4.0 MINERAL RESOURCES DEVELOPMENT POTENTIAL

The most important potential mineral resources in the RMPPA are hydrocarbon resources. The long history of production and developments in the last decade document the presence of source rocks, reservoir rocks, and trapping mechanisms that provide a significant hydrocarbon resource. The non-CBM gas resource has the greatest development potential. Oil and CBM are of lesser importance.

There are a variety of non-fluid minerals that are produced within the RMPPA; foremost amongst these would be coal, mined from the Hanna Coalfield northeast of Rawlins. In addition to coal, a number of industrial minerals are produced (e.g., limestone, gypsum, pumice and scoria, silica sand, decorative stone, etc.). The area is a former uranium producing area and if/when uranium prices rise sufficiently to justify production, it is likely that the area will again be a uranium producer. However, it is unlikely that this would occur within the projected 20-year planning period.

In addition, aggregates will be a significant mineral commodity for the RMPPA due to the projected development associated with oil and gas and CBM. Infrastructure requirements, primarily in the form of access roads, will drive the demand for aggregate resources.

4.1 Leasable Minerals

Leasable fluid minerals (oil and gas) are present in the RMPPA. Oil and gas have been produced for many decades from sandstone, limestone, and fractured shale/chalk reservoirs. Recent assessments by governmental agencies indicate there are significant amounts of undiscovered recoverable hydrocarbon resources in the RMPPA from these reservoirs. Gas produced from coal reservoirs has recently been considered and preliminary data suggests a sizable amount of gas may be produced from coal reservoirs. The discussion of hydrocarbon resource development potential in Sections 4.1.1 through 4.1.4 was provided by BLM's RMG in Casper, Wyoming. All maps, graphs, and discussion are the product of the RMG and it is solely responsible for the content and the conclusions contained therein.

Leasable non-fluid minerals known to be present within the RMPPA are coal, oil shale, phosphate and sodium. With the exception of coal (which is currently mined in the Hanna Coalfield), these minerals, where present, occur in sub-economic deposits. Further, current and projected market conditions are such that exploitation of these mineral resources (within the RMPPA) is highly unlikely within the projected planning period, as discussed below.

4.1.1 Hydrocarbon Plays

In 1995, the USGS conducted an assessment of the oil and gas resources of the U.S. (Beeman and others, 1996; Charpentier and others, 1996; Gautier and others, 1996). The assessment presents information about potential undiscovered accumulations of oil and gas in the Rawlins RMPPA. Information from that assessment is presented below.

The 1995 USGS assessment identified 71 geologic or structural provinces from which hydrocarbon resources are produced. The RMPPA is located partly within two of the provinces. The western and central portions of the RMPPA are located within the Southwestern Wyoming Province (USGS Number 037). The Southwestern Wyoming Province encompasses a number of basins and adjacent uplifts in Wyoming, Colorado, and Utah. The second province (Denver Basin Province, USGS Number 039) occupies the easternmost part of the RMPPA. The Denver Basin Province is a structural basin located in northeastern Colorado, southeastern Wyoming, the southwestern corner of South Dakota, and the Nebraska Panhandle. The Denver Basin also is referred to as the Denver-Cheyenne Basin and that terminology will be used in this report.

Provinces are further divided into oil and gas plays. A play is a set of discovered or undiscovered oil and (or) gas accumulations or prospects that are geologically related. A play is defined by the geological properties (such as trapping style, type of reservoir, nature of the seal) that are responsible for the accumulations or prospects.

Six of nine conventional Southwestern Wyoming Province plays lie partly within the Rawlins RMPPA (**Figures 4-1** through **4-3**). A conventional play contains oil and gas accumulations that have hydrocarbon-water contacts (due to the hydrocarbons being a separate phase and the buoyancy of hydrocarbons in water) and seals that hold or trap the hydrocarbons. Hydrocarbons in conventional plays can be recovered using traditional development and production practices. Data on the six plays is summarized in (**Table 4-1**). Five of six conventional Denver-Cheyenne Basin Province plays also lie partly within the Rawlins RMPPA (**Figures 4-4** through **4-7**). Data on the five plays is summarized in (**Table 4-2**).

The USGS also identified five unconventional basin-centered gas plays in the Southwestern Wyoming Province. All five basin-centered gas plays lie partly within the Rawlins RMPPA boundaries (**Figures 4-8** through **4-12**). In addition, four of the six Southwestern Wyoming Province unconventional coal reservoir or CBM plays lie within the Rawlins RMPPA boundary (**Figures 4-13** through **4-15**). Data on all nine plays is summarized in **Table 4-3**.

The USGS has identified five unconventional continuous-type plays in the Denver Basin Province. Continuous-type accumulations are pervasive throughout a large area and do not owe their existence to the buoyancy of hydrocarbons as a separate phase in water as conventional accumulations do. The reservoir rock of a continuous-type accumulation is everywhere oil or gas

Figure **4-1** Location of USGS Conventional Southwestern Wyoming Province Rock Springs Uplift, Cherokee Arch, and Subthrust Plays

Figure **4-2** Location of USGS Conventional Southwestern Wyoming Province Basin Margin and Platform Plays

Figure **4-3** Location of USGS Conventional Southwestern Wyoming Province Deep Basin Structure Play

Table **4-1** USGS Conventional Play Data for Southwestern Wyoming Province (037)

Figure **4-4** Location of USGS Conventional Denver-Cheyenne Basin Province Pierre Shale Sandstone Play

Figure **4-5** Location of USGS Conventional Denver-Cheyenne Basin Province Dakota Group Play

Figure **4-6** Location of USGS Conventional Denver-Cheyenne Basin Province Basin Margin Structural Play

Figure **4-7** Location of USGS Conventional Denver-Cheyenne Basin Province Permian-Pennsylvanian and Subthrust Structural Plays

Table **4-2** USGS Conventional Play Data for the Denver-Cheyenne Basin Province (039)

Figure **4-8** Location of USGS Unconventional Southwestern Wyoming Province Cloverly-Frontier Basin-centered Gas Play

Figure **4-9** Location of USGS Unconventional Southwestern Wyoming Province Mesaverde Basin-centered Gas Play

Figure **4-10** Location of USGS Unconventional Southwestern Wyoming Province Lewis Basin-centered Gas Play

Figure **4-11** Location of USGS Unconventional Southwestern Wyoming Province Fox Hills-Lance Basin-centered Gas Play

Figure **4-12** Location of USGS Unconventional Southwestern Wyoming Province Fort Union Basin-centered Gas Play

Figure **4-13** Location of USGS Unconventional Southwestern Wyoming Province Isles and Lance Coalbed Gas Plays

Figure **4-14** Location of USGS Unconventional Southwestern Wyoming Province Almond Coalbed Gas Plays

Figure **4-15** Location of USGS Unconventional Southwestern Wyoming Province Fort Union CBM Play

Table **4-3** USGS Unconventional Play Data for Southwestern Wyoming Province (037)

charged. Other characteristics include low reservoir permeability, abnormal pressures, and close association of the reservoir with the source rocks from which hydrocarbons were generated. Coal reservoirs CBM plays are a form of continuous-type accumulation but none were recognized in the Denver Basin Province. Two of the five continuous-type plays lie partly within the RawlinsRMPPA and one play lies completely within its boundaries (**Figures 4-16** and **4-17**). Data on the three plays is summarized in (**Table 4-4**).

4.1.2 Hydrocarbon Resources

The USGS 1995 assessment of U.S. oil and gas resources (Beeman and others, 1996; Charpentier and others, 1996; and Gautier and others, 1996) also presents information about the potential resources in each hydrocarbon play. For the assessment, undiscovered technically recoverable resources were defined as estimated quantities of resources hypothesized to exist on the basis of geologic knowledge, data on past discoveries, source, and trapping theories. These resources are to be found in undiscovered accumulations outside of known fields. Estimates of resource quantities were determined to be producible using current recovery technology but without considering economic viability. Only accumulations greater than or equal to 1 million barrels of oil or 6 BCFG are included in this part of the assessment.

USGS hydrocarbon resource estimates are shown for conventional plays in the Southwestern Wyoming Province (**Table 4-5**) and Denver Basin Province (**Table 4-6**). Estimates also are shown for unconventional plays in the Southwestern Wyoming Province (**Table 4-7**) and Denver-Cheyenne Basin Province (**Table 4-8**). Four types of hydrocarbons (oil, natural gas liquids, associated-dissolved gas, and non-associated gas) can be produced in the conventional plays. Non-associated gas production and natural gas liquids can be produced in unconventional plays in the Southwestern Wyoming Province. Oil, natural gas liquids, and gas can be produced in unconventional plays in the Denver-Cheyenne Basin Province. Associated-dissolved gas is produced as a by-product of oil production, non-associated gas is produced as a by-product of condensate production, and natural gas liquids may be produced as a by-product of either type gas production.

For each type of hydrocarbon, a mean estimated resource (**Tables 4-5** and **4-6**) or mean potential reserve (**Tables 4-7** and **4-8**) volume was recorded for each play. Assuming hydrocarbons were evenly distributed across each play area, hydrocarbon volume was calculated from each play that would be contained within the RMPPA. Using **Tables 4-5, 4-6, 4-7,** and **4-8**, it was estimated that the RMPPA area contains a mean volume of 696 million barrels of undiscovered recoverable liquid hydrocarbons. It also was estimated that the RMPPA contains a mean volume of 44 TCF of undiscovered recoverable gas.

Fractile values of F99 to F1 for **Tables 4-5 and 4-6** and F95 to F5 for **Tables 4-7 and 4-8**) were used to describe the range of resource or reserve volumes that could be present in each play.

Figure **4-16** Location of USGS Continuous-type Denver-Cheyenne Basin Province J Sandstone Deep Gas Play

Figure **4-17** Location of USGS Denver-Cheyenne Basin Province Fractured Niobrara-type Plays

Table **4-4** USGS Unconventional Play Data for Denver-Cheyenne Basin Province (037)

Table **4-5** USGS Conventional Play Resources for Southwestern Wyoming Province (037)

Table **4-6** USGS Conventional Play Resources for Denver-Cheyenne Basin Province (039)

Table **4-7** USGS Unconventional Play Resources for Southwestern Wyoming Province (037)

Table **4-8** USGS Unconventional Play Resources for Denver-Cheyenne Basin Province (039)

Fractiles portray the potential distribution of volume of undiscovered resource. For example, F5 means that there is a 5 percent chance that more than the listed amount of resource will occur, and F95 means that there is a 95 percent chance that more than the listed amount of resource will occur. For the Rawlins RMPPA, the range of undiscovered recoverable liquid hydrocarbons was estimated to be between 273 and 1,567 million barrels. The range of undiscovered recoverable gas was estimated to be between 17 and 84 TCF.

Advanced Resources International (ARI) (ARI, 2001) prepared the most recent analysis of the hydrocarbon resource in southern Wyoming and northwestern Colorado. This analysis is part of a larger project planned for the Department of Energy. ARI (2001) used the USGS 1995 assessment, supplemented by data from the Wyoming State Geological Survey, and their own work, to estimate undiscovered, technically recoverable, natural gas resources for the area studied. They did not evaluate proven hydrocarbon reserves or undiscovered, technically recoverable, oil resources. For all of the USGS plays, ARI (2001) assumed a homogenous distribution of resource within play boundaries. Using the three sources of data listed above, they predicted the undiscovered, technically recoverable, gas resource for each township in the region assessed. The total predicted gas resource is 47 TCF in the RMPPA. Advanced Resources International's resource prediction is greater than the 44 TCF predicted from USGS data, but is within their estimated range of 17 to 84 TCF.

Figure 4-18 shows undiscovered, technically recoverable, gas resources. Those gas resources are shown by township, in three resource volume ranges, and in townships where a zero gas resource is predicted. Townships with zero gas resource are located in areas of mountain ranges that are made up of Precambrian granites, where traps and hydrocarbons are not known to occur. Highest predicted volumes of gas are located in townships scattered across parts of the eastern Washakie Basin, Wamsutter Arch, and eastern Great Divide Basin. Mid-range predicted volumes of gas are located in the rest of the Washakie and Great Divide Basins, and in most of the Hanna Basin. Hanna Basin CBM resource estimates, made by the Wyoming Geological Survey, account for a part of the predicted mid-range volumes for that area. The Denver-Cheyenne Basin Province is predicted to contain only low volumes of undiscovered gas. Almost all the "Atlantic Rim" proposed CBM project area lies in the low volume prediction area, along the eastern most margin of the Washakie Basin.

4.1.3 Hydrocarbon Occurrence Potential

Most of the Rawlins RMPPA is considered as having a high potential for the occurrence of hydrocarbons **(Figure 4-19)**. This rating considers a variety of geologic characteristics, including the following:

- the presence of hydrocarbon source rocks;
- the presence of reservoir rocks with adequate porosity/permeability;

Figure **4-18** Undiscovered Technically Recoverable Natural Gas Resources

Figure **4-19** Oil and Gas Occurrence Potential

- the potential for structural/stratigraphic traps to exist;
- the opportunity for migration from source to trap; and
- the presence of other conditions, such as temperature, depth of burial, and subsurface pressures.

All oil and gas plays, as defined by the USGS, are considered as being in areas of high occurrence potential. Approximately 77 percent of the RMPPA falls within this category.

Approximately 23 percent of the RMPPA falls outside of play areas designated by the USGS (Beeman and others, 1996; Charpentier and others, 1996; and Gautier and others, 1996). These areas are mostly located in parts of mountain ranges that are made up of Precambrian granites, where traps, reservoir strata, and hydrocarbons are not known to occur.

4.1.4 Projections of Future Activity

4.1.4.1 Oil and Natural Gas Price Estimates

Oil and gas price estimates are the single most important factor controlling the amount of future oil and gas drilling and production activity in the RMPPA. These prices can be very volatile as shown for gas in **Figure 4-20** and for oil in **Figure 4-21**. Gas prices to 2020 (**Figure 4-20)** were estimated from two sources. Henry Hub, Louisiana futures (the only gas futures contract location in the U.S.) prices for gas are from the Enerfax Daily (2002). The Energy Information Administration (EIA, 2001) estimated a 2020 gas price ranging from $2.94 to $3.65 per thousand cubic feet of gas. Price estimates for Wyoming natural gas require subtracting a price differential from Henry Hub futures and the EIA estimates. This price differential generally reflects transportation costs. A price differential of $0.50 per million Btu (MMBtu) was used for the low estimate projection in **Figure 4-20** and $0.25 per MMBtu was used for the high estimate projection.

The estimated cost of liquefied natural gas delivered to the east coast of the U.S. is about $1.75 to $2.75 per MMBtu (Cook, 2002). The availability of this liquefied natural gas in large quantities is expected to act as a moderating influence on gas prices, not allowing for large long-term price increases. Therefore, any price scenario should not consider long-term prices to exceed about $3.00 per MMBtu for natural gas produced in Wyoming.

Review of **Figure 4-20** price estimates allows some generalization about future gas drilling and production activity in the Rawlins RMPPA. Future price scenarios suggest that gas exploration and production will be positively affected by increased prices only during the next few years. Starting in about 2004, gas production in southwest Wyoming will be mainly a function of the ability of industry to discover and economically develop new accumulations, and the ability to

Figure **4-20** Historical Spot Gas Prices for Northwest Pipeline at Opal, Wyoming, with Projections to 2020

Figure **4-21** Plot of Historical Wyoming Crude Oil Prices, with Projections to 2020

increase drilling, production, processing, and transportation efficiency to take advantage of higher projected prices. Beyond about 2007, prices are expected to remain flat or decline. Those projected future gas prices alone are not expected to buoy exploration and production activity beyond 2007. This analysis assumes that the projected LNG imports will progressively supplant domestically produced gas as demand increases.

U.S. demand for natural gas is expected to increase about 50 percent by 2020. Increases in future natural gas production, to meet increased demand, are projected to come partly from the Rocky Mountain area. Anticipated production increases in Wyoming are expected to be mainly from unconventional energy sources such as CBM and deep basin-centered gas deposits.

Anticipated oil prices are based on a combination of futures prices for West Texas Intermediate crude oil and EIA (2001) estimates. **Figure 4-21** shows historical Wyoming sweet crude oil prices, future prices, and projected prices to 2020. Although oil prices have been in the $17 to $24 per barrel range during the past 12 months and as high as $30 per barrel in the past 18 months, futures prices suggest a steady decline to an average price of about $21.00 per barrel in 2008. The EIA (2001) estimates the price of crude oil will be between $17.06 and $23.79 per barrel in 2020. However, EIA's "High World Oil Price" is projected to be as high as $30.58 per barrel (EIA, 2001) and this should be expected to influence gas prices based on historical correlations. It should be remembered that much of the world's crude oil comes from politically unstable areas. Occasional unforeseen and abrupt price increases should be expected.

4.1.4.2 Leasing

General Leasing Information

After initial project evaluation, research, and subsurface mapping (which frequently includes use of seismic data), leasing is often the next step in oil and gas development. Leases on lands where the U.S. owns the oil and gas rights are offered via oral auction at least quarterly. Lease bids are based on industry speculation about amounts of potential hydrocarbons that may be present. Lowest prices are generally bid on leases with the highest risk of recovering economic amounts of hydrocarbons. Maximum lease size is 2,560 acres and the minimum bid is $2.00 per acre. An administrative fee of $75.00 per lease is charged and each successful bidder must meet citizenship and legal requirements. In addition to the lease bid, a $1.50 per acre per year rental is charged for the first 5 years and $2.00 per acre per year is charged thereafter. Leases are issued for a 10-year term. Each lease contains restrictive stipulations, which protect potentially affected resource values. Leases that become productive are held by production and do not terminate until all wells on the lease have ceased production. A 12.5 percent royalty is paid on all production. Many private oil and gas leases contain a "Pugh clause," which allows only the developed portion of the lease to be held by production. However, federal leases have no such clause, allowing one well to hold an entire lease.

Wyoming federal oil and gas lease sales are held on even numbered months, usually in Cheyenne. However, no lease sale was held in April 1996 due to the partial government shutdown. Since August 1996, only lands requested for lease have been offered. Before that, virtually all lands available for lease were offered at each sale.

Rawlins RMPPA Leasing

In April 2002, there were 2,300 federal oil and gas leases covering 2,113,552 acres in the RMPPA **(Table 4-9)**. **Figure 4-22** shows the location of all federal leased lands. The BLM managed about 99 percent of all federal leases and leased federal lands. The BLM leases average 920 acres in size. Those lands will be covered by decisions made during the plan update. The BOR and the USFS manage the remaining 31 leases. BOR leases average 897 acres in size. There is only one USFS lease and it is 204 acres in size.

Table 4-9
Distribution of Federal Acreage Covered by
Active Federal Oil and Gas Leases in the Rawlins RMPPA

Surface Management	Leases	Acreage
BLM	2,269	2,086,444
Bureau of Reclamation	30	26,904
U.S. Forest Service	1	204
Total	2,300	2,113,552
Held by Production	608	441,562

About 21 percent of the total leased federal acreage (26 percent of the federal leases) is held by production. Each lease that is held by production will not expire until the last well on that lease ceases production. Forty-three percent of the BLM managed lands is leased. The majority of the leased federal acreage is in western Carbon and eastern Sweetwater counties **(Figure 4-22)**.

As federal oil and gas leases expire, those lands may be nominated for leasing again. The number of federal acres in the RMPPA offered for lease, and leased competitively, on a year-by-year basis, is shown in **Figure 4-23**. During 1996-2001 over 1,186 leases were issued for acreage in the RMPPA. Eighty-three percent of the acreage offered was leased competitively. Since 1997, an average of 238,000 acres has been leased each year. The average lease size was about 1,034 acres.

A summary of bonus bid data received from leasing is shown in **Figure 4-24**. The average bid was $32.43/acre, which is nearly the same as the overall Wyoming average. Total bonus bids received were $40 million. This is 20 percent of all the lease bonus revenue received for Wyoming during 1996-2001. The largest per-acre bid was $875 per acre for a 640-acre tract in T17N,

Figure **4-22** Location of Federal Oil and Gas Leases

Figure **4-23** Summary of Federal Oil and Gas Lease Sale Results, by Year, for the 1996-2001 Period, Rawlins RMPPA

Figure **4-24** Summary of the Total Amount of Bonus Money Received from Federal Oil and Gas Leasing and the Average Bid by Year, for the 1996-2001 Period, Rawlins RMPPA

R94W. The largest bonus bid was $841,940 for a 1,958-acre tract in T21N, R93W. Half of the bonus dollars came from just 8 percent of the leased acreage.

Half of the bonus money bid for public domain minerals went to the state of Wyoming. Forty percent of the bonus went to the Reclamation Fund administered by the Bureau of Reclamation and the remaining 10 percent went to the General Fund of the Treasury. It is anticipated that the amount of federal oil and gas acreage under lease in the RMPPA between 2001 and 2020 will range between 1.0 and 2.5 million acres. Annual federal acreage leased is projected to average between 100,000 and 300,000 acres. As new producing wells are drilled, the amount of acreage held by production will increase substantially from the current 0.4 million acres. Bids should average between $10 and $50 per acre. Gas prices and exploration success will determine the amount of lands leased and bonus bids received. The size of federal leases will continue to be large, probably in excess of 900 acres. Leasing in the RMPPA should generate a minimum of $20 million during the 2001 to 2020 period. If leasing remains at the bonus rates of the past six years, approximately $132 million could be received in bonus payments during the 20-year planning cycle.

4.1.4.3 Seismic Surveys

Seismic surveys are a critical part of oil and gas exploration. They are authorized on BLM managed surface by approval of Notices of Intent (NOIs) to Conduct Geophysical Operations. The numbers of yearly approved NOIs for the RMPPA are shown in **Figure 4-25** for 1992 to 2001. Approximately 60 percent of the surveys used dynamite and 40 percent used vibroseis methods to obtain data (see Appendix A). About 40 percent of the seismic surveys were three-dimensional (3-D) surveys.

The number of surveys on BLM administered surface in the RMPPA is expected to remain at about the 1997-2001 level (about eight per year) in the short term. As additional seismic data are acquired, the need for new data will decrease assuming that neither new technological breakthroughs nor new exploration plays will occur that require resurveying old areas. The number of surveys should decrease and be closer to the 1992-1996 (about two per year) level during the second half of the planning cycle. Although two-dimensional surveys will probably be run in the future, it is expected that most of the NOIs will be for 3-D surveys. Most will be located in eastern Sweetwater County or the far southwest part of Carbon County.

4.1.4.4 Projections of Future Drilling Activity

Non-CBM Hydrocarbons

It is difficult to predict what will occur a few years into the future. It is even more difficult to predict 20 years ahead. In an attempt to get more insight as to what may occur in the Rawlins RMPPA,

Figure **4-25** Approved Seismic Notices of Intent to Conduct Geophysical operations (NOIs), by Year, on BLM Managed Surface in the Rawlins RMPPA

geologists and engineers in the oil and gas industry were contacted. Twenty-one oil and gas companies, which operate in the RMPPA, were contacted by letter and asked their opinion of what exploration and development activity will occur and where it is likely to occur. Each company was contacted by telephone about 5 days after the letters were sent. Eight companies provided information useful in constructing development potential maps. Some companies requested that the details of the information they provided be held confidential. Due to time constraints, only a very limited review of technical data was conducted from wells in the RMPPA. Structure contour maps drawn by the Rocky Mountain Map Company (2001) were used as working base maps on which to construct development potential maps.

The BLM anticipates that as many as 4,475 new non-CBM wells may be drilled in the Rawlins RMPPA in the 2001-2020 period. In 2001, industry drilled 252 new wells in the RMPPA. For the rest of the 20-year period, new wells will be drilled at an average rate of 222 per year. This estimate does not include re-completing wells to new formations or zones, plugging back wells to test shallower formations or zones, or re-entering wells to drill deeper.

Figure 4-26 shows the results of mapping areas of development potential for the 2001 through 2020 period. Development potential was projected for the RMPPA including national forest lands. Development potential is mapped as high, moderate, low, and no potential. High development potential areas are those where the average drilling density is projected to be more than 100 wells per township (36 square miles). Moderate development potential areas are those where the drilling density is projected to be between 20 and 100 wells per township. Low development potential areas are those where the drilling density is projected to be fewer than 20 wells per township. No development potential areas are those where no drilling activity is anticipated during 2001-2020. **Figure 4-26** was prepared assuming that there will be no restrictions that will preclude or greatly hinder oil and gas leasing, exploration, and development during 2001-2020.

Mapped boundaries in **Figure 4-26** vary in type, depending on available data and industry information used to define those boundaries. In areas where information available was most limited, boundaries were drawn at the township scale. The no development potential area was defined as those lands not included in hydrocarbon plays defined by the USGS (Beeman and others, 1996: Charpentier and others, 1996: Gautier and others, 1996).

Statistical data on the four development potential areas are summarized in **Table 4-10**. High and moderate development potential areas cover only about one-eighth of the area, while low and no development potential areas cover the remaining seven-eighths.

High development potential is anticipated in the area surrounding the Siberia Ridge-Wamsutter-Echo Springs-Standard Draw complex of fields (**Figure 4-26**). Generally, the nature of drilling activity in this area will be additional infill locations in and around the existing fields. Locally, well density may be up to 16 per square mile or 40-acre spacing.

Figure **4-26** Non-coalbed Methane Development Potential Areas

Table 4-10
Oil and Gas Development Potential Classifications
Determined for the Rawlins RMPPA

Development Potential	Acres (thousands)	Number of Townships	Percent of Field Office
High	340	14.8	3.03
Moderate	1,026	44.5	9.16
Low	7,213	313.1	64.34
No	2,631	114.2	23.47
Total	**11,210**	**486.6**	**100.00**

Drilling activity in the larger area of moderate development potential will vary from relatively dispersed, about four wells per square mile, to more intense drilling activity in local areas. The oil and gas industry will search diligently for production in trapping situations similar to those found in the area of high potential. If similar trapping situations are encountered, well densities could be as high as 16 per square mile. There also will be areas with little or no drilling activity. In areas that are already developed, some of the new wells will be for replacement and infill.

Low well densities are anticipated in the area of low development potential. Wells may be scattered (mainly exploration wells) or locally closely spaced, but the total number of wells will average less than 20 per township. In areas that are already developed, some of the new wells will be for replacement and infill.

No drilling activity during the 2001-2020 period is expected in the area of no development potential. As described above, the USGS has not identified any potential hydrocarbon plays in this area. This area appears to be underlain by non-hydrocarbon-bearing Precambrian rocks. There will probably never be interest in testing this area, based on current concepts of hydrocarbon generation and accumulation. Also based on past history, it is unlikely that any oil or gas drilling will be allowed in the National Forests.

BLM anticipates that average well depths will continue to increase with many new wells drilled in the 12,000- to 14,000-foot range. Deep wells, greater than 15,000 feet deep, will probably be much less common. It is anticipated that only about 30 deep wells will be drilled in the 2001 to 2020 period. They will be scattered throughout those parts of the RMPPA where there is deep reservoir potential (**Figure 3-6**).

It is anticipated that the number of producing non-CBM gas wells will continue to increase at historical trends and also, that as the total number of producing wells increases, gas production in the RMPPA also will continue to increase. Development drilling will continue in the Siberia Ridge-Wamsutter-Echo Springs-Standard Draw complex of fields. Additional reservoirs will almost certainly be discovered in the 2001-2020 period. Gas production increases are expected to continue as short-term prices increase above the 2001 level. Gas production is expected to be

between 150 and 350 billion cubic feet per year by 2020. Production increases through 2020 also are expected; however, long-term prices will probably keep these increases to approximately historical levels or less. In other words, it is unlikely that the production increase from 2001-2020 will be larger than production increases during the period from 1981 to 2001. Furthermore, it is highly probable that production will peak before 2020 and begin a long-term downward trend reflecting depletion of the gas reserves in the RMPPA.

BLM expects that oil production will continue to decline. The rate of decline should slow, as condensate production from gas wells becomes an increasingly larger proportion of the oil produced from the RMPPA. The Lost Soldier-Wertz field is presently the major oil producer in the RMPPA. Its production will decline in the future and produce proportionally less of the total oil. Although the overall trend is expected to be downward during 2001-2020, there will probably be some year-to-year increases in oil production.

CBM Drilling

CBM or coal reservoir production is another category of oil and gas exploration and production. This category utilized the same leasing requirements, APD authorization, pipeline outlets, water disposal authorization, and all other aspects of oil and gas exploration and production. CBM drilling activity in the RMPPA is at an early stage. There has been considerable interest in CBM drilling in the RMPPA. The status of wells as of February 2002 is shown in **Figure 4-27**. In 2001, 122 permits were approved, although only 11 had so far been drilled by the end of the year. Historically, 74 percent of the CBM wells permitted have been drilled.

Locations of CBM exploratory units are shown in **Figure 3-11**. These units indicate present areas of high interest for activity. Initial industry drilling proposals have been highest for the Hanna Basin area and for the Atlantic Rim area, which lies along the eastern boundary of the Washakie Basin. **Figure 4-28** shows the areas of anticipated development potential for the period 2001 through 2020. Statistical data on the five development potential areas is summarized in **Table 4-11**. High and moderate development potential areas only cover about 6 percent of the RMPPA. Much of the RMPPA is expected to have little or no coalbed gas development. Low and very low development potential areas cover 41 percent of the RMPPA and no potential areas cover about 53 percent.

Mapped boundaries in **Figure 4-28** vary in type, depending on available data and industry information used to define those boundaries. Section boundaries were used to define the high and moderate development potential areas. Here information allowed potential to be defined by an approximate depth contour, so boundaries were drawn at the section (640 acres) scale. The outer boundary of the low and very low development potential areas are from Jones (1991). This boundary defines the limit of the Green River, Hanna, Rock Creek, and Goshen Hole Coalfields within the RMPPA (**Figure 3-13**).

Figure **4-27** Rawlins RMPPA, Coalbed Gas Wells and Their Status

Figure **4-28** Coalbed Methane Development Potential Areas

Table 4-11
Coalbed Gas Development Potential Classifications
Determined for the Rawlins RMPPA

Development Potential	Acres (thousands)	Number of Townships	Percent of Field Office
High	408	17.7	3.64
Moderate	291	12.6	2.59
Low	2,801	121.6	24.98
Very Low	1,804	78.3	16.09
No	5,907	256.4	52.70
Total	**11,211**	**486.6**	**100.00**

Note: Up to 4,425 coalbed gas wells could be drilled during the 2001-2020 period.

The Green River and Hanna Coalfields are known to contain potential CBM targets (DeBruin and others, 2001). Those areas of the Green River and Hanna Coalfields not already defined as high or moderate potential, are designated as low development potential. The Rock Creek and Goshen Hole Coalfields have an unknown potential for CBM (DeBruin and others, 2001). They are designated as very low development potential. The area of no development potential, is defined as those lands not included within the Green River, Hanna, Rock Creek, or Goshen Hole Coalfields, as defined by Jones (1991).

It is very early in the life of the CBM play in the Rawlins RMPPA. Very little information is presently available about its viability as an economic play. Although there is very little development history, the BLM anticipates that as many as 4,850 wells may be drilled between 2001 and 2020. Eleven wells were drilled in 2001 (**Figure 4-27**) and approximately 90 wells were drilled in 2002. For the rest of the 20-year period, new wells are expected to be drilled at an average rate of 264 per year. The actual drilling rate in any year could vary widely from this average. Elements that may affect the yearly drilling rate could be the results of the most recent exploratory and development activity; availability of drilling rigs, equipment, and crews; an infrastructure (pipelines) in place to receive new production; permitting delays; or economic conditions.

Drilling density will vary across the RMPPA. High development potential areas could have an average drilling density greater than 100 wells per township during 2001-2020. Drilling density could be 20 to 100 wells per township in the moderated development potential areas. Low development potential areas could have drilling densities up to 20 wells per township and very low development potential areas could have densities up to 2 wells per township. In reality, initial CBM exploration wells may be drilled in pods of 4 to 10 wells or more. When these pods are determined to be commercial, additional surrounding locations also will be drilled. This means that in some townships, actual future well densities may exceed the average density projected above. A lack of exploratory or development interest in other townships may mean that the number of wells actually drilled will be much less than the projected density.

Wells will probably be drilled on 80- or 160-acre patterns. Depths of CBM wells in the Greater Green River Basin area (western part of the RMPPA) will initially be relatively shallow. As shallower prospects get drilled, activity will progress toward deeper parts of the basin. In the Hanna Basin area, CBM targets are presently being tested in the deeper 5,000- to 6,000-foot range. WOGCC records (2002a) indicate CBM wells as deep as about 6,000 feet have been drilled in the RMPPA.

Results from CBM pilot projects in Wyoming suggest that often too few wells have been drilled to adequately evaluate the economic viability of those projects. Past history indicates that pilots should contain from 16 wells (4 interior wells and 12 surrounding wells) to 25 (9 interior wells and 16 surrounding wells) to adequately evaluate an area (Cook, 2002 and Likwartz, 2002). These results suggest that fewer wells may not adequately reduce hydrostatic pressure over a sufficient area. Also, coal heterogeneity may preclude the 1 interior well in a 5- or 9-well pilot from providing the data necessary to adequately evaluate economic viability. For those reasons, CBM pilot projects should contain 16 to 25 wells. This should provide a better chance of obtaining adequate project feasibility data and thus avoid duplicate projects. This would also suggest that past CBM projects in the Rawlins RMPPA might not have adequately tested the economics of the project.

In 2000, CBM was about 7 percent of the total natural gas produced in the U.S. CBM is about 15 percent of total natural gas production in Wyoming. The Wyoming percentage of CBM production has increased substantially during the past 4 years (**Figure 4-29**). It has been estimated that future increases in natural gas production in Wyoming will be mostly from CBM (Cook, 2002). CBM development in new producing areas, such as the Hanna and Carbon Basins and the eastern Washakie Basin, will account for some of the projected future increase in natural gas production.

The PGC (PGC, 2001) has published estimates of CBM resources in the Hanna-Carbon and Green River (including the Wyoming Overthrust Belt) coal regions. Since about 19 percent of the surface area in the CBM plays identified by Gautier and others (1996) lies within the RMPPA, the BLM estimated that about 19 percent of the PGC (2001) gas resource estimate also lies in the RMPPA. Almost all of the estimates of CBM resources in these areas are classified as speculative. The “Most Likely Resource” estimate of CBM resources totals 4,851 billion cubic feet for the Rawlins RMPPA (**Table 4-12**). This is about 14 percent of the total estimate of undiscovered CBM resource in Wyoming, and 3.1 percent of the total estimated undiscovered CBM in the U.S. including Alaska.

The published gas resource estimate for the greater Green River Basin portion of the RMPPA may be too low based on the BLM’s projection of future drilling activity. The USGS is scheduled to have an updated estimate available in October 2002, and the PGC will issue another estimate in the spring of 2003. These estimates may provide information necessary to modify the CBM resources estimate for the RMPPA.

Figure **4-29** Coalbed Gas Production as a Percent of Total Natural Gas Produced in Wyoming

Table 4-12
Estimates of Coalbed Gas Resources in the Rawlins RMPPA

Basin	Minimum Resource (BCFG)	Maximum Resource (BCFG)	Most Likely Resource (BCFG)
Hanna-Carbon	600	9,700	4,371
Greater Green River	12	3,450	480
Total	**612**	**13,150**	**4,851**

BCFG = billion cubic feet of gas

Note: Estimates for Greater Green River Basin are a ratio based on surface area within Rawlins RMPPA. Data are compiled and modified from PGC (2001).

Initial pilot programs indicate that CBM resources are present and will be developed at least in local areas. It is still too early to predict whether or not CBM will develop into a large play in the Rawlins RMPPA. If pilot projects prove that a viable CBM resource over a large area exists and gas prices are favorable, drilling and production could increase at a rapid rate. By 2020, CBM production could increase to half or more of the total gas produced from the RMPPA, and CBM wells could equal the number of non-CBM wells drilled. If long-term gas prices prove to be less than anticipated by the industry, development would be more limited.

Projected Surface Disturbance

General assumptions used to anticipate drilling related surface disturbance is presented in **Table 4-13**. Disturbance guidelines are presented for CBM shallow and deep wells and for intermediate and deep non-CBM wells. Road standards would be in conformance with guidelines issued in BLM Manual 9113 (1985).

Table 4-14 summarizes present well numbers and associated acres of surface disturbance (through 2001) directly associated with those wells. Acres of estimated future surface disturbance are calculated from the assumptions portrayed in **Table 4-13**. In addition, it projects well numbers and associated surface disturbance for the short term (through 2010) and for the long term (through 2020). The projections of well numbers assume that the yet to be drilled wells (4,850 non-CBM wells and 4,425 CBM wells) will be evenly distributed across the 2002 to 2020 period. The future surface disturbance estimate is based on one well per location.

4.1.5 Coal

Records indicate that during the year 2000, there were a total of 21 producing coal mines in Wyoming. There were additional mines that were idle, closed, or reclaimed that remained carried on state records. Year 2000 coal production by coal field is shown in **Table 4-15**. The production statistics for the year 2000 represent a 0.7 percent increase over 1999s production of

Table **4-13** Anticipated Drilling Related Disturbance, in Acres, for Rawlins RMPPA

Table 4-14
Projections of Short-term (2010) and Long-term (2020) Drilling Activity with Associated Surface Disturbance

	Status Through 2001	Short-term Through 2010	Long-term Through 2020
Drilled Wells	5,515	10,178	14,840
Abandoned Wells	2,955	4,680	6,405
Active Wells	2,560	5,498	8,435
Acres of Disturbance	8,163	15,267	22,260

Note: An abandonment rate of 37 percent is assumed in the calculation. Surface disturbance associated with roads, power lines, and compressor stations is not included in these projections.

336,459,938 tons, even though one mine closed and another was idled in 2000. It should be noted that as of 2000, all currently producing mines are surface mines. For comparative purposes, the following production statistics (Wyoming Coal Information Committee, 2002) provide an indication of the relative distribution of coal production within Wyoming.

Table 4-15
Wyoming Coal Production – 2000

Coalfield	No. Producing Mines	Tons Produced	As Percent of Total[1]
Powder River Basin			
Campbell County	12	299,542,969	88.4
Converse County	2	23,599,855	7.0
Sheridan County	1	38,411	0.01
Green River Coalfield			
Sweetwater County	2	9,959,737	2.9
Hams Fork Coalfield			
Lincoln County	1	3,725,983	1.1
Hanna Coalfield			
Carbon County	3	1,985,193	0.6
Totals	**21**	**338,852,148**	**100.0**

[1]Due to rounding, the percentages may not total exactly 100 percent.

It is important to note that the indicated Carbon County production data reflects Hanna Coalfield production. For the year 2000, three mines were operational: the Shoshone Mine (underground; closed mid-year), the Seminoe II Mine, and the Medicine Bow Mine. Since then, only the Medicine Bow and Seminoe II mines (both operated by Arch of Wyoming, Inc.) have remained operational in the Hanna Field. Based on an estimated remaining 2 million tons of recoverable reserves, it is anticipated that these two mines will cease production in approximately 2 years.

Wyoming is the nation's leading coal-producing state. The Wyoming Coal Information Committee predicted a production increase of 3.9 percent for 2001. Actual 2001 production was tallied at 368.9 million tons, an increase of 8.82 percent (Harris and others, 2002). Increases of approximately 1 percent per year for the years 2002-2005 are predicted. Approximately 97 percent of Wyoming's coal production is consumed in electrical generation in over 25 states, Canada, and overseas.

It would be anticipated that most of the production increases would be absorbed by existing (permitted but unused) capacity available within Powder River Basin mines or in other coal producing regions within the state; however, the Seminoe II and Medicine Bow mines will likely remain operational until reserves are fully depleted.

The Seminoe II Mine exploits the Bed No. 78 seam (average thickness 18 feet), the Hanna No. 2 seam (average thickness 30 feet), and the Hanna No. 5 seam (average thickness 14 feet) of the Tertiary Hanna Formation. Overburden removal (average thickness 200 feet; ranging from 150 to 225 feet) is by combination dragline and shovel/truck; coal removal is by shovel/truck. The mine is estimated to have approximately 2 years remaining life. The Medicine Bow Mine is currently extracting coal from Beds 38, 39, 40, 24, and 25, with approximate overburden thickness again ranging from 150 to 225 feet and averaging about 200 feet. The mine is anticipated to have a 2-year remaining life.

4.1.5.1 Coal Development Potential

There are a total of seven coal areas classified as having development potential (see **Table 4-16**). These include the Red Rim, China Butte, Indian Springs, Indian Springs North, Atlantic Rim, Hanna Basin, and Carbon Basin tracts. Of these, the Carbon Basin tract (discussed below) is viewed as having the most probable development potential within the projected 20-year planning period.

The remainder of the tracts, while possessing tonnage and quality characteristics sufficient to categorize them as having development potential, will likely not be developed within the projected 20-year planning period; however, if one or more of these tracts were to escalate to development status, development would have to be managed on a case-by-case basis.

Proposed Carbon Basin Coal Project

Arch of Wyoming LLP has obtained the Elk Mountain/Saddleback Hills coal lease (WYW139975) tract, and is expected to begin development in the Carbon Basin Coal Project at some time following the closure of the Seminoe II and Medicine Bow mines. The Carbon Basin federal lease tract (5,235 acres) is approximately 11 miles south of the current Seminoe II mine. The federal lease tract contains approximately 39 percent of the total estimated reserve, and would be

Table **4-16** Summary of Coal Development Potential Rawlins RMPPA

combined with state and private holdings to develop a feasible mining unit. The leased coal is estimated to represent approximately 119.12 million tons of surface and underground recoverable coal. Arch would establish two mines on the tract, the Elk Mountain Mine for surface mineable coal reserves and the Saddleback Hills mine for underground mineable coal. The projected life of the project would be approximately 20 years (BLM, 1999).

The Carbon Basin Coal Project Area encompasses a total of 18,360 acres, including the 5,235 acres in the federal lease tract. The project area is generally located north of I-80, between Highway 115 and the Medicine Bow River. More specifically, it occupies portions of T20-21N, R79-80W.

Surface mining would begin with a dragline pit in the southwestern portion of the area, advancing in a northeasterly direction. An estimated 31.1 million tons of recoverable coal would be surface mined, with the anticipated production rate for the surface operation being 1.3 to 3.1 million tons per year. Underground mine development would occur shortly after the surface mine pits are developed, with portals being established in the pit highwalls. Main entries would be driven by continuous miner; however, full-scale production would utilize a longwall system. Estimated production rates for the underground mine would range from 1.3 to 7.7 million tons per year.

4.1.5.2 Unlikely Coal Development Potential

Cherokee (Creston)

Three coal seams in the Fort Union Formation have been identified in this area. The Cow Butte seam averages 7,417 Btu/lb and 3.26 percent sulfur. The Lower Cherokee seam averages 8,293 Btu/lb and 1.66 percent sulfur. The Upper Cherokee seam averages 7,714 Btu/lb and 1.82 percent sulfur (Janssen, 2002).

Given the indicated coal quality parameters, it is highly unlikely that there would be development of this tract during the 20-year planning period.

Kindt Basin

Coal reserves in this area are in the Mesaverde Group of the Allen Ridge Formation. Two seams have been identified, the Bolten seam and the I seam which occurs about 20 feet above the Bolten. The Bolten averages 3.9 feet thick with a range of 2.0 to 7.6 feet. It occurs near the middle of the area and also near the east end by the North Platte River. In other areas, the Bolten seam is split. The Upper Bolten split averages 3.1 feet thick with a range of 0 (at the split line) up to 6.5 feet. The Lower Bolten split averages 3.4 feet thick with a range of 0 (at the split line) to 7.4 feet. The I seam occurs only locally in the central part of the area and again in the eastern part near the Platte River. The I seam averages 2.3 feet thick where it occurs with a range of 0.7 to

5.5 feet. Bolten seam quality parameters are 11,500 to 11,600 Btu/lb and 1.05 percent sulfur. Total reserves are not known (Janssen, 2002).

Given the minimal seam thicknesses, it is highly unlikely that there would be development of this tract during the 20-year planning period.

4.1.6 Oil Shale

There has been no known commercial production of shale oil from oil shale occurrences within the RMPPA.

As indicated in Section 3.1.4, oil shale bearing rocks of the Green River Formation are present in the Washakie Basin and the northwest portion of the Red Desert Basin.

Though the RMPPA does contain oil shale resources, there are more extensive and higher grade deposits in other parts of the Green River Basin, particularly in Colorado and Utah. Commercial exploitation of oil shale, if it were to occur, would likely take place where these more extensive and higher grade deposits are present. However, production of kerogen, or shale oil, remains in the developmental stages and is considered sub-economic at this time.

The nature of the oil shale deposits within the RMPPA, in conjunction with the status of oil shale development in general, suggests that there is minimal to no potential for commercial exploitation of these oil shale deposits within the projected 20-year planning period.

4.1.7 Phosphate

There has been no known commercial production of phosphate ores from the phosphate occurrences within the RMPPA. As indicated in Section 3.1.5, the RMPPA phosphate occurrences are at considerable depth, and present only in the western half of the area.

Though the RMPPA does contain limited phosphate resources, there are more extensive and higher grade deposits that are currently being commercially exploited. These include a number of mining and processing operations situated near the Wyoming – Idaho state line, and in the Vernal, Utah area. In addition, significant phosphate production emanates from operations in North Carolina and Florida. Thicker phosphate zones containing higher-grade phosphate at these locations, in combination with their existing processing and transportation infrastructure, will ensure that domestic phosphate production will continue to be largely from these locales.

The nature of the phosphate deposits within the RMPPA, in conjunction with the alternatively available domestic resource and production capacity, suggests that there is minimal to no

potential for commercial exploitation of the RMPPA's phosphate deposits within the projected 20-year planning period.

4.1.8 Other Leasable Minerals

4.1.8.1 Sodium

There has been limited, small-scale production of sodium sulfate at various locations within the RMPPA, possibly in conjunction with other brine commodities. However, there is no known current commercial production of sodium sulfate products within the RMPPA, nor has there been an indicated leasing interest with respect to these types of deposits.

Sodium production is Wyoming's most important industrial mineral in terms of value and employment. Trona is produced from five underground mines located west of Green River and refined into soda ash and other sodium products. An estimated resource of 134,400,000,000 tons of mineable trona and mixed trona and halite is present in the Green River Basin. A total of 42 trona beds are known to exist within the Wilkins Peak Member of the Green River Formation, of which 25 are considered mineable (Culbertson, 1986; Harris, 1992).

The nature of the sodium deposits within the RMPPA, in conjunction with the alternatively available domestic resource and production capacity, suggests that there is minimal to no potential for commercial exploitation of the RMPPA's sodium deposits within the projected 20-year planning period.

Although there is an extensive area of potash mineralization known to be present in the eastern portion of the RMPPA (in the vicinity of the Wyoming-Nebraska state line), there has been no indicated leasing or other expression of interest relative to potential commercial development.

Potash demand within the U.S. is largely supplied by production originating in New Mexico. To date, there has been no recorded production of potash ores from Wyoming sources.

The nature of the phosphate deposits within the RMPPA, in conjunction with the alternatively available domestic resource and production capacity, suggests that there is minimal to no potential for commercial exploitation of the RMPPA's phosphate deposits within the projected 20-year planning period.

4.1.8.2 Geothermal

The geothermal resources of the RMPPA are of low to moderate temperatures (less than 150°C) resources (James, 1979) and with this characteristic, have limited economic application. The primary applications of low to moderate geothermal resources in other parts of the world are for

space heating, horticulture, industrial processes and spas (White, 1973). Geothermal resources are considered to be a renewable resource and could be an alternative resource to oil and gas. Due to the relative isolation from any population centers and little indigenous population within the RMPPA, there does not appear to be any economic future for this resource for the next 20 years.

4.2 Locatable Minerals

Remaining resource potential in the Rawlins RMPPA (but outside of the National Forest) for locatable minerals is found in five main areas: 1) Shirley Basin, 2) the Poison Buttes uranium deposit by Baggs, 3) the Seminoe Mountains, 4) the Iron Mountain Magnetite district, and 5) the Silver Crown Mining District (exclusive of USFS lands). These locations are shown on **Figure 3-13**.

The Shirley Basin uranium deposits were never mined out. Mining ceased in the early 1980s due to a sharp drop in price for uranium. Uncertainty as to the safety of nuclear power plants and the return to "more normal" oil prices undercut the price of uranium and the price plummeted, leading to the closure of most uranium mines in the western U.S. Although there are no published estimates as to the remaining resources in Shirley Basin, a rough estimate would be that about half of the original 50 million pounds of probable resources estimated by the Atomic Energy Commission (Harshman, 1972b) still remain. These resources could be mined by in-situ solution mining methods, should the world demand for uranium and resultant price increase over the next 10 years due to political tensions in the Middle East.

The Poison Buttes uranium deposit contains 8 to 15 million pounds of U_3O_8 at mineable grades. Like the Shirley Basin, this deposit is just waiting for higher uranium prices. Newer mining techniques, such as in-situ solution mining, that were developed after the drop in uranium prices in the 1980s will make this district economic once the demand for uranium returns.

Other areas of remaining or potential mineral resources in the Rawlins RMPPA can be found in Precambrian rocks in the uplifts of the Seminoe Mountains and the Laramie Range Iron Mountain Titaniferous Magnetite district. The Seminoe Mountains have Archean stratabound iron and gold deposits similar to those found in Canada. These deposits have not been developed because of low demand for iron and the relatively low price for gold over the past 10 years. Both of these economic factors could change in the next 10 years.

The iron, titanium, and vanadium resources of the Iron Mountain district have been demonstrated through drilling and simply await a rise in economic demand before they are developed and mined once again. Resource estimates range from 30 million tons of massive ore at the Iron Mountain Deposit with grades of 16 to 23 percent TiO_2 to a disseminated resource at the Strong Creek Deposit with 300 million tons at 5 to 30 percent TiO_2.

The Silver Crown Mining District has a proven resource of 35 million tons of copper at a grade of 0.2 percent copper. This deposit is simply waiting for higher copper prices. The deposit can be mined by open-pit methods, making it very attractive once the price of copper goes above about $1.00/lb.

The Laramie anorthosite complex has been evaluated as a source of alumina; however, technological limitations associated with the alumina recovery processes render the occurrence non-economic at this time. Significant advances in recovery technology would be required before the development potential of this occurrence can be considered significant, and this is not anticipated to occur within the projected 20-year planning period.

4.3 Salable Minerals

The salable mineral category includes, but is not limited to, common varieties of sand, stone, gravel, pumice, pumicite, cinders, clay, and petrified wood. Of these, there are known exploitable occurrences of sand and gravel (or aggregate materials), limestone, sandstone, decorative stone, silica sand, and other similar mineral commodities within the RMPPA (refer to Section 3.3). To a lesser degree, there may be a limited potential for exploitation of common clay. Petrified wood resources, where present, would likely be of interest for hobby or specimen collecting.

Extraction and sale of aggregate materials are governed by the Mineral Materials Disposal regulations codified within 43 CFR 3600 through 3622. These regulations allow for mineral materials disposal through either mineral material sales or non-exclusive disposal.

Mineral material sales can be made on the initiative of the authorized BLM officer or be made subsequent to receipt of a request to purchase by an applicant. Sales can be made under a competitive bid basis or under a non-competitive bid basis, subject to certain volume or weight equivalent limitations.

Non-exclusive disposal of mineral materials can be occur through sale or “free-use,” and can be made from the same deposit within areas designated by the BLM authorized officer. These areas are designated as “community pit” sites (defined sites) or “common-use” areas (generally a broad geographic area), neither of which is necessarily limited in size.

The differentiating factor between a “community pit” site and a “common-use” area is that designation of a community pit constitutes a superior right to remove the material as against any subsequent claim or entry of the lands, whereas designation as a common-use area does not constitute a superior right (however, a person authorized by permit or sale has a superior right against any subsequent claim or entry).

Mineral materials may be disposed through “fair market value” sales from either community pit sites or common-use areas. In addition, “free-use permits” can be issued to any federal or state agency, unit or subdivision, including municipalities and, under certain conditions and limitations to non-profit organizations.

4.3.1 Aggregates (Sand and Gravel)

Natural construction aggregate is one of the most abundant natural resources and one of the most widely used. Aggregates consist of crushed and sized rock (either quarried stone of crushed gravel) or natural sand and gravel, which are not crushed, but sized. Sand and gravel is less expensive than crushed stone aggregate, but crushed stone has the advantage of consistency in size and angularity.

Construction aggregates are the lowest priced of all mined products. Since they are so low priced, transportation costs from the pit to the point of use can become the major part of their cost to the consumer. For example, crushed rock that may cost $2.00 per ton to produce can be subject to transportation costs on the order of $1.00 per ton-mile or greater. As such, at transportation distances of even 2 miles the cost of transportation can easily exceed the cost of production. Therefore, it is imperative that aggregate sources be located as close as possible to the point of use.

It is anticipated that demand for aggregate production within the RMPPA will increase in proportion to expanding gas (and CBM) exploration, development, and production activity. These industries require significant quantities of aggregate products primarily for purposes of constructing and stabilizing drill pad installations and access/service roadways. While the oil and gas industry will be the primary consumer of aggregate products over the projected 20-year planning period, additional consumption also will occur relative to increased town/city public works and county and state highway departments’ requirements. These governmental and quasi-governmental entities require aggregate materials for public works projects, new road construction, and existing road maintenance and resurfacing.

It should be noted that the existing permitted pits (i.e., community pits, free-use pits, common-use pits, and negotiated sale pits) indicated in the following sections are representative of the major producing or known past production areas. However, it should be further stated that there is potential for other deposits to occur throughout the RMPPA where geologic conditions are proven to be favorable, as previously described in Section 3.1.1. Limited information precludes specific identification of these other occurrences at this time.

It is probable that the greatest proportion of oil and gas industry demand for aggregate will be fulfilled through the utilization of existing and development of new “community pits.” A total of

five active or pending community pits (representing an original authorized total surface area of approximately 3,000 acres) exist within the RMPPA (**Table 4-17**):

Table 4-17
Designated Community Pits
(Sand and Gravel)

Pit Name	Serial Number	Location	Authorized Acreage
Coal Bank Draw	WYW130911	T12N, R89W	800
Savery Creek	WYW130911	T12N, R89W	Included in above
Big Gulch	WYW130912	T13N, R89W	1,680
Baggs SE	WYW130913	T12N, R90W	520
Dixon Airport S	WYW130913	T12N, R91W	Included in above
Total			**3,000**

No information concerning remaining acreage was available. In general, it can be stated that quality aggregate resources within the central and western portions of the RMPPA are scarce. In these areas, consumption usually targets available resources of scoria (baked and fused shale), crushed sandstone, and/or crushed limestone. All of these materials are inferior to higher quality aggregate resources, and as a result are subject to advanced deterioration and weathering (resulting from heavy equipment traffic), comparatively high rates of dust generation, and increased frequency of maintenance and/or replacement. As such, identification and permitting of quality aggregate sources within these portions of the RMPPA should be considered a high priority.

The estimated gravel resource requirement for the projected 20-year planning period is on the order of 8.5 million cubic yards (yd^3) of material, as follows:

Oil and Gas Industry (Direct) Demand:	1,700,000 yd^3
State/County/Municipal Demand:	6,250,000 yd^3
Other:	500,000 yd^3
Total:	8,450,000 yd^3

Existing community pits, based on authorized acreages, should contain sufficient reserves to satisfy the demand projection. However, utilization of the community pits will be dependent on transportation cost (distance) to point of use. This, in combination with area-specific shortages of quality aggregate will likely result in the establishment of additional pits.

In addition to the above-mentioned community pits, there also are a number of authorized common use pits, free use pits, and negotiated sale pits, as indicated below in **Tables 4-18**, **4-19**, and **4-20**. No information was available concerning remaining acres of reserves in the pits.

Table 4-18
Designated Common Use Pits (Sand and/or Gravel)

Pit Name	Serial Number	Location	Authorized Acreage
Powder Wash	WYW093699G	T12N, R96-97W	8,220
Gay Johnson	WYW135292	T21N, R88W	200
Eight Mile Lake	WYW136493	T20N, R88W	1,280
Five Mile Ridge	WYW136493	T20N, R88W	Included in above
Shirley Mountains	WYW136494	T25N, R81W	1,920
RFO Multiple Areas	WYW152999	T15-26N, R71-89W	5,120
Seminoe Dune	WYW135293	T25N, R84W	20
Seminoe Dune	WYW154284	T25N, R84W	20 Grosch
Seminoe Dune	WYW155257	T25N, R84W	2 Dudley
Seminoe Dune	WYW155258	T25N, R84W	2 Carbon County
Total			**16,784**

Table 4-19
Designated Free-Use Pits (Sand and/or Gravel)

Pit Name	Serial Number	Location	Authorized Acreage
Carbon Cty – Merrill	WYW137411	T12N, R81W	10
Carbon Cty – McCarry	WYW141967	T15N, R89W	0.873
Carbon Cty – Browns Hill	WYW143282	T14N, R90W	120
Carbon Cty – Buck Draw	WYW146551	T17N, R85W	40
Carbon Cty – Saratoga	WYW144385	T17N, R84W	5
Carbon Cty – Buzzard	WYW145367	T27N, R86W	120
Carbon Cty – CCRoad	WYW148169	T18N, R88W	1
Carbon Cty – Miller Hill	WYW148169	T18N, R88W	Included in a
Carbon Cty – CCRd305	WYW148710	T28N, R85W	1
Carbon Cty – Collins	WYW148710	T28N, R85W	Included in a
Carbon Cty- Red Hills Q	WYW151840	T25N, R84W	25
Sweetwater Cty – Sun Q	WYW151845	T23N, R88W	15
Wyoming Water Dev. Co.	WYW152331	T16N, R88W	5 High Savery Dam
Red Hills	WYW145972	T25N, R84W	160
Total			**502.9**

Table 4-20
Authorized Negotiated Sale Pits (Various Commodities)

Pit Name	Serial Number	Location	Authorized Acreage
ICM Quarry	WYW146559	T16N, R72W	5 Wyoming Stone Industrialists
Delaney Rim	WYW149123	T19N, R95W	1 J. Reynolds
Turritella Agate	WYW149123	T19N, R95W	Included in above
Sun Quarry	WYW151514	T23N, R88W	15 Rissler & McMurray
Creston Jct.	WYW153012	T20N, R91W	5 K&H Construction
Creston Jct.	WYW155306	T20N, R91W	80 H.B. Lee – Pending
Total			**106**

Estimates for the demand potential for aggregate consumption over the projected 20-year planning period have been formulated on the following bases:

4.3.1.1 Oil and Gas Industry Requirements

The most significant increase in aggregate demand will originate from gas (natural and CBM) development activity occurring in the west-central portions of the RMPPA. Due to the transportation cost sensitivity of aggregates, aggregate sources proximal to these developmental areas will bear the burden of aggregate production before more distant sources are utilized.

The total aggregate demand associated with oil and gas industry requirements consists of gravel utilized to stabilize long-term wellpad locations and roadway infrastructure. That demand is estimated to be approximately 1,700,000 yd^3 (as rounded upward from an estimated 1,680,796 yd^3, as calculated below).

4.3.1.2 Oil and Gas Industry

Aggregate Demand Projections

In order to assemble an aggregate demand projection (for oil and gas industry requirements), a number of assumptions have been made, based upon data pertaining to oil and gas and CBM development projections (see Section 4.1.4.4).

A total of 4,475 non-CBM wells and a total of 4,850 CBM wells are projected over the planning period. Assuming a nominal 63 percent completion rate (inferring a 37 percent abandonment rate) as indicated by historic data, it would be anticipated that approximately 2,819 non-CBM and 3,055 CBM wells, respectively, would be "permanent" installations.

1. Wellpads (Non-CBM) - Based on the indicated average wellpad dimension of 1.5 acres, and assuming a nominal 4-inch lift of surface-stabilizing gravel utilized across a nominal 5 percent of the wellpad surface, each wellpad will require (on average) an estimated 40 yd^3 of gravel material for initial surface stabilization, calculated as follows:

   $$\frac{(1.5 \text{ acres/wellpad} \times 43{,}560 \text{ feet}^2/\text{acre} \times 0.33 \text{ feet})}{27 \text{ feet}^3/\text{yd}^3} \times 0.05 = 40 \text{ yd}^3/\text{wellpad}$$

   Allowing for pad maintenance on a regular basis, a nominal 10 yd^3 per wellpad is assumed to be required every other year. Therefore, the total amount of gravel required (over the 20-year planning period) for wellpad surface stabilization at 3,356 wellpads would be the total of initial surfacing placement plus biennial maintenance, resulting in an estimated total requirement of 469,840 yd^3, calculated as follows:

2,819 wellpads x [40 yd^3/wellpad + 10 (10 yd^3)] = 394,660 yd^3

Wellpads (CBM) – Same assumptions as above, but applying a 25 percent factor (0.25) against total to account for smaller CBM locations.

3,055 wellpads x [40 yd^3/wellpad + 10(10 yd^3] x 0.25 = 305,500 yd^3

Total wellpad requirements are therefore: 394,660 yd^3
+305,500 yd^3
700,160 yd^3

2. *Access roads:* Access roads will (to varying degrees, dependent on classification) require gravel surfacing, primarily in areas of weak soils not conducive to supporting loads or volumes associated with anticipated traffic. BLM road standards (Manual 9113) provide for three types of access roads, as follows:

   Collector Roads: These roads normally provide access to large blocks of land and connect with or are extensions of a public road system. Collector roads usually require application of the highest standards used by the BLM. Design speed is 30 to 50 mph, and subgrade width is a minimum of 28 feet (24-foot full surfaced travelway).

   Local Roads: These minimum volume roads usually provide the internal access network within an oil and gas field. Design speed is 20 to 50 mph and subgrade width is a minimum of 24 feet (20-foot full surfaced travelway).

   Resource Roads: These are normally spur roads that provide point access. Roads servicing individual wellpads typically fall within this classification. Design speed is 15 to 30 mph and subgrade width is a minimum of 16 feet (12-foot full surfaced travelway).

   Projections for access road development indicate an average access road (classified as "resource roads") requirement of 0.4 mile per well. Thus, given the projected incremental total of 2,819 active non-CBM wellpads and 3,055 CBM wells over the 20-year planning period, a total of 2,349 miles of new resource roads are projected [(2,819 x 0.4) + (3,055 x 0.4) = 2,349 miles]. Projected aggregate (gravel) requirements are estimated in the following manner:

   Resource Roads

   Basis: Assume a nominal 10 percent of the projected total resource road miles (2,349 miles x 0.10 = 235 miles) will initially require gravel stabilization (4-inch lift) across the entire 16-foot

subgrade width. It also is assumed that infrequent spot maintenance of these roadways will require a nominal 2,000 yd^3 on an annual basis over the 20-year planning period.

$$\frac{235 \text{ miles} \times 5{,}280 \text{ feet/mile} \times 16 \text{ feet} \times 0.33 \text{ feet}}{27 \text{ ft}^3/\text{yd}^3} + 20\ (2{,}000\ \text{yd}^3) = 282{,}645\ \text{yd}^3$$

Local Roads

Basis: Assume total mileage to be a nominal 25 percent of the projected total resource road miles (2,349 miles x 0.25 = 587 miles) and that a nominal 30 percent of the resulting miles (587 miles x 0.30 = 176 miles) will require gravel stabilization (4-inch lift) across the entire 24-foot subgrade width. It also is assumed that infrequent spot maintenance of these roadways will require a nominal 4,000 yd^3 on an annual basis over the 20-year planning period.

$$\frac{176 \text{ miles} \times 5{,}280 \text{ feet./mile} \times 24 \text{ feet} \times 0.33 \text{ feet}}{27 \text{ feet}^3/\text{yd}^3} + 20\ (4{,}000\ \text{yd}^3) = 352{,}589\ \text{yd}^3$$

Collector Roads

Basis: Assume total mileage to be a nominal 10 percent of projected total resource road miles (2,349 miles x 0.10 = 235 miles) and that 100 percent of the resulting mileage will require gravel surfacing and/or stabilization (6-inch lift) across the entire 28-foot subgrade width. It also is assumed that infrequent spot maintenance of these roadways will require a nominal 7,500 yd^3 on an annual basis over the 20-year planning period.

$$\frac{235 \text{ miles} \times 5{,}280 \text{ feet/mile} \times 28 \text{ feet} \times 0.50 \text{ feet}}{27 \text{ feet}^3/\text{yd}^3} + 20\ (7{,}500\ \text{yd}^3) = 793{,}378\ \text{yd}^3$$

Therefore, the total oil and gas and CBM industry development demand for aggregate is estimated to be the total of all of the above, calculated as follows:

Wellpads	700,160 yd^3
Resource Roads	282,645 yd^3
Local Roads	352,589 yd^3
Collector Roads	793,378 yd^3
Total	2,128,772 yd^3

4.3.1.3 State/County/Municipality Requirements

State/County/Municipality demand projections are based upon an independent estimate for the Wyoming Department of Transportation (WYDOT) and Carbon County (as the primary county to be impacted by projected development activity). [Note: Analysis of data pertaining to BLM mineral material disposal records for the 5-year period 1997-2001 indicates fluctuating mineral disposal volumes under the relevant category "Free-Use Permit – Government Subdivisions" that are likely not indicative of current and future demand scenarios.]

Most aggregate utilized by state/county/municipal entities is consumed in roadway construction, road maintenance, and other related paving or construction applications. As oil and gas development intensifies (as projected), it would be reasonable to anticipate that the need for public road construction, road maintenance, and other infrastructure improvements would increase proportionately.

Typically, major infrastructure improvements are incurred in the early to middle stages of a natural resources "boom" period. As such, the gravel demand estimate for state/county/municipal consumption is based on (an estimated) 2001 consumption (as the base year), with a projected escalation in demand over the first 5 years of the planning period (**Table 4-21**). A leveling of demand is projected for 10 years and then a slight drop-off for the remainder of the planning period.

It has been assumed that approximately 75 percent of Carbon County's aggregate demand will be met through BLM-sourced material, with the remainder being from private sources. It also has been assumed that WYDOT obtains minimal volume of aggregate through BLM-sourced materials, with the majority of aggregate demand being fulfilled through private sources.

4.3.1.4 Other Demand

There are other aggregate demand requirements that include, but are not necessarily limited to private entity demand (disposal through negotiated or non-negotiated sales) and free-use permit disposal (e.g., non-profit entity demand).

Recent historic sales have been made relative to the Seminoe Sand Dune resource, which has become a highly sought after sand for utilization in golf course construction and maintenance (i.e., sand traps). This demand has been mostly regional; however, it is indicated that the demand region will grow beyond the immediate area (Wyoming, Colorado) to other states.

This demand has been estimated at a nominal 25,000 yd^3 per year over the 20-year planning period, resulting in a total estimated demand on the order of 500,000 yd^3.

Table 4-21
Estimated Gravel Requirements for State/County/Municipal Roads

Year	Volume (yd^3)
2001 (base)	150,000 (estimated – not actual)
2002	200,000
2003	250,000
2004	300,000
2005	350,000
2006	350,000
2007	350,000
2008	350,000
2009	350,000
2010	350,000
2011	350,000
2012	350,000
2013	350,000
2014	350,000
2015	350,000
2016	300,000
2017	300,000
2018	300,000
2019	300,000
2020	300,000
Total	**6,250,000 yd^3**

4.3.2 Silica Sand

Production of silica sand in the U.S. for the year 2000 declined 1.7 percent from 1999, and the trend generally continued through 2001 due to the economy. Declining markets included foundry, fiberglass, hydraulic fracturing, ground filters, and ceramics.

Roughly 40 percent of the silica sand production in the U.S. is based in the midwest (Illinois and Michigan). The unit price of silica sand is relatively low compared with its transportation cost to the consumer. Consequently, most sand does not ship more than 200 miles from its point of origin.

Market drivers for silica sand include construction and automotive production (foundry applications). Concern related to utilization of silica and possible silica dust exposure in the workplace could negatively impact the demand for silica sand. However, increased usage of glass products has reversed the downward trend in glass container markets.

To the extent that Wyoming silica sand sources are in demand, it is anticipated that the demand function will remain relatively stagnant (major markets are addressed through production from the midwest and other sources).

As mentioned previously, there is a specialized market for sand utilized in golf course construction. This sand, present as deposits associated with the Seminoe Sand Dunes, will be mined on an as-needed basis. Since the sand dunes represent a substantial resource base, there should not be significant depletion of available reserves, and siting of sand quarries (or extraction areas) should not pose a concern.

Accordingly, annualized silica sand production within the RMPPA would be anticipated to remain relatively consistent over the projected 20-year planning period. Existing silica sand operations should sustain production requirements for the foreseeable future; however, when additional silica sand operations are determined to be warranted, siting and permitting will be largely dependent on the distance to market and predominant end-consumer.

4.3.3 Limestone and Dimension Stone

Limestone is quarried in the Laramie area for the manufacture of cement, its primary consumptive end-use. However, limestone also is utilized locally, albeit to a significantly lesser degree, as a decorative and/or dimension stone in various applications.

It is likely that those limestone quarries currently operational will remain so as long as there is a demand for production. Although 2001 was a record year for the U.S. portland cement industry (representing a 2.7 percent increase from 2000), forecasts for 2002 indicate a decline of 3.1 percent in portland cement shipments (MacFadyen, 2002). This demand scenario will largely apply to projected limestone production (as associated with the production of portland cement).

Accordingly, annualized limestone production within the RMPPA would be anticipated to remain relatively flat over the projected 20-year planning period. Existing limestone quarries should sustain production requirements for the foreseeable future; however, when additional limestone quarries are determined to be warranted, siting and permitting will be largely dependent on the distance to market and predominant end-consumer.

4.3.4 Vermiculite

Vermiculite occurs in Wyoming in several areas in biotite schist, hornblende schist, diorite and metadiorite, hornblendite, and serpentinite at or near a contact with granite, granite gneiss, granite pegmatite, or vein quartz.

Worldwide production of vermiculite during 2001 declined by 14 percent. It is projected that North American markets will continue to decline due to concerns of asbestos contamination in vermiculite (from the former Libby, Montana, mine; closed since 1990). Current domestic production comes from three producers, one in Virginia and two in South Carolina (Moeller, 2002).

Domestic production was down 25 percent in 2001, and consumption down 8.2 percent. Domestic demand is increasingly being fulfilled by foreign sources, inclusive of South Africa and China.

Vermiculite has been produced in the past from Wyoming sources from deposits near Encampment, west of Casper, and in the central Laramie Mountains. There are probably sufficient resources of vermiculite in the southern Saratoga Valley (near Encampment) to support renewed production (Harris, 1990). However, the nature of the vermiculite deposits within the RMPPA, in conjunction with the alternatively available foreign and domestic resource and/or production capacity, suggests that there is minimal potential for commercial exploitation of the RMPPA's vermiculite deposits within the projected 20-year planning period.

4.3.5 Pumice and Scoria

Pumice and scoria are utilized in industrial applications (as an abrasive), as a filler in concrete block manufacture, and as aggregate. In most industrial applications, scoria can be utilized as a substitute for pumice, differing primarily in angularity and color.

Although deposits of pumice are present within the RMPPA, production has not been significant. Roughly 98 percent of domestic production comes from 15 mines or producers in California, Idaho, New Mexico, and Oregon. Production on an annual basis declined 1 percent last year, and 2002 production is estimated to further decline.

Based on the limited occurrence of pumice and scoria within the RMPPA and the relative availability of regional sources, no significant expansion in commercial exploitation of pumice and scoria resources is anticipated within the RMPPA for the projected 20-year planning period. However, there may be limited, small-scale production to satisfy localized demand.

4.3.6 Common Clay

There were a number of former commercial common clay operations within the RMPPA; however, all are apparently now inactive. It is possible that localized demand for clay materials may evolve for special use applications (e.g., landfill or lagoon liner material).

The major uses of common clay are building brick, lightweight aggregate, and portland cement clinker. Leading producers of common clay are North Carolina, Texas, Alabama, Georgia, Ohio, Missouri, Virginia, Kentucky, California, and Arkansas. Domestic demand for common clay remains fairly strong, and projections are that sales and use will remain relatively steady over the next couple of years.

Based on the limited occurrences of common clay within the RMPPA and the relative availability of suitable and cost-effective alternatives (e.g., synthetic liners, etc.), no significant commercial

exploitation of common clay resources is anticipated within the RMPPA for the projected 20-year planning period. However, there may be limited, small-scale production to satisfy localized demand such as cement manufacture.

4.3.7 Decorative Rock and/or Stone

Decorative rock (as either moss rock or boulders) has been produced within the RMPPA for a number of years, with demand increasing proportional to population increases in the region. The moss rock is generally utilized as either a structural or decorative building material, whereas the boulders are generally utilized for landscaping purposes.

Moss Rock: Significant deposits of moss rock (defined as a moss or lichen covered sandstone) are known to occur in the southwest region of the RMPPA in the vicinity of the Wyoming-Colorado state line (north of Powder Wash, Colorado). Under current conditions, recoverable deposits are generally limited to those that are readily accessible (proximal to existing roadways) and obtainable through manual extraction or retrieval. However, as demand for moss rock increases, there will be an increasing need to establish greater accessibility (new roadways) to more remote deposits, or there will likely be increased unauthorized off-road activity and trespass. It is unlikely that recovery methods will vary significantly, as mechanized removal would damage the rock's desirability by scarring or scraping the moss or lichen veneer. As such, manual (by hand) extraction will likely remain the primary mode of removal.

It would be anticipated that moss rock demand would increase at least in direct proportion to population increases and the number of structural building permits issued. In fact, the demand curve may well exceed the region's growth rate as the rock's desirability is increasingly recognized by the existing populace and determined to be desirable for architectural renovation of existing structures. Further, interest in the rock may extend to areas outside of the region (e.g., Colorado and Utah). In fact, it has been noted that there has been significant trespass/theft of moss rock resources in the RMPPA.

Material disposal records maintained by the RMPPA do not clearly indicate the tonnage of moss rock that was extracted/sold during the 5-year period 1997 through 2001; however, estimates place the total in excess of 100 tons per year for most years. It is anticipated that there will be increased demand for the moss rock, reflective of increasing regional population as well as increased or more widespread usage of the moss rock as a building material (inclusive of demand related to neighboring states). With time (owing to stabilization of any population influx), it would be anticipated that there would be a leveling of demand, followed by a marginal drop in demand.

In all likelihood, the relative rate of increase in demand will level off in approximately 8 to 10 years as the oil and gas/CBM driven population growth slows due to maturation of the fields. For purposes of estimating overall demand, it has been assumed that any over-estimate error

introduced by reduction in demand (attributable to the leveling effect) would effectively offset any under-estimate error attributable to non-consideration of increased demand originating from outside the immediate area. [Note: No attempt has been made to estimate this external demand factor due to the fact that resource potential and/or limitations external to the RMPPA have not been evaluated as part of this (planning-area specific) mineral report.]

Estimated moss rock demand is anticipated to be on the order of 250 tons (possibly ranging in some years to in excess of 500 tons) per year over the projected 20-year planning period. That demand projection indicates a total of 5,000 tons over the 20-year planning period.

It is anticipated that this volume (tonnage) of moss rock is available in the State Line area. However, in order to maximize the resource base and optimize resource utilization within the already identified areas, consideration will need to be given to: 1) establishing and maintaining routes of accessibility when and where needed, and 2) establishing commercial-scale operations and providing for private product stockpile/transfer points locations (in order to avoid seasonal limitations on production or retrieval of the moss rock products).

As available moss rock inventories immediately adjacent to existing roadways are depleted, it may be necessary to extend existing or construct new spur roads or access drives into the talus fields to enable continued roadside collection of the rock.

Seasonal avoidance criteria will result in the establishment of seasonal limitations on moss rock collection, and in turn, may result in a recognition that offsite stockpiling might be a viable means of ensuring year-round accessibility to the moss rock resource.

Boulders

Significant deposits of boulders (arbitrarily defined as alluvial debris over 18 inches in diameter) are known to occur in and around fringe areas associated with various mountainous areas where present within the RMPPA. Typical of these areas are the Shirley Mountains, Ferris Mountains, Medicine Bow Mountains, and the Sierra Madre. It is likely that numerous other areas exist within the RMPPA where boulders are recoverable, given enhanced accessibility conditions.

Under current conditions, recoverable deposits are generally limited to those that are readily accessible (proximal to existing roadways) and obtainable through manual extraction or retrieval. However, as demand for boulders increases, there will be an increasing need to establish greater accessibility (new roadways) to the more remote deposits, or there will likely be increased unauthorized off-road activity and/or trespass.

It is likely that boulder extraction/recovery methods will continue unchanged. Most boulders are individually obtained through mechanized removal (e.g., backhoe or front-end loader) or, where

size and mass allow, by hand. Stipulations imposed on boulder extraction will ensure that a combination of hand and mechanized removal of individual boulders will continue to be the primary mode of removal.

In order to maximize the resource base as well as optimize resource utilization within existing boulder resource areas, consideration will need to be given to: 1) establishing and maintaining routes of accessibility when and where needed, and 2) establishing commercial-scale operations and providing for private product stockpile/transfer points locations (in order to avoid seasonal limitations on production or retrieval of the decorative boulder products).

Further, additional boulder resource areas must be identified and developmental requirements identified. As the available boulder inventories that are immediately adjacent to existing roadways are depleted, it may be necessary to construct spur roads or access drives into boulder fields, where present, to enable continued roadside collection of the boulders.

Seasonal avoidance criteria will result in the establishment of seasonal limitations on boulder collection, and in turn, may result in a recognition that offsite stockpiling might be a viable means of ensuring year-round accessibility to the decorative boulder resource.

4.3.8 Epsomite

A small epsomite production plant was operated at Rock Creek Lakes (Albany County) in the early years of the 20th century. As indicated in Section 3.3.8, small resources of epsomite remain present at this, and possibly other locations.

However, the nature of the epsomite deposits within the RMPPA, in conjunction with the alternatively available domestic resource and production capacity, suggests that there is minimal to no potential for commercial exploitation of the RMPPA's epsomite deposits within the projected 20-year planning period.

4.3.9 Petrified Wood

The only known concentration of petrified wood within the RMPPA occurs in the Shirley Basin. It is not anticipated that the development potential of this resource would exceed that of limited quantity collecting (free-use). Mineral material disposal regulations allow that persons may collect limited quantities of petrified wood for noncommercial purposes under terms and conditions consistent with the preservation of significant deposits as a public recreational resource (40 CFR 3622.1). In that regard, petrified wood is considered to be not only a salable mineral, but also a paleontological resource, and may accordingly be subject to protective measures afforded thereto under certain circumstances.

Under the free-use collection scenario, no permit is required except for specimens over 250 pounds in weight. Other rules apply, as follows:

- One person is allowed to remove a maximum of 25 pounds plus one piece of petrified wood per day, subject to a limitation of 250 pounds per year.

- No explosives or mechanized equipment may be used for the excavation or removal of petrified wood. Light trucks (up to 1-ton capacity) may be used as a principal means of transporting/hauling.

- Free-use petrified wood may not be bartered or sold to commercial dealers.

- Extraction and removal of specimens must be done in a manner that avoids damage to the surface.

There are no specific reporting requirements associated with free-use collection; however, the BLM has the authority to establish and publish additional rules to supplement those contained within 40 CFR 3622.

As such, there is no basis upon which to estimate demand or development potential, other than stating that collection quantities will likely diminish as readily observable and accessible specimens are depleted.

4.4 Mineral Potential Summary

In summary, the primary mineral occurrence and development potential within the RMPPA is associated with oil, natural gas, coal, aggregates, and decorative stone. There are several types other mineral commodities that have well-documented occurrences, but their development potential is limited by poor market conditions. The RMPPA is a proven hydrocarbon producing area for over 80 years, and estimates of undiscovered resources indicate that the area will provide abundant supplies of hydrocarbons (especially natural gas) through the end of the 20-year planning period and beyond. CBM is still an unproven resource, but the RMPPA currently contains several proposed CBM exploratory projects. It is anticipated that hydrocarbon development projects will drive the exploitation of aggregate resources (to supply infrastructure development needs). Because of abundant supplies of coal in the Powder River Basin of Wyoming, coal development may occur only to a limited degree. Although there was past mining of uranium and mineable grades of uranium remain in several areas, world market prices of the commodity will probably preclude development in the foreseeable future. Iron, titanium, vanadium, and copper are present as demonstrated resources, but development of those materials is also subject to world market conditions and not likely to occur in the near future. Diamonds have been found in the RMPPA, but no commercially developable deposits have been discovered to date.

A number of other minerals are present within the RMPPA; however, noted occurrences are typically sub-economic or development potential is "low", based on varying demand parameters (generally dependent on the mineral being considered).

The BLM (1985) in its Manual 3031 (Energy and Mineral Assessment) specifies the following classification system for mineral potential (utilized to rank the potential for presence or occurrence, as opposed to the potential for development or extraction):

Level of Potential

Classification	Level of Potential
O	The geologic environment, the inferred geologic processes, and the lack of mineral occurrences do not indicate potential for accumulation of mineral resources.
L	The geologic environment and the inferred geologic processes indicate low potential for accumulation of mineral resources.
M	The geologic environment, the inferred geologic processes, and the reported mineral occurrences or valid geochemical/geophysical anomaly indicate moderate potential for accumulation of mineral resources.
H	The geologic environment, the inferred geologic processes, the reported mineral occurrences and/or valid geochemical/geophysical anomaly, and the known mines or deposits indicate high potential for accumulation of mineral resources. The "known mines and deposits" do not have to be within the area that is being classified, but have to be within the same type of geologic environment.
ND	Mineral(s) potential not determined due to lack of useful data. This notation does not require a level of certainty qualifier.

Level of Certainty

Classification	Level of Certainty
A	The available data are insufficient and/or cannot be considered as direct or indirect evidence to support or refute the possible existence of mineral resources within the respective area.

B The available data provide indirect evidence to support or refute the possible existence of mineral resources.

C The available data provide direct evidence but are quantitatively minimal to support or refute the possible existence of mineral resources.

D The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral resources.

Based on the BLM classification system (BLM 1985), the RMPPA mineral potential for those minerals determined present is as follows:

Mineral	Classification	Mineral	Classification
Leasable Minerals		Locatable Minerals	
Oil	H/D	Uranium	H/D
Natural Gas	H/D	Iron	H/D
Coalbed Methane	H/C	Titanium	H/D
Coal	H/D	Gold	H/C
Oil Shale	M/C	Copper	H/C
Phosphate	L/C	Diamonds	H/C
Sodium	M/C	Rare Earths	H/C
Geothermal	L/C	Bentonite	L/C
		Zeolites	M/C
Saleable Minerals			
Aggregates	H/D		
Baked Shale	H/D		
Silica Sand	H/D		
Dimension Stone	H/D		
Vermiculite	H/C		
Pumice and Scoria	H/C		
Common Clay	H/C		
Gypsum	H/D		
Decorative Stone	H/D		
Epsomite	H/D		
Aluminum	M/C		
Jade	M/B		
Petrified Wood	M/B		