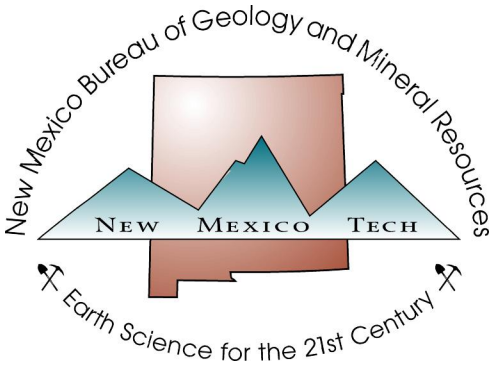

Coal Availability Study-Upper Menefee Formation in the Chacra Mesa, La Ventana fields, northwest New Mexico

By

G. K. Hoffman and Glen E. Jones
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Coal Availability Study—Upper Menefee Formation in the Chacra Mesa, La Ventana fields, Northwest New Mexico

Final Report for US Geological Survey Contract No. 99HQAG0089- Availability of Coal Resources in the Upper Member of the Menefee Formation, Chacra Mesa La Ventana Fields, San Juan Basin, northwest New Mexico

by
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Introduction

New Mexico ranks 12th in the nation in coal production and the state's coal industry contributes significantly New Mexico's educational funds through royalties and taxes. Production in the state comes primarily from the San Juan Basin with three mines producing from the Fruitland Formation and two mines producing coal from the Cleary Coal Member of the Menefee Formation.

Although no coal is presently produced from the upper coal member Menefee Formation, there are relatively thick coals in this sequence in the Chacra Mesa and La Ventana fields (Fig. 1) on the southeast side of the San Juan Basin. The four 7.5 minute quadrangles chosen for this study are Wolf Stand, Headcut Reservoir, Arroyo Empredrado, and San Luis. The cropline of the upper Menefee defines the southern edge of the 238-sq mi study area. Fourteen miles northeast of the study area is Cuba, New Mexico on State Highway 44. This highway is the main highway from Farmington to Bernalillo where State Highway 44 intersects Interstate 25. Interstate 25 traverses the Rio Grande corridor where the majority of the state's population lives.

Past Mining

The La Ventana coal field had several periods of mining, beginning in the 1880s and continuing into the 1980s. With the exception of the Arroyo No. 1 mine in the Cleary coals, all the mines in this area have been underground. Early mining (1884-1900) concentrated on the eastern edge of the field near the village of La Ventana and many of these mines provided fuel for the nearby metal mines in the Nacimiento Mountains. Interest in coal mining waned until the 1920s when a railroad from Bernalillo to La Ventana was built.

Washouts along the Rio Puerco were a problem for the railroad and by 1931 the trains were no longer running to the mines near La Ventana, although a few mines continued to operate to meet local fuel needs. In 1964 Consolidation Coal became interested in the thick upper coal member seam, often referred to as the Padilla Seam, and obtained leases in the area north of the town of La Ventana (Fig. 1). Consol sold their leases to Ideal Basic Industries who acquired a state permit for an underground mine to supply coal to their Tijeras Canyon cement plant. Lack of rail transportation and economics hindered the development of this mine and Ideal Basic relinquished their leases. This lease area is north of the study area (Fig. 1). Recent mining (1976 to mid-1984) in the La Ventana field has been limited to the Arroyo No. 1 mine near San Luis in the Cleary Coal Member (N½, Sec. 16, T17N, R2W), which is south of the study area. No mining activity is reported for the Chacra Mesa field.

Geologic Setting

Both the Chacra Mesa and La Ventana fields are on the southeastern edge of the San Juan Basin. The Chacra Mesa field extends from the Range line between R8W and R9W to the La Ventana field (R3W) and the La Ventana extends to the Nacimiento uplift on the eastern edge of the basin (Fig. 1). The coal-bearing Menefee Formation along the south side of the San Juan Basin defines both field areas. The general strike of the beds in the Chacra Mesa field is NW-SE and, because this field is within the Chaco slope province, the beds have gentle dips of 1-5^0 N-NE. The Cliff House Sandstone that caps the prominent northeast-trending Chacra Mesa defines the northern boundary of the Chacra Mesa field. The western two-thirds of the study area is within the Chacra Mesa field. The coal beds in this field are often overlain by a very thick overburden of Cliff House Sandstone that inhibits surface mining there as well (Speer, 1971).

In the western La Ventana field, the beds are gently dipping (2-5ºN-NW) but the eastern La Ventana field is close to the Nacimiento uplift (Fig.1) where the dip of the beds increases from 35-45ºNW-W to vertical. There is some high-angle faulting in the La Ventana field, and many of the faults are oriented in a NE-SW direction. This field encompasses the Cleary Coal and upper coal members of the Menefee Formation (Fig. 1). Coal beds average 3-6 ft thick in both coal-bearing sequences, although some individual

coal beds in the upper coal member attain a thickness of 10-12 ft. There are significant resources in the Cleary Coal Member and upper coal member of the Menefee Formation, but because of excessive dips on the east edge and thick sandstone overburden associated with the upper coal member, surface minable resources are reduced.

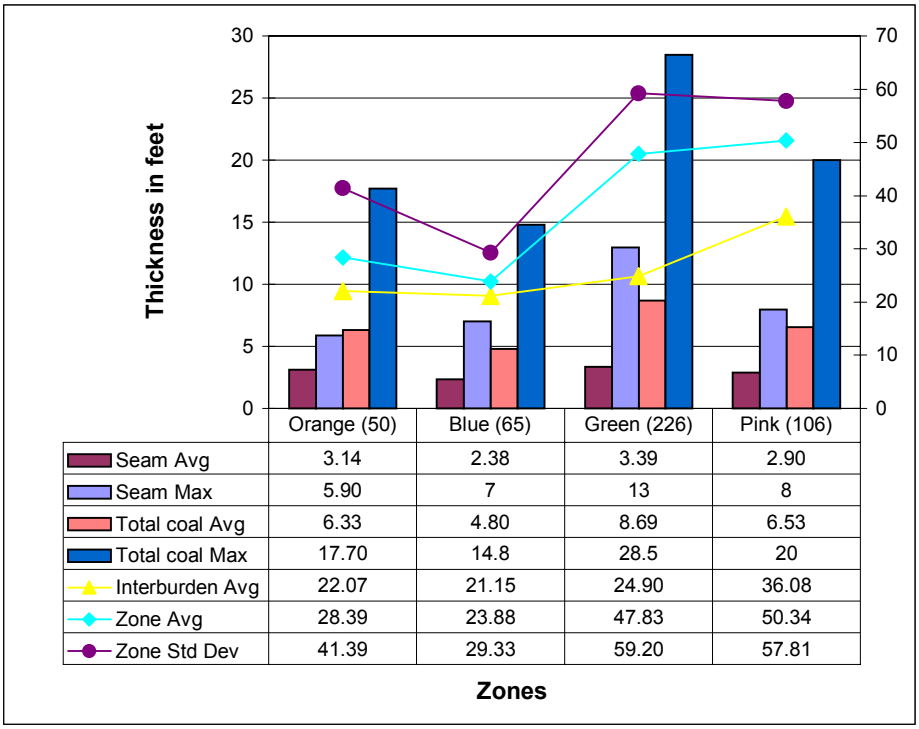
Coal Geology

The Menefee Formation represents transitional sequences deposited during a major advance and retreat of the Late Cretaceous shoreline across the San Juan Basin. The lower coal-bearing sequence, the Cleary Coal Member was deposited landward of a retreating shoreline, in mires behind the barrier beach sands of the Point Lookout Sandstone. Between the Cleary Coal Member and the upper coal member is a thick, barren continental sequence, the Allison Member .The deposits of the upper coal member of the Menefee Formation, the paralic Cliff House Sandstone, and the lower marine Lewis Shale (Fig. 2) represent the subsequent advance of the shoreline. Within this overall transgressive sequence are minor regressions and major stillstands in the shoreline that allowed the buildup of the La Ventana Tongue (Beaumont and Hoffman, 1992) of the Cliff House Sandstone that intertongues shoreward with the upper coal member of the Menefee Formation (Fig. 2). The upper coal member is one of the few coal sequences in the San Juan Basin that is within an overall transgressive sequence that has a significant thickness of coals. Where the upper coal member intertongues with the La Ventana buildup the sequence is up to 500 ft thick (Fig. 3). Landward, this coal-bearing sequence thins to about 75 ft thick.

Within the study area four zones were recognized in ascending order: the Pink, Green, Blue and Orange zones (Fig. 3). These four zones are moderately consistent in the study area. There are a few coals that occur above and below these zones, but they are very localized and were not considered in the resource evaluation. The Pink, Green, Blue, and Orange zones were recognized using the cross section constructed for the study done in 1992 (Beaumont and Hoffman, 1992) and illustrated in Figure 4 of that report. This cross section covers 18 miles and is perpendicular to strike in the area. Because the coals developed shoreward of the La Ventana Tongue of the Cliff House during shifts and pauses in the

shoreline, the sequence has significant intertonguing marine sandstones, which helped in correlating the zones. Further from the shoreline the sequence becomes more mudstone-siltstone dominant.

The seam average for these four zones varies little from 2.38 ft to 3.14 ft, but the seam maximum shows a wider spread from 5.9 ft in the Orange to 13 ft in the Green zone that has the thickest seam average. The Padilla seam, which was mined in the past at the crop, is within the Green zone. The average total coal within a zone is greatest for the Green, with 8.69 ft and thinnest in the Blue, 4.8 ft. The Green zone averages three seams within the zone, the remaining zones average two seams. From Figure 4 it is apparent the thickness of the zones varies considerably. In part this is because the farther from the shoreline, the greater the accommodation of continental deposits between the sandstone tongues of the La Ventana Tongue. The greater thickness of non-marine units and thinning of marine La Ventana Sandstones is illustrated in Figures 2 and 10, which show cross sections of the area perpendicular to the shoreline. The landward sections on the left and the shoreward sections on the right in both illustrations.



	Orange (50)	Blue (65)	Green (226)	Pink (106)
Seam Avg	3.14	2.38	3.39	2.90
Seam Max	5.90	7	13	8
Total coal Avg	6.33	4.80	8.69	6.53
Total coal Max	17.70	14.8	28.5	20
Interburden Avg	22.07	21.15	24.90	36.08
Zone Avg	28.39	23.88	47.83	50.34
Zone Std Dev	41.39	29.33	59.20	57.81

Figure 4. Coal thickness and interburden characteristics by zone. Seam refers to individual coal beds; total coal is total coal thickness within a zone. Numbers in parenthesis are the number of data points for each zone. Interburden Avg.-Zone Std. Dev. values are plotted on the secondary y-axis.

Total coal isopachs for the Orange, Blue, Green, and Pink zones (descending order, Figs. 5-8) illustrate the variability of thickness between zones and within the zones and their distribution. The Orange zone illustrates predominance of coals in the eastern part of the study area, on the Headcut Reservoir quadrangle and the general orientation of the isopachs is in a north-south direction. The Blue zone isopachs (Fig. 6) are also concentrated in the eastern study area, but do not have as great a thickness as the Orange, which is also shown in Figure 4. The Green zone is the most widespread of all the zones (Fig. 7) and has the thickest total coal for a zone that is concentrated in the middle of the study area. The Pink zone, at the base of the upper coal member Menefee- La Ventana Tongue intertonguing sequence, shows a shifting of the coals to the western part of the study area (Fig. 8). In stratigraphic order the isopachs show a shifting of coal development from the west (Pink zone) to east (Orange zone).

The three cross sections (Figs. 10-12) are located on the general geologic map of the area (Fig. 9). Figure 10 (A-A') is part of the cross section used by Beaumont and Hoffman (1992) to study the intertonguing relationships of the upper coal member of the Menefee and La Ventana and used in this study as a basis to determine coal zones. Correlation of seams on these cross sections and for resource calculation is by zone rather than by coal bed. Any coal on the cross section does not necessarily represent the same bed on an adjacent section; rather the coals are correlated as being within the same zone. All three cross sections illustrate the lenticularity and variability of the coal zones. Some of the sections have coals above and below the recognized zones, but these are of such limited extent that they were not used in the resource calculations. The numbers identifying each cross section refer to the ID number used in the Microsoft Access® database used in this study (See Appendix).

Coal quality

The apparent rank of upper coal member coals in the La Ventana and Chacra Mesa fields is subbituminous A (Hoffman, 1996a). Weighted–average analyses on an as–received basis are shown in Table 1 for the La Ventana and Chacra Mesa fields and the zones in this study area. Zone analyses are illustrated in Figure 13.

The sulfur values of all the zones, possibly with the exception of the Pink, are high for the San Juan Basin but within the range for the entire La Ventana field. These upper Menefee coals would not meet the New Source Performance Standards of the Clean Air Act of 1.2 lbs of SO_2 per million Btu (Energy Information Administration, 1993). The pyritic sulfur content is less than 15% of the total sulfur content in the Orange and Pink zones and is 25–30% of the total sulfur content in the Green and Blue zones. Washing would do little to improve the sulfur content in the upper and lowermost zones, but might be beneficial with the Blue and Green zone coals. Blending of the Pink and Green zones is a possibility as these two zones have the lowest sulfur content within the study area and the Green has some of the thickest coals.

The coals in the study area are low to medium-ash, nonagglomerating, Subbituminous B to A coal with weighted zone averages from 9,840 to 10,650 moist, mineral matter-free Btu/lb (MMFBtu/lb). These rank values are higher than Fruitland coals that are mined elsewhere in the San Juan Basin and the ash content of these coals is lower than the Fruitland Formation coals, but the rank value is lower than the Cleary coals being mined today. An average of the few oxide analyses (18 weighted) available reveal the major constituent of the ash is SiO_2 (55.44%), followed by Al_2O_3 (18.60%), Fe_2O_3 (6.75%), CaO (6.71%), Na_2O (2.27%), and MgO (1.72%). The remaining oxides (K_2O and TiO_2) are individually less than 1%. If this coal was to be used in electrical generation, the combustion would yield a Class F fly ash that could be used as a pozzolanic admixture in concrete (ASTM C 618, 1995).

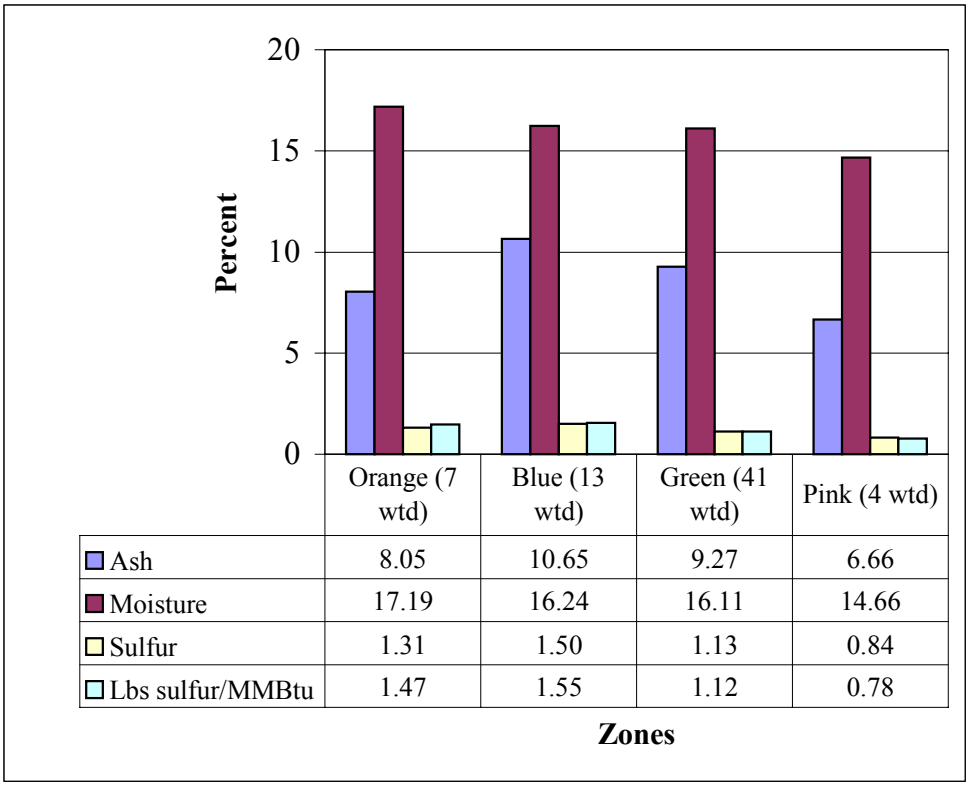


Figure 13. Weighted averages of quality analyses by zones in the Chacra Mesa-La Ventana study area. Numbers in parenthesis are number of weighted averages for each zone.

Available data

The database for the Chacra Mesa-La Ventana study is a subset of the data collected and entered by the New Mexico Bureau of Mines (NMBM&MR) into the National Coal Resource Data System (NCRDS). The NMBM&MR has had cooperative grants with the U.S. Geological Survey (USGS) to enter data into NCRDS for the past 21 years. Drill hole data from the NMBM&MR Coal Quality Drilling project were a major source of data in the surface minable area. Less data is available for the deep coal area except where oil and gas logs are available. Other sources of drill hole data are the La Ventana mine plan, the Coal Resource Occurrence and Coal Development Potential maps (CROCDP) and US Geological Survey Bulletin 860-C (Dane, 1936). After the project began, additional data were entered into the database, in particular oil and gas logs from NMBM&MR subsurface library, to help fill in gaps.

A total of 70 data points were evaluated for the four-quadrangle study area (Wolf Stand, Arroyo Empredrado, Headcut Reservoir, and San Luis). Additionally, 68 data points from the quadrangles surrounding this area were used to calculate resources. The number of drill holes used in this study is less

than previous evaluations for two reasons. First, only the upper fourth of the San Luis and Arroyo Empredrado quadrangle are within the upper coal member cropline and the adjoining quadrangles for these two quadrangles have little or no upper coal member as well. Secondly, in previous availability investigations, areas were chosen that had large amounts of exploration data or had data from inactive or active mine plan areas. Although the surrounding area for this study does encompass an inactive mine plan, it was a relatively small area (Ideal Basic lease, see Fig. 1).

Coal availability studies in New Mexico

Detailed methodology

The upper coal member Menefee coals in the Chacra Mesa-La Ventana area are subbituminous; therefore, resource calculations are based on a minimum thickness of 2.5 ft and 1770 tons/acre ft. The following parameters, which conform to USGS Circular 891 (Wood et al., 1983), were used to calculate resources for each zone. Total coal (≥2.5 ft) within a zone instead of individual seams is the basis of resource calculations because of the lenticularity of the coals. Coals that are thinner than 2.5 ft and above or below coals meeting the thickness criteria and are separated by a parting less than the thickness of the thinner coal are included in the calculation. The following are the resource criteria used in this study:

Thickness (ft):	**Depth (ft):**	**Reliability**
2.5–5	10:1 stripping ratio	Measured (1/4 mi)
5–10	0–250	Indicated (1/4–3/4 mi)
10–20	250–500	Inferred (3/4–3 mi)
>20	500–1000	
	>1000	

Reliability categories are limited to measured, indicated and inferred. No hypothetical reliability category was used in this study because of the lenticularity of these coal beds.

Line data for the upper coal member Menefee contact was digitized from Beaumont (1998). These line data form a boundary mask between areas of upper coal and the barren Allison Member of the Menefee Formation. Data files with elevations for tops of coal zones were gridded in Arc Info® and

overlain with a Digital Elevation Model (DEM) grid from National Elevation Data Set. From this combined layer, the overburden maps for each zone were generated. This overburden layer supplied the zero depth line, or crop line, for each zone. The resulting overburden maps for the Pink, Green, Blue, and Orange zones is illustrated in Figures 14-17. The upper depth limits for the categories are highlighted on these maps.

From the original database created for the study, subset files were produced for each zone with latitude, longitude, total thickness, and point identification. These files included data from quadrangles surrounding the four-quadrangle study area. By using data from surrounding quadrangles, reliability categories that overlap into the study area were included in the resource calculations. The data files were used to produce coal thickness grids and polygon files for the reliability categories. The reliability polygons were gridded and each cell (28.213 meter^2) assigned a thickness from the thickness grid. By overlaying the overburden layer onto the reliability layers, the total area (calculated in m^2 and converted to acres) for each thickness, depth, and reliability category were determined for the four-quadrangle area. Volumes (acre-ft) were calculated using the thickness attribute of the cells, and finally multiplied by 1770 tons/acre-ft to result in original resource tonnage for each zone.

Land-use restrictions were digitized from the four 7.5 minute topographic quadrangles (Arroyo Empredrado, San Luis, Wolf Stand, Headcut Reservoir). A few mines at the crop were opened in the 1920s; in particular the Anderson-Sackett mine on the Headcut Reservoir quadrangle had 41,538 tons of production from 1929-1956. This mine area and two other small mines on this quadrangle were digitized and subtracted from the original resource of each zone. Technical restriction filters were applied to the remaining resource layers for each zone. Appropriate buffers, as discussed in the following section, were assigned to the digitized land-use restrictions. These restriction layers were consecutively overlain on the combined overburden, reliability, and thickness layers with the mined-out areas and technical restrictions to calculate the resource tonnage removed by each restriction.

Overview of restrictions

The following is a list of restrictions that were considered for this area. The buffers applied to these restrictions adhere to the New Mexico Coal Surface Mining Regulations 19 NMAC 8.2 subpart 2, which follow the Federal regulations:

Restrictions	Buffer
NM State Highway 197, runways	100 ft on either side
Pipelines, powerlines	50 ft on either side
Buildings, public or private	300 ft
Cemeteries	100 ft
Ponds, Torreon Wash	100 ft

Figure 18 illustrates these restrictions along with the upper coal member of the Menefee outcrop.

Technological restrictions

Technical parameters that influence the resources of this study are:

Coal too close to the surface. Coal with less than 20 ft of overburden is subtracted from the remaining resource estimate. Coal with less than 20 ft of overburden is removed because San Juan Basin coal within this interval is generally weathered or sometimes burned and can not be used for energy production. Most operating mines in the San Juan Basin use the greater-than-20-ft depth guideline for calculating mine reserves

Coal too thin at depth. Coal beds 2.5 ft to 5 ft thick are not considered minable at depths greater than 250 ft. The original resources are calculated for this depth category but these results are removed under the technical restrictions.

Land-use restrictions

Restrictions to mining in the project area are few, but some are significant. A secondary state road (NM State Highway 197), pipelines, and powerlines transect the area (Figs. 1, 18). All but the powerline restrictions were digitized from the 7.5-minute topographic quadrangles. Powerlines had been updated on the photorevised Wolf Stand quadrangle, but were not present on the other quadrangle maps, therefore the

county map at a 1:126,720 scale was used. The buildings, cemeteries, hydrologic features, and oil and gas wells were also digitized from the 7.5-min quadrangles. Torreon Wash cuts across the western edge of the Chacra Mesa-La Ventana study area. This is an intermittent stream, but is a major wash in the area. This stream is not considered an Alluvial Valley Floor, which is defined as supporting agriculture by the Coal Surface Mining Regulations. However, during certain times of the year, significant water flows in this wash. Although archeological sites are within the study area, they would likely be mitigated, and were not considered.

Chacra Mesa-La Ventana study area resources

Total original resources in the Chacra Mesa-La Ventana study area are 3.09 billion st. Mining removes no resources from the original value. This may be a result of the lack of data in the area where past mining occurred, but may also be a reflection of how little area was effected by previous mining. The technological restrictions, removing near surface coal (0–20 ft) and thin coal (≥2.5–5 ft) at depths greater than 250 ft removed 317 million st from the total resource, the largest depletion of remaining resources. This restriction withdraws 8.98 % from the remaining total available resource, and 88 million st from the 10:1 stripping ratio category resource. Within the >250–>1000 ft categories 13.2% of the available coal is removed by the technological restriction of too thin a coal seam.

Restrictions related to pipelines, powerlines, cemeteries, and major roads in the study area remove 23 million st from the remaining available resource. It is unlikely that NM State Highway 197 would be mitigated. There are oil and gas wells in the area, but they have little to no effect on surface or deep coal. Figure19a-d illustrates the proportion of coal removed by these restrictions for each of the zones. Figure 20, Tables 2 and 3 demonstrate how the restrictions influence the available coal resources in each zone and the available resource. Overall, these restrictions deplete the original resources in the Blue zone the most (22%) followed by the Pink zone (17%).

Restrictions with potential for mitigation

The restrictions applied to the remaining resource with potential for mitigation are buildings, and hydrology. Buildings remove 19 million st from the remaining resource. If mining were to take place these buildings, which are mostly homes would be moved and the owners compensated. The Torreon Day School is on the Wolf Stand quadrangle and may or may not have the potential for mitigation. Many of the buildings at the school are mobile units, so these could easily be moved. Seasonal, man-made ponds (i.e. Headcut Reservoir, Cornfield Tank) and the Torreon Wash remove 17 million st of coal resource from the study area. The Torreon Wash is a major wash, but does not flow except during the rainy season and is not considered an Alluvial Valley Floor, consequently mining would not be restricted in the wash area.

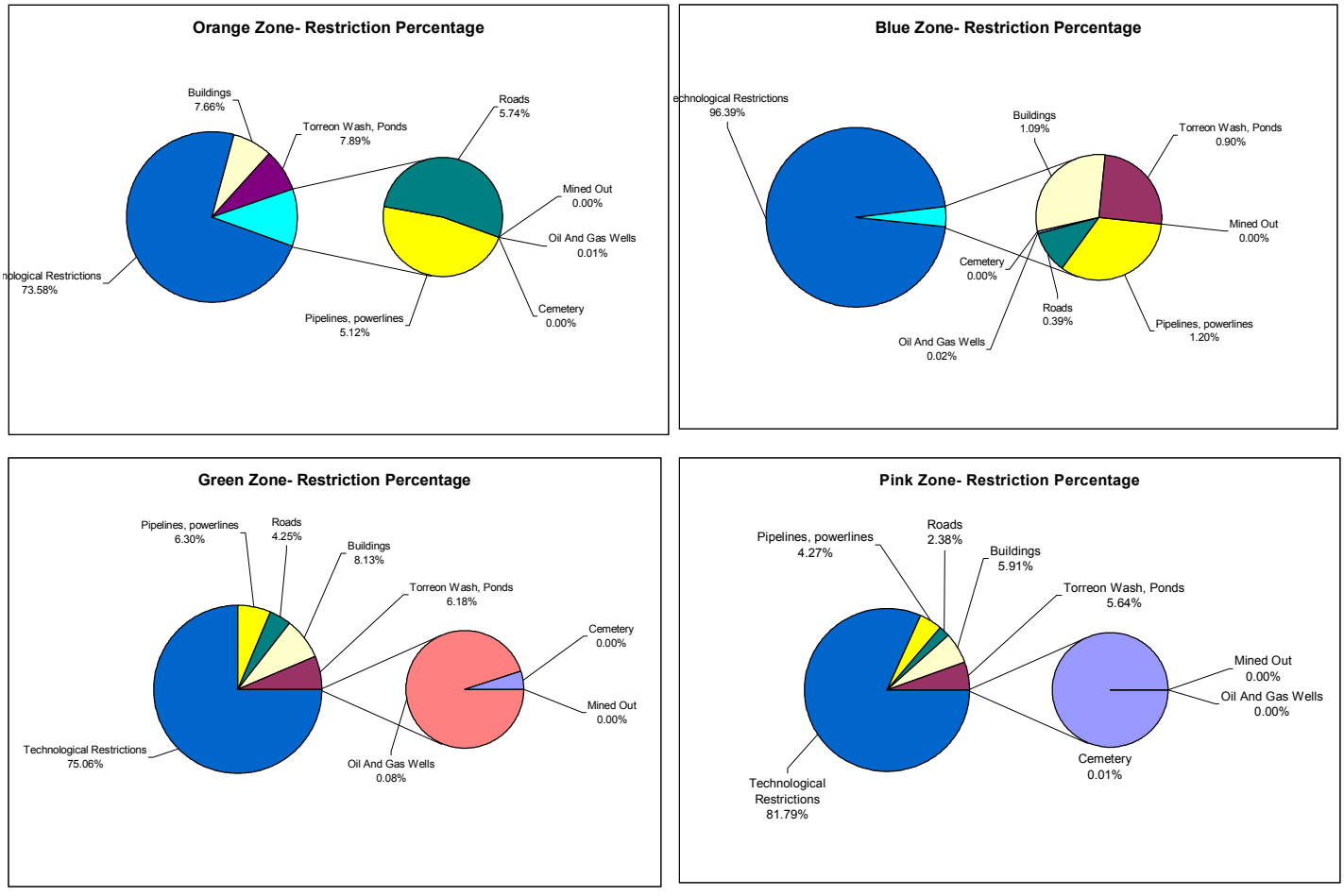


Figure 19a-d. Percentages of resources removed by technological and land use restrictions.

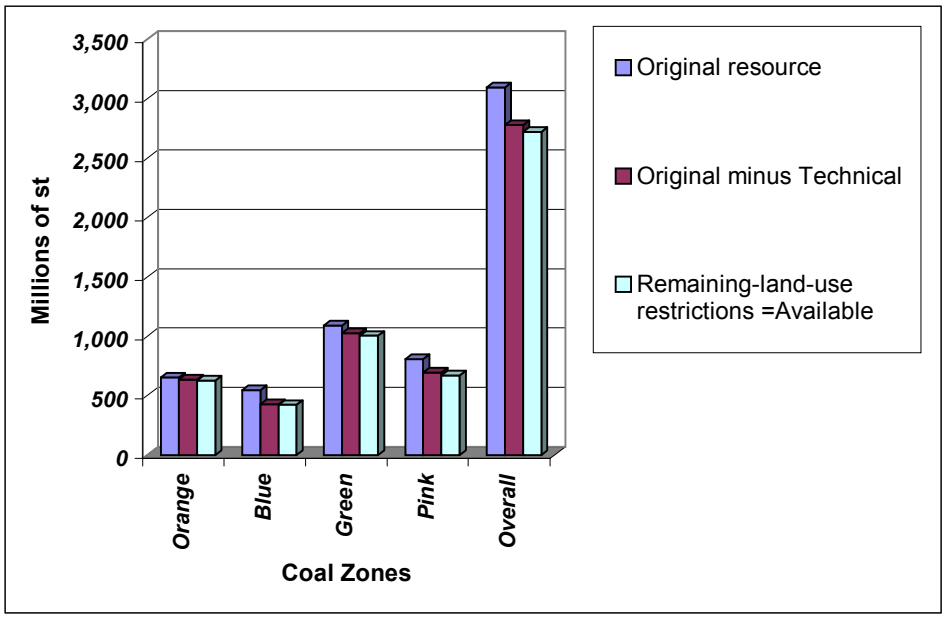


Figure 20. Chacra Mesa-La Ventana study area resources by zone.

Comparison with other resource studies

NMBM&MR Memoir 25 (Shomaker, Beaumont, and Kottlowski, 1971) did not estimate reserves for the upper coal member of Menefee Formation in the La Ventana and Chacra Mesa area, because the coals were considered uneconomic for strip mining and they lacked sufficient drill hole data to make any estimates. However, T18N, R3-4W was an area mentioned in this publication as likely to have strippable coal reserves. Shomaker and Whyte (1977) evaluated deep coals in the San Juan Basin in the Fruitland Formation and the upper coal member of the Menefee. They referred to the upper coal member as the Hogback Mountain tongue of the Menefee, a landward unit laterally equivalent, and intertonguing with the La Ventana Tongue of Cliff House Sandstone. Only one township that Shomaker and Whyte (1977) estimated resources for is within the study area. Their estimate for T19N, R4W from 0 to >2000 ft depths was 187 million st. Tabet and Frost (1979) did geologic mapping and drilling in the Torreon Wash area and used additional drilling data to calculate resources on for measured and indicated resources. Their published shallow indicated resources for upper coal member Menefee coals in T18N R3W are 28.75 million st and for T18N R4W are 6 million st, a total of 34.76 million st.

The DOE Demonstrated Reserve Base study (Hoffman, 1996b) estimates for the Chacra Mesa and La Ventana fields are impossible to compare to this study because the Cleary Coal and upper coal members were combined for the resource calculations. Hoffman (1996a) estimated 56 million st of near surface (0-200 ft) demonstrated coal resources in the upper coal member, La Ventana area, about 4.5% the estimated value of this study's estimated available surface resource (1.235 billion st). In the 1996 study, the inferred category was not used. If the inferred is subtracted from the present study, the available demonstrated resource would 301 million st. The depth values for the surface resources are different from this study which used 250 ft as a maximum depth. A different area is covered by the study area, which includes two townships in the Chacra Mesa field that have upper coal member near the surface and does not include the eastern edge of the La Ventana field. New point source data, particularly in the deeper coal areas, was added during this study increasing the accuracy of the resource estimate and filled in areas of no data. Although more data was added for this study, this area is sparsely covered by the data and the available resource figures from the present study are probably conservative.

Summary

The upper coal member of the Menefee Formation in the Chacra Mesa-La Ventana study area contains medium-ash, medium-sulfur, Subbituminous B to A-rank coals. This resource does not meet compliance coal standards of less than 0.6 lbs sulfur/MMBtu. Within the upper coal member, four coal zones were recognized and evaluated for original and available resources in the study area. These zones, Pink, Green, Blue, and Orange contain relatively thin, variable coal seams with average seam thickness of 2.38-3.14 ft with an average of two seams within the zones except for the Green, which averages three seams.

Using Arc Info® facilitates calculating resources for areas with many restrictions and allows for faster recalculation of resources with new data. Original resources for this study area are 3.09 billion st and are greater than previous studies because the inferred category and depths greater than 1000 ft are included. Another factor influencing the resource total is the acquisition of oil and gas data during the

study. Technical restrictions removed about 317 million st from the original resource, which is the largest restriction on the resource. The available resource is 2.72 billion st for this study area. A percentage breakdown by zone of this total is 25% in the Pink, 37% in the Green, 15% in the Blue, and 23% in the Orange. Of this available resource, 0.42 billion st is within the 10:1 stripping ratio category (Table 1). The Orange zone contains 36% (0.15 billion st) and the Green zone contains 32% (0.13 billion st) of the surface-minable resource. Overall, the underground available resources are slightly greater (1.49 billion st) than the surface minable available resources (1.23 billion st).

Acknowledgements

Leo Gabaldon of the NMBM&MR cartographic section designed all of the figures in this report except for Figures 4, 13, 19 and 20.

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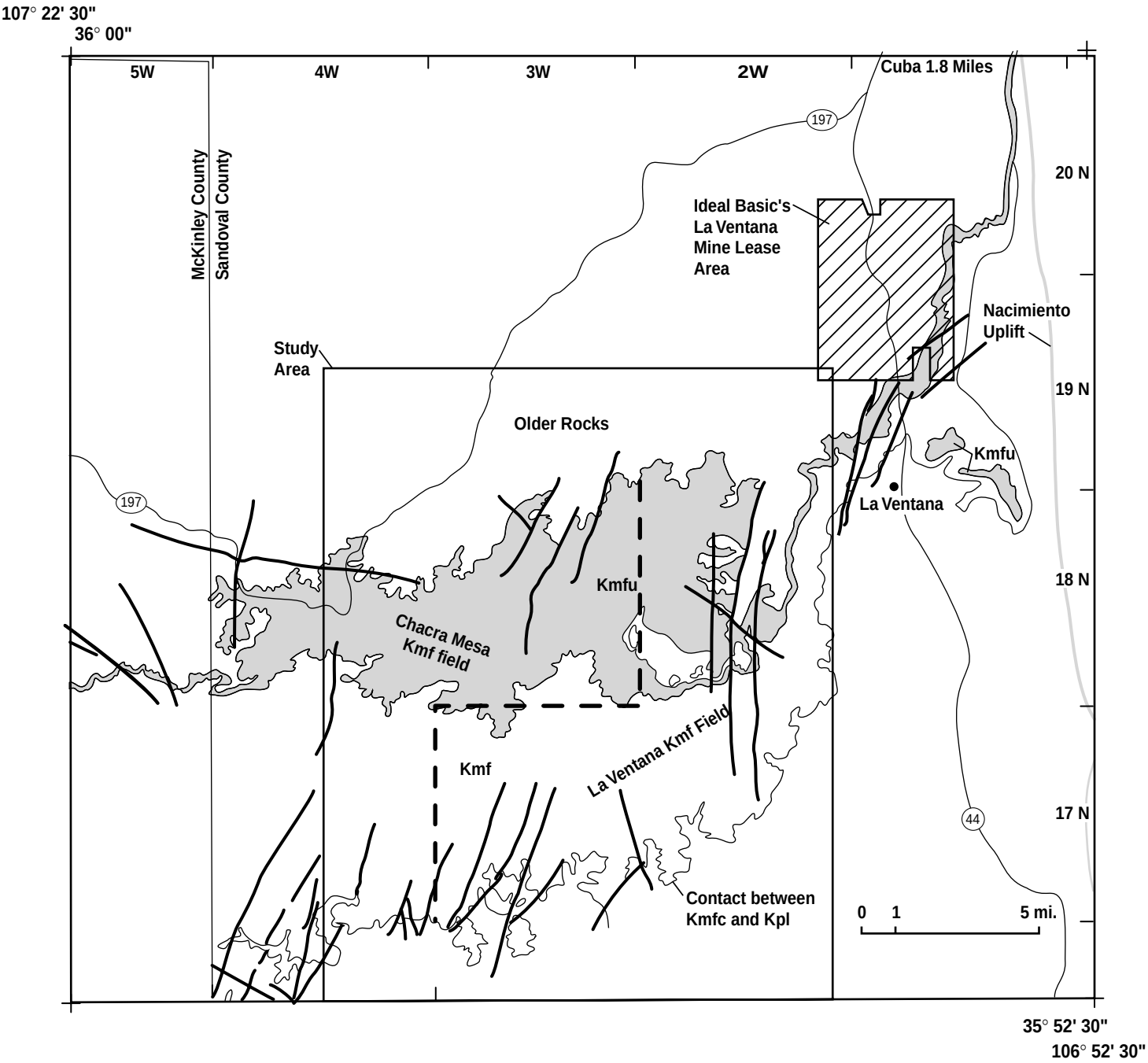

Figure 1. Map of Chacra Mesa-La Ventana fields and study area.
Crop lines from Beaumont 1998. Shaded area represents upper coal member, Menefee Formation (Kmfu) from crop line to over burden depth of 200 ft. Kmf = Menefee Formation, Kmfc = Cleary Coal Member, Menefee Formation, Kpl = Point Lookout Sandstone.

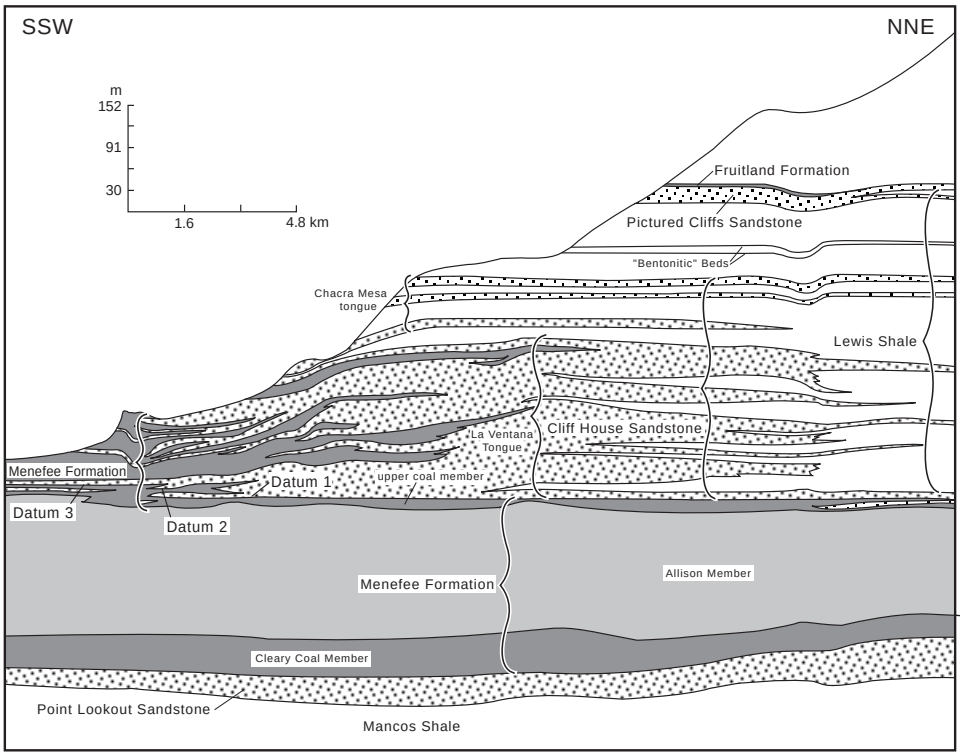

Figure 2 Generalized cross section of Torreon-La Ventana area. From Beaumont and Hoffman (1992) reproduced with permission from New Mexico Geological Society.

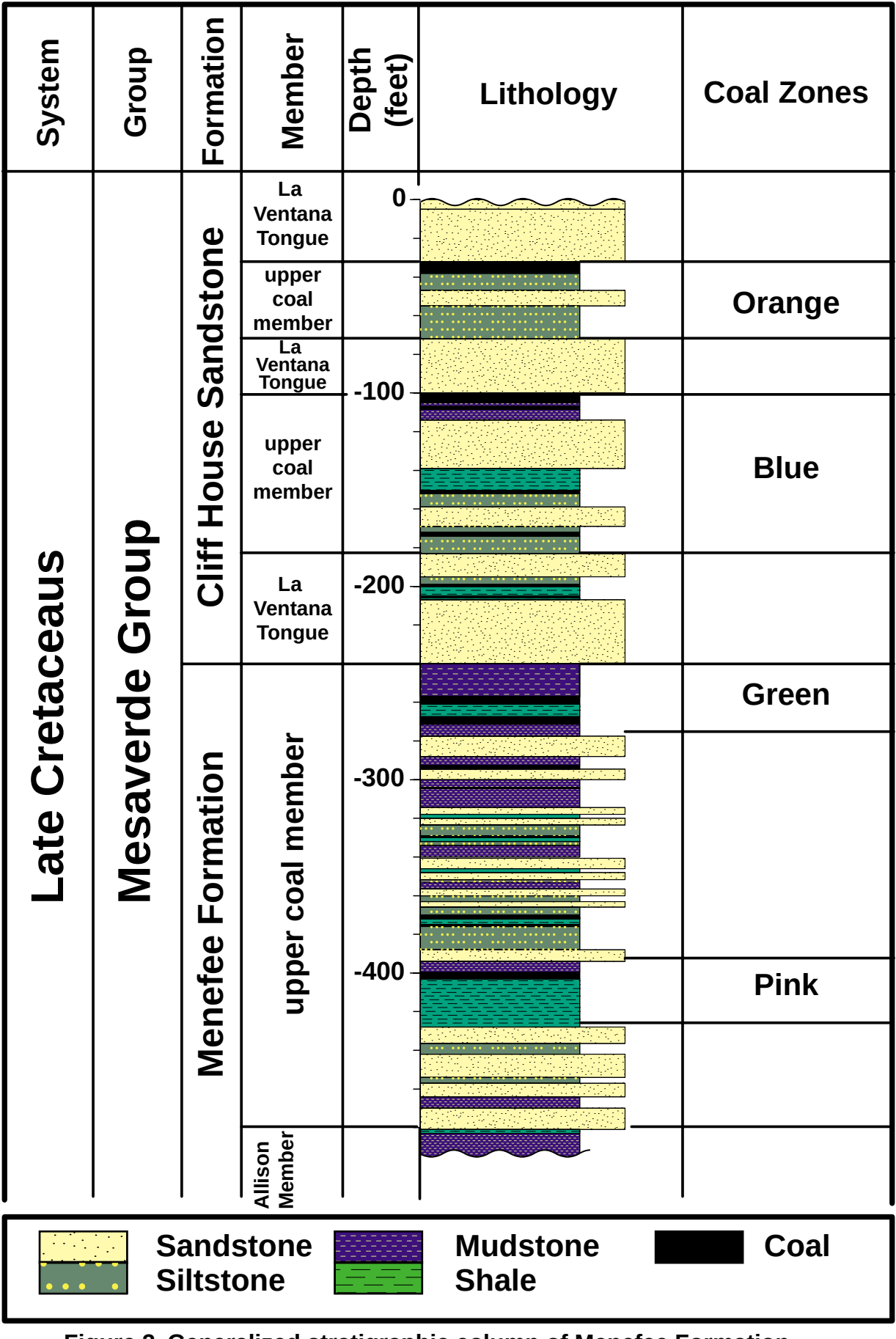

Figure 3. Generalized stratigraphic column of Menefee Formation, upper coal member with intertonguing La Ventana Tongue of the Cliff House Sandstone with Chacra Mesa- La Ventana Study area.

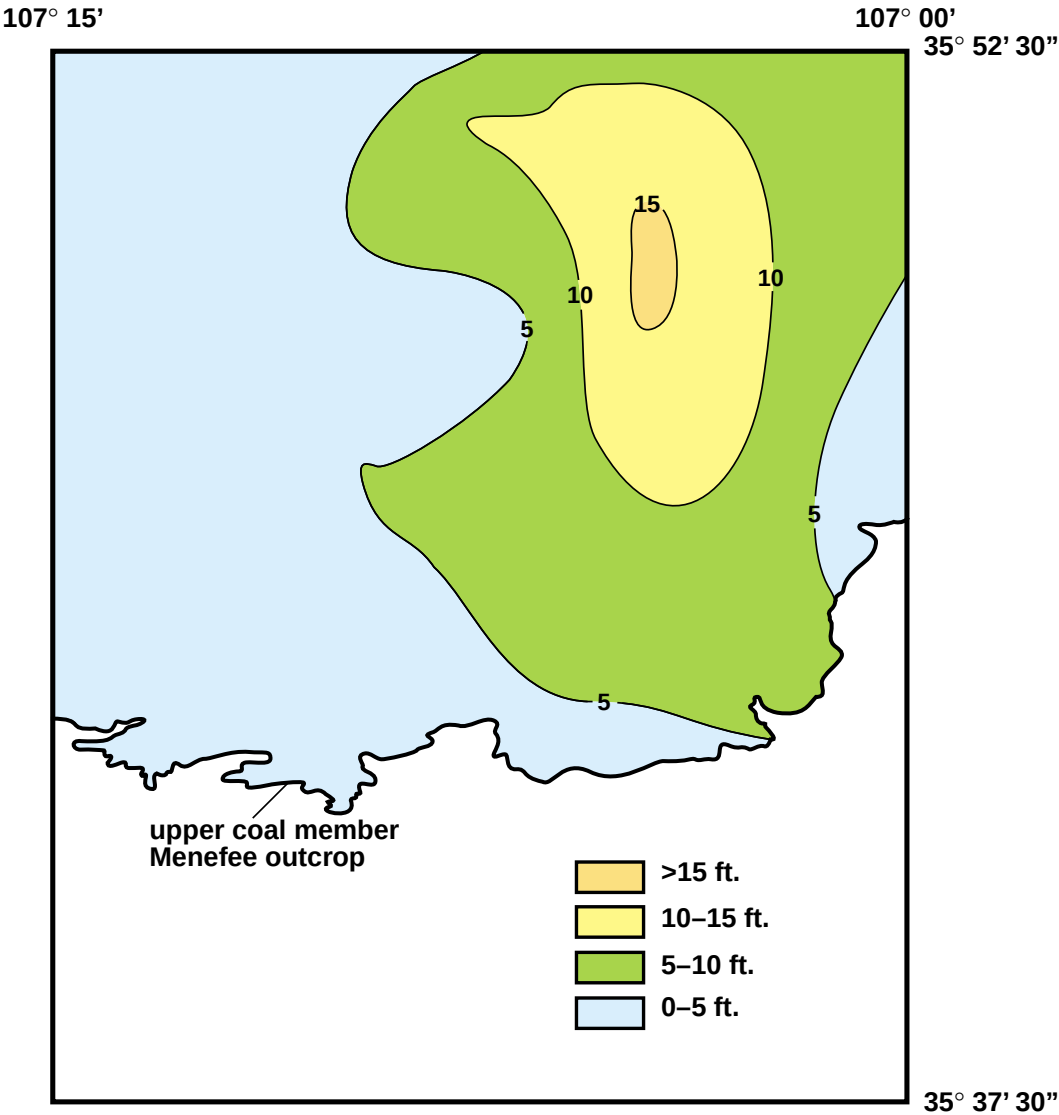

Figure 5. Orange zone isopach of total coal in Chacra Mesa - La Ventana Study area, Northwest New Mexico. Scale = 1: 200,000. Upper coal member Menefee outcrop from Beaumont, 1998.

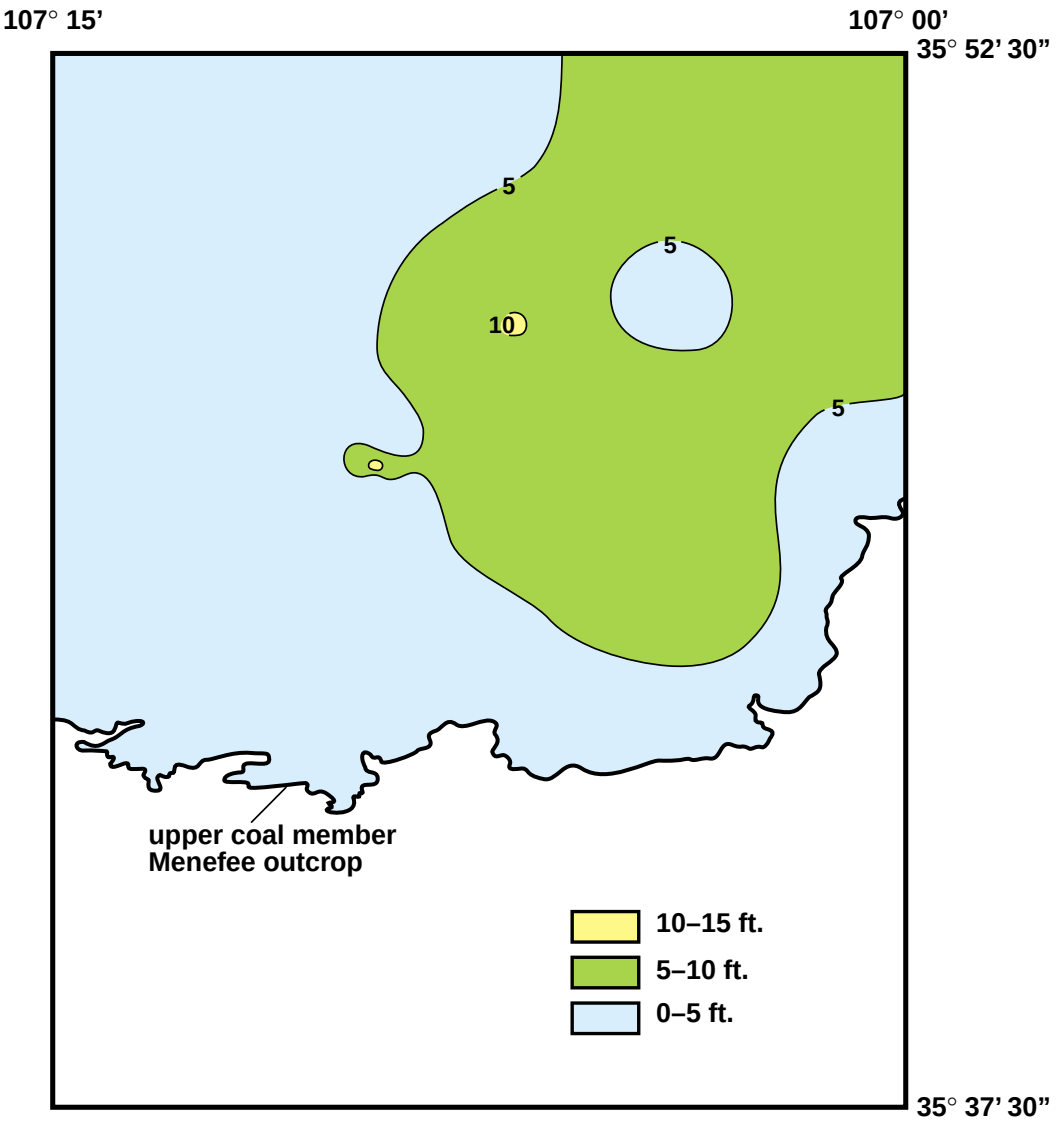

Figure 6. Blue zone isopach of total coal in Chacra Mesa - La Ventana Study area, Northwest New Mexico. Scale = 1: 200,000. Upper coal member Menefee outcrop from Beaumont, 1998.

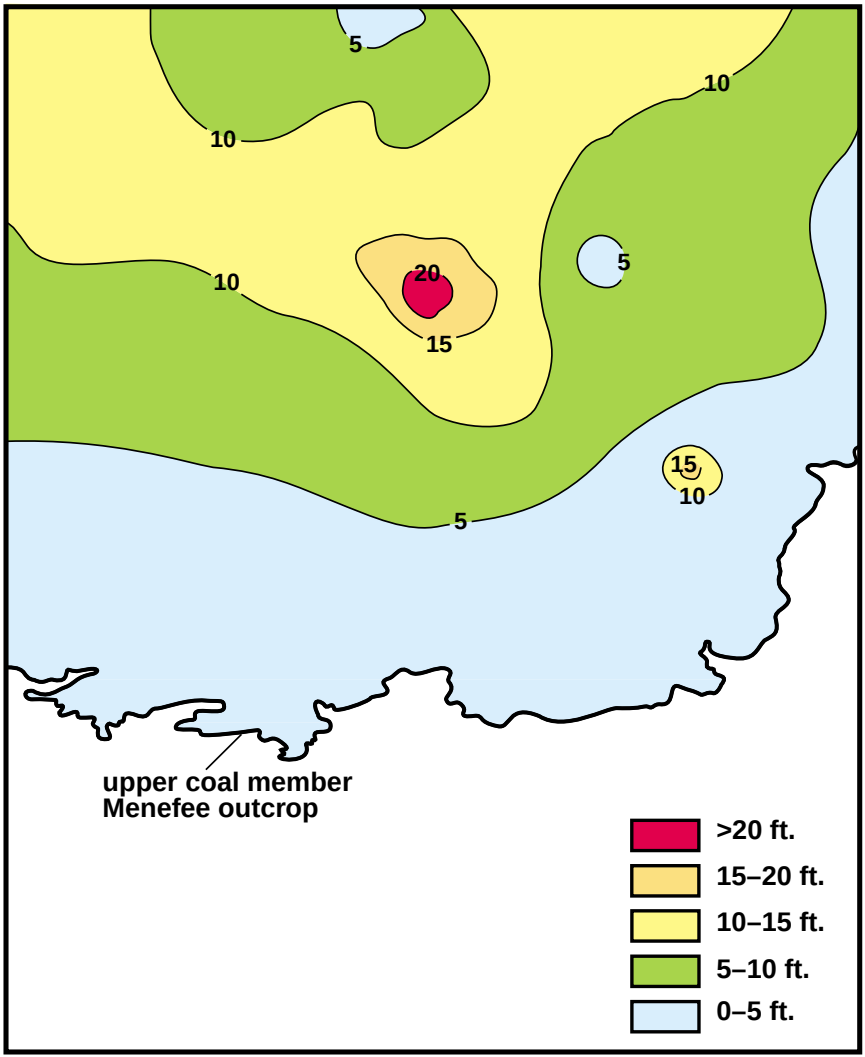

Figure 7. Green zone isopach of total coal in Chacra Mesa - La Ventana Study area, Northwest New Mexico. Scale = 1: 200,000. Upper coal member Menefee outcrop from Beaumont, 1998.

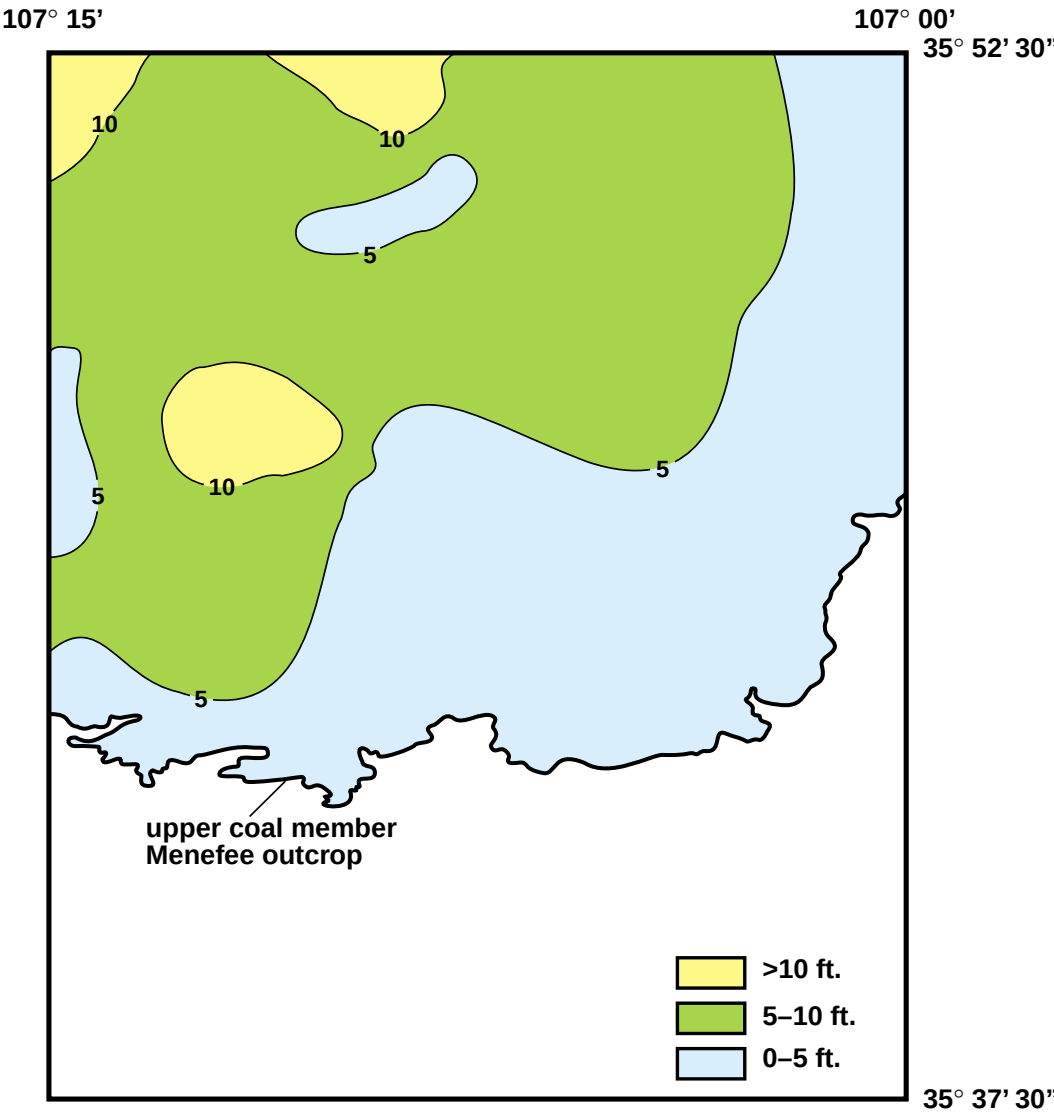

Figure 8. Pink zone isopach of total coal in Chacra Mesa - La Ventana Study area, Northwest New Mexico. Scale = 1: 200,000. Upper coal member Menefee outcrop from Beaumont, 1998.

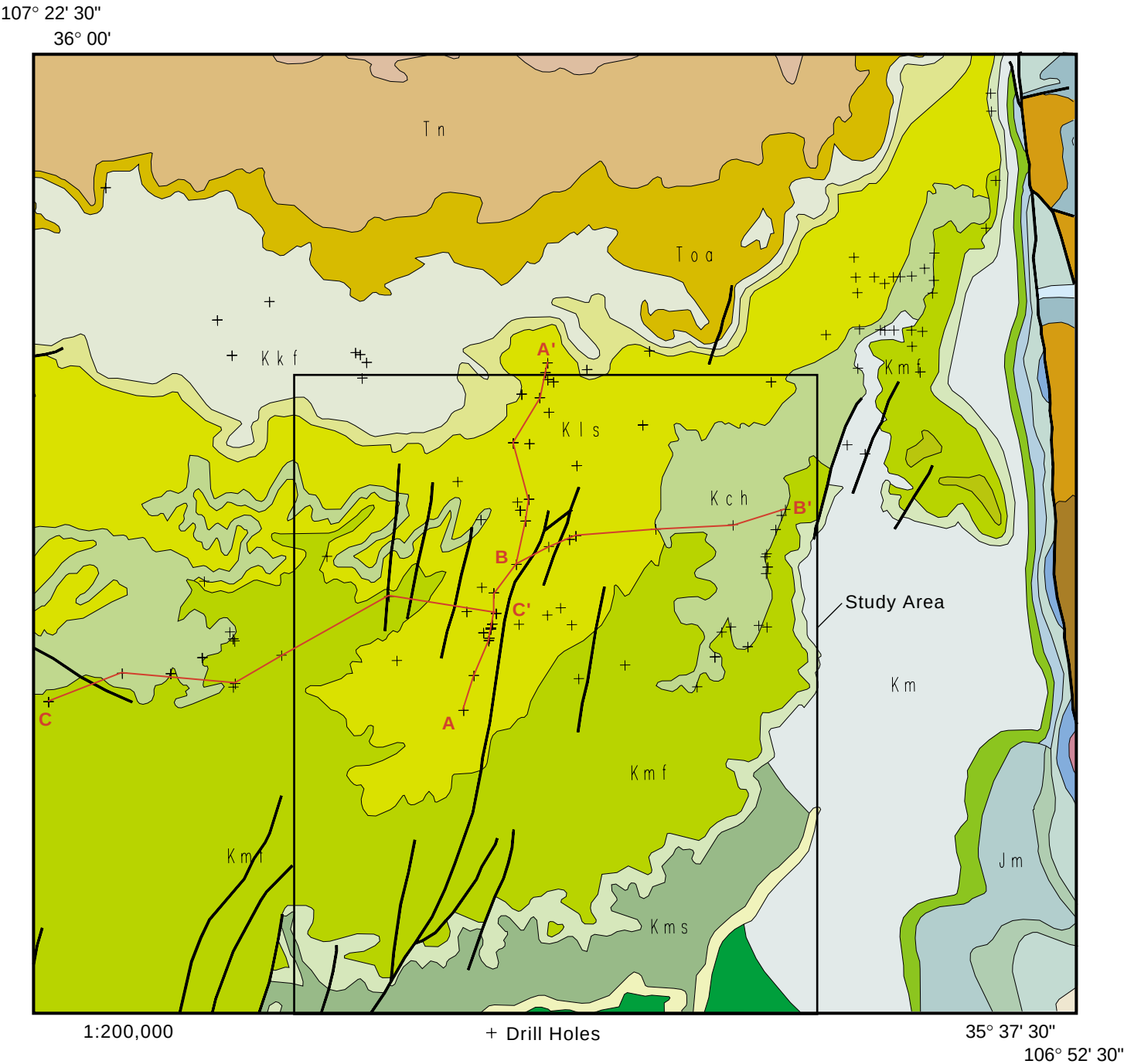

Figure 9. Geologic map of Chacra Mesa - La Ventana study area with cross section locations.
Geology is from Anderson, Jones, and Green, 1997.
Note upper coal member cropline used in study for Arc Info files is not on this map.
Kmf= Menefee Formation, Kch= Cliff House Sandstone, Kls= Lewis Shale.

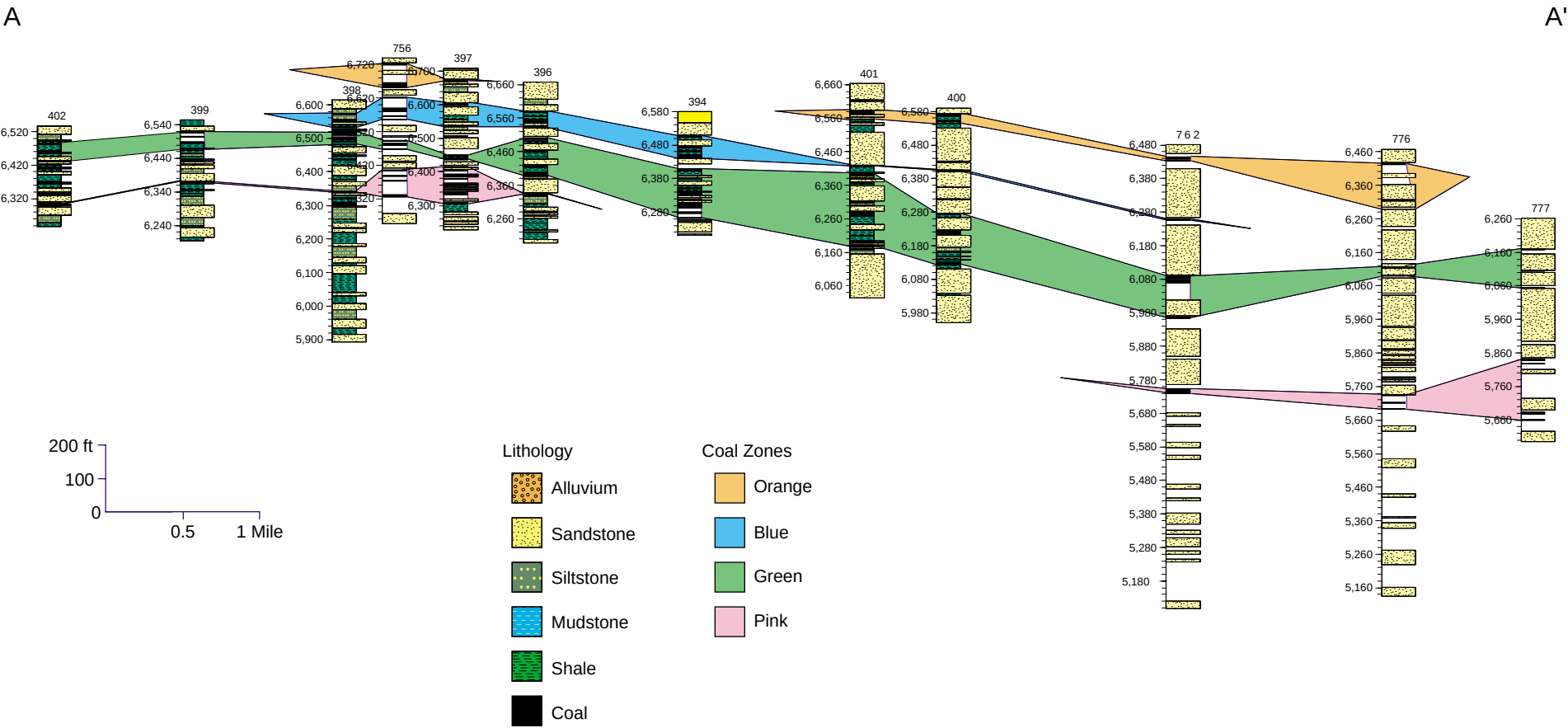

Figure 10. Cross section along strike in Chacra Mesa-La Ventana study area, See Figure 9 for location.

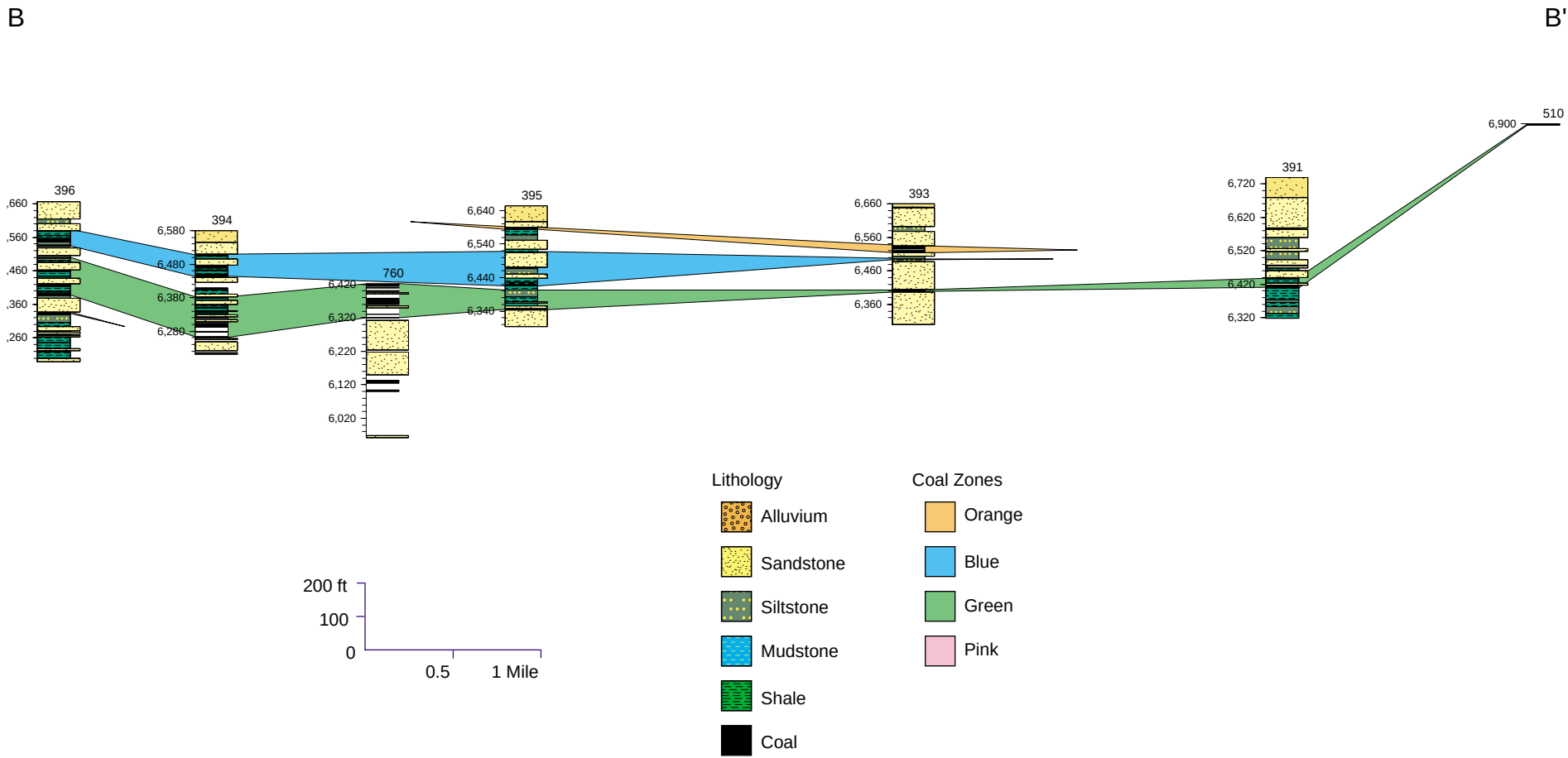

Figure 11. Cross section in eastern Chacra Mesa-La Ventana study area, See Figure 9 for location.

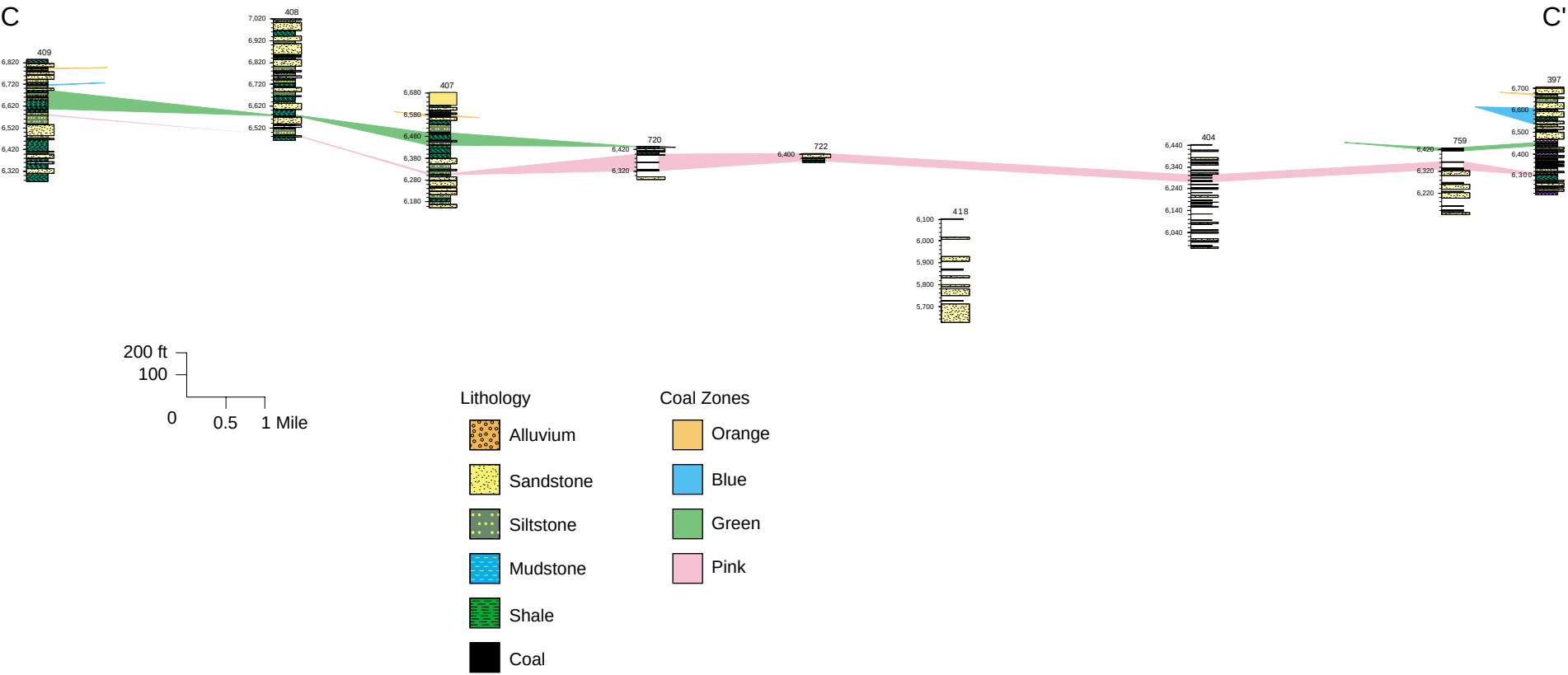

Figure 12. Cross section in western Chacra Mesa-La Ventana study area, See Figure 9 for location.

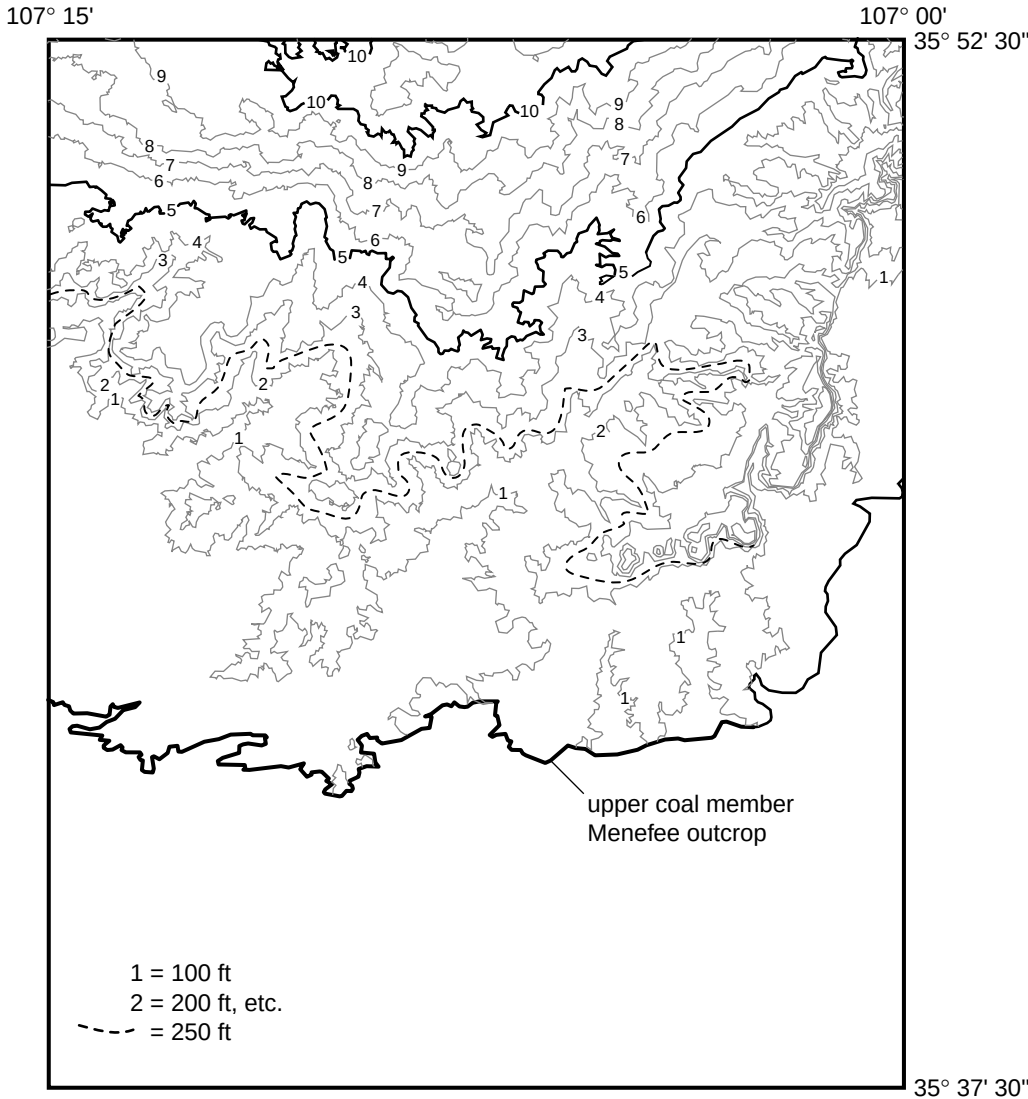

Figure 14. Overburden on top of Pink coal zone, Chacra Mesa-La Ventana Study area, Northwest New Mexico. Upper coal member Menefee outcrop from Beamont, 1998. Contour interval 100 ft. Scale 1: 200,000.

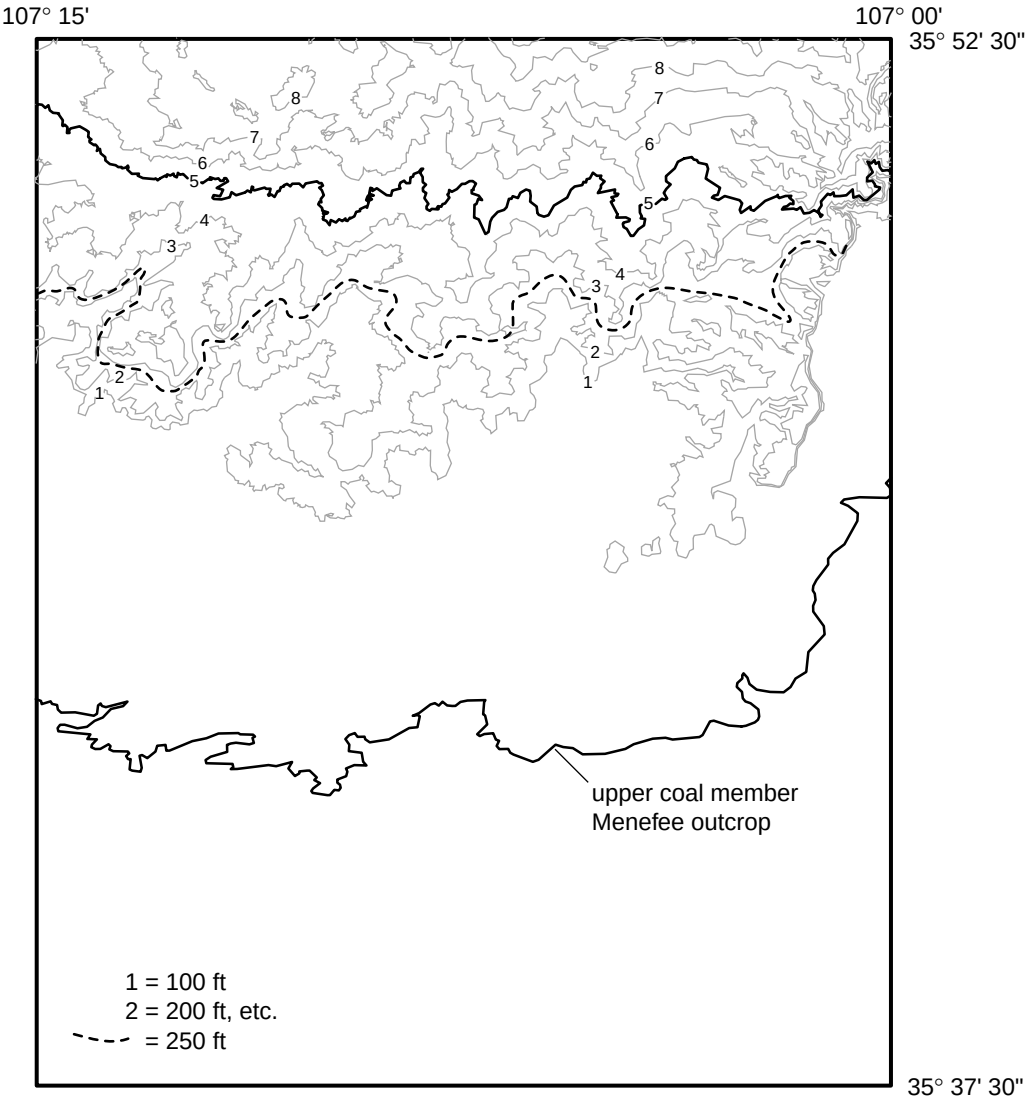

Figure 15. Overburden on top of Green coal zone, Chacra Mesa-La Ventana Study area, Northwest New Mexico. Upper coal member Menefee outcrop from Beamont, 1998. Contour interval 100 ft. Scale 1: 200,000.

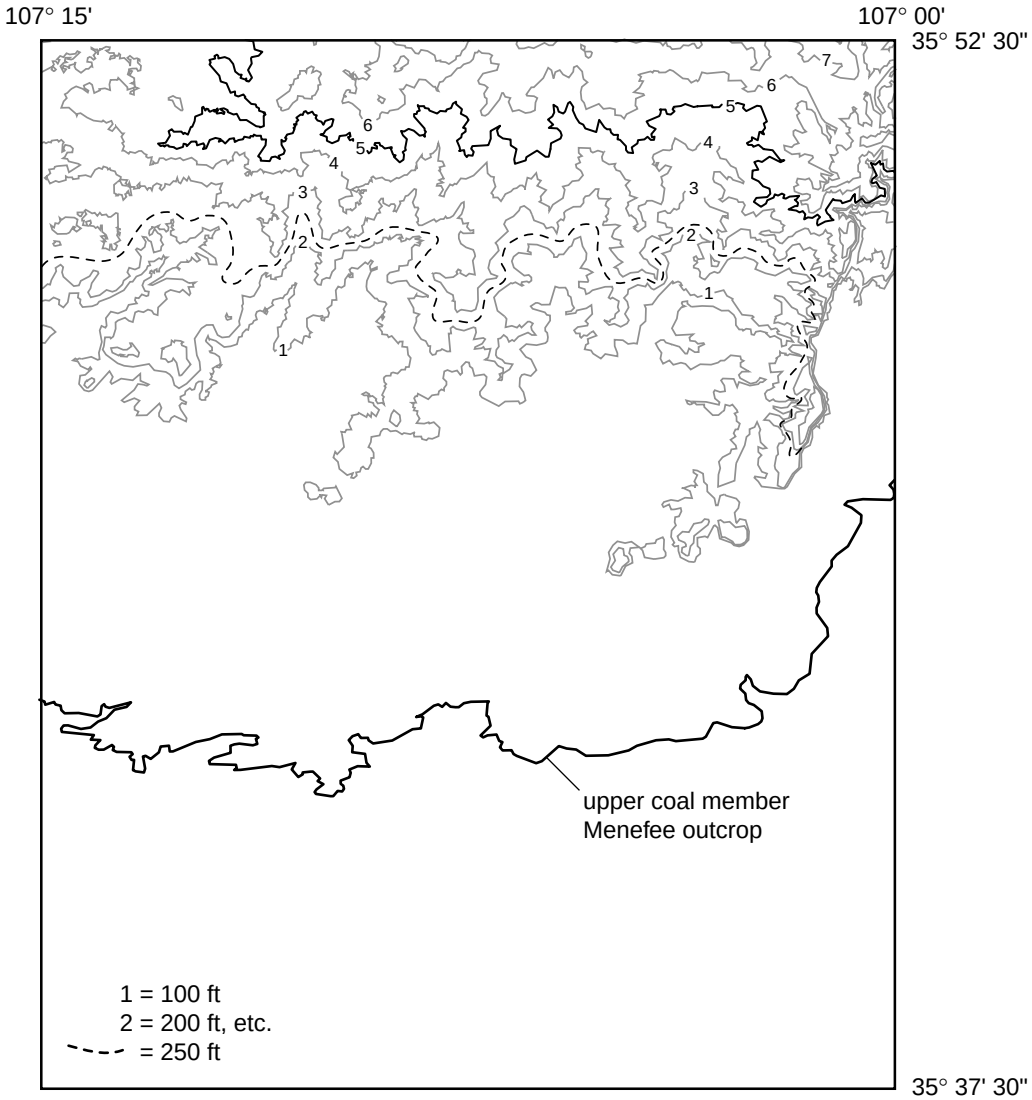

Figure 16. Overburden on top of Blue coal zone, Chacra Mesa-La Ventana Study area, Northwest New Mexico. Upper coal member Menefee outcrop from Beamont, 1998. Contour interval 100 ft. Scale 1: 200,000.

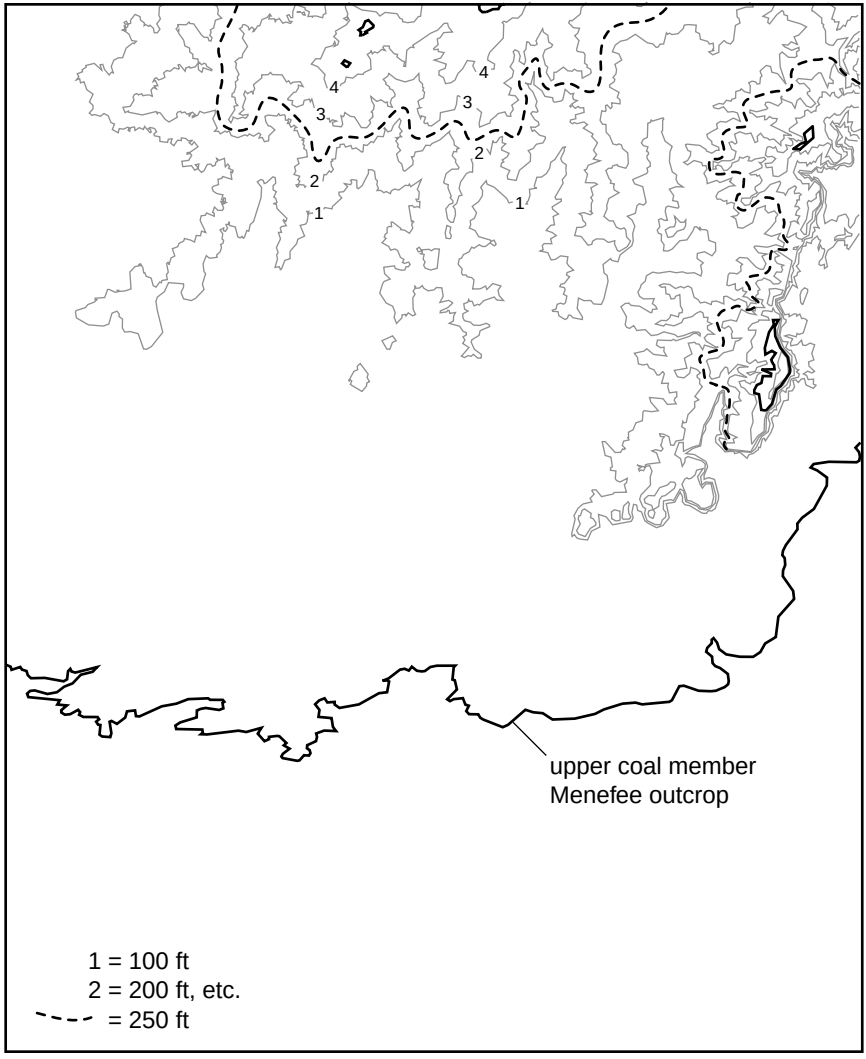

Figure 17. Overburden on top of Orange coal zone, Chacra Mesa-La Ventana Study area, Northwest New Mexico. Upper coal member Menefee outcrop from Beamont, 1998. Contour interval 100 ft. Scale 1: 200,000.

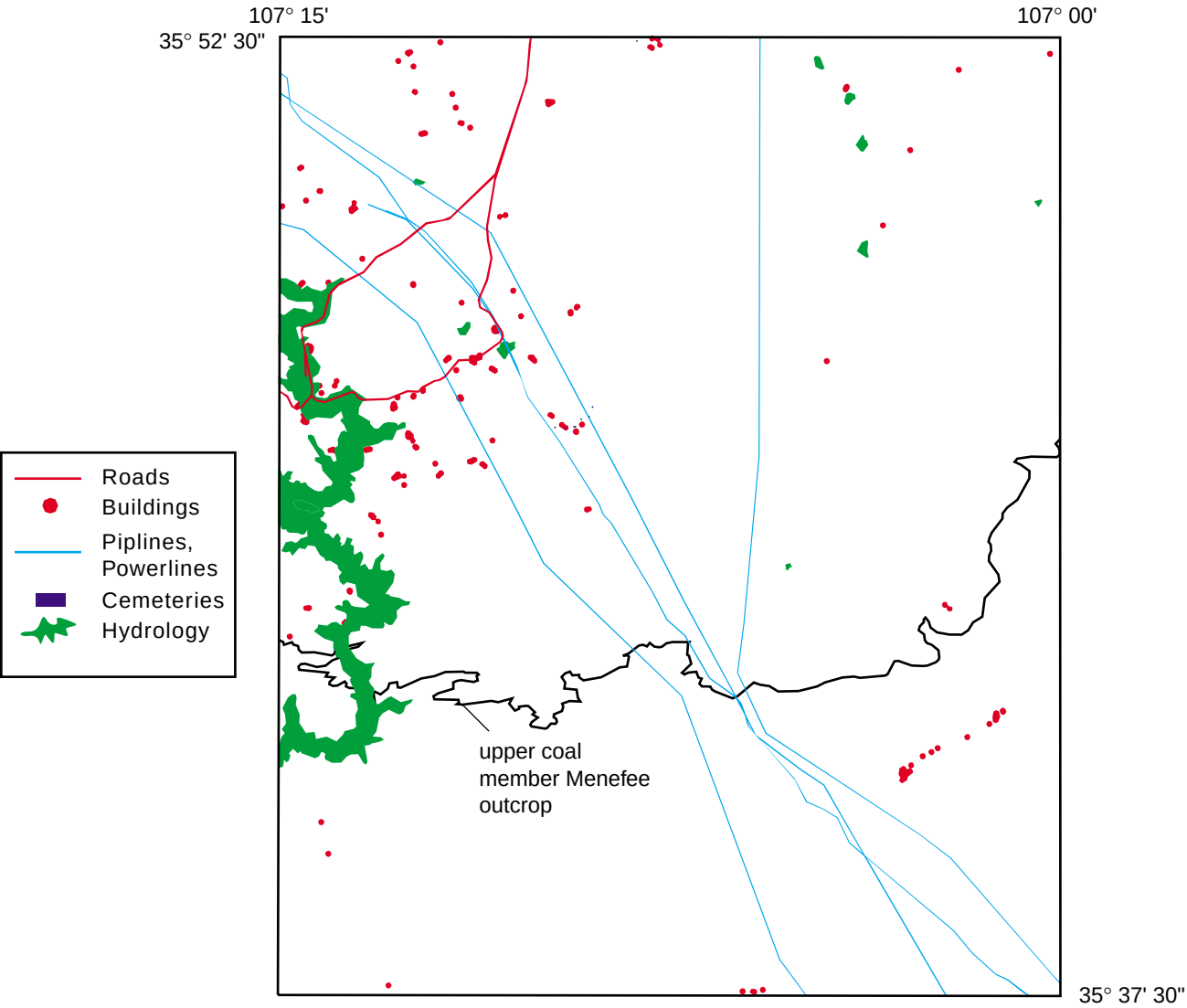

Figure 18. Land-use restrictions in Chacra Mesa - La Ventana Study area, Scale 1: 200,000. Cropline from Beaumont,1998.

Table 1 . Weighted averages for the upper coal member in the La Ventana and Chacra Mesa fields and the individual zones within the Chacra Mesa-La Ventana study area. Number in parentheses is the number of weighted averages for each zone.

	La Ventana Field			Chacra Mesa Field			Average for Zones this study			
	Average	Std Dev.	No. of Samples	Average	Std Dev.	No. of Samples	Orange (7)	Blue (13)	Green (41)	Pink (4)
Moisture(%)	16.40	2.54	20	15.29	3.05	14	17.19	16.24	16.11	14.66
Ash(%) 11.06	8.14	4.34	20	9.69	3.29	14	8.05	10.65	9.27	6.66
Volatile matter(%)	34.81	2.68	20	35.24	2.57	14	38.85	35.37	34.37	37.35
Fixed carbon(%)	40.63	3.09	20	39.73	2.38	14	35.68	37.55	40.13	41.15
Sulfur(%)	1.36	0.55	20	0.72	0.41	14	1.31	1.50	1.13	0.84
Calorific value (Btu/lb)	10171	696	20	10207	615	14	10500	9840	10159	10650
Lbs of Sulfur/MBtu	1.35	0.49	21	0.72	0.43	14	1.47	1.55	1.12	0.78

Table 2. Summary of surface and underground coal resources and available coal by zone for the upper Menefee-La Ventana-Chacra Mesa area, reported in millions of st.

Depth Categories	Coal Zone	Original Resources	Likely Restrictions to mining								Restrictions that might be mitigated			
			Technological Restrictions	Mined Out	Pipelines, powerlines	Roads	Oil And Gas Wells	Cemetery	Total Restrictions	Available	%Available	Buildings	Torreon Wash, Ponds	Total Land use restrictions
10:1 Stripping ratio	Orange	172	19	0	0	0	0	0	21	151	88%	0	1	2
	Blue	129	36	0	0	0	0	0	37	92	72%	0	0	0
	Green	157	21	0	0	1	0	0	25	132	84%	1	2	4
	Pink	55	12	0	0	1	0	0	18	38	68%	2	3	6
	Overall	*513*	*88*	*0*	*0*	*2*	*0*	*0*	*100*	*414*	*81%*	*4*	*7*	*12*
Surface (0-250 ft)	Orange	460	19	0	1	1	0	0	25	435	95%	1	2	6
	Blue	306	36	0	1	0	0	0	39	266	87%	1	0	3
	Green	326	21	0	2	1	0	0	31	295	90%	3	4	10
	Pink	268	11	0	3	2	0	0	30	238	89%	6	7	18
	Overall	*1,360*	*88*	*0*	*7*	*5*	*0*	*0*	*125*	*1,235*	*91%*	*11*	*14*	*37*
Underground (>250 ft->1000 ft)	Orange	193	1	0	0	1	0	0	2	190	99%	1	0	2
	Blue	239	82	0	0	0	0	0	83	156	65%	1	1	1
	Green	764	44	0	3	2	0	0	55	709	93%	4	1	11
	Pink	541	102	0	3	1	0	0	110	431	80%	2	0	7
	Overall	*1,736*	*229*	*0*	*7*	*4*	*0*	*0*	*250*	*1,486*	*86%*	*8*	*3*	*21*

Table 3. Summary of coal resources and available coal by zone for the upper Menefee - La Ventana-Chacra Mesa area, reported in millions of st.

Coal Zone	Original Resources	Likely Restrictions to mining								Restrictions that might be mitigated			
		Technological Restrictions	Mined Out	Pipelines, powerlines	Roads	Oil And Gas Wells	Cemetery	Total Restrictions	Available	%Available	Buildings	Torreon Wash, Ponds	Total Land use restrictions
Orange	652	20	0	1	2	0	0	27	625	96%	2	2	7
Blue	544	118	0	1	0	0	0	122	422	78%	1	1	4
Green	1,090	65	0	5	4	0	0	87	1,004	92%	7	5	22
Pink	809	114	0	6	3	0	0	139	670	83%	8	8	25
Overall	*3,096*	*317*	*0*	*14*	*9*	*0*	*0*	*375*	*2,721*	*88%*	*19*	*16*	*59*

WellNumber	Quadrangle	Township	Range	Section	Elevation	Source	Depth	CoalThickness
18N2W3	HEADCUT RESERVOIR	18N	2W	3	6738.50	NMBM COAL QUALITY PROJECT		

Location: NWSWSW

ID: 391 **Pet. Id** **USTRAT:** S109 **Latitude:** 354857 **Longitude:** 1070222

6438.50	Green	300.00	2.00
6417.50	Green	321.00	7.50

DepthtoContact: **Total Coal** 9.50

WellNumber	Quadrangle	Township	Range	Section	Elevation	Source	Depth	CoalThickness
18N2W5	HEADCUT RESERVOIR	18N	2W	5	6661.00	NMBM COAL QUALITY PROJECT		

Location: SWSWSW

ID: 393 **Pet. Id** **USTRAT:** S110 **Latitude:** 354851 **Longitude:** 1070435

6535.50	Orange	125.50	2.50
6532.00	Orange	129.00	5.80
6520.20	Orange	140.80	6.70
6496.00	Blue	165.00	3.50
6402.00	Green	259.00	4.00

DepthtoContact: **Total Coal** 22.50

WellNumber	Quadrangle	Township	Range	Section	Elevation	Source	Depth	CoalThickness
18N3W10	WOLF STAND	18N	3W	10	6580.00	NMBM COAL QUALITY PROJECT		

Location: NWSESW

ID: 394 **Pet. Id** **USTRAT:** S120 **Latitude:** 354802 **Longitude:** 1070836

6507.00	Blue	73.00	4.75
6445.00	Blue	135.00	2.50
6380.50	Green	199.50	2.50
6342.20	Green	237.80	3.35
6303.20	Green	276.80	5.75
6279.05	Green	300.95	2.35
6273.00	Green	307.00	0.80
6270.00	Green	310.00	1.00
6263.00	Green	317.00	1.00

DepthtoContact: **Total Coal** 24.00

WellNumber	Quadrangle	Township	Range	Section	Elevation	Source	Depth	CoalThickness
18N3W11	HEADCUT RESERVOIR	18N	3W	11	6654.00	NMBM COAL QUALITY PROJECT		

Location: NENENE

ID: 395 **Pet. Id** **USTRAT:** S119 **Latitude:** 354842 **Longitude:** 1070653

6590.50	Orange	63.50	2.00
6585.50	Orange	68.50	2.00
6517.50	Blue	136.50	3.00
6471.50	Blue	182.50	2.00
6469.00	Blue	185.00	1.50
6420.00	Blue	234.00	4.00
6403.00	Green	251.00	1.00
6347.00	Green	307.00	0.80
6344.00	Green	310.00	1.00

DepthtoContact: 315.00 **Total Coal** 17.30

WellNumber	Quadrangle	Township	Range	Section	Elevation	Source	Depth	CoalThickness
18N3W16	WOLF STAND	18N	3W	16	6668.00	NMBM COAL QUALITY PROJECT		

Location: SWNESE

ID: 396 **Pet. Id** **USTRAT:** S147 **Latitude:** 354722 **Longitude:** 1070915

6580.50	Blue	87.50	2.00
6553.80	Blue	114.20	3.00
6534.00	Blue	134.00	1.00
6499.00	Green	169.00	1.00
6417.30	Green	250.70	2.60
6398.45	Green	269.55	2.15
6392.20	Green	275.80	4.50
6334.00	Pink	334.00	2.00
6221.90	P1	446.10	3.50

DepthtoContact: **Total Coal** 21.75

WellNumber	Quadrangle	Township	Range	Section	Elevation	Source	Depth	CoalThickness
41-20	WOLF STAND	18N	3W	20	6572.00	CHAMPLIN PETROLEUM CORP		

Location: SWNENENE

ID: 759 Pet. Id **USTRAT:** S176 **Latitude:** 354656 **Longitude:** 1071002

6428.00	Green	144.00	2.00
6420.00	Green	152.00	1.00
6415.00	Green	157.00	2.00
6379.00	Pink	193.00	2.00
6363.50	Pink	208.50	3.50
6336.00	Pink	236.00	4.00
6330.50	Pink	241.50	3.50
6268.00	P1	304.00	3.50
6228.00	P1	344.00	2.00
6162.00	P2	410.00	3.00
6132.00	P2	440.00	2.50

DepthtoContact: 434.00 **Total Coal** 29.00

18N3W21	WOLF STAND	18N	3W	21	6708.00	NMBM COAL QUALITY PROJECT		

Location: NWSESW

ID: 397 Pet. Id **USTRAT:** S121 **Latitude:** 354653 **Longitude:** 1070911

6675.45	Orange	32.55	3.60
6607.50	Blue	100.50	3.15
6602.40	Blue	105.60	1.50
6557.00	Blue	151.00	1.00
6536.00	Blue	172.00	1.40
6451.00	Green	257.00	3.80
6441.00	Green	267.00	5.10
6308.50	Pink	399.50	3.50

DepthtoContact: **Total Coal** 23.05

18N3W21-88	WOLF STAND	18N	3W	21	6615.00	NMBM COAL QUALITY PROJECT		

Location: SWSWSE

ID: 398 Pet. Id **USTRAT:** S145 **Latitude:** 354615 **Longitude:** 1070924

6557.00	Blue	58.00	1.80
6533.15	Blue	81.85	1.65
6517.40	Green	97.60	1.25
6514.00	Green	101.00	3.85
6504.40	Green	110.60	1.50
6500.10	Green	114.90	1.80
6483.00	Green	132.00	1.70
6342.30	Pink	272.70	1.90

DepthtoContact: **Total Coal** 15.45

TORREON #4	WOLF STAND	18N	3W	21	6776.00	NOEL REYNOLDS		

Location: NWNWNWSE

ID: 756 Pet. Id **USTRAT:** S173 **Latitude:** 354633 **Longitude:** 1070921

6723.60	Orange	52.40	5.30
6665.00	Orange	111.00	10.50
6652.10	Orange	123.90	1.90
6622.40	Blue	153.60	2.70
6588.80	Blue	187.20	1.80
6582.80	Blue	193.20	3.80
6558.00	Blue	218.00	2.50
6494.30	Green	281.70	3.30
6484.00	Green	292.00	5.00
6468.00	Green	308.00	2.00
6406.00	Pink	370.00	2.00
6388.50	Pink	387.50	2.50
6375.00	Pink	401.00	3.00

WellNumber	Quadrangle	Township	Range	Section	Elevation	Source	Depth	CoalThickness
					6331.00	Pink	445.00	5.00
	DepthtoContact:		450.00			Total Coal		51.30
18N3W28	WOLF STAND	18N	3W	28	6554.00	NMBM COAL QUALITY PROJECT		
		Location:	NWSWSW					

ID: 399 Pet. Id **USTRAT:** S144 **Latitude:** 354526 **Longitude:** 1070950

6518.00	Green	36.00	1.00
6505.50	Green	48.50	1.50
6489.00	Green	65.00	1.00
6468.00	Green	86.00	1.50
6374.00	Pink	180.00	2.00

DepthtoContact: Total Coal 7.00

18N3W3_1 | WOLF STAND | 18N | 3W | 3 | 6590.00 | NMBM COAL QUALITY PROJECT
Location: NWNWNE

ID: 400 Pet. Id **USTRAT:** S148 **Latitude:** 354934 **Longitude:** 1070814

6567.00	Orange	23.00	1.00
6552.00	Orange	38.00	1.00
6544.00	Orange	46.00	1.00
6404.00	Blue	186.00	1.00
6275.15	Green	314.85	2.85
6225.35	Green	364.65	6.50
6218.00	Green	372.00	1.80
6160.00	Green	430.00	1.50
6152.00	Green	438.00	1.30
6131.00	Green	459.00	1.20
6124.00	Green	466.00	1.00

DepthtoContact: Total Coal 20.15

18N3W3_2 | WOLF STAND | 18N | 3W | 3 | 6663.00 | NMBM COAL QUALITY PROJECT
Location: NWNWSE

ID: 401 Pet. Id **USTRAT:** S149 **Latitude:** 354903 **Longitude:** 1070820

6581.50	Orange	81.50	4.00
6573.00	Orange	90.00	1.00
6556.00	Orange	107.00	1.80
6416.00	Blue	247.00	0.50
6393.00	Green	270.00	1.50
6371.35	Green	291.65	6.20
6313.60	Green	349.40	6.35
6276.45	Green	386.55	3.00
6271.95	Green	391.05	3.15
6229.50	Green	433.50	2.00
6211.00	Green	452.00	2.00
6181.50	Green	481.50	2.00

DepthtoContact: Total Coal 33.50

18N3W32 | ARROYO EMPEDRADO | 18N | 3W | 32 | 6537.00 | NMBM COAL QUALITY PROJECT
Location: SWNESE

ID: 402 Pet. Id **USTRAT:** S146 **Latitude:** 354437 **Longitude:** 1071008

6486.00	Green	51.00	2.00
6483.00	Green	54.00	1.50
6463.00	Green	74.00	1.00
6459.50	Green	77.50	1.50
6431.00	Green	106.00	1.50
6304.50	Pink	232.50	1.00

DepthtoContact: Total Coal 8.50

18N4W13 | WOLF STAND | 18N | 4W | 13 | 6462.00 | NMBM COAL QUALITY PROJECT
Location: SWNESE

ID: 404 Pet. Id **USTRAT:** S122 **Latitude:** 354717 **Longitude:** 1071216

WellNumber	Quadrangle	Township	Range	Section	Elevation	Source	Depth	CoalThickness
				6303.60	Pink		158.40	4.10
				6292.00	Pink		170.00	4.50
				6278.75	Pink		183.25	2.55
				6274.90	Pink		187.10	1.65
				6221.80	P1		240.20	1.65
				6189.50	P2		272.50	2.00
				6186.70	P2		275.30	1.50
				6176.00	P2		286.00	7.00
				6161.00	P2		301.00	1.00
				6125.20	P3		336.80	2.00
				6097.50	Allison		364.50	2.00
	DepthtoContact:					Total Coal		29.95
R-53	TINIAN	18N	4W	28	6440.00	NMBM OF 102		
		Location: NENE						

ID: 722 *Pet. Id* **USTRAT:** S017 **Latitude:** 354555 **Longitude:** 1071522

				6401.80	Pink		38.20	2.50
				6383.60	Pink		56.40	2.20
				6369.40	Pink		70.60	1.40
	DepthtoContact:					Total Coal		6.10
R-51	TINIAN	18N	4W	32	6460.00	NMBM OF 102		
		Location: NWNE						

ID: 720 *Pet. Id* **USTRAT:** S015 **Latitude:** 354515 **Longitude:** 1071642

				6433.20	Green		26.80	1.30
				6397.00	Pink		63.00	1.00
				6361.20	Pink		98.80	1.00
				6329.00	Pink		131.00	1.30
				6324.40	Pink		135.60	1.50
	DepthtoContact:					Total Coal		6.10
18N5W25	TINIAN	18N	5W	25	6682.10	NMBM COAL QUALITY PROJECT		
		Location: SENESE						

ID: 407 *Pet. Id* **USTRAT:** M0526 **Latitude:** 354529 **Longitude:** 1071833

				6575.10	Blue		107.00	1.00
				6573.10	Blue		109.00	1.00
				6494.25	Green		187.85	2.65
				6466.10	Green		216.00	2.00
				6456.60	Green		225.50	0.50
				6440.90	Green		241.20	1.55
				6308.10	Pink		374.00	3.00
				6229.60	Allison		452.50	1.00
				6194.10	Allison		488.00	2.00
	DepthtoContact:					Total Coal		14.70
18N5W26	TINIAN	18N	5W	26	7021.00	NMBM COAL QUALITY PROJECT		
		Location: SWNWSE						

ID: 408 *Pet. Id* **USTRAT:** M527 **Latitude:** 354530 **Longitude:** 1071957

				6576.00	Green		445.00	2.00
				6485.50	Pink		535.50	1.50
	DepthtoContact:					Total Coal		3.50
18N5W33	MESITA DEL GAVILAN	18N	5W	33	6833.00	NMBM COAL QUALITY PROJECT		
		Location: SWSWNW						

ID: 409 *Pet. Id* **USTRAT:** M528 **Latitude:** 354450 **Longitude:** 1072204

				6792.00	Orange		41.00	1.00
				6717.00	Blue		116.00	1.25
				6691.50	Green		141.50	0.50
				6667.00	Green		166.00	1.00
				6649.50	Green		183.50	1.00

WellNumber	Quadrangle	Township	Range	Section	Elevation	Source	Depth	CoalThickness
				6616.00	Green		217.00	1.00
				6605.00	Green		228.00	1.00
				6579.00	Pink		254.00	1.00
DepthtoContact:			300.00			**Total Coal**		7.75
SAN LUIS #1	WOLF STAND	*18N*	*3W*	*11*	*6685.00*	*TESORO PETROLEUM CO*		
			Location: SWNW					

ID: **760** ***Pet. Id*** 24120 ***USTRAT:*** S171 ***Latitude:*** 354827 ***Longitude:*** 1070740

				6421.00	Green		264.00	4.50
				6412.00	Green		273.00	4.00
				6400.50	Green		284.50	1.00
				6379.00	Green		306.00	3.00
				6375.00	Green		310.00	6.00
				6368.00	Green		317.00	8.00
				6331.00	Green		354.00	1.00
				6321.00	Green		364.00	1.00
				6134.00	P1		551.00	4.40
				6127.40	P1		557.60	2.40
DepthtoContact:			580.00			**Total Coal**		35.30
#2-27	WOLF STAND	*19N*	*3W*	*27*	*6782.00*	*RIJAN OIL CO*		
			Location: NENENWSW					

ID: **762** ***Pet. Id*** 26083 ***USTRAT:*** S169 ***Latitude:*** 355053 ***Longitude:*** 1070841

				6444.00	Orange		338.00	5.00
				6434.00	Orange		348.00	2.50
				6259.00	Blue		523.00	2.50
				6089.00	Green		693.00	7.00
				6077.50	Green		704.50	3.50
				6071.00	Green		711.00	2.00
				5966.00	Green		816.00	3.00
				5753.00	Pink		1029.00	3.00
				5747.00	Pink		1035.00	2.50
				5742.00	Pink		1040.00	3.00
DepthtoContact:						**Total Coal**		34.00