Black Mountain secondary. It had been over fifty years since the last major flooding.
- At one time there were quicksand spots in the creek bed.
- Damage to the channel lowered the water table which led to the loss of irrigation water from Kirby Creek.

5.6 UPPER CATCHMENT STREAMS

In general, the waterways in the upper catchment of the study area are in good shape. Most are intermittent creeks, carrying water only when there is rain. There are springs, some of which are commandeered for stock water ponds.

The smallest drainages are grassed swales (Photograph 2 and Transects 70 and 75), the yellow part of the waterway in the center of the photo. In the lower part, the vegetation is green; perhaps sedge as seepage water appears. Here the divide is capped by hard rocks, some of which have rolled down the slope. Otherwise, most everywhere there is a layer of soil.

Photograph 2. Grassy swales are the lowest order of streams in the upper catchment. This is not a stream type in the Rosgen classification.

Grassy swales turn into narrow defined waterways with grassed bottoms and a few small trees (Photograph 3). Off to the sides there is brush. As the stream order increases, there is more variability to the stream character.

Photograph 3. A small stream in the upper catchment.

Photograph 4 is of West Kirby Creek eroding a canyon through hard rock and then winding down a broader valley. In this reach, the creek bottom is grassed in most places. It is joined by a grassy swale on the right. The scar on the left side is the pipeline right-of-way.

Photograph 4. West Kirby Creek in the upper catchment.

Along Kirby Creek at approximately Elevation 4800, there is a short section of channel, probably quite flat, with a sinuosity of 2.2. That is, in about one-half mile of valley the stream meanders a distance of 1.1 miles. Otherwise the streams in the upper catchment are fairly straight.

The Rosgen classification for upper catchment streams is most closely 'A' and 'B' but without many of the features Rosgen uses to define these types of streams. A Rosgen 'A' stream is narrow and nearly straight, very steep, deeply entrenched, with torrents carrying debris. It inhabits a catchment of very high relief with erosional, bedrock, or depositional features. It has vertical steps with deep scour pools and waterfalls. Upper Kirby streams are not deeply entrenched, nor do they have torrents carrying debris. There is an absence of vertical steps, deep scour pools, and waterfalls.

A Rosgen 'B' stream is narrow and nearly straight, steep, entrenched, cascading, with steps and pools. It is a high energy and debris transporting stream. "B' streams are found in high relief with erosional or depositional features and bedrock forms. They cascade in some reaches and have frequently spaced deep pools associated with step/pool bed morphology. Upper Kirby 'B' streams are not debris transporting, do not cascade, and do not have deep pools.

For stream sections sampled by Maier and Ivory (2003) in the upper catchment (all streams not in the Cody Formation), 55 percent of the transects are judged stable, 25 percent unstable, and the rest of the transects show some signs of erosion (either bank or bed), see **Figure V-1**.

Upper Catchment Gully

Not far upstream from its confluence with Kirby Creek, there is a deep, narrow gully in West Kirby Creek (Photograph 5 looking downstream). The gully is working upstream in deep, old sediments in the valley. In the background of the photograph, the dressed slope of the gully bank is at a pipeline crossing. A large cottonwood in the bottom of the gully is approximately eight years old, signifying that the headcut passed this point more than eight years ago. The gully floor is sediment and supports vegetation. The gully banks are nearly vertical and void of vegetation. Transect 47 is in this gullied reach.

The headcut (Photograph 6) is a short distance upstream. It is in two steps, each about the same height. The men in the photograph are standing at the upstream headcut; the other headcut is at the bottom of the photograph. The gully is working it way up into wetlands and a pond. There is a spring somewhere upstream supplying water to this wetland.

Transect 47 is a Rosgen G6 type Level II stream. The wetland upstream from the head-cut is in a very flat reach and has a very small E6 stream.

Photograph 5. Looking downstream at a deep and narrow gully Type G6 in West Kirby Creek.

Photograph 6. Looking upstream at the two headcuts in a West Kirby Creek gully.

5.7 LOWER CATCHMENT STREAMS

In the lower catchment, the valleys are wide (Photograph 1) and the valley slope is a modest 0.45 percent. In much of this region, the streams are gullies in various stages of erosion and deposition. In the last 2 miles as it approaches the Big Horn River, Kirby Creek is in the backwater influence of the river. Here the creek is stable and well vegetated (see Transects 1 and 4 and Geological Map).

There is a slight sinuosity to the top banks of Kirby Creek. Within these top banks, the new downcutting within the old gully meanders more severely. That is, there is a smaller gully within an old, larger gully. The USGS 1:24,000 scale topographic maps of the flattest part of Kirby Creek were made in 1960. Here, the sinuosity was measured for two reaches. In Section 36 - T 44N - R 94W, about 3.5 miles upstream from the Big Horn, the sinuosity in 1960 was 1.6. It now appears to be much the same. That is, the sinuous creek was 1.6 miles long as it crossed the 1-mile wide section. The same sinuosity was measured 11 miles upstream across Section 5 - T 43N - R 92W.

Streams are judged stable if there are no significant ongoing changes in their geometry. In a stable stream, the bed is not aggrading or degrading and the banks are not eroding. At the transects sampled by Maier and Ivory (2003) in the Cody Formation, half of the transects are judged stable, 30 percent are unstable, and the remainder show some sign of bed or bank erosion, see **Figure V-I**.

Some gullies are downcutting now; others are in the depositional stage. The different conditions of the gullies are illustrated by three cases. The streams have mostly a G6 Rosgen classification, gullies with a silt/clay bed, but with slopes greater than Rosgen specifies for G streams. Moreover, some reaches of the streams have been gullied more than once. There is a small gully within a large gully. Some gullies are healing leaving them in yet another class not specifically defined by Rosgen.

Red Hole Road Gully

Red Hole Road 1426 branches off the Black Mountain Road approximately 6.7 miles upstream from the Big Horn River. Kirby Creek used to pass through a culvert under Red Hole Road. This culvert was washed out and replaced by a single span bridge. In destroying the culvert, Kirby Creek began headcutting upstream, entrenching itself again in its old gully. Photograph 7 is a view of the present conditions. The floor of the previous gully is now a terrace with a growth of brush. The banks of both the new and old incisions are nearly vertical and bare. At the base of the new downcutting, vegetation has been established, narrowing the base flow of the creek. Transect 87 is in this reach, a Level II Rosgen Type G6 stream, gullied twice or a gulley within a gulley.

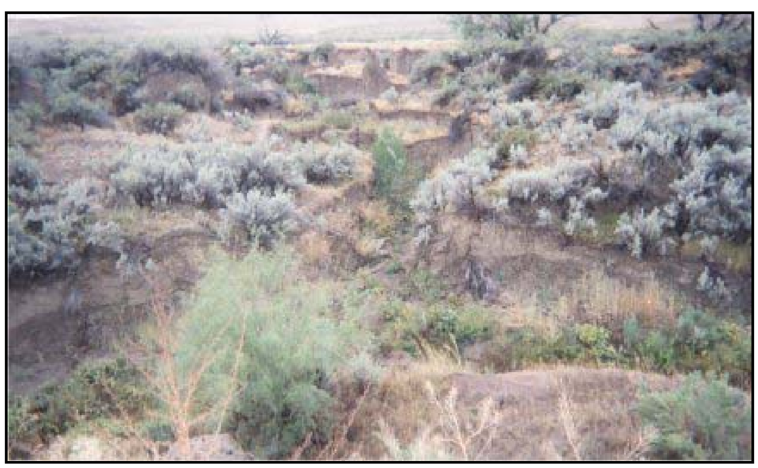
Photograph 7. View looking downstream at Kirby Creek incising itself upstream from the Red Hole Road. The bridge is visible as the dark object in the upper center of the photo. This stream is a Rosgen Type E.

The new incision has caused rejuvenation of gullying in the tributaries (Photograph 8). The previous gully was broad and healed with sloping banks and a well vegetated floor. The rejuvenated gully is within the older one. The new gully is deep and narrow with nearly vertical raw banks and a clay bed.

New tributary gullies are being formed as water falls into the deep gullied sections of Kirby Creek. The located headcut of a short new gully is shown in Photograph 9. Side by side, both headcuts are vertical but not nearly as deep as the Kirby gully. This tributary gully is not very active as its water supply is delivered by a small grassy swale.

Water from a tributary enters the new gully in the main channel in two ways. It can flow down a slope from its bed level to that of the main gully, or it can 'pipe' its way into the main gully. A pipe is literally that – a hole into the ground and with a hollow passage to the gully wall (Photographs 10). Photograph 11 is a view of a 'pipe' looking downstream along the course of a grassy tributary. The entrance to the 'pipe' is the small dark hole in the upper center of the photo. The gully is at the top of the photo. Piping is common in the lower catchment streams that are being gullied. Over time, water erodes the 'pipe' to such as size that the pipe collapses, leaving the water to flow over the surface in a depression. Thus, a new gully is formed.

Photograph 8.
Looking upstream at gullying being rejuvenated in a tributary to Kirby Creek near Red Hole Road.



Photograph 9. Two headcuts in a small tributary to Kirby Creek near Red Hole Road.

Photograph 10. Water from the tributary enters the Kirby Creek gully through the 'pipe,' the black hole in the ground (upper center of photo) from the tributary bed level to the vertical bank of the creek

Photograph 11. A small tributary (foreground) flowing down towards a gully (background) entering through a 'pipe' in the ground. The entrance to the pipe is the small back hole in the upper center of the photo.

Box Culvert Gully

Ten miles up Black Mountain Road from Highway 20 along the Big Horn River, there is a large rectangular box culvert under the road. On the upstream side with its curved wall inlet, the drainageway is broad and stable with flat sloping banks and no inner channel (Photograph 12). There are no signs of erosion.

Photograph 12. Curved inlet to box culvert under Black Mountain road. Upstream, there is no channel, only a grassy swale in may have been a gully in the past.

On the downstream side conditions are different (Photograph 13). There is an old gully here with a newly deposited flat bed of clay covered with grass. The tops of the gully banks are still raw and vertical. There has been bank slumping so that the bottom is sloped and supporting vegetation.

Photograph 13. Outlet of the box culvert under Black Mountain Road. The stream bed is recently deposited sediment with large drying cracks and a dense growth of grass.

Photograph 14. Looking upstream in a tributary gully to Kirby Creek. The gully is downstream from the box culvert under Black Mountain Road. The tree on the left side is a tamarisk.

Where this tributary enters Kirby Creek, the creek is a wide gully formed in the past and now heavily infested with the trees, brush, plants and grasses. A small incised inner channel carries the lower flows. The tributary flows into the creek at the terrace level.

Arrested Headcut

This gully headcut has been arrested by grading the cut and covering it with riprap (Photograph 15). The headcut was repaired in 1998. The gully had been excavating itself in a wide shallow grassy swale with no defined channel. The drainage way is a tributary to Kirby Creek.

Photograph 15. Headcut with grading and rip-rap on a tributary to Kirby Creek.

Photograph 16 is a view downstream at the most recent gullying. There are fresh soil falls from the raw vertical banks. A Marathon oil pipeline constructed in 1954, suspended across the gully, is visible. It is presumed that the pipeline was constructed before the gully formed.

Photograph 16. View of gully looking downstream. There is an oil pipeline suspended across the gully. This is another Rosgen Type G stream for a short ways downstream.

Farther downstream time has healed the gully scars (Photograph 17). The banks have slumped inward and are now stable and covered with vegetation. There is no more erosion of the bottom. One sagebrush in the bottom just downstream from the pipeline was estimated to be 13 years old.

Photograph 17. Farther downstream from the pipeline, the gully has become stabilized with vegetated banks and channel bed.

Jones Dam

There is an earth embankment dam on Kirby Creek approximately 8.5 miles upstream from the Big Horn River, photograph 18. It is about 25 feet high with an overflow spillway on one abutment. A 5-foot diameter corrugated metal pipe serves as another spillway, this one through the dam. Sediment has filled the reservoir to the level of the intake for the vertical-drop pipe spillway. There is seepage through the abutment on the north side. Repairs should be made so the dam does not fail during a flood causing an eroding gully in the sediment deposited upstream in the reservoir and new deposition downstream.

Photograph 18. Spillway of the Jones Dam

5.8 SUMMARY

Up to the early part of the 20th century, Kirby Creek catchment streams were not gullied according to Milek's historical accounts. Gullying became noticeable by 1915. Drought followed by flooding increased the gullying.

The upper catchment waterways and streams are, for the most part, in good shape (Photographs 2, 3, 4). There are exceptions where deep gullying is occurring (Photographs 5, 6).

Kirby Creek and other streams in the lower catchment are in various stages of gullying. Some are now downcutting in old gullies (Photographs 7, 8); some are new gullies in tributaries (Photographs 9, 10); some are in the depositional stage (Photographs 12, 13, 14); at least one gully headcut has been structurally arrested (Photograph 15); and some are healing (Photograph 17).

6.0 WATERSHED MANAGEMENT PLAN

6.1 INTRODUCTION

As has been discussed in previous sections, the degradation of the Kirby Creek Watershed began in the early 1900's. Some of the contributing factors of the degradation were overgrazing, severe drought, flooding, and the geological make up of the basin. As the stream channels began to down cut, the ground water became deeper. As the depth to ground water increased, the grasses were replaced with grease wood, which attributed to more erosion and head cutting of the channel. It is not feasible to restore approximately 100 years of down cutting with a few simple and inexpensive projects. A more realistic approach is to try to stop further down cutting of the watershed. This section will discuss methods in which this may be accomplished and identify some of the more problematic areas which are recommended to be addressed first.

6.2 GRAZING MANAGEMENT STRATEGIES

The rangeland areas described in Section 4 were based on site-specific key areas. These key areas can be applied to a pasture, allotment, or ranch with the understanding that a larger area must first be looked at to determine if the point applies to the larger area. Rangeland health differs from point to point, and pasture to pasture. Once the rangeland health for a particular pasture is known, it can then be determined how to best rehabilitate the pasture if there are indeed problems. Some grazing management strategies are shown described below. Additional studies may be necessary to determine which strategy will work best for each individual pasture.

Grazing Management Strategies:

- Exclude the riparian area within a separate pasture with separate management objectives and strategies. Put riparian areas in separate pastures to gain control over the season, duration, and intensity of livestock use.
- Fence or herd livestock out of riparian areas for as long as necessary to allow vegetation and streambanks to recover.
- Control the timing of grazing to meet management objectives.
- Add more rest to the grazing cycle to increase plant vigor, allow streambanks to heal, or encourage more desirable plant species composition.
- Limit grazing intensity to a level which will maintain desired species composition and vigor.
- Use different types of livestock to obtain better forage utilization of a variety of species and better animal distribution.
- Permanently exclude livestock from riparian areas at high risk and with poor recovery potential when there is no feasible way to protect them while grazing adjacent uplands. Exclude livestock from the riparian area with stream corridor fencing.

- Limit grazing intensity and season of use to provide sufficient rest to encourage plant vigor, regrowth, and soil retention.
- Consider management strategies to allow for sufficient vegetation during periods of high flow to protect stream banks, dissipate stream energy, and trap sediment.
- Install water developments and mineral licks in the uplands to better distribute livestock in underutilized areas.
- Cross-fence riparian corridors to prevent livestock from using them as trails.

6.3 STREAM MORPHOLOGY AND EROSION CONTROL

Stopping the degradation of the stream channels and reducing erosion are key elements to the rehabilitation of the Kirby Creek Watershed. This Section discusses various ways in which this may be accomplished:

1. The first priority is to stop or impede the most serious gully headcuts, those likely to cause the most damage.

2. The second priority is restore rangeland health therby reducing the 'piping' at the deep gully banks in places where the adjacent land is judged most valuable.

This report will identify some key areas that need to be addressed immediately. In order to further accomplish these items, studies should be carried out to identify and map head-cutting and piping and prioritize each as to seriousness.

The Natural Resources Conservation Services Engineering Field Handbook, especially Chapters 10 and 16, (Wyoming Edition 2003), and the Stream Corridor Restoration Principles, Processes, and Practices (1998) are recommended for consideration in stopping gullying in the Kirby Creek catchment. The experience of the former Soil Conservation Service in controlling gullies is of prime interest. This is contained in the Engineering Field Handbook. Practices of the NRCS for the control of gullies include the following:

1. Interception of runoff water above the gullied area.

2. Retention of runoff water on the drainage area by tillage practices, vegetation and structures.

3. Elimination of the gully by shaping, filling, and protection with vegetation.
4. Revegetation and grassed waterway development.

5. Construction of grade stabilization structures to control the grade of the gully and detain or impound water.

6. Rest and Rotation of pastures.

7. Control of sediment from active gullies with debris basins.

8. Drainage of seep areas where gully banks are unstable.

Not all of these practices may be applicable or feasible for gullies on the Kirby Creek catchment.

Two recommended practices for arresting head cuts are shown in **Appendix E**. Cost estimates based on height, width, and length have been developed for each practice. These estimates will assist the CRM and landowners in determining costs for different channel sizes and head-cut lengths. The rip rap methods were chosen as preferred methods because they are relatively inexpensive and have been proven to work within the basin.

6.3.1 Beavers

Several studies have been performed in the past suggesting that the reintroduction of beavers in cold-desert, gully-cut streams can significantly reduce the elements which cause erosion as well as speed the recovery from erosion. These studies show that some of the benefits from having beavers in the area are a decrease in or reversal of the effects of erosion and an increase in wildlife and plant life.

Erosion

As beavers settle into an area they build dams and lodges. These dams produce lower stream velocities by dissipating energy laterally across the dam rather than having the stream flows being concentrated vertically. This type of stream flow is less likely to produce an eroded stream channel. The dams can also reduce stream velocity over a larger area by creating a step-down gradient in the stream. One study has shown that stream velocities in beaver dam areas were approximately 1/5 of stream velocities outside of beaver dam areas.

Another benefit of beaver dams is a decrease in the number of particles suspended in the water. The slower water velocities produced by the beaver dams allow particles suspended in the water to settle out. Depending on the number of dams in series, the amount of particles being transported by the stream can be reduced by up to 70%. Over time this will produce mud bars behind the dam. These mud bars contribute to the vegetative stabilization of the stream by providing a high-nutrient environment where vegetation can grow. The vegetation serves to stabilize the stream channel. The dams, when not completely sealed, also function as filters for larger objects in the water. Lower velocities and the filtering effects of the dam can reduce the amount of sediment being transported by the stream, which results in a slowing or even a reversing of the erosion process.

Wildlife

The dams created by beavers can have other benefits to riparian areas. The pond behind the dam has a larger surface area than the regular stream channel. The larger surface area is likely to contain more forms of wildlife. Studies show that more species of birds, mammals, reptiles, and amphibians are present in beaver dam areas than in areas without beaver dams.

Plant Life

As beaver dams are created, the water level immediately upstream of the dam will fluctuate less and rise slightly. As the water level rises a wet meadow area behind the dam can be created. With stream bank erosion reduced because of lower water velocities and a higher water table because of the higher water level in the stream, an environment for increased plant life is created.

Reintroduction Factors

In order for reintroduction to be successful, a suitable site must be chosen. Sites previously occupied by beaver are most likely to be successful for reintroduction. Signs of previous occupation are old dams and lodges, beaver cuttings, and collapsed bank dens. If the site has not been occupied for many years these indicators may be grown over and appear as humps or ridges. Other factors that make a site suitable include stream characteristics, available food and construction materials, and interaction with humans.

Beavers tend to settle in areas where the stream gradient is less than 6%. Studies have been inconclusive about the width of stream required and stream width is not considered a critical issue. The available water, however, is a significant issue. Areas with fluctuating flows are less attractive to beavers, although their activities can serve to buffer those fluctuations. Beavers typically prefer larger flows but can make use of smaller flows as long as they can be dammed. The stream characteristics also need to allow for a pond deep enough to serve the beaver’s needs. The pond needs to be deep enough to accommodate lodges or dens and winter food supplies. It also needs to be sufficiently deep to lessen the chance that the pond will freeze solid in the winter.

One of the most influential factors in reintroduction is the available vegetation in the chosen site. This vegetation provides the beaver with food, building materials, and cover. Beaver diet varies throughout the year. In the summertime they prefer herbs, including forbs, reeds, and aquatic plants. During other times of the year they eat woody species, such as aspen, willow, and cottonwood. Studies have shown that beavers can survive on one one-inch aspen tree per day.

Often the same woody species used for food are used to construct dams and lodges. The preferred building materials are aspen and willow, but beavers are known to be adaptable in what they use. Beavers will usually not travel more than 100 yard away from the stream to find food and construction materials, so enough of this vegetation needs to be located within that distance. Beavers will, however, travel upstream to find food and construction materials. Reintroduction efforts in the past have had food and construction materials brought to the site from aspen thinning activities. Having the materials readily available gives the beavers motivation to remain in the selected area.

As beavers leave the stream to find food and construction materials, they look for areas that will provide them with adequate cover. Deeply wooded and shaded areas are not preferred by beaver. They are also hesitant to pass through thick stands of conifers to obtain hardwoods for food and construction materials.

While beavers can offer many benefits to streams and the surrounding environment, care must be taken to reduce negative effects with humans. Beavers are known to dam culverts and ditches, which can result in flooded roads and dry ditches. Beavers will also cut down trees in the surrounding area. For these reasons a site must be chosen that will minimize these effects or mitigative actions must be taken.

Existing Population

As was mentioned in Section 2, there is currently a beaver population in existence on East Kirby Creek as can be seen in the photo shown below.

Hurley 2003

Beavers can provide a cost effective way to slow erosion and develop riparian areas.

6.4 REHABILITATION OF EXISTING RESERVOIRS

Two existing on-channel dams are in need of repair and are in danger of being washed out; 1) The Jones diversion dam and 2) The Norman Sanford reservoir. The loss of these structures would lead to renewed head-cutting. The Jones dam is approximately 25-30 ft.

in height, and the Norman Sanford reservoir is approximately 10-15 ft. in height. The local NRCS office is currently working to rehabilitate the Norman Sanford reservoir with repairs scheduled to begin in the summer of 2004. If the repairs for some reason are not able to be performed, then this reservoir will again become a high priority. The Jones dam repair is a high priority. This will be discussed in later sections.

There are approximately 62 stock reservoirs located in the Watershed. Several of these are in need of repair. Reservoirs that have been breached are head-cutting, and causing large amounts of eroded soil to enter into the stream channels. It is recommended that an inventory be made of these reservoirs, and repairs prioritized. Once repairs have been made, the reservoirs will also assist in the distribution of cattle, as water is made available.

6.5 SUMMARY OF MANAGEMENT PLAN

A Summary of the items discussed in the Sections 6.1 to 6.4 is shown below:

Stream Morphology and Erosion Control

1. The first priority is to stop or impede the most serious gully headcuts, those likely to cause the most damage.
2. The second priority is restore rangeland health thereby reducing the 'piping' at the deep gully banks in places where the adjacent land is judged most valuable.
3. Encourage beaver habitat by providing suitable stream characteristics, available food and construction materials.
4. Rehabilitation of reservoirs.

Grazing Management

1. Determine if the Rangeland Health Point can be applied to a larger area such as a pasture or allotment.
2. Determine and apply the best management strategy to rehabilitate problem areas.

Recommended priority areas of the Watershed are discussed in Section 6.5.

6.6 PRIORITY AREAS

Jones Dam

The area of greatest concern and in need of immediate repair is the Jones dam. The dam and overflow structure is unstable and in danger of being washed out. Over the years, the suspended soil particles have been deposited upstream of the structure as the water velocity slowed. If the structure were to be breached in a flood event, the head-cutting would continue upstream at a high rate and put any upstream structures such as bridges in danger.

It is recommended that an initial condition assessment be made of the dam. This will be compiled into a report which will document findings and make recommendations for further studies or work. The tasks of the initial condition assessment will be performed by engineers experienced in the construction and rehabilitation of dams and will include the following:

- Inspection of the upstream and downstream faces of the dam to identify potential seepage areas, sinkholes, etc.
- Field measurements to determine the approximate dimensions of the embankment, spillway, and outlet works, and to document the approximate dimensions and locations of areas of concern.
- Photograph documentation
- If possible, a video inspection of the lower interior portion of the outlet pipe to establish the condition of the pipe.

The cost to complete the initial condition assessment and prepare the letter report would be approximately $9,500.

Norman Stanford Reservoir

This reservoir, located just upstream of Lake Creek and Kirby Creek confluence, is also in need of immediate repair. It too has an overflow structure that is unstable and in danger of being washed out. At this time, the owner and NRCS are in the processes of designing repairs and anticipate construction for the summer of 2004. Without this project, the landowner will need to readdress this reservoir.

East Kirby Creek

A long riparian corridor along East Kirby Creek is threatened by head-cuts and an exposed oil pipeline trench. The creek formed a new channel by overflowing an existing diversion structure and then following an oil pipeline trench, exposing and undercutting the high pressure line. The NRCS is currently working with the pipeline company to remedy the problem. The stream will be redirected into the old existing channel and the undercut pipeline will be backfilled. This area should be monitored closely as several smaller head-cuts may require stabilization after the stream has been returned to the original channel.

West Kirby Creek Transect 47

This area has relatively new head-cutting. Tree size along the channel indicates that this head-cutting has occurred in the last 10 years. There are two head-cuts approximately 10 feet wide with a 5-foot drop. The costs associated with the construction of rip-rap bank stabilization are shown in **Appendix E**. The tables in **Appendix E** allow for estimating construction costs for different widths and heights of the head-cuts. The table shows that for a head-cut approximately 10 feet wide with a 5-foot drop, the construction costs are approximately $2,700.

Reed Creek

Road erosion and livestock grazing have caused severe degradation along Reed Creek. Cattle use the creek bottom as a trail through most of Reed Creek canyon. Overgrazing of riparian vegetation is severe. In addition, the county road has channelized the creek. Consequently, stream flow has increased in Reed Creek, causing excessive erosion and an unnatural, altered channel morphology.

It is recommended that the riparian zone of the stream channel be fenced in order to move the cattle out of the creek bottoms and to assist in grazing management. A program to consider for this area is the Continuous Conservation Reserve Program (CCRP). The maximum rental rates are calculated for each CCRP area prior to enrollment. The FSA also provides cost-share assistance of up to 50 percent of the cost in establishing approved practices. Placing the area into CCRP would provide assistance for fencing, as well as provide the landowner with yearly payments.

It is estimated that approximately 1 mile of fence would be required to fence both sides of the more severe areas of the creek bottom. Costs for fencing vary with the type of fence constructed.

Other Areas

As was discussed in Sections 4 and 5, the transect data needs to be further studied and evaluated on a point by point basis. Further study of key areas will provide greater information as to how to address problems associated with each area. As land owners and members of the Kirby Creek CRM read and evaluate the report, it is anticipated that other areas of concern will be brought up. These areas will need to be prioritized and construction costs determined.

Stream-gauging Station

Because there is no stream-gauging station in the Kirby Creek Watershed, the CRM and land owners need to evaluate the need to install one. The start-up costs and yearly monitoring costs must be evaluated and compared to actual benefit of knowing stream flows. The USGS Water Resources office in Cheyenne was contacted and asked about the possibility of providing a stream-gauging station for the Kirby Creek Watershed. They were very open to the idea as long as the stream-gauging station is long term. The estimated cost to start up a stream-gauging station is $24,000. Yearly costs for maintenance and data collection are estimated at $13,000 per year.

6.7 PERMITS

The application of hydromodification (in channel) best management practices (BMP's) is more carefully regulated than the application of BMP's in other activity areas. A Section 404 permit from the U.S. Army Corps of Engineers is required for activities relating to in channel BMP's. Prior to issuing a 404 permit, the Corps must be presented with a

Section 401 certification from DEQ indicating that the proposed project will not result in a violation of the state's water quality standards. Also, if the proposed improvements are diverting or consuming water, a permit must be obtained from the State Engineer's Office.

The permit process will vary depending on the project's complexity, location, and environmental effects. It is recommended that a pre-application consultation be made to identify key issues. Some types of activities have been authorized by nationwide or regional permits called "general permits". It is important to keep the process within the limits of the different nation wide permits. If the proposed activity does not qualify for a general permit, an individual permit may be obtained but the process is more complex.

A standard individual permit process begins with a public notice. Depending on the comments received, a public hearing may be requested. The Corps then reviews that proposal ensuring that it complies with the Section 404 guidelines. The permit process of "general permits" normally is completed within 60 days. The time of completion of the standard individual permits is normally completed within 120 days. Some of the Nation Wide Permits that apply to the watershed rehabilitation that has been discussed are Permits 13-Bank Stabilization, 18-Minor Discharges, 31-Maintenance of Existing Flood Control Facilities, and 37-Emergency Watershed Protection & Rehabilitation.

Construction activities will be evaluated on a case by case basis. Any activity in the riparian areas or reservoirs will more than likely require an Environmental Assessment (EA).

Information on the Nation Wide Permits and the 401 certification can be viewed on line at www.nwo.usace.army.mil/html/od-rwy/nwpermits.htm.

6.8 FINANCING

In order to qualify for grant monies and loans a legal entity such as a Watershed Improvement District will need to be formed. Once this is accomplished, the newly formed district will have the ability to obtain funding from various sources. After the CRM and other interested parties have had a chance to review the report and further prioritize the proposed projects, funding of these projects becomes the next key step. Funding agencies each have individual guidelines as to what project they are able to fund and projects that don't qualify. Once the prioritization of the projects has been accomplished, the funding will need a more thorough review to determine under which available funding the project qualifies. More than likely it will be a combination of funding agencies.

The funding agencies that will be further reviewed include: the Wyoming Water Development Commission (WWDC). The WWDC provides grants for further studies as well as grant-to-loan ratios of 50/50 for construction projects. The current interest rate for loans from WWDC is 6%. The State Land Investment Board (SLIB) also provides funding to eligible Wyoming projects and are considered at a grant-to-loan ratio of 50/50.

Priority for this money is normally to drinking water and wastewater projects. The loan rate is currently being issued at an interest rate of 6%. The Hot Springs County Conservation District (HSCD) has requested funds of $238,000 from the Non Point Source Pollution Control Program. This program is administered by DEQ and the EPA. This money is available at 60% grant and 40% recipient funding. More money from this program can be applied for to fund proposed projects for the Kirby Creek Watershed through a separate entity or the current HSCD.

The Natural Resources Conservation Service (NRCS) in Wyoming administers the Agricultural Management Assistance (AMA) program. Applications will be considered at 75% AMA cost share assistance. First priority is water quality issues, such as livestock waste systems. Second priority will be irrigation and erosion control projects. This money can be applied for a large project, or if landowners wish to complete smaller projects on their own they can apply individually. Once priority projects have been determined, the best combination of funding agencies will be scrutinized.

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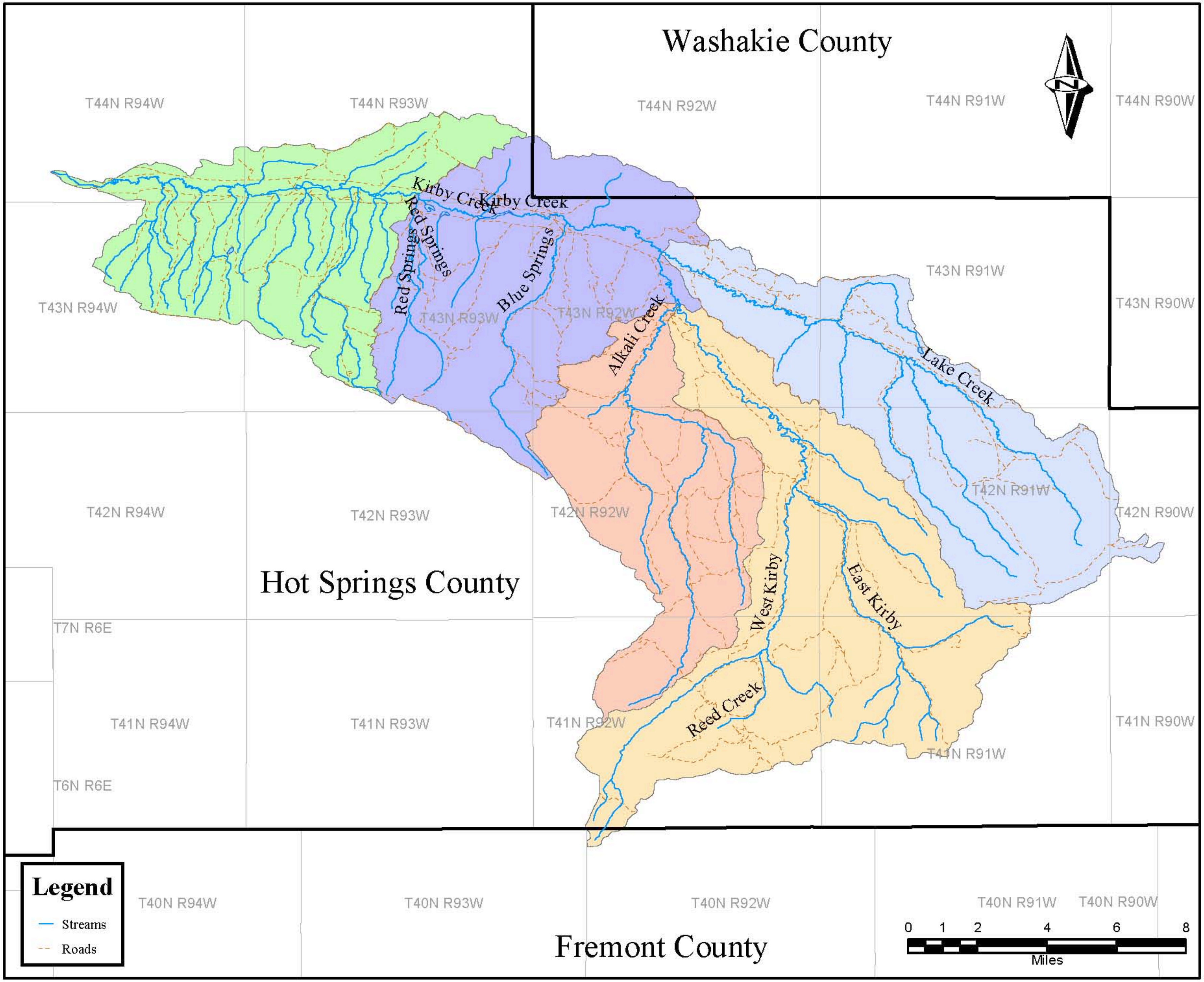
FIGURES



Kirby Creek Watershed

Watershed and Drainages

Figure I - 1

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Kirby Creek Watershed

Bedrock Geology

Figure II - 1

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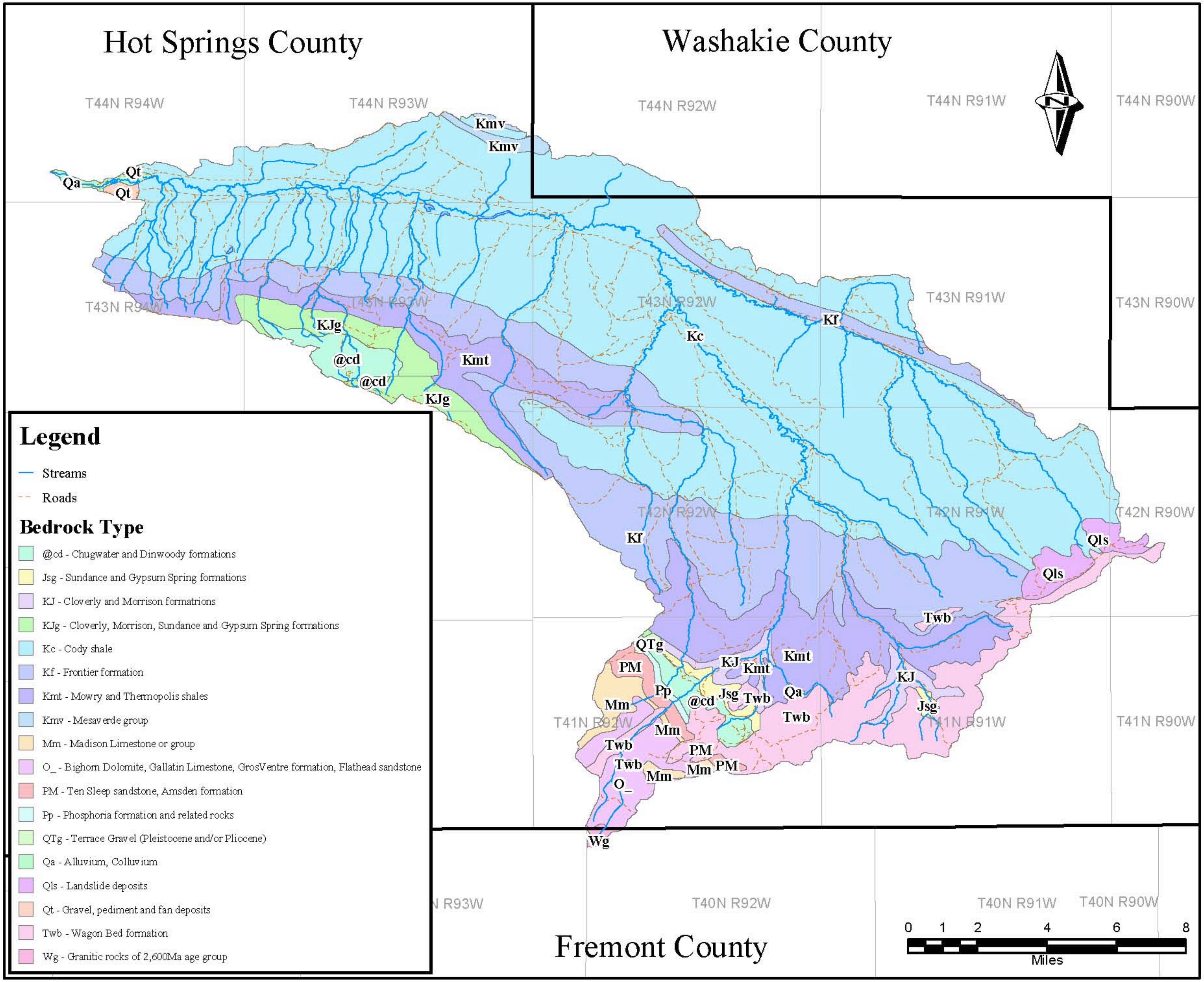

Kirby Creek Watershed

Land Ownership and Allotments

Figure 1 - 2

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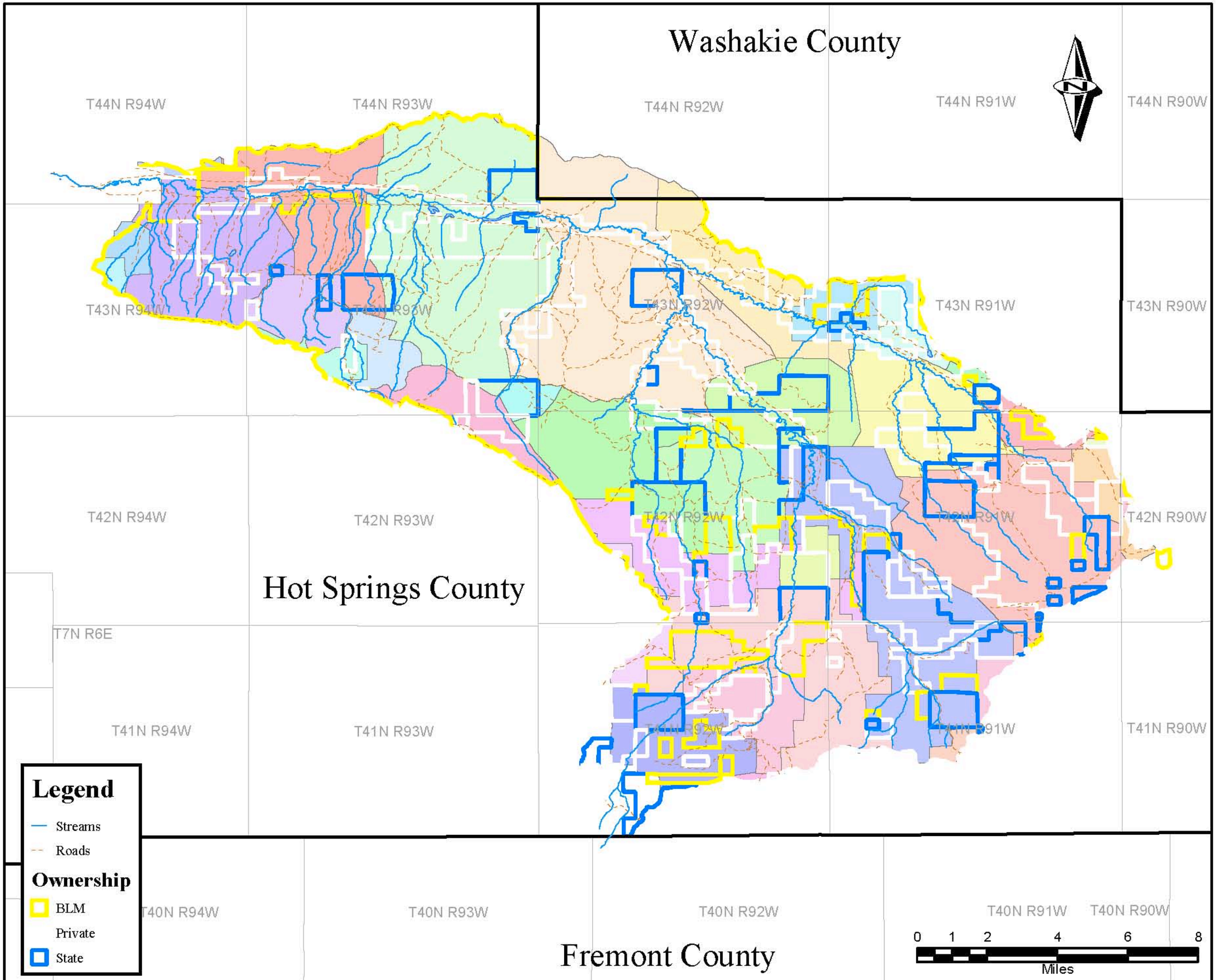

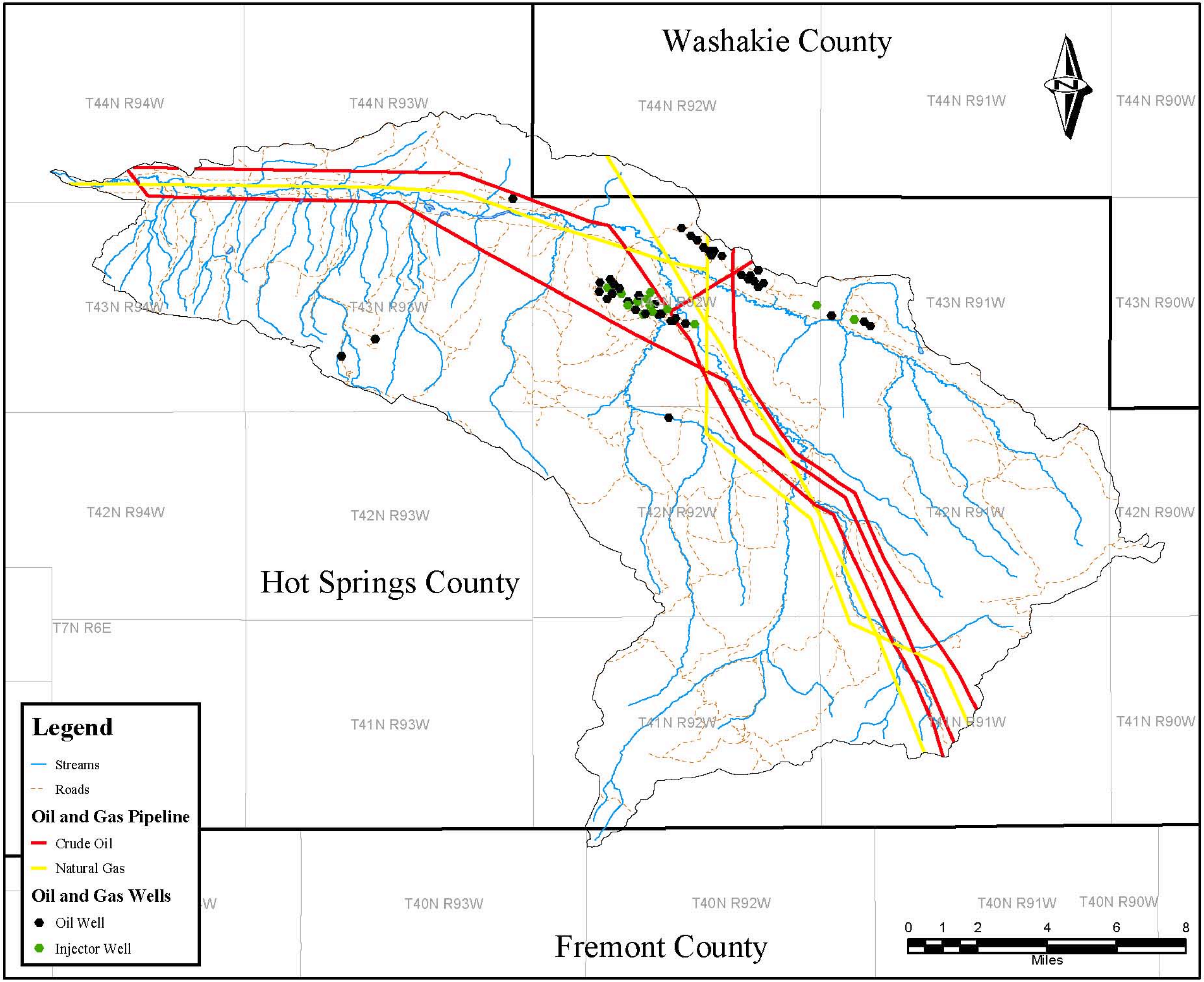

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Kirby Creek Watershed

Active Oil and Gas, Wells and Pipeline

Figure II - 3

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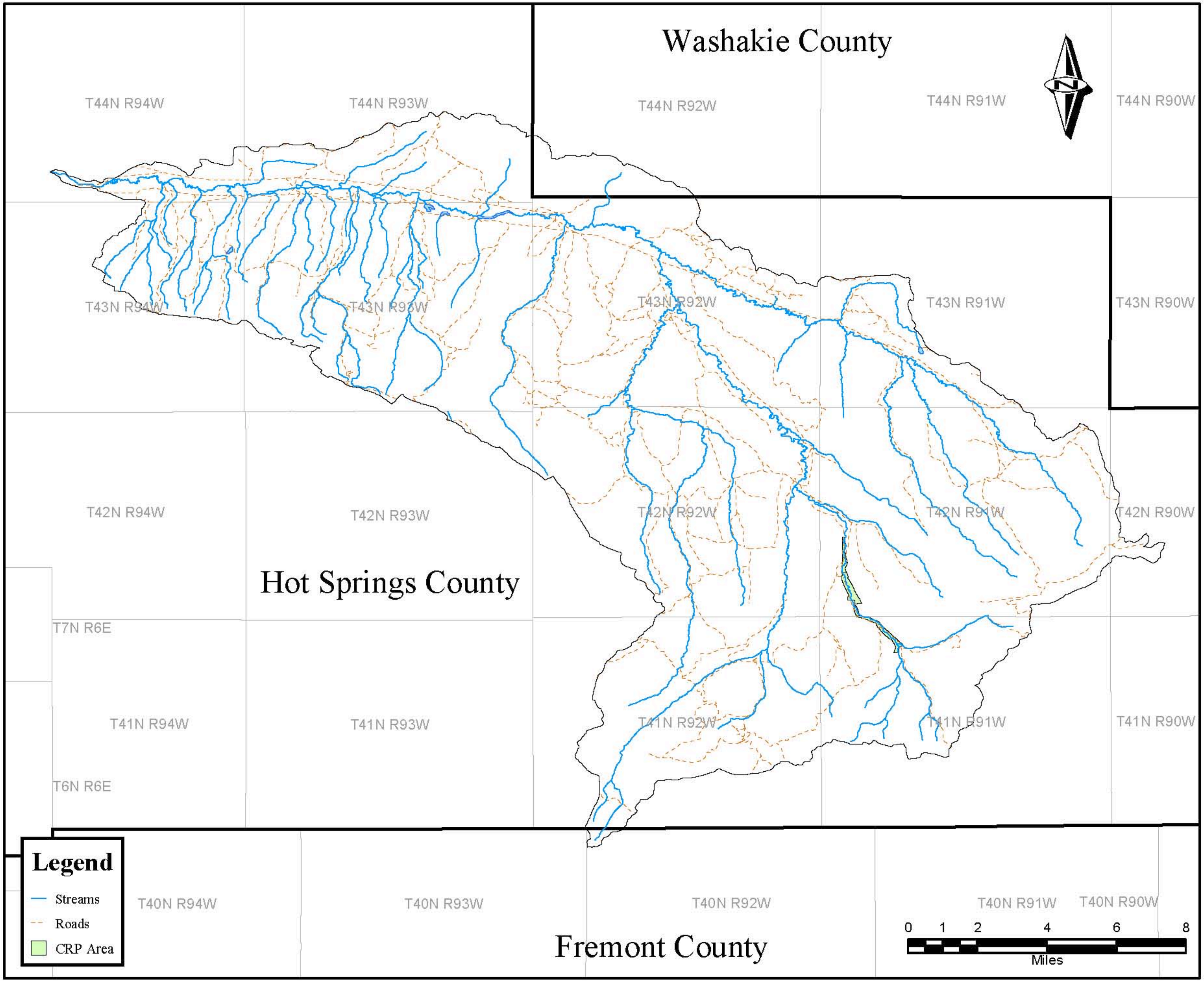
Kirby Creek Watershed

CRP Area

Figure II - 4



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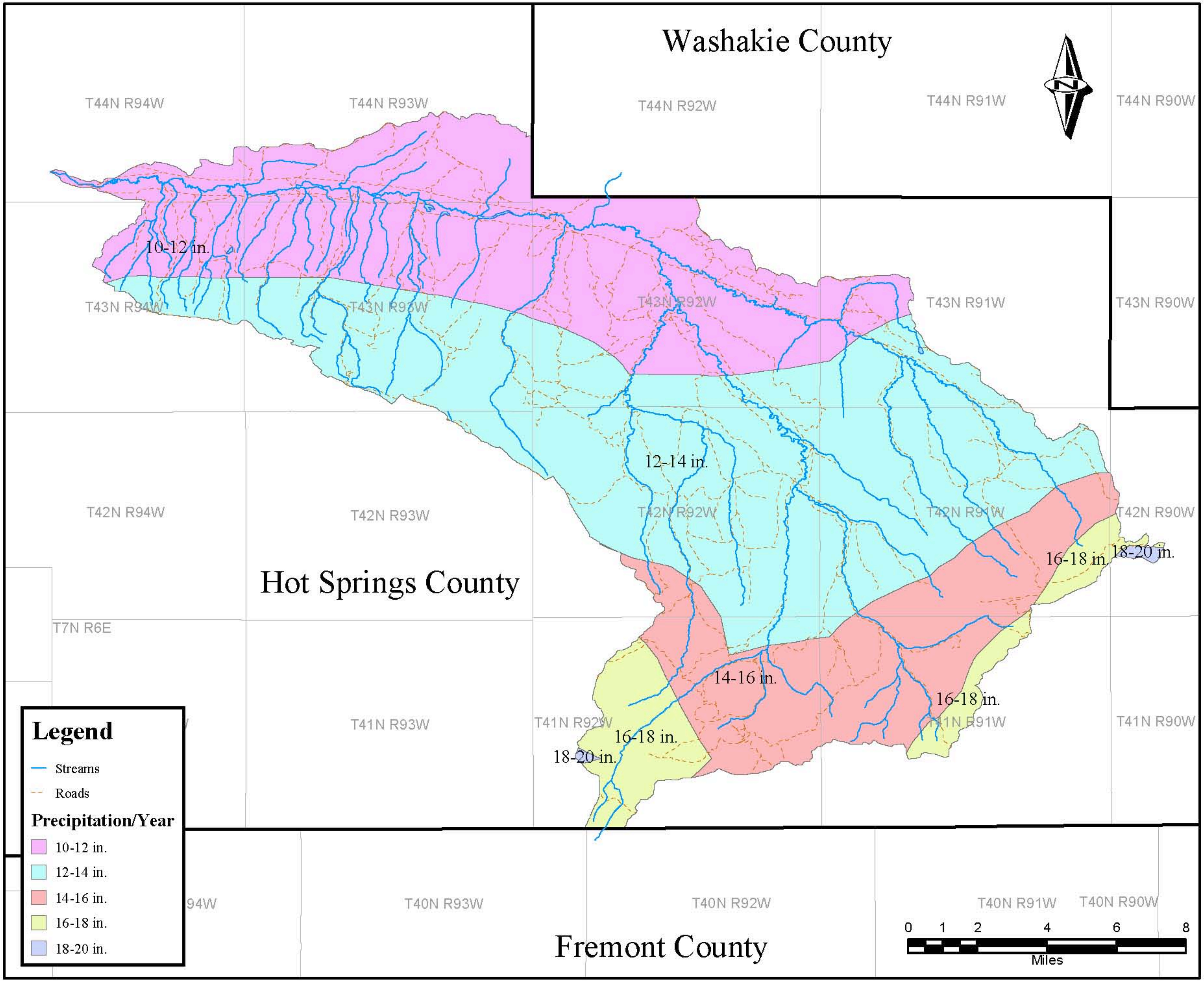
Kirby Creek Watershed

Precipitation

Figure II - 5



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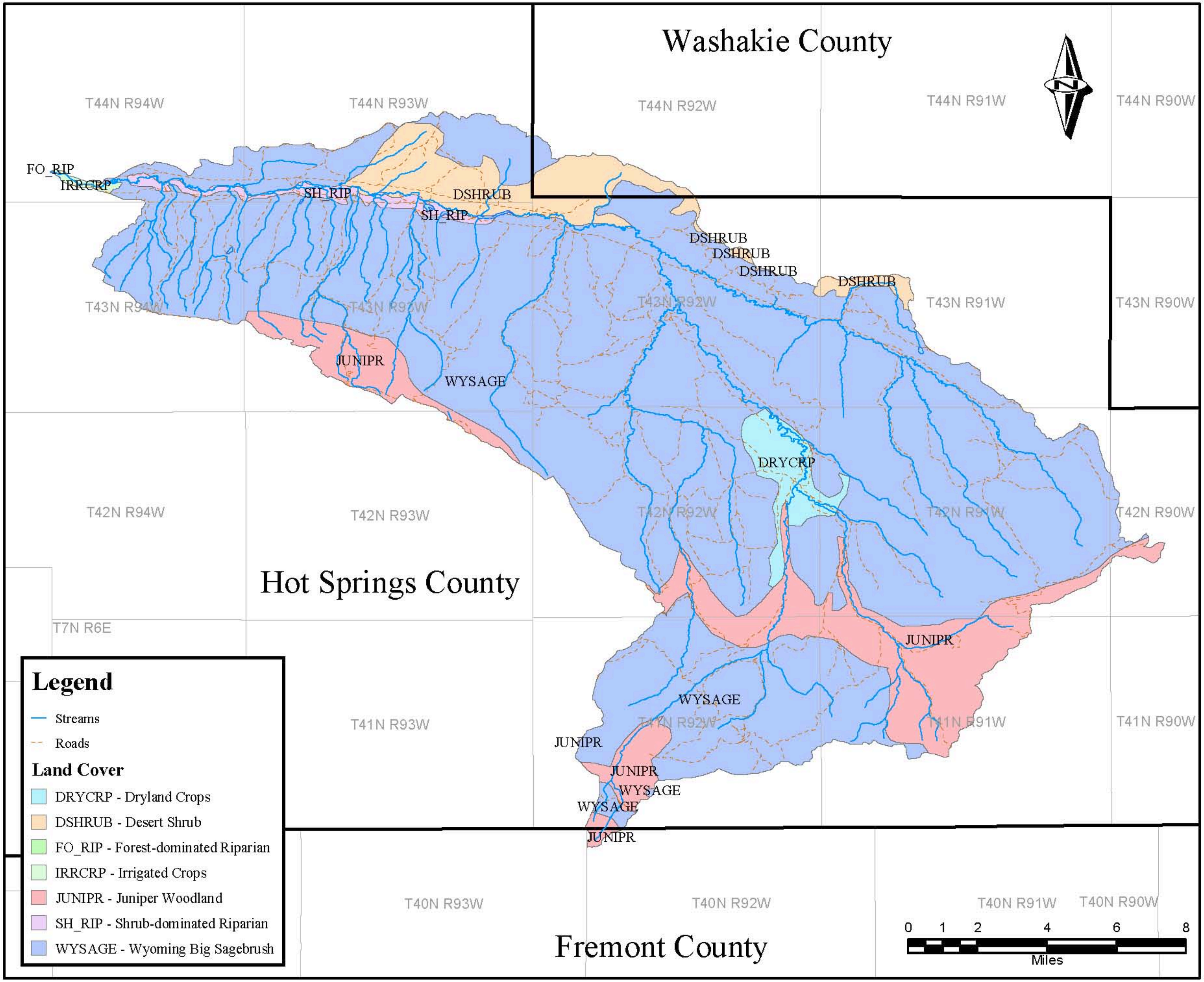
Kirby Creek Watershed

Land Cover

Figure II - 6



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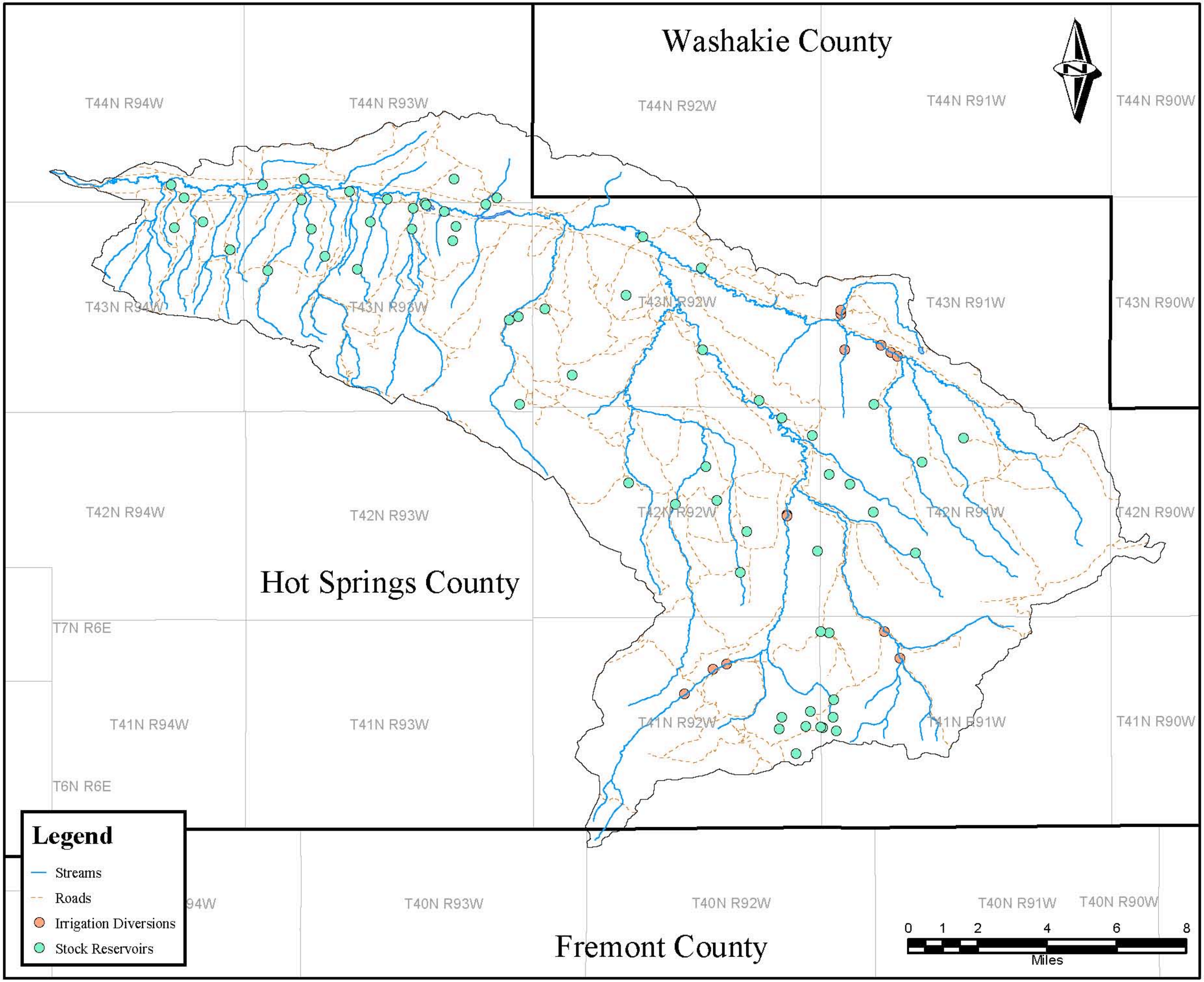
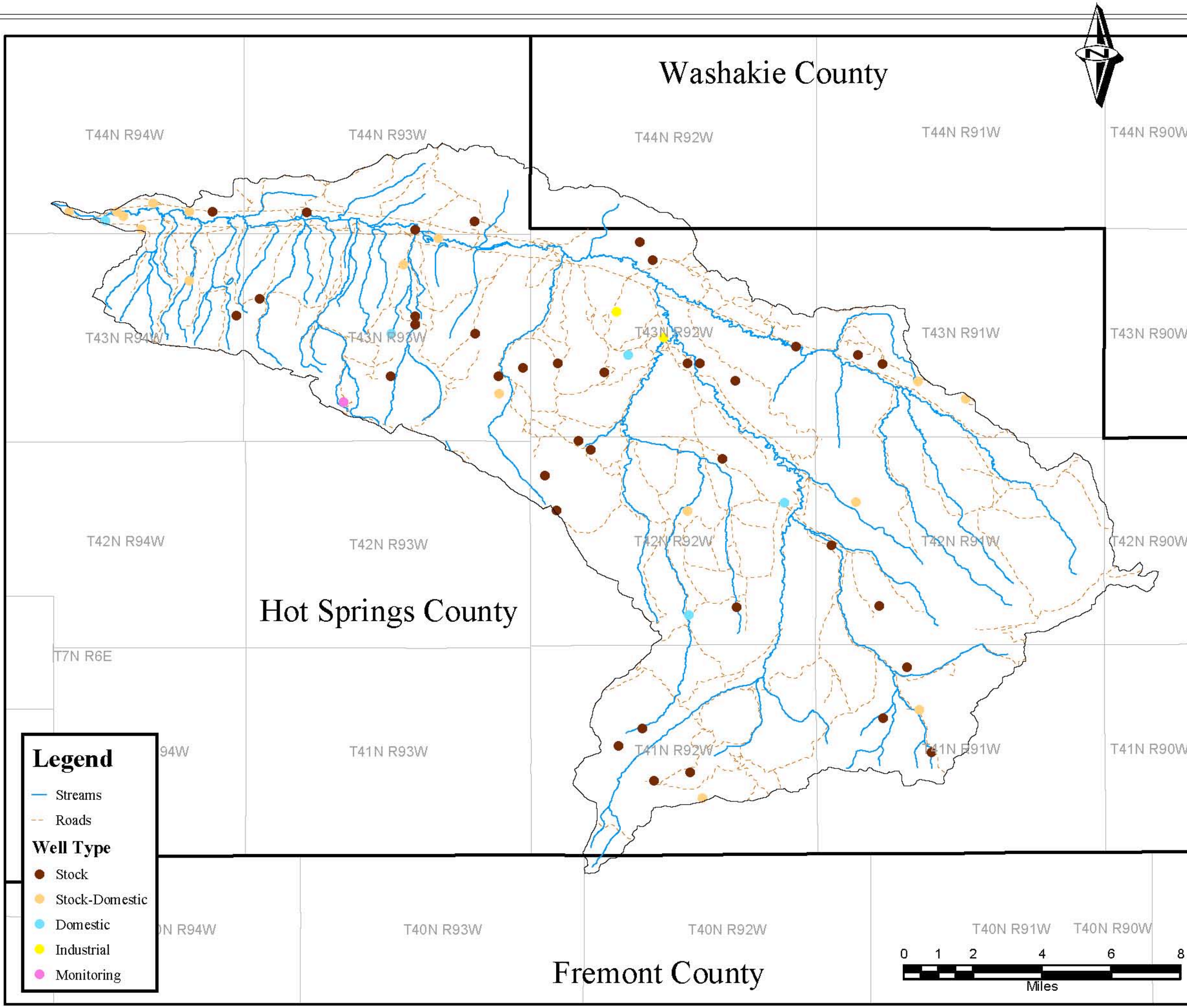
Kirby Creek Watershed

Irrigation Diversions and Stock Reservoirs

Figure II - 7





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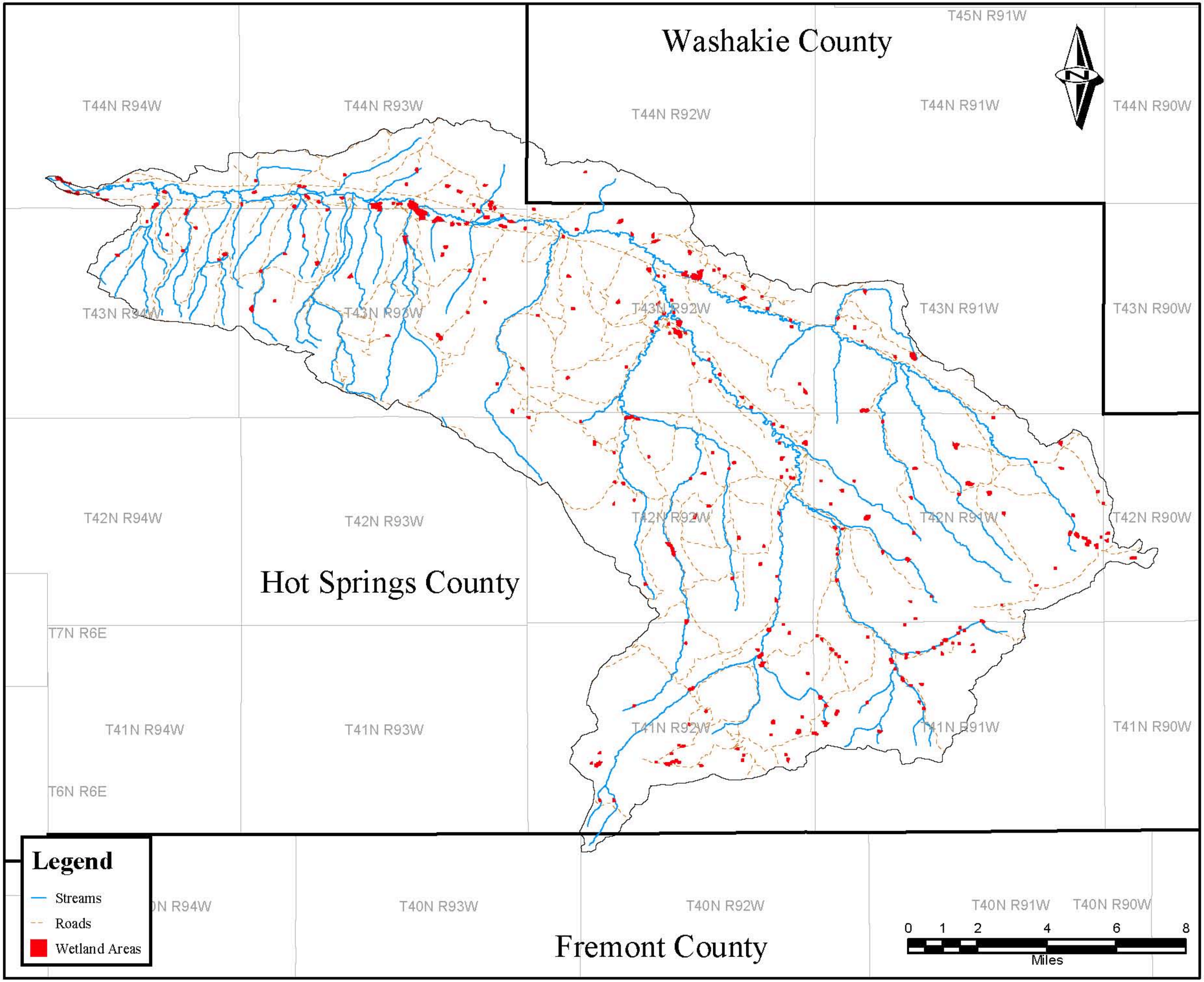
Kirby Creek Watershed

Water Wells

Figure II - 8



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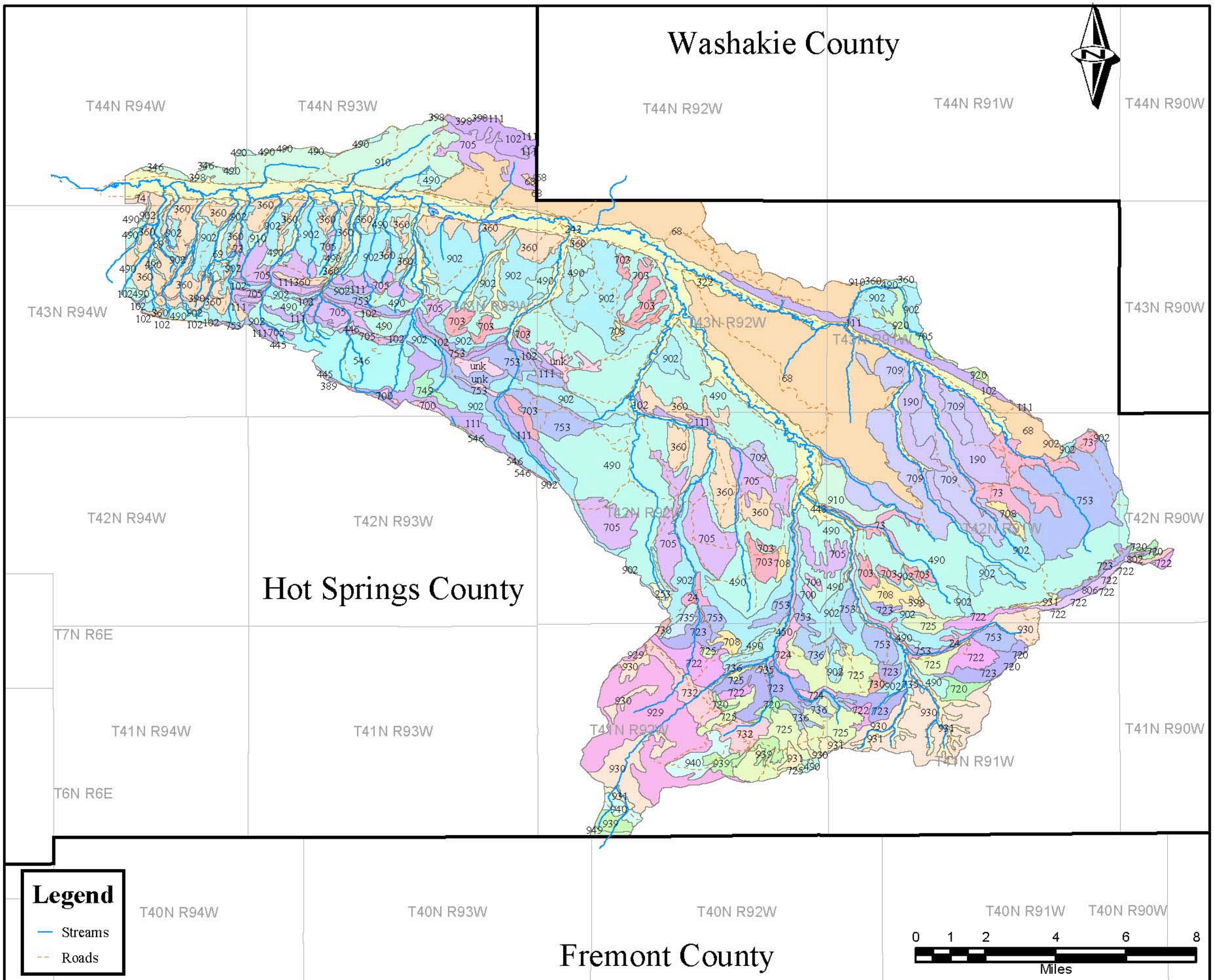
Kirby Creek Watershed

Wetland Areas

Figure II - 9



Kirby Creek Watershed

Soils

Figure II - 10

Sunrise Engineering Inc.
47 East 4th Avenue
P.O. Box 609
Afton, Wyoming 83110
www.sunrise-eng.com

Sunrise Engineering Inc.
47 East 4th Avenue
P.O. Box 609
Afton, Wyoming 83110
www.sunrise-eng.com

Kirby Creek Watershed

Land Ownership

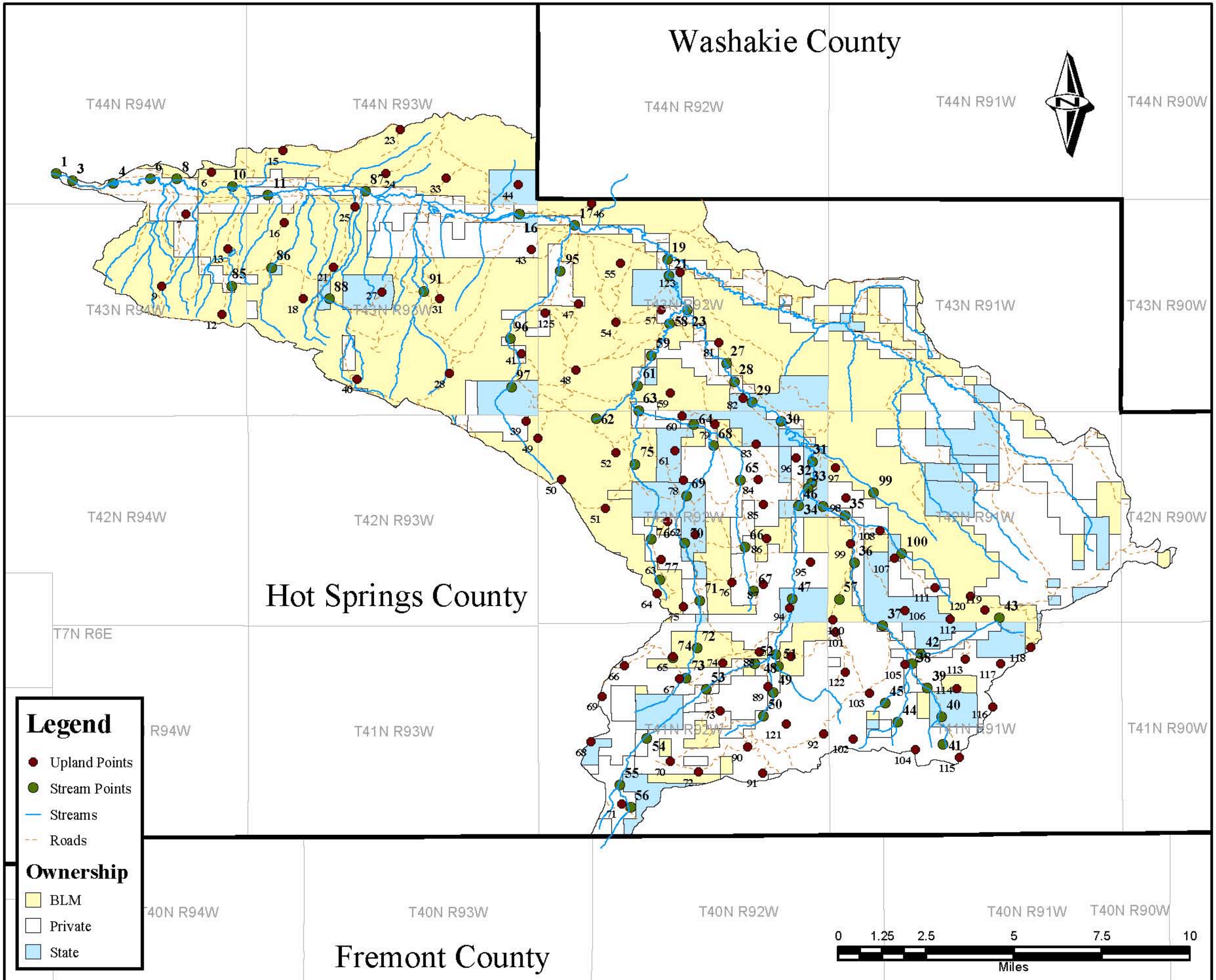
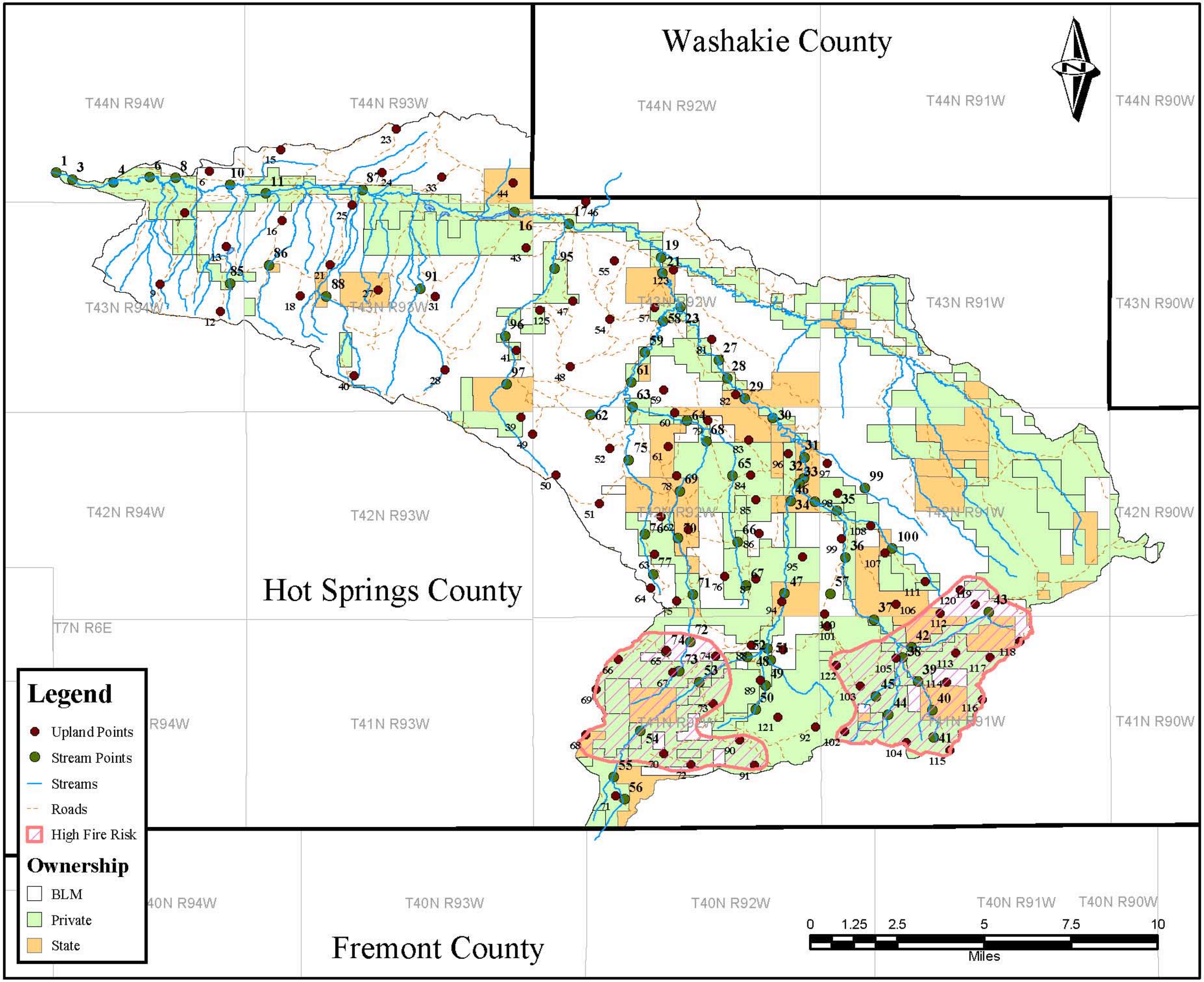


Figure III - 1



Kirby Creek Watershed

Areas With High Fire Risk

Figure IV - 1

Sunrise Engineering Inc.
47 East 4th Avenue
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Kirby Creek Watershed

Riparian Points Functioning Condition

Figure IV - 2

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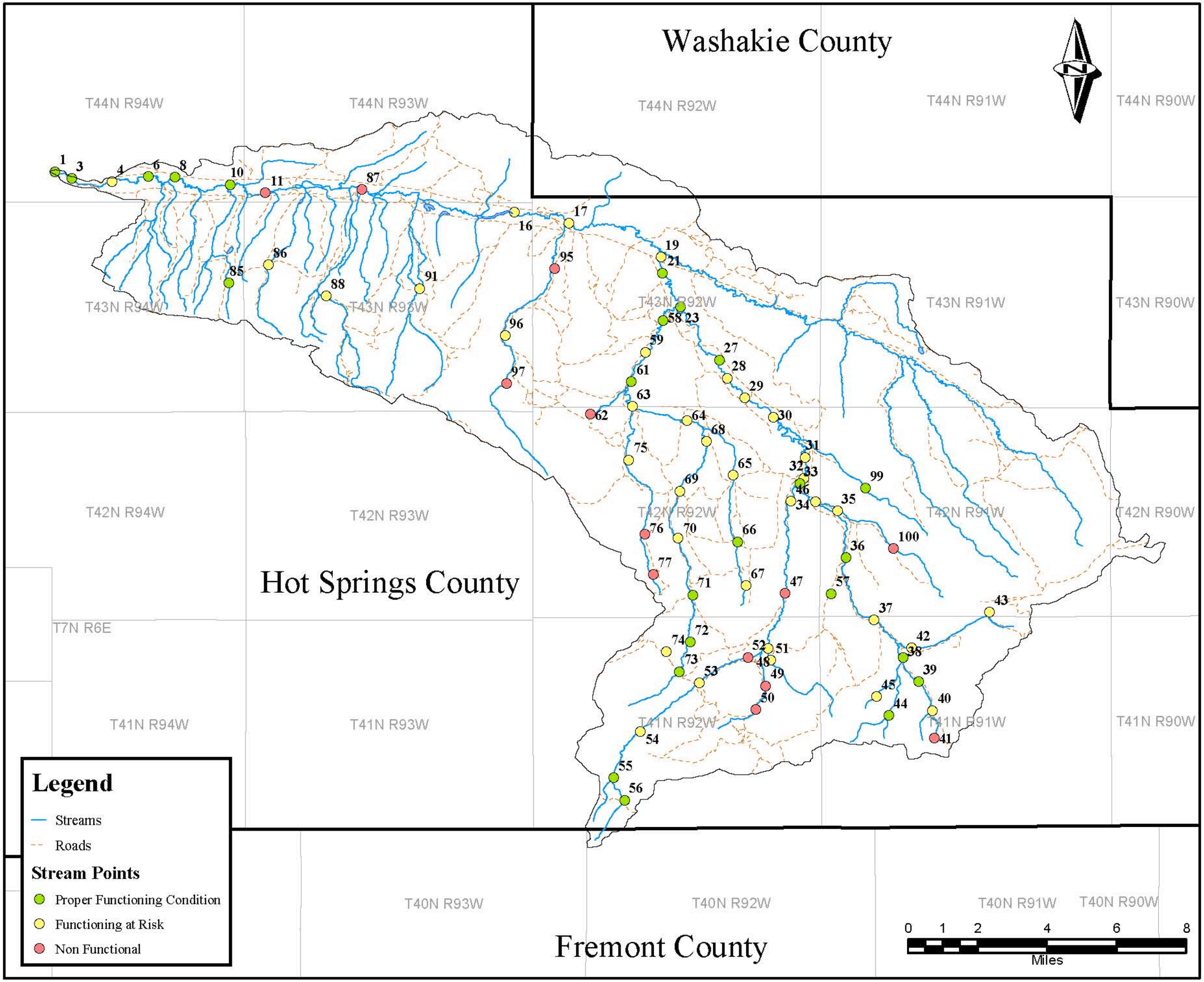

Kirby Creek Watershed

Riparian Points Erosion

Figure V - 1

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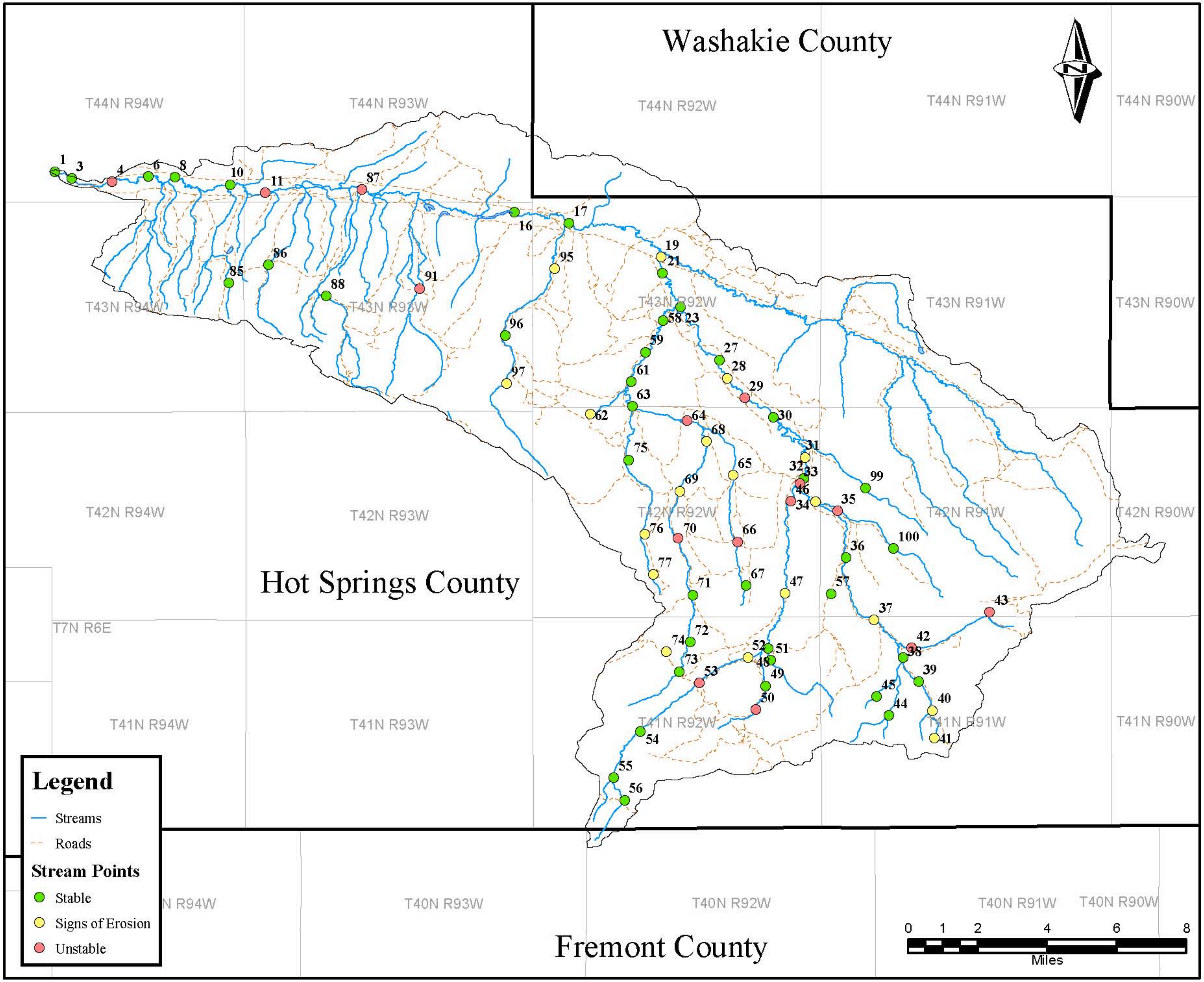

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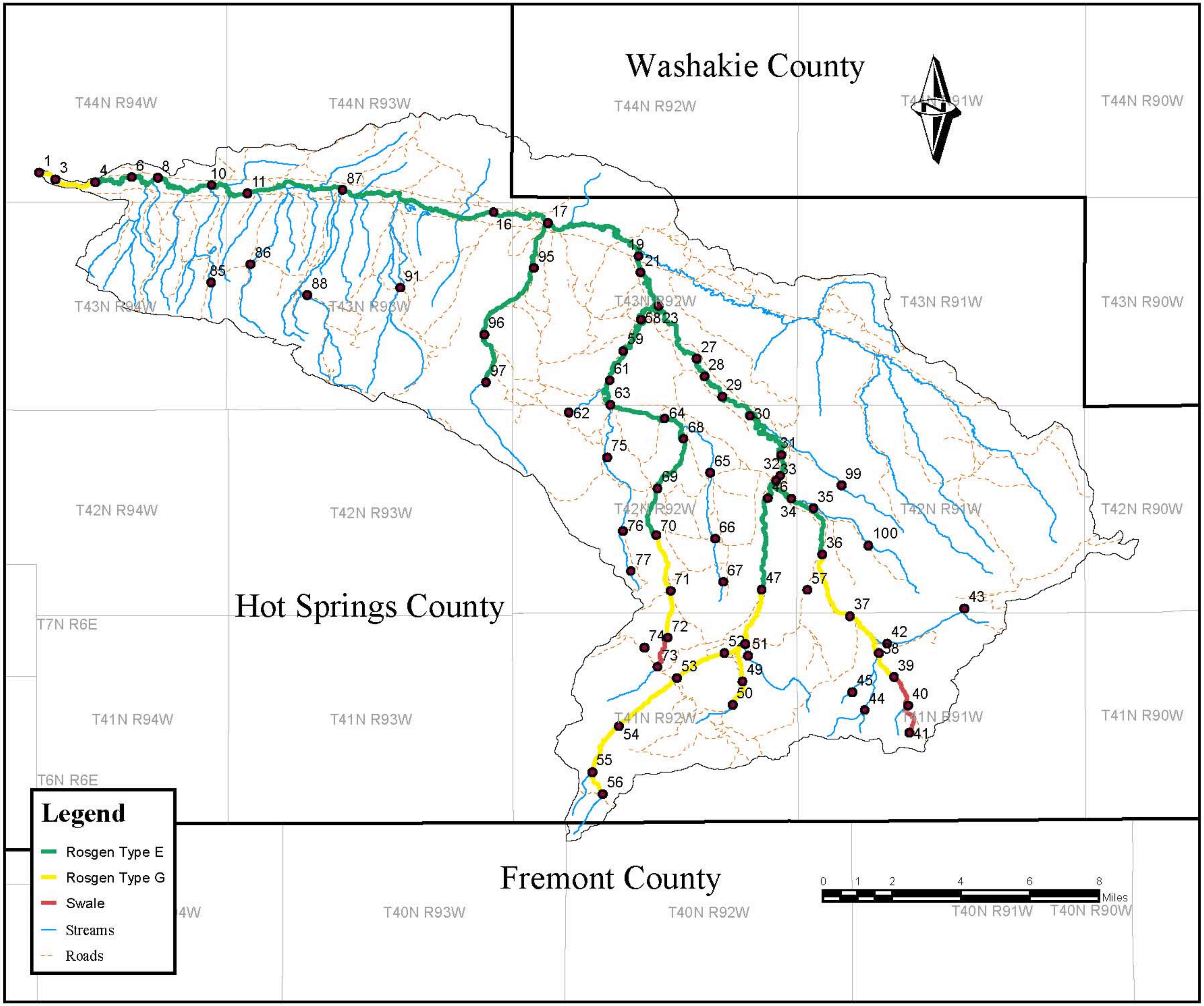
Kirby Creek Watershed

Stream Types

Figure V-11



APPENDIX A

RESERVOIR INVENTORY

ID	Reservoir Name	USGS Quadrangle	Township	Range	Section	Quarter Section
1		Cedar Mountain	44N	93W	07	NWNW
2		Cedar Mountain	44N	93W	10	SWSE
3		Cedar Mountain	44N	93W	16	SESE
4		Cedar Mountain	44N	93W	17	SWSE
5		Cedar Mountain	44N	93W	19	E/2NE/4
6		Cedar Mountain	44N	93W	19	SWSE
7	"Kirby" Reservoir	Rathbun Ranch	42N	92W	25	NENE
8	Reed No. 1 Stock Res.	Rathbun Ranch	41N	92W	13	SWSW
9		Rathbun Ranch	41N	92W	13	NESE
10		Rathbun Ranch	41N	92W	24	NWNW
11		Rathbun Ranch	41N	92W	24	NWNE
12	Friday Reservoir	Rathbun Ranch	41N	92W	24	NENE
13		Rathbun Ranch	41N	92W	24	SESW
14	Rathbun Irr. #1 Res.	Rathbun Ranch	41N	91W	18	SWSW
15		Rathbun Ranch	41N	91W	19	NWNW
16		Rathbun Ranch	41N	91W	19	NWNW
17		Rathbun Ranch	42N	91W	20	NWNW
18		Rathbun Ranch	42N	91W	29	NENE
19		Rathbun Ranch	41N	91W	06	SWNW
20		Rathbun Ranch	41N	91W	06	SWNW
21		Rathbun Ranch	42N	92W	23	NESW
22		Rathbun Ranch	42N	91W	07	SWSW
23		Rathbun Ranch	42N	91W	18	NWNE
24		Rathbun Ranch	42N	91W	09	NWSW
25	Haynes #1 Stk. Res.	Rathbun Ranch	42N	92W	26	NESW
26		Rathbun Ranch	41N	91W	18	SWNW
27		Cedar Mountain	44N	93W	16	SWSW
28	"Norman Sanford" Res.	Coyote Hill	43N	92W	27	SWNE
29		Coyote Hill	43N	92W	09	SWSE
30		Coyote Hill	43N	92W	15	NENW
31		Coyote Hill	43N	92W	17	SESE
32		Coyote Hill	43N	92W	19	NWNW
33	Jones Reservoir	Coyote Hill	43N	93W	01/02	N 1/2 Sec 1, 2
34	J&J No. 2 Res.	Red Hole	43N	93W	03	N1/2
35	J&J No. 3 Res.	Red Hole	43N	93W	03	N1/2
36		Coyote Hill	43N	93W	02	E/2SW/4
37		Coyote Hill	43N	93W	11	NENW
38		Coyote Hill	43N	93W	02	NW/4
39		Coyote Hill	43N	93W	36	SE/4
40	Blue Springs Draw Res.	Coyote Hill	43N	93W	24	NE/4
41		Coyote Hill	43N	93W	24	SWNE
42		Coyote Hill	44N	93W	36	SWSW
43		Coyote Hill	44N	93W	35	SENW
44	Blue Spring	Coyote Hill	43N	93W	36	NWNE
45	Spring	Coyote Hill	43N	93W	25	NENW
46	Malcolm Spring	Coyote Hill	42N	92W	05	NWNW
47	Brontley Spring	Coyote Hill	42N	92W	04	NWNW
48	Spring	Coyote Hill	42N	92W	03	SWNE
49		Red Hole	43N	93W	03	NWNE
50		Red Hole	43N	93W	03	SWSE
51		Red Hole	43N	93W	04	NWSE
52		Red Hole	43N	93W	05	SESW
53	Rock Springs	Red Hole	43N	93W	07	SESW
54		Red Hole	43N	93W	08	NWSE
55		Red Hole	43N	93W	09	SESW
56	Red Springs	Red Hole	43N	93W	17	NWSE
57		Red Hole	44N	93W	31	NESW
58		Red Hole	44N	93W	32	SWSW
59		Red Hole	44N	93W	32	S/2NW/4
60		Red Hole	44N	93W	33	SESE
61		Red Hole	44N	94W	35	NESW
62		Red Hole	44N	94W	35	S/2S/2
63		Red Hole	43N	94W	01	NWSW
64		Red Hole	43N	94W	02	SWSE
65		Red Hole	43N	94W	12	NE/4
66		Red Hole	44N	93W	33	SW/4
67		Packsaddle Creek	43N	92W	35	SESE
68		Packsaddle Creek	42N	92W	01	NW/4
69		Packsaddle Creek	42N	91W	04	SESE

70		Packsaddle Creek	43N	91W	32	SWSW
71		Packsaddle Creek	42N	92W	01	SESE
72	Ray Spring No. 3	Coyote Hill	43N	92W	15	?
73	Ray Spring No. 2	Coyote Hill	43N	92W	14	?
74	Ray Spring No. 1	Coyote Hill	43N	92W	14	?
75	Fees Spring No. 1	Packsaddle Creek	43N	91W	19	?
76	Walker Spring No. 1	Packsaddle Creek	43N	91W	29	?
77	Walker Spring No. 2	Packsaddle Creek	43N	91W	29	?
78		Blue Hill	42N	92W	10	W/2SE/4
79		Blue Hill	42N	92W	16	NWNW
80		Blue Hill	42N	92W	15	SE/4
81		Blue Hill	42N	92W	15	SWSW
82		Zimmerman Buttes	44N	93W	13	NESW
83		Zimmerman Buttes	44N	93W	15	SESE
84		Coyote Hill	43N	92W	09	NENW
86		Coyote Hill	43N	92W	19	NWNW
87	"Beaver Pond No. 1"	Rathbun Ranch	41N	91W	08	NWNE
88	"Beaver Pond No. 2"	Rathbun Ranch	41N	91W	05	SENW
89	"Beaver Pond No. 3"	Rathbun Ranch	41N	91W	05	SENW
90	Rock Springs Draw Res #1	Red Hole	43N	93W	07	SWSE
91	Monument Hill Res #1	Coyote Hill	43N	92W	31	NENE

ID	UTM Northing (Outlet)	UTM Easting (Outlet)	Land ownership	Type of Dam	Condition of Dam
1	4,853,769N	735,555.3E Z12	BLM	Stock Res.	OK
2	4,852,665.3N	740,922.3E Z12	BLM	Stock Res.	OK
3	4,851,392.6N	739,892.5E Z12	State	Stock Res.	OK
4	4,851,067.2N	738,076.1E Z12	State	Stock Res.	OK
5	4,850,465.8N	736,852.7E Z12	BLM	Stock Res.	OK
6	4,849,254.9N	736,214.3E Z12	BLM	Stock Res.	OK
7	4,829,636.5N	270,879.2E Z13	Private	Stock Res.	OK
8	4,822,050.9N	269,417.6E Z13	Private	Stock Res.	Possible breach
9	4,822,198.96N	270,414.7E Z13	Private	Stock Res.	OK
10	4,821,436.9N	269,339.2E Z13	Private	Stock Res.	OK
11	4,821,602.4N	270,292.8E Z13	Private	Stock/Irr. Res.	Good
12	4,821,450.02N	270,754.3E Z13	Private	Stock Res.	Good
13	4,820,317.9N	269,874.8E Z13	Private	Stock Res.	Good
14	4,821,976.9N	271,150.6E Z13	Private	Stock/Irr. Res.	Good
15	4,821,284.6N	270,980.8E Z13	Private	Stock Res.	OK
16	4,821,463.1N	271,120.1E Z13	Private	Stock Res.	OK
17	4,831,288.2N	272,839.9E Z13	Private	Stock Res.	Good
18	4,829,399.5N	274,179.6E Z13	BLM	Stock Res.	Breached
19	4,825,900.2N	270,922.6E Z13	Private	Stock Res.	OK
20	4,825,820.3N	271,178.4E Z13	Private	Stock Res.	OK
21	4,830,611.4N	268,553.3E Z13	Private	Stock Res.	OK
22	4,833,120.8N	271,453.5E Z13	BLM	Stock Res.	OK
23	4,832,648.0N	272,125.3E Z13	BLM	Stock Res.	OK
24	4,833,559.02N	274,549.7E Z13	State	Stock Res.	
25	4,828,729.9N	268,291.9E Z13	Private	Stock Res.	OK
26	4,822,751.9N	271,228.96E Z13	Private	Stock Res.	OK
27	4,851,259.6N	738,911.2E Z12	State	Stock Res.	OK
28	4,838,966.1N	267,474.6E Z13	Private	Stock Res.	OK
29	4,843,128.2N	266,008.5E Z13	State	Detention Dam	OK
30	4,842,776.1N	267,460.1E Z13	Private	Stock Res.	OK
31	4,841,628.3N	264,933.0E Z13	BLM	Stock Res.	OK
32	4,841,078.5N	262,164.7E Z13	BLM	Detention Dam	OK
33	4,845,485.0N	259,938.1E Z13	Private	Stock/Irr. Res	breached
34	4,846,142.5N	741,534.1E Z12	Private	Stock/Irr. Res	OK
35	4,846,142.5N	741,534.1E Z12	Private	Stock/Irr. Res	OK
36	4,844,832.5N	259,247.6E Z13	Private	Stock Res.	OK
37	4,844,399.2N	259,228.6E Z13	Private	Stock Res.	OK
38	4,845,732.7N	258,990.4E Z13	Private	Stock Res.	Breached?
39	4,836,765.4N	261,171.2E Z13	State	Stock Res.	OK
40	4,841,101.13N	262,184.16E Z13	BLM	Stock Res.	OK
41	4,840,652.6N	260,938.7E Z13	Private	Stock Res.	OK
42	4,846,310.2N	260,737.8E Z13	State	Stock Res.	OK
43	4,847,148.8N	259,337.2E Z13	BLM	Stock Res.	OK
44	4,837,903.2N	260,809.5E Z13	State	Spring	NA
45	3,839,583.2N	260,760.5E Z13	BLM	Spring	NA
46	4,836,129.6N	263,452.0E Z13	BLM	Spring	NA
47	4,836,294.5N	265,154.2E Z13	Private	Spring	NA
48	4,845,759.8N	267,155.1E Z13	Private	Spring	NA
49	4,845,888.4N	741,215.4E Z12	Private	Stock Res.	Breached?
50	4,844,922.4N	741,185.4E Z12	Private	Stock Res.	OK
51	4,845,228,4N	739,721,4E Z12	Private	Stock Res.	OK
52	4,844,790.4N	737,777.4E Z12	BLM	Stock Res.	OK
53	4,842,924.4N	736,355.4E Z12	BLM	Spring	NA
54	4,843,578.4N	738,281.4E Z12	BLM	Stock Res.	OK
55	4,843,014.4N	739,421.4E Z12	BLM	Stock Res.	OK
56	4,841,855.8N	738,113,8E Z12	State	Spring	NA
57	4,846,730.2N	736,997.9E Z12	Private	Stock Res.	OK
58	4,846,155.3N	737,426.1E Z12	Private	Stock Res.	OK
59	4,847,003.96N	737,446.6E Z12	Private	Stock Res.	Breached?
60	4,846,273.9N	740,289.3E Z12	Private	Stock Res.	OK
61	4,846,684.6N	733,006.9E Z12	Private	Stock Res.	OK
62	4,846,141,6N	733,134.0E Z12	Private	Stock Res.	OK
63	4,845,046.5N	734,170.4E Z12	BLM	Stock Res.	OK
64	4,844,676.9N	733,180.3E Z12	Private	Stock Res.	OK
65	4,843,869.3N	735,165.2E Z12	BLM	Stock Res.	OK
66	4,846,596.3N	739,003.9E Z12	Private	Stock Res.	OK
67	4,836,614.4N	269,178.02E Z13	State	Stock Res.	OK
68	4,835,794.5N	270,889.2E Z13	Private	Stock Res.	OK
69	4,835,662.1N	275,991.5E Z13	State	Stock Res.	OK

70	4,836,336.8N	273,109.1E Z13	BLM	Stock Res.	OK
71	4,834,854.2N	278,889.2E Z13	BLM	Stock Res.	OK
72	?	?	Private	Spring	NA
73	?	?	Private	Spring	NA
74	?	?	Private	Spring	NA
75	?	?	Private	Spring	NA
76	4,838,742.4N	274,254.98E Z13	Private	Spring	NA
77	4,838,742.4N	274,254.98E Z13	Private	Spring	NA
78	4,833,490.8N	267,053.9E Z13	Private	Stock Res.	OK
79	4,833,234.6N	264,780.01E Z13	State	Stock Res.	OK
80	4,832,099.2N	267,614.7E Z13	Private	Stock Res.	OK
81	4,832,144.9N	266,323.1E Z13	State	Stock Res.	OK
82	4,851,717.7N	261,024.5E Z13	BLM	Stock Res.	OK
83	4,851,422.8N	258,647.8E Z13	BLM	Stock Res.	OK
84	4,844,174.6N	265,666.1E Z13	Private	Stock Res.	Breached/ headcutting
86	4,841,102.6N	261,995.9E Z13	BLM	Stock Res.	OK
87	4,824,570.68N	273,603.64E Z13	Private	Beaver Dam	Good 7/28/01
88	4,825,835.77N	273,094.42E Z13	Private	Beaver Dam	Good 7/28/01
89	4,826,006.58N	272,998.70E Z13	Private	Beaver Dam	Good 7/28/01
90	4,843,066.34N	736,376.02E Z12	State	Stock Res.	Poor but holding
91	4,838,121.69N	262,976.60E Z13	BLM	Stock Res.	Good

ID	SEO Permit Number (Adjudicated)	Approx Capacity (acre-feet)	Dam Length (feet)	Dam Width (feet)	Reservoir length (full)	Reservoir width (full)
1			50'	10'	250'	100'
2			100'	12'	600'	100'
3			200'	12'	550'	200'
4			200'	12'	100'	100'
5			200'	12'	900'	200'
6			100'	12'	150'	100'
7			235'	12'	325'	300'
8	1257SR	5.32 a.f.	225'	12'	315'	300'
9			50'	10'	50'	40'
10			50'	10'	100'	60'
11			363'	15'	665'	350'
12	5074R	4.23 a.f.	198'	12'	185'	160'
13			196'	12'	170'	266'
14	6401R	23.11 a.f.	215'	50'	764'	200'
15			100'	10'	100'	75'
16			100'	10'	100'	75'
17			360'	53' (base)	840'	350'
18			181'	15'	328'	40'
19			50'	10'	300'	50'
20			100'	10'	300'	70'
21			60'	12'	200'	100'
22			80'	10'	100'	100'
23			150'	12'	150'	150'
24			150'	12'	300'	200'
25	4664SR	2.60 a.f.	50'	10'	250'	100'
26			100'	10'	150'	100'
27			100'	10'	150'	75'
28			252'	40'	699'	200'
29			384'	12'	137'	300'
30			180'	35'	283'	150'
31			200'	20'	300'	200'
32			100'	10'	100'	100'
33			670'		2900'	300'
34	6028R	16.40 a.f.	850'	45'	1115'	800'
35	6029R	7.0 a.f.				
36			236'	12'	336'	200'
37			225'	12'	435'	250'
38			422'	10'	760'	350'
39			48'	10'	190'	150'
40			100'	12'	150'	100'
41			50'	10'	50'	50'
42			200'	12'	300'	200'
43			100'	10'	200'	100'
44			NA	NA	NA	NA
45			NA	NA	NA	NA
46			NA	NA	NA	NA
47			NA	NA	NA	NA
48			NA	NA	NA	NA
49			300'	12'	400'	300'
50			50'	10'	200'	50'
51			200'	12'	350'	200'
52			75'	10'	250'	50'
53			NA	NA	NA	NA
54			100'	10'	250'	80'
55			120'	10'	300'	90'
56			NA	NA	NA	NA
57			50'	10'	100'	40'
58			300'	12'	500'	300'
59						
60			150'	10'	550'	100'
61			100'	10'	200'	80'
62			228'	12'	1125'	120'
63			229'	10'	842'	200'
64			289'	10'	132'	200'
65			490'	60' (base)	735'	350'
66			200'	10'	220'	150'
67			50'	10'	100'	80'
68			200'	10'	150'	180'
69			550'	20'	700'	450'

70			200'	12'	400'	200'
71			100'	10'	350	100'
72	15110	0.01 c.f.s.	NA	NA	NA	NA
73	15109	0.02 c.f.s	NA	NA	NA	NA
74	15108	0.02 c.f.s	NA	NA	NA	NA
75	15105	NA	NA	NA	NA	NA
76	15089	0.08 c.f.s	NA	NA	NA	NA
77	15090	0.04 c.f.s.	NA	NA	NA	NA
78			92'	10'	102'	50'
79			140'	12'	250'	100'
80			239'	12'	176'	200'
81			73'	137'	200'	70'
82			168'	12'	620'	150'
83			300'	12'	495'	300'
84			300'	20'	1000'	200'
86			150'	10'	200'	150'
87	NA	2 a.f.	250'	12'	800'	250'
88	NA	1 a.f.	80'	10'	600'	70'
89	NA	0.6 a.f.	75'	10'	400'	75'
90		0.4 a.f.	180'	1-10'	500'	200'
91		0.10 a.f. or less	100'	6'	200'	120'

ID	Date last inspected	Date of DOQ used	Photos available?	Source of water to reservoir	Active riparian area?
1		1994	Yes	Unnamed trib. To Double Draw	No
2		1994	Yes	Unnamed trib. To Sand Draw	No
3		1994	Yes	Unnamed trib. To Sand Draw	No
4		1994	Yes	Unnamed trib. To Sand Draw	No
5		1994	Yes	Unnamed trib. To Sand Draw	No
6		1994	Yes	Unnamed trib. To Sand Draw	No
7		1994		Unnamed trib. to E. Kirby Cr.	
8		1994		Friday Draw trib. To Reed Crk.	No
9		1994		Seeps trib. To Dry Fk. W. Kirby	None
10		1994		Seeps trib. To Dry Fk. W. Kirby	Yes
11		1994	Yes	Springs trib. To Reed Crk.	Yes
12		1994	Yes	Friday Draw trib. Reed Crk.	Yes
13		1994	Yes	Springs trib. To Reed Crk.	Yes
14		1994	Yes	Springs trib. To Dry Fk. W. Kirby Cr.	Yes
15		1994	Yes	Springs trib. To Dry Fk. W. Kirby Cr.	
16		1994	Yes	Springs trib. To Dry Fk. W. Kirby Cr.	
17		1994	Yes	Unnamed trib. To E. Kirby Crk.	Yes
18		1994	Yes	Unnamed trib. To E. Kirby Crk.	No
19		1994	Yes	Unnamed trib.to Ackles Fk. E. Kirby Cr.	Yes
20		1994	Yes	Unnamed trib.to Ackles Fk. E. Kirby Cr.	Yes
21		1994		Unnamed trib. To Olsen Draw	No
22		1994		Unnamed trib. To Kirby Crk.	No
23		1994		Unnamed trib. To Kirby Crk.	
24		1994		Unnamed trib. To Kirby Crk.	
25		1994		Haynes Draw trib. Kirby Crk.	
26		1994		Dry Fork trib. To Reed Crk.	
27		1994		Unnamed trib. To Sand Draw	No
28		1994	Yes	Kirby Creek (on channel)	Yes
29		1994	Yes	Unnamed trib. To Kirby Crk.	No
30		1994	Yes	Unnamed trib. To Lake Crk.	Yes
31		1994		Unnamed trib. To Kirby Crk.	Yes
32		1994		Unnamed trib. To Blue Springs Draw	No
33		1994		Kirby Creek (on channel)	No
34		1994	Yes	Kirby Creek (on channel)	Yes
35		1994		Kirby Creek (on channel)	
36		1994		Unnamed trib. To Kirby Crk.	
37		1994		Unnamed trib. To Kirby Crk.	
38		1994		Unnamed trib. To Kirby Crk.	
39		1994		Unnamed trib. To Blue Springs Draw	
40	7/22/01 G. Hurley	1994	Yes	Blue Springs Draw trib. Kirby Crk.	Yes
41		1994		Blue Springs Draw trib. Kirby Crk.	Yes
42		1994		Oil wells, unnamed trib. To Kirby Crk.	No
43		1994		Unnamed trib. To Kirby Crk.	No
44		1994		Groundwater	Yes
45		1994		Groundwater	Yes
46		1994		Groundwater	Yes
47		1994		Groundwater	Yes
48		1994		Groundwater	
49		1994		Unnamed trib. To Kirby Crk.	No
50		1994		Unnamed trib. To Kirby Crk.	Yes
51		1994		Unnamed trib. To Kirby Crk.	Yes
52	8/14/2001	1994	Yes	Unnamed trib. To Rock Springs Draw	Yes
53		1994		Groundwater	
54		1994		Unnamed trib. To Kirby Crk.	
55		1994		Unnamed trib. To Kirby Crk.	
56		1994		Groundwater	
57		1994		Unnamed trib. To Kirby Creek	
58		1994		Rock Springs Draw trib. Kirby Crk.	
59		1994		Unnamed trib. To Kirby Crk.	No
60		1994		Unnamed trib. To Kirby Crk.	Yes
61		1994		Unnamed trib. To Kirby Crk.	Yes
62		1994		Unnamed trib. To Kirby Crk.	Yes
63		1994		Unnamed trib. To Kirby Crk.	Yes
64		1994		Unnamed trib. To Kirby Crk.	
65		1994		Unnamed trib. To Kirby Crk.	No
66		1994		Unnamed trib. To Kirby Crk.	Yes
67		1994		Unnamed trib. To Kirby Crk.	
68		1994		Unnamed trib. To Kirby Crk.	Yes
69		1994		Unnamed trib. To Lake Creek	Yes

70			1994		Unnamed trib. To Cottonwood Crk.	Yes
71			1994		Unnamed trib. To Kirby Crk.	No
72			1994		Groundwater	Yes
73			1994		Groundwater	Yes
74			1994		Groundwater	Yes
75			1994		Groundwater	Yes
76			1994		Groundwater	
77			1994		Groundwater	
78			1994		Alkali Creek trib. Kirby Crk.	
79			1994		Major Basin Draw	
80			1994		Unnamed trib. To Alkali Crk.	Dry
81			1994		Alkali Crk. Trib. To Kirby Crk.	Wet in '94
82			1994		Unnamed trib. To Nowater Crk.	
83			1994		Unnamed trib. To Kirby Creek	
84	7/2001		1994		Kirby Creek (on channel)	No
86	7/2001		1994	Yes	Unnamed trib. Kirby Crk.	Yes
87	7/28/01		NA	Yes	East Kirby Creek (on channel)	Yes
88	7/28/01		NA	Yes	East Kirby Creek (on channel)	Yes
89	7/28/01		NA	Yes	East Kirby Creek (on channel)	Yes
90	8/14/01	G. Hurley	1994	Yes	Rock Springs Draw	Yes
91	8/14/01	G. Hurley	1994	Yes	Unnamed Trib. to Alkali Creek	Yes

ID	Riparian vegetation types	Comments
1		
2		
3		
4		
5		
6		
7		
8	None	Permitee: Clinton C. Reed; Priority: 10-14-1955
9	None	More of a pond than a reservoir
10		
11		
12		Permitee: Twila Wood; Priority date 6/13/1939
13		
14		Permitee: Twila Wood; Priority date 7/5/1956
15		
16		
17		
18		
19		Located just downstream of Rathun Ranch
20		Located just downstream of Rathun Ranch
21		
22		
23		
24		
25		Permitee: L.M. Haynes; Priority date 9/17/1962
26		
27		
28	Willow, cattail, rushes	Norman Sanford - owner
29		
30	Cattail, rushes	Lyman ranches - owner
31	Cattail, rushes	Dave and Joann Jones owners
32		
33		Dry
34	Cattails, rushes, willow	Dave and Joann Jones owners
35		Dave and Joann Jones owners
36		
37		
38		Dry
39		
40	Cottonwoods, cattails, bulrushes	Spillway headcutting towards reservoir, dam unstable, holding water 7/22/2001 after recent storm eve
41	cattails, bulrushes	Spring fed, green on 7/22/01
42		
43		
44		
45		
46		
47		
48		
49		
50		
51		
52	Cottonwoods	Reservoir inspected from a distance and photographed 8/14/2001
53		
54		
55		
56		
57		
58		
59		Dry, may just be a depression not a reservoir
60		
61		
62		
63		
64		
65		Dry shallow depression with a dam
66		
67		
68		
69		

70		
71		Dry
72		Permittee: Bertie Ray Priority Date: 6/6/1918
73		Permittee: Bertie Ray Priority Date: 6/6/1918
74		Permittee: Bertie Ray Priority Date: 6/6/1918
75		Permittee: Jada Fees Priority Date: 6/5/1918
76		Permittee: Myra Walker Priority Date 5/15/1918
77		Permittee: Myra Walker Priority Date 5/15/1918
78		
79		
80		
81		Wet in 1994
82		In Nowater Creek watershed
83		
84		Totally breached and in disrepair
86	Cottonwoods	Holding water July 2001
87	Willow, cattails, rushes etc.	Holding water/good condition 7/28/01, dam made of cattails
88	Willow, cattails, rushes etc.	Holding water/good condition 7/28/01, dam made of cottonwood
89	Cottonwoods, chokecherry	Holding water/good condition 7/28/01, dam made of cottonwood
90	Tamarisk	Dam holding, but downstream end badly eroded and ready to breach, dry on date of inspection
91	Cottonwoods	Inspected from hill above res, dry but good condition on 8/14/2001

APPENDIX B

SOILS

Table 2. Identification legend and range sites.

Map Symbol	Map Unit (with components and their proportions)	Range Site
11	Larimer loam, 0 to 8 percent slopes	Loamy 10-14" PZ
11L	Larimer sandy loam, 0 to 8 percent slopes	Sandy 10-14" PZ
11T	Garland-Preatorson complex, 0 to 10 percent slopes	
	Garland loam, 0 to 10 percent slopes (65%)	Loamy 5-9" PZ
	Preatorson very gravelly loam, 0 to 10 percent slopes (25%)	Gravelly 5-9" PZ
45	Youngston-Glenton loams, 0 to 6 percent slopes	
	Youngston loam, 0 to 6 percent slopes (50%)	Loamy 5-9" PZ
	Glenton loam, 0 to 6 percent slopes (25%)	Loamy 5-9" PZ
46	Petrie-Kim alkali complex, 0 to 10 percent slopes	
	Petrie silty clay loam, 0 to 10 percent slopes (45%)	Saline upland 10-14" PZ
	Kim alkali loam, 0 to 10 percent slopes (30%)	Saline lowland 10-14" PZ
47	Petrie-Cadoma-Epsie complex, 0 to 15 percent slopes	
	Petrie silty clay loam, 0 to 10 percent slopes (55%)	Saline upland 10-14" PZ
	Cadoma silty clay loam, 3 to 15 percent slopes (25%)	Saline upland 10-14" PZ
	Epsie silty clay, 3 to 15 percent slopes (15%)	Saline upland 10-14" PZ
60	Cadoma-Kim complex, 1 to 10 percent slopes	
	Cadoma silty clay loam, 1 to 10 percent slopes (45%)	Saline upland 10-14" PZ
	Kim loam, 1 to 10 percent slopes (45%)	Loamy 10-14" PZ
		*Clayey 10-14" PZ [1]
67	Cadoma-Worfka complex, 0 to 20 percent slopes	
	Cadoma silty clay loam, 0 to 20 percent slopes (55%)	Saline upland 10-14" PZ
	Worfka loam, 0 to 20 percent slopes (20%)	Shallow loamy 10-14" PZ
		*Shallow clayey 10-14" PZ [2]
68	Cadoma-Epsie complex, 3 to 45 percent slopes	
	Cadoma silty clay loam, 3 to 20 percent slopes (50%)	Saline upland 10-14" PZ
	Epsie silty clay, 3 to 45 percent slopes (25%)	Saline upland 10-14" PZ
69	Kim loam, 0 to 10 percent slopes	Loamy 10-14" PZ
		*Clayey 10-14" PZ [1]
70	Cadoma silty clay loam, 1 to 15 percent slopes	Saline upland 10-14" PZ

Map Symbol	Map Unit (with components and their proportions)	Range Site
71	Cadoma-Shingle complex, 3 to 45 percent slopes	
	Cadoma silty clay loam, 3 to 20 percent slopes (60%)	Saline upland 10-14" PZ
	Shingle loam, 3 to 45 percent slopes (25%)	Shallow loamy 10-14" PZ
72	Absted-Arvada complex, 0 to 10 percent slopes	
	Absted loam, 0 to 10 percent slopes (40%)	Loamy 10-14" PZ
	Arvada fine sandy loam, 0 to 10 percent slopes (35%)	Saline upland 10-14" PZ
73	Absted-Stoneham-Ulm loams, 3 to 10 percent slopes	
	Absted loam, 3 to 10 percent slopes (40%)	Loamy 10-14" PZ
	Stoneham loam, 3 to 10 percent slopes (30%)	Loamy 10-14" PZ
	Ulm loam, 3 to 10 percent slopes (20%)	Loamy 10-14" PZ
		*Clayey 10-14" PZ [1]
74	Petrie-Ulm complex, 0 to 10 percent slopes	
	Petrie silty clay loam, 0 to 10 percent slopes (45%)	Saline upland 10-14" PZ
	Ulm loam, 0 to 10 percent slopes (30%)	Loamy 10-14" PZ
		*Clayey 10-14" PZ [1]
75	Arvada-Kim alkali complex, 0 to 10 percent slopes	
	Arvada fine sandy loam, 0 to 10 percent slopes (40%)	Saline upland 10-14" PZ
	Kim loam alkali, 0 to 10 percent slopes (35%)	Saline lowland 10-14" PZ
93	Vona-Olney sandy loams, 0 to 10 percent slopes	
	Vona sandy loam, 0 to 10 percent slopes (50%)	Sandy 10-14" PZ
	Olney sandy loam, 0 to 10 percent slopes (30%)	Sandy 10-14" PZ
102	Rock outcrop, very steep	None
109	Epsie-Rock outcrop complex, 3 to 60 percent slopes	
	Epsie silty clay, 3 to 45 percent slopes (45%)	Saline upland 10-14" PZ
	Rock outcrop (40%)	None
110	Shingle-Tassel complex, 3 to 45 percent slopes	
	Shingle loam, 3 to 45 percent slopes (50%)	Shallow loamy 10-14" PZ
	Tassel sandy loam, 3 to 45 percent slopes (35%)	Shallow sandy 10-14" PZ
111	Rock outcrop-Shingle-Tassel complex, 3 to 60 percent slopes	
	Rock outcrop (30%)	None
	Shingle loam, 3 to 45 percent slopes (25%)	Shallow loamy 10-14" PZ
	Tassel sandy loam, 3 to 45 percent slopes (25%)	Shallow sandy 10-14" PZ

Map Symbol	Map Unit (with components and their proportions)	Range Site
112	Oceanet-Persayo-Rock outcrop complex, 3 to 60 percent slopes	
	Oceanet sandy loam, 3 to 40 percent slopes (25%)	Shallow sandy 5-9" PZ
	Persayo clay loam, 3 to 45 percent slopes (25%)	Saline upland 5-9" PZ
		*Shallow loamy 5-9" PZ [3]
	Rock outcrop (25%)	None
190	Epsie-Shingle complex, 6 to 45 percent slopes	
	Epsie silty clay, 6 to 45 percent slopes (45%)	Saline upland 10-14" PZ
	Shingle loam, 6 to 45 percent slopes (30%)	Shallow loamy 10-14" PZ
192	Cadoma-Shingle-Rock outcrop complex, 3 to 60 percent slopes	
	Cadoma silty clay loam, 3 to 20 percent slopes (30%)	Saline upland 10-14" PZ
	Shingle loam, 3 to 60 percent slopes (25%)	Shallow loamy 10-14" PZ
	Rock outcrop (20%)	None
243	Kim alkali-Kim loams, 0 to 6 percent slopes	
	Kim alkali loam, 0 to 6 percent slopes (50%)	Saline lowland 10-14" PZ
	Kim loam, 0 to 6 percent slopes (30%)	Loamy 10-14" PZ
		*Clayey 10-14" PZ [1]
244	Kim alkali loam, 0 to 6 percent slopes	Saline lowland 10-14" PZ
245	Orella silty clay, 0 to 15 percent slopes	Saline upland 10-14" PZ
246	Orella-Epsie-Rock outcrop complex, 0 to 45 percent slopes	
	Orella silty clay, 0 to 25 percent slopes (45%)	Saline upland 10-14" PZ
	Epsie silty clay, 0 to 25 percent slopes (25%)	Saline upland 10-14" PZ
	Rock outcrop (20%)	None
247	Torriorthents, severely eroded, 0 to 15 percent slopes	None assigned
315	Persayo-Clifterson complex, 3 to 45 percent slopes	
	Persayo gravelly clay loam, 15 to 45 percent slopes (50%)	Saline upland 5-9" PZ
		*Shallow loamy 5-9" PZ [3]
	Clifterson very gravelly loam, 3 to 20 percent slopes (30%)	Gravelly 5-9" PZ
322	Nihill-Shingle gravelly loams, 3 to 45 percent slopes	
	Nihill gravelly loam, 3 to 30 percent slopes (45%)	Gravelly 10-14" PZ
	Shingle gravelly loam, 0 to 45 percent slopes (30%)	Shallow loamy 10-14" PZ
323	Nihill cobbly loam, 3 to 45 percent slopes	Gravelly 10-14" PZ

Map Symbol	Map Unit (with components and their proportions)	Range Site
324	Larimer-Nihill complex, 3 to 45 percent slopes	
	Larimer loam, 3 to 15 percent slopes (40%)	Loamy 10-14" PZ
	Nihill gravelly loam, 3 to 45 percent slopes (40%)	Gravelly 10-14" PZ
325	Larimer-Stoneham-Nihill complex, 3 to 30 percent slopes	
	Larimer loam, 3 to 15 percent slopes (30%)	Loamy 10-14" PZ
	Stoneham loam, 3 to 15 percent slopes (30%)	Loamy 10-14" PZ
	Nihill gravelly loam, 3 to 30 percent slopes (20%)	Gravelly 10-14" PZ
345	Vona-Otero sandy loams, 3 to 15 percent slopes	
	Vona sandy loam, 3 to 12 percent slopes (45%)	Sandy 10-14" PZ
	Otero sandy loam, 3 to 15 percent slopes (35%)	Sandy 10-14" PZ
346	Nelson-Terry-Otero complex, 3 to 20 percent slopes	
	Nelson fine sandy loam, 3 to 12 percent slopes (30%)	Sandy 10-14" PZ
	Terry sandy loam, 3 to 20 percent slopes (30%)	Sandy 10-14" PZ
	Otero sandy loam, 3 to 15 percent slopes (20%)	Sandy 10-14" PZ
360	Stoneham-Kim association, nearly level and gently sloping	
	Stoneham loam, 2 to 8 percent slopes (50%)	Loamy 10-14" PZ
	Kim loam, 0 to 3 percent slopes (30%)	Loamy 10-14" PZ
		*Clayey 10-14" PZ [1]
371	Pavillion-Persayo complex, 3 to 45 percent slopes	
	Pavillion loam, 3 to 20 percent slopes (40%)	Loamy 5-9" PZ
	Persayo clay loam, 3 to 45 percent slopes (35%)	Saline upland 5-9" PZ
372	Tassel-Nelson sandy loams, 3 to 45 percent slopes	
	Tassel sandy loam, 3 to 45 percent slopes (50%)	Shallow sandy 10-14" PZ
	Nelson sandy loam, 3 to 12 percent slopes (25%)	Sandy 10-14" PZ
373	Neville-Tensleep association, gently sloping and sloping	
	Neville very fine sandy loam, 2 to 10 percent slopes (45%)	Loamy 10-14" PZ
	Tensleep very fine sandy loam, 2 to 10 percent slopes (35%)	Loamy 10-14" PZ
375	Bowbac-Olney-Arvada complex, 0 to 15 percent slopes	
	Bowbac fine sandy loam, 0 to 15 percent slopes (30%)	Sandy 10-14" PZ
	Olney sandy loam, 0 to 10 percent slopes (25%)	Sandy 10-14" PZ
	Arvada loam, 0 to 10 percent slopes (25%)	Saline upland 10-14" PZ

Map Symbol	Map Unit (with components and their proportions)	Range Site
382	Rock outcrop-Tassel complex, 3 to 60 percent slopes	
	Rock outcrop (40%)	None
	Tassel sandy loam, 3 to 45 percent slopes (40%)	Shallow sandy 10-14" PZ
383	Rock outcrop-Tassel-Nelson complex, 3 to 60 percent slopes	
	Rock outcrop (30%)	None
	Tassel sandy loam, 3 to 45 percent slopes (30%)	Shallow sandy 10-14" PZ
	Nelson sandy loam, 3 to 12 percent slopes (20%)	Sandy 10-14" PZ
389	Spearfish-Neville association, gently sloping and steep	
	Spearfish very fine sandy loam, 15 to 40 percent slopes (50%)	Shallow loamy 10-14" PZ
	Neville very fine sandy loam, 3 to 15 percent slopes (30%)	Loamy 10-14" PZ
393	Olney-Bowbac fine sandy loams, 3 to 15 percent slopes	
	Olney fine sandy loam, 3 to 10 percent slopes (45%)	Sandy 10-14" PZ
	Bowbac fine sandy loam, 3 to 15 percent slopes (35%)	Sandy 10-14" PZ
394	Saddle-Oceanet fine sandy loams, 0 to 15 percent slopes	
	Saddle fine sandy loam, 0 to 15 percent slopes (60%)	Sandy 5-9" PZ
	Oceanet fine sandy loam, 0 to 15 percent slopes (20%)	Shallow sandy 5-9" PZ
398	Tassel-Bowbac-Terry complex, 3 to 30 percent slopes	
	Tassel sandy loam, 3 to 30 percent slopes (30%)	Shallow sandy 10-14" PZ
	Bowbac fine sandy loam, 3 to 20 percent slopes (25%)	Sandy 10-14" PZ
	Terry fine sandy loam, 3 to 20 percent slopes (25%)	Sandy 10-14" PZ
410	Bondman-Worfka-Worf complex, 0 to 15 percent slopes	
	Bondman fine sandy loam, 0 to 15 percent slopes (30%)	Shallow sandy 10-14" PZ *Sandy 10-14" PZ [4]
	Worfka loam, 0 to 15 percent slopes (25%)	Shallow loamy 10-14" PZ *Shallow clayey 10-14" PZ [2]
	Worf loam, 0 to 15 percent slopes (25%)	Shallow loamy 10-14" PZ
411	Bondman-Rock outcrop-Worf complex, 3 to 45 percent slopes	
	Bondman fine sandy loam, 3 to 15 percent slopes (35%)	Shallow sandy 10-14" PZ *Sandy 10-14" PZ [4]
	Rock outcrop (25%)	None
	Worf loam, 3 to 15 percent slopes (20%)	Shallow loamy 10-14" PZ
426	Larim-Larimer complex, 3 to 15 percent slopes	
	Larim gravelly loam, 3 to 15 percent slopes (50%)	Gravelly 10-14" PZ
	Larimer loam, 3 to 15 percent slopes (40%)	Loamy 10-14" PZ

Map Symbol	Map Unit (with components ant their proportions)	Range Site
445	Rekop-Gystrum loams, 3 to 60 percent slopes	
	Rekop loam, 3 to 60 percent slopes (45%)	Shallow loamy 10-14" PZ
	Gystrum loam, 3 to 30 percent slopes (35%)	Loamy 10-14" PZ
446	Rock outcrop-Travessilla-Spearfish complex, 3 to 60 percent slopes	
	Rock outcrop (35%)	None
	Travessilla stony loam, thick solum, 3 to 60 percent slopes (25%)	Shallow loamy 10-14" PZ
	Spearfish very fine sandy loam, 3 to 40 percent slopes (20%)	Shallow loamy 10-14" PZ
447	Travessilla stony loam, thick solum, 3 to 45 percent slopes	Shallow loamy 10-14" PZ
448	Torrifluvents saline, 0 to 6 percent slopes	None assigned
449	Travessilla-Rock outcrop complex, 6 to 60 percent slopes	
	Travessilla stony loam, 6 to 60 percent slopes (45%)	Very shallow 10-14" PZ
	Rock outcrop (40%)	None
450	Torrifluvents-Fluvaquents complex, 0 to 6 percent slopes	
	Torrifluvents, 0 to 6 percent slopes (40%)	None assigned
	Fluvaquents, 0 to 3 percent slopes (40%)	None assigned
490	Shingle-Thedalund loams, 3 to 45 percent slopes	
	Shingle loam, 3 to 45 percent slopes (40%)	Shallow loamy 10-14" PZ
	Thedalund loam, 3 to 30 percent slopes (35%)	Loamy 10-14" PZ
546	Spearfish-Rock outcrop-Neville complex, 3 to 60 percent slopes	
	Spearfish very fine sandy loam, 3 to 40 percent slopes (35%)	Shallow loamy 10-14" PZ
	Rock outcrop (30%)	None
	Neville very fine sandy loam, 3 to 15 percent slopes (20%)	Loamy 10-14" PZ
572	Worland-Oceanet sandy loams, 3 to 15 percent slopes	
	Worland sandy loam, 3 to 15 percent slopes (50%)	Sandy 5-9" PZ
	Oceanet sandy loam, 3 to 15 percent slopes (25%)	Shallow sandy 5-9" PZ
590	Shingle-Rock outcrop complex, 3 to 60 percent slopes	
	Shingle loam, 3 to 60 percent slopes (50%)	Shallow loamy 10-14" PZ
	Rock outcrop (30%)	None
601	Youngston-Uffens-Glenton complex, 0 to 6 percent slopes	
	Youngston loam, 0 to 6 percent slopes (35%)	Loamy 5-9" PZ
	Uffens very fine sandy loam, 0 to 6 percent slopes (30%)	Saline upland 5-9" PZ
	Glenton loam, 0 to 6 percent slopes (20%)	Loamy 5-9" PZ

Map Symbol	Map Unit (with components and their proportions)	Range Site
602	Binton-Uffens complex, 0 to 6 percent slopes	
	Binton loam, 0 to 6 percent slopes (50%)	Saline upland 5-9" PZ
	Uffens very fine sandy loam, 0 to 6 percent slopes (30%)	Saline upland 5-9" PZ
604	Effington-Effington Variant complex, 0 to 10 percent slopes	
	Effington silt loam, 0 to 6 percent slopes (50%)	Saline upland 5-9" PZ
	Effington Variant silty clay loam, 0 to 10 percent slopes (30%)	Saline upland 5-9" PZ
606	Hoot-Rock outcrop complex, 3 to 60 percent slopes	
	Hoot channery loam, 3 to 60 percent slopes (40%)	Shallow loamy 10-14" PZ
	Rock outcrop (35%)	None
645	Mudray-Persayo-Effington Variant complex, 3 to 30 percent slopes	
	Mudray very fine sandy loam, 3 to 15 percent slopes (40%)	Saline upland 5-9" PZ
	Persayo clay loam, 3 to 30 percent slopes (25%)	Shale 5-9" PZ
	Effington Variant silty clay loam, 3 to 10 percent slopes (15%)	Saline upland 5-9" PZ
650	Mudray clay loam, 0 to 15 percent slopes	Saline upland 5-9" PZ
671	Rock outcrop-Persayo complex, 3 to 60 percent slopes	
	Rock outcrop (50%)	None
	Persayo clay loam, 3 to 45 percent slopes (35%)	Shale 5-9" PZ
675	Pavillion-Youngston loams, 0 to 15 percent slopes	
	Pavillion loam, 2 to 15 percent slopes (40%)	Loamy 5-9" PZ
	Youngston loam, 0 to 10 percent slopes (35%)	Loamy 5-9" PZ
700	Stoneham-Cushman loams, 3 to 15 percent slopes	
	Stoneham loam, 3 to 15 percent slopes (50%)	Loamy 10-14" PZ
	Cushman loam, 3 to 15 percent slopes (30%)	Loamy 10-14" PZ
701	Fort Collins-Kim loams, 3 to 15 percent slopes	
	Fort Collins loam, 3 to 15 percent slopes (50%)	Loamy 10-14" PZ *Clayey 10-14" PZ [1]
	Kim loam, 3 to 15 percent slopes (30%)	Loamy 10-14" PZ *Clayey 10-14" PZ [1]
702	Absted-Fort Collins loams, 3 to 15 percent slopes	
	Absted loam, 3 to 10 percent slopes (45%)	Loamy 10-14" PZ *Clayey 10-14" PZ [1]
	Fort Collins loam, 3 to 15 percent slopes (35%)	Loamy 10-14" PZ *Clayey 10-14" PZ [1]

Map Symbol	Map Unit (with components and their proportions)	Range Site
703	Fort Collins-Cushman loams, 3 to 15 percent slopes	
	Fort Collins loam, 3 to 15 percent slopes (50%)	Loamy 10-14" PZ
		*Clayey 10-14" PZ [1]
	Cushman loam, 3 to 15 percent slopes (30%)	Loamy 10-14" PZ
		*Clayey 10-14" PZ [1]
705	Kim-Thedalund loams, 3 to 15 percent slopes	
	Kim loam, 3 to 15 percent slopes (50%)	Loamy 10-14" PZ
		*Clayey 10-14" PZ [1]
	Thedalund loam, 3 to 15 percent slopes (30%)	Loamy 10-14" PZ
706	Cushman-Terry-Worf complex, 3 to 20 percent slopes	
	Cushman loam, 3 to 20 percent slopes (35%)	Loamy 10-14" PZ
	Terry sandy loam, 3 to 20 percent slopes (25%)	Sandy 10-14" PZ
	Worf loam, 3 to 20 percent slopes (20%)	Shallow loamy 10-14" PZ
708	Renohill-Cushman-Worfka complex, 3 to 20 percent slopes	
	Renohill clay loam, 3 to 20 percent slopes (40%)	Clayey 10-14" PZ
		*Loamy 10-14" PZ [5]
	Cushman loam, 3 to 20 percent slopes (20%)	Loamy 10-14" PZ
	Worfka loam, 3 to 20 percent slopes (20%)	Shallow loamy 10-14" PZ
		*Shallow clayey 10-14" PZ [2]
709	Renohill-Cadoma-Worfka complex, 0 to 20 percent slopes	
	Renohill clay loam, 0 to 20 percent slopes (40%)	Clayey 10-14" PZ
		*Loamy 10-14" PZ [5]
	Cadoma silty clay loam, 0 to 20 percent slopes (25%)	Saline upland 10-14" PZ
	Worfka loam, 0 to 20 percent slopes (20%)	Shallow loamy 10-14" PZ
		*Shallow clayey 10-14" PZ [2]
710	Cadoma-Renohill-Ulm complex, 3 to 20 percent slopes	
	Cadoma silty clay loam, 3 to 20 percent slopes (40%)	Saline upland 10-14" PZ
	Renohill clay loam, 3 to 20 percent slopes (25%)	Clayey 10-14" PZ
		*Loamy 10-14" PZ [5]
	Ulm loam, 3 to 10 percent slopes (20%)	Loamy 10-14" PZ
		*Clayey 10-14" PZ [1]
720	Blazon-Rock outcrop complex, 3 to 60 percent slopes	
	Blazon loam, 3 to 45 percent slopes (45%)	Shallow loamy 10-14" PZ
	Rock outcrop (30%)	None

Map Symbol	Map Unit (with components and their proportions)	Range Site
750	Worfka-Cushman association, gently sloping and steep	
	Worfka loam, 3 to 20 percent slopes (50%)	Shallow loamy 10-14" PZ
		*Shallow clayey 10-14" PZ [2]
	Cushman loam, 3 to 20 percent slopes (30%)	Loamy 10-14" PZ
751	Worfka-Shingle-Rock outcrop complex, 3 to 45 percent slopes	
	Worfka loam, 3 to 20 percent slopes (45%)	Shallow loamy 10-14" PZ
		*Shallow clayey 10-14" PZ [2]
	Shingle loam, 3 to 45 percent slopes (20%)	Shallow loamy 10-14" PZ
	Rock outcrop (15%)	None
752	Epsie silty clay, 3 to 15 percent slopes	Saline upland 10-14" PZ
753	Gaynor-Samsil clays, 3 to 15 percent slopes	
	Gaynor clay, 3 to 15 percent slopes (40%)	Clayey 10-14" PZ
	Samsil clay, 3 to 15 percent slopes (40%)	Shallow clayey 10-14" PZ
802	Rock outcrop-Starman complex, 6 to 60 percent slopes	
	Rock outcrop (50%)	None
	Starman gravelly loam, 6 to 60 percent slopes (40%)	Very shallow 15-19" PZ
804	Rock outcrop-Merino complex, 6 to 60 percent slopes	
	Rock outcrop (45%)	None
	Merino gravelly sandy clay loam, 6 to 60 percent slopes (35%)	Shallow loamy 15-19" PZ
		*Shallow clayey 15-19" PZ [7]
806	Starley-Starman-Rock outcrop complex, 6 to 60 percent slopes	
	Starley loam, 6 to 40 percent slopes (50%)	Shallow loamy 15-19" PZ
	Starman gravelly loam, 6 to 60 percent slopes (20%)	Very shallow 15-19" PZ
	Rock outcrop (15%)	None
808	Nielsen-Nielsen Variant-Rock outcrop complex, 6 to 60 percent slopes	
	Nielsen channery loam, 6 to 60 percent slopes (30%)	Shallow loamy 15-19" PZ
	Nielsen Variant clay loam, 6 to 60 percent slopes (25%)	Shallow clayey 15-19" PZ
	Rock outcrop (20%)	None
810	Gilispie-Bachus-Nielsen complex, 3 to 60 percent slopes	
	Gilispie cobbly loam, 6 to 55 percent slopes (40%)	Shallow loamy 15-19" PZ
		*Woodland [8]
	Bachus loam, 3 to 20 percent slopes (20%)	Loamy 15-19" PZ
	Nielsen channery loam, 6 to 60 percent slopes (20%)	Shallow loamy 15-19"PZ

Map Symbol	Map Unit (with components and their proportions)	Range Site
870	Wix-Judkins complex, 6 to 60 percent slopes	
	Wix very fine sandy loam, 6 to 45 percent slopes (50%)	Woodland
	Judkins stony silt loam, 15 to 60 percent slopes (25%)	Woodland
872	Burnette-Nielsen Variant-Rock outcrop complex, 3 to 45 percent slopes	
	Burnette loam, 3 to 30 percent slopes (30%)	Loamy 15-19" PZ
	Nielsen Variant clay loam, 3 to 45 percent slopes (25%)	Shallow clayey 15-19" PZ
	Rock outcrop (20%)	None
876	Wetterhorn-Wetterhorn Variant complex, 6 to 60 percent slopes	
	Wetterhorn stony loam, 6 to 60 percent slopes (40%)	Woodland
	Wetterhorn Variant very stony loam, 6 to 60 percent slopes (40%)	Woodland
902	Samsil-Shingle-Rock outcrop complex, 3 to 45 percent slopes	
	Samsil clay, 3 to 45 percent slopes (50%)	Shallow clayey 10-14" PZ
	Shingle loam, 3 to 45 percent slopes (20%)	Shallow loamy 10-14" PZ
	Rock outcrop (15%)	None

*Range site on this soil in some areas of this unit.

[1]The clay loam phase included in mapping covelates to the Clayey 10-14" PZ range site.
[2]The clay loam phase included in mapping covelates to the Shallow clayey 10-14" PZ range site.
[3]The nonalkali phase included in mapping covelates to the Shallow loamy 5-9" PZ range site.
[4]Moderately deep soils included in mapping covelate to the Sandy 10-14" PZ range site.
[5]The loam phase included in mapping covelates to the Loamy 10-14" PZ range site.
[6]The sandy loam phase included in mapping covelates to the Sandy 10-14" PZ range site.
[7]The gravelly clay loam phase included in mapping covelates to the Shallow clayey 15-19" PZ range site.
[8]The moist phase included in mapping supports woodland vegetation and is not covelated to a range site.
[9]The cobbly loam phase included in mapping covelates to the Loamy 15-19" PZ range site.

APPENDIX C

RANGELAND HEALTH & VEGETATION TRANSECT FORMS

APPENDIX 1. UPLAND RANGELAND FIELD FORM TEMPLATES

Rangeland Health Evaluation Summary Worksheet

Part 1. Area of Interest Documentation (**Bold** items require completion, other information is optional)

State ____________ **Office** ____________ **Management Unit** ____________

Pasture/Watershed ____________ ID# ____________ Major Land Resource Area ____________

Location (description) ____________

Legal T ____ ,R ____ ,Sec ____ , ____ 1/4, ____ 1/4 or Lat ____ ,Long ____ or UTM Coord ____________

Size of Evaluation Area ____________ **Photo(s) Taken** Yes ____ No ____

Observer(s) ____________ **Date** ____________

Ecological Site ____________ Soil Map Unit Name ____________

Soil/Site Verification

Rangeland Ecological Site Description and/or Soil Survey
Surface Texture ____________
Depth: Very Shallow ☐ (<10") Shallow ☐ (10"-20") Moderate ☐ (20"-40") Deep ☐ (>40")
List diagnostic horizons in profile and depth
1 ____________ 3 ____________
2 ____________ 4 ____________

Area of Interest Determination
Surface Texture ____________
Depth: Very Shallow ☐ (<10") Shallow ☐ (10"-20") Moderate ☐ (20"-40") Deep ☐ (>40")
List diagnostic horizons in profile and depth
1 ____________ 3 ____________
2 ____________ 4 ____________

Parent Material ________ **Slope** ____ % Elevation ____ ft Topographic Position ______ **Aspect** ______

Avg Annual Precip ______ **Recent Weather (last 2 years)** Drought _____ Normal _____ Wet ______

Describe wildlife and livestock use and recent disturbances ____________

Describe offsite influences on area of interest ____________

Part 2. Indicator Rating

Attribute	Indicators	Departure from Ecological Site Description/ Ecological Reference Area(s): Extreme	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
S,H	1. Rills					
Comments:						
S,H	2. Water Flow Patterns					
Comments:						
S,H	3. Pedestals and/or Terracettes					
Comments:						
S,H	4. Bare Ground					
Comments:						
S,H	5. Gullies					
Comments:						
S	6. Wind-Scoured, Blowouts, and/or Deposition Areas					
Comments:						

Part 2. Indicator Rating (continued)

		Departure from Ecological Site Description/ Ecological Reference Area(s)				
Attribute	**Indicators**	**Extreme**	**Moderate to Extreme**	**Moderate**	**Slight to Moderate**	**None to Slight**
H	7. Litter Movement					
Comments:						
S,H,B	8. Soil Surface Resistance to Erosion					
Comments:						
S,H,B	9. Soil Surface Loss or Degradation					
Comments:						
H	10. Plant Community Composition and Distribution Relative to Infiltration and Runoff					
Comments:						
S,H,B	11. Compaction Layer					
Comments:						
B	12. Functional/Structural Groups					
Comments:						
B	13. Plant Mortality/Decadence					
Comments:						
H,B	14. Litter Amount					
Comments:						
B	15. Annual Production					
Comments:						
B	16. Invasive Plants					
Comments:						
B	17. Reproductive Capability of Perennial Plants					
Comments:						

Part 3. Summary

A. Indicator Summary

Departure from Ecological Site Description/ Ecological Reference Area(s)

Rangeland Health Attributes		Extreme	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight	Σ
S	Soil/Site Stability (Indicators 1-6, 8, 9 &11)						9
H	Hydrologic Function (Indicators 1-5, 7-11 & 14)						11
B	Biotic Integrity (Indicators 8-9 & 11-17)						9

B. Attribute Summary - Check the category that best fits the "preponderance of evidence" for each of the three attributes relative to the distribution of indicator ratings in the preceding Indicator Summary table.

Attribute	Extreme	Moderate to Extreme	Moderate	Slight to Moderate	None to Slight
Soil/Site Stability Rationale:					
Hydrologic Function Rationale:					
Biotic Integrity Rationale:					

Range Transect

Page____of____.

Transect Number	Date	Examiner	Property	Pasture
Line Length	Transect Location			

NOTES	Category									NOTES
	Warm Grass	Cool Grass	Weed	Woody	Forb	Soil	Lichen	Rock	Litter	
Instructions: Mark category at 1 meter intervals across transect (100 points)										TOTALS
TOTALS										
% COVER										
% COMPOSITION										100%

APPENDIX D

RIPARIAN TRANSECT FORM

APPENDIX 2. RIPARIAN FIELD FORM TEMPLATES

RIPARIAN PROPER FUNCTIONING CONDITION CHECKLIST

Riparian-Wetland Area: ______________________ RAIDS Segment ID: __________

Allotment Name\No.: ______________________ Under Management (Y/N): ____

Evaluation Location (T. R. S. ¼ ¼): ______________ Riparian Width (feet): ____

ID Team/Observers: ______________________ Date: __________

USGS Quad: ______________________ Entered in RAIDS( ): ____

Miles: __________ Acres: __________

#	YES	NO	N/A	HYDROLOGIC
1				Floodplain above bankfull is inundated in "relatively frequent events (1-3 years)"
2				Where beaver dams are present, they are active and stable
3				Sinuosity, width/depth ratio, and gradient are in balance with the landscape setting, (i.e. landform, geology, and bioclimatic region)
4				Riparian-wetland area is widening or has achieved potential extent
5				Upland watershed not contributing to riparian-wetland degradation

#	YES	NO	N/A	VEGETATION
6				There is diverse age-class distribution of riparian-wetland vegetation (recruitment for maintenance/recovery)
7				There is diverse composition of riparian-wetland vegetation (for maintenance/recovery)
8				Species present indicate maintenance of riparian-wetland soil moisture characteristics
9				Streambank vegetation is comprised of those plants or plant communities that have root masses capable of withstanding high streamflow events
10				Riparian-wetland plants exhibit high vigor
11				Adequate riparian-wetland vegetative cover is present to protect banks and dissipate energy during high flows
12				Plant communities in the riparian area are an adequate source of coarse and/or large woody debris (for maintenance/recovery)

#	YES	NO	N/A	EROSION DEPOSITION
13				Floodplain and channel characteristics, (i.e. rocks, overflow channels, coarse and/or large woody material) are adequate to dissipate energy
14				Point bars are revegetating with riparian-wetland vegetation (bankfull)
15				Lateral stream movement is associated with natural sinuosity
16				System is vertically stable
17				Stream is in balance with the water and sediment being supplied by the watershed, (i.e. no excess erosion or deposition)

Remarks

____

____

____

____

____

____

____

____

____

Summary Determination

Functional Rating		Trend for Functional at Risk	
Proper Functioning Condition	________	Upward	__________
Functioning At Risk	________	Downward	__________
Non Functional	________	Not Apparent	__________
Unknown	________		

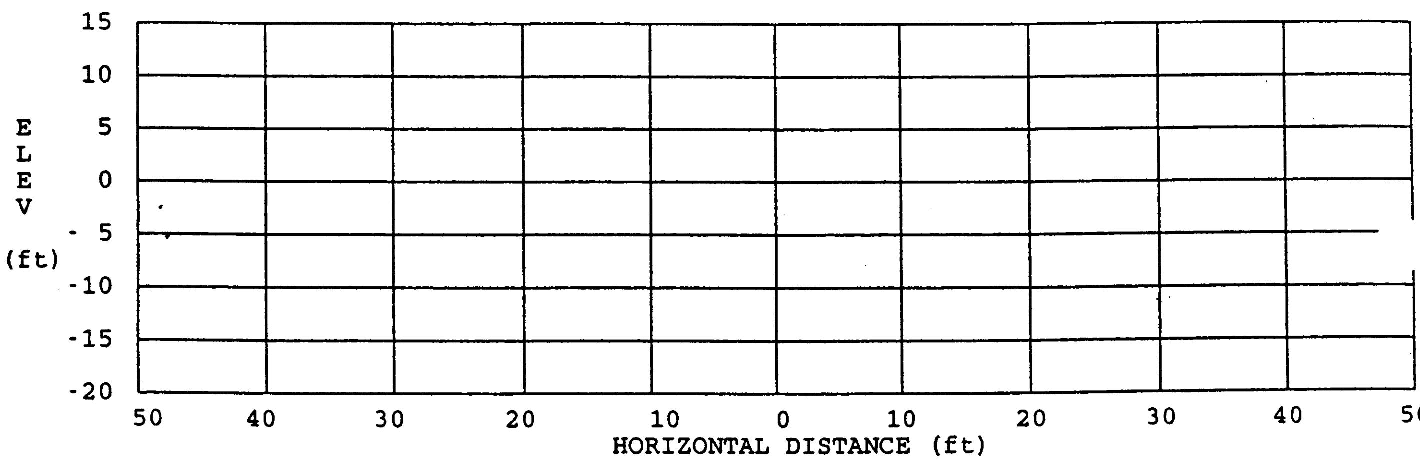
Are factors contributing to unacceptable conditions outside BLMs control or management ? Yes ____ No _____ If yes, what are those factors ?

____ Flow regulation ____ Mining activities ____ Upstream channel condition
____ Channelization ____ Road Encroachment ____ Oil field water discharge
____ Augmented flows ____ Other (specify) ____

Vegetation Association (dominant overstory/understory): ____

Other observed species: ____

Construct a representative stream channel cross-section including water surface elev. and vegetation using the scaled grid below, (0 feet is the historic channel elev).



Photographic Monitoring is recommended in each RAIDS segment using the following guidelines:

- Establish at least one permanent photo point illustrating the channel cross section with one photo looking upstream and one photo looking down stream.
- Use color slides with a 28 mm lens oriented with the top 1/3 of photo in skyline.
- Map the photo point on a field map for later transfer to RAIDS master quads.

Other Comments:

____
____
____
____
____
____
____
____

Riparian Transect

Page____of____.

Transect Number	Date	Examiner	Property	Drainage
Line Length	Transect Location			

NOTES	Community Type									NOTES
	Upland Shrub	Wet Meadow Grass	Sedge / Rush	Willow	Cotton - wood	Upland Soil	Bank	Rock	Water	
Instructions: Record community type location at 0.5 meter increments along transect (~100 m)										TOTALS
TOTALS										
% COVER										
% COMPOSITION										100%

Summary of Rosgen Level I Geomorphic Data

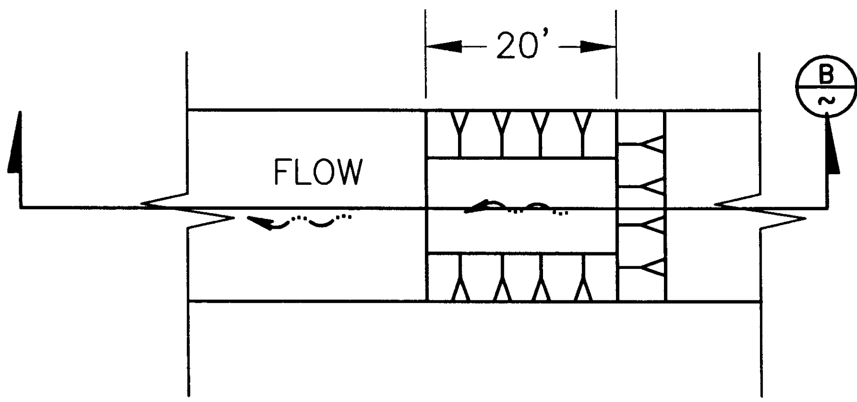
Stream Point	Slope	Sinuosity	Entrenchment Ratio	Width/Depth Ratio	Rosgen Stream Type
Kirby Creek					
1	0.002	1.1	1.4	6.7	G
3	0.002	1.1	1.3	6.4	G
4	0.003	1.5	2.6	3.5	E
6	0.003	1.7	2.0	3.0	E
8	0.003	1.7	3.0	2.5	E
10	0.003	1.7	5.6	2.0	E
11	0.002	1.3	2.2	4.8	E
87	0.002	1.3	2.3	6.5	E
16	0.003	1.4	2.8	10.0	E
17	0.003	1.6	2.2	8.0	E
19	0.004	1.6	1.4	5.5	E
21	0.004	1.6	1.6	2.3	E
23	0.004	1.6	2.6	3.5	E
27	0.005	1.4	5.7	3.8	E
28	0.005	1.4	6.9	1.6	E
29	0.004	2.2	2.3	1.8	E
30	0.004	2.2	2.8	6.3	E
31	0.006	1.9	5.7	5.8	E
32	0.007	1.5	3.0	9.3	E
33	0.007	1.5	3.9	2.3	E
West Kirby Creek					
46	0.008	1.5	3.6	3.3	E
47	0.015	1.5	3.5	10.0	E
48	0.026	1.1	1.5	4.0	G
52	0.031	1.1	3.3	3.6	G
53	0.040	1.1	4.0	2.3	G
54	0.039	1.1	2.9	2.8	G
55	0.060	1.1	1.8	10.0	G
56	0.055	1.0	2.0	30.0	G
East Kirby Creek					
34	0.012	1.3	2.2	2.5	E
35	0.012	1.3	1.4	2.5	E
36	0.019	1.2	4.6	5.0	E
37	0.022	1.1	4.2	5.0	G
38	0.031	1.4	3.3	4.0	G
39	0.043	1.2	5.0	2.7	G
40	0.040	1.3	N/A	4.0	Swale*
41	0.052	N/A	N/A	24.0	Swale*
Blue Springs					
95	0.009	1.3	3.0	3.3	E
96	0.014	1.4	3.0	10.0	E
97	0.019	1.2	4.2	2.0	E
Alkali Creek					
58	0.004	2.1	2.5	2.7	E
59	0.006	1.9	2.4	2.5	E
61	0.012	1.4	10.0	2.0	E
63	0.011	1.6	3.6	7.0	E
64	0.008	1.3	4.0	6.7	E
68	0.009	1.4	3.0	2.0	E
69	0.017	1.1	2.4	2.8	E
70	0.012	1.3	4.0	10.0	E
71	0.019	1.2	3.0	2.7	G
72	0.031	1.2	2.5	4.0	G
73	0.069	1.1	N/A	15.0	Swale*
Reed Creek					
49	0.031	1.1	2.4	5.0	G
50	0.046	1.1	1.9	5.3	G

* There is no Rosgen classification for an ephemeral swale without defined banks.

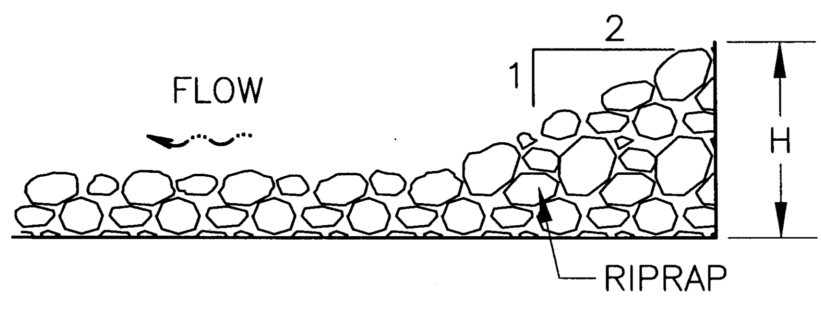
APPENDIX E

RIVER BANK PROTECTION

RIVER BANK PROTECTION
RIP-RAP OPTION 1



A ~ RIP-RAP PLAN



B ~ RIP-RAP PROFILE

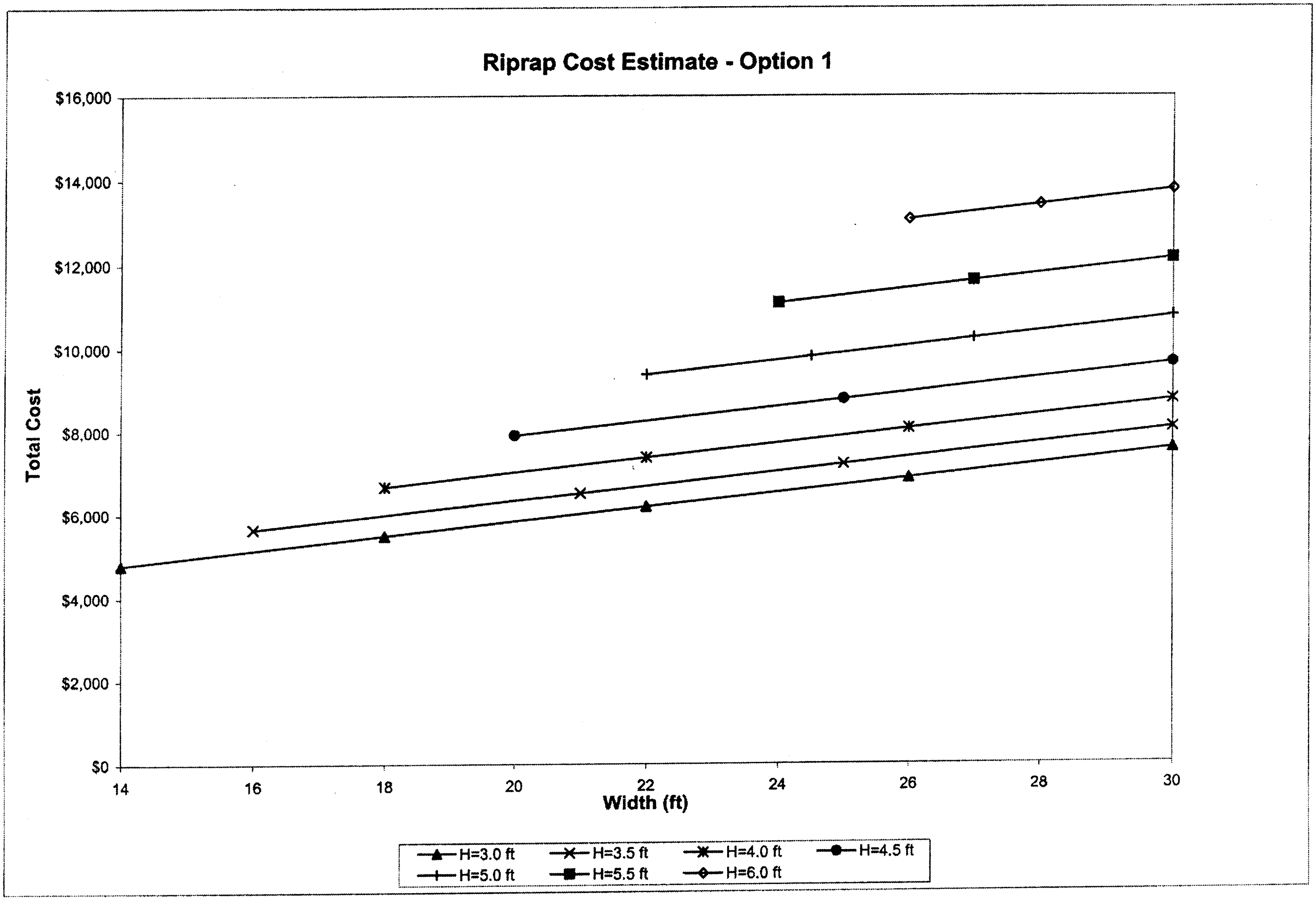
SUNRISE ENGINEERING INC.

Riprap Option 1

River Width (ft)	Height (ft)	Volume (CY)	Unit Cost (CY)	Mobilization (EA)	Total Cost
14	3.0	43.39	$94	$726	$4,800
18	3.0	50.80	$94	$726	$5,500
22	3.0	58.20	$94	$726	$6,200
26	3.0	65.61	$94	$726	$6,890
30	3.0	73.02	$94	$726	$7,590
16	3.5	52.41	$94	$726	$5,650
21	3.5	61.67	$94	$726	$6,520
25	3.5	69.07	$94	$726	$7,220
30	3.5	78.33	$94	$726	$8,090
18	4.0	63.39	$94	$726	$6,680
22	4.0	70.80	$94	$726	$7,380
26	4.0	78.20	$94	$726	$8,080
30	4.0	85.61	$94	$726	$8,770
20	4.5	76.56	$94	$726	$7,920
25	4.5	85.81	$94	$726	$8,790
30	4.5	95.07	$94	$726	$9,660
22	5.0	92.13	$94	$726	$9,390
25	5.0	96.76	$94	$726	$9,820
27	5.0	101.39	$94	$726	$10,260
30	5.0	106.94	$94	$726	$10,780
24	5.5	110.33	$94	$726	$11,100
27	5.5	115.89	$94	$726	$11,620
30	5.5	121.44	$94	$726	$12,140
26	6.0	131.39	$94	$726	$13,080
28	6.0	135.09	$94	$726	$13,420
30	6.0	138.80	$94	$726	$13,770

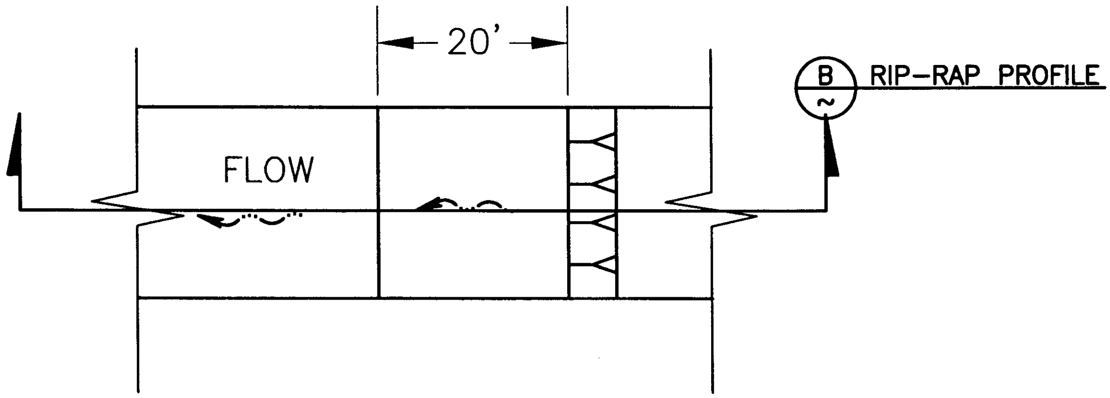
Notes: Cost was based on:

1. Riprap thickness = 30 in; Riprap length = 20 ft
2. Mobilization, assumes up to 25 miles haul distance (50 miles round trip) for equipment
3. Average haul distance of 100 miles (200 miles round trip)

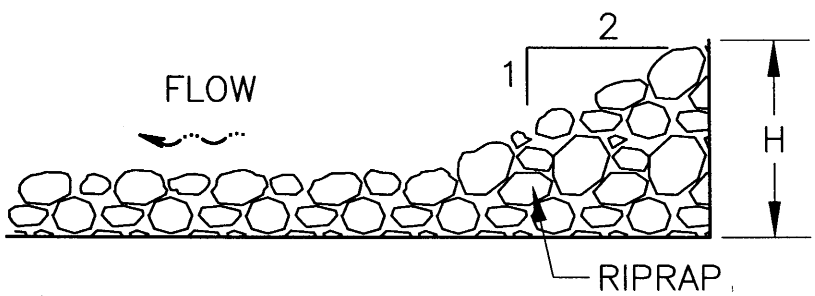


Riprap Cost Estimate - Option 1
$16,000
$14,000
$12,000
$10,000
$8,000
$6,000
$4,000
$2,000
$0
Total Cost
14
16
18
20
22
24
26
28
30
Width (ft)
H=3.0 ft
H=3.5 ft
H=4.0 ft
H=4.5 ft
H=5.0 ft
H=5.5 ft
H=6.0 ft

RIVER BANK PROTECTION
RIP-RAP OPTION 2



A ~ RIP-RAP PLAN



B ~ RIP-RAP PROFILE

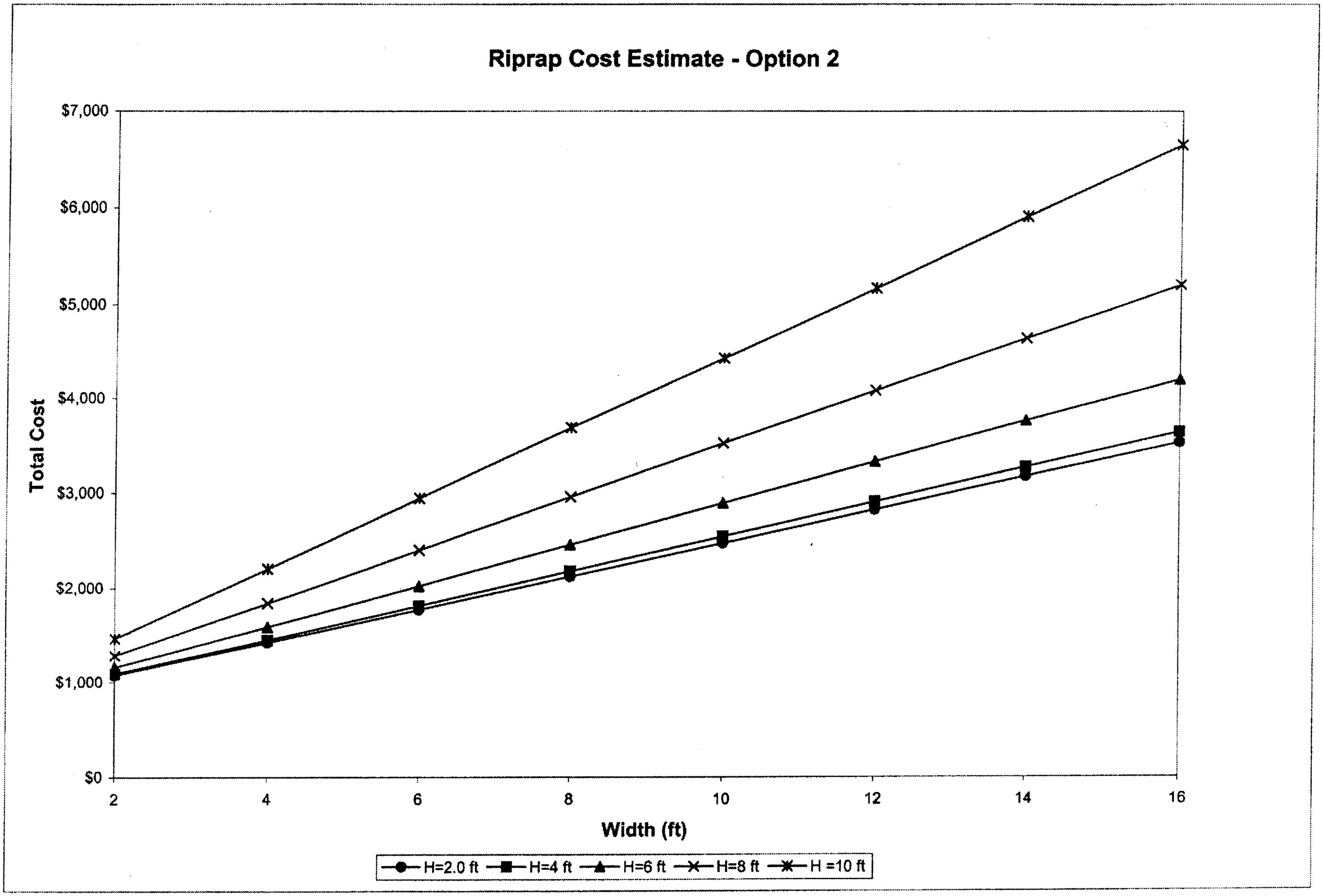
SUNRISE ENGINEERING INC.

Riprap Option 2

River Width (ft)	Height (ft)	Volume (CY)	Unit Cost (CY)	Mobilization (EA)	Total Cost
2	3	3.72	$94	$726	$1,076
4	3	7.44	$94	$726	$1,426
6	3	11.17	$94	$726	$1,776
8	3	14.89	$94	$726	$2,126
10	3	18.61	$94	$726	$2,475
12	3	22.33	$94	$726	$2,825
14	3	26.06	$94	$726	$3,175
16	3	29.78	$94	$726	$3,525
2	4	3.87	$94	$726	$1,090
4	4	7.74	$94	$726	$1,454
6	4	11.61	$94	$726	$1,817
8	4	15.48	$94	$726	$2,181
10	4	19.35	$94	$726	$2,545
12	4	23.22	$94	$726	$2,909
14	4	27.09	$94	$726	$3,273
16	4	30.96	$94	$726	$3,637
2	6	4.61	$94	$726	$1,159
4	6	9.22	$94	$726	$1,593
6	6	13.83	$94	$726	$2,026
8	6	18.44	$94	$726	$2,460
10	6	23.06	$94	$726	$2,893
12	6	27.67	$94	$726	$3,327
14	6	32.28	$94	$726	$3,760
16	6	36.89	$94	$726	$4,194
2	8	5.94	$94	$726	$1,285
4	8	11.89	$94	$726	$1,844
6	8	17.83	$94	$726	$2,402
8	8	23.78	$94	$726	$2,961
10	8	29.72	$94	$726	$3,520
12	8	35.67	$94	$726	$4,079
14	8	41.61	$94	$726	$4,637
16	8	47.56	$94	$726	$5,196
2	10	7.87	$94	$726	$1,466
4	10	15.74	$94	$726	$2,206
6	10	23.61	$94	$726	$2,945
8	10	31.48	$94	$726	$3,685
10	10	39.35	$94	$726	$4,425
12	10	47.22	$94	$726	$5,165
14	10	55.09	$94	$726	$5,905
16	10	62.96	$94	$726	$6,645

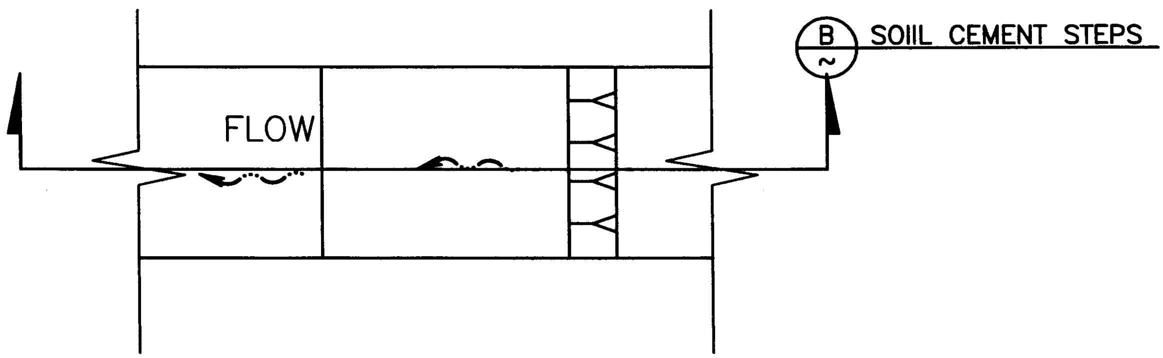
Notes: Cost was based on:

1. Riprap thickness = 30 in; Riprap length = 20 ft
2. Mobilization, assumes up to 25 miles haul distance (50 miles round trip) for equipment
3. Average haul distance of 100 miles (200 miles round trip)

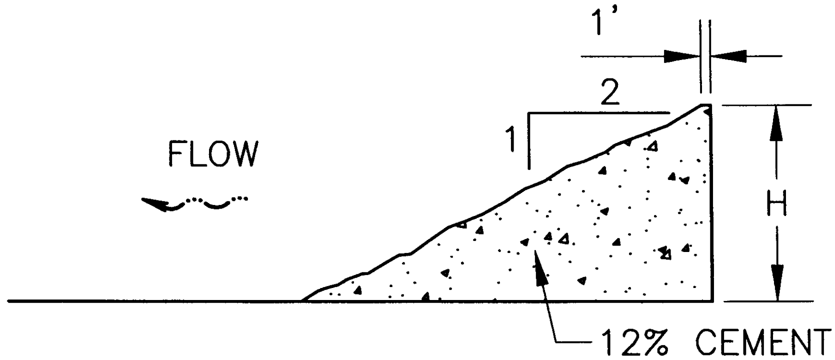


Riprap Cost Estimate - Option 2
$7,000
$6,000
$5,000
$4,000
$3,000
$2,000
$1,000
$0
Total Cost
2
4
6
8
10
12
14
16
Width (ft)
H=2.0 ft
H=4 ft
H=6 ft
H=8 ft
H =10 ft

RIVER BANK PROTECTION
SOIL CEMENT STEPS



A ~ SOIL CEMENT STEPS



B ~ SOIL CEMENT STEPS

SUNRISE ENGINEERING INC.

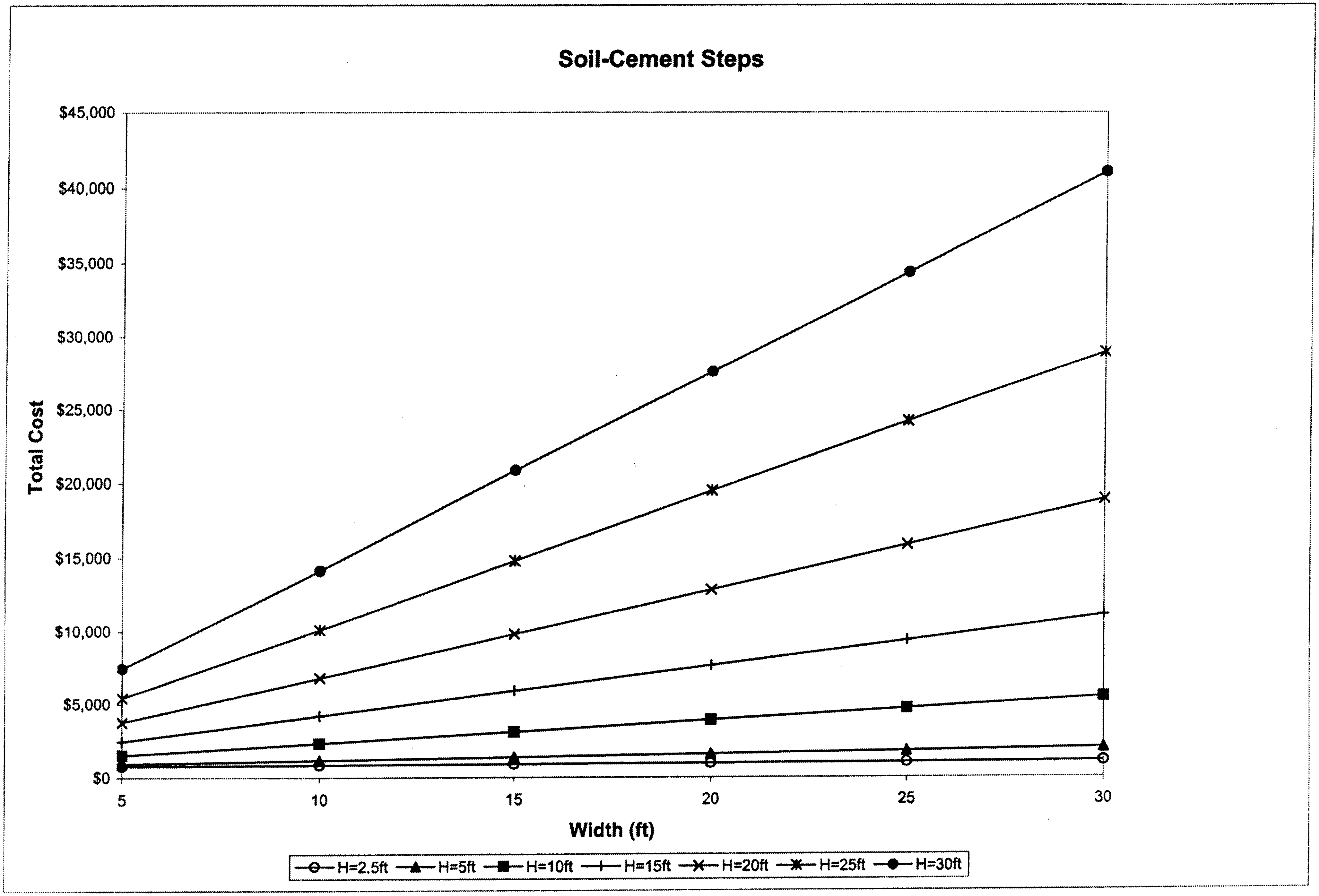
Soil-Cement Steps

River Width (ft)	Height (ft)	Volume (CY)	Unit Cost (CY)	Mobilization (EA)	Total Cost
5	2.5	1.62	$39	$726	$789
10	2.5	3.24	$39	$726	$852
15	2.5	4.86	$39	$726	$916
20	2.5	6.48	$39	$726	$979
25	2.5	8.10	$39	$726	$1,042
30	2.5	9.72	$39	$726	$1,105
5	5	5.56	$39	$726	$943
10	5	11.11	$39	$726	$1,159
15	5	16.67	$39	$726	$1,376
20	5	22.22	$39	$726	$1,593
25	5	27.78	$39	$726	$1,809
30	5	33.33	$39	$726	$2,026
5	10	20.37	$39	$726	$1,520
10	10	40.74	$39	$726	$2,315
15	10	61.11	$39	$726	$3,109
20	10	81.48	$39	$726	$3,904
25	10	101.85	$39	$726	$4,698
30	10	122.22	$39	$726	$5,493
5	15	44.44	$39	$726	$2,459
10	15	88.89	$39	$726	$4,193
15	15	133.33	$39	$726	$5,926
20	15	177.78	$39	$726	$7,659
25	15	222.22	$39	$726	$9,393
30	15	266.67	$39	$726	$11,126
5	20	77.78	$39	$726	$3,759
10	20	155.56	$39	$726	$6,793
15	20	233.33	$39	$726	$9,826
20	20	311.11	$39	$726	$12,859
25	20	388.89	$39	$726	$15,893
30	20	466.67	$39	$726	$18,926
5	25	120.37	$39	$726	$5,420
10	25	240.74	$39	$726	$10,115
15	25	361.11	$39	$726	$14,809
20	25	481.48	$39	$726	$19,504
25	25	601.85	$39	$726	$24,198
30	25	722.22	$39	$726	$28,893
5	30	172.22	$39	$726	$7,443
10	30	344.44	$39	$726	$14,159
15	30	516.67	$39	$726	$20,876
20	30	688.89	$39	$726	$27,593
25	30	861.11	$39	$726	$34,309
30	30	1033.33	$39	$726	$41,026

Notes: W = Width of Soil-Cement Steps

Cost was based on:

1. Cement, 12% mix, 12" deep
2. Mobilization, Dozer, loader, backhoe, excav., grader, paver, roller, above150 H.P.
4. Average haul distance of 100 miles (200 miles round trip)



Soil-Cement Steps
Total Cost
$45,000
$40,000
$35,000
$30,000
$25,000
$20,000
$15,000
$10,000
$5,000
$0
5
10
15
20
25
30
Width (ft)
H=2.5ft
H=5ft
H=10ft
H=15ft
H=20ft
H=25ft
H=30ft

APPENDIX F

WATER WELLS ATTRIBUTE DATA

USE	ID	WELLS99_	WELLS99_ID	TNS	TSF	RNG	RSF	SEC	QTR	QQ	CTY1	TOWN	RANGE	PERMITNO	ARVSTATUS	PRIORITY	YLDACT	WELLDEPTH	STATDEPTH	MWBZTOP	MWBZBOT
DOM	23635	21966	21966	43.000	N	92.000	W	21	10.000	NANWSW	15.000	43	92	P18932P		12/31/1936	12.000	85.000	-1.000	-1.000	-1.000
DOM	15009	13776	13776	42.000	N	92.000	W	34	5.000	NANENW	15.000	42	92	P11360P		12/12/1952	17.500	152.000	-4.000	143.000	148.000
DOM	42455	39380	15060	44.000	N	94.000	W	34	10.000	NANWSW	15.000	44	94	P40529W		9/7/1977	14.000	52.000	18.000	40.000	47.000
DOM	63323	58881	12766	42.000	N	92.000	W	12	12.000	NASESW	15.000	42	92	P68818W		10/22/1984	20.000	381.000	-4.000	356.000	377.000
DOM	90428	82683	13716	43.000	N	93.000	W	15	11.000	NASWSW	20.000	43	93	P98246W	UNA	1/30/1995	4.000	161.000	31.000	110.000	120.000
DOM,STO	6930	6199	6199	41.000	N	91.000	W	9	11.000	NASWSW	15.000	41	91	P106465W	UNA	6/16/1997	-9999.000	-9999.000	-9999.000	-9999.000	-9999.000
DOM,STO	7008	6269	6269	43.000	N	92.000	W	22	12.000	NASESW	15.000	43	92	P106534W	UNA	6/27/1997	25.000	200.000	-4.000	-1.000	-1.000
DOM,STO	14656	13439	13439	44.000	N	94.000	W	34	0.000	NANANA	15.000	44	94	P113292W	UNA	12/7/1998	0.000	0.000	0.000	0.000	0.000
IND	1102	988	988	43.000	N	92.000	W	17	4.000	NASENE	15.000	43	92	P101110W	UNA	10/31/1995	16.000	4099.000	800.000	3994.000	4099.000
MON,MIS	17597	16261	16261	43.000	N	93.000	W	28	11.000	NASWSW	15.000	43	93	P1310W		8/27/1964	110.000	2963.000	2102.000	2406.000	-1.000
OIL,IND	27142	25269	949	43.000	N	92.000	W	21	1.000	NANENE	15.000	43	92	P2226W		5/24/1968	21.000	733.000	500.000	506.000	512.000
STO	86005	78904	9937	43.000	N	93.000	W	27	6.000	NANWNW	15.000	43	93	P93953W	ADJ	2/29/1916	4.000	-1.000	-1.000	-1.000	-1.000
STO	86006	78905	9938	43.000	N	93.000	W	15	3.000	NASWNE	15.000	43	93	P93954W	ADJ	2/29/1916	3.000	-1.000	-1.000	-1.000	-1.000
STO	86169	79063	10096	43.000	N	93.000	W	24	16.000	NASESE	15.000	43	93	P94094W	ADJ	2/29/1916	4.000	-1.000	-1.000	-1.000	-1.000
STO	85655	78558	9591	42.000	N	92.000	W	18	2.000	NANWNE	15.000	42	92	P93646W	ADJ	4/17/1926	5.000	-1.000	-1.000	-1.000	-1.000
STO	85662	78565	9598	42.000	N	92.000	W	18	2.000	NANWNE	20.000	42	92	P93651W	ADJ	4/17/1926	2.000	-1.000	-1.000	-1.000	-1.000
STO	86010	78909	9942	43.000	N	93.000	W	7	12.000	NASESW	15.000	43	93	P93958W	ADJ	4/17/1926	1.000	-1.000	-1.000	-1.000	-1.000
STO	86112	79007	10040	43.000	N	92.000	W	4	15.000	NASWSE	15.000	43	92	P94046W	ADJ	4/17/1926	3.000	-1.000	-1.000	-1.000	-1.000
STO	86166	79061	10094	42.000	N	92.000	W	5	6.000	NANWNW	15.000	42	92	P94092W	ADJ	4/17/1926	5.000	-1.000	-1.000	-1.000	-1.000
STO	86168	79062	10095	43.000	N	92.000	W	22	15.000	NASWSE	15.000	43	92	P94093W	ADJ	4/17/1926	1.000	-1.000	-1.000	-1.000	-1.000
STO	86170	79064	10097	43.000	N	93.000	W	25	5.000	NANENW	15.000	43	93	P94095W	ADJ	4/17/1926	3.000	-1.000	-1.000	-1.000	-1.000
STO	43641	40475	16155	44.000	N	93.000	W	32	8.000	NASENW	15.000	44	93	P421C	UNA	11/12/1936	4.500	2037.000	0.000	1845.000	2021.000
STO	16741	15458	15458	44.000	N	93.000	W	34	15.000	NASWSE	15.000	44	93	P122G	UNA	12/3/1951	2.000	1388.000	0.000	-1.000	-1.000
STO	23633	21964	21964	43.000	N	92.000	W	21	10.000	NANWSW	15.000	43	92	P18930P		7/31/1958	5.000	15.000	4.000	-1.000	-1.000
STO	15020	13787	13787	42.000	N	92.000	W	26	12.000	NASESW	15.000	42	92	P11361P		12/12/1960	4.000	706.000	10.000	658.000	690.000
STO	2450	2212	2212	43.000	N	91.000	W	19	13.000	NANESE	15.000	43	91	P10241P		8/18/1962	0.500	1235.000	0.000	-1.000	-1.000
STO	2740	2476	2476	43.000	N	91.000	W	20	12.000	NASESW	15.000	43	91	P10269P	ADJ	10/27/1962	10.000	3469.000	-4.000	-1.000	-1.000
STO	2731	2467	2467	42.000	N	92.000	W	2	10.000	NANWSW	15.000	42	92	P10268P		9/14/1964	7.500	600.000	-4.000	-1.000	-1.000
STO	2685	2432	2432	44.000	N	93.000	W	35	13.000	NANESE	15.000	44	93	P10264P		6/29/1965	7.500	4319.000	-4.000	-1.000	-1.000
STO	2498	2259	2259	42.000	N	92.000	W	7	5.000	NANENW	15.000	42	92	P10246P		12/15/1966	2.500	275.000	48.000	160.000	180.000
STO	2607	2363	2363	43.000	N	92.000	W	26	8.000	NASENW	15.000	43	92	P10257P		2/1/1968	7.500	1020.000	0.000	-1.000	-1.000
STO	56168	52226	6111	43.000	N	92.000	W	4	8.000	NASENW	15.000	43	92	P5934P		12/20/1968	23.000	4043.000	-4.000	-9999.000	-9999.000
STO	38198	35567	11247	43.000	N	92.000	W	29	2.000	NANWNE	15.000	43	92	P35214W		9/13/1976	4.000	310.000	110.000	212.000	230.000
STO	81773	75170	6203	43.000	N	94.000	W	13	4.000	NASENE	15.000	43	94	P89672W	ADJ	11/1/1982	21.000	559.000	1.000	-1.000	-1.000
STO	81774	75171	6204	43.000	N	93.000	W	15	14.000	NANWSE	15.000	43	93	P89673W	ADJ	11/1/1982	5.000	-1.000	-1.000	-1.000	-1.000
STO	81775	75172	6205	44.000	N	94.000	W	36	8.000	NASENW	15.000	44	94	P89674W	ADJ	11/1/1982	5.000	-1.000	-1.000	-1.000	-1.000
STO	81791	75188	6221	43.000	N	92.000	W	19	15.000	NASWSE	15.000	43	92	P89687W	ADJ	11/1/1982	4.000	310.000	1.000	-1.000	-1.000
STO	81792	75189	6222	43.000	N	93.000	W	14	16.000	NASESE	15.000	43	93	P89688W	ADJ	11/1/1982	5.000	-1.000	-1.000	-1.000	-1.000
STO	81793	75190	6223	43.000	N	92.000	W	4	8.000	NASENW	15.000	43	92	P89689W	ADJ	11/1/1982	23.000	4043.000	0.000	-1.000	-1.000
STO	81800	75197	6230	43.000	N	92.000	W	4	8.000	NASENW	10.000	43	92	P89695W	ADJ	11/1/1982	25.000	237.000	100.000	-1.000	-1.000
STO	73479	68171	22056	41.000	N	92.000	W	21	15.000	NASWSE	15.000	41	92	P80965W	UNA	10/5/1989	4.000	2.000	-4.000	0.000	2.000
STO	73480	68172	22057	41.000	N	92.000	W	22	9.000	NANESW	15.000	41	92	P80966W	UNA	10/5/1989	10.000	2.000	-4.000	0.000	2.000
STO	73481	68173	22058	41.000	N	92.000	W	17	16.000	NASESE	15.000	41	92	P80967W	UNA	10/5/1989	3.000	2.000	-4.000	-1.000	-1.000
STO	73482	68174	22059	41.000	N	92.000	W	16	8.000	NASENW	15.000	41	92	P80968W	UNA	10/5/1989	2.000	2.000	-4.000	0.000	2.000
STO	78760	72618	3651	42.000	N	92.000	W	5	8.000	NASENW	15.000	42	92	P86545W	UNA	11/4/1991	2.000	3.000	-4.000	-1.000	-1.000
STO	84943	77906	8939	43.000	N	92.000	W	24	3.000	NASWNE	15.000	43	92	P92902W	UNA	9/28/1993	3.000	110.000	68.000	75.000	100.000
STO	6926	6195	6195	42.000	N	91.000	W	19	5.000	NANENW	15.000	42	91	P106461W	UNA	6/16/1997	-9999.000	-9999.000	-9999.000	-9999.000	-9999.000
STO	6927	6196	6196	42.000	N	91.000	W	29	12.000	NASESW	15.000	42	91	P106462W	UNA	6/16/1997	-9999.000	-9999.000	-9999.000	-9999.000	-9999.000
STO	6928	6197	6197	42.000	N	91.000	W	29	12.000	NASESW	15.000	42	91	P106463W	UNA	6/16/1997	-9999.000	-9999.000	-9999.000	-9999.000	-9999.000
STO	6929	6198	6198	41.000	N	91.000	W	5	13.000	NANESE	15.000	41	91	P106464W	UNA	6/16/1997	-9999.000	-9999.000	-9999.000	-9999.000	-9999.000
STO	6931	6200	6200	41.000	N	91.000	W	17	5.000	NANENW	15.000	41	91	P106466W	UNA	6/16/1997	-9999.000	-9999.000	-9999.000	-9999.000	-9999.000
STO	6932	6201	6201	42.000	N	91.000	W	19	5.000	NANENW	15.000	42	91	P106466W	UNA	6/16/1997	-9999.000	-9999.000	-9999.000	-9999.000	-9999.000
STO	6933	6202	6202	41.000	N	91.000	W	21	5.000	NANENW	15.000	41	91	P106467W	UNA	6/16/1997	-9999.000	-9999.000	-9999.000	-9999.000	-9999.000
STO	7010	6270	6270	43.000	N	92.000	W	22	12.000	NASESW	15.000	43	92	P106535W	UNA	6/27/1997	25.000	200.000	-1.000	-1.000	-1.000
STO,DOM	23634	21965	21965	43.000	N	92.000	W	21	10.000	NANWSW	15.000	43	92	P18931P		12/31/1917	25.000	110.000	-1.000	-1.000	-1.000
STO,DOM	48004	44580	20260	43.000	N	91.000	W	28	7.000	NASWNW	15.000	43	91	P481C	UNA	12/31/1921	25.000	690.000	-6.000	-1.000	-1.000
STO,DOM	57060	53056	6941	42.000	N	91.000	W	7	16.000	NASESE	15.000	42	91	P6064W		6/29/1970	5.000	3719.000	-4.000	-1.000	-1.000
STO,DOM	57065	53061	6946	43.000	N	93.000	W	25	9.000	NANESW	15.000	43	93	P6065W		6/29/1970	5.000	2216.000	-4.000	-1.000	-1.000
STO,DOM	78611	72486	3519	44.000	N	94.000	W	35	6.000	NANWNW	15.000	44	94	P8639W		4/15/1971	20.000	70.000	32.000	48.000	52.000
STO,DOM	30531	28428	4108	44.000	N	94.000	W	33	8.000	NASENW	15.000	44	94	P25692W		1/26/1974	8.000	28.000	6.000	6.000	18.000
STO,DOM	34117	31774	7454	42.000	N	92.000	W	15	5.000	NANENW	15.000	42	92	P30059P		6/4/1975	5.000	90.000	45.000	-1.000	-1.000
STO,DOM	37676	35091	10771	43.000	N	94.000	W	11	4.000	NASENE	15.000	43	94	P34570W		8/27/1976	5.000	655.000	85.000	635.000	245.000
STO,DOM	39313	36593	12273	43.000	N	93.000	W	3	12.000	NASESW	15.000	43	93	P36661W		3/9/1977	25.000	1500.000	-4.000	-1.000	-1.000
STO,DOM	39893	37127	12807	44.000	N	94.000	W	34	8.000	NASENW	15.000	44	94	P37404W		4/1/1977	10.000	58.000	19.000	46.000	56.000
STO,DOM	45115	41856	17536	43.000	N	93.000	W	2	6.000	NANWNW	15.000	43	93	P44210W		7/14/1978	25.000	60.000	25.000	50.000	60.000
STO,DOM	45303	42029	17709	44.000	N	94.000	W	35	4.000	NASENE	15.000	44	94	P44501W		8/4/1978	2.000	160.000	37.500	65.000	-1.000
STO,DOM	45304	42030	17710	44.000	N	94.000	W	34	16.000	NASESE	15.000	44	94	P44502W		8/8/1978	20.000	60.000	29.000	29.000	42.000
STO,DOM	60834	56558	10443	43.000	N	91.000	W	27	11.000	NASWSW	15.000	43	91	P65641W		9/30/1983	12.000	3608.000	125.000	-1.000	-1.000
STO,DOM	82861	76140	7173	41.000	N	92.000	W	27	3.000	NASWNE	15.000	41	92	P90762W	UNA	6/17/1992	10.000	2.000	0.000	-1.000	-1.000