Chapter 3 — Affected Environment

This chapter describes the affected environment for the project alternatives. The affected environment is the portion of the existing environment that could be affected by the project. The information presented here focuses on issues identified through the scoping process and interdisciplinary analyses.

The affected environment varies for each issue. Both the nature of the issue and components of the proposed project and alternatives dictate this variation. The following sections concentrate on providing only the specific environmental information necessary to assess the potential effects of the Proposed Action and alternatives.

Groundwater

This section describes the groundwater resource. More detailed information on groundwater resources in the Project Area is contained in the groundwater technical support document for the FEIS (AHA and Greystone 2002).

Regional Characterization

Groundwater resources are contained in permeable underground aquifers composed of rock and sediments through which water can flow. Water moves slowly in aquifers in response to the prevailing hydraulic gradient, through tiny open spaces in the rock and sediment. Groundwater is replaced, or recharged, from precipitation that falls directly on the aquifers or by leakage through the beds of streams that intercept aquifers or from adjacent aquifers. Movement of groundwater is from recharge areas down the hydraulic gradient to discharge areas.

Aquifer permeability is directly related to the nature and type of porosity of the material that makes up the aquifer. Primary porosity is the open space between individual grains or rock clasts. Secondary porosity consists of joints and fractures that form after a rock is consolidated (Whitehead 1996). Primary porosity is the porosity type of unconsolidated-deposit aquifers and consolidated sandstone aquifers in the PRB (Whitehead 1996). Coal aquifers in the PRB contain significant secondary porosity.

Davis (1976) describes groundwater resources as part of a hydrologic system. The components that describe a hydrologic system are the following: aquifer type (or geologic unit); water chemistry; confined (artesian) or unconfined conditions; and groundwater recharge or discharge areas.

Aquifer Types

The groundwater resources of the PRB are described by Whitehead (1996). Groundwater resources that are at or near the land surface within the PRB are contained in unconsolidated Quaternary alluvial or basin fill deposits or in semi-consolidated to consolidated lower Tertiary sandstones and coal beds that are the uppermost aquifers in the Northern Great Plains aquifer system. Clinker, which is also an aquifer, has formed from some of the lower Tertiary sediments (Heffern and Coates 1999). These Quaternary and Tertiary aquifers are described below in more detail.

Quaternary Alluvial Aquifers

Aquifers in stream-valley alluvium generally occur along rivers and major drainages within the PRB. The groundwater resources contained in alluvial aquifers are described by Whitehead (1996). These unconsolidated deposits of silt, sand, and gravel occur as floodplains, stream terraces, and alluvial fans. Coarser alluvial deposits occur in valleys of the Belle Fourche, Cheyenne, Powder, Tongue, and Little Powder rivers and in the larger tributaries of the Powder and Tongue rivers. Alluvium overlying formations of Tertiary age in the central part of the PRB is mostly fine to medium grained (Hodson et al. 1973).

The thickness of alluvial deposits within the Project Area is mostly less than 50 feet, but may be as much as 100 feet in some valleys near mountains (Hodson et al. 1973). Wells (1982) describes alluvial deposits as commonly 30 feet thick or less, but also reports that deposits 100 feet thick have been measured. Lowry et al. (1986) also describe alluvial deposit thickness and water yield from the PRB. The thickest and coarsest-grained alluvium occurs near the Bighorn Mountains along the western margin of the PRB, where saturated horizons are thick and high yields of water are possible. Mostly fine-grained alluvial deposits with a saturated thickness less than 20 feet occur distant from the mountains, resulting in low yields of water.

Northern Great Plains Aquifer System

The Northern Great Plains aquifer system is an extensive sequence of aquifers and confining units arranged in a stack of layers that may be discontinuous locally within the PRB, but that functions regionally as an aquifer system. This system includes the lower Tertiary aquifers that are exposed at the surface in the PRB and underlying, deeply buried regional aquifers that are stacked with intervening confining layers. The deeply buried aquifer systems are composed of upper Cretaceous sandstones and coals, lower Cretaceous sandstones, upper Paleozoic limestones and dolomites, and lower Paleozoic sandstones, limestones, and dolomites (Whitehead 1996). These deeply buried regional aquifers are stratigraphically below, isolated from, and older than the aquifers that may be affected by CBM development in the PRB and are not described further.

Lower Tertiary Aquifer System

The lower Tertiary aquifer system consists of semi-consolidated to consolidated Oligocene to Paleocene sediments (Whitehead 1996). The Oligocene White River Formation is present in the Project Area only as isolated erosional remnants, such as Pumpkin Buttes in southwestern Campbell County (Lewis and Hotchkiss 1981), and is not described further.

The lower Tertiary aquifers consist of sandstones and coal seams contained in the Eocene Wasatch Formation and the Paleocene Fort Union Formation (Whitehead 1996). Both of these geologic units are continental deposits consisting of sandstones, siltstones, claystones, and beds containing lignite and subbituminous coal. Stratigraphically, from youngest to oldest, the Lower Tertiary Aquifer System consists of the Wasatch aquifers, the Fort Union aquifers contained in the Tongue River member of the Fort Union Formation, the Lebo confining layer, and the Tullock aquifer. Clinker has been formed from these geologic formations in locations where these sediments have been altered in place by spontaneous combustion of coal beds (Coates and Heffern 1999).

Clinker plays an important role as an aquifer in the storage and flow of water within the PRB. Rainfall and snowmelt infiltrate rapidly in clinker exposure areas. The stored water is discharged slowly to springs, streams, and aquifers, which helps maintain flow in perennial streams during dry periods (Heffern and Coates 1999). Clinker outcrops cover about 460 square miles of the Project Area and are concentrated in the following areas: along the eastern boundary of the Project Area in the Rochelle Hills, within the Powder River Breaks in the northern portion of the Project Area, within the Tongue River Breaks north of Sheridan, within the Lake DeSmet area north of Buffalo, and within the Felix coal outcrop area west of Gillette and northeast of Wright (Heffern and Coates 1997).

Wasatch Aquifers

The Wasatch Formation consists of fine- to coarse-grained, lenticular sandstone interbedded with shale and coal (Hodson et al. 1973). Minor constituents include coarse conglomerates occurring along the western margin of the PRB, carbonaceous shales, and thick coal beds (Seeland 1992). Sandstone layers comprise an estimated one-third of the sequence and are important PRB aquifers. High percentages of sand (from 30 to 50 percent and more) have been documented along a trend paralleling the western margin of the PRB, beginning east of Buffalo and west of the Powder River and continuing toward the southeast (Seeland 1992). Wasatch coal beds are thickest in the central and western portions of the PRB (Seeland 1992). Locally, in the northwest part of the PRB near the Bighorn Mountains, the Wasatch is divided into two conglomeratic members.

The Wasatch Formation is as much as 1,800 feet thick in the southern portions of the PRB (Keefer 1974). Southeast of Buffalo, the maximum preserved thickness of the Wasatch Formation is about 3,000 feet (Seeland 1992).

Fort Union Aquifers

The Fort Union Formation yields water from fine-grained sandstone, jointed coal, and clinker overlying the Lebo confining layer (Zelt et al. 1999). The Sandstone content of the Fort Union aquifer ranges from 21 to 91 percent and is hydrologically confined, except near the land surface (Hotchkiss and Levings 1986). The Fort Union Formation is as much as 3,900 feet thick in the southern part of the PRB (Hotchkiss and Levings 1986).

Numerous thick and laterally widespread coal beds occur within the Fort Union Formation and are important PRB aquifers (Lewis and Hotchkiss 1981). The thickness of the Fort Union coal aquifers varies greatly within the PRB. The maximum thickness of a single Fort Union coal seam is less than 25 feet along the western margin of the PRB and in the northern portion of PRB in southeastern Montana. The maximum thickness of a single Fort Union coal seam is more than 100 feet near Wright and extending west and northwest of Wright, within the central portion of the PRB in Wyoming (Seeland 1992).

Lebo Confining Layer

The lower Paleocene Tullock member of the Fort Union Formation is partially isolated and confined by the overlying Lebo member (Brown 1993). The Lebo confining layer generally retards water movement (Hotchkiss and Levings 1986).

The Lebo confining layer consists predominantly of dark shales containing discontinuous zones of white calcareous banding (paleosol horizons). The Lebo confining layer in the northern portion of the Project Area contains rare beds of gray sandstone as much as 10 feet thick. Some coal beds, a few thicker than 2 feet, occur within the Lebo member and form clinker horizons in the southern PRB. The Lebo member ranges in thickness from about 500 feet in the northwestern portions of the PRB to about 1,700 feet in the southwestern portions of the PRB (Brown 1993).

Tullock Aquifer

The lower Paleocene Tullock member of the Fort Union Formation contains alluvial sediments deposited in a continental fluvial environment and is an important PRB aquifer. The Tullock aquifer consists of fine-grained sandstone, sandy siltstone, shale, rare thin limestone, and coal. Sandstone content of the Tullock aquifer ranges from 21 to 88 percent (Hotchkiss and Levings 1986). On average, an estimated one-third of the sequence is composed of channel sandstones. An estimated two-thirds of the sequence is composed of fine-grained overbank deposits containing thin coal beds (Brown 1993).

Tullock sediments have a maximum thickness of about 370 feet in the north and 1,440 feet in the south (Brown 1993). Tullock sediments are thickest in the southeastern and western portions of the PRB.

Groundwater Chemistry

Overview

Two systems of differing groundwater chemistry are described within the PRB (Bartos and Ogle 2002, Rice et al. 2002). A shallow, chemically dynamic system, generally 200 to 500 feet deep, exhibits localized flow and consists of groundwater with a mixed composition of ions (charged particles in solution). Shallow groundwater contains calcium, magnesium, and lesser amounts of sodium as cations (positively charged ions) and bicarbonate or sulfate as the dominant anion (negatively charged ion). A deeper, underlying system that is chemically static exhibits regional flow and consists of groundwater with sodium and bicarbonate as the dominant ions.

Bartos and Ogle (2002) discuss the variation in water chemistry with depth. The zonation appears to be related to geochemical processes such as dissolution and precipitation of minerals, ion exchange, sulfate reduction, and mixing of waters. Significant differences in concentrations of sulfate exist between the coalbed aquifers and the overlying Wasatch aquifer. Sulfate reduction is probably the dominant geochemical process in the coalbed aquifers.

Rankl and Lowry (1990) describe the same change in water chemistry with depth in their overview of water chemistry in water wells within the PRB. Water wells, excluding municipal water supply wells, generally are shallow (less than 500 feet deep) and yield calcium sulfate or calcium-sodium-sulfate waters. There is a decrease in calcium, magnesium, and sulfate and an increase in bicarbonate down to a depth of about 500 feet; however, the concentration of dissolved constituents is relatively uniform deeper than 500 feet. Deep wells generally yield sodium bicarbonate type water.

Hydraulic connections among aquifers in the PRB result in some degree of groundwater mixing, affecting groundwater chemistry of the aquifers involved. Hydraulic connections among aquifers in the PRB are not well understood and are subject to interpretation; however, some leakage between layers probably occurs where the hydraulic gradient allows for vertical groundwater flow and where sandstones directly overlie other sandstones or coal beds (Rice et al. 2002).

Rice et al. (2002) provide the following overview of the chemistry of groundwater in the PRB. Groundwater associated with recharge typically consists of oxygenated water dominant in calcium, magnesium, bicarbonate, and sulfate, with lesser amounts of sodium. Away from the recharge area, interactions among water, aquifer minerals, and bacteria change the chemical composition of the groundwater. The net result of these reactions and processes is a decrease in calcium, magnesium, and sulfate and a corresponding increase in sodium and bicarbonate as groundwater flows away from the source of recharge.

Rice et al. (2002) also summarize the reactions and processes that affect the composition of groundwater in the PRB. Sodium enrichment likely results from dissolution of plagioclases (feldspar minerals), cation exchange of calcium and magnesium for sodium on clay minerals, or removal of calcium and magnesium by carbonate precipitation. Initially, oxygen-rich water near the recharge area oxidizes pyrite minerals, increasing the relative abundance of sulfate over bicarbonate. As water moves farther from the source of oxygen at the recharge area, evidence suggests that bacterial sulfate reduction occurs, depleting the water of sulfate and enriching it in bicarbonate. The precipitation of gypsum may remove sulfate along with calcium from the water.

Processes associated with coalification (coal formation) also influence the composition of groundwater (Rice et al. 2002). A series of bacterially mediated processes occurs in a progressively more reducing environment. Reactions include reduction of nitrate, manganese, and iron oxides, sulfate reduction, and methanogenesis (methane formation), that produce NH^{+4}, Mn^{+2}, Fe^{+2}, HS^{-}, CO_2, and CH_4. The overall effect of coalification processes that produce methane of biological origin in the PRB is to deplete sulfate, increase bicarbonate, and establish a reducing environment in groundwater within the coal zone aquifer.

Analysis of tritium in groundwater in the PRB has been used to date the recharge of the water (Bartos and Ogle 2002, Rice et al. 2002). Groundwater that contains little or no tritium is defined as submodern or older and is referred to as “pre-bomb” water that was recharged before 1952; modern groundwater contains tritium. Analysis indicates that although the groundwater in the Fort Union coals is meteoric in origin, it is older than 1952. Water samples from springs at two locations provide evidence that they were recharged after 1952. Water samples from Wasatch sandstones at two locations provide evidence that they contain a mixture of submodern and modern water, but are mostly submodern water. Concentrations of tritium in all other samples from coal zones within the Wasatch and Fort Union Formations suggest the water is submodern.

Effects of Existing Development

CBM produced water that is exposed at the surface typically undergoes immediate changes in chemical composition that are the result of introducing oxygen to the water. Sulfate-rich surface waters also can mix with the extracted groundwater. Where oxygen has been introduced at the surface, iron and manganese have oxidized and precipitated, as evidenced by iron stains that are commonly associated with CBM discharge outfalls. Barium has precipitated as barium sulfate where CBM produced water that is rich in sodium and bicarbonate and contains barium has been mixed with sulfate-type water.

Pumping at existing CBM wells that dewaters or depressurizes the coal aquifers to stimulate gas desorption from the coals likely has moved waters with different chemistry from overlying or underlying units into the coal aquifer through leakage. However, no quantitative estimate of changes in groundwater chemistry is possible as a result of the limited availability of data from monitoring of groundwater quality in CBM development areas.

Some groundwater contained in Wasatch sandstones that directly overlies coal zones likely has leaked into the Fort Union coal aquifer during CBM development that has occurred to date. Preliminary results from sampling of a limited number of monitoring well clusters indicate the potential for movement of groundwater within the Wasatch Formation downward into the Fort Union Formation (Bartos and Ogle 2002; Rice et al. 2002). Groundwater in Wasatch sandstones and coals varies somewhat from the Fort Union coal aquifer, having a slightly higher median pH and higher concentrations of total dissolved solids (TDS), sulfate, and manganese, but lower concentrations of barium (Bartos and Ogle 2002, Rice et al. 2002). Leakage of groundwater from Wasatch sandstones into the Fort Union Formation that has occurred to date likely has not noticeably affected groundwater chemistry or water type of the Fort Union coal aquifer.

Infiltration of CBM produced water that has already been extracted likely has moved waters with different chemistry through the underlying aquifer units as the CBM produced water infiltrated downward through the section. As CBM recharge waters infiltrated downward, the groundwater likely became enriched in sulfate initially, as oxygenated recharge waters oxidized pyrite (iron sulfate) minerals. As water moved deeper, farther from the source of oxygen, the infiltrating waters likely became enriched in bicarbonate as sulfate was removed through bacterial sulfate reduction. Reduction of nitrate, manganese, iron oxides, and sulfates also likely occurred, producing NH^{+4}, Mn^{+2}, Fe^{+2}, and HS^{-}. However, no quantitative estimate of changes in groundwater chemistry is possible as a result of the limited availability of data from monitoring of groundwater quality in CBM development areas.

Bone Pile Creek, located south of Gillette, has been receiving discharges of CBM produced water since 1993. Shallow monitoring wells located along the creek were sampled by the BLM for major water quality parameters in June 1999 and May 2001. No significant change in water quality was detected in the wells. The alluvial well had a sodium adsorption ration (SAR) of 2 and a specific conductance (EC) of 4,330 ΦS per cm in 1999. When sampled again in 2001, the SAR was still 2, and EC was 4,330 ΦS per cm. Major anions and cations also remained relatively unchanged over the two-year period. Water quality analysis of the shallow Wasatch sand unit measured an SAR of 5 in 1999 and 2001, and an EC of 4,110 ΦS per cm in 1999 and 4,100 ΦS per cm in 2001. As with the alluvial aquifer, major cations and anions also remained relatively unchanged during this period. Since monitoring began after CBM discharge, the impact of CBM discharge on water quality cannot be determined.

The BLM also is monitoring water quality in shallow wells located along Burger Draw, an ephemeral stream near the center of the PRB. The BLM installed shallow monitoring wells in 2001, before the onset of discharge of CBM produced water in early 2002. Water quality samples obtained from the alluvial wells prior to CBM discharge indicated that the EC of alluvial water ranged from 5,000 to 9,000 ΦS per cm, and SAR ranged from 2.5 to 7. CBM produced water in the area has an EC of approximately 3,000 to 4,000 ΦS per cm and a SAR of 25 to 30.

Water quality in the alluvium along Burger Draw has remained essentially unchanged since the discharge of CBM produced water began. Water quality samples collected from shallow wells that were unsaturated prior to CBM discharge indicate infiltrating CBM produced water dissolves minerals as it interacts with the alluvium, and the resulting water quality is very similar to that of shallow alluvial water along the reach prior to the discharge of CBM produced water. CBM discharges that had an EC of approximately 4,000 ΦS per cm and a SAR of 30 produced alluvial water with an EC of 5,000 to 8,000 ΦS per cm and a SAR of 3 to 8.

Numerous reservoirs and impoundments currently used within the Project Area to manage CBM produced water typically are open systems that are unlined to facilitate infiltration or are designed with an inlet and outlet to allow water to flow through the structure. Constituents of groundwater extracted during CBM development to date, including trace elements, are not likely to have become concentrated in these open systems, as they would if they were contained in a closed system where the volume of water is reduced primarily by evaporation. Data from analysis of water samples are generally not available for reservoirs and impoundments where CBM produced water is stored. Data that are available often represent outfalls authorized by WDEQ that are located near (but not in) reservoirs.

Drilling and completion procedures for CBM wells are strictly controlled by WOGCC and BLM requirements that ensure each formation remains as isolated as it is under natural conditions and that the integrity of the well bore remains intact. Development that occurs in accordance with these requirements is not likely to have allowed any leakage or mixing of groundwater in the formations that were penetrated.

However, leakage and mixing between aquifers of differing water quality likely has occurred where aquifer zones in existing non-CBM wells were not isolated during well completion or abandonment because of a lack of mechanical integrity, including inadequate casing, cementing, or plugging. High pH values are typical in wells contaminated with alkaline cement or bentonite (Bartos and Ogle 2002).

Many existing non-CBM well bores likely do not effectively isolate the formations penetrated and may serve as conduits for mixing of waters from different aquifers. Water wells frequently are screened over multiple aquifer zones, which would facilitate mixing of groundwater from different aquifer zones. Many older, conventional oil and gas wells likely are inadequately cased, which could have allowed any groundwater present to leak from one formation to another. Numerous uncased boreholes were drilled in the PRB to evaluate uranium potential and were not properly plugged, which could have allowed any groundwater present to leak through the formations penetrated. No comprehensive evaluation of the integrity of existing wells within the Project Area has been conducted. Many thousands of water wells, non-CBM oil and gas wells, and uncased boreholes are located within the Project Area.

Alluvial Aquifers

Water quality in alluvium within the PRB is variable. Lowry et al. (1986) report concentrations of TDS for alluvial aquifers that vary from 106 to 6,610 milligrams per liter (mg/L) and averaging 2,128 mg/L for 38 samples. Water from surficial deposits that contains less than 600 mg/L TDS may be divided into two chemical types: a calcium magnesium carbonate type, and a calcium-magnesium-sulfate type (Rankl and Lowry 1990). Concentrations of TDS greater than 600 mg/L generally are a result of increased values for sodium and sulfate (Rankl and Lowry 1990).

Hodson et al. (1973) characterize alluvial groundwater in various geographic areas within and near the PRB. Water in alluvium near the Bighorn Mountains and the Black Hills is of better quality than water in alluvium within the central part of the PRB. Water in alluvium within the southwest part of the basin and the Powder River valley is generally of poorer quality than water in alluvium elsewhere in the PRB. No dominant water type is prevalent (Hodson et al. 1973).

The chemical compositions of water in the Powder River and in the river's alluvium are similar (Ringen and Daddow 1990). Water in the Powder River is dominated by sodium and sulfate ions, while water in the river's alluvial deposits is dominated by sodium, calcium, and sulfate ions. The water in the underlying bedrock is dominated by sodium and bicarbonate ions. The quality of water in the alluvium limits its use as a water supply, as it is unacceptable for drinking water, acceptable for most livestock, and marginal for irrigation or industrial use.

Springs and Seeps

Data from analysis of water samples generally are not available for the thousands of springs and seeps located in Project Area. Data are, however, available for 10 springs located in areas that are undergoing CBM development within the Project Area (WRDS 2002) (Table 3-1).

Clinker Springs

Rice et al. (2002) report the results of sampling at two clinker springs. The locations of springs that were sampled are shown in Rice et al. (2002). One spring located north of Gillette was sampled. The other spring that was sampled is located near the southeastern corner of Campbell County. When compared with groundwater conditions in the Wasatch Formation, the clinker springs contain lower concentrations of TDS, sodium, bicarbonate, chloride, and fluoride, and have lower temperatures. When compared with groundwater conditions in the Fort Union Formation, the clinker springs contain lower concentrations of sodium, bicarbonate, chloride, and fluoride, higher concentrations of calcium and sulfate, and have lower temperatures.

Heffern and Coates (1999) describe groundwater conditions in clinker areas within the PRB. The concentration of TDS within clinker varies widely from under 200 mg/L to more than 10,000 mg/L. Water in clinker from recharge areas near the burn line tends to be a calcium sulfate type, and water in clinker from discharge areas tends to be a sodium bicarbonate type, similar to water in the coal. Ash residue at the base of the clinker may contribute to high concentrations of TDS (Heffern and Coates 1999). The interaction of groundwater with ash and clinker results in higher TDS values for water in coal near clinker areas.

Table 3-1 Water Quality of Springs

Spring Information	Conductivity (µmhos/cm)[1]	Temperature (°C)	pH[2]	HCO_3 (mg/L)	Ca (mg/L)	Mg (mg/L)	Na (mg/L)	K (mg/L)	Cl (mg/L)	SO_4 (mg/L)	Fl (mg/L)	Fe[5] (µg/L)	SAR[4] (mg/L)
Hansen Spring													
42N/69W S15 (1999)	303	12	8.2	---[6]	35	10	8	7	2	28	0.5	---	---
Moyer Spring													
51N/71W S30 (1999)	1,610	---	7.8	---	211	65	46	25	12	719	0.8	---	---
Amax RH Spring 1													
51N/72W S16 (1975)	5,300	---	7.5	522	454	454	423	42	29	3,497	1.2	---	3.36
Amax RH Spring 2													
51N/72W S16 (1975)	2,870	---	8.0	330	180	240	210	20	9.3	1,700	1.1	430	2.41
Raymond Tolman													
51N/82W S36 (1977)	---	---	---	---	---	---	130	---	---	250	---	---	---
Brooder Spring													
53N/83W S18 (1974)	---	---	---	---	---	---	---	---	---	8.2	---	---	---
Bard Spring													
54N/82W S13 (1974)	---	---	---	---	---	---	---	---	---	165	---	---	---
56N/72W S21 (1976)	530	9	7.8	208	68	26	19	14	2.5	140	0.8	20	0.5
56N/72W S29 (1976)	2,350	6	7.4	106	260	130	140	27	4.4	1,400	0.6	80	1.8
Jensen Spring													
56N/84W S32 (1973)	---	---	---	---	---	---	---	---	---	778	---	---	---

Notes:
1. µmhos/cm mean < micromnos per centimeter
2. pH is in standard units
3. mg/L means milligrams per liter
4. SAR means sodium adsorption ratio
5. µg/L means micrograms per liter
6. --- means not reported

Source: Wyoming Water Resources Data System 2002.

Lower Tertiary Aquifer System

The quality of water in the Wasatch aquifer within the PRB is variable. Lowry et al. (1986) report concentrations of TDS for Wasatch aquifers that vary from 227 to 8,200 mg/L and average 1,298 mg/L for 191 samples. Sodium sulfate and sodium bicarbonate are the dominant water types (Hodson et al. 1973).

Dahl and Hagmaier (1976) describe changes in groundwater chemistry along the regional flow path near the Highland uranium deposits in the southern PRB. The chemistry changes from a sulfate-rich groundwater with minor bicarbonate in the recharge area southwest of the Highland area to a bicarbonate-rich groundwater in the discharge area northeast of the uranium deposits. This change in groundwater chemistry is attributable to sulfate reduction, which decreases the concentration of sulfate and increases the concentration of bicarbonate. The Highland uranium deposits (T.36N. R.72W.) are located in Converse County within the Southern Powder River Uranium District (Harris et al. 1985).

The major dissolved-ion chemistry of water from the Wasatch Formation in the PRB has been described based on information from four wells completed in coals and eight wells completed in sandstones (Bartos and Ogle 2002; Rice et al. 2002). The locations of wells completed in Wasatch coals or sandstones that were sampled are shown in Rice et al. (2002). Wells located in the central portion of Campbell County, north of Buffalo, and north of Sheridan were sampled. Water produced from the Wasatch Formation varies in composition from mixed-type waters (calcium-magnesium-bicarbonate-sulfate) at relatively shallow depths (less than 200 feet) to sodium-bicarbonate waters at greater depths.

The pH of some samples from Wasatch aquifers exceeds the secondary maximum contaminant level for drinking water established by the U.S. Environmental Protection Agency (EPA) (Bartos and Ogle 2002). Bartos and Ogle (2002) also report dissolved concentrations of some constituents in groundwater from sandstones and coals within the Wasatch Formation. The median concentration of TDS reported for sandstones is 1,010 mg/L, which exceeds the secondary maximum contaminant level for drinking water established by EPA. The median concentration of sulfate is 130 mg/L, which is below the secondary maximum contaminant level for drinking water established by EPA. However, the concentration of sulfate in some samples exceeds EPA's standard for drinking water. The concentration of manganese in some samples analyzed also exceeds the secondary maximum contaminant levels for drinking water established by EPA. The concentration of manganese likely is relatively high because of its higher solubility as Mn^{+2} in anoxic waters. The median SAR is nine.

Hodson et al. (1973) provide an overview of water quality in the Fort Union aquifer. TDS concentrations range from about 200 to more than 3,000 mg/L, but commonly range between 500 and 1,500 mg/L. Water type is mostly sodium bicarbonate, and to a lesser extent sodium sulfate. The water from deep wells is soft, meaning sodium plus potassium exceeds calcium plus magnesium, and many water samples contain carbonate as well as bicarbonate (Rankl and Lowry 1990). The dominant chemical processes that control the chemistry of Fort Union groundwater are cation-exchange softening and sulfate reduction (Rankl and Lowry 1990).

Davis (1976) describes the chemistry of groundwater in the Fort Union aquifer within the eastern PRB. Along the coal outcrop the water generally is calcium-magnesium sulfate type, changing to sodium bicarbonate type westward where confined aquifer conditions exist. There is a relationship between the confined and unconfined state of the aquifer and the chemical quality of water within the aquifer. As a rule, waters within unconfined portions of the coal aquifer are calcium-magnesium-sulfate type and within confined portions of the aquifer are sodium bicarbonate type.

CBM Produced Water

Rice et al. (2002) summarize the major dissolved-ion chemistry of CBM produced water from the Fort Union coal zone within the PRB based on results for 83 groundwater samples from wells completed in the Fort Union coal zone (Table 3-2). The locations of wells completed in Fort Union coal zones that were sampled are shown in Rice et al. (2002). Most wells sampled are located in Campbell County. Most wells sampled in Campbell County are located south-

southwest and south-southeast of Gillette; however, some are located north and west of Gillette. One cluster of wells sampled is located north of Sheridan. A few wells sampled are located in Johnson County. Water produced from the Fort Union Formation is exclusively sodium bicarbonate-type water. The concentrations of iron and manganese in some samples analyzed exceed the secondary maximum contaminant levels for drinking water established by EPA. Concentrations of iron and manganese are relatively high because of their higher solubility as Fe^{+2} and Mn^{+2} in anoxic (without oxygen) waters. Concentrations of barium are relatively high, likely as a result of the low concentrations of sulfate. In waters that contain sulfate, barium has low solubility and forms a precipitate (barium sulfate).

Table 3-2 Composition of CBM Produced Water– Fort Union Formation

Parameter (units)	Minimum	Maximum	Median	DWS[1]
Temperature (°C)	12	29	19	---[2]
pH (standard units)	6.8	8	7.3	6.5–8.5
TDS (mg/L)	270	2,720	838	500
Calcium (mg/L)	1.8	68.9	26.3	---
Magnesium (mg/L)	0.6	45.7	14	---
Sodium (mg/L)	109	1,000	270	---
Potassium (mg/L)	3.1	48	7.3	---
Bicarbonate (mg/L)	289	3,134	952	---
Sulfate (mg/L)	<0.3	16.7	X[4]	250
Chloride (mg/L)	5.1	64.6	10.6	250
Fluoride (mg/L)	0.4	4.13	1.1	2
Iron (mg/L)	0.02	4.9	0.38	0.3
Manganese (mg/L)	0.0014	0.0914	0.0136	0.05
Barium (mg/L)	0.14	1.6	0.6	2
Sodium adsorption ratio	5	68.7	8.8	---

Note:
1. DWS means Drinking Water Standard (Primary or Secondary Maximum Contaminant Level).
2. --- means no recommended values.
3. mg/L means milligrams per liter
4. X means less than the minimum reporting level for that constituent.

Source: Rice et al. 2002

Rice et al. (2002) summarize the dissolved trace-element chemistry of CBM produced water from the Fort Union coal zone within the PRB based on results for groundwater samples from wells completed in the Fort Union coal zone (Table 3-3). All concentrations of trace elements are uniformly low and are below the primary and secondary maximum contaminant levels for drinking water established by EPA. There are no noticeable basinwide trends in concentrations of trace elements.

Table 3-3 Trace Elements in CBM Produced Water – Fort Union Formation

Element (Symbol)	MRL[1] (µg/L)[3]	Maximum (µg/L)	Detection Ratio (detections/total samples))	DWS[2] (µg/L)
Aluminum (Al)	<50	<50	0/70	50 to 200
Silver (Ag)	<1	<1	0/70	100
Arsenic (As)	<0.2	2.6	38/70	50
Boron (B)	<0.1	390	24/70	---[4]
Beryllium (Be)	<0.1	<0.1	0/70	---
Bismuth (Bi)	<20	46	30/70	---
Cadmium (Cd)	<0.1	<0.1	0/70	5
Cerium (Ce)	<0.1	14	2/70	---
Cobalt (Co)	<0.1	0.24	19/70	---
Chromium (Cr)	<1	1.8	10/70	---
Cesium (Cs)	<0.1	0.78	30/70	---
Copper (Cu)	<0.1	29	70/70	1,000
Mercury (Hg)	<0.1	0.25	1/70	2
Lanthanum (La)	<10	<10	0/70	---
Lithium (Li)	<10	208	70/70	---
Molybdenum (Mo)	<0.2	4.1	32/70	---
Nickel (Ni)	<0.5	35	66/70	100
Lead (Pb)	<0.1	0.43	5/70	---
Rubidium (Rb)	<0.1	38	70/70	---
Antimony (Sb)	<2	<2	0/70	6
Scandium (Sc)	<0.1	3	66/70	---
Selenium (Se)	<2	<2	0/70	50
Tin (Sn)	<0.1	5.5	7/70	---
Strontium (Sr)	<0.1	1,900	70/70	---
Thorium (Th)	<20	<20	0/70	---
Thallium (Tl)	<0.2	0.34	1/70	---
Uranium (U)	<0.1	<0.1	0/70	---
Vanadium (V)	<0.2	1.1	1/70	---
Tungsten (W)	<20	51	4/70	---
Yttrium (Y)	<20	<20	0/70	---
Zinc (Zn)	<1	80	39/70	5,000
Zirconium (Zr)	<50	<50	0/70	---

Notes:
1. MRL = minimum reporting level
2. DWS = Drinking Water Standard (Primary or Secondary Maximum Contaminant Level).
3. µg/L means micrograms per liter
4. --- means no recommended values.

Source: Modified from Rice et al. 2002

The median value for TDS (838 mg/L) reported by Rice et al. (2002) exceeds the secondary maximum contaminant level for drinking water established by EPA. The TDS values reported by Rice et al. (2002) indicate that the concentration of TDS increases from south to north and from east to west in the PRB. This increase generally results from an increase in sodium and bicarbonate within the water.

The SAR, a calculation of the abundance of sodium relative to calcium and magnesium in water, also increases toward the west and north, with the lowest values reported near and south of Gillette (Rice et al. 2002). The SAR values range from 5 to 69 and the median value is 8.8 (Rice et al. 2002).

The BLM has summarized and modeled SAR and specific conductance (EC) values for CBM produced water by sub-watershed (BLM 2002). The SAR and EC are physical properties of water that indicate the relative suitability of water for beneficial and state-designated uses. In the near-surface environment, water that contains high SAR values would cause an exchange of ions in clay minerals within soils. In this case, calcium (Ca^{+2}) and magnesium (Mg^{+2}) are exchanged for sodium (Na^{+}), creating sodium-rich clays with an increased swelling potential and greatly reduced permeability (Rice et al. 2002). The EC is a measure of the capacity of the water to conduct an electric current and indicates the degree of mineralization of the water (Bartos and Ogle 2002).

Data for samples from 132 wells were compiled for analysis and modeling. Data for 122 wells were provided by the USGS (Rice et al. 2002). Data from seven wells were provided by the BLM, the WDEQ supplied data for two wells, and Williams Production Company provided the results of chemical analysis from one well. The well locations are shown in Figure 3-1.

Because of the limited amount of data for the Upper Tongue River, Clear Creek, and Crazy Woman Creek sub-watersheds, it was necessary to estimate one data point in the north-central portion of the basin (T57N R79W). Values for SAR and EC at this data point were calculated by averaging values from the two closest data points. The estimated point was required to permit modeling of data from the widely spaced wells without generating anomalies in the SAR/EC model grid.

Data from each well were imported into contouring software and transformed into a uniform grid with a spacing of 400 by 400 meters over the Project Area. The grid points generated were exported as X – Y – Z coordinates to allow spatial analysis and data interpretation. The values for SAR and EC in each sub-watershed and the interpreted variations in SAR and EC values within the Project Area are shown in Figure 3-1.

Confined (Artesian) vs. Unconfined Conditions

The groundwater resources contained in alluvial aquifers are under unconfined or water table conditions (Whitehead 1996). Normally, clinker is an unconfined aquifer (Heffern and Coates 1999). Groundwater resources contained in the Wasatch aquifers occur under partially confined conditions (Whitehead 1996).

The Fort Union coal zone aquifers are hydrologically confined, except near the land surface (Hotchkiss and Levings 1986). Artesian conditions can exist (Bartos and Ogle 2002). Gas present within the coal beds and in underlying or overlying

Figure 3-1 SAR + EC

sandstone lenses can contribute significantly to the hydraulic head in wells within the PRB, and may cause water levels to rise higher than would be expected if only artesian pressure were present (Bartos and Ogle 2002). The underlying Lebo confining layer generally retards water movement (Hotchkiss and Levings 1986). The lower Paleocene Tullock member of the Fort Union Formation is partially isolated and confined by the overlying Lebo member (Brown 1993). The Tullock aquifer is hydrologically confined, except near outcrop areas (Hotchkiss and Levings 1986).

Groundwater Flow Systems (Groundwater Recharge vs. Groundwater Discharge Areas)

Overview

No consensus exists among experts on the interpretations and assumptions that should be used to represent groundwater flow conditions in the PRB. Flow paths, the extent of flow between hydrogeologic units, and the relationship between local and regional flow in lower Tertiary aquifers are not well understood. The results of a number of studies in the PRB are summarized by Bartos and Ogle (2002).

Bartos and Ogle (2002) present two conceptual models for groundwater flow in the lower Tertiary aquifers of the Wasatch and Fort Union Formations within the PRB: (1) separate shallow and deep systems with little vertical migration between them; and (2) significant vertical flow through the Wasatch Formation and into the underlying Fort Union coal zone. Both of these models, and the clinker recharge model of Heffern and Coates (1999), operate at the basin scale, according to Bartos and Ogle (2002). Either of these groundwater flow models would explain the variations in groundwater chemistry within the PRB.

A similar model for shallow and deep flow of groundwater is summarized by Slagle et al. (1985) in their description of groundwater resources and groundwater flow in the northern PRB within Montana. The groundwater system can be divided into two general flow patterns: an upper localized flow pattern, controlled by topography that occurs in aquifers at depths of 200 feet or less; and a lower, regionalized, northward flow pattern that occurs at depths of 200 to 1,200 feet. Groundwater discharge areas for aquifers less than 200 feet deep primarily coincide with the valleys of perennial and intermittent streams. Water enters the shallow system by infiltration, flows downslope, and discharges to streams and rivers. Discharge areas for deeper aquifers generally coincide with the major drainages. Vertical movement between the aquifers is known to exist, but the rate of exchange is unknown. Subsurface inflow from Wyoming into the northern PRB enters Montana primarily in three areas: along the Tongue River; along Hanging Woman Creek; and between the Powder and Little Powder Rivers. Total inflow is estimated as 500 to 1,000 acre-feet per year.

Rankl and Lowry (1990) summarize the relative amounts of regional and local groundwater flow in the Powder River structural basin of Wyoming and Montana, concluding that alluvial systems that deplete flow in the streams probably are the typical alluvial system in the basin, however, some streams may gain water from alluvial aquifers. Of the three largest streams included in the analysis, the Powder, Belle Fourche, and Cheyenne Rivers, only the Belle Fourche River had identified base flow, which was present only during the period of largest precipitation, but not during the period of minimum evapotranspiration. The loss of water to the alluvium in the reach of the Powder River between Sussex, Wyoming and Locate, Montana is attributed to evapotranspiration from the alluvium. The average loss of flow from the Powder River in the reach from Arvada, Wyoming to Moorhead, Montana and from Moorhead to Locate is about 0.3 cubic feet per second during late fall and early winter. This type of system probably is prevalent in the basin.

Effects of Existing Developments

Brown Reservoir Monitoring Study - A study of evapotranspiration and infiltration in the Brown Reservoir area (T44N R76W) is described by Day (2000). For almost one year during 1999-2000, produced water from eight coalbed methane (CBM) wells was piped to Brown Reservoir. The effects of this discharge were observed in shallow monitoring wells installed upstream of the reservoir dike and downstream of the reservoir outlet in locations adjacent to the stream channel. Alluvial groundwater levels in the shallow well located within 15 feet of the high water line of the reservoir rose nearly 10 feet within five months of the onset of discharge. Within five months of the cessation of discharge, alluvial groundwater levels in this well, located immediately adjacent to the reservoir, had returned to the level observed when discharge began. Water levels rose just over two feet in the alluvial well located farthest downstream of the reservoir during one measurement in February 2000, however, at all other times the downstream alluvial wells, which were 20 feet deep, were dry.

Bone Pile Creek Monitoring Study - The only long term study measuring the impacts of CBM produced water on alluvial aquifers was established by the BLM in April 1998. The BLM installed monitoring wells south of Gillette along Bone Pile Creek in alluvial deposits and shallow Wasatch sands. An alluvial well is located on a low terrace above the stream channel. The alluvium is approximately 65 feet thick at this point along the stream. A second well is completed to a total depth of 185 feet in a shallow Wasatch sand unit that is over 70 feet thick. CBM produced water has been discharging to Bone Pile Creek since March 1993. Water level data from these monitoring wells document the interactions of CBM produced water, surface water, the alluvial aquifer, and the shallow Wasatch sand aquifer.

Measured water levels in Bone Pile Creek typically are 0.5 to 1.5 feet higher than water levels in the alluvial sand well. Water levels in the alluvial well typically are 15 feet or more higher than water levels in the shallow Wasatch sand well. The water levels in Bone Pile Creek, alluvium along the creek, and the underlying shallow Wasatch sand unit indicate a downward gradient in hydraulic head, suggesting water should move from the stream into the alluvium, and then into the shallow Wasatch sand.

Water levels in the alluvium of Bone Pile Creek show a distinct seasonal pattern, with water levels reaching a maximum during May in most years, and declining to a minimum by late September or early October. There is a strong correlation between alluvial water levels and monthly precipitation (Graph 3-1). This seasonal variation in water level also can be seen in the shallow Wasatch sand unit monitored at Bone Pile Creek (Graph 3-2), indicating a hydraulic connection between the alluvium and the shallow Wasatch sand unit.

The net change in alluvial water levels has been downward since 1998, with a measured net water level decline of nearly 1.5 feet. The trend in the water level within the shallow Wasatch sand has been the opposite of the trend observed in the alluvial well. Water levels in the shallow Wasatch sand unit have increased more than a foot since 1998.

No baseline measurements of water levels in the alluvium or shallow Wasatch sand underlying Bone Pile Creek were made prior to the onset of CBM discharges. Bone Pile Creek is ephemeral in nature, and did not exhibit sustained flow prior to the discharge of CBM produced water. Since the onset of CBM production, the creek has exhibited perennial pools and intermittent surface flows.

Bone Pile Creek has received constant discharge of CBM produced water since March 1993, yet alluvial water levels have shown a net decline of nearly 1.5 feet. The decline in alluvial water levels could be the result of several factors. Previous investigators (Rankl and Lowry 1990) have suggested that evapotranspiration in the alluvium may be greater than average annual precipitation in the basin. Precipitation in the Bone Pile Creek area during much of 2001 and 2002 has been below average, resulting in less opportunity for alluvial recharge from natural sources. Low precipitation during 2001 and 2002 may have magnified the effects of evapotranspiration on recharge of the alluvium.

The discharge of CBM produced water into Bone Pile Creek also has decreased over time. In March 1998, the average water production for CBM wells in the Bone Pile Creek drainage was 17.3 gallons per minute. By March 2002, the average water production rate for CBM wells in the area was only 1.2 gallons per minute. Declining alluvial water levels could reflect this decrease in CBM water production.

A comparison of water levels in the alluvium and shallow Wasatch sand underlying Bone Pile Creek indicates a hydraulic connection between these aquifer zones (Graph 3-2). Recharge to the shallow Wasatch sand aquifer has continued despite a decline in alluvial water levels. It is possible that the rate of leakage between the alluvial aquifer and the shallow Wasatch sand aquifer is greater than the current rate of recharge to the alluvium.

CBM produced water has been discharged into Bone Pile Creek for over nine years, yet alluvial water levels have declined 1.5 feet over the last four years. Water levels in the shallow Wasatch sand aquifer are continuing to increase, indicating net recharge to the zone. The causes of water level declines in the alluvium cannot be determined, but most likely result from recent dry climate conditions, decreased discharges of CBM produced water, and leakage from the alluvium into the shallow sand of the Wasatch Formation.

Burger Draw Monitoring Study - Similar trends in alluvial water levels have been documented in ongoing studies initiated in Burger Draw, an ephemeral stream near the center of the PRB. During October 2001, the BLM installed a number of shallow alluvial monitoring wells along a 2.5-mile long segment of Burger Draw.

Wells along the reach of Burger Draw being studied range in depth from 12 to 100 feet, with an alluvial thickness of approximately 25 feet. Most of the wells were installed prior to the discharge of CBM produced water along this stream segment.

The water levels in Burger Draw prior to the discharge of CBM produced water indicated the alluvium along the channel was unsaturated over most of the thickness of the deposit. At one site, nested monitoring wells indicate a shallow confined aquifer is present below the alluvium.

Since the onset of CBM discharge in Burger Draw in early 2002, alluvial water levels have increased nearly six feet. A hydraulic gradient similar to that observed in Bone Pile Creek has been documented. Water levels measured in surface water, alluvium along the creek, and the underlying shallow Wasatch sand unit indicate a downward gradient in hydraulic head, suggesting water should move from the stream into the alluvium, and then into the shallow Wasatch sand.

Local Flow Systems

The hydrology of the alluvium along the Powder River between Sussex, Wyoming and Moorhead, Montana is described by Ringen and Daddow (1990). The fine-grained alluvium usually is 10 to 30 feet thick and about one-half mile wide. Flow-duration curves, used to identify groundwater discharge to rivers, indicate that low flows at Sussex are sustained by groundwater discharge that may be 2.8 cfs or greater, however, groundwater discharge is small in the downstream reach between Arvada, Wyoming and Moorhead. The water table is projected to be less than 15 feet below the land surface near the location where Interstate 90 crosses the Powder River.

Ringen and Daddow (1990) conclude that the alluvium of the Powder River has direct hydraulic connection with the river, as evidenced by the response of the static water level in alluvial wells to changes in river stage. The main source of water in the alluvium is seepage from the Powder River, stored during periods of high streamflow and discharged back to the river in some reaches during low flow. Groundwater storage in the alluvium declines during the growing season because transpiration exceeds recharge.

Ringen and Daddow (1990) also conclude that water levels in bedrock aquifers do not respond substantially to changes in river stage or water levels in the alluvium. A thick blue clay or shale at the top of the bedrock sequence isolates the bedrock from the alluvium hydraulically, and therefore, from the river, in some locations. In addition, the hydraulic head in the underlying confined aquifer was much higher than the water level in the alluvium.

Slagle et al. (1985) describe groundwater conditions and the hydrology of the alluvium in the northern portion of the PRB, within southeastern Montana. Alluvium along the streams generally is saturated. However, terrace deposits commonly occur above the saturated zone. Losses from perennial streams recharge the alluvium during periods of high flow. Intermittent and ephemeral streams serve as a major source of recharge during times of runoff. Much of the water recharged as a result of irrigation is recirculated to the stream from which it was obtained. Frequently, water moving downward is retarded or intercepted by relatively impermeable material, causing the water to move laterally. Water that reaches the saturated zone raises the water table in the alluvium to above-normal levels, which induces lateral flow and results in increased groundwater discharge to the stream. Water in bedrock aquifers that doesn't drain directly into perennial streams, infiltrates the alluvium along intermittent and ephemeral streams.

Lowry and Rankl (1987) describe the alluvium in the White Tail Butte area along and west of the Little Powder River, north of Gillette. The alluvium is estimated to be 30 feet thick. Depth to water in alluvium below the land surface was reported be between 5 and nearly 14 feet, based on records from three wells included in the study.

Lenfest (1987) characterizes the hydrology of the alluvium and its relation to streamflow in ephemeral streams at several sites in the Cheyenne River Basin. Alluvium generally is more permeable and can store and transmit more water than upland soils. Surface water infiltrates into the alluvial aquifer at a relatively rapid rate because of the larger hydraulic conductivity of alluvium, and is transmitted through the bedrock aquifer at a slower rate because of the smaller hydraulic conductivity of the bedrock.

Hydrologic data from 1982-1983 for several sites in the Cheyenne River basin are presented by Lenfest (1987). In the North Fork Dry Fork Cheyenne River area (T37N R75W), the alluvial aquifer is 24 to 83 feet thick and contains silt and fine to coarse-grained sand. The unsaturated thickness of the alluvium is 30 feet or more. Alluvium in the Black Thunder area (T42N R66W) consists of silt, fine sand, and gravel that is about 20 feet thick, and has an unsaturated thickness of about 10 feet or less. In the Black Thunder area, recharge to the aquifers from streamflow is indicated. Water levels in the alluvial aquifer increased within three hours of streamflow in Black Thunder Creek. Some water in the alluvial aquifer leaked into the bedrock aquifer, causing water level rises in the bedrock aquifer. Water levels in the alluvial aquifer slope away from Black Thunder Creek, indicating movement of groundwater away from the creek after recharge. Hydraulic head in the alluvial aquifer increased during recharge; the increased hydraulic head in the alluvial aquifer caused increases in hydraulic heads within the bedrock aquifer.

Lenfest (1987) concludes that surface water infiltrates the alluvium and causes water levels in the alluvial aquifer to rise in response to streamflow. Some of the infiltrated water reaches the bedrock aquifer, causing water-level rises. The remaining water probably is lost to evapotranspiration, horizontal flow down valley, or soil moisture in the unsaturated zone.

Computed streamflow loss along a stream reach could not be equated to groundwater recharge by Lenfest (1987), because not all inflow and outflow of the system could be determined. The computed streamflow losses and lower limit of groundwater recharge along the North Fork Dry Fork Cheyenne River ranged from 0.43 to 1.44 acre feet per mile. The computed streamflow loss may be significantly underestimated because of unmeasured inflow and outflow along the reach. An estimate for recharge of 26.5 acre-feet per mile for the same reach was made using a convolution method. Along Black Thunder Creek, estimates of recharge to the alluvial aquifer ranged from 3.56 to 12.4 acre-feet per mile.

The surface water model for this EIS assumes that lateral movement of shallow groundwater would occur. This lateral movement of groundwater would affect the fate of CBM produced water that infiltrates the surface.

Regional Flow Systems

The regional groundwater model used in this EIS emphasizes significant vertical flow through the Wasatch Formation and into the underlying Fort Union coal zone. This flow model is supported by observations in monitoring wells. A downward vertical gradient from the Wasatch aquifer to the Wyodak Anderson coalbed aquifer was measured in three of four monitoring-well clusters that were completed in both zones (Bartos and Ogle 2002). However, many investigators have suggested that downward vertical flow or leakage into the coal zone aquifer is small because of the low hydraulic conductivity of the overlying rocks (Bartos and Ogle 2002). The regional groundwater model is one representation of the complex hydrologic units and groundwater flow systems within the PRB. This model emphasizes regional flow to the north, toward Montana.

The following summary of groundwater flow emphasizes the assumptions used in the groundwater model. The assumptions used in developing the model are not the only that could be applied to the PRB using sound professional judgment.

Groundwater discharge from the Project Area is principally by groundwater outflow; by loss to gaining streams, springs, and seeps; by evapotranspiration; and by well pumpage (Hotchkiss and Levings 1986). The regional pattern of groundwater flow is complicated by lenticular (discontinuous) beds and local differences in hydraulic conductivity (how the water moves through the aquifer). Water in the lower Tertiary aquifers generally moves northward from recharge areas at higher elevations toward discharge areas at lower elevations (Whitehead 1996). The regional trend of movement changes locally where the aquifers discharge water to large streams, primarily within the lower portions of the Powder River drainage in the Project Area.

Rankl and Lowry (1990) describe groundwater flow systems in the PRB. Northward regional groundwater flow is expected in the PRB from potentiometric data that relate the position of the underground aquifers with respect to the topography of the land surface and streams. Groundwater (potentiometric surface) data suggest most streams in the PRB should receive base flow (groundwater discharge) from a regional groundwater system. However, streamflow records do not support this conclusion. The locations of streams having base flows and the period of time that base flows occur indicate base flows are discharged to surface waters from local groundwater systems rather than a regional system. Additionally, groundwater discharge areas have not been identified in the northern part of the Project Area on the basis of chemistry of springs and shallow wells. The chemical quality of shallow groundwater in the northern part of the PRB is affected more by local conditions than by regional flow.

Rankl and Lowry (1990) analyzed data from streamflow gaging stations on streams that originate in the area underlain by the Lower Tertiary Aquifer System and have five or more years of record. Base flow occurring during the period of greatest precipitation, but not after the growing season, indicates that base flow is from a local system dependent upon precipitation for each year's discharge. Much of the groundwater discharge from bedrock aquifers is above stream level and is lost due to evapotranspiration, resulting in no measurable contribution to base flow. Within the Project Area, only the Little Powder River had measurable groundwater contribution (1 cubic foot per second [cfs]) during the non-growing season. Groundwater contribution of less than 1 cfs was indicated for the Belle Fourche River and Dead Horse Creek (near Buffalo). No groundwater contribution was indicated for Black Thunder Creek or the Cheyenne River.

The major sources of groundwater recharge are infiltration of water from precipitation, streamflow on areas of outcrops, or losing streams, including some perennial stream reaches along the front of the Bighorn Mountains. Regional groundwater flow simulations performed by Hotchkiss and Levings (1986) indicate recharge by direct precipitation accounted for about 30 percent of the total recharge.

Heffern and Coates (1999) describe the role of clinker in the storage and flow of water in the PRB. Normally, clinker outcrop areas are highly permeable, allowing rapid infltration of rainfall and snowmelt and then slowly discharging the stored water to springs, streams, and aquifers. This stored water helps maintain flow in perennial streams during dry periods. The rate of recharge is often limited by a relatively low permeability zone that typically occurs at the contact between the clinker and the underlying coal or shale (AHA and Greystone 2002).

Davis (1976) describes groundwater recharge and discharge within the eastern PRB. Most of the eastern PRB is a recharge area for the groundwater system below the Wasatch Formation. There are no perennial streams near the coal outcrop. The scoria (clinker) along the coal outcrop appears to be an area of recharge to the coal aquifers. Stream valleys provide primary recharge areas for the Wasatch Formation.

Springs

Springs and seeps occur where groundwater or overland flow (water that infiltrated the surface and is flowing within about 20 feet of the land surface, in response to topographic relief) are discharged to the surface. The locations of springs are usually controlled by topography, faults, or contacts between rock layers or unconsolidated materials that represent a barrier to water movement.

Slagle et al. (1985) describe the nature of springs within the northern PRB. Numerous contact springs and seeps reflect the discontinuous and lenticular nature of bedding and high topographic relief characteristic of the northern PRB. Slagle et al. (1985) estimated that 2,000 springs and seeps exist within more than 10,000 acres of the northern PRB. The average discharge rate for springs is reported as 5.2 gallons per minute (gpm) in the northern PRB, north of the Project Area (Slagle et al. 1985). The primary source of recharge to springs and seeps in the northern PRB comes from infiltration of precipitation and seepage from streams and rivers (Slagle et al. 1985).

Within the Project Area, springs also are most numerous where topographic relief is great and stratigraphic units are discontinuous. In addition, springs and seeps also emerge at the base of clinker deposits, along the contact between the permeable clinker and impermeable layers below (Heffern and Coates 1999). The primary source of recharge to springs and seeps within the Project Area is assumed to be the same as is reported for the northern PRB. No comprehensive inventory of springs within the Project Area is available.

Data from the WSEO were compiled to identify permitted springs (groundwater rights identified as springs) within Campbell, Converse, Johnson, and Sheridan Counties (WSEO 2002). A total of 596 permitted springs are located within these four counties, as follows: Campbell (126); Converse (136); Johnson (145); and Sheridan (189). Only 18 of the permitted springs within Converse County are located within townships where CBM development is occurring or proposed. Only eight of the permitted springs within Johnson County are located within townships where CBM development is occurring or proposed.

WSEO data on permitted springs also contained the following information on shallow flowing wells located within townships where CBM development is occurring or proposed, that were identified in the WSEO database as springs (WSEO 2002). In Campbell County, five shallow flowing wells (10 feet or less deep) are identified as springs, and yield 1.5 to 25 gpm. In Converse County, one shallow flowing well (10 feet or less deep) is identified as a spring, and yields 1 gpm. In Johnson County, three shallow flowing wells (10 feet or less deep) are identified as springs, and yield 3 to 25 gpm. In Sheridan County, 21 shallow flowing wells (20 feet or less deep) are identified as springs and yield 1 to 25 gpm.

Deep flowing wells identified as springs in the WSEO groundwater rights database and located within townships where CBM development is occurring or proposed are shown on Table 3-4

Table 3-4 Deep Flowing Wells Identified as Springs in the Project Area

Well Location	County	Well Depth (feet)	Yield (gpm)	Priority Year for Water Right
T56N/R75W Sec. 2	Campbell	140	25	1991
T57N/R74W Sec. 10	Campbell	100	5	2000
T43N/R76W Sec. 7	Johnson	740	3	?
T54N/R83W Sec. 7	Sheridan	1,845	8	1983
T54N/R83W Sec. 7	Sheridan	92	16	?
T54N/R83W Sec. 7	Sheridan	100	2	1927
T54N/R83W Sec. 8	Sheridan	200	16	1983

Source: WSEO 2002

Groundwater Storage

Prior to development by wells, aquifers are in a state of dynamic equilibrium, where recharge and discharge virtually balance over long periods (Lohman 1972). A natural groundwater flow system approximates steady-state groundwater flow, where there is no change in head over time (Lohman 1972).

The groundwater flow system of the PRB continues to be affected by activities that extract groundwater, preventing the flow equilibrium from being reestablished. Only a portion of the groundwater extracted would be replaced through additional recharge or reduced discharge. The remaining portion of the groundwater extracted would come from storage within the coal aquifer and surrounding aquifers, as groundwater in storage within the PRB would leak between hydrologic units.

The Lower Tertiary aquifers in the PRB consist of sandstone beds and coals within the Wasatch Formation and the Fort Union Formation. The water-yielding sandstones and coals are interbedded with claystones and siltstones. Although numerous studies have been conducted on these Lower Tertiary Aquifers, there have been no previous estimates of the volume of recoverable groundwater they contain.

Recoverable groundwater is the water present within an aquifer that can be extracted using pumping wells. Recoverable groundwater is considerably less than the total volume of groundwater in storage because a portion of the water is retained in the voids of formations by capillary forces and cannot flow to wells.

Most calculations of recoverable groundwater are determined from the specific yield of the aquifers. The specific yield is the amount of water that can be removed from the saturated pores of the aquifer by gravity drainage to wells. The specific yield can be determined or estimated through one or more of the following methods:

- Results for observation wells obtained during pumping tests conducted within the unconfined portion of the aquifer
- Laboratory analysis of cores of aquifer materials, or
- Literature values for aquifers with similar characteristics..

These calculations of recoverable groundwater do not consider the economics of groundwater recovery. As aquifer storage is depleted, the cost of pumping and the required well spacing would usually need to increase in order to maintain yields. Generally, the recovery of groundwater becomes uneconomic before all recoverable groundwater has been removed. Estimates of recoverable groundwater do not consider the component of groundwater stored in the claystones and siltstones that would leak into the sandstones and coals when these units are pumped for water supply or CBM production. However, the volume of groundwater released from storage in the claystones and siltstones is small relative to the recoverable groundwater in the sandstones and coals.

Methodology for Estimating Volume of Recoverable Groundwater

The volume of recoverable groundwater in the Wasatch and Fort Union Formations within the Project Area was estimated as follows:

The thickness, areal extent, and percentage of sandstone and coal units in the Wasatch and Fort Union Formations were determined from Lewis and Hotchkiss (1981), USGS (1999), and Goolsby, Finley and Associates (unpublished data). Coals occurring south of T38N are not included in the estimated volume; however, these coals are very thin and would not contribute much to the cumulative volume.

The volume of sandstones and coal units within the formations was multiplied by the appropriate specific yield of the sandstone and coal units to determine the volume of recoverable groundwater within each unit.

Estimating the Specific Yield for Sandstone and Coal Units

The estimates of the specific yields for the sandstone and coal units within the Lower Tertiary Aquifers of the Wyoming portion of the PRB were based on literature information and interpretations from results for observation wells obtained during pumping tests conducted within the unconfined portion of these aquifer units (AHA and Greystone 2002).

A review of pumping tests associated with coal mines provided estimates of specific yield for the coals and overburden. The median value for specific yield of the coal was found to be 0.4 percent while the median value for the specific yield of the overburden was 13 percent. The 0.4 percent specific yield for the coal is consistent with the approximate cleat porosity for coals and was used for estimation of recoverable groundwater in the coals. The specific yield of 13 percent for the overburden is for a well completed in sandstone with interbeds of mudstone and siltstone and is lower than might be expected for a clean sandstones. The specific yield estimate of 13 percent was used to calculate recoverable groundwater from the sandstone units within the Tongue River-Wasatch Aquifer, the Lebo Confining Layer, and the Tullock Aquifer.

Volume of Recoverable Groundwater

The volumes of recoverable groundwater from the sandstones within the Tongue River-Wasatch Aquifer, the Lebo Confining Layer, and the Tullock Aquifer were determined from the volume of sandstone in each of these units multiplied by the 13 percent specific yield value for sandstone. Similarly, the volume of recoverable groundwater from the coals within the Tongue River-Wasatch Aquifer was calculated from the volume of coal multiplied by the 0.4 percent specific yield value for coal. These results are summarized in Table 3-5.

These results show the very large volumes of recoverable groundwater that occur in the Lower Tertiary aquifers within the Project Area. Most of the recoverable groundwater occurs in the sandstone units. The recoverable groundwater in the coals is only a small fraction of the recoverable groundwater in the sandstones.

Estimates similar to those in Table 3-5 are made by the USGS (1999) in evaluating coal resources of the Wyodak-Anderson coal zone in the PRB. The coal resources in the Wyodak-Anderson coal zone within the Wyoming portion of the PRB are estimated to total 510,000 million short tons of coal, considering coals that are 2.5 feet or more thick. Using the USGS conversion factor of 1,770 short tons per acre-foot of coal, an estimated 288,000,000 acre-feet of coal exist within the Wyodak-Anderson coal zone within Wyoming. The recoverable groundwater resource within the Wyodak-Anderson coal zone can be estimated using a 0.4 percent specific yield (AHA and Greystone 2002) or an average value for the porosity of the coals (2 percent), as analyzed in the Montana portion of the PRB (BLM 2002). Using these two methodologies to bracket the recoverable groundwater within the Wyodak-Anderson coal zone only, values ranging from 1,152,000 acre-feet to 5,760,000 acre-feet are obtained.

Table 3-5 Estimates of Recoverable Groundwater in the Powder River Basin, Wyoming

Hydrogeologic Unit	Surface Area (acres)	Average Formation Thickness (feet)	Percentage of Sand/Coal	Average Sand/Coal Thickness (feet)	Specific Yield (percent)	Recoverable Groundwater (acre-feet)
Wasatch-Tongue River Aquifer Sandstones	5,615,609	2,035	50	1,018	13	743,121,790
Wasatch-Tongue River Aquifer Coals	4,988,873	2,035	6.2	126	0.40	2,516,519
Lebo Confining Layer Sandstones	6,992,929	1,009	33	250	13	227,137,336
Tullock Aquifer Sandstones	7,999,682	1,110	52	430	13	447,246,784

Source: AHA and Greystone 2002

Water Balance in the Powder River Area

A water balance was performed by O'Hayre (2002) for the alluvium of the Powder River between Sussex and Moorhead in order to estimate the likely magnitude for regional bedrock discharge to the alluvium. This water balance is summarized in the following paragraphs.

The surface area of alluvium within the 155-mile reach of the Powder River valley from Sussex to Moorhead is approximately 32,600 acres. A surface flow analysis of the Powder River was performed using the historical streamflow records for the USGS gauging stations on the Powder River at Sussex, Wyoming, and at Moorhead, Montana, and for Clear Creek and Crazy Woman Creek near their confluence with the Powder River. Concurrent measurements are available at all of these stations for 11 water years (1951-1957 and 1978-1981). The average annual gain in flow in the Powder River during these years is 20 cfs.

The average annual runoff from the unmeasured watershed area along the reach between Sussex and Moorhead was estimated using two methods. First, the method of Lowham (1988) was used to estimate average annual streamflow of 50 cfs for this 2,932 square mile watershed area. Second, an average annual water yield of 0.0211 cfs/square mile for this reach of the Powder River was estimated from 9 years of streamflow measurements for Headgate Draw, an ephemeral stream draining a 3.32 square mile watershed near Buffalo, Wyoming. This was the only ephemeral stream within the Powder River watershed between Sussex and Moorhead that was used in the study by Lowham (1988). The estimated average annual water yield for this relatively small drainage was similar to the average annual water yield water yield estimated for the 1,235 square mile drainage of the Little Powder River above Dry Creek near Weston, Wyoming.

Average annual alluvial groundwater discharge to evapotranspiration (ET) was estimated from the study by Lenfest (1987). The author estimated alluvial groundwater loss to ET during the growing season at 12 sites located within the PRB. Groundwater loss to ET ranged from 8.3 inches to 14.9 inches and averaged 12.7 inches. Using the average rate of 12.7 inches of alluvial groundwater loss to ET, the total annual groundwater loss over the reach of the Powder River would average 47.7 cfs. The water balance evaluation assumes that the alluvial groundwater inflow at the upstream boundary near Sussex is approximately the same as the alluvial groundwater outflow at the downstream boundary near Moorhead, Montana. Differences between alluvial groundwater flow at the boundaries would have negligible effect on the overall water balance because groundwater outflow in the alluvium near Moorhead is low relative to the other variables in the water balance.

The water balance indicates that regional groundwater discharge from bedrock may be in the range from 5 cfs to perhaps as high as 20 cfs. If the regional groundwater discharge from the bedrock to the valley of the Powder River is assumed to be 5 cfs, the bedrock inflow at the contact with the alluvium of the Powder River would average only 1.3 inches/year or about 10 percent of the groundwater loss to evapotranspiration.

Ringen and Daddow (1990) suggest that the annual gain in surface flows within the reach of the Powder River between Sussex and Moorhead is caused by to runoff from the ephemeral streams along the reach that are not measured. With increased rates in the range of 5 cfs, it is unlikely that Rankl and Lowry (1990) or Ringen and Daddow (1990) would have been able to detect a measurable effect of regional groundwater discharge in their studies of streamflows, water chemistry, and alluvial ground fluctuations along this reach of the Powder River. However, if the regional groundwater discharge from the bedrock to the valley of the Powder River is on the order of 20 cfs, the contribution would be more than 40 percent of the estimated loss to ET and it would be more likely that the study of Ringen and Daddow (1990) would have been able to detect a measurable effect of regional groundwater discharge.

An additional regional groundwater discharge component occurs at the flowing artesian wells located along the Powder River valley in this reach between Sussex and Moorhead. Lowry and Cummings (1966) identified 35 flowing artesian wells located along the Powder River valley within Sheridan County. Estimates or measurements of flow rates were reported for 31 of the 35 wells. The combined flow rate from these 31 wells was 0.57 cfs. Based on these results, it is expected that regional groundwater discharge from flowing artesian wells located along the entire Powder River valley from Sussex to Moorhead probably exceeds 1 cfs.

Water Yield

Water yields of about 5 to 1,000 gpm from PRB alluvial aquifers have been reported (Hodson et al. 1973, Lewis and Hotchkiss 1981). Zelt et al. (1999) report a water yield of 5 to 100 gpm for alluvium. Water yield from PRB alluvial deposits is constrained in areas where the alluvium is fine grained (Rankl and Lowry 1990).

Water yields from Wasatch/Fort Union sandstone, coal, or clinker deposits have been described by Lewis and Hotchkiss (1981). In the southern part of the PRB, yields as great as 500 gpm may be possible from sandstone or clinker deposits, with proper well construction techniques. Well yields of 10 to 50 gpm have been measured. Zelt et al. (1999) report a water yield of about 3 to 50 gpm in the northern PRB, becoming greater moving southward in the PRB, with about 500 gpm or more possible in the southern PRB. Water yields from the Fort Union aquifer reported by Zelt et al. (1999) are about 3 to 160 gpm. Hodson et al. (1973) report a maximum water yield of about 150 gpm.

Historical records of static water levels in wells arecontained in Wyoming's Water Resources Data System, within the Water Well Level Database that holds WSEO data. Static levels of water in wells and yields from wells have been affected by coal mining, urban and rural development, CBM development, and other industrial development in the PRB. Meyer (1999) summarizes the drawdown of hydrostatic head in the Wyodak Anderson coal zone from 1980 to 1998. The approximate drawdown in 2000 at selected BLM monitoring wells is shown on Figure 3-2. Existing drawdowns of the hydrostatic head in wells are interpreted to be 100 to 200 feet in extensively developed areas (AHA and Greystone 2002). However, water levels can vary considerably over short distances due to changes in geologic conditions. The greatest existing drawdowns are interpreted to occur in the following four townships: T.47N. R.72W.; T.48N.R.72W.; T.47N. R.73W.; and T.48N. R.73W.

CBM development within the PRB has generated detailed water yield information for the coal zones within the Fort Union aquifer. The increase in water production from CBM wells between 1990 and 2000 is shown in Figure 3-3. Data on the production of water from CBM wells in the PRB are summarized by sub-watershed (hydrologic unit) for 2000 and 2001 in Table 3-6.

Table 3-6 Water Production from Pre-2002 CBM Wells, Powder River Basin

Sub-Watershed	Number of Pre-2002 CBM Wells[1]	2000 Water Production (barrels)[2]	2001 Water Production (barrels)[2]
Upper Tongue River	819	6,590,722	26,984,948
Upper Powder River	2,808	42,736,739	90,426,440
Crazy Woman Creek	150	28,706	9,862
Clear Creek	389	43,877	301,126
Middle Powder River	727	7,563,589	19,034,451
Little Powder	1,814	66,667,649	79,325,493
Antelope Creek	251	1,769,502	7,209,092
Upper Cheyenne River	401	48,491,981	46,919,356
Upper Belle Fourche River	4,659	200,409,537	242,735,454
Middle North Platte River	6	0	524
Total	12,024	374,302,302	512,946,746

Notes:
1. Pre-2002 wells include all wells drilled or authorized, and projected for completion by 2002. Production shown for 2000 and 2001 comes from these wells. Not all pre-2002 wells produced during 2000 or 2001.
2. Data were compiled from WOGCC (2001b, 2002b); one barrel equals 42 gallons.

Water yield from the Lebo confining layer has been described by Lewis and Hotchkiss (1981). Wells penetrating a sufficient saturated thickness of lenticular channel deposits may yield as much as 10 gpm.

Water yield from the Tullock aquifer has been described by Lewis and Hotchkiss (1981). Fine-grained sandstones and jointed coal beds may yield as much as 40 gpm, but yields of 15 gpm are more common. Where the aquifer is confined, wells generally flow less than 10 gpm.

Groundwater Use

Rankl and Lowry (1990) describe water wells and groundwater use in the PRB. Water wells generally are less than 500 feet deep and principally support livestock and domestic uses. These shallow wells generally produce calcium sulfate or calcium sodium sulfate waters. Yields from shallow wells completed in sandstone aquifers generally are about 20 gpm. Deep wells yield larger quantities of water that generally is a sodium bicarbonate type. Water from alluvium has not

Figure 3-2 Approximate Drawdown in 2000 at Selected BLM Monitoring Wells

Figure 3-3 CBM Water Production in the Powder River Basin, Wyoming

been developed extensively because the underlying Tertiary aquifers contain better-quality groundwater and yield higher volumes.

Lowry et al. (1986) describe the existing conditions in the PRB before CBM development. Enough water for stock and domestic use can be obtained in most areas from wells that are less than 500 feet deep. The large thickness of saturated rocks provides potential for flowing wells in topographically low areas, such as river valleys. Flowing wells can be developed principally in the valleys of the major streams such as the Powder, Little Powder, and Cheyenne Rivers. Yields that exceed 200 gpm can be developed locally from wells less than 1,000 feet deep. One flowing well often supports an extensive distribution system for stock water.

Permitted, non-CBM groundwater withdrawals are summarized for the Project Area on Table 3-7 Almost 25 percent of the nearly 27,000 permitted, non-CBM water wells in the PRB are used for domestic purposes. About 1.5 percent of the permitted wells provide for irrigation or municipal uses. Monitoring wells make up 35 percent of the permitted wells. The remaining nearly 39 percent of the water wells in the Project Area are used for stock watering and other purposes. Thousands of unpermitted wells are not included in the totals shown on Table 3-7 No comprehensive inventory of unpermitted wells is available.

Table 3-7 WSEO-Permitted Non-CBM Wells in the Project Area

Well Type	Formation Name[1]	Number of Wells[2]
Domestic	Fort Union	2,218
	Wasatch	3,173
	Unknown	1,192
	Total	6,583
Irrigation	Fort Union	45
	Wasatch	92
	Unknown	117
	Total	254
Monitoring	Fort Union	2,754
	Wasatch	4,860
	Unknown	1,877
	Total	9,491
Municipal	Fort Union	50
	Wasatch	42
	Unknown	43
	Total	135
Other	Fort Union	4,017
	Wasatch	4,255
	Unknown	2,211
	Total	10,483
Total		26,946

Note:

1. Applied Hydrology, Inc. (Bedard 2001), associated formation names with completed wells wherever well depths were available from WSEO data.
2. Data are current through May 10, 2001.

Sources: Bedard 2001, WSEO 2001a

An estimated 46 percent of the permitted non-CBM water wells in the Project Area are completed in the Wasatch Formation. An estimated 34 percent of the permitted non-CBM water wells are completed in the Fort Union Formation. No formation name is available for the remaining almost 20 percent of the wells.

Figure 3-4 shows the relative numbers of permitted water wells and existing CBM wells located within the Project Area. The Upper Belle Fourche River and the Upper Tongue River sub-watersheds contain the largest number of permitted non-CBM water wells, 23 percent for the Upper Belle Fourche and 16 percent of the totals for the Project Area in the Upper Tongue River.

Surface Water

Regional Characterization

The Project Area is contained within several large river basins, which are headwaters to the much larger Missouri River Basin. Major rivers in the Project Area include the Powder River, Little Powder River, Tongue River, Belle Fourche River, and Cheyenne River. The major river valleys have wide, flat floors and broad floodplains. Tributaries in the Project Area are incised in and drain areas of isolated, flat-topped, clinker-covered buttes and mesas, 100 to 500 feet above the valley floor. Flow in the Project Area is generally toward the northeast. Perennial streams generally originate in the mountainous areas as a result of significant annual precipitation and geologic conditions that foster groundwater discharge.

The Project Area is semi-arid with average annual precipitation ranging from 12 to 16 inches. Precipitation increases with elevation and can exceed 20 inches in some portions of the Project Area. Normal annual precipitation increases generally eastward in the downstream direction (Taylor 1978). The majority of annual runoff in streams draining mountainous areas occurs during spring and early summer as a result of snowmelt. Nearly one-half of the average annual precipitation occurs during the months of April, May, and June (Rankl and Lowry 1990). Streamflow generally peaks during June, but varies from year to year depending on both local weather conditions and physical features of individual basins. Late summer, fall, and winter flows are largely the result of groundwater inflows. Minimum streamflows occur generally from January through March (Lowham 1988).

Surface water quality in the Project Area is generally adequate to support designated uses. Surface waters in the Project Area are typically alkaline, with moderate to high levels of hardness. These waters vary from a calcium bicarbonate type in the mountain streams, to a sodium sulfate type in the lowlands. Surface water quality in the Project Area is affected by depletions and return flows from irrigation. Surface water withdrawals in the Project Area are used to support agricultural, domestic, and stock water uses. Irrigation use accounts for about 98 percent of the surface water withdrawals in the Project Area.

Figure 3-4 Water Well Density & Existing CBM Wells

Characteristics of River Basins and Surface Drainage Systems

The Project Area is divided into 18 sub-watersheds. The sub-watersheds in the Project Area comprise two distinct hydrologic regions: the mountainous region, where snowmelt has a dominant influence on streamflows, and the plains region, where runoff from convective storms has a significant influence on peak flows (Lowham 1988). In the mountainous region, headwaters of the streams are situated in mountains and foothills, at elevations ranging from 6,000 to 13,000 feet above mean sea level (msl). Annual precipitation ranges from 14 to 25 inches, mostly from snow (Lindner-Lunsford et al. 1992). Streams are cascading, with relatively steep slopes. Concentrations of suspended sediments and dissolved solids are lower in mountain streams overlying older geological formations and increase significantly as the streams flow toward lower elevations. Streamflows originating in the mountainous region are perennial. Annual runoff typically exceeds 0.3 cubic feet per square mile (Hodson et al. 1973).

In the plains region, streams are situated in plains, tablelands, badlands, and open high hills, at elevations ranging from 3,000 to 6,000 feet above msl. Annual precipitation ranges from 10 to 14 inches (Lindner-Lunsford et al. 1992). Streams are meandering, with relatively flat slopes. Concentrations of suspended sediments and dissolved solids are higher than in the mountain streams, because of the contact with younger geologic formations and disturbance from human activities in the lower elevations. Streams originating in the plains and desert areas generally are ephemeral, flowing mainly in direct response to rainstorms and snowmelt (Lowham 1988). Annual runoff is generally less than 0.05 cubic feet per square mile (Hodson et al. 1973).

Within these two regions, each sub-watershed in the Project Area has a unique combination of water quantity, quality, and existing water use.

Surface Water Quantity

Major contributions to streamflows in the Project Area include direct precipitation, surface runoff, and releases from surface reservoirs. Evaporation, evapotranspiration, and infiltration cause decreases in streamflow. These components are described below.

For this discussion, surface water flow is expressed in cfs. The water produced from wells is expressed in gpm. One cfs is equivalent to 448.83 gpm. Large flows or volumes of water are expressed as acre-feet. One acre-foot is equivalent to 43,560 cubic feet, or 325,851 gallons. Large volumes of produced water also are expressed as barrels (Bbls) or thousand barrel units (MBbls). There are 42 gallons in one barrel.

Natural Streamflow

Statistics on flow statistics have been compiled from selected USGS stream gauging stations to provide a perspective of perennial stream flow within the Project Area. This information is summarized in Table 3-8. Baseflow conditions in the streams are represented by the low of the mean monthly flows in the streams and typically occur in the winter months. Conversely, high flow conditions in the streams are represented by the maximum of the mean monthly flows, and typically occur during periods of snowmelt runoff or significant precipitation events. Critical low flow conditions are represented by a 7Q10 flow, defined as the lowest flow during 7 consecutive days with a 10-year recurrence interval.

Streamflow characteristics in the Project Area depend on the specific features unique to each drainage basin. These features include geology, topography, vegetative cover, size, and climate. Flow regimes in the Middle Fork Powder River are representative of streams that originate in the mountainous areas of the Project Area. Flows in these streams are perennial and influenced by snowmelt in the late spring and early summer (Clark et al. 2001). Base flows are generally sustained by groundwater discharge. Flow regimes in the Little Powder River are representative of the streams that originate in the plains region of the Project Area. Flows in these streams generally are more variable than are flows in the mountain streams and are influenced by lowland snowmelt during the late spring and early summer, as well as from rainstorms during the remainder of the summer and fall. These streams are more likely to have little or no flow during the late summer and early winter (Clark et al. 2001). Flow regimes in the Upper Powder River exhibit characteristics of streams originating in both the mountainous and plains regions of the Project Area. Flows are generally more variable throughout the year than flows in mountain streams, and periods of little or no flow still occur but with less frequency than for plains streams (Clark et al. 2001). Flows in the Project Area are further influenced by irrigation diversions and releases from storage reservoirs.

Peak Flow/Stormwater Flow

Peak flows to date in the northern portion of the Project Area occurred in May 1978, when the region experienced a flood of 1 percent probability, or a flood so large that there is only a 1 percent chance that a similar flood would exceed its magnitude in any year (Parrett et al. 1984). Peak flows during this event measured 5,300 cfs in the Little Powder River, 33,000 cfs in the Middle Powder River, 17,500 cfs in the Tongue River, and 15,300 cfs in the Upper Belle Fourche River. Flood events in September 1923 in the Upper Powder River (100,000 cfs) and June 1965 in Crazy Woman Creek (15,800 cfs) were the peak flows recorded to date in the southern portion of the Project Area (Swanson et al. 2002).

Table 3-8 Statistics on Flow at Selected USGS Gauging Stations Within the Powder River Basin

Sub-Watershed	Drainage Area (mi^2)	Station Location	Station ID	7Q10 Flow (cfs)	Minimum Mean Monthly Flow (cfs)	Mean Monthly Flow (cfs)	Maximum Mean Monthly Flow (cfs)	Median Monthly Flow (cfs)	Daily Discharge Period of Record
Little Bighorn River	193.0	Little Bighorn River at state line near Wyola, MT	06289000	36.3	61.9	149.8	523.0	144.0	1940-2001
Upper Tongue River	1,477	Tongue River at state line near Decker, WY	06306300	43.2	178.3	453.2	1,669.8	425.6	1961-2001
Middle Fork Powder River	45.2	Middle Fork Powder River near Barnum, WY	06309200	2.5	5.2	29.8	160.4	26.4	1962-2001
Upper Powder River	6,050	Powder River at Arvada, WY	06317000	0.0	75.4	275.1	752.2	216.0	1931-2001
South Fork Powder River	1,150	South Fork Powder River near Kaycee, WY	06313000	0.5	10.6	37.2	90.0	24.3	1939-40; 1951-1969; 1979-1980; 1983-1984
Salt Creek	769	Salt Creek near Sussex, WY	06313400	8.4	29.0	45.0	84.7	37.3	1976-1993
Crazy Woman Creek	945	Crazy Woman Creek at Upper Station near Arvada, WY	06316400	0.0	13.9	48.9	217.0	36.5	1963-1970; 1978-1981; 2001
Clear Creek	1,110	Clear Creek near Arvada, WY	06324000	0.1	62.3	178.9	658.6	154.4	1940-1982
Middle Powder River	8,088	Powder River at Moorhead, MT	06324500	0.3	144.6	452.5	1,384.3	368.5	1930-1972; 1975-2001
Little Powder River	1,235	Little Powder River above Dry Creek near Weston, WY	06324970	0.0	2.6	21.8	61.9	8.1	1973-2001
Antelope Creek	959	Antelope Creek near Teckla, WY	06364700	NC	0.2	9.8	58.8	4.2	1978-1981
Dry Fork Cheyenne River	128.0	Dry Fork Cheyenne River near Bill, WY	06365300	NC	<0.1	0.8	5.1	0.2	1977-81; 1986-1987
Upper Cheyenne River	5,270	Cheyenne River near Riverview, WY	06386500	NC	0.4	58.0	231.3	20.0	1949-1974
Lightening Creek	2,070	Lance Creek near Riverview, WY	06386000	NC	0.8	25.4	78.4	10.1	1948-54; 1957-1983
Upper Belle Fourche River	1,690	Belle Fourche River below Moorcroft, WY	06426500	0.0	2.3	23.7	68.1	9.0	1943-70; 1976-1983; 1986-1987; 1991-2001
Middle North Platte River	10,812	North Platte River at Alcova, WY	06642000	277.0	756.8	1,347.8	2,341.6	1,275.1	1959-1998

Source: Kuhn 2002

Peak flows have been estimated for each sub-watershed in the Project Area using the basin characteristics methodology as outlined by Lowham (1988). The methodology incorporates basin characteristics and climatic data into regression equations to estimate peak flow and mean annual flow characteristics at ungauged locations. This method is applicable only to sites with natural streamflows, and results may not be reliable in drainage basins where streamflows are significantly affected by dams or diversions (Lowham 1988). This information is summarized in Table 3-9.

Table 3-9 Estimated Peak Flows by Sub-Watershed within the PRB

	Peak Flow (cfs) Recurrence Interval (years)					
Sub-Watershed	2	5	10	25	50	100
Little Bighorn River	3,008	5,042	6,678	9,486	12,355	14,851
Upper Tongue River	4,037	6,807	8,937	12,496	16,022	18,910
Middle Fork Powder River	2,309	3,904	5,050	6,931	8,686	10,164
North Fork Powder River	4,432	7,158	9,074	12,177	15,116	17,383
Upper Powder River	3,560	6,140	8,185	11,651	15,128	18,065
South Fork Powder River	2,300	4,018	5,318	7,475	9,538	11,299
Salt Creek	1,476	2,651	3,577	5,134	6,637	7,987
Crazy Woman Creek	1,787	3,155	4,217	5,992	7,704	9,207
Clear Creek	2,384	4,020	5,243	7,257	9,182	10,800
Middle Powder River	1,712	2,915	3,899	5,604	7,340	8,935
Little Powder River	3,007	5,042	6,678	9,486	12,355	14,851
Little Missouri River	4,714	7,610	9,929	13,938	18,141	21,706
Antelope Creek	1,959	3,398	4,514	6,379	8,187	9,762
Dry Fork Cheyenne River	917	1,694	2,322	3,391	4,423	5,393
Upper Cheyenne River	2,269	3,937	5,272	7,541	9,804	11,793
Lightning Creek	1,810	3,156	4,217	6,006	7,757	9,306
Upper Belle Fourche River	5,311	8,347	10,621	14,401	18,183	21,151
Middle North Platte River	5,959	9,966	12,864	17,621	22,210	25,748

Source: Lowham 1998

Evaporation

Evaporation losses in the Project Area occur from water surfaces, such as reservoirs and stream channels. Throughout the Project Area, annual lake evaporation averages from 39 to 45 inches, greatly exceeding annual precipitation (Whitehead 1996). Pan evaporation rates in the Project Area are as much as 60 inches per year. Evaporation data are typically collected only during periods of warm weather, or seasonally. The highest evaporation rates generally occur during the summer months of June, July, and August and typically decrease during the winter months. Evaporation is large during periods of intense solar radiation, low relative humidity, and rapid wind movement (Taylor 1978).

Evapotranspiration (ET) measurements include evaporation from water and soil surfaces and the transpiration from plants. Lowry et al. (1986) describe ET rates highest during the month of July, but still significant over the fall months due to warm soil temperatures. Rankl and Lowry (1990) compare ET rates with the growing season for vegetation. During the growing season, April through September, ET is greatest. from October through March, which approximates the dormant period of vegetation, ET rates are lower. Miller (1981) calculated potential ET rates for the Powder River Basin in southeastern Montana, which range from 24 to 41 inches per year. This rate of ET is considerably greater than the average annual precipitation of 16 inches for the area, except for extremely wet years.

Infiltration

Infiltration and seepage losses into underlying alluvium and geologic substrates occur along stream channels and surface impoundments in the Project Area.

Meyer (2000) analyzed CBM water production and streamflow data for a portion of the Upper Belle Fourche River sub-watershed during May through September. The analysis indicated that little or none of the water discharged as a result of CBM operations reached the stream gauging locations. During periods of little or no precipitation, conveyance losses caused by ET and infiltration may be greater than 90 percent (Meyer 2000). Similar trends were noted by Meyer in the Little Powder River sub-watershed. Meyer concludes that "water production volumes are not as great as estimated in the Wyodak EIS (BLM 1999c) and streamflow conveyance losses have been significantly greater than predicted."

AHA (2001b) studied conveyance loss on representative drainages receiving discharges of CBM produced water in the Project Area. These studies were conducted during October 2000 when ET rates are typically minimal and conveyance losses from stream channels and reservoirs are primarily caused by infiltration. Results indicated infiltration of about 80 percent, on average, with infiltration as high as 99 percent in selected drainages. Lower convenance losses are likely to be observed in cold seasons, when evaporation decreases or CBM discharges are piped directly to stream channels.

Lateral movement of shallow groundwater systems would affect the fate of CBM produced water that infiltrates the surface. Groundwater discharge from shallow aquifers to surface drainages would occur in the valleys of perennial and intermittent streams. The surface water model discussed in Chapter 4 uses the assumption that lateral movement of shallow groundwater and subsequent discharge to surface water systems would occur.

CBM Produced Water

Produced water from CBM wells is currently gathered and discharged to the surface at outfall locations authorized in accordance with guidance and requirements of the WDEQ and possibly the WSEO.

In portions of the Project Area, produced water from existing CBM development is supplementing stream flows or wetting otherwise dry channels year-round for some stream channel length or segment below the surface discharge points.

Discharge Outfalls

A search of the State of Wyoming's National Pollutant Discharge Elimination System (NPDES) database reveals 746 existing CBM point source discharge permits within the Project Area, corresponding to 3,565 permitted outfalls (WDEQ 2002c). The permitted outfalls for CBM facilities within the Project Area are summarized in Table 3-10 and illustrated on Figure 3-5.

Almost 43 percent of the existing CBM outfalls are located within the Upper Belle Fourche River sub-watershed. The majority of the remaining existing CBM outfalls are distributed in the Upper Powder River sub-watershed (21 percent), and the Little Powder River sub-watershed (16 percent).

Table 3-10 Permitted Outfalls for CBM Discharges in the Powder River Basin

Sub-watershed	Number of Existing CBM Discharge Permits	Number of CBM Existing Discharge Outfalls	Year 2001 CBM Discharges[1] (cfs)	Estimated Discharge per Outfall (cfs)
Upper Tongue River	22	105	4.8	0.05
Upper Powder River	160	760	16.1	0.02
Clear Creek	18	67	0.05	0.0007
Crazy Woman Creek	4	10	0.002	0.00022
Middle Powder River	38	184	3.4	0.02
Little Powder River	118	561	14.1	0.002
Antelope Creek	59	223	1.3	0.006
Upper Cheyenne River	37	125	8.4	0.07
Upper Belle Fourche River	290	1,530	43.2	0.03
Total	746	3,565		

Note:
1. Calculated from Table 3-6.
Source: WDEQ 2002c

Discharge Volumes/Flow

On average, point source discharges from existing CBM operations in the Project Area are estimated to range from 0.0002 to 0.05 cfs, or about 1 to 25 gpm, at each discharge outfall. Existing outfalls are located in accordance with WDEQ guidance and requirements to maximize conveyance loss and minimize CBM discharged water from reaching the main stems.

Surface Water Quality

The chemical composition of surface water changes continously. Most changes are related to the amount of water and the source of water flowing in a stream at a given time. Surface water quality is directly influenced by higher amounts of precipitation associated with the mountainous regions and the composition of rocks in the area. Streamflows resulting from snowmelt and precipitation are in contact with soils and rocks for only a limited time; thus, these waters have only small amounts of dissolved minerals. Surface water type also changes with elevation. Streams in the higher elevations are typically calcium bicarbonate type waters. As the streams flow across the lowlands, both as natural flow and irrigation return flow, they change to sodium sulfate type waters. The waters are typically alkaline and have moderate to high levels of hardness.

Ambient Water Quality

Salinity

Water quality in surface streams within the Project Area is commonly a function of streamflow. Consequently, the variations in streamflow presented in Table 3-8 can influence water quality throughout the year. Water quality in most of the drainages varies inversely with streamflow. A general indicator of water quality

Figure 3-5 Existing Outfall Density and Water Production

is salinity. Salinity refers to the amount of dissolved solids in a water sample and is generally expressed as mg/L of TDS. Electrical conductance (EC) can also be used as a measure of salinity and is considerably easier to measure and monitor. Resuls for EC are expressed as microSiemens per centimeter (µS/cm).

Sodium Adsorption Ratio

A second indicator of water quality in streams within the Project Area is sodium adsorption ratio (SAR), which can be used to assess the suitability of the water for irrigation of crops. SAR represents the proportion of sodium ions to calcium and magnesium ions in water. SAR is an indicator of the potential for water to affect soil structure. Surface waters with high SARs that are used for irrigation pose a potential hazard to the health of individual plants growing in the irrigated soils, and thus, to the productivity and yield of the irrigated cropland. The application of irrigation waters with high SAR values results in a disproportionate concentration of sodium adsorbed by the soil at the expense of calcium and magnesium, which alters the physical condition of the soil growth medium. The sodium imbalance causes soil structure to break down and the soil particles to disperse, particularly with clayey soils.

In surface water systems, there is a dynamic relationship between EC and SAR; for a given SAR, potential effects to soil structure decrease as the EC increases. However, when evaluating SAR values for the protection of irrigated agriculture, a number of interrelated factors should be considered, including: the crop or native plant species to be irrigated or exposed to these conditions; the texture of the irrigated soils; predominant clay mineralogy; soil chemistry; water management practices; and the chemistry of the irrigation water.

Data on surface water quality summarized from historical water quality records obtained at USGS monitoring stations in the Project Area are presented in Table 3-11. EC and SAR values corresponding to periods of critical low flow (7Q10), and minimum and maximum mean monthly flows are included. The information was compiled using the following methodology:

Stream water quality and quantity for each of the sub-watersheds in the Project Area were compiled by the USGS (Kuhn 2002). The relationship between streamflow rate and EC and SAR was calculated by generating a series of plots with the water quality constituent of interest plotted against streamflow. Power curves were fitted to the data to develop a mathematical relationship between flow and water quality. As a result of the large variability in the data at some locations, the power curve relationships only approximated the actual data (BLM 2002).

Seasonal variations are evident in the data on water quality from each site. All data on water quality were grouped by the month of the year when the sample was collected, and a mean of each month’s values was calculated. A comparison of the data projected by the power curve relationship at each monthly mean discharge versus the mean value of all water quality samples for the month indicates that neither method fully captures the natural variation of water quality caused by changes in streamflow, or seasonal fluctuations with time (BLM 2002). Consequently, averaging the value computed using the power curve with the mean of the monthly water quality values appears to yield the best approximation of water quality at mean monthly flow rates throughout the year and was used as representative of stream water quality at the monthly mean discharge. Values that correspond to 7Q10 streamflow rates were estimated from the power curve analysis only.

The data presented in Table 3-11 illustrate the variability in ambient EC and SAR in streams within the Project Area. The representative stream water quality is used in the impact analysis presented in Chapter 4 as the baseline for evaluating potential impacts to water quality and existing uses from future discharges of CBM produced water of varying chemical composition to surface drainages within the Project Area. USGS (2000) reports that existing effects to water quality in streams in the Project Area from existing CBM produced water discharges is unknown. Kuhn (2002) also compiled time-series graphs using streamflow and water quality records from the USGS gauging stations identified in Table 3-11. The data were separated into pre- and post-1995 periods to enable distinction of any potential differences in the data that would be attributable to increased CBM development in the Project Area in the mid-1990s. Although differences in water quality and streamflow during these two periods are difficult to ascertain from the analysis, Kuhn reports that differences in the length of and climatic variability in the two periods, which were not evaluated, could have a substantial effect on any indicated differences (Kuhn 2002).

Trace Metals

Concentrations of trace metals in surface waters that drain the Project Area are generally low. Levels of iron and manganese that exceed the secondary drinking water standards of 0.3 mg/L for iron and 0.05 mg/L for managanese have been detected occasionally in samples of surface water in the Project Area. Manganese and iron can cause staining and bitter tastes but are not present in concentrations that would limit use of the water for stock watering or irrigation. Several streams in the Project Area are exempt from meeting human health standards for iron and manganese based on elevated ambient concentrations of geologic origin (WDEQ 2002a).

Concentrations of selenium greater than the drinking water standard of 10 micrograms per liter (µg/L) have been measured in surface water from localized streams in the Project Area (Lowry et al. 1986). Sources of selenium within the Project Area generally are geologic in origin (Seiler et al. 1999). Although concentrations of selenium exceed the drinking water standard, the streams of concern are not used as public water supplies (EPA 2001a). Concentrations of selenium do not limit use of the water for stock watering; however, certain vegetation could become toxic to livestock through uptake of selenium. Concentrations of selenium greater than 2 to 5 µg/L can cause reproductive failure in fish and wildlife (USFWS 1987).

Table 3-11 Mean EC and SAR for Given Streamflow Conditions at Selected USGS Gauging Stations in the Powder River Basin

Sub-Watershed	Drainage Area (mi²)	Station Location	Station ID	Electrical Conductivity (EC) (µS/cm)			Sodium Adsorption Ratio (SAR)			Water Quality Period of Record
				7Q10	Low Monthly Flow	Maximum Monthly Flow	7Q10	Low Monthly Flow	Maximum Monthly Flow	
Upper Tongue River	1,477	Tongue River at state line near Decker, WY	06306300	1179	731	318	1.29	0.86	0.36	1981-2001
Upper Powder River	6,050	Powder River at Arvada, WY	06317000	NA	3,400	1,797	NA	7.83	4.76	1981-2001
Salt Creek	769	Salt Creek near Sussex, WY	06313400	6,741	5,668	5,204	25.1	23.6	18.9	1981-2001
Crazy Woman Creek	945	Crazy Woman Creek at Upper Station near Arvada, WY	06316400	NA	1,937	1,066	NA	2.26	1.29	1972-1990; 2001
Clear Creek	1,110	Clear Creek near Arvada, WY	06324000	3,879	1,276	883	3.96	1.46	1.07	1981-1989; 2001
Middle Powder River	8,088	Powder River at Moorhead, MT	06324500	4,400	2,154	1,421	6.15	4.62	3.92	1930-1972; 1975-2001
Little Powder River	1,235	Little Powder River above Dry Creek near Weston, WY	06324970	NA	3,300	1,785	NA	6.94	4.44	1981-2001
Antelope Creek	959	Antelope Creek near Teckla, WY	06364700	NA	2,354	1,800	NA	2.60	2.82	1978-1981; 2001
Upper Cheyenne River	5,270	Cheyenne River near Riverview, WY	06386500	NA	4,127	2,271	NA	8.66	5.63	1969-1970; 1975-1980
Upper Belle Fourche River	1,690	Belle Fourche River below Moorcroft, WY	06426500	NA	2,755	1,532	NA	6.77	3.81	1981-1993; 2000-2001

Source: BLM 2002

Suspended Sediment

Concentrations of suspended sediment are high throughout the Project Area. Concentrations reflect the highly erosive nature of the shale deposits through which the rivers flow. Concentrations of sediment increase in a direct relationship to flow. Suspended sediment particles provide a surface onto which moderately soluble chemical constituents can adsorb to and be transported downstream. Thus, chemically enriched sinks can form in sediment deposition areas (Lowry et al. 1986). Quantities of suspended sediment in a flowing stream limit the stream's capability to acquire and transport additional sediment. Suspended sediment loads are often trapped in downstream reservoirs.

Temperature

The temperature of water in streams within the Project Area can range from 0 degrees Celsius (C) during winter to 25°C or more during late summer (Lowry et al. 1986). Water temperatures in streams also vary as a function of elevation. The temperature of water in streams depends on physical conditions, such as shading, stream width, depth and velocity, and can be further altered by groundwater inflows, waste dischargers, and reservoirs (Lowry et al. 1986).

Changes in water temperature can have an effect on water quality. As water temperatures increase, dissolved oxygen concentrations decrease due in part to the lower saturation capacity of the water and additional oxygen consumption by aquatic life (Lowry et al. 1986). The solubility of various chemical constituents in water also increases with temperature, which could affect the levels of chemical constituents potentially harmful to aquatic life.

Impaired Water Bodies

The quality of water in the rivers and streams within the Project Area is protected for designated uses in accordance with the State of Wyoming's water quality standards. Section 303(d) of the Clean Water Act requires the state to develop a listing of all waters of the state that are impaired and do not fully support existing or designated uses. The State of Wyoming's 305(b) Report for 2002 lists waterbodies with impairments to water quality in the Upper Tongue River, Upper Powder River, Upper Belle Fourche River, and the Middle North Platte River sub-watersheds (WDEQ 2002b). Listed impairments are caused primarily by pathogens, trace metals (specifically selenium) chloride, TDS, and salinity. Most sources of the impairments are unknown, although some have been attributed to agricultural practices as well as natural background sources.

Downstream of the Project Area, the Cheyenne River in South Dakota is listed as impaired from the Wyoming border to Angostura Reservoir as a result of sedimentation and salinity (SDDNR 2002). Total maximum daily loads (TMDLs) are scheduled for development but have been assigned a low priority (SDDNR 2002). Existing data and information do not suggest similar water quality concerns in the Cheyenne River upstream in Wyoming (WDEQ 2002a). The Belle Fourche River in South Dakota is also listed as impaired by sedimentation from the Wyoming border to the mouth (SDDNR 2002). This stretch of river has been assigned a high priority for TMDL development (SDDNR 2002).

Segments of the Tongue River, Powder River, and Little Powder Rivers in Montana downstream of the Wyoming border are listed in Montana's 303(d) list for 2000 for impairments caused by siltation and flow alteration (MDEQ 2002). Montana's 2002 303(d) list has not been finalized, but these segments are proposed to remain listed as impaired and TMDLs are scheduled for development in 2002 to protect water quality and guide future CBM development in those drainages (MDEQ 2002).

Surface Water Distribution

The distribution of surface water flows in the Project Area is influenced by natural streamflow, discharges of CBM produced water, and releases from reservoirs.

Streamflows

About 80 percent of the streams in the Project Area are ephemeral and intermittent. Major perennial streams in the Project Area include the Upper Tongue River, Upper Powder River, Middle Powder River, Little Powder River, Clear Creek, and Crazy Woman Creek.

CBM Produced Water

The distribution of existing surface water flows are influenced by CBM produced water discharges, depending on the volume of water produced and how the water is handled. Sub-watersheds with high volumes of CBM water production, such as the Upper Belle Fourche River, Little Powder River, and Upper Powder River sub-watersheds, exhibit more continuity in flows than sub-watersheds with limited CBM development. Water handling also influences the distribution of surface flows. Direct discharges of CBM produced water into surface drainages have a greater influence on surface flows than surface discharge into flow-through stock reservoirs or infiltration impoundments.

Reservoir Outflows

Reservoirs in the Project Area are used to hold water supplied from precipitation and snowmelt, and to make stored water available during summer and fall, periods of limited precipitation and heavy demand. Major reservoirs receiving potential discharges of CBM produced water in or downstream of the Project Area include Keyhole Reservoir in the Upper Belle Fourche River sub-watershed, Lake DeSmet, an off-channel reservoir, in the Clear Creek sub-watershed, and Angostura Reservoir in the Upper Cheyenne River sub-watershed. The storage capacities of these three reservoirs are 340,000 acre-feet, 239,000 acre-feet, and 103,431 acre-feet, respectively. Annual releases to the Belle Fourche River from Keyhole Reservoir average about 16,000 acre-feet.

Numerous small reservoirs and stock impoundments are used in the Project Area to manage CBM produced water. These impoundments typically are open systems that are unlined to facilitate infiltration or designed with an inlet and outlet to allow water to flow through the structure. These impoundments are authorized in accordance with guidance and requirements of the State of Wyoming (WDEQ and WSEO).

Surface Water Use

Surface water withdrawals in the Project Area totaled 1,636 million gallons per day (mgd) in 1995. Table 3-12 summarizes water use within the PRB in 1995 (USGS 1995). Nearly 35 percent of the surface water withdrawals were from the Upper Tongue River sub-watershed. surface water consumption in the Project Area is predominantly associated with irrigation use. About 98 percent of the surface water withdrawals (1,602 mgd) are used for irrigation. Nearly 72 percent of the irrigation occurs in the Upper Tongue River, North Fork of the Powder River, Upper Powder River, and Clear Creek sub-watersheds. Mining use accounts for only 1 percent, or 18.26 mgd of the total surface water withdrawals. About 47,130 people living in the Project Area obtained their water supply from surface water sources in 1995, consuming 11.75 mgd, or about 1 percent of the surface water withdrawals (USGS 1995).

Table 3-12 1995 Surface Water Use within the Powder River Basin

	Water Use by Category (mgd)						
Sub-watershed	Public Supply	Commercial	Domestic	Industrial	Mining	Livestock	Irrigation
Little Bighorn River	0.00	0.00	0.00	0.00	0.00	0.11	90.66
Upper Tongue River	5.37	0.02	0.00	0.01	0.03	0.7	526.72
Middle Fork Powder River	0.00	0.01	0.00	0.00	0.21	0.13	70.54
North Fork Powder River	0.00	0.00	0.00	0.00	0.28	0.33	276.27
Upper Powder River	0.00	0.00	0.00	0.00	0.52	0.27	134.4
South Fork Powder River	0.00	0.00	0.00	0.00	0.71	0.19	43.98
Salt Creek	0.39	0.01	0.00	0.00	0.38	0.11	28.21
Crazy Woman Creek	0.00	0.00	0.00	0.00	0.09	0.09	63.04
Clear Creek	1.26	0.02	0.04	0.00	0.08	0.29	215.44
Middle Powder River	0.00	0.00	0.00	0.00	0.12	0.04	14.4
Little Powder River	0.00	0.00	0.00	0.00	2.65	0.1	0.39
Little Missouri River	0.00	0.00	0.00	0.00	0.37	0.15	8.56
Antelope Creek	0.00	0.00	0.00	0.00	1.78	0.11	6.79
Dry Fork Cheyenne River	0.00	0.00	0.00	0.00	0.15	0.06	5.05
Upper Cheyenne River	0.00	0.00	0.00	0.00	4.31	0.14	2.92
Lightning Creek	0.00	0.00	0.00	0.00	0.2	0.1	6.86
Upper Belle Fourche River	0.00	0.03	0.03	0.02	4.37	0.39	17.3
Middle North Platte River	4.73	0.07	0.02	0.02	1.98	0.53	90.32
Project Area Total	11.75	0.16	0.09	0.05	18.26	3.93	1,601.85

Source: USGS 1995

Permitted Water Diversions/Structures

Surface water adjudication rights in the Project Area are summarized in Table 3-13. Of the 78,316 filings of surface water adjudications, 57 percent are used for irrigation. About 20 percent are used for domestic purposes. The remaining 23 percent of the surface water adjudications in the PRB are used for stock watering and other purposes. The adjudication does not necessarily mean that all of the water is available every year for the intended use, but reflects legal claims on the water. Permitted reservoirs and stock reservoirs in the Project Area are summarized in Table 3-14.

Municipal Water Sources

Communities in the Project Area that use surface water as a municipal water supply include the City of Sheridan, and the towns of Buffalo, Dayton, and Ranchester (EPA 2001a). Surface water sources in the Tongue River sub-watershed supply the communities of Sheridan, Dayton, and Ranchester. Buffalo uses surface water from the Clear Creek sub-watershed. Surface water withdrawals for municipal water supplies account for about one percent of the total surface water use in the Project Area. The majority of municipal water supplies in the Project Area are acquired mainly from groundwater sources.

Table 3-13 Surface Water Adjudications within the Powder River Basin

	Use			
Sub-Watershed	Irrigation	Domestic	Stock	Other
Little Bighorn River	1,120	42	67	39
Upper Tongue River	19,885	8,824	1,728	1,067
Middle Fork Powder River	2,024	423	450	44
North Fork Powder	7	6	24	0
Upper Powder River	2,085	668	1,810	36
South Fork Powder River	196	42	195	21
Salt Creek	4	33	57	6
Crazy Woman Creek	3,508	787	648	501
Clear Creek	10,458	2,032	989	4,091
Middle Powder River	454	47	324	6
Little Powder River	2,299	776	1,534	148
Little Missouri River	85	0	116	0
Antelope Creek	884	158	728	273
Dry Fork Cheyenne River	253	67	384	36
Upper Cheyenne River	53	72	366	151
Lightning Creek	410	7	356	50
Upper Belle Fourche River	954	1,792	1,016	246
Middle North Platte River	136	88	113	17
Project Area Total	44,815	15,864	10,905	6,732

Source: WSEO 2001 c

Table 3-14 Surface Water Impoundments in the Powder River Basin

Sub-Watershed	# Permitted Reservoirs	Average Capacity (acre-feet)	# Permitted Stock Reservoirs[1]	Average Capacity (acre-feet)
Little Bighorn River	26	55.0	10	9.2
Upper Tongue River	287	32.8	321	4.2
Middle Fork Powder River	30	56.7	68	4.0
North Fork Powder	0		0	
Upper Powder River	162	46.0	345	6.0
South Fork Powder River	13	59.9	20	8.9
Salt Creek	6	44.9	16	3.5
Crazy Woman Creek	116	95.7	86	5.8
Clear Creek	123	36.0	187	5.1
Middle Powder River	17	19.6	63	6.0
Little Powder River	117	50.5	346	4.5
Little Missouri River	11	29.2	24	4.4
Antelope Creek	58	79.3	101	4.6
Dry Fork Cheyenne River	27	60.4	85	5.2
Upper Cheyenne River	19	30.6	49	4.3
Lightning Creek	28	92.6	75	5.6
Upper Belle Fourche River	103	49.2	167	5.3
Middle North Platte River	18	110.0	13	8.1
Project Area Total	1,161	55.8 (Average)	1,976	5.6 (Avg)

Note:
1. As per WSEO regulations, stock reservoirs limited to 20 acre-feet.
Source: WSEO 2001c.

CBM Produced Water Use and Treatment

The primary method of handling the produced water is direct surface discharge through outfalls. Outfalls may feed into small stock reservoirs, constructed infiltration impoundments or other facilities before the outflows reach surface drainages. In addition to direct surface discharge, alternative methods of disposing of produced water that are being used, tested, or considered by CBM operators include evaporation enhancement, injection, percolation, irrigation, surface containment, and treatment (WGRI 2001). The method of handling the produced water varies with water quality, water volume, and the desires of the surface owners. Each of these options is discussed below.

Surface Discharge

Surface discharge of the produced water represents both direct discharge and discharge retained temporarily in flow-through upland or bottomland impoundments. These discharges are authorized in accordance with guidance and requirements of the State of Wyoming (likely WDEQ and WSEO). Surface application of CBM produced water for dust control on county roads is not permitted as a discharge to surface waters of the state, but can be used to dispose of limited quantities of produced water, provided authorization is obtained in accordance with the guidance and requirements of the WOGCC.

Evaporation

Evaporation enhancement uses atomizers installed on towers above the ground or on floating platforms in the middle of a reservoir. Atomizers located above ground have been successful in managing the volumes of CBM water produced, but because of their limited use, the duration of use to avoid buildup of trace elements in the ground beneath the tower is not known. Pilot testing using atomizers placed on floating platforms in the middle of a reservoir has indicated that 50 percent of the CBM water can be eliminated. Buildup of trace elements in the reservoir is purged during heavy runoff when the reservoir overflows. This method of water handling is in use at multiple locations within the study area.

Injection

Injection is accomplished by injecting the water into deep disposal wells. Potential injection zones include the sands and coals within the Wasatch and Fort Union Formations, including the Big George and deeper horizons, primarily the Fox Hills. Data are limited on the success of this method of water handling. Successful water disposal by injection depends on the characteristics of the injection well, including site permeability, capacity, depth, pressure, and water quality (O&G 2001). A nine-well injection project was initiated into the Wall Coal, using produced water from the Anderson/Canyon Coal. These wells received water for 6 months; however, injection pressures became so elevated that fracturing was a concern.

A 10-well injection project was initiated into the Fort Union Formation near the City of Gillette. Results of injection were favorable. Since the receiving aquifer had been partially depleted by a multitude of shallow private and municipal water wells, injection could occur at low surface pressures. Injection would not likely be a feasible method for water disposal in areas where the aquifer is not partially depleted because of the excessive injection pressures.

WOGCC's 2001 statistics for disposal (injection) wells have been summarized for the four counties included within the Project Area (WOGCC 2002a). A total of 122 injection wells (Campbell County – 91 wells; Converse County – 22 wells; Johnson County – 6 wells; and Sheridan County – 3 wells) inject water from 71 fields into 28 different formation horizons. The injection zones used most frequently occur within the following formations: Minnelusa; Muddy; and Parkman. No injection wells are listed as injecting water from the PRB coal field.

Percolation

Percolation of the produced water into scoria formations or other near-shallow aquifers is being tested by at least one company. This method of water handling relies on a trench or narrow pit excavated along a scoria bed and allows the produced water to percolate from the trench or pit into the scoria bed. Thus far, this method is only being used in areas where the scoria bed does not outcrop because of the potential for seepage.

Infiltration

Infiltration basins are constructed to dispose of the produced water through evaporation and infiltration into the underlying alluvial or basin fill deposits, clinker, or sandy bedrock horizons. These basins are situated in existing drainages and in upland areas. These basins are often permitted as stock ponds to allow for beneficial use of the disposed water.

Irrigation

CBM produced water is often suitable for irrigation. Center-pivot irrigation systems are being piloted on a limited basis (O&G 2001). The complexity of the pivot system and the suitability of the water for irrigation depend on a number of interrelated factors including: the crop or native plant species to be irrigated or exposed to these conditions; the texture of the irrigated soils; predominant clay mineralogy; soil chemistry; water management practices; and the chemistry of the irrigation water. Center-pivot systems currently in operation are designed to discharge about 700 to 1,000 gpm from 20 wells (O&G 2001).

Containment

Surface containment includes lined impoundments, located off-channel, with no direct surface discharge or lateral subsurface movement of water and downgradient expression in seeps or springs. This method of water handling generally would be selected as a result of the poor quality of the CBM produced water. Disposal through evaporation with no infiltration or discharge to surface drainages would require containment impoundments with large surface areas. This method is less favorable because of the high cost and surface impact.

Treatment

Treatment of the produced water is used to amend the water quality to meet NPDES standards for surface discharge. Treatment methods may be passive, such as implementation of BMPs for oxidation and precipitation of iron before surface discharge. BMPs implemented for removal of iron include the addition of rip-rap, trickle towers, perforated pipe, and aeration systems (O&G 2001). Active treatment would use a chemical process, a reverse-osmosis process, or a combination to reduce SAR values, barium concentrations, or other constituents of concern. Pilot testing using active treatment has been performed with varying degrees of success; however, to date, no full-scale projects have been installed (WRGI 2001).

Physiography, Geology, Paleontology, and Mineral Resources

Physiography

The PRB is part of the Missouri Plateau of the Great Plains (Trimble 1980). This region is characterized by rolling uplands that have been greatly dissected by tributaries of the Missouri River system. The great continental glaciers never extended into the PRB. The Bighorn Mountains, which are part of the Rocky Mountains, lie just west of the PRB, partially within the westernmost portion of the Project Area. The east slope of this imposing mountain barrier, facing the PRB, is steep and rugged for the most part, and is cut by many deep, narrow canyons (Keefer 1974).

The PRB is a structural basin extending about 220 miles from north to south, and generally less than 95 miles from east to west, that formed at the foot of the Bighorn Mountains. The PRB is bounded on its margins by upturned rocks or mountainous masses rising from the plains. On the east, the PRB is bounded by the Black Hills. On the south, the PRB is bounded by the Casper arch, the Laramie Mountains, and the Hartville Uplift (Macke 1993). To the north and northeast, the terrain of the PRB merges with, and cannot be distinguished from, the remainder of the Missouri Plateau (Keefer 1974).

The PRB consists of a dissected, rolling upland plain with low to moderate relief, broken by buttes, mesas, hills, and ridges. Extensive areas of open high hills in the northern portion of the Project Area indicate rough, broken terrain where moderate to deep erosion has occurred (Keefer 1974). Erosion-resistant clinker, produced by the natural burning of coal beds in the PRB, caps many hills and ridges within the Project Area with a characteristic broken, red brick or scoria-like rock. Elevations in the Project Area range from 3,350 to 9,250 feet above msl.

The present-day landforms of the semi-arid PRB have been shaped mostly by the action of water, even though precipitation is low and evaporation greatly exceeds precipitation. The drainages dissecting the Project Area are incised, typically are ephemeral or intermittent, and do not naturally provide permanent or year-round sources of water along the entirety of their reaches. Major river valleys have wide, flat floors and broad floodplains. Badlands, such as the Powder River Breaks and Tongue River Breaks, have formed where water has flowed over sloping surfaces of soft, fine-grained materials. Playa lakebeds are relics from wetter periods. Surface springs and seeps are fed by groundwater from shallow aquifers. Drainage catchments and open basins are separated by upland landforms such as hills, ridges, and buttes.

The PRB is drained toward the north by the Tongue, Powder, and Little Powder Rivers, which flow into the Yellowstone River and toward the east by the Belle Fourche and Cheyenne Rivers, which flow into the Missouri River. The low watershed divides among these drainage systems are included in the Project Area. Northwestern and western portions of the area, generally those areas west of Highway 50 and north of Highway 387, are drained by the north-flowing Powder River, which is tributary to the Yellowstone River of the Missouri River system. A small area within the northwestern portion of the Project Area is drained by the Tongue River, another tributary of the Yellowstone River. The northeastern portion of the Project Area is drained by tributaries of the Little Powder River, which flows into the Powder River. The area east of Highway 50, located between the communities of Gillette and Wright, is drained by the Belle Fourche River and its tributaries. The areas south and east of Highway 387 are drained by the Cheyenne River.

Geology

The PRB is a northwest-southeast trending structural basin filled with Cenozoic sediments of continental origin that were derived from surrounding uplifted areas (Brown 1993). The PRB formed during the Laramide Orogeny (mountain building era) about 60 million years ago (Glass and Blackstone 1996).

Portions of the eastern flank of the Bighorn Mountains also are included within the Project Area. The Paleozoic and Mesozoic rocks exposed along the eastern flank of the Bighorn Mountains, within the westernmost portion of the Project Area, are stratigraphically below and older than the geologic formations that may be affected by CBM development in the PRB, and are not described further.

The PRB was shaped by folding and minor faulting that occurred during the early Tertiary period and ended before the deposition of the Oligocene White River Formation (Macke 1993). The PRB margins are folded asymmetrically upward along a northwest trending basin axis that is closer to the western margin than it is to the eastern margin. Rock layers dip gently several degrees throughout much of the PRB; however, dips steepen significantly in the western portions of the basin (Macke 1993).

Geologic formations exposed at the surface within the PRB are, from youngest to oldest, the Oligocene White River Formation, the Eocene Wasatch Formation, and the Paleocene Fort Union Formation (Ellis and Colton 1994). Outcrops of the geologic formations exposed at the surface within the Project Area can contain significant amphibian and mammalian fossils.

Basin sediments were derived from the Bighorn Mountains to the west, the Laramie Mountains and Hartville Uplift to the south, and the Black Hills to the east. The early Tertiary basin fill sediments of the PRB (Wasatch and Fort Union Formations) attain a maximum thickness of more than 6,500 feet along the basin axis (Brown 1993). Along drainages, Quaternary alluvial deposits overlie the Tertiary geologic formations exposed in the PRB.

The Cretaceous Lance Formation, of continental origin, underlies the early Tertiary formations in the PRB (Brown 1993) The Lance Formation is stratigraphically below and older than the geologic formations that may be affected by CBM development in the PRB and is not described further. The generalized surface geology of the PRB is shown in Figure 3-6. Geologic formations occurring at the surface and shallow underlying formations in the PRB are shown in Figure 3-7.

The natural burning of coal beds in the PRB over the past few million years has consumed billions of tons of coal and has baked and melted the overlying bedrock (see page 3–76). This rock, known as clinker or as scoria, now covers about 460 square miles of the Project Area (Heffern and Coates 1997). Clinker rock types vary greatly, depending on lithology of the parent rock, temperature and duration of heating, and degree of oxidation (Coates and Heffern 1999).

Quaternary Alluvial Deposits

Unconsolidated and poorly consolidated Quaternary alluvial deposits have been accumulating over the last several million years (Trimble 1980). These deposits generally occur along rivers and major drainages within the PRB and consist of clay, silt, sand, and gravel occurring as floodplains, stream terraces, and alluvial fans. Alluvial deposits commonly are 30 feet or less thick, but deposits that are 100 feet thick have been measured (Wells 1982).

Oligocene White River Formation

The White River Formation is Oligocene in age (24 to 37 milliion years ago). It has been removed by erosion throughout most of the PRB and is present in the Project Area only as isolated erosional remnants, such as Pumpkin Buttes in southwestern Campbell County (Lewis and Hotchkiss 1981). It is composed of tuffaceous claystone and siltstone with conglomerate lenses near its base (Love et al. 1987).

Figure 3-6 Generalized Geology of the Powder River Basin

Figure 3-7 Stratigraphic Nomenclature for the Powder River Basin

Eocene Wasatch Formation

The Eocene Wasatch Formation consists primarily of mudstone and sandstone, with minor amounts conglomerate, carbonaceous shale, and coal (Rice et al. 2002). Coarse conglomerates occur along the western margin of the PRB (Seeland 1992). Sandstone makes up about one-third of the sequence (Seeland 1992). The upper part of the Wasatch Formation has been removed by erosion in the central portion of the PRB. The thickness of the remaining Wasatch sequence is a maximum thickness of 1,400 feet. The Wasatch Formation has been removed entirely by erosion in places along the margins of the PRB (Molnia and Pierce 1992).

Paleocene Fort Union Formation

The Paleocene Fort Union Formation, which consists of sandstone, conglomerate siltstone, and coal beds, was deposited by alluvial fans, lacustrine and fluvial systems, and raised bogs (Flores et al. 1999). Fort Union sediments were deposited by north-flowing braided, meandering streams, and swamps in the basin center, and by alluvial fans at the basin margin (Flores et al. 1999). Numerous thick and laterally widespread coal beds occur within the Fort Union Formation (Lewis and Hotchkiss 1981). Goolsby and Finley (2000) suggest the Fort Union coals were continuously deposited in a migrating depositional center in the PRB. Flores and Bader (1999) report the thickness of the Fort Union Formation to be as much as 5,200 feet along the basin axis of the western PRB in Wyoming.

The thickness of the Fort Union (Wyodak-Anderson) coal zone varies greatly within the PRB. The Wyodak-Anderson coal zone has a maximum net coal thickness of 284 feet, using coal beds greater than 2.5 feet thick, and the entire zone is more than 600 feet thick in the center of the basin (Ellis 1999). The total thickness of the coal beds in this zone commonly ranges from 50 to150 feet (Seeland 1992). The individual coal beds average 25 feet in thickness and contain clastic (non-coal) interbeds ranging from a few feet to 150 feet in thickness (Ellis 1999). The coal beds merge in places into a single bed as much as 200 feet thick (Seeland 1992). The thickness of a single coal seam is more than 100 feet near Wright and extending west and northwest of Wright, within the central portion of the PRB in Wyoming (Seeland 1992). The net thickness of the Wyodak Anderson coal zone ranges from less than 2.5 feet up to 30 feet along the western and southern margins of the PRB (Flores et al. 2001).

Regionally, the different coal zones merge, split, and pinch out laterally in complex patterns (Flores 1999, Flores et al. 1999), and can be traced intermittently over distances of several tens of miles (Pierce et al. 1990). The coal zone, such as Wyodak-Anderson, sometimes called the Big George or Sussex, contains up to 11 coal beds (Flores et al. 1999). Flores and Bader (1999) and others have studied the number of coal beds occurring within the Fort Union coal zone in different portions of the PRB. Along the eastern margin and within the south central portion of the Project Area, predominantly one coal bed occurs. Within the north-central and western portions of the Project Area, there are typically three or more coal beds. Within the remaining portions of the Project Area, there are predominantly two coal beds. Important coal beds are described in the coal section of this chapter, under mineral and energy resources. The coal zone nomenclature used in this analysis for groundwater modeling is described later, at the beginning of the groundwater section in Chapter 4.

The Fort Union Formation is subdivided into three members within the central and northern portions of the Project Area. From youngest to oldest, the three members are the Tongue River, Lebo shale, and Tullock. The Tongue River is the uppermost member and is rich in sandstone and coal. The middle Lebo shale member has a high percentage of shale, and the lowest Tullock member is dominated by sandstone. Along the western margin of the Project Area, the Fort Union Formation is undifferentiated. East of Gillette and within most southern portions of the Project Area, the Tongue River and Lebo members are mapped together as one unit (Ellis and Cotton 1994).

The Tongue River member is composed of thick channel sandstones, fine-grained overbank deposits, and coal beds. This unit thins toward the southeastern portion of the PRB (Pierce et al. 1990). The Tongue River member was formed during episodes of high-energy stream activity having intervening periods of quiet activity that led to the accumulation of thick peat deposits in swamps (Pierce et al. 1990). The maximum thickness of the Tongue River member is more than 2,100 feet near the basin axis in the central portion of the Project Area. The Tongue River member thins toward the east, and is only 1,000 feet thick north of Gillette (Molnia and Pierce 1992). Flores and Bader (1999) report the thickness of the Tongue River member to be as much as 1,800 feet.

The Lebo shale member is of stream and lake origin and consists primarily of fine-grained deposits and some channel sandstones (Pierce et al. 1990). It is characterized by dark shales containing discontinuous zones of white calcareous banding (paleosol horizons). The Lebo shale in the northern PRB contains rare beds of gray sandstone as much as 10 feet thick. In the southern PRB, some coal beds, a few thicker than 2 feet, occur within the Lebo shale and form clinker horizons. The Lebo shale member ranges in thickness from about 500 feet in the northwestern portions of the PRB to about 1,700 feet in the southwestern portions of the PRB (Brown 1993). The Lebo shale member thins toward the southeastern portion of the Project Area (Pierce et al. 1990). Flores and Bader (1999) report the thickness of the Lebo shale member to be as much as 2,600 feet.

The Tullock member contains alluvial sediments deposited in a stream environment. It consists of fine-grained sandstone, sandy siltstone, shale, rare thin limestone, and coal. An estimated one-third of the sequence is composed of channel sandstones. An estimated two-thirds of the sequence is composed of fine-grained overbank deposits containing thin coal beds. Tullock sediments have a maximum thickness of about 370 feet in the north and 1,440 feet in the south (Brown 1993). Tullock sediments are thickest in the southeastern and western portions of the PRB. Flores and Bader (1999) report the thickness of the Tullock member to be as much as 740 feet.

Paleontologic Resources

Scientifically significant paleontologic resources, including vertebrate, invertebrate, plant, and trace fossils, are known to occur in many of the geologic formations within the Project Area. These fossils are documented in the scientific literature, in museum records, and are known by paleontologists and land managers familiar with the area.

The paleontologic potential of the Project Area was evaluated using the Probable Fossil Yield Classification (PFYC) developed by the FS, which is also employed by the BLM. The classifications include:

- Class 1: Igneous and metamorphic geologic units (excluding tuffs) that are not likely to contain recognizable fossil remains.
- Class 2: Sedimentary geologic units that are not likely to contain vertebrate fossils or scientifically significant nonvertebrate fossils.
- Class 3: Fossiliferous sedimentary geologic units where fossil content varies in significance, abundance, and predictable occurrence.
- Class 4: Class 4 geologic units are Class 5 units that have lowered risks of human-caused adverse impacts or lowered risk of natural degradation. Proposed ground-disturbing activities would require assessment to determine whether significant paleontologic resources occur in the area of a proposed action and whether the action would impact the resources.
- Class 5: Highly fossiliferous geologic units that regularly and predictably produce vertebrate fossils or scientifically significant nonvertebrate fossils and that are at high risk of natural degradation or human-caused adverse impacts.

The Project Area contains 34 mapped geologic units (Flores 2001, Love 1985, Love et al. 1987). Of these, one is classified as Class 1, two are classified as Class 2, 27 are classified as Class 3, none are classified as Class 4, and four are classified as Class 5. The four units classified as Class 5 are the Morrison Formation, Lance Formation, Wasatch Formation, and White River Formation.

Most of the geologic formations exposed at the surface within the Project Area are exposed only along the margins of the PRB. The most widely distributed units are the Wasatch Formation and Fort Union Formation, both of which are discussed below. Within the Project Area, the highly fossiliferous White River Formation (Class 5) occurs only on Pumpkin Buttes in southwestern Campbell County.

The Wasatch Formation (Class 5) is by far the most geographically widespread formation in the Project Area and is the bedrock geologic formation exposed at the surface in most of the PRB in Wyoming (Murphey et al. 2001). Because surface exposures are mostly vegetated, the formations within the PRB historically have not been perceived to be as rich in fossils as nearby basins, such as the Bighorn and Wind River, which have extensive badland exposures. Nevertheless, the ubiquitous anthills in the PRB contain locally abundant remains of small animals (mouse to rabbit sized), which can be successfully sampled even in vegetated areas.

Murphey et al. (2001) determined no institution has collected articulated bones from the lower Eocene part of the Wasatch Formation in the PRB. The Eocene fossils consist primarily of isolated teeth, with more complete dentary/maxillary fragments comprising approximately 10 percent of total the total number of specimens in the University of Colorado Museum's collections. Articulated material, particularly a partial skeleton of the aberrant reptile *Champsosaurus gigas*, is known from older deposits of the Wasatch Formation. Such finds are very rare and appear to be restricted to the Paleocene part of the formation. The Wasatch Formation fossil localities include 106 localities recorded at the University of Colorado Museum, four localities recorded at the University of Wyoming Museum of Geology, and 46 localities listed in Delson (1971), who was collecting for the American Museum of Natural History. These localities were originally documented by Wood (Delson 1971).

The Fort Union Formation (Class 3) is not as widely distributed as the Wasatch Formation, but occurs around the margins of the PRB. This formation contains locally abundant fossil vertebrates, invertebrates, and plants, and samples an important time interval during the early Tertiary evolution of mammals. No Fort Union Formation localities within the Project Area were identified during the museum record search for this analysis, but they do occur nearby in Montana.

Other fossil localities occur in the Mesaverde, Mowry, White River, and Gros Ventre Formations. Fossil localities outside the Project Area from formations that exist within the Project Area were also identified during this analysis. Data from fossil localities outside the Project Area were used in the class designations recommended for formations that occur within the Project Area.

The lack of localities from any of the geologic units in the Project Area does not mean that no scientifically significant fossils are present. Much of the area within and surrounding the PRB in Wyoming has not been adequately explored for paleontologic resources and new scientifically significant fossil occurrences are being discovered regularly.

Mineral and Energy Resources

The Project Area is one of the major mineral development areas in North America. Coal, oil, gas, and uranium have been the principal mineral and energy resources extracted from the PRB.

Coal

The PRB contains some of the largest accumulations of low sulfur subbituminous coal in the world. Thick coal deposits occur at or near the surface along the eastern boundary of the Project Area, along a north-south trend situated west of both Gillette and Wright, and in the northwestern portion of the Project Area. Coal occurs at depth, below the surface, throughout most of the remainder of the Project Area. Coal from the PRB in Wyoming is valued for its clean-burning properties.

Glass (1997) describes important coal seams of the Powder River Coal Field in Wyoming. These descriptions are summarized in the following paragraphs. Important coal seams within the Wasatch Formation, from oldest to youngest, include the School, Badger, Felix, and Lake De Smet coals. Important coal seams within the Fort Union Formation, from oldest to youngest, include the Canyon, Anderson, Wyodak, and Big George coals.

The School and Badger coals within the Wasatch Formation are developed in the Dave Johnston deposit in the southern part of the PRB. The Felix coal is a persistent coal bed in the northern and central portions of the Project Area, and varies between 5 and 20 feet thick, but is up to 50 feet thick in the central and southern portions of Campbell County. Felix coal exposures located east of the Powder River in southern Campbell County have been burned (Coates and Heffern 1999). The Felix coal is not currently mined.

The Lake De Smet coal is the thickest known coal seam in the contiguous U.S. Although limited in areal extent, in the northwestern portion of the Project Area the Lake De Smet coal attains a thickness of 250 feet. The Lake De Smet coal is not currently mined, and the uppermost portions of this coal bed are burned over much of its area of occurrence.

The Canyon coal of the Fort Union Formation is a persistent 10 to 65 feet thick coal bed over most of the Project Area. It is correlative with the Monarch coal in the Sheridan area. The Anderson coal is well developed throughout most of the Project Area, and coalesces with the Canyon coal in the Gillette area to form the thick Wyodak coal, which is 25 to 190 feet thick and averages 100 feet thick. The Wyodak coal has the largest strippable reserve base of any coal bed in Wyoming. In 2000, 12 surface coal mines located in Campbell and Converse Counties produced 323 million tons of coal from the Wyodak coal zone. The mines are located near the eastern boundary of the Study Area, near the outcrop of the Wyodak coal (Figure 2–1 and Figure 3-6), where the overburden thickness is lowest. Extensive clinker deposits exist east of many of the coal mines, which resulted from the spontaneous burning of the Wyodak coal near its outcrop.

Westward from Gillette the Wyodak coal splits into an Upper Wyodak coal composed of the Anderson and Canyon coals, and a lower, less persistent, Lower Wyodak coal. North of Gillette the Wyodak coal splits into an Upper Wyodak coal (including the Anderson coal) and a Lower Wyodak coal (including the Canyon coal). Farther west near the Campbell and Johnson County line, the Upper Wyodak coal thickens and becomes the Big George coal. However, in areas southwest of Gillette, both the Wyodak and the Big George coals are present, with the Big George coal zone positioned stratigraphically above the Wyodak coal zone.

The Big George coal is not exposed at the surface. It is reportedly up to 200 feet thick and averages more than 100 feet thick. It occurs in the subsurface of the west central portion of the PRB at depths between 1,000 and 2,000 feet and is not currently mined.

Coal resources in the northwestern portion of the Project Area are summarized by the BLM (1999b). The prominent coal beds within the Tongue River member of the Fort Union Formation are, from oldest to youngest, the Carney, Monarch, Dietz 3, Dietz 2, Dietz 1, Anderson, Smith, and Roland coals. North of Sheridan, underground coal mines operated between 1894 and 1953. Surface mining began in 1944 and continued until 1996. Two active surface coal mines (Decker and Spring Creek) are located northwest of the Project Area in southern Montana.

Most of the coal in the Project Area is federally owned. These federal coal lands are within the Wyoming portion of the decertified Powder River Federal Coal Region (BLM 1999c).

Coal Bed Methane

About 25 trillion cubic feet (tcf) of CBM may be recoverable from coal beds in the PRB within Wyoming (WSGS 2001). For this estimate, data for coals greater than 20 feet thick, occurring deeper than 200 feet below the surface were used, and a recovery factor of 67 percent was assumed. The BLM estimated that 28 tcf of CBM may be recoverable in the development scenario prepared for the PRB (Appendix A). Estimates of recoverable CBM in the U.S. increased from 90 to 141 trillion cubic feet (tcf) over 10 years as a result of technological advances (USGS 2000). Advances in technology likely would continue to result in improved evaluation and recovery of CBM resources.

De Bruin et al. (2001) describe CBM resources occurring in the PRB. CBM is natural gas (methane) occurring in coal beds. In the PRB, CBM was formed as buried plant material was subjected to bacterial activity during emplacement of groundwater and coalification (conversion to coal). CBM in the Powder River Coal Field is composed almost entirely of methane (CH_4) and nitrogen (N) (Gorody 1999).

A large percentage of the CBM generated during coalification escapes to the surface or migrates into nearby rocks, but a portion is trapped within the coal beds (De Bruin and Lyman 1999). Gas is trapped and stored in coal beds in one of four ways: (1) as free gas in tiny pores or cleats (fractures) within the coal; (2) as dissolved gas in water within the coal; (3) as adsorbed gas on coal surfaces; or (4) as absorbed gas within coal molecules (De Bruin et al. 2001).

Although it has been known for many years that methane often vents from shallow water wells and coal exploration drill holes in the PRB, drilling for CBM began only in 1986 (De Bruin and Lyman 1999). The first economic production of CBM from the PRB occurred in the Rawhide Butte field just north of Gillette, where production began in 1989 (De Bruin and Lyman 1999, Sawyer and Jeffries 1999). CBM development has been expanding rapidly since 1993 (Flores et al. 2001) and began accelerating in 1997 (De Bruin et al. 2001).

Historical CBM development in the PRB is summarized by Flores et al. (2001). During 1976 to 1996, 1,169 CBM wells were drilled. CBM drilling during 1997 to 1999 increased dramatically to 4,379 wells. During 2000, CBM development activity exploded and 3,831 wells were drilled. About 4,000 CBM wells were producing as of October 2000. From January 1994 through May 2001, CBM production increased at a nominal rate of 65 percent per year.

During 2000 a total of 150,544,625 million cubic eet (Mcf) of methane and 370,994,154 Bbls of water were produced from PRB coal beds in Wyoming (WOGCC 2001a). By the end of 2001, about 12,024 CBM wells would have been drilled or permitted for drilling in the Project Area. As of November 30, 2000 an estimated 4,093 CBM wells were producing (BLM 2000a).

At the time CBM development accelerated in the PRB, Western's MIGC pipeline was the only line out of the basin, and its capacity was filled rapidly (Shirley 2000). De Bruin et al. (2001) describe new gas pipelines in the Project Area. Three major pipelines (large diameter, high pressure gathering lines) were built in the PRB during 1999 and 2000: Bighorn Gas Gathering; Fort Union; and Thunder Creek. Currently CBM flows south out of the PRB on three interstate pipelines and to the north on one interstate pipeline (Sawyer and Jeffries 1999). As of early 2001, nearly 0.5 billion cubic feet (bcf) of gas per day was being transported out of the PRB (De Bruin et al. 2001).

Oil and Gas

Conventional (non-CBM) oil and gas exploration and production also have occurred for many years within the Wyoming portion of the PRB. Non-CBM oil and gas fields are concentrated within the central, eastern, and southern portions of the Project Area, and the infamous Salt Creek and Teapot Dome oil fields are located on the southwestern shoulder of the PRB (Lageson and Spearing 1991). Wyoming's annual oil production was increasing during the 1950s and 1960s, peaked at nearly 160 million barrels in the early 1970s, and has been declining since then (WOGCC 1998). According to WOGCC production statistics, 336 fields were producing non-CBM oil or gas within the Project Area during 2000 (WOGCC 2001a, c). Nearly 25 million barrels of oil and nearly 60 million Mcf of natural gas were produced from non-CBM PRB fields in Wyoming during 2000 (WOGCC 2001a). PRB production comes from a variety of upper and lower Cretaceous strata, as well as from upper Paleozoic strata in the northeastern part of the basin (Lageson and Spearing 1991).

There are currently about 2,546 productive non-CBM wells within the Wyoming portion of the PRB. About 1,347 existing non-CBM wells are federal wells, 1,006 well are fee wells, and 193 wells are state wells (WOGCC 2001c). About 1,282 productive federal non-CBM wells are located in the BLM's BFOA. The number of non-CBM wells abandoned through 2010 is expected to exceed the number of non-CBM wells drilled during that same period (BLM 2001c). From 1985 to 1999, the WOGCC approved 2,851 permits for non-CBM wells. An estimated 50 percent of the wells permitted (1,397 permits) were federal wells, and around 80 percent of the wells approved were actually drilled (BLM 2001c).

Uranium

Uranium occurs in the southern portion of the PRB, within the Tertiary (Eocene) Wasatch Formation, the Tertiary (Paleocene) Fort Union Formation, and the Cretaceous Lance Formation (Seeland 1976, Raines and Marrs 1983, Lowry et al. 1993). Uranium is present as roll-type deposits within Tertiary fluvial sandstones (Curry 1976). The following uranium districts occur within the PRB: Pumpkin Buttes; Southern Powder River; and Kaycee.

Before near-surface uranium deposits were depleted, 36,787 tons of uranium ore averaging 0.28 percent U_3O_8 were produced by 55 small surface mining operations in the Pumpkin Buttes Mining District of Campbell, Johnson, and Converse Counties during 1953 through 1967 (Lane et al. 1972, Breckenridge et al. 1974). Numerous prospects and abandoned uranium mines from the 1950s and 1960s remain. Uranium exploration within the PRB peaked during the 1960s and 1970s and substantial reserves were delineated deeper below the surface (Curry 1976).

More recently, uranium has been leached from subsurface deposits located in Converse and Johnson Counties. However, the two in situ leach (ISL) project operations are currently inactive.

Other Minerals

Several geologic materials occurring in the PRB are used as aggregate sources or construction materials. Clinker is produced from burned coal beds and is widely used as a road surfacing material in the PRB. Clinker occurring in coal beds within the Fort Union Formation covers about 290 square miles of the Project Area. Clinker occurring in coal beds within the Wasatch Formation covers about 170 square miles of the Project Area (Heffern and Coates 1997). Sand and gravel are produced from terrace and alluvial deposits occurring near rivers and larger tributary streams in the PRB. Clay occurring in association with coal in the Fort Union Formation is suitable for use in brick and tile manufacturing and has been mined in the past (Boyd et al. 1999). No estimate of existing disturbance from past and present quarries for aggregate and construction materials in the Project Area is available.

Deposits of bentonite, high-calcium limestone, and gypsum occur in Mesozoic and Paleozoic rocks exposed along the uplifted margins of the Project Area (Wolfbauer 1976, Harris and King 1989). Deposits occurring along the eastern flank of the Bighorn uplift are described by Wendell et al. (1976) and Lageson et al. (1978). These non-metallic industrial minerals are used in various industries, manufacturing, and agriculture for their chemical and physical properties. They occur stratigraphically below the geologic formations that may be affected by CBM development in the PRB.

Bentonite is produced from surface pits in Cretaceous deposits occurring in south central Johnson County (Wendell et al. 1976). No estimate of existing disturbance from past and present bentonite mining in the Project Area is available.

Geologic Hazards

Earthquake Hazards

The Federal Emergency Management Agency and the USGS have classified Wyoming as having a very high seismic hazard (Wyoming Water Resources Data System [WRDS] 2001a). Magnitude 6.25 to 6.5 events can occur within the Project Area. However, the Project Area is not within the portion of Wyoming that is included in the high-risk Intermountain Seismic Belt (University of Utah 2001).

Earthquake hazards in Wyoming are summarized by the Wyoming Emergency Management Agency (WEMA 2001b). Between 1871 and 1993, 69 earthquakes of moderate intensity have originated in Wyoming. The largest recorded earthquake in central and eastern Wyoming occurred near Casper on November 14, 1897. The magnitude of this earthquake was estimated to be between 5.0 and 5.9.

Earthquakes Induced by Injection of CBM Produced Water

Today, underground injection is strictly controlled and occurs in an injection zone (geological formation) that is sufficiently porous and permeable that fluids can enter the rock formation without causing an excessive build-up of pressure or fracturing of rocks. An earthquake would occur when pressure is released as rocks move in the subsurface.

Underground injection has been regulated by the EPA (and by some states, including Wyoming, on behalf of EPA) only since 1974, when the Safe Drinking Water Act was enacted. Prior to 1974, there were inadequate controls on injection wells. Many past examples exist of environmental impacts resulting from fracturing of rock layers or release of built-up pressure caused by injection.

Flood Hazards

Most surface water in the Project Area flows in response to storm events, snowmelt, releases from reservoirs, or surface discharges of CBM produced water. Flood hazards within the Project Area can be associated with weather conditions such as intense local storm events or rapid snowmelt, CBM discharge into low-capacity stream channels, and the failure or inadequacy of human-engineered drainage or impoundment structures to retain water. Minimization of flood hazards within the Project Area is dependent upon adequate control of surface flows.

Minimization of flood damage from an intense local storm within the Project Area in 2001 has been attributed to the existence of many small reservoirs that store increased flows of CBM produced water for the beneficial use of landowners (Associated Press 2001). A localized storm dumped 7.5 inches of rain near Gillette in May 2001, causing much less loss than an August 1985 storm in Cheyenne (WEMA 2001a, 2001b, Associated Press 2001). Although it appears that reservoirs built or upgraded to contain CBM produced water provided a measure of protection from flooding during a storm in 2001, reservoirs may pose a more significant hazard than extreme flooding if they are not adequately designed to withstand extreme hydrologic events.

Landslide Hazards

Landslides are slow or rapid downslope movement of rock and surficial deposits. The landscape is altered by these events, which have many causes and many forms. Landslides in the Project Area occur in bedrock, debris, or earth, as topples, slides, spreads, flows, or a combination of these types (Case 1997, 2001). The density of landslides is high along the Little Powder River north of Gillette, along the Powder River in Johnson and Sheridan Counties, and in western portions of Johnson and Sheridan Counties (WRDS 2001b). Minimization of mass movement depends, in part, on limiting additional disturbance to existing landslides and areas that are susceptible to movement.

The following physical characteristics of portions of the Project Area contribute to its susceptibility to landslides: steep slopes; surface exposure of shales or clays; surface exposure of brittle sandstones; and surface exposure of sandy, permeable materials on slopes underlain by clayey layers. The following natural processes that occur in the Project Area can contribute to its susceptibility to landslides: precipitation; erosion; weathering, including freeze and thaw action; intense storms; rain-on-snow events; loss of vegetation or soil damage caused by wildfires; and earthquakes. Within the Project Area, the following human activities also contribute to its susceptibility to landslides: removal of vegetation from slopes; construction occurring on slopes, including cuts that remove supporting rock and fills that add weight, overloading and destabilizing a slope; loss of vegetation caused by prescribed burns; and vibration from traffic or blasting. The addition of moisture to a geologic unit or slope that becomes less stable when wet is a key factor in many landslides.

No landslide hazards or mass movements that resulted from existing CBM development have been documented. However, infiltration of CBM produced water could cause movement on hillsides or embankments of impoundments where the addition of moisture or other changed conditions triggers slope failures.

The BLM and FS complete site-specific environmental analysis before they approve ground-disturbing activities. APD conditions of approval developed for each project minimize the likelihood that new landslides would be caused by surface disturbance. Avoidance of existing landslides and areas susceptible to landslides is the preferred mitigation measure for these geologic hazards. The BLM and FS require site-specific information on landslide and slope stability for all areas where ground-disturbing activity is proposed.

Windblown Deposits

There are scattered occurrences of windblown sand deposits along the southeastern and eastern margins of the PRB. This type of deposit is subject to continuing migration unless it is stabilized by a good vegetative cover (Boyd et al. 1999).

Aquifer Collapse and Ground Subsidence

Case et al. (2000) describe the conditions present in areas where the removal of fluids from subsurface aquifers has caused subsidence and make a comparison with PRB conditions. The geologic conditions in the PRB are not the same as were observed in the cases cited below.

Significant ground subsidence has occurred where unconsolidated alluvial aquifers have compressed in other geographic areas as a result of dewatering. In the United States, ground surface subsidence related to fluid withdrawal has been documented at a number of localities, including the San Joaquin Valley in California; Las Vegas, Nevada; New Orleans, Louisiana; and Houston, Texas. The common geological tie between these localities is that all are underlain by saturated, unconsolidated sands and gravels with interbeds or overlying beds of saturated clays. Water or oil is being removed (pumped) from the sands and gravels, causing ground subsidence.

In the PRB, the Fort Union Formation is a consolidated rock unit and is not being substantially dewatered. Instead, the Fort Union Formation is being only partially dewatered to the top of the coal seam. The bedrock underlying the surface is compacted and consolidated. Instead of loose sand, sandstone is present; instead of unconsolidated clay, shale is present. However, even saturated bedrock, such as sandstone, can compress if water is removed under certain conditions.

Using a formula to estimate how much a confined aquifer may compress when water is removed, it appears that for CBM development levels analyzed in the Wyodak CBM Project EIS, minor aquifer compression up to 1/2 inch may occur in the coal beds that are being developed for coal bed methane in the Gillette area. That entire compression, however, may not be transmitted to the surface. To date, no surface subsidence has been associated with significant municipal water withdrawals in the Gillette area (Case et al. 2000, Edgar and Case 2000).

Gas Migration, Seepage, and Methane Venting

De Bruin et al. (2001) describe the conditions associated with methane migration and seepage. Methane seeps usually occur where coal beds are extremely close to the surface. Natural cracks or passageways for the gas to flow usually do not exist where the coal is deeper. The methane contained in Fort Union coals is present in a free state, adsorbed on interior pore surfaces and micropores of the coal matrix and dissolved in water contained within the coal seam. Reducing the hydrostatic pressure on the coal seam by pumping off the water enhances the release of methane that was previously trapped in the coal matrix as well as gas dissolved in the water. Extraction of CBM removes the gas before it flows into shallower areas.

Gas migration and seepage can be increased by coal mining or CBM development. The Gillette coalfield extends beneath the City of Gillette and surrounding areas (Ellis et al. 2002). Coal mining has encroached on the eastern city limits of Gillette and occurs along the trend of the coal outcrop that extends north and south of the city. CBM development has encroached on the southern, western, and northern city limits of Gillette.

Methane migration and seepage in the PRB have been associated with the escape of methane from coal mines located along the coal outcrop that extends north and south of Gillette. Experience in the PRB has shown that seeps that involve potentially explosive concentrations of methane have occurred in coal seams near the surface. Escaping methane has created hazardous conditions, such as were documented in 1987 at the Rawhide Village subdivision 10 miles north of Gillette (Flores et al. 2001). The impacts of methane migration and concentration in a populated area can be serious. Rawhide Village was abandoned after explosive concentrations of methane were found to underlie the entire subdivision (Flores et al. 2001).

Methane seepage also can occur naturally in near-surface coal seams (Glass et al. 1987; Jones et al. 1987). The potential for methane migration within the PRB is not limited to areas that contain near-surface coal seams or areas where dewatering has occurred. Methane migration could occur at widespread locations within the PRB, as methane can migrate long distances along joints or fractures in rocks. Gas generated in coal beds has migrated into adjoining sandstone beds (Rice and Finn 1995).

The escape of methane can result from inadequate well control procedures and faulty casing or plugging. Many existing non-CBM well bores likely do not effectively isolate the formations penetrated and may serve as conduits for the vertical migration of methane. Water wells frequently are screened over multiple aquifer zones, which would facilitate migration of methane through the well bore. Many older, conventional oil and gas wells likely are inadequately cased, allowing methane, if present, to migrate. Numerous uncased boreholes were drilled in the PRB to evaluate the potential for uranium and were not properly plugged, which could allow methane, if present, to move through the formations penetrated.

Areas near the coal outcrop and areas of coal or CBM production where substantial dewatering has occurred or is occurring represent possible migration or seepage areas. Methane could emerge from water wells near CBM production areas, affecting stock and residential wells. Other potential migration or seepage areas include areas that contain existing well bores and areas where faults, fractures, or sandstone layers occur in an orientation that provides a conduit for movement of methane. Methane hazard areas have not been mapped or compiled within the Project Area. Furthermore, the integrity of existing wells within the Project Area has not been comprehensively evaluated. No estimate of seepage is available for the PRB.

Comparison with Methane Migration and Seepage in the SJB

Methane migration and seepage associated with CBM development in the San Juan Basin (SJB) of southwest Colorado are specific to the local conditions in that area. Geologic conditions differ significantly between the PRB and the SJB. Most experience from the SJB is therefore not directly applicable to the PRB.

First, basin pressurization and groundwater flow systems are not comparable between the two basins. The SJB is more deformed than the PRB and contains more faults and fractures that could serve as conduits for methane migration. In addition, coals are higher grade within the SJB with a much higher gas content and have cleats and fractures that are better developed than the lower-grade coals within the PRB. The PRB is not characterized by naturally occurring gas seeps, as is the SJB. The following description of conditions in the SJB is provided to illustrate the diversity of the two basins.

Naturally occurring gas seeps existed throughout the SJB before the earliest oil and gas drilling operations or CBM development. Shallow water wells that penetrate coals in the SJB produced methane. Intensified seepage was, however, reported as CBM development progressed (BLM 2000a). Some residents noticed an apparent increase in the occurrence of methane in domestic wells as CBM development progressed. Others noted the presence of gas seeps and dead vegetation in pastures. Stands of stressed and dying trees were discovered aligned with coal beds beneath the surface. Explosive accumulations of methane were discovered in wells and residences (BLM 2000a). As of early 2000, seepage was estimated (by a computer model) to have increased by at least 3 million cubic feet per day (MMcfd), and possibly as much as 10 MMcfd over predevelopment levels (Questa 2000).

In the SJB, agencies recognized that older gas wells may have been acting as conduits for migration of gas into groundwater and implemented aggressive procedures to test existing wells, remediate problem wells, and ensure that new and future wells could not act as conduits (COGCC 2000). Through May 2000, 269 repair procedures were completed on gas wells in La Plata County to eliminate the possibility that these wells would serve as conduits for migration of methane. Most of these repairs (all except 36) were completed on conventional gas wells (COGCC 2000).

Greenhouse Gases

Methane is a greenhouse gas that acts to trap heat in the Earth's atmosphere, contributing to global warming (USGS 2000). Methane is second only to carbon dioxide as a major contributor to potential global warming (EPA 2002c). Over 100 years, methane is about 20 times more effective than carbon dioxide at trapping heat in the atmosphere (EPA 2002c).

The concentration of methane in the Earth's atmosphere has increased rapidly, more than doubling over the last two centuries (EPA 2002c). Concentrations of methane continue to rise, largely caused by increasing emissions from human-related (anthropogenic) sources (EPA 2002c). EPA estimates that it would be technologically feasible to reduce methane emissions from human-related sources by about 50 percent (EPA 2002c).

The relative contributions of methane from various sources to greenhouse gases in the atmosphere were estimated in 1997 (USGS 1997): natural systems, including wetlands and decomposing forested areas (40 percent); rice cultivation (19 percent); livestock (11.5 percent); biomass burning (11.5 percent); landfills (8 percent); coal mining (6 percent); and venting from oil and gas wells (4 percent). The emissions from human-related sources now constitute about 70 percent of global total emissions (EPA 2002a).

Most experts agree that potential reductions from many sources of methane associated with human activity, such as rice cultivation or livestock raising, would be small (USGS 1997). However, improved recovery and use of methane from coal mines could result in important reductions (USGS 1997). Methane is an explosive gas in coal mines and is vented to the atmosphere (wasted) in an attempt to achieve safe working conditions. Where CBM development occurs in an area before coal mining, less methane may be vented to the atmosphere during mining.

Emissions of methane are considered minimal in the basin because of the low gas content of the coals in the PRB and because all coal is mined on the surface (Rice and Finn 1995). However, venting of methane from oil and gas wells or CBM wells contributes to the concentration of greenhouse gases in the atmosphere.

Venting or flaring of methane may occur for a few days or up to a month during initial completion and testing of a gas well and may continue, temporarily, until a pipeline is connected. Typically, CBM wells drilled in the PRB initially produce only water, but not gas. Wells are completed by open-hole methods that involve enlarging the open, uncased portion of the borehole, so that a downhole, submersible pump can be used to produce the well. Water and gas are separated at the wellhead as water is pumped up the production tubing and gas flows up the outside of the production casing. Gas produced initially, if any, would be flared, not vented, for safety reasons for this completion method. Non-CBM wells typically are not completed using open-hole methods. Gas is produced during completion and initial testing as a result. Typically, gas and water flow to a separator tank where the gas is separated from the water and vented to the atmosphere until the tank can be connected to the gas- and water-gathering system. No estimate of the volume of methane vented or flared is available for the PRB.

Spontaneous Combustion of Coals

In the PRB and other regions where coal occurs at or near the surface, exposure of clinker can be associated with coal outcrops, marking the locations where coal has burned in place. Burning coal in the PRB is a natural process that has been going on ever since erosion began to expose the coal beds (Coates 1991). Lyman and Volkmer (2001) summarize the history and occurrence of coal fires in the PRB. Coal outcrop fires occurred during the Tertiary period several million years ago and have continued to the present. It has long been recognized that spontaneous combustion, range fires, and lightning cause coal outcrops to burn naturally, producing clinker (Rogers 1918).

Clinker outcrops are concentrated in the following areas: along the eastern boundary of the study area in the Rochelle Hills; within the Powder River Breaks in the northern portion of the study area; within the Tongue River Breaks north of Sheridan; within the Lake De Smet area north of Buffalo; and within the Felix area west of Gillette and northeast of Wright (Heffern and Coates 1997). As coal combusts, the burn front advances into the hillside until, with increasing depth, fissures in deposits that overlie the coal fail to reach the surface. At that point, the supply of air to the coal is cut off, extinguishing the fire (Coates and Heffern 1999, Heffern and Coates 1999). Clinker can be found at depth by drilling as far as several hundred feet back from where it is apparent at the surface (Heffern and Coates 1997).

Environmental factors that contribute to the self-ignition of coals are exposure of coals to oxygen, causing oxidation to occur and releasing heat, and exposure of dry coals to moisture, producing heat during the wetting process. The rise in temperature, also known as the heat of wetting, accelerates oxidation of the coal (Coates and Heffern 1999). When these two reactions release heat more quickly than it can dissipate, the temperature of the coal can rise to the self-heating point where these reactions occur more quickly, releasing volatile gasses and causing self ignition (Coates and Heffern 1999). A larger surface area is available on small particles of coal for oxidation to take place; small particles therefore are highly susceptible to self ignition (Lyman and Volkmer 2001).

The coals in the PRB contain the reactive materials required for spontaneous combustion. However, conditions that favor the self ignition of coal are not present in undisturbed coal beds in the immediate vicinity of CBM wells. In an undisturbed coal bed, fluctuations in the water table may release the heat of wetting, but the supply of oxygen is not sufficient to support combustion (Coates and Heffern 1999).

Lyman and Volkmer (2001) compare conditions that favor spontaneous combustion of coal with CBM development in the PRB. Conditions necessary to foster spontaneous combustion of coal are not present during the production phase of CBM. CBM wells are designed to keep oxygen (a contaminant) out and to maintain airflow out of the well. Any heat generated is vented to the surface before enough builds up to result in ignition of coal. The relatively small diameter of a CBM well bore prohibits large volumes of fines from accumulating. Fines that accumulate are flushed from the hole before production or during well maintenance. Faults and fractures that may be present in the overburden are sealed via casing and cement. CBM wells are plugged and sealed after production of methane ceases.

Lyman and Volkmer (2001) also compare the conditions that favor spontaneous combustion of coal with conditions associated with mining and CBM development. Unlike surface coal mining, the likelihood of completely dewatering a coal bed during CBM development and exposing large areas of fine coal particles to oxygen is extremely remote. Unlike abandoned underground mines, CBM wells leave no underground voids that are susceptible to further subsidence and associated spontaneous ignition of coal.

Coates and Heffern (1999) describe the conditions that are characteristic of shallow coal seams above the water table, such as would occur along the margins of the PRB. Coal, where it is above the water table, degasses at a rate that is related to its distance from the ground surface or a cut bank and the permeability of the materials that surround it. In general, coal at a shallow depth or near a cut bank degasses faster than deeper coal. Shallow coals that have existed near the surface for a long time may be degassed and unable to ignite spontaneously. In addition, slow oxidation beneath a shallow cover can consume a coal bed without combustion ever occurring.

If near-surface coals were to burn, the introduction of methane to the outcrop area through seepage could intensify or prolong the natural process of combustion if the methane were to burn along with the coal. Alternatively, because the gas has a lower Btu (heat) content than the coal, it might make a fire less intense, because the coal and methane would compete for oxygen in the combustion setting (WSGS 2002). According to the WSGS model that describes the possible interaction between methane seepage and a coal outcrop fire, only a few thousand Btu (Mbtu) per day might be added through methane seepage at an outcrop fire. The Btu equivalent for coals in the PRB is 8,400 to 8,800 per pound, so the gas would represent only the added heat of 5 or 10 pounds of coal.

Coates and Heffern (1999) describe the coal fires at the Acme Mine area, located north of Sheridan, Wyoming, that continue to burn. Abandoned underground coal mines burn more or less continuously in this area. The mine workings introduce oxygen needed for oxidation and moisture needed for the heat of wetting to the coal seams, causing combustion. No connection between the development of CBM and coal fires in the Acme mine area has been identified.

Soils

Soils within the Project Area have developed in residual material and alluvium in a climatic regime characterized by cold winters, warm summers, and low to moderate precipitation. The upland soils are derived from both residual material (derived from flat-lying, interbedded sandstone, siltstone, and shale) and stream alluvium. Valley soils have developed in unconsolidated stream sediments including silt, sand, and gravel. Soils are generally low in organic matter and are alkaline (Lowry et al. 1986). Textures range from clay loams to sandy loams with varying amounts of gravel or coarser materials. Slopes range from nearly level to very steep with deeper soils found in the less steeply sloping areas. These soils support little crop agriculture except in irrigated valleys of perennial streams. The predominant land use is rangeland. Vegetation is predominantly grass-shrub that is used for grazing and wildlife habitat.

County soil surveys have been completed in Sheridan, southern Johnson, southern Campbell, and northern Converse Counties. However, county surveys are still in the preliminary mapping stages in northern Johnson and northern Campbell Counties. Because of the incomplete county-level soil survey coverage and the large geographical area involved, STATSGO mapping for the State of Wyoming was used to provide generalized soils coverage for the Project Area. Although the STATSGO mapping is adequate for this level of analysis, it is insufficient for use in locating specific well pads, access roads, pipelines, and other associated facilities. The companies would select the specific locations of proposed CBM activity (wells, pads, access roads, pipelines, and other ancillary facilities) during the application for permit to drill (APD), NPDES, and other local permits process. Therefore, since exact locations are unknown at this point, the analysis of soils is all-inclusive of the Project Area and is not based on site-specific information.

Each association in STATSGO is named for the three dominant soil series within that association. The areal extent of all STATSGO map units in the Project Area is listed in Table 3-15. Appendix E lists the dominant soil series for each STATSGO map unit association in the Project Area and shows the major general characteristics of each. Characteristics for each of these dominant soil series were identified using both the published and preliminary county soil surveys. In addition, slope data were used in combination with series data to identify areas with higher potential for water erosion.

Table 3-15 General Information on Soils – Areal Extent of Soil Units

STATSGO Map Unit	Map Unit Name	Percent of Area
WY002	Midway - Samday - Rock Outcrop	0.20
WY004	Haverson - Glenberg - Bone	0.46
WY042	Cabbart - Yawdim - Hesper	0.20
WY043	Ridge - Broadus - Reeder	0.05
WY044	Havre - Hanly - Glendive	0.16
WY045	Cabbart - Yawdim - Thurlow	0.49
WY046	Cabba - Ringling - Yawdim	0.55
WY047	Draknab - Arvada - Bidman	0.41
WY048	Riverwash - Haverdad Clarkelen	2.50
WY049	Shingle - Renohill - Forkwood	8.12
WY050	Shingle - Taluce - Kishona	11.47
WY051	Wyarno - Hargreave - Moskee	0.72
WY053	Shingle – Cushman - Taluce	3.22
WY055	Haverdad - Havre - Zigweid	2.08
WY056	Samday - Shingle - Rock Outcrop	0.56
WY057	Doney - Shaak - Wayden	0.92
WY058	Abac - Peritsa - Rock Outcrop	<0.01
WY059	Rock Outcrop - Starley - Woosley	2.69
WY060	Tolman - Abac - Rock Outcrop	0.67
WY061	Agneston - Rock Outcrop - Granile	0.55
WY062	Owen Creek - Tongue River - Gateway	<0.01
WY063	Wolf - Platner - Platsher	1.48
WY064	Plashter - Recluse - Parmleed	0.99
WY065	Baux - Bauxson - Harlan	2.50
WY066	Moskee - Hargreave - Shingle	1.20
WY078	Frisco - Troutville - Teewinot	0.04
WY081	Barnum - Haverdad - Rock Outcrop	0.40
WY082	Reno - Shingle - Parmleed	8.17
WY084	Keyner - Samday - Rock Outcrop	1.93
WY085	Samday - Badland - Rock Outcrop	0.81
WY086	Cambria - Shingle - Kishona	1.44
WY087	Shingle - Cambria - Renohill	0.83

Table 3-15 General Information on Soils – Areal Extent of Soil Units

STATSGO Map Unit	Map Unit Name	Percent of Area
WY088	Sunup - Rock Outcrop - Spearfish	1.55
WY114	Tassel - Turnercrest - Terro	0.01
WY115	Shingle - Samday - Absted	0.21
WY124	Plashter - Kishona - Hiland	1.98
WY125	Shingle - Theedle - Wibaux	2.40
WY126	Hiland - Vonalee - Maysdorf	4.27
WY127	Kishona - Shingle - Theedle	4.10
WY128	Renohill - Cushman - Cambria	3.15
WY129	Bidman – Parmleed - Renohill	2.70
WY130	Renohill - Bidman - Ulm	6.29
WY203	Clarkelen - Draknab - Haverdad	0.25
WY204	Hiland - Ustic Torriorthents - Bowbac	1.50
WY205	Dwyer - Orpha - Hiland	0.61
WY206	Wibaux - Rock Outcrop - Shingle	1.40
WY207	Hiland - Bowbac - Tassel	3.02
WY208	Shingle - Samday - Hiland	1.53
WY209	Hiland - Shingle - Tassel	5.52
WY210	Ulm - Renohill - Shingle	1.33
WY211	Shingle - Tassel - Rock Outcrop	1.74
WY315	Rock Outcrop - Hazton - Redsun	0.20
WY316	Hiland - Bowbac - Keyner	<0.01
WY317	Shingle - Taluce - Amodac	0.10
WY321	Hiland - Orpha - Bowbac	0.08
WY322	Roughlock - Rock Outcrop - Rekop	0.08
WY323	Lolite - Hiland - Vonalee	0.01
WY324	Hiland - Forkwood - Zigweid	0.11
WY325	Lolite - Rock Outcrop - Keyner	0.06
WYW	Surface Water	0.02

Soil Descriptions

Appendix E lists the dominant soil series for all the associations in the Project Area. The general characteristics of the soil are listed for each series. Series with severe wind and water erosion hazards, high compaction potential (based on clay content and type and high shrink-swell capacity), high salinity and sodicity, soils with a poor potential for revegetation, and prime or otherwise valuable agricultural soils are marked in Appendix E. A brief description of each parameter in the table follows this discussion.

"Rock Outcrop" is listed numerous times in Table 3-15 as one of the three predominant soil types in the series. Though the nature of this outcrop is not described in county soil surveys, the "Rock Outcrop" notation refers to exposed bedrock or a formation known as clinker. Clinker, also referred to as "scoria," is rock that has been baked by subsurface coal fires and has migrated to the surface. This baked rock is highly resistant to erosion and, as a result, is often found atop plateaus and ridges in the Powder River Basin. The Geology section (beginning on page 3–57) describes clinker concentrations in the Project Area in more detail.

Generally, clinker consists of fractured rock on a base of porous ash. Semipermeable clay frequently underlies clinker formations (Heffern and Coates 1999). This structure allows clinker to absorb, store, and transfer large amounts of water. The quality of water from clinker aquifers is highly variable but in general, TDS values are lower for older formations (Heffern and Coates 1999). The irregular terrain of clinker formations provides a unique habitat for plant and animals species that would otherwise not survive on the treeless plain (Heffern and Coates 1999). Clinker is not considered a valuable agricultural soil and has a very poor revegetation potential. Soil types in rock outcrops that do not refer to clinker are most likely exposed sandstone, shale, or other bedrock. Like clinker, this exposed bedrock has poor revegetation potential, but provides valuable wildlife habitat.

Wind Erosion Hazard

Severe wind erosion hazards were identified by determining the wind erosion group for each soil. These groups are based on soil texture (grain size, parent material, cohesiveness, and wetness), and indicate the susceptibility of a soil to wind erosion. Nine groupings have been developed (1, 2, 3, 4, 4L, 5, 6, 7, 8); the lower the number, the greater the risk of wind erosion. Group 1 includes soils that consist entirely of fine sand, which is highly susceptible to wind erosion, and Group 8 contains very wet or stony soils, which are not at all subject to wind erosion. Soils listed in Groups 1 and 2 were considered Severe Hazards for this section.

Severe wind erosion hazards primarily run down the center of Campbell County from the Wyoming-Montana border to about 14 miles south of Gillette and along the Little Powder River. These soils cover much of Converse County as well (Figure 3-8).

Slope Hazards

A soil's stability is greatly affected by the slope on which it occurs. In general, the greater the slope, the greater the potential for slumping, landslides, and water erosion. Slope Ranges used to identify slope hazards were determined by the U.S. Department of Agriculture (USDA) National Soil Survey Handbook and appropriate conditions of approval (COAs). For this analysis, slopes from 0 to 25 percent are considered minimal hazards, 25 to 40 percent slopes are moderate, and slopes 40 and above are considered severe hazards. Hazards for minimal slopes have been further broken down in the Water Erosion Hazard Section. These ranges are quite general and the exact stability and susceptibility to water erosion depends greatly on each soil's characteristics.

Severe and moderate slope hazards in the Project Area occur primarily along the southwest corner of the Project Area in Johnson County (Figure 3-8). Small areas of these slope hazards are scattered throughout the Project Area as well.

Water Erosion Hazard

Severe water erosion hazards were identified using permeability classes, K-factor, and slope. Slopes above from 25 to 40 percent are considered moderate water erosion hazards and slopes 40 percent and above are considered severe water erosion hazards.

As so much of the Project Area falls within the 25 percent and below slope range, permeability class and K-factor for each soil type were used to determine which soils might be more susceptible to water erosion on gentle topography. At slopes less than 5 percent, only the least permeable and highest K-factor soils (neither of which occur in the Powder River Basin) are susceptible to water erosion. At slopes greater than 25 percent, only the most permeable and lowest K-factor soils (neither of which occur in the Powder River Basin) are not susceptible to water erosion (U.S. Department of Agriculture, Soil Conservation Service 1994).

Water erosion hazards for soils on slopes between 5 percent and 25 percent were identified with permeability classes and K-factors. Soil permeability classes were determined by infiltration rates in inches per hour (in/hr). Rates from 0 to 0.2 in/hr were considered slow, 0.2 through 6.0 inches/hour moderate, and 6.0 in/hr and greater were considered rapid. Generally, primarily sandy soils had the greatest infiltration rates, while clayey soils had very slow infiltration rates.

K–factor is one of six factors used in the Universal Soil Loss Equation to predict annual rate of soil loss due to water erosion. Soil structure, percentage of silt, sand, and organic matter, and permeability all affect the K-factor of a soil (U.S. Department of Agriculture, Natural Resources Conservation Service [NRCS] 1986a, b, c). Values for K range from 0.02 to 0.69. The higher value, the more susceptible the soil is to water erosion. Soils with low permeability and high K–factors were determined to be severe water erosion hazards for slope ranges between 5 percent and 25 percent (SCS 1994).

Severe and moderate water erosion hazards (based on the 25 to 40 percent and 40 percent and above slope ranges) in the Project Area occur primarily along the southwest corner of the Project Area in Johnson County. Soils with severe water erosion potential in the five to 25 percent slope range occur along the northern and eastern borders of the Project Area and extend down the center of the Project Area along the Powder River and into Converse County.

Compaction/Shrink-Swell Potential

Compaction and shrink-swell potential affect a soil's ability to support construction and to be reclaimed. Both characteristics are related to the amount of clay in a soil. A soil with high clay content is very compactable and has a high shrink-swell potential. Clay grains are extremely small and can be forced so closely together that few pore spaces remain. Thus, most air and water is pushed out of the soil. In addition, the soil grains may become so tightly compacted that plants roots would not be able to penetrate the soil. The composition of the clay soils plays an even more important role, however, in determining compaction and

Figure 3-8 Soils and Slope

shrink-swell potential than does clay particle size. For example, the mudstones of the Wasatch and Fort Union formations contain montmorillonite (smectite or bentonite) and mixed-layer clays, which expand and contract depending on the introduction or deletion of oxygen and hydrogen (Devine 2002). Because of the absence of air and water and the difficulty of root growth, reclamation of a tightly compacted clay soil is extremely difficult without loosening the soil before seeding.

Shrink-swell potential is the potential for volume change in a soil with a gain or loss in moisture. Like compaction, a soil's shrink-swell potential is determined partially by its clay content. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. Montmorillonite clays are derived from the decomposition of shales and volcanic rock and can swell up to 15 times their dry-state volume when exposed to water. Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to capacity. A change of 3 percent is considered low, 3 to 6 percent is moderate, and a change of greater than 6 percent is classified as high. In soils with a high shrink-swell potential, Rapid changes in volume can damage structures and roads (NRCS 1986a, b, c). Appendix E identifies the soil series in the Project Area that exhibit a high clay composition and related high shrink-swell potential. Soils with a clay composition of 35 percent of greater are classified as high clay (NRCS 1971-1997). Soils classified as high shrink-swell potential in the county soil survey are marked as severe hazards in this section.

Severe shrink-swell potential soils occur along the northern and western borders of the Project Area and on either side of the Powder River, down the center of Sheridan and Johnson Counties and the eastern portion of Campbell County. The entire south half of Campbell County and small, widely separated portions of Converse County are dominated by these soils also.

Salinity and Sodicity

The SAR, or sodicity, of surface water and groundwater and salinity of soils are important chemical characteristics based on their effects on plant life and soils productivity. SAR is the ratio of the concentration of sodium ions relative to calcium and magnesium ions in water. Salinity in soil and water is commonly represented as a measurement of the amount of soluble salts in water, or TDS, measured in mg/L or parts per million (ppm). Measuring TDS in soils requires complete chemical analysis in a laboratory and can be time consuming and expensive. A more practical measurement of salinity in soils and water is electrical conductivity (EC), which is measured in deci-Siemens per centimeter (∂S/cm), or millimhos per centimeter (mmhos/centimeter) at 25 °C (Ayers and Westcot 1985). SAR can be measured only in water, whereas salinity can be measured in both soil and water. Salinity detracts from a plant's ability to take in water, whereas sodicity slows the movement of water through the soil.

Plant roots exclude salt from the water they extract from the soil. A plant must expend significant energy to take in water in highly saline water. This expenditure diverts energy from growth and reproduction, reducing the productivity of the plant. Soils with salinity levels from 0 to 8 mmhos/centimeters are considered slightly saline, soils with levels of 8 to 16 mmhos/centimeters are considered moderately saline, and soils with salinity levels above 16 mmhos/centimeters are considered strongly saline.

Soils with high clay content are most likely to experience adverse effects from high sodium. Sodicity is a more serious threat than salinity because it is much more difficult to reclaim sodic soils than saline soils. High sodium levels impair the permeability and infiltration rates of clay soils as a result of dispersion (Munn 2002a, b).

Catious such as calcium, magnesium, and sodium are attracted to negative charges on clay particles. Sodium can displace other catious on the clay exchange sites and cause the clay particles to disperse. This dispersion of the clay particles destroys soil structure, resulting in a reduction in water movement into and through the soil.

Salinity in soils can be affected by the SAR in and duration of exposure to surface water. Consequently, the salinity of soils can change rapidly over time and can differ greatly between similar soil types depending on the quality of the local water and the irrigation program. Additionally, any soil that is poorly drained, such as clay, has flat slopes, impermeable bedrocks, or is flooded frequently, could retain water and concentrate salts. These types of soils cover 40.6 percent of the Project Area.

Small sections of the Project Area concentrated near the confluence of the Powder River and the South Fork of the Powder River and along the Bell Fourche River, Black Thunder, and Little Black Thunder creeks are classified as high salinity. The saline soils in these areas most likely occupy toe slopes, alluvial fans, and stream terraces. Soils near or downstream from coal mines have also been found to be highly saline (Tidball and Ebens 1976). These statements are very general possible locations for saline soils. Chemical characteristics in soils can vary greatly over a large geographic area, regardless of soil type.

Poor Revegetation Potential

Soils with poor revegetation potential were identified using the land capability classification given in the county soil surveys. Soils are grouped according to their limitations for field crops, the risk of damage if used for agriculture, and response to management. Capability classes are divided into eight groups (Roman Numerals I–VIII), with Class I soils having few limitations and Class VII soils having multiple limitations that prevent commercial crop production. Class VII and Class VIII soils were determined have poor revegetation potential for this analysis.

Soils with poor revegetation potential occur throughout the Project Area, except the central portion of Campbell County.

Figure 3-9 Species Richness

Prime Agricultural Soils

Prime soils were identified by the Wyoming state office of the NRCS. Sheridan County, Converse County, and the central section of Campbell County are covered extensively by prime agricultural soils. Additionally, these soils extend into Johnson County along the Powder River and Clear Creek.

Landscape Processes

Biodiversity

Biodiversity is "the variety of living organisms considered at all levels, from genetics through species, to higher taxonomic levels, and including the variety of habitats and ecosystems." (Meffe and Carroll 1994). Biodiversity is generally discussed and analyzed at four different levels: genetic diversity, population/species diversity, community/ecosystem diversity, and landscape diversity (Orians 1994). At the genetic level, the concern is that diversity of genes may decrease through inbreeding or lack of genetic flow between populations as a result of decreased or fragmented populations. At the population/species level, changes in birth and death rates, immigration, and emigration become important as they influence attributes such as presence and absence, abundance, and density for each species. At the community/ecosystem level, species richness, the variety of habitats present (including the ratios between these habitats), and the frequency, intensity, and return interval of disturbance events (for example fire, drought) are important parameters of diversity. At the landscape level, components of habitat fragmentation, such as the distribution of and connectivity between habitat patches, extent of edge habitats, and structural contrast between patches become important (Orians 1994).

Species richness, a count of all species known to occur in a particular area, is one measure of biodiversity (Orians 1994). Although it is not as complete a measure of biodiversity as other indices that include measures of abundance and proportional distribution, species richness is the only measure available for the Project Area. Data from the Wyoming Gap Analysis Project (Merrill et al. 1996) show that some parts of the Project Area are higher in species richness than others (Figure 3–9). Table 3-16 summarizes species richness for each sub-watershed in the Project Area. Some of the patterns of species richness seen in Figure 3–9 and Table 3-16 may reflect sampling effort, rather than absolute biodiversity. For example, an area of higher species richness south and slightly east of Gillette is likely an artifact of intensive sampling associated with existing surface coal mines. Likewise, areas of apparent low species richness in the central and southeastern portions of the Project Area may be artifacts of incomplete sampling because of the large amount of private lands in these areas.

Table 3-16 Species Richness by Sub-watershed

	Species Richness Category (Percent)					
Sub-watershed	0–102	103–117	118–136	137–165	166–297	Mean[1]
Little Bighorn River	7	5	6	51	32	152
Upper Tongue River	24	28	20	13	14	128
Middle Fork Powder River	19	24	33	20	4	122
North Fork Powder River	32	15	24	27	1	112
Upper Powder River	39	49	10	3	0	107
South Fork Powder River	36	28	29	7	0	112
Salt Creek	26	66	4	4	0	108
Crazy Woman Creek	32	41	16	9	2	113
Clear Creek	35	25	24	6	10	123
Middle Powder River	12	48	37	3	0	116
Little Powder River	19	53	22	6	0	113
Little Missouri River	19	67	3	10	1	113
Antelope Creek	27	55	14	3	0	108
Dry Fork Cheyenne River	55	36	8	2	0	105
Upper Cheyenne River	11	55	27	7	0	115
Lightning Creek	87	12	1	0	0	98
Upper Belle Fourche River	15	39	31	16	0	119
Middle North Platte River	38	35	24	2	1	109
Total	30	41	19	7	3	114

Note:
1. Developed as a weighted average for all polygons in the sub-watershed
Source: Merrill et al. 1996.

The Nature Conservancy (1999) has defined "conservation sites" for the Northern Great Plains Steppe Ecoregion, which includes the Project Area. These conservation sites consist of a group of areas that would, if protected, provide the greatest protection for plant and animal species in the ecoregion. They include federal, state, and private lands and are, for the most part, not currently protected. The boundaries of the conservation sites are loosely drawn; therefore, they are not displayed in Figure 3–9. Eleven sites fall partially or completely within the Project Area. Biodiversity within these areas ranges from low to very high. Agricultural conversion, exotic species, habitat fragmentation, hydrologic alteration, oil and gas development, poor grazing management, prairie dog control, railroad construction, residential development, and strip mining have been identified as threats to conservation sites.

The biodiversity of aquatic systems is under stress nationwide, with the largest number of imperiled species found in the Southeast. Fewer species inhabit the arid, western states, but a greater proportion of them are at risk of extinction (Aldrich et al. 1998). Fourteen percent of the freshwater fish population is at risk in Wyoming (Aldrich et al. 1998). More specifically within the Project Area, nine WGFD sensitive fish species, one FS sensitive fish species, two FS sensitive amphibian species, one BLM sensitive fish species, and two BLM sensitive amphibian species may be present within the aquatic ecosystem (see the Threatened, Endangered, or Sensitive Species section).

Anthropogenic disturbances to aquatic ecosystems such as dam construction, water withdrawals, land-use alterations, pollution, and introductions of non-native species have an effect on all four levels of biodiversity (genetic diversity, population/species diversity, community/ecosystem diversity, and landscape diversity). Wyoming does not have a formal biodiversity policy; however, by statute, the policy of the state is to provide for the conservation of lands and protection of natural resources and wildlife and public lands (State of Wyoming 2002a). In addition, the legislature finds that wetlands protection and preservation are important for wildlife habitat (State of Wyoming 2002b). An instream flow statute recognizes the value of water flows in protecting fish and wildlife resources (State of Wyoming 2002c).

Habitat Fragmentation

Habitat fragmentation is made up of two primary components: (1) loss of a natural habitat type or types within a greater landscape; and (2) division of the remaining natural habitats into isolated patches (Wilcove et al. 1986). Several effects of fragmentation on biological resources include:

(1) Elimination of species that occurred in habitat patches that are lost. This effect can be substantial for species that occur in a narrow range or in a particular habitat that is limited in distribution (Noss and Csuti 1994);

(2) Isolation of remaining habitat patches by the formation of migration barriers. The extent of this effect is highly species-specific and is based on the mobility of the species, the type of barrier formed, and the reaction of each species to each type of barrier (Noss and Csuti 1994);

(3) Crowding of species into remaining patches, followed by declines in population. This decline occurs because the patches do not contain the resources necessary to support all of the species crowded into the patch (Lovejoy et al. 1986);

(4) Edge effects that render the edges of remaining patches less suitable for species that are sensitive to the biological and environmental effects of edges. Changes in the availabilityi of light, water, and wind typically occur along edges, as do increased rates of predation and nest parasitism on bird nests (Saunders et al. 1991);

(5) Changes in species composition resulting from increased access by highly mobile or invasive species. The disturbances that fragment habitats, such as road construction, provide opportunities for non-native species, especially invasive weeds, to invade and displace native species (Trombulak and Frissel 2000); and

(6) Synergistic effects that result in local or regional extinctions. Interactions including loss of habitats, barriers to migration, crowding, edge effects, and changes in species composition can combine to affect species that are particularly sensitive to several of these factors. Although one effect of fragmentation may not result in loss of a particular species, several effects combined can be enough to cause local or regional extinctions (Noss and Csuti 1994).

Native vegetation and wildlife habitats in the Project Area are largely intact. Most disturbances have been small or linear (such as highways and railroads) and have not resulted in substantial loss of native landscapes (see the figure on Land Use and Recreation Sites). The primary effects of this small degree of fragmentation have likely been an increase in edge effects related to disturbance from activities along roads and other linear features, and an increase in invasive species along these same features. No data exist on the degree of existing fragmentation or on the effects of this fragmentation on landscapes in the Project Area. The specific effects of existing fragmentation on individual habitats and species are discussed in the following resource sections where data are available.

Ecosystem Function

Within functioning ecosystems, a number of different processes operate that serve to maintain the structure of those ecosystems, keeping them relatively stable in a human time frame. These processes, which operate between the various components of an ecosystem, include: (1) the flow of energy; (2) the flow of nutrients; (3) the hydrologic cycle; (4) disturbance regimes; (5) equilibrium processes; and (6) feedback systems (Noss and Cooperrider 1994). Ecosystems have generally evolved with a certain level of disturbance and are, therefore, capable of recovering. When disturbance reaches a certain level, or the type of the disturbance is different than the regime present when the ecosystem evolved, these processes can be altered to the point that the ecosystem itself is changed (Pimm 1986).

Some ecosystem processes that function in the Project Area have not been substantially altered from natural conditions. For example, energy flow, nutrient flow, the hydrologic cycle, equilibrium processes, and feedback systems continue to operate as they have historically. Disturbance regimes, however, may have been substantially altered over the last century. Fire suppression can result in reduced frequency of fire and disrupt community and ecosystem processes. Changes in the type of grazing animals present (bison versus cattle and sheep) and the type of grazing system that have occurred can also alter species diversity and ecosystem processes. In addition, changes in the nature of soil disturbances and habitat fragmentation can affect ecosystem processes (Hobbs and Huenneke 1992). There are no specific data on the effects of these changes in disturbance regimes on ecosystem processes in the Project Area; however, it can be assumed that there has been some alteration of the native landscape as a result of changes in the native ecosystems during the last century or more.

Vegetation and Land Cover Types

WGFD land cover classifications mapping and Gap Analysis Project (GAP) resources were used to identify vegetation types within the Project Area. Fourteen vegetation types were identified within the Project Area: short-grass prairie, mixed-grass prairie, wet meadow, herbaceous riparian, sagebrush shrubland, other shrubland, shrubby riparian, coniferous forest, aspen, forested riparian, agriculture, urban/disturbed, barren, and water. These broad categories often represent several vegetation types that were similar in terms of dominant species and ecological importance.

The Project Area is characterized as a mosaic of vegetation types that includes prairie grasslands, shrublands, riparian areas, and forested areas. Figure 3–10 presents the mosaic of vegetation types. The distribution of vegetation types presented on Figure 3–10 was derived primarily from extremely detailed WGFD land cover classifications mapping data. Because this data set does not cover the entire Project Area (the southern portion of Converse County and a small portion of the Bighorn Mountains), GAP data were used to fill the remaining portions. The vegetation type polygons shown on Figure 3-10 provide the source for all the data that were generated and incorporated into the vegetation type distribution tables (Table 3-17 and Table 3-18) and existing disturbance by vegetation type tables (Table 3-19 and Table 3-20).

Table 3-17 Distribution of Vegetation Types by Surface Ownership

	Surface Owner (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	196	18	121	4,128	109,181	113,643
Aspen	0	0	0	2	69	71
Barren	18,119	2,974	2,424	8,903	83,104	115,524
Coniferous Forest	46,732	5,893	5,723	20,993	112,844	192,184
Forest Riparian	283	0	291	925	9,994	11,491
Herbaceous Riparian	26	416	617	2,297	8,982	12,337
Mixed-grass Prairie	89,933	25,976	28,690	154,418	1,249,493	1,548,511
Other Shrubland	52,141	1,645	262	16,535	107,298	177,880
Sagebrush Shrubland	186,588	27,189	83,148	169,594	1,767,584	2,234,103
Shortgrass Prairie	396,226	26,777	138,877	223,681	2,488,290	3,273,850
Shrubby Riparian	744	32	130	5,780	52,232	58,917
Urban/Disturbed	0	0	0	34	4,328	4,362
Water	241	29	98	489	8,332	9,189
Wet Meadow	884	0	628	17,153	140,272	158,937
Total	792,113	90,948	261,009	624,930	6,142,001	7,911,001

Table 3-18 Distribution of Vegetation Types by Sub-watershed

	Vegetation Type (acres)														
Sub-watershed	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herbaceous Riparian	Mixed-Grass Prairie	Other Shrubland	Sagebrush Shrubland	Shortgrass Prairie	Shrubby Riparian	Urban/Disturbed	Water	Wet Meadow	Total
Little Bighorn River	683	0	0	4,497	601	0	22,088	190	4,331	1,093	10,607	0	44	5,450	49,584
Upper Tongue River	59,054	12	4,121	15,268	3,172	67	303,681	538	119,743	124,204	32,931	0	1,106	75,985	739,883
Middle Fork Powder River	584	3	16,300	50,714	1,767	5	107,780	106,068	61,800	117,613	173	0	202	1,441	464,450
North Fork Powder River	0	0	0	3,060	1,628	0	8,583	643	4,788	109	0	0	0	1,864	20,674
Upper Powder River	5,958	0	25,154	6,715	0	0	108,273	13	424,945	1,020,637	582	0	1,385	9,857	1,603,520
South Fork Powder River	1	0	1,803	2,545	48	0	24,744	30,090	12,255	42,727	0	0	145	0	114,355
Salt Creek	0	0	186	3,562	0	0	3,892	779	42,588	101,205	0	0	148	0	152,360
Crazy Woman Creek	8,567	56	9,114	33,127	636	46	112,690	15,892	124,132	237,516	1,059	0	426	5,021	548,283
Clear Creek	27,184	0	4,754	11,510	1,033	41	170,380	1,799	128,218	156,872	9,347	0	3,607	32,732	547,476
Middle Powder River	1,143	0	3,265	10,636	0	0	72,552	0	47,363	81,888	547	0	0	6,835	224,230
Little Powder River	998	0	9,447	26,102	0	0	172,184	0	375,460	267,547	1,750	0	636	11,359	865,482
Little Missouri River	320	0	144	567	0	0	20,842	0	7,175	5,853	550	0	0	3,078	38,528
Antelope Creek	398	0	5,095	6,750	948	0	15,336	387	124,618	506,336	0	0	430	0	660,298
Dry Fork Cheyenne River	795	0	8,827	9,040	1,518	5,198	105,618	1,340	58,898	116,898	771	384	29	0	309,316
Upper Cheyenne River	108	0	2,771	4,477	141	114	6,147	0	87,729	104,629	169	0	419	99	206,803
Lightning Creek	7,085	0	2,093	0	0	4,263	95,124	20,143	166,207	11,710	0	1,698	0	0	308,321
Upper Belle Fourche River	764	0	18,302	3,355	0	0	85,962	0	353,206	377,016	432	0	612	5,215	844,863
Middle North Platte	0	0	4,147	260	0	2,604	112,635	0	90,647	0	0	2,280	0	0	212,573
Total	113,643	71	115,524	192,184	11,491	12,337	1,548,511	177,880	2,234,103	3,273,850	58,917	4,362	9,189	158,937	7,911,001

Table 3-19 Existing Vegetation Disturbance from Oil and Gas Development by Surface Owner

	Disturbance (acres)					
	BLM					
Vegetation Type	BFO	CFO	FS	State	Private	Total
Agriculture	0	0	0	9	139	148
Aspen	0	0	0	0	0	0
Barren	17	0	6	22	753	798
Coniferous Forest	34	0	7	3	46	91
Forest Riparian	0	0	2	0	2	5
Herbaceous Riparian	0	0	0	2	14	16
Mixed-grass Prairie	300	19	14	498	6,011	6,842
Other Shrublands	19	2	0	0	49	71
Sagebrush Shrublands	132	24	141	1,266	13,996	15,559
Shortgrass Prairie	626	35	445	1,522	14,957	17,585
Shrubby Riparian	0	0	0	6	31	37
Urban/Disturbed	0	0	0	0	0	0
Water	0	0	0	0	15	15
Wet Meadow	6	0	0	35	504	541
Total	1,130	80	616	3,363	36,519	41,708

Table 3-20 Existing Vegetation Disturbance from Oil and Gas Development by Sub-watershed

Sub-watershed	Vegetation Type (acres)														
	Agriculture	Aspen	Barren	Coniferous Forest	Forest Riparian	Herba-ceous Riparian	Mixed-grass Prairie	Other Shrublands	Sagebrush Shrublands	Shortgrass Prairie	Shrubby Riparian	Urban /Disturbed	Water	Wet Meadow	Total
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	49	0	24	0	0	0	198	0	173	291	18	0	2	74	830
Middle Fork Powder River	0	0	5	0	0	0	0	16	2	40	0	0	0	0	63
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	34	0	117	5	0	0	977	0	1,887	3,282	1	0	2	153	6,459
South Fork Powder River	0	0	0	26	0	0	2	21	12	0	0	0	0	0	61
Salt Creek	0	0	0	0	0	0	0	0	19	89	0	0	0	0	108
Crazy Woman Creek	0	0	0	0	0	0	12	0	47	145	0	0	0	0	204
Clear Creek	36	0	2	0	0	0	216	0	58	54	4	0	0	55	425
Middle Powder River	6	0	15	16	0	0	1,174	0	923	1,465	4	0	0	90	3,693
Little Powder River	14	0	209	29	0	0	2,289	0	3,920	2,492	3	0	3	117	9,076
Little Missouri River	0	0	0	0	0	0	26	0	0	5	2	0	0	2	35
Antelope Creek	6	0	9	7	5	0	50	0	635	2,206	0	0	0	0	2,914
Dry Fork Cheyenne River	0	0	12	0	0	7	82	0	96	63	0	0	0	0	261
Upper Cheyenne River	0	0	6	0	0	0	15	0	653	886	0	0	0	0	1,561
Lightning Creek	2	0	5	0	0	9	341	33	501	2	0	0	0	0	893
Upper Belle Fourche River	4	0	394	8	0	0	1,393	0	6,627	6,564	4	0	8	50	15,052
Middle North Platte River	0	0	0	0	0	0	68	0	5	0	0	0	0	0	73
Total	148	0	798	91	5	16	6,842	71	15,559	17,585	37	0	15	541	41,708

Figure 3-10 Distribution of Vegetation Types within the Project Area

Vegetation Types

The acres of occurrence and relative distribution of vegetation types within the Project Area are presented by surface owner and sub-watershed in Table 3-17 and Table 3-18. These major vegetation types are described in the following text.

Short-grass Prairie

The short-grass prairie vegetation type accounts for 3,273,850 pre-disturbance acres (41 percent) within the Project Area. This vegetation type represents very sparse, sparse, and thin dry herbaceous rangeland types, as defined by the WGFD. Short-grass prairie occurs on drought-prone, mildly alkaline, medium- and fine-textured soils. Few shrubs grow consistently in short-grass prairie because the soils are too dry and compacted to support them. Precipitation is an important determinant of the composition of plant species in grasslands. Average annual precipitation for short-grass prairie is between 10 and 16 inches (CNAP 1998). In Wyoming, short-grass prairie occurs primarily in the southeastern portion of the state and southward into Colorado. Within the Project Area, short-grass prairie habitats are most common in the south, occurring as the dominant plant community from the southern foothills of the Bighorn Mountains to the eastern Project Area boundary. The two dominant vegetation species are blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*). Other plant species common to the short-grass prairie include western wheatgrass (*Pascopyrum smithii*), sand dropseed (*Sporobolus cryptandrus*), needle-and-thread (*Hesperostipa comata*), scarlet globemallow (*Sphaeralcea coccinea*), and four-wing saltbush (*Atriplex canescens*).

Mixed-grass Prairie

The mixed-grass prairie vegetation type accounts for 1,548,511 pre-disturbance acres (20 percent) within the Project Area. This vegetation type is a combination of low, medium, and high herbaceous rangeland types, as defined by WGFD. Low, medium, and high refer to the chlorophyll content of the vegetation, as determined by remote sensing that was used to generate the vegetation type maps. The measure of chlorophyll content provides a rough approximation of the density of the vegetation. Mixed-grass prairie can be divided into several types and is characterized by several common species including needle-and-thread, western wheatgrass, blue grama, prickly pear cactus (*Opuntia* spp.), and scarlet globemallow. Wyoming big sagebrush (*Artemisia tridentata* var. *wyomingensis*) is a common shrub of this grass community in the Powder River Basin (Knight 1994). Within the Project Area, mixed-grass prairie habitats are most common along the eastern foothills of the Bighorn Mountains and sporadically occur throughout much of the northern and central portions of the Project Area.

Wet Meadow

The wet meadow vegetation type accounts for 158,937 pre-disturbance acres (2 percent) within the Project Area. This vegetation type is a combination of green and very green herbaceous rangeland types, as defined by WGFD. Wet meadow is a grassland community that typically occurs on fine-textured soils in valley bottoms where the water table is high enough to saturate the soil during a portion of the growing season. In addition, this community commonly occurs where springs emerge, along reservoirs, and in irrigated pastures (Knight 1994). Depending on salinity and water table, common species include Baltic rush (*Juncus balticus*), Nebraska sedge (*Carex nebrascensis*), prairie cordgrass (*Spartina pectinata*), and redtop bentgrass (*Agrostis stolonifera*). Species composition in the proximity of human activity, such as reservoirs and irrigated pasture, tends to exhibit dominance by introduced species such as Kentucky bluegrass (*Poa pratensis*), timothy (*Phleum pratense*) and smooth brome (*Bromus inermis*). Within the Project Area, wet meadow habitats are widely distributed and often insular in their occurrence. Wet meadows are more common in the northern and western than in the southern and eastern portions of the Project Area. Wet meadows tend to exist as island habitats surrounded by dominant plant communities such as grasslands or shrublands.

Herbaceous Riparian

The herbaceous riparian vegetation type accounts for 12,337 pre-disturbance acres (less than 1 percent) within the Project Area. This vegetation type consists of a variety of riparian moist grasses, sedges, and rushes, as defined by WGFD. The herbaceous riparian vegetation type occurs near drainages including rivers, streams, and creeks. This vegetation type includes plant species common to the wet meadow community and may include woolly sedge (*Carex lanuginosa*), common spike-rush (*Eleocharis palustris*), foxtail barley (*Hordeum jubatum*), wild licorice (*Glycyrrhiza lepidota*), and Canada goldenrod (*Solidago canadensis*). Very similar to the wet meadow community, this vegetation cover type often occurs in similar environments. Herbaceous riparian communities occur throughout the Project Area with most occurrences associated with streams, rivers, and other aquatic habitats.

Sagebrush Shrubland

The sagebrush shrubland vegetation type accounts for 2,234,103 pre-disturbance acres (28 percent) within the Project Area. This vegetation type includes a combination of sparse, moderately dense, and dense big sagebrush crown closure with a variety of understory grasses and forbs. The sagebrush shrubland is widely distributed and occupies a large proportion of the Project Area. Plant species that typically occur in this community may include Wyoming big sagebrush, silver sagebrush (*Artemisia cana*), western wheatgrass, junegrass (*Koeleria macrantha*), needle-and-thread grass, Sandberg bluegrass (*Poa secunda*), prickly pear cactus, scarlet globemallow, and rabbitbrush (*Chrysothamnus* spp.). Sagebrush shrublands occur throughout the entire Project Area, with the Bighorn Mountains and associated foothills as the only exceptions. Larger, more contiguous tracts of sagebrush occur in the northeastern, central, and eastern portions of the Project Area.

Other Shrubland

The other shrubland vegetation type accounts for 177,880 pre-disturbance acres (2 percent) within the Project Area. This vegetation type is composed of three distinct shrub-dominated vegetation communities: mountain-mahogany shrubland, mixed foothill shrubland, and greasewood shrubland. The mountain-mahogany shrubland community is the largest component of the other shrubland vegetation type and has two species-dominated sub-classes. The first community occurs primarily in the foothills of the Bighorn Mountains in southwestern Johnson County and is dominated by curl-leaf mountain mahogany (*Cercocarpus ledifolius*). The second community, occurring in the southern portion of the Project Area, is dominated by true mountain mahogany (*Cercocarpus montanus*). The two mountain-mahogany shrubland communities occur on poorly developed soils derived from sandstone, limestone, and shale (Knight 1994). Plant species found in the undergrowth of this community include fringed sage (*Artemisia frigida*), sulfurflower buckwheat (*Eriogonum umbellatum*), bluebunch wheatgrass (*Elymus spicatum*), and junegrass.

The other two components of the other shrubland vegetation type are intermingled among the distribution of the mountain-mahogany communities. The mixed foothill shrubland is dominated by mountain big sagebrush (*Artemisia tridentata* var. *vaseyana*) interspersed with antelope bitterbrush (*Purshia tridentata*), serviceberry (*Amelanchier alnifolia*), skunkbush sumac (*Rhus trilobata*), common chokecherry (*Prunus virginiana*), and snowberry (*Symphoricarpos* spp.). Common forbs and grasses found in the mixed foothill shrubland may include lupine (*Lupinus* spp.), arrowleaf balsamroot (*Balsamorhiza sagittata*), hairy goldenaster (*Heterotheca villosa*), basin wildrye (*Elymus cinereus*), and junegrass. Greasewood shrubland, dominated by greasewood (*Sarcobatus vermiculatus*), exhibits limited distribution on saline soils near seeps or perched water tables.

Shrubby Riparian

The shrubby riparian vegetation type accounts for 58,917 pre-disturbance acres (less than 1 percent) within the Project Area. This vegetation category includes a variety of shrubs and herbaceous plants that exist adjacent to draws, gullies, and streams. Within the Project Area, plant species in this community may include hawthorn (*Crataegus* spp.), chokecherry, peachleaf willow (*Salix amygdaloides*), sandbar willow (*Salix exigua*), other willow species (*Salix* spp.), silver sagebrush, bluejoint reedgrass (*Calamagrostis canadensis*), and tufted hairgrass (*Deschampsia cespitosa*). This vegetation type occurs in small, scattered locations throughout the Project Area.

Coniferous Forest

The coniferous forest vegetation type accounts for 192,184 pre-disturbance acres (2 percent) within the Project Area. This vegetation type includes Engelmann spruce (*Picea engelmannii*), Douglas fir (*Pseudotsuga menziesii*), lodgepole pine (*Pinus contorta* var. *latifolia*), ponderosa pine (*Pinus ponderosa*), limber pine (*Pinus flexilis*), and juniper (*Juniperus* spp.), as defined by WGFD. These species tend to form associations based on elevation, exposure, and soil moisture. Typically, these species are segregated according to elevation. Juniper and pine forests tend to be lower in elevation, while spruce and fir forests occur at higher elevations. This vegetation type occurs primarily along the western edge of the Project Area, where the upper-elevation conifer species are more common and in the northeastern corner where the lower elevation species are more common.

Aspen

The aspen vegetation type accounts for 71 pre-disturbance acres (less than 1 percent) within the Project Area. Aspen communities typically occur in depressions, ravines, valley bottoms, or on the lee sides of wedges. Aspen seedlings are intolerant of drier conditions, and therefore this community distribution is typically dictated by the availability of soil moisture. The understory of the aspen vegetation type has greater productivity and species diversity than any other forested upland vegetation type within the Project Area (Mueggler 1985). Quaking aspen (*Populus tremuloides*) is the dominant species in the aspen vegetation type. Common plant species in aspen stands include common snowberry (*Symphoricarpos albus*), serviceberry, Woods' rose (*Rosa woodsii*), western yarrow (*Achillea millefolium* var. *lanulosa*), wild geranium (*Geranium* spp.), mountain brome (*Bromus marginatus*) and elk sedge (*Carex geyeri*). Many stands of aspen are a seral community that would have conifers of various ages growing within them. This vegetation type is limited to the Bighorn Mountains in the Project Area.

Forested Riparian

The forested riparian vegetation type accounts for 11,491 pre-disturbance acres (less than 1 percent) within the Project Area. Areas covered by forested riparian are more common along some drainages today than in pre-settlement times because of the reduced frequency of tree-damaging floods that has resulted from reservoir construction, and lateral drainage from irrigated uplands (Knight 1994). Forested riparian areas may be shrinking in other locations, particularly where cottonwoods are dominant, because of low cottonwood regeneration rates. This vegetation type is characterized by a variety of deciduous and coniferous tree species that occur along riparian areas, as defined by WGFD. Coniferous forested riparian areas are rare, occurring only in the Foothills of the Bighorn Mountains on the west edge of the Project Area. Decidious forested riparian areas are much more common and occur throughout the Project Area. Some common species include plains cottonwood (*Populus deltoides*), narrow-leaf cottonwood (*Populus angustifolia*), quaking aspen, boxelder (*Acer negundo*), green ash (*Fraxinus pennsylvanica*), Russian olive (*Elaeagnus angustifolia*), and willow (*Salix* spp). This vegetation type occurs along the major drainages throughout the Project Area.

Agriculture

The agricultural vegetation type accounts for 113,643 pre-disturbance acres (1 percent) with the Project Area. This land cover type is defined as croplands that are plowed or planted. These areas may also include wooded or shrubby draws and riparian areas. Agricultural areas are most common along the eastern edge of the Bighorn Mountains, along the major drainages, and near Wright and Gillette.

Urban/Disturbed

The urban/disturbed vegetation type accounts for 4,362 pre-disturbance acres (less than 1 percent) within the Project Area. This cover type includes lands covered by homes, businesses, streets, and a portion of the unvegetated surface mining areas present within the Powder River Basin. It is most common around cities and towns and along the eastern edge of the Project Area where many coal mines are located. A detailed description of the areas disturbed by surface mining is included in the section on existing disturbance below.

Barren

The barren vegetation type accounts for 115,524 pre-disturbance acres (1 percent) within the Project Area. This cover type includes rock outcrops, roads, sandbars, eroded gullies, and areas with less than 10 percent ground cover and perennial snow and ice areas, as defined by WGFD. It occurs as small, scattered areas throughout the Project Area, and as several large blocks in the southwest portion.

Water

The water cover type accounts for 9,189 pre-disturbance acres (less than 1 percent) within the Project Area. This land cover type includes lakes, ponds, streams, and open water in wetlands, as defined by WGFD, and is scattered throughout the Project Area.

Noxious Weeds

Once they have become established, non-native plant species can outcompete and eventually replace native species, thereby reducing forage productivity and the overall vigor of existing native plant communities. As a consequence of these effects, many non-native species are viewed as detrimental to the environment, and as such are regulated. A designated noxious weed is defined by the Wyoming Statutes (Title 11, Chapter 5, Section 102.a.xi) as the weeds, seeds or other plant parts that are considered detrimental, destructive, injurious or poisonous, either by virtue of their direct effect or as carriers of diseases or parasites that exist within this state, and are on the designated list. The State of Wyoming has designated 23 plant species as noxious weeds. These species are listed in Table 3-21.

Wyoming is experiencing rapid introduction and spread of noxious weeds on all lands throughout the state, regardless of surface ownership. The potential for noxious weeds to continue spreading to new areas is great. As a collaborative effort, the BLM, South Goshen Cooperative Extension Conservation District, Wyoming Department of Agriculture, Natural Resources Conservation Service, and 42 private surface owners joined WGFD and Weed and Pest (W&P) District officials in the fight against noxious weeds. This group agreed to a long-term integrated weed management plan, public awareness and prevention programs, and a common inventory, while monitoring and reporting on their progress.

Table 3-21 State of Wyoming Designated Noxious Weeds

Common Name	Scientific Name
Skeletonleaf bursage	*Ambrosia tomentosa*
Common burdock	*Arctium minus*
Hoary cress	*Cardaria draba*
Hairy whitetop	*Cardaria pubescens*
Plumeless thistle	*Carduus acanthoides*
Musk thistle	*Carduus nutans*
Diffuse knapweed	*Centaurea diffusa*
Spotted knapweed	*Centaurea maculosa*
Russian knapweed	*Centaurea repens*
Canada thistle	*Cirsium arvense*
Field bindweed	*Convolvulus arvensis*
Houndstongue	*Cynoglossum officinale*
Quackgrass	*Elytrigia repens*
Leafy Spurge	*Euphorbia esula*
Dyer's woad	*Isatis tinctoria*
Perennial pepperweed	*Lepidium latifolium*
Ox-eye daisy	*Leucanthemum vulgare*
Dalmation toadflax	*Linaria dalmatica*
Yellow toadflax	*Linaria vulgaris*
Purple loosestrife	*Lythrum salicaria*
Scotch thistle	*Onopordum acanthium*
Perennial sowthistle	*Sonchus arvensis*
Saltcedar	*Tamarix chinensis*

Noxious weeds occur throughout the Project Area. Their occurrence, distribution, and density are variable and are influenced by many factors, including disturbance type and frequency, climatic conditions, soil conditions, and local management efforts. Noxious weed lists are maintained by the Wyoming Department of Agriculture and by county weed and pest districts. Scientific data that indicates precise areas of occurrence of individual noxious weeds or species of concern are scarce, however. County specific information obtained from the University of Wyoming Cooperative Agricultural Pest Survey (CAPS) detailing the estimated acres of infestation for 18 of the state-designated noxious weeds is listed in Table 3-22. Information for black henbane (*Hyoscyamus niger*), foxtail barley, rush skeletonweed (*Chondrilla juncea*), and jointed goatgrass (*Aegilops cylindrical*) is included in Table 3-22.

Table 3-22 Known Occurrences of Other Weed Species of Concern

Plant Species of Concern	Campbell	Converse	Johnson	Sheridan
Broom snakeweed	Yes	Yes	Yes	Yes
Buffalobur	Yes	Yes	Yes	Yes
Bull thistle	No	Yes	Yes	Yes
Cheatgrass	Yes	Yes	Yes	Yes
Common cocklebur	Yes	Yes	Yes	Yes
Common lambsquarters	Yes	Yes	Yes	Yes
Common mullein	Yes	Yes	Yes	Yes
Common sunflower	Yes	Yes	Yes	Yes
Curlycup gumweed	Yes	Yes	Yes	Yes
Dyer's woad	No	No	No	No
Halogeton	No	No	No	No
Kochia	Yes	Yes	Yes	Yes
Milkweed	Yes	Yes	No	No
Ox-eye daisy	No	No	Yes	Yes
Perennial sowthistle	Yes	Yes	No	No
Pigweed	Yes	Yes	Yes	Yes
Plains larkspur	Yes	Yes	No	No
Platte thistle	No	Yes	Yes	No
Plumeless thistle	No	Yes	Yes	No
Pricklypear cactus	Yes	Yes	Yes	Yes
Puncturevine	No	Yes	No	No
Ragweed	Yes	Yes	Yes	Yes
Russian thistle	Yes	Yes	Yes	No
Sandbur	Yes	Yes	N/A	N/A
Sulfur cinquefoil	Yes	No	No	Yes
Sumpweed	N/A	Yes	Yes	Yes
Tarweed	N/A	Yes	N/A	N/A
Wild licorice	Yes	Yes	Yes	Yes
Wild oat	Yes	Yes	Yes	Yes
Yellow bedstraw	No	Yes	No	No

Sources: Dorn 1992, CAPS 1999, Griswold 2002, Lewis 2002, Litzel 2002
N/A = Not available

In addition to the state designated list of noxious weeds, Campbell, Converse, Johnson, and Sheridan Counties declared weeds of concern in the year 2000 under the authority of the Wyoming Weed and Pest Control Act. Noxious weeds tracked by individual counties include: Campbell: common cocklebur (*Xanthium strumarium*) and wild licorice (*Glycyrrhiza lepidota*); Converse: chicory (*Cichorium intybus*) and Dames rocket (*Hesperis matronalis*); Johnson: common mullein (*Verbascum thapsus*), common cocklebur, and wild licorice; and Sheridan: no vegetation species.

The distribution and spread of many plant species of concern are currently being monitored by CAPS in association with county weed and pest districts and the Wyoming Department of Agriculture. Some additional species being monitored that occur within the Project Area include broom snakeweed (*Gutierrezia sarothrae*), buffalobur (*Solanum rostratum*), bull thistle (*Cirsium vulgare*), cheatgrass (*Bromus tectorum*), common lambsquarters (*Chenopodium album*), common sunflower (*Helianthus annuus*), curlycup gumweed (*Grindelia squarrosa*), halogeton (*Halogeton glomeratus*), kochia (*Kochia scoparia*), milkweed (*Asclepias* spp.), pigweed (*Amaranthus* spp.), plains larkspur (*Delphinium geyeri*), platte thistle (*Cirsium canescens*), pricklypear cactus (*Opuntia polyacantha*), puncturevine (*Tribulus terrestris*), ragweed (*Ambrosia* spp.) Russian thistle (*Salsola australis*), sandbur (*Cenchrus longispinus*), sulfur cinquefoil (*Potentilla recta*), sumpweed (*Iva xanthifolia*), tarweed (*Madia glomerata*), wild oat (*Avena fatua*), and yellow bedstraw (*Galium verum*).

Table 3-23 lists the known presence or absence per county of the plant species of concern monitored by the CAPS program and individual weed and pest control districts. Included in Table 3-23 are state-designated noxious weeds where no estimates of the acres of infestation were available.

Existing Disturbance

Because of past and current human activities in the Project Area, substantial areas of vegetation have been altered from their natural condition. The primary sources of surface disturbance to vegetation types have resulted from: oil and gas development; coal mining; uranium mining; sand, gravel, and scoria mining; ranching; agriculture; road and railroad construction; and rural and urban housing and business development. Some of these alterations are included in the previous discussion of vegetation types, particularly in the agriculture, urban/disturbed, and barren land cover types. Estimates of existing disturbance acreage in each vegetation type by surface owner and sub-watershed are presented in Table 3-19 and Table 3-20. These estimates of existing disturbances are based on the sum of existing CBM and non-CBM well disturbances, including secondary roads, oil and gas well pads, compressor sites, and other ancillary facilities, within the Project Area.

The combination of WGFD land cover mapping and GAP data used to generate the vegetation figure and its derived tables inadequately quantify the existing disturbance caused by coal mining within the Powder River Basin. According to information obtained from the WDEQ Land Quality Division, 97,546 acres of land are currently disturbed within the permitted boundaries of active coal mines within the Project Area. Recently disturbed land on actively permitted coal mines that has been reclaimed totals 18,104 acres. Reclaimed land is defined by WDEQ as affected land which has been backfilled, graded, topsoil reapplied, and permanently seeded according to approved practices specified in the reclamation plan (Christensen 2002).

Table 3-23 Occurrence of Noxious Weeds in Campbell, Converse, Johnson, and Sheridan Counties, Wyoming

	Areal Extent of Infestation						
Noxious Weed	<10 acres	11 to 100 acres	101 to 1,000 acres	1,001 to 5,000 acres	5,001 to 10,000 acres	>10,000 acres	Known to occur
Black henbane	Co	Ca					
Canada thistle					S	Ca, Co, J	
Common burdock		Ca	Co	J, S			
Dalmation toadflax	J, S	Co	Ca				
Diffuse knapweed		Co	Ca, J				
Field bindweed			Co	Ca, J			S
Foxtail barley				C			Ca, J
Hoary cress			Ca, Co, S	J			
Houndstongue		Ca		S	Co, J		
Jointed goatgrass			Ca,				
Leafy spurge		Co		Ca		J, S	
Musk thistle		Ca, S		J		Co	
Perennial pepperweed	Ca	Co					
Purple loosestrife	S						
Quackgrass			Co, S				Ca, J
Rush skeletonweed	Ca			J			
Russian knapweed			S	Ca, J	Co		
Saltcedar	Co	Ca	s				J
Scotch thistle	S	Ca, Co			J		
Skeletonleaf bursage				Ca			Co, J
Spotted knapweed		Co	Ca, J, S				
Yellow toadflax	Co, J, S						

Note:
1. Ca = Campbell County, Co = Converse County, J = Johnson County, S = Sheridan County.
Source: CAPS 1999, Griswold 2002, Lewis 2002, Litzel 2002

Uranium mining has resulted in the disturbance of 4,400 acres, and sand, gravel, and scoria mining have resulted in the disturbance of 1,200 acres. Urban development has resulted in the loss of 4,362 acres of native vegetation. Agriculture has resulted in impacts to 113,643 acres of land formerly occupied by native vegetation. The figures on vegetation and land use figure depict differing distribution of agricultural land within the Project Area. The extent of agricultural land on these two figures varies because of the different sources used to derive the data. The figure on vegetation was derived from WGFD land cover and GAP data. The source for the figure on land use was BLM land-use mapping data.

Other human disturbances to native vegetation are typically smaller in scale and are difficult to quantify in terms of affected acres. One such form of disturbance is damage to vegetation caused by fugitive dust that settles on plants primarily along the periphery of gravel roads. The source of fugitive dust is usually passing vehicles, but may also result from gusty winds blowing across previously disturbed areas such as road corridors or over-grazed land. Fire suppression is another human-induced alteration of native vegetation. By suppressing wildland fires, humans have caused shifts in the vegetation types that are present in the Project Area. Grazing presents another form of widespread disturbance within the Project Area, although no solid quantification of impacts to native vegetation can be ascertained. Finally, quantification of the impacts of species such as grasshoppers, Mormon crickets, and prairie dogs presents similar difficulties. Disturbance to native vegetation that results from the above factors is not included in the analysis of the Project Area vegetation types.

Wetlands/Riparian Areas

Regional Characterization

Wetlands and riparian areas are highly important water-related features in the arid landscape of northeastern Wyoming. Wetlands and riparian areas occur throughout the Project Area in all 18 watersheds and are typically restricted to the lands immediately surrounding major and minor rivers, streams, creeks, draws, topographical depressions, lakes, and ponds. Many plant and wildlife species are found in no other habitat types (for example, certain plant and bird species, amphibians and turtles), while other wildlife species such as shorebirds, waterfowl, and weasels frequent these habitat types. These small, but important, ecosystems serve as biological oases and represent a vegetation structure, soil, and hydrology that is unique relative to the vast expanses of sagebrush and prairie grass that dominate the landscape of the region. Additional information about the hydrology of the Project Area is provided in the section on Surface Water. Additional information about the aquatic life of the water bodies of the Project Area is discussed in the section on Wildlife.

Definitions

Riparian Areas

Riparian areas are ecosystems whose soils and soil moisture are influenced by the adjacent river, stream, or creek and are unique because of their linear form. Riparian areas are often called riparian corridors or riparian zones because of the linear form that is related to the dependency of the ecosystem's structure and functions on nearby water. One definition of riparian ecosystems (Johnson and McCormick 1979) is the following:

> Riparian ecosystems are ecosystems with a high water table because of proximity to an aquatic ecosystem or subsurface water. Riparian ecosystems usually occur as an ecotone between aquatic and upland ecosystems but have distinct vegetation and soil characteristics. Aridity, topographic relief, and pres-

ence of depositional soils most strongly influence the extent of high water tables and associated riparian ecosystems. Riparian ecosystems are uniquely characterized by the combination of high species diversity, high species densities, and high productivity. Continuous interactions occur between riparian, aquatic, and upland terrestrial ecosystems through exchanges of energy, nutrients, and species.

Wetlands

Similar to riparian ecosystems, hydrology determines the structure and functions of wetlands. Wetlands are, like riparian ecosystems, transitions between terrestrial and aquatic ecosystems and contain elements and life forms of both ecosystems. Several important features that include soil and water conditions and vegetation type distinguish wetlands from all other ecosystems. The scientific definition of a wetland that was developed and is used by the USFWS (Cowardin et al. 1979) is as follows:

> Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. Wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

Types, Distribution, and Extent

Four types of riparian ecosystems, including wetlands, have been identified in the Project Area, including forested riparian, shrubby riparian, herbaceous riparian, and wet meadow. Detailed descriptions of these types are included in the sectons on vegetation and land cover types. The extent and distribution of these four types is shown in Figure 3-10. Table 3-18 describes the extent of riparian areas and wetlands. Approximately 88 percent of the riparian areas and wetlands within the Project Area are located on private lands. The proportion of riparian areas in the Project Area that are located on public lands managed by the BLM is 2.5 percent for forested riparian, 1.3 percent for shrubby riparian, 3.6 percent for herbaceous riparian, and 0.5 percent for wet meadow.

Many of the riparian areas in the Project Area are too small to be plotted on a map of this size, including the riparian corridors of nearly all of the major rivers and streams. Three percent of the Project Area is made up of riparian and wetland areas. Almost 50 percent (112,156 acres) of the 250,000 acres of riparian areas and wetlands in the Project Area is contained in the Upper Tongue River sub-watershed. The dominant type of riparian area and wetland is the wet meadow that constitutes about 67 percent (about 160,000 acres) of all riparian areas and wetlands within the Project Area. The sub-watershed with the greatest proportion of riparian areas and wetlands, about 34 percent, is the Little Bighorn River. The Upper Tongue River sub-watershed has the greatest extent (3,172 acres) of the forested riparian ecosystem, but the North Fork Powder River sub-watershed has the highest proportion, almost 8 percent, of this type. The Upper Tongue River sub-watershed has the greatest extent (32,931 acres) of the shrubby riparian ecosystem, but the Little Bighorn River sub-watershed has the highest proportion, about 21 percent, of this type. The Dry Fork Cheyenne River sub-watershed has the greatest extent (5,198 acres) of the herbaceous riparian ecosystem and the highest proportion, almost 2 percent, of this type. The Upper Tongue River sub-watershed has the greatest extent (75,985 acres) and second-highest proportion (about 10 percent) of the wet meadow wetland type, but the Little Bighorn River sub-watershed has the highest proportion, almost 11 percent, of this type.

Ecosystem Functions

Riparian and wetland ecosystems have various functions that at the landscape scale, including: (1) flood storage and flood-peak desynchronization; (2) recharge to the groundwater aquifer; (3) flood-flow attenuation; (4) purification of water via removal of nutrients and toxic compounds, and (5) recreation (Carter 1986, Zinn and Copeland 2001). These functions apply to all riparian zones of the sub-watersheds within the Project Area. Evaporation rates in much of Wyoming, including the Project Area, greatly exceed precipitation rates, and the gentle slopes or relatively flat valleys of many of the 18 sub-watersheds contribute to generally low-flow, highly sinuous rivers and streams spaced widely apart that have very narrow and limited riparian corridors.

The ecological community-scale functions of riparian ecosystems include: (1) the presence of surface water and abundant soil moisture that attract or facilitate plant and animal occurrence; (2) high productivity within various food chains; (3) disproportionate species richness and abundance relative to surrounding areas; (4) diversity and interspersion of habitat features that create more niches for plants and animals; and (5) corridors for animal dispersion and migration (Brinson et al. 1981). The functions of riparian and wetland ecosystems at the ecological community scale ultimately depend on the hydrology of the watershed. The rates of sedimentation and nutrient deposition, as well as the energy of water flow and local soils types, affect the vegetation community that establishes itself and thrives in the riparian zone. Other factors that influence the riparian vegetation include elevation and moisture gradients, floodplain width, and shallow groundwater depth. These components influence the wildlife communities that are attracted to, and use, the riparian zone.

Hunters, anglers, bird watchers, and biologists have long recognized the value of riparian ecosystems to fish and wildlife. Riparian ecosystems are particularly valuable in a dry environment such as Wyoming. It has been estimated that, although only 1 percent or less of the region is classified as riparian land, about 80 percent of the native animals depend on riparian zones for food, water, shelter, and migration routes during some time of the year (Olson and Gerhart 1982). Riparian ecosystems are known for high animal species richness relative to other ecosystem types. Individual stands of riparian woodland average 20 to 34 species of breeding birds, and population densities of breeding birds in riparian areas average 1.5 to almost 6 pairs per acre. Riparian woodlands may also contain, on average, five to 30 species of mammals with a comparable species richness for amphibians and reptiles (Brinson et al. 1981). The modeling of the Gap Analysis Program predicts 201 to 319 species of terrestrial vertebrates in wetlands and riparian areas that are contained in the Project Area (University of Wyoming 2002).

Existing Impacts

Alteration of hydrologic conditions can affect the physical and chemical properties in a wetland, such as pH, soil salinity, sediment properties, oxygen content, and nutrient availability. These wetland properties affect the biota in terms of establishment, recruitment, maintenance, and spatial arrangement. Small changes in the hydrologic conditions can result in massive responses by wetland biota in terms of species composition, species richness, and ecosystem productivity (Mitsch and Gosselink 1993). Peak flows, periodic flooding, and related stream channel processes, such as meandering, are closely related to the reproduction and growth of riparian plant species (Busch and Scott 1995). The maintenance of cottonwood and willow populations in riparian ecosystems depends on ground availability of water that, in turn, depends on instream flows (Busch et al. 1992). Changes to the interrelationships among surface water dynamics, groundwater level, and river channel processes can lead to changes in the establishment and maintenance of dependent riparian plant communities (Busch and Scott 1995).

The primary existing impacts to the riparian ecosystems of the Project Area, livestock grazing and agricultural water withdrawals, are similar to riparian ecosystems throughout the West. Riparian vegetation and the availability of water in an otherwise dry landscape tend to attract livestock. Livestock spend more time grazing in riparian ecosystems than in adjacent uplands. Grazing along primarily low-order streams can cause increased erosion and sedimentation, decreased water quality via introduction of pathogens and excess nutrients, and channel downcutting (Brinson et al. 1981; Kauffman and Kreuger 1984). Grazing removes plants through consumption and trampling, particularly young plants, and the age structure and reproduction of the plant population are harmed. Species composition of the riparian ecosystem may also be altered (Brinson et al. 1981). As a result of these impacts, the functions of the riparian and wetland ecosystems may be diminished or disappear altogether. The indirect effects that would follow include increased flows, diminished flood storage capacity, increased frequency of flooding, increased uplands erosion and sedimentation, decreased water quality, increased water temperature, and decreased aquatic biota species diversity. Details about the current condition of riparian ecosystems on specific rivers within the Project Area are not available.

Agricultural uses have, in many cases, diminished the minimum instream flows necessary to sustain aquatic life and the riparian ecosystem for numerous streams and rivers in the arid Rocky Mountain states (Mitsch and Gosselink 1993). Water withdrawal reduces the availability of water for the maintenance of riparian ecosystems and, in extreme cases, can alter the composition of the plant community to include more upland species or eliminate the riparian or wetland ecosystem. Water diversions and withdrawals can also upset the salt balance by minimizing the flood frequency that usually leaches soil salts within the floodplain (Brinson et al. 1981). Additionally, return flows from irrigated fields in the arid West often contain high levels of inorganic salts, selenium, and other metals that may negatively affect water quality in the rivers or streams. Downstream users, such as livestock, populations in towns, and aquatic life, may be adversely affected by excessive amounts of salts and metals that are being introduced by the return flows from irrigated fields. Details about the existing water quality parameters (for example, concentrations of metals such as selenium, sodium adsorption ratio, salinity, and total dissolved solids) are discussed in the section on surface water. Ninety-eight percent of the surface water withdrawals from the rivers and streams in the Project Area are for irrigation. About one-third of the surface water withdrawals in the Project Area occur in the Upper Tongue River sub-watershed. The other major surface water withdrawals occur in the North Fork Powder River (17 percent) and Clear Creek (13 percent) sub-watersheds. Recent data on surface water withdrawal for the Upper Tongue River sub-watershed indicate that nearly twice the mean flow and about 50 percent of the maximum flow was withdrawn for irrigation. Consequently, little, if any, water flows that year and similar years were reaching riparian areas and wetlands that had historically received normal water flows. Many riparian ecosystems and wetlands in the Upper Tongue River sub-watershed, and others with such major water withdrawals, may have been eliminated or substantially degraded in recent years.

The extraction of oil and gas resources, primarily coal bed methane, has created impacts to vegetation and wildlife via construction and operation of roads, well pads, and compressor station. Wet meadows have been disproportionately disturbed, by one to two orders of magnitude, relative to the three riparian ecosystem types in the Project Area (Table 3-19). Most of the existing disturbance of wetlands and riparian areas caused by oil and gas extraction has occurred in the Upper Powder River sub-watershed, with the wetlands and riparian areas of the Little Powder River sub-watershed being disturbed to a slightly lesser degree (Table 3-20). Very little of the forested riparian and herbaceous riparian ecosystem types have been disturbed by oil and gas extraction in the Project Area to date (Table 3-20).

Water that is produced by the extraction of coal bed methane is currently being gathered from individual wells and discharged at the surface. In 2000, almost 4,000 permitted outfalls were discharging water at the surface within the Project Area (WDEQ 2001). Nearly all (94 percent) of these discharges were related to coal bed methane wells. About 50 percent of the permitted outfalls are within the Upper Belle Fourche River sub-watershed, while 21 percent are in the Upper Powder River sub-watershed and 14 percent are in the Little Powder River sub-watershed. Tables 3-6 and 3-10 contain details on the volume and locations of current CBM produced water discharge. It is not known how much of the produced water reaches the streams and wetlands of the sub-watersheds of the Project Area. Some stream segments, including ephemeral and often dry segments, received produced water continuously over the course of the year 2000. It can be supposed that existing riparian areas that received continuous inputs of produced water were adversely affected through abnormal inundation, overly saturated soils, increased flow velocity and subsequent erosion, impediment of seedling recruitment, and other factors. Parameters of water quality for the produced water from existing coal bed methane wells are also likely to cause adverse effects to riparian ecosystems and wetlands. A sodium absorption ratio of 47 was computed from the data contained in Table 3-1. Sodium absorption ratios of only 13 or more can cause irreversible changes to soil structure that cause reduced percolation of rainfall and surface water flows, restrict root growth, limit permeability of gases and moisture, and cause difficult tillage (Seelig 2000; U.S. Salinity Laboratory Staff 1954). Such effects from the releases of produced water during recent years may have caused increased erosion of uplands leading to greater sedimentation in riparian areas and wetlands, as well as a reduction in plant seedling recruitment and vigor of established plant communities.

Wildlife

Regional Characterization

Terrestrial wildlife species occur in a variety of habitats throughout the Project Area. The groups of wildlife species identified as specific issues during project development include: big game, raptors, upland game birds, waterfowl, and neotropical migrant birds. Aquatic resources in the Project Area occur within major drainage systems, such as rivers, streams, minor creeks, draws, and playa lakes, and ponds. The following sections present information on the major wildlife groups common to terrestrial and aquatic environments in the Project Area.

Terrestrial Species

Wildlife Habitats

All of the vegetation types listed in the section on vegetation provide habitat for some wildlife species. In an undisturbed condition, the major vegetation types in the Project Area provide high-quality habitats for many wildlife species. Because these habitats tend to occur in a mosaic across the landscape, many wildlife species use more than one habitat. The following paragraphs list some of the wildlife species that can be found in the common vegetation types in the Project Area, although these species may also be found in other habitat types if the necessary habitat components are available.

Common wildlife species that typically occur in short-grass and mixed-grass prairie habitats include prairie rattlesnake (*Crotalus viridis*), golden eagle (*Aquila chrysaetos*), prairie falcon (*Falco mexicanus*), ferruginous hawk (*Buteo regalis*), Swainson's hawk (*Buteo swainsoni*), sharp-tailed grouse (*Tympanchus phasianellus*), lark bunting (*Calamospiza melanocorys*), horned lark (*Eremophila alpestris*), western meadowlark (*Sturnella neglecta*), lark sparrow (*Chondestes grammacus*), vesper sparrow (*Pooecetes gramineus*), chestnut collared longspur (*Calcarius ornatus*), McCown's longspur (*Calcarius mccownii*), badger (*Taxidea taxus*), coyote (*Canis latrans*), swift fox (*Vulpes velox*), thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*), black-tailed jackrabbit (*Lepus californicus*), Ord's kangaroo rat (*Dipodomys ordii*), deer mouse (*Peromyscus maniculatus*), western harvest mouse (*Reithrodontomys megalotis*), plains pocket gopher

(*Geomys bursarius*), black-tailed prairie dog (*Cynomys ludovicianus*), and pronghorn *(Antilocapra americana*).

Common wildlife species that may occur in sagebrush shrublands include: eastern short-horned lizard *(Phrynosoma douglasii brevirostre*), prairie rattlesnake, northern harrier (*Circus cyaneus*), Swainson's hawk, sage grouse (*Centrocercus urophasianus*), Say's phoebe (*Sayornis saya*), western kingbird (*Tyrannus verticalis*), horned lark, sage thrasher (*Oreoscoptes montanus*), Brewer's sparrow (*Spizella breweri*), vesper sparrow, sage sparrow *(Amphispiza belli*), western meadowlark, desert cottontail (*Sylvilagus auduboni*), black-tailed jackrabbit, thirteen-lined ground squirrel, northern pocket gopher (*Thomomys talpoides*), Ord's kangaroo rat, deer mouse, and prairie vole (*Microtus ochrogaster*), pronghorn, mule deer (*Odocoileus hemionus*).

Common wildlife species that may occur in other shrublands are similar to those that inhabit sagebrush shrublands, and include: garter snake (*Thamnophis elegans*), chukar (*Alectoris chukar*), sharp-tailed grouse (*Tympanuchus phasianellus*), western kingbird, horned lark, black-billed magpie (*Pica pica*), rock wren (*Salpinctes obsoletus*), sage thrasher, lazuli bunting (*Passerina amoena*), spotted towhee (*Pipilo maculates*), Brewer's sparrow, lark sparrow, lark bunting, bobolink (*Dolichonyx oryzivorus*), masked shrew (*Sorex cinereus*), desert cottontail, least chipmunk (*Tamias minimus*), Wyoming ground squirrel (*Spermophilus elegans*), thirteen-lined ground squirrel, deer mouse, northern grasshopper mouse (*Onychomys leucogaster*), coyote, western spotted skunk (*Spilogale gracilis*), pronghorn, and mule deer.

Wildlife species that may occur in riparian areas (including herbaceous, shrubby, and forested riparian areas) include: bull snake (*Pituophis catenifer*), tiger salamander (*Ambystoma tigrinum*), northern leopard frog (*Rana pipiens*), northern harrier, Virginia rail (*Rallus limicola*), sora (*Porzana carolina*), common snipe (*Gallinago gallinago*), short-eared owl (*Asio flammeus*), marsh wren (*Cistothorus palustris*), common yellowthroat (*Geothlypis trichas*), savannah sparrow (*Passerculus sandwichensis*), song sparrow (*Melospiza melodia*), red-winged blackbird (*Agelaius phoeniceus*), yellow-headed blackbird (*Xanthocephalus xanthocephalus*), deer mouse, meadow vole (*Microtus pennsylvanicus*), red fox (*Vulpes vulpes*), pronghorn, mule deer, and white-tailed deer (*Odocoileus virginianus*). Wet meadows tend to provide habitats for wildlife species associated with nearby dominant vegetation cover types (such as prairie or sagebrush shrublands), although in areas of large wet meadow complexes species common to riparian habitats may also occur.

Although they occur only sporadically throughout the Project Area, coniferous woodlands support a different set of wildlife species than other habitat types, primarily a result of seed production and potential nest substrates provided by the various conifer species. Common wildlife species in coniferous forest include: mountain chickadee (*Poecile gambeli*), mourning dove (*Zenaida macroura*), golden eagle, mountain bluebird (*Sialia currucoides*), northern flicker (*Colaptes auratus*), western tanager (*Piranga ludoviciana*), pinyon jay (*Gymnorhinus cyanocephalus*), chipping sparrow (*Spizella passerina*), lark sparrow, Nuttall's cottontail (*Sylvilagus nuttallii*), mule deer, gray fox (*Urocyon cinereoargenteus*), black-tailed jackrabbit, porcupine (*Erethizon dorsatum*), bushy-tailed woodrat (*Neotoma cinerea*), and mountain lion (*Felis concolor*).

Existing Impacts to Wildlife Habitats

Past and on-going human activities in the Project Area have altered substantial areas of wildlife habitats from their natural condition. These human disturbances include, but are not limited to, agriculture, mining, roads, urban areas, oil and gas well pads, compressor sites, and other ancillary facilities. Where data were available, the amount of this existing direct disturbance has been estimated and is included in the discussions for individual species below.

Oil and gas development may have resulted in indirect impacts to wildlife habitats in addition to direct habitat loss. The extent of indirect impact to wildlife species by human uses adjacent to their habitats varies by species and other factors such as topography, vegetation screening, habituation to disturbance, and frequency and intensity of disturbance. Mule deer, for example, tend to reduce their habitat use within one-eighth mile of roads (Rost and Bailey 1979). Elk, on the other hand, tend to reduce their use of habitats within one-half mile of roads (Ward 1976). By applying a buffer to existing roads, the amount of habitat that has been reduced in effectiveness for a species can be estimated. The locations of many existing roads in the Project Area, particularly associated with recent oil and gas development, are not known; therefore, a spatial analysis using buffers on existing roads is not possible.

Road density has been correlated with habitat effectiveness (Lyon 1983). The measurement of road density provides an approximation of the potential for effects to wildlife in several ways. First, it allows an estimate to be made of the amount of wildlife habitat that might be adjacent to roads and, therefore, the amount of habitat that might be less effective because it is avoided by wildlife species sensitive to human disturbance. Second, it provides a measure of the amount of habitat fragmentation, which is important in assessing the effects of development on wildlife species that require large tracts of habitat. Third, it allows an estimate of other parameters that are important to wildlife populations, such as the potential for road-kill and the potential for disturbance and mortality related to hunting. Table 3-24 shows the existing road density within each subwatershed in the Project Area.

Big Game

Big game species that are expected to occur in suitable habitats throughout the Project Area include pronghorn, white-tailed deer, mule deer, elk (*Cervus elaphus*), and moose (*Alces alces*). Nomenclature follows Jones et al. (1997). WGFD has identified various ranges for big game species. These ranges are defined as:

Table 3-24 Existing Road Density by Sub-watershed

Sub-watershed	Road Density (miles per square mile) Primary Roads	Secondary Roads	Estimated Oil and Gas Roads	Total
Little Bighorn River	0.03	1.44	0.00	1.47
Upper Tongue River	0.14	1.52	0.23	1.88
Middle Fork Powder River	0.09	1.45	0.00	1.54
North Fork Powder River	0.00	1.70	0.00	1.70
Upper Powder River	0.04	1.31	0.41	1.76
South Fork Powder River	0.06	1.38	0.00	1.45
Salt Creek	0.08	1.68	0.00	1.76
Crazy Woman Creek	0.09	1.32	0.05	1.45
Clear Creek	0.15	1.40	0.13	1.68
Middle Powder River	0.00	1.15	0.80	1.94
Little Powder River	0.06	1.29	1.06	2.41
Little Missouri River	0.00	1.64	0.00	1.64
Antelope Creek	0.03	1.54	0.77	2.34
Dry Fork Cheyenne River	0.02	1.76	0.00	1.78
Upper Cheyenne River	0.01	1.64	0.69	2.35
Lightning Creek	0.05	1.94	0.00	1.99
Upper Belle Fourche River	0.11	1.59	1.66	3.36
Middle North Platte River	0.06	1.51	0.06	1.63
Total	0.07	1.45	0.52	2.04

Crucial Range: any particular seasonal range or habitat component, but describes that component which has been documented as the determining factor in a population's ability to maintain and reproduce itself at a certain level.

Summer or Spring-Summer-Fall: A population or portion of a population of animals uses the documented habitats within this range annually from the end of previous winter to the onset of persistent winter conditions.

Severe Winter Relief: A documented survival range, which may or may not be considered a crucial range area as defined above. It is used to a great extent, only in occasionally extremely severe winters. It may lack habitat characteristics that would make it attractive or capable of supporting major portions of the population during normal years but is used by and allows at least a significant portion of the population to survive the occasional extremely severe winter.

Winter: A population or portion of a population of animals uses the documented suitable habitat sites within this range annually, in substantial numbers only during the winter period.

Winter/Yearlong: A population or a portion of a population of animals makes general use of the documented suitable habitat sites within this range on a year-round basis. During the winter months there is a significant influx of additional animals into the area from other seasonal ranges.

Yearlong: A population or substantial portion of a population of animals makes general use of the suitable documented habitat sites within the range on a year-round basis. Animals may leave the area under severe conditions on occasion.

Parturition Areas: Documented birthing areas commonly used by females. It includes calving areas, fawning areas, and lambing grounds. These areas may be used as nurseries by some big game species.

Other than the specific ranges identified for each species by the WGFD, baseline data on other aspects of each species' seasonal activities and movements (for example, fawning areas and migration corridors) are not available.

Pronghorn

Pronghorn typically inhabit grasslands and semi-desert shrublands of the western and southwestern United States. This species is most abundant in short- and mixed-grass habitats and is less abundant in more xeric habitats. Home ranges for pronghorn can vary between 400 acres and 5,600 acres, according to several factors including season, habitat quality, population characteristics, and local livestock occurrence. Typically, daily movement does not exceed 6 miles. Some pronghorn make seasonal migrations between summer and winter habitats, but these migrations are often triggered by availability of succulent plants and not local weather conditions (Fitzgerald et al. 1994). Wyoming supports the largest population of pronghorn in North America (Clark and Stromberg 1987).

Pronghorn antelope occur in most of the Project Area, except in the foothills in the western margin of the central portion of the area (Figure 3-11). These range data area based on seasonal range maps that were available from the WGFD at the time this report was prepared. Seasonal range maps are subject to change as new management data becomes available. The type and distribution of pronghorn ranges by surface owner, sub-watershed, and vegetation type are presented in Table 3-25, Table 3-26 , and Table 3-27.

WGFD has divided pronghorn into herd units to estimate population sizes. The following herd units reside entirely or partially within the Project Area: 308, 309, 310, 316, 318, 339, 351, 352, 353, 354, 740, 742, and 748. WGFD has estimated that the population size of all herd units within the Project Area is 142,963 animals (WGFD 2000a, 2000b). This number excludes data from herd unit 742, which were unavailable. The overall population goal of this same group of herd units is 138,600 animals; therefore, population levels are currently at 103 percent of the goal. Several individual herd units are not currently at their goal, while others have greatly exceeded the goal, with population levels ranging from 90 to 247 percent of goals. Of the herd units that are not meeting their goal, poor winter weather conditions, high fawn mortality, and limited forage availability are the presumed causes of low population levels. In several herd units, lack of public access for hunting has resulted in herd numbers that greatly exceed population goals (WGFD 2000a, 2000b).

Table 3-25 Distribution of Pronghorn Ranges by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	Buffalo Field Office	Casper Field Office	Forest Service	State	Private	Total
Crucial Winter Yearlong	0	77	0	0	68	145
Severe Winter	0	0	34,095	3,198	13,674	50,968
Spring, Summer, Fall	28,035	4,557	0	14,581	76,303	123,476
Winter	22,043	0	0	11,454	123,462	156,959
Winter Yearlong	97,361	39,769	37,372	125,254	1,493,761	1,793,516
Yearlong	385,440	46,543	179,753	394,094	3,670,364	4,676,195
Total	532,879	90,946	251,220	548,581	5,377,633	6,801,259

Table 3-26 Distribution of Pronghorn Ranges by Sub-watershed

	Range (acres)						
Sub-watershed	Crucial Winter Yearlong	Severe Winter	Spring, Summer, Fall	Winter	Winter Yearlong	Yearlong	Total
Little Bighorn River	0	0	0	0	0	1,010	1,010
Upper Tongue River	0	0	0	0	13,095	527,235	540,330
Middle Fork Powder River	0	0	59,887	0	118,112	42,363	220,362
North Fork Powder River	0	0	801	0	0	18,286	19,086
Upper Powder River	0	0	132	67,047	470,778	854,516	1,392,472
South Fork Powder River	0	0	0	0	57	114,151	114,208
Salt Creek	0	0	17,817	0	17,866	104,143	139,825
Crazy Woman Creek	0	0	18,580	0	36,565	446,033	501,178
Clear Creek	0	0	1,196	0	37,930	442,745	481,872
Middle Powder River	0	0	24,841	23,727	0	124,443	173,011
Little Powder River	0	0	0	66,185	218,718	446,048	730,951
Little Missouri River	0	0	0	0	6,406	27,558	33,964
Antelope Creek	0	31,773	221	0	57,524	570,716	660,234
Dry Fork Cheyenne River	0	19,195	0	0	83,172	206,949	309,316
Upper Cheyenne River	0	0	0	0	62,975	115,763	178,738
Lightning Creek	0	0	0	0	58,830	249,491	308,321
Upper Belle Fourche River	0	0	0	0	491,023	292,784	783,806
Middle North Platte River	145	0	0	0	120,466	91,963	212,574
Total	145	50,968	123,476	156,959	1,793,516	4,676,195	6,801,259

Figure 3-11 Pronghorn Ranges

The overall population trend for pronghorn in the Project Area has been stable to increasing herd numbers. Where a decreasing trend was noted (only in herd unit 740), bad winter weather with poor survival, particularly of fawns, was implicated in this trend (WGFD 2000a, 2000b). Extensive on-going and planned future CBM development were noted as a potential management concern for a number of herd units. Impacts caused by CBM development are unknown at this time; however, increased road density, produced water discharge, loss of vegetation, and increased human presence have the potential to adversely affect herd units subject to substantial CBM development (WGFD 2000a, 2000b).

Table 3-27 Distribution of Pronghorn Ranges by Vegetation Type

	Range (acres)						
Vegetation Type	Crucial Winter Yearlong	Severe Winter	Spring, Summer, Fall	Winter	Winter Yearlong	Yearlong	Total
Agriculture	0	0	163	291	2,720	71,920	75,094
Aspen	0	0	2	0	0	0	2
Barren	0	745	937	1,256	30,664	65,071	98,673
Coniferous Forest	0	144	14,284	6,650	4,983	44,892	70,953
Forested Riparian	0	212	20	0	1,089	4,414	5,735
Herbaceous Riparian	0	781	1	0	7,113	4,286	12,181
Mixed-grass Prairie	145	14,167	39,351	34,354	281,538	896,260	1,265,815
Other Shrublands	0	1,243	12,557	0	48,381	58,653	120,834
Sagebrush Shrublands	0	6,239	26,931	51,134	600,008	1,309,525	1,993,838
Shortgrass Prairie	0	27,408	28,399	59,673	805,680	2,080,990	3,002,150
Shrubby Riparian	0	0	414	308	1,464	18,036	20,223
Urban/Disturbed	0	0	0	0	1,698	2,664	4,362
Water	0	29	0	101	1,510	4,449	6,089
Wet Meadow	0	0	415	3,192	6,668	115,036	125,311
Total	145	50,968	123,476	156,959	1,793,516	4,676,195	6,801,259

Table 3-28 and Table 3-29 present existing disturbance to pronghorn ranges from oil and gas development by surface owner and sub-watershed, respectively. Specific data on other existing disturbances are not available in sufficient detail to allow comparison with these data and are not presented in Table 3-28 and Table 3-29.

Table 3-28 Existing Disturbance to Pronghorn Ranges by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Crucial Winter Yearlong	0	0	0	0	0	0
Severe Winter	0	0	14	2	16	33
Spring, Summer, Fall	216	0	0	10	215	441
Winter	35	0	0	63	712	810
Winter Yearlong	465	24	162	1,122	14,979	16,751
Yearlong	315	56	440	2,108	19,900	22,819
Total	1,031	80	616	3,306	35,822	40,854

Table 3-29 Existing Disturbance to Pronghorn Ranges by Sub-watershed

	Range (acres)						
Sub-watershed	Crucial Winter Yearlong	Severe Winter	Spring, Summer, Fall	Winter	Winter Yearlong	Yearlong	Total
Little Bighorn River	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	192	612	804
Middle Fork Powder River	0	0	0	0	63	0	63
North Fork Powder River	0	0	0	0	0	0	0
Upper Powder River	0	0	0	471	2,497	3,130	6,098
South Fork Powder River	0	0	0	0	0	61	61
Salt Creek	0	0	0	0	2	54	56
Crazy Woman Creek	0	0	0	0	0	204	204
Clear Creek	0	0	0	0	0	412	412
Middle Powder River	0	0	441	294	0	2,847	3,582
Little Powder River	0	0	0	45	3,854	4,964	8,863
Little Missouri River	0	0	0	0	16	16	33
Antelope Creek	0	19	0	0	357	2,538	2,914
Dry Fork Cheyenne River	0	14	0	0	68	179	261
Upper Cheyenne River	0	0	0	0	391	1,170	1,561
Lightning Creek	0	0	0	0	268	625	893
Upper Belle Fourche River	0	0	0	0	9,030	5,946	14,977
Middle North Platte River	0	0	0	0	12	61	73
Total	0	33	441	810	16,751	22,819	40,854

White-tailed Deer

White-tailed deer occur throughout North America from the southern United States to Hudson Bay in Canada. Across much of its range, this species inhabits forests, swamps, brushy areas, and nearby open fields. In Wyoming, white-tailed deer are found throughout the state, typically concentrated in riparian woodlands, shrubby riparian, and associated irrigated agricultural lands, and are generally absent from dry grasslands and coniferous forests (Clark and Stromberg 1987). Their diet is diverse, capitalizing on the most nutritious plant matter available at any time. In addition to native browse, grass, and forbs, this species would rely on agricultural crops, fruits, acorns, and other nuts. Mortality to white-tailed deer is typically related to hunting, winter starvation, collisions with automobiles, and predation. Predators may include coyotes, mountain lions, wolves, and, occasionally, bears, bobcats, and eagles (Fitzgerald et al. 1994).

In the Project Area, white-tailed deer are restricted to river and stream drainages across the Powder River Basin and to riparian habitats associated with the northern foothills of the Bighorn Mountains (Figure 3-12). They tend to be absent from large expanses of prairie and shrubland. These range data are based on seasonal range maps that were available from the WGFD at the time this report was prepared. Seasonal range maps are subject to change as new management data becomes available. The type and distribution of white-tailed deer ranges by surface owner, sub-watershed, and vegetation type are presented in Table 3-30, Table 3-31, and Table 3-32.

Table 3-30 Distribution of White-tailed Deer Ranges by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Winter Yearlong	257	0	0	515	3,900	4,671
Yearlong	21,869	1,059	4,929	65,960	667,151	760,967
Total	22,126	1,059	4,929	66,474	671,051	765,638

Table 3-31 Distribution of White-tailed Deer Ranges by Sub-watershed

	Range (acres)		
Sub-watershed	Winter Yearlong	Yearlong	Total
Little Bighorn River	0	16,475	16,475
Upper Tongue River	0	265,926	265,926
Middle Fork Powder River	0	31,635	31,635
North Fork Powder River	0	0	0
Upper Powder River	0	71,095	71,095
South Fork Powder River	0	9,383	9,383
Salt Creek	0	321	321
Crazy Woman Creek	0	67,472	67,472
Clear Creek	0	130,988	130,988
Middle Powder River	4,671	12,554	17,225
Little Powder River	0	102,406	102,406
Little Missouri River	0	4,681	4,681
Antelope Creek	0	17,986	17,986
Dry Fork Cheyenne River	0	11,681	11,681
Upper Cheyenne River	0	0	0
Lightning Creek	0	4,731	4,731
Upper Belle Fourche River	0	13,633	13,633
Middle North Platte River	0	0	0
Total	4,671	760,967	765,638

WGFD has divided white-tailed deer into herd units to estimate population sizes. The following herd units reside entirely or partially within the Project Area: 303, 702, and 707. The WGFD has estimated the population size of one of these herd units (17,078 in herd unit 303 with a goal of 8,000); however, survey data were not adequate to allow estimates of the sizes of the other two herd units. The population is thought to be substantially higher than the goals for all three herd units. with a stable or increasing trend (WGFD 2000a, 2000b). The stated cause for populations that are substantially higher than the goals is lack of public access for hunting and urbanization in the northwest part of the Project Area.

Table 3-32 Distribution of White-tailed Deer Ranges by Vegetation Type

Vegetation Type	Range (acres)		
	Winter Yearlong	Yearlong	Total
Agriculture	0	78,999	78,999
Aspen	0	0	0
Barren	91	10,121	10,212
Coniferous Forest	473	9,034	9,507
Forested Riparian	0	5,647	5,647
Herbaceous Riparian	0	2,281	2,281
Mixed-grass Prairie	1,818	242,601	244,418
Other Shrublands	0	13,730	13,730
Sagebrush Shrublands	382	133,545	133,927
Shortgrass Prairie	1,469	161,211	162,680
Shrubby Riparian	11	34,041	34,052
Urban/Disturbed	0	0	0
Water	0	2,367	2,367
Wet Meadow	428	67,390	67,818
Total	4,671	760,967	765,638

Table 3-33 and **Table 3-34** present existing disturbance to white-tailed deer ranges from oil and gas development by surface owner and sub-watershed. Specific data on other existing disturbances are not available in sufficient detail to allow comparison with these data and are not presented in Table 3-33 and **Table 3-34**.

Table 3-33 Existing Disturbance to White-tailed Deer Ranges by Surface Owner

Range	Surface Owner (acres)					
	BLM					
	BFO	CFO	FS	State	Private	Total
Winter-Yearlong	0	0	0	0	0	0
Yearlong	16	0	0	233	1,746	1,995
Total	16	0	0	233	1,746	1,995

Figure 3-12 White-tailed Deer Ranges

Table 3-34 Existing Disturbance to White-tailed Deer Ranges by Sub-watershed

	Range (acres)		
Sub-watershed	Winter Yearlong	Yearlong	Total
Little Bighorn River	0	0	0
Upper Tongue River	0	402	402
Middle Fork Powder River	0	7	7
North Fork Powder River	0	0	0
Upper Powder River	0	719	719
South Fork Powder River	0	0	0
Salt Creek	0	0	0
Crazy Woman Creek	0	80	80
Clear Creek	0	265	265
Middle Powder River	0	53	53
Little Powder River	0	363	363
Little Missouri River	0	0	0
Antelope Creek	0	12	12
Dry Fork Cheyenne River	0	7	7
Upper Cheyenne River	0	0	0
Lightning Creek	0	7	7
Upper Belle Fourche River	0	81	81
Middle North Platte River	0	0	0
Total	0	1,995	1,995

Mule Deer

Mule deer occur throughout western North America from central Mexico to northern Canada. Typical habitats include shortgrass and mixed-grass prairies, sagebrush and other shrublands, coniferous forests, and forested and shrubby riparian areas. In Wyoming, mule deer occur in mountains and associated foothills, broken hill country, and prairie grasslands and shrublands (Clark and Stromberg 1987). Browse is an important component of the mule deer's diet throughout the year, making up as much as 60 percent of total intake during autumn, while forbs and grasses typically make up the rest of their diet (Fitzgerald et al. 1994). This species tends to be more migratory than white-tailed deer, traveling from higher elevations in the summer to winter ranges that provide more food and cover. Fawn mortality is typically due to predation or starvation. Adult mortality often occurs from hunting, winter starvation, and automobile collisions. Typical predators may include coyotes, bobcats, golden eagles, mountain lions, bears, and domestic dogs (Fitzgerald et al. 1994).

In the Project Area, mule deer ranges occur in nearly all areas, except in several areas located between Wright and Gillette (Figure 3-13). These range data are based on seasonal range maps that were available from the WGFD at the time this report was prepared. Seasonal range maps are subject to change as new management data becomes available. The type and distribution of mule deer ranges by surface owner, sub-watershed, and vegetation type are presented in Table 3-35, Table 3-36, and Table 3-37.

Table 3-35 Distribution of Mule Deer Ranges by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Spring, Summer, Fall	25,485	0	81	13,824	88,428	127,818
Winter Yearlong	544,938	18,012	72,997	340,271	2,855,569	3,831,786
Yearlong	211,413	72,936	154,062	224,670	2,578,640	3,241,722
Total	781,836	90,948	227,140	578,766	5,522,636	7,201,326

Table 3-36 Distribution of Mule Deer Ranges by Sub-watershed

	Range (acres)			
Sub-watershed	Spring, Summer, Fall	Winter Yearlong	Yearlong	Total
Little Bighorn River	1,427	44,368	3,790	49,584
Upper Tongue River	8,091	589,641	135,812	733,543
Middle Fork Powder River	101,251	341,119	22,080	464,450
North Fork Powder River	1,824	0	18,850	20,674
Upper Powder River	0	950,798	611,226	1,562,024
South Fork Powder River	0	75,343	39,012	114,355
Salt Creek	0	71,511	73,308	144,819
Crazy Woman Creek	13,373	368,629	166,281	548,283
Clear Creek	1,852	466,854	78,158	546,865
Middle Powder River	0	158,914	65,316	224,230
Little Powder River	0	468,752	291,837	760,589
Little Missouri River	0	37,105	1,422	38,528
Antelope Creek	0	68,433	517,314	585,746
Dry Fork Cheyenne River	0	67,232	242,084	309,316
Upper Cheyenne River	0	1,502	142,945	144,447
Lightning Creek	0	49,550	258,772	308,321
Upper Belle Fourche River	0	7,954	425,023	432,977
Middle North Platte River	0	64,082	148,492	212,573
Total	127,818	3,831,786	3,241,722	7,201,326

Figure 3-13 Mule Deer Ranges

Table 3-37 Distribution of Mule Deer Ranges by Vegetation Type

	Range (acres)			
Vegetation Type	Spring, Summer, Fall	Winter Yearlong	Yearlong	Total
Agriculture	0	74,474	37,726	112,200
Aspen	68	3	0	71
Barren	632	59,801	44,276	104,709
Coniferous Forest	31,044	118,776	41,538	191,358
Forested Riparian	394	7,910	3,159	11,463
Herbaceous Riparian	67	10,191	2,079	12,337
Mixed-grass Prairie	39,527	911,058	526,676	1,477,261
Other Shrub lands	12,407	128,794	36,680	177,880
Sagebrush Shrublands	33,402	872,251	1,033,798	1,939,450
Shortgrass Prairie	7,766	1,469,557	1,473,425	2,950,747
Shrubby Riparian	1,502	48,790	7,178	57,470
Urban/Disturbed	0	1,744	2,618	4,362
Water	87	3,872	4,662	8,621
Wet Meadow	923	124,565	27,907	153,396
Total	127,818	3,831,786	3,241,722	7,201,326

WGFD has divided mule deer into herd units to estimate populations. The following herd units reside entirely or partially within the Project Area: 319, 320, 321, 322, 752, 753, and 755. WGFD has estimated that the population of all herd units within the Project Area is 157,128 animals (WGFD 2000a, 2000b). The overall population goal of this same group of herd units is 146,100 animals; therefore, population levels are currently at 108 percent of the goal. Several individual herd units are not currently at the goal, but others have greatly exceeded the goal, with population levels ranging from 81 to 167 percent of goals. Of the herd units that are not meeting the goal, poor winter weather conditions, high fawn mortality, and lack of reliable population estimates are the presumed causes of low population levels. In several herd units, lack of public access for hunting has resulted in herd numbers that greatly exceed population goals (WGFD 2000a, 2000b).

The overall population trend for mule deer in the Project Area has been stable to increasing. Where a decreasing trend was noted (only in herd unit 753), management actions designed to reduce the population, which is currently at 114 percent of the goal, were implicated in the trend (WGFD 2000a, 2000b), as were high fawn production and survival. Extensive on-going and planned future CBM development were noted as a potential management concern for a number of herd units. Impacts caused by CBM development are unknown at this time; however, increased road density, produced water discharge, loss of vegetation, and increased human presence have the potential to adversely affect herd units that are subject to substantial CBM development (WGFD 2000a, 2000b).

Table 3-38 and Table 3-39 present existing disturbance to mule deer ranges from oil and gas development by surface owner and sub-watershed. Specific data on other existing disturbances are not available in sufficient detail to allow comparison with these data and are not presented in Table 3-38 and Table 3-39.

Table 3-38 Existing Disturbance to Mule Deer Ranges by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Spring, Summer, Fall	0	0	0	0	0	0
Winter Yearlong	572	21	59	736	7,841	9,229
Yearlong	512	59	291	1,710	17,706	20,279
Total	1,084	80	350	2,447	25,547	29,508

Elk

Elk formerly ranged over much of central and western North America from the southern Canadian Provinces and Alaska south to the southern United States, and eastward into the deciduous forests. In Wyoming, this species occurs throughout the state in a variety of habitats, including coniferous forests, mountain meadows, short- and mixed-grass prairies, and sagebrush and other shrublands. Similar to other members of the deer family, this species relies on a combination of browse, grasses, and forbs, depending on their availability throughout the seasons. Elk tend to be migratory, moving between summer and winter ranges. Typically, mortality is a result of predation on calves, hunting, and winter starvation. Predators may include coyotes, mountain lions, bobcats, bears, and golden eagles.

In the Project Area, elk ranges are concentrated in the Bighorn Mountains and associated foothills, the Fortification Creek Area west of Gillette, the Pine Ridge area in the south, and the Rochelle Hills in the southeast (Figure 3-14). Specific studies on seasonal movement and range use have been completed for the Fortification Creek herd unit; therefore, data for this area are presented separately from the other herd units. The type and distribution of elk ranges (excluding the Fortification Creek herd unit) by surface owner, sub-watershed, and vegetation type are presented in Table 3-40, Table 3-42, and Table 3-43. These range data are based on seasonal range maps that were available from the WGFD at the time this report was prepared. Seasonal range maps are subject to change as new management data becomes available. The type and distribution of elk ranges in the Fortification Creek herd unit by surface owner and vegetation type are presented in Table 3-41 and Table 3-44. The entire Fortification Creek herd unit is within the Upper Powder River sub-watershed.

Table 3-39 Existing Disturbance to Mule Deer Ranges by Sub-watershed

	Range (acres)			
Sub-watershed	Spring, Summer, Fall	Winter Yearlong	Yearlong	Total
Little Bighorn River	0	0	0	0
Upper Tongue River	0	827	4	830
Middle Fork Powder River	0	63	0	63
North Fork Powder River	0	0	0	0
Upper Powder River	0	3,590	2,507	6,097
South Fork Powder River	0	56	5	61
Salt Creek	0	24	47	71
Crazy Woman Creek	0	115	90	204
Clear Creek	0	310	116	425
Middle Powder River	0	3,006	687	3,693
Little Powder River	0	877	6,664	7,541
Little Missouri River	0	35	0	35
Antelope Creek	0	51	1,547	1,599
Dry Fork Cheyenne River	0	75	186	261
Upper Cheyenne River	0	0	989	989
Lightning Creek	0	197	696	893
Upper Belle Fourche River	0	0	6,673	6,673
Middle North Platte River	0	2	70	73
Total	0	9,229	20,279	29,508

Table 3-40 Distribution of Elk Ranges (excluding Fortification Creek) by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Crucial Winter	928	0	4,592	5,952	37,024	48,496
Crucial Winter Yearlong	40,786	0	0	12,196	51,945	104,927
Spring, Summer, Fall	17,628	0	0	11,803	75,976	105,407
Winter	140	0	0	2,930	8,771	11,841
Winter Yearlong	3,392	0	21,414	3,658	16,793	45,256
Yearlong	45,786	15,364	39,135	22,783	171,417	294,485
Total	108,660	15,364	65,141	59,322	361,926	610,412

Table 3-41 Distribution of Elk Ranges (Fortification Creek only) by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Crucial Winter	15,763	0	0	2,223	20,247	38,233
Parturition	27,851	0	0	3,331	28,109	59,291
Winter Year-long	33,256	0	0	4,500	33,367	71,123
Yearlong	54,298	0	0	7,116	61,516	122,930
Total	131,168	0	0	17,170	143,239	291,577

Figure 3-14 Elk Ranges

Table 3-42 Distribution of Elk Ranges (excluding Fortification Creek) by Sub-watershed

Sub-watershed	Range (acres)						
	Crucial Winter	Crucial Winter Yearlong	Spring, Summer, Fall	Winter	Winter Yearlong	Yearlong	Total
Little Bighorn River	4,734	266	1,752	33	2,563	0	9,347
Upper Tongue River	26,992	0	10,265	842	10	0	38,109
Middle Fork Powder River	0	88,622	43,725	0	745	85,916	219,009
North Fork Powder River	0	0	8,489	0	0	12,185	20,674
Upper Powder River	0	0	0	0	0	15,345	15,345
South Fork Powder River	0	0	0	0	0	16,929	16,929
Salt Creek	0	0	0	0	0	19,303	19,303
Crazy Woman Creek	0	16,039	34,759	1,616	10,170	0	62,585
Clear Creek	9,980	0	6,416	9,349	0	0	25,745
Middle Powder River	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0
Antelope Creek	3,401	0	0	0	21,472	61,188	86,060
Dry Fork Cheyenne River	0	0	0	0	597	4,339	4,936
Upper Cheyenne River	3,390	0	0	0	9,699	68,814	81,903
Lightning Creek	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	0	0	10,466	10,466
Middle North Platte River	0	0	0	0	0	0	0
Total	48,496	104,927	105,406	11,840	45,256	294,485	610,412

Table 3-43 Distribution of Elk Ranges (excluding Fortification Creek) by Vegetation Type

	Range (acres)						
Vegetation Type	Crucial Winter	Crucial Winter Yearlong	Spring, Summer, Fall	Winter	Winter Yearlong	Yearlong	Total
Agriculture	795	0	6	22	0	0	823
Aspen	1	0	68	0	2	0	71
Barren	8	1,104	63	0	762	4,092	6,029
Coniferous Forest	7,698	23,673	43,185	3,905	6,004	36,822	121,287
Forested Riparian	1,385	60	2,891	202	460	772	5,769
Herbaceous Riparian	47	11	49	25	12	70	215
Mixed-grass Prairie	14,918	33,227	24,286	3,990	6,090	42,884	125,395
Other Shrublands	273	16,229	4,590	111	9	23,506	44,719
Sagebrush Shrub-lands	8,947	18,396	24,078	2,469	10,784	69,705	134,379
Shortgrass Prairie	4,378	11,838	1,507	166	19,671	113,326	150,888
Shrubby Riparian	7,472	347	3,125	690	1,091	133	12,857
Urban/Disturbed	0	0	0	0	0	0	0
Water	108	0	87	25	56	219	495
Wet Meadow	2,466	40	1,471	237	315	2,955	7,484
Total	48,496	104,927	105,407	11,841	45,256	294,485	610,412

Table 3-44 Distribution of Elk Ranges (Fortification Creek only) by Vegetation Type

	Range (acres)			
Vegetation Type	Crucial Winter	Parturition	Winter Yearlong	Yearlong
Agriculture	0	0	0	0
Aspen	0	0	0	0
Barren	410	665	781	1,578
Coniferous Forest	820	1,571	1,024	1,915
Forested Riparian	0	0	0	0
Herbaceous Riparian	0	0	0	0
Mixed-grass Prairie	5,847	9,255	9,805	16,134
Other Shrublands	0	0	0	0
Sagebrush Shrub-lands	12,616	18,781	22,829	37,340
Shortgrass Prairie	18,439	28,806	36,532	65,592
Shrubby Riparian	90	123	134	150
Urban/Disturbed	0	0	0	0
Water	0	0	0	0
Wet Meadow	12	90	18	222
Total	38,234	59,291	71,123	122,931

WGFD has divided elk into herd units to estimate population sizes. The following herd units reside entirely or partially within the Project Area: 320, 321, 322, 344, and 743. WGFD has estimated the total population size of four of these herd units at 11,387; however, survey data were not adequate to allow a population estimate of the size of herd unit 743. For this herd unit, the population is thought to be substantially higher than the goal of 125 animals (WGFD 2000a, 2000b).

The overall population goal of the same group of four herd units is 7,550 animals; therefore, population levels are currently at 151 percent of the goal. All herd units are currently at their goal, but others have greatly exceeded the goal, with population levels ranging from 97 to 206 percent of goals. The stated cause for populations that are substantially higher than the goals is lack of public access for hunting and unwillingness on the part of some landowners to allow access to private lands for hunting at a level sufficient to allow effective herd management.

The overall population trend for elk in the Project Area has been stable to increasing. For several herd units, the recent trend has been decreasing herd numbers; however, this decrease has been in response to management actions (increased hunting opportunities) designed to reduce populations (WGFD 2000a, 2000b). Extensive on-going and planned future CBM development were noted as a potential management concern for one herd unit. Impacts caused by CBM development are unknown at this time; however, increased road density, produced water discharge, loss of vegetation, and increased human presence have the potential to adversely affect herd units subject to substantial CBM development (WGFD 2000a, 2000b).

Table 3-45 and Table 3-47 present existing disturbance to elk ranges (excluding the Fortification Creek herd unit) from oil and gas development by surface owner and sub-watershed. Table 3-46 presents existing disturbance to elk ranges in the Fortification Creek herd unit from oil and gas development by surface owner. All existing disturbance to the Fortification Creek herd unit has occurred in the Upper Powder River sub-watershed. Specific data on other existing disturbances are not available in sufficient detail to allow comparison with these data and are not presented in Table 3-42, Table 3-43, and Table 3-44.

Table 3-45 Existing Disturbance to Elk Ranges (excluding Fortification Creek) by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Crucial Winter	0	0	24	0	0	24
Crucial Winter Yearlong	0	0	0	0	0	0
Spring, Summer, Fall	0	0	0	0	0	0
Winter	0	0	0	0	0	0
Winter Yearlong	0	0	35	5	12	52
Yearlong	47	0	47	12	59	165
Total	47	0	106	17	71	241

Table 3-46 Existing Disturbance to Elk Ranges (Fortification Creek only) by Surface Owner

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Crucial Winter	0	0	0	0	2	2
Winter Yearlong	2	0	0	0	5	7
Yearlong	11	0	0	6	19	36
Parturition	16	0	0	14	63	93
Total	29	0	0	20	87	138

Table 3-47 Existing Disturbance to Elk Ranges (excluding Fortification Creek) by Sub-watershed

	Range (acres)						
Sub-watershed	Crucial Winter	Crucial Winter Yearlong	Spring, Summer, Fall	Winter	Winter Yearlong	Yearlong	Total
Little Bighorn River	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0
Middle Fork Powder River	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0
Upper Powder River	0	0	0	0	0	14	14
South Fork Powder River	0	0	0	0	0	61	61
Salt Creek	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0
Little Powder River	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0
Antelope Creek	24	0	0	0	49	45	118
Dry Fork Cheyenne River	0	0	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	2	45	47
Lightning Creek	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	0	0	0	0
Middle North Platte River	0	0	0	0	0	0	0
Total	24	0	0	0	51	165	240

Moose

In North America, moose occur from Alaska to the northeastern United States and south along the Rocky Mountains into Colorado. In Wyoming, this species occurs in the western half and isolated southern areas of the state. Typical moose habitats in the Rocky Mountains include willow, spruce, fir, aspen, or birch. These habitats are common to forested riparian, shrubby riparian, and wet meadow vegetation types. Willow is an important dietary component on all seasonal ranges, especially in winter range when grasses, forbs, and aquatic vegetation are less available. Moose tend to have strong affinity for specific home ranges, but would make seasonal migrations in search of suitable forage and habitat. Major mortality factors include hunting, starvation, and predation. Common predators include mountain lion, wolverine, coyote, bear, lynx, and domestic dog (Fitzgerald et al. 1994).

Moose ranges are extremely limited within the Project Area and are restricted to areas along the western boundary in the Bighorn Mountains (Figure 3-15). These range data are based on seasonal range maps that were available from the WGFD at the time this report was prepared. Seasonal range maps are subject to change as new management data becomes available. The type and distribution of moose ranges by surface owner, sub-watershed, and vegetation type are presented in Table 3-48, Table 3-49, and Table 3-50. No existing disturbance to moose habitats attributed to agriculture, oil and gas well pads, or urban areas occurs within the Project Area. Specific data on mining, roads, compressors, and ancillary oil and gas facilities are not available in sufficient detail to allow a determination of their effects on moose habitats.

Table 3-48 Distribution of Moose Ranges by Surface Ownership

	Surface Owner (acres)					
	BLM					
Range	BFO	CFO	FS	State	Private	Total
Crucial Winter-Yearlong	92	0	1	1,075	8,954	10,123
Crucial Yearlong	0	0	6	0	1,488	1,493
Winter Yearlong	87	0	6	1,818	17,626	19,537
Yearlong	1,568	0	33	3,067	29,833	34,501
Total	1,741	0	46	5,960	57,901	65,654

Raptors

Common raptor species expected to occur in suitable habitats within the Project Area include the northern harrier, golden eagle, red-tailed hawk (*Buteo jamaicensis*), Swainson's hawk, ferruginous hawk, American kestrel (*Falco sparverius*), prairie falcon, short-eared owl, and great horned owl (*Bubo virginianus*). Less common raptors in the Project Area include: osprey, bald eagle, rough-legged hawk (*Buteo lagopus*), merlin, and burrowing owl (*Athene cunicularia*). Several of these species (osprey, bald eagle, ferruginous hawk, merlin, and burrowing owl) have been recognized as special status species and are discussed in the section on Threatened, Endangered, and Sensitive Species. The following sections briefly describe the ecology, distribution, and populations for the remaining raptor species that may occur within the Project Area.

Table 3-49 Distribution of Moose Ranges by Sub-watershed

Sub-watershed	Range (acres) Crucial Winter Yearlong	Crucial Year-long	Winter Year-long	Yearlong	Total
Little Bighorn River	0	0	0	4,523	4,523
Upper Tongue River	10,123	1,493	15,983	23,266	50,865
Middle Fork Powder River	0	0	0	0	0
North Fork Powder River	0	0	0	0	0
Upper Powder River	0	0	0	0	0
South Fork Powder River	0	0	0	0	0
Salt Creek	0	0	0	0	0
Crazy Woman Creek	0	0	0	4,770	4,770
Clear Creek	0	0	3,554	1,942	5,496
Middle Powder River	0	0	0	0	0
Little Powder River	0	0	0	0	0
Little Missouri River	0	0	0	0	0
Antelope Creek	0	0	0	0	0
Dry Fork Cheyenne River	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	0
Lightning Creek	0	0	0	0	0
Upper Belle Fourche River	0	0	0	0	0
Middle North Platte River	0	0	0	0	0
Total	10,123	1,493	19,537	34,501	65,654

Raptor monitoring efforts at two surface coal mines in the Powder River Basin were reviewed and used to characterize raptro occurrence within the project area (Seacross 2002). Annual raptor nesting density in these two areas ranged from 2.8 to 4.6 square miles per pair, and the total density of all nests was one per square mile (Seacross 2002). Extrapolating these data across the entire Project Area yields an estimate of 2,690 to 4,410 nests active on an annual basis and a total count of 12,360 nests (active and inactive).

Figure 3-15 Moose Ranges

Table 3-50 Distribution of Moose Ranges by Vegetation Type

Vegetation Type	Range (acres) Crucial Winter Yearlong	Crucial Yearlong	Winter Yearlong	Yearlong	Total
Agriculture	120	0	670	499	1,289
Aspen	1	10	0	53	64
Barren	0	0	0	0	0
Coniferous Forest	1,371	843	2,800	10,976	15,990
Forested Riparian	965	41	798	947	2,751
Herbaceous Riparian	0	5	3	43	51
Mixed-grass Prairie	2,772	239	7,261	9,231	19,503
Other Shrublands	0	0	0	244	244
Sagebrush Shrublands	841	252	2,436	4,120	7,649
Shortgrass Prairie	47	0	111	222	380
Shrubby Riparian	3,151	8	3,666	6,128	12,953
Uban/Disturbed	0	0	0	0	0
Water	0	0	38	0	38
Wet Meadow	854	96	1,755	2,037	4,742
Total	10,121	1,494	19,538	34,501	65,653

Northern Harrier

This species occurs throughout much of North America, with highest densities in the prairie pothole region of the U.S. and Canada. Harriers nest in a variety of habitats, including native and non-native grasslands, agricultural lands, and emergent wetland marshes and mountain sagebrush (Carter 1998a). In Wyoming, this species is a common summer resident, feeding mostly on small mammals (often voles) that it discovers while gliding (Luce et al. 1999). Limited population data are available; however, on one coal mine study area in Campbell County, as many as four and as few as no breeding pairs were recorded, depending on year (Seacross 2002). Using this study, there may be as many as 250 breeding pairs of northern harriers in the Project Area.

Golden Eagle

In North America, this species occurs throughout the mountain and grassland regions where medium-sized mammals are available and abundant (Glinski 1998). Golden eagles typically nest on open cliffs or in trees (most often cottonwoods in the Project Area). Important foraging habitats include grasslands, sagebrush, and farmlands (Barrett 1998a). In Wyoming, this species is considered a common year-round resident, feeding mostly on jackrabbits, rodents, small mammals, and carrion in the winter (Luce et al. 1999). Based on past studies in the Powder River Basin, it has been estimated that there are between 500 and 630 breeding pairs of golden eagles in the Project Area (Phillips et al. 1984; Seacross 2002).

Red-tailed Hawk

Red-tailed hawks use a variety of habitats and range from Alaska south to Panama and east to Nova Scotia and the Virgin Islands (Preston 1998b). This species typically nests in patches of tall trees or on secluded cliff faces, but would also use tree windbreaks where available. In Wyoming, this species is considered year-round resident common to most habitats below 9,000 feet in elevation, including prairie grasslands, riparian areas, sagebrush communities, and piñon/juniper woodlands (Luce et al. 1999). They nest mainly in trees and are more tolerant of human activities than are other raptors. Typical prey species include rodents and other small mammals. The density of nesting pairs varies from one pair per 10 to 20 square miles (Seacross 2002), depending on the availability of suitable trees or other structures for nesting; therefore, breeding populations in the Project Area probably range between 620 and 1,240 pairs.

Swainson's Hawk

The Swainson's hawk is a New World hawk, breeding in North America and wintering in South America. Breeding pairs would build their own nest in the tops of isolated trees or use nests built by magpies, crows, ravens, or other hawks (Preston 1998c). In Wyoming, this species is considered a summer resident common to grasslands below 9,000 feet in elevation (Luce et al. 1999). This species typically preys on rodents, small mammals, and occasionally rabbits. Concern for this species has increased following reports of significant habitat loss and exposure to pesticides on wintering grounds in South America. Swainson's hawks are relatively sensitive to human disturbance near active nests. The reported density of nesting pairs varies from as high as one pair per 3.7 square miles where prey are abundant to as low as one pair per 40 square miles (Seacross 2002). Using these values, the number of breeding pairs in the Project Area has been estimated to range between 310 and 3,340, and is most likely between 1,000 and 2,000.

Rough-legged Hawk

The rough-legged hawk occurs in the northern latitudes of Canada during the summer and in the United States from California east to Maine in the winter. In Wyoming, this species occurs in the shortgrass and mixed-grass prairies and sagebrush and other shrublands. Winter prey species include rodents, medium-sized mammals, and upland birds. This species is considered a common winter resident in Wyoming (Luce et al. 1999). No population estimate has been made for this species because most raptor surveys occur during the breeding season, when rough-legged hawks are not present in the Project Area. In addition, the number of wintering hawks in a particular area is highly variable from year to year, depending on weather conditions and availability of prey (Ehrlich et al. 1988).

American Kestrel

The American kestrel is found throughout North and South America from Alaska south to the southernmost tip of South America. This species is known to breed in every state of the U.S., except Hawaii, and each province of Canada. American kestrels prefer open country with sufficient perches (for example, dead trees, rock outcrops, utility poles and wires) for hunting insects and small mammals (Winn 1998a). Nesting sites often include tree cavities, crevices, cliffs, and nest boxes. Most commonly found along riparian corridors, kestrels forage for mice and voles, but would also take larger invertebrates (for example, grasshoppers) where other prey is limited. In Wyoming, the kestrel is a very common summer resident of suitable habitats below 8,500 feet in elevation. No attempts have been made to estimate the population density of kestrels in the Project Area (Seacross 2002).

Prairie Falcon

The prairie falcon range over the western half of North America from southern Alberta, Saskatchewan, and British Columbia south to central Mexico (Jones 1998c). This species nests almost exclusively on tall cliff faces. Prairie falcons hunt birds and small mammals from perches and while soaring. In Wyoming, the prairie falcon is considered a common resident, nesting in cliff habitats in open areas (Luce et al. 1999). Where nesting substrates are present, as at the Pumpkin Buttes in the Project Area, several pairs can be found in close proximity; however, large areas of otherwise suitable habitats can be unoccupied if nesting substrates are absent. No estimate of population density in the Project Area has been made because of the scattered and uncommon nature of prairie falcon nesting sites.

Short-eared Owl

The short-eared owl occurs throughout Canada and the central and northern United States. In Wyoming, this species is a common year-resident (Luce et al. 1999). This owl is a ground-nesting species, building its nest of grasses, weeds, and down feathers in short- and mixed-grass prairies and herbaceous wetlands (Boyle 1998a). Density of nesting short-eared owls appears to be highly variable and is based on the abundance of voles and other small mammals (Seacross 2002). No population estimate has been made for the Project Area because of this variability in occurrence and lack of data.

Great Horned Owl

The great horned owl occurs from the northern edge of the boreal forest in Alaska and Canada to the southern tip of South America. This owl typically nests in wooded areas adjacent to open spaces such as shrublands, grasslands, and farm fields that provide excellent opportunity for hunting rodents and other small mammals (Boyle 1998b). In Wyoming, this owl is considered a common resident of most habitats below 9,000 feet in elevation, especially in riparian areas dominated by cottonwood (Luce et al. 1999). Great horned owls are tolerant of human activities and would nest in a variety of structures, including industrial facilities. The nesting density of this owl varies from 18.5 to 40 square miles per pair, although the secretive nature of the species makes nest detection difficult (Seacross 2002). An estimated 310 to 670 pairs may occur in the entire Project Area.

Upland Game Birds

Several species of upland game birds may occur within the Project Area, including ring-necked pheasant (*Phasianus colchicus*), gray partridge (*Perdix perdix*), wild turkey (*Meleagris gallopavo*), mourning dove (*Zenaida macroura*), greater sage grouse (*Centrocercus urophasianus*), and sharp-tailed grouse (*Tympanuchus phasianellus*) (Luce et al. 1999). Specific concerns for greater sage grouse and plains sharp-tailed grouse were identified during the scoping process. The greater sage grouse is discussed in detail in the section on Threatened, Endangered, and Sensitive Species. The plains sharp-tailed grouse is discussed below. No other species were specifically identified during the scoping process; therefore, they are mentioned briefly below, but not analyzed in detail. Mourning doves are abundant in a variety of habitats that occur in the Project Area. Both the gray partridge and ring-necked pheasant occur locally near agricultural lands and along river bottomland. Wild turkeys occur locally in ponderosa pine and shrubby or forested riparian areas. None of these species is specifically monitored or managed for other than through normal hunting seasons.

Plains Sharp-tailed Grouse

The sharp-tailed grouse occurs throughout much of central Canada and from Montana to central Nebraska. This species inhabits short- and mixed-grass prairie, sagebrush shrublands, woodland edges, and river canyons. In Wyoming, this species is locally common where grasslands are intermixed with other shrublands, especially in wooded draws, shrubby riparian areas, and wet meadows (Luce et al. 1999). Species of shrubs that produce berries (such as chokecherry and Russian olive) provide important winter forage for sharp-tailed grouse. Each spring, the males perform elaborate mating dances on historical dancing grounds called leks (Terres 1980). Leks are typically located on hilltops, ridges, or other high points in low, open grassland habitats.

Data provided by the WGFD, Nongame Division, indicate that plains sharp-tailed grouse leks occur primarily in the northern portion of the Project Area, where its preferred habitats are most common. There are 40 documented lek sites in the Project Area. Past surveys have not covered the entire Project Area because of the amount of private land present; therefore, the actual number of leks may be higher. Table 3-51 summarizes the distribution of known lek sites and the amount of each sub-watershed within several protective buffers around each known lek site. No estimate of sharp-tailed grouse populations in the Project Area has been made.

Table 3-51 Sharp-tailed Grouse Lek Sites, Protective Buffers, and Existing Impacts to Protective Buffers by Sub-watershed

	Leks and proportion of the sub-watershed within protective buffers			Proportion of lek sites with oil and gas development within the specified buffer	
Sub-watershed	Sites (no.)	0.25 mile buffer (%)	0.5 mile buffer (%)	0.25 mile buffer (%)	0.5 mile buffer (%)
Little Bighorn River	6	1.5	5.5	0.0	0.0
Upper Tongue River	27	0.5	1.8	3.7	11.1
Middle Fork Powder River	0	0.0	0.0	0.0	0.0
North Fork Powder River	0	0.0	0.0	0.0	0.0
Upper Powder River	0	0.0	0.0	0.0	0.0
South Fork Powder River	0	0.0	0.0	0.0	0.0
Salt Creek	0	0.0	0.0	0.0	0.0
Crazy Woman Creek	0	0.0	0.0	0.0	0.0
Clear Creek	7	0.2	0.7	14.3	14.3
Middle Powder River	0	0.0	0.0	0.0	0.0
Little Powder River	0	0.0	0.0	0.0	0.0
Little Missouri River	0	0.0	0.0	0.0	0.0
Antelope Creek	0	0.0	0.0	0.0	0.0
Dry Fork Chey-enne River	0	0.0	0.0	0.0	0.0
Upper Cheyenne River	0	0.0	0.0	0.0	0.0
Lightning Creek	0	0.0	0.0	0.0	0.0
Upper Belle Fourche River	0	0.0	0.0	0.0	0.0
Middle North Platte River	0	0.0	0.0	0.0	0.0
Total	40	0.1	0.3	5.0	10.0

As a result of past and continuing human activities in the Project Area, substantial areas of sharp-tailed grouse habitat have been altered from their natural conditions. Human disturbances include, but are not limited to, agriculture, mining, roads, urban areas, oil and gas well pads, compressor sites, and other ancillary facilities. The amount of loss of habitats as a result of existing activities is shown by surface owner and sub-watershed in Table 3-19 and Table 3-20. Table 3-51 presents the number of sharp-tailed grouse leks with existing oil and gas development within their protective buffers by sub-watershed. Specific data on roads are not available in sufficient detail to allow comparison with lek locations and are not presented in Table 3-51. Road density is discussed above.

Waterfowl

Suitable waterfowl habitats within the Project Area include major rivers, streams, creeks, draws, lakes, and ponds. These features provide stopover habitats for migrating waterfowl in the spring and fall as well as breeding habitats in the summer months. Waterfowl species that can be expected to occur in the Project Area include Canada goose (*Branta canadensis*), wood duck (*Aix sponsa*), mallard (*Anas platyrhynchos*), gadwall (*Anas strepera*), green-winged teal (*Anas crecca*), American widgeon (*Anas americana*), northern pintail (*Anas acuta*), northern shoveler (*Anas clypeata*), blue-winged teal (*Anas discors*), cinnamon teal (*Anas cyanoptera*), canvasback (*Aythya valisineria*), and redhead (*Aythya americana*). Several wading birds and shorebirds also use similar habitats in the Project Area, including great blue heron (*Ardea herodias*), killdeer (*Charadrius vociferus*), American avocet (*Recurvirostra americana*), black-necked stilt (*Himantopus mexicanus*), spotted sandpiper (*Actitis macularia*), and Wilson's phalarope (*Phalaropus tricolor*) (National Geographic 1999).

The occurrence and distribution of these species are variable and influenced by local conditions such as aquatic habitat, adjacent upland habitat, season, and land use practices. These waterfowl species are expected to occur in suitable habitats within the Project Area during the appropriate species-specific nesting, migration, and wintering seasons. No estimates of population size within the Project Area are available for any of these species.

There is no existing information on the specific impacts of existing oil and gas development on waterfowl. Existing impacts that may have occurred are related to the various methods of water handling. At present, much of the CBM produced water is discharged to surface drainages. Approximately 48,600 acre-feet per year of CBM discharge have been permitted as of the year 2000 in the Project Area (calculated from Table 3-6). Although much of this water evaporates or infiltrates, substantial quantities remain on the surface and have resulted in the expansion of wetlands, stock ponds, and reservoirs, potentially increasing waterfowl breeding and foraging habitats. Produced water in some parts of the Project Area is disposed of in containment reservoirs, which may also provide waterfowl habitats although in many cases appropriate vegetative cover and foraging areas have not developed around these reservoirs. In addition, toxic concentrations of salts may be accumulating in some containment reservoirs, making them unsuitable for use by waterfowl.

Neotropical Migrant Birds

Neotropical migrants are birds that migrate long distances from wintering grounds in the New World tropics of Central and South America to breeding grounds in North America. A wide variety of neotropical migrants uses the Project Area during migration or the breeding season. All habitat types in the Project Area are potentially used by these species; the highest level of use by the most species occurs in the more productive and diverse habitats (for example, forested riparian areas). Shrub-steppe habitats (sagebrush shrublands and other shrublands in part) and shortgrass prairie habitats are both common in the Project Area and are of critical importance to some neotropical migrants (Rothwell 1992). Many species that are of high concern to management because of declining populations use shrub-steppe and shortgrass prairie areas for their primary breeding habitats (Saab and Rich 1997).

In response to concerns about neotropical migrants, the Wyoming Bird Conservation Plan (Cerovski et al. 2001) has identified two groups of high-priority species in Wyoming. A number of these species are addressed elsewhere in this EIS. Table 3-52 lists the migratory bird species of management concern in Wyoming (Cerovski et al. 2001) that are not discussed elsewhere in this document and that are known or expected to occur in the Project Area (Luce et al. 1999). Level I species are those that clearly need conservation action. They include species for which Wyoming has a high percentage of and responsibility for the breeding population. Fourteen other Level I species not included in Table 3-52 are discussed in other sections of this EIS. The remaining three Level I species were determined to not occur, or to occur only rarely, in the Project Area and are not discussed in this EIS. The focus for Level II species is monitoring, rather than active conservation. Nine other level II species not included in Table 3-52 are discussed in other sections of this EIS. The remaining 27 Level II species were determined to not occur, or to occur only rarely, in the Project Area and are not discussed in this EIS. Level III (local interest) and Level IV (not considered priority) species are not discussed in this EIS because they are not high priority (Cerovski et al. 2001); however, a number of these species are of interest for other reasons and are discussed in the appropriate sections of this EIS.

Table 3-52 Migratory Bird Species of Management Concern in Wyoming

Species	Habitats (from Cerovski et al. 2001 and Luce et al. 1999)	Comments (from Luce et al. 1999)	BBS Trend (from Sauer et al. 2001)[1]
Level I species			
McCown's Longspur	Shortgrass prairie, shrub-steppe, eastern great plains and great basin-foothills grasslands, basin-prairie shrublands, agricultural areas.	Nests in a shallow natural or scraped depression on the ground. Feeds on seeds, insects.	WY: Increase – S* US: Increase - NS
Wilson's Phalarope	Wetlands, marshes, lakes, shorelines.	Nests in a lined scrape on damp ground near water. Feeds mostly on aquatic invertebrates, seeds of aquatic plants.	WY: Decrease – NS* US: Decrease - S
Level II species			
Cassin's Kingbird	Juniper woodlands, plains/basin riparian, ponderosa pine savannah, pine-juniper, cottonwood-riparian, cottonwood-dryland, woodland-chaparral, basin-prairie, and mountain-foothills shrublands.	Nests on a horizontal branch near the trunk of a tree. Feeds on insects, berries.	WY: Increase – NS* US: Decrease - NS
Lark Bunting	Shortgrass prairie, shrub-steppe, basin-prairie and mountain-foothills shrublands, eastern great plains and great basin-foothills	Nests on the ground, with the rim of the nest usually flush with the ground. Feeds on in-	WY: Stable - NS US: Decrease -

Table 3-52 Migratory Bird Species of Management Concern in Wyoming

Species	Habitats (from Cerovski et al. 2001 and Luce et al. 1999)	Comments (from Luce et al. 1999)	BBS Trend (from Sauer et al. 2001)[1]
	grasslands, agricultural areas.	sects, especially grasshoppers, seeds.	S
Dickcissel	Shortgrass prairie, eastern great plains grasslands.	Nest is bulky, placed in grass. Feeds on insects, seeds.	WY: Increase – NS* US: Decrease - S
Chestnut-collared Longspur	Shortgrass prairie, eastern great plains and great basin-foothills grasslands, basin-prairie shrublands, agricultural areas.	Nests in a shallow depression on the ground, usually concealed by a tuft of grass. Feeds on insects, seeds.	WY: Decrease - NS* US: Decrease - NS
Willow Flycatcher	Montane riparian, plains/basin riparian, riparian shrub including willow, hawthorne, water birch, alder, below 9,000 feet.	Nests in an upright or slanting fork in a shrub. Feeds primarily on insects, occasionally berries.	WY: Decrease – NS* US: Decrease - NS
Marsh Wren	Wetlands, marshes, drier habitats during migration.	Nest is attached to reeds. Feeds on insects, snails. Abundant in some areas.	WY: Decrease – NS* US: Increase - S
Western Bluebird	Juniper woodland, low elevation conifer, pine-juniper, juniper woodlands, associated with edges.	Often nests in a woodpecker excavated cavity in a snag. Feeds on insects, fruit, some invertebrates.	WY: No trend data available US: Decrease - NS
Grasshopper Sparrow	Shortgrass prairie, shrub-steppe, basin-prairie shrublands, eastern great plains grasslands, wet-moist meadow grasslands, agricultural areas.	Nest is sunk in a slight depression on the ground. Feeds on insects, seeds.	WY: Decrease – NS* US: Decrease - S
Bobolink	Shortgrass prairie, shrub-steppe, basin-prairie shrublands, eastern great plains grasslands, great basin-foothills grasslands, alfalfa, irrigated and native introduced meadows.	Nests in dense cover of forbs in a natural or scraped depression on the ground. Feeds primarily on insects, seeds.	WY: Increase – S* US: Decrease - S
Black-billed Cuckoo	Plains/basin riparian, deciduous and mixed deciduous/coniferous forests, open woodlands, especially cottonwood-riparian, urban areas.	Nest is placed horizontally against a tree trunk, also on a log, occasionally in vine tangles. Feeds primarily on hairy caterpillars, also mollusks, fish, small vertebrates, berries.	WY: Decrease – NS* US: Decrease - S
Vesper Sparrow	Shrub-steppe, basin-prairie and mountain-foothills shrublands, grasslands, agricultural areas.	Nests in an excavated depression on the ground. Food is 50% insects, 50% grass and forb seeds.	WY: Decrease – NS US: Decrease - S
Lark Sparrow	Shrub-steppe, pine-juniper, woodland-chaparral, basin-prairie and mountain-foothills shrublands, grasslands, agricultural areas.	Nests in a hollow depression on the ground, feeds on seeds, insects.	WY: Decrease – NS US: Decrease - S

* Data used for this trend estimate have substantial problems such as very low species abundance, small sample size, and high variance.

[1] S: Trend is statistically significant. NS: Trend is not statistically significant.

Few data are available on population numbers of these species; however, Breeding Bird Survey (BBS) data (Sauer et al. 2001) can be used to determine population trends in a geographic area. There are approximately 15 active BBS routes, as well as data available from two discontinued routes, in the Project Area (Cerovski et al. 2001). This number is too few to support statistically valid estimates of population; however, trends for the State of Wyoming and the United States are shown in Table 3-52. Even at the state scale, estimates for many species are not statistically robust (Sauer et al. 2001). Likewise, no data on existing impacts from oil and gas development are available. Much of the recent CBM development is too recent to have had a measurable effect on populations of migratory birds. Loss and degradation of habitats has likely occurred, as has disturbance to individual birds resulting from construction and production activities. In areas of concentrated development, breeding density of some species may have been reduced because of these and other effects. Species that are specific to grassland and shrub-steppe habitats, and that are sensitive to disturbance and habitat fragmentation have likely been the most affected.

Aquatic Species

The Project Area encompasses all or parts of 18 fourth order watersheds (sub-watersheds) (Figure 1-1). The U.S. EPA Watershed Profile for the State of Wyoming (2002a) was used to identify these sub-watersheds and the rivers, streams, and reservoirs within them. Portions or all of these sub-watersheds are included in Wyoming Game and Fish Department's Water Basin Management Plans (Table 3-53). Additional details about the sub-watersheds are presented in the section on surface water.

Existing disturbances from oil and gas and agriculture occur within the sub-watersheds within the Project Area. Of the 18 sub-watersheds within the Project Area, 10 would receive produced water from CBM wells (Table 2–2). Before 2002, 12,024 wells have been drilled throughout these sub-watersheds, with the majority (77 percent) in three sub-watersheds (Upper Powder River, Little Powder River, and Upper Belle Fourche) (Table 2–2). Recent data on surface water adjudication for the sub-watersheds within the Project Area indicate large withdrawals for irrigation (Table 3-12). During these withdrawals, many riparian ecosystems and habitat for aquatic species in the Upper Tongue River sub-watershed, and others with such major water withdrawals, is changed or significantly altered.

Published journals, agency records (for example, USFWS, BLM, WGFD, and WYNDD), and other available peer-reviewed scientific literature were examined for information on populations and distribution of fish and invertebrates within the Project Area. Information was limited regarding invertebrate populations, patterns of occurrence, and habitats in all, or portions of, the sub-watersheds.

Invertebrate communities can be indicators of the quality of aquatic environments (Peterson 1990). The U.S. Geological Survey sampled invertebrate communities of streams within northeastern Wyoming during the period between 1980 and 1981. Aquatic invertebrates found in this region are generally immature insects, such as nymphs (*Ephemeroptera*), dragonfly and damselfly nymphs

(*Odonata*), caddisfly larvae (*Trichoptera*) and midge, blackfly, deerfly and other true fly larvae (*Diptera*) (Peterson 1990). Beetles (*Coleoptera*) and true bugs (*Hemiptera*) can be aquatic during both juvenile and adult stages. Aquatic invertebrates that are not insects include snails, leeches, aquatic earthworms, and crustaceans.

Three of the four perennial streams sampled during this study supported invertebrate communities that included many taxa adapted to flowing water (Peterson 1990). Salt Creek was the only perennial stream that lacked a well-defined community adapted to flowing water. Ephemeral stream communities generally were composed of taxa adapted to standing water (Peterson 1990).

Within the Project Area, major rivers, creeks, draws, lakes, and ponds support a variety of fish species. Table 3-54 shows the occurrence of fish species by sub-watershed. Presence or absence of fish within a sub-watershed was based on data collected from various Water Basin Management Plans written by the Wyoming Game and Fish Department and a thesis study written by Patton (1997). No information on presence or absence was available in four of the 18 sub-watersheds. Table 3-55 lists preferred habitats and food for fish species identified to occur within the Project Area. Some species occur only in streams and rivers, others occur only in lakes and ponds, while others occur in all four habitat types. A complete review of WGFD sensitive fish species status, distribution, habitat requirements, and life history is provided in the section on Threatened, Endangered, or Sensitive Species.

Table 3-53 Basins and Corresponding Sub-watersheds

Basin	Corresponding Sub-watershed
Powder River Basin	Upper Powder River
	Salt Creek
	Crazy Woman Creek
	Clear Creek
	Middle Powder River
	Middle Fork Powder River
	South Fork Powder River
	North Fork Powder River
Little Powder River Basin	Little Powder River
Tongue River Basin	Upper Tongue River
Cheyenne River Basin	Antelope Creek
	Upper Cheyenne River
	Dry Fork Cheyenne River
	Lightning Creek
Belle Fourche River Basin	Upper Belle Fourche River
Pine Ridge to Nebraska Basin	Middle North Platte River
Little Bighorn River Basin	Little Bighorn River
Little Missouri River Basin	Little Missouri River

Specific data on habitat for many of the streams and rivers within the sub-watersheds of the Project Area were not available; however, general information pertaining to existing conditions for the five major basins was available. Descriptions of the existing conditions for the Powder River Basin, Little Powder River Basin, Tongue River Basin, Belle Fourche River Basin, and Cheyenne River Basin follow.

Powder River Basin

The Powder River is a rare example of a free-flowing prairie stream. No dams exist over its entire length. Including tributaries, the drainage basin encompasses 8,000 square miles. Eight sub-watersheds (Upper Powder River, Salt Creek, Crazy Woman Creek, Middle Powder River, Middle Fork Powder River, South Fork Powder River, and North Fork Powder River) are partially or wholly contained within this basin (Table 3-56). The South Fork Powder, Salt Creek, Clear Creek, and Crazy Woman Creek are all major tributaries to the Powder River. Fifty-two additional intermittent or ephemeral tributaries to the Powder River also exist. Although data on species presence or abundance are lacking for most of these seasonal tributaries, none support game fish and most are believed to hold no fish at all (Bradshaw 1996a).

The Powder River is a low-gradient meandering stream that contains highly fluctuating flows, high turbidity, and a very unstable sand bottom (Hubert 1993). The Powder River is naturally turbid and saline because of its flows through erodible sedimentary material. The macroinvertebrate productivity of the Powder River is low relative to other rivers (Hubert 1993). The Powder River has a typical snowmelt hydrograph driven by accumulations in the southern Bighorn Mountains. Peak flows occur from April through June, and low flows occur from November through February. Flow variation is naturally high and is exacerbated by irrigation withdrawals throughout the drainage. Repeated withdrawal and return of irrigation water undoubtedly contributes to high summer water temperatures that reach 85 to 90°F. Such high water temperatures are lethal to salmonids and may influence diversity of aquatic invertebrates that has been characterized as low (Bradshaw 1996a).

Though occasionally the river clears, it is typically very turbid during spring runoff and after storms. The river is generally shallow and contains portions of shifting streambed composed of fine sands and clays that provide minimal habitat for aquatic invertebrates. Low light penetration through the turbid water also contributes to low aquatic invertebrate production by inhibiting vegetation growth (Bradshaw 1996a).

The Powder River and its tributaries support 32 known fish species, 25 that are native. Most of these species are tolerant of widely fluctuating environmental conditions, such as turbidity, salinity, and water temperature. The common species in the river include flathead chub, sturgeon chub, goldeye, river carpsucker, stonecat, common carp, longnose dace and channel catfish (Table 3-54) (Hubert 1993). Salmonids are captured occasionally in the river and warmwater portions of the tributaries (Smith and Hubert 1989). The game species in the Powder

Table 3-54 Occurrence of Fish Species by Sub-watershed

Fish Species	Sub-watershed																		
Common Name (scientific name)	Wyoming Native Species Status[3]	Little Bighorn River[2]	Upper Tongue River[1,2]	Middle Fork Powder River[1,2]	North Fork Powder River[4]	Upper Powder River[1,2]	South Fork Powder River[1]	Salt Creek[1]	Crazy Woman Creek[1]	Clear Creek[1]	Middle Powder River[1]	Little Powder River[1,2]	Little Missouri River[1,2]	Antelope Creek[4]	Dry Fork Cheyenne River[4]	Upper Cheyenne River[2]	Lightning Creek[4]	Upper Belle Fourche River[1,2]	Middle North Platte[4]
Black bullhead (*Ameirus melas*)(N)	NSS3		X			X					X	X				X		X	
Brassy minnow (*Hybognathus hankinsoni*)(N)	NSS6									X									
Brook trout (*Salvelinus fontinalis*)(I)		X	X	X			X					X						X	
Brown trout (*Salmo trutta*)(I)		X	X	X			X												
Channel catfish (*Ictalurus punctatus*)(N)	NSS4		X			X					X	X							
Common carp (*Cyprinus carpio*)(I)			X			X		X		X	X	X				X		X	
Creek chub (*Semotilus atromaculatus*)(N)	NSS5		X				X	X		X								X	
Cutthroat trout (*Salmo clarki*)(N)		X																	
Fathead minnow (*Pimephales promelas*)(N)	NSS6	X	X			X	X	X	X	X	X	X				X		X	
Flathead chub (*Platygobio gracilis*)(N)	NSS3	X	X	X		X	X	X	X	X	X	X				X			
Golden shiner (*Notemigonus crysoleucas*)(I)			X																
Goldeye (*Wiodon alosodies*)(N)	NSS2					X				X	X	X							
Green sunfish (*Lepomis cyanellus*)(I)			X					X			X	X				X		X	
Lake chub (*Couesius plumbeus*)(N)	NSS3		X									X						X	

Table 3-54 Occurrence of Fish Species by Sub-watershed

Fish Species		Sub-watershed																	
Common Name (scientific name)	Wyoming Native Species Status[3]	Little Bighorn River[2]	Upper Tongue River[1,2]	Middle Fork Powder River[1,2]	North Fork Powder River[4]	Upper Powder River[1,2]	South Fork Powder River[1]	Salt Creek[1]	Crazy Woman Creek[1]	Clear Creek[1]	Middle Powder River[1]	Little Powder River[1,2]	Little Missouri River[1,2]	Antelope Creek[4]	Dry Fork Cheyenne River[4]	Upper Cheyenne River[2]	Lightning Creek[4]	Upper Belle Fourche River[1,2]	Middle North Platte[4]
Largemouth bass (*Micropterus salmoides*)(I)												X							
Longnose dace (*Rhinichthys cataractae*)(N)	NSS7	X	X	X		X	X	X	X	X	X	X				X			
Longnose sucker (*Catostomus catostomus*)(N)	NSS4		X	X						X	X	X							
Mountain sucker (*Catostomus platyrhynchus*)(N)	NSS3		X	X		X	X	X			X	X							
Mountain whitefish (*Prosopium williamsoni*)(N)	NSS4		X					X											
Northern redhorse (*Maxostoma macrolepidotum*)(N)	NSS4		X			X				X	X	X							
Plains killifish (*Fundulus zebrinus*)(N)	NSS6					X	X	X								X			
Plains minnow (*Hybognathus placitus*)(N)	NSS3		X			X	X	X		X	X	X				X		X	
Quillback (*Carpiodes cyprinus*)(N)	NSS4					X													
Rainbow trout (*Oncorhynchus mykiss*)(I)		X	X									X						X	
River carpsucker (*Carpiodes carpio*)(N)	NSS4					X				X	X	X				X			
Rock bass (*Ambloplites rupestris*)(I)			X			X		X		X									
Sand shiner (*Notropis stramineus*)(N)	NSS7		X			X	X	X	X	X	X	X				X		X	

Table 3-54 Occurrence of Fish Species by Sub-watershed

Fish Species		Sub-watershed																	
Common Name (scientific name)	Wyoming Native Species Status[3]	Little Bighorn River[2]	Upper Tongue River[1,2]	Middle Fork Powder River[1,2]	North Fork Powder River[4]	Upper Powder River[1,2]	South Fork Powder River[1]	Salt Creek[1]	Crazy Woman Creek[1]	Clear Creek[1]	Middle Powder River[1]	Little Powder River[1,2]	Little Missouri River[1,2]	Antelope Creek[4]	Dry Fork Cheyenne River[4]	Upper Cheyenne River[2]	Lightning Creek[4]	Upper Belle Fourche River[1,2]	Middle North Platte[4]
Sauger (*Stizostedion canadense*)(N)	NSS2		X			X				X									
Shovelnose sturgeon (*Scaphirhynchus platorynchus*)(N)						X													
Silvery minnow (*Hybognathus nuchalis*)(N)	NSS1										X	X							
Smallmouth bass (*Micropterus dolomieui*)(I)			X							X									
Snake River cutthroat trout (*Oncorhynchus clarki ssp.*)(N)	NSS4		X																
Stonecat (*Notorus flavus*)(N)	NSS4		X	X		X			X	X	X	X							
Sturgeon chub (*Macrhybopsis gelida*)(N)	NSS1					X													
Walleye (*Stizostedion vitreum*)(I)			X																
White crappie (*Pomoxis annularis*)(I)			X																
White sucker (*Catostomus commersoni*)(N)	NSS7		X	X		X	X	X	X	X	X	X						X	
Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*)(N)	NSS2		X																
Yellow perch (*Perca flavescens*)(I)			X																

Notes:

1. Data from Patton, 1997.
2. Data from Wyoming Game and Fish Basin Management Plans (Wiley 2001a). (I) = Introduced species in Wyoming. (N) = Native species in Wyoming.
3. Status 1 Species – Populations are physically isolated and/or exist at extremely low densities throughout range. Habitats are declining or vulnerable. Extirpation appears possible. The Wyoming Game and Fish Commission mitigation category is "Vital." The mitigation objective for this resource category is to realize "no loss of habitat function." Under these guidelines, it would be very important that the project be conducted in a manner that avoids alteration of habitat function. Status 2 Species - Populations are physically isolated and/or exist at extremely low densities throughout range. Habitat conditions appear stable. The Wyoming Game and Fish Commission mitigation category is "Vital." Status 3 Species – Populations are widely distributed throughout its native range and appear stable. However, habitats are declining or vulnerable. The Wyoming Game and Fish Commission mitigation category is "High." The mitigation objective for this category is to realize "no net loss of habitat function within the biological community which encompasses the project site." Under these guidelines, it would be important that the project be conducted in a manner that avoids the impact, enhances similar habitats, or results in the creation of an equal amount of similarly valued fishery habitat. Status 4-7 Species – Populations are widely distributed throughout native range and are stable or expanding. Habitats are also stable. There is no special concern for these species.
4. No data were available for the occurrence of fish species within the sub-watershed.
5. Occurrence data provided by WGFD.

Table 3-55 Preferred Habitats of Fish Species

	Habitat Types[1]			
Common Name	Streams and Rivers (Lotic)	Ponds and Lakes (Lentic)	All Habitats (Lotic and Lentic)	Specific Preferred Habitats and Food
Black bullhead			X	This fish prefers small muddy lakes and can also be found in pools in large and small streams. Food primarily consists of aquatic insects.
Brassy minnow			X	It is common in weedy streams, clear creeks with sand and gravel bottoms and occasionally in lakes. This species is mainly herbivorous but also eats aquatic insects.
Brook trout			X	This fish prefers small, cold streams and beaver ponds, mountain lakes and plains lakes occasionally. Food primarily consists of other fishes, but the diet also includes invertebrates and plankton.
Brown trout	X			This fish prefers larger foothill streams with slower-moving waters. Food primarily consists of other fishes, but the diet also includes invertebrates and plankton.
Channel catfish			X	This fish prefers large clear rivers and tolerates turbid water. It is managed as a game fish in lakes. The channel catfish is omnivorous as an adult, feeding on a wide variety of items including algae, plants, terrestrial insects, dead fish, and garbage.
Common carp			X	The carp prefers lakes, pools and backwaters in rivers. The carp feeds by "rooting" in the mud for bottom-dwelling organisms.
Common shiner	X			The common shiner prefers clear, gravel-bottomed streams. Food primarily consists of aquatic insects.
Creek chub				This species prefers clear, gravel-bottomed creeks. It is rarely abundant in large lakes or rivers. The creek chub is largely carnivorous, feeding on a large variety of animals including insects, crustaceans, and small fish.
Cutthroat trout	X			Cutthroat trout prefer cool mountain streams, preferably of moderate (6 percent or less) gradient. Fingerlings are primarily insectivores feeding frequently at the surface. Adults are more predaceous and prefer other fish species.
X				

Table 3-55 Preferred Habitats of Fish Species

Common Name	Habitat Types[1] Streams and Rivers (Lotic)	Ponds and Lakes (Lentic)	All Habitats (Lotic and Lentic)	Specific Preferred Habitats and Food
Fathead minnow			X	The preferred habitat of this species is slow-flowing, weedy streams and shallow lakes and ponds. The fathead minnow diet consists almost entirely of vegetable matter and some insects.
Flathead chub	X			This species inhabits large silty rivers. It is omnivorous, feeding on insects and some vegetation.
Golden shiner			X	The golden shiner prefers standing or slowly moving water with abundant vegetation. The golden shiner eats an extremely diverse assortment of food such as algae, plant fragments, water fleas, insect larva, and occasionally small fish.
Goldeye			X	The goldeye prefers lakes and streams and is adapted for turbid conditions. It is mainly a surface feeder in shallow water, consuming insects, snails, and other fish, including grasshoppers, moths, fireflies, crustaceans, mollusks, frogs, shrews, mice, trout perch, shiners, darters, and perch.
Green sunfish			X	This fish prefers pools in small to medium-sized streams, small lakes, ponds, and sloughs. Its diet includes insects and small fishes.
Lake chub			X	The lake chub prefers cool foothill streams and sometimes lakes. Food consists of microcrustaceans for young fish and aquatic and terrestrial insects for adults.
Largemouth bass			X	The preferred habitat is larger lakes and backwaters of slow streams with summer water temperatures exceeding 75°F and abundant beds of aquatic vegetation. This species is carnivorous, feeding on golden shiners or bluegills.
Longnose dace			X	The longnose dace prefers riffles in small and large streams. It may be found in lakes, usually around a rocky shoreline. Food of this species consists primarily of aquatic insects, but includes some algae.
Longnose sucker			X	The longnose sucker prefers cold- water lakes, streams and rivers. The food of this fish is almost entirely plant materials.

Table 3-55 Preferred Habitats of Fish Species

Common Name	Habitat Types[1] Streams and Rivers (Lotic)	Ponds and Lakes (Lentic)	All Habitats (Lotic and Lentic)	Specific Preferred Habitats and Food
Mountain sucker			X	The mountain sucker lives in a variety of habitats including larger creeks and rivers at lower elevations, and alpine lakes and streams in the mountains. Food consists almost entirely of algae.
Mountain whitefish	X			Although abundant in some lakes, the mountain whitefish prefers large, cold, clear rivers where it prefers deep, fast water. Mountain whitefish spend much of their time near the bottom of streams and feed mainly on aquatic insect larvae.
Northern redhorse			X	The northern redhorse prefers medium-sized streams and some lakes, where the water is clear and cool. Its diet consists largely of aquatic insects such as midges, mayflies, and caddis flies.
Plains killifish				The plains killifish prefers shallow sandy streams. It is tolerant of high salinities and a shifting sand bottom. It is mostly carnivorous, feeding on insect larvae near the surface and in open water.
Plains minnow X				The plains minnow prefers slower water and side pools in silty streams. It becomes less common in clear streams and is replaced by the silvery minnow in large rivers. The plains minnow is largely herbivorous but its diet also includes some aquatic invertebrates.
Quillback X	X			Quillbacks live in slow-moving pools and backwaters of streams and rivers. They favor a gravel bottom and little silt in the water. They may also be found in lakes and reservoirs. Quillbacks feed on the bottom, with aquatic insect larvae and other small animal organisms forming the bulk of their diet.
Rainbow trout			X	Rainbow trout thrive in well oxygenated, broken rock bottomed waters that are cool and clear. The rainbow trout is somewhat more herbivorous than the cutthroat or the brown trout. Their diet largely consists of algae, insects, and small fish.

Table 3-55 Preferred Habitats of Fish Species

Common Name	Streams and Rivers (Lotic)	Ponds and Lakes (Lentic)	All Habitats (Lotic and Lentic)	Specific Preferred Habitats and Food
	Habitat Types[1]			
River carpsucker	X			The river carpsucker has adapted to living in both clear and turbid rivers and streams. It prefers quiet water, often at the mouths of tributary streams. Its food is principally algae, but includes some small invertebrates.
Rock bass	X			The preferred habitat for this fish is pools in streams that are rubble-bottomed. Food items for this fish include aquatic invertebrates and small fishes.
Sand shiner	X			The sand shiner prefers permanent sandy streams. Its diet includes aquatic insects, plant material, crustaceans, and detritus.
Sauger			X	The sauger prefers large rivers and reservoirs. Adults largely feed on other fishes, while young feed upon aquatic insects and crustaceans.
Shovelnose sturgeon	X			The shovelnose is primarily a river fish, very seldom being found in the absence of a current. Primarily a bottom feeder, shovelnose sturgeon feed principally upon insect larvae, small mollusks, and other bottom organisms.
Silvery minnow	X			The silvery minnow prefers larger rivers and is not common in the smaller silty streams of northeastern Wyoming where the plains minnow is a predominant species. Detailed food studies have not been conducted but bottom ooze and algae have been reported from the stomachs and probably are the main food items.
Smallmouth bass			X	This fish prefers cool, clear rivers and large, cool, clear lakes. The smallmouth bass is almost entirely carnivorous. The fry feed on microcrustaceans, and as they grow larger they shift to small minnows and larger fishes.
Snake River cutthroat trout	X			This cutthroat prefers large swift, streams. Fingerlings are primarily insectivores feeding frequently at the surface. Adults are more predaceous and prefer other fish species.
Stonecat	X			This fish prefers rubble-bottomed streams with large rocks. It feeds on other bottom-dwelling fish and invertebrates.

Table 3-55 Preferred Habitats of Fish Species

Common Name	Habitat Types[1] Streams and Rivers (Lotic)	Ponds and Lakes (Lentic)	All Habitats (Lotic and Lentic)	Specific Preferred Habitats and Food
Sturgeon chub	X			The sturgeon chub prefers swift current areas of channels of large silty rivers, usually to gravel bottoms. Its diet is suspected to be mainly bottom-dwelling invertebrates.
Walleye			X	The walleye prefers clean, cold lakes and clear rivers. Adult walleye feed upon other fishes and some aquatic insects.
White crappie			X	The white crappie prefers larger ponds, reservoirs, and rivers. They are tolerant of a wide variety of conditions, including areas of silt and turbidity. This species is usually found near structures such as fallen trees, stumps, docks, rocks, and aquatic vegetation. The white crappie subsists on microcrustaceans and small fish.
White sucker			X	The white sucker inhabits both lakes and streams and avoids rapid current. It feeds primarily on animal food and predominantly on insects.
Yellow perch			X	Yellow perch prefer lakes, reservoirs, ponds and slow-moving rivers. They are most abundant in nutrient-rich waters with high phytoplankton and macroinvertebrate productivity. They are tolerant of low oxygen conditions. Yellow perch feed on benthic macroinvertebrates and small fish.
Yellowstone cutthroat trout			X	Yellowstone cutthroat trout inhabit relatively clear, cold streams, rivers, and lakes. Fingerlings are primarily insectivores feeding frequently at the surface. Adults are more predaceous and prefer other fish species.

1. Sources: Baxter and Simon 1970, Woodling 1985

River and its tributaries include black bullhead, channel catfish, stonecat, smallmouth bass, rock bass, green sunfish, shovelnose sturgeon, sauger, and walleye (Table 3-57) (Hubert 1993).

Smith and Hubert (1989) divided the fish found within the Powder River and Crazy Woman Creek into four groups: creek residents, creek-river migrants, river residents, and creek-river residents. Creek residents included residents found only in Crazy Woman Creek such as fathead minnow, white sucker, and longnose sucker. River residents occurred only in the Powder River and included shovelnose sturgeon, sturgeon chub, burbot, and sauger. Creek-river residents occurred at all life stages and in all seasons in both the creek and river. These residents included flathead chub, longnose dace, sand shiner, stonecat, and walleye. Creek-river migrants move into Crazy Woman Creek from the Powder River to spawn and then return to the river before summer periods of low discharge. They include goldeye, common carp, river carpsucker, and channel catfish (Smith and Hubert 1989).

The Powder River supports a diverse fish fauna of mostly native, nongame species, but specific life history information is lacking for most main-stem Powder River fishes. Sturgeon chub, once endemic to several Wyoming rivers but now found only in the Powder River, is considered rare (NSS1) by the WGFD. In April 2001, USFWS ruled that it would not list the sturgeon chub (*Macrhybopsis gelida*) as endangered under the Endangered Species Act of 1973 (USFWS 2001c). Studies conducted since 1994 using benthic trawls designed to collect small fish from deep-water areas of the border and main channel have provided new information about the distribution and relative abundance of sturgeon chub. Although the chub has suffered a reduction in its range, the status surveys determined that it currently has a wider distribution than previously thought, and numerous populations appear to be viable throughout its range (USFWS 2001c). This spring spawner is found over swift rocky riffles throughout the Powder River (Bradshaw 1996a). The amount of CBM water involved with the potential depletions is not expected to be of a sufficient magnitude to suggest major impacts to the sturgeon chub (USFWS 2001c).

Until 1978, the shovelnose sturgeon was considered rare; however, more recently it has been recognized as a fairly common seasonal migrant from the Yellowstone River in Montana. When they are present in the Powder River during the spring, a small, but unknown, number of fish are taken by anglers. Shovelnose sturgeon are known to use Clear Creek and Crazy Woman Creek for spawning but, because of difficulties in sampling, it is unknown if they use the Powder River for spawning or to what distance they ascend the river (Bradshaw 1996a).

Salt Creek is a major tributary of the Powder River and, during low-flow periods, contributes the majority of the flow to the Powder River. Stream flows in Salt Creek are augmented by water discharged from oil and gas wells drilled in the Salt Creek Field near Midwest, Wyoming. This water contains elevated levels of TDS, chlorides, sulfates, and sodium. Depending on the time of year, these constituents can be diluted quickly after Salt Creek joins the Powder River or may remain at elevated levels during low-flow periods. Although fish in Salt Creek apparently do not suffer from elevated chemical constituents or the small amounts of oil found in the water, toxicity for zooplankton (*Cereodaphnia* spp.) and fathead minnows has been documented (Bradshaw 1996a).

Extreme fluctuation in streamflow and temperature, low aquatic invertebrate production, high turbidity and dissolved solids, and an unstable streambed limit the population viability of salmonids and most Wyoming gamefish. Consequently, sportfish management options are limited. Similar conditions prevail in the tributaries of the Powder River (Bradshaw 1996a).

Virtually all of the bottomland and riparian areas of the Powder River Basin are privately owned. Public lands, usually sagebrush or grasslands in uplands adjacent to the river, are managed by the BLM and are concentrated in the PRB about midway down the Powder River and in the upper reach of the South Fork Powder River (Bradshaw 1996a). Historically, the PRB was used extensively and almost exclusively for cattle and sheep grazing. Oil and gas developments and recently developed coal mines have become dominant land uses over the past 80 years (Bradshaw 1996a).

Little Powder River Basin

The Little Powder River Drainage Basin covers 1,836 square miles. The Little Powder River Drainage Basin contains the entire Little Powder River subwatershed. Roughly 10 percent of the drainage basin is public land, including National Grasslands, BLM, and State of Wyoming lands. Elevation in the drainage ranges from 3,340 feet at the Wyoming-Montana border to 4,900 feet on the Belle Fourche-Little Powder hydrographic divide near Gillette (Stewart 1996).

Flowing water in this drainage is restricted to three stream reaches, all of which are on private land. The Little Powder River and a short reach of the Dry Fork of the Little Powder River below its confluence with Moyer Springs Creek are perennial. The only coldwater habitat in the drainage is Moyer Springs Creek, a 0.5-mile reach of stream that contains a wild brook trout population with flows usually less than 1 cfs. There is no perennial water in any of the other tributary streams in the drainage. Only one small standing lake, Weston Reservoir (Little Powder Reservoir) is suitable for gamefish and is on accessible public land (Stewart 1996).

Aquatic invertebrate communities were sampled near the headwaters of the Little Powder River from 1980 to 1981 (Peterson 1990). The riffle samples were dominated by invertebrates that are adapted to flowing waters, such as *Cheumatopsyche* (Trichoptera). The mayflies *Caenis* and *Choroterpes*, the midge *Cricotpous*, the creeping water bug *Ambrysus*, the snail *Physa*, and fingernail clams were also present but not in large numbers (Peterson 1990). The runs supported smaller numbers of benthic invertebrates than the riffles. Invertebrates found only in the runs included the beetle *Optioservus*, the biting midge *Palpomyia*, the moth fly *Pericoma*, the cranefly *Tipula*, and the Muscid fly *Limnophora*. The pools generally supported larger densities of invertebrates than the riffles and runs. The dominant invertebrate in the pool samples was the scud *Hyallela azteca*. The midge *Tanytarsus*, the beetle larvae *Dubiraphia*, the mayfly *Caenis*, the caddisfly

Polycentropus, the damselfly *Ishnura*, the snail *Gyralus,* the diving beetle larvae *Deronectes*, and mites were also present.

Habitats for fish are limited in this drainage because of the low mean annual water balance and overall small size of the ephemeral streams during extreme low water periods, Habitat may be restricted to large pools that become isolated when streamflows cease. Many standing waters do not consistently support fish populations because of drying or low water levels during drought periods. The low water levels contribute to winter kill or summer die-offs. Populations of channel catfish exist in the lower Little Powder River, but the potential for a sport fishery is very low because of the stream's small size. There are several limiting factors in the Little Powder River Basin. Lack of water limits fish habitats and low-water conditions in standing waters and lack of perennial flow in most of the drainage limits sport fishery potential and indigenous fishes in the basin (Stewart 1996).

The fish assemblage in the Little Powder River basin in northeast Wyoming is limited because of a lack of habitat and low flow. The northern three-fourths of the Little Powder River Basin flow through habitats of sagebrush steppe and ponderosa forest, whereas the southern one-fourth flows through mixed-grass prairie. Land use in the basin is primarily livestock grazing with hay production in the valleys and riparian areas (Stewart 1996).

Tongue River Basin

The assemblage of fish in the Tongue River Drainage Basin in north-central Wyoming is diverse. Streams in the headwaters contain Snake River cutthroat trout, rainbow, brown, and brook trout, whereas a reach of the lower river contains sauger and smallmouth bass. The headwaters of the Tongue River drainage originate on the east side of the hydrographic divide of the Bighorn National Forest. After the North and South Tongue Rivers join to form the main stem Tongue River, the flow is primarily east and north until the Tongue River enters Montana. The Upper Tongue River sub-watershed is contained within the Tongue River Basin. Standing waters in this basin are primarily privately owned ponds, many of which are unsuitable for supporting fish populations. Elevations in the Tongue River drainage vary from 3,470 feet to10,046 feet (Stewart 1995).

The South Tongue and North Tongue Rivers are conducive to natural reproduction of trout. Suitable spawning habitat for sauger, smallmouth bass, stonecats, rockbass, mountain whitefish and other native and non-native nongame species exists on the Lower Tongue River (Stewart 1995). Although some of these streams support suitable trout spawning habitat, much of this drainage basin supports native and non-native game fish.

The absence or scarcity of deep pools in several of the headwater tributary streams limits the habitat diversity and potential for populations of larger fish. Sedimentation limits natural production of fish and macroinvertebrates in many streams, especially the Upper North Tongue River. Irrigation diversions reduce flows on many streams, and these reduced flows usually occur during critical life stages of fish and macroinvertebrates. From Interstate 90 downstream to the border, irrigation diversions form barriers that impede seasonal upstream movements of channel catfish, sauger, and smallmouth bass, as well as certain nongame species. Fish, especially channel catfish, move downstream in the fall and winter in Tongue River Reservoir in Montana, and the barriers impede upstream movement during spring (Stewart 1995).

The area surrounding the North and South Tongue Rivers is predominantly conifer and alpine meadows with extensive willow complexes in some riparian areas. Logging, livestock grazing, and road building have accelerated the natural erosion process that contributes silt to the system. The Tongue River flows through a canyon for several miles before it exits onto the plains near the Bighorn National Forest boundary at the town of Dayton. From Dayton to the state line, it flows through an alluvial floodplain. Land use on this floodplain is predominantly agriculture, but residential development and one coalmine also exist (Stewart 1995).

Belle Fourche River Basin

The Belle Fourche River Drainage Basin covers over 3,762 square miles. Elevations in the drainage range from 3,100 feet in the northeast corner of Crook County at the Wyoming-South Dakota state line to 6,645 feet at Warren Peak. The Upper Belle Fourche River sub-watershed is entirely within Campbell County in the western portion of the Belle Fourche River Drainage Basin (Figure 1-1). The topography is mostly rolling grasslands and sagebrush. The principal use of the drainage basin is for livestock grazing and hay production. Water diversions for irrigation are common. Other uses common in the drainage basin include oil and gas production, timbering, mining for coal and bentonite, and recreation (McDowell 1996a).

Most of the streams are unsuitable for coldwater fish and offer limited potential for warmwater game fish because of water diversion and lack of suitable habitat. Beaver ponds on some minimal flow streams provide localized trout habitat and many of the small streams in the Black Hills depend on beaver ponds to provide habitat for fish; however, flash flood events or heavy sedimentation periodically eliminate these ponds for fisheries. Only four streams in the drainage basin contain self-sustaining trout populations, and none is located in the Upper Belle Fourche River sub-watershed within the Project Area. Instead, these streams are located within the Black Hills National Forest and include Sand Creek, Spottedtail Creek, Cold Springs Creek, and Ogden Creek. The majority of the potential for game fish exists in the numerous farm ponds and reservoirs, but many are subject to periodic winter or summer kills because of limited water availability. Many of the farm ponds and privately owned reservoirs contain stunted populations of bullhead or green sunfish. The largest lentic fishery in the drainage is Keyhole Reservoir (McDowell 1996a). There is a general lack of accurate data on fish population and habitat in portions of the drainage basin. This lack of data limits information on distribution of fish, particularly for non-native game fish (McDowell 1996a)

Suitable habitats for game fish are minimal in the Belle Fourche River Drainage Basin because of the small size and low flow of the Belle Fourche River and its tributaries. Small reservoir impoundments are abundant in this drainage, and game fish habitats are restricted to small impoundments and to a relatively few stream segments. Fish habitats in many streams are mainly confined to pools that may be isolated during extreme low-water conditions. Lentic water habitats are limited by drought periods, drawdowns for irrigation, and stock watering. Shallow depths of lentic habitat often limit overwintering for fish, periodically resulting in partial or complete winterkills (McDowell 1996a).

Existing limiting factors for the production of game fish in the Belle Fourche River Basin include low oxygen and high temperatures during periods of low flow, cattle grazing impacts (that is, nutrient enrichment, compacting and devegetation of upland and riparian areas leading to increased erosion and siltation), and invasion of exotic species (McDowell 1996a).

Cheyenne River Basin

The Upper Cheyenne River qualifies as one of Wyoming's free-flowing prairie streams because it is not dammed until it reaches Angostura Reservoir in South Dakota. The surface area of the basin is 5,160 square miles. The basin contains the southern end of the Black Hills, the breaks of the Rochelle Hills south of Gillette, and the rolling hills and grasslands north of Lusk. The drainage basin contains four sub-watersheds (Antelope Creek, Upper Cheyenne River, Dry Fork Cheyenne River, and Lightning Creek) that are within Campbell and Converse Counties of the Project Area (Figure 1-1). Elevations range from 3,500 feet where the river enters South Dakota to 6,000 feet in the sand hills of Converse County. Sagebrush and grasslands are the predominant vegetation types in the basin, with ponderosa pine in the Black Hills and Rochelle Hills (Bradshaw 1996b).

Virtually all of the bottomland and riparian areas of the Cheyenne River are privately owned; however, about 45 percent of the basin is public land managed by the BLM, FS, and State Land and Farm Loan Office. Major land uses include oil and gas development, bentonite mining, and livestock grazing and associated irrigation diversions, reservoirs, and stock ponds (Bradshaw 1996b).

Existing limiting factors for the Cheyenne River Basin, such as extreme fluctuation in streamflow and temperature, low aquatic invertebrate production, and high turbidity, limit the ability of most streams to support game fish, particularly cold- and cool-water species. Little is known of the habitat requirements, relative abundance, or spatial distribution of indigenous fish in the Cheyenne River Basin. There is no baseline that can be used to measure trends in the population of indigenous fish. There have been repeated illegal introductions of Green sunfish and black bullhead into waters where they become overabundant, precluding game species and native non-game species from some areas (Bradshaw 1996b).

The hydrograph for the Upper Cheyenne River is driven by low-elevation accumulations of snow, seasonal rainfall, and periodic storms. Flows cease during most years near the South Dakota state line. The repeated withdrawal, warming, and return of irrigation water undoubtedly contributes to high water temperatures that reach 70 to 80ºF during the summer. The Cheyenne River and many of its tributaries flow through erodible shales, claystones, sandstones, and bentonite deposits. This underlying geology causes most basin streams to be generally turbid, particularly during runoff or after storms. Turbidity prevents light penetration needed for growing aquatic vegetation, channel instability, and high temperatures probably inhibiting aquatic macroinvertebrate production and creating an environment hostile to fish species that are not adapted to such conditions (for example, game fish) (Bradshaw 1996b).

The Lower Cheyenne River becomes intermittent in most years. Because the Cheyenne River and major tributaries are intermittent most years, the drainage has been considered unsuitable for game fish, but Patton (1997) confirmed the presence of green sunfish and black bullhead in Beaver Creek. Within the Upper Cheyenne River drainage, there are 56 other tributaries WGFD considers unsuitable to support game fish (Bradshaw 1996b).

North Platte River — Pine Ridge to Nebraska Basin

The Middle North Platte Casper sub-watershed is contained within a small portion of this basin (northwest corner) and includes watercourses such as Sage Creek and Sand Creek. The area on the north side of the North Platte River is arid with typical plains streams (Deromedi 1996). The streams within this basin are generally small and flows are intermittent or low throughout the year (Deromedi 1996). They flow through low-gradient sandy and silty soils that are generally not suitable habitat for game fish species. Because fishing pressure is low and access is limited, no trout have been stocked in this basin for many years (Deromedi 1996).

Little Bighorn River Basin

The topography of the Little Bighorn River Basin is variable. The upper drainage is mountainous, with deeply incised canyons, coniferous forest, and alpine meadows. At lower elevations, the topography consists of rolling hills and valleys used primarily as irrigated hay and livestock pasture (McDowell 1996b). The Little Bighorn River sub-watershed within the Project Area is at the northern tip of the basin and is exclusively located in the lower elevations. It contains portions of a few small watercourses such as Lodgegrass Creek, Stockade Creek, East Pass Creek, West Pass Creek, and East Twin Creek.

The Little Bighorn River Basin is a tributary to the Yellowstone River and historical range for native Yellowstone cutthroat trout (McDowell 1996b). Because of the remoteness of part of the drainage basin, especially the West Fork of the Little Bighorn River Basin, fishery surveys have been limited and data are lacking to evaluate the presence of endemic populations of Yellowstone Cutthroat Trout (McDowell 1996b).

Lodgegrass Creek is a tributary that enters the Little Bighorn River in Montana. Livestock grazing is the predominant commercial use and access is typically via foot or horseback. The stream channel is rocky and relatively steep gradient with scattered pools and dense riparian vegetation (McDowell 1996b). Lodgegrass Creek has been historically stocked with rainbow trout, cutthroat trout, and brook trout.

East Pass and West Pass Creek have historically been stocked with rainbow trout, brook trout, and brown trout. Gay Creek, a tributary to West Pass Creek, may be capable of supporting trout but none were found during the last recorded survey in 1982 (McDowell 1996b). Stockade Creek, a tributary to Gay Creek, has limited habitat for trout because of high turbidity and warm water. Flow in Twin Creek, a tributary to East Pass Creek, is insufficient to support trout. Electrofishing surveys conducted in 1958 found small dace, fathead minnows, and numerous suckers and cyprinids (McDowell 1996b).

Little Missouri River Basin

The Little Missouri River Drainage Basin covers 735 square miles of northeastern Wyoming. Although some state and federal land is present, no public access is available to flowing water within the basin (McDowell 1996c). The majority of the drainage basin is contained within Crook County except for some very small sections in Campbell County (McDowell 1996c). These small sections within Campbell County contain the Little Missouri River sub-watershed within the Project Area (Figure 1-1).

The majority of the drainage basin area is sagebrush and grassland, with ponderosa pine along the ridges and breaks of low rolling hills (McDowell 1996c). Livestock production is the primary land use within the drainage basin. Small stock water ponds and irrigation reservoirs provide the majority of fisheries habitat (McDowell 1996c). WGFD listed the majority of the waterbodies and watercourses in this drainage basin as unsuitable for sustaining a fishery (McDowell 1996c).

Threatened, Endangered, or Sensitive Species

Regional Characterization

This section briefly discusses the biology of species that have been afforded special status by federal and state agencies including USFWS, FS, BLM, and WGFD. The special status designations include:

- Species listed as threatened or endangered, proposed for listing as threatened or endangered, or considered as a candidate for listing as threatened or endangered by the USFWS,
- Species listed as sensitive by the BLM or FS, and
- Species categorized by WGFD as NSS 1, NSS 2, and NSS 3, which have the highest priority for conservation of the species on the state sensitive list.

The ESA directs USFWS to identify and protect threatened and endangered plant and animal species. The ESA identifies the following categories to rank listed and candidate species.

The term “endangered species” means any species that is in danger of extinction throughout all or a significant portion of its range [(ESA §3(6)]. In addition to determining that a species would be listed as endangered, the USFWS may also designate critical habitat for a species as defined in section 3(5) of the ESA [ESA §4(b)(6)(C)].

Except as provided in sections 6(g)(2) and 10 of the ESA, with respect to any endangered species of fish or wildlife listed pursuant to Section 4 of the ESA, it is unlawful for any person subject to the jurisdiction of the United States to import, export, take, possess, deliver, receive, carry, transport, ship, or sell or offer for sale any such species, or violate any regulation pertaining to such species [ESA §9(a)(1)(A-G)]. The term “take” means to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct [ESA §3(18)].

Except as provided in sections 6(g)(2) and 10 of the ESA, with respect to any endangered species of plant listed pursuant to section 4 of the ESA it is unlawful for any person subject to the jurisdiction of the United States to import, export, remove and reduce to possession, maliciously damage or destroy, remove, cut, dig up, deliver, receive, carry, transport, ship, or sell or offer for sale any such species, or violate any regulation pertaining to such species [ESA §9(a)(2)(A-E)].

The term “threatened species” means any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range [ESA §3(19)]. In addition to determining that a species would be listed as threatened, the USFWS may also designate critical habitat for a species as defined in section 3(5) of the ESA [ESA §4(b)(6)(C)].

Whenever a species is listed as threatened pursuant to section 4(c) of the ESA, the USFWS shall issue such regulations as deemed necessary and advisable to provide for the conservation of such species. The USFWS may by regulation prohibit any act prohibited under section 9(a)(1) for fish and wildlife species, or section 9(a)(2) for plant species with respect to endangered species [ESA §4(d)]. In general, equivalent protections are given for threatened species as are given for endangered species, based on the USFWS’ implementing regulations for threatened species (50 CFR 17.31).

Proposed species are species for which USFWS has published a proposed rule for listing under the provisions of section 4(b)(5) of the ESA. USFWS has 12 months to act on such a proposal, although this period may be extended in cases where additional information is needed to complete the listing package, or where other priorities postpone completion of the listing package.

Candidate species are those species for which the USFWS has sufficient information on biological vulnerability and threats to warrant issuance of a proposed rule for listing, but for which publication of a proposed rule for listing is precluded by other higher priority listing actions (“warranted but precluded”). The candidate list also includes all species for which a petition finding of warranted but precluded has been issued. For example, a petition was submitted to USFWS requesting that the black-tailed prairie dog be listed as threatened. USFWS has ruled that it has sufficient information to list the black-tailed prairie dog, but that other listing priorities preclude the issuance of a proposal to list the black-tailed prairie dog (USFWS 2000). The candidate list is reviewed on an annual basis; most recent findings were issued on June 13, 2002 (USFWS 2002a).

Candidate species are not afforded any federal statutory protections until a proposed rule for listing is published. Nevertheless, candidate species are often considered during project development to avoid the need for additional consultation and the potential for project delays in the event that a species is proposed for listing, or listed, before the project is complete.

The National Forest Management Act includes provisions which state that the maintenance of biodiversity must be considered in managing National Forest lands. Forest Service Manual 2670.22 requires the FS to maintain viable populations of all native and desired non-native wildlife, fish, and plants in habitats distributed throughout their geographic range on National Forest System lands. In recognition of the need to specially manage rare plants and animals on the lands that it administers, the FS designates certain species as sensitive. Specific management requirements and standards are often implemented for sensitive species in individual Forest Plans. The FS sensitive species are provided protection only in situations where the agency has some control over activities.

The FLPMA requires that the BLM manage the public lands in a manner that would protect the quality of scientific, ecological, and environmental values (including native plants and animals) and that would protect certain public lands in their natural condition.

BLM Manual 6840 states that BLM policy requires management consistent with the principles of multiple use for the conservation of candidate plant and animal species and their habitats and to ensure that actions authorized, funded, or carried out do not contribute to the need to list any of these species as threatened or endangered.

The BLM has developed a policy and list for sensitive species on public lands in Wyoming. Under this policy, State BLM Directors may designate sensitive species, usually in cooperation with the state wildlife agency. By definition, the designation includes species that could easily become endangered or extinct in the state. Therefore, if the state director designates sensitive species then the protection provided by the policy for candidate species shall be used as the minimum level of protection.

WGFD has developed a matrix of habitat and population variables to determine the conservation priority of all native species of fish, breeding birds, and mammals in the state. Seven classes of native Species Status Categories recognized; classes 1, 2, and 3 are considered high priorities for conservation attention. These three highest priority designations are defined here.

- NSS1: Includes species with ongoing significant loss of habitat and with populations that are greatly restricted or declining (extirpation appears possible).

- NSS2: Species in which (1) habitat is restricted or vulnerable (but no recent or significant loss has occurred) and populations are greatly restricted or declining; or (2) species with on-going significant loss of habitat and populations that are declining or restricted in numbers and distribution (but extirpation is not imminent).

- NSS3: Species in which (1) habitat is not restricted, but populations are greatly restricted or declining (extirpation appears possible); or (2) habitat is restricted or vulnerable (but no recent or significant loss has occurred) and populations are declining or restricted in numbers or distribution (but extirpation is not imminent); or (3) significant habitat loss is on-going but the species is widely distributed and population trends are thought to be stable.

Much of the information available for the following special status species is restricted to public lands, including lands administered by BLM, FS, and USFWS. Unfortunately, similar information is generally not available for privately owned lands. Therefore, the occurrence of the following special status species is unverified for much of the privately owned lands within the Project Area. Although unverified, sensitive species would be assumed to occur in all suitable habitats within the Project Area, despite land ownership, for this assessment. Published reports from the WGFD, *Atlas of Birds, Mammals, Reptiles, and Amphibians in Wyoming* (Luce et al. 1999) and *Threatened, Endangered, and Nongame Bird and Mammal Investigations* (Cerovski et al. 2000), *Mammals in Wyoming* (Clark and Stromberg 1987), and *Wyoming Fishes* (Baxter and Simon 1970) were relied on heavily for general information on the occurrence of species within the Project Area.

USFWS Listed Species

In a letter dated June 5, 2001, USFWS acknowledged that the list of threatened or endangered species, threatened, endangered, or proposed, that may occur within the Project Area that were included in an earlier letter dated June 5, 2000, are appropriate for evaluation, with the exception of the swift fox and sturgeon chub (USFWS 2001a, c). After the June 5, 2000, letter was drafted, USFWS announced that listing of the swift fox and sturgeon chub was not warranted. USFWS identified the following threatened, endangered, or proposed species in a letter dated June 5, 2000 (status is indicated as provided in June 5, 2000 letter):

- Black-footed ferret (endangered)

- Bald eagle (threatened)

- Ute ladies'-tresses (threatened)

- Mountain plover (proposed)

Other federally listed and candidate species, including Preble's meadow jumping mouse (threatened), black-tailed prairie dog (candidate), and boreal toad (candidate), were not included in the June 5, 2000 letter from USFWS but were assessed in this report. In addition, USFWS has recently received two petitions for listing the greater sage grouse, including the population in the Project Area. USFWS has not yet ruled on these petitions (Deibert 2002).

Black-footed Ferret

Black-footed ferret (*Mustela nigripes*) is listed as a federally endangered species (USFWS 1970). The black-footed ferret historically occurred throughout Texas, Oklahoma, New Mexico, Arizona, Utah, Kansas, North and South Dakota, Montana, Wyoming, Nebraska, and Colorado. The black-footed ferret is closely associated with prairie dogs, depending almost entirely upon the prairie dog for its survival. The decline in populations of the ferret has been attributed to the reduction in the extensive prairie dog colonies that historically existed in the western United States. Ferrets may occur within colonies of white-tailed or black-tailed prairie dogs. USFWS has concluded that, at a minimum, potential habitat for the black-footed ferret must include a single white-tailed prairie dog colony of more than 200 acres, or a complex of smaller colonies within a 4.3 mile (7 kilometer) radius totaling 200 acres (USFWS 1989). The minimum colony size for black-tailed prairie dog is 80 acres (USFWS 1989). The last known wild population of black-footed ferrets was discovered in Meeteetse, Wyoming. Individuals from this population were captured and raised in protective captive breeding facilities in an effort to prevent extinction (Clark and Stromberg 1987).

Recent survey efforts in the Shirley Basin have identified a population at this former re-introduction site. This population is the only known in Wyoming. Extensive efforts have failed to identify any existing wild populations of this species within the Project Area (Marinari 2001). This species is not expected to occur within the Project Area.

Bald Eagle

The bald eagle (*Haliaeetus leucocephalus*) was listed as endangered on February 14, 1978, in all of the conterminous United States with the exception of Minnesota, Wisconsin, Michigan, Oregon, and Washington, where it was classified as threatened (USFWS 1978). On July 12, 1995, the U.S. Fish and Wildlife Service (USFWS) reclassified the bald eagle from endangered to threatened throughout its range in the lower 48 states (USFWS 1995). Most recently, on July 6, 1999, the bald eagle was proposed for deslisting (USFWS 1999). This proposal has not been finalized or withdrawn to date. Bald eagles occur throughout North America from Alaska to Newfoundland, and from the southern tip of Florida to southern California. In Wyoming, this species builds large nests in the crown of large mature trees such as cottonwoods or pines. The availability of food is probably the single most important determining factor for distribution and abundance of bald eagles. Fish and waterfowl are the primary sources of food where eagles occur along rivers and lakes. Big game and livestock carrion, as well as larger rodents (for example, prairie dogs) also can be important dietary components where these resources are available (Ehrlich et al. 1988). This species is an uncommon breeding resident in Wyoming, using mixed coniferous and mature cottonwood-riparian areas near large lakes or rivers as nesting habitat (Luce et al. 1999). As reported in the WGFD *Annual Completion Report 2000* (Cerovski et al. 2000), there were 97 nesting attempts in the state 1999. This number of nest attempts is the highest recorded since 1978. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant positive trend for populations of this species in Wyoming during the period between 1996 and 2001. The trend for the United States, during the same period, is highly significant and positive.

Eagles are expected to winter within areas of suitable habitat within the Project Area. Feeding areas, diurnal perches, and night roosts are fundamental elements of bald eagle winter habitats. Although eagles can fly as far as 15 miles (24 kilometers) to and from these elements, they primarily occur where all three elements are available in comparatively close proximity (Swisher 1964). The availability of food is probably the single most important factor in the winter distribution and abundance of the eagle (Steenhof 1978). Typically, fish and waterfowl are the primary sources of food where eagles occur along rivers, lakes, streams, and dams. In Wyoming, the availability of carrion, including big game and livestock, is an important winter food source for wintering bald eagles.

This species is a documented breeder and winter resident of suitable habitats within the Project Area (Luce et al. 1999). Twelve active nests are known from within the Project Area, with seven nests within the Buffalo Field Office (FO) and one within the Casper FO. WGFD has also identified numerous winter roosts in the Project Area. The population of the bald eagle within the Project Area is expected to increase during the winter, when migrating individuals and winter residents use roosts sites and suitable foraging areas. Winter roost sites are typically associated with large cottonwood galleries or coniferous trees located along rivers, streams, or reservoirs. In Wyoming, the diet of bald eagles is more varied than in other regions where fish are the primary food source. Wyoming grassland and shrubland habitats include a variety of suitable bald eagle prey species, including prairie dogs, lagomorphs, and big game and livestock carrion. Fish and waterfowl are also preyed upon, when available.

Preble's Meadow Jumping Mouse

Preble's meadow jumping mouse (PMJM) (*Zapus hudsonius preblei*) was listed as a federally threatened species in 1998 by USFWS (USFWS 1998). It is endemic to the Colorado Piedmont east of the Front Range in east-central Colorado, along the Laramie Mountains in southeastern Wyoming, and following the North Platte River to Douglas, Wyoming (USFWS 1998).

Little is known about the habitat requirements of PMJM except what has been revealed in recent unpublished reports and anecdotal information from studies of small mammals in riparian areas. Apparently, this subspecies is restricted to multi-strata, streamside vegetation often in association with willows (*Salix* spp.) and in areas of thick herbaceous undergrowth. Other studies of meadow jumping mice in the eastern half of North America have reported habitat associations with grassy vegetation of adequate herbaceous ground cover (Whitaker 1963) and moist lowlands areas as opposed to mesic uplands (Quimby 1951).

In Wyoming, PMJM have been documented in two counties: along Crow Creek at F.E. Warren Air Force Base (Laramie County), and in the Lodgepole Creek drainage within the Medicine Bow National Forest (Albany County) (USFWS 1998). Northern and eastern distribution limits for this species are not firmly established. A recent report published by Wyoming Natural Diversity Database states that this species has been documented in the North Platte and South Platte River basins, with collection sites as far north as the town of Douglas, west to the town of Boxelder, and east to the vicinity of Slater (Beauvais 2001). This report also states that surveys for members of the same genus on the Thunder Basin National Grasslands were conducted in 2000 with no captures. This species is not expected to occur within the Project Area.

Ute ladies'-tresses Orchid

Ute ladies'-tresses orchid (*Spiranthes diluvialis*), listed as a federally threatened species, is a perennial herb with erect, glandular-pubescent stems 12 to 50 centimeters tall arising from tuberous-thickened roots (USFWS 1992). This species flowers from late July to September. Plants probably do not flower every year and may remain dormant below ground during drought years. It is currently known from western Nebraska, southeastern Wyoming, north-central Colorado, northeastern and southern Utah, east-central Idaho, southwestern Montana, and central Washington. In Wyoming, the Ute ladies'-tresses orchid is known from the western Great Plains in Converse, Goshen, Laramie, and Niobrara counties. Rangewide, the Ute ladies'-tresses orchid occurs primarily on moist, subirrigated or seasonally flooded soils in valley bottoms, gravel bars, old oxbows, or floodplains bordering springs, lakes, rivers, or perennial streams at elevations between 1,780 and 6,800 feet (Fertig 2000a). Suitable soils vary from sandy or coarse, cobbley alluvium to calcareous, histic, or fine-textured clays and loams. Populations have been documented from alkaline sedge meadows, riverine floodplains, flooded alkaline meadows adjacent to ponderosa pine, Douglas fir woodlands, sagebrush steppe, and streamside floodplains. Some occurrences are also found on agricultural lands managed for winter or early season grazing or hay production. Known sites often have low vegetative cover and may be subjected to periodic disturbances such as flooding or grazing. Populations are often dynamic and "move" within a watershed as disturbances create new habitat or succession eliminates old habitat (Fertig and Beauvais 1999).

This species is known from four occurrences in Wyoming, all discovered between 1993 and 1997 (Fertig 2000b). As reported by Fertig (2000b), the only population known to occur within the Project Area is located in Converse County, along a tributary of Antelope Creek.The Casper Field Office of the BLM administers the land at this location. This population is characterized as stable, with the number of observed individual plants varying between 11 and 35 during the period between 1990 and 1994. The three remaining populations found outside of the Project Area are located in Goshen, Niobrara, and Laramie Counties and are located on lands owned by the State of Wyoming and private parties. These populations are characterized as stable to increasing.

Mountain Plover

The mountain plover (*Charadrius montanus*) was proposed for federal listing in 1999 (USFWS 1999a). USFWS has 60 days after the proposal is received to seek input from three species experts, the public, scientific community, and federal and state agencies. USFWS published a 60-day extension to the comment period on April 19, 1999 (USFWS 1999a). As of June 13, 2002, USFWS designated the mountain plover as a proposed threatened species (USFWS 2001a).

This species uses high, dry, shortgrass prairie with vegetation typically shorter than four inches tall. Within this habitat, areas of blue grama (*Bouteloua gracilis*) and buffalo grass (*Buchloe dactyloides*) are most often used, as well as areas of mixed-grass associations dominated by needle-and-thread (*Hesperostipa comata*) and blue grama (Dinsmore 1983).

Nests consist of a small scrape on flat ground in open areas. Most nests are placed in April on slopes of less than 5 degrees in areas where vegetation is less than 3 inches tall. More than half of identified nests occurred within 12 inches of old cow manure piles and almost 20 percent were found against old manure piles in similar habitats in Colorado. Nests in similar habitats in Montana (Dinsmore 1983) and other areas (Ehrlich et al. 1988) were nearly always associated with the heavily grazed short-grass vegetation of prairie dog colonies.

Mountain plovers arrive on their breeding grounds in late March with egg laying beginning in late April. Clutches are hatched by late June, and chicks fledge by late July. The fall migration begins in late August, and most birds are gone from the breeding grounds by late September.

In Wyoming, this species is a common breeding resident (Luce et al. 1999) and is expected to occur in suitable habitats within the Project Area. Data compiled by the BLM office in Buffalo indicate that mountain plover nesting occurs sporadically throughout the Project Area, including northeastern Converse County, near Gillette, and Sheridan. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant, negative trend for populations of this species in Wyoming and along all survey routes in the United States during the period between 1996 and 2001.

Records of mountain plover observations in the WYNDD database include sightings near Buffalo and Gillette and in the Thunder Basin National Grassland. Surveys by Keinath and Ehle (2001) and Good et al. (2002) were conducted on federal lands within the Project Area. Keinath et al. (2001) reported 11 mountain plover observations, with one sighting in the Buffalo RA south of Gillette, Wyoming. Good et al. (2002) reported six mountain plover observations, and five were located in the Buffalo RA between Buffalo and Kaycee, Wyoming. These surveys were conducted on federal lands and collectively represent a small fraction of the Project Area and the suitable habitat for plover within the Project Area. Non-federal lands, including private and state lands, were not included in these surveys but represent the majority of the Project Area (85 percent of the total acreage). Keinath et al. (2001) characterized mountain plover habitat within the Project Area as sparse and fragmented. Suitable mountain plover habitat is expected to occur throughout the Project Area.

Black-tailed Prairie Dog

Black-tailed prairie dog (*Cynomys ludovicianus*) was added to the list of candidate species for federal listing on February 4, 2000 (USFWS 2000). At that time, USFWS concluded that listing the black-tailed prairie dog was warranted but precluded by other, higher-priority actions to amend the lists of threatened and endangered species. No specific date for proposal for listing was provided, but USFWS had committed to reviewing the status of the species 1 year after publication of the notice (that is, on February 4, 2001) (USFWS 2000). As of June 13, 2002, the candidate status of the black-tailed prairie dog status had not been changed (USFWS 2002a).

The black-tailed prairie dog is a highly social, diurnally active, burrowing mammal. Aggregations of individual burrows, known as colonies, form the basic unit of prairie dog populations. Found throughout the Great Plains in shortgrass and mixed-grass prairie areas (Fitzgerald et al. 1994), the black-tailed prairie dog has declined in population and extent of colonies in recent years because of habitat destruction or disturbance and pest control. In Wyoming, this species is primarily found in isolated populations in the eastern half of the state (Clark and Stromberg 1987). Many other wildlife species, such as the black-footed ferret, swift fox, mountain plover, ferruginous hawk, and burrowing owl, depend on the black-tailed prairie dog for some portion of their life cycle (USFWS 2000).

This species is considered a common resident, inhabiting shortgrass and mid-grass habitats in eastern Wyoming (Luce et al. 1999). Active and inactive prairie dog colonies are known to occur within the Project Area; however, specific data on population and occurrence patterns are not available.

Boreal Toad

The southern population of the boreal toad (*Bufo boreas boreas*), which occurs in the Medicine Bow Mountains, is listed as a USFWS candidate species (USFWS 2002a). Region 2 of the FS also lists this species as sensitive (USFS 2001c). This species ranges from southeast Alaska throughout British Columbia and Alberta southward through the northwestern United States. In Wyoming, this species occurs in two distinct populations. The northern population, not listed as a federal candidate species, ranges from mid to higher elevations of Yellowstone and Grand Teton National Parks, and the Bridger-Teton, western Shoshone, and Targhee National Forests. The southern population is restricted to a few isolated areas of the Medicine Bow National Forest. The southern population may be extirpated. In 2000, survey efforts located three individuals and did not observe signs of reproduction at historical breeding locations. Habitat for this species includes moist or wet areas of foothill, montane, and subalpine regions including subalpine meadows, aspen and spruce-fir forests, and all riparian habitats occurring between 8,000 and 11,900 feet elevation (USGS 2001c). Adult toads are sometimes found in drier habitats when they disperse (Keinath and Bennett 2000). However, current distributions are not known north of Carbon County, south of the Project Area. This species is not expected to occur within the Project Area.

Forest Service Sensitive Species

The Rocky Mountain Region Endangered, Threatened, Proposed, and Sensitive Species List (USFS 2001c) was used to identify sensitive plant and wildlife species that may be affected by the proposed project. Thunder Basin National Grassland (TBNG) is the only property that is administered by the USFS within the PRB project boundary. Therefore, only sensitive species identified as occurring within TBNG were considered in this analysis. The black-tailed prairie dog is federally listed as candidate species and is addressed previously in this section. The following FS sensitive species were identified from the TBNG for further analysis:

- Flathead chub
- Plains topminnow
- Tiger salamander
- Northern leopard frog
- Black Hills redbelly snake
- Milk snake
- Common loon
- American bittern
- White-faced ibis
- Osprey
- Ferruginous hawk
- Merlin
- Greater sandhill crane
- Long-billed curlew
- Upland sandpiper
- Black tern
- Western yellow-billed cuckoo
- Flammulated owl
- Western burrowing owl
- Lewis' woodpecker
- Olive-sided flycatcher
- Loggerhead shrike
- Purple martin
- Pygmy nuthatch
- Baird's sparrow
- Fox sparrow
- Fringed-tailed myotis
- Townsend's big-eared bat
- Black-tailed prairie dog
- Swift fox

Fish

Flathead Chub

The flathead chub (*Platygobio gracilis*) inhabits large silty rivers on the Great Plains from the Northwest Territories, Canada, south to Oklahoma and New Mexico. In Wyoming, it is common in the major river systems east of the Continental Divide, with the exception of the Madison, Yellowstone, Niobrara, and South Platte River systems. This species is omnivorous, primarily feeding on aquatic and terrestrial insects and vegetation (Baxter and Simon 1970). The flathead chub is known from 11 of the 18 sub-watersheds within the Project Area (Table 3-54). Primary threats to this species include nonpoint source pollution and mainstem impoundments that greatly alter the natural water flow regimes.

Plains Topminnow

The distribution of the plains topminnow (*Fundulus sciadicus*) includes in the central plains from South Dakota to Oklahoma. In Wyoming, its characteristic habitat is clear, sand or gravel-bottomed streams with considerable vegetation (Baxter and Simon 1970). The life history of this species is largely unknown. It commonly occurs with other species that include the Iowa darter, fathead minnow, plains killifish, brassy minnow, and finescale dace. Baxter and Simon

(1970) reported this fish occurring in North and South Platte drainages, Niobrara River, and headwaters of the Cheyenne River System. This species is not expected to occur in sub-watersheds included in the Project Area (Table 3-54).

Amphibians and Reptiles

Tiger Salamander

The tiger salamander (*Ambystoma tigrinum*) is a distinct amphibian that is uniformly dark with an intermingling of different shades of brown to yellow mottling. This species inhabits ponds, lakes, and impoundments ranging in size from several feet in diameter to several acres. Suitable habitats include clear water lakes, glacial kettle ponds, and beaver ponds below 12,000 feet in elevation. Tiger salamanders are most common in permanent or semi-permanent ponds, but they also use ephemeral ponds that fluctuate with local moisture conditions (Hammerson 1999). This species is typically absent from waters inhabited by predatory fish. Tiger salamanders typically prey on insects, earthworms, and occasionally small vertebrates (Baxter and Stone 1985). This species is expected to occur in suitable habitats throughout the Project Area.

Northern Leopard Frog

The Northern leopard frog (*Rana pipiens*) is found throughout much of the southern half of Canada, south through the upper mid-west and central plains states, westward into Idaho, Nevada, northern Arizona, and New Mexico (Stebbins 1985). The Northern leopard frog has experienced contractions in its range resulting from local extirpations of breeding populations, particularly in western North America (Wagner 1997). In Wyoming, this species occurs in cattail marshes and beaver ponds from the plains to montane conditions as high as 9,000 feet (Luce et al. 1999). Adult leopard frogs typically feed on insects, invertebrates, and small vertebrates including tadpoles, snakes, and fish. This species is expected to occur in suitable habitats throughout the Project Area.

Black Hills Redbelly Snake

The Black Hills redbelly snake (*Storeria occipitomaculata pahasapae*) is found in the isolated refuge of the wooded Black Hills, inhabiting moist microhabitats within wooded uplands (WBN 2002). It can be found near water under flat rocks, logs, and other surface objects (Luce et al. 1999). Documented occurrence in Wyoming for this species is restricted to Crooke and Weston Counties. There have been no documented sightings of this species within the Project Area. This species is not expected to occur within the Project Area.

Milk Snake

The milk snake (*Lampropeltis triangulum)* probably has the widest distribution of any snake species in the world (Hammerson 1999). The western subspecies occurs in the western and central states from Montana southward to northern Texas, including isolated populations in Utah, Colorado, and New Mexico (Stebbins 1985). In Wyoming, this species is also known from scattered records in the Bighorn Basin, the east slope of the Bighorn Range, and the Laramie Range in Albany, Big Horn, Washakie, Hot Springs, Platte, and Goshen Counties. It is also suspected to occur in Sheridan, Campbell, Crook, Weston, Niobrara, Converse, and Natrona Counties. In Wyoming, this species is found in diverse habitats from lowlands to mountains, grasslands to open forests, and wilderness to suburban. It often occurs in plains and foothills below 5,900 feet, but is almost never found in the shortgrass communities of the plains (Welp et al. 2000). Diet of this snake typically includes small mammals, birds, lizards, snakes, and bird eggs. This species may occur in suitable habitats within the Project Area.

Birds

Common Loon

The common loon (*Gavia immer*) breeds throughout Canada and northern states of the U.S. This species typically nests on floating vegetation, muskrat houses, or shorelines of lakes with suitable prey fish and invertebrate populations. In Wyoming, this species typically nests in lakes above 6,000 feet elevation and is seen using lakes at lower elevations during migration (Luce et al. 1999). This species has been observed throughout the majority of the state. Breeding records are restricted to the northwest portion of the state (Luce et al. 1999). This species is not expected to nest in the Project Area, but may be observed in suitable habitats during migration. Data presented in the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant, positive trend for common loon populations in the central Rocky Mountains and the United States during the period between 1966 and 2001. An analysis specific to Wyoming was not available.

American Bittern

The American bittern (*Botaurus lentiginosus*) breeds from south-central British Columbia to Newfoundland. In the United States, this species nests in all western and northern states. This species rarely wanders far from marshy, swampy areas (Yaeger 1998). This species typically feeds on fish, aquatic invertebrates, and insects. In Wyoming, this species is an uncommon summer resident occurring throughout much of the state, including the Project Area (Luce et al. 1999). This species may occur in suitable habitats within the Project Area. Data presented in the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant, positive trend for American bittern populations in Wyoming and the United States during the period between 1966 and 2001.

White-faced Ibis

The white-faced ibis (*Plegadis chihi*) nests from central Mexico to Louisiana and Texas and through the Great Basin, with isolated colonies in Alberta, New Mexico, California, Montana, North Dakota, Iowa, and Kansas (Ryder 1998b). Preferred nesting habitat includes tall emergent vegetation such as bulrushes and cattails growing as islands surrounded by water deeper than 18 inches. Feeding habitats may include wet hay meadows and flooded agricultural croplands, as well as marshes and shallow water ponds, lakes, and reservoirs (Ryder 1998b). This species primarily feeds on aquatic invertebrates and insects. In Wyoming, this species is an uncommon summer resident found throughout much of the state, including the Project Area (Luce et al. 1999). Luce et al. (1999) reported no breeding records for this species within the Project Area. This species is not expected to nest in the Project Area, but may occur as a seasonal migrant. Data from the BBS Trend Analysis (Sauer et al. 2001) were not presented for this species in Wyoming. Data were presented for USFWS Region 6, which includes Wyoming; they indicate a non-significant, positive trend for white-faced ibis populations in Region 6. The trend for the U.S. was highly significant and positive.

Osprey

The osprey (*Pandion haliaetus*) occurs across North America and southern Canada. This species nests in a variety of habitats throughout its range, all of which provide two primary components: a large body of water with fish large enough to catch and suitable nesting sites. Suitable nesting structures include tall dead trees, standing trees with dead, broken tops, power poles, and goose nest platforms (Barrett 1998b). In Wyoming, the osprey is a common breeding resident nesting in suitable habitats throughout the state (Luce et al. 1999). Nesting and non-breeding observations have been documented in the Project Area, with nesting observations restricted to the northwest portion of the Project Area. This species is expected to occur in suitable habitats throughout the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant positive trend for populations of this species in Wyoming during the period between 1996 and 2001. The trend for the United States, during the same period, is positive and significant.

Ferruginous Hawk

The Ferruginous hawk (*Buteo regalis*) is an uncommon and locally distributed occupant of grasslands, sagebrush, and desert scrub habitats in the Great Plains and Great Basin regions. On the Great Plains, breeding pairs are normally associated with native grasslands (Gilmer and Stewart 1983). In Wyoming, this species is a common breeding resident occupying basin-prairie shrublands, short-grass prairie, rock outcrops, and cottonwood-riparian habitats (Luce et al. 1999). This hawk would nest in trees and similar structures when available, but would also readily nest on the ground (Preston 1998a). Nest sites include cliff faces, rock outcrops, and grassy knolls (Luce et al. 1999). This hawk preys almost exclusively on small to medium-sized mammals including jackrabbits, cottontails, prairie dogs, and ground squirrels (Preston 1998a). Studies conducted near coal-mines in Campbell County, Wyoming, have reported nesting densities of one nest per 16 or 20 square miles (Seacross 2002). The ferruginous hawk is known to nest in suitable habitats throughout Wyoming and is expected to occur within the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant, positive trend for populations of this species in Wyoming and the Wyoming Basin during the period between 1996 and 2001. The population trend for the United States, during the same period, is positive and highly significant.

Merlin

Merlin (*Falco columbarius*) nest in boreal forests below treeline from coast to coast and along the western mountains south to Oregon, Idaho, and Montana. It winters in southern latitudes from the southern United States to South America

(Udvardy 1977). In Wyoming, this species is an uncommon resident that occurs in a diversity of habitats below 8,500 feet, including open grasslands and shrublands and coniferous forests (Luce et al. 1999). In the Project Area, merlin often lay their eggs in abandoned black-billed magpie (*Pica pica*) nests. Most merlin nests in the Project Area are known from Rochelle Hills in southeastern Campbell County (Seacross 2002). Merlin typically rely on locally abundant populations of small birds as prey species, but would also prey on toads, reptiles, and mammals (Welp et al. 2000). This species is a documented breeder throughout much of the state, including the Project Area (Luce et al. 1999). This species may occur in suitable habitats within the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate non-significant, positive trends in population change for this species in the Central Rocky Mountains and the U.S. during the period between 1966 and 2001.

Greater Sandhill Crane

The greater sandhill crane (*Grus canadensis tabida*) nests in a broad band between the fortieth and forty-fifth parallel (as far south as northern Illinois to as far north as Vancouver Island). Suitable habitat for this species includes open prairies in moist grass and sedge meadows, marshes, and shorelines (Dorn and Dorn 1990). Cranes roost at night along river channels, on alluvial islands of braided rivers, or natural basin wetlands. Along the North Platte River during the spring months, roosts are generally in shallow water (less than 20 centimeters), 11 to 50 meters from the nearest visual obstruction, and located away from paved or gravel roads, single dwellings, and bridges (Norling et al. 1992). This species often feeds and rests in fields and agricultural lands. This species nests on the ground or in shallow water in large marshes or wet forest meadows. As omnivores, sandhill cranes have a varied diet including grains, roots, small mammals, frogs, toads, snakes, crayfish and insects (Barrett 1998c). In the Project Area, this species is not expected to nest, but may occur as a migrant. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant, positive trend in population change for this species in Wyoming during the period between 1966 and 2001. During the same period in the U.S., the trend was highly significant and positive.

Long-billed Curlew

Long-billed curlew (*Numenius americanus*) occurs from southern British Columbia to Manitoba, southeast to Wisconsin, Illinois, and Kansas, south to northern California and northern Texas (Nelson 1998a). The long-billed curlew nests on shortgrass prairies and feeds on insects and aquatic invertebrates in salt marshes, mud flats, and beaches (Udvardy 1977). In Wyoming, suitable habitat may include sagebrush shrublands, wet meadows, irrigated meadows, and agricultural areas (Luce et al. 1999). This species is a common summer breeding resident throughout much of central and western Wyoming. Breeding curlews have been reported from Johnson and Natrona Counties and part of the Project Area (Luce et al. 1999). Data from the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant, positive trend in population change for this species in Wyoming during the period between 1966 and 2001. During the same period across all BBS survey routes in the U.S., the trend was non-significant and negative.

Upland Sandpiper

The upland sandpiper (*Bartramia longicauda*) nests from Alaska to Maine, south to northwestern Oklahoma and the Mid-Atlantic states. The upland sandpiper nests in mid- to tall-grasslands and croplands, using the tall vegetation to hide the nest (Nelson 1998b). In Wyoming, this species nests in grasslands in the eastern portion of the state (Luce et al. 1999). Upland sandpipers typically feed on insects, terrestrial invertebrates, and seeds. This species is an uncommon breeding resident occurring in suitable habitats throughout much of eastern Wyoming, including the Project Area (Luce et al. 1999). Data from the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant, positive trend in population change for this species in Wyoming during the period between 1966 and 2001. During the same period in the U.S., the trend was highly significant and positive.

Black Tern

In North America, the black tern (*Chlidonias niger*) breeds from southern Canada to northern California, southern Colorado, and southern New England (Nelson 1998c). This species occupies two distinct habitats during the year. During the nesting season, nests are constructed along ponds and reedy and cattail wetlands where this species feeds on insects that are picked from the air and from the surface of the water. Large wetland complexes of at least 50 acres are preferred nesting habitats for this species. In the winter, this species occurs along marine coasts, where it feeds on small fish it captures from the surface (Nelson 1998c). Some evidence of black tern breeding exists within the Project Area (Luce et al. 1999). This species is expected to occur within the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) were not presented for this species in Wyoming. Data presented for USFWS Region 6, which includes Wyoming, and the United States indicate positive trends for populations of this species.

Western Yellow-billed Cuckoo

The western yellow-billed cuckoo (*Coccyzus americanus*) once ranged throughout the United States, southern Canada, and Mexico. The range of the western subspecies has been dramatically reduced and is mostly limited to California and Arizona (Carter 1998b). In Wyoming, this species is an uncommon summer resident, occupying cottonwood riparian habitats below 7,000 feet and urban areas. Typical prey includes insects, especially hairy caterpillars. It has been recorded in most areas of the state except for the montane regions (Luce et al. 1999). This species may occur in suitable habitats within the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) were not presented for this species in Wyoming. Data presented for USFWS Region 6, which includes Wyoming, indicate a non-significant, negative trend for populations of this species during the period between 1966 and 2001. For the same period across all BBS routes in the U.S., the population trend was highly significant and negative.

Flammulated Owl

The flammulated owl (*Otus flammeolus*) breeds in montane forests of the western U.S. from southern British Columbia to the highlands of Mexico and Guatemala. Winter range is southern Mexico and northern Central America (Winn 1998). This species primarily depends on open montane forests of ponderosa or aspen for nesting, feeding, and roosting. Flammulated owls are cavity nesters and rely on old growth forests with existing woodpecker cavities for nesting. In Wyoming, this species in considered a rare accidental (Luce et al. 1999). This is supported by only limited observations in the WGFD Lat/Long study from the extreme northwestern and central portion of the state (Luce et al. 1999). Luce et al. (1999) did not report any observation records for this species within the Project Area. This species is not expected to occur within the Project Area. An evaluation of data on population trends for this species was not included in the BBS Trend Analysis (Sauer et al. 2001). This species was most likely excluded from this report because BBS surveys are conducted during daylight, which would most likely miss species that are strictly nocturnal, such as the flammulated owl.

Western Burrowing Owl

The burrowing owl (*Athene cunicularia*) occurs from south-central British Columbia eastward to southern Saskatchewan and south through most of the western United States. Burrowing owls primarily nest in rodent burrows, particularly prairie dog burrows, in grasslands, shrublands, deserts, and grassy urban settings (Jones 1998a). In Wyoming, this species uses grasslands, sagebrush and other shrublands, and agricultural areas. Burrowing owls typically feed on insects, rodents, lizards, and small birds. This species is a confirmed breeder throughout much of the state (Luce et al. 1999). Populations of this species can vary considerably within the Project Area, influenced by fluctuations in availability of prey. This species is known to occur as a summer resident in suitable habitats within the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate non-significant, negative trends in population change for this species in Wyoming and the United States during the period between 1966 and 2001.

Lewis' Woodpecker

Lewis' woodpecker (*Melanerpes lewis*) occurs from southern British Columbia and Alberta south to northern Arizona and south-central California. Suitable habitat for this species includes pine-oak woodlands, oak or cottonwood groves in grasslands, and ponderosa pine forests (Udvardy 1977). In Wyoming, this species principally occurs in open ponderosa and lodgepole pine forests and savannah and recently burned forests with abundant snags or stumps, mainly below 9,000 feet. It also uses aspen, mixed pine-juniper, and cottonwood riparian habitats. Mated pairs may return to the same nest site in successive years (Welp et al. 2000). This woodpecker is opportunistic, foraging on locally and temporarily abundant insect populations during spring and summer (for example, ants, beetles, flies, grasshoppers, and tent caterpillars) and on fruits during fall and winter. It is known to occur throughout most of Wyoming, except for higher elevation mountain regions (Luce et al. 1999). This species may occur in suitable habitats within the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate non-significant, positive trends in population change for this species in Region 6 of the USFWS, which includes Wyoming, and the United States during the period between 1966 and 2001.

Olive-sided Flycatcher

The olive-sided flycatcher (*Contopus cooperi*) breeds in boreal forests from Alaska to Newfoundland and in the mountains of the western U.S. (Jones 1998b). Most nesting takes place in coniferous forests from 8,000 feet elevation to timberline (Luce et al. 1999). In Wyoming, this species is a common summer resident with documented breeding limited to montane habitats of the south, central, and western portion of the state. Suitable habitats for this species are not expected to occur within the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant, positive trend for populations of this species in Wyoming during the period between 1966 and 2001. For the same period across all BBS routes in the U.S., the population trend was highly significant and negative.

Loggerhead Shrike

Loggerhead shrike (*Lanius ludovicianus*) occurs from North America south of the coniferous forest region into Mexico (Udvardy 1977). The loggerhead shrike is typically associated with open vegetation types, including agricultural areas, sagebrush shrublands, desert scrub, piñon-juniper woodlands, and montane meadows (Johnsgard 1986). In Wyoming, this species is a common summer resident, using pine-juniper, woodlands, short- and mixed-grass prairies, and shrublands. Loggerhead shrikes typically feed on grasshoppers and crickets as well as other insects, mice, and small birds. This species is known to breed throughout the state (Luce et al. 1999) and is known to occur in suitable habitats within the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant, positive trend for populations of this species in Wyoming during the period between 1966 and 2001. For the same period across all BBS routes in the U.S., the population trend was highly significant and negative.

Purple Martin

The purple martin (*Progne subis*) breeds locally throughout the eastern U.S. from the Atlantic to the Great Plains, across the Southwest, and up the Pacific coast from south-central California to British Columbia (Levad 1998). Throughout their range, purple martin nest in a variety of habitats, including cavities in cacti, cliffs, trees, and manmade nest houses, typically near a stream, spring, or pond (Levad 1998). In Wyoming, most nesting occurs in similar habitats below 7,000 feet. This species has been recorded in the Bighorn, Medicine Bow, and Wind River Ranges of Wyoming (Luce et al. 1999). No observations have been reported for the Project Area (Luce et al. 1999). This species is not expected to occur within the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate non-significant, positive trends in population change for this species in Region 6 of the USFWS, which includes Wyoming, and the United States during the period between 1966 and 2001.

Pygmy Nuthatch

The pygmy nuthatch (*Sitta pygmaea*) is widespread from southern British Columbia eastward through the Black Hills, and south to Baja California and mainland Mexico (Udvardy 1977). In Wyoming, it occurs in scattered locales during the winter. During the breeding season, it is associated with mountain habitats in coniferous forests at the periphery of the state. This species has been observed breeding in the Bighorn and Medicine Bow National Forests and in most other coniferous habitats within the state. Ponderosa pine woodlands in the Black Hills and in the Douglas/Guernsey regions have the best potential to support large groups of breeding birds (Welp et al. 2000). Pygmy nuthatches typically feed on insects and conifer seeds. This species may occur in suitable habitats within the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate non-significant, positive trends in population change for this species from the Central Rocky Mountains, which includes Wyoming, and the United States during the period between 1966 and 2001.

Baird's Sparrow

The Baird's sparrow (*Ammodramus bairdii*) ranges from Alberta, Saskatchewan, and Manitoba and Montana to South Dakota (Udvardy 1977). In Wyoming, this species is an uncommon summer resident using shortgrass prairie habitats (Luce et al. 1999). Typical diet for this species consists of seed and insects. This species may occur in suitable habitats within the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate non-significant, negative trends in population change for this species in Region 6 of the USFWS, which includes Wyoming, and the United States during the period between 1966 and 2001.

Fox Sparrow

The fox sparrow (*Passerella iliaca*) is a North American migrant, breeding across Canada and the western U.S. and wintering south of Colorado along the Pacific coast and in the southern U.S. and northern Mexico (Potter and Roth 1998). In Wyoming, this species occupies a variety of breeding habitats including riparian shrublands with adjacent coniferous forest or woodland chaparral and burned or logged forests (Luce et al. 1999). The fox sparrow has a varied diet consisting of insects, seeds, and berries. This species occurs widely in Wyoming with most confirmed breeding records west of the Rocky Mountains. This species has been observed and unconfirmed breeding has been documented within the Project Area (Luce et al. 1999). Data from the BBS Trend Analysis (Sauer et al. 2001) indicate non-significant, positive trends in population change for this species from Wyoming and the United States during the period between 1966 and 2001.

Mammals

Fringed-Tailed Myotis

The fringed-tailed myotis (*Myotis thysanodes pahasapensis*) ranges from British Columbia through western North America to southern Mexico. In Wyoming, this species is found along the eastern edge of the state from the Black Hills to Laramie in Weston, Platte, Albany, Sublette, and Laramie Counties (Welp et al. 2000). This species is associated with a variety of vegetation community types, including montane meadows, sagebrush shrublands, desert scrub, mixed grass prairies, and woodlands, although it appears to prefer coniferous forests (Fitzgerald et al. 1994). Caves, mines, and buildings are used as day and night roosts for colonies of up to several hundred individuals. Although no breeding has been reported within the Project Area, this species has been observed within the Project Area (Luce et al. 1999). This species may occur in suitable habitats within the Project Area.

Townsend's Big-eared Bat

Townsend's big-eared bat (*Corynorhinus townsendii* [*Plecotus townsendii*]) is most common throughout the western half of North America and occurs south into central Mexico. Although Wyoming forms part of the core of this main range, it is distributed sparsely throughout the state (Clark and Stromberg 1987). It has been recorded in Converse, Goshen, Platte, Crook, Fremont, Big Horn, Hot Springs, Sweetwater, Washakie, Park, and Johnson Counties. Suitable habitats in Wyoming include deciduous forests, dry coniferous forests, sagebrush and other shrublands, shortgrass and mixed grass prairies, and juniper woodlands. This species uses caves, buildings, and rock outcrops for day and night roosts and hibernation sites (Luce et al. 1999). Although no breeding has been reported within the Project Area, this species has been observed within the Project Area (Luce et al. 1999). This species may occur in suitable habitats within the Project Area.

Swift Fox

In January 2001, the USFWS did not support listing this species as threatened under the Endangered Species Act (USFWS 2001a) based on new biological information. The swift fox (*Vulpes velox*) is found in short- and mixed-grass prairie habitats. It appears to prefer flat to gently rolling terrain. The swift fox preys on small rodents, rabbits, and birds. Pups emerge from the den in June. Dens are generally located along slopes or ridges that offer good views of the surrounding area (Fitzgerald et al. 1994). Where they are abundant, they occur at a density of one pair per 1,200 to 2,000 acres. Individuals may roam over 2,000 to 2,500 acres during a night of hunting (Clark and Stromberg 1987). In Wyoming, this species is considered a common resident using grasslands in the eastern plains, agricultural areas, irrigated native meadows, and the banks of roads and railroads (Luce et al. 1999). This species may occur in suitable habitats within the Project Area.

Wyoming BLM Sensitive Species

In a memorandum dated April 9, 2001, the Wyoming BLM issued its Sensitive Species Policy and List (Pierson 2001). An update to this was published September 20, 2002 (BLM 2002) Sensitive plant and wildlife species that may be affected by the proposed project were identified from this list and evaluated in this assessment. Species within the Buffalo and Casper Field Offices were selected from the sensitive species list for further evaluation. The following BLM sensitive species were identified for analysis:

- Laramie columbine
- Porter's sagebrush
- Nelson's milkvetch
- Many-stemmed spider-flower
- William's wafer-parsnip
- Northern goshawk
- Ferruginous hawk
- Peregrine falcon
- Greater sage grouse
- Long-billed curlew

- Laramie false sagebrush
- Long-eared myotis
- Spotted bat
- Townsend's big-eared bat
- White-tailed prairie dog
- Swift fox
- White-faced ibis
- Trumpeter swan
- Yellow-billed cuckoo
- Burrowing owl
- Sage thrasher
- Loggerhead shrike
- Brewer's sparrow
- Sage sparrow
- Baird's sparrow
- Yellowstone cutthroat trout
- Northern leopard frog
- Spotted frog

The northern leopard frog, white-faced ibis, ferruginous hawk, long-billed curlew, yellow-billed cuckoo, burrowing owl, loggerhead shrike, Baird's sparrow, Townsend's big-eared bat, and swift fox are also FS Region 2 sensitive species and have been addressed previously in the section on Forest Service Sensitive Species.

Plants

Laramie Columbine

Laramie columbine (*Aquilegia laramiensis*) is a perennial, leafy, many-stemmed herb 10 to 20 centimeters tall. This species flowers and fruits during June through August. The Laramie columbine is endemic to the Laramie Range of southeast Wyoming (Albany and Converse Counties). It is often found in shady crevices of north-facing granite boulders and cliffs with pockets of rich soil between 6,250 and 8,000 feet elevation (Fertig 2000c). Laramie columbine is known from the eight extant populations all restricted to extreme southern Converse County and northern Albany County (Fertig and Beauvais 1999). These documented occurrences are not within the Project Area. This species may occur in suitable habitats within the Project Area.

Porter's Sagebrush

Porter's sagebrush (*Artemisia porteri*) is a mat-forming perennial sub-shrub with numerous slender stems less than 15 centimeters tall. This species flowers in June and July. Porter's sagebrush is endemic to Wyoming and is restricted to the Wind River Basin and Powder River Basin in Fremont, Johnson, and Natrona Counties. Suitable habitat includes sparsely vegetated badlands of ashy or tufaceous mudstones and clay slopes between 5,300 and 6,500 feet elevation. In the northern Wind River Basin, this species is found in semi-barren, low desert shrub communities dominated by Porter's sagebrush, birdfoot sagebrush, and longleaf wormwood on dry, whitish, ashy-clay hills, gravelly-clay flats, and shaley erosional gullies of the Wagon Bed Formation (Fertig 2000a). Porter's sagebrush is known from eight extant populations in Fremont, Johnson, and Natrona Counties (Fertig 2000a). A single population documented in southwestern Johnson County is within the Project Area. This species may occur in other suitable habitats within the Project Area.

Nelson's Milkvetch

Nelson's milkvetch (*Astragalus nelsonianus*) is a perennial herb with fleshy-leathery stems 10 to 30 centimeters tall. This species flowers from mid-May to late June. Nelson's milkvetch is regionally endemic to southwest and central Wyoming, northeast Utah, and northwest Colorado. In Wyoming, it is known from the Wind River, Green River, Washakie, southern Powder River, and Great Divide basins, Owl Creek Mountains, and the Rock Springs Uplift in Fremont, Natrona, and Sweetwater Counties. Suitable habitat for this species includes alkaline, often seleniferous, clay flats, shale bluffs and gullies, pebbly slopes, and volcanic cinders. Known occurrences are found primarily in sparsely vegetated sagebrush, juniper, and cushion plant communities at elevations between 5,200 and 7,600 feet (Fertig 2000e). This species is known from 24 extant populations all located on private lands within central Wyoming (Fertig 2000e). Three populations are known from Johnson County, two of which are located in the eastern portion of the county that is within the Project Area. These species may occur in other suitable habitats within the Project Area.

Many-stemmed Spider-Flower

Many-stemmed spider-flower (*Cleome multicaulis*) is a slender, glabrous annual forb with erect, unbranched, or sparingly branched leafy stems 20 to 70 centimeters tall. This species flowers and sets fruit from June to August. Its global distribution includes central Mexico (near Mexico City) to southeast Arizona, southwest New Mexico, and southwest Texas, with disjunct populations in south-central Colorado and central Wyoming. Wyoming populations are restricted to the Sweetwater River Valley in Natrona County. In Wyoming, many-stemmed spider-flower is found primarily on whitish, alkali-rich, strongly hydrogen-sulfide scented soils that border shallow, spring-fed playa lakes or dried lake-beds. Populations are most abundant on damp, but not flooded, flats with approximately 90 percent cover of alkali-cordgrass, desert saltgrass, Baltic rush, Nuttall's alkali grass, Nevada bulrush, and sea arrowgrass bordering playa lakes. This species may also be present in lower numbers on clayey dunes surrounding alkaline lakes with less than 50 percent cover of cordgrass, arrowgrass, and alkali sacaton or on low hummocks of greasewood. Small patches may also occur in dry alkaline depressions with 20 percent cover of saltgrass, cordgrass, plains sea-blite, smooth hawk's beard, and goldenweed. All Wyoming colonies occur at about 5,860 feet elevation (Fertig 2000f). This species is known from a single extant site in Natrona County (Fertig 2000f). Because all known Wyoming populations of this species occur in Natrona County, this species is not expected to occur within the Project Area.

Williams' Wafer-Parsnip

Williams' wafer-parsnip (*Cymopterus williamsii*) is a tufted, perennial herb with basal, once-pinnately compound leaves and a flowering stalk 5 to 10 centimeters tall. This species flowers from May through mid-June. Williams' wafer-parsnip is endemic and is restricted to the Bighorn Mountains of north-central Wyoming in Bighorn, Johnson, Natrona, and Washakie Counties. Suitable habitat includes open, south, or east-facing ridge tops and upper slopes with exposed limestone outcrops or talus between 6,000 and 8,300 feet elevation. Soils tend to be thin, sandy, and often restricted to small cracks or pockets in limestone bedrock. Barren rock can provide up to 50 percent of total cover. This species is usually absent or very uncommon where grass cover is high or where western mountain mahogany and ponderosa pine are dominant. It also tends to be absent from lower slopes or valley bottoms with deeper or better-developed soils. Common associates include timber milkvetch, spatulate milkvetch, alpine bladderpod, whitlow-wort, and stemless hymenoxys (Fertig 2000g). This species is known from 23 extant populations found in the limestone or talus outcrops of the Bighorn Mountains (Fertig 2000g). This species may occur in suitable habitats in Johnson County and may occur in other suitable habitats within the Project Area.

Laramie False-Sagebrush

Laramie false-sagebrush (*Sphaeromeria simplex*) is a mat-forming perennial herb or sub-shrub less than 10 centimeters tall. This species flowers between May and August. It is endemic to southeast Wyoming in the western foothills of the Laramie Range, Shirley Basin, and Shirley Mountains (Albany, Carbon, Converse, and Natrona Counties) (Fertig 2000i). This species is known from 11 extant populations that occur in Albany, Carbon, Converse, and Natrona Counties (Fertig 2000i). All of the known populations in Converse County occur in the southern portion of the county and south of the southern extent of the Project Area. Based on the current information on distribution for this species, it is not expected to occur within the Project Area.

Fish

Yellowstone Cutthroat Trout

In February 2001, USFWS concluded that a petition to list the Yellowstone cutthroat trout (*Oncorhynchus clarki bouvieri*) as a threatened species under the Endangered Species Act did not provide substantial biological information to indicate that listing may be warranted (USFWS 2001b). Streams immediately below and above Yellowstone Lake are the global strongholds for this taxon. This species is native to the Yellowstone River drainage downstream to the Tongue River, including the Big Horn/Wind and Clarks Fork River drainages (Welp et al. 2000). This species is also found west of the Continental Divide in the Snake River drainage below Palisades Reservoir in Idaho and in Pacific Creek and other tributaries of the Snake River above the Gros Ventre River. It has been introduced to waters east of the Continental Divide (Baxter and Simon 1970). The Yellowstone cutthroat trout has been recorded from Teton, Park, Sheridan, Johnson, and Big Horn Counties (Welp et al. 2000). Suitable habitats include coldwater rivers, creeks, beaver ponds, and large lakes. Optimum water temperature generally may be 4.5 to 15.5°C, but they probably were tolerant of much warmer temperatures historically in larger rivers. Warm-water populations occur in some geothermally heated streams (Gresswell 1995), including some at least 81°F in Yellowstone National Park (Clark et al. 1989b). This species may occur in suitable aquatic habitats of the Upper Tongue sub-watershed within the Project Area (Table 3-57).

Amphibians

Columbia Spotted Frog

The Columbia spotted frog (*Rana luteiventris* [*Rana pretiosa*]) occurs throughout much of British Columbia and in Washington, Oregon, Idaho, Montana, Nevada, Utah, and Wyoming (Stebbins 1985). Wyoming is on the eastern edge of the range, where it is known from Park, Teton, Lincoln, Fremont, Sheridan, and Sublette Counties. The primary population is in the northwest part of the state, where it is contiguous with populations in Idaho and Montana (Welp et al. 2000). A glacial disjunct population occurs in the Bighorn Mountains about 100 miles to the east of the primary, contiguous population. It is confined to the headwaters of the South Tongue River drainage and its tributaries in Sheridan County (Garber 1994). In Wyoming, suitable habitats can be found in foothills and montane zones usually near permanent water such as ponds, sloughs, small streams, and beaver ponds. This species may avoid areas with warm stagnant water and dense cattails. It breeds in old oxbow ponds in which fish are absent, with emergent sedges in wet meadows at the edge of lodgepole pine forests (Garber 1994). Adult spotted frogs typically feed on insects, invertebrates, and small vertebrates including tadpoles and other frogs. The disjunct population of this species associated with the Tongue River is within the Project Area. No other populations are known to exist in the Project Area.

Birds

Trumpeter Swan

The trumpeter swan (*Cygnus buccinator*) breeds in southern Alaska, northern British Columbia, western Alberta, Oregon, Idaho, Montana, and Wyoming. As a result of habitat destruction and over-hunting, this species was close to extinction, but careful management and reintroduction practices have helped return the population to several thousand individuals (Udvardy 1977). Suitable habitats for this species include lakes and ponds with developed aquatic vegetation for feeding and nesting materials (Terres 1980). Trumpeter swans typically feed on aquatic vegetation, aquatic invertebrates, and insects. This species has been observed throughout the state, including the Project Area (Luce et al. 1999). No confirmed nesting has been reported for this species in the Project Area (Luce et al. 1999). This species may nest in suitable habitats within the Project Area, but most occurrences are expected to be migrating individuals. Population trend data for this species were not included in the BBS Trend Analysis (Sauer et al. 2001).

Northern Goshawk

The northern goshawk (*Accipiter gentiles*) occurs from Alaska through the Rocky Mountains to New Mexico and in the mountains and forests of Washington, Oregon, and interior California (Udvardy 1977). Goshawks typically prey on squirrels, ducks, and other birds. Northern goshawks nest in a variety of habitats including conifer and aspen forests, and occasionally cottonwood trees (Barrett 1998d). This species is a documented breeding resident of Wyoming and the Project Area (Luce et al. 1999). This species is expected to occur in suitable habitats within the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant, positive trend for populations of this species in Wyoming during the period between 1966 and 2001. For the same period across all BBS routes in the U.S., the population trend was non-significant and negative.

Peregrine Falcon

The peregrine falcon (*Falco peregrinus anatum*) was removed from the federal list of endangered species in 1999 (USFWS 1999c). This species occurs across North America and uses a variety of habitats. The peregrine falcon is typically associated with open country near rivers, marshes, and coasts. Cliffs are preferred nesting substrate; however, tall man-made structures may also be used. Peregrines typically prey on birds such as waterfowl, shorebirds, grouse, and pigeons. In Wyoming, this species is a rare resident with most breeding records from the western portion of the state (Luce et al. 1999). This species is not expected to nest in the Project Area, but may occur as a seasonal migrant. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate significant, positive trends in population change for this species in Region 6 of USFWS, which includes Wyoming, and the United States during the period between 1966 and 2001.

Greater Sage Grouse

The sage grouse is highly dependent on sagebrush communities (Schroeder et al. 1999). It occurs on the plains and foothills of the arid west and can be found in shortgrass and mixed-grass prairies, sagebrush shrublands, other shrublands, wet meadows, and agricultural areas, always associated with substantial stands of sagebrush. In Wyoming, this species occurs as a breeding resident in suitable habitats below 8,300 feet (Luce et al. 1999). Unlike in many other western states, the current range of the sage grouse in the Project Area has not substantially contracted from its historical extent (WGFD 2002). Although the range of this species is relatively unchanged, the population numbers have been trending downward in recent years. This decrease has been associated with the disturbance and destruction of suitable grouse habitats (Oedekoven 2001). Figure 3-16 shows the distribution of potentially suitable habitats in the Project Area. Table 3-56 summarizes the extent of potentially suitable habitats in the Project Area.

Males of this species have an extravagant mating display that is performed on historical strutting areas termed “leks.” Male sage grouse, particularly juveniles, are known to attend several different leks within a single breeding season (Schroeder et al. 1999). The components of lek habitat are discussed below. There are 277 documented lek sites in the WGFD’s Sheridan Region, which approximates the Project Area (Oedekoven 2002). Only 249 of these sites are shown in Table 3-56 because spatial data needed for this analysis were not available for 28 new lek sites found during the 2002 survey. Past surveys have not covered the entire Project Area because of the amount of private land present; therefore, the actual number of leks is expected to be much higher (Braun et al. in press). Lek complexes occur in many locations and are defined as one or more leks within 0.5 to 2.0 miles of each other. Figure 3–16 shows the distribution of known lek sites in the Project Area. Table 3-56 summarizes the distribution of known lek sites and the amount of each sub-watershed within several protective buffers around each known lek site.

Table 3-56 Sage Grouse Potential Habitats, Lek Sites, and Protective Buffers by Sub-watershed

Sub-watershed	Potentially Suitable Habitats			Leks and proportion of the sub-watershed within protective buffers		
	Primary Habitats (%)	Secondary Habitats (%)	Non-habitat (%)	Sites (no.)	0.25 mile buffer (%)	2.0 mile buffer (%)
Little Bighorn River	8.1	24.4	67.5	0	0.0	0.0
Upper Tongue River	45.5	28.5	26.0	14	0.2	11.1
Middle Fork Powder River	21.6	23.5	54.9	13	0.3	12.7
North Fork Powder River	2.0	12.6	85.4	0	0.0	0.0
Upper Powder River	73.4	25.8	0.9	44	0.3	16.7
South Fork Powder River	54.4	19.7	25.9	10	1.1	22.5
Salt Creek	76.4	16.5	7.1	5	0.3	13.6
Crazy Woman Creek	56.4	16.2	27.3	19	0.4	11.9
Clear Creek	58.2	27.3	14.5	11	0.2	12.3
Middle Powder River	53.0	39.4	7.6	2	0.1	7.1
Little Powder River	63.1	32.1	4.8	28	0.4	23.1
Little Missouri River	15.7	79.1	5.2	0	0.0	1.0
Antelope Creek	30.9	56.5	12.6	11	0.2	7.9
Dry Fork Cheyenne River	29.1	70.8	0.1	20	0.7	24.7
Upper Cheyenne River	79.1	9.4	11.6	8	0.5	21.5
Lightning Creek	62.3	34.0	3.8	6	0.2	14.3
Upper Belle Fourche River	68.7	29.2	2.1	45	0.6	27.0
Middle North Platte River	45.9	53.1	1.1	13	0.7	26.6
Total	55.9	31.7	12.4	249	0.4	16.5

WGFD relied on lek data as the basis for analyzing trends in the population of sage grouse. These lek data represent minimum population estimates because not all of the leks in the Project Area have been identifed. Approximately one-half to one-third of the known leks are checked every year; for the last several years, searches for new leks have also been conducted, resulting in the discovery of 65 new leks over the last 4 years (Oedekoven 2001, 2002). The number of active leks and lek complexes has varied over the past 10 years, as has the estimated population. The population in the Sheridan Region appears to follow a 10-year cycle. Starting in 1992 with an estimate of 6,256 grouse, the population declined until reaching a low of 2,091 grouse in 1994, stayed at this level until 1997 and then increased to a high of 10,804 in 2000. The population decreased in 2001 in response to poor weather and perhaps the decline after the population peak the previous year. Each successive peak of this cycle has been lower than the proceeding peak, suggesting a long-term population decline (Oedekoven 2001).

Seasonal range use and movements of sage grouse vary considerably between populations, with movements in some populations exceeding 45 miles (Connelly et al. 1988). Depending on the migratory nature of the population, these ranges may overlap or may be geographically distinct (Connelly et al. 2000). Within the overall range of a population, a series of habitats are used during the year. Their spatial arrangement, relative availability, and the condition of the vegetation all affect the potential of these habitats to support sage grouse. Six seasonal habitats have been defined for sage grouse in Wyoming (WGFD 2002). Each of these habitats has components that are important for sage grouse reproduction and survival. These habitats include:

Winter Habitat

Sage grouse feed almost exclusively on sagebrush during the winter period. Winter habitats generally contain a canopy cover of 15 percent or greater of taller sagebrush and are located in areas where snow depths do not restrict access to sagebrush, such as south facing slopes and windswept areas (Connelly et al. 2000, WGFD 2002).

Breeding Habitat (Leks) — Early Spring

Leks are used from late March to April and are generally located in open areas such as broad ridges, grassy areas, and disturbed sites (WGFD 2002). Sage grouse select sites with less sagebrush and other shrub cover than the surrounding landscape, although these sites are often surrounded by sagebrush that is used as cover and for foraging by females that attend the lek and by non-displaying males (Schroeder et al. l999). Habitats that surround the lek site are also important because they provide the forage needed by hens to produce eggs and are often used for nesting (Braun et al. 1977), although migratory populations are much less centered around lek sites than are non-migratory populations (Connelly et al. 2000).

Nesting Habitat — Late Spring

Nests are generally placed under sagebrush, but other large shrubs can be used (WGFD 2002). Sage grouse select nest sites with higher than average canopy cover of sagebrush and herbaceous plant density, which leads to increased nest success (Connelly et al. 2000).

Early Brood Rearing Habitat — June to Mid-July

This habitat is used during the first month of the brood’s life (WGFD 2002). The brood is moved from the nest site immediately after it hatches and may move up to 5 miles in the first 10 days. This habitat generally has a higher herbaceous cover because brood survival is closely related to the availability of forbs and insects, which make the most important part of chick diets (Schroeder et al. 1999).

Figure 3-16 Sage Grouse Habitats

Late Brood Rearing Habitat — Mid-July through Mid-September

During this period, many upland forbs have dried up and sage grouse typically move to wetter locations, such as higher elevations or riparian areas (WGFD 2002). Broods tend to move to sites with higher than average forb cover and would focus on relatively small areas if the necessary forage is available (Connelly et al. 2000).

Fall Habitat — Mid-September to First Major Snow

Movement to, and use of, fall habitat is variable, depending on the weather and condition of forage. In Wyoming, this habitat is typically used from mid-September until the first major snow (WGFD 2002). During this period, grouse shift from feeding on forbs for the most part, to relying heavily on sagebrush as the forbs are killed or become dormant caused by frost (Connelly et al. 2000).

None of these habitats has been defined for the Project Area. Little is known of the seasonal movements of sage grouse in the Project Area. Based on the general distribution of sagebrush, it is likely that some sage grouse are present in much of the Project Area throughout the year. Populations are probably non-migratory or exhibit minimal migratory behavior, moving locally to different food resources or to escape deep snow.

As a result of past and on-going human activities in the Project Area, substantial areas of sage grouse habitats have been altered from their natural conditions. Human disturbances include, but are not limited to, agriculture, mining, roads, urban areas, oil and gas well pads, compressor sites, and other ancillary facilities. The amount of loss of habitats, including sagebrush, as a result of existing activities is shown by surface owner and sub-watershed in Table 3-19 and Table 3-20. Specific data on roads are not available in sufficient detail to allow comparison with these data and are not presented in Table 3-57. Road density is discussed in the Wildlife Habitat sub-section of the Wildlife section. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate statistically significant, positive trends in population change for this species in Wyoming and the United States, during the period between 1966 and 2001. BBS data may be misleading because 2000 appears to have been the peak year of the 10-year sage grouse population cycle. Subsequent years are likely to have lower population numbers. In addition, long-term data indicate that each successive population cycle peak is lower than the previous one, suggesting a long-term population decline (Oedekoven 2001).

Sage Thrasher

The sage thrasher (*Oreoscoptes montanus*) occurs from south-central British Columbia to southern Nevada, Utah, through Texas and Oklahoma, and in the San Joaquin Valley of California (Udvardy 1977). In Wyoming, this species is a common summer resident breeding in sagebrush shrublands throughout the state (Luce et al. 1999). Sage thrashers typically feed on insects and some fruit. This species may occur in suitable habitats within the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant, positive trend for populations of this species in Wyoming during the period between 1966 and

2001. For the same period across all BBS routes in the U.S., the population trend was non-significant and negative.

Table 3-57 Existing Impacts to Sage Grouse Protective Buffers by Sub-watershed

Sub-watershed	Proportion of lek sites with oil and gas development within the specified buffer 0.25 mile buffer (%)	2.0 mile buffer (%)
Little Bighorn River	0.0	0.0
Upper Tongue River	7.1	28.6
Middle Fork Powder River	0.0	0.0
North Fork Powder River	0.0	0.0
Upper Powder River	11.4	84.1
South Fork Powder River	0.0	0.0
Salt Creek	20.0	20.0
Crazy Woman Creek	0.0	0.0
Clear Creek	0.0	63.6
Middle Powder River	50.0	100.0
Little Powder River	21.4	78.6
Little Missouri River	0.0	0.0
Antelope Creek	9.1	63.6
Dry Fork Cheyenne River	5.0	85.0
Upper Cheyenne River	12.5	100.0
Lightning Creek	16.7	50.0
Upper Belle Fourche River	33.3	95.6
Middle North Platte River	7.7	38.5
Total	13.7	24.5

Brewer's Sparrow

The Brewer's sparrow (*Spizella breweri*) ranges from British Columbia east to Saskatchewan, south to New Mexico, Arizona, and southern California (Udvardy 1977). In Wyoming, this species is a common summer resident occupying sagebrush shrubland and other shrubland habitats throughout the state (Luce et al. 1999). Brewer's sparrow typically feed on insects and seeds. This species may occur in suitable habitats within the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant, negative trend for populations of this species in Wyoming during the period between 1966 and 2001. For the same period across all BBS routes in the U.S., the population trend was highly statistically significant and negative.

Sage Sparrow

The sage sparrow (*Amphispiza belli*) occurs from Washington south to Baja California and throughout the Great Basin (Udvardy 1977). The sage sparrow is a common summer resident in the Wyoming grasslands and shrublands typically feeding on insects and seeds (Luce et al. 1999). This species may occur in suitable habitats within the Project Area. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate no significant trend changes for populations of this species in

Wyoming during the period between 1966 and 2001. For the same period across all BBS routes in the U.S., the population trend was non-significant and positive.

Mammals

Long-eared Myotis

The long-eared myotis (*Myotis evotis*) occurs throughout the western portion of North America, south to Baja California. Wyoming is close to the eastern periphery of its range. Clark and Stromberg (1987) reported this species is distributed throughout Wyoming, with records in Park, Bighorn, Teton, Platte, Fremont, Sublette, Natrona, Sweetwater, Carbon, and Laramie Counties. In sagebrush steppe habitat, such as Sweetwater County, they are probably limited to small stands of conifers. Preferred habitats include coniferous forests, including ponderosa pine and spruce-fir, forests, sagebrush shrublands, and grasslands (Luce et al. 1999). This species roosts in caves, buildings, and mine tunnels (Clark and Stromberg 1987). This species may occur in suitable habitats within the Project Area.

Spotted Bat

Spotted bat (*Euderma maculatum*) occurs in western North America from Mexico to the southern border of British Columbia. Wyoming is on the northeast periphery of its range (Welp et al. 2000). In Wyoming, a single documented occurrence of this species exists from near Byron (Clark and Stromberg 1987). Suitable habitat in Wyoming includes juniper and sagebrush shrublands, short-, and mixed-grass prairies (Luce et al. 1999). Roosting sites in rock crevices and cliff complexes are also known to be important (Welp et al. 2000). This species is often described using cliffs over perennial water (Clark and Stromberg 1987). In Wyoming, occurrence records are restricted to the Bighorn Mountains and the southwestern portion of the state (Luce et al. 1999). This species is not expected to occur within the Project Area.

White-tailed Prairie Dog

White-tailed prairie dog (*Cynomys leucurus*) occurs in parts of Colorado, Utah, Wyoming, and Montana. In Wyoming, it occurs in the western half of the state, occupying grasslands, shrublands, and desert-grass communities (Clark and Stromberg 1987). In Wyoming, it is a common resident, occupying sagebrush shrublands, and short-and mixed-grass prairie throughout much the state, excluding the northeastern portion (Luce et al. 1999). This species is not expected to occur in the Project Area (USFWS 2002a).

Wyoming Game and Fish Department Sensitive Species

The Native Status Species (NSS) list for WGFD sensitive species was reviewed, and species with the potential to occur in the Project Area were identified. Sources including Clark and Stromberg (1987), Luce et al. (1999), and WBN were used to evaluate the presence or absence of a species in the Project Area.

The following WGFD sensitive species may occur in the Project Area and therefore are included in this analysis.

- Sturgeon chub
- Black bullhead
- Flathead chub
- Lake chub
- Mountain sucker
- Plains minnow
- Sauger
- Shovelnose sturgeon
- Yellowstone cutthroat trout
- Common loon
- American white pelican
- American bittern
- Black-crowned night heron
- Snowy egret
- White-faced ibis
- Trumpeter swan
- Black tern
- Bald eagle
- Ferruginous hawk
- Merlin
- Peregrine falcon
- Long-billed curlew
- Yellow-billed cuckoo
- Lewis' woodpecker
- Long-eared myotis
- Long-legged myotis
- Townsend's big eared bat
- Little brown myotis
- Big brown bat
- Western small-footed myotis
- Black-tailed prairie dog
- Black-footed ferret
- Swift fox

The black-footed ferret is also a federally listed endangered species. The bald eagle is also a federally listed threatened species. The black-tailed prairie dog is federally listed as a candidate species. Each of these species has been addressed previously in the USFWS Listed Species section. The flathead chub, Yellowstone cutthroat trout, common loon, American bittern, black tern, merlin, Lewis' woodpecker, Townsend's big-eared bat, and swift fox are also FS Region 2 sensitive species and have been addressed previously in the section on Forest Service Sensitive Species. The white-faced ibis, ferruginous hawk, long-billed curlew, and yellow-billed cuckoo are also FS Region 2 and Wyoming BLM sensitive species and have been addressed previously in the section on Forest Service Sensitive Species. The trumpeter swan, peregrine falcon, and long-eared myotis are also Wyoming BLM sensitive species and have been addressed previously in the section on Wyoming BLM Sensitive Species.

Fish

Sturgeon Chub

As recently as 2001, the sturgeon chub (*Macrhybopsis gelida*), once endemic to several Wyoming rivers but now found only in the Powder River, was considered rare by the WGFD. In April 2001, USFWS ruled that it would not list the sturgeon chub (*Macrhybopsis gelida*) as endangered under the Endangered Species Act (USFWS 2001c). Studies conducted since 1994 using benthic trawls designed to collect small fish from deep-water areas of the border and main channel have provided new information about the distribution and relative abundance of sturgeon chub. Although the chub has suffered a reduction in its range, the status surveys concluded that its distribution is currently wider than previously thought and that numerous populations appear to be viable throughout its range (USFWS

2001c). This species spawns in the spring and can be found over swift rocky riffles throughout the Powder River (Bradshaw 1996a).

Black Bullhead

The black bullhead (*Ameiurus melas*) is widely distributed across the U.S., occurring from New York west to the Rocky Mountains and from Manitoba south to Tennessee (Baxter and Simon 1970). In Wyoming, it is found in all of the major river drainages east of the Continental Divide and is likely native to these drainages. This species prefers small muddy lakes but is often found in pools of both large and small streams. The black bullhead is omnivorous, eating primarily insects and vegetation. This species is known to occur in six of the 18 sub-watersheds within the Project Area (Table 3-54).

Lake Chub

The lake chub (*Couesius plumbeus*) occurs from British Columbia south to Montana and Wyoming, across Canada and the northern states to the Atlantic Coast. In Wyoming, the lake chub is known to inhabit the Belle Fourche, Little Missouri, Tongue, and Big Horn river drainages, and in the Sweetwater River in the upper North Platte drainage. In Wyoming, this species can be found in cool foothill streams, and occasionally in lakes. This species is described as carnivorous, eating primarily micro-crustaceans and aquatic and terrestrial insects. Table 3-54 of the Aquatics Section indicates the occurrence of this species in three of the 18 sub-watersheds included in the Project Area.

Mountain Sucker

The mountain sucker (*Catostomus platyrhynchus*) occurs from California to western South Dakota and Nebraska and from southern Alberta and Saskatchewan to southern Utah (Baxter and Simon 1970). In Wyoming, this species occurs in most drainages throughout the state with the exception of the Niobrara and the South Platte. Baxter and Simon (1970) reported that this species was not collected from the Powder River. This species occurs in a variety of habitats including larger rivers and creeks at lower elevations, and alpine lakes and streams at higher elevations. The primary dietary component for this species is algae that it removes from underwater surfaces using the cartilaginous sheaths on the jaws. This species is likely an important component of the food chain. As a strict algae eater, it occupies an important link in the aquatic food web between primary producers and predatory fish. This species is known to occur in seven of the 18 sub-watersheds within the Project Area (Table 3-54).

Plains Minnow

The plains minnow (*Hybognathus placitus*) occurs from the Great Plains primarily west of the Missouri River from Montana and North Dakota south to central Texas (Baxter and Simon 1970). In Wyoming, its preferred habitat is slower water and side pools of silty streams. In clearer streams or larger rivers this species is less common and is replaced by the silvery minnow. The plains minnow is largely herbivorous with a portion of its diet consisting of aquatic invertebrates. Because of its association with silty, cloudy waters, the breeding habits of this species are poorly understood. However, similar species of the same genus typically scatter eggs in silt-bottomed backwaters (Baxter and Simon 1970). This species is known to occur in nine of the 18 sub-watersheds included within the Project Area (Table 3-54).

Sauger

The sauger (*Stizostedion canadense*) occurs from southern Canada east to New England, south to Arkansas and Tennessee and west to Montana and Wyoming (Baxter and Simon 1970). Adult fish are predominantly piscivorous, while juveniles feed on aquatic insects and crustaceans. During spawning, mature fish migrate into tributary streams and backwater lakes to spawn in shallow water over rocky or gravel bottoms (Baxter and Simon 1970). The sauger is known to occur in three of the 18 sub-watersheds included within the Project Area (Table 3-54).

Shovelnose Sturgeon

The shovelnose sturgeon (*Scaphirhynchus platorynchus*) is common in the Missouri River drainage, generally occurring in large rivers. The preferred habitat of this species is in the current at or near the bottom of large rivers. The shovelnose sturgeon feeds primarily on bottom-dwelling insects, and occasionally on vegetation and minnows. Although little is known about the breeding habits of this species, it likely lays a large number of eggs and migrates from the large rivers to smaller tributaries to spawn. This species is now considered rare in Wyoming, with known occurrences within the Project Area restricted to the Upper Powder River (Baxter and Simon 1970; Table 3-54).

Birds

American White Pelican

The American white pelican (*Pelecanus erythrorhynchos*) breeds in widely scattered colonies in western North America from northern Alberta to western Ontario and northeastern California to Utah and Colorado. In winter, this species migrates to coastal Texas and Mexico (Potter 1998a). This species feeds on non-game fish, salamanders and crayfish. Although breeding has been documented in the state, no recent observations have been recorded (Luce et al. 1999). This species may occur in the Project Area as a nonbreeding migrant. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate statistically significant, positive trends in population change for this species in both Wyoming and the United States, during the period between 1966 and 2001.

Black-crowned Night Heron

The black-crowned night heron (*Nycticorax nycticorax*) breeds throughout most of the U.S. (Potter 1998b). These herons typically construct flimsy twig nests in the lower branches of cottonwood trees, willows, and shrubs, and occasionally build their nests in emergent vegetation over water. Black-crowned night herons forage for mollusks, insects, fish, amphibians, reptiles, birds, and small mammals in shallow water bodies and along the edge of aquatic habitats. Documented observations of this species have been recorded throughout much of the state, with historical breeding records from the southern half of the state. This species is not expected to nest in the Project Area, but may occur as a seasonal migrant. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant, positive trend in population change for this species in Region 6 of the USFWS, which includes Wyoming, during the period between 1966 and 2001. The population trend for this species across the United States for the same period was highly significant and positive.

Snowy Egret

The snowy egret (*Egretta thula*) nests throughout the Great Basin, Texas, Louisiana, Florida, and in the San Luis Valley in Colorado (Ryder 1998a). This species nests in colonies, typically in willow or cottonwood trees and in tall cattail or bulrush wetlands. Snowy egret feeding habitats include marshes, wet meadows, streams, rivers, and shorelines of shallow ponds and reservoirs (Ryder 1998a). Evidence of breeding has been recorded in southern and southwestern Wyoming. This species is not expected to nest in the Project Area, but may occur as a seasonal migrant. Data from the BBS Trend Analysis (Sauer et al. 2001) indicate a non-significant, negative trend in population change for this species in Region 6 of the USFWS, which includes Wyoming, during the period between 1966 and 2001. The population trend for this species across the United States for the same period was highly significant and positive.

Mammals

Long-legged Myotis

The long-legged myotis (*Myotis volans*) lives throughout the western half of North America. They are the most abundant *Myotis* in the west and are common throughout Wyoming (Clark and Stromberg 1987). Habitats include oak, ponderosa pine, and mixed deciduous-coniferous forests, shrublands, and riparian areas (Luce et al. 1999). The long-legged myotis may occur in suitable habitats within the Project Area.

Little Brown Myotis

The little brown myotis (*Myotis lucifugus*) occurs throughout North America except in the extreme portions of the southern states (Burt and Grossenheider 1980). This bat occupies a variety of habitats that are near water, including coniferous and deciduous forests, sagebrush shrublands, grasslands, and riparian areas (Luce et al. 1999). This bat hunts for insects over water. The little brown myotis may occur in suitable habitats within the Project Area.

Big Brown Bat

The big brown bat (*Eptesicus fuscus*) occurs throughout North America with the exception of parts of Florida (Burt and Grossenheider 1980). This species forages over open meadows, tree-lined streets, corrals, and around farms and ranches (Clark and Stromberg 1987). Historical records and recent observations have been documented within the Project Area (Luce et al. 1999). This species may occur in suitable habitats within the Project Area.

Western Small-footed Myotis

The western small-footed myotis (*Myotis ciliolabrum*) occurs throughout the western half of the US and parts of Mexico (Clark and Stromberg 1987). In Wyoming, this species may occupy a variety of habitats, including pine-juniper, sagebrush shrublands, grasslands, foothills, cliffs, and outcrops (Luce et al. 1999). This species has been observed throughout Wyoming, including the Project Area (Luce et al. 1999). This species may occur in suitable habitats within the Project Area.

Cultural Resources

Regional Characterization

The Project Area is located in the Powder River Basin of northeast Wyoming and includes all of Campbell County and large portions of Converse, Johnson, and Sheridan Counties. The principal current land uses are ranching and energy development. For analysis, this large area is subdivided into 18 sub-watersheds. Current land use is dominated by ranches that raise cattle, sheep, and smaller numbers of bison, and by mineral and energy development. Coal mines are largest and most numerous in the eastern edge of the Project Area in the Fort Union Formation. In the past, the Project Area supported large herds of bison. Prior to Euroamerican settlement, the seasonal to irregular availability of water and general lack of sheltered areas discouraged large, permanent settlements.

Most of the central portion of the Project Area is underlain by lower Eocene sandstones, claystones, and coal beds of the Wasatch Formation. Smaller but locally extensive areas around the edges of the Project Area are underlain by Paleocene sandstones, shales, and coal beds of the Lebo, Tongue River, and Tullock members of the Fort Union Formation. Little high-quality raw material for prehistoric stone tool manufacture occurs in these deposits. Local raw materials for stone tools are dominated by high-quality clinkers produced through the metamorphosis of claystones by burning coal seams. Exotic raw materials from the Black Hills, the Hartville Uplift, the Bighorn Mountains, or more distant sources stand out from drab local materials.

Cultural Context

Cultural resource sites are defined as discrete locations of past human activity, which can include artifacts, structures, works of art, landscape modifications, and natural features or resources important to history or cultural tradition. These sites can include extensive cultural landscapes, such as farm or ranch landscapes, linear landscapes, such as historic trails with associated towns, forts and way stations, or railroad landscapes, and traditional use areas. In this document important sites (sites that would require additional consideration) include both listed and eligible sites (those sites that are listed on, determined eligible for, or recommended eligible for the National Register of Historic Places under the Criteria for Evaluation (36 CFR § 60.4) or National Landmarks) and sites that have not been evaluated. For the purposes of this analysis, unevaluated sites are considered potentially eligible because they have not been determined to be not eligible, and therefore require avoidance or evaluative investigations.

Prehistoric

All recognized prehistoric cultural periods, from Clovis through Protohistoric (about 11,500 to 200 years ago), are represented to some extent in the Project Area. The broad prehistoric chronological periods used in this region are:

- Paleoindian Period (11,500 to 8,000 years ago)
- Early Plains Archaic (8,000 to 5,000 years ago)
- Middle Plains Archaic (5,000 to 2,500 years ago)
- Late Plains Archaic (2,500 to 1,500 years ago)
- Late Prehistoric and Protohistoric (1,500 to 200 years ago)

Approximately 10 percent of the Project Area has been investigated, primarily in the eastern portion of the Basin. In this small sample of the Project Area, the earliest prehistoric cultural periods, Paleoindian through Early Plains Archaic, are represented by only a small number of sites. Archaic and later prehistoric period sites (Archaic to Protohistoric) are represented in increasing numbers as a result of higher populations through time and better preservation of more recent sites (Table 3-58).

Important prehistoric site types in the region include artifact scatters, stone circle sites, kill sites and faunal processing sites, rock alignments and cairns, and stone material procurement areas. The following prehistoric site types are used in the tabulation of known sites from a files search for the Project Area conducted through the Wyoming Cultural Records Office in Laramie.

Artifact Scatters – Artifact Scatters are predominantly scatters of stone tools and stone tool-making debris in this region, but also include ground stone, ceramics, and composite artifact scatters. These sites are important because they are often the only remnants indicating the presence of human activity. Artifact Scatters may provide information on chronology, subsistence, technology, settlement patterns, and resource choices, and help to understand past lifeways.

Camp – Camps are predominantly sites with artifact scatters and features or a range of artifact types that indicate habitation of the area. Camp includes sites that are listed in the files search as open camp, habitation sites, or artifacts and features. These sites are more often field evaluated as eligible than artifact scatters. These sites are important because they have the potential to yield information that can inform on issues of settlement, subsistence, technology, chronology, and social organization by various prehistoric peoples. Camps may contain concentrations of associated tools and materials known as activity areas, hearths, storage pits, or other clusters of materials that represent discrete episodes of human activity.

Multi-Component – Multi-component sites are predominantly artifact scatters and camps that contain evidence of use by different cultural groups or by the same group over different periods. These sites include diagnostic artifacts and potential for buried remains and are often considered eligible. These sites are important because they provide evidence of settlement and use of the land by a specific cultural group or for a specific time. Multi-component sites may provide information on the migrations of people or technology and help inform on cultural use of the landscape.

Habitation Features – Habitation features are predominantly stone circle sites in this region, but also include open architecture, structures, lodges, and rockshelters. These sites are important because they are habitation sites that can provide evidence of the range of habitation structural types and preferences and may provide information on settlement patterns, seasonal use of the area, social organization, and past lifeways.

Rock Features – Rock features are predominantly cairns, hunting blinds, and rock alignments but can include any non-habitation rock feature such as a medicine wheel. These sites are important because they provide information on the variety of site types that are possible in the area. These sites may provide information on ceremonial uses in the area, subsistence, territorial markers, and cultural use of the landscape.

Bone – Bone sites are marked by the predominance of animal bone and include bone scatters, kill sites, and butchering sites. These sites are often encoded as eligible. In addition to animal bone, they frequently contain a variety of stone tools, some of which may be time diagnostic. They may also contain hearth or storage features which can yield dateable carbon and other organic materials that can yield important information about the age of the site, the season the site was used, plants that were used, or butchering and processing techniques. They are important because they may inform on technology, subsistence, and social structure for various prehistoric peoples for identifiable temporal periods

Rock Art – Rock art includes pictographs (painted images) and petroglyphs (images that are carved, ground, incised, or pecked into the rock surface) that depict iconography on stone surfaces. These sites are important because they depict iconography of prehistoric people and may provide information on ceremony or subsistence related topics. Many portions of the Project Area do not contain suitable rock surfaces for the production or preservation of rock art.

Lithic Source – Lithic source is location used for acquisition of stone suitable for chipped stone tool manufacture. These locations may be areas of bedrock outcrops containing usable stone, or may be areas where pebbles, cobbles, or boulders of raw material have been redeposited by past geological processes. These sites are important because they may inform on resource choices and technology of prehistoric peoples. Some materials that were preferred for their appearance or the quality of tools that could be made from them may be found quite far from their sources. The distribution of culturally modified materials away from lithic source areas can provide important information on the movement or interaction of cultural groups over time.

Feature Only – The category Feature Only is dominated by hearth features that are found as isolated cultural remains but can include any non-architectural feature not in association with artifact scatters. These sites are important because they can provide chronological information and special use or temporary use areas for specific activities. These sites may provide information on resource choices and cultural use of the landscape.

Human Remains – Human remains are the osteological remains of the prehistoric inhabitants usually found as an interment. These are the physical remains of direct and indirect ancestors of tribes in the region and are spiritually important to the tribes. Human remains are important for many other reasons. For anthropologists they can help provide information on the belief systems and social structures of past people. In addition, they are the remains of the people who once occupied the area and may provide information on ancestry, migrations, health, and basic biological information such as age at death, sex, and stature.

Prehistoric Cultural Landscapes – Any setting that was used frequently or over a prolonged period by one or more cultural groups has the potential to be considered a cultural landscape. A cultural landscape is "a geographic area (including both cultural and natural resources and the wildlife or domestic animals therein), associated with a historic event, activity, or person or exhibiting other cultural or aesthetic values" (Birnbaum 1996:4). Vernacular landscapes encompass cultural materials, cultural features, intentional or casual modifications to the landscape, and resources or physiographic features that made that landscape culturally important. Consequently, an eligible landscape cannot be avoided and protected simply by avoiding cultural objects, features, and structures. The entire location and setting must be considered in terms of the historic character; that is, the sum of all visual aspects, features, materials, and spaces associated with the historic context of the landscape.

Prehistoric site densities can vary from extremely high in some settings, such as certain ridgetops and areas near larger, more reliable drainages, to nonexistent in other settings. The factors affecting these differences in density are not always readily apparent. Sites are areas where the evidence of one or more episodes of past human activity is visible on the landscape. If a location is used by a large number of people, or repeatedly over a long period, lost or discarded cultural materials would accumulate and sediments may be altered by the incorporation of organic materials. If the landform remains stable over time and is not degraded, deeply buried, or mechanically disturbed, the site would remain visible. Site density, that is the number of sites found in a given unit area, would be influenced by the size and number of groups that used the area and the extent or density of sought after resources. High site densities are often associated with locations that have a predictable abundance of particular resources, locations that have a moderate abundance of several distinct resources, or locations that are strategically located with access to several resource zones. Another factor that is frequently noted in site location is proximity to a reliable source of water. Other factors may be responses to seasonal conditions, such as winter camps with minimal snow accumulation that are sheltered from the wind, or summer camps on higher benches away from swarming bugs.

Table 3-58 Tally of Prehistoric Components by Sub-watershed

Sub –watershed	Paleo-indian	General Archaic	Early Archaic	Middle Archaic	Late Archaic	Late Pre-historic	Proto-historic	Total	Total (per-cent)
Upper Tongue River	2	2	2	5	8	20	4	43	3.6
Middle Fork Powder River	9	5	4	20	32	52	1	123	10.2
North Fork Powder River						1		1	.1
Upper Powder River	4	11	2	23	31	75	1	147	12.2
South Fork Powder River					2	3		5	.4
Salt Creek				1	1			2	.2
Crazy Woman Creek	1				8	6	2	17	1.4
Clear Creek	4				3	8		17	1.4
Middle Powder River	1	2		3	7	13		26	2.1
Little Powder River	9	10	5	21	51	96	12	204	16.9
Antelope Creek	11	5	18	25	49	86	4	198	16.4
Upper Cheyenne River	9	15	4 2	23	47	70	4	172	14.2
Total	59	66	40	157	299	545	42	1,208	100
Total (percent)	4.8	5.5	3.3	13.0	24.8	45.1	3.5	100	

Note: Data were available for Campbell, Johnson, and Sheridan counties only. Some sub-watersheds are not listed and others have only minimal data.

In the Protohistoric and early historic periods the Project Area was the territory of numerous tribes including, the Arikara, Crow, Lakota/Dakota, Arapaho, Kiowa, Comanche, Blackfeet, Cheyenne, and Shoshone. The region was a crossroads for many different Plains tribes, some of which used the area on a regular basis, and others, which entered the region occasionally for particular resources. Numerous confrontations occurred in the area among tribal groups, and with Euroamerican settlers and emigrants passing through to other areas.

Historic

The historic period of the area falls within the last 200 years, and begins with transient, widely separated incursions by explorers and fur traders. Exploration and the establishment of the Rocky Mountain Fur Trade intensified Euroamerican presence in the Powder River Basin in the early 1800s. Early market trade in the region was centered on bulk items such as furs and depended on river transport. Trading forts at Fort William (later known as Fort Laramie) and several major forts along the Yellowstone River were major centers with a dynamic system of smaller forts and periodic rendezvous. European and Indian trappers and traders ranged through the mountains and basin for furs and returned to the trading forts to exchange marketable goods for supplies. First-hand accounts indicate that a significant part of many trappers' income was also spent on gaming and whiskey. For many years, these trading forts were major focal points of Euroamerican activities in the region.

After the decline of the fur trade in the late 1830s, several of the major emigrant trails of the 1840s and 1850s passed the south end of the Project Area along the North Platte corridor. Fort Laramie served as a major supply point along the Oregon, California, and Mormon trails and was a focal point for overland emigrants. Portions of the emigrant trails in the Fort Laramie region were notorious for predations by Pawnee and Lakota bands. In 1845, Fort Laramie was still controlled by the American Fur Company, but Colonel Stephen Kearney left a detachment of about 100 men to provide protection for emigrants stopping at the fort. This famous fur-trading post was purchased by the U.S. government in 1849 to become the second regular military installation along the Oregon and California trails, the first having been Fort Kearny in Kansas. In 1851, Fort Laramie was the site of an historic general treaty with the plains tribes. The Fort Laramie Treaty Council of 1851 was the greatest gathering of plains tribes ever and though it was considered a success, it did not completely eliminate hostilities. Fort Laramie provided many important services to the overland immigrant such as protection, a place to stay in winter, health care, and mail (Unruh 1982:156).

With the emergence of the Montana gold fields in the 1860s, trails were established through the Project Area. The mid to late 1860s were intense years in Wyoming, and in the Powder River Basin in particular. In 1863, a group of 46 wagons attempted the first variant of the Bozeman Trail. This first wagon train was turned back by Cheyenne and Lakota near present-day Buffalo. Three wagon trains followed the route in 1864. One of the latter wagon trains, often called the Townsend Train, was attacked by Cheyenne near the Powder River, and several emigrants were killed. There were several competing expeditions from 1864 through 1866 to identify a better route for a trail to the Montana gold fields and many gold seekers set out on their own without an established trail. Among the competing expeditions were the Sawyer expeditions of 1864, and 1865-1866, which attempted to establish a trail through the Powder River Basin south of Gillette and through Sheridan. Sites associated with these expeditions have been documented in Campbell and Sheridan Counties. The expeditions were harassed by groups of Arapaho, Cheyenne, and Lakota, and on several occasions were pinned down for days or weeks. It became a customary practice in this region for several years to circle the wagons at the end of the day, dig rifle pits around the perimeter, and post pickets around the wagons and livestock. No viable trail was established across the middle of the basin due to Indian predations, unreliable water sources, and difficult terrain.

The Bozeman route along the western edge of the basin proved more viable. There were many documented confrontations between native tribes and Euroamericans along the Bozeman Trail. Among the more famous were the Wagon Box Fight, the Fetterman Fight, and the Crazy Woman Battle. The area around the crossing at Crazy Woman Creek was the site of many other skirmishes as well. Despite sustained problems with the native groups, the Bozeman Trail was used sporadically, and military forts were established to protect the wagon trains, including Fort Reno and Fort Phil Kearney. In the Fort Laramie Treaty of 1868 the tribes were granted control of the Powder River Basin, troops were withdrawn from the forts, and the trail was closed for several years.

East of the Project Area, the discovery of gold in the Black Hills by Lieutenant Colonel Custer in 1874 stimulated an influx of gold seekers and settlers into the Black Hills and Powder River Basin. The influx into the sacred Black Hills enraged the tribes, particularly the Cheyenne and the Lakota. The tribes refused to negotiate or come into the agencies. The United States launched major campaigns against the “hostiles” in 1876, with the troops out of Fort Fetterman, near present Douglas, following the Bozeman Trail north. With the major Plains Indian campaigns of the late 1870s, the tribes were driven out of the Powder River Basin and the Bozeman Trail reopened. The arrival of the railroad and the establishment of Cheyenne in 1867 had made the Powder River Basin more accessible, and with the removal of the Indian threat, settlers began to filter in. In 1878 and 1879, mail and stage service was established roughly following the Bozeman Trail. Other historic corridors crossing the Project Area in this period included the Black and Yellow Trail, the Texas Cattle Trail, and the Cheyenne-Deadwood Stage Road.

When the initial Homestead Act of 1862 was passed, the Project Area was Indian territory. In 1877, the Indian threat had been removed and the Desert Land Act was passed. The latter act allowed homestead entries as large as 160 acres, large enough for small livestock operations in this arid region. The first to take advantage of the reopening of the Powder River country were cattle ranchers. Some of the ranches also served as stage stops and roadhouses along the trails. Large, speculative cattle companies overwhelmed the public rangeland in the 1880s. Sheep also became important soon afterwards, and competed with the cattle. Relations between the sheep and cattle ranchers were strained. The large corporate cattle ranches, which used broad areas of open range, also competed for land with towns and homesteaders. The large cattle companies were devastated by the harsh winter of 1886-1887, and already strained relations with sheep ranchers, towns, and homesteaders became worse. A major period of conflict in 1892 in the Project Area is known as the Johnson County Cattle War. In this same general period outlaws, including cattle rustlers, bank robbers, and train robbers were a prominent element of local lore and tradition, but left little in the way of recognizable cultural remains. Nonetheless, there are historic sites such as Hole-in-the-Walll and Outlaw Cave in the Red Wall country southwest of Kaycee that are associated with actual historic events and lore of famous outlaws.

The entry of the Burlington Railroad in the 1890s made travel to the region quicker and less hazardous, and for a time homesteaders and small ranches prevailed. In 1909, the Enlarged Homestead Act was passed, allowing larger homestead entries and an additional surge of homesteaders and small ranchers entered the region. The Stock Raising Homestead Act of 1916, which had less stringent requirements for improvements than the Enlarged Homestead Act, followed this and with the end of the First World War, many veterans moved west to claim vacant land. This continued increase in settlement was brought to an end by droughts and agricultural recession in the 1920s and the Great Depression of the 1930s. Many homesteads and small ranches failed, and those that survived did so by absorbing failed ranches and establishing larger and more viable expanses of land. Many more failed ranches and homesteads were bought or reclaimed by the government under the provisions of the Bankhead-Jones Land Utilization Act of 1937.

The Homestead Act of 1862 had included subsurface rights, especially mineral rights, with homestead patents. The later homestead acts partially or entirely reserved federal mineral rights while granting surface rights in the patent. Entries for mineral rights were handled under a separate patent system. The separation of surface and mineral rights and several changes in the mineral patent system have resulted in a complex hodge-podge of surface and subsurface ownership. Extensive areas also have contrasting subsurface mineral rights where different types of minerals are covered by different ownership or control. Areas of contrasting surface and mineral ownership, most often private surface and federal minerals, are referred to as split estate. Such areas are especially common in portions of the Project Area, and result in challenging management problems.

With the establishment of the railroads in the early 1890s, coal mining was also emerging as an important element of the regional economy. Sheep and cattle production have remained important elements of the regional economy, but they have been surpassed by mineral and energy development. The onset of the First World War increased the market for oil and coal and these industries expanded. Energy exploration and production were not strongly affected by the agricultural recession of the 1920s. However, the depression of the 1930s did suppress the energy market until the outbreak of the Second World War.

Historic site categories documented for the Project Area are based on broad historic themes. The Wyoming Cultural Records Office database does not list districts or cultural landscapes. The site categories used in the tables in this document are Rural, Urban, Mining, Transportation, Military, Exploration, and Communication. Each of these site categories, the types of sites they include, and the importance they may have in history are discussed briefly below.

Rural sites include:

- Small and large ranch/agrarian core complexes
- Outlying ranch/agrarian features (field barns, machinery yards, stock shelters, loadouts, stock ponds or tanks, water control systems, and stock herding camps)
- Homesteads/farmsteads
- Rural community buildings (grange halls, rural schools, rural churches, and mercantiles)

This theme involves historic rural settlement from the expulsion of the Native American tribes in the late 1870s to the early 1950s. Settlement was initially focused around the new or reestablished forts and military camps along the Bozeman Trail. As military and civilian wagon roads and stage roads were established, settlements formed along those arteries. Large corporate ranches soon occupied open lands for grazing and homesteaders began to spread through the region. Several cycles of expanded settlement and failure may be reflected in building styles and materials in surviving structures. More favorable locations were repeatedly reoccupied, and many of the earlier structures were destroyed or modified by later uses. In some cases, each occupation or use episode in a core complex is centered in a slightly different location, and the earlier episodes retain a degree of spatial and structural integrity. Some marginal locations may retain fairly unmodified sites reflecting discrete settlement episodes, although it is a common practice to reuse abandoned buildings for stock shelters or other purposes.

Important parts of rural settlement were rural community buildings including churches, schools, and community halls such as grange halls. In some cases, all of these functions were combined in a single building that might be located on a state-owned section or on land provided by one of the landowners. These types of buildings were also commonly located in small communities that served the nearby farms and ranches, as well as serving as political or economic centers at various levels. Many of the rural community buildings began to fall into disuse with the development of motorized traffic and maintained public roads. This is clearly manifested in the centralization of public schools with the development of busing.

These kinds of sites are important for their association with the broad patterns of settlement and development in this region. They represent the homesteads, small and large ranches, small communities, and support facilities that characterized these patterns. Some are important because of their association with specific historic events or the contributions of persons important in history. Others are rare surviving examples representing once common patterns. Some may be important for their potential to yield information important in history that is not available in written documents.

Urban sites include:

- Urban Architecture/Buildings
- Courthouse; Government and Community Buildings
- Dance Hall; Saloon, Café/Diner;
- Fairgrounds; Parks
- Home; House; Residence
- Hotel/Lodge;
- Store; Commercial Building
- Church;
- Power Plant;
- Warehouses

This theme involves the emergence of towns. Towns developed as commercial or political centers and are characteristically a mix of residential, commercial, and public buildings. Industrial or industrial support facilities may also be an important element of a town. As energy development and railroads entered the region, towns formed along or moved to the railroad as railheads and transfer points, or formed near mines or well fields as residential areas for laborers and as centers for supply and support services. Urban architecture is more varied than rural architecture, partly because there is generally a wider range of functions represented, and partly because a greater financial base is expressed in more current or elaborate styles. Urban buildings and structures may also exhibit more time-sensitive styles than rural vernacular buildings and structures and may be more easily associated with particular periods or themes.

Mining sites, which includes liquid mineral and energy development, include:

- Mine;
- Mining Support Facilities;
- Tipple;
- Loadout;
- Well Field;
- Energy Exploration

The mining theme includes energy and mineral development facilities. The most conspicuous of these facilities are surface mine complexes, loadouts, and tipples. Oil and gas facilities are generally more dispersed than surface mine complexes. Earlier mines were often abandoned and not reclaimed. Although foundations or deteriorated structures may remain, equipment was typically moved to new mine locations or salvaged over the years. Old mines and oil fields are best identified through mineral claims and public records. Even if little remains in the way of surface structures and associated artifacts, these sites reflect changes in mining strategy and technology in the patterns of landscape modification.

Transportation sites include:

- Overland Migration Corridor/Emigrant Trail;
- Inscriptions;
- Tie Hack Camp;
- Trail/Stage Route;
- Stage Station;
- Freight Road;
- Airstrip;
- Ferry;
- Bridge;
- Road;
- Railroad

This theme represents changes in the patterns and technology of transportation from early historic trails that often followed prehistoric trails, to the emergence of trucks and automobiles and maintained public roads. The early trapper's trails and emigrant roads had locations along them that could be called points of convergence. These might be river crossings, low passes, water sources, sources of wood, areas of good pasture, or landmarks. Between these points the trails might vary with the season, the whim of the traveler, or other conditions, and were more like broad swaths across the landscape than marked roads or trails as we might envision today. With more regular freight wagon routes and stage lines, roads were improved and maintained. When the railroads entered the scene, these were necessarily engineered corridors that responded to a different set of economic needs and to different design constraints.

Military sites include:

- Military Camp/Cantonment;
- Blockhouse/Powder Magazine;
- Battlefield/Battle Site;
- Military Fort;
- Proving Grounds;
- Air Bases;
- Chemical and Weapons Depots;
- Missile Silos

The military theme covers evidence of military camps and installations, support facilities, and sites of battles, beginning with the military encampments of the 1860s up through the military facilities of the Cold War. In the Project Area, military sites are clustered along the Bozeman Trail corridors. Many of these sites are not conspicuous on the landscape, but must be identified from historic accounts and detailed surface inspection.

Exploration sites include:

- Fur Trade Cabin;
- Trading Post;
- Trade Beads;
- Expedition Camps;
- Survey Marker

The theme of exploration covers early exploration of the region by fur traders, government expeditions, early travelers, and railroad or General Land Office surveyors. These sites may be comparatively small and transient but are generally either locations described in historic accounts that may or may not be marked by physical remains, or sites marked by distinctive early historic artifacts, including goods made for Indian trade or trapping paraphernalia.

Communication sites include:

- Telegraph/Telephone Lines;
- Pony Express Stations;
- Transmission Lines

These sites represent early communications systems and energy distribution systems. They may be marked by little more than occasional insulator fragments or remnants of crudely hewn poles. Pony Express stops often need to be identified from historic sources. Some were little more than a rural shack and a corral, others were located at existing ranches, and many others became stage stops, retaining little to identify them as Pony Express stops.

Other sites consist of site types that occur in small numbers in the Project Area and do not fall in any of the themes listed above. Sites that have been counted in this category include:

- Civilian Conservation Corps (CCC) Camp/Conservation Site;
- Hatchery;
- Monument;
- Prison Camp;
- Lumber Mill;
- Timber Camp;
- Shooting Range;
- Burial/Cemetery/Grave;
- Cairns;
- Historic Camp;

- Dump/Trash Scatter

The Wyoming guidelines also define historic periods that crosscut the themes and site types listed above. The major periods are:

- Early Historic (AD 1800 to 1842)
- Pre-Territorial (AD 1842 to 1868)
- Territorial (AD 1868 to 1890)
- Expansion (AD 1890 to 1920)
- Depression (AD 1920 to 1939)
- Modern (AD 1939 to present)

Evaluation of the importance of historic sites, districts, and landscapes must consider aspects of both theme and period in assessing the historic character and contributing attributes of the resources.

Native American Traditional Cultural Places

General ethnographies of the Lakota, Crow, Mandan, Hidatsa, Arikara, Cheyenne, Arapaho, Shoshone, and other tribes that may have had traditional ties to this region do not provide information on specific resources in the Project Area that are likely to be traditional cultural concerns. There are certainly prominent and identifiable places to the west in the Big Horn Mountains and to the east in the Black Hills area. Probably the most widely known examples would be the Big Horn Medicine Wheel and Devils Tower. The known sacred and traditional places offer some indications of the types of places valued by the Plains Equestrian cultures in the historic period. However, any identification of sacred or traditional localities must be verified in consultation with authorized tribal representatives.

Conspicuous landmarks, prominences, and high locations were often held in reverence. It would be reasonable to assume that Pumpkin Buttes, several of the more distinctive or isolated buttes throughout the Project Area, and distinct rock formations in the Middle Fork and Red Wall country were traditionally important places. Some of these natural features may have associated rock art, cairns, offering sites, vision quest sites, or other tangible evidence of traditional importance, while others may be embedded in oral traditions.

Distinctive natural water bodies and confluences of flowing streams and rivers were held by many tribes to be sources of power and inspiration, and mirrors of the inner spirit. The presence of flowing water or bodies of water and high isolated locations such as buttes in close proximity to one another were sometimes considered especially powerful or close to the spirits. These kinds of locations were commonly used for fasting or vision quests. Some vision quest sites that were used repeatedly over the generations have physical features, such as cairns, small stone circles, offerings, small clusters of stone, or stone alignments, in addition to the character of their physical setting.

At a smaller scale, traditional rock art marks localities that were important or sacred to past populations and the rock art itself is a traditional concern to most existing tribes. Similarly, stone intaglios and effigies, some rock alignments, and many ancient rock cairns, mark traditionally significant locations. Any location with cobble effigy figures, unusually small or large stone circles or medicine wheels, geometric stone alignments, or prominent cairns should be considered a potential sacred or traditional site. Tribes may also hold alignments and cairns associated with more mundane functions such as trails and game drives to be sacred or traditionally important, and may also consider most archaeological sites to be traditional cultural places important to their tribal identity. Several of the tribes that have traditional ties to the Project Area consider "tipi rings" (that is, stone circle sites) to be sensitive sites that may have spiritual or sacred associations. Traditional tribal concerns can also include traditional gathering areas for medicinal and ceremonial materials.

If tribal representatives agree,

an ethnohistorian could assist in identifying and documenting traditional cultural places and concerns. An ethnohistorian working with traditional tribal elders, recorded oral traditions, historic accounts, and ethnographic data would be able to identify traditional cultural places and document customs and traditions associated with those places.

Files Search

A files search for all four counties (Campbell, Converse, Johnson, and Sheridan) was conducted through the Wyoming Cultural Records Office database in late March of 2001. This files search covers most investigations in the four counties through the year 2000. The database of cultural resource reports, cultural resource sites, and isolated finds was then narrowed to the project area and subdivided by sub-watershed. This database contains records for 8,120 cultural resource sites, and 2,831 isolated finds. Of the total cultural resource reports in the files search, 2,359 were completed prior to 1983 when statewide standards were implemented for cultural resource investigations and reporting. Some of those earlier reports might not be considered adequate by current standards and must be reviewed individually to evaluate their adequacy. Nonetheless, they provide information that might not be otherwise available on the nature and distribution of prehistoric and historic resources. A comparison of the surveyed acres listed in the files search and the total acreage of the Project Area indicates that approximately 10 percent of the Project Area has been investigated. Using this information, the quantity of significant cultural resource sites can be estimated that may be affected the projected area of potential effect of the proposed oil and gas development.

Table 3-59 and Table 3-60 list the numbers of prehistoric and historic cultural resource sites that have been documented in each of the sub-watersheds in the Project Area by site type or historic theme, and by National Register evaluation. Table 3-61 lists the number of isolated finds documented in each of the sub-watersheds. The files search for this area contains a high proportion of sites that are unevaluated or for which information on evaluation is lacking – 35.6 percent for prehistoric and 35 percent for historic. The files search tables show 13 percent of the prehistoric sites and 9.6 percent of the historic sites as listed or eligible. Currently, when adequate information is available, about 20 to 25 percent of the documented sites in an area are evaluated as eligible (Wolf 2002).

Artifact scatters dominate prehistoric sites in the Project Area. When there is adequate information to evaluate this type of site, the majority is not eligible. However, complex sites and sites with buried levels and dateable materials/artifacts can yield important information. Prehistoric sites in the category of "camp" are a combination of artifacts and features, or a range of artifact types. These sites are more often field evaluated as eligible than are simple artifact scatters. The small categories of multi-component/stratified, habitation features, rock features, bone beds/scatters, and rock art are high-profile categories that are very often evaluated as eligible. Bone beds and stratified sites that are key in understanding of all periods of Plains prehistory occur in the Project Area. Subwatersheds where there have been more studies and more follow-up studies, such as Antelope Creek, Upper Cheyenne, and Upper Belle Fourche, have a lower proportion of unevaluated sites. This is especially true of large coal mine developments. Areas within some of the subwatersheds have more varied habitats, particularly attractive resources, or conditions more conducive to preservation, and are very rich in significant prehistoric sites. These areas include the Upper Tongue, the Middle Fork Powder, the lower Antelope Creek Drainage, and the eastern portions of the Upper Belle Fourche.

Rural/agrarian sites dominate known historic sites because that is where the majority of systematic surveys have been conducted. These include homesteads, farms, ranches, agrarian and ranching features, irrigation features, and rural residences. The principal exception is the Upper Tongue River sub-watershed, in which a large number of urban buildings and structures have been documented in Sheridan. The next most common site type is transportation features, which includes trails, roads, bridges, railroads, stage stations, railroad stations, and related structures or features. Where historic military sites, early exploration sites, and early transportation sites have been recognized and documented, most are considered significant because of their associations with significant historic events. Urban buildings and structures are often recorded as part of surveys of significant historic buildings, rather than in response to unrelated actions. This also produces a moderately high proportion of sites evaluated as eligible. The Bozeman Trail, its several variants, and related sites, were highly significant in western history and retain a large number of well-preserved segments. The Outlaw Cave/Red Wall area of the Middle Fork Powder River is rich in prehistoric caves and rockshelters, premiere prehistoric rock art sites, prehistoric stone features, and historic sites that figure prominently in Western lore. The proportion of significant historic sites is high in most categories, and these sites require additional work beyond basic field recording. In addition, many of the historic sites are unevaluated and require additional background or context research to assess their eligibility.

Table 3-59 Prehistoric Site Types by Sub-watershed

Sub-watershed	Evaluation	Artifact Scatter[1]	Camp[2]	Multi-Component	Habitation Features[3]	Rock Features[4]	Bone[5]	Rock Art	Lithic Source	Features Only	Human Bone	Unknown	Total	%[6]
Little Bighorn River	Eligible	0	0	0	0	0	0	0	0	0	0	0	0	0
	Unevaluated	2	0	0	0	0	0	0	0	0	0	0	2	66.7
	Not Eligible	1	0	0	0	0	0	0	0	0	0	0	1	33.3
	Total	3	0	0	0	0	0	0	0	0	0	0	3	<.1
Upper Tongue River	Eligible	3	8	0	1	0	0	0	0	0	0	0	12	5.6
	Unevaluated	69	41	1	25	4	3	2	8	3	0	0	156	72.9
	Not Eligible	26	12	0	4	3	0	0	1	0	0	0	46	21.5
	Total	98	61	1	30	7	3	2	9	3	0	0	214	4.0
Middle Fork Powder River	Eligible	24	78	0	6	2	2	5	8	0	0	0	125	29.4
	Unevaluated	66	41	0	15	5	2	2	12	0	1	1	145	34.1
	Not Eligible	77	63	0	2	4	0	0	9	0	0	0	155	36.5
	Total	167	182	0	23	11	4	7	29	0	1	1	425	7.7
North Fork Powder River	Eligible	0	1	0	0	0	0	0	0	0	0	0	1	25.0
	Unevaluated	2	0	0	0	0	0	0	0	0	0	0	2	50.0
	Not Eligible	1	0	0	0	0	0	0	0	0	0	0	1	25.0
	Total	3	1	0	0	0	0	0	0	0	0	0	4	<.1
Upper Powder River	Eligible	1	43	0	2	0	6	0	0	0	0	0	52	6.5
	Unevaluated	124	81	1	22	0	3	0	5	4	0	0	240	30.0
	Not Eligible	288	199	0	12	4	2	0	2	2	0	0	509	63.5
	Total	413	323	1	36	4	11	0	7	6	0	0	801	15
South Fork Powder River	Eligible	2	0	0	0	0	1	0	0	0	0	0	3	17.4
	Unevaluated	4	5	0	2	0	0	0	0	1	0	0	12	52.2
	Not Eligible	4	3	0	0	0	0	0	0	0	0	0	7	30.4
	Total	10	8	0	2	0	1	0	0	1	0	0	22	.4
Salt Creek	Eligible	2	1	0	1	0	0	0	0	0	0	0	4	6.2
	Unevaluated	10	14	0	7	3	0	1	1	0	0	0	36	55.4
	Not Eligible	16	4	0	0	5	0	0	0	0	0	0	25	38.4
	Total	28	19	0	8	8	0	1	1	0	0	0	65	1.2

Table 3-59 Prehistoric Site Types by Sub-watershed

Sub-watershed	Evaluation	Artifact Scatter[1]	Camp[2]	Multi-Component	Habitation Features[3]	Rock Features[4]	Bone[5]	Rock Art	Lithic Source	Features Only	Human Bone	Unknown	Total	%[6]
Crazy Woman Creek	Eligible	3	5	0	2	0	1	1	0	0	0	0	12	12.2
	Unevaluated	14	15	0	12	0	0	1	2	0	0	1	45	45.9
	Not Eligible	19	10	0	7	4	0	0	0	0	1	0	41	41.9
	Total	36	30	0	21	4	1	2	2	0	1	1	98	1.8
Clear Creek	Eligible	3	6	0	3	0	0	0	0	0	0	0	12	9.7
	Unevaluated	10	14	0	27	2	3	0	2	1	0	1	60	48.4
	Not Eligible	24	10	0	5	9	0	0	4	0	0	0	52	41.9
	Total	37	30	0	35	11	3	0	6	1	0	1	124	2.3
Middle Powder River	Eligible	2	1	0	0	0	0	0	0	0	0	0	3	2.3
	Unevaluated	33	37	0	6	0	0	0	2	0	0	0	78	61.5
	Not Eligible	40	5	0	2	0	2	0	0	0	0	0	49	36.2
	Total	75	43	0	8	0	2	0	2	0	0	0	130	2.4
Little Powder River	Eligible	11	40	0	16	1	5	0	0	0	0	1	74	13.6
	Unevaluated	66	21	1	26	2	3	0	3	0	0	0	122	22.4
	Not Eligible	256	33	0	29	9	7	0	12	1	1	1	349	64.0
	Total	333	94	1	71	12	15	0	15	1	1	2	545	9.9
Little Missouri River	Eligible	0	1	0	0	0	0	0	0	0	0	0	1	5.3
	Unevaluated	2	1	0	2	0	0	0	0	0	0	0	5	26.3
	Not Eligible	6	7	0	0	0	0	0	0	0	0	0	13	68.4
	Total	8	9	0	2	0	0	0	0	0	0	0	19	.3
Antelope Creek	Eligible	53	122	1	20	0	2	0	2	2	1	0	203	23.0
	Unevaluated	125	49	0	28	14	3	1	0	5	1	0	226	25.6
	Not Eligible	298	104	0	38	11	1	0	2	0	0	1	455	51.4
	Total	476	275	1	86	25	6	1	4	7	2	1	884	16.1
Dry Fork Cheyenne River	Eligible	1	32	0	11	1	1	0	1	0	0	0	47	11.1
	Unevaluated	58	58	0	59	50	2	0	1	2	0	0	230	54.4
	Not Eligible	90	31	0	11	7	3	0	4	2	0	0	148	34.5
	Total	149	121	0	81	58	6	0	6	4	0	0	425	7.7

Table 3-59 Prehistoric Site Types by Sub-watershed

Sub-watershed	Evaluation	Artifact Scatter[1]	Camp[2]	Multi-Component	Habitation Features[3]	Rock Features[4]	Bone[5]	Rock Art	Lithic Source	Features Only	Human Bone	Unknown	Total	%[6]
Upper Cheyenne River	Eligible	8	28	0	5	2	3	0	0	0	1	0	47	9.4
	Unevaluated	51	30	1	19	2	2	0	5	0	0	0	110	21.2
	Not Eligible	289	47	1	12	5	4	0	3	0	0	0	361	69.7
	Total	348	105	2	36	9	9	0	8	0	1	0	516	9.4
Lightning Creek	Eligible	3	15	0	2	0	0	0	0	0	0	0	20	8.8
	Unevaluated	80	29	0	12	4	3	0	1	0	0	0	129	56.6
	Not Eligible	54	19	0	4	2	0	0	0	0	0	0	79	34.6
	Total	137	63	0	18	6	3	0	1	0	0	0	228	4.1
Upper Belle Fourche River	Eligible	15	26	0	25	2	0	0	0	0	0	0	68	9.0
	Unevaluated	109	33	1	53	23	8	0	7	5	0	1	240	31.7
	Not Eligible	284	88	0	63	10	1	0	3	0	0	0	449	59.3
	Total	408	147	1	141	35	9	0	10	5	0	1	757	13.8
Middle North Platte River	Eligible	2	19	0	7	0	1	0	0	0	0	0	29	11.9
	Unevaluated	21	36	0	48	17	0	0	0	1	0	0	123	50.6
	Not Eligible	40	31	0	8	5	1	0	5	0	0	0	91	37.5
	Total	63	86	0	63	22	2	0	5	1	0	0	242	4.4
Total Eligible Sites		135	426	1	102	8	22	6	11	2	2	1	716	13.0
Total Unevaluated Sites		846	505	5	363	126	32	7	49	22	2	4	1,961	35.6
Total Sites		2,792	1,597	7	661	212	75	13	105	29	6	7	5,504	100
Percent of Total Sites		50.8	29.0	0.1	12.0	3.9	1.4	0.2	1.9	0.5	0.1	0.15	100	

Notes:
1. Artifact Scatters are predominantly lithic (that is, chipped stone tool) scatters in this region, but also include ground stone, ceramics, and composite artifact scatters.
2. Camp includes sites encoded as open camp, habitation, or artifacts and features.
3. Habitation Features includes stone circles, open architecture, structures, lodges, and rockshelters. The most common of the latter are stone circles.
4. Rock Features includes cairns, hunting blinds, rock alignments, and other non-habitation rock features.
5. Bone includes bone beds, bone scatters, kill sites, and butchering sites.
6. % is given as percent Eligible for each subwatershed and then percent of total sites represented by the subwatershed.

Table 3-60 Historic Site Types by Historic Theme and Sub-watershed

Sub-watershed	Evaluation	Rural	Urban	Mining	Transportation	Military	Exploration	Communication	Other	Unknown	Total	%
Little Bighorn River	Eligible	0	0	0	3	0	0	0	0	0	3	60
	Unevaluated	0	0	0	0	0	0	0	0	0	0	0
	Not Eligible	1	0	0	1	0	0	0	0	0	2	30
	Total	1	0	0	4	0	0	0	0	0	5	0.2
Upper Tongue River	Eligible	8	11	3	13	4	0	0	0	1	40	16.9
	Unevaluated	37	13	14	2	5	1	0	9	12	93	39.2
	Not Eligible	12	60	8	22	0	0	0	2	0	104	43.9
	Total	57	84	25	37	9	1	0	11	13	237	10.5
Middle Fork Powder River	Eligible	8	1	0	1	1	0	0	0	1	12	12.1
	Unevaluated	34	6	0	2	0	0	0	8	6	56	56.6
	Not Eligible	16	1	0	2	0	0	0	11	1	31	31.3
	Total	58	8	0	5	1	0	0	19	8	99	4.4
North Fork Powder River	Eligible	1	0	0	0	0	0	0	0	0	1	50
	Unevaluated	0	0	0	0	0	0	0	0	0	0	0
	Not Eligible	0	0	0	0	0	0	0	1	0	1	50
	Total	1	0	0	0	0	0	0	1	0	2	<.1
Upper Powder River	Eligible	10	0	0	13	2	0	0	3	1	29	8.5
	Unevaluated	74	1	2	3	4	1	0	10	23	118	34.7
	Not Eligible	120	0	2	13	0	1	0	49	8	193	56.8
	Total	204	1	4	29	6	2	0	62	32	340	15.1
South Fork Powder	Eligible	1	0	0	1	0	0	0	1	0	3	18.8
	Unevaluated	1	1	0	0	0	3	0	1	1	7	43.7

Table 3-60 Historic Site Types by Historic Theme and Sub-watershed

Sub-watershed	Evaluation	Rural	Urban	Mining	Transportation	Military	Exploration	Communication	Other	Unknown	Total	%
River	Not Eligible	2	0	0	4	0	0	0	0	0	6	37.5
	Total	4	1	0	5	0	3	0	2	1	16	.7
Salt Creek	Eligible	0	0	0	2	0	0	0	0	0	2	7.1
	Unevaluated	6	0	0	2	0	0	0	0	1	9	32.2
	Not Eligible	5	0	1	6	0	0	0	5	0	17	60.7
	Total	11	0	1	10	0	0	0	5	1	28	1.2
Crazy Woman Creek	Eligible	1	0	0	6	1	0	0	1	0	9	12.7
	Unevaluated	18	1	2	2	0	2	0	3	1	29	40.8
	Not Eligible	17	0	1	8	0	0	0	5	2	33	46.5
	Total	36	1	3	16	1	2	0	9	3	71	3.1
Clear Creek	Eligible	16	8	0	6	3	0	0	1	1	35	19.7
	Unevaluated	32	12	4	5	0	0	0	4	12	69	38.7
	Not Eligible	15	10	3	39	0	0	2	5	0	74	41.6
	Total	63	30	7	50	3	0	2	10	13	178	7.9
Middle Powder River	Eligible	2	0	0	0	0	0	0	0	0	2	5.5
	Unevaluated	18	0	0	0	0	0	0	1	0	19	52.8
	Not Eligible	7	1	0	2	0	0	0	5	0	15	41.7
	Total	27	1	0	2	0	0	0	6	0	36	1.6
Little Powder River	Eligible	9	0	0	0	0	1	0	0	0	11	5.8
	Unevaluated	49	2	0	2	0	0	0	6	5	64	33.7
	Not Eligible	66	2	2	10	0	0	0	22	13	115	60.5
	Total	124	4	2	12	0	1	0	29	18	190	8.4

Table 3-60 Historic Site Types by Historic Theme and Sub-watershed

Sub-watershed	Evaluation	Rural	Urban	Mining	Transportation	Military	Exploration	Communication	Other	Unknown	Total	%
Little Missouri River	Eligible	0	0	0	0	0	0	0	0	0	0	0
	Unevaluated	3	1	0	1	0	0	0	1	1	7	70
	Not Eligible	2	0	0	0	0	0	0	0	1	3	30
	Total	5	1	0	1	0	0	0	1	2	10	.4
Antelope Creek	Eligible	14	1	0	4	0	0	0	2	2	23	7.9
	Unevaluated	37	1	2	0	0	0	0	16	13	69	23.5
	Not Eligible	123	0	5	6	1	0	0	55	11	201	68.6
	Total	174	2	7	10	1	0	0	73	26	293	13.0
Dry Fork Cheyenne River	Eligible	3	0	0	2	0	0	0	1	0	6	4.1
	Unevaluated	50	0	0	3	0	0	0	20	7	80	54.8
	Not Eligible	32	0	1	4	1	0	0	18	4	60	41.1
	Total	85	0	1	9	1	0	0	39	11	146	6.5
Upper Cheyenne River	Eligible	4	0	0	1	0	0	0	3	0	8	4.8
	Unevaluated	13	0	0	2	0	0	0	7	8	30	18.0
	Not Eligible	85	0	1	7	0	0	0	35	1	129	77.2
	Total	102	0	1	10	0	0	0	45	9	167	7.4
Lightning Creek	Eligible	2	0	0	0	0	0	0	0	0	2	3.9
	Unevaluated	8	0	0	0	0	0	0	3	10	21	41.2
	Not Eligible	15	0	0	0	0	0	0	11	2	28	54.9
	Total	25	0	0	0	0	0	0	14	12	51	2.3
Upper Belle Fourche	Eligible	17	0	0	5	3	0	0	1	1	27	8.6
	Unevaluated	37	1	4	4	0	0	0	9	18	73	23.3

Table 3-60 Historic Site Types by Historic Theme and Sub-watershed

Sub-watershed	Evaluation	Rural	Urban	Mining	Transportation	Military	Exploration	Communication	Other	Unknown	Total	%
River	Not Eligible	130	3	4	10	0	0	0	47	19	213	68.1
	Total	184	4	8	19	3	0	0	57	38	313	13.9
Middle North Platte River	Eligible	0	0	0	4	0	0	0	0	0	4	5.6
	Unevaluated	34	0	0	1	0	0	0	8	1	44	61.1
	Not Eligible	14	0	0	4	0	0	0	4	2	24	33.3
	Total	48	0	0	9	0	0	0	12	3	72	3.2
Total Eligible Sites		96	21	3	61	14	1	0	14	7	217	9.6
Total Unevaluated Sites		451	39	28	29	9	7	0	106	119	788	35.0
Total Sites		1209	137	59	228	25	9	2	395	190	2,254	100
Percent Total Sites		53.6	6.1	2.6	10.1	1.1	0.4	<0.1	17.5	8.4	100	

Native American Consultation

Federal legislation and regulation, including but not limited to 36 CFR §800 implementing Section 106 of the National Historic Preservation Act, as amended, and the Native American Graves Protection and Repatriation Act (NAGPRA), requires consultation with recognized Native American tribes. Within the Project Area, they include the Apache, Northern Arapaho, Crow, Northern Cheyenne, Arikara, Mandan, Hidatsa, Kiowa, Shoshone, Salish and Kootenai, Turtle Mountain Chippewa, and Lakota (Sioux) tribes. The BLM has notified tribes that may have traditional interests and concerns in the region of the EIS process. The intent of BLM in Native American consultation is to:

- Identify places of traditional religious or cultural importance to the tribes within the planning area; Identify whether the tribes have any needs for access to these places which need to be considered in the BLM's planning effort; and

Table 3-61 Number of Isolated Finds by Sub-watershed

	Isolated Finds			
Sub-watershed	Prehistoric	Historic	Unknown	Total
Little Bighorn River	1	0	0	1
Upper Tongue River	25	0	7	32
Middle Fork Powder River	82	2	14	98
North Fork Powder River	1	1	0	2
Upper Powder River	437	57	80	574
South Fork Powder River	1	10	8	19
Salt Creek	22	3	3	28
Crazy Woman Creek	13	4	5	22
Clear Creek	17	5	0	22
Middle Powder River	33	1	2	36
Little Powder River	227	8	25	260
Little Missouri River	2	0	0	2
Antelope Creek	462	24	127	613
Dry Fork Cheyenne River	137	2	20	159
Upper Cheyenne River	216	7	30	253
Lightning Creek	30	0	9	39
Upper Belle Fourche River	408	40	82	530
Middle North Platte River	111	1	29	141
Total	2,225	165	441	2,831

- Identify the individuals, such as traditional cultural leaders or religious practitioners, who must be consulted.

To help obtain this information, the BLM has sent out letters to tribes and is seeking to meet with all applicable tribes to discuss their concerns. The BLM has also invited the tribes to tour the planning area to begin to identify areas of traditional importance where impacts could occur.

Land Use and Transportation

Land Use

This section discusses the existing land surface and mineral ownership, land uses, and land use management and planning in the Project Area.

Regional Characterization

The BLM-administered lands within the Project Area include both the BFOA and the CFOA. In Campbell, Johnson, and Sheridan Counties, BLM lands within the Project Area are administered by the BFO. For the northern potion of Converse County within the Project Area, BLM lands are administered by the CFO.

FS-administered lands in the Project Area include portions of the TBNG administered by the Medicine Bow-Routt National Forest. The TBNG is located in the eastern portions of Campbell and Converse Counties.

Land ownership in the Project Area consists primarily of private lands intermingled with federal and state lands, as shown on Figure 3-17. Mineral ownership in the Project Area consists primarily of federal mineral estates as shown on Figure 3-17. Rangeland/livestock grazing is the dominant land use for both public and private lands in the Project Area. The management of planned future land uses within the Project Area is also discussed for BLM- and FS-administered lands, state-owned lands, and the local governments.

Land Status/Surface Ownership

The distribution of surface ownership of the land within each watershed of the Project Area is summarized on Table 3-62 and shown on Figure 3–17.

Approximately 76 percent of the surface ownership in the Project Area is private land. The State of Wyoming owns 9 percent of the surface land within the Project Area. Federal land comprises 14 percent of the Project Area.

Federal lands within the Project Area are administered by the BLM BFO and CFO and the FS and consist of numerous noncontiguous tracts of land surrounded by private lands. Approximately 10 percent of the lands within the Project Area are federally owned within the BFOA. Within the CFOA, 1 percent of the land is federally owned. FS-administered lands in the area include portions of the TBNG administered by the Medicine Bow-Routt National Forest. The TBNG is located in the eastern portions of Campbell and Converse Counties. Approximately 3 percent of the lands within the FS-administered lands within the Project Area are federally owned.

Mineral Ownership

The mineral estate (mineral ownership) within the Project Area is shown in Figure 3–18. Many areas of the Project Area are considered “split-estate,” meaning the surface owner is different from the owner of the mineral rights. For example, the surface may be privately owned but the mineral estate is, at least in part, federally owned. In addition, there may be more than one owner among the different mineral estates. For example, the federal government may own only the oil and gas mineral resources, while coal and other mineral resources on the same lands are owned by the state or private parties. For CMB operations where the mineral resource is federally owned and the surface is privately owned, the operator is responsible for reaching an agreement with the private surface owner for access to the property under regulations at 43 CFR Part 3814. Based on the discretion of the surface owner, a surface use agreement also may be required.

The mineral ownership within each sub-watershed in the Project Area is shown on Table 3-63. The categories of mineral ownership shown include several categories that must be combined to determine the total federal ownership for oil and gas rights. Total oil and gas ownership includes the sum of properties with federal ownership of all mineral rights; oil and gas rights only; oil, gas and coal rights only; and oil, gas, coal and other minerals (but not all mineral rights). The mineral category “other” includes locatable minerals (bentonite, uranium, and others) and salable minerals (sand, gravel and scoria).

Most of the oil and gas mineral estates within the Project Area are federally owned. Within the BFOA, 63 percent of the oil and gas mineral estate within the Project Area is federally owned. Approximately 63 percent of the oil and gas minerals for that portion of the Project Area within the CFOA are federally owned. Within the FS-administered lands of the Project Area, approximately 52 percent of the oil and gas rights are under federal ownership.

Existing Land Uses

Several primary land uses occur within the Project Area as shown on Figure 3-19, and as discussed in the following sections. The land use categories for the BLM-administered lands for both the BFOA and the CFOA, and the FS-administered lands within the Project Area are shown on Table 3-64 and summarized in the following discussion.

Agriculture

Agricultural land uses within the Project Area include cropland and pasture, confined feeding operations, and other agricultural uses. Most of the cropland in the Project Area is not irrigated; however, irrigated cropland occurs in limited areas, primarily adjacent to drainage ways.

Barren

Barren lands are generally defined as dry salt flats, beaches, sandy areas other than beaches, bare exposed rock, quarries, gravel pits, and transitional areas. Barren lands include active and historic mines. The locations of the coal strip mines within the Project Area are shown on Figure 2–1. Existing producing coal mines are discussed in the section on Coal**.** There are historical mines for coal, uranium, bentonite, and aggregate materials (sand and gravel) within the Project Area. Within the Project Area, oil and gas resources are frequently located in the same general vicinity as coal resources. Federal coal lands being considered as having development potential are primarily in the easternmost portion of the Project Area (BLM 2001f).

Forested and Mixed Rangeland

Rangeland is generally used for livestock operations and grazing and is the dominant land use in the Project Area. The primary use of the BLM- and FS-administered forest lands within the Project Area is also grazing. The forest land category shown on Figure 3-19 includes deciduous, evergreen, wetland/riparian, and mixed forest land.

Urban

Urban land uses within the Project Area include residential, industrial/ commercial areas, and transportation, communications, and utility ROWs, as well as transitional areas, as shown on Figure 3–19**.**

Although rural residences are scattered throughout the Project Area, residences are primarily concentrated in the areas within and immediately adjacent to the incorporated areas of Project Area. The incorporated communities within the Project Area include Gillette and Wright in Campbell County; Douglas and Glenrock in Converse County; Buffalo and Kaycee in Johnson County; and Sheridan in Sheridan County. Additional residential areas within the Project Area are also concentrated near numerous unincorporated communities.

The transportation and utility corridors for the Project Area are shown on Figure 3–19**.** The transportation network and railroad corridors are discussed in the section on Transportation.

Water and Wetlands

The water and wetland areas in the Project Area are discussed in the sections on Surface Water and Wetlands and Riparian Areas.

Existing Oil and Gas Development

Approximately 12,024 CBM wells and 1,302 non-CBM wells are already permitted or drilled on federal, state, and private lands within the Project Area. Existing CBM wells, non-CBM wells, and conventional oil or gas wells within the Project Area are discussed in the section on Groundwater (beginning on page 3-1). The existing disturbance by land use category, surface owner, and sub-watershed is shown on Table 3-65. Approximately 41,708 acres of the existing land uses have been previously disturbed, primarily in the mixed rangeland category, by the wells and ancillary facilities.

Existing Coal Mines

The locations of the coal strip mines within the Project Area are shown in Figure 2-1. Existing, producing coal mines are discussed in the section on coal. There are historical mines for coal, uranium, bentonite, and aggregate materials (sand and gravel) within the Project Area, and oil and gas resources are frequently located in the same general vicinity. Federal coal lands being considered as posing potential for development are primarily in the easternmost portion of the Project Area (BLM 2001f).

Table 3-62 Surface Ownership by Sub-watershed

	Areal Extent (acres)						Portion of Project Area (percent)				
	Federal BLM						Federal BLM				
Watershed	BFO	CFO	FS	State	Private	Total	BFO	CFO	FS	State	Private
Little Bighorn River	436	0	7	3,683	45,458	49,584	0.9%	0.0%	0.0%	7.4%	91.7%
Upper Tongue River	13,439	0	289	84,251	641,905	739,883	1.8%	0.0%	0.0%	11.4%	86.8%
Middle Fork Powder River	150,904	0	28	47,147	266,372	464,450	32.5%	0.0%	0.0%	10.2%	57.4%
North Fork Powder River	1,413	0	0	1,190	18,071	20,674	6.8%	0.0%	0.0%	5.8%	87.4%
Upper Powder River	329,048	197	0	91,060	1,183,216	1,603,520	20.5%	0.0%	0.0%	5.7%	73.8%
South Fork Powder River	31,486	0	0	8,441	74,428	114,355	27.5%	0.0%	0.0%	7.4%	65.1%
Salt Creek	42,510	7,731	0	14,372	87,747	152,360	27.9%	5.1%	0.0%	9.4%	57.6%
Crazy Woman Creek	55,585	0	42	64,479	428,177	548,283	10.1%	0.0%	0.0%	11.8%	78.1%
Clear Creek	22,324	0	94	67,301	457,758	547,476	4.1%	0.0%	0.0%	12.3%	83.6%
Middle Powder River	33,987	0	0	10,389	179,854	224,230	15.2%	0.0%	0.0%	4.6%	80.2%
Little Powder River	75,771	0	42,534	58,498	688,679	865,482	8.8%	0.0%	4.9%	6.8%	79.6%
Little Missouri River	396	0	6,685	2,931	28,516	38,528	1.0%	0.0%	17.4%	7.6%	74.0%
Antelope Creek	817	27,181	88,857	47,826	495,618	660,298	0.1%	4.1%	13.5%	7.2%	75.1%
Dry Fork Cheyenne River	0	20,862	45,915	23,761	218,778	309,316	0.0%	6.7%	14.8%	7.7%	70.7%
Upper Cheyenne River	4,733	0	61,352	13,381	127,337	206,803	2.3%	0.0%	29.7%	6.5%	61.6%
Lightning Creek	0	6,598	15,209	17,993	268,521	308,321	0.0%	2.1%	4.9%	5.8%	87.1%
Upper Belle Fourche River	29,266	0	0	53,975	761,622	844,863	3.5%	0.0%	0.0%	6.4%	90.1%
Middle North Platte Casper	0	28,379	0	14,251	169,943	212,573	0.0%	13.4%	0.0%	6.7%	79.9%
Total	792,113	90,948	261,009	624,930	6,142,001	7,911,001	10.0%	1.1%	3.3%	7.9%	77.6%

Table 3-63 Mineral Ownership by Federal Management Area and Sub-watershed

						Portion of Area (percent)	
Watershed	Coal	Other	Oil & Gas	Non-federal Oil & Gas	Total Oil & Gas	Federal Oil & Gas	Non-federal Oil & Gas
BFO							
Little Bighorn River	234	0	5,210	44,140	49,350	11%	89%
Upper Tongue River	202,976	769	140,504	398,320	538,824	26%	74%
Middle Fork Powder River	324	3,261	326,571	134,295	460,866	71%	29%
North Fork Powder River	0	0	15,029	5,645	20,674	73%	27%
Upper Powder River	318,402	988	1,092,078	190,298	1,282,377	85%	15%
South Fork Powder River	0	3,402	74,597	36,356	110,953	67%	33%
Salt Creek	1,056	0	98,779	25,258	124,036	80%	20%
Crazy Woman Creek	81,594	0	276,315	191,516	467,832	59%	41%
Clear Creek	155,202	384	172,837	219,396	392,234	44%	56%
Federal Middle Powder River	52,223	0	153,935	18,330	172,265	89%	11%
Little Powder River	160,471	160	453,142	181,360	634,502	71%	29%
Little Missouri River	39	0	4,769	10,980	15,748	30%	70%
Antelope Creek	11,927	283	38,542	9,170	47,711	81%	19%
Dry Fork Cheyenne River	0	0	0	0	0	0%	0%
Upper Cheyenne River	21,211	341	28,284	7,119	35,403	80%	20%
Lightning Creek	0	0	0	0	0	0%	0%
Upper Belle Fourche River	340,977	1,424	323,855	157,719	481,573	67%	33%
Middle North Platte Casper	0	0	0	0	0	0%	0%
Total	1,346,635	11,013	3,204,448	1,629,901	4,834,349	66%	34%
CFO							
Little Bighorn River	0	0	0	0	0	0%	0%
Upper Tongue River	0	0	0	0	0	0%	0%
Middle Fork Powder River	0	0	0	0	0	0%	0%
North Fork Powder River	0	0	0	0	0	0%	0%
Upper Powder River	0	0	2,625	882	3,506	75%	25%

Table 3-63 Mineral Ownership by Federal Management Area and Sub-watershed

						Portion of Area (percent)	
Watershed	Coal	Other	Oil & Gas	Non-federal Oil & Gas	Total Oil & Gas	Federal Oil & Gas	Non-federal Oil & Gas
South Fork Powder River	0	0	0	0	0	0%	0%
Salt Creek	0	0	22,729	4,539	27,268	83%	17%
Crazy Woman Creek	0	0	0	0	0	0%	0%
Clear Creek	0	0	0	0	0	0%	0%
Middle Powder River	0	0	0	0	0	0%	0%
Little Powder River	0	0	0	0	0	0%	0%
Little Missouri River	0	0	0	0	0	0%	0%
Antelope Creek	25,011	0	155,352	50,919	206,271	75%	25%
Dry Fork Cheyenne River	3,377	409	100,955	52,383	153,337	66%	34%
Upper Cheyenne River	0	0	0	0	0	0%	0%
Federal							
Lightning Creek	19,175	3,879	143,741	105,539	249,280	58%	42%
Upper Belle Fourche River	0	0	0	0	0	0%	0%
Middle North Platte Casper	5,712	485	140,935	66,835	207,770	68%	32%
Total	53,275	4,773	566,337	281,096	847,433	67%	33%
FS							
Little Bighorn River	0	0	0	0	0	0%	0%
Upper Tongue River	0	0	0	0	0	0%	0%
Middle Fork Powder River	0	0	0	0	0	0%	0%
North Fork Powder River	0	0	0	0	0	0%	0%
Upper Powder River	0	0	0	0	0	0%	0%
South Fork Powder River	0	0	0	0	0	0%	0%
Salt Creek	0	0	0	0	0	0%	0%
Crazy Woman Creek	0	0	0	0	0	0%	0%
Clear Creek	0	0	0	0	0	0%	0%
Middle Powder River	0	0	0	0	0	0%	0%
Little Powder River	0	4,936	52,785	14,744	67,528	78%	22%

Table 3-63 Mineral Ownership by Federal Management Area and Sub-watershed

						Portion of Area (percent)	
Watershed	Coal	Other	Oil & Gas	Non-federal Oil & Gas	Total Oil & Gas	Federal Oil & Gas	Non-federal Oil & Gas
Little Missouri River	0	320	13,853	8,606	22,459	62%	38%
Antelope Creek	64,424	11,206	251,602	42,503	294,105	86%	14%
Dry Fork Cheyenne River	14,625	6,199	107,640	23,727	131,367	82%	18%
Upper Cheyenne River	26,068	8,304	98,180	17,901	116,080	85%	15%
Lightning Creek	8,381	3,681	20,295	4,108	24,403	83%	17%
Upper Belle Fourche River	8,980	0	11,565	1,464	13,029	89%	11%
Middle North Platte Casper	0	0	0	0	0	0%	0%
Total	122,477	34,647	555,920	113,053	668,972	83%	17%
Grand Total	1,522,387	50,432	4,326,704	2,024,050	6,350,755	68%	32%

Federal

Figure 3-17 Surface Ownership

Figure 3-18 CBM Mineral Ownership

Figure 3-19 Land Use and Recreation Sites

Table 3-64 Distribution of Land Uses by Surface Owner

	Distribution of Land Classifications by Surface Owner					
	BLM					
Category	BFOA	CFOA	FS	State	Private	Total
Agriculture	1,106	1,521	16,521	13,581	475,010	507,739
Barren	77	86	209	197	10,265	10,834
Forested	130,112	7,240	15,080	48,023	332,980	533,434
Mixed Rangeland	659,852	82,080	224,106	559,380	5,260,609	6,786,026
Urban	863	0	13	1,041	25,677	27,593
Water	19	20	70	332	4,776	5,217
Wetlands	0	0	337	571	1,760	2,667
Coal Mine	84	0	4,676	1,805	30,926	37,490
Total	792,113	90,947	261,012	624,930	6,142,003	7,911,000

Mines

Recreation

Recreational sites and facilities within the Project Area are discussed in the section on recreation and shown on Figure 3–20**.** Public lands within the Project Area are generally available for dispersed recreational land uses. Several developed recreational facilities are located in special management areas (SMAs) on BLM-administered lands. Although no developed campgrounds are located in the FS-administered lands within the TBNG, this area provides land use opportunities for recreational activities.

Land Use Planning and Management

Land use planning and management are described generally in this section for lands administered by the BLM, FS, State of Wyoming, and the four counties encompassed by the Project Area. Public lands administered by the BLM and FS are generally available for oil and gas leasing, exploration and development.

Existing federal (BLM or FS) oil and gas leases within the Project Area contain various stipulations concerning surface disturbance, surface occupancy, limited surface use, and timing (seasonal) restrictions. These lease stipulations provide for the imposition of such reasonable conditions, not inconsistent with the purposes for which the lease was issued, as the BLM and or FS may require, to protect the surface of the leased lands and the environment. Mitigation measures can be imposed upon a lessee who pursues surface-disturbing activities; however, leased land without a No Surface Occupancy (NSO) or other similarly restrictive lease stipulation cannot be denied a permit to drill.

Within the Project Area, oil and gas estates are frequently located in the same vicinity as coal resources. Oil and gas leases are generally issued with special lease stipulations to help prevent a development conflict with coal. These stipulations may require as conditions of approval that a plan of mitigation of anticipated impacts be negotiated between the oil and gas and coal lessees prior to surface use. Coals mines in the Project Area are discussed under Coal.

Table 3-65 Distribution of Existing Disturbances by Land Use and Sub-watershed

	Land Use Category								
Sub-watershed	Agriculture (acres)	Barren (acres)	Forested (acres)	Mixed Rangeland (acres)	Urban (acres)	Water (acres)	Wetlands (acres)	Coal Mine (acres)	Total (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0
Upper Tongue River	117	4	15	695	0	0	0	0	831
Middle Fork Powder River	5	0	0	56	2	0	0	0	63
North Fork Powder River	0	0	0	0	0	0	0	0	0
Upper Powder River	1,008	0	45	5,392	12	1	0	0	6,458
South Fork Powder River	0	0	35	26	0	0	0	0	61
Salt Creek	0	0	0	108	0	0	0	0	108
Crazy Woman Creek	0	2	0	202	0	0	0	0	204
Clear Creek	44	3	6	372	0	0	0	0	425
Middle Powder River	811	0	522	2,358	0	2	0	0	3,693
Little Powder River	1,504	3	67	7,483	9	0	0	9	9,075
Little Missouri River	5	0	0	31	0	0	0	0	36
Antelope Creek	364	0	9	2,539	0	0	0	2	2,914
Dry Fork Cheyenne River	0	0	5	256	0	0	0	0	261
Upper Cheyenne River	461	0	2	1,066	0	0	24	7	1,560
Lightning Creek	26	0	0	867	0	0	0	0	893
Upper Belle Fourche River	2,686	15	24	12,299	20	0	1	6	15,051
Middle North Platte Casper	0	0	0	73	0	0	0	0	73
Total	7,031	27	730	33,823	43	3	25	24	41,706

BLM Land Management

Overall BLM land management is described in detail in Chapter 5. Thus, this discussion focuses on more specific, smaller-scale management units.

Several BLM SMAs that provide recreational opportunities are located within the Project Area (Figure 3-20). These areas include the Fortification Creek SMA and Fortification Creek Wilderness Study Area (which is encompassed by the larger Fortification Creek SMA), the Dry Creek Petrified Tree Environmental Area, the Weston Hill and Mosier Gulch Recreation Areas, and several additional Wilderness Study Areas (WSAs). Oil and gas leases are not issued with surface occupancy rights (for drilling, access routes, or production facilities) within WSAs to preserve the wilderness values. Surface disturbances are also restricted within Recreational Areas (RAs) and Wildlife Habitat Management Areas (WHMAs). WHMAs are managed in cooperation with the WGFD. The BLM land use planning and management goals for these areas are also discussed in the section on Recreation.

Because oil and gas resources are frequently located in the same vicinity as coal resources, oil and gas leases are generally issued with special stipulations to help prevent a development conflict with coal. These stipulations may require that a plan of mitigation of anticipated impacts be negotiated between the oil and gas and coal lessees before surface use. The current BLM oil and gas stipulation (BLM 2001a) prohibits or restricts surface occupancy or use within areas of conflict with ongoing coal mining. In addition to standard lease terms, special stipulations identifying specific terms and conditions of use may be attached to oil and gas leases, where needed to protect specific natural resources.

National Forest Land Management

Numerous land parcels within the TBNG are scattered throughout Campbell and Converse Counties in the Project Area. Although the Bighorn National Forest is on the western boundary of the Project Area, none of the Bighorn National Forest lands are within the Project Area. Most of the CBM resources on the FS land within the Project Area are located in the westernmost portion of the TBNG.

Under the 1987 Federal Onshore Oil and Gas Leasing Reform Act, FS lands that are available for oil and gas leasing were identified, along with the stipulations that are considered appropriate to protect surface resources. The FS administers the land uses on National Forest System lands based on multiple use principles.

The Douglas Ranger District of the Medicine Bow-Routt National Forest administers the public lands and activities within the TBNG. Oil and gas leasing and development activities on FS-administered federal lands within the TBNG are allowed, subject to the limitations imposed by the LRMP for the Medicine Bow National Forest and TBNG (FS 1985). Actions proposed within the TNBG must be in conformance with the management goals within the LRMP (FS 1985).

The FS completed an FEIS and issued a ROD in 1994 for Oil and Gas Leasing on the TBNG (FS 1994). In 1994, the FS developed many special leasing restrictions for oil and gas activities within the TBNG. Leasing restrictions applicable to drilling or production activities within the TBNG may be included as conditions of approval for APDs on post-1994 leases. The restrictions outlined in the site-specific environmental effects analyses must contain documentation at to whether or not proposed development is consistent with the 1994 FEIS/ROD and the 1985 LRMP.

The 1999 Proposed LRMP for the TBNG (Forest Plan) provides the proposed land use guidelines for the eight management areas within the TBNG. Most of the FS land within the Project Area is managed for livestock grazing. The FS also has special stipulations to protect identified resources within FS-administered lands.

Federal Lands Grazing Allotments

Most of the BLM and FS lands within the Project Area are used for livestock grazing under permitted grazing allotments. Livestock grazing is not allowed in specified areas due to conflicts with other uses, such as big game winter ranges, and timber sale areas. Grazing allotments are classified by BLM into one of three management categories. These categories in priority order are: maintain (M), improve (I), and custodial (C). M category allotments have high production potential where no resource use conflicts have been identified. Allotments in category I have a high production potential but are producing below the potential level. C category allotments are generally isolated or scattered parcels of public land interspersed with nonfederal lands, and have little potential for multiple use management or positive economic returns. Most of the public land in the Project Area is in the M and I management categories.

Each BLM or FS grazing allotment is classified by how many animal unit months (AUMs) are provided by the acreage in the allotment. AUMs are defined as the amount of forage to sustain one cow and calf for one month.

BLM requires land use activities within allotment areas to comply with the specific standards and guidelines for healthy rangeland in cooperation with the State of Wyoming (BLM 1997b). Wyoming BLM Mitigation Guidelines (BLM 1995a) are also employed to avoid and mitigate impacts and conflicts among resources and land uses for surface-disturbing activities on BLM-administered lands in Wyoming.

Wyoming State Land Management

The State Land Use Planning Act (W.S. 9-849 through 9-862) was enacted by the Wyoming legislature in 1975, and established the State Land Use Commission to guide land use planning in the state. The Office of State Lands and Investments, the administrative and advisory arm of the Board of Land Commissioners and State Loan and Investment Board, is responsible for oil and gas leases, and easements within and temporary uses of state lands.

The state-owned lands in the Project Area are generally available for mineral and agricultural leasing, timber leasing and sales, and public recreation. State Trust Lands are lands granted by the federal government to the State of Wyoming to generate revenues for the benefit of designated beneficiaries. These beneficiaries are the common (public) schools, universities, and other public institutions in Wyoming (Wyoming Office of State Lands 1996).

The Wyoming State Land Commissioners, Office of Land and Investments, administers oil and gas leases and developments on state-owned lands in Wyoming. State Trust Lands are managed to generate revenues that are reserved for the benefits of designated beneficiaries, including the public schools, universities, and public institutions in Wyoming. State-owned lands in the Project Area are generally available for mineral and agricultural leasing and sales, and public recreation.

The WOGCC regulates drilling and well spacing, and requires an approved APD for all oil and gas wells drilled in the State of Wyoming regardless of land ownership, including wells on federal lands. The APD approval process includes securing the necessary legal access to or across state- or privately owned lands.

Campbell County Land Use Planning and Local Governments

Within Campbell County, the City of Gillette and the Town of Wright have zoning ordinances and land use plans for the incorporated areas. Planned future land uses within Campbell County are addressed in the City of Gillette/Campbell County Comprehensive Planning Program and shown on the Campbell County Zoning District Map (City of Gillette and Campbell County Planning Commission 1994). Adjacent to and outside of the city limits of the City of Gillette, Campbell County has designated zoning districts, including numerous subdivisions, and designated suburban and rural residential districts (Campbell County 2000a, 2000b). The unincorporated portions of the county outside of the Gillette Planning District are considered to be “Open District” zoning or agricultural (Bryson 2001).

Construction within the jurisdictional areas of the City of Gillette or other incorporated areas within the Project Area requires additional permitting with the local government agencies. The City of Gillette zoning regulations (City of Gillette 1992) define oil, gas and mineral exploration and production activities as “permitted uses” within the agricultural or heavy industrial districts within the city limits. Oil and gas production activities require City Council permission and must meet the applicable provisions in the Gillette Municipal Code. Permits are required from the City of Gillette for construction within the city limits, or the use of existing ROWs and easements dedicated or owned by the city. City noise ordinances would apply to drilling or construction operations within the city limits.

Numerous residential developments exist in the areas surrounding the City of Gillette, but outside of the incorporated area. If CBM development is proposed near any of these developments, current permitting requirements and stipulations would apply.

There are similar permits and mitigation measures would be required for CBM activities within the jurisdictional area of the Town of Wright (Town of Wright 1998) and other incorporated areas within the Project Area.

Johnson County Land Use Planning and Local Governments

Johnson County currently does not have countywide zoning districts, land use districts, or a comprehensive land use plan, although they are in the process of developing one (Yingling 2001). The communities of Buffalo and Kaycee have land use plans for the urban areas. The Buffalo/Johnson Joint Land Use Plan was adopted in August 2001, and is currently under revision. This plan primarily addresses land uses adjacent to the residential areas within less than 10 miles from Buffalo.

The Powder River Conservation District Long Range Program Resource Conservation and Land Use Plan, adopted February 10, 1998, also provides land use guidance primarily to prevent erosion of soils for the southern half of Johnson County.

Sheridan County Land Use Planning and Local Governments

Development within the unincorporated portions of Sheridan County is regulated by the Sheridan County Zoning Resolution (Sheridan County 2001b), and the Sheridan County Growth Management Plan (2001a). With the exception of several designated growth areas near the existing residential developments, the anticipated future land uses and current zoning for most of the county is agricultural (Springer 2001). Designated growth areas are defined for the areas in the immediate vicinity of the City of Sheridan, Town of Clearmont, and the unincorporated urban and residential communities of Story/Banner, Big Horn, Big Goose Valley, Ranchester/Dayton, and Arvada (Sheridan County 2001a). The City of Sheridan has designated zoning districts for the incorporated areas (City of Sheridan 2000).

Within Sheridan County, a buffer zone area of several miles adjacent to and east of the Big Horn National Forest is designated as a Resource Conservation Area on the Sheridan County Comprehensive Plan Land Use Map (Sheridan County 1999). In addition, a low-density development area is identified surrounding the City of Sheridan, including and extending south of the community of Big Horn. These planning areas are not currently addressed in the Sheridan County Zoning Resolution (Sheridan County 2000a).

Converse County Land Use Planning and Local Governments

The Project Area is within the northwestern portion of Converse County and north of Interstate 25. Within the Project Area, the Converse County Land Use Plan (Converse County 1978) describes the current land use as primarily agriculture, predominantly dryland (nonirrigated) grazing. Mineral extraction is the current secondary use for this portion of the county. Mineral extraction is exempted from local regulations; however, mineral processing is regulated to minimize conflicts between mineral extraction and historic surface land uses. Converse County does not currently have countywide zoning. The city zoning ordinances for Douglas and Glenrock have development requirements (Musselman 2001).

Transportation

The existing public road network, BLM roads, county transportation planning, and other transportation are discussed in the following sections. Scenic byways, areas designated for off road vehicle (ORV) use, and historic transportation corridors, are discussed in the section on Recreation. Public lands are accessible via public roads or across private land that requires landowner permission.

Public Road Network

Gillette and Sheridan are the hubs for the transportation network in the Project Area. Interstate highways in the Project Area include I-25 and I-90 (Figure 3–

20). The major north-south transportation corridors include State Route 59 in Campbell and Gillette Counties and I-25 in Johnson and Sheridan Counties. The principal east-west highway for Campbell and Johnson Counties is I-90. I-90 runs north from the Town of Buffalo to the City of Sheridan and then continues north to the Montana state line. U.S. Highways in the Project Area include U.S. Routes 14, 16 to the east of Buffalo, and 87. The primary state highways in the Project Area are Routes 59, and 387. Secondary state highways traversing the area include Routes 50, 51, 192, 196, 338, and 450. Numerous county roads also provide local access to public and private lands within the Project Area. There are more than 19,000 miles of roads in the Project Area, and 2,400 miles are county roads.

Recent annual average daily traffic counts (ADT) suggest use of highways and roads in the Project Area is highly variable (Table 3-66). Not surprisingly, the interstates and major highways account for the highest ADTs.

BLM Road Design and Maintenance

There are numerous improved and unimproved (four-wheel drive) roads within the Project Area. BLM transportation planning for both the Buffalo and Casper resource districts is discussed in the 1985 RMPs, and in the updates to these documents (BLM 1985b and c, 2001a and b).

Table 3-66 Annual Average Daily Traffic Counts

			Annual ADT	
County	Route Name	Description	1998	1999
Campbell	I-90	Sheridan-Johnson County Line	5,700	5,970
	I-90	Wyodak Intersection	5,660	5,790
	I-90	Gillette East Urban Limits	5,970	6,100
	I-90	WYO 59 Intersection	6,070	6,380
	US 14-16	Rozet Intersection	5,100	5,320
	WYO 50	Savageton	500	550
	WYO 59	Gillette South of Urban Limits	18,690	17,760
	WYO 59	Johnson-Campbell County Line	1,110	1,210
	WYO 59	Wright	2,150	2,250
	WYO 59	Converse-Campbell County Line	1,350	1,450
	WYO 59	Wyoming-Montana State Line	300	300
	WYO 387	Johnson-Campbell County Line	1,110	1,210
Converse	I-25	Platte-Converse County Line	5,500	5,980
	WYO 59	Bill	1,350	1,450
Johnson	I-90	Junction US 25 (Buffalo Tri-level Intersection)	3,680	3,700
	I-90	Johnson-Campbell County Line	5,030	5,140
	I-25 & US 87	Junction Kaycee Interchange	2,800	2,802
	US 16	Johnson-Sheridan County Line	260	280
Sheridan	I-90	Sheridan-Johnson County Line	5,700	5,970
	I-90 & US 87	Wyoming-Montana State Line	3,710	3,760
	US 14-16	I-90	2,400	2,400
	US 14-16	Ucross Junction	560	560
	US 14-16	Sheridan-Campbell County Line	180	180
	WYO 336	Sheridan East Urban Limits	4,100	4,200
	WYO 338	Sheridan North Urban Limits	1,050	1,050

Source: WYDOT 1999

Based on the BLM Manual, Section 9113 (BLM 1985a), roads on BLM lands are classified, based on the amount of traffic movement, into three road classes, consisting of temporary, resource, local, and collector roads. Collector roads generally provide access to large land tracts and are the major access routes into development areas with high average daily traffic rates. They usually connect with or are extensions of public road systems and are operated for long-term land uses. Local roads normally serve a smaller area and lower traffic volume than collector roads. They connect with collectors or public road systems. In mountainous terrain, local roads may be single lane roads with turnouts. Resource roads are generally point access or spur roads that connect with local or collector roads and carry low traffic volumes.

BLM and the FS are responsible for ensuring that new roads on federal lands meet the criteria for design and construction. BLM minimum road design and maintenance requirements are provided in BLM Manual Section 9113 – Roads (BLM 1985a). Road routes, locations, and design criteria are included in the APD or ROW applications. For oil and gas roads on federal lands, the operators must provide the BLM with copies of all road maintenance agreements. Because some operators do not need access to sites during winter months, snow removal is generally a separate maintenance agreement item.

State of Wyoming Road Access Permits and Maintenance

New project roads would comply with the design and maintenance requirements of the State of Wyoming and local jurisdictions. Before new project roads can be constructed that are to access an existing state or county road, an access permit must be obtained from the Wyoming Department of Transportation (WYDOT). An access permit is also required for existing private or ranch roads that access state roads if they are converted to use in CBM development. The application for an access permit must include location of proposed road construction, and roadway design specifications, including type of surface material, drainage structures, roadway width, profile, and grades.

Snow removal operation performed by the WYDOT is primarily mechanical, using snowplows, and fences (Milburn 2001). An aggregate (sand) and salt mixture is generally used for tunnels and areas requiring deicing.

Many of the existing roads within the Project Area need repairs or improvement. In the 2000 Surface Transportation Improvement Program (STIP) compiled by the WYDOT Planning Program, more than 200 highway improvement projects to begin for the year 2000. Major improvements projects scheduled for roads within the Project Area, in the Primary highway category, include widening and resurfacing a section of I-90 west of Gillette. In the Secondary highway category, scheduled improvements include 7 miles of U.S. 14-16 northwest of Clearmont, and 4 miles of WYO 335 between Big Horn and Sheridan. The STIP also provides a projection of the transportation improvements scheduled to occur in the 5-year-plus period beginning in 2001.

County Transportation Planning

Transportation plans and goals for the four counties in the Project Area are discussed in this section.

The general planning goals for transportation for Campbell County are discussed in the City of Gillette/Campbell County Comprehensive Planning Program (City of Gillette and Campbell County 1994). Traffic generation and potential conflicts would be considered in evaluating new developments and zoning changes. The county is currently replacing scoria-surfaced roads with river gravel to reduce dust.

Currently, Johnson County has no formal transportation plan.

In Sheridan County, the Comprehensive Plan (Sheridan County 1982) provides a proposed transportation plan for improvement of the roads only for the City of Sheridan and the adjacent growth management area.

Transportation issues identified in the Converse County Land Use Plan (Converse County 1978) include paving and other road improvements that may be required due to increased traffic from increased rural residential development and mineral extraction and processing in rural areas. Gravel roads were previously suitable.

Other Transportation

Rail service and airports within the Project Area are discussed in the following sections.

Rail Service

One major railroad serves the Project Area. In Sheridan County, the Burlington Northern/Santa Fe Railroad runs north-south from the Montana State line through the City of Sheridan, and then east through Clearmont, and continues east to the City of Gillette in Campbell County. The railroad then travels east of the City of Gillette, and runs north-south through Converse County. Several spur lines connect the railroad with historical mines in the area. In the BFOA, the average ROW width for the railroad is 400 feet (BLM 2001a).

Airports

Three public airports exist in the Project Area (AirNav.com 2001). The Gillette-Campbell County Airport is located 4 miles northwest of Gillette. The Gillette VOR (radio aid used for navigation) is located at the airport. CBM development has already occurred near the Gillette-Campbell County Airport. The Sheridan County Airport and VOR are located southwest of the City of Sheridan. All development within the Sheridan County designated Airport Zone must comply with the Airport Master Plan (Barnard Dunkelberg & Company 1996). The Johnson County Airport and Crazy Woman VOR are located 3 miles northwest of the City of Buffalo.

Federal Aviation Administration (FAA) regulations require a 2-mile radius safety zone around airports to promote air navigational safety at the airport, and to reduce the potential for safety hazards for property and for persons on lands near airports. FAA regulations also require filing a notice (FAA Form 7460-1) for construction projects which extend 200 feet or greater above natural terrain and located within 5 miles of an airport. Portions of Project Area are located within 2-mile safety zones for these airports.

Visual Resources

Regional Characterization

The Project Area consists of public, state, and private lands in Sheridan, Campbell, Johnson, and part of Converse County in northern Wyoming. The Project Area lies in the Powder River Basin portion of the Great Plains physiographic province and is bordered by the Big Horn Mountains to the west and the Black Hills to the east.

The Project Area landscape is composed of open grasslands, low rolling hills, and unobstructed views of many miles. Most of the area is covered with dryland vegetation consisting of grasses and shrubs. Ponderosa pine covers large portions of the northeast quarter of the Project Area. Outside the urban areas of Sheridan, Gillette, Buffalo, and Wright, the Project Area is characterized by a rural landscape that has been modified by oil and gas field development, coal mines, grazing, and urban areas. Grazing is evident in most of the Project Area. Highways, county roads, private roads, and utility lines also are evident throughout the Project Area. Portions of the Project Area remain natural and undeveloped in character despite widespread mineral development and grazing. Most of the Project Area landscape is composed primarily of scenery that is common for the region.

General Visual Characteristics

Oil and gas pumping units and associated well pads and access roads are evident throughout the Project Area. The majority of existing well development occurs in the eastern half of the Project Area in 40- and 80-acre well spacing patterns. Well development is most evident in Campbell County between the cities of Gillette and Wright, and north, west, and northwest of Gillette. Development is also evident along Interstate 90 and State Highway 14 and 93 in Campbell and Sheridan Counties. The landscape that has resulted from ongoing oil and gas development in this area is rural/industrial in character. The wells are intrusive (defined as readily visible) and visually dominant in foreground (¼ to ½ mile from the observer) views from roads and trails. In middleground (generally ½ mile to 3 miles) and background (more than 3 miles) distance zones, well pads and associated access road clearings are the most obvious feature of oil and gas developments. Clearings are visible as light brownish gray exposed soils in geometrically shaped areas with straight, linear edges that provide textural and color contrasts with the surrounding undisturbed vegetation. In general, oil and gas facilities are visually subordinate to the landscape in middle to background distance zones.

The majority of areas with significant scenic values occur in the western part of the Project Area. The South Big Horns Area is located in the southwest quarter of Johnson County, primarily within the Middle Fork Powder River sub-watershed. The area provides sensitive and unique resource values, including scenery. Special management areas within the South Big Horns Area include the Middle Fork Recreation Area, the Red Wall/Hole-in-the-Wall area, Outlaw Cave, Dull Knife Battlefield site, and the Gardner Mountain and North Fork Wilderness Study Areas. The Powder River breaks in eastern Johnson County, the Fortification Creek SMA and WSA, and the Weston Hills Recreation Area in the eastern part of the Project Area also provide scenic settings for a variety of dispersed recreational activities.

Two scenic byways in the western part of the Project Area provide access to the Bighorn Mountains. The Bighorn Scenic Byway is on U.S. Route 14 west of Ranchester. The Cloud Peak Skyway is on U.S Route 16 west of Buffalo.

Visual Resource Management

BLM

The BLM has inventoried visual resources for all BLM, state, and private land in the Buffalo and Casper Field Office areas according to the Visual Resource Management (BLM 1986) and established VRM classes. The VRM system is the basic tool used by the BLM to inventory and manage visual resources on public lands. The VRM classes are objectives that outline the amount of disturbance an area can tolerate before it no longer meets the objectives of the class. There are four VRM classes, each of which combines and evaluates visual quality, visual sensitivity of the area, and view distances. The inventory includes state, National Forest, and private lands as well as BLM lands. However the BLM manages visual resources only on BLM lands. Many private and public lands in the area have increased in sensitivity since the last inventory conducted in the 1970s as a result of increases in population and lifestyle shifts that emphasize outdoor recreation. Four VRM classes have been inventoried within the Project Area, as shown on Figure 3-20 and summarized in Table 3-67. The objectives of VRM classes applied to lands within the Project Area are:

- Class II — Class II provides for activities that would not be evident in the characteristic landscape. Contrasts are seen, but must not attract attention. Lands along the base of the Bighorn Mountain foothills in the western part of the Project Area, and lands along Interstate 90 and State Route 14 in the Upper Powder River Sub-watershed are Class II lands. These lands are sensitive to public view.

- Class III — The objective is to provide for management activities that may contrast with the basic landscape elements, but remain subordinate to the existing landscape character. Activities may be visually evident, but should not be dominant. Class III areas occur primarily along major highway corridors such as Interstates 25 and 90, State Route 14, Fortification Creek SMA and WSA, and along a broad corridor at the base of the Big Horn Mountains between Buffalo and the Montana/Wyoming state line.

- Class IV — The objective is to provide for management activities that may require major modifications to the existing landscape. The level of change to the landscape can be high and may be visually dominant. Most of the Project Area is managed with Class IV objectives.

- Class V — This class is applied to areas where the landscape character has been so disturbed that rehabilitation is needed. It should be considered an interim short-term classification until one of the other classes can be reached through rehabilitation or enhancement. Lands currently managed with Class V objectives occur near urban areas of Sheridan, Buffalo, Gillette, and at coal mining areas in the eastern part of the Project Area.

Table 3-68 shows the distribution of 12,024 CBM wells already permitted or drilled on federal, state, and private lands in the Project Area. The majority of permitted wells (10,218 wells, or nearly 85 percent) are on private lands, which is consistent with the distribution of surface ownership in the Project Area (see Land Use and Transportation – Affected Environment). Out of the total VRM inventory of 12,024 wells, only 196 wells (1.6 percent) are on BLM lands. The remaining wells are on state (1,430 wells) or National Forest lands (97 wells). Nearly 84 percent of permitted wells, regardless of land ownership, are in the VRM Class IV inventory.

The distribution of existing compressors in each watershed is shown by VRM class on Table 3-69. Out of the total 18,332 acres of existing disturbance from compressors, more than 90 percent occurs on lands inventoried with Class IV.

There are 2,546 non-CBM wells on 2,546 well pads in the Project Area as shown on Table 3-70. The majority of non-CBM wells (2,091, or 82 percent) are on private lands. The remaining 455 wells are distributed on BLM lands (7.7 percent), FS lands (4.1 percent), and state lands (7.4 percent). The existing non-CBM facilities consist of pump jacks, which provide a greater contrast to the characteristic landscape than existing CBM facilities. Of the total 34 non-CBM wells on BLM lands, 33 are located on lands managed with VRM Class IV. Only one well is on VRM Class III managed BLM lands.

Coal mining occurs primarily in the east-central part of the Project Area, east and south of Gillette. There are currently 14 open-pit coal mines actively producing coal in Campbell County, and one coalmine north of the City of Sheridan. Open pit mining results in landscapes that have been altered considerably from the natural topography, consisting of significant contrasts from exposed soils and spoil piles with surrounding vegetation, dust from mining operations, and associated infrastructure such as buildings, rail haulage, and road systems. Coal mines dominate foreground and middleground views in the affected viewsheds, and are generally classified with VRM Class IV or V objectives in the Project Area.

Figure 3-20 Visual Resource Management Classes

Table 3-67 VRM Inventory for Sub-watersheds in the Powder River Basin Project Area

	Class II		Class III		Class IV		Class V		
Sub-watershed	acres	%	acres	%	acres	%	acres	%	Total
Little Bighorn River	33,315	67.2	16,268	32.8	0	0	0	0	49,584
Upper Tongue River	94,708	12.8	281,984	38.1	352,639	47.7	10,552	1.4	739,883
Middle Fork Powder River	265,724	57.2	42,510	9.2	155,786	33.5	429	0.1	464,450
North Fork Powder River	18,900	91.4	1,774	8.6	0	0	0	0	20,674
Upper Powder River	49,484	3.1	183,975	11.5	1,370,062	85.4	0	0	1,603,520
South Fork Powder River	0	0	24,805	21.7	89,550	78.3	0	0	114,355
Salt Creek	0	0	9,634	6.3	142,726	93.7	0	0	152,360
Crazy Woman Creek	53,719	9.8	74,738	13.6	419,8325	76.6	0	0	548,283
Clear Creek	40,519	7.4	133,701	24.4	370,439	67.7	2,818	0.5	547,476
Middle Powder River	0	0	0	0	224,230	100	0	0	224,230
Little Powder River	0	0	90,610	10.5	746,920	86.3	27,953	3.23	865,482
Little Missouri River	0	0	150	0.4	38,378	99.6	0	0	38,528
Antelope Creek	0	0	33,209	5.0	627,089	95.0	0	0	660,298
Dry Fork Cheyenne River	0	0	31,345	10.1	277,971	89.9	0	0	309,316
Upper Cheyenne River	0	0	0	0	183,945	89.0	22,858	11.1	206,803
Lightning Creek	0	0	64,529	20.9	243,794	79.1	0	0	308,321
Upper Belle Fourche River	11,320	1.3	93,619	11.1	695,146	82.3	44,778	5.3	844,863
Middle North Platte River	0	0	0	0	212,573	100	0	0	212,573
Total	567,689	7.2	1,082,849	13.7	9,929,573	77.8	109,388	1.4	7,910,999

Forest Service

The Medicine Bow-Routt National Forest has developed a Revised LRMP for the TBNG (FS 2001a). The forest has inventoried visual resources under the new Scenery Management System (SMS), which incorporates viewing distance zones, concern level (public importance), scenic attractiveness (indicator of intrinsic scenic beauty of a landscape), scenic class (determined by combining the scenic attractiveness with distance zone and concern levels), and existing scenic integrity (state of naturalness).

Scenic Integrity Objectives (SIO) were assigned to each management area based on the intent of the management area direction. SIOs, provide goals for management of grassland and forest scenic resources. There are five SIOs ranging from very low to very high. TBNG lands within the Project Area have been inventoried with two scenic integrity levels. The scenic integrity level of Low refers to landscapes where the valued landscape character appears moderately altered. Most of the TBNG lands in the Project Area are managed with the scenic integrity level of Low, as the grassland landscape appears moderately altered by oil, gas, and mineral development, and to a lesser extent, some grazing improvements such as fences. The scenic integrity level of Moderate refers to landscapes where the valued landscape character appears slightly altered. A portion of TBNG lands along Antelope Creek and TBNG lands in east of state Highway 59 in Converse County are assigned a scenic integrity level of Moderate.

Visual management objectives for SIOs are associated with desired landscape character for each management area and are based on the intent of the management area direction. The desired condition for landscapes in each of the seven management areas within the Project Area is summarized in Table 3-71.

Counties

The Sheridan County Growth Management Plan, a comprehensive master plan for the City of Sheridan and all of Sheridan County, was prepared in May 2001 (Shridan County 2001a). One of the primary themes identified in the Sheridan Plan is to maintain a community character that preserves the quality of life, values, and traditions of the area. The goals and the associated implementation strategies that relate to mineral development for achieving this theme are described below.

Table 3-68 Distribution of Existing CBM Wells and Disturbance by VRM Class and Sub-watershed in the Powder River Basin Project Area

	Class II			Class III			Class IV			Class V			Total		
SubWatershed	Wells	Pads	Disturbance (acres)	Wells	Pads	Disturbance (acres)	Wells	Pads	Disturbance (acres)	Wells	Pads	Disturbance (acres)	Wells	Pads	Disturbance (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	329	136	251	86	55	97	404	206	370	0	0	0	819	397	718
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	181	133	161	189	162	193	2,438	1,959	2,352	0	0	0	2,808	2,254	2,706
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	126	46	83	24	17	28	0	0	0	150	63	111
Clear Creek	12	7	10	233	138	200	144	86	125	0	0	0	389	231	335
Middle Powder River	0	0	0	0	0	0	727	438	694	0	0	0	727	438	694
Little Powder River	0	0	0	13	13	39	1,564	1,098	3,369	237	190	580	1,814	1,301	3,988
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	1	1	9	250	248	2,228	0	0	0	251	249	2,237
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	0	0	384	374	446	17	16	19	401	390	466
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	508	490	696	4,114	3,740	5,337	37	36	51	4,659	4,266	6,084
Middle North Platte River	0	0	0	0	0	0	6	6	54	0	0	0	6	6	54
Total	522	276	422	1,156	905	1,317	10,055	8,172	15,003	291	242	650	12,024	9,595	17,392

Source: BLM 2002

Table 3-69 Existing Compressors in VRM Classes by Sub-watershed in the Powder River Basin Project Area

	Class II			Class III			Class IV			Class V			Total		
Sub-watershed	Booster	Recip.	Disturbance (acres)	Booster	Recip.	Disturbance (acres)	Booster	Recip.	Disturbance (acres)	Booster	Recip.	Disturbance (acres)	Booster	Recip.	Disturbance (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	0	1	98	0	0	0	0	0	0	0	0	0	0	1	98
Middle Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	1	2	111	4	6	360	49	20	2,136	0	0	0	54	28	2,608
South Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	1	1	94	0	0	0	1	1	94
Clear Creek	0	0	0	0	1	90	0	0	0	0	0	0	0	1	90
Middle Powder River	0	0	0	0	0	0	32	8	2,884	0	0	0	32	8	2,884
Little Powder River	0	0	0	1	0	37	50	26	3,810	6	1	296	57	27	4,143
Little Missouri River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Antelope Creek	0	0	0	0	0	0	1	2	125	0	0	0	1	2	125
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Cheyenne River	0	0	0	0	0	0	5	4	898	0	0	0	5	4	898
Lightning Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Belle Fourche River	0	0	0	14	3	715	93	51	6,678	0	0	0	107	54	7,393
Middle North Platte River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	3	210	19	10	1,203	231	112	16,624	6	1	296	257	126	18,332

Source: BLM 2002

Table 3-70 Existing Non-CBM Wells in VRM Classes by Sub-watershed in the Powder River Basin Project Area

	Class II			Class III			Class IV			Class V			Total		
SubWatershed	Wells	Pads	Disturbance (acres)	Wells	Pads	Disturbance (acres)	Wells	Pads	Disturbance (acres)	Wells	Pads	Disturbance (acres)	Wells	Pads	Disturbance (acres)
Little Bighorn River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Tongue River	6	6	14	0	0	0	0	0	0	0	0	0	6	6	14
Middle Fork Powder River	0	0	0	16	16	38	11	11	26	0	0	0	27	27	63
North Fork Powder River	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Upper Powder River	1	1	2	32	32	75	454	454	1,067	0	0	0	487	487	1,144
South Fork Powder River	0	0	0	0	0	0	26	26	61	0	0	0	26	26	61
Salt Creek	0	0	0	0	0	0	46	46	108	0	0	0	46	46	108
Crazy Woman Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Clear Creek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	49	49	115	0	0	0	49	49	115
Little Powder River	0	0	0	48	48	113	351	351	825	3	3	7	402	402	945
Little Missouri River	0	0	0	0	0	0	15	15	35	0	0	0	15	15	35
Antelope Creek	0	0	0	3	3	7	232	232	545	0	0	0	235	235	552
Dry Fork Cheyenne River	0	0	0	0	0	0	111	111	261	0	0	0	111	111	261
Upper Cheyenne River	0	0	0	0	0	0	75	75	176	9	9	21	84	84	197
Lightning Creek	0	0	0	67	67	157	313	313	736	0	0	0	380	380	893
Upper Belle Fourche River	14	14	33	85	85	200	553	553	1,300	18	18	42	670	670	1,575
Middle North Platte River	0	0	0	0	0	0	8	8	19	0	0	0	8	8	19
Total	21	21	49	251	251	590	2,244	2,244	5,274	30	30	70	2,546	2,546	5,983

Source: BLM 2002

Table 3-71 Desired Conditions for TBNG Management Areas in the Project Area

Management Area		Desired Condition for Scenic Values
3.63	Black-Footed Ferret Reintroduction Habitat	NA[1]
3.65	Rangelands with Diverse Natural-Appearing Landscapes	Natural appearing landscapes predominate; however, oil and gas facilities may occur and are subordinate to the landscape.
3.68	Big Game Range	NA
4.32	Dispersed Recreation: High Use	Appears as a natural landscape over large areas, but modifications on a small scale are acceptable and blend with the area's natural features.
5.12	General Forest and Rangelands: Range Vegetation Emphasis	These areas are dominated by open meadows, grasslands, shrublands, and areas of woody vegetation. Signs of motorized travel, hunting, hiking, timber harvest, mining and grazing may be evident.
6.1	Rangeland with Broad Resource Emphasis	NA
8.4	Mineral Production and Development	Facilities and landscape modifications are visible but are reasonably mitigated to blend and harmonize with natural features. Reclamation activities restore the area to a reasonable level of its pre-mining condition.

Note:
1. NA = not applicable

Goal D. Maintain Natural and Historic Resources and Environmental Quality

1.D.1 Sheridan County should complete a comprehensive countywide inventory, from existing resources, of environmental, scenic, and historical resources and wildlife habitat. Data should be mapped using a Geographic Information System (GIS). This data should be used in the review and evaluation of proposed subdivisions as well as all commercial and industrial development. In the event that resources are impacted by a proposed development, the site would either not be developed or mitigation would be required. Resources to be inventoried should include, but are not limited to:

- Natural or scenic resource areas;
- Land reserved as open space or buffer areas as part of development;
- Linear open space, such as utility and trail corridors;
- Coal bed methane resources areas

The City of Gillette and Campbell County have jointly prepared a Comprehensive Planning Program, last updated March 1994. The program identifies parks and recreation planning, including landscaping and beautification, as an essential element determining the character and quality of an environment. The program recommendation is that where industrial areas are located adjacent to residential areas, landscaping should be developed into the buffer zone between two uses.

The General Land Use Plan for Converse County was developed in August 1978. The Converse Plan does not identify any objectives or policies for scenic resources or landscape character in the county. Converse County is currently updating the Land Use Plan.

Johnson County currently does not have a countywide zoning districts, land use districts, or a comprehensive land use plan, although they are in the process of developing one (Yingling 2001). The Buffalo/Johnson Joint Land Use Plan was adopted August 2001 and is currently under revision. This plan primarily addresses land uses adjacent to the residential areas within less than 10 miles from Buffalo. There are currently no goals for the management of scenic resources in the county.

Sensitive Viewing Areas

The level of sensitivity to modifications of the landscape in the Project Area ranges from low to high. Most of the Project Area is not visually sensitive because of its remoteness from viewpoints used by the public. The overall population density of the rural portion of the Project Area is low. Visitor use of most public lands in the Project Area is light for recreation or other activities. The portions of the Project Area that have a high level of sensitivity to modification to the landscape occur near communities, along highway corridors, and at recreation-use areas. A significant number of residents and visitors exposed to these landscapes would have a concern for scenic quality, and who would be sensitive to modifications to the landscape. In general, residents and other users of some portions of the area already developed with gas wells and coal mining are accustomed to viewing existing mineral resource development, but could be sensitive to increased levels of development.

The majority of sensitive areas occur in the western part of the Project Area, including Interstate 25, the cities of Sheridan and Buffalo, and several recreation and historic sites. The Interstate 25 highway corridor, which connects several communities within the Project Area, has the highest levels of traffic of any highway in the Project Area. Recreational use areas are described in the following section on Recreational Resources. Sensitive areas in the remainder of the Project Area include Gillette and recreational use areas in the eastern part of the Project Area. Other travel routes include Interstate 90, several state highways, and numerous county roads and BLM roads that access the area from the highways. Public use of BLM roads is relatively low with motorists falling into the categories of local ranchers and residents, coal mine and gas field personnel, and recreationists.

Recreational Resources

Regional Characterization

The proposed Project Area consists of BLM, Forest Service, state and private lands in four counties in northern Wyoming. A significant portion of each county in the Project Area is public land. Public lands provide open space for a variety of dispersed outdoor recreation opportunities, as well as developed facilities to help meet the demand for site-oriented recreation. Recreation opportunities offered by the private sector consist of community facilities in urban areas and the infrastructure of tourist services and facilities.

The Project Area counties offer broad, panoramic prairie landscapes, which provide a setting for a variety of outdoor recreational activities. Major attractions include the Thunder Basin National Grassland, several state historic sites, and the historic Bozeman Trail. Most areas that provide recreational activities occur in the western portion of the Project Area, near the foothills of the Bighorn Mountains, and in the Powder River Breaks.

Recreational Use

Recreational use of the Project Area is limited, as more than 75 percent of the land is privately owned. Opportunities for dispersed recreation exist on federal and state lands throughout the Project Area. There are few developed recreational sites or facilities within special management areas on federal lands in the Project Area. Developed recreational facilities such as campgrounds are generally limited to private lands in or near to larger communities in the Project Area, and to state historical sites located in the western part of the Project Area. Communities in the Project Area, including Sheridan, Gillette, Wright, Buffalo, and Kaycee, provide a variety of municipal and private recreational facilities, including golf courses, rodeo grounds, ball parks, and swimming pools.

Dispersed Recreation

Dispersed recreational opportunities in the Project Area include hunting, fishing, sightseeing, ORV use, and camping. Hunting is a major recreation use of state and federal lands in the Project Area. Various big game and upland game bird species are hunted in the region. Big game species include deer, elk, and pronghorn. Game birds hunted in the Project Area include wild turkey, sage grouse, sharp-tailed grouse, Hungarian partridge, chukar partridge, and ring-necked pheasant.

Accessible public lands managed by BLM's Buffalo and Casper Field Offices provide diverse opportunities for recreation, including hunting, fishing, ORV use, sightseeing, and wildlife observation. Public lands generally provide dispersed recreational uses in the Project Area. Some developed recreational facilities occur in special management areas, including recreation areas. Public lands support about 3 percent of the recreational use in the Buffalo Field Office area. While opportunities are available on BLM lands throughout the Project Area, the majority of dispersed recreational uses occur in the western part of the Project Area, including the South Big Horns Area, and along the Powder River. Public lands in much of the Project Area consists of isolated tracts of land managed by the BLM that are too small to provide a quality recreational experience. Larger parcels of public lands occur in the southwest part of Johnson County and along the Powder River. Public lands are accessible via public roads or across private land that requires landowner permission.

Recreational use of public lands in the Project Area has increased substantially over the past two decades, and is expected to continue to increase by about 5 percent every 5 years for most recreational activities. Visitation to BLM and non-BLM lands in the Buffalo Field Office area, which includes most of the Project Area, is summarized in Table 3-72. Total visitor use by residents and nonresident visitors in 1980 was 730,000 visitor days. The total visitor days of 1,881,763 estimated for 1990 was more than quadruple the 1980 visitor days.

The WGFD manages big game populations in big game management units. The Project Area contains all or part of 18 antelope game units, 22 deer (white-tail and mule) game units, and 9 elk game units. The majority of hunting that occurs in antelope and deer hunting units is non-resident hunting. Table 3-73 summarizes the number of participating hunters, total hunter days, and non-resident hunters for big game management units in the Project Area.

Fishing is a popular year-round activity with residents of the Project Area. Bodies of water that are fished within the Project Area are summarized in Table 3-74.

Table 3-72 Recreation Visitor Days in the Buffalo Field Office Area for 1990

	Resident Visitors			Nonresident Visitors			Total Visitor Days		
Type of Visitor Use	Non-BLM	BLM	Total	Non-BLM	BLM	Total	Non-BLM	BLM	Total
Consumptive									
Antelope	4,503	261	4,764	12,263	837	13,100	16,766	1,098	17,864
Deer	49,195	3,042	52,237	39,980	3,861	43,841	89,175	6,903	96,078
Elk	102,421	2,139	104,560	12,449	272	12,721	114,870	2,411	117,281
Small Game	8,000	200	8,200	400	100	500	8,400	300	8,700
Fishing	300,000	3,000	303,000	75,000	1,000	76,000	375,000	4,000	379,000
Total	464,119	8,642	472,761	140,092	6,070	146,162	604,211	14,712	618,923
Nonconsumptive	578,000	15,440	593,440	652,000	17,400	669,400	1,230,00	32,840	1,262,840
Total Visitor Use	1,042,119	24,082	1,066,201	792,092	23,470	815,562	1,834,211	47,552	1,881,763

Source: BLM 2001a

Table 3-73 Big Game Hunting in the Powder River Basin Project Area, 2000

Game Unit	Active Hunters	Total Harvest	Hunter Success	Hunter Days	Non-Resident Hunters	Percent Non-Resident Hunters
Antelope	6,877	6,168	89.7%	19,128	5,272	76.7%
Deer	14,680	8,936	60.9%	49,811	7,781	53.0%
Elk	5,934	1,688	28.4%	39,328	981	16.5%

Source: WGFD 2001a

ORV use in the Project Area is available on most BLM lands. In the BFO, 20,386 acres are open to unlimited vehicle travel on and off roads. No areas are open to unlimited use on CFO lands in the Project Area. There are 3,650 acres in the BFO and 1,030 acres in the CFO that are closed to all ORV use. Areas open to limited ORV use include 774,812 acres in the BFO and 92,722 acres in the CFO within the Project Area.

Some private landowners in the Project Area receive supplemental income from providing hunting and fishing opportunities. In 2001, following evaluation as a trial project, the Walk-in Area (WIA) was implemented as a permanent program by the Wyoming Game and Fish Department. The WIA program allows the Wyoming Game and Fish Department to assist landowners who support wildlife and maintain public hunting and fishing opportunities. The Game and Fish Department leases hunting rights on private land tracts. Participating landowners receive monetary compensation based on the size of the tract of land enrolled in the program.

Table 3-74 Fishing Areas in the Powder River Basin Project Area

Sub-Watershed	Water Body	Fish species
Middle Fork Powder River	Beartrap Creek	Brook, Rainbow
	Blue Creek	Brown, Brook, Rainbow
	Dull Knife Reservoir	Brown, Rainbow
	Powder River, Middle Fork	Brown
	Powder River, North Fork	Brown, Rainbow
Crazy Woman	Crazy Woman Creek	Brown, Brook, Rainbow
	Doyle Creek	Brown, Brook
Clear Creek	Clear Creek	Brown, Rainbow
	Lake De Smet	Brown, Rainbow
	North Piney Creek	Brook, Rainbow
Upper Belle Fourche	Gillette Lake	Rainbow

Source: WGFD 2001b

Developed Recreation Areas and Recreation Use Sites

Project Area counties include several special recreation management areas on public and private lands. Recreation sites on public lands within each sub-watershed are summarized in Table 3-75. Connor Battlefield State Historic Site and Trail End State Historic Site are in western Sheridan County, near the city of Sheridan. Fort Phil Kearney State Historic Site is in west Johnson County between the cities of Sheridan and Buffalo. Recreational activities available in the Connor Battlefield site include camping and fishing. The Trail End and Fort Phil Kearney sites feature museums and tours. Limited developed recreation facilities are also located in special management areas on BLM-administered public lands.

Visits to the historic sites in the years between 1994 and 1998 are characterized by annual increases and decreases, as shown in Table 3-76. These fluctuations are not related to population changes in the counties, which have steadily increased, with the exception on Sheridan County (see Socioeconomics section).

Declines in visits to the parks probably result from ongoing renovation and construction.

Two scenic byways in the western part of the Project Area provide access to the Bighorn Mountains. The Bighorn Scenic Byway is on U.S. Route 14 west of Ranchester. The Cloud Peak Skyway is on U.S. Route 16 west of Buffalo.

Table 3-75 Recreational Sites in the Powder River Basin Sub-watersheds

Sub-Watershed	Recreation Site	Managing Agency
Little Bighorn River	None	
Upper Tongue River	Amsden Creek Winter Game Refuge	Wyoming Game and Fish Dept.
	Connor Battlefield	Wyoming State Parks and Historical Resources
	Trail End State Historical Site	Wyoming State Parks and Historical Resources
	Cloud Peak Skyway (Wyoming State Scenic Byway)	Wyoming Department of Transportation
	Bozeman Trail	NA[1]
Middle Fork Powder River	Middle Fork Recreation Area	BLM – Buffalo Field Office
	Ed O. Taylor Wildlife Habitat Management Area	BLM – Buffalo Field Office
	Gardner Wilderness Study Area	BLM – Buffalo Field Office
	North Fork Wilderness Study Area	BLM – Buffalo Field Office
	Outlaw Cave Recreation Site	BLM – Buffalo Field Office
	Dull Knife Battlefield	Wyoming State Parks and Historical Resources
	Bozeman Trail	NA
North Fork Powder River	NA	
Upper Powder River	Fortification Creek SMA and WSA	BLM – Buffalo Field Office
	Cantonment Reno	BLM – Buffalo Field Office
	Bozeman Trail	NA
South Fork Powder River	NA	
Salt Creek	Bozeman Trail	NA
Crazy Woman Creek	Dry Creek Petrified Tree Environmental Education Area	BLM – Buffalo Field Office
	Bozeman Trail	NA
Clear Creek	Bud Love Wildlife Habitat Management Area	Wyoming Game and Fish Dept.
	Ft. Phil Kearny State Historical Site	Wyoming State Parks and Historical Resources

Table 3-75 Recreational Sites in the Powder River Basin Sub-watersheds

Sub-Watershed	Recreation Site	Managing Agency
	Mosier Gulch Recreation Area	BLM – Buffalo Field Office
	Big Horn Scenic Byway (Wyoming State Scenic Byway)	Wyoming Department of Transportation
	Bozeman Trail	NA
Middle Powder River	NA	
Little Powder River	Weston Hills Recreation Area	BLM – Buffalo Field Office
Little Missouri River	NA	
Antelope Creek	Bozeman Trail	NA
Dry Fork Cheyenne River	Bozeman Trail	NA
Upper Cheyenne River	NA	
Lightning Creek	NA	
Upper Belle Fourche River	NA	
Middle N. Platte River	Bozeman Trail	NA

Note:
1. NA = not applicable
Source: BLM 1984, 2001a; National Scenic Byways Program 2001; WDSP&HS 2001

BLM

Several developed recreational sites and areas occur on BLM lands administered by the Buffalo Field Office, as summarized on Table 3-76. There were no developed recreation sites identified on BLM lands administered by the Casper Field Office within the Project Area. The South Big Horns Area is located in the southwest quarter of Johnson County, primarily within the Middle Fork Powder River sub-watershed. The area provides sensitive and unique resource values, including fisheries, cultural, wildlife, wilderness, and scenery. Special management areas that provide recreational opportunities within the South Big Horns Area include Middle Fork Recreation Area, the Red Wall/Hole-in-the-Wall area, Outlaw Cave Recreation Site (or Cultural Area), Dull Knife Battlefield site, and the Gardner Mountain and North Fork WSAs.

Table 3-76 State Historic Site Visitors: 1994–1998

Historic Site	1994	1995	1996	1997	1998
Connor Battlefield	23,694	18,592	18,926	18,670	15,379
Fort Phil Kearney	27,068	25,167	23,136	22,657	22,128
Trail End	16,584	12,247	16,828	18,004	19,377

Source: Wyoming Division of Economic Analysis 1999

The Middle Fork Recreation Area covers 48,400 acres within the South Big Horns Area along the Middle Fork of the Powder River. The area contains a variety of outstanding natural resources and is protected from mineral entry because it has unique visual qualities, wildlife habitat, fisheries, and general outdoor recreational qualities. The State of Wyoming has rated the Middle Fork of the Powder River as a Class I trout fishery that is of national importance. The Outlaw Cave Recreation Site, located along the Middle Fork of the Powder River in the Middle Fork Recreation Area, is an important historical site that provides camping, fishing, hiking, and other dispersed recreational activities.

The Dry Creek Petrified Tree Environmental Education Area, located near the town of Buffalo, has been designated as an outstanding natural area. The area contains a parking lot road, picnic table, and interpretive facilities.

Three WSAs provide primitive, undeveloped types of recreation. There is no public access to the North Fork and Fortification Creek WSAs. Public access to Gardner Mountain WSA is difficult because of the scattered land ownership.

There are two recreation areas on BLM-administered public lands in the Project Area. The Mosier Gulch Recreation Area (RA), is west of Buffalo on U.S. Highway 16. The RA includes a picnic area. The RA provides off-highway vehicle use of designated roads and a loop trail open to foot, horse, mountain bike, and all-terrain vehicle (ATV) use. Two additional loop trails that also would provide these uses may be constructed in the RA. The Weston Hills RA is located in the eastern part of the Project Area, adjacent to a portion of the TBNG. The RA provides hunting and dispersed camping recreational opportunities.

The Bozeman Trail is a historic transportation corridor that was used by Indian tribes, trappers and traders, exploration expeditions, American emigrants, the military, and settlers. Several historic sites associated with the Bozeman Trail provide recreational opportunities. Interpretive programs and historic sites along the trail include Fort Phil Kearny, Cantonment Reno, and the Connor Battlefield. The trail originates near Fort Laramie, south of the Project Area, and runs through public and private lands along the eastern side of the Big Horn Mountains through the Project Area into Montana.

Approximately 798,848 acres of public land in Johnson, Sheridan, and Campbell Counties has been inventoried and designated as open, limited, or closed to ORV use. Most ORV use in the counties is limited to existing roads and vehicle routes.

Forest Service

The TBNG provides a variety of wildland recreational opportunities to local residents, including many who are employed in mineral industries. Nearly all of the TBNG is open to use by ORVs. The area provides hunting opportunities for residents and non-residents, primarily big game species such as antelope and deer. Shooting restrictions have recently been implemented on the TBNG to protect the special biological community associated with the future reintroduction of the endangered black-footed ferret.

Recreation Planning

BLM

The goals of recreation management for all BLM lands in the Project Area are to provide outdoor recreational opportunities on BLM-administered public land while providing for resource protection, visitor services, and the health and safety of public land visitors.

The BLM has also developed a management objective for special management areas within the Project Area, including the South Big Horns Area, the Dry Creek Petrified Tree Environmental Education Area, the Fortification Creek Area, the Weston Hill Recreation Area, and the Mosier Gulch Recreation Area. The management objective for recreation in these areas is to ensure continued public use and enjoyment of recreation activities while protecting and enhancing natural and cultural values; improve opportunities for high-quality outdoor recreation; and, improve visitor services related to safety, information, interpretation, and facility development and maintenance.

In order to protect the sensitive and unique resource values of the South Big Horns Area, surface disturbance or occupancy is prohibited in the Red Wall/Hole-in-the-Wall area and within ½-mile of the rim of the Middle Fork Canyon. Goals for the two WSAs in the Area include preserving the existing wilderness characteristics of the WSAs and not allowing activity that would impair the suitability of the WSAs for preservation as wilderness.

Management decisions for the Dry Creek Petrified Tree Environmental Education Area are to preserve the area near its natural state, prevent or slow down deterioration of the petrified trees, and inform the visitor about the area. Surface disturbance or occupancy is prohibited within ½-mile of the site unless waived by the authorized officer.

Management objectives specific to the Fortification Creek Area, which includes the Fortification Creek WSA, are to allow orderly development of mineral resources while protecting wildlife habitat and sub-watershed areas, and maintaining wilderness values. No surface occupancy is allowed in elk calving areas, and a seasonal timing limitation is applied to elk wintering areas.

Public lands managed by the Casper Field Office are in three Resource Management Units: (RMU) 6, 11, and 14. The RMUs are within the Middle North Platte River, Dry Fork Cheyenne, and Lightning Creek sub-watersheds. There are no developed recreation sites on public lands administered by the Casper Field Office in the Project Area. Recreational activities consist of dispersed activities such as hunting and ORV use. Recreation management for each RMU is described below:

- RMU 6 (Casper Sand Dunes) – The RMU is managed as an extensive recreation management unit where dispersed recreation would be encouraged in areas where soil and sub-watershed values permit. ORV designations would limit travel to designated roads and vehicle routes on public land, except during the fall hunting season, when travel would be permitted on existing roads and vehicle routes. Recreation management is minimal, with emphasis on monitoring, use supervision, and enforcement to resolve user conflicts and provide resource protection.
- RMU 11 (Ross) – The RMU is managed as an extensive recreation management unit where dispersed recreation would be encouraged and where visitors would have freedom of recreational choice with minimal regulatory constraint. ORV use is limited to existing roads and vehicle routes on all public lands within the unit.
- RMU 14 (Remaining Platte River Resource Area) – RMU 14 comprises all lands managed by the Casper Field Office not included in the other RMUs, and contains portions of the Thunder Basin National Grassland. It is managed as an extensive recreation management unit where dispersed recreation would be encouraged and where visitors would have freedom of recreational choice with minimal regulatory constraint. ORV use is limited to existing roads and vehicle routes for the Project Area on all public lands within the unit.

Forest Service – Thunder Basin National Grassland

The Medicine Bow-Routt National Forest has developed an LRMP for the TBNG (FS 2001a). Under the preferred Alternative 3, TBNG lands within the Project Area are within seven management areas. Each management area is managed for a particular emphasis or theme. The standards and guidelines for recreation in each management area are summarized in Table 3-77.

National Forest System lands are inventoried and mapped by Recreation Opportunity Spectrum (ROS) class to identify the opportunities for recreation activities that occur on National Forest System lands. The ROS system is a continuum divided into six classes ranging from Primitive to Urban. All of the TBNG lands in the Project Area have been inventoried with the Semi-Primitive Motorized class (FS 1985).

The Semi-Primitive Motorized class is characterized by a predominantly unmodified natural environment in a location that provides good to moderate isolation from sights and sounds of man except for facilities and travel routes sufficient to support motorized recreational travel opportunities that present at least moderate challenge, risk, and a high degree of skill testing.

Table 3-77 Recreation Standards and Guidelines for TBNG Management Areas in the Project Area

Management Area		Standards & Guidelines
3.63	Black-Footed Ferret Reintroduction Habitat	-Prohibit shooting in prairie dog colonies unless needed to help reduce unwanted colonization of adjoining lands. (Guideline) -Work with Animal and Plant Health Inspection Service and state agencies to prohibit the use of leg-hold traps without pan-tension devices for predator control and fur harvest on National Forest System lands in this management area. (Guideline)
3.65	Rangelands with Diverse Natural-Appearing Landscapes	NA
3.68	Big Game Range	Permit recreation facilities needed to support summer recreational activities, but close them during periods when big game are present in concentrated numbers. (Guideline)
4.32	Dispersed Recreation: High Use	-Allow uses and activities (for example, grazing, mineral leasing) only if they do not degrade the characteristics for which the area was identified. (Guideline) -Do not salt or supplement feed within ¼-mile of designated roads. (Guideline)
5.12	General Forest and Rangelands: Range Vegetation Emphasis	NA
6.1	Rangeland with Broad Resource Emphasis	NA
8.4	Mineral Production and Development	NA

State

The mission of Wyoming State Parks and Historic Sites is to provide quality recreational and cultural land and opportunities, and to be responsible stewards of these resources. The Wyoming Department of State Parks & Cultural Resources has the authority to promulgate rules and regulations governing state parks. These rules include and cover the following areas: (a) conservation of peace and good order within each park; (b) preservation of state property; and (c) promotion of well being for park visitors and residents. There is no provision in the rules and regulations governing the development of mineral or other industrial developments within state parks.

Counties

The Sheridan County Growth Management Plan, a comprehensive master plan for the City of Sheridan and all of Sheridan County, was prepared in May 2001. One of the primary themes identified in the Sheridan Plan is to maintain a community character that preserves the quality of life, values, and traditions of the area. The goals and the associated implementation strategies that relate to mineral development for achieving this theme are described below.

Goal E. Enhance Recreational Opportunities

1.E.1 Protect open spaces, flood channels, and waterways throughout Sheridan County by planning for an integrated open space network compatible with existing trails or pathway plans, open space plans, or flood management plans. As subdivisions and other development are reviewed, achieve over time a comprehensive open space network.

1.E.2 As part of subdivision review, encourage the development of the Sheridan Pathways project and the development of a trail along Little Goose Creek.

1.E.3 Encourage recreation activities in Sheridan County.

1.E.5 Support efforts to identify and obtain open space in the county. The Sheridan County Planner should investigate and pursue mechanisms that can enable open space to be preserved. Open space, to be meaningful and usable, should be lands that:

- Are adjacent to existing open space or public lands;
- Have special scenic or environmental qualities;
- Enable the preservation of scenic, recreational, or environmental resources, and;
- Include pathways, bikeways, trails, golf courses, recreational areas, parks, historic areas, and conservation easements. With the long-term goal of eventual connection of various units of open space acquired through the subdivision process, an open space network can be created.

The City of Gillette and Campbell County have jointly prepared a Comprehensive Planning Program, last updated March 1994. The program identifies parks and recreation planning as an essential element determining the character and quality of an environment. Existing parks and their facilities that are maintained by the Campbell County Parks and Recreation Department are listed in the program document. Existing facilities are located primarily within or near the cities of Gillette and Wright. The Savageton Community Park is located ¼-mile south of Savageton in southwestern Campbell County.

The General Land Use Plan for Converse County was developed in August 1978. According to the Converse Plan, Objective #3 for Rural Centers is to provide for those recreational activities as required by the increase of population. The policy to achieve this objective is to have recreational developments only in those areas with adequate access and in conformance with the Land Use Plan and Converse County Subdivision and Development Regulations. Converse County is currently updating the land use plan.

Johnson County is currently developing a land use plan. There are no goals for management of recreation resources in the county.

Wild and Scenic Rivers

The BLM has identified public lands along four waterway segments that were determined to meet the eligibility criteria for Wild and Scenic River (WSR) designation. The waterway review segments that were evaluated for eligibility criteria are along the Beartrap Creek, the Middle Fork of the Powder River, the Powder River at Cantonment Reno, and the North Fork of the Powder River review segments. The Beartrap Creek, North Fork of the Powder River, and the Powder River at Cantonment Reno were found to be not suitable for Wild and Scenic Rivers status primarily because of private land use and public access conflicts, or because they would not be worthy additions to the system. The Middle Fork of the Powder River was determined to be a worthy addition to the Wild and Scenic River System. The eligibility analyses for the four waterway review segments are included in the attachments A, B, and C of BLM's Approved Resource Management Plan for the BFO (2001a). The analysis for the Middle Fork of the Powder River is summarized on Table 3-78.

Noise

Noise is generally described as unwanted sound. Discussions of environmental noise do not focus on pure tones because commonly heard sounds have complex frequency and pressure characteristics. Accordingly, sound measurement equipment has been designed to account for the sensitivity of human hearing to different frequencies. Correction factors for adjusting actual sound pressure levels to correspond with human hearing have been determined experimentally. For measuring noise in ordinary environments, A-Weighted correction factors are employed. The filter de-emphasizes the very low and very high frequencies of sound in a manner similar to the response of the human ear. Therefore, the A-weighted decibel (dBA) is a good correlation to a human's subjective reaction to noise.

The following discussion sets a basis of familiarity with known and common noise levels. A quiet whisper at 5 feet is 20 dBA; a residential area at night is 40 dBA; a residential area during the day is 50 dBA; a large and busy department store is 60 dBA; rush hour traffic at 100 feet from the road is 60 to 65 dBA; interstate traffic at 200 feet is 65 dBA; a heavy truck at 50 feet is 75 dBA; and a typical construction site is 80 dBA. At the upper end of the noise spectrum, a jet takeoff at 200 feet is 120 dBA (Harris 1991).

The dBA measurement is on a logarithmic scale. The apparent increase in "loudness" doubles for every 10 dBA increase in noise (Bell 1982). Taking a baseline noise level of 50 dBA in a daytime residential area, noise of 60 dBA would be twice as loud, 70 dBA would be four times as loud, and 80 dBA would be eight times as loud.

Table 3-78 Middle Fork of the Powder River Waterway Segments Eligible for WSR Designation in the Powder River Project Area

Reviewed Waterway Segment	Length of segment across BLM Land Parcel	Outstandingly Remarkable Values	Tentative Classification
sec. 25, 26; T42N, R86W	1.2	Fisheries; Class 1 fishery	Recreational
W½ NW¼ sec. 30; T42N, R85W	0.25	Fisheries; Class 1 fishery	Wild
sec. 19-23, 28-30; T42N, R85W	3.25	Scenic, Fisheries, Cultural, Wildlife, Recreational; Class 1 fishery. Native American cultural sites. Recreational hiking and cultural interpretation opportunities.	Wild
sec. 22, 23; T42N, R85W	1.0	Scenic, Fisheries, Cultural, Wildlife, Recreational. Class 1 fishery. Native American cultural sites. Recreational hiking and cultural interpretation opportunities.	Wild
sec. 19-22, 30; T42N, R84W and sec. 24; T42N, R85W	5.0	Scenic, Fisheries, Wildlife, Recreational, Historic, Cultural; Spectacular, primitive canyon. Nationally and regionally historic Outlaw Cave. Native American rock art and shelter sites. Class 1 fishery. Recreational hiking and cultural interpretation opportunities.	Wild

Source: BLM 2001a

The land uses in the Project Area range from sparsely populated rural regions to more densely populated urbanized areas to industrial areas, such as coal mining and CBM operations. Major sources of noise are towns; industrial facilities; major roadways, such as Interstate 90; railroad corridors; and frequent high winds. Background noise surveys have not been conducted in the area. However, noise in rural areas away from industrial facilities and transportation corridors is generally 30 to 40 dBA when the wind speeds are low. Levels of noise close to industrial facilities and transportation corridors are likely to be in the range of 50 to 70 dBA, depending on the proximity to these sources. The most significant noise from CBM operations results from the operation of compressor stations that use multiple engines to move natural gas from central gathering facilities and along high-pressure transmission pipelines. Noise from these compressor stations has been estimated to be 55 dBA at 600 feet from the compressor station (BLM 2000b).

Socioeconomics

The Project Area encompasses all or portions of Converse, Campbell, Johnson, and Sheridan Counties in Wyoming. It also includes four incorporated municipalities: Gillette, Wright, Sheridan, and Buffalo. Gillette is the county seat and the largest incorporated city in Campbell County. Wright is in southern Campbell

County. Sheridan is the county seat of Sheridan County, and Buffalo is the county seat of Johnson County. These four counties are the primary counties that potentially would experience socioeconomic impacts. However, socioeconomics, with respect to Environmental Justice, would also be addressed here for four counties in Montana, just north of the Project Area.

Population

The 2000 population in the Project Area is: Converse County, estimated at 12,052; Campbell County, estimated at 33,698; Johnson County, estimated at 7,075; and Sheridan County, estimated at 26,560. The total population is 79,385 for these four counties combined, which make up 16 percent of the population in State of Wyoming. Table 3-79 summarizes population growth and projections of population growth between 1980 and 2002.

Table 3-79 Population Estimates in Campbell, Converse, Johnson, and Sheridan Counties, and Wyoming

Location	1980	1990	1996	1997	2000
Campbell County	24,367	29,370	31,931	32,071	33,698
Gillette	14,545	17,545	21,585	19,289	19,646
Wright	NA	1,117	1,385	1,347	1,347
Converse County	14,069	11,128	12,125	12,295	12,052
Douglas	NA	5,076	5530	5,634	5,288
Glenrock	NA	2,153	2329	2,367	2,231
Johnson County	6,700	6,145	6,717	6,796	7,075
Buffalo	NA	3,302	NA	NA	3,900
Kaycee	NA	260	303	308	307
Sheridan County	25,048	23,562	25,203	25,199	26,560
Sheridan	NA	13,900	NA	NA	15,804
State of Wyoming	469,551	453,588	480,085	480,031	493,782

Source: U.S. Census Bureau 2000a, Wyoming Division of Economic Analysis 1997a
NA = Not available

Growth in these counties has also been prevalent over the last 10 years. According to the U.S. Census Bureau, the counties within the Project Area have undergone 12.7 percent growth between 1990 and 2000. Johnson County had a 15.1 percent growth in that period, ahead of Campbell (14.7 percent), Sheridan (12.7 percent) and Converse (8.3 percent) Counties.

Between 2000 and 2008, it is projected that the counties within the Project Area would experience the following population increases: Campbell County would increase by 4 percent; Converse County would increase by 8 percent; Johnson County would increase by 4 percent; and Sheridan County would decrease by 0.5 percent. All counties within the Project Area, with the exception of Sheridan County, would have higher population increases than the projected population increase for the State of Wyoming of 2 percent. Projected population within the Project Area is provided in Table 3-80.

Table 3-80 Projected Populations in Campbell, Converse, Johnson, and Sheridan Counties, and Wyoming

Location	2001	2002	2003	2004	2005	2006	2007	2008
Campbell County	33,210	33,490	33,780	34,080	34,370	34,670	34,970	35,270
Gillette	19,970	20,075	20,249	20,429	20,603	20,783	20,962	21,142
Wright	1,384	1,396	1,408	1,420	1,432	1,445	1,457	1,470
Converse County	12,550	12,640	12,720	12,810	12,900	12,990	13,080	13,170
Douglas	5,725	5,766	5,803	5,844	5,885	5,926	5,967	6,008
Glenrock	24,00	2,428	2,444	2,461	2,478	2,496	2,513	2,530
Johnson County	6,970	7,030	7,090	7,150	7,210	7,270	7,330	7,390
Buffalo	3,741	3,773	3,806	3,838	3,870	3,902	3,934	3,967
Sheridan County	25,480	25,600	25,740	25,870	26,010	26,140	26,270	26,410
Sheridan	14,864	14,934	15,016	15,092	15,173	15,249	15,325	15,407
State of Wyoming	486,240	488,480	490,810	493,230	495,630	498,020	500,380	502,780

Source: Wyoming Division of Economic Analysis 1997a

Employment

The annual average labor force for the Project Area consists of 37,337 employees and the overall unemployment rate for the Project Area is 6.7 percent, 0.4 percent higher than the unemployment rate for the State of Wyoming. Specific labor force estimates, by county and for the State of Wyoming, are provided in Table 3-81.

Table 3-81 Labor Force Estimates

Location	Labor Force	Employment	Unemployment	Unemployment Rate (percent)
Campbell County	18,520	17,541	979	5.3
Converse County	6,508	6,105	403	6.2
Johnson County	3,750	3,579	171	4.6
Sheridan County	13,364	12,655	709	5.3
State of Wyoming	239,000	224,000	15,000	6.3

Source: Wyoming Department of Employment 1997a

Employment Sectors and Wages

Wyoming Department of Employment (WDOE), Employment Resources Division, records describe the employment sectors in the affected counties. The 1997 Campbell County employment statistics indicated that the primary employment sectors were dominated by Mining (consists of coal mining, oil and gas extraction, crude, petroleum-natural gas, oil and gas field service and nonmetalic minerals as defined by the U.S. Bureau of Labor Statistics), Local Government, Retail Trade and Services. Specifically, 25 percent of the income was from Mining, 17 percent was from Local Government, 17 percent was from Retail Trade, and 15 percent was from Services. Agriculture accounted for 1 percent of the employment in the county.

The 1997 Converse County employment statistics indicated that the primary employment sectors were dominated by Mining, Local Government, Retail Trade, and Services. Specifically, 21 percent of the income was from Mining, 29 percent was from Local Government, 25 percent was from Retail Trade, and 15 percent was from Services. Agriculture accounted for 2 percent of the employment in the county.

The 1997 Johnson County employment statistics indicated that the primary employment sectors were dominated by Local Government, Retail Trade, and Services. Specifically, 22 percent was from Local Government, 24 percent was from Retail Trade, and 18 percent was from Services. Agriculture accounted for 2 percent of the employment in the county and, unlike Converse and Campbell Counties, only 5 percent of the income was from Mining.

The 1997 Sheridan County employment statistics indicated that the primary employment sectors were dominated by Local Government, Retail Trade, and Services. Specifically, 18 percent was from Local Government, 22 percent was from Retail Trade, and 25 percent was from Services. Agriculture accounted for less than 1 percent of the employment in the county and, unlike Converse and Campbell Counties, less than 1 percent of the income was from Mining.

Table 3-82 also identifies the Income and Earnings by industry for all four counties. Mining consistently averages to be one of the highest paying industries, as does Finance, Insurance, and Real Estate (FIRE) and Transportation, Communication and Utilities (TCU). Employment in Agriculture and Retail Trade tends to represent the lowest earnings in all four counties.

Employment information from the Wyoming Department of Employment Research and Planning 2000 and 2001 is provided in Table 3-83. The data were collected for the oil and gas extraction portion of the mining industry within the Project Area. Numbers of CBM related workers are not publicly available; however, analysis assumed that the majority of oil and gas extraction employment primarily consists of CBM employment. Oil and gas extraction was reported in 2000 and 2001 for Campbell, Converse, and Johnson Counties. Sheridan County information was not available for the oil and gas extraction industry for 2000 and 2001, so employment number for the umbrella category of "mining" was assumed, which consists of coal mining, metal mining, oil and gas extraction, and nonmetallic minerals. According to the 2000 fourth-quarter information, it is estimated that 2,074 employees worked in the industry within the Project Area (Wyoming Department of Employment Research and Planning 2001a, 2001b). Based on similar assumptions, 2001 employment within the Project Area is estimated to be 2,943 employees in the oil and gas extraction industry.

Table 3-82 Employment Income and Earnings by Industry

Industry	Average Annual Wage ($)				
	Campbell County	Converse County	Johnson County	Sheridan County	State of Wyoming
Agriculture	13,976	14,625	18,882	14,886	16,161
Construction	27,655	27,957	17,730	20,738	25,509
Finance, Insurance, Real Estate	22,704	20,414	24,284	33,695	28,954
Manufacturing	33,534	19,746	18,358	25,147	30,798
Mining	52,702	45,018	35,188	41,514	47,053
Public Administration	28,431	26, 172	26,600	30,252	27,863
Trade-Retail	13,447	10,234	10,703	12,196	12,884
Trade-Wholesale	35,988	12,995	17,480	25,704	29,133
Services & Misc.	20,276	14,047	15,511	18,197	18,712
Transportation, Communication & Utilities	30,884	48,433	24,527	25,547	32,283
Total (average)	30,420	24,682	18,517	20,920	26,935

Source: Wyoming Department of Employment, Employment, 1997a and 1997b

The median household income in Converse, Johnson, and Sheridan Counties increased between 1969 to 1997 by an average of 64 percent. The median household income in Campbell County decreased by 3 percent between 1969 and 1997. All four counties experienced a peak in median household income in 1979. Campbell County median household incomes were higher than the State of Wyoming average, while Johnson and Sheridan Counties experienced lower median household income than the State of Wyoming average. Converse County also experienced higher median household income (Table 3-84) than the State of Wyoming, with the exception of 1969, when the average was slightly lower.

Housing

The property values within each community could be affected by an influx in population. Currently, home values within the Project Area range from $76,000 to $130,000 for an existing three-bedroom home and $120,000 to $160,000 for a new three-bedroom home (Table 3-85).

Table 3-83 Oil and Gas Extraction Employment

County	2000 Average Monthly Empoyment[1]	2001 Fourth Quarter Employment[2]
Campbell	1,788	2,511
Converse	162	181
Johnson	69	136
Sheridan	55[3]	115[4]
Total	2,074	2,943

Notes:
[1] Wyoming Department of Employment Research and Planning 2001b
[2] Wyoming Department of Employment Research and Planning 2001a
[3] Mining Industry – not delineated by coal mining, metal mining, oil and gas extraction and non-metallic minerals, except fuels
[4] Projected Mining Industry employment, based on the third quarter 2001 (most recent information available).

Table 3-84 Median Household Income

Location	1969	1979	1989	1997
Campbell County	34,103	43,668	37,055	33,197
Converse County	23,365	38,026	27,713	37,978
Johnson County	21,313	27,659	22,157	31,832
Sheridan County	20,699	30,348	24,772	33,000
State of Wyoming	25,288	33,503	27,096	33,197

Source: Wyoming Division of Economic Analysis 1997b, and U.S. Census Bureau 2000b

Housing costs within the Project Area vary considerably. Of all counties within the Project Area, Campbell County has experienced some of the higher cost for real estate. According to the Campbell County Board of Realtors, residential property in Gillette, 71 percent of homes sold during the second quarter 2000 through first quarter 2001 were priced less than $120,000 (Campbell County Economic Development Corporation 2001). In the same period, 94 percent of residential properties in Wright were priced at $100,000 or less. However, the greatest number of sales occurred in the $60,000 to $70,000 range. No properties in this price range were sold following second quarter 2000.

Table 3-85 Property Valuation

	Cost of Individual Homes in 2001	
Location	Average New Three Bedroom	Average Existing Three Bedroom
Campbell County		
Gillette	$132,560	$106,110
Wright	$120,000	$76,531
Converse County	$132,000	$106,111
Johnson County		
Buffalo	$160,000	$130,000
Sheridan County		
Sheridan	$107,000[a]	NA

Note:
a. U.S. Census Bureau 2000c; 1999 data only. In 2001, the average cost of a three-bedroom home in rural areas was $125,000.
Sources: Buffalo Chamber of Commerce 2001, Campbell County Chamber of Commerce 2001

The majority of the available housing in the Project Area is located in the communities of Gillette, Wright, Sheridan, and Buffalo. There were 35,037 housing units in the Project Area in 2000. In 2000, the average rental and housing availability rate for the Campbell and Johnson Counties was 3.95 percent. Table 3-86 identifies the housing units and vacancy within the Project Area. The population in the northeast portion of Wyoming grew 12.7 percent, twice as fast as the housing stock (6.2 percent) between 1990 and 2000 (Wyoming Department of Employment 2001b). The northeast portion of this study area includes three counties in the Project Area (Sheridan, Campbell, and Johnson), as well as two counties outside the Project Area (Crook and Weston) (Wyoming Division of Economic Analysis 2000b).

According to the Campbell County Housing Needs Assessment, it is estimated that in 2001, 98 housing units would be rentals and 92 housing units would be purchased as a result of coal bed methane development and production. It is also estimated that, county wide, as a result of all industries, 449 housing units would be rentals and 861 housing units would be purchased. Current projections from this study indicated that rental demand associated with CBM continue to increase (249 rentals) through 2008, and would slowly decrease thereafter (study limited to 2020). Projected purchase demand would continue to increase (465 purchases) through 2009, and would slowly decrease thereafter (study limited to 2020).

The housing and rental availability is relatively limited within the Project Area. Housing and rental vacancies are lower than the state average in Campbell, Johnson, and Sheridan Counties. Campbell County has a homeowner vacancy rate of 1.2 percent and a rental vacancy rate of 9.0 percent (Wyoming Division of Economic Analysis 2000b). Johnson County has a homeowner vacancy rate of 1.8 and a rental vacancy rate of 3.8 percent and Sheridan County has a homeowner vacancy rate of 1.1 percent and a rental vacancy rate of 4.7 percent. All of these counties are below the state average of 2.1 percent for homeowner vacancy and 9.0 percent for rental vacancies. In Johnson County, homeowner vacancy is 2.3 percent and rental vacancy is 19.0 percent, which above the state average.

Table 3-86 Housing Units and Vacancy

Location	Housing Units (count) in 2000	Rental Vacancy in 2000 (%)	Housing Availability in 1990 (%)
Campbell County	13,288	9.0	15.8
Gillette	7,31	NA	
Wright	544	NA	
Converse County	5,669	19.0	29.4
Douglas	2,385	NA	
Glenrock	1,131	NA	
Johnson County	3,503	3.8	29.8
Buffalo	1,842	NA	
Sheridan County	12,577	4.7	18.3
Sheridan	7,413	NA	

Source: U.S. Census Bureau 1990, 2001, and Wyoming Division of Economic Analysis 2000b

Housing costs range from $353 per month in Converse County to $432 per month in Campbell County for a 2-bedroom apartment. The average two- to three-bedroom house ranges from $436 per month in Converse County to $632 per month in Campbell County. In all housing categories and all counties, mobile homes tend to provide the most economical housing value. Overall, housing costs are highest in Campbell County and lowest in Converse County. Housing costs are shown in Table 3-87.

Table 3-87 Monthly Housing Costs for the 4th Quarter of 2000

	Housing Cost by County per Month			
Housing Cost (4qtr 2000):	Campbell	Converse	Johnson	Sheridan
Two-bedroom Apartment	$432	$353	$396	$405
Single-wide mobile home w/ water	$197	$115	$137	$175
Two- to three-bedroom house	$632	$436	$569	$580
Monthly mobile home rent including lot rent	$483	$324	$488	$447

Source: Wyoming Division of Economic Analysis 2000b

Community and Government Services

Natural gas and CBM exploration and resource development activities have the potential to affect existing community facilities and infrastructure. The use of, or connection to, existing infrastructure including roads with project activities may affect service agencies, capacities, or conveyance systems, or may require installation of new facilities. In addition, project activities in the four-county area may affect employment and population, which subsequently can affect local community services such as schools, law enforcement, or medical facilities. The following paragraphs present a baseline description of these facilities and services

Water and Wastewater Systems, and Solid Waste Disposal

Generally, each county relies on the municipal population centers to provide water, wastewater systems, and solid waste disposal. In some instances, the counties contribute financially to the municipal infrastructure. Communities that are not incorporated into the city water and septic system generally provide for themselves with water wells and septic tanks on the personal property. In Campbell County, water and wastewater systems and solid waste disposal are operated by the City of Gillette. In Converse County, the water and wastewater systems and solid waste disposal are operated by the communities of Glenrock and Douglas. Glenrock and Douglas each have their own landfill, and the county contributes financially. In Johnson County the water and wastewater systems and solid waste disposal are operated by the City of Buffalo. In Sheridan County, the water and wastewater systems and solid waste disposal are operated by the City of Sheridan.

Public Schools, Law Enforcement and Fire Protection, Medical Facilities, Community Services

There are 78 pre-kindergarten through 12^{th} grade public schools in the Project Area. Campbell County operates 22 public schools, Converse County operates 14 public schools, Johnson County operates nine public schools, and Sheridan County operates 24 public schools. Sheridan College, Eastern Wyoming College in Glenrock and Douglas, and University of Wyoming extension services are higher education learning centers within the Project Area.

Law enforcement services within Campbell County are provided by the Campbell County Sheriff's Department. The department consists of 39 sworn officers and 22 patrol officers. Law enforcement services within Converse County are provided by the Converse County Sheriff's Department, which has nine sworn officers. Law enforcement services within unincorporated Johnson County are provided by the Johnson County Sheriff's Department, which has 14 sworn officers. Kaycee and Buffalo (Johnson County) also have police departments, each with 1 and 13 sworn officers. Law enforcement services within unincorporated Sheridan County are provided by the Sheridan County Sheriff's Department, which has 15 sworn officers. The City of Sheridan Police Department also has 29 sworn officers. In spite of an increase in CBM employment between 1999 and 2000 (Wyoming Department of Employment Research and Planning 2002), most crimes, including larceny, aggravated assault, burglary, motor vehicle theft, and robbery have decreased (Campbell County Sheriff's Department 2000) between 1999 and 2000 in Campbell County, where mosdt of the CBM workers live. Simple assault was the only category that showed an increase in arrests (Campbell County Sheriff Department, 2000). Crimes by employment sector are not available in any of the counties within the Project Area; therefore, the number of arrests of CBM workers is not available.

Other studies conducted in Campbell County indicate similar trends for the period from 1990 to 2001. According to *The Analysis of Campbell County Crime Data for the Years of 1990-2001*, arrests increased between 1990 and 2001; however, the majority of these arrests were for minor offenses such as contempt of court, citations for barking dogs, trespass, admitting minors to improper places, and tobacco law violations. A small increase in arrests was attributable to possession of drugs, disorderly conduct, and drunkenness. Arrests for drug possession accounted for 4 percent of the arrests in 2001, which is not unexpected since many communities across the country are experiencing growth in drug possession. Disorderly conduct and drunkenness, usually considered low-level offenses, increased between 1990 and 2001. More serious crimes, such as aggravated assault, weapons violations, burglary and motor vehicle theft, larceny, and sex offenses did not increase from 1990 to 2002 and in some cases have declined (Beck 2002).

Each county in the Project Area operates a detention center. The Campbell County Detention Facility has 101 beds, the Converse County Detention Facility has 34 beds, the Johnson County Detention Facility has 17 beds, and the Sheridan County Detention Facility has 46 beds. According to personnel at the Sheridan County Detention Facility, the presence of CBM development has had a direct impact on the facility. The facility has increased in population in the last year by approximately one third, primarily due to driving under the influence arrests and secondarily as a result of public intoxication by CBM employees (Smith 2001).

Fire protection in Campbell County is provided by the Campbell County fire department, which consists of 13 full time fire fighters and 150 volunteer fire fighters. Fire protection in Converse County is provided by the Campbell County Rural Fire Department, Glenrock Fire Department, and Douglas Fire Department, which consist of 125 volunteer fire fighters. Fire protection in Johnson County is provided by the Johnson County Fire Department. Sheridan County has 24 full-time fire fighters, employed by the City of Sheridan and assisted through a mutual aid agreement, which involvers approximately 50 fire fighters in the surrounding communities of Ranchester, Dayton, Bighorn, and Story.

There are six 24-hour emergency service hospitals within the Project Area. The Campbell County Memorial Hospital is a 119-bed community hospital. Two hospitals operate in Converse County, , one in Douglas, which has 44 beds, and one in Glenrock. In Johnson County, the hospital has 29 beds. In Sheridan County, the Sheridan County Memorial Hospital has 80 beds. The Veterans Administration Hospital also serves Sheridan County. All the counties in the Project Area have ambulance service, additional medical facilities, and specialized physicians.

A number of social service resources exist within the Project Area, generally sponsored by the cities and counties. The Way Station (Gillette) and the Volunteers of America Homeless Center (City of Sheridan) are homeless shelters in the Project Area. In Johnson County, there are additional social services through the Family Crisis Center and Ministerial Association in Buffalo.

Public Finance

Wyoming is the top coal producing state in the United States. According to the Campbell County Chamber of Commerce, more than 90 percent of the coal produced in the State of Wyoming comes from Campbell County (BLM 1999c). Campbell County also produces approximately 25 percent of oil mined in Wyoming each year. Table 3-88 shows the state assessed mineral production valuations for the affected counties and the State for Wyoming for its 2000 fiscal year, which are based on 1999 production.

Table 3-88 Taxable Valuation of Mineral Production for Fiscal Year 1999 Campbell, Converse, Johnson, and Sheridan Counties

Valuation Source	Taxable Mineral Valuation						
	Coal	Crude and Stripper Oil	Natural Gas	Sand & Gravel	Uranium	Other Minerals1	Total Assessed Valuation
Wyoming Valuation ($ million)	1,246	908	1,624	10.9	19.4	275	4,083
Campbell County Valuation ($ million)	976	215	98.9	2.98	1.58	0	1,294
Percent of State's Valuation	79%	24%	6.0%	27%	8.1%	0	32%
Converse County Valuation ($ million)	74.8	64	39.3	0.557	0	.245	186
Percent of State's Valuation	6.0%	6.0%	2.4%	0.01%	0	0.09%	4.6%
Johnson County Valuation ($ million)	0	20.8	1.35	0.808	0.095	0.969	23.4
Percent of State's Valuation	0	2.3%	0.08%	7.0%	0.50%	0.35%	0.56%
Sheridan County Valuation ($ million)	0.897	0.486	0.001	0.420	0	0	1.80
Percent of State's Valuation	0.07%	0.05%	0.001%	3.8%	0	0	0.044%

Note:
1. Includes bentonite produced in Johnson County and leonardite produced in Converse County.
Source: Wyoming Department of Revenue 2000

Agriculture, consisting of livestock production and dryland farming, also is an important sector of the economic base within the affected counties. According to the Campbell County Economic Development Corporation, livestock population in the county consists primarily of cattle and sheep. Most cropland in Campbell County produces wheat, barley, oats, and hay for fed. Agriculture in Converse, Johnson, and Sheridan Counties consists of ranching, crops such as wheat, barley and oats, and irrigated forage crops (BLM 1999c).

The taxable valuation of mineral production provides a significant amount of capital to the governing agencies. According to the Wyoming Department of Revenue, for the fiscal year 1999 through June 30, 2000, 37 percent of State of Wyoming's Taxable Valuation of Minerals Production was from the Project Area. Campbell County accounted for the highest taxable mineral valuation of the State of Wyoming for coal with in the Project Area (79 percent) and was the highest taxable mineral valuation of the State of Wyoming for crude and stripper oil (24 percent). Based on the existing tax structure for the State of Wyoming, mineral production creates a significant tax-generating stream. The taxes on production are provided in Table 3-89.

Table 3-89 State of Wyoming Oil and Gas Taxes

Tax	Rate
Severance Tax	6 percent on normal
Ad Valorem Taxes	6.3 percent (Campbell and Converse Counties in 1999) 6.8 percent (Johnson and Sheridan Counties in 1999)
Wyoming Oil and Gas Tax Variances	Tertiary Oil Production (4 percent) Renewed Production (1.5 percent severance tax for first 60-month production period); Workover/Recompletion Production (2 percent severance tax for first 24 months of production after Workover/Recompletion) New wells drilled (7/1/93-3/31/03) (2 percent severance tax for first 24 months of production up to 60 bbls/day or 6MCF/bbl gas equivalent)
Wyoming Oil and Gas Conservation Tax	0.060 percent
Tribal Severance Tax	8.5 percent on non-stripper oil production and gas production and 4 percent on oil stripper wells (bpd or less)
Source: BLM 2001c	

Quality of Life

Public lands within the Project Area also provide a variety of benefits to adjacent landowners and communities that are much more difficult to quantify than the socioeconomic indicators provided here. These benefits include contributions to a person's quality of life, such as scenic view, open space, and opportunities for recreation, habitat for wildlife, range for agriculture, clean air, and water. Although oil and gas development provides economic opportunities for some residences and communities, such as employment and tax revenue, this development is also viewed as a detraction to quality of life for some residents. For some individuals, a high quality of life is unrelated to direct or indirect benefits such as financial gain and improved shopping. For other individuals, a high quality of life is directly and indirectly related to non-monetary benefits of oil and gas, such as: produced water for irrigation, which sustains an agricultural way of life; use of a clean source of fuel compared with other fuels; and ensured national security and stable, enjoyable employment.

Since quality of life is more a matter of personal perspective than a definitive outcome that BLM can directly affect, BLM would not attempt to quantify quality of life issues or prescribe a desired outcome. Rather, the focus would be on more site-specific factors within the EIS that might affect the quality of life, such as wildlife, agriculture, recreation, air quality, water quality, and scenic viewsheds.

A range of social and community values as well as positive and negative impacts from existing CBM development are presented here, based on scoping and comments on the DEIS. Positive impacts include opportunities for retaining secure and well-paid employment in the area, economic diversification of local economies, greater access to public lands for recreation and other uses, increased tax revenues, and supplying a needed source of energy. Negative impacts include an increase in the dust, traffic, and noise in certain residential areas at certain times of the year, an increase in the amount and extent of modification to the natural landscape, which in turn potentially changes an area from a natural setting to a more industrial setting, and the stress resulting from disruptions of daily activity as a result of working with industry on surface owner agreements and related activities. Social aspects such as strong community and family relationships, control of private lands without interference from outside agencies or groups, and lack of urban problems are social considerations, which, according to some, are currently hampered by the development of oil and gas.

Environmental Justice

Executive Order 12898 on Environmental Justice in Minority and Low Income Populations, issued on February 11, 1994, identifies and addresses, as appropriate, disproportionately high and adverse human health and environmental effects of programs, policies, or activities on minority or low-income populations. In the Project Area for this EIS, minority populations include Native American, Hispanic, and low-income Caucasian populations. Large segments of these populations also compose the low-income groups in this area.

Although the Project Area is within Wyoming, socioeconomic impacts with respect to Environmental Justice may be felt beyond the Project Area, specifically in four counties (Big Horn, Powder River, Rosebud and Yellowstone) in Montana, which are the home of two Indian Reservations (Crow and Northern Cheyenne), and an Amish community. The majority of the Crow Reservation and approximately half of the Northern Cheyenne Indian Reservation are located within Big Horn County, Montana. A very small portion of the Crow Indian reservation is located in Yellowstone County, Montana, and the remaining half of the Northern Cheyenne Indian Reservation occupies one-tenth of Rosebud County, Montana.

Several Hutterite communities are located in central Montana. Hutterite colonies are similar to, but different from, the Amish culture (Strand 2002). These communities are communal farms operated by German-speaking Anabaptists who are known for their production of eggs, pork, and produce, and for their strict religious commitments (Rocky Mountain Front Visitors Guide 2002). A small Amish Community, consisting of 15 individuals, is located 2 miles north of Ashland in Rosebud County (Bell 2002).

It is estimated that a small number of the existing CBM employees commute from Montana (Keanini 2001a); however, the socioeconomic status and race of these populations are unknown. Wyoming Department of Employment Research and Planning has information on the states from which the employees commute, but there are no data for the State of Montana.

Because the socioeconomic effects may be felt in these adjacent communities, it is important to evaluate the social composition of these areas as well. Specifically, due to the proximity of the Crow and Northern Cheyenne Indian Reservations, an Environmental Justice analysis is incorporated in this EIS, as the project has the potential to affect these communities. Differential patterns of consumption of natural resources occur just outside the Project Area. The Northern Cheyenne hunt and fish on Tribal lands. According to a recent survey, 84 percent of respondents hunt on the Northern Cheyenne Reservation. More than 95 percent of those interviewed consider themselves a hunter, fisher, berry picker, or gatherer of food plants. Sixty percent of the people interviewed fished last year in the Tongue River or Reservation ponds. According to the survey, the wild game and plants are primarily shared with others within the household and are considered by 90 percent of the respondents as very important to their social way of life, their economic way of life, and their spiritual way of the life in the Cheyenne Community (Boggs 2002). The Crow Reservation is bordered on the south by the State of Wyoming, with its northwestern boundary bordered by the City of Billings, Montana's largest metropolitan area. According to the Wyoming-Montana Tribal Leaders Council, 76 percent of the 9,024 enrolled members live on the Crow Reservation. The total labor force on the Crow Reservation is 1,546. The unemployment rate is 44 percent. The average per capita income is $4,243. Approximately 69.8 percent have a high school diploma and more than 6 percent have a Bachelor's Degree or higher (Tribal Leaders Council 2001b).

The Northern Cheyenne Reservation covers 445,000 acres and is bounded on the east by the Tongue River and on the west by the Crow Reservation. The total tribal enrollment is 6,479. Approximately 4,064 Northern Cheyenne live on or near the reservation. The total labor force of the reservation is 1,218 and the unemployment rate is 31.4 percent. The per capita income is $4,479. Approximately 62 percent of the tribal members have a high school diploma and 5.6 percent have a Bachelor's Degree or higher (Tribal Leaders Council 2001b).

It is estimated that there are more than 2,000 Hutterites in Montana (Hoffer 2002). The colony near Hardin is likely the southernmost Hutterite Colony in Montana (Hoffer 2002). Hardin is roughly 100 miles from the Montana-Wyoming border. Statistics on education, income, and age are not available for these colonies. Some colonies allow for higher education, while other colonies limit the amount of education. Generally, individual incomes are low since the colony owns the land and all the resources (Strand 2002). The Amish community north of Ashland quilts, makes furniture, and grows produce (Bell 2002).

Racial Composite

The racial composite of four counties in Wyoming (Campbell, Converse, Johnson and Sheridan) and four counties in Montana (Big Horn, Powder River, Rosebud, and Yellowstone) is generally white. As shown in Table 3-90, Big Horn County and Rosebud County, which are occupied by both Indian Reservations, have much higher percentage of American Indians (32 percent and 60 percent, respectively) than the State of Montana (6.2 percent).

Table 3-90 Racial Composite by County and State for 2000

Location	Portion of Racial Composite (percent)							
	White	Black	Amer. Indian, Eskimo, or Aleut	Asian	Native Hawaiian or Pacific Islander	Some Other Race	Two or More Races	Hispanic Origin
Campbell County	96.1	0.2	0.9	0.3	0.1	1.1	1.3	3.5
Converse County	94.7	0.1	0.9	0.3	0.0	2.5	1.5	5.5
Johnson County	97.0	0.1	0.6	0.1	0.0	0.6	1.6	2.1
Sheridan County	95.9	0.2	1.3	0.4	0.1	0.8	1.3	2.4
State of Wyoming	92.1	0.8	2.2	0.5	0.1	2.5	1.8	6.4
Big Horn County	36.6	0	60.0	0.2	0	0.7	2.8	3.7
Powder River County	97.4	0	1.8	0.1	0	0.2	0.5	0.6
Rosebud County	64.4	0.2	32.4	0.3	0	0.6	2.0	6.0
Yellowstone County	92.8	0.4	3.1	0.5	0.04	1.3	1.8	3.7
State of Montana	90.6	2.9	6.2	0.5	0.05	0.6	1.7	2.0

Source: U.S. Census Bureau 2000d and Wyoming Division of Economic Analysis 2000a

Population by Age

Population by Age indicates that generally the majority of the population affected by the Proposed Project is between the ages of 25 and 44 years. The percentage of the population within the Project Area is consistent with the percentage of the population in the State of Wyoming, with the exception of Powder River County, which has 21.9 percent over the age of 65, compared with 13.1 percent for the State of Wyoming. Table 3-91 provides the percentage of the population by age.

Poverty

As shown in Table 3-92, the poverty rates are 12.6 percent in Converse County, 13 percent in Johnson County, and 12.5 percent in Sheridan County. These rates are slightly higher than the poverty rate for the State of Wyoming of 12 percent. Campbell County, which has a poverty rate of 7.8, is significantly lower than the average for the State of Wyoming. The poverty rates in Big Horn, Powder River, Rosebud, and Yellowstone Counties do not exceed the Montana poverty rate.

Table 3-91 Percentage of the Total Population by Selected Age Groups by County and State in 1999

Location	0-4 years (percent of population)	5-17 years (percent of population)	18-24 years (percent of population)	25-44 years (percent of population)	45-64 years (percent of population)	65+ years (percent of population)
Campbell County	7.8	24.8	9.7	32.0	20.5	5.2
Converse County	6.5	22.6	8.6	26.6	25.2	10.5
Johnson County	5.0	18.1	8.1	22.6	27.9	18.3
Sheridan County	4.9	18.7	9.0	25.2	26.9	15.3
State of Wyoming	6.3	20.1	11.2	26.5	24.3	11.6
Big Horn County	9.3	27.4	10.1	25.3	19.7	8.2
Powder River County	5.5	17.8	6.7	21.5	26.6	21.9
Rosebud County	7.7	27.3	8.6	28	20.6	7.8
Yellowstone County	6.0	18.6	10.3	26.9	25.1	13.1
State of Montana	6.0	19.3	10.1	26.3	25	13.3

Source: U.S. Census Bureau 1999

Table 3-92 Percentage of the Total Population by Poverty Level by County and State for 1997

Location	Poverty Rate (%)
Campbell County	7.8
Converse County	12.6
Johnson County	13.0
Sheridan County	12.5
State of Wyoming	12.0
Big Horn County	15.5
Powder River County	15.3
Rosebud County	15.5
Yellowstone County	12.1
State of Montana	15.5

Source: U.S. Census Bureau 1997

Air Quality and Climate

Air Quality and Climate

The air quality of any region is controlled primarily by the magnitude and distribution of pollutant emissions and the regional climate. The transport of pollutants from specific source areas is strongly affected by local topography. In the mountainous western United States, topography is particularly important in channeling pollutants along valleys, creating upslope and downslope circulations that may entrain airborne pollutants, and blocking the flow of pollutants toward certain areas. In general, local effects are superimposed on the general synoptic weather regime and are most important when the large-scale wind flow is weak.

Topography

The Project Area is located in the southern portion of the Powder River Basin (PRB) of the northwestern Great Plains Steppe in northeastern Wyoming. The Great Plains Steppe is a large physiographic province extending throughout most of eastern Wyoming, Montana and Colorado, as well as portions of western North and South Dakota, Nebraska, Kansas, and the Oklahoma panhandle. The topography of the Project Area varies from moderately steep to steep mountains and canyons in the western portions, to rolling plains and tablelands of moderate relief (with occasional valleys, canyons and buttes) in the eastern regions. Elevations generally range from about 3,000 to 5,000 feet above mean sea level, with mountain peaks rising to over 10,000 feet west of the Project Area.

Climate and Meteorology

Because of the variation in elevation and topography throughout the Project Area, climatic conditions vary considerably. Most of the area is classified as a semi-arid cool steppe, where evaporation exceeds precipitation, with relatively short warm summers and longer cold winters. On the plains, average daily temperatures typically range from 5 to 10 (low) and 30 to 35 (high) degrees Fahrenheit (°F) in mid-winter, and between 55 to 60 (low) and 80 to 85 (high) degrees Fahrenheit in mid-summer. The frost-free period (at 32°F) generally occurs for 120 days between late May and mid-September. The annual average total precipitation is nearly 12 to 16 inches, with 36 to 60 inches of total annual snowfall. Temperatures generally are cooler, frost-free periods shorter, and both precipitation and snowfall greater at the higher elevations, including the mountains along the western margin of the Project Area.

Prevailing winds occur from the southwest, but local wind conditions reflect channeling (mountain and valley flows) due to complex terrain. Nighttime cooling enhances stable air, inhibiting air pollutant mixing and transport along the valley drainages. dispersion potential improves along ridge and mountain tops, especially during winter-spring weather transition periods and summer convective heating periods. Graphical presentations of wind speed and direction (wind roses) are presented in the Technical Support Document (Argonne 2002).

Existing Air Quality

WDEQ detects changes in air quality through monitoring and maintains an extensive network of air quality monitors throughout the state. Particulate is most commonly measured as particles finer than 10 microns or PM_{10}. The eastern side of the Powder River Basin has one of the most extensive networks of monitors for PM_{10} in the nation due to the density of coal mines. In addition to the network associated with the mines, there are also monitors in Sheridan and Gillette, Wyoming. To better monitor particulate related to coal bed methane, Wyoming is currently installing monitors in Arvada and Wright, Wyoming.

Wyoming DEQ uses monitoring located throughout the state to anticipate issues related to air quality. These monitoring stations are located to measure ambient air and not located to measure impacts from a specific source. Monitors located to measure impacts from a specific source may also be used for trends. This data is used to pro-actively arrest or reverse trends towards air quality problems. When WDEQ became aware that particulate readings were increasing due to increased coal bed methane activity and exacerbated by prolonged drought, the WDEQ approached the counties, coal mines and coal bed methane industry. A “coalition of the counties”, coal companies and coal bed methane operators have made significant efforts towards minimizing dust from roads. Measures taken have ranged from the implementation of speed limits to paving of heavily traveled roads.

Monitoring is also used to measure compliance. Where monitoring shows a violation of any standard, the WDEQ can take a range of enforcement actions to remedy the situation. Where a standard is exceeded specific to an operation, the enforcement action is specific to the facility. For many facilities, neither the cause nor the solution are simple. The agency normally uses a negotiated settlement in those instances.

There are also monitors for nitrogen oxides (NO_x) spread along the east side of the Basin. WDEQ has also sited two visibility monitoring stations in the Basin. One of these sites is 32 mi north of Gillette and includes a Nephelometer, a Transmissometer, an Aerosol Monitor (IMPROVE Protocol), instruments to measure meteorological parameters (temp., RH, wind speed, wind direction), a digital camera, instruments to measure Ozone and instruments to measure Oxides of Nitrogen (NO, NO_2, NO_x).

The other visibility monitoring station is located 14 miles west of Buffalo and includes a Nephelometer, a Transmissometer, an Aerosol Monitor (IMPROVE Protocol), instruments to measure meteorological parameters (temp., RH, wind speed, wind direction), and a digital camera.

Although specific air quality monitoring is not conducted throughout most of the Project Area, air quality conditions in rural areas are likely to be very good, as characterized by limited air pollution emission sources (few industrial facilities and residential emissions in the relatively small communities and isolated ranches) and good atmospheric dispersion conditions, resulting in relatively low air pollutant concentrations. Occasional high concentrations of carbon monoxide (CO) and particulate matter may occur in more urbanized areas (for example, Buffalo, Gillette, and Sheridan) and around industrial facilities, especially under stable atmospheric conditions common during winter.

Existing air pollutant emission sources within the region include the following:

- Exhaust emissions (primarily CO and oxides of nitrogen [NOx]) from existing natural gas fired compressor engines used in production of natural gas and coal bed methane; gasoline and diesel vehicle tailpipe emissions of combustion pollutants (Volatile Organic Compounds [VOC], CO, NOx, inhalable particulate matter less than 10 microns in effective diameter [PM10], fine particulate matter less than 2.5 microns in effective diameter [PM2.5], and sulfur dioxide [SO2]);

- Dust (particulate matter) generated by vehicle travel on unpaved roads, windblown dust from neighboring areas and road sanding during the winter months;

- Transport of air pollutants from emission sources located outside the region;

- Dust (particulate matter) from coal mines; and

- SO2 and NOx from power plants.

As part of the analysis, monitoring data measured throughout northeastern Wyoming and southeastern Montana were assembled and reviewed. Although monitoring is primarily conducted in urban or industrial areas, the data selected are considered the best available representation of background air pollutant concentrations throughout the Project Area. Specific values are presented in Table 3-12, along with applicable ambient air quality standards and Prevention of Significant Deterioration (PSD) increments, and were used to define background conditions in the air quality impact analysis. The assumed background pollutant concentrations are below applicable National Ambient Air Quality Standards (NAAQS) and Wyoming Ambient Air Quality Standards (WAAQS) for all criteria pollutants and averaging times.

Table 3-93 Assumed Background Air Pollutant Concentrations, Applicable Ambient Air Quality Standards, and PSD Increment Values (in µg/m3)

Pollutant	Averaging Time[1]	Background Concentration	Primary NAAQS[2]	Secondary NAAQS[2]	Wyoming Standards	PSD Class I Increments	PSD Class II Increments
Carbon monoxide	1-hour	3,500[3]	40,000	40,000	40,000	-----	-----
	8-hour	1,500	10,000	10,000	10,000	-----	-----
Nitrogen dioxide	Annual	16.5[4]	100	100	100	2.5	25
Ozone	1-hour	82[5]	235	235	235	-----	-----
	8-hour	130[5]	157	157	157	-----	-----
PM_{10}	24-hour	42[7]	150	150	150	8	30
	Annual	17[7]	50	50	50	4	17
$PM_{2.5}$	24-hour	19[7]	65	65	65	-----	-----
	Annual	7.6[7]	15	15	15	-----	-----
Sulfur dioxide	3-hour	8[6]	-----	1,300	1,300	25	512
	24-hour	8[6]	365	-----	260	5	91
	Annual	3[6]	80	-----	60	2	20

Notes:
1. Annual standards are not to be exceeded; short-term standards are not to be exceeded more than once per year.
2. Primary standards are designed to protect public health; secondary standards are designed to protect public welfare.
3. Per Riley Ridge EIS (BLM 1983)
4. Data collected in Gillette, WY (1996 - 1997)
5. Data collected in Pinedale, WY (1992 - 1994)
6. Data collected at Devil's Tower, WY (1983)
7. Data collected in Gillette, Wyoming (1999)

Source: (Argonne 2002)

Air Quality Related Values — Visibility and Acidification of Lakes

Air Quality Related Values (AQRVs), including the potential air pollutant effects on visibility and the acidification of lakes and streams, are applied to PSD Class I and sensitive Class II areas. The land management agency responsible for the Class I area sets a Level of Acceptable Change (LAC) for each AQRV. The AQRVs reflect the land management agency's policy and are not legally enforceable standards.

Visibility

Potential impacts to visibility were considered at 29 PSD Class I and sensitive Class II areas near the Project Area. Table 3-94 shows the nearest distances from the sensitive receptor areas to the proposed project area.

Visibility can be defined as the distance one can see and the ability to perceive color, contrast, and detail. Fine particulate matter ($PM_{2.5}$) is the main cause of visibility impairment. Visual range, one of several ways to express visibility, is the furthest distance a person can see a landscape feature. Maximum visual range in the western United States would be about 140 miles. Presently, the visibility conditions monitored in the Bridger Wilderness Area are among the best in the United States. Visual range monitoring in the Bridger Wilderness Area shows that one can see more than 70 miles 70 percent of the time.

Visibility impairment is expressed in terms of deciview (dv). The dv index was developed as a linear perceived visual change (Pitchford and Malm, 1994), and is the unit of measure used in the U. S. Environmental Protection Agency's (EPA) Regional Haze Rule to achieve the National Visibility Goal. A change in visibility of 1.0 dv represents a "just noticeable change" by an average person under most circumstances. Increasing dv values represent proportionately larger perceived visibility impairment. Figure 3-21 and Figure 3-22 below show annual averages for the 20 percent best, worst and middle visibility days at Badlands and Bridger Wilderness Areas from 1988 to 1998, respectively (IMPROVE, 2002)

Acidification of Lakes

The acidification of lakes and streams is caused by atmospheric deposition of pollutants (acid rain). Lake acidification is expressed as the change in acid neutralizing capacity (ANC) measured in microequivalents per liter (μeq/l), the lake=s capacity to resist acidification from acid rain. Table 3-14 shows the existing ANC monitored in mountain lakes within the Project Area.

Table 3-94 Approximate Distances and Directions from the Project Area to PSD Class I and Class II Sensitive Receptor Areas

Receptor Area	Distance (miles)	Direction to Receptor
Mandatory Federal PSD Class I		
Badlands Wilderness Area[1]	120	ESE
Bridger Wilderness Area	180	WSW
Fitzpatrick Wilderness Areas	175	WSW
Gates of the Mountains Wilderness Area	300	NW
Grand Teton National Park	220	W
North Absaroka Wilderness Area	155	W
Red Rock Lakes Wilderness Area	260	W
Scapegoat Wilderness Area	345	NW
Teton Wilderness Area	180	W
Theodore Roosevelt National Park (North Unit)	210	NNE
Theodore Roosevelt National Park (South Unit)	170	NNE
U. L Bend Wilderness Area	200	NNW
Washakie Wilderness Area	150	W
Wind Cave National Park	90	ESE
Yellowstone National Park	190	W
Tribal Federal PSD Class I		
Fort Peck Indian Reservation	210	N
Northern Cheyenne Indian Reservation	45	NNW
Federal PSD Class II		
Absaroka-Beartooth Wilderness Area	160	WNW
Agate Fossil Beds National Monument	130	SE
Bighorn Canyon National Recreation Area	100	WNW
Black Elk Wilderness Area	85	E
Cloud Peak Wilderness Area	40	W
Crow Indian Reservation	45	NW
Devils Tower National Monument	35	ENE
Fort Belknap Indian Reservation	230	NNW
Fort Laramie National Historic Site	125	SSE
Jewel Cave National Monument	65	ESE
Mount Rushmore National Memorial	90	E
Popo Agie Wilderness Area	170	WSW
Soldier Creek Wilderness Area	125	SE

1. The U.S Congress designated the Wilderness Area portion of Badlands National Park as a mandatory federal PSD Class I area. The remainder of Badlands National Park is a PSD Class I area.

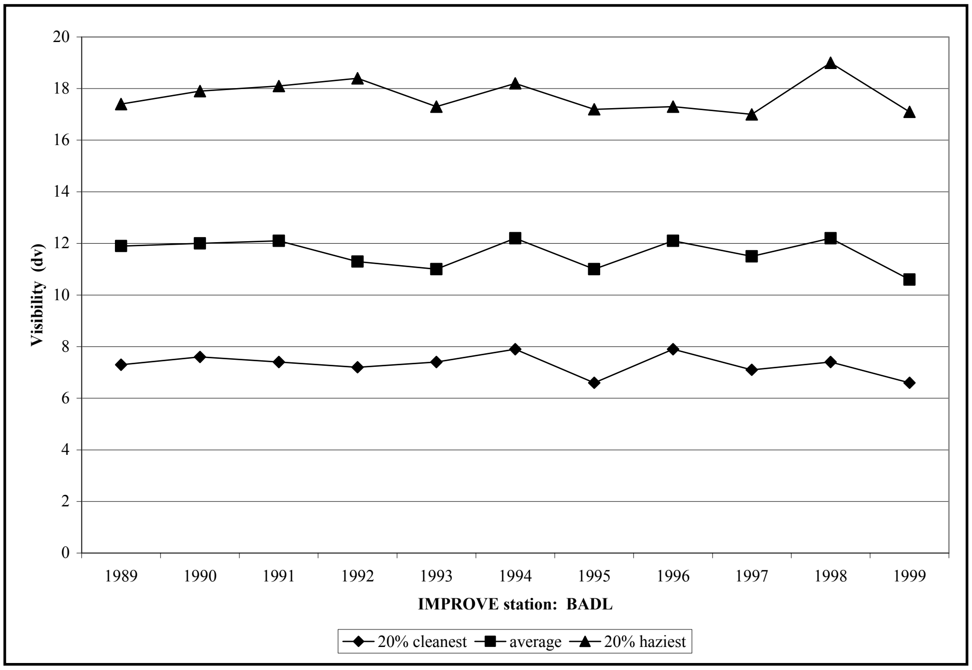

Figure 3-21 Visibility in the Badlands Wilderness Area

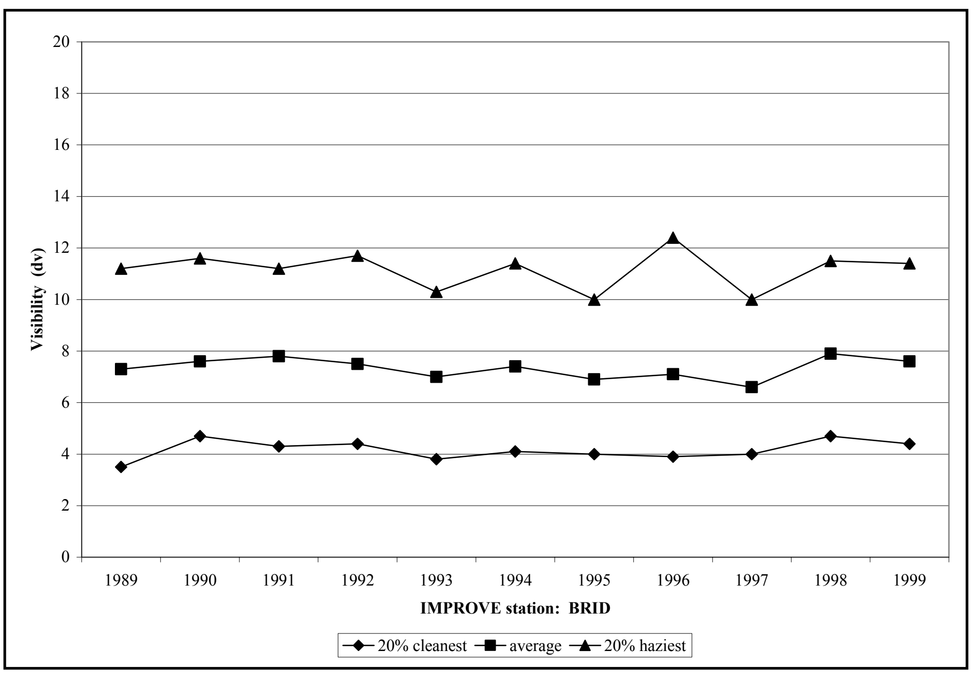

Figure 3-22 Visibility near Bridger Wilderness Area

Table 3-95 Existing Acid Neutralizing Capacity in Sensitive Lakes

Wilderness Area	Lake	Background ANC (μeq/L)
Bridger	Black Joe	69.0
	Deep	61.0
	Hobbs	68.0
	Upper Frozen	5.8[1]
Cloud Peak	Emerald	55.3
	Florence	32.7
Fitzpatrick	Ross	61.4
Popo Agie	Lower Saddlebag	55.5

Note:

1. Since the background ANC value is less than 25 μeq/L, the potential ANC change is expressed in μeq/L, and the applicable threshold is one μeq/L

Source: Argonne (2002)

Regulatory Framework

The NAAQS and WAAQS set the absolute upper limits for specific air pollutant concentrations at all locations where the public has access. Existing air quality throughout most of the Project Area is in attainment with all ambient air quality standards, as demonstrated by the relatively low concentration levels presented in Table 3-12. However, the Sheridan, Wyoming area has been designated as a federal non-attainment area (PM_{10} – moderate) where the applicable standards have been violated in the past. EPA Region 8 staff are concerned that PM_{10} monitoring data collected near and south of Gillette, Wyoming, have also exceeded both the NAAQS and the available PSD Class II increment. Specific monitoring data are presented in the Air Quality Appendix (Appendix F). The analysis of the proposed Alternatives must demonstrate continued compliance with all applicable local, state, tribal and federal air quality standards.

Given most the Project Area's current attainment status, future development projects which have the potential to emit more than 250 tons per year of any criteria pollutant (or certain listed sources that have the potential to emit more than 100 tons per year) would be required to undergo a regulatory PSD Increment Consumption analysis under the federal New Source Review permitting regulations. Development projects subject to the PSD regulations must also demonstrate the use of Best Available Control Technology (BACT) and show that the combined impacts of all PSD sources will not exceed the allowable incremental air quality impacts for NO_2, PM_{10}, or SO_2. A regulatory PSD Increment Consumption analysis may be conducted as part of a New Source Review, or independently. The determination of PSD increment consumption is a legal responsibility of the applicable air quality regulatory agencies, with EPA oversight. Finally, an analysis of cumulative impacts due to all existing sources and the permit applicant's sources, is also required during PSD analysis to demonstrate that applicable ambient air quality standards will be complied with during the operational lifetime of the permit applicant's operations. In addition, sources subject to PSD permitting requirements would provide specific analysis of potential impairment of AQRVs such as visibility and acid rain.

The federal Clean Air Act (CAA) also provides specific visibility protection of mandatory federal Class I areas. Mandatory Federal Class I areas were designated by the U.S. Congress on August 7, 1977, and include wilderness areas greater than 5,000 acres in size and national parks greater than 6,000 acres in size. The mandatory federal Class I areas located nearest to the Project Area are listed in Table 3-13. In addition, the Northern Cheyenne Tribe (located north of the Project Area in Montana) has designated their lands as PSD Class I. As shown in Table 3-12, the allowable incremental impacts for NO_2, PM_{10}, and SO_2 within these PSD Class I areas are very limited. Most of the Project Area is designated as PSD Class II with less stringent requirements.

This National Environmental Policy Act (NEPA) analysis compares potential air quality impacts from the Proposed Action and Alternatives to applicable ambient air quality standards, PSD increments, and AQRVs (such as visibility), but it does not represent a regulatory PSD analysis. Comparisons to the PSD Class I and II increments are intended to evaluate a threshold of concern for potentially significant adverse impacts, and do not represent a regulatory PSD Increment Consumption Analysis. Even though the development activities would occur within areas designated PSD Class II, the potential impacts are not allowed to cause incremental effects greater than the stringent Class I thresholds to occur inside any distant PSD Class I area. Finally, the CAA directs the EPA to promulgate the Tribal Authority Rule, establishing tribal jurisdiction over air emission sources within the exterior boundaries of tribal lands. Pursuant to this rule, the Crow and Northern Cheyenne tribes north of the Project Area in Montana may request that they be treated in the same manner as a state (including Section 105 grants and formal recognition as an affected "state" when emission sources are located within 50 miles of tribal lands) under the CAA.