Update of the Task 2 Report for the Powder River Basin Coal Review Past and Present and Reasonably Foreseeable Development Activities

Prepared for

Bureau of Land Management
High Plains District Office
and
Wyoming State Office

Submitted by

AECOM, Inc.
Fort Collins, Colorado

December 2009

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ACRONYMS AND ABBREVIATIONS

APD	Application for Permit to Drill
API	American Petroleum Institute
AQD	Air Quality Divisions
ARI	Advanced Resources, International
BACT	Best Available Control Technology
bbls	barrels
BCF	billion cubic feet
BLM	Bureau of Land Management
BNSF	Burlington Northern and Santa Fe Railroad
BOE	barrels of oil equivalent
CANDO	Converse Area New Development Organization
CBNG	coal bed natural gas
CCEDC	Campbell County Economic Development Corporation
CO_2	carbon dioxide
DM&E	Dakota, Minnesota, & Eastern
EA	environmental assessment
EIS	environmental impact statement
EOR	enhanced oil recovery
FERC	Federal Energy Regulatory Commission
FS	U.S. Department of Agriculture, Forest Service
GDP	gross domestic product
GIS	Geographical Information System
I	Interstate
lb/MMBtu	pounds per million British thermal unit
LBA	lease by application
LQD	Land Quality Division
Mcf	thousand cubic feet
MDEQ	Montana Department of Environmental Quality
MMbtus	million British thermal units
MMcfpd	million cubic feet per day
mmtpy	million tons per year
MSHA	Mine Safety and Health Administration
MW	megawatts
MWH	Montgomery Watson Harza
NEPA	National Environmental Policy Act
NO_x	oxides of nitrogen
P&A	plugged and abandoned
P&M	Pittsburg and Midway Coal Mining Company
PM_{10}	particulate matter with an aerodynamic diameter of 10 microns or less
PRB	Powder River Basin
PSO	Public Service Company of Oklahoma
RFD	reasonably foreseeable development
RMG	Reservoir Management Group
SR	State Route
SO_2	sulfur dioxide
STB	U.S. Surface Transportation Board

STIP	State Transportation Improvement Program
Tcf	trillion cubic feet
TRRC	Tongue River Rail Company
U.S.	United States
UP	Union Pacific
USDOE	U.S. Department of Energy
USEPA	U.S. Environmental Protection Agency
USGS	U. S. Geological Survey
USNRC	U.S. Nuclear Regulatory Commission
WDEQ	Wyoming Department of Environmental Quality
WIA	Wyoming Infrastructure Authority
WOGCC	Wyoming Oil and Gas Conservation Commission
WSFC	Wyoming School Facilities Commission
WYDOT	Wyoming Department of Transportation

CONTENTS

Contents

LIST OF TABLES

LIST OF FIGURES

1.0 INTRODUCTION

The Powder River Basin (PRB) of Wyoming and Montana is a major energy development area with diverse environmental values. The PRB is the largest coal-producing region in the United States (U.S.); PRB coal is used to generate electricity both within and outside the region. The PRB also has produced, and continues to produce large quantities of oil and natural gas resources. Within the last decade, this region has experienced nationally significant development of natural gas from coal seams.

The PRB Coal Review is a regional technical study to assess cumulative impacts associated with past, present, and reasonably foreseeable development (RFD) in the PRB. For purposes of this study, the Wyoming portion of the PRB study area (**Figure 1-1**) comprises all of Campbell County, all of Sheridan and Johnson counties less the Bighorn National Forest lands to the west of the PRB, and the northern portion of Converse County. It includes all of the area administered by the Bureau of Land Management (BLM) Buffalo Field Office, a portion of the area administered by the BLM High Plains District Office, and a portion of the Thunder Basin National Grasslands, which is administered by the U.S. Department of Agriculture, Forest Service (FS) (**Figure 1-2**). The Montana portion of the PRB study area (**Figure 1-1**) comprises the area of relevant coal mines and the air quality study area and includes the lands administered by the BLM Miles City Field Office (**Figure 1-2**). State and privately owned lands also are included in the PRB study area (**Figure 1-3**).

As shown in **Figure 1-3**, the majority of the surface ownership in the PRB study area is private. Conversely, the majority of the mineral ownership in the study area is federal (**Figure 1-4**). Federal mineral ownership may include all minerals in some locations and only specific minerals (e.g., coal or oil and gas) in other locations. As a result, split-estates (where the surface ownership is different than the mineral ownership) exist in a large portion of the PRB.

The Task 2 component of the PRB Coal Review defines the past and present development actions in the study area that have contributed to the current environmental and socioeconomic conditions in the PRB study area. This report also defines the projected RFD scenarios in the Wyoming and Montana PRB for years 2010, 2015, and 2020. For the Wyoming PRB, the past and present development and RFD scenarios include coal mine development as well as coal-related activities (e.g., railroads and coal-fired power plants) and non-coal-related activities (e.g., other minerals, coal bed natural gas [CBNG], and conventional oil and gas). Coal mine development and coal-related activities in the Montana PRB study area are included in this study. The past and present activities identified in the original Task 2 report (ENSR 2005b) were based on the available data at the end of 2003 and provided the basis for the resource-specific descriptions of current conditions presented in the PRB Coal Review Task 1 reports. The past and present activities described in this updated report were based on the available data for energy-related development in the study area through base year 2007 and reflect updated information on the status of existing projects, as well as identification of newly constructed and operational projects since 2003.

The RFD scenarios presented in the original Task 2 report (ENSR 2005b) were based on information available through the end of 2004 and provided the basis for the analysis of potential cumulative impacts in the Task 3 component of the study. The RFD scenarios presented in this updated report reflect updated information available on previously identified foreseeable development, as well as information on newly identified foreseeable development projected to be

operational or constructed by 2010, 2015, or 2020. The accuracy of any projected cumulative impact analysis is dependent on the adequacy and accuracy of information regarding potential future development activities in the affected area. While it is impossible to identify all potential future activities over the next 10 years, it is possible and desirable to identify RFDs based on current industry announcements, agency plans, economic trends, and technological advances affecting major industry sectors. Information regarding potential new development is constantly changing; however, to facilitate development of the information in this study, the RFDs identified in this report reflect information available from approximately mid-2008 through mid-2009.

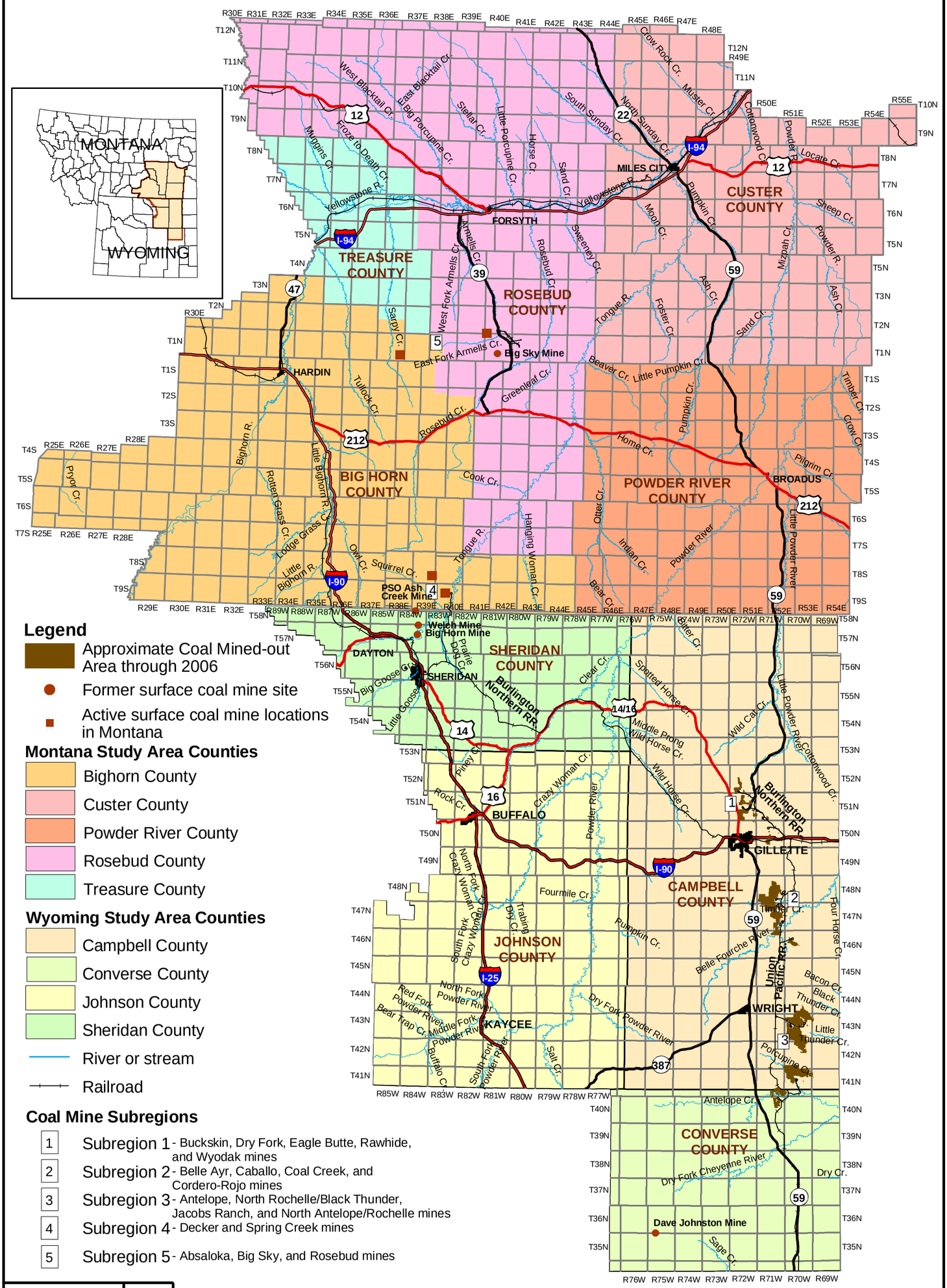
The past and present actions in this report were identified based on information in existing National Environmental Policy Act (NEPA) documents on file with federal and state agencies, the Coal Development Status Check (BLM 1996), operating permits and annual reports on file with state agencies, and industry contacts. The RFD scenarios in this report were developed based on recent information that identifies proposed and anticipated development in the PRB, including NEPA documents; various other technical reports and studies; federal, state, and local (county) agency management plans; and permit applications. The specific development scenarios and development activities identified in these sources were assessed as to their current status prior to inclusion in the RFD scenarios for the PRB Coal Review. In addition, potential additional projects were identified through interviews with agency and industry representatives, review of published news articles and trade publications, and discussions with community leaders.

The identified RFD activities subsequently were evaluated as to their probability for occurrence. Due to the lack of detailed information for many developments beyond the next few years, the degree of uncertainty associated with the predicted developments and trends increases as the timeframe extends further into the future.

For each of the past and present and RFD projects and activities, project-specific impact-causing parameters (e.g., disturbance acreage, groundwater pumping rates, employment levels, etc.) have been compiled from the sources identified above. Where specific information was unavailable, assumptions were developed and included based on typical industry-specific standards, permit criteria for similar existing industries, and professional judgment.

In order to account for the variables associated with future coal production, two detailed coal production scenarios (reflecting upper and lower production estimates) were projected for this study to bracket the most likely foreseeable regional coal production level and to provide a basis for quantification of related impact-causing parameters. These future production levels were derived from the analysis of historic production levels and current PRB coal market forecasts, public and private information sources, and input from individual PRB coal operators.

The methodology used to define the past and present and RFD activities is summarized in Chapter 2.0. Information specific to the past and present and RFD activities identified for this study is summarized in Chapter 3.0. The summary of the associated impact-causing parameters is provided in Appendices A through D of this report.



Legend

- Approximate Coal Mined-out Area through 2006
- Former surface coal mine site
- Active surface coal mine locations in Montana

Montana Study Area Counties

- Bighorn County
- Custer County
- Powder River County
- Rosebud County
- Treasure County

Wyoming Study Area Counties

- Campbell County
- Converse County
- Johnson County
- Sheridan County
- River or stream
- Railroad

Coal Mine Subregions

1. Subregion 1 - Buckskin, Dry Fork, Eagle Butte, Rawhide, and Wyodak mines
2. Subregion 2 - Belle Ayr, Caballo, Coal Creek, and Cordero-Rojo mines
3. Subregion 3 - Antelope, North Rochelle/Black Thunder, Jacobs Ranch, and North Antelope/Rochelle mines
4. Subregion 4 - Decker and Spring Creek mines
5. Subregion 5 - Absaloka, Big Sky, and Rosebud mines

N W E S

0 8 16 24 Miles

0 8 16 24 Kilometers

Note: Approximate coal mined-out areas were not available for the Montana mine sites.

Source: BLM 2009.

Powder River Basin Coal Review

Figure 1-1

Montana and Wyoming Study Area

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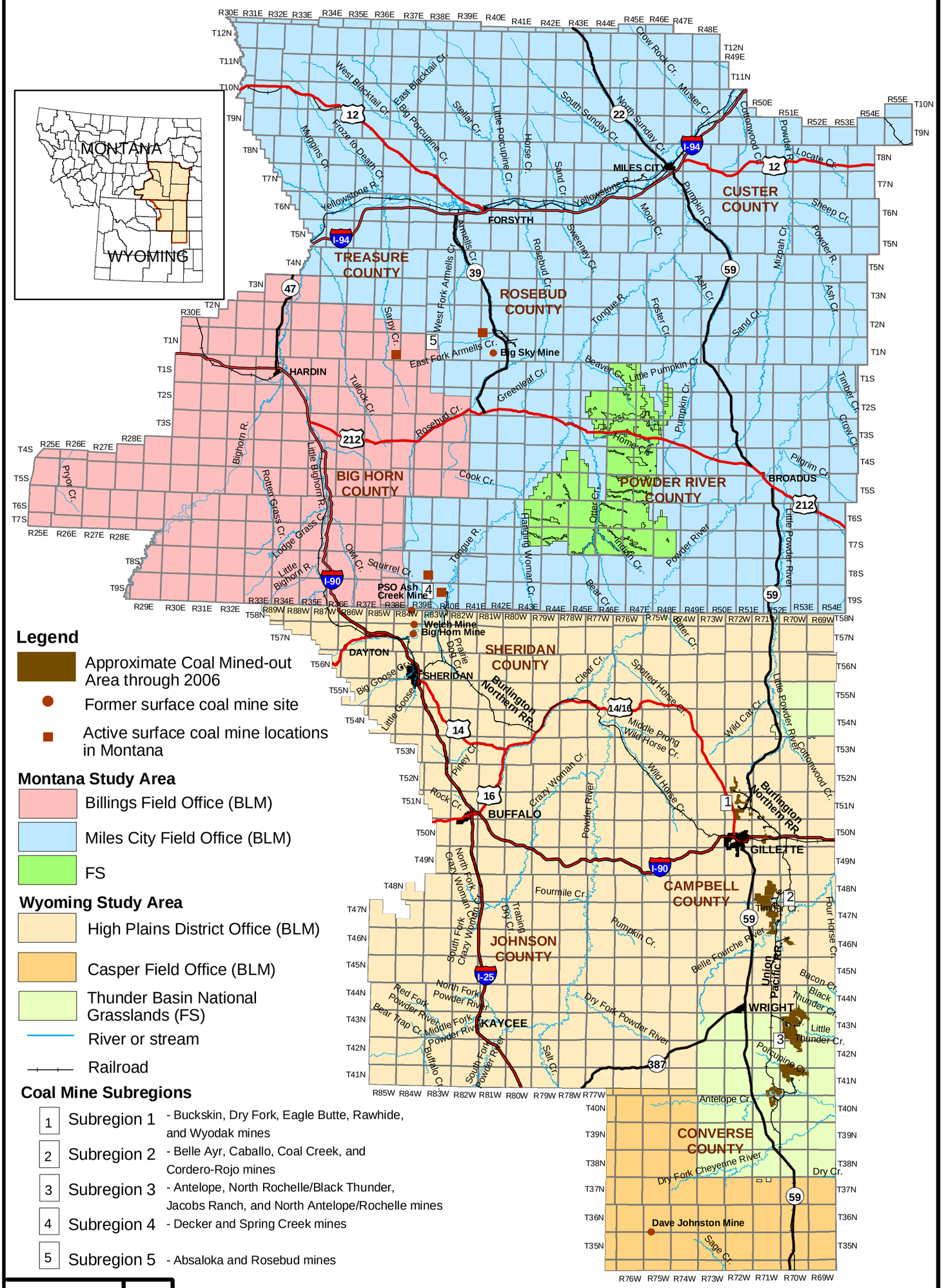


Note: Approximate coal mined-out areas were not available for the Montana mine sites.

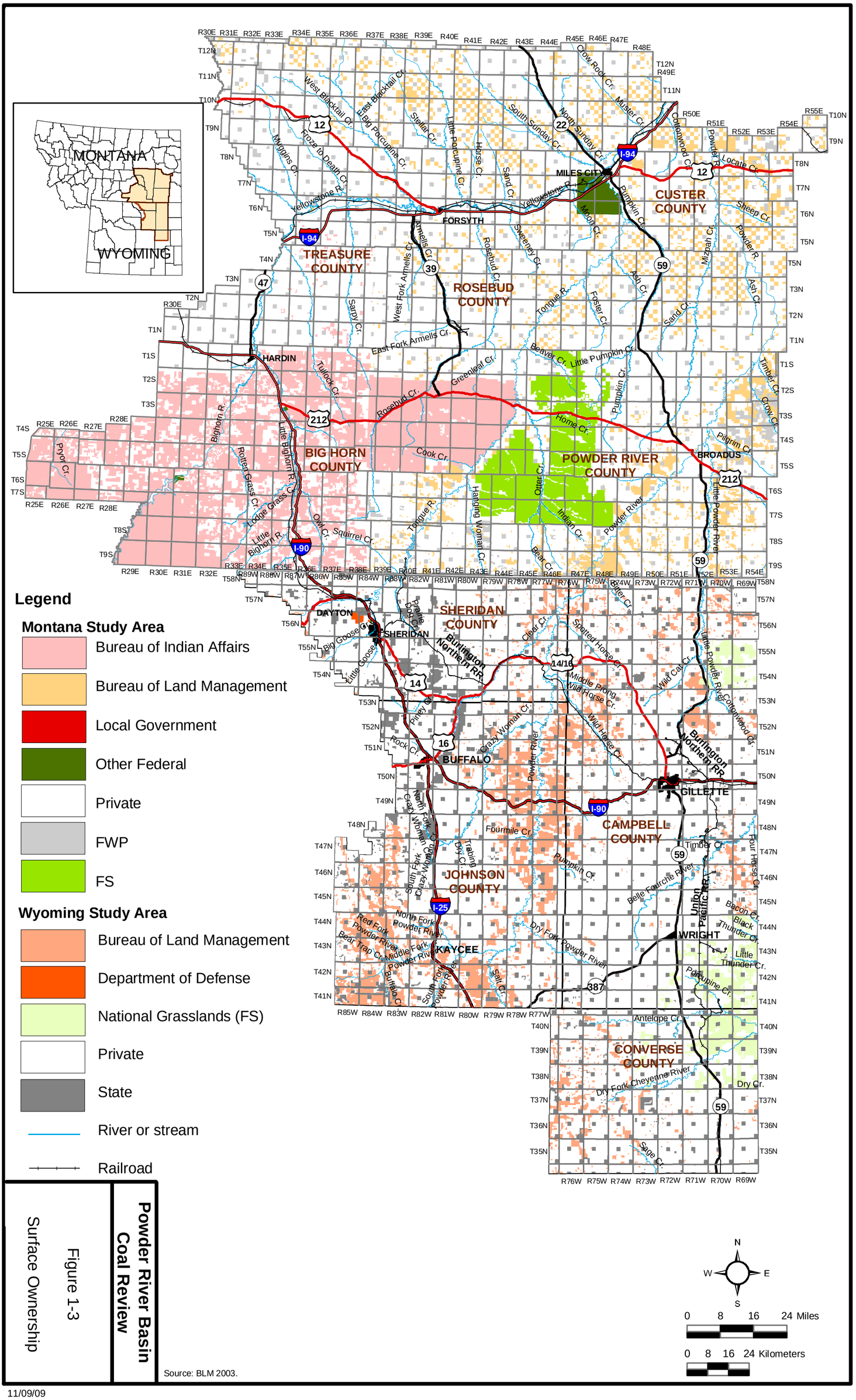
Source: BLM 2003, 2009..

Powder River Basin Coal Review

Figure 1-2

Federal Land Management

11/09/09



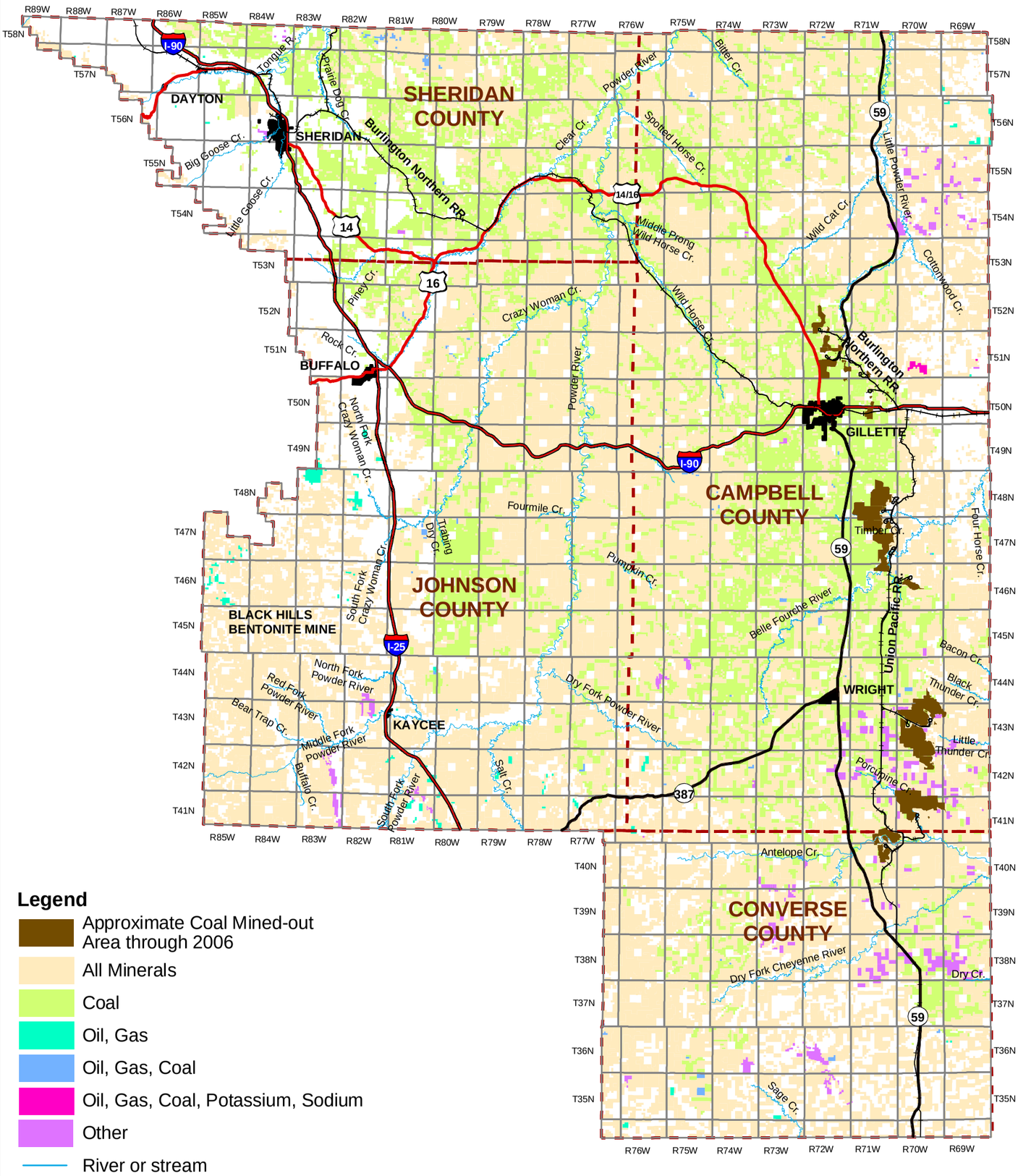
Source: BLM 2003.

Powder River Basin Coal Review

Figure 1-3

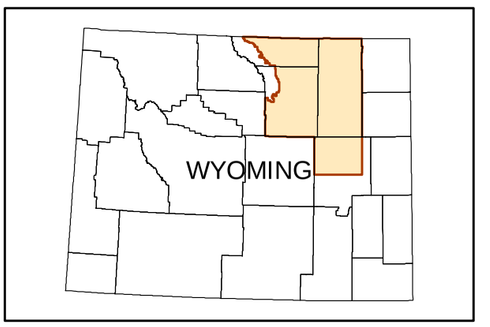
Surface Ownership

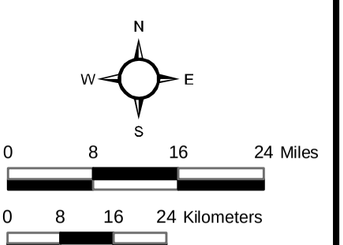
11/09/09



Legend

- Approximate Coal Mined-out Area through 2006
- All Minerals
- Coal
- Oil, Gas
- Oil, Gas, Coal
- Oil, Gas, Coal, Potassium, Sodium
- Other
- River or stream
- Railroad





Sources: BLM 2003, 2009.

Powder River Basin Coal Review

Figure 1-4
Federal Mineral Ownership

11/09/09

2.0 METHODOLOGY

To the extent possible, identification parameters (e.g., proponent/project name and/or location) and impact-causing parameters were identified for each of the past and present and RFD actions identified in this report. These parameters include factors that are common to all resources and resource-specific factors, as discussed below. This information was used to describe the past and present actions and RFD scenarios analyzed in this study and is summarized in the tables in Appendices A through D. These summaries have been formatted to facilitate the update of Task 1 (current conditions) and Task 3 (impact analyses) information for use in BLM's lease by application (LBA) environmental impact statement (EIS) cumulative analyses.

The existing disturbance acreages for this update were based on the updated database compiled for this Task 2 report (**Tables A-1** through **A-4**, **C-1** through **C-6**, and **D-1** through **D-6** in Appendices A, C, and D, respectively) and, where resource-specific data were required, the associated Geographical Information System (GIS) data (**Tables B-1** and **B-2** in Appendix B). The existing disturbance acreages generated through GIS vary from the disturbance acreages in the Task 2 database due to the following variables. The information in the database was compiled based on information obtained from the data sources and the applied assumptions identified in this Task 2 report. As a result, the database specifies a discrete disturbance acreage for each of the development activities (e.g., coal mines, individual oil and gas wells, etc.) identified for the study. Conversely, the GIS analysis accounted for the spatial relationship of the various development activities, thereby avoiding double counting of disturbance acreages where mapped disturbance areas overlap. In addition, the application of the new-versus-existing well disturbance acreage assumptions varied, as follows. For the database, the number of new wells developed during 2007 versus the number of existing wells at the end of 2007 was quantified, and the appropriate acreage assumptions were applied. The observed ratio in the database between new and existing wells could be determined at the subwatershed level; however, the breakdown could not be applied to the resource-specific information within each subwatershed due to the lack of actual discrete locations for new versus existing wells in the GIS map layers. As a result, for GIS calculation purposes, the existing well acreage was applied to all (existing and new) wells in the GIS layer. Also, slight variations between the GIS study area boundary and GIS resource-specific layers resulted in some under-counting of disturbance acreages. Where disturbance acreages are presented in this study, the appropriate source is noted.

Future disturbance and reclamation acreages for the RFD scenarios in this study were based on the updated database compiled for this report with the following variables and uncertainties associated with using GIS analysis for defining this information. The methodology and assumptions in Appendix E relative to oil and gas development provide a means of identifying the number of new wells to be developed and the number of existing wells to be plugged and abandoned within each of the subwatersheds for each of the target years of this study (i.e., 2010, 2015, and 2020). However, discrete locations for new and plugged and abandoned well sites for these future time periods are not available. For coal mines, the methodology and assumptions presented in Section 3.1 provide for calculation of future disturbance and reclamation acreages. However, although the general area of potential future coal mine-related disturbance can be identified based on projected reserves, the actual disturbance footprint associated with future mining and the actual locations of future reclaimed areas for the target years are not known. As a result, based on existing information, the spatial relationship between projected future disturbance and reclamation areas and the

resource-specific information in the GIS layers for these industries cannot be determined. Conversely, the database information does provide for quantification of future disturbance and reclamation acreages on a subwatershed basis and, with other information (e.g., projected locations of future coal reserves), a means of qualitatively analyzing future resource-specific impacts for those resources that are site-specific (e.g., vegetation, soils, wildlife habitat). The disturbance acreages for the RFD scenarios (based on the updated Task 2 database) are presented in the tables in Appendices A, C, and D.

2.1 Factors Common to All Resources

Proponent/Project Name. The proponent or operator and associated project name have been identified for tracking purposes in the database for all past, present, and RFD actions with the exception of oil and natural gas (conventional and CBNG) projects and facilities; the latter typically are geographically dispersed and, therefore, are more appropriately tracked on a general location basis.

Location. Based on the inclusion of project-specific locations in the database, and the structuring of the database using 4th level sub-basins (referred to as subwatersheds in this study for consistency with the PRB Oil and Gas EIS [BLM 2003a]) as a common denominator, the impact-causing parameters within specified areas have been summarized to facilitate cumulative impact evaluations. Mapped locations of the past and present and RFD projects analyzed in this study are presented in Chapter 3.0 in association with the industry-specific discussions.

Timeframe. The database has been structured to link specific, identified levels of development with the target dates for this study. Past and present actions have been summarized based on 2007 (or earlier) data, depending on data availability; parameters for RFD scenarios have been established for 2010, 2015, and 2020 based on information available between approximately mid-2008 and mid-2009.

Land Ownership. Surface ownership in the Wyoming PRB study area is primarily private, with federal and state lands comprising approximately 14 and 8 percent of the area, respectively (see **Figure 1-3**). In the Montana PRB study area, the majority of the land is privately owned, with federal and state lands comprising approximately 25 and 5 percent, respectively. This information has been included in the database to distinguish BLM-authorizing actions from other jurisdictional oversight.

Acreage. Mining activity has been projected forward in 5-year increments based on available reserves and high and low projected production levels to facilitate the estimation of future coal mine disturbance and reclamation. The projected mining activity was combined with industry input from the PRB coal producers, and public historical and permitted reclamation activity data, to forecast future disturbance and reclamation acreages.

Future disturbance and reclamation acreages related to coal technology projects and coal railroad transportation infrastructure were estimated from numerous information sources including: the Dakota, Minnesota, & Eastern Railroad (DM&E) Final EIS; Tongue River Railroad U.S. Surface Transportation Board (STB) application; Montgomery Watson Harza (MWH) Coal Planning Report; Burlington Northern and Santa Fe Railroad (BNSF) Guide to Coal Mines report; Wyoming Department of Environmental Quality (WDEQ), Land Quality Division (LQD) annual reports for

individual mines; Montana Department of Environmental Quality (MDEQ) mine permit documents; and related trade magazine articles. Information compiled from these sources was compared against historic production levels. Future disturbance and reclamation acreages were projected to correspond to historic trends for the high and low production forecasts.

Acreages for other past and present and RFD actions were obtained from permit applications, EISs or environmental assessments (EAs), or estimated, where appropriate, based on typical facility sizes (e.g., well pads).

Schedule. The estimated schedule for the construction, operation, and closure/reclamation of proposed coal mines, non-coal mines, coal technology projects, and coal railroad transportation infrastructure, was derived from public information on record with the WDEQ and MDEQ, industry input (including information contained on corporate and agency websites) detailed mine-specific reserve sequencing projections, and press releases and other published articles. Given the projected high and low production rates, there are adequate economic reserves to sustain all proposed coal mining activity through the year 2020.

Schedules for other past and present and RFD actions have been based on industry input, permitting documents, and assumptions related to trends for related industries (e.g., coal production forecasts in relation to rail capacity).

Production Estimate. Analysis of historic PRB coal production levels, and current reports forecasting future PRB coal market activity from sources including Hill and Associates, Inc., Platts Research and Consulting, Global Insight, and the U.S. Department of Energy (USDOE), were combined with input from the PRB coal mine operators, and regulatory agency input from specialists within the Wyoming and Montana BLM, WDEQ, and MDEQ to project the upper and lower total coal production levels for the PRB. Individual mine production then was allocated based on historic market share performance, current air quality permit limitations, proposed expansion applications on file with the U.S. Environmental Protection Agency (USEPA), WDEQ and MDEQ Air Quality Divisions (AQDs), coal rail loadout capacities, and coal mine operator input.

Capital Investment. Capital investment information relative to RFD actions is presented in the text portion of this report, as available. Capital investment related to coal mine development was estimated based on requirements for site-specific mine infrastructure (e.g., rail loop and loadout facilities, major mobile equipment purchases, and highway relocations within permitted mine boundaries). Estimated costs are based on historic costs for similar facilities and equipment.

Likelihood. Following identification of the RFDs through year 2020 for the study area, each capital project was assigned a rating for the likelihood of development or occurrence. Both private and public sector activities have been considered. Likelihood ratings were assigned to the identified actions based on the numerical rating system presented below. The numerical rating for each action is identified in the Chapter 3 discussion, with the exception of oil and gas activities. Oil and gas activities differ from individual capital projects due to the dispersed nature of the facilities; therefore, the projection of these activities reflects their likelihood and timeframe.

- Certain/highly likely (1) – Inclusive of actions that have been fully funded, permitted, are under construction, or are necessitated to achieve expanded coal output. These actions have an

identified proponent/sponsor, project location, and specific details regarding capacity, output, and/or costs.

- Moderately likely (2) – Inclusive of actions for which applications have been submitted to an agency, that are part of a defined capital improvement plan/program, involve an established technology or process, have an identified proponent/sponsor with a demonstrated track record in undertaking/completing similar or related projects, or for which an EIS or EA is in preparation.

- Low likelihood (3) – Inclusive of actions that are undergoing market or feasibility analyses, previously were proposed but failed to proceed and are now under reconsideration, or for which some descriptive information is available but for which no formal regulatory or administrative approval processes have been initiated.

- Speculative (4) - Projects for which insufficient information is available for analysis purposes, or to determine the likelihood of the project moving forward, have been assigned a likelihood of speculative. These actions are identified in text with an explanation for their elimination from consideration.

Included in this update of the Task 2 report is information on potential future development for which specific projects have not been identified but for which the potential for development or expansion of a specific industry (e.g., carbon sequestration) has been identified. This potential for development or expansion was based on increased activity in an industry sector or new technologies, and the resources in the PRB conducive to their future development.

2.2 Resource-specific Factors

Air Emissions Estimates. Information relative to current conditions has been based on air emissions inventories obtained from WDEQ, MDEQ, the PRB Oil and Gas EIS (BLM 2003a), and the Montana Statewide Oil and Gas Supplemental EIS (ALL Consultants 2006). Air emissions for RFDs have been based on average operations in 2002 and 2004, as well as air emissions estimates published in air permits or EISs. For each group of sources, an average emissions profile was developed for modeling purposes, based on production and design data. Air emissions data is presented in the technical support documents prepared for the Task 1A and 3A reports.

Water Production/Disposal. Coal mine-related groundwater production data were obtained from individual mine operators and data as reported to the Wyoming State Engineer's Office for permitted wells through 2002. This data and the assumptions presented in Section 3.1.4 of this report were used to determine the future coal mine-related groundwater pumping rates.

Current water production and disposal volumes associated with conventional oil and gas and CBNG development have been based on data in the IHS Energy Services™ (IHS) (2008) and Wyoming Oil and Gas Conservation Commission databases. Future CBNG water production and discharge was estimated by the BLM (2007a), based on actual permitted pumping rates and the scaling down of pumping rates over the 7-year life cycle of a pod of wells.

Water Consumption. Dust suppression practices at active coal mines are the single largest factor in water consumption, accounting for an estimated 85 percent of the total water used. Mine operators

are required to submit an annual fugitive emissions control report to the WDEQ/AQD that summarizes the annual gallons of water consumed, dust suppression additives, and application techniques used to control dust emissions. For coal mines in the Wyoming PRB, the past several years of reports (which reflect water consumption levels in recent drought years) were reviewed and analyzed, and future water consumption was projected forward based on current practices and forecasted production levels. As a result, the projections for water consumption reflect potential higher use rates in the event dry conditions persist. Water consumption projections for Montana mines were based on the information for Wyoming mines and adjusted for annual production and mining method.

Current and future non-coal mine, coal technology projects, and coal railroad transportation-related water consumption is expected to be minimal and was estimated from existing data on file with the WDEQ and MDEQ, as applicable. Power plant-related water consumption was estimated based on recent analyses at other facilities.

Workforce. Current and future PRB coal mine-related Wyoming employment was estimated by reviewing the past annual reports of the Wyoming State Mine Inspector, correlating productivity gains to changes in mine production, and forecasting total employment forward as a function of mine productivity and production. Montana employment information was based on historic levels of personnel from U.S. Mine Safety and Health Administration (MSHA) records.

Current and future non-coal mine and coal railroad transportation-related employment is expected to increase only moderately above current levels and was estimated from existing data on file with the WDEQ and MDEQ, as applicable.

Due to the lack of existing commercial-scale coal beneficiation facilities, current and future coal technology employment is based on information from company press releases, securities filings, and information relative to proposed projects. These estimates are of necessity “order of magnitude” and subject to revision as any future projects move forward into the environmental permitting process.

Current and future Wyoming workforce requirements for the oil and gas industry are a function of the pace of drilling, number of producing wells, anticipated production life of the wells, and future reclamation activities. Employment assumptions for modeling of social and economic impacts are discussed in the Task 3C report.

Current and future Wyoming workforce requirements for power plants in the PRB are based on information obtained from the operators, project application filings, local economic development organizations, the Wyoming Department of Employment, and the WDEQ/Industrial Siting Division.

3.0 PAST, PRESENT, AND REASONABLY FORESEEABLE DEVELOPMENT

This section presents a brief description of the industries evaluated in this study. Past and present and RFD coal and coal-related industries (e.g., railroads and power plants) are described below for both the Wyoming and Montana PRB study areas. Non-coal-related industries (e.g., oil and gas, etc.) only are described for the Wyoming PRB study area.

A summary of the data sources that were used to define the past and present conditions and RFD scenarios is presented for each industry following the past and present and RFD descriptions. Where information relative to project-specific, impact-causing parameters was unavailable, industry-specific assumptions have been developed to assist in defining existing conditions and to facilitate preparation of the cumulative impact analyses. These industry-specific assumptions are summarized at the end of each of the following sections.

The impact-causing parameters have been tabulated in the supporting updated database for the Task 2 report. A summary of the impact-causing parameters associated with each Wyoming coal mine subregion under both the lower and upper production scenarios is presented in **Tables A-1** and **A 2**, respectively, in Appendix A. Impact-causing parameters associated with the Montana coal mine subregions under the lower and upper production scenarios are summarized in **Tables A-3** and **A-4**. **Tables C-1** through **C-6** in Appendix C summarize by subwatershed the impact-causing parameters associated with all past and present and RFD actions (including coal mining activity) in the previously established Wyoming PRB Task 1D study area (**Figure C-1**). **Tables D-1** through **D-6** in Appendix D summarize by subwatershed the impact-causing parameters associated with all past and present and RFD actions (including coal mining activity) in the previously established Wyoming PRB Task 3D study area (**Figure D-1**). As discussed in Chapter 2.0, GIS data for base year 2003 were used to facilitate the resource-specific disturbance acreage estimates for the Task 1D Report for the PRB Coal Review, Current Environmental Conditions (ENSR 2005a). **Table B-1** in Appendix B summarizes the GIS-derived coal mine-related disturbance for the Wyoming PRB study area for the original base year (2003); **Table B-2** summarizes by subwatershed the GIS-derived disturbance acreages associated with all past and present actions for the original base year (2003).

3.1 Coal

3.1.1 Past and Present Development

3.1.1.1 Wyoming

The first coal mine in the Wyoming PRB was developed near Glenrock, in Converse County, in 1883 (Foulke et al. 2002). During the 1970s and early 1980s, the PRB emerged as a major coal production region. As a result, federal coal leasing became a high profile activity since the PRB's coal is over 90 percent federally owned. In 1982, the BLM temporarily halted further coal leasing; however, the existing mines continued producing coal, which depleted their leased federal coal reserves. As a result, interest in leasing federal coal to extend mining operations at existing mines

in the PRB increased in the late 1980s. However, there was little to no interest in opening new mines, and therefore, there was not enough interest in leasing to justify a regional coal sale. In early 1990, the Powder River Regional Coal Team decertified the Powder River Federal Coal Region, which allowed BLM to begin processing applications by existing mines to lease maintenance tracts of federal coal using the LBA process.

The 13 currently operating coal mines in the Wyoming PRB are grouped by subregion as shown in **Figure 3-1** and as described below. For purposes of this study, the mines in the Sheridan, Wyoming, area have been included in Subregion 4 (Sheridan/Decker), which is discussed in Section 3.1.1.2 of this report.

- Subregion 1 (North Gillette) – Buckskin, Dry Fork (which includes the old Fort Union), Eagle Butte, Rawhide, and Wyodak mines.

- Subregion 2 (South Gillette) – Belle Ayr, Caballo, Coal Creek, and Cordero-Rojo mines.

- Subregion 3 (Wright) – Antelope, North Rochelle/Black Thunder, Jacobs Ranch, and North Antelope/Rochelle mines.

Of these operations, the Coal Creek Mine was inactive in 2005 when the original Task 2 report was prepared; however, it has since resumed operations.

Other coal mines within the Wyoming PRB study area and their status are described below. Based on their status, these facilities are not analyzed further in this study.

- Clovis Point Mine – part of operating Wyodak and Dry Fork mines

- Izita – permitted dragline walkway from the Coal Creek Mine to the Black Thunder Mine

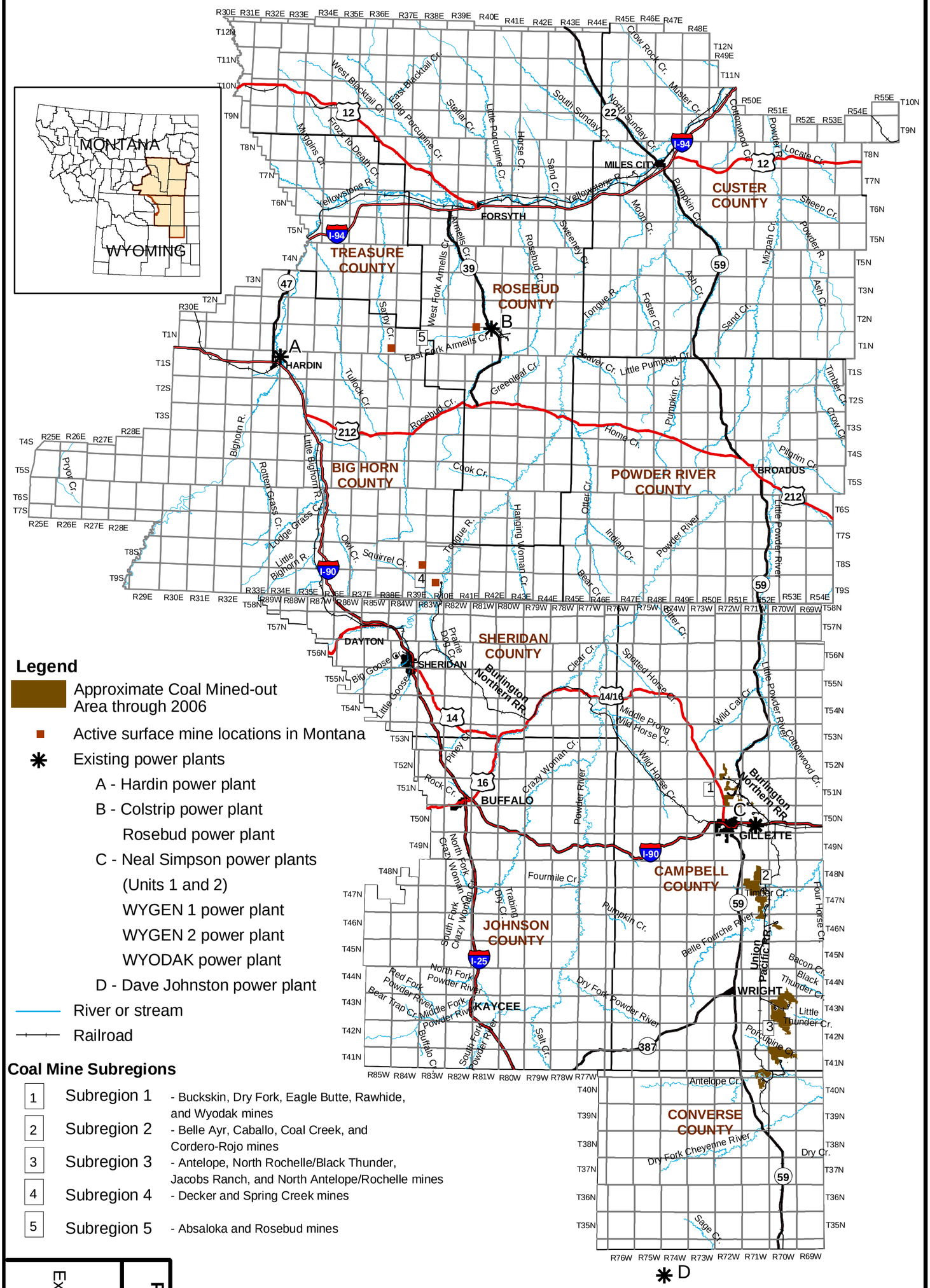
- KFx – haul road to supply coal from the Wyodak Mine to the adjacent KFx facilities located at the old Fort Union Mine (now part of Dry Fork) area

3.1.1.2 Montana

For purposes of this study, Subregion 4 encompasses the coal mining activities in the Sheridan, Wyoming, and Decker, Montana, areas. Subregion 5 encompasses mining activity in the Ashland/Colstrip, Montana, area. The currently active mines in these subregions are shown in **Figure 3-1** and are identified below.

- Subregion 4 (Sheridan/Decker) – Decker (east and west pits) and Spring Creek mines.

- Subregion 5 (Ashland/Colstrip) – Absaloka and Rosebud mines.



Note: The Dave Johnston power plant, which is included in this study, is located outside of but adjacent to the study area. Approximate coal mined-out areas were not available for the Montana mine sites.

Source: BLM 2003, 2009.

Powder River Basin Coal Review

Figure 3-1

Existing Coal Mine, Power Plant, and Railroad Development

11/11/09

Other coal mines in Subregions 4 and 5 and their status are described below. These mines are shown in **Figure 3-1**. Based on their status, these facilities are not analyzed further in this study.

- Big Horn Mine – in final reclamation and awaits final bond release
- Welch Mine – in final reclamation, for final bond release part of an exchange with the Pittsburg & Midway Coal Mining Company (P&M)
- Public Service Company of Oklahoma's (PSO) Ash Creek Mine – has been reclaimed and awaits final bond release
- Big Sky Mine – idle and in final reclamation stages
- Other historic underground mines - Many square miles of historic underground workings exist to the south-southwest of the historic Welch Mine lands. These mines were closed and sealed off in 1953. Subsequent roof collapses over one of these mines (the Acme Mine No. 42) led to the development of underground coal fires in the Monarch and possibly Carney coal beds, which may have spread to other overlying coal beds (i.e., Dietz 2 and Dietz 3). These fires may have been the cause of the 5,207-acre Thunder Child Range Fire in 2001, although the actual cause has not been determined. The WDEQ/Abandoned Mine Land Division has conducted a number of reclamation and emergency rehabilitation projects in recent years in attempts to extinguish the underground coal bed fires; however, based on BLM's 2003 site visit, the fires continue to burn (BLM 2003b). Due to the lack of information relative to the extent of the underground burn area and the uncertainty of the cause of the Thunder Child Range Fire, these historic workings have been eliminated from further analysis in this study.

3.1.2 Reasonably Foreseeable Development

Due to the variables associated with future coal production, two coal production levels (an upper and a lower production level) were projected for the PRB Coal Review to bracket the most likely foreseeable regional coal production level and to provide a basis for quantification of associated impact-causing parameters. **Figures A-1** through **A-6** in Appendix A show projected coal development under the lower and upper development scenarios. Figures A-6 and A-7 graphically compare the production levels for Wyoming and Montana, respectively. The basis for the projected production ranges included: 1) an analysis of historic PRB production levels in comparison to the gross domestic product (GDP) and national coal demand; 2) an analysis of current PRB coal market forecasts that model the impact of GDP growth, potential regulatory changes affecting coal fired power plants, and mining and transportation costs on PRB coal demand; 3) the availability, projected production cost, and quality of future mine-specific coal reserves within the PRB region; and 4) the availability of adequate infrastructure for coal transportation. The projected upper and lower production levels subsequently were allocated to coal mine subregions in the PRB and to individual mines based on past market shares. Individual mine production levels were reviewed relative to potential future production constraints (e.g., loadout capacities), permitted production levels, mining costs, and coal quality.

The methodology used to develop the future coal mine projections for both the lower and upper production scenarios is summarized below.

- The upper end of the range of total PRB coal mine production was increased from the MWH Coal Planning Estimates Report of March 2003 to bracket higher production forecasted by the Hill and Associates PRB Coal Demand Study of 2003. The Hill and Associates 2003 data were not available at the time of the MWH study.

- The upper end of the production range by coal mine closely resembles the Hill and Associates 2003 study, with the exception that mine production was not curtailed in the latter years of the study. This adjustment was made to account for a published "glitch" in the Hill and Associates modeling technique ("caused by the fact that we used reserves listed in the state mining permit applications… In many cases, the coal producer simply lists enough reserves to satisfy his 20 year mine plan in the permit application [instead of true geologic reserves] [Hill and Associates 2003a].")

- The lower end of the range of total PRB coal mine production was decreased slightly from the MWH Coal Planning Estimates Report of March 2003 to bracket Platts data and better account for a potential downward market adjustment forecasted in the Hill and Associates 2003 study resulting from possible clean air regulatory changes previously projected for 2009.

- Wright area coal mines were projected based on a number of limiting factors including WDEQ air quality permit levels. Since the time of this projection, there has been an increase in the air quality permit levels for these mines. As discussed below, the projected overall coal forecasts for the PRB have not been changed; however, it is recognized that the Wright area mines would now be able to compete for a larger portion of the overall forecast coal sales from the PRB.

- Specific mine loadout capacities were estimated from BNSF railroad reports and mine permit data. Some mines are forecasted to produce above these estimated capacities.

- The South Gillette and Wright subregion mines (Subregions 2 and 3, respectively) are served by Wyoming State Route (SR) 59, and the North Gillette subregion is serviced by U.S. Highway 14/16. Numerous spur roads, tied to these main highways, serve as access roads into the mines in the Wyoming PRB region. The acreages associated with the access roads have been accounted for in the mine-specific acreages for this study.

- The existing road infrastructure provides access to all existing mines and proposed development projects in Subregion 4. It is assumed that only minor upgrades to portions of these routes would be required to address possible increases in traffic and capacity of the routes.

3.1.2.1 Wyoming

Based on the analysis originally conducted for this study and included in the original Task 2 report (ENSR 2005b), the forecasted upper production range for the coal mines in the Wyoming PRB study area was projected to mirror the Hill & Associates (2003b) forecast, with a strong period of

growth through 2007, at which point production was projected to be 490 million tons per year (mmtpy). Coal production was projected to flatten in response to new environmental regulations scheduled to take effect in 2008 that would further limit electric power plant emissions. The growth in coal production was projected to resume in 2010 and continue through 2020, at which point production was projected to be 625 mmtpy. The forecasted lower production level was projected to mirror the more conservative forecasts by Platts (2004) and Global Insight (2004) and the lower production level identified by MWH (2003). Under the projected lower production level, a production of 490 mmtpy would not be realized until 2015, and production in 2020 would be 531 mmtpy. The resulting 2 percent annualized growth rate for the lower production level and 3 percent annualized growth rate for the upper production level through 2020 compared conservatively to the historic 6.8 percent annualized growth rate for the prior 20 years in the Wyoming PRB.

Based on more recent data collected for this update of the Task 2 report, the actual production in 2008 was 446.5 mmtpy. This is between the upper and lower production scenarios identified in the original 2005 Task 2 report, although it is closer to the upper production scenario. Currently, there is considerable uncertainty in coal demand forecasting due to the uncertainty of the regulation of coal use for electric generation in response to proposals to regulate greenhouse gas emissions. Coal production has been reduced in the immediate (2009) timeframe. Based on the fact that actual production has been tracking between the upper and lower production forecasts from the 2005 Task 2 report, and there is no clear indication of a substantial change in that trend, the upper and lower production forecasts to year 2020 were not modified for this updated report. However, as noted above, some of the Wright area mines have been permitted for increased production capacity under their air quality permits so they could compete for an increased share of the total forecast PRB coal sales.

Since the 2005 Task 2 report was completed, the School Creek Mine has been permitted in the Wright area (Subregion 3); however, it is not currently operating. The mine is composed of lands leased by Peabody in 2005 (West Roundup LBA), an existing lease acquired from Arch Minerals, and existing leases assigned from the North Antelope/Rochelle Mine. The loadout facilities already exist and were acquired from Arch Minerals (the original North Rochelle facilities). WDEQ approved the School Creek Mine permit application on July 17, 2009. WDEQ also has issued an air quality permit for the mine, for a production rate of 40 mmtpy. The U.S. Office of Surface Mining has not completed a license to mine for this operation. School Creek Mine representatives have indicated that coal production is not scheduled to occur until 2010. It is expected that this mine would compete with the other Subregion 3 coal mines for a portion of that subregion's forecast production. Also, in the fall of 2009, a sale of the Jacobs Ranch Mine to the owners of the Black Thunder Mine was approved. At this time, the operation of both mines remains the same. Therefore, the projected production rates under the upper and lower production scenarios were not revised for this update.

Following the projection of individual mine production levels for the upper and lower production scenarios, likely reserve and mining sequence layouts were developed based on geologic information, 2003 mine pit progressions and projected mine reserve sequence maps on file with the WDEQ/LQD, and recovery information provided by the PRB operators. The mapped areal extent of mine reserves subsequently were projected in 5-year increments and provided to the PRB coal operators for review and comment. Future coal mining in the Wyoming PRB through 2020 is considered certain/highly likely based on the anticipated production rates in relation to the available economic reserves.

Mine-related capital investment under both the projected lower and upper production scenarios is presented in **Table 3-1**.

Table 3-1
Projected Coal Mine Total Capital Investment by Year
(million dollars)

Mine Subregion	Year					
	Lower Production Scenario			Upper Production Scenario		
	2010	2015	2020	2010	2015	2020
Mobile Equipment						
Subregion 1 – North Gillette	18	56	6	56	89	9
Subregion 2 – South Gillette	35	89	31	68	91	50
Subregion 3 – Wright	110	140	150	150	153	129
Subregion 4 – Sheridan/Decker	32	0	0	34	7	0
Subregion 5 – Ashland/Colstrip	0	0	0	15	39	2
Subtotal	**195**	**285**	**187**	**323**	**379**	**190**
Rail Loadout Facilities[2]						
Subregion 1 – North Gillette	0	0	0	0	5	0
Subregion 2 – South Gillette	0	0	0	0	10	10
Subregion 3 – Wright	5	10	5	20	5	5
Subregion 4 – Sheridan/Decker	20	0	0	20	0	0
Subregion 5 – Ashland/Colstrip	0	0	0	20	20	0
Subtotal	**25**	**10**	**5**	**60**	**40**	**15**
Highway Transportation[3]						
Subregion 1 – North Gillette	0	5	0	0	5	0
Subregion 2 – South Gillette	0	0	5	0	0	5
Subregion 3 – Wright	0	0	0	0	0	0
Subregion 4 – Sheridan/Decker	0	0	0	0	0	0
Subregion 5 – Ashland/Colstrip	0	0	0	0	0	0
Subtotal	**0**	**5**	**5**	**0**	**5**	**5**
Total	**220**	**300**	**197**	**383**	**424**	**210**

[1] Calculate in 2003 dollars at $0.85 per bank cubic yard annual capacity.
[2] Calculate in 2003 dollars at $1.00 per ton annual capacity.
[3] Calculate in 2003 dollars at $5 million per mile relocated excluding land acquisition costs.

Other impact-causing parameters associated with Wyoming coal mine operations are summarized in Tables A-1 and A-2 in Appendix A of this report.

3.1.2.2 Montana

The projected upper and lower production trends for the coal mines in the Montana PRB study area would parallel those described in Section 3.1.2.1 for the mines in the Wyoming PRB study area.

Based on the analysis conducted for this study, it is estimated that the original base year (2003) production of 36.1 mmtpy of coal in the Montana PRB study area would increase to 56.0 mmtpy under the lower production scenario and to 83.0 mmtpy under the upper production scenario by 2020. Production at currently operating mines is projected to continue throughout the study period. Base on more recent data, the actual 2008 production in the Montana PRB was 43.8 mmtpy. This is between the upper and lower production scenarios identified in the 2005 Task 2 report; however, it

is closer to the upper production scenario. Currently, there is considerable uncertainty in coal demand forecasting due to the uncertainty of the regulation of coal use for electric generation in response to proposals to regulate greenhouse gas emissions. Coal production has been reduced in the immediate (2009) timeframe. Based on the fact that actual production has been tracking in between the upper and lower production forecasts from the 2005 Task 2 report, and there is no clear indication of a substantial change in that trend, the upper and lower production forecasts to year 2020 were not modified for this update.

The 2005 Task 2 report projected the potential development of the Ash Creek Mine by 2010. This mine is in the Sheridan/Decker area (Subregion 4). The mine is located in Wyoming just south of the Montana-Wyoming state line, with the coal to be shipped by a new rail spur in Montana. The WDEQ is expecting an application by December 2009. Based on more recent information, it is projected that the Ash Creek Mine would be developed by 2015. In addition, two other potential mines (i.e., Otter Creek Mine and the Many Stars Project) have been identified in the Montana PRB study area.

Under the lower production scenario, it is projected that production at the Ash Creek Mine would be initiated by 2015; and the Otter Creek and Many Stars mines would not be developed. Under the upper production scenario, it is projected that production would be initiated at the Ash Creek mine, and at either or both the Otter Creek Mine and the Many Stars Project by 2015. Development of these mines would be dependent on markets for the coal and may be tied to development of infrastructure including the Tongue River Railroad and/or power plants or coal-to-liquids plants. It is assumed that development of the Otter Creek Mine would require construction of Tongue River Rail Company's (TRRC's) proposed Tongue River Railroad and a power plant near Miles City, Montana. However, at this time, no application has been filed for a new power plant at this location. It is assumed that the Many Stars project would be developed in response to construction of a mine-mouth coal-to-liquids plant; however, an application for a new plant at this location has not been filed at this time. In late 2009, the Ark Land Company leased the privately owned coal at the Otter Creek Mine area. The state reserves at Otter Creek presently are unleased.

Following the development of individual mine production levels for the two scenarios, individual mine reserves and mining sequence layouts were developed based on geologic information and 2003 mine pit progressions on file with the MDEQ. Reserves beyond the current mine permit boundaries and existing mine lease boundaries (e.g., potential developments including P&M Ash Creek and Otter Creek) were sequenced based on strip ratio and proximity to past mining. The mapped areal extent of mine reserves subsequently were projected in 5-year increments (**Figures A-3** and **A-4** in Appendix A). Future coal mining in the Montana PRB study area is considered certain/highly likely based on the anticipated production rates in relation to the available economic reserves. However, the likelihood for the Otter Creek Mine is considered low under the upper production scenario due to its inter-dependency on other developments. The Many Stars project is not projected due to insufficient information to identify a discrete location or production rate. These two mines would not be developed under the lower production scenario.

Four additional properties (Kinsey, CX Ranch, Young's Creek, and North Ashland) were identified by Hill and Associates (2003) as potential coal mine sites. However, based on the lack of information for these potential mine sites, their likelihood for development is speculative. As a result, they have been eliminated from further analysis in this study.

Mine-related capital investment under both the projected lower and upper production scenarios is presented in **Table 3-1**.

3.1.3 Data Sources

Public information in the form of permit documents, annual reports, permit applications, LBAs, EISs, correspondence, and articles was obtained from the WDEQ (Land Quality and Air Quality divisions), MDEQ, BLM High Plains District Office and Wyoming State Office, BLM Montana State Office and Miles City Field Offices, Wyoming State Mine Inspector's Office, USDOE, STB, Federal Energy Regulatory Commission (FERC), and numerous trade and industry publications.

Proprietary economic reports forecasting regional coal market activity from Hill and Associates Inc., Platts, Global Insight, and proprietary industry input from the individual coal mine operators in the Wyoming and Montana PRB study area, also were used in the preparation of the coal resources sections of this report.

3.1.4 Assumptions

In addition to the information obtained from the identified data sources, the following assumptions were used to define specific impact-causing parameters for coal mines:

Past and Present Development:

- Existing operations are not part of the abandoned mine lands programs.

- Annual groundwater production rates for 2003 through 2007 are assumed to be the same as previously reported for 2002/2003.

RFD:

- It is assumed that Ash Creek and the other Decker area mines would obtain new WDEQ- and MDEQ-approved air quality permits, as applicable, consistent with their forecasted production levels.

- Consistent with historical trends, it is assumed that currently idle mines would be brought back into production during periods of high growth in the projected upper end of the production range.

- Under the lower production scenario, it is assumed that the Ash Creek Mine would initiate production by 2015; the Otter Creek and Many Stars mines would not be developed. Under the upper production scenario, it is assumed that production would be initiated by 2015 at the Ash Creek mine and at either or both the Otter Creek and Many Stars mines. However, development of the TRRC's proposed rail line and construction of a power plant near Miles City would be required for the Otter Creek Mine to become operational. Development of the Many Stars Project would be dependent on construction of a mine mouth coal-to-liquids plant. No permits have been submitted at this time for plants in either of these locations.

- It is assumed that production from the Ash Creek Mine in Wyoming would be serviced by a new spur line connecting to rail service at the Decker and Spring Creek mines.

- It is anticipated that TRRC's construction of 130 miles of new rail line between Miles City and Decker, Montana, would be completed and operational by 2015; however, construction of the rail line would be dependent on the development of the Otter Creek Mine, which only would be developed under the upper production scenario. The new rail line would have a capacity of approximately 100 mmtpy.

- No major state or interstate highways would be impacted by future mining activities in Montana.

- Construction of the proposed DM&E rail line is estimated to be completed between 2010 and 2014 (or when production in the Wyoming PRB approaches 450 mmtyp); operation is assumed starting with the 2015 time period. The rail line would add approximately 100 mmtpy of rail transportation capacity for the Wright and South Gillette subregion mines.

- Projections for groundwater production beyond 2002 assume that groundwater production rates under both the lower and upper production scenarios would remain the same as during the period between 2000 and 2002.

- Based on information provided by the coal mines, it is assumed that the majority of groundwater pumpage would come from the Wasatch Formation.

3.2 Power Plants

3.2.1 Past and Present Development

3.2.1.1 Wyoming

Currently, there are five coal-fired power plants in the PRB study area (see **Figure 3-1**). Black Hills Power Corporation owns and operates the Neal Simpson Units 1 and 2 (21.7-megawatts [MW] and 80-MW, respectively), WYGEN 1 (80-MW), WYGEN 2 (90-MW), and Wyodak (330-MW) power plants, all of which are located approximately 5 miles east of Gillette, Wyoming. WYGEN 2 began operation in 2008. Pacific Power and Light's Dave Johnston Power Plant is located near Glenrock, Wyoming, outside of, but adjacent to, the study area.

Hartzog, Arvada, and Barber Creek are three separate interconnected gas-fired power plants located near Gillette, Wyoming. Each contains three separate 5-MW rated turbines to provide electric power to Basin Electric and its customers. All units are in operating condition, although they do not operate at maximum capacity.

3.2.1.2 Montana

Three coal-fired power plants currently operate in the Montana PRB study area (**Figure 3-1**). The major existing coal-fired power plant in the Montana PRB study area is the Colstrip Power Plant, which is located near Colstrip, Montana, in Rosebud County. The facility consists of four separate

coal-fired units on the same plant site. Units 1 and 2 are estimated at 450 MWs of power generation capacity each, and units 3 and 4 each are 778-MW design capacity. The facility has a permit to burn up to 28 percent petroleum coke in its Units 1 and 2 boilers, replacing coal as a fuel source.

A smaller coal-fired power plant (Colstrip Energy Limited's Rosebud Power Plant) is in operation at a site approximately 1.5 miles north of Colstrip (**Figure 3-1**). The facility generally burns waste coal and has operated below maximum capacity in recent years. Permitting officials indicate that it has approximately 120 MW of electric generation capacity.

The Hardin Generation Project initiated operation in 2007 (Wheeler 2008) at a site approximately 1.2 miles northeast of Hardin, Montana. This coal-fired boiler unit has a capacity of 113 MWs of electric generation capacity.

3.2.2 Reasonably Foreseeable Development

Coal-fired power plants have been, and likely would continue to be, constructed in the PRB to avoid high shipping costs for coal. Currently, adequate transmission line capacity exists to deliver the existing generating capacity to market; however, that capacity would need to be increased in order to provide adequate markets for new power plants.

Construction of new coal-fired power plants may involve some of the largest capital investments undertaken by industry, and substantial time would be required for obtaining permits and constructing such facilities. Recent estimates for a major coal-fired power plant are that a project would require 2 to 4 years to obtain the required permits, with an additional 4 to 6 years for construction. An estimated development cost of over $1 billion would apply to most major coal-fired power plants (based on an estimated $1,500 per installed kilowatt [$1.5 million per installed MW] generating capacity). A workforce of up to 1,500 personnel would be required at peak construction, with a likely operating workforce of 100 to 150 for each operating plant, based on estimates from current operating facilities.

Air emissions from coal-fired power plants are undergoing intense scrutiny by regulatory agencies, environmental groups, and the general public. Recent proposed legislation in the U.S. Congress and proposed regulations by the USEPA may influence air emissions, including limits on carbon dioxide, which is not currently regulated but will require reporting for some facilities. Even a well-regulated facility would have major emissions of criteria air pollutants. For example, for a 1,000-MW plant using the Best Available Control Technology (BACT) for this industry, the estimate of sulfur dioxide and nitrogen oxides emissions would be approximately 2,500 tons per year for each pollutant. Particulate matter emissions likely would be 600 to 700 tons per year from the power plant stack, with additional fugitive and handling emissions for coal and waste. The air permit for each facility would need to demonstrate BACT for each of the major criteria air pollutants, including lead.

Water requirements for each coal-fired power plant would involve both a determination of the control technologies (wet scrubber versus dry scrubber for sulfur dioxide [SO_2]) and the facility cooling operations (wet or dry cooling towers, or a potential hybrid). An approximate estimate of the maximum water supply requirements for a wet scrubber and a wet cooling tower is 10,000 to 12,000 acre-feet per year for a typical 1,000-MW coal-fired power plant, based on recent analyses at other facilities.

3.2.2.1 Wyoming

There are no new coal-fired power plants currently being constructed; therefore, no new plants are projected for operation by 2010. Any proposed coal-fired power plant that plans to initiate operation by 2015 currently would have to be undergoing air permit review in order to obtain the required construction permits and complete construction by 2015. The following four identified projects currently are considered likely for 2015 development (**Figure 3-2**).

- Black Hills Power and Light has received an air permit for the start of construction of WYGEN 3; issues related to that permit currently are being resolved. WYGEN 3 would be a 100-MW facility located adjacent to WYGEN 2. Operation of this facility by 2015 is considered highly likely.

- North American Power Group has permitted a 280-MW coal-fired power plant (Two-Elk Unit 1) at a 40-acre site located approximately 15 miles southeast of Reno Junction (near Wright), Wyoming. As originally permitted, the project also would include installation of a 45-MW gas-fired turbine. The air permit originally was issued in August 2002; construction has been initiated, with actual startup expected in 2011. This unit would be dry-cooled, requiring very little water. Campbell County approved more than $123 million in industrial revenue bonds for application to the Two-Elk financing. Operation of this facility by 2015 is considered moderately likely.

- Basin Electric Power Cooperative has obtained an air construction permit for a 250-MW coal-fired power plant (Dry Fork) near Gillette, Wyoming. The estimated startup date is 2011. It is estimated that 1.2 million tons of coal per year would be required to fuel the facility. The cooling technology includes a dry scrubber, since that type of operation commonly is installed for PRB coal-fired units. Operation of this facility by 2015 is considered highly likely.

- Wyoming Power Company (a subsidiary of North American Power Group) has submitted a permit application for Two-Elk Unit 2. This unit would be a 750-MW supercritical pulverized coal-fired electric generating unit that would burn coal from the nearby mines. The unit would be located on an approximately 60-acre site adjacent to Two-Elk Unit 1. The permit is expected to be issued in 2008, and operation of this unit is considered moderately likely in 2015.

It is estimated that under the upper production scenario, a maximum of one additional 700-MW coal-fired power plant would be constructed through 2020. It is assumed the additional unit, if developed, would be constructed in the Gillette area or near operating coal mines. The main restriction appears to be the lack of electric power transmission capacity from the area to customers outside the state. All existing power plants in the PRB region are assumed to remain operational through 2020.

3.2.2.2 Montana

In the original Task 2 report (ENSR 2005b), the Otter Creek Energy Project (**Figure 3-2**) (previously projected for potential construction near Ashland, Montana) was identified as having a low likelihood for development for both 2015 and 2020. Based on updated information, the likelihood for development of this facility currently is considered speculative throughout the 2010-2015 period. It is assumed there would be a low likelihood for development by 2020, with an expected capacity of

750 MW under the lower production scenario and a capacity of 1,500 MW under the upper production scenario.

By 2015, under both the lower and upper production scenarios, it is assumed that only the Colstrip Units 1-4, the Rosebud Power Plant, and the Hardin Generation Project would be operating in the Montana PRB study area.

As discussed in Section 3.1.2.2, construction of a new power plant near Miles City, Montana, would be required for development of the Otter Creek Mine. However, due to the lack of a permit application or project-specific information, the likelihood for development of a new power plant in this location currently is considered speculative. As a result, it has been eliminated from further analysis in this study.

Bull Mountain Development Company has permitted the Roundup Power Project, a coal-fired power plant that would operate two 390-MW pulverized coal-fired boilers. This mine-mouth power plant, if constructed, would be located adjacent to the Bull Mountains Mine, approximately 12 miles south-southeast of Roundup, Montana, and just east of U.S. Highway 87 in Musselshell County. As this power plant would be located greater than 30 miles west of the Montana PRB study area, the facility has been eliminated from further analysis in this study.

3.2.3 Data Sources

Information relative to existing power plants in the Wyoming PRB study area was obtained from construction and operating permits on file with the WDEQ and direct contact with power plant operators. Data for existing power plants in the Montana PRB study area were obtained from the facility permits available through the MDEQ web site and from discussions with MDEQ staff.

Information relative to reasonably foreseeable power plants through 2015 was obtained from existing permit applications either under review or extended for a start of construction and news releases. Data also were obtained from identified proponents (Black Hills Power and Light and North American Power Group).

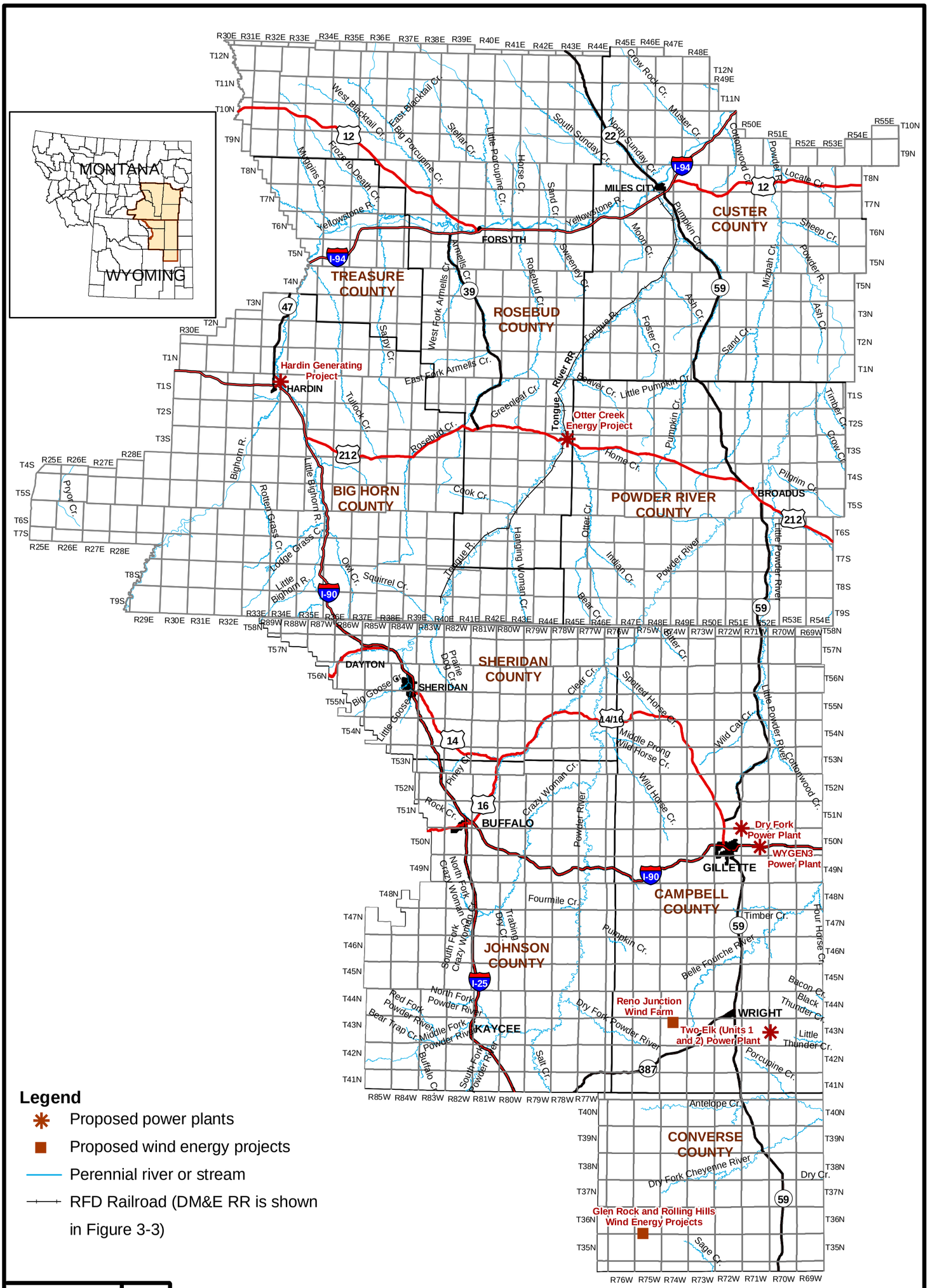
3.2.4 Assumptions

In addition to the information obtained from the identified data sources, the following assumptions were used to define specific impact-causing parameters for power plants:

Past and Present Development:

- Surface disturbance associated with a typical power plant facility would be 60 to 200 acres, based on available acreage data from other power plants.

- Annual emissions for the Colstrip Power Plant would be approximately 16,000 tons per year of SO_2, 32,000 ton per year of oxides of nitrogen (NO_x), and 500 tons per year of particulate matter with an aerodynamic diameter of 10 microns or less (PM_{10}) from the main stacks.



Note: Final site selection for the Otter Creek Energy Project is pending.

Source: BLM 2003, 2009; STB 2004.

Powder River Basin Coal Review

Figure 3-2

RFD Power Plants, Wind Energy Projects, and Railroad Development

11/11/09

RFD (2015):

- New power plants would comply with BACT for maximum controls.

- Existing power plants would be required to apply additional controls for NO_x, SO_2, PM_{10}, and particulate matter with an aerodynamic diameter of 2.5 microns or less in response to the regional haze rule.

- As originally permitted, annual emissions for the WYGEN 3 power plant would be 2,028 ton per year of NO_x, 3,381 ton per year of SO_2, and 421 ton per year of PM_{10}. Construction of the WYGEN 3 power plant would require a workforce of 750 to 1,000 construction workers, employed over a 4- to 5-year period, and an additional 75 to 100 employees for operations.

- As originally permitted, annual emissions for the Two-Elk Unit 1 power plant would be 1,756 ton per year of NO_x, 1,991 ton per year of SO_2, and 234 ton per year of PM_{10}. Project construction would occur over a 2-year period, with a temporary peak workforce of 750 workers. The estimated operating workforce would include 50 full-time equivalent staff. Total expected capital investment would be approximately $450 million.

- As currently being permitted, annual emission limits for the Two-Elk Unit 2 power plant would be 1,375 ton per year of NO_X, 1,927 ton per year of SO_2, and 1,100 ton per year of PM_{10}. Project construction would occur over a 2 to 3 year period, with a temporary work force up to 750 workers. The estimated operating workforce would include 50 full-time equivalent staff. Total estimated capital investment would be approximately $1.2 billion.

- As currently being permitted, Basin Electric Power Cooperative's 250-MW Dry Fork power plant would be constructed near Gillette, Wyoming.

- Assume minimal added rail shipping and associated emissions.

RFD (2020):

- Under the upper production scenario, one additional 700-MW power plant also could be constructed in the Wyoming PRB by 2020.

- Under the lower coal production scenario, it is assumed that one 750-MW (Otter Creek Energy Project) coal-fired power plant would be constructed in the Montana PRB study area by 2020. Under the upper production scenario, it is assumed that two 750-MW units would be constructed by 2020, bringing the total capacity to 1,500 MW. The Otter Creek Energy Project size could reach 2,000 acres, depending on design issues such as disposal of coal combustion wastes and local terrain limitations.

- Construction would require a workforce of 750 to 1,000 construction workers employed over a 4-year period. The operating workforce is estimated at 75 to 100 workers.

- The new power plant would comply with BACT for maximum controls. These current factors would be used to estimate emissions from any proposed new project. (For example 0.06 pounds per million British thermal unit [lb/MMBtu] for NO_X and sulfur oxides, and 0.025 lb/MMBtu for PM_{10} emissions controls.)

- For the proposed power plant, the modeling assumes representative stack parameters, such as a stack height of 500 feet, diameter of 30 feet, and temperature and flow rate similar to other coal-fired power plants with wet scrubbers.

3.3 Wind Energy

3.3.1 Past and Present Development

No wind energy generating projects currently exist in the Wyoming PRB study area.

3.3.2 Reasonably Foreseeable Development

Due to increasing concerns over global climate change, there is strong interest from consumers, investor-owned utilities, and environmental and economic sustainability interests in wind energy generating projects and other forms of renewable energy projects. The current development interest in wind energy generation is driven in part by mandates for many utilities to increase the use of renewables in the their overall energy portfolio, decisions by environmentally conscious firms to use renewable energy sources, and also due to the development of wind energy manufacturing infrastructure in the region. Examples of the above include: XCEL Energy (a leading electricity and natural gas energy company with major operations in Colorado) plans to meet 20 percent of its energy sales in Colorado from renewable resources; a decision by New Belgium Brewing Company to buy all of its commercial power from wind generated sources; and, Vestas Americas has begun manufacturing blades for wind turbines at a new facility in Windsor, Colorado (New Belgium Brewing Company 2008; Jackson 2008; XCEL Energy 2007).

Wyoming ranks among the top states in terms of wind energy potential. Although many Wyoming locations having the highest potential are in the southern portion of the state, areas in both Converse and Campbell counties offer sufficient potential to support commercial-scale wind generation projects.

One such project currently is under development in the Wyoming PRB study area, and another is under active consideration. PacifiCorp is constructing a three-phase project in Converse County, approximately 15 miles north of the existing Dave Johnston Power Plant, on and near the site of the former Dave Johnson Mine (**Figure 3-2**). The first two phases, known as the Glenrock Wind Energy Project and the Rolling Hills Wind Energy Project, initiated construction in 2008 and began operations in 2008 and 2009, respectively (Pacificorp 2009). The third, currently unnamed phase is anticipated to be constructed between 2009 and 2011, depending on market demands and the performance of the first two phases. Each phase would consist of 66 wind turbine generators (each rated at 1.5 MW [99-MW total]) mounted on 80-meter-tall tubular towers, plus ancillary support facilities (PacifiCorp 2007). This project is considered highly likely.

Third Planet Windpower is in the initial development phase of a wind generating project (Reno Junction Wind Farm) in the Pumpkin Buttes area of southwestern Campbell County (**Figure 3-2**). Third Planet Windpower has actively pursued land leases for the project, installed meteorological towers on site, and initiated environmental and feasibility studies. Contingent upon the meteorological data and other results, the company could install up to 167 1.5-MW towers, yielding a total capacity of 250 MW, if fully constructed (Gartrell 2008b). The project is considered moderately likely to occur in the 2013 to 2015 timeframe, which would coincide with the anticipated development of one or more new electrical transmission lines in the region.

Land use disturbance for wind energy projects is associated with development of access roads, a turbine assembly pad, and foundation pad for each wind turbine tower. Additional land disturbance results from installation of transformers and substations, underground electric and fiber optic communications cables, one or more operations and maintenance facilities, meteorological towers, and a transmission line connecting the project to the regional grid. Much of the disturbance area is reclaimed immediately following construction, with long-term disturbance associated with permanent facilities (i.e., access roads, support facilities, and tower foundations).

Wind generating projects have an expected life of approximately 25 years, which could be extended based on market conditions and the overall condition of the infrastructure. Some redisturbance would occur at the time of decommissioning, followed by final reclamation.

3.3.3 Data Sources

Information regarding wind generation potential was obtained from the Wyoming Infrastructure Authority, PacifiCorp permit applications posted on the Wyoming Industrial Siting Administration's website, news coverage on the internet, and from posting on the Wyoming Legislative Services Office.

3.3.4 Assumptions

Past and Present Development: There are no assumptions relative to past and present wind energy projects.

RFD:

- It is assumed that the third phase of Pacificorp's wind energy project (99 MW) would be completed and brought on line in 2010.

- It is assumed that Third Planet Windpower would construct a 250-MW wind generating facility near Pumpkin Buttes between 2013 and 2015.

- It is assumed that an additional 500 MW of commercial wind generation would be constructed in the PRB study area and brought on line between 2015 and 2020. Of this total, it is assumed that 300 MW would be located in southern Campbell County, with an additional 200 MW located in Converse County. These projects would coincide with the anticipated expansion of transmission line capacity in and adjacent to the PRB study area.

- Disturbance acreage assumptions include:

    - Substations: 3 acres per 100-MW phase or project
    - Roads/power lines: 0.25 mile per tower, with a combined 50-foot-wide ROW
    - Tower foundations: 0.5 acre per tower

3.4 Transportation

Information relative to past and present and RFD railroad activities is presented below. Information relative to highways is presented in Section 3.14.

3.4.1 Past and Present Development

3.4.1.1 Wyoming

The Wright and South Gillette subregion coal mines located south of Interstate (I) 90 are serviced by a joint Union Pacific (UP)/BNSF rail line (see **Figure 3-1**). In 2003, the shipping capacity of the joint line was estimated at approximately 350 mmtpy. The 2003 coal production from the same mines totaled 308 mmtpy, equating to an 88 percent utilization of the available rail capacity. By the end of 2007, the capacity of the line was estimated at over 400 mmtpy as the result of a series of capacity expansion projects. The 2007 coal production from the same mines totaled 359 mmtpy, equating to a 90 percent utilization of the existing rail capacity. In July 2008, expansion work was completed to increase capacity to approximately 450 mmtpy.

In 2003, the capacity of the BNSF line servicing the Subregion 1 coal mines north of I-90 (see **Figure 3-1**) was estimated at 250 mmtpy. The 2003 coal production from the Subregion 1 mines totaled 55 mmtpy, equating to an approximate 22 percent utilization of the available rail capacity. No major expansion projects had been constructed on this line by the end of 2007. The 2007 coal production from these same mines totaled 78 mmtpy, equating to 31 percent utilization of the existing rail capacity. An unknown amount of coal shipped from the Subregion 1 mines on the BNSF line is transported farther south along the joint UP/BNSF line. This unknown amount was not included in the estimated utilization of the joint UP/BSNF line, and therefore, current actual utilization of the joint line could be higher.

3.4.1.2 Montana

Existing BNSF rail lines are in place with adequate capacity for all existing mines. The existing BNSF rail line extends from the mainline to both the Decker and Spring Creek mines. It is assumed that the existing railroad infrastructure has capacity for approximately 100 mmtpy from the region.

3.4.2 Reasonably Foreseeable Development

3.4.2.1 Wyoming

UP/BNSF Expansion. The single largest capital and infrastructure cost related to the projected future coal mining rates is rail expansion for the mines south of Gillette. Work to improve sections of

the existing joint UP/BNSF rail line and to increase capacity from 350 to 450 mmtpy was completed by July 2008, with plans to improve additional sections of the existing joint UP/BNSF rail line and to further increase capacity to 500 mmtpy by 2012. This would accommodate the projected upper and lower production rates at the southern mines, which are projected to produce 439 mmtpy by 2015 and 455 mmty by 2020. This further expansion has a likelihood rating of highly likely.

DM&E Rail Line. The proposed DM&E rail line, which would include new rail construction in South Dakota and Wyoming (approximately 15 and 265 miles, respectively) and 600 miles of rail line rehabilitation in South Dakota and Minnesota, would provide additional rail capacity for the coal mines in the Wyoming PRB (**Figure 3-3**), primarily those in the south Gillette and Wright areas (i.e., Subregions 2 and 3). Approximately 78 miles of the new rail construction would occur in the PRB study area.

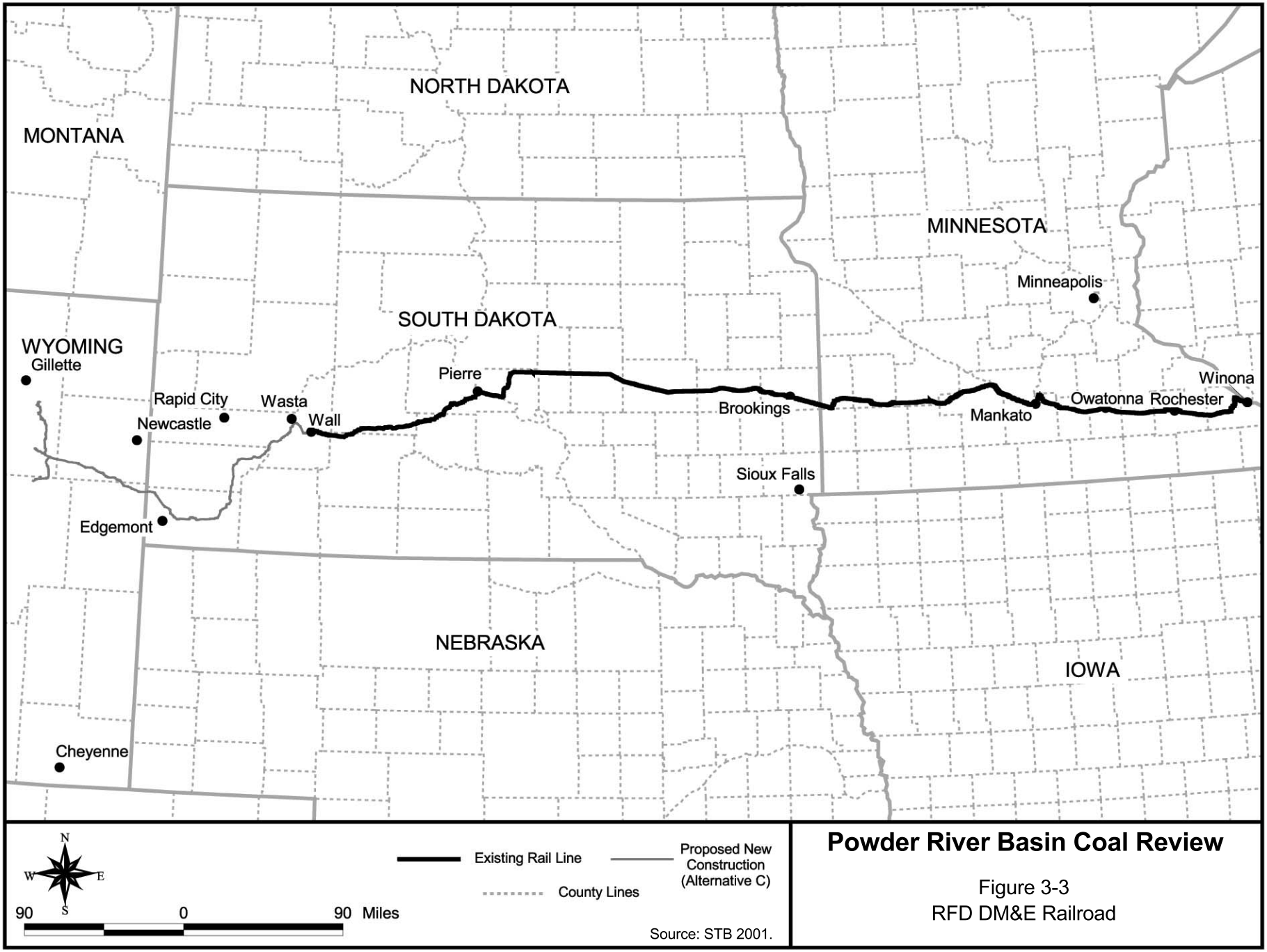
On January 28, 2002, the STB issued a final written decision granting DM&E authority to construct and operate the line subject to 147 environmental conditions, including an environmental oversight period that would continue through the first 2 years of operation. The Record of Decision was successfully appealed, and additional environmental analysis was required as a result. The additional environmental analysis was completed in 2005, and the STB granted approval to construct in 2006.

In 2007, Canadian Pacific Railway acquired DM&E with plans to integrate DM&E's operations into their operations as soon as they receive STB approval. Last year, the Canadian Pacific Railway said it would pay almost $1.5 billion for the DM&E and its subsidiaries. It would cost another $1 billion or more if the company expands to Wyoming's PRB coal fields. The Canadian Pacific Railway is concentrating on the DM&E acquisition before moving on to a PRB decision.

Construction of the DM&E rail line in the PRB would provide 100 mmtpy of new rail capacity for the southern PRB mines and open new markets for this coal. The project also would provide new rail spur services to the Jacobs Ranch, Black Thunder, Caballo-Rojo, Coal Creek, Cordero, and Belle Ayr mines. It is projected that when the total rail haulage requirement from the eastern Wyoming PRB reaches between 450 to 500 mmtpy, the DM&E line would be constructed. Although the timing would depend on actual production, haulage contracts, and near-term forecasts from the southern portion of the PRB, it is assumed for this study that the new rail line would be operational by 2015. The construction of this rail line has a likelihood rating of moderately likely.

3.4.2.2 Montana

It is anticipated that future production rates from the currently operating mines in Subregion 4 would not exceed the capacity of the existing BNSF rail line (100 mmtpy) through 2020. It also is anticipated that the existing capacity (100 mmtpy) of the currently operating BNSF rail line would be sufficient to accommodate additional production from the P&M Ash Creek Mine in the Wyoming portion of Subregion 4. Any upgrades would be minor and limited to spur track connections.



Powder River Basin Coal Review

Figure 3-3
RFD DM&E Railroad

3.4.2.3

It is anticipated that reasonably foreseeable railroad development within the Montana PRB study area would be limited to the construction of TRRC's proposed rail line. The proposed route for TRCC's rail line generally follows the Tongue River from near the Spring Creek Mine to Miles City, Montana (**Figure 3-2**). The rail line would provide for transportation of coal from existing and future mines to markets in the midwest and northeastern states. It also would be required to facilitate development of the proposed Otter Creek Mine and would supplement existing transportation choices available to the existing Decker and Spring Creek mines. It also may alter the existing coal transport patterns from these operations. TRRC's proposed rail line received STB approval in 2007. In 2008, a request was submitted to lease two tracts of state coal at Otter Creek. However, it is projected that construction of the railroad would not occur unless the Otter Creek Mine is developed. There may be some phased development of the railroad.

The $109 million project would provide 100 mmtpy of new rail capacity. Based on the inter-dependency of this rail line with the development of the Otter Creek Mine, it is assumed for this study that development of the rail line would not occur under the lower development scenario. Under the upper development scenario, it is assumed that the rail line would be operational by 2015; a low likelihood has been assigned to this action.

3.4.3 Data Sources

Information from the BNSF Railway Coal Business Unit, DM&E Railroad Corporation Final EIS, Canadian Pacific Railway announcements, Tongue River Railroad STB Application, Surface Transportation Board web site, Hill and Associates, CANAC (a presentation at Coal Marketing Days in Pittsburgh in 2007), MWH Coal Planning Estimates Report, and media reports were used in the preparation of the coal railroad transportation sections of this report.

3.4.4 Assumptions

In addition to the information obtained from the identified data sources, the following assumptions were used to define specific impact-causing parameters for transportation:

Past and Present Development:

- Existing railroad disturbance rights-of-way are assumed to be 150 feet in width.

RFD:

- It is assumed that the UP/BNSF rail capacity for the southern portion of the PRB would increase from 450 mmtpy in 2008 to 500 mmtpy by 2012; associated construction would include the addition of sidings and trackage parallel to existing facilities within the existing right-of-way.

- The construction right-of-way for the portion of the DM&E rail line in the Wyoming PRB study area would be approximately 78 miles long and 100 feet wide. Although the timing would depend on final STB approval, Canadian Pacific Railway's final decision relative to extension of

the rail line into the PRB, and production and near-term forecasts from the southern portion of the PRB, it is assumed for this study that the new rail line would be operational by 2015.

- The construction right-of-way for TRRC's new rail line in the Montana PRB study area would be 130 miles long and 100 feet wide. It is assumed this new rail line would be operational by 2015. However, project financing and construction would be dependent on the development of the Otter Creek Mine, which only would be developed under the upper production scenario. Under the lower production scenario, it is assumed that the rail line would not be constructed.

- It is assumed that the initial use of TRRC's rail line would be for the transport of coal from the Otter Creek Mine to a yet-to-be proposed power plant near Miles City, Montana.

3.5 Coal Technology

3.5.1 Past and Present Development

3.5.1.1 Wyoming

There are no existing commercial-scale coal technology projects operating in the Wyoming PRB study area. Test facilities previously were constructed by AMAX (predecessor to Foundation Coal West, Inc.) at the Belle Ayr Mine and ENCOAL at the Buckskin Mine. No commercial production has occurred, and these facilities either have been dismantled or are no longer in use.

Evergreen Energy (formerly operating as KFx) previously built a prototype commercial-scale coal upgrading plant near the old Fort Union Mine (now part of the Dry Fork Mine). The facility did achieve commercial production levels of K-Fuel® (the company's enhanced coal product) for a short period (2006 through early 2008); it was used for testing and demonstration purposes. Approximately 60 people were employed at the plant. Evergreen Energy decided to idle the plant in May 2008, laying off all but a caretaker staff.

3.5.1.2 Montana

A coal processing facility used to reduce moisture content and remove sulfur previously was associated with the Rosebud Mine. However, this facility has been dismantled and removed from the mine site. Therefore, it is not considered further in this analysis.

3.5.2 Reasonably Foreseeable Development

The PRB has long been a focal point for coal enhancement technologies. In part, this interest has been driven by the vast reserves of sub-bituminous coal in the PRB, which represent a substantial supply of energy resources. Coal enhancement technologies have been viewed as a means to expand the market for PRB coal by addressing its distance from major markets, relative lower energy content, high transportation costs, and associated environmental concerns. Interest in coal enhancement technology in general, and other energy technologies, has risen in response to concerns regarding the supply and price of crude, the possibility of "peak oil" (a concept that the global annual output of crude oil has peaked or will soon peak), rising prices of natural gas, and

global climate change. However, such facilities are costly and competition exists for available capital, other resources, and current markets for production. There have been a number of recent developments in the area of coal enhancement technologies, including the successful completion of several demonstration/pilot projects that have shifted the immediate focus away from the PRB. Nonetheless, the initiation of several commercial-scale facilities and infusion of private capital and joint development agreements, appear to have increased the overall likelihood of one or more coal technology facilities being developed in the PRB prior to 2020.

3.5.2.1 Wyoming

Evergreen Energy Coal Beneficiation Project. Long-term plans for Evergreen Energy's coal upgrading plant near the Dry Fork Mine have not been announced, although re-opening and dismantling the currently idle plant and redeploying some of the equipment to another location have surfaced as possibilities. Evergreen Energy has raised the possibility of developing a new facility incorporating the recently redesigned plant and process. The new design (developed in conjunction with Bechtel Power Corporation) would offer improved operating economics and would raise the potential output capacity above the prototype plant's 750,000 tons per year. The company, however, currently is focused on completing two international projects and is evaluating other domestic locations for new facilties. The company has indicated that rail access at economically supportable rates is important to its decision. As a result, Evergreen Energy may be waiting on further resolution of plans for the DM&E rail line into the PRB (see Section 3.4, Transportation) (Associated Press 2008; Evergreen Energy 2008,a,b,c). Given the various uncertainties regarding economics, markets, and transportation, the likelihood of Evergreen Energy re-opening or developing a new facility in the Wyoming PRB study area currently is considered speculative. Therefore, it has been eliminated from further analysis in this study.

Rentech Inc. Coal Liquefaction Project. In 2004, Rentech completed a feasibility study for a coal liquefaction facility, based on the historic Fischer-Tropsch process, to produce low-sulfur diesel fuel from sub-bituminous coal. Thereafter, Rentech continued to consider the potential of developing a commercial-scale facility in the PRB, while simultaneously investing in a product demonstration facility near Denver. The latter served as a demonstration and test facility to evaluate the process and suitability of alternative feedstocks. More recently, Rentech's development activities have been focused outside of the PRB, including the company's first commercial-scale project, a synthetic fuels plant near Natchez, Mississippi. The company also licensed its technology to DKRW, which plans to employ it at a new coal-to-liquids facility currently under development in the Hanna Basin in southcentral Wyoming. Rentech also has a joint development agreement with Peabody Energy to develop a coal-to-liquids plant using Peabody's extensive coal reserves in Montana. Rentech's various commercialization initiatives appear to have drawn its immediate attention away from the PRB. However, based on the substantial coal reserves in the PRB, it is anticipated that future development of a coal-to-liquids plant in the Wyoming PRB study area is a potential, although the timing and level of development currently are unknown (Rentech 2008a,b). As a result, the likelihood for project development currently is considered speculative. Therefore, it has been eliminated from further analysis in this study.

White Energy Company, NRG Energy, and Buckskin Mining Company. In March 2008, the three companies entered into a joint development agreement to complete a feasibility study of building and operating a plant having a capacity to produce at least 1 million tons of binderless coal briquettes annually at the Buckskin Mine. The plant would use White Energy's patented mechanical

coal upgrading process, which essentially pulverizes and dries sub-bituminous coal and forms the bulk output into briquettes with lower moisture and higher British thermal unit value per pound. According to White Energy, the process and product offer a number of benefits including relatively low processing costs, higher energy content and energy generation efficiencies, lower spontaneous combustion risk, relatively lower transportation costs, and reduced levels of fines and dust resulting in lower environmental and safety issues during handling, shipping, and storage. Pilot tests by White Energy reportedly concluded that the coal produced at the Buckskin Mine is suited to the process. (NRG Energy currently burns coal from the Buckskin Mine at one of its generating plants in Louisiana.) If the initial plant proves successful, White Energy's business plan envisions upgrading capacity, eventually expanding to 8 mmtpy. White Energy recently completed a commercial-scale facility overseas and has joint venture agreements for several more. However, the timetable for completing the study and tentative target date for plant construction and operation in the PRB currently is unknown (bnet business network 2008; NRG 2008; White Energy 2008). As a result, the likelihood for project development currently is considered speculative. Therefore, it has been eliminated from further analysis in this study.

GreatPoint Energy and Peabody Coal. These two companies entered into an agreement in January 2008, under which Peabody Coal would become the preferred provider of coal to GreatPoint Energy for use in a commercial-scale coal-to-gas conversion plant in the PRB. GreatPoint Energy is in the early stages of planning a facility that would use a proprietary catalytic conversion process to produce pipeline quality gas. According to GreatEnergy, its process also would allow it to capture carbon dioxide (CO_2), which then could be sequestered (see Section 3.6). Per GreatPoint Energy, its product is as clean as natural gas and could be used in the same applications as natural gas (e.g., residential heating and power generation). A demonstration project testing the process was completed at a facility in Illlinois, where a pilot test plant is under construction. Studies to validate the feasibility of a commercial-scale facility in Wyoming presumably are ongoing. GreatPoint Energy has raised $100 million from various corporate investors for potential development of a commercial-scale facility. A company spokesman noted "…that such a project is no sure thing for Wyoming..." and, if constructed, would not be operational before 2012 (Gartrell 2008; GreatPoint Energy 2008). As a result, the likelihood for project development currently is considered speculative. Therefore, it has been eliminated from further analysis in this study.

Wyoming Infrastructure Authority. The Wyoming Infrastructure Authority (WIA) was created in 2004 by the Wyoming State legislature. It was tasked with promoting the state's economic development by assisting in the development of interstate electric transmission infrastructure. In 2006, WIA's role was expanded to also promote advanced coal technologies related to electric generation (WIA 2008a).

In 2007, WIA selected PacifiCorp from a list of 17 candidate firms and entered into a public-private partnership to assess the feasibility of developing an integrated gasification combined cycle power plant. In addition to its coal- and gas-fired generating facilities, PacifiCorp is actively developing substantial wind generating capacity (see Section 3.3). The initial study focused on a site in southwestern Wyoming, but may open the way for similar projects elsewhere in the state (WIA 2008a), including the PRB.

Following the conclusion of several internal feasibility studies, WIA and PacifiCorp announced that the project was on hold, although WIA plans to remain active in efforts to promote coal beneficiation related to electrical generation. Factors contributing to the decision to put the project on hold

included remaining technology risks, concerns regarding the lack of a federal legal and policy framework regarding long-term liability associated with carbon sequestration, and financing (WIA 2008b). As a result, the likelihood for project development currently is considered speculative, and it currently has been eliminated from further consideration in this study. However, since WIA will remain active in promoting coal beneficiation related to electric generation, a project of this type could be proposed in the PRB in the future.

There currently is a developing technology that would use existing oil and gas wells to generate biologically-formed methane by enhancing the methane production from naturally occurring microbes in the coal. This process is proposed for commercial testing. It is a hybrid between conventional in situ coal gasification and conventional CBNG development. A policy to authorize and regulate this activity currently is being developed.

3.5.2.2 Montana

Rentech Inc. Coal Liquefaction Project. Rentech has a commercially-viable process for converting coal to synthetic ultra-clean diesel and aviation fuels. Rentech has a joint development agreement with Peabody Energy to develop a coal-to-liquids plant intended to use Peabody's coal reserves near Colstrip Montana. This project is one of two to be undertaken under the joint development agreement; the other project would be located in the Midwest. The two projects are characterized as having production capacities of 10,000 and 30,000 barrels per day; however, it is not clear at this time which capacity plant would be in which location. An exact location and timetable for the Montana project has not been announced; however, a mine-mouth facility is one possibility as are locations near Billings and Miles City that have good rail access (Rentech 2008a,b). Based on this information, the likelihood for project development currently is considered speculative. Therefore, it has been eliminated from further analysis in this study.

The Crow Tribe and Australian-American Energy Company, LLC. The two parties announced an agreement to pursue a $7 billion project involving construction of a new coal mine (see Section 3.1) and a coal-to-liquids conversion plant on the Tribe's reservation. Based on preliminary information, the initial production capacity of the Many Stars Project would include the conversion of 38,000 tons per day of coal into 50,000 barrels per day of fuels and naphta, with potential expansion to 125,000 barrels per day. Australian-American Energy is engaged in ongoing evaluation of the coal resources and facility site location studies. Current project planning efforts indicate a construction workforce of up to 4,000 workers, with 900 permanent workers during production. Australian-American Energy is a privately held company that has initiated two other coal conversion projects in Australia. At this time, an application for the coal-to-liquids plant has not been submitted. In addition, the plant would be inter-dependent on development of the Many Stars coal mine project. As discussed in Section 3.1, development of the Many Stars coal mine project is considered speculative due to insufficient information to identify a discrete location or production rate. As a result, the coal-to-liquids plant also is considered speculative at this time and has been eliminated from further analysis in this study.

3.5.3 Data Sources

Information on the status of coal enhancement projects was derived from the corporate websites of Evergreen Energy, Rentech, White Energy, GreatPoint Energy, NRG, the Crow Tribe, and the WIA. Information also was obtained from published news articles.

3.5.4 Assumptions

RFD:

- Although a specific project has not been identified, based on the substantial coal reserves in the PRB, it is assumed that one commercial-scale coal beneficiation project would begin construction in the Wyoming PRB study area by 2015, with production occurring by 2020. Based on the coal-to-liquids project now being developed in Carbon County, it is assumed that construction of a similar plant in the Wyoming PRB study area would take approximately 3 to 4 years. It is assumed the facility would employ approximately 2,000 workers during construction and 400 workers at full operation. It is assumed the total site would occupy approximately 400 to 500 acres.

3.6 Carbon Sequestration

3.6.1 Past and Present Development

Carbon sequestration, the process of carbon capture, separation, and storage or reuse, is being researched as a means to stabilize and reduce concentrations of carbon dioxide (a greenhouse gas). Direct options for carbon sequestration would involve means to capture carbon dioxide at the source (e.g., power plant) before it enters the atmosphere coupled with “value-added” sequestration (e.g., use of captured CO_2 in enhanced oil recovery [EOR] operations). Indirect sequestration would involve means of integrating fossil fuel production and use with terrestrial sequestration and enhanced ocean storage of carbon (USDOE 2008).

No carbon sequestration projects currently exist in the Wyoming PRB study area. However, there is CO_2 being injected underground for the purpose of EOR near the study area in the Salt Creek area (see Section 3.9.2.2).

3.6.2 Reasonably Foreseeable Development

The 59th Session of the Wyoming Legislature passed, and Governor Freudenthal signed into law, legislation that could affect long-term energy-related development in the PRB (House Bills 0089 and 0090) (Wyoming Legislative Services 2008). The former (now part of Wyoming Statute 34-1) specified the ownership of subsurface “pore” space, established the rights to use such space for the purpose of carbon sequestration, and maintained the primacy of the mineral estate and the owners of such estate to reasonable use of the surface for the purpose of mineral exploration and production.

Legal provisions enacted as a result of House Bill 0090 vested regulatory control over carbon sequestration with WDEQ and directed the department to promulgate rules, regulations (including permitting processes), and standards for such use. The legislation also specifies that applications for a carbon sequestration project must describe the geology of the area, aquifers above and below the intended injection zone, drill holes and operating wells in the area, potential impacts to other fluid resources, and identify a program for detecting migration or excursion of the CO_2. Finally, the enacted legislation (Wyoming Statute 35-11-103) specifically states that the act is not intended to impede or impair the rights of oil and gas operators to inject CO_2 through an approved EOR project and establish, verify, register, and sell emissions reduction credits.

Based on the coal- and oil and gas-related development in the PRB study area, the potential exists for future development of carbon sequestration in the area. However, no commercial projects specifically targeted at capturing and sequestering carbon have been identified at this time. Therefore, carbon sequestration has been eliminated from further consideration in this study.

3.6.3 Data Sources

Information relative to the carbon sequestration legislation was collected from news coverage posted on the internet and the Wyoming Legislative Services Office and USDOE's websites.

3.6.4 Assumptions

Past and Present Development: There are no assumptions relative to past and present carbon sequestration.

RFD:

- It is assumed that no commercial-scale carbon sequestration projects would be developed in the PRB study area during the 2010 to 2020 timeframe.

3.7 Transmission Lines

3.7.1 Past and Present Development

Major transmission lines in the Wyoming PRB study area that support the regional distribution system are associated with PacifiCorp's Dave Johnston power plant located near Glenrock, Wyoming; the power plants operated by Black Hills Power and Light, located east of Gillette; and also will support Basin Electric's Dry Fork Station now under construction north of Gillette (**Figure 3-4**). These 230-kilovolt transmission lines have been in place for several years, and their associated permanent disturbance is minimal. Distribution power lines associated with conventional oil and gas and CBNG development also occur within the study area; for purposes of this study, these power lines have been factored in proportionally on a per well basis as discussed in Appendix E.

3.7.2 Reasonably Foreseeable Development

Transmission lines are a necessary supporting infrastructure for power generating facilities, including wind energy projects, to provide interconnections to the national grid. As a result, it is assumed that transmission line capacity expansion would be required as part of the overall system development for the RFD power plants identified in Section 3.2.2.1 and other industrial development in Section 3.13.2.

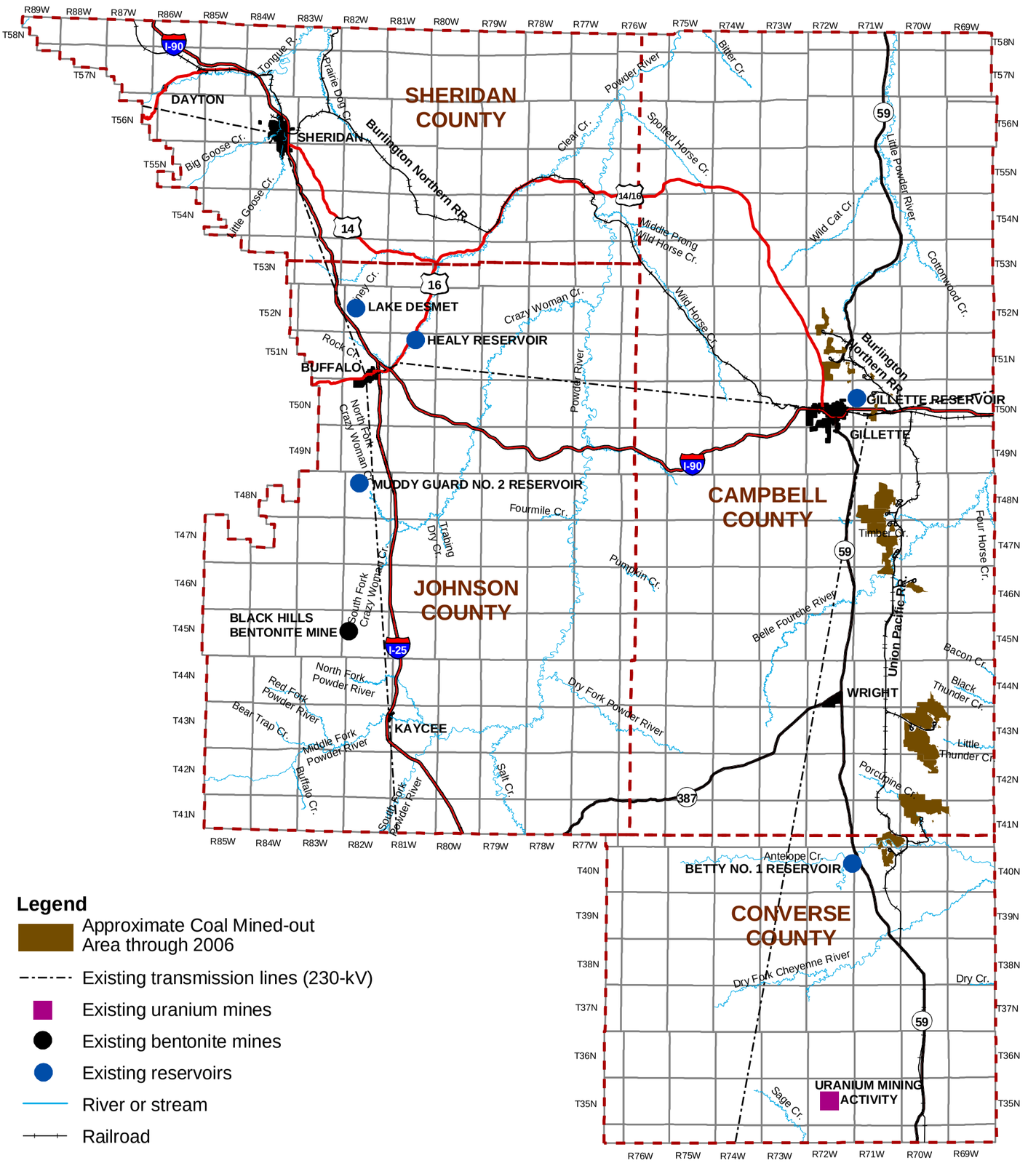
Several new transmission line projects currently are under consideration in or adjacent to the PRB at present. These include:

- Wyoming-Colorado Intertie (previously known as the TOT-3) - multiple sponsors including the WIA, proposed from the PRB to the Colorado Front Range
- TransWestern Express - multiple sponsors, proposed from the southern PRB to Arizona, either through Colorado or Utah
- High Plains Express - proposed from the southern PRB through Colorado to New Mexico and Arizona
- Gateway West - proposed by PacifiCorp from the southern PRB to Idaho
- Gateway South - proposed by PacifiCorp from the southern PRB to Nevada
- Northern Lights - proposed by TransCanada from the southern PRB to Nevada

All but the Wyoming-Colorado Intertie project have a proposed terminus, requiring construction of a substation/grid interties, in the vicinity of the Dave Johnston power plant near Glenrock, Wyoming.

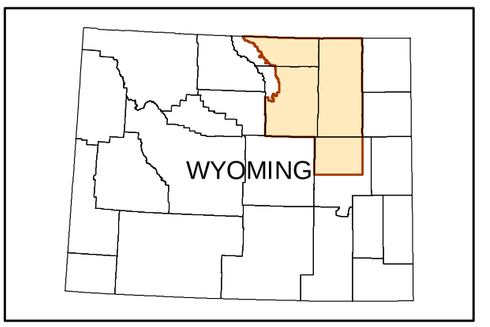
It is anticipated that during the timeframe of this study (through 2020), as many as four major new transmission lines would be built within the PRB; one major transmission line constructed running south to Colorado markets, one running south into Colorado then westward, and two heading westward or to the southwest. Markets would dictate the size and timing of such facilities, although several of the projects have progressed beyond the basic feasibility analysis. For example, an open-season for the Wyoming-Colorado Intertie project, which essentially allows power companies to bid for capacity on the line and ultimately determines its fate, was held in early 2008. The two PacifiCorp projects are intended to address the firm's long-term market demands in its service territory and are considered highly likely (WIA 2007, 2008; PacifiCorp 2008).

However, based on the lack of specific alignment information for these transmission lines, the relatively limited length of corridors located in the PRB study area, and the minimal amount of long-term disturbance following post-construction reclamation, they are not analyzed further in this study.



Legend

- Approximate Coal Mined-out Area through 2006
- Existing transmission lines (230-kV)
- Existing uranium mines
- Existing bentonite mines
- Existing reservoirs
- River or stream
- Railroad



N W E S

0 8 16 24 Miles

0 8 16 24 Kilometers

Note: Transmission line corridors are approximate.

Sources: BLM 2003, 2009; HKM et al. 2002 a, b; Western Electric Coordinating Council 2004; WDEQ 2004.

Powder River Basin Coal Review

Figure 3-4
Existing Transmission Lines, Other Mines, and Reservoirs

11/09/09

3.7.3 Data Sources

Information relative to RFD transmission line projects was based on information provided by the WIA and posted on various government and industry websites.

3.7.4 Assumptions

Past and Present Development: No assumptions relative to past and present transmission lines have been identified.

RFD:

- It is assumed that the Wyoming-Colorado Intertie would be completed in 2012/13 and that it would include a length of approximately 130 miles within the Wyoming PRB study area, beginning at the Wyodak generating station.
- It is assumed that PacifiCorp's Gateway West project would be constructed in the 2011/2013 timeframe.
- It is assumed that PacifiCorp's Gateway South and one other transmission line would be constructed post-2015.
- Depending on the final alignments, it is assumed that short segments of the two other transmission lines potentially could be included in the PRB study area, depending on the locations of substations/grid interties.
- It is assumed that the long-term disturbance associated with future construction of transmission lines in the PRB would be minimal.

3.8 Other Mines

3.8.1 Past and Present Development

Past and present uranium, sand, gravel, bentonite, clinker, and scoria mines exist in the Wyoming PRB study area. There are three defined uranium districts in the PRB, including Pumpkin Buttes, Southern Powder River, and Kaycee (BLM 2003a). Numerous uranium mining sites occurred in these districts; however, they were mined out or uneconomic. Uranium currently is produced via the in situ leach method in the Southern Powder River district at Smith Ranch and Highland/Morton Ranch (Harris 2003) (**Figure 3-4**).

There are several bentonite localities in the PRB study area, and bentonite is mined at Kaycee (Wyoming Mining Association 2008) (**Figure 3-4**).

The more important aggregate mining localities are in Johnson and Sheridan counties (Wyoming State Geological Survey/U.S. Geological Survey [USGS] 2004). The largest identified aggregate

operation is located in the Lighting Creek subwatershed. It has an associated total disturbance area of approximately 67 acres, of which 4 acres have been reclaimed. The remainder of the identified operations are relatively small (less than 5 acres each) and are scattered throughout Campbell and Converse counties.

Scoria or clinker (which is formed when coal beds burn and the adjacent rocks become baked) is used as aggregate where alluvial gravel or in-place granite/igneous rock is not available. Scoria generally is mined in the Converse and Campbell counties portion of the Wyoming PRB study area.

The smaller operations are not considered further in this study due to the lack of information relative to their specific locations and the low overall associated acreage (approximately 100 acres), which per subwatershed would be minimal.

3.8.2 Reasonably Foreseeable Development

Increased sand, gravel, and scoria production and associated surface disturbance are anticipated in the Wyoming PRB study area in the future. The likelihood of increased production of these materials is high, as aggregate would be required for road maintenance and new construction activities. As other primary resources (e.g., coal and oil and gas) are developed, aggregate would need to be produced to support these ongoing activities. New quarries and increased production from existing operations are expected. It is anticipated that these operations would vary in size based on the immediate need from the primary industries. However, based on the lack of specific information relative to related impact-causing parameters, these activities are not analyzed further in this analysis.

In the original Task 2 report (ENSR 2005b), RFD uranium development was eliminated from further consideration because: 1) there were no specific projects with pending applications and 2) no development was anticipated, based on market conditions. Due to increased overall demand for energy in recent years, uranium prices have increased from a low of $7.00 a pound in 2001 to over $138 a pound in 2007 (Barry 2008). The price fell precipitously after that, but appears to be stabilizing at approximately $75 per pound.

In response to the increased price of uranium, a number of uranium mine developments currently are proposed in the Wyoming PRB study area (**Table 3-2**). These include seven new proposed developments, two proposed expansions, and one proposed restart, all of which would use in situ recovery. Most of the proposed developments are in the Pumpkin Buttes uranium district in southwestern Campbell County. The actual number of the proposed developments that would become operational would depend on several factors including price and approval of permits.

It is assumed that bentonite mining would continue throughout the study period. It is anticipated that production would continue from existing active mines, with no new mines developed through 2020.

3.8.3 Data Sources

The information for past, present, and RFD sand, gravel, scoria, and uranium operations was obtained from public information available through WDEQ, USNRC, and industry-related websites. Where operations are large enough to file annual reports, acreages of disturbance and reclamation

were tabulated. Information relative to bentonite mines was based on WDEQ/LQD permit information and annual reports.

Table 3-2
U.S. Nuclear Resources Commission Applications for In Situ Recovery Uranium Projects in the Wyoming PRB Study Area

Project/Company	Location	Type Application	Subwatershed/ Mining District	Likelihood/ Rationale
Moore Ranch/Uranium One (formerly Energy Metals Corporation)	T41-42N, R74-75W; Campbell and Converse counties	New	Antelope Creek, Upper Powder River/Pumpkin Buttes District	Moderate for 2010/application filed with U.S. Nuclear Regulatory Commission (USNRC) October 2007
Nichols Ranch-Hank Unit/ Uranerz	Nichols Ranch: T43N, R76W; Campbell and Johnson counties Hank Unit: T43-44N, R75W; Campbell County	New	Upper Powder River/Pumpkin Buttes District	Moderate for 2010/ applications filed with USNRC and WDEQ
Christensen Ranch/Cogema	T44N, R76W; Johnson County	Restart	Upper Powder River/Pumpkin Buttes District	Moderate for 2010/USNRC application pending, received April 2007
Smith Ranch/Cameco (Power Resources)	T36N, R74W; Converse County	Expansion	Middle North Platte River/South Powder	Moderate for 2015/expansion of existing facility, letter of intent March 2008, application expected 2009
North Butte/Cameco	T44N, R76W; Campbell County	Expansion	Upper Powder River/Pumpkin Buttes District	Moderate for 2015/letter of intent to USNRC March 2008, application expected 2009
Collins Draw/Uranerz	T42N, T43N, R76W; Campbell County	New	Upper Powder River/Pumpkin Buttes District	Moderate for 2015/letter of intent to USNRC March 2008, application expected 2009
Ludeman-Allemand-Ross/Uranium One	Converse County	New	Antelope Creek	Moderate for 2015/letter of intent to USNRC March 2008, application expected 2009
Ruby Ranch/Cameco	T43N, R75W; Campbell County	New	Upper Belle Fouche River/Pumpkin Buttes District	Moderate for 2015/letter of intent to USNRC March 2008, application expected 2009
Reno Creek/Strathmore Minerals Corporation	T43N, R73; Campbell County	New	Upper Belle Fourche River, Antelope Creek/Pumpkin Buttes District	Moderate for 2015/letter of intent to USNRC March 2008, application expected 2010
Southwest Reno Creek/Strathmore Minerals Corporation	T42-43N, R73-74W	New	Antelope Creek/Pumpkin Buttes District	Speculative/no information on applications available.

Sources: Strathmore Minerals Corporation 2008; USNRC 2008a,b,c; World Information Service on Energy 2007.

3.8.4 Assumptions

In addition to the information obtained from the identified data sources, the following assumptions were used to define specific impact-causing parameters for sand, gravel, scoria, and uranium mines:

Past and Present Development: No assumptions relative to past and present sand, gravel, scoria, or uranium mines have been identified.

RFD:

- It is assumed that growth in demand for aggregates for use as construction materials would occur.

- It is assumed that demand for uranium would encourage the development of in situ leach method recovery facilities. Currently three projects have a likelihood rating of moderate for 2010; six projects have a likelihood rating of moderate for 2015.

- It is assumed that any new uranium mining would be conducted by in situ leach method recovery, not surface or underground mining.

- A nominal 40 acres of long-term disturbance for each uranium in situ recovery project is assumed (International Atomic Energy Agency 2005).

3.9 Oil and Gas

3.9.1 Past and Present Development

3.9.1.1 Conventional Oil and Gas

Early oil exploration in the PRB was based on direct evidence of surface seeps or drilling anticlinal structures that were exposed on the surface. Oil was first produced from the PRB in 1887 from the Newcastle Formation on the east side of the basin near Moorcroft, Wyoming (MacGregor 1972). In 1889, oil seeps led to the discovery of oil production at Shannon Field on the north end of the Salt Creek anticline. In 1908, the crest of the anticline was drilled resulting in the discovery of the Salt Creek Oil Field. Salt Creek had produced over 669 million barrels (bbls) of oil to the end of 2002 and is still in production. The discovery of Salt Creek led to the drilling of other large anticlines located on the southern periphery of the basin. Big Muddy was discovered in 1916, and Lance Creek was discovered in 1918 (WOGCC 2004).

During the 1930s, low prices depressed exploration in the basin. After World War II, a new round of exploration began with extensive use of seismic surveys to look for structural traps that could not be readily verified from surface mapping (McGregor 1972). Also in the early 1950s, stratigraphic trapping of oil was discovered in the Newcastle Sandstone on the east side of the basin. A number of other Cretaceous reservoirs formed by stratigraphic trapping were discovered in the 1950s; however, with a few exceptions, drilling generally was confined to relatively shallow targets. In the

late 1950s, oil production was found in sandstones of the Minnelusa Formation. Minnelusa production has been prolific over the years with the main production fairway being in the northeast portion of the basin. However, the Minnelusa equivalents ("Leo" Sands) also produce on the southeast side of the basin. Pennsylvanian rocks also produce along the basin axis in the western part of the basin.

In the 1960s and 1970s, drilling moved into deeper parts of the basin that resulted in the discovery of some prolific oil fields in stratigraphic traps in upper and lower Cretaceous rocks (McGregor 1972). The discovery of giant Bell Creek in 1967 (reserves greater than 150 million barrels of oil from the Muddy Sandstone) on the Montana side of the basin set off a wave of exploration that resulted in a number of discoveries in Wyoming in the Muddy Sandstone (Drew 1990). Such Muddy fields included Recluse, Kitty, and Highlight. Drilling continued for deeper targets and resulted in the discovery of upper Cretaceous fields such as House Creek, Hartzog Draw, Holler Draw, and Jepson Draw, all characterized by long narrow reservoirs that were deposited as marine bars. Stratigraphic traps in upper Cretaceous rocks remained as prime targets for drillers in the late 1970s into the early 1980s with discoveries such as Well Draw and Scott Field, located in southern Converse County. The Minnelusa also provided a mainstay for wildcat drillers during that time period.

Very little conventional oil and gas activity has occurred in the last 15 years in the study area, and only approximately 1,500 wells were drilled from 1990 to 2003. The 1,500 wells include producing, injection, and wildcat (exploration) wells. The only significant discovery has been the African Swallow Field, discovered in 2000, which produced over a million barrels of oil and 14 billion cubic feet (BCF) of gas from two wells by the end of 2003 (WOGCC 2004).

As of the end of 2003, there were approximately 3,500 productive conventional oil and gas wells in the Wyoming PRB study area plus 1,386 seasonally active wells (IHS 2004). **Figure 3-5** shows the location of all wells (producing, non-producing, and plugged and abandoned). Approximately 13 million barrels of oil and 41 BCF of conventional gas (20.24 million barrels of oil equivalent [BOE]) were produced from these wells in 2003 based on WOGCC (2004) data; IHS (2004) data report approximately 13 million barrels of oil and approximately 40 BCF of conventional gas. The USGS (2002) estimated that the mean undiscovered non-coal bed hydrocarbon resource in the PRB (including Montana) is 1.8 BOE.

By the end of 2007, there were approximately 3,857 productive conventional oil and gas wells in the Wyoming PRB study area plus an estimated 1,500 seasonally active wells (IHS 2008). Approximately 11.4 million barrels of oil and 22.0 BCF of conventional gas were produced from these wells in 2007 based on WOGCC (2008) data.

3.9.1.2 CBNG

CBNG activity began in the 1980s, however it took a number of years before commercially viable production was established. A total of three Applications for Permit to Drill (APDs) were issued in 1986 for CBNG wells in Campbell County (WOGCC 2004). The first commercial gas production directly from coal seams occurred in 1989 at Rawhide Butte north of Gillette (Debruin and Jones 1989). Annual submission of APDs did not exceed 100 until 1992 when 110 APDs were filed. By the late 1990s, after commercially viable production was proven, the number of APDs submitted began to soar: 561 in 1996, 808 in 1997, 1,494 in 1998, and 5,101 in 1999 (WOGCC 2004). In the

1-year period from June 2003 to May 2004, over 6,700 APDs were received statewide by the WOGCC.

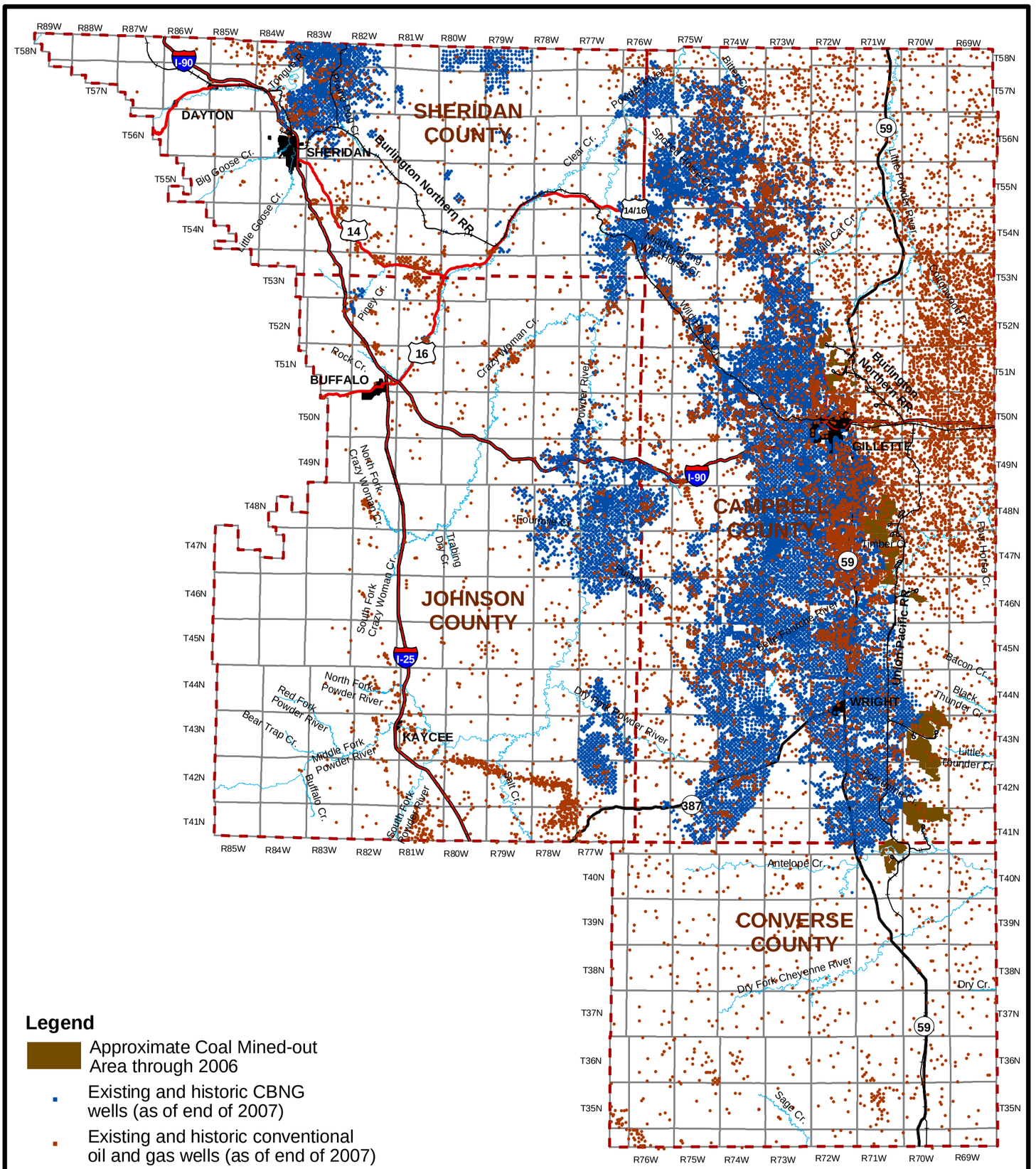
The initial coal bed development in the early 1990s was concentrated in the area between Gillette and Wright, Wyoming, and SRs 59 and 50 in the Marquiss and Lighthouse project areas (Flores et al. 2001). The development soon moved out of that area and spread to the west and northwest. At the end of 2003, there were 14,758 producing CBNG wells in the study area (IHS 2004), and total production for 2003 was 346 BCF, or 88 percent of the total gas production from the basin (WOGCC 2004). From 1987 to 2003, the total cumulative gas production from PRB coals was over 1.2 trillion cubic feet. The total water production for the same time period was approximately 2.3 billion barrels. Annual methane production has increased rapidly since 1999 and as of 2003 appeared to have started to level off or even decrease. Water production decreased slightly; however, it still was more than 500 million barrels during 2003. In 2003, the average CBNG production was 900 million cubic feet per day (MMcfpd) (Holcomb 2003). CBNG production appeared to have peaked from a high of 977 MMcfpd in October 2003 to 899 MMcfpd in March 2004 (Oil and Gas Journal 2004). In 2007, the annual CBNG production was 432 MMcf. CBNG wells in the Wyoming PRB study area as of the end of 2007 are shown in **Figure 3-5**.

3.9.2 Reasonably Foreseeable Development

Conventional oil and gas and CBNG development does not fit in the capital project likelihood of occurrence classifications as discussed in Section 2.1. Oil and gas exploration and development have inherent characteristics that set it apart from other capital projects. These characteristics include the following:

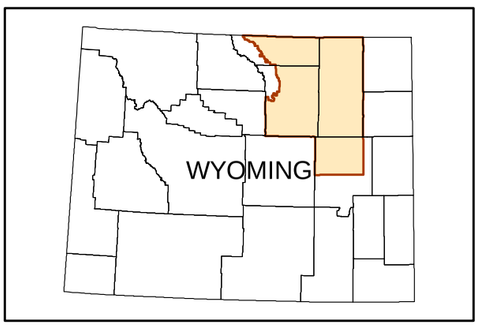
- The activities are conducted by multiple companies or entities;
- The activities cover broad geographic areas;
- Generally, permitting can take place in a relatively short timeframe compared to other capital projects;
- The activities are extremely price sensitive and, therefore, hard to predict over long periods of time; and
- Technological advancements can be rapidly implemented resulting in sudden increases of activity in a relatively short period of time.

The probability for new oil and gas activities (including CO_2 enhanced oil recovery [EOR] and associated pipelines) to occur in the future is a certainty; however, the level of activity is uncertain. The following discussions of reasonably foreseeable activity for conventional oil and gas and CBNG are estimates of the level of activity that could be expected to occur, based on recent trends analyzed for this study and the methodology and assumptions presented in Appendix E.



Legend

- Approximate Coal Mined-out Area through 2006
- Existing and historic CBNG wells (as of end of 2007)
- Existing and historic conventional oil and gas wells (as of end of 2007)
- Perennial stream
- Railroad



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Source: BLM 2009; IHS 2008.

Powder River Basin Coal Review

Figure 3-5

Existing and Historic Oil and Gas Wells

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3.9.2.1 Conventional Oil and Gas

Table 3-3 summarizes the projected production, number of wells, and long-term disturbance associated with conventional oil and gas development through 2020. From 1990 to 2004, a total of approximately 1,500 wells were drilled in the study area (IHS 2004). Of those, 60 percent were development wells drilled in established producing areas. The other 40 percent of wells were classified as wildcat wells or wells drilled outside of producing areas or wells drilled to test non-producing prospective zones in producing areas. Of the wildcat wells, approximately 75 percent were plugged and abandoned. From 1990 through 2003, new field wildcat wells resulted in the discovery of 61 new fields that provided 719,000 barrels of oil and 1.45 BCF of non-CBNG in 2003 (WOGCC 2004).

Table 3-3
Projection of Conventional Oil and Gas Activity

Wells and Production	Actual		Projected		
	2003	2007	2010	2015	2020
Annual Gas Production (BCF)	39.9	22.0	42.7	39.0	35.1
Annual Oil Production (million barrels)	12.9	11.4	15.7	14.3	12.9
Active Wells	5,067[1]	3,857[2]	5,603	5,115	4,625
Inactive Wells	1,994	0[3]	954	563	332

[1] The total includes approximately 1,500 seasonally active wells.
[2] The total includes approximately 1,500 seasonally active wells and an unknown number of inactive wells.
[3] Unknown.

In a departure from the trend of the last 15 years, it is expected that the increases in oil prices would reverse the decline in oil production, with production increasing and peaking at approximately 18.5 million barrels (BLM Reservoir Management Group [RMG] 2005). (Refer to Appendix E for assumptions used in well numbers, production, and disturbance projections.)

The active wells identified in **Table 3-3** include wells that produce year-round, seasonally producing wells, and service wells (mainly injection wells). It was estimated that in 2005 there were approximately 2,000 idle conventional oil and gas wells in the PRB study area (WOGCC 2005a); however, these wells gradually have been and would continue to be reduced through aggressive plugging programs, and the idle well locations (once the wells are abandoned) would be reclaimed and no longer represent a disturbance.

A typical drilling location, including access road, is assumed to initially disturb approximately 2.75 acres. Long-term disturbance at existing well sites is assumed to be 2.0 acres, following partial reclamation (BLM 2003a). If a well is abandoned, the entire disturbance area is reclaimed. If a well is productive, a portion of the disturbance area is reclaimed initially, with final reclamation occurring at the end of production.

It is certain that conventional oil and gas exploration and development would continue, but at a rate far below previous levels in the basin's history. If the trends of the last 10 to 15 years are indicative

of future activity, conventional oil and gas would continue to be produced but at ever decreasing rates.

The USGS (2002) estimated that the mean undiscovered non-coal bed hydrocarbon resource in the PRB (including Montana) is 1.8 billion BOE. This number indicates that the PRB, as well as the study area, has a potentially important non-coal bed hydrocarbon resource base. Whether that resource is exploited is dependent upon a number of factors. At present, the economics favor the shallow and easier exploitable CBNG resource. The low oil prices and preferential investment in CBNG resources probably has resulted in the investment into other plays in the basin, with an associated decline of oil and non-CBNG activity over the past 15 years. If the non-coal bed resource is to be exploited to any great degree in the future, industry would have to invest in those plays. As the CBNG play moves into maturity, and if oil prices stabilize over $45 per barrel, then oil and non-CBNG resources potentially could become attractive exploration targets. However, it is not likely that the PRB ever would reach a producing rate of 30 million barrels of oil per year again (BLM 2001).

As of the end of 2004, there were no readily available data concerning incremental production data from CO_2 flooding (WOGCC 2004). There is a potential for additional EOR activity in the study area, but so far the projects that have been conducted are pilot scale and involve the “huff and puff” process whereby the gas is brought to individual injection wells by tanker truck. Possible EOR candidates in the PRB include Harzog Draw, House Creek, Hilight, Raven Creek, Rozet, Kitty, Gas Draw, and Recluse Fields (DeBruin 2001). These fields could qualify for EOR because they had 50 million barrels or more of original oil in place; however, many smaller fields also could qualify. The potential for additional EOR activity would be dependent upon the availability of a CO_2 source. Wyoming has a large resource of CO_2 produced from the La Barge Anticline in the Green River Basin. There also are abundant CO_2 resources at the Madden Unit in the Wind River Basin. In total, Wyoming has a CO_2 production capacity in excess of 500 MMcfpd (DeBruin 2001). Pipelines would need to be constructed to transport this available CO_2 into the PRB (see Section 3.10, Pipelines). The State of Wyoming has a severance tax break of 2 percent on oil produced from WOGCC-approved CO_2 EOR projects to encourage producers to take advantage of the CO_2 resource and to encourage oil production. However, there are no proposals to extend the CO_2 pipeline that ends at Salt Creek and Sussex Fields in the near term (the next 5 years). The likelihood rating of any such CO_2 EOR project would be low, since the CO_2 pipeline at Salt Creek originally was proposed to end at Hartzog Draw (DeBruin 2002).

3.9.2.2 CBNG

The future of CBNG development is highly sensitive to the price of gas. For a number of years, Wyoming natural gas production has been affected by the so-called price differential. The price differential is the difference in the gas price at the Opal and Cheyenne hubs in Wyoming and the national benchmark price recorded at the Henry Hub in Louisiana. The differential results when there is inadequate pipeline capacity to move Rocky Mountain region gas to markets outside of the area. Historically, the differential has been as high as $2.40 per million British thermal units (MMbtus) (Holcomb 2003) (1 thousand cubic feet [Mcf] is roughly equivalent to 1 MMBtus). This disparity in price has resulted in an estimated loss of more than $2 billion dollars to producers and attendant fiscal impacts for state and federal governments (Holcomb 2004). The lack of interstate pipeline transmission capacity in Wyoming is cited as the major reason for the price differential. The differential was somewhat eased in 2003 with the opening of the Kern River Pipeline expansion that

moves gas from southwestern Wyoming, northwestern Colorado, and northeastern Utah. At that time, the differential went from $1.86 per MMbtus to $0.60 per MMbtus (Holcomb 2004). However, the addition of the Kern River system capacity did not completely solve the differential problem.

The consequences of the price differential were researched by Advanced Resources, International (ARI) (2002). ARI evaluated the impacts to the CBNG resource associated with various water disposal methods. ARI (2002) also evaluated the effects of three price scenarios on the CBNG resource as follow:

- Under a status quo price scenario (basin price differential of $1.80 per Mcf), the economically recoverable CBNG resource only would be 1.5 trillion cubic feet (Tcf), with the primary water disposal option being surface discharge. No other disposal options were economical under this price scenario. ARI (2002) states that much of this development already has occurred, and if the differential does not change, not much increase in development would be expected.

- In a transitional price scenario, where the basin differential narrows to $0.80 per Mcf after a number of years and beyond, variable amounts of the resource would be economical for a number of disposal options. Under this scenario, the economically recoverable resource ranges were projected to be 22.4 Tcf with surface discharge, 20.0 Tcf with impoundment infiltration, 18.8 Tcf with shallow re-injection, and 7.1 to 10.2 Tcf with active treatment.

- In the third scenario, the basin differential immediately would go to $0.80 per Mcf. Under this scenario, the economically recoverable resource ranges would be 29.1 Tcf with surface discharge, 27.8 Tcf with impoundment infiltration, 27.1 Tcf with shallow re-injection, and 17.8 to 2.6 Tcf with active treatment.

In the Final EIS and Proposed Plan Amendment for the PRB Oil and Gas Project (BLM 2003a), the preferred alternative favored the disposal of produced CBNG water in infiltration impoundments to be accompanied by groundwater and surface water monitoring, except in the Belle Fourche and Cheyenne River drainages where direct discharge to ephemeral streams was allowed. The disposal of produced coal bed water in infiltration impoundments would fit with the second or third ARI scenarios described above. The recoverable CBNG resource would be in the range of 20 to 29 Tcf if the price differential remains at $0.80 per Mcf or less, and gas prices in general remain at reasonable long-term levels ($3.56 per Mcf or equivalent to crude oil at $25 per barrel). In spite of recent record highs for crude oil, the long-term forecast (10 years or more) for crude oil prices is expected to be around $25 per barrel (Winnecke 2003). The size of the differential would be dependent upon the magnitude of production capacity in the Wyoming PRB and available pipeline capacity to deliver the gas to external markets. As a comparison to the ARI estimate, the USGS (2002) estimated that the undiscovered CBNG resource in the PRB is 14.3 Tcf.

The amount of CBNG activity appears to be at a lower rate than was forecast by earlier projections in the Final EIS and Proposed Plan Amendment for the PRB Oil and Gas Project (BLM 2003a). New CBNG well numbers fell from a high of slightly more than 4,600 in 2001 to approximately 2,000 in 2004. It is anticipated that the number of new wells would increase so that between 2010 and 2020 the number of new wells drilled per year basin-wide would range between 2,892 to 3,943. (Refer to Appendix E for assumptions used in the analysis of CBNG activity.) As shown in **Table 3-4**, there would be 31,943 CBNG wells basin-wide by 2010, much lower than the over 40,000 wells predicted for the same time period in the Final EIS and Proposed Plan Amendment for

the PRB Oil and Gas Project (BLM 2003a). It is anticipated that production in the cumulative effects study area would increase from the 432 BCF per year observed in 2007 to approximately 1,026 BCF per year in 2020.

Table 3-4
Projection of CBNG Activity

Wells and Production	Actual		Projections		
	2003	2007	2010	2015	2020
Annual Production (BCF)	338	432	708	1,005	1,026
Active Wells	14,758	20,408	31,943	42,980	42,108

3.9.3 Data Sources

The data and information for conventional oil and gas and CBNG resource development projections were derived from several sources including: WOGCC on-line well files, BLM public documents, IHS well data, Wyoming Geological Survey publications, and the BLM Wyoming State Office RMG.

3.9.4 Assumptions

Assumptions relative to past and present and reasonably foreseeable oil and gas activity are presented in Appendix E.

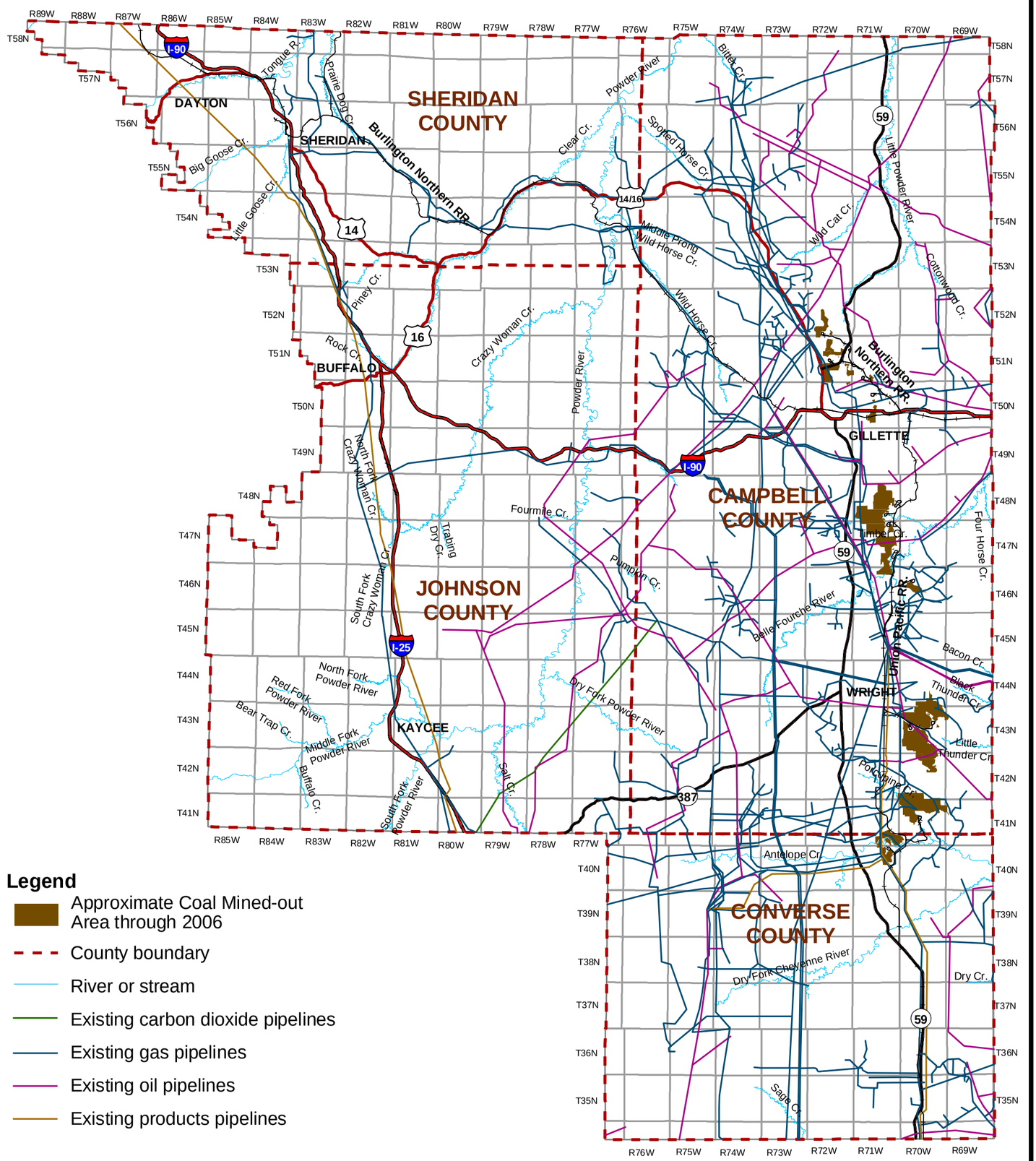
3.10 Pipelines

3.10.1 Past and Present Development

Major transportation pipelines for the transport of product to outside markets are a key factor in the development of CBNG and conventional oil and gas resources in the Wyoming PRB study area. Major transportation pipelines also provide for transport of CO_2 to crude oil well fields, which depend somewhat on the availability of CO_2 for EOR. Since preparation of the original Task 2 report (ENSR 2005b), no major natural gas transportation lines have been constructed in the Wyoming PRB study area. Currently, there are over 13 major transportation pipeline systems in the PRB that transport gas resources to markets outside of the basin (Flores et al. 2001; Wyoming Pipeline Authority 2008). The current capacity of these pipeline systems is approximately 2.1 BCF per day. Currently, the combined natural gas production (CBNG and conventional gas) in the Wyoming PRB study area is approximately 1.22 BCF per day. As shown in **Figure 3-6**, there also are numerous oil, gas, and products pipelines in the study area. Gathering lines associated with conventional oil and gas and CBNG development also occur within the study area; for purposes of this study, these gathering lines have been factored in proportionally on a per well basis as discussed in Appendix E.

3.10.2 Reasonably Foreseeable Development

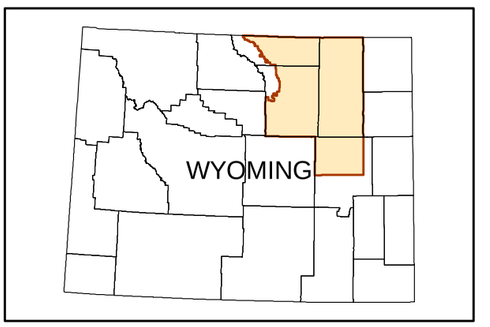
The availability of major transportation pipeline capacity is a key factor in the future development of CBNG and conventional gas resources in the Wyoming PRB study area. Increased recovery of crude oil also may depend somewhat on the availability of CO_2 for EOR projects.



Legend

- Approximate Coal Mined-out Area through 2006
- County boundary
- River or stream
- Existing carbon dioxide pipelines
- Existing gas pipelines
- Existing oil pipelines
- Existing products pipelines

Note: Existing pipelines as of end of 2007.



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Source: BLM 2009; Debruin 2002.

Powder River Basin Coal Review

Figure 3-6
Existing Pipelines

11/11/09

Currently, there are two proposed natural gas transportation pipeline projects (Bison and Pathfinder) that would cross the study area (**Figure 3-7** and **Table 3-5**). Northern Border Pipeline (50 percent owner of the proposed Bison Pipeline Project) was actively seeking shippers through an open season that began in April 2008 (TC Pipelines 2008). The Bison Pipeline would originate in the Wyoming PRB study area and transport gas from the PRB to outside markets. The proposed Pathfinder Pipeline Project would cross the Wyoming PRB study area; however, its main supply of gas would come from the Green River Basin, where it would originate. An open season for Pathfinder also commenced in April 2008 (TransCanada 2008). It is possible that an interconnect at Dead Horse Creek might provide an outlet for PRB-produced gas into Pathfinder. Beyond the Wyoming PRB study area, these projects essentially would parallel one another to the interconnect with Northern Border's main pipeline in North Dakota. Since these projects would be interstate gas transportation pipelines, they would be regulated by the FERC. Although FERC lists these projects as "on the horizon" (FERC 2008), no formal applications have been filed with the regulatory agencies (FERC 2008; WDEQ 2008). Both of these projects are dependent upon acquisition of sufficient support in the open season process. Based on the lack of formal applications, their likelihood currently is considered low.

Table 3-5
Proposed Pipeline Projects in the Wyoming PRB Study Area

Project/Company	Location	Product	Description	Watersheds	Likelihood
Bison/Northern Border Pipeline	Campbell County	Natural gas	24-inch, 289-mile pipeline, 400 to 660 MMcfpd, from Dead Horse Creek, Wyoming, to Morton County, North Dakota.	Upper Powder River (12 miles), Upper Belle Fouche River (15 miles), Little Powder River (30 miles), Little Missouri River (5 miles).	Low. Project previously was proposed but not constructed due to market uncertainties. Project now has firm shipper (Anadarko); however, submittal of FERC application is pending. In-service estimate of 2010.
Pathfinder/Trans-Canada	Campbell and Johnson counties	Natural gas	42-inch, 500-mile, 1.2 to 2.0 BCF per day, from Wamsutter, Wyoming, to Morton County, North Dakota.	Salt Creek (15 miles), Upper Powder River (57 miles), Little Powder River (51 miles).	Low. FERC application expected in 2009. In-service estimate of 2010.

Sources: FERC 2008; TC Pipelines 2008; TransCanada 2008.

There currently are proposed and construction in-progress natural gas transportation pipeline projects that would not cross the Wyoming PRB study area; however, they would influence the ability of PRB gas producers to access outside markets. These projects are the Alliance Pipeline (a

42-inch-diameter natural gas pipeline proposed from Wamsutter, Wyoming, to Emerson, Manitoba) and the Rockies Express (from Rio Blanco County, Colorado, to Monroe County, Ohio) (Rockies Express Pipeline LLC 2008; Wyoming Pipeline Authority 2008). The Alliance Pipeline is expected to commence construction in 2012, with a proposed in-service date sometime in 2013. Rockies Express Pipeline (western segment from western Colorado to Missouri) was in-service in January 2008. The expected in-service date for the eastern segment (Missouri to Ohio) is October 2011. Although important to PRB gas producers, because these projects would not cross the Wyoming PRB study area, they are not considered further in this analysis.

In the original Task 2 report (ENSR 2005b), reported estimates of the growth of Wyoming PRB CBNG production ranged from a 2003 level of 900 MMcfpd to 3 to 4 BCF per day around 2007, and it was anticipated that production would remain at or above those levels until 2015 (Holcomb 2003). However, production rates of 3 to 4 BCF per day were not realized by 2007, and the average daily production for all gas (conventional and CBNG) was approximately 1.22 BCF per day (WOGCC 2008). Average CBNG production in 2007 was approximately 1.24 BCF per day. The addition of the Bison Pipeline Projects would increase the take-away capacity of the PRB by approximately 0.5 BCF per day, resulting in total take-away capacity for the basin of approximately 2.55 BCF per day. The addition of the Pathfinder Pipeline Project would increase the take-away capacity by approximately an additional 1.6 BCF per day, for a total of approximately 4.15 BCF per day. Based on the assumptions in Appendix E, the projected total gas production (conventional and CBNG) would increase to 2.06 BCF per day in 2010, 2.86 BCF per day in 2015, and 2.91 BCF per day in 2020. Therefore, likelihood for additional new pipeline construction for 2010 is low, with a higher likelihood in subsequent years.

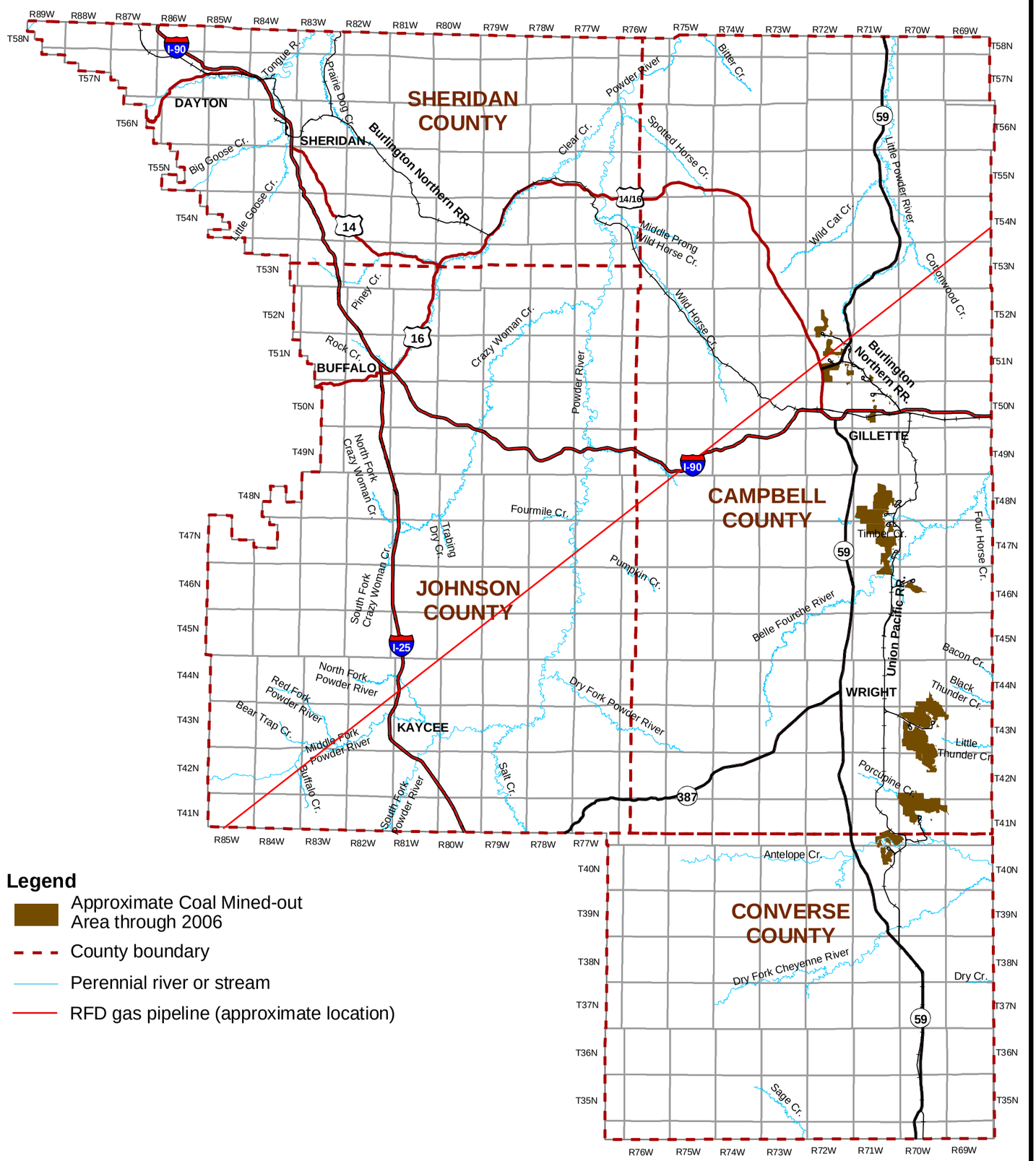
In the original Task 2 report (ENSR 2005b), it was indicated that Anadarko Petroleum Corporation was planning to extend its CO_2 pipeline that runs between Bairoil, Wyoming, and Salt Creek, Wyoming, to the Sussex Field located in the southern Johnson County portion of the Wyoming PRB study area. However, more recent information indicates that this has not occurred (Anadarko Petroleum Corporation 2008). According to the Wyoming Enhanced Oil Recovery Institute, fields in the Wyoming PRB study area that would be good candidates for EOR using CO_2 include Hartzog Draw, Hilight, and House Creek (Boyles and vant Veld 2006). Since no CO_2 projects have been proposed for construction in the Wyoming PRB study area, they are not considered further in this analysis.

3.10.3 Data Sources

Information on major natural gas transportation pipelines was derived from FERC website data, the Wyoming Pipeline Authority website, applicant websites, BLM documents, and published sources.

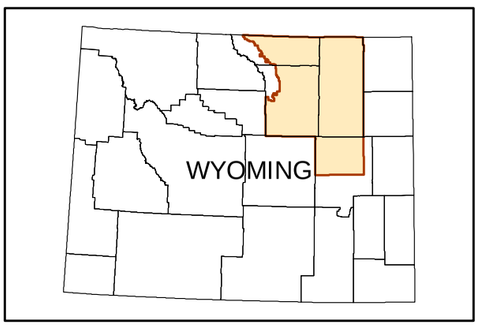
3.10.4 Assumptions

In addition to the information obtained in the identified data sources, the following assumptions were used to define specific impact-causing parameters for pipelines:



Legend

- Approximate Coal Mined-out Area through 2006
- County boundary
- Perennial river or stream
- RFD gas pipeline (approximate location)



N W E S

0 8 16 24 Miles

0 8 16 24 Kilometers

Source: BLM 2009; Debruin 2002; FERC 2004.

Powder River Basin Coal Review

Figure 3-7

RFD Major Pipelines

11/11/09

Past and Present Development:

- Present pipeline capacity out of the PRB is 2.1 BCF per day, and daily production as of 2007 was 1.24 BCF.

- It is assumed that existing pipeline rights-of-way have a disturbance width of 50 feet, which conservatively accounts for access roads, ground-disturbing maintenance activities, and permanent facilities (e.g., compressor stations, valves, etc.) located at intervals along the rights-of-way.

- In the study area, there are 2,672 miles of natural gas transportation pipelines, 906 miles of crude oil pipelines, 210 miles of petroleum product pipelines, and 37 miles of CO_2 pipeline.

RFD:

- Any new major transportation pipelines would incur a disturbance area based on an average construction right-of-way width of 100 feet during the year of construction. It is assumed that in subsequent years there would be a potential right-of-way disturbance width of 50 feet, which conservatively accounts for access roads, ground-disturbing maintenance activities, and permanent facilities (e.g., compressor stations, valves, etc.) located at intervals along the rights-of-way.

3.11 Refineries

3.11.1 Past and Present Development

Construction of a new refinery was completed in the Wyoming PRB study area in 2008. The NorthCut Refinery, owned and operated by Interline Resources, is located in Converse County, approximately 20 miles north of the town of Douglas, Wyoming. Construction of the refinery, which was a conversion of the previously existing Well Draw Gas Plant, included installation of a crude oil pipeline between the company's existing crude gathering system and the refinery.

The NorthCut Refinery is a crude oil topping plant, specifically engineered to process 4,000 barrels per day of sweet crude produced in the PRB. Output from the refinery will include naptha, off-road diesel, and reduced crude oil. The markets for the products include ethanol manufacturers, mines, and other refineries. The company-owned crude oil pipeline and third-party tanker trucks will be used for delivery of crude stocks. Tanker trucks also will be used to transport finished products from the facility (Interline Resources 2008).

The refinery is adjacent to and east of SH 59, with the joint UP/BNSF rail line located just to the west of the highway. The site previously had been the location of the Well Draw Gas Plant (approximately 20 acres), which shut down in 2002 following a fire. Interline has acquired an additional 12 acres bordering the original site for administrative, maintenance, and transportation-related uses (Interline Resources 2008).

3.11.2 Reasonably Foreseeable Development

The level and composition of outputs from the existing NorthCut Refinery would respond to various markets, potentially resulting in the construction of additional infrastructure and/or facilities in the future. Any future changes and associated disturbances would occur within the property currently owned by Interline Resources at the NorthCut site (Williams 2008). No specific plans for expansion currently have been identified. As a result, the likelihood for project expansion currently is considered speculative. Therefore, it has been eliminated from further analysis in this study.

No other reasonably foreseeable plans for construction and operation of new petroleum refineries in the Wyoming portion of the PRB have been identified.

3.11.3 Data Sources

Data sources that were reviewed for potential information relative to refineries in the Wyoming PRB study area included databases maintained by the USDOE Energy Information Administration and WDEQ, input from the Cambell County Economic Development Corporation (CCEDC) and Wyoming Business Council, and online internet data searches. Information relative to the NorthCut Refinery was obtained from Interline Resources.

3.11.4 Assumptions

In addition to the information obtained from the identified data sources, the following assumptions were used to define specific impact-causing parameters for refineries:

Past and Present Development: There are no assumptions for past and present refineries.

RFD:

- It is assumed that potential additional expansion at the NorthCut Refinery would be within the currently owned 32-acre site.

3.12 Reservoirs and Other Water Developments

Reservoirs in the PRB study area were identified based on the Powder/Tongue River Basin Water Plan (HKM et al. 2002a) and Northeast Wyoming River Basins Water Plan (HKM et al. 2002b). These plans, which encompass the PRB study area, were prepared for the Wyoming Water Development Commission for their Basin Planning Program. The plans identified the key water supply reservoirs (generally 1,000 acre-feet or greater) in these basins; industrial ponds and impoundments were not addressed in the plans.

Industrial ponds or impoundments associated with mining and CBNG development occur within the study area. For purposes of this study, impoundments associated with coal mining activity have been accounted for in the mine-related disturbance areas. The disturbance area associated with CBNG-related impoundments has been factored in on a per well basis as discussed in Appendix E. As of 2000, there were a total of 1,976 stock water ponds in the study area (BLM 2003a); however,

based on the assumed low overall associated acreage per subwatershed, they have been eliminated from further analysis.

3.12.1 Past and Present Development

Currently, there are 14 key water storage reservoirs in the Powder/Tongue River Basin and 5 key water storage reservoirs in the Northeast Wyoming River Basins (HKM Engineering et al. 2003a,b). Three of the key water storage reservoirs located in the Powder/Tongue River Basin planning area (Healy, Lake Desmet, and Muddy Guard No. 2) and two of the key water storage reservoirs in the Northeast Wyoming River Basins planning area (Gillette and Betty No. 1) occur in the Wyoming PRB study area (**Figure 3-4)**. These reservoirs provide for irrigation water and recreational activities.

3.12.2 Reasonably Foreseeable Development

Based on the Powder/Tongue River Basin Water Plan (HKM Engineering et al. 2002a) and the Northeast Wyoming River Basins Water Plan (HKM Engineering et al. 2002b) that were prepared for the Wyoming Water Development Commission for its Basin Planning Program, there are long-range projections for development of additional reservoirs in the Wyoming PRB study area. However, no new reservoirs are currently proposed (Besson 2008); therefore, their likelihood is currently considered speculative. As a result, they have been eliminated from further analysis.

3.12.3 Data Sources

Information presented in the Powder/Tongue River Basin Water Plan (HKM Engineering et al. 2002a) and the Northeast Wyoming River Basins Water Plan (HKM Engineering et al. 2002b) was used to develop the reservoirs and other water developments section of this report. These plans were developed for the Wyoming Water Development Commission for their Basin Planning Program. Information also was obtained directly from the Wyoming Water Development Commission.

3.12.4 Assumptions

No assumptions were required for this study to define specific impact-causing parameters for reservoirs and water developments.

3.13 Other Industrial Manufacturing

3.13.1 Past and Present Development

There are a number of existing industrial manufacturing and service establishments located in the Wyoming PRB study area. Most are relatively small with fewer than 50 employees, and most serve local and regional markets, the majority of which are directly or indirectly related to energy resource development and production. Hettinger Welding and L&H Welding and Machine, both based in Gillette, are the largest industrial manufacturing firms in the region specializing in repairs, rebuilding,

and manufacturing for the mining industry. Though classified as wholesalers and repair establishments, rather than as manufactures, firms such as Wyoming Machinery and P&H Mining Equipment also serve the mining and oil and gas industries. Other industrial manufacturing and service establishments in the region provide metal fabrication, metal plating, custom and precast concrete products, and specialized chemical products and services (Dun & Bradstreet 2008). Over the years, some of these firms have expanded such that they now support activities and serve markets outside the PRB region. However, they remain dependent upon the local and regional markets to sustain their existing operations.

3.13.2 Reasonably Foreseeable Development

Local economic development organizations, including CCEDC and Converse Area New Development Organization (CANDO) are continually engaged in efforts to recruit or assist new business formation in the PRB study area. For example, CANDO is pursuing development of an ammonium nitrate plant (using methane as a feedstock) in the Bill, Wyoming, area, as well as location of an aluminum mill in the same general location. These and similar prospects are long-term potential whose outcomes are uncertain and for which little information and detail are available. As a result, they have been eliminated from analysis in this study.

3.13.3 Data Sources

Information relative to potential major industrial development was obtained from state and local business and economic development organizations.

3.13.4 Assumptions

There are no assumptions relative to other industrial manufacturing.

3.14 Other Development

3.14.1 Past and Present Development

In addition to the specific projects and developments described above, the PRB hosts a vast network of additional public and private physical infrastructure, private businesses, and public activities that has developed over time. Examples of infrastructure include the highway and road networks, airports, government offices, hospitals, public schools, municipal water systems, and extensive residential and commercial real estate development. Private enterprises include local retail and service establishments, newspaper publishing, and transportation and distribution firms.

The construction, maintenance, and continuing operations associated with this network of development represent an extensive series of public and private investments, as well as changes in land use, surface disturbances, water consumption, and the factors that characterize local air quality. Those investments and changes have occurred over a period of time and in response to many different influences.

3.14.2 Reasonably Foreseeable Development

There are numerous current and anticipated plans for future investment in public and private infrastructure in the PRB. Such investments would include state and local investment in transportation, administrative, and educational facilities. A number of planned investments are summarized below. Given the timing, scale, year-to-year variability, relatively short construction timetables associated with such public investments, the existence of a relatively large and diversified construction industry in the region and nearby areas, and the limited potential for these projects to alter long-term conditions in the PRB, they are not included in the RFD database. However, one or more of these and similar projects could warrant consideration in a cumulative analysis for a site-specific project due to proximity or coincidental project schedules and timetables.

3.14.2.1 Highways and Airports

Public highways and airports are important components of the public infrastructure in the PRB. The Wyoming Department of Transportation (WYDOT) prepares an annual State Transportation Improvement Program (STIP) based on an ongoing process of needs assessment, priority rating, fiscal analysis, and manpower analysis. The 2008 STIP includes planned construction for the 2008 fiscal year and preliminary engineering estimates for projects with anticipated construction dates through 2013. In general, Wyoming transportation projects scheduled over the next 6 years include maintenance, reconstruction, and improvement projects. Airport improvement plans consist primarily of pavement rehabilitation and overlays, with some minor expansion of taxiways, aprons, and parking. No construction of new highways is scheduled, and no new airports are proposed.

The estimated 2008 through 2013 construction costs for highway and airport maintenance, reconstruction, improvement projects, and preliminary engineering studies in the study area total approximately $219.5 million, of which $55.6 million was obligated toward projects in fiscal year 2008. Overall, these activities primarily include reconstruction, overlays, widenings, and bridge replacements, as opposed to new construction. Approximately $19.6 million of the total is obligated for airport improvements, the majority of which are planned for airports in Sheridan and Gillette. The level of construction and location of the projects included in these estimates would vary from year to year, and the actual completion of projects funded in a given year may extend into subsequent years (WYDOT 2008).

In addition to highway projects included in the 2008 STIP, the Eagle Butte Mine is proposing the relocation of U.S. Highway 14/16 in the vicinity of the Gillette/Campbell County Airport, north of the City of Gillette. The relocation is proposed to facilitate the recovery of approximately 40 million tons of additional coal recently acquired by the mine through a LBA coal sale. Three alternative alignments, involving the construction of up to 6.8 centerline miles of new roadway, have been identified. Assuming an affirmative decision to proceed with relocation, construction of the new highway segment is anticipated in 2011/2012 (WYDOT and Foundation Coal Company 2008). The likelihood for the relocation is considered moderate under both the upper and lower production scenarios.

3.14.2.2 Other Public Facilities

Local governments, school districts, and other special service districts and public entities continually engage in long-term planning. A vital element of such planning assesses the condition of existing facilities and infrastructure and outlines a capital improvement plan to ensure adequate capacity to meet future needs, and in some case to provide new services to residents and businesses, Capital improvement plans reflect a balance between needs and available funding resources. Constrained fiscal times tend to focus spending on maintenance of core administrative, utility, and transportation facilities. Increases in anticipated revenues generally allow more consideration to service expansion, community development, parks and recreation, and other more "discretionary" projects. Depending on a community's fiscal health and resources, capital spending may be funded by transfers from general tax revenues, a local option sales and use tax, ad valorem tax revenues generated by a specific electorate approved mill levy, or state and federal governmental grants. The cumulative level of capital investment spending can be substantial; however, individual projects are seldom sufficiently extensive enough to warrant analysis in the RFD scenario. Such is the case at present. Examples of some of the larger public projects that recently have been completed, are ongoing, or anticipated in the near future are listed below:

- A new $10 million headquarters for the Campbell County Fire Department providing administrative, training, and storage space in addition to multiple parking bays for firefighting apparatus.

- An expansion and renovation of the county courthouse were completed in 2006, and a new public health building was completed in 2007.

- Expansion of the county's detention center and remodeling of the sheriff's office were undertaken in 2007.

- A $55 million county recreation center is being planned, with opening expected in 2010.

- Construction for a major expansion of the CAM-Plex conference and multi-event center was initiated in 2006 and completed in 2008. The expansion includes more exhibit space, conference and indoor athletic facilities with seating for up to 9,000, an indoor ice rink, and various concession and support spaces.

- Multiple transportation and drainage system improvements by the City of Gillette.

- Completion of a wastewater treatment facility upgrade and completion of water system improvements.

- The city completed construction of a new Health Sciences Center at Gillette College. The facility will house the school's nursing program, providing classrooms, labs, faculty offices, and other spaces. The nursing program functions in conjunction with the Campbell County Memorial Hospital.

- The county, city, and Gillette College are partnering on a Campus Housing Complex and Industrial Technical Education Center. These facilities are part of a long-range master plan for

the college that is designed to provide a broad college-level curriculum and provide more focused education and training to support local business and industry.

- Campbell County Memorial Hospital is in the planning stage for a major expansion and renovation project (City of Gillette 2008).

- The Wyoming School Facilities Commission (WSFC) oversees all aspects of construction and maintenance of school facilities and physical plant. School districts submit 5-year plans for facilities spending, which are subject to approval and funding by the WSFC. Currently approved master plans for the seven school districts serving some portion of the Wyoming PRB study area include defined needs for more than $115 million in capital construction, some of which have already been funded (WSFC 2008). The total includes approximately $51 million for the Campbell County School District, the bulk of which would fund three new elementary schools and one new high school (WSFC 2008).

3.14.2.3 General Industrial and Commercial Development

Additional private sector industrial and commercial development is expected to occur within the context of normal community and economic development. With the strong economic base provided by the coal mines, oil and gas companies, and power plant construction, major goals for local economic development currently include workforce recruitment and training, diversification of the economic base, expansion of retail trade and personal services to serve the growth in consumer demand, and development of affordable housing. The strong growth and relatively high income of residents is being used to recruit regional and national retailers (e.g., The Home Depot) to the area. Gillette's location on I-90 and the strong demand for lodging by energy workers, travelers, and visitors associated with events at the CAM-Plex also have spurred construction of several new motels (CCEDC 2008; City of Gillette 2008).

While these economic stimuli are collectively noteworthy in the context of local economic development, there is no single employer or event warranting inclusion in the RFD analysis.

3.14.3 Data Sources

Information regarding public sector infrastructure plans was compiled from published state and local documents and discussions with local officials.

3.14.4 Assumptions

- It is assumed that a portion of U.S. Highway 14/16 would be relocated to accommodate coal mining activities at the Eagle Butte Mine under both the upper and lower production scenarios. Mining of coal from a recently acquired LBA tract is projected to begin in 2013/2014. Pending WYDOT approval to proceed with the relocation, it is assumed highway construction would occur in 2011/2012. For purposes of this analysis, it is assumed that the relocation would involve approximately 2.7 miles of miles of new construction, with a right-of-way width of 100 feet.

- Any new surface disturbance associated with highway and airport maintenance projects (e.g., resurfacing) would be minimal or would involve previously disturbed lands that have since been revegetated.

- New surface disturbance associated with future public infrastructure and private commercial and industrial development would be limited and occur primarily within or adjacent to the presently urbanized areas in the study area.

3.15 Relationship Among Projects

Many of the energy-related and industrial projects in the PRB study area are interdependent. In addition, many of the RFD activities in the PRB are interrelated or dependent upon other types of industries to provide the necessary infrastructure to support their development and operation. For example, coal mines are dependent on rail lines with sufficient capacity to transport coal to power plants outside of the PRB, or on the presence of mine-mouth coal-fired power plants. Power plants in turn are dependent on the availability of sufficient transmission line capacity for the transport of electricity to markets. The oil and gas industry is dependent upon the availability of sufficient transportation pipeline capacity for the transport of product to markets outside of the basin. Alternately, some of the identified projects are related from the standpoint of resource impacts, such as the potential cumulative effects of groundwater drawdown associated with the coal mine and CBNG industries. As a result, the PRB Coal Review has included the array of projects identified above to define the development limitations that exist as a result of their interdependency (a factor in determining the likelihood for development of the RFDs) and to fully analyze the potential impacts in the study area.

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APPENDIX A

SUPPORTING TABLES AND FIGURES – COAL MINE SUBREGIONS

Table A-1
Wyoming PRB Coal Development by Subregion
Impact-causing Parameters under the Lower Production Scenario[1]
(based on database)

Subregion	Annual Production for Most Recent Report Year (million tons)	Cumulative Disturbed Area for Year (acres)	Cumulative Permanently Reclaimed Areas through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas Available for Reclamation through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas Unavailable for Reclamation through Most Recent Report Year (acres)	Total Employment for Report Year	Annual Water Consumption (mmgpy)	Annual Water Production (acre-feet)
Original Base Year (Actual 2003)								
Subregion 1	55	12,047	3,054	3,360	5,633	746	387	191
Subregion 2	77	21,249	6,783	6,107	8,359	861	544	447
Subregion 3	232	35,498	11,401	13,992	10,105	3,090	1,709	748
Total for 2003 Actual	**364**	**68,794**	**21,238**	**23,459**	**24,097**	**4,697**	**2,640**	**1,386**
Current Base Year (Actual 2007)								
Subregion 1	78	14,421	3,658	8,342	5,781	1,032	351	191
Subregion 2	100	23,630	6,441	12,353	9,273	1,424	544	447
Subregion 3	250	45,542	15,785	31,577	11,941	3,077	1,709	748
Total for 2007 Actual	**428**	**83,593**	**25,884**	**52,272**	**24,338**	**5,533**	**2,604**	**1,386**
Reasonably Foreseeable Development (2010)								
Subregion 1	62	15,231	5,004	3,968	6,260	787	628	165
Subregion 2	95	28,021	12,183	6,830	9,008	1,323	50	675
Subregion 3	254	55,410	27,751	16,588	11,070	3,153	1,115	1,419
Total for 2010	**411**	**98,662**	**44,938**	**27,386**	**26,338**	**5,263**	**1,793**	**2,258[2]**
Reasonably Foreseeable Development (2015)								
Subregion 1	74	17,457	6,654	4,202	6,601	830	724	165
Subregion 2	112	32,356	15,683	7,314	9,359	1,369	458	675
Subregion 3	281	67,423	38,851	16,983	11,589	3,186	1,277	1,419
Total for 2015	**467**	**117,236**	**61,188**	**28,499**	**27,549**	**5,405**	**2,059**	**2,258[2]**
Reasonably Foreseeable Development (2020)								
Subregion 1	78	19,729	8,429	4,350	6,950	840	456	165
Subregion 2	126	36,994	19,683	7,589	9,723	1,476	72	675
Subregion 3	291	80,720	51,351	17,243	12,124	3,215	1,334	1,419
Total for 2020	**495**	**137,443**	**79,463**	**29,182**	**28,797**	**5,531**	**2,162**	**2,258[2]**

[1]Applies to both the Task 1D and Task 3D study areas (**Figures C-1** and **D-1**, respectively).
[2]Slight differences are due to rounding.

Table A-2
Wyoming PRB Coal Development by Subregion
Impact-causing Parameters under the Upper Production Scenario[1]
(based on database)

Subregion	Annual Production for Most Recent Report Year (million tons)	Cumulative Disturbed Area for Year (acres)	Cumulative Permanently Reclaimed Areas through Most Recent Report Year(acres)	Cumulative Unreclaimed Areas Available for Reclamation through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas Unavailable for Reclamation through Most Recent Report Year (acres)	Total Employment for Report Year	Annual Water Consumption (mmgpy)	Annual Water Production (acre-feet)
Original Base Year (Actual 2003)								
Subregion 1	55	12,047	3,054	3,360	5,633	746	387	191
Subregion 2	77	21,249	6,783	6,107	8,359	861	544	447
Subregion 3	232	35,498	11,401	13,992	10,105	3,090	1,709	748
Total for 2003 Actual	**364**	**68,794**	**21,238**	**23,459**	**24,097**	**4,697**	**2,640**	**1,386**
Current Base Year (Actual 2007)								
Subregion 1	78	14,421	3,658	8,342	5,781	1,032	351	191
Subregion 2	100	23,630	6,441	12,353	9,273	1,424	544	447
Subregion 3	250	45,542	15,785	31,577	11,941	3,077	1,709	748
Total for 2007 Actual	**428**	**83,593**	**25,884**	**52,272**	**24,338**	**5,533**	**2,604**	**1,386**
Reasonably Foreseeable Development (2010)								
Subregion 1	78	15,911	5,404	4,217	6,290	811	788	165
Subregion 2	117	29,279	13,416	7,536	8,328	1,375	58	675
Subregion 3	284	57,258	27,951	18,236	11,070	3,153	1,184	1,419
Total for 2010	**479**	**102,448**	**46,771**	**29,989**	**25,688**	**5,339**	**2,030**	**2,258[2]**
Reasonably Foreseeable Development (2015)								
Subregion 1	104	18,490	7,329	4,500	6,660	905	492	165
Subregion 2	138	35,624	18,616	8,248	8,760	1,431	75	675
Subregion 3	301	70,431	39,451	19,391	11,589	3,186	1,333	1,419
Total for 2015	**543**	**124,545**	**65,396**	**32,139**	**27,009**	**5,522**	**1,897**	**2,258[2]**
Reasonably Foreseeable Development (2020)								
Subregion 1	121	21,311	9,529	4,766	7,013	1,019	880	165
Subregion 2	148	42,981	25,016	8,758	9,206	1,444	86	675
Subregion 3	307	84,797	51,651	21,021	12,124	3,215	1,437	1,419
Total for 2020	**576**	**149,089**	**86,196**	**34,545**	**28,345**	**5,678**	**2,403**	**2,258[2]**

[1] Applies to both the Task 1D and Task 3D study areas (**Figures C-1** and **D-1**, respectively).
[2] Slight differences are due to rounding.

Table A-3
Montana PRB Coal Development by Subregion
Impact-causing Parameters under the Lower Production Scenario
(based on database)

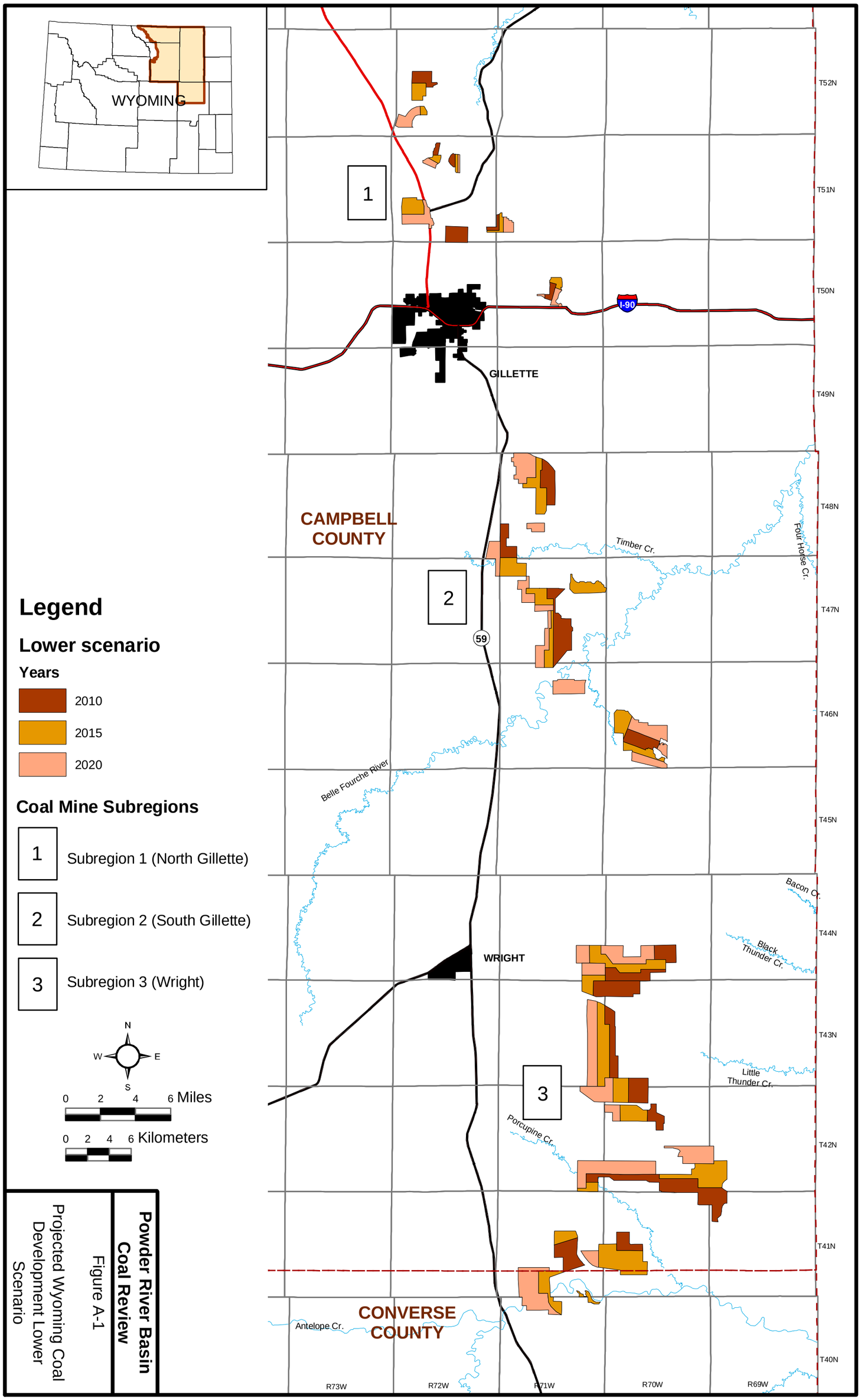
Subregion	Annual Production for Most Recent Report Year (million tons)	Cumulative Disturbed Area for Year (acres)	Cumulative Permanently Reclaimed Areas through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas Available for Reclamation through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas Unavailable for Reclamation through Most Recent Report Year (acres)	Total Employment for Report Year	Annual Water Consumption (mmgpy)	Annual Water Production (acre-feet)
Original Base Year (Actual 2003)								
Subregion 4	17	12,054	2,474	6,151	3,430	277	122	0
Subregion 5	19	33,355	11,318	19,149	2,888	456	141	0
Total for 2003 Actual	**36**	**45,409**	**13,792**	**25,300**	**6,318**	**733**	**263**	**0**
Current Base Year (Actual 2007)								
Subregion 4	23	13,401	2,729	13,081	3,393	277[1]	122	0
Subregion 5	21	37,558	12,991	27,026	2,577	456[1]	141	0
Total for 2007 Actual	**44**	**50,959**	**15,720**	**40,107**	**5,970**	**773**[1]	**263**	**0**
Reasonably Foreseeable Development (2010)								
Subregion 4	16	13,270	3,614	6,206	3,450	239	115	0
Subregion 5	20	36,462	15,718	17,836	2,908	432	144	0
Total for 2010	**36**	**49,732**	**19,332**	**24,042**	**6,358**	**671**	**259**	**0**
Reasonably Foreseeable Development (2015)								
Subregion 4	24	14,829	4,614	6,555	3,660	345	173	0
Subregion 5	20	38,782	18,924	16,941	2,918	411	144	0
Total for 2015	**44**	**53,611**	**23,538**	**23,496**	**6,578**	**756**	**317**	**0**
Reasonably Foreseeable Development (2020)								
Subregion 4	30	16,478	5,914	6,868	3,695	443	231	0
Subregion 5	20	41,359	22,303	16,730	2,327	391	144	0
Total for 2020	**50**	**57,837**	**28,217**	**23,598**	**6,022**	**834**	**375**	**0**

[1] For purposes of this study, it was assumed that 2007 employment numbers were the same as for 2003.

Table A-4
Montana PRB Coal Development by Subregion
Impact-causing Parameters under the Upper Production Scenario
(based on database)

Subregion	Annual Production for Most Recent Report Year (million tons)	Cumulative Disturbed Area for Year (acres)	Cumulative Permanently Reclaimed Areas through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas Available for Reclamation through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas Unavailable for Reclamation through Most Recent Report Year (acres)	Total Employment for Report Year	Annual Water Consumption (mmgpy)	Annual Water Production (acre-feet)
Original Base Year (Actual 2003)								
Subregion 4	17	12,054	2,474	6,151	3,430	277	122	0
Subregion 5	19	33,355	11,318	19,149	2,888	456	141	0
Total for 2003 Actual	**36**	**45,409**	**13,792**	**25,300**	**6,318**	**733**	**263**	**0**
Current Base Year (Actual 2007)								
Subregion 4	23	13,401	2,729	13,081	3,393	277[1]	122	0
Subregion 5	21	37,558	12,991	27,026	2,577	456[1]	141	0
Total for 2007 Actual	**44**	**50,959**	**15,720**	**40,107**	**5,970**	**733**[1]	**263**	**0**
Reasonably Foreseeable Development (2010)								
Subregion 4	22	13,613	3,614	6,549	3,450	298	159	0
Subregion 5	21	36,582	15,718	17,957	2,908	416	152	0
Total for 2010	**43**	**50,195**	**19,332**	**24,506**	**6,358**	**714**	**311**	**0**
Reasonably Foreseeable Development (2015)								
Subregion 4	40	16,149	4,764	7,801	3,068	436	288	0
Subregion 5	24	39,181	18,880	17,233	3,885	518	174	0
Total for 2015	**64**	**55,330**	**23,644**	**25,034**	**6,953**	**954**	**462**	**0**
Reasonably Foreseeable Development (2020)								
Subregion 4	37	17,249	5,979	7,635	3,635	431	266	0
Subregion 5	36	42,466	22,302	17,538	2,627	615	260	0
Total for 2020	**73**	**59,715**	**28,281**	**25,173**	**6,262**	**1,046**	**526**	**0**

[1] For purposes of this study, it was assumed that 2007 employment numbers were the same as for 2003.

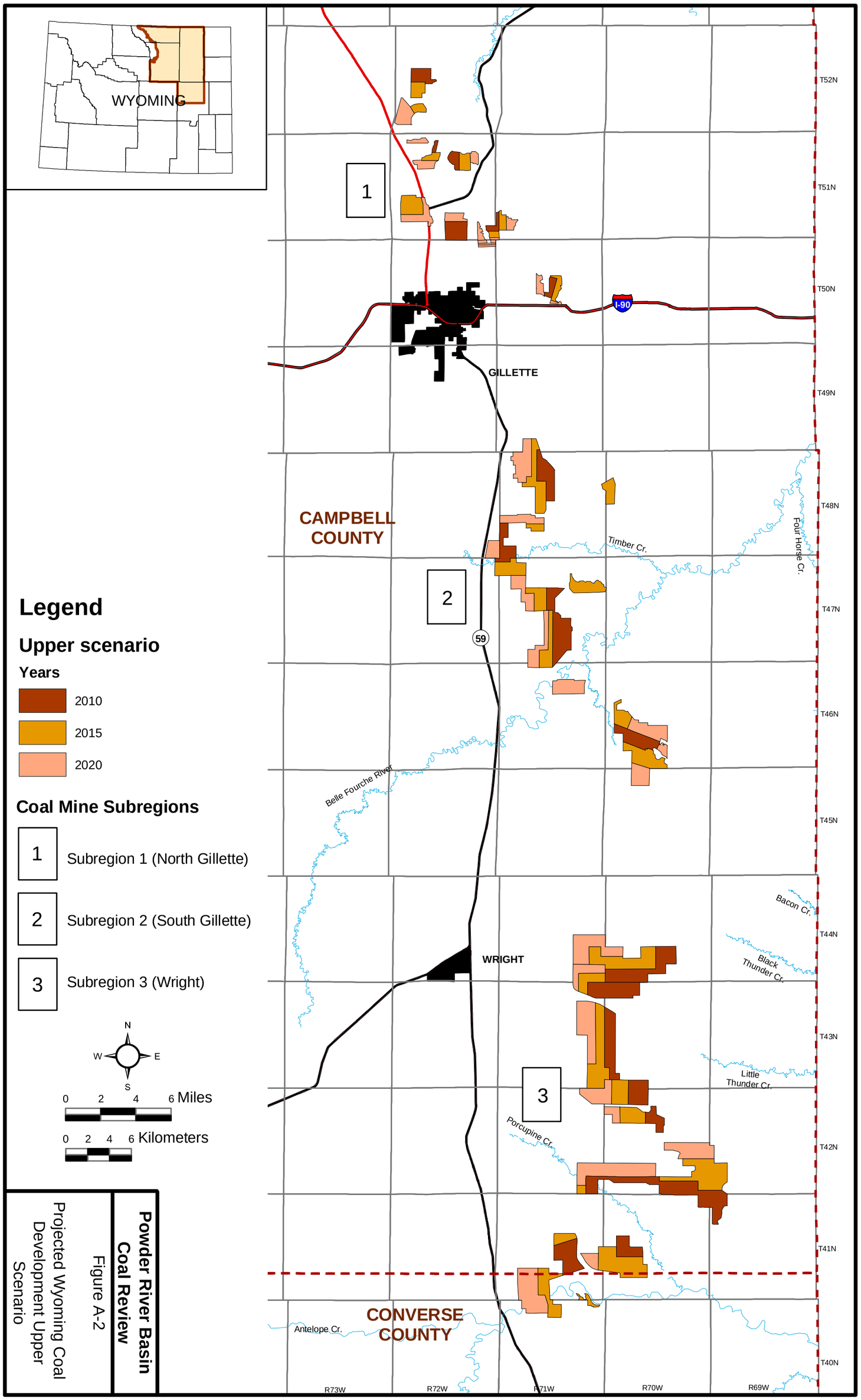


Powder River Basin Coal Review

Figure A-1

Projected Wyoming Coal Development Lower Scenario

11/11/09

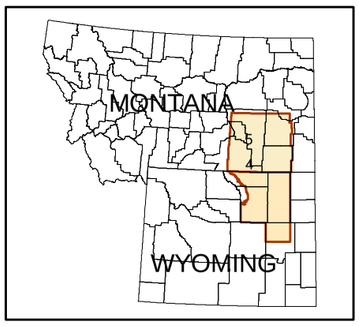


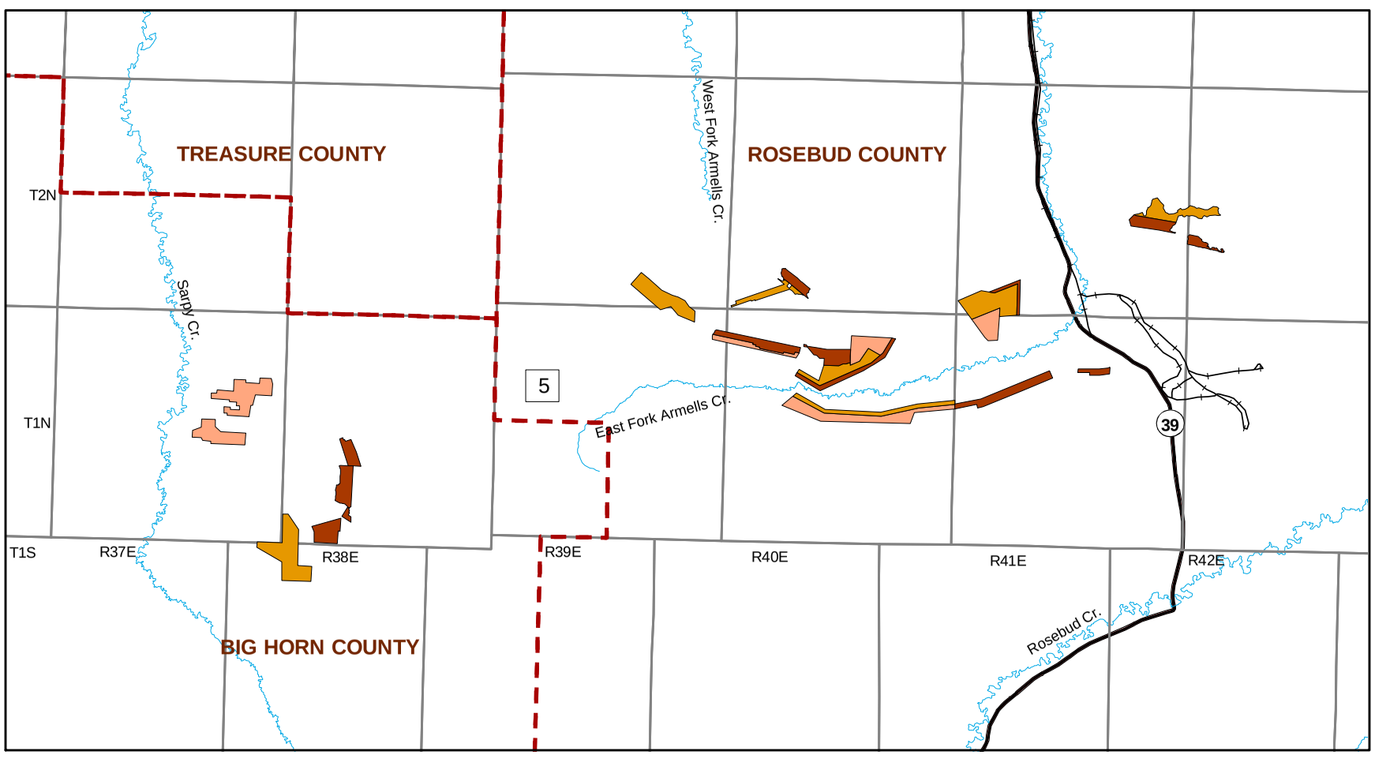
Powder River Basin Coal Review

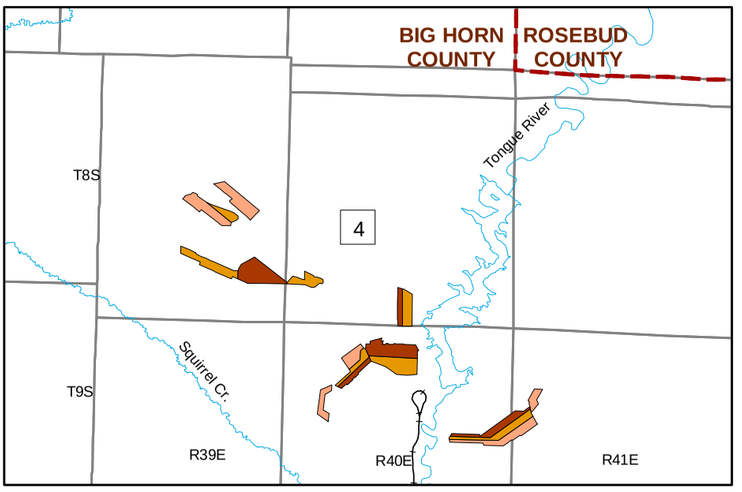
Figure A-2

Projected Wyoming Coal Development Upper Scenario

11/09/09







Legend

Lower Scenario

Years

- 2010
- 2015
- 2020

Coal Mine Subregions

- 4 Subregion 4 (Sheridan/Decker)
- 5 Subregion 5 (Ashland/Colstrip)

N
W E
S

0 2 4 6 Miles

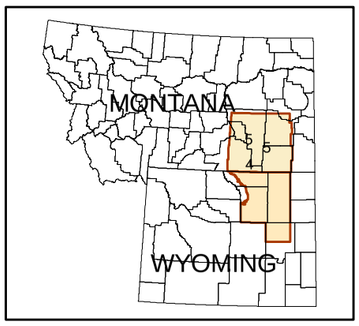
0 2 4 6 Kilometers

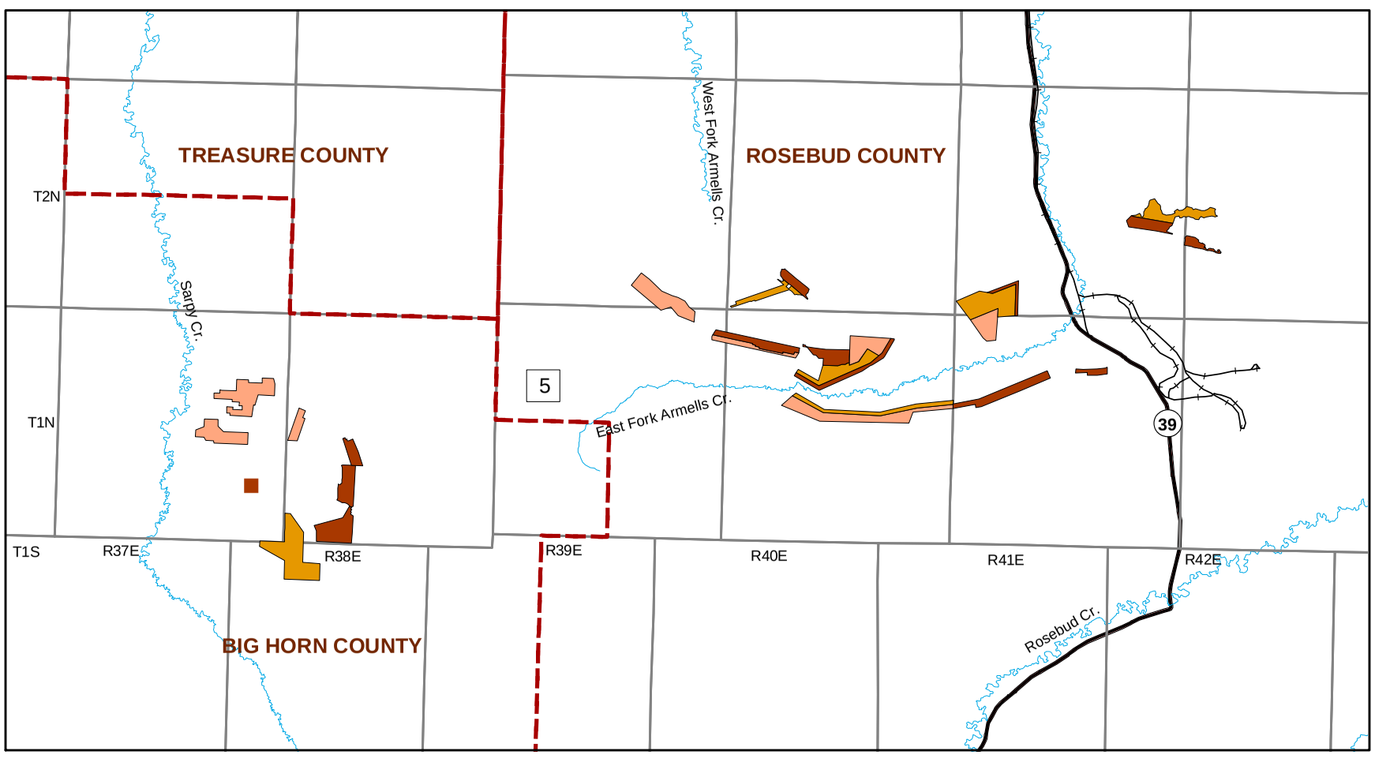
Powder River Basin Coal Review

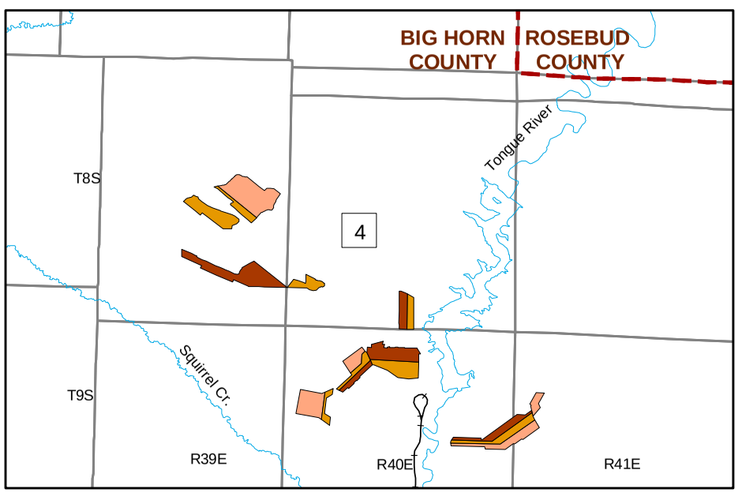
Figure A-3

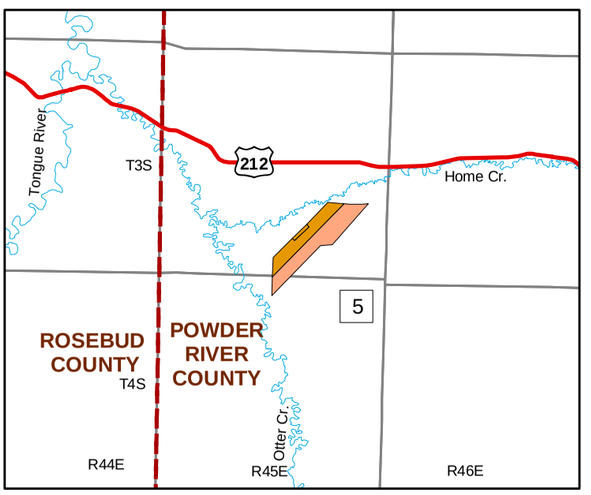
Projected Montana Coal Development Lower Scenario

11/11/09









Legend

Upper Scenario

Years

- 2010
- 2015
- 2020

Coal Mine Subregions

- 4 Subregion 4 (Sheridan/Decker)
- 5 Subregion 5 (Ashland/Colstrip)

N
W E
S

0 2 4 6 Miles

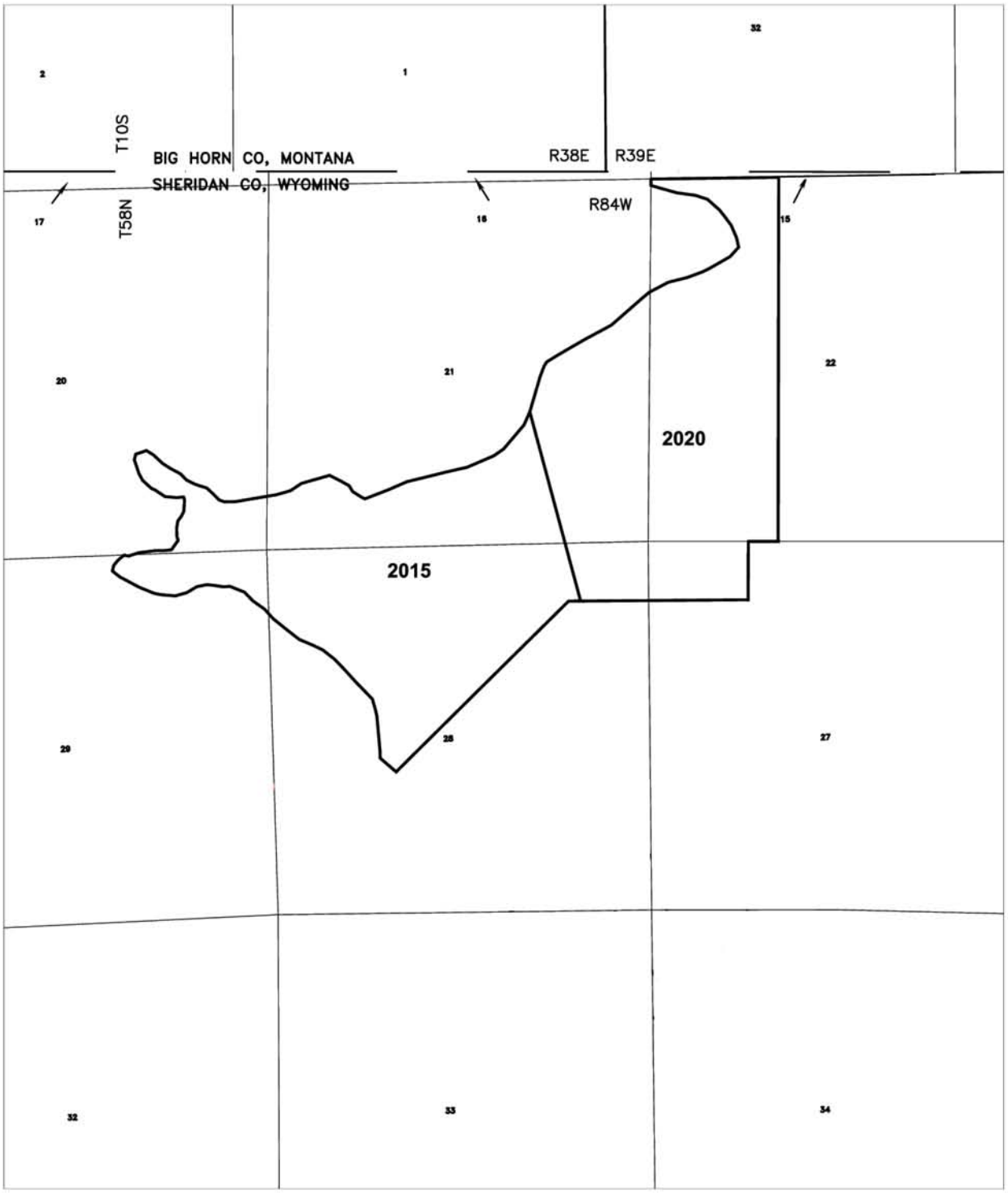
0 2 4 6 Kilometers

Powder River Basin Coal Review

Figure A-4

Projected Montana Coal Development Upper Scenario

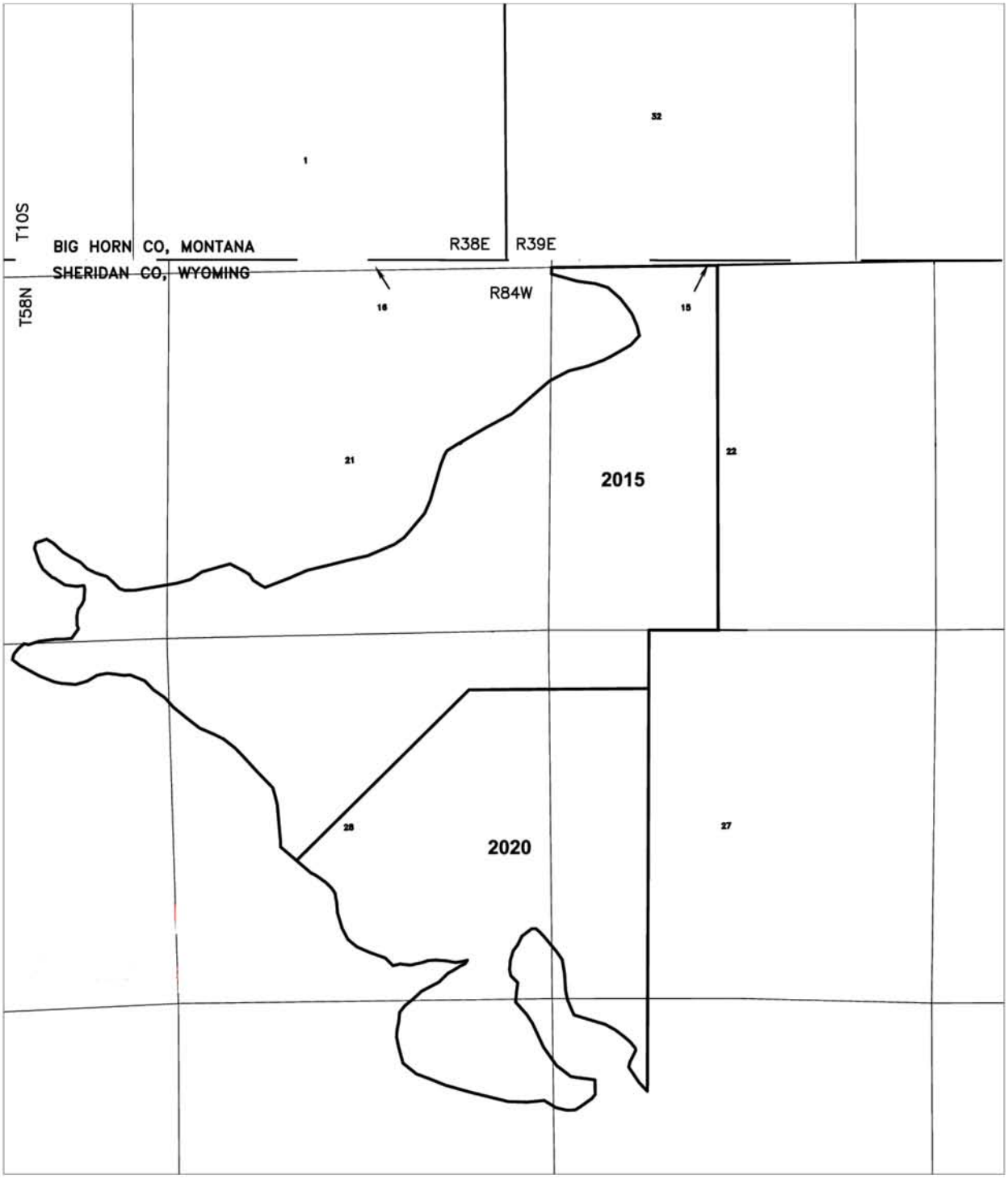
11/09/09



Powder River Coal Review

Figure A-5

Wyoming Portion of Subregion 4
Lower Scenario



LEGEND:

RESERVE DEVELOPMENT

N

SCALE IN FEET

1,000 0 1,000 2,000

Powder River Coal Review

Figure A-6

Wyoming Portion of Subregion 4
Upper Scenario

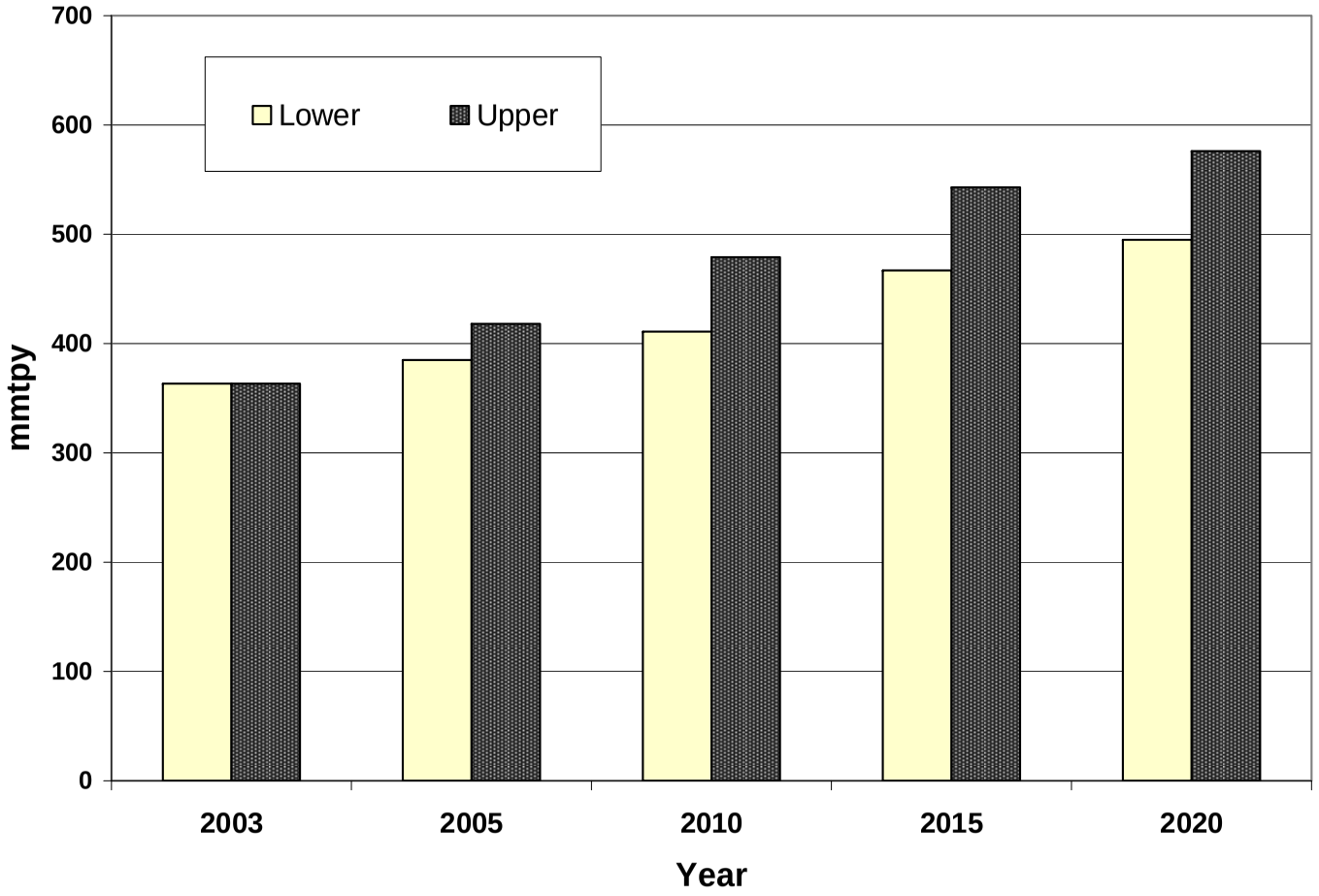


Figure A-7. Total Coal Production for Mines in Subregions 1, 2, and 3 – Lower and Upper Production Scenarios

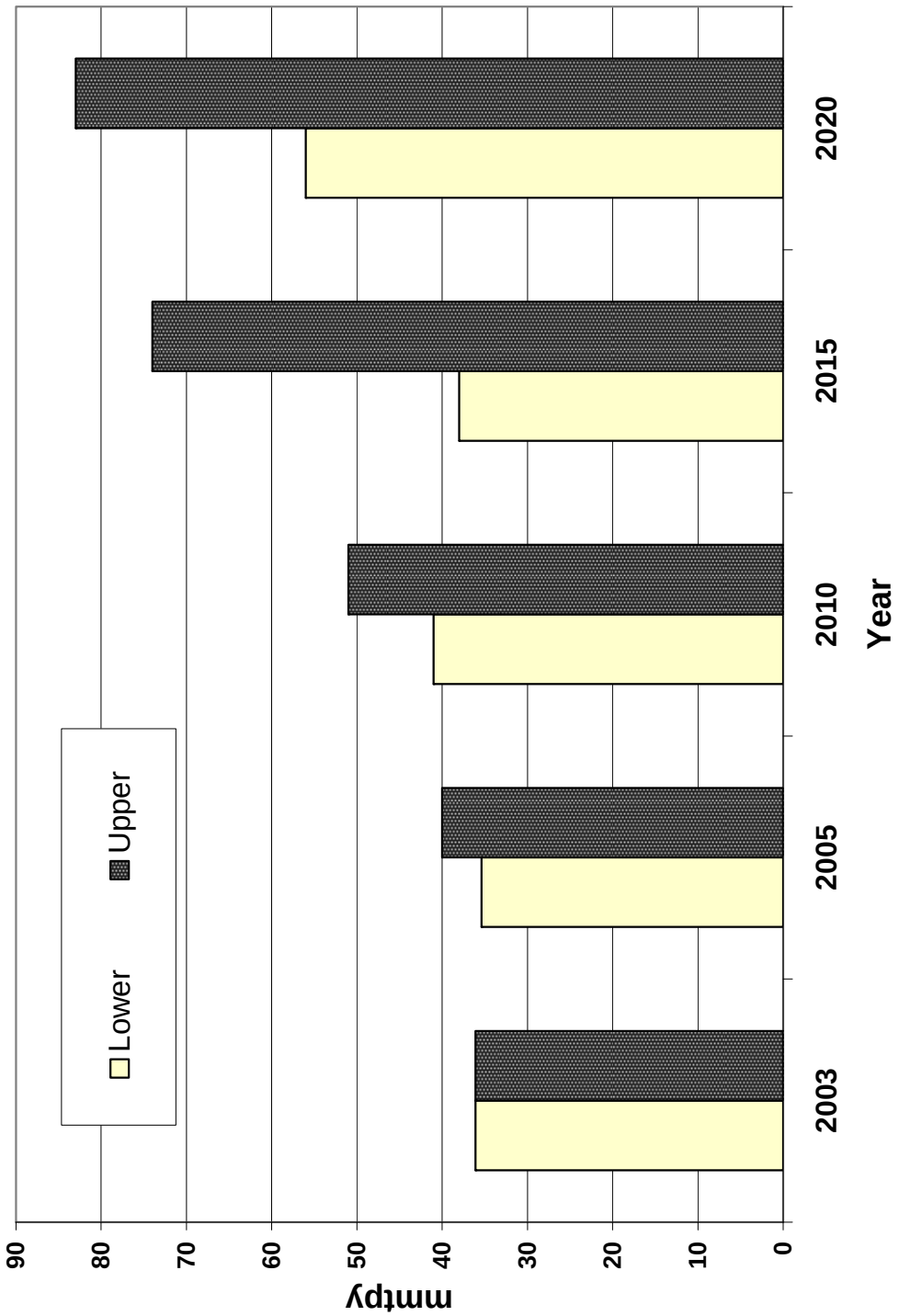


Figure A-8. Total Coal Production for Mines in Subregions 4 and 5 – Lower and Upper Production Scenarios

APPENDIX B

GIS DATA FOR ACTUAL 2003 (ORIGINAL BASE YEAR) DISTURBANCE

Table B-1
Coal Mine-related Disturbance in the Wyoming PRB Study Area
(based on GIS)

Area	Disturbance (acreage as of end 2003)
Disturbance by Subregion	
Subregion 1	8,968
Subregion 2	14,628
Subregion 3	27,511
Total	**51,107**
Disturbance by Subwatershed	
Little Powder River	8,018
Antelope Creek	13,785
Upper Cheyenne River	13,726
Upper Belle Fourche River	15,578
Total	**51,107**

Table B-2
Total Past and Present Development-related Disturbance in the Wyoming PRB Study Area by Subwatershed
(based on GIS)

Subwatershed	Total Disturbance (acres as of end of 2003)
Little Bighorn River	64
Upper Tongue River	3,574
Middle Fork Powder River	259
North Fork Powder River	0
Upper Powder River	12,444
South Fork Powder River	313
Salt Creek	1,225
Crazy Woman Creek	494
Clear Creek	4,405
Middle Powder River	2,297
Little Powder River	17,896
Little Missouri River	163
Antelope Creek	19,807
Dry Fork Cheyenne River	1,684
Upper Cheyenne River	16,656
Lightning Creek	2,900
Upper Belle Fourche River	37,148
Middle North Platte River	561
Total Disturbance Acreage	**121,890**

APPENDIX C

SUPPORTING TABLES AND FIGURES– TASK 1D STUDY AREA

Table C-1
Wyoming PRB Coal-related Development Disturbance Acreages
in the Task 1D Study Area[1]
(based on database)

Subwatershed	Lower and Upper Production Scenarios		
	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)
Original Base Year (Actual 2003)			
Antelope Creek	376	0	376
Clear Creek	364	0	364
Crazy Woman Creek	0	0	0
Dry Fork Cheyenne River	145	0	145
Lightning Creek	400	0	400
Little Bighorn River	36	0	36
Little Missouri River	0	0	0
Little Powder River	339	0	339
Middle North Platte River	0	0	0
Middle Powder River	0	0	0
Middle Fork Powder River	0	0	0
North Fork Powder River	0	0	0
Salt Creek	0	0	0
South Fork Powder River	0	0	0
Upper Belle Fourche River	1,317	0	1,317
Upper Cheyenne River	291	0	291
Upper Powder River	521	0	521
Upper Tongue River	1,103	0	1,103
Total for 2003 Actual	**4,892**	**0**	**4,892**
Current Base Year (Actual 2007)			
Antelope Creek	564	0	564
Clear Creek	364	0	364
Crazy Woman Creek	0	0	0
Dry Fork Cheyenne River	218	0	218
Lightning Creek	600	0	600
Little Bighorn River	36	0	36
Little Missouri River	0	0	0
Little Powder River	339	0	339
Middle North Platte River	0	0	0
Middle Powder River	0	0	0
Middle Fork Powder River	0	0	0
North Fork Powder River	0	0	0
Salt Creek	0	0	0
South Fork Powder River	0	0	0
Upper Belle Fourche River	1,620	0	1,620
Upper Cheyenne River	436	0	436
Upper Powder River	521	0	521
Upper Tongue River	1,103	0	1,103
Total for Actual 2007	**5,802**	**0**	**5,802**
Reasonably Foreseeable Development (2010)			
Antelope Creek	563	0	563
Clear Creek	369	0	369

Table C-1 (continued)

Subwatershed	Lower and Upper Production Scenarios		
	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)
Crazy Woman Creek	0	0	0
Dry Fork Cheyenne River	218	0	218
Lightning Creek	600	0	600
Little Bighorn River	36	0	36
Little Missouri River	0	0	0
Little Powder River	340	0	340
Middle North Platte River	0	0	0
Middle Powder River	0	0	0
Middle Fork Powder River	0	0	0
North Fork Powder River	0	0	0
Salt Creek	0	0	0
South Fork Powder River	0	0	0
Upper Belle Fourche River	1,677	0	1,677
Upper Cheyenne River	536	0	536
Upper Powder River	521	0	521
Upper Tongue River	1,103	0	1,103
Total for 2010	**5,963**	**0**	**5,963**
Reasonably Foreseeable Development (2015)			
Antelope Creek	781	0	781
Clear Creek	369	0	369
Crazy Woman Creek	0	0	0
Dry Fork Cheyenne River	218	0	218
Lightning Creek	600	0	600
Little Bighorn River	41	0	41
Little Missouri River	0	0	0
Little Powder River	340	0	340
Middle North Platte River	0	0	0
Middle Powder River	0	0	0
Middle Fork Powder River	0	0	0
North Fork Powder River	0	0	0
Salt Creek	0	0	0
South Fork Powder River	0	0	0
Upper Belle Fourche River	1,933	0	1,933
Upper Cheyenne River	1,009	0	1,009
Upper Powder River	521	0	521
Upper Tongue River	1,103	0	1,103
Total for 2015	**6,915**	**0**	**6,915**
Reasonably Foreseeable Development (2020)			
Antelope Creek	781	0	781
Clear Creek	369	0	369
Crazy Woman Creek	0	0	0
Dry Fork Cheyenne River	218	0	218
Lightning Creek	600	0	600
Little Bighorn River	41	0	41
Little Missouri River	0	0	0
Little Powder River	340	0	340
Middle North Platte River	0	0	0
Middle Powder River	0	0	0
Middle Fork Powder River	0	0	0

Table C-1 (continued)

Subwatershed	Lower and Upper Production Scenarios		
	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)
North Fork Powder River	0	0	0
Salt Creek	0	0	0
South Fork Powder River	0	0	0
Upper Belle Fourche River	1,932	0	1,932
Upper Cheyenne River	1,009	0	1,009
Upper Powder River	521	0	521
Upper Tongue River	1,103	0	1,103
Total for 2020	**6,914**	**0**	**6,914**

[1]Coal-related activities as defined for this study include coal-fired power plants, railroads, major (230-kV) transmission lines, and coal technology projects. However, as discussed in Section 3.7, disturbance associated with major (230-kV) transmission lines is not analyzed in this study as the disturbance related to existing lines is minimal and information in relation to RFD transmission lines is lacking. The Task 1D study area is presented in **Figure C-1**.

Table C-2
Wyoming PRB Oil and Gas and Related Development Disturbance Acreages in the Task 1D Study Area[1]
(based on database)

Subwatershed	Lower and Upper Production Scenarios		
	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)
Original Base Year (Actual 2003)[2]			
Antelope Creek	12,708	6,994	5,714
Clear Creek	4,575	3,314	1,291
Crazy Woman Creek	1,640	1,031	609
Dry Fork Cheyenne River	3,265	1,673	1,592
Lightning Creek	4,954	2,240	2,714
Little Bighorn River	48	24	24
Little Missouri River	624	457	166
Little Powder River	31,600	20,998	10,602
Middle Fork Powder River	1,874	1,610	263
Middle North Platte River	1,159	714	445
Middle Powder River	7,133	4,502	2,631
North Fork Powder River	88	88	0
Salt Creek	3,402	1,966	1,435
South Fork Powder River	1,005	687	318
Upper Belle Fourche River	54,899	36,336	18,563
Upper Cheyenne River	6,815	3,860	2,955
Upper Powder River	30,040	20,780	9,260
Upper Tongue River	11,310	7,501	3,809
Total for 2003 Actual	**177,140**	**114,777**	**62,363**
Current Base Year (Actual 2007)			
Antelope Creek	9,914	5,572	4,342
Clear Creek	3,687	2,615	1,071
Crazy Woman Creek	1,079	966	113
Dry Fork Cheyenne River	1,160	569	591
Lightning Creek	2,541	766	1,775
Little Bighorn River	0	0	0
Little Missouri River	399	343	56
Little Powder River	30,070	18,951	11,119
Middle Fork Powder River	1,522	1,423	99
Middle North Platte River	560	503	57
Middle Powder River	10,104	5,793	4,311
North Fork Powder River	88	88	0
Salt Creek	2,769	1,437	1,333
South Fork Powder River	696	505	191
Upper Belle Fourche River	50,830	31,664	19,165
Upper Cheyenne River	4,653	2,952	17,001
Upper Powder River	42,348	27,788	14,559
Upper Tongue River	15,602	9,989	5,613
Total for 2007 Actual	**178,023**	**111,926**	**66,097**
Reasonably Foreseeable Development (2010)			
Antelope Creek	13,652	7,947	5,704
Clear Creek	12,777	8,425	4,352

Table C-2 (continued)

Subwatershed	Lower and Upper Production Scenarios		
	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)
Crazy Woman Creek	7,665	4,692	2,973
Dry Fork Cheyenne River	1,432	858	574
Lightning Creek	2,729	1,144	1,585
Little Bighorn River	0	0	0
Little Missouri River	440	435	6
Little Powder River	35,714	23,246	12,468
Middle Fork Powder River	5,531	3,764	1,767
Middle North Platte River	855	686	170
Middle Powder River	11,114	7,299	3,815
North Fork Powder River	88	88	0
Salt Creek	2,900	1,646	1,254
South Fork Powder River	707	533	174
Upper Belle Fourche River	55,761	36,290	19,471
Upper Cheyenne River	5,418	3,286	2,132
Upper Powder River	67,570	42,725	24,825
Upper Tongue River	23,731	14,737	8,993
Total for 2010	**248,086**	**157,803**	**90,283**
Reasonably Foreseeable Development (2015)			
Antelope Creek	18,498	12,507	5,991
Clear Creek	25,190	15,573	9,616
Crazy Woman Creek	16,292	9,526	6,766
Dry Fork Cheyenne River	1,717	1,030	688
Lightning Creek	2,852	1,360	1,492
Little Bighorn River	0	0	0
Little Missouri River	459	455	4
Little Powder River	39,766	27,037	12,729
Middle Fork Powder River	10,225	5,880	4,345
Middle North Platte River	1,073	823	250
Middle Powder River	12,134	8,523	3,611
North Fork Powder River	88	88	0
Salt Creek	3,014	1,719	1,295
South Fork Powder River	712	535	177
Upper Belle Fourche River	59,808	42,162	17,646
Upper Cheyenne River	5,426	3,646	1,780
Upper Powder River	111,696	72,245	39,450
Upper Tongue River	35,763	23,643	12,119
Total for 2015	**344,713**	**226,755**	**117,959**
Reasonably Foreseeable Development (2020)			
Antelope Creek	22,609	17,094	5,515
Clear Creek	36,367	25,692	10,675
Crazy Woman Creek	23,661	16,384	7,256
Dry Fork Cheyenne River	1,997	1,277	720
Lightning Creek	2,966	1,469	1,497
Little Bighorn River	0	0	0
Little Missouri River	476	472	37
Little Powder River	39,992	30,249	9,743
Middle Fork Powder River	14,058	9,651	4,407
Middle North Platte River	1,123	907	216
Middle Powder River	12,835	9,046	3,789

Table C-2 (continued)

Subwatershed	Lower and Upper Production Scenarios		
	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)
North Fork Powder River	88	88	0
Salt Creek	3,096	1,801	1,295
South Fork Powder River	718	540	177
Upper Belle Fourche River	60,163	45,196	14,967
Upper Cheyenne River	5,432	3,955	1,477
Upper Powder River	155,092	112,703	42,388
Upper Tongue River	46,884	34,434	12,450
Total for 2020	**427,557**	**310,959**	**116,598**

[1] Inclusive of conventional oil and gas and CBNG activities and major transportation pipelines. Disturbance associated with ancillary facilities (including gather lines and distribution power lines) has been factored in on a per well basis as discussed in Appendix E of this report. The Task 1D study area is presented in **Figure C-1**.

[2] The 2003 base year cumulative information was adjusted to reflect updated 2003 conventional oil and gas and CBNG information.

Table C-3
Wyoming PRB Total Development-related Disturbance Acreages
In the Task 1D Study Area[1]
(based on database)

Subwatershed	Lower Production Scenario			Upper Production Scenario		
	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Areas through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)
Original Base Year (Actual 2003)[2]						
Antelope Creek	27,811	10,442	17,369	27,811	10,442	17,369
Clear Creek	4,575	3,314	1,261	4,575	3,314	1,261
Crazy Woman Creek	1,640	1,031	609	1,640	1,031	609
Dry Fork Cheyenne River	3,265	1,673	1,592	3,265	1,673	1,592
Lightning Creek	4,954	2,240	2,714	4,954	2,240	2,714
Little Bighorn River	48	24	24	48	24	24
Little Missouri River	624	457	167	624	457	167
Little Powder River	41,720	23,641	18,079	41,720	23,641	18,079
Middle Fork Powder River	1,874	1,610	264	1,874	1,610	264
Middle North Platte River	1,159	714	445	1,159	714	445
Middle Powder River	7,133	4,502	2,631	7,133	4,502	2,631
North Fork Powder River	88	88	0	88	88	0
Salt Creek	3,402	1,966	1,436	3,402	1,966	1,436
South Fork Powder River	1,005	687	318	1,005	687	318
Upper Belle Fourche River	80,050	43,530	36,520	80,050	43,530	36,520
Upper Cheyenne River	27,210	11,813	15,397	27,210	11,813	15,397
Upper Powder River	30,040	20,780	9,260	30,040	20,780	9,260
Upper Tongue River	11,310	7,501	3,809	11,310	7,501	3,809
Total for 2003 Actual	**247,909**	**136,015**	**111,894**	**247,909**	**136,015**	**111,894**

Table C-3 (Continued)

Subwatershed	Lower Production Scenario			Upper Production Scenario		
	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Areas through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)
Current Base Year (Actual 2007)						
Antelope Creek	30,850	11,130	26,113	30,850	11,130	26,113
Clear Creek	3,687	2,615	1,071	3,687	2,615	1,071
Crazy Woman Creek	1,080	966	113	1,080	966	113
Dry Fork Cheyenne River	1,160	569	591	1,160	569	591
Lightning Creek	2,541	766	1,775	2,541	766	1,775
Little Bighorn River	0	0	0	0	0	0
Little Missouri River	399	343	56	399	343	56
Little Powder River	42,203	22,066	22,917	42,203	22,066	22,917
Middle Fork Powder River	1,522	1,423	100	1,522	1,423	100
Middle North Platte River	560	503	57	560	503	57
Middle Powder River	10,104	5,793	4,311	10,104	5,793	4,311
North Fork Powder River	88	88	0	88	88	0
Salt Creek	2,769	1,437	1,333	2,769	1,437	1,333
South Fork Powder River	696	505	191	696	505	191
Upper Belle Fourche River	76,747	38,649	44,785	76,747	38,649	44,785
Upper Cheyenne River	29,259	13,179	23,679	29,259	13,179	23,679
Upper Powder River	42,348	27,788	14,559	42,348	27,788	14,554
Upper Tongue River	15,602	9,989	5,613	15,602	9,989	5,613
Total for 2007 Actual	**261,616**	**137,810**	**147,265**	**261,616**	**137,810**	**147,265**

Table C-3 (Continued)

Subwatershed	Lower Production Scenario			Upper Production Scenario		
	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Areas through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)
Reasonably Foreseeable Development (2010)						
Antelope Creek	38,075	18,995	19,080	39,034	18,995	20,039
Clear Creek	12,777	8,425	4,352	12,777	8,425	4,352
Crazy Woman Creek	7,665	4,692	2,973	7,665	4,692	2,973
Dry Fork Cheyenne River	1,432	858	574	1,432	858	574
Lightning Creek	2,729	1,144	1,586	2,729	1,144	1,586
Little Bighorn River	0	0	0	0	0	0
Little Missouri River	440	435	5	440	435	5
Little Powder River	48,471	27,689	20,783	49,086	28,089	20,997
Middle Fork Powder River	5,531	3,764	1,767	5,531	3,764	1,767
Middle North Platte River	856	686	170	856	686	170
Middle Powder River	11,113	7,299	3,815	11,113	7,299	3,815
North Fork Powder River	88	88	0	88	88	0
Salt Creek	2,900	1,646	1,254	2,900	1,646	1,254
South Fork Powder River	707	533	173	707	533	173
Upper Belle Fourche River	86,256	49,034	37,222	87,580	50,267	37,313
Upper Cheyenne River	36,405	19,989	16,416	37,294	20,189	17,105
Upper Powder River	67,570	42,725	29,845	67,570	42,725	24,845
Upper Tongue River	23,731	14,737	8,993	23,731	14,737	8,993
Total for 2010	**346,748**	**202,741**	**144,008**	**350,535**	**204,574**	**145,961**
Reasonably Foreseeable Development (2015)						
Antelope Creek	48,985	29,155	19,831	50,506	29,155	21,351
Clear Creek	25,190	15,573	9,616	25,190	15,573	9,616
Crazy Woman Creek	16,292	9,526	6,766	16,292	9,526	6,766
Dry Fork Cheyenne River	1,717	1,029	688	1,717	1,029	688
Lightning Creek	2,852	1,360	1,492	2,852	1,360	1,492
Little Bighorn River	0	0	0	0	0	0

Table C-3 (Continued)

Subwatershed	Lower Production Scenario			Upper Production Scenario		
	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Areas through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)
Little Missouri River	459	455	4	459	455	4
Little Powder River	54,488	32,980	21,508	55,403	33,655	21,747
Middle Fork Powder River	10,225	5,880	4,345	10,225	5,880	4,345
Middle North Platte River	1,073	823	250	1,073	823	250
Middle Powder River	12,134	8,523	3,611	12,134	8,523	3,611
North Fork Powder River	88	88	0	88	88	0
Salt Creek	3,014	1,741	1,273	3,014	1,741	1,273
South Fork Powder River	712	535	177	712	535	177
Upper Belle Fourche River	94,899	58,556	36,344	98,285	61,489	36,797
Upper Cheyenne River	42,363	25,850	16,513	43,849	26,450	17,399
Upper Powder River	111,696	72,245	39,450	111,696	72,245	39,450
Upper Tongue River	35,763	23,644	12,119	35,763	23,644	12,119
Total for 2015	**461,950**	**287,943**	**174,010**	**469,258**	**292,151**	**177,108**
Reasonably Foreseeable Development (2020)						
Antelope Creek	60,324	40,542	19,781	62,936	40,042	22,894
Clear Creek	36,367	25,692	10,675	34,367	25,692	10,675
Crazy Woman Creek	23,661	16,384	7,277	23,661	16,384	7,277
Dry Fork Cheyenne River	1,997	1,277	720	1,997	1,277	720
Lightning Creek	2,966	1,469	1,497	2,966	1,469	1,497
Little Bighorn River	0	0	0	0	0	0
Little Missouri River	476	472	4	476	472	4
Little Powder River	56,737	37,817	18,919	58,062	38,867	19,195
Middle Fork Powder River	14,058	9,651	4,407	14,058	9,651	4,407
Middle North Platte River	1,124	907	216	1,124	907	216
Middle Powder River	12,835	9,046	3,789	12,835	9,046	3,789
North Fork Powder River	88	88	0	88	88	0
Salt Creek	3,096	1,801	1,296	3,096	1,801	1,296
South Fork Powder River	718	540	177	718	540	177

Table C-3 (Continued)

Subwatershed	Lower Production Scenario			Upper Production Scenario		
	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Areas through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)
Upper Belle Fourche River	100,140	65,740	34,402	106,385	71,123	35,260
Upper Cheyenne River	48,437	31,858	16,578	49,902	32,658	17,244
Upper Powder River	155,092	112,703	42,388	155,092	112,703	42,388
Upper Tongue River	46,884	34,434	12,450	46,884	34,434	12,450
Total for 2020	**564,999**	**390,422**	**174,576**	**576,646**	**397,155**	**179,489**

[1] Inclusive of disturbance associated with coal mining, coal-related activities, oil and gas and related development, and other development activities identified for this study. Other quantifiable activities include approximately 171, 2,899, 48, and 145 acres of disturbance associated with major water storage reservoirs in the Antelope Creek, Clear Creek, Crazy Woman Creek, and Little Powder River subwatersheds (2003 through 2020), respectively. The Task 1D study area is presented in **Figure C-1**.

[2] The 2003 base year cumulative information was adjusted to reflect updated 2003 conventional oil and gas and CBNG information.

Note: Minor discrepancies in total acreages are the result of rounding.

Table C-4
Wyoming PRB Coal Mine-related Production, Employment, and Water-related Information for the Task 1D Study Area[1] (based on database)

Subwatershed	Lower Production Scenario				Upper Production Scenario			
	Annual Coal Production for Report Year (million tons)	Total Employment for Report Year[2]	Annual Water Consumption (mmgpy)	Annual Water Production[3] (acre-feet)	Annual Coal Production for Report Year (million tons)	Total Employment for Report Year[2]	Annual Water Consumption (mmgpy)	Annual Water Production[3] (acre-feet)
Original Base Year (Actual 2003)								
Antelope Creek	110	1,386	763	472	110	1,386	763	472
Clear Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Little Bighorn River	0	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0	0
Little Powder River	50	676	359	191	50	676	359	191
Middle North Platte River	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0
Middle Fork Powder River	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
South Fork Powder River	0	0	0	0	0	0	0	0
Upper Belle Fourche River	81	1,001	572	447	81	1,001	572	447
Upper Cheyenne River	122	1,704	946	276	122	1,704	946	276
Upper Powder River	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Total for Actual 2003	**363**	**4,767**	**2,640**	**1,386**	**363**	**4,767**	**2,640**	**1,386**
Current Base Year (Actual 2007)								
Antelope Creek	126	1,400	763	472	126	1,400	763	472
Clear Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0

Table C-4 (Continued)

Subwatershed	Lower Production Scenario				Upper Production Scenario			
	Annual Coal Production for Report Year (million tons)	Total Employment for Report Year[2]	Annual Water Consumption (mmgpy)	Annual Water Production[3] (acre-feet)	Annual Coal Production for Report Year (million tons)	Total Employment for Report Year[2]	Annual Water Consumption (mmgpy)	Annual Water Production[3] (acre-feet)
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Little Bighorn River	0	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0	0
Little Powder River	73	841	323	191	73	841	323	191
Middle North Platte River	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0
Middle Fork Powder River	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
South Fork Powder River	0	0	0	0	0	0	0	0
Upper Belle Fourche River	105	1,785	660	447	105	1,785	660	447
Upper Cheyenne River	124	1,677	946	276	124	1,677	946	276
Upper Powder River	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Total for Actual 2007	**428**	**5,703**	**2,692**	**1,386**	**428**	**5,703**	**2,692**	**1,386**
Reasonably Foreseeable Development (2010)								
Antelope Creek	121	1,414	250	899	127	1,414	250	899
Clear Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Little Bighorn River	0	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0	0
Little Powder River	57	715	259	165	70	739	333	165
Middle North Platte River	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0
Middle Fork Powder River	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0

Table C-4 (Continued)

Subwatershed	Lower Production Scenario: Annual Coal Production for Report Year (million tons)	Lower Production Scenario: Total Employment for Report Year[2]	Lower Production Scenario: Annual Water Consumption (mmgpy)	Lower Production Scenario: Annual Water Production[3] (acre-feet)	Upper Production Scenario: Annual Coal Production for Report Year (million tons)	Upper Production Scenario: Total Employment for Report Year[2]	Upper Production Scenario: Annual Water Consumption (mmgpy)	Upper Production Scenario: Annual Water Production[3] (acre-feet)
Salt Creek	0	0	0	0	0	0	0	0
South Fork Powder River	0	0	0	0	0	0	0	0
Upper Belle Fourche River	100	1,566	489	675	125	1,617	513	675
Upper Cheyenne River	133	1,739	865	520	157	1,739	934	520
Upper Powder River	0	0	0	0	0	0	0	0
Upper Tongue River	0	0	0	0	0	0	0	0
Total for 2010	**411**	**5,433**	**1,863**	**2,258**	**479**	**5,509**	**2,030**	**2,258**
Reasonably Foreseeable Development (2015)								
Antelope Creek	133	1,429	282	899	133	1,429	282	899
Clear Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Little Bighorn River	0	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0	0
Little Powder River	69	758	303	165	88	833	377	165
Middle North Platte River	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0
Middle Fork Powder River	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
South Fork Powder River	0	0	0	0	0	0	0	0
Upper Belle Fourche River	117	1,561	549	675	154	1,603	187	675
Upper Cheyenne River	148	1,957	995	520	168	1,857	1,051	520
Upper Powder River	0	0	0	0	0	0	0	0
Upper Tongue River	95	132	94	0	15	207	188	0
Total for 2015	**562**	**5,837**	**2,223**	**2,258**	**558**	**5,929**	**3,705**	**2,258**
Reasonably Foreseeable Development (2020)								
Antelope Creek	137	1,442	282	899	137	1,442	282	899
Clear Creek	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	0	0	0	0	0	0	0

Table C-4 (Continued)

Subwatershed	Lower Production Scenario				Upper Production Scenario			
	Annual Coal Production for Report Year (million tons)	Total Employment for Report Year[2]	Annual Water Consumption (mmgpy)	Annual Water Production[3] (acre-feet)	Annual Coal Production for Report Year (million tons)	Total Employment for Report Year[2]	Annual Water Consumption (mmgpy)	Annual Water Production[3] (acre-feet)
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Little Bighorn River	0	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0	0
Little Powder River	71	767	333	165	103	946	406	165
Middle North Platte River	0	0	0	0	0	0	0	0
Middle Powder River	0	0	0	0	0	0	0	0
Middle Fork Powder River	0	0	0	0	0	0	0	0
North Fork Powder River	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
South Fork Powder River	0	0	0	0	0	0	0	0
Upper Belle Fourche River	133	1,649	565	675	166	1,617	630	675
Upper Cheyenne River	154	1,873	1,052	520	170	1,873	1,155	520
Upper Powder River	0	0	0	0	0	0	0	0
Upper Tongue River	13	181	94	0	15	181	94	0
Total for 2020	**508**	**5,912**	**2,326**	**2,258**	**591**	**6,179**	**2,567**	**2,258**

[1] The Task 1D study area is shown in **Figure C-1**.
[2] Based on coal mine information, with the exception of power plant-related employees identified in the Little Powder River, Upper Belle Fourche River, and Upper Cheyenne River subwatershed numbers. There were 70 power plant-related employees identified for 2003, with an assumed operational work force of 100 per power plant for the other time periods.
[3] For purposes of this study, the annual coal mine-related water production is assumed to be the same under both the lower and upper production scenarios.

Table C-5
Wyoming PRB Oil and Gas Production and Conventional Oil and Gas Water-related Information for the Task 1D Study Area[1] (based on database)

Subwatershed	Annual Oil Production for Report Year (barrels)	Annual Gas Production for Report Year[2] (mmcf)	Annual Conventional Oil- and Gas-related Water Production (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume Direct) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Passive Treatment) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Active Treatment) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume to Infiltration Impoundments) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume to Containment Impoundments) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Land Application) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Injection) (mmgpy)
Original Base Year (Actual 2003)										
Antelope Creek	831,582	31,887	5	3	0	0	2	0	0	0
Clear Creek	17,042	5	7	2	0	1	2	0	1	1
Crazy Woman Creek	0	0	0	0	0	0	0	0	0	0
Dry Fork Cheyenne River	398,311	10,277	1	0	0	0	0	0	0	0
Lightning Creek	508,091	983	16	4	0	2	6	1	2	2
Little Bighorn River	108,053	<1	212	53	0	21	74	11	32	21
Little Missouri River	0	0	0	0	0	0	0	0	0	0
Little Powder River	2,961,036	39,619	1,777	800	0	0	533	178	178	89
Middle Fork Powder River	160,366	0	314	78	0	31	110	16	47	31
Middle North Platte River	104,066	2,467	56	14	0	6	20	3	8	6
Middle Powder River	428,817	18,756	26	9	131	1	8	3	3	1
North Fork Powder River	0	0	0	0	0	0	0	0	0	0
Salt Creek	171,352	28	231	58	0	23	81	12	35	23
South Fork Powder River	85,143	1	99	25	0	10	35	5	15	10
Upper Belle Fourche River	4,728,251	146,805	1,350	607	0	0	540	67	0	135
Upper Cheyenne River	153,924	26,899	13	7	0	0	5	1	0	1
Upper Powder River	2,305,549	65,143	133	47	0	13	53	7	7	7
Upper Tongue River	18,076	35,389	37	0	934	2	17	4	2	4
Total for 2003 Actual	**12,979,659**	**378,259**	**4,278**	**1,707**	**1,064**	**110**	**1,485**	**306**	**329**	**330**

Table C-5 (Continued)

Subwatershed	Annual Oil Production for Report Year (barrels)	Annual Gas Production for Report Year[2] (mmcf)	Annual Conventional Oil- and Gas-related Water Production (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume Direct) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Passive Treatment) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Active Treatment) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume to Infiltration Impoundments) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume to Containment Impoundments) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Land Application) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Injection) (mmgpy)
Current Base Year (Actual 2007)										
Antelope Creek	802,033	32,771	8	4	0	0	3	0	0	0
Clear Creek	0	1,130	0	0	0	0	0	0	0	0
Crazy Woman Creek	0	1,345	0	0	0	0	0	0	0	0
Dry Fork Cheyenne River	268,295	2,041	4	1	0	0	1	0	1	0
Lightning Creek	502,278	858	16	4	0	2	6	1	2	2
Little Bighorn River	0	0	0	0	0	0	0	0	0	0
Little Missouri River	138,518	0.335	255	64	0	25	89	13	38	25
Little Powder River	2,437,033	23,756	2,181	982	0	0	654	218	218	109
Middle Fork Powder River	144,485	0	367	92	0	37	128	18	55	37
Middle North Platte River	87,786	750	15	4	0	1	5	1	2	1
Middle Powder River	227,449	21,762	34	12	172	2	10	3	3	2
North Fork Powder River	0	0	0	0	0	0	0	0	0	0
Salt Creek	235,757	22	30	7	0	3	10	1	4	3
South Fork Powder River	82,835	0.666	100	25	0	10	35	5	15	10
Upper Belle Fourche River	4,033,653	58,013	1,387	624	0	0	555	69	0	139
Upper Cheyenne River	99,222	6,497	8	4	0	0	3	0	0	0
Upper Powder River	2,337,089	248,621	188	66	0	19	75	9	9	9
Upper Tongue River	15,014	56,193	30	0	761	2	14	3	2	3
Total for 2007 Actual	**11,411,447**	**453,760**	**4,623**	**1,889**	**932**	**101**	**1,589**	**343**	**350**	**341**
Reasonably Foreseeable Development (2010)										
Antelope Creek	699,364	48,219	5	3	0	0	2	0	0	0
Clear Creek	34,084	11,460	14	4	0	1	5	1	2	1
Crazy Woman Creek	12,808	19,932	4	1	0	0	1	0	1	0
Dry Fork Cheyenne River	381,362	11,003	49	12	0	5	17	2	7	0

Table C-5 (Continued)

Subwatershed	Annual Oil Production for Report Year (barrels)	Annual Gas Production for Report Year[2] (mmcf)	Annual Conventional Oil- and Gas-related Water Production (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume Direct) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Passive Treatment) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Active Treatment) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume to Infiltration Impoundments) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume to Containment Impoundments) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Land Application) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Injection) (mmgpy)
Lightning Creek	298,985	2,275	10	2	0	1	3	0	1	1
Little Bighorn River	0	0	0	0	0	0	0	0	0	0
Little Missouri River	179,312	552	59	15	0	6	21	3	9	6
Little Powder River	4,178,501	31,477	2,508	1,129	0	0	752	251	251	125
Middle Fork Powder River	276,996	15,059	542	135	0	54	190	27	81	54
Middle North Platte River	250,826	6,956	135	34	0	14	47	7	20	14
Middle Powder River	531,616	36,947	32	11	162	2	10	3	3	2
North Fork Powder River	0	0	0	0	0	0	0	0	0	0
Salt Creek	186,403	267	251	63	0	25	88	13	38	25
South Fork Powder River	72,529	364	85	21	0	8	30	4	13	8
Upper Belle Fourche River	6,612,754	64,313	1,888	849	0	0	755	94	0	189
Upper Cheyenne River	54,368	6,930	5	3	0	0	2	0	0	0
Upper Powder River	1,894,972	406,348	110	38	0	11	44	5	5	5
Upper Tongue River	71,701	88,731	148	0	3,703	7	67	15	7	15
Total for 2010	**15,736,580**	**750,837**	**5,843**	**2,320**	**3,865**	**135**	**2,032**	**427**	**439**	**447**
Reasonably Foreseeable Development (2015)										
Antelope Creek	640,214	49,201	4	2	0	0	1	0	0	0
Clear Creek	29,824	25,898	12	3	0	1	4	1	2	1
Crazy Woman Creek	10,246	44,297	3	1	0	0	1	0	1	0
Dry Fork Cheyenne River	349,581	11,129	52	13	0	5	18	3	8	1
Lightning Creek	277,891	3,243	9	2	0	1	3	0	1	1
Little Bighorn River	0	0	0	0	0	0	0	0	0	0
Little Missouri River	158,820	489	52	13	0	5	18	3	8	5
Little Powder River	3,807,528	29,352	2,285	1,028	0	0	686	229	229	114
Middle Fork Powder River	247,838	29,512	485	121	0	48	170	24	73	48
Middle North Platte River	224,142	6,804	121	30	0	12	42	6	18	12

Table C-5 (Continued)

Subwatershed	Annual Oil Production for Report Year (barrels)	Annual Gas Production for Report Year[2] (mmcf)	Annual Conventional Oil- and Gas-related Water Production (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume Direct) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Passive Treatment) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Active Treatment) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume to Infiltration Impoundments) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume to Containment Impoundments) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Land Application) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Injection) (mmgpy)
Middle Powder River	496,370	39,968	30	11	151	2	9	3	3	2
North Fork Powder River	0	0	0	0	0	0	0	0	0	0
Salt Creek	177,720	570	239	60	0	24	84	12	36	24
South Fork Powder River	67,799	340	79	20	0	8	28	4	12	8
Upper Belle Fourche River	5,963,186	55,380	1,702	766	0	0	681	85	0	170
Upper Cheyenne River	52,249	5,140	4	2	0	0	2	0	0	0
Upper Powder River	1,723,898	603,908	100	35	0	10	40	5	5	5
Upper Tongue River	64,471	117,812	133	0	3,330	7	60	13	7	13
Total for 2015	**14,291,777**	**1,043,635**	**5,312**	**2,108**	**3,841**	**123**	**1,847**	**388**	**401**	**405**
Reasonably Foreseeable Development (2020)										
Antelope Creek	581,064	44,274	4	2	0	0	1	0	0	0
Clear Creek	25,563	28,743	11	3	0	1	4	1	2	1
Crazy Woman Creek	10,246	48,303	3	1	0	0	1	0	1	0
Dry Fork Cheyenne River	317,801	10,562	42	10	0	4	15	2	6	0
Lightning Creek	257,714	3,227	8	2	0	1	3	0	1	1
Little Bighorn River	0	0	0	0	0	0	0	0	0	0
Little Missouri River	140,888	434	46	12	0	5	16	2	7	5
Little Powder River	3,436,555	18,159	2,063	928	0	0	619	206	206	103
Middle Fork Powder River	218,681	30,046	428	107	0	43	150	21	64	43
Middle North Platte River	197,459	6,057	106	27	0	11	37	5	16	11
Middle Powder River	461,125	35,924	28	10	140	1	8	3	3	1
North Fork Powder River	0	0	0	0	0	0	0	0	0	0
Salt Creek	168,457	545	227	57	0	23	79	11	34	23
South Fork Powder River	63,069	316	74	18	0	7	26	4	11	7
Upper Belle Fourche River	5,313,617	42,627	1,517	683	0	0	607	76	0	152

Table C-5 (Continued)

Subwatershed	Annual Oil Production for Report Year (barrels)	Annual Gas Production for Report Year[2] (mmcf)	Annual Conventional Oil- and Gas-related Water Production (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume Direct) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Passive Treatment) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Active Treatment) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume to Infiltration Impoundments) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume to Containment Impoundments) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Land Application) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Injection) (mmgpy)
Upper Cheyenne River	50,131	3,609	4	2	0	0	1	0	0	0
Upper Powder River	1,555,456	667,179	90	32	0	9	36	5	5	5
Upper Tongue River	56,638	120,771	117	0	2,925	6	53	12	6	12
Total for 2020	**12,854,466**	**1,060,777**	**4,767**	**1,893**	**3,066**	**111**	**1,656**	**349**	**361**	**363**

[1] The Task 1D study area is shown in **Figure C-1**.
[2] Natural gas produced by conventional gas and CBNG wells.

Table C-6
Wyoming PRB CBNG Water-related Information for the Task 1D Study Area[1] (based on database)

Subwatershed	Annual CBNG-related Water Production (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume Direct) (mmgpy)	Annual CBNG-related Water Disposal (Passive Treatment) (mmgpy)	Annual CBNG-related Water Disposal (Active Treatment) (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume to Infiltration Impoundments) (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume to Containment Impoundments) (mmgpy)	Annual CBNG-related Water Disposal (Land Application) (mmgpy)	Annual CBNG-related Water Disposal (Injection) (mmgpy)
Original Base Year (Actual 2003)								
Antelope Creek	1,290	710	0	0	452	65	0	65
Clear Creek	367	92	0	37	128	18	55	37
Crazy Woman Creek	0	0	0	0	0	0	0	0
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Lightning Creek	0	0	0	0	0	0	0	0
Little Bighorn River	0	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0	0
Little Powder River	2,753	1,239	0	0	826	275	275	138
Middle Fork Powder River	0	0	0	0	0	0	0	0
Middle North Platte River	0	0	0	0	0	0	0	0
Middle Powder River	1,147	402	5,736	57	344	115	115	57
North Fork Powder River	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
South Fork Powder River	0	0	0	0	0	0	0	0
Upper Belle Fourche River	7,566	3,405	0	0	3,026	378	0	757
Upper Cheyenne River	1,078	593	0	0	377	54	0	54
Upper Powder River	5,237	1,833	0	524	2,095	262	262	262
Upper Tongue River	2,689	0	67,233	134	1,210	269	134	269
Total for 2003 Actual	**22,127**	**8,272**	**72,969**	**752**	**8,458**	**1,436**	**841**	**1,637**
Current Base Year (Actual 2007)								
Antelope Creek	785	432	0	0	275	39	0	39
Clear Creek	283	71	0	28	99	14	42	28
Crazy Woman Creek	125	44	0	12	37	6	19	6

Table C-6 (Continued)

Subwatershed	Annual CBNG-related Water Production (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume Direct) (mmgpy)	Annual CBNG-related Water Disposal (Passive Treatment) (mmgpy)	Annual CBNG-related Water Disposal (Active Treatment) (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume to Infiltration Impoundments) (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume to Containment Impoundments) (mmgpy)	Annual CBNG-related Water Disposal (Land Application) (mmgpy)	Annual CBNG-related Water Disposal (Injection) (mmgpy)
Dry Fork Cheyenne River	100	25	0	10	35	5	15	1
Lightning Creek	0	0	0	0	0	0	0	0
Little Bighorn River	0	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0	0
Little Powder River	2,483	1,117	0	0	745	248	248	124
Middle Fork Powder River	0	0	0	0	0	0	0	0
Middle North Platte River	0	0	0	0	0	0	0	0
Middle Powder River	2,302	806	11,510	115	691	230	230	115
North Fork Powder River	0	0	0	0	0	0	0	0
Salt Creek	0	0	0	0	0	0	0	0
South Fork Powder River	0	0	0	0	0	0	0	0
Upper Belle Fourche River	2,943	1,324	0	0	1,177	147	0	294
Upper Cheyenne River	301	166	0	0	105	15	0	15
Upper Powder River	13,880	4,858	0	1,388	5,552	694	694	694
Upper Tongue River	3,913	0	97,821	196	1,761	391	196	391
Total for 2007 Actual	**27,115**	**8,842**	**109,332**	**1,750**	**10,477**	**1,791**	**1,444**	**1,709**
Reasonably Foreseeable Development (2010)								
Antelope Creek	1,173	645	0	0	411	59	0	59
Clear Creek	2,841	710	0	284	994	142	426	284
Crazy Woman Creek	1,843	645	0	184	553	92	276	92
Dry Fork Cheyenne River	73	18	0	7	26	4	11	1
Lightning Creek	111	28	0	11	39	6	17	11
Little Bighorn River	0	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0	0
Little Powder River	3,248	1,461	0	0	974	325	325	162
Middle Fork Powder River	946	236	0	95	331	47	142	95
Middle North Platte River	66	16	0	7	23	3	10	7
Middle Powder River	2,271	795	11,356	114	681	227	227	114
North Fork Powder River	0	0	0	0	0	0	0	0
Salt Creek	15	4	0	1	5	1	2	1

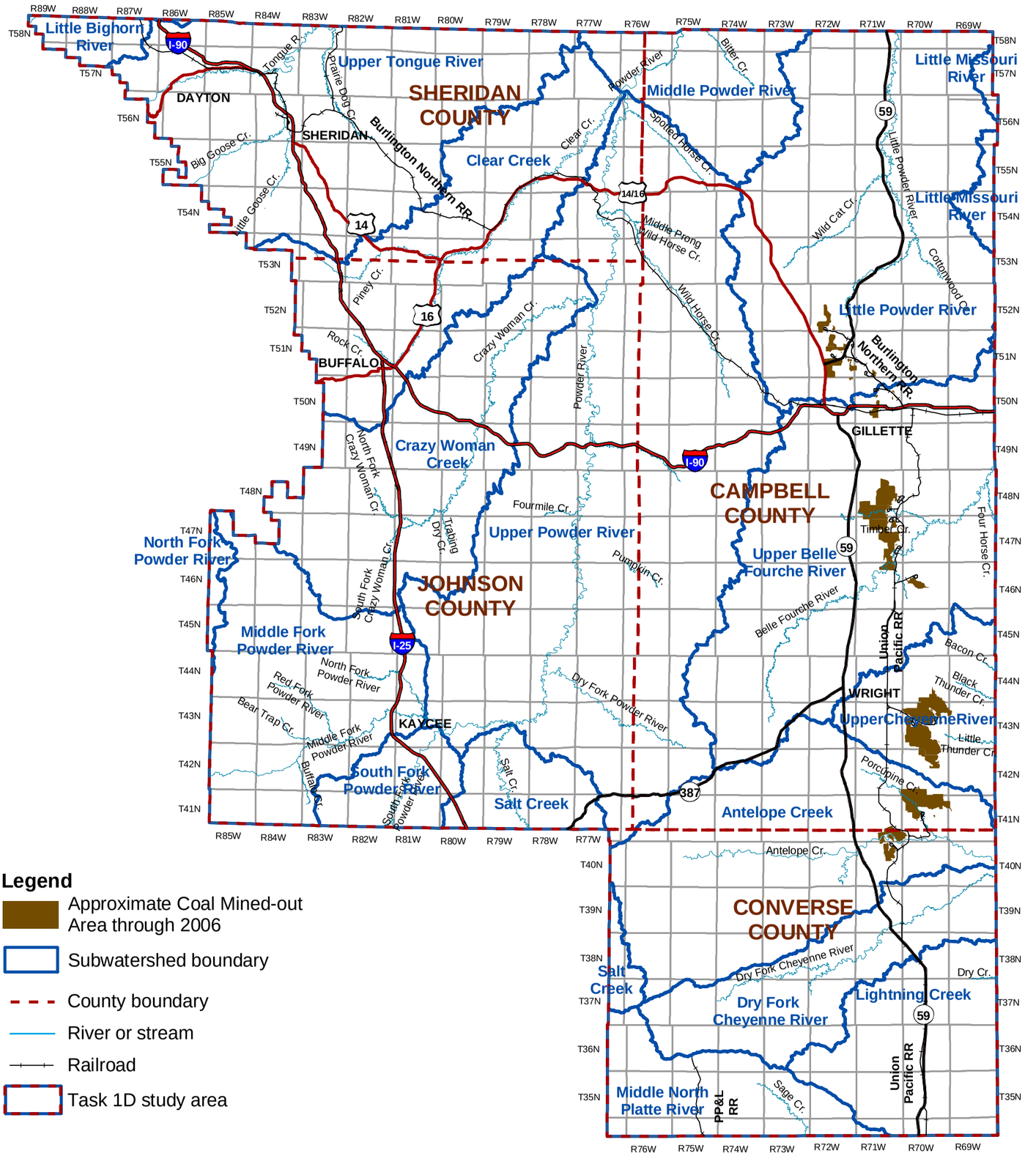
Table C-6 (Continued)

Subwatershed	Annual CBNG-related Water Production (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume Direct) (mmgpy)	Annual CBNG-related Water Disposal (Passive Treatment) (mmgpy)	Annual CBNG-related Water Disposal (Active Treatment) (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume to Infiltration Impoundments) (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume to Containment Impoundments) (mmgpy)	Annual CBNG-related Water Disposal (Land Application) (mmgpy)	Annual CBNG-related Water Disposal (Injection) (mmgpy)
South Fork Powder River	4	1	0	0	2	0	1	0
Upper Belle Fourche River	3,196	1,438	0	0	1,279	160	0	320
Upper Cheyenne River	357	196	0	0	125	18	0	18
Upper Powder River	22,762	7,967	0	2,276	9,105	1,138	1,138	1,138
Upper Tongue River	6,115	0	152,884	306	2,752	612	306	612
Total for 2010	**45,022**	**14,162**	**164,241**	**3,285**	**17,299**	**2,833**	**2,881**	**2,913**
Reasonably Foreseeable Development (2015)								
Antelope Creek	1,244	684	0	0	436	62	0	62
Clear Creek	6,454	1,614	0	645	2,257	323	968	645
Crazy Woman Creek	4,160	1,456	0	416	1,248	208	624	208
Dry Fork Cheyenne River	132	33	0	13	46	7	20	1
Lightning Creek	177	44	0	18	62	9	27	18
Little Bighorn River	0	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0	0
Little Powder River	3,032	1,365	0	0	910	303	303	152
Middle Fork Powder River	1,853	463	0	185	649	93	278	185
Middle North Platte River	97	24	0	10	34	5	15	10
Middle Powder River	2,460	861	12,299	123	738	246	246	123
North Fork Powder River	0	0	0	0	0	0	0	0
Salt Creek	34	8	0	3	12	2	5	6
South Fork Powder River	3	1	0	0	1	0	0	0
Upper Belle Fourche River	2,740	1,233	0	0	1,096	137	0	274
Upper Cheyenne River	259	143	0	0	91	13	0	13
Upper Powder River	35,059	12,271	0	3,506	14,024	1,753	1,753	1,753
Upper Tongue River	8,148	0	203,691	407	3,666	815	407	815
Total for 2015	**65,854**	**20,200**	**215,990**	**5,327**	**25,271**	**3,975**	**4,646**	**4,263**
Reasonably Foreseeable Development (2020)								
Antelope Creek	1,117	614	0	0	391	56	0	56
Clear Creek	7,181	1,795	0	718	2,513	359	1,077	718

Table C-6 (Continued)

Subwatershed	Annual CBNG-related Water Production (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume Direct) (mmgpy)	Annual CBNG-related Water Disposal (Passive Treatment) (mmgpy)	Annual CBNG-related Water Disposal (Active Treatment) (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume to Infiltration Impoundments) (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume to Containment Impoundments) (mmgpy)	Annual CBNG-related Water Disposal (Land Application) (mmgpy)	Annual CBNG-related Water Disposal (Injection) (mmgpy)
Crazy Woman Creek	4,473	1,566	0	447	1,342	224	671	224
Dry Fork Cheyenne River	148	37	0	15	52	7	22	1
Lightning Creek	178	45	0	18	62	9	27	18
Little Bighorn River	0	0	0	0	0	0	0	0
Little Missouri River	0	0	0	0	0	0	0	0
Little Powder River	1,828	822	0	0	548	183	183	91
Middle Fork Powder River	1,887	472	0	189	660	94	283	189
Middle North Platte River	90	22	0	9	31	4	13	9
Middle Powder River	2,210	774	11,052	111	663	221	221	111
North Fork Powder River	0	0	0	0	0	0	0	0
Salt Creek	32	8	0	3	11	2	5	3
South Fork Powder River	3	1	0	0	1	0	0	0
Upper Belle Fourche River	2,077	935	0	0	831	104	0	208
Upper Cheyenne River	176	97	0	0	62	9	0	9
Upper Powder River	37,517	13,131	0	3,762	15,007	1,876	1,876	1,876
Upper Tongue River	8,361	0	209,024	418	3,762	836	418	836
Total for 2020	**67,280**	**20,382**	**220,076**	**5,680**	**25,938**	**3,984**	**4,797**	**4,349**

[1] The Task 1D study area is shown in **Figure C-1**.



Source: BLM 2009.

Powder River Basin Coal Review

Figure C-1

Task 1D Study Area and Subwatersheds

11/09/09

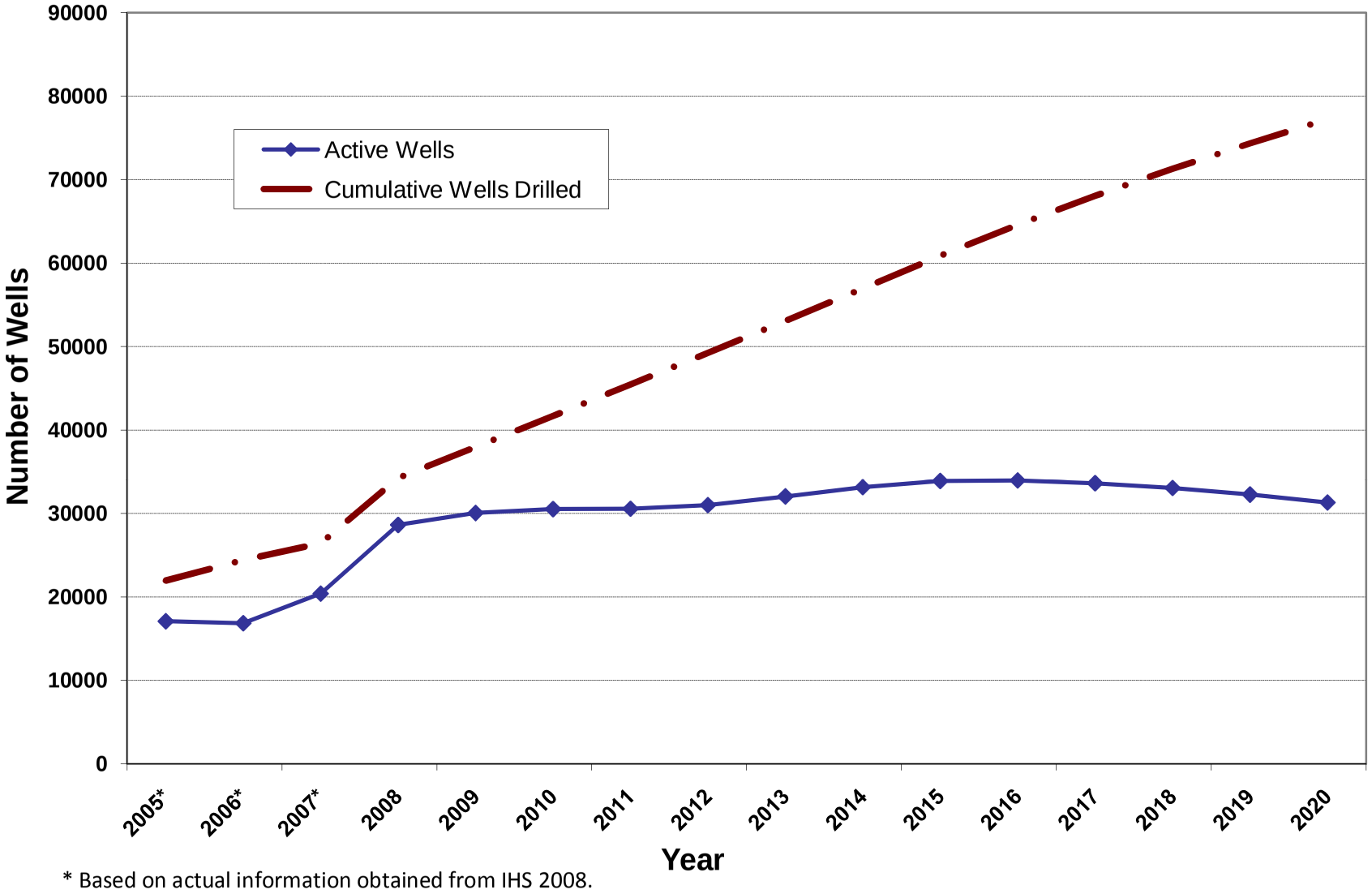


Figure C-2. Projected Numbers of Active CBNG Wells and Cumulative CBNG Wells Drilled in the Wyoming PRB

Note: See Appendix E for assumptions and methodology used in developing CBNG projections.

APPENDIX D

SUPPORTING TABLES AND FIGURES– TASK 3D STUDY AREA

Table D-1
Wyoming PRB Coal-related Development Disturbance Acreages in the Task 3D Study Area[1] (based on database)

Subwatershed	Lower and Upper Production Scenarios		
	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Areas through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)
Original Base Year (Actual 2003)			
Antelope Creek	376	0	376
Dry Fork Cheyenne River	145	0	145
Little Powder River	339	0	339
Upper Belle Fourche River	1,317	0	1,317
Upper Cheyenne River	291	0	291
Upper Powder River	521	0	521
Total for Actual 2003	**2,989**	**0**	**2,989**
Current Base Year (Actual 2007)			
Antelope Creek	564	0	564
Dry Fork Cheyenne River	218	0	218
Little Powder River	339	0	339
Upper Belle Fourche River	1,620	0	1,620
Upper Cheyenne River	436	0	436
Upper Powder River	521	0	521
Total for Actual 2007	**3,698**	**0**	**3,698**
Reasonably Foreseeable Development (2010)			
Antelope Creek	563	0	563
Dry Fork Cheyenne River	218	0	218
Little Powder River	340	0	340
Upper Belle Fourche River	1,677	0	1,677
Upper Cheyenne River	536	0	536
Upper Powder River	521	0	521
Total for 2010	**3,855**	**0**	**3,855**
Reasonably Foreseeable Development (2015)			
Antelope Creek	781	0	781
Dry Fork Cheyenne River	218	0	218
Little Powder River	340	0	340
Upper Belle Fourche River	1,933	0	1,933
Upper Cheyenne River	1,009	0	1,009
Upper Powder River	521	0	521
Total for 2015	**4,802**	**0**	**4,802**
Reasonably Foreseeable Development (2020)			
Antelope Creek	781	0	781
Dry Fork Cheyenne River	218	0	218
Little Powder River	340	0	340
Upper Belle Fourche River	1,932	0	1,932
Upper Cheyenne River	1,009	0	1,009
Upper Powder River	521	0	521
Total for 2020	**4,801**	**0**	**4,801**

[1] Coal-related activities as defined for this study include coal-fired power plants, railroads, major (230-kV) transmission lines, and coal technology projects. However, as discussed in Section 3.7, disturbance associated with major (230-kV) transmission lines is not analyzed in this study as the disturbance related to existing lines is minimal and information in relation to RFD transmission lines is lacking. The Task 3D study area is presented in **Figure D-1**.

Table D-2
Wyoming PRB Oil and Gas and Related Development Disturbance Acreages in the Task 3D Study Area[1]
(based on database)

Subwatershed	Lower and Upper Production Scenarios		
	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Areas through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)
Original Base Year (Actual 2003)[2]			
Antelope Creek	12,708	6,994	5,714
Dry Fork Cheyenne River	3,265	1,673	1,592
Little Powder River	31,600	20,998	10,602
Upper Belle Fourche River	54,899	36,366	18,563
Upper Cheyenne River	6,815	3,860	2,955
Upper Powder River	30,040	20,780	9,260
Total for 2003 Actual	**139,327**	**90,671**	**48,686**
Current Base Year (Actual 2007)			
Antelope Creek	9,914	5,572	4,342
Dry Fork Cheyenne River	1,160	569	591
Little Powder River	30,070	18,951	11,119
Upper Belle Fourche River	50,830	31,664	19,165
Upper Cheyenne River	4,653	2,952	1,701
Upper Powder River	42,348	27,788	14,559
Total for 2007 Actual	**138,975**	**87,496**	**51,477**
Reasonably Foreseeable Development (2010)			
Antelope Creek	13,652	7,947	5,704
Dry Fork Cheyenne River	1,432	858	574
Little Powder River	35,714	23,246	12,468
Upper Belle Fourche River	55,761	36,290	19,471
Upper Cheyenne River	5,418	3,286	2,132
Upper Powder River	67,570	42,725	24,825
Total for 2010	**179,547**	**114,353**	**65,194**
Reasonably Foreseeable Development (2015)			
Antelope Creek	18,498	12,507	5,991
Dry Fork Cheyenne River	1,717	1,030	688
Little Powder River	39,766	27,037	12,729
Upper Belle Fourche River	59,808	42,162	17,646
Upper Cheyenne River	5,426	3,646	1,780
Upper Powder River	111,696	72,245	39,450
Total for 2015	**236,911**	**158,628**	**78,283**
Reasonably Foreseeable Development (2020)			
Antelope Creek	22,609	17,094	5,515
Dry Fork Cheyenne River	1,997	1,277	720
Little Powder River	39,992	30,249	9,743
Upper Belle Fourche River	60,163	45,196	14,967
Upper Cheyenne River	5,432	3,955	1,477
Upper Powder River	155,092	112,703	42,388
Total for 2020	**285,285**	**210,474**	**74,811**

[1] Inclusive of conventional oil and gas and CBNG activities and major transportation pipelines. Disturbance associated with ancillary facilities (including gather lines and distribution power lines) has been factored in on a per well basis as discussed in Appendix E of this report. The Task 3D study area is presented in **Figure D-1**.

[2] The 2003 base year cumulative information was adjusted to reflect updated 2003 conventional oil and gas and CBNG information.

Table D-3
Wyoming PRB Total Development-related Disturbance Acreages
In the Task 3D Study Area[1]
(based on database)

Subwatershed	Lower Production Scenario			Upper Production Scenario		
	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Areas through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)
Original Base Year (Actual 2003)[2]						
Antelope Creek	27,811	10,442	17,369	27,811	10,442	17,369
Dry Fork Cheyenne River	3,265	1,673	1,592	3,265	1,673	1,592
Little Powder River	41,720	23,641	18,079	41,720	23,641	18,079
Upper Belle Fourche River	80,050	43,530	36,520	80,050	43,530	36,520
Upper Cheyenne River	27,210	11,813	15,397	27,210	11,813	15,397
Upper Powder River	30,040	20,780	9,260	30,040	20,780	9,260
Total for 2003 Actual	**210,096**	**111,879**	**98,217**	**210,096**	**111,879**	**98,217**
Current Base Year Actual 2007						
Antelope Creek	30,850	11,130	26,113	30,850	11,130	26,113
Dry Fork Cheyenne River	1,160	569	591	1,160	569	591
Little Powder River	42,203	22,066	22,917	42,203	22,066	22,917
Upper Belle Fourche River	76,747	38,649	44,785	76,747	38,649	44,785
Upper Cheyenne River	29,259	13,179	23,679	29,259	13,179	23,679
Upper Powder River	42,348	27,788	14,559	42,348	27,788	14,554
Total for 2007 Actual	**222,568**	**113,382**	**132,645**	**222,568**	**113,382**	**132,645**
Reasonably Foreseeable Development (2010)						
Antelope Creek	38,075	18,995	19,080	39,034	18,995	20,039
Dry Fork Cheyenne River	1,432	858	574	1,432	858	574
Little Powder River	48,471	27,689	20,783	49,086	28,089	20,997
Upper Belle Fourche River	86,256	49,034	37,222	87,580	50,267	37,313

Table D-3 (Continued)

Subwatershed	Lower Production Scenario			Upper Production Scenario		
	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)	Cumulative Disturbance Through Most Recent Year (acres)	Cumulative Permanently Reclaimed Areas through Most Recent Report Year (acres)	Cumulative Unreclaimed Areas through Most Recent Report Year (acres)
Upper Cheyenne River	36,405	19,989	16,416	37,294	20,189	17,105
Upper Powder River	67,570	42,725	24,845	67,570	42,725	24,845
Total for 2010	**278,209**	**159,291**	**118,919**	**281,996**	**161,124**	**120,872**
Reasonably Foreseeable Development (2015)						
Antelope Creek	48,985	29,155	19,831	50,506	29,155	21,351
Dry Fork Cheyenne River	1,717	1,029	688	1,717	1,029	688
Little Powder River	54,488	32,980	21,508	55,403	33,655	21,747
Upper Belle Fourche River	94,899	58,556	36,344	98,285	61,489	36,797
Upper Cheyenne River	42,363	25,850	16,513	43,849	26,450	17,399
Upper Powder River	111,696	72,245	39,450	111,696	72,245	39,450
Total for 2015	**354,148**	**219,816**	**134,334**	**361,456**	**224,024**	**137,432**
Reasonably Foreseeable Development (2020)						
Antelope Creek	60,324	40,542	19,781	62,936	40,042	22,894
Dry Fork Cheyenne River	1,997	1,277	720	1,997	1,277	720
Little Powder River	56,737	37,817	18,919	58,062	38,867	19,195
Upper Belle Fourche River	100,140	65,740	34,402	106,385	71,123	35,260
Upper Cheyenne River	48,437	31,858	16,578	49,902	32,658	17,244
Upper Powder River	155,092	112,703	42,388	155,092	112,703	42,388
Total for 2020	**422,727**	**289,937**	**132,789**	**434,374**	**296,670**	**137,702**

[1] Inclusive of disturbance associated with coal mining, coal-related activities, oil and gas and related development, and other development activities identified for this study. Other quantifiable activities include approximately 171 and 145 acres of disturbance associated with major water storage reservoirs in the Antelope Creek and Little Powder River subwatersheds (2003 through 2020), respectively. The Task 3D study area is presented in **Figure D-1**.

[2] The 2003 base year cumulative information was adjusted to reflect updated 2003 conventional oil and gas and CBNG information.

Note: Minor discrepancies in total acreages are the result of rounding.
Based on GIS, the total land area in the Task 3D study area encompasses 4,490,205 acres.

Table D-4
Wyoming PRB Coal Mine-related Production, Employment, and Water-related Information for the Task 3D Study Area[1]
(based on database)

Subwatershed	Lower Production Scenario				Upper Production Scenario			
	Annual Coal Production for Report Year (million tons)	Total Employment for Report Year[2]	Annual Water Consumption (mmgpy)	Annual Water Production[3] (acre-feet)	Annual Coal Production for Report Year (million tons)	Total Employment for Report Year	Annual Water Consumption (mmgpy)	Annual Water Production[3] (acre-feet)
Original Base Year (Actual 2003)								
Antelope Creek	110	1,386	763	472	110	1,386	763	472
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Little Powder River	50	676	359	191	50	676	359	191
Upper Belle Fourche River	81	931	572	447	81	931	572	447
Upper Cheyenne River	122	1,704	946	276	122	1,704	946	276
Upper Powder River	0	0	0	0	0	0	0	0
Total for Actual 2003	**363**	**4,697**	**2,640**	**1,386**	**363**	**4,697**	**2,640**	**1,386**
Current Base Year (Actual 2007)								
Antelope Creek	126	1,400	763	472	126	1,400	763	472
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Little Powder River	73	841	323	191	73	841	323	191
Upper Belle Fourche River	105	1,615	660	447	105	1,615	660	447
Upper Cheyenne River	124	1,677	946	276	124	1,677	946	276
Upper Powder River	0	0	0	0	0	0	0	0
Total for Actual 2007	**428**	**5,533**	**2,692**	**1,386**	**428**	**5,533**	**2,692**	**1,386**
Reasonably Foreseeable Development (2010)								
Antelope Creek	121	1,414	250	899	127	1,414	250	899
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Little Powder River	57	715	259	165	70	739	333	165

Table D-4 (Continued)

Subwatershed	Lower Production Scenario				Upper Production Scenario			
	Annual Coal Production for Report Year (million tons)	Total Employment for Report Year[2]	Annual Water Consumption (mmgpy)	Annual Water Production[3] (acre-feet)	Annual Coal Production for Report Year (million tons)	Total Employment for Report Year	Annual Water Consumption (mmgpy)	Annual Water Production[3] (acre-feet)
Upper Belle Fourche River	100	1,566	489	675	125	1,617	513	675
Upper Cheyenne River	133	1,739	865	520	157	1,739	934	520
Upper Powder River	0	0	0	0	0	0	0	0
Total for 2010	**411**	**5,433**	**1,863**	**2,258**	**479**	**5,509**	**2,030**	**2,258**
Reasonably Foreseeable Development (2015)								
Antelope Creek	133	1,429	282	899	133	1,429	282	899
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Little Powder River	69	758	303	165	88	833	377	165
Upper Belle Fourche River	117	1,561	549	675	154	1,603	187	675
Upper Cheyenne River	148	1,957	995	520	168	1,857	1,051	520
Upper Powder River	0	0	0	0	0	0	0	0
Total for 2015	**467**	**5,705**	**2,129**	**2,258**	**543**	**5,722**	**1,897**	**2,258**
Reasonably Foreseeable Development (2020)								
Antelope Creek	137	1,442	282	899	137	1,442	282	899
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Little Powder River	71	767	333	165	103	946	406	165
Upper Belle Fourche River	133	1,649	565	675	166	1,617	630	675
Upper Cheyenne River	154	1,873	1,052	520	170	1,873	1,155	520
Upper Powder River	0	0	0	0	0	0	0	0
Total for 2020	**495**	**5,731**	**2,232**	**2,258**	**576**	**5,998**	**2,473**	**2,258**

[1] The Task 3D study area is shown in **Figure D-1**.
[2] Based on coal mine information, with the exception of power plant-related employees identified in the Little Powder River, Upper Belle Fourche River, and Upper Cheyenne River subwatershed numbers. There were 70 power plant-related employees identified for 2003, with an assumed operational work force of 100 per power plant for the other time periods.
[3] For purposes of this study, the annual coal mine-related water production is assumed to be the same under both the lower and upper production scenarios.

Table D-5
Wyoming PRB Oil and Gas Production and Conventional Oil and Gas Water-related Information for the Task 3D Study Area[1]
(based on database)

Subwatershed	Annual Oil Production for Report Year (barrels)	Annual Gas Production for Report Year[2] (mmcf)	Annual Conventional Oil- and Gas-related Water Production (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume Direct) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Passive Treatment) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Active Treatment) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume to Infiltration Impoundments) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume to Containment Impoundments) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Land Application) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Injection) (mmgpy)
Original Base Year (Actual 2003)										
Antelope Creek	831,582	31,887	5	3	0	0	2	0	0	0
Dry Fork Cheyenne River	398,311	10,277	1	0	0	0	0	0	0	0
Little Powder River	2,961,036	39,619	1,777	800	0	0	533	178	178	89
Upper Belle Fourche River	4,728,251	146,805	1,350	607	0	0	540	67	0	135
Upper Cheyenne River	153,924	26,899	13	7	0	0	5	1	0	1
Upper Powder River	2,305,549	65,143	133	47	0	13	53	7	7	7
Total for 2003 Actual	**11,378,653**	**320,629**	**3,280**	**1,464**	**0**	**13**	**1,133**	**253**	**185**	**231**
Current Base Year (Actual 2007)										
Antelope Creek	802,033	32,771	8	4	0	0	3	0	0	0
Dry Fork Cheyenne River	268,295	2,041	4	1	0	0	1	0	1	0
Little Powder River	2,437,033	23,756	2,181	982	0	0	654	218	218	109
Upper Belle Fourche River	4,033,653	58,013	1,387	624	0	0	555	69	0	139
Upper Cheyenne River	99,222	6,497	8	4	0	0	3	0	0	0
Upper Powder River	2,337,089	248,621	188	66	0	19	75	9	9	9
Total for 2007 Actual	**9,997,325**	**371,698**	**3,776**	**1,681**	**0**	**19**	**1,291**	**298**	**228**	**258**
Reasonably Foreseeable Development (2010)										
Antelope Creek	699,364	48,219	5	3	0	0	2	0	0	0
Dry Fork Cheyenne River	381,362	11,460	49	12	0	5	17	2	7	0
Little Powder River	4,178,501	19,932	2,508	1,129	0	0	752	251	251	125

Table D-5 (Continued)

Subwatershed	Annual Oil Production for Report Year (barrels)	Annual Gas Production for Report Year[2] (mmcf)	Annual Conventional Oil- and Gas-related Water Production (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume Direct) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Passive Treatment) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Active Treatment) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume to Infiltration Impoundments) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Discharge Volume to Containment Impoundments) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Land Application) (mmgpy)	Annual Conventional Oil- and Gas-related Water Disposal (Injection) (mmgpy)
Upper Belle Fourche River	6,612,754	64,313	1,888	849	0	0	755	94	0	189
Upper Cheyenne River	54,368	6,930	5	3	0	0	2	0	0	0
Upper Powder River	1,894,972	406,348	110	38	0	11	44	5	5	5
Total for 2010	**13,821,319**	**568,291**	**4,563**	**2,034**	**0**	**16**	**1,572**	**354**	**264**	**321**
Reasonably Foreseeable Development (2015)										
Antelope Creek	640,214	49,201	4	2	0	0	1	0	0	0
Dry Fork Cheyenne River	349,581	11,129	52	13	0	5	18	3	8	1
Little Powder River	3,807,528	29,352	2,285	1,028	0	0	686	229	229	114
Upper Belle Fourche River	5,963,186	55,380	1,702	766	0	0	681	85	0	170
Upper Cheyenne River	52,249	5,140	4	2	0	0	2	0	0	0
Upper Powder River	1,723,898	623,908	100	35	0	10	40	5	5	5
Total for 2015	**12,536,656**	**774,110**	**4,148**	**1,847**	**0**	**15**	**1,428**	**322**	**241**	**290**
Reasonably Foreseeable Development (2020)										
Antelope Creek	581,064	44,279	4	2	0	0	1	0	0	0
Dry Fork Cheyenne River	317,801	10,562	42	10	0	4	15	2	6	0
Little Powder River	3,436,555	18,159	2,063	928	0	0	619	206	206	103
Upper Belle Fourche River	5,313,617	42,627	1,517	683	0	0	607	76	0	152
Upper Cheyenne River	50,131	3,609	4	2	0	0	1	0	0	0
Upper Powder River	1,555,456	667,179	90	32	0	9	36	5	5	5
Total for 2020	**11,254,625**	**786,410**	**3,719**	**1,657**	**0**	**13**	**1,279**	**289**	**217**	**260**

[1] The Task 3D study area is shown in **Figure D-1**.
[2] Natural gas produced by conventional gas and CBNG wells.

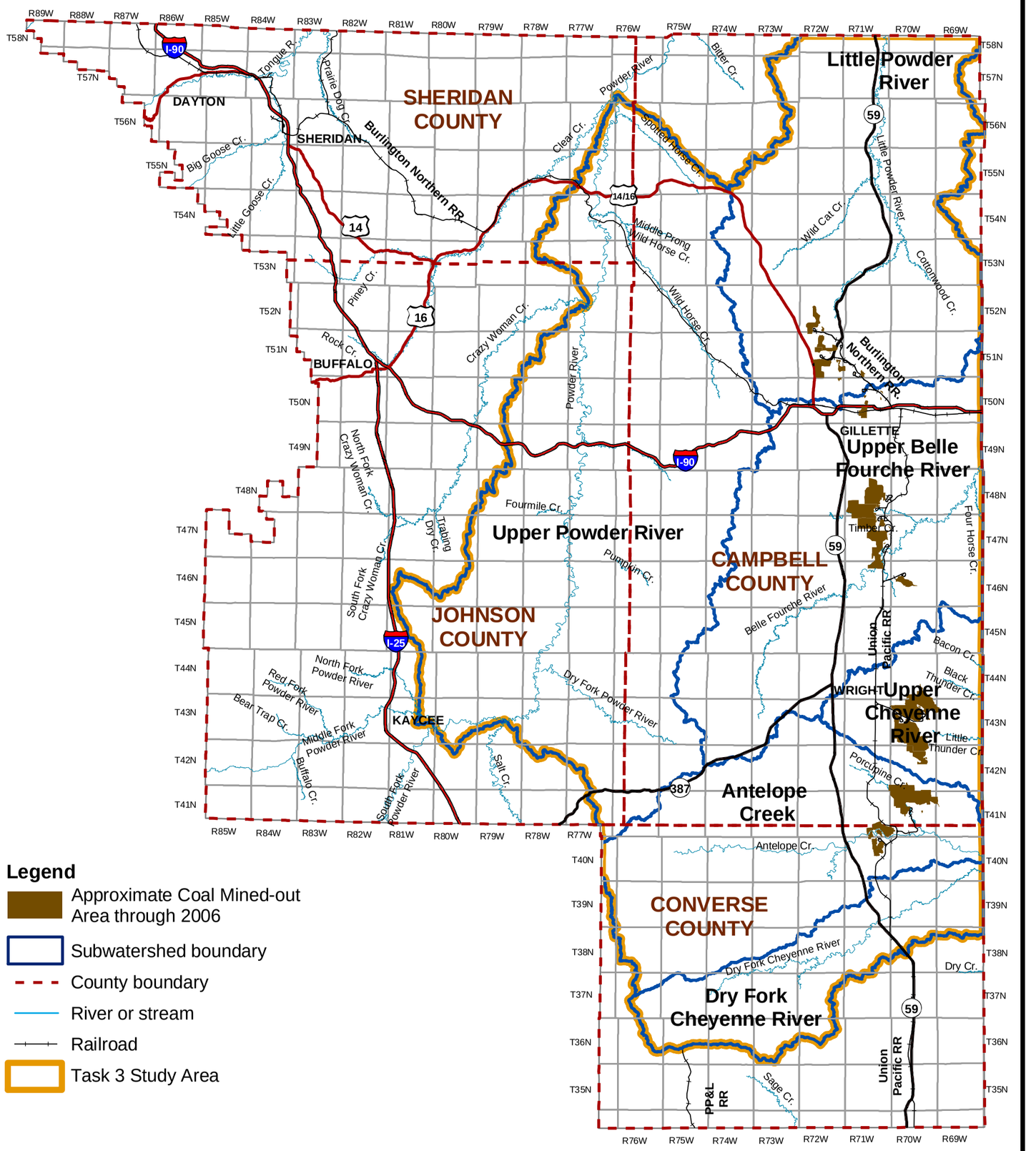
Table D-6
Wyoming PRB CBNG Water-related Information
for the Task 3D Study Area[1]
(based on database)

Subwatershed	Annual CBNG-related Water Production (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume Direct) (mmgpy)	Annual CBNG-related Water Disposal (Passive Treatment) (mmgpy)	Annual CBNG-related Water Disposal (Active Treatment) (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume to Infiltration Impoundments) (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume to Containment Impoundments) (mmgpy)	Annual CBNG-related Water Disposal (Land Application) (mmgpy)	Annual CBNG-related Water Disposal (Injection) (mmgpy)
Original Base Year (Actual 2003)								
Antelope Creek	1,290	710	0	0	452	65	0	65
Dry Fork Cheyenne River	0	0	0	0	0	0	0	0
Little Powder River	2,753	1,239	0	0	826	275	275	138
Upper Belle Fourche River	7,566	3,405	0	0	3,026	378	0	757
Upper Cheyenne River	1,078	593	0	0	377	54	0	54
Upper Powder River	5,237	1,833	0	524	2,095	262	262	262
Total for 2003 Actual	**17,924**	**7,779**	**0**	**524**	**6,776**	**1,034**	**537**	**1,274**
Current Base Year (Actual 2007)								
Antelope Creek	785	432	0	0	275	39	0	39
Dry Fork Cheyenne River	100	25	0	10	35	5	15	1
Little Powder River	2,483	1,117	0	0	745	248	248	124
Upper Belle Fourche River	2,943	1,324	0	0	1,177	147	0	294
Upper Cheyenne River	301	166	0	0	105	15	0	15
Upper Powder River	13,880	4,858	0	1,388	5,552	694	694	694
Total for 2007 Actual	**20,492**	**7,922**	**0**	**1,398**	**7,889**	**1,149**	**957**	**1,168**

Table D-6 (Continued)

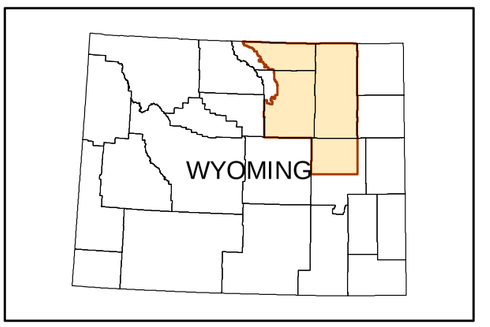
Subwatershed	Annual CBNG-related Water Production (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume Direct) (mmgpy)	Annual CBNG-related Water Disposal (Passive Treatment) (mmgpy)	Annual CBNG-related Water Disposal (Active Treatment) (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume to Infiltration Impoundments) (mmgpy)	Annual CBNG-related Water Disposal (Discharge Volume to Containment Impoundments) (mmgpy)	Annual CBNG-related Water Disposal (Land Application) (mmgpy)	Annual CBNG-related Water Disposal (Injection) (mmgpy)
Reasonably Foreseeable Development (2010)								
Antelope Creek	1,173	645	0	0	411	59	0	59
Dry Fork Cheyenne River	73	18	0	7	26	4	11	1
Little Powder River	3,248	1,461	0	0	974	325	325	162
Upper Belle Fourche River	3,196	1,438	0	0	1,279	160	0	320
Upper Cheyenne River	357	196	0	0	125	18	0	18
Upper Powder River	22,762	7,967	0	2,276	9,105	1,138	1,138	1,138
Total for 2010	**30,809**	**11,726**	**0**	**2,284**	**11,919**	**1,703**	**1,474**	**1,697**
Reasonably Foreseeable Development (2015)								
Antelope Creek	1,244	684	0	0	436	62	0	62
Dry Fork Cheyenne River	132	33	0	13	46	7	20	1
Little Powder River	3,032	1,365	0	0	910	303	303	152
Upper Belle Fourche River	2,740	1,233	0	0	1,096	137	0	274
Upper Cheyenne River	259	143	0	0	91	13	0	13
Upper Powder River	35,059	12,271	0	3,506	14,024	1,753	1,753	1,753
Total for 2015	**42,468**	**15,729**	**0**	**3,519**	**16,602**	**2,275**	**2,076**	**2,255**
Reasonably Foreseeable Development (2020)								
Antelope Creek	1,117	614	0	0	391	56	0	56
Dry Fork Cheyenne River	148	37	0	15	52	7	22	1
Little Powder River	1,828	822	0	0	548	183	183	91
Upper Belle Fourche River	2,077	935	0	0	831	104	0	208
Upper Cheyenne River	176	97	0	0	62	9	0	9
Upper Powder River	37,517	13,131	0	3,762	15,007	1,876	1,876	1,876
Total for 2020	**42,863**	**15,636**	**0**	**3,767**	**16,890**	**2,235**	**2,081**	**2,241**

[1] The Task 3D study area is shown in **Figure D-1**.



Legend

- Approximate Coal Mined-out Area through 2006
- Subwatershed boundary
- County boundary
- River or stream
- Railroad
- Task 3 Study Area



N W E S

0 3 6 9 Miles

02.557.5 Kilometers

Source: BLM 2009.

Powder River Basin Coal Review

Figure D-1

Task 3D Study Area and Subwatersheds

11/09/09

APPENDIX E

METHODOLOGY AND ASSUMPTIONS FOR OIL AND GAS RFD PROJECTIONS

1.0 GENERAL INFORMATION

Information on the methodologies discussed in this appendix are consistent with those used in developing data for this current Task 2 update. Methodologies used for developing the original Task 2 report actual and projected data are discussed in Appendix E of the original Task 2 report (revised October 2005).

Primary Data Source: IHS (2008) data files were sorted by the BLM for use in this study. Files included wells permitted within all of Campbell, Johnson, Sheridan, and Converse counties; however, only wells identified as within the PRB study area were considered in the analysis. Information included in the IHS files included production data on producing wells in the study area by year between 1974 and 2008 according to permit number. Additionally, information on location (latitude/longitude), completion depth, and initial target product for all wells within the study area was available for all wells in the study area. Wells were identified by comparing American Petroleum Institute (API) numbers, and all wells were mapped and 4th level sub-basins (referred to as subwatersheds for consistency with the PRB Oil and Gas EIS [BLM 2003a]) assigned through the GIS.

Secondary Information Source: The WOGCC (2008) website provided a current searchable CBNG database, which was used during this analysis for production comparisons. It also provided mineral rights ownership on a well-by-well basis.

Tertiary Information Source: BLM and WOGCC. BLM information concerning projected federal APDs for CBNG, the rate of APDs that actually become wells, information on CBNG production lives, and mineral rights ownership was used in this study. The WOGCC provided information concerning potential numbers of inactive conventional wells that may be present in the study area. Distribution of RFD CBNG wells by subwatershed was based on data provided by BLM (2007b).

The following sections describe the methodology and key assumptions used in developing the database of past, present, and reasonably foreseeable oil and gas development in the Wyoming PRB.

2.0 ACTUAL PRODUCTION DATA DETERMINATION

Well locations, well types, initial production date, and production data were available in the IHS (2008) database from 1990 to 2008. Wells were identified as conventional wells or CBNG wells based on the tax credit type in the database, and wells subsequently were plotted and assigned subwatershed locations using GIS. The number of new and active wells was determined for each production type and subwatershed based on the first and last production dates in the IHS data set. The number of inactive wells was determined based on the filing date of a Notice of Intent to abandon. Conventional wells designated as inactive maybe either shut-in (destined for plugging and abandonment) or seasonally active. Seasonally active wells were categorized separately (see Section 5.0 for further discussion). CBNG wells designated as inactive were determined to be drilled and ready to produce (Eggerman 2005), and therefore, were included with active wells for current and future calculations.

Production (baseline and cumulative) information was developed for wells grouped by subwatershed and well type. Cumulative data included all production through 2003, plus production in each subsequent year.

Assumptions;

1) Wells were categorized as CBNG or conventional based on their listed tax credit type. Those wells listed with a CBNG tax credit were categorized as such; remaining wells were categorized as conventional.

3.0 ESTIMATE OF FUTURE CONVENTIONAL OIL AND GAS WELLS DRILLED PER YEAR

Methodology for conventional well locations remained consistent with those described in Appendix E of the original Task 2 report (revised October 2005). Numbers of conventional wells drilled since 1990 were determined using the IHS *all wells* file. Only wells with a completion date between December 31, 1989, and 2003 were used in this analysis. Also, only wells that were located in T34N through T58N were used. Only wells deeper than 2,000 feet were considered to be conventional oil and gas wells. A breakdown according to the well classification provided in the IHS data file (e.g., plugged and abandoned [P&A], wildcat, injection, etc.) subsequently was performed. The final result was an estimate of 100 conventional oil and gas wells drilled in the PRB per year from 1990 through 2004.

Because estimating future activity in the region based on past activity did not account for increases in oil prices (which may cause an increased interest in oil in the region), or the potential for reactivating dormant wells, the future estimate was based on the predicted number of operating conventional wells in the region. Numbers of predicted operating wells were based on the expected numbers of operating wells per year taken from a graph provided by the BLM RMG (2005), which accounts for the potential increase in oil and gas production in the region based on increasing oil price estimates (based on changing percent increases or decreases in wells) (see **Table E-1**). Unanticipated future price fluctuations could affect (increase or decrease) future well projection numbers. The previous year estimate of active wells was multiplied by the indicated factor to estimate the current year number of active wells. The numbers of historic wells used by the BLM RMG closely tracked with the number of wells from the IHS database designated as crude oil, but production information and well counts produced for this study also included the wells designated as gas, oil, or injection that had produced oil. The year the additional wells came on line was determined, and they were added to the historic numbers from the BLM RMG (2005) based on these dates. Therefore, the historic active well numbers were adjusted upward based on the number of those wells that came on line each year. All wells operating prior to 1974 were added to 1974. Future well numbers then were projected.

Table E-1
Changes In Projected Number of Operating Conventional Wells

Years	Increase or Decrease	Percent
2006-2009	Increase	5
2010-2012	Decrease	2
2013-2020	Decrease	3

Source: BLM RMG 2005.

The number of projected new wells each year was estimated based on the assumptions that the P&A rate of operating conventional wells is 10 percent, and the percent of new wells drilled that are unsuccessful (therefore P&A) is 40 percent (IHS 2004). Wells that are not P&A were assumed to be producing. This equation follows:

New active wells = 0.6 x current year new wells – 0.9 x previous year active wells

Assumptions:

1) Wells located in T34N through T58N are within the PRB study area.
2) All historic shallow wells (completion depth of less than 2,000 feet) are CBNG wells.
3) The PRB will see a short-term increase in the number of operating wells in the region, followed by a slow decline.
4) Forty percent of wells drilled will be nonproductive and P&A within that year, and an additional 10 percent of active wells will be P&A each year.

4.0 ESTIMATE OF FUTURE P&A CONVENTIONAL OIL AND GAS WELLS RELATIVE TO THE TOTAL NUMBER OF WELLS

Methodology for conventional well locations remained consistent with those discussed in Appendix E of the original Task 2 report (revised October 2005). Between 1989 and 2004, the percent of new wells that have been drilled and P&A in the study area has been 40 percent (IHS 2004). This includes all classifications of wells: wildcats, development wells, and injection wells. The number of wells P&A in each subwatershed was determined by year from 1990 to 2004 using the IHS *all wells* file. Historically, the mean percent of P&A wells relative to the number of active wells was 1.6 percent (IHS 2004). This ratio was applied to yearly totals of conventional wells to estimate the number of P&A wells for the years 2004 to 2009. Because the predicted decline of active wells between 2010 and 2020 (BLM RMG 2005) required an increase in the number of P&A wells, the P&A rate was adjusted to equal the decline rate of those years plus 0.5 percent. The sum of the new P&A wells and the operating P&A wells was the total for each year.

Assumptions:

1) Forty percent of new wells are unproductive and P&A within the first year after drilling.
2) Decline rates were based on data provided by BLM RMG (2005).
3) The wells to be abandoned were not depend on geographic location.

5.0 ESTIMATE OF THE NUMBER OF FUTURE ACTIVE, INACTIVE, P&A, AND TOTAL CONVENTIONAL OIL AND GAS WELLS

Methodology for conventional well locations remained consistent with those discussed in Appendix E of the original Task 2 report (revised October 2005). The estimated number of P&A wells was based on the number of estimated new wells for each year multiplied by a factor of 0.4 (which is the approximate rate of new wells closed within the first year of operation based on oil field data within the area), plus the previous year's cumulative total wells and the current number of inactive wells multiplied by a factor of 0.1. The following equation was used:

P&A wells = (previous years cumulative wells x 0.100) + (new wells for year x 0.4) + (0.1 x inactive wells)

The number of cumulative wells was determined based on the sum of the previous year's cumulative wells plus the new wells. The following equation was used:

Cumulative wells = (previous year's cumulative wells) x (1-0.100) + new wells for year

The number of inactive wells (over 3,000) for 2003 was determined using the IHS production file. According to WOGCC (2005b), it is possible and reasonable that the number of shut-in wells in the region could be estimated at 2,000. The remaining wells could be considered to be seasonally active, but may not have been listed as active in the IHS production database, because the information was downloaded during winter months while these wells were inactive. Because locating individual shut-in or seasonally active wells was not realistic; wells reclassified as seasonally active (approximately 1,000 wells) were removed from the inactive category and distributed throughout subwatersheds proportionally to the number of active wells. Future rates of seasonally active wells were estimated to remain constant, while a yearly P&A rate of 10 percent was applied to the remaining inactive (shut-in) wells.

Assumptions:

1) Approximately 2,000 inactive (shut-in) wells exist within the PRB study area. Remaining wells designated as inactive in the IHS database are actually seasonally active. These wells were distributed proportionally to the active wells in the region.

6.0 ALLOCATION OF FUTURE CONVENTIONAL OIL AND GAS WELLS BY SUBWATERSHED

Methodology for conventional well locations remained consistent with those discussed in Appendix E of the original Task 2 report (revised October 2005). The number of wells drilled per subwatershed was determined by year from 1990 to 2004, using the IHS database and GIS. The mean ratio of wells drilled per subwatershed relative to the basin-wide total number of wells was determined for this period, and the mean ratio was applied to the estimated future total number of wells to distribute them throughout the subwatersheds.

Assumptions:

1) The future distribution pattern of wells by subwatershed will be similar to distribution patterns through 2003.

7.0 ESTIMATE OF THE RATE OF P&A CBNG WELLS PER SUBWATERSHED PER YEAR

P&A rates were estimated to remain consistent with those discussed in Appendix E of the original Task 2 report (revised October 2005). Rates of unsuccessful wells drilled in the region were estimated at 4.1 percent (BLM RMG 2005). Estimated rates for plugging and abandoning successful wells were based on well age, with the majority of wells ending their productive lives at 10 years (**Table E-2**).

Table E-2
Expected Lifespan of CBNG Wells

Age of Well (year)	Percent of Active Wells for Year Expected to be P&A
8	10
9	20
10	30
11	30
12	10
Total	**100**

P&A wells were distributed among the subwatersheds based on the proportion of active wells in the subwatershed. Wells were further subdivided by oil and gas mineral ownership proportionally to the ownership distribution of the previous years active wells.

Assumptions:

1) It is assumed that abandonment rates of new wells will be 4.1 percent (BLM RMG 2005).
2) Wells will be P&A between 8 and 12 years after they start producing, with the majority of wells abandoned after 10 years of operation (BLM RMG 2005). Wells with a first production year of 2003 or later were closed based on age according to **Table E-2**.
3) Rates of abandonment for wells active prior to 2003 with an untracked first production year will be similar to the average closure rate in each subwatershed between 2003 and 2008.
4) The distribution pattern of abandoned wells between subwatersheds will be proportional to the numbers of active wells in the subwatersheds.

8.0 ESTIMATE OF THE FUTURE RATE OF CBNG WELLS DRILLED PER SUBWATERSHED PER YEAR

The number of CBNG wells drilled per subwatershed between 1990 and 2007 was determined from the IHS database based on the dates the wells went on line and the dates the wells were completed (the numbers were within 0.1 percent of each other). The total number of wells drilled from 2002 to 2007 was compared to future estimates presented in Table 2-1 in the PRB Oil and Gas Final EIS (BLM 2003a). The (then) future estimates from the Final EIS were higher than the actual data from the IHS file. Because mineral rights in the region are primarily federal, future wells drilled would be largely dependent on the projected number of APDs to be issued by the BLM Field Offices in the region.

The BLM High Plains District Office expects to issue 35 federal APDs each year through 2020. The BLM Buffalo Field Office expects to issue 2,500 APDs per year through 2015, which would decline by 200 wells per year from 2016 to 2020. The number of wells drilled through 2007 were obtained from the IHS database. Approximately 89.8 percent of federally issued APDs would result in drilled wells (BLM RMG 2005).

The number of state/fee permits anticipated per year in the PRB study area was calculated in several steps. Estimates of available pads were determined using GIS, as follows: 1) The area of consideration in each subwatershed was defined as that area overlying the major coal-bearing strata of the Fort Union Formation. 2) Currently active conventional wells and all CBNG wells were plotted, and an 80-acre buffer around each existing well was removed from consideration for future development. 3) The areas remaining were quantified in acres according to oil and gas mineral ownership. Although areas that contain thin multiple coal seams or low gas content could not be economically drilled, they have not been defined for or excluded from this study which looked at the averages. 4) Available acreages were divided into 80-acre parcels to estimate the number of available well pads. Each year, the number of available pads was reduced by the estimated number of APDs issued for each ownership divided by 1.45, which is the overall number of CBNG wells per pad (BLM 2003a). First, the ratio of available state/fee 80-acre pads available for development relative to federal mineral ownership lands was estimated. This proportion was applied to the number of federal APDs issued to calculate the anticipated number of state/fee APDs issued. An estimated 72.4 percent of state/fee APDs are drilled (BLM RMG 2005). The estimated number of wells drilled was calculated by the following equation:

BLM High Plains District Office APDs through 2020 = 35/year

BLM Buffalo Field Office APDs through 2020 = X/year

where

X = 2,500 per year through 2015, 2,300 in 2016, 2,100 in 2017, 1,900 in 2019, and 1,500 in 2020

Federal APDs = BLM Buffalo Field Office APDs or BLM High Plains District Office APDs

Federal wells drilled = Federal APDs x 0.898

and

$$\textit{State/Fee APDs} = \frac{\textit{State/Fee Available Pads}}{\textit{Federal Available Pads}} \times \textit{Federal APDs}$$

State/Fee wells drilled = State/Fee APDs x 0.724

and

Current year Federal pads = Previous year Federal Pads – Previous year Federal APDs/1.45

Current year State/Fee pads = Previous year State/Fee Pads – Previous year State/Fee APDs/1.45

and

Wells drilled for year = Federal Wells Drilled + State/Fee Wells Drilled

Distribution of new wells into subwatersheds was based on the proportion of available pads within geological features anticipated to produce natural gas.

Assumptions:

1) The BLM Buffalo Field Office will issue 2,500 APDs/year through 2015. Starting in 2016, the number of federal permits issued per year will decline at a rate of 200 per year until 2020 to account for a tapering off of activity that is expected to occur after 25 years of activity in the play. The BLM High Plains District Office will issue 35 APDs per year through 2020. Of all federal APDs issued, 89.8 percent will be drilled (BLM RMG 2005).
2) The number of state/fee APDs that the WOGCC will issue will be proportional to the number of federal APDs issued by each BLM office, as well as to the amount of remaining available spacing for state/fee pads within the BLM field office boundaries. Of the state APDs issued, 72.4 percent will be drilled.
3) An average of 1.45 wells will be drilled per pad (BLM 2003a).
4) Distribution of new wells in the PRB subwatersheds will be proportional to remaining available pads within the jurisdiction of each BLM office.
5) No significant CBNG development will occur outside of the Wasatch/Fort Union coal outcrop.
6) Technology used to extract CBNG will not change significantly during the time frame of this study.
7) Future wells will be drilled based on 80-acre pad spacing.

9.0 DETERMINATION OF FUTURE YEARLY TOTAL PRODUCTION OF NATURAL GAS AND WATER FROM CBNG WELLS AND OIL, GAS, AND WATER FROM CONVENTIONAL WELLS

The mean base year (2007) well production (oil, natural gas, and water) was determined by subwatershed on a per operating well basis. The mean production rate was applied on a per well basis for future estimates. Where no historical production information was available to develop future subwatershed-based estimates, basin-wide mean per-well production was used. Because production levels varied greatly between and within subwatershed data, and because current means were not available for some subwatersheds (i.e., no wells were producing within the subwatershed), means of the production of each product or water across all subwatersheds for each production type (conventional oil and gas and CBNG) were used. These means were multiplied by the estimated number of producing wells in each future time period analyzed for this study. It should be noted that estimates of future production rates could be affected by unanticipated oil and gas price fluctuations, potential lower production rate per well, or the tapping of thinner coal seams that proportionally would produce less gas.

Assumption:

1) While production from individual wells can vary greatly, because the number of wells is fairly large, the overall mean is representative of regional production.
2) The average rate of production per well will not change greatly over the period of this study.
3) Average annual production per subwatershed is based on the number of wells for each year divided into the total production each year, then averaged.

10.0 DETERMINATION OF FUTURE CUMULATIVE VALUES FOR PRODUCTION OF OIL, NATURAL GAS, AND WATER

Future cumulative production values were identified by determining the estimated yearly production (products and water) for the yearly estimated number of wells and adding these to the previous dataset's cumulative estimate. The equation for this is:

Estimated cumulative production for given year = previous year estimated cumulative + current year estimated production

11.0 DETERMINATION OF WATER PRODUCTION, CONSUMPTION, INJECTION, AND DISCHARGE AMOUNTS

The number of injection wells and volumes of injection water for 2003 were determined from the IHS production file for wells identified as injection. The number of injection wells in relation to the overall number of wells in the basin was negligible.

Assumptions:

1) Water reported in the IHS database for wells identified as injection was assumed to be the volume of water injected.
2) Water produced within a subwatershed either would be injected or discharged within the same subwatershed.

12.0 ESTIMATE OF DISTURBED AND RECLAIMED ACREAGE RELATED TO CONVENTIONAL OIL AND GAS AND CBNG ACTIVITIES

The overall rates of disturbance due to CBNG well development were estimated in the PRB Oil and Gas Final EIS (BLM 2003a); the following information was developed from Tables 2-1, 2-23, and 2-24, which summarized alternative 2A. Total short- and long-term per-well disturbance was estimated by dividing the estimated total acreages disturbed (inclusive of pads, roads, pipelines, etc.) (Tables 2-23 and 2-24) by the estimated number of new wells drilled during the period (Table 2-1). Estimated disturbance was 5.2 acres per well for short-term disturbance, and 2.4 acres per well for long-term disturbance. As a result, each per pad disturbance acreage also accounts for a portion of the well field-related road, pipeline, water handling facilities, and other associated facilities disturbance. Drilling multiple wells per pad was factored in the EIS calculations. The short-term disturbance area was calculated based on the number of new wells during the year. Long-term disturbance was calculated based on the cumulative number of wells excluding new wells for the year. Reclamation each year was based on the addition of the number of new P&A wells multiplied by the long-term disturbance (5.2 acres), old P&A wells multiplied by short-term disturbance (2.4 acres), and the partial reclamation of new well pads for operating wells for the year (2.8 acres).

The rates of disturbance due to conventional oil and gas wells were estimated in the PRB Oil and Gas Final EIS (BLM 2003a) at 2.75 acres for wells during construction, and as 2.0 acres during production. The per-well disturbance of 2.75 acres was applied to wells developed within the last year, and the per-well disturbance of 2.0 acres was applied to all other active and inactive wells for the period. Each per pad disturbance acreage also accounts for a portion of the associated ancillary facilities. Reclamation each year was based on the addition of the number of new P&A wells multiplied by the short-term disturbance (2.75 acres), old P&A wells multiplied by long-term disturbance (2.0 acres), and the partial reclamation of new operating wells for the year (0.75 acres).

Assumptions:

1) The estimated per-well disturbance acreages will not change during the study (initial disturbance of 2.75 acres for conventional oil and gas wells and 5.2 acres for CBNG wells).
2) Overall disturbance will be distributed evenly among wells.
3) A portion of the short-term disturbance will be reclaimed within the year after the well is drilled (0.75 acre for each conventional oil and gas well and 2.8 acres for each CBNG well).
4) Long-term disturbance due to conventional oil and gas and CBNG wells will be reclaimed within the year wells are listed as abandoned (2.0 acres for each conventional oil and gas wells and 2.4 acres for each CBNG well). This accounts for reclamation of associated roads, pipelines, water handling facilities, etc., as proportionally included in the disturbance acreage for each pad.

13.0 ESTIMATE OF THE VOLUME OF WATER DISPOSED OF BY VARIOUS DISPOSAL METHODS

It is assumed that the volume of water to be disposed of through each disposal method will vary between subwatersheds, according to the following table from the PRB Oil and Gas Final EIS (BLM 2003a).

Percent of Total Water Production per Discharge Method

Subwatershed	Untreated Discharge	Passive Treatment	Active Treatment	Infiltration Impoundment	Containment Impoundment	LAD	Injection
Upper Tongue River	0	25	5	45	10	5	10
Upper Powder River	35	0	10	40	5	5	5
Salt Creek	55	0	0	35	5	0	5
Crazy Woman Creek	35	0	10	30	5	15	5
Clear Creek	25	10	10	35	5	15	10
Middle Powder River	35	5	5	30	10	10	5
Little Powder River	45	0	0	30	10	10	5
Antelope Creek	55	0	0	35	5	0	5
Upper Cheyenne River	55	0	0	35	5	0	5
Upper Belle Fouche River	45	0	0	40	5	0	10

Sources: Beels 2005; BLM 2003a.

Where possible, estimated produced water volumes within subwatersheds were allocated among disposal methods according to this table. Water disposal in subwatersheds without an indicated preferred allocation for disposal methods (Dry Fork Cheyenne River, Lightning Creek, Little Bighorn River, Little Missouri River, Middle Fork Powder River, Middle North Platte River, North Fork Powder River, Salt Creek, and South Fork Powder River) was assumed to be allocated in the same way as Clear Creek, since Clear Creek offered the most widely distributed disposal methods.

Assumptions:

1) It is assumed that the percent of total produced water discharged to impoundments, outfalls, or through injection in each subwatershed will be allocated per the PRB Oil and Gas Final EIS (BLM 2003a) estimates.
2) It is assumed that water disposal in subwatersheds without an indicated allocation in the PRB Oil and Gas Final EIS (BLM 2003a) will be the same as identified in that document for the Clear Creek subwatershed.