

DAKOTA PRAIRIE NATIONAL GRASSLAND  
LITTLE MISSOURI AND CEDAR RIVER NATIONAL GRASSLANDS

REASONABLY FORESEEABLE  
DEVELOPMENT SCENARIO  
FOR OIL AND GAS

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May 31, 2001, 2001

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## **Acknowledgements**

The authors acknowledge the following individuals and groups for their support and information during the preparation of this Reasonably Foreseeable Development Scenario: at Bureau of Land Management, Allen Ollila and Pascual Laborda, for their help with production predictions, Jim Albano and the Dickinson ND BLM Office for their information and reviews, and Fred Crockett, Casper Wyoming BLM, for his assistance with background information on coalbed methane development; at R1 USDA Forest Service, Norm Bishop, Barb Plattes, Richard Marshall, Marvin Giese, and Mark Sexton, for their reviews and work to collect the Forest Service statistics given in this report; at the North Dakota Geological Survey and Industrial Commission, Oil and Gas Division, several individuals whose publications I have referenced and Jim Lindholm, Mark Bohrer, and Lynn Helm for their help supplying wells statistics and maps; and at R2 USDA Forest Service, Nebraska National Forest, Jeff Ulrich and Terry Dilts for their editorial, computer analysis and mapping skills.

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## Introduction

This Reasonably Foreseeable Development Scenario (RFDS) describes the geology and the potential for petroleum occurrence in the Little Missouri National Grassland in western North Dakota and the Cedar River National Grassland in the southern portion of North Dakota. It also projects amounts of activity that could result from the oil and gas mineral potential. Oil and gas are the primary economic minerals in this area. This information is required by regulations at 36 CFR 228.102 as part of the environmental analysis process for making the leasing decision and by pre-November 2000 regulations at 36 CFR 219.22 as part of the planning process under which this plan was developed.

The Little Missouri National Grassland (LMNG) lies in the hydrocarbon-rich Williston Basin. The southwest corner of the Grassland is about six miles from the prolific Cedar Creek anticline. As of October 2000, there were 1,206 issued leases on Federal minerals in the LMNG that covered about 641,000 acres. About 360 of the leases were held by oil or gas production.

The Cedar River National Grassland (CRNG) lies 70 to 100 miles southeast of the Little Missouri National Grassland, and is in a lightly explored area of the Williston Basin in North Dakota. As of October 2000, there were no leases in the CRNG.

An RFDS has several parts. It predicts the potential for mineral occurrence based on the geologic information. It also predicts the potential for mineral development based on historical drilling trends, economic trends, and other factors that affect the rate of development. The assessment of development potential includes a drilling activity forecast which is an estimate of the type and amount of drilling and development activity which might take place should all legally available lands be allowed to be leased and developed. The drilling activity forecast is unconstrained in the sense that limiting factors such as lease stipulations, or the possibility that some areas may not be administratively available for leasing, are not taken into consideration at this stage of analysis. This RFDS also includes a surface use forecast and a prediction of possible well locations. The forecast of activity helps analyze the effect of the alternatives on the unconstrained RFDS. Various lease stipulations are applied which could preclude or alter the activity taking place in some areas. The RFDS also provides information for the analysis of effects of the Grasslands Plan and leasing decision on many resources such as wildlife, recreation, or air. It is a representation to the public and decision maker of the potential "on-the-ground" effects of a leasing decision.

## Executive Summary

The majority of the Little Missouri NG is classified as high potential for oil and gas occurrence. The remainder is moderate potential. Cedar River NG has moderate and low potential for occurrence. Approximately 660 wells are forecast to be drilled over the 10 year planning horizon in the Little Missouri area. Maps showing hypothetical well locations are Figure RFDS-1A and 1B. Two exploratory wells are predicted for the Cedar River NG.

The 660 wells are predicted for all types of land ownership in the Little Missouri area: federal, state or private. Approximately 405 wells, or 60% of the 660 wells, are predicted on federal minerals. Also, 660 wells are forecast to be plugged and reclaimed over the same time period. Sixty of the predicted 660 wells may test the coal bed methane potential of the lignite beds under the Little Missouri NG.

The following table shows the effects of the alternatives on the unconstrained RFDS.

TABLE RFDS-T1 VARIATION OF LMNG WELLS, ACRES LEASED, BY ALTERNATIVE VARIATION OVER 10 YEAR PLANNING HORIZON UNLESS NOTED (WELLS ARE PREDICTED 'ELIMINATED' ON FEDERAL MINERALS ONLY)

	ALT. 1	ALT. 2	ALT 3 FEIS	ALT. 3 DEIS	ALT. 4	ALT. 5
Average acres leased/year	678,432	641,936	601,577	613,713	608,814	626,558
Wells precluded by constraints in alts.	13	14	26	21	39	18
Wells drilled in LMNG	647	646	634	639	621	642
Wells affected (but not eliminated) by constraints in alts.	64	63	63	98	104	78
Wells drilled in Cedar River	2	2	2	2	2	2

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## Background

Three documents describe the oil and gas development potential of the LMNG and adjacent areas in western North Dakota. These reports are incorporated in their entirety by reference into this analysis:

- The North Dakota Geological Survey's (NDGS) 1990 report "Oil and Gas of the Little Missouri and Petroleum Database"
- Northern Little Missouri National Grassland Oil and Gas Leasing EIS (NLMNG EIS);  
Appendix A - The Reasonably Foreseeable Development Scenario (RFDS),  
Appendix B - Methodology Used to Determine Lease Parcels For Currently Unleased Areas,  
Appendix C - Oil and Gas Exploration, Development and Production
- Southern Little Missouri and Cedar River National Grasslands Oil and Gas Leasing EIS (SLM&CRNG EIS),  
Appendix C - Oil and Gas Exploration, Development and Production  
Appendix E - Oil and Gas Activity Scenario

These reports contain an overview of the basin geology, a historical overview of oil and gas exploration, a tabulation of production by formation, an estimate of the number and size of oil pools remaining to be discovered, a discussion of petroleum occurrence and development potential and a historic breakdown by formation and year of all drilling activity in the project area between 1951 and 1988 for the NLMNG and between 1955 and 1992 for the SLM&CRNG. They also describe the leasing process and the activities that occur during the exploration for and development of, the petroleum resource. This report summarizes portions of the three reports cited above and updates area-wide information on drilling and development activity through 1999 and Forest Service managed activity through Fiscal Year (FY) 2000. It reviews the RFDS projections and revises them as necessary.

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## Geology

The Williston Basin, a large sedimentary and structural basin known for its petroleum resources, underlies the Little Missouri and Cedar River National Grasslands. The Williston Basin occupies much of western North Dakota, eastern Montana, northwestern South Dakota, and south-central Canada. The basin is a major source of oil and gas, lignite, and potash. Sedimentary units representing each geologic period through the Pleistocene are present in the basin. The sedimentary rocks of the basin consist of sandstones, shales, limestones and dolomites, and range in age from early Cambrian through late Quaternary.

Numerous oceans filled and retreated from the Williston basin area from the Cambrian time, 570 million years ago to the end of the Cretaceous, about 66 million years ago. Each advance and retreat of marine waters left unique deposits of marine organisms and sedimentary strata. All system ages (epochs) are represented in the approximately 17,000 feet of sediments preserved in this basin (Figure RFDS-F2). This does not mean that deposition was continuous. There are numerous erosional unconformities and stratigraphic changes caused by basin tilting, sea level changes and transgressive - regressive marine and non-marine deposition.

Marine hydrocarbon source beds were developed in the Ordovician, Devonian, Mississippian, Pennsylvanian and Cretaceous Systems. The Tertiary System is predominantly non-marine, but contains substantial amounts of hydrocarbon as lignite.

Petroleum exploration in the Williston Basin has been targeted at oil production, which has resulted in some associated gas discoveries. Important economically recoverable supplies of oil and gas have been found to occur throughout the Williston Basin. A 1999 map of oil and gas development is Figure RFDS-F3. Reservoir rocks are present in almost all groups from the Cambrian Deadwood Formation up through the Triassic Spearfish Formation, as evidenced by oil and/or gas production. The Broom Creek Formation of the Upper Minnelusa Group of the Permian System does not produce oil or gas, but a sizeable reserve of nitrogen gas has been indicated. It has not been exploited. The Eagle and the Judith River Formations of the lower Montana Group of upper Cretaceous age produce gas. These "stacked" reservoirs make the basin a very attractive target for exploratory drilling.

Historically, the most important producing formations in the Williston Basin have been those that comprise the Madison Group. Other formations that have attracted major exploration efforts and are, or have been, significant producers include (from oldest to youngest): the Deadwood, Red River, Interlake, Duperow, Nisku, Bakken and Tyler. Of these formations, the Bakken was a primary exploration target in the late 1980's and early 1990's. (LaFever) (Hansen) The Mississippian Lodgepole has been a target of great interest to the east of the Little Missouri National Grassland in the 1990's. Geologic interpretations indicate that Lodgepole may have oil potential in the Little Missouri. (LeFever) (Burke)

There are numerous other intervals that are not now productive which appear to have reservoir properties if encountered in trapping conditions. These include, but are not limited to, the Minnekahta Formation of Permian age, several formations in the Dakota Group of lower Cretaceous Age, the Greenhorn Formation in the Colorado Group of Cretaceous age, the Hell Creek Formation of late Cretaceous age and individual sands in Tertiary age rocks.

The North Dakota Geological Survey reviewed the potential of North Dakota lignites to produce coalbed methane gas. (Murphy, 1998, 1998, 1999, 2000) They concluded that there is no current coalbed gas production in the state and methane gas had been encountered in scattered wells. However, they pointed out that most of the drilling programs they analyzed did not exceed 400 feet in depth and had not been run specifically aimed at detecting coal bed methane. The Harmon Coal bed is approximately 20 feet thick and extends under the Little Missouri NG in southern Billings and central Slope Counties. A 20 to 50 foot seam of coal that extends under southern McKenzie County at a depth of approximately 600 feet may be a northern extension of the Harmon coal. While the North Dakota lignites are not the same quality coal as coal found in the Thunder Basin NG, there might be future gas potential in these zones.

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## Petroleum Potential

The potential for petroleum occurrence in the LMNG was predicted in the RFDS for the NLMNG and SLM&CRNG. These qualitative estimates are based on the Bureau of Land Management handbook as follows:

High Potential: The demonstrated presence of a mature source bed, suitable reservoir strata (containing adequate porosity and permeability) and traps into which petroleum has migrated.

Moderate Potential: The inferred presence of a mature source bed, suitable reservoir strata, migration pathways and traps with a hydrocarbon charge.

Low Potential: The inference that a mature source bed, suitable reservoir strata, migration pathways and charged traps may not be present.

In the NLMNG O&G EIS the entire area was rated as high potential for occurrence. Since that analysis was completed in 1988, the numerous productive wells have supported that assessment (see Drilling and Development Activity section).

Since the SLM&CRNG Leasing EIS, was completed in 1995, advances in horizontal drilling technology and new exploration theories created a mini drilling boom immediately south of the Grasslands. Over 100 successful horizontal wells have been completed in the Red River formation in Bowman and Slope Counties. Approximately six wells have been drilled on NFS lands in the southwestern quadrant of the LMNG. This demonstration of production changes the rating of the southwestern corner from moderate to high potential for occurrence. Predictions of field limits were made and mapped for the Cedar Hills Red River B Field that extend into T133N R105W and R106W. (Stark) (State of North Dakota Industrial Commission Case No. 7287, Order No. 8601, Nov. 8, 1999) (Red River structure map - State of North Dakota Industrial Commission Case No. 7221, Exhibit No. 16)

Information from Lodgepole exploration to the east of the Grasslands has resulted in new geologic theories about how and where oil bearing carbonate mounds were formed. The theories indicate that the northern portion of the SLMNG has high potential for oil and gas occurrence (Burke). Industry has collected 3-D seismic information along the eastern edge of the Grasslands to look for the mounds.

The ranking of moderate potential is based on the inferred presence of the factors necessary for oil or gas accumulation. The demonstrated presence of oil to the southwest of the Grasslands suggests the presence of oil, reservoir strata, migration paths and stratigraphic traps throughout the southern portion of the Grasslands. As the technology of producing coal bed methane advances, lignite beds under the Little Missouri may become productive. All low potential has been changed to moderate or high potential for occurrence. A revised potential for occurrence map for the southern portion of the Little Missouri is shown in Figure RFDS-F4.

The SLM&CRNG Leasing EIS predicted a combination of moderate and low potential for the Cedar River NG. There has been no new drilling in the Cedar River study area. Thus there is no information indicating that the assessment of potential, shown in Figure RFDS-F5, should be changed.

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## Past Drilling, Production and Revenues

Ownership of surface lands and subsurface minerals within the boundary Little Missouri and Cedar River Grasslands includes federal, state and private. Since the RFDS for the Northern Little Missouri was completed in 1986, the number of wells drilled per year on all ownerships has ranged from a high of 108 wells in 1990 to a low of 7 wells in 1999, Figure RFDS-F6. Since 1986, oil and gas production from federal wells has declined from 10.2 million barrels of oil per year and 16.7 billion cubic feet of gas in 1986 to a low of 3.7 million barrels of oil in 1996 and 3.1 billion cubic feet of gas in 2000. Oil production increased to 4.7 million barrels in 2000 as shown on RFDS- F7.

Oil and gas leasing decisions made by the Forest Service and Bureau of Land Management only affect a portion of the Grasslands area. The State of North Dakota requires a state drilling permit for all wells drilled in the state. Wells on private surface and private minerals are permitted and inspected by the state. Wells on private surface with federal minerals are permitted and inspected by the BLM in addition to the state. On Forest Service managed federal surface and federal minerals Forest Service approval of the surface use portion of the federal permit is required. The Forest Service also establishes reasonable terms and conditions for the surface use portion of wells drilled to private or state minerals that lie under Forest Service managed surface. Data on past Applications for Permits to Drill (APD) on federal minerals is included in Figures RFDS-F8. Since 1986, a high of 67 requests to drill were processed by the Forest Service in 1990 (34 APDs, and 33 plans for drilling to reserved or outstanding private minerals.) The Forest Service processed a low of 3 APDs in 1999. There were no requests to drill to private minerals in 1999 as shown on Figure RFDS-F8.

Royalty revenue from Federal leases is shown on RFDS-F9. Royalties ranged from a high of 19.6 million dollars in 1987 to a low 7.4 million in 1999. Portions of the federal royalties are shared with the State of North Dakota and the counties where the grasslands are located.

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## Factors Affecting RFDS Projections

Future oil and gas development in the Williston Basin will be influenced by a number of interrelated factors. First, there are economic trends such as oil and gas prices, national economic growth, and supply and demand. Second, there are technology and equipment trends such as technological advances and equipment supply. Third, past drilling trends can be used to predict future activity. Finally, past Forest Service, Bureau of Land Management, and State decisions such as land access and past leasing decisions can affect the rate and location of petroleum development. Events of the last 25 years indicate that some important aspects of the petroleum and natural gas industries are inherently difficult or impossible to predict. Despite uncertainties, the purpose of the following discussion is to identify and interpret those factors based upon the best available information.

### Economic Trends

A primary source for the economic analysis is projections developed by the U.S. Department of Energy (DOE) in the Annual Energy Outlook 2001, published in December, 2000. The DOE's projections are not intended as prophecies. Instead, the projections provide pictures of how energy futures might look with current energy policies and various assumptions for world and national oil prices, and supply and demand.

**Oil Prices** - Crude oil pricing is critical to future oil and gas development. The level of activity on the Little Missouri varies with the price of crude oil as shown by Figure RFDS-F6. Uncertainty exists as to the future trend of crude oil prices. The most recent long-range projections published by the DOE project world crude oil prices will be gradually increasing at 1.2 per cent per year as measured in 1999 dollars until the year 2020. Table RFDS-T1 shows base, low, and high world oil price scenarios. Table RFDS-T2 also shows predictions for United States lower 48 production prices.

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TABLE RFDS-T2 PRICE PREDICTIONS AS OF DECEMBER 2000

Source: Dept. of Energy, Annual Energy Outlook 2001, 2000

Year	1999	2005	2010	2015	2020
	World Crude Energy Prices (1999 dollars per barrel)				
Base	17.35	20.83	21.37	21.89	22.41
Low Economic Growth Price	17.35		20.70	20.93	21.16
High Economic Growth Price	17.35		21.87	22.76	23.51
	United States Lower 48 Oil Prices (1999 dollars per barrel)				
Base	16.49		20.80	21.00	21.45
	Gas Wellhead Prices (1999 dollars per Mcf)				
Base	2.08	2.49	2.69	2.83	3.13
Low Economic Growth Price	2.08		2.49	2.59	2.66
High Economic Growth Price	2.08		3.08	3.20	3.68

Pricing is probably one of the most important factors affecting U.S. production. The most recent oil price forecasts are lower than the predictions at the time the NLMNG EIS was prepared (just after the August, 1990 invasion of Kuwait). The NLMNG EIS cited prices reaching \$47.40 in 1989 dollars by the year 2010. (Annual Energy Outlook, 1990) Price levels below that forecast have resulted in reduced drilling during the 1990's on the Little Missouri NG. Pricing predictions have been adjusted since the 1997 prediction used in the draft Plan and DEIS released in 1999.

**Other Economic Trends** - Several other economic trends affect the path of future prices and thus the rate of oil development in the Williston Basin. The following trends were analyzed in the 1991 NLMNG EIS and need to be reanalyzed to check their effect on the oil price predictions.

The first is the U.S. economy's rate of growth as measured by changes in the gross domestic product. In general, the greater the increase in the gross domestic product, the higher the demand will be for all energy. The 2001 DOE base case economic growth projections assume an annual growth rate of 3.0 percent per year between 1999 and 2020. Under the low and high growth assumptions, the economy grows at annual rates of approximately 2.5 and 3.5 percent, respectively. The 1988 base case economic growth projections analyzed in the 1991 NLMNG EIS assumed an annual growth rate of 2.4 percent per year within a range of approximately 2.0 and 2.8 percent, respectively. The current projections are somewhat higher than the trends used to predict drilling activity in the NLMNG Leasing EIS.

Second, demand is another economic trend that influences prices and petroleum development. It is clearly linked to economic growth, but other factors such as price and environmental and national security issues will also affect demand. Lower world oil prices result in increased domestic demand but reduced domestic production. Consequently, demand is met by increased imports. Conversely, when world oil prices are high, domestic production is stimulated, but domestic demand is reduced.

As forecasted by the DOE in the Annual Outlook for Oil and Gas 1990, United States petroleum consumption was projected to increase moderately at 0.8 percent per year from 17.2 million barrels per day in 1989 to 18.8 million barrels per day in 2000 under the base price scenario. The 2001 DOE, Annual Energy Outlook forecast petroleum demand would increase to 25.3 million barrels of oil per day, low case, to 27.0 million BOPD, high case, in 2020. Current reported use was approximately 19.4 million BOPD in 2000. Current projections are higher than the trends used to predict drilling activity in the NLMNG Leasing EIS.

Economic trends such as domestic oil production and imports can affect the rate of development in the Williston Basin. Despite forecasts of higher prices and increased demand, domestic production was predicted to decline in the 1990 report. The Annual Energy Outlook 2001 continues the same prediction for declining domestic production and raising amounts of imports.

In conclusion, signals from economic trends affecting oil prices are mixed. Oil prices may continue to fluctuate as they have during the last ten years.

**Natural Gas** - Nationally, natural gas use and production is on an upward trend that is expected to continue. The most recent long-range projections published by the DOE project gas wellhead prices will be gradually increasing at 2.0 per cent per year as measured in 1999 dollars until the year 2020. Table RFDS-T1 shows base, low, and high gas wellhead price scenarios. Consequently, it is projected that higher gas prices and the interest in coal bed methane, may result in some coal bed methane gas exploration in the LMNG.

## **Technology and Equipment Trends**

Advances in petroleum exploration, drilling and production technology have resulted in additional drilling in the Williston Basin. Advances in technology that have reduced the risk and cost of horizontal drilling have made wells to the Mission Canyon, Duperow, Bakken and Red River economical. Vertical wells could not effectively drain these reservoirs but horizontal wells can. Exploration techniques, such as 3-D seismic, have helped pinpoint additional drilling opportunities around existing fields. 3-D also helps find reservoirs of limited aerial extent such as the algal mounds of the Lodgepole formation. Technology will continue to advance, causing new opportunities in the Williston Basin.

The availability of conventional and directional (i.e. horizontal) exploration and development well-drilling personnel, equipment, and supplies, are a factor that influences the rate of oil and gas development. Availability of pipelines and transportation infrastructure also influences the rate of oil and gas development. The boom-bust cycles of petroleum development in the Grasslands area can cause local shortages of personnel and equipment associated with oil and gas exploration and development. The shortages are reflected in the delay between oil price increases and increased numbers of wells drilled.

## **Historic Drilling Trends**

From the discovery of oil in the Williston Basin in 1951 through 1999, about 2600 wells were drilled in the area immediately adjacent to or within the boundary of the Little Missouri National Grassland. This is an average of 53 wells per year. Over this same period, 17 percent of the wells drilled in the study area have been wildcats and 83 percent are development wells. Of the wildcat wells, 26 per cent produced oil. Of the development wells, 77 per cent were successful producers.

A significant boom in oil exploration and development activities occurred in the study area between 1979 and 1985 in response to a rapid, sharp increase in world oil prices. Approximately 1227 wells, 47 per cent of all wells in the study area, were drilled during this seven-year period. An average of 175 wells were drilled each year during the boom period. An average of 22 wells per year were drilled prior to the boom in 1951 through 1978. In post-boom years of 1986-1999, 682 wells were drilled in the grassland area. An average of 48 wells per year have been drilled. Only a portion of these wells have been drilled on Federal lands.

In the Cedar River National Grassland, seven exploratory wells have been drilled in the 15 townships within and surrounding the Grasslands. All were dry holes. Only two of the seven were drilled during the past 20 years.

## **Agency Land Management Decisions**

The Forest Service manages about 50 percent of the surface acres within the boundary of the Little Missouri National Grasslands and three percent within the Cedar River. Acreages are shown on Table RFDS-T2. The Federal government owns approximately 47 percent of the oil and gas mineral estate in the LMNG and five percent in the Cedar River NG. Bureau of Land Management (BLM) manages the approximately 83,000 acres of Federal minerals beneath private surface in the Little Missouri and 3,000

in Cedar River. The Forest Service makes leasing decisions for the Federal minerals under Forest Service managed Federal surface.

TABLE RFDS-T3 FEDERAL AND NON-FEDERAL OWNERSHIP  
LITTLE MISSOURI AND CEDAR RIVER NG  
Rounded to nearest thousand acres

Source: January 2001 computer runs

	FEDERAL	PRIVATE, STATE, OR OTHER	TOTAL*
<u>Little Missouri</u>			
Surface Acres	1,026,000	1,058,00	2,084,000
Oil & Gas Estate Acres	980,000	1,104,000	2,084,000
<u>Cedar River</u>			
Surface Acres	7,000	246,000	253,000
Oil & Gas Estate Acres	13,000	240,000	253,000

\*Total may vary because Little Missouri boundaries (administrative, purchase unit, or district boundaries) are in different places and enclose different numbers of acres.

Past agency land management decisions can affect the rate and the location of future mineral development. The Records of Decision (RODs) for the NLMNG and SLM&CRNG display the area of lands that will not be leased, - six per cent of the land in the Northern and less than one per cent of the land in the Southern EIS. The RODs also display lands for which stipulations that may limit development will be attached to leases. No-Surface-Occupancy stipulations cover fifteen per cent of the Federal minerals in the Little Missouri NG. All Federal oil and gas rights in the Cedar River NG were authorized for lease.

It is difficult to distinguish the effect of Federal leasing decisions on the overall rate of development in the Little Missouri NG. Variations in the price of oil cause large variations in the number of wells drilled. Low numbers of wells drilled in the late 1990's can be better attributed to the price of oil than to the implementation of the leasing decisions.

During the early 1990's, state lands that usually have fewer stipulations than Federal lands averaged higher bonus bids than Federal tracts. Information in Figure RFDS-F10 compares the average bonus bid for Federal acres to the average paid for State lands in the Little Missouri area during the early 1990's, a time of moderate oil prices. An average of bonus for federal acres was \$21.68 versus \$27.55 for state lands for the years of 1991 through 1994. In 1995, state lands received average bonus bids of \$97.12 per acre versus \$31.56 for federal lands. The averages were not adjusted for parcels that because of proximity to production, may have skewed the average price.

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## Reasonably Foreseeable Development Scenario

Site-specific reasonably foreseeable development (RFDS) scenarios were used to estimate effects of exploration, development, and production activity in the NLMNG Leasing EIS and SLM&CRNG Leasing EIS. The hypothetical well locations were projected based on historical oil and gas development information from the North Dakota Geological Survey, other known geologic information, interpretation of the information by BLM and Forest Service geologists, economic trends, and technology and equipment supply trends.

A purpose of the RFDS is to provide a basis for analyzing and estimating environmental effects. Wells have been predicted in different biophysical settings throughout the grasslands. To the extent that the biophysical settings are the same or similar throughout the analysis area, the effects of the action(s) will be the same, or similar, if the development occurs at locations different than forecast in the RFDS. Therefore, the site-specific RFDS forecast can serve as the basis for leasing decisions for "specific lands" throughout the area of analyzed effect, regardless of whether a specific area was, or was not, forecast to be affected in the RFDS. It must be recognized that future exploration and development may not occur where predicted in the RFDS. The RFDS also provides a basis for analyzing and estimating social, and economic effects.

The steps required formulating a reasonably foreseeable oil and gas development scenario (RFDS) for the LMNG include application of the assumptions described below in order to identify possible locations where oil and gas exploration and development could occur. This is only one of many possible scenarios. The probability of divergence between the RFD scenario and actual development increases the further into the future the projections are extended. Regardless of where development actually occurs, the effects of drilling and field development within any given biophysical area (or other grouping of lands with similar biophysical characteristics) are highly similar. Therefore, the effects of development in grasslands are known with sufficient precision to make the leasing decision.

The primary components of the RFDS are: (1) leasing forecast; (2) the drilling and development activity forecast; and (3) the surface use forecast.

### Leasing Forecast

The leasing forecast is shown in table RFDS-T4. The following assumptions and background information were used for the leasing forecast for the Little Missouri. Minimal to no leasing is predicted for the Cedar River NG because of the low geologic potential for oil and gas:

- Federal oil and gas mineral acres in the Little Missouri were calculated by computer runs at 980,000 acres.
- As of October 1998, there were 265,000 leased Federal acres held by production (HBP). The amount of acres held by production will remain basically constant at 265,000 acres over the planning horizon. The number of acres that come under new production during the planning period will balance with the number of acres on which leases expire or go to nonproductive status. The 265,000-acre number was checked on October 2000, at which time about 260,000 acres were held by production. The assumption was not revised between the draft EIS and the final EIS.

- The number of acres leased will vary by alternative by:
  - A. Number of acres of land available and authorized for lease. Leases are not predicted for lands made “Not Available” or “Not authorized for lease.
  - B. The amount of land leased with a No Surface Occupancy stipulation. All alternatives have areas with large blocks of lands which are stipulated NSO. These lands will be less attractive to industry for leasing because much of the mineral estate will not be reachable with current technology. The smaller, linear NSO areas will not affect the amount of leasing because potential well sites can be moved to avoid the resource being protected, and the downhole target reservoir may be reached by directional drilling.
- As of October 1998, 73 percent of available and authorized lands in the LMNG were leased. This percentage of leased vs. unleased available and authorized lands incorporates the concept of the desirableness of some lands and the lower desirability of other lands. I assumed this percentage will hold approximately the same (73 percent) if conditions (i.e. the leasing decision does not change substantially or oil prices do not fluctuate dramatically over the long term) remain relatively constant. A historical trend or average was not used because leasing was suspended between 1987 through 1996 in portions or all of the Little Missouri NG.
- Currently, 27 percent of the Little Missouri's federal mineral acres are producing (FY98 Year-End Report with adjustments made for Sioux and Beartooth Ranger District statistics). I assume that 27 percent of acres under the proposed NSO areas are producible and the leases would not expire during the planning period. The remaining 73 percent of the acres are either unleased, or leases would expire over the next ten years. I assume nonproducing leases will expire at a constant rate of ten percent per year. Once current leases expire, the acres offered with NSO stipulations would not be as desirable for new leases and would not be leased.
- The percent of available, authorized and non-NSO lands leased will hold approximately the same at seventy-three percent. Therefore, seventy-three percent of available, authorized and non-NSO lands would be leased in each alternative.

TABLE RFDS-T4 PROJECTED - TOTAL LEASED ACRES BY YEAR  
LITTLE MISSOURI NG

YEAR	ALT. 1	ALT. 2	ALT. 3	ALT. 3-D	ALT. 4	ALT. 5
1	678,432	686,364	650,499	681,182	680,292	683,519
2	678,432	676,491	639,628	666,189	664,408	670,861
3	678,432	666,618	628,756	651,196	648,524	658,203
4	678,432	656,745	617,884	636,202	632,640	645,545
5	678,432	646,873	607,013	621,209	616,756	632,887
6	678,432	637,000	596,141	606,216	600,872	620,229
7	678,432	627,127	585,269	591,223	584,987	607,571
8	678,432	617,254	574,397	576,230	569,103	594,913
9	678,432	607,382	563,526	561,237	553,219	582,255
10	678,432	597,509	552,654	546,243	537,335	569,597
AVERAGE	678,432	641,936	601,577	613,713	608,814	626,558

## Drilling, Development and Reclamation Activity

Predicted Amount of Drilling, Development and Reclamation - The estimate of drilling and development activity in the LMNG over the next ten years is based on:

- Projected economic factors as discussed above in Section "Economic Trends"
- Advances in technology and equipment supply
- Historical and current drilling activity in the LMNG project area

As discussed in the "Economic Factors" section of this report, it is impossible to definitely gauge future consumption patterns and oil prices that will affect drilling activity. Production levels predicted in the NLMNG and SLM&CRNG Leasing EISs projected increases consistent with historical trends. Since those predictions were made, some indicators, such as increasing domestic demand and technology advances, indicate that development could increase. But other trends, such as erratic oil prices, increasing import levels, and movement of major oil companies and large independents out of the Williston area have caused the Williston Basin development levels to decline.

The NLMNG Leasing EIS predicted that 50 wells per year would be drilled in the project area (north of T139N) based on the historic rate over the 1951-1988 period of an average of 48 wells per year. The SLM&CRNG Leasing EIS predicted 130 new wells over the next 15 years. This is approximately nine wells per year for the grasslands area in T138N and south.

The combined prediction of the two Oil and Gas Leasing EIS's is an average of 59 Federal, state and private wells drilled per year in the Grasslands area. Economic and other factors have been erratic during the past years, 1987 -1999. The number of wells drilled has varied from a high of 108 wells in 1990 to a low of 7 wells in 1999. The prediction in the EIS of 59 wells is slightly above but comparable to the average 44 wells per year over the period 1987 - 1999. Therefore, the prediction of 59 wells per year for the level of future oil and gas development from the Williston's traditional formations will not be revised. It will be rounded to 60 wells per year, or 600 wells, over the 10 year planning horizon.

At the same time wells are being drilled in the Little Missouri wells are being plugged and reclaimed. Historically, 25% of the wells drilled are dry holes that are plugged and reclaimed at the completion of drilling. In addition, depleted wells are plugged and the sites reclaimed. Between 1997 and 2000 more wells on federal minerals have been reclaimed than have been drilled. Overall the number of active or shut-in wells on federal minerals or federal surface has remained at approximately 600 sites. I forecast that plugging will approximately equal drilling over the next ten to fifteen years and the number of active wells to traditional formations will remain approximately constant.

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TABLE RFDS-T5  
WELLS DRILLED AND RECLAIMED ON FEDERAL SURFACE 1997-2000\*

<b>Fiscal Year</b>	<b>Wells Drilled on Federal Surface</b>	<b>Wells Reclaimed on Federal Surface</b>
1997	10	23
1998	15	29
1999	3	15
2000	12	6

Over the last several years, increased gas prices and technical advances in producing methane from coal beds created some interest in learning more about the lignite beds in the Williston Basin. The lignite beds are a lower quality coal than the bituminous coals in northeastern Wyoming. In order to assess the possible effects of coalbed methane (CBM) development, three experimental fields are predicted over the next ten years. The experimental fields are modeled after the Thunder Basin development "pods" which consist of approximately twenty wells each for a total of 60 wells. The addition of the possible coal bed methane development increases the overall RFDS prediction to 660 wells over the 10 year planning horizon. A graph of the conventional and CBM reasonably foreseeable wells predictions are shown on Figure RFDS-F11.

Based on Wyoming experiences and production rates, the life of the CBM wells is predicted to be approximately seven years. (Lance Petroleum) While the CBM wells are active the average number of active wells in the Little Missouri will increase by approximately 30 wells to 630 wells active in any one year.

The RFDS in the SLM&CRNG Leasing EIS predicted that two wells would be drilled in the Cedar River area over the next ten to fifteen years. The SLM&CR RFDS predicted that neither well would discover oil or gas and be productive. There has been no new information suggesting that this projection should be revised.

**Predicted Location of Drilling and Development** - Hypothetical locations for the projected wells were assigned using the following steps. (See Figures RFDS 1A and 1B) At this stage of prediction, no consideration was given to ownership of minerals, past leasing decisions, or constraints imposed by the alternatives in the Plan Revision EIS. One exception is no hypothetical wells were plotted inside Theodore Roosevelt National Park.

Areas of " predicted high development" were based on known productive areas and areas of recent drilling. The predicted high development areas are within but smaller than "high potential areas". These areas were delineated by mapping and counting wells actually drilled between 1989 and 1995. A ratio of wells inside the predicted high development areas to the number outside was calculated. Two-thirds of all wells drilled in the project area from 1989 to 1995 were drilled in the predicted high development areas. The assumption is that the majority of future drilling will be in the vicinity of proven production. The predicted well locations were allocated inside and outside the high potential development areas based on the ratio. Two-thirds, or 400 of the 600 wells, are projected to be located within the areas of predicted high development.

Once the areas of predicted development were identified, hypothetical well locations inside the potential high development areas were positioned within the area by: 1) emulating "step-out" well locations for existing fields; 2) some infill drilling; 3) new trend exploration; 4) and new fields modeled after existing fields. Locations for wells outside the predicted high development areas were determined by emulating the spacing and locations of dry holes that have been drilled in the past. Several small field models were also located in lightly drilled areas of moderate potential.

Several comments were received on the predicted wells locations following the DEIS. Based on those comments I made the following changes to the reasonable foreseeable prediction of well locations.

1. I moved wells out the Red River play in southwestern Slope County based on comments from North Dakota Oil and Gas Division (NDIC Order 8601). I moved the wells primarily to the Lone Butte area south of Theodore Roosevelt NP North Unit, and two other areas in the northwestern portion of McKenzie Ranger District based on comments from North Dakota and Amerada Hess.
2. I moved wells to reflect the successful Bell Lake area drilling and Belco drilling along the eastern edge of the grasslands.
3. I added 60 wells in 3 "pods" to model possible interest in coal bed methane. The wells in the pods are on 80 acre spacing and are on thick coal seam areas. The coal thickness maps were supplied by NDIC.

The hypothetical locations were used to predict the percentage of wells that would be drilled to access federal minerals versus the percentage of wells projected to access state or private minerals.

TABLE RFDS-T6  
NUMBER OF WELLS IN THE UNCONSTRAINED RFDS BY OWNERSHIP

Mineral Estate	Projected Wells
Federal	405
Nonfederal	255
Total	660 Wells
Of the total 405 wells on Federal minerals, 24 are Coal Bed Methane. Of the total 255 wells on Nonfederal minerals (state and private), 36 are CBM wells.	

**Predicted Result of Drilling: Success Ratio and Production Forecast** - Historically, in the Little Missouri area, the majority of wells have been drilled as development wells. As a result, the Little Missouri area and North Dakota have a high percentage of successful producing wells vs. dry holes. The historical average in the Grasslands area is that 25 percent of the wells drilled are dry holes and 75 percent are producers. This compares to the North Dakota statewide average of 28 percent dry holes and 72 percent producers (North Dakota Petroleum Council). The historical Grasslands average, 75%, was used to predict a number for successful producing future traditional wells.

Experiences in Montana and Wyoming indicate that while some test coal bed methane wells are non-commercial a very high percentage usually becomes producing wells. All 60 of the hypothetical CAM wells are predicted to be producers. (Wyodak EA)

For the traditional wells, the hypothetical rate of oil production was calculated based on a weighted average of typical decline curves from three common areas/producing horizons. Representative decline curves were built for primary production from the Heath Formation in the Tracy Mountain area, the Dupe row Formation in the Roughrider area, and the Red River Formation in Slope County. A hypothetical rate of gas production per well was calculated based on a five-year average gas/oil ratio and the projected oil production. The rate was applied to the 75 percent of Federal wells in each alternative. The total estimated production was used in the economic analysis. The production estimate is shown on Fig. RFDS-F12.

Production rates for the coal bed methane wells were estimated based on a comparison of coal density, depth, and gas content of North Dakota lignite relative to the Wyoming bituminous coals. The production rate was applied to all 60-forecasted CBM wells based on the high success ratios in Wyoming. Water production per well was also estimated. Gas and water production predictions are shown on Fig. RFDS-F13.

## Surface Use Forecast

Both the NLMNG and SLM&CRNG Leasing FEIS's described how oil and gas development is likely to occur in the future. Those descriptions of wells and technology for the traditional Williston formations will not be repeated here but are incorporated by reference (NLMNG Oil and Gas Leasing FEIS pgs. A-24 through A-26 and Appendix C) (SLM&CRNG Oil and Gas Leasing FEIS pg. E-4 and Appendix C).

Typically, producing wells/water injection wells on federal lands in the Little Missouri disturb slightly less than 5 acres during the time the well is actively operating. (Norm Bishop, personal communication) The disturbance includes well pads, and access roads. Pipelines and utility lines such as electricity or phone are usually in the road corridor. Production facilities are normally built on the well pads. All disturbance is reclaimed with a year or two of well plugging. Dry holes disturb approximately 5.7 acres that is reclaimed within a year or two. Factors that contribute to the total ground disturbance per producing well include:

- +2.40 acres for roads;
- +3.25 acres for well pad during drilling
- -0.75 acres of well pad is reclaimed between drilling and the production/injection phase
- 4.90 acres average ground disturbance per active well.

The surface use forecast for coal bed methane (CBM) developments is modeled on developments in the Powder River Basin. (The following information was presented in the Wyodak Drainage Coal Bed Methane EA.) Wyoming developments often group approximately 20 wells to minimize costs of gas compression and transmission pipelines. Currently, wells are spaced on 40 to 80 acres spacing, with the trend moving toward the larger spacing.

Wyoming BLM measured actual ground disturbance of approximately 100 CBM wells for the Wyodak EA. The disturbance included wells, access roads, pipelines, and central gathering and metering facilities. Factors that contribute to the total ground disturbance per well include:

- 0.30 acres for up-graded roads;
- 0.33 acres for two-track roads;
- 0.62 acres for pipeline construction; and
- 0.13 acres for well pad and central gathering and metering facilities.
- 1.38 acres average total ground disturbance per CBM well.

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## **RFDS - Use in Effects Analysis**

The projected well locations were used to estimate the effects of the alternatives on oil and gas development and the effects of the oil and gas development on other resources. The predicted locations of wells did not vary by alternative. Whether or not a location could be drilled was assessed for each alternative and certain wells were “eliminated” if they were located in an undevelopable management area or area of stipulations.

Wells on private or state lands were not directly affected by any alternative. No private or state wells were predicted “eliminated” by any alternative. However, it is recognized that if adjacent Federal wells cannot be developed because of management decisions, it may make some fields and private wells uneconomic to develop efficiently. Another indirect effect on private or state lands is if wells cannot be located directly above a downhole target, the oil company may ask the private or state landowner for permission to relocate the well onto private lands.

The predicted location of wells in areas with standard lease terms, timing limitation and controlled surface use stipulations were maintained through the various alternatives. Wells located on lands with No Surface Occupancy (NSO) stipulations were treated in two ways. First, locations of wells on lands with NSO stipulations covering small areas, such as stipulations for steep slopes or woody draws, were maintained in the alternative because it was assumed that the wells could be directionally drilled to reach the bottomhole target. Therefore, the small area NSO stipulations would not preclude the development of that well.

Secondly, for alternatives that have lands with NSO stipulations covering large areal extents, wells located more than ½ mile within the NSO area were eliminated under that alternative. Well locations that were plotted less than ½ mile from the edge of the NSO boundary were retained because it was assumed that the bottomhole locations could be reached by directional drilling. If the original preferred surface location of a well is required to be relocated because of stipulations for protecting surface resources, effects include increased drilling costs, technical difficulties associated with directional drilling, more difficult completion of the well, and higher operating costs.

**TABLE RFDS-T7 VARIATION OF WELLS BY ALTERNATIVE  
(WELLS ARE PREDICTED 'ELIMINATED' ON FEDERAL MINERALS ONLY)**

Wells Eliminated By Alternative on Federal Minerals						
	ALT 1	ALT 2	ALT 3	ALT 3-D	ALT 4	ALT 5
MED - Regular	3	6	15	10	20	9
MED - CBM	0	0	0	0	3	0
MCK - Regular	10	8	11	11	16	9
MCK - CBM	0	0	0	0	0	0
<b>Total</b>	<b>13</b>	<b>14</b>	<b>26</b>	<b>21</b>	<b>39</b>	<b>18</b>

Wells Effected (in 1/2 mile NSO buffer) By Alternative on Federal Minerals						
	ALT 1	ALT 2	ALT 3	ALT 3-D	ALT 4	ALT 5
MED - Regular	42	41	36	68	76	51
MCK - Regular	22	22	27	30	28	27
<b>Total</b>	<b>64</b>	<b>63</b>	<b>63</b>	<b>98</b>	<b>104</b>	<b>78</b>

MED – Medora Ranger District (Southern portion of Little Missouri NG)

MCK – McKenzie Ranger District (Northern portion of Little Missouri NG)

CBM – Coal Bed Methane

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Appendix A - The Reasonably Foreseeable Development Scenario (RFDS),  
Appendix B - Methodology Used to Determine Lease Parcels For Currently Unleased Areas,  
Appendix C - Oil and Gas Exploration, Development and Production

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Appendix C - Oil and Gas Exploration, Development and Production  
Appendix E - Oil and Gas Activity Scenario

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