USGS
science for a changing world

Status Report: USGS Coal Assessment of the Powder River Basin, Wyoming

James A. Luppens[1] , Timothy J. Rohrbacher[2], Jon E. Haacke[2], David C. Scott[2], and Lee M. Osmonson[2]

U.S. Geological Survey Open-File Report 2006-1072

Available on the Internet at http://infotrek.er.usgs.gov/pubs/

U.S. Department of the Interior
U.S. Geological Survey

[1] USGS, Reston, VA
[2]USGS, Denver, CO

Figure 1. Title Slide: "Status Report: USGS Coal Assessment of the Powder River, Wyoming" by James A. Luppens , Timothy J. Rohrbacher, Jon E. Haacke, David C. Scott, and Lee M. Osmonson; U.S. Department of the Interior, U.S. Geological Survey.

USGS Coal Program

- Current and future coal assessments – not just another in-place coal resource number.
- Regional estimates of economically recoverable coal will be an integral part of current and future assessments.
- How much economically recoverable coal do we have left?

USGS

Figure 2. Objectives of the current and future USGS coal assessment programs. An inventory of the estimated economically recoverable coal provides a better foundation for energy planning than simply relying on in-place coal resources.

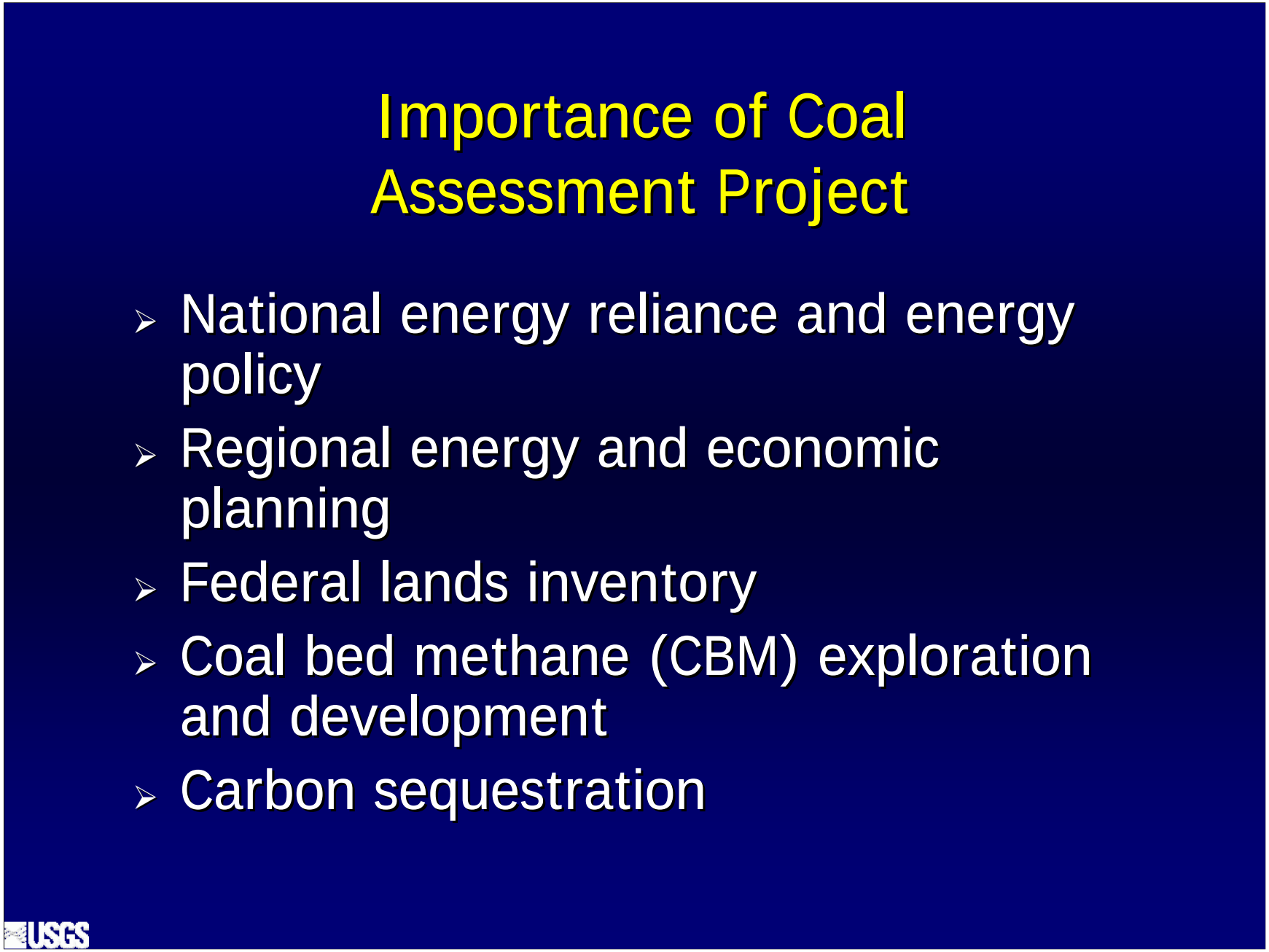


Figure 3. Importance of USGS coal assessment project to energy policy and research.

Current and Future Coal Assessment Work, Where do we go from here?

- Reserve investigations require more up front geology and engineering work.
- However, new, highly automated regional mine modeling and economic programs developed by the USGS facilitate the reserves evaluation.
- The USGS assessment methodology was formally evaluated by an external review panel with an open file report published in February, 2005 Rohrbacher, T. J., and others, 2005 (http://pubs.usgs.gov/of/2005/1076).
- Builds on the digital geologic framework of past coal resource assessments.
- Started next coal assessment phase in the greater Powder River Basin (PRB) in FY2005.

USGS

Figure 4. The direction of current and future USGS coal assessments.

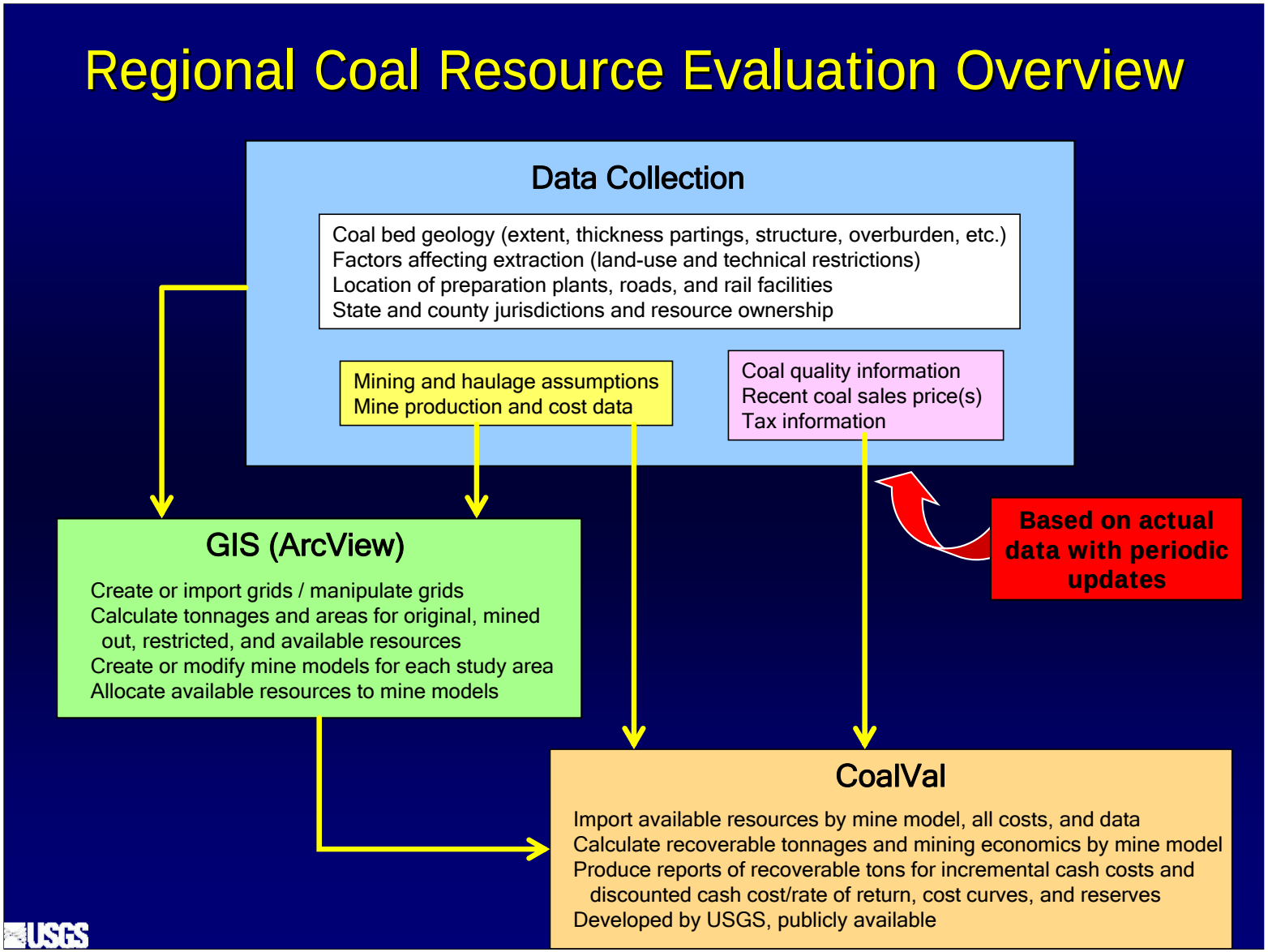
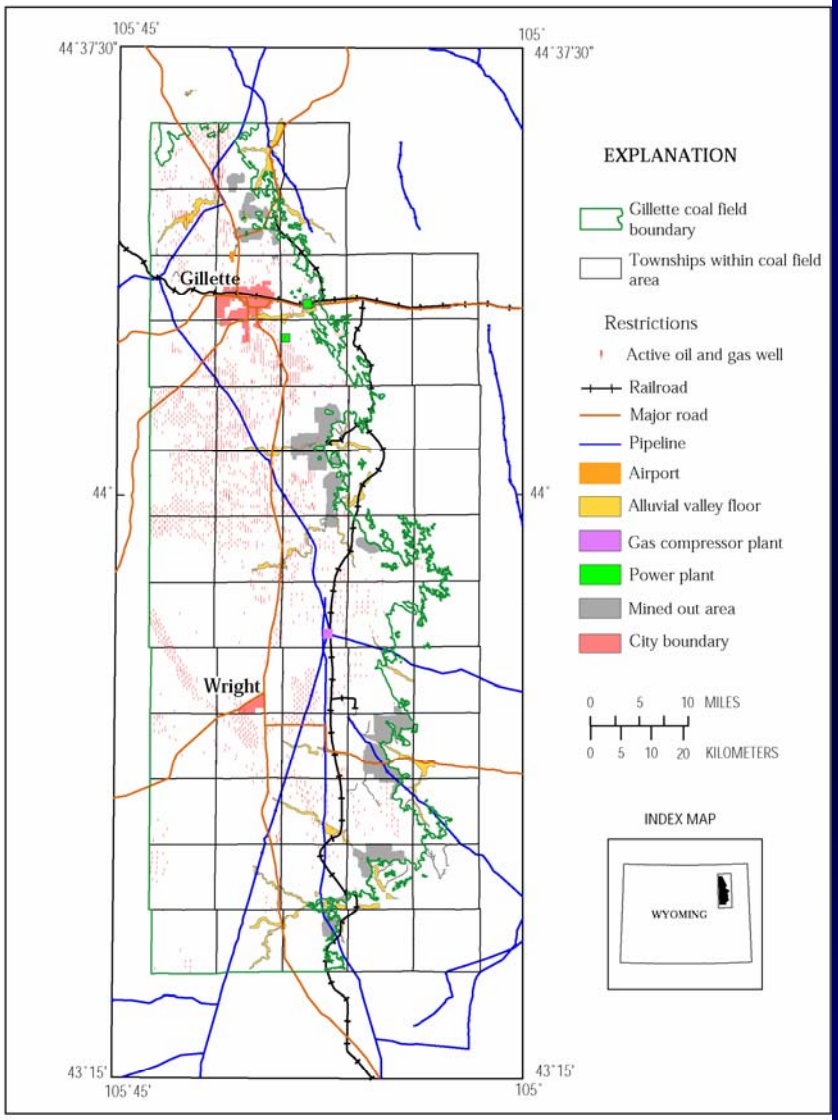


Figure 5. The USGS coal assessment project is designed to provide regional estimates of economically recoverable resources (reserves). Data collection and geological modeling are typically the most time intensive phase. Once the geology model is complete, the GIS program allocates the available coal resources to the various mine models. Finally, a program developed in-house called CoalVal performs the economic analyses.



Environmental, Societal, and Technical Restrictions to Mining in the Gillette Coal Field, Wyoming

USGS

Figure 6. In addition to subtracting previously mined out resources, coal restricted by societal and environmental constraints are subtracted to determine the remaining available resources. An economic analysis of the available resources yields an estimate of reserves for the study area.

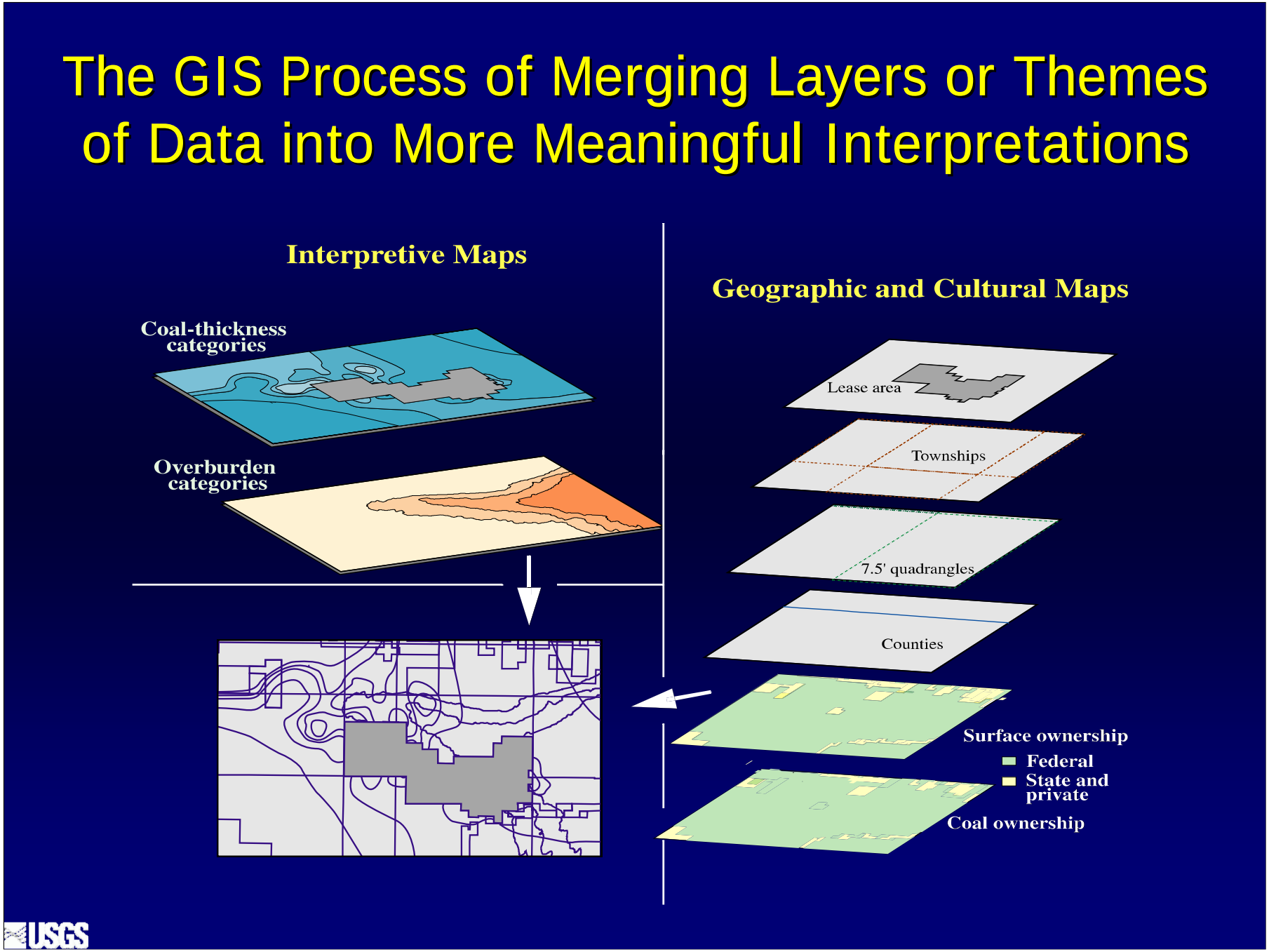
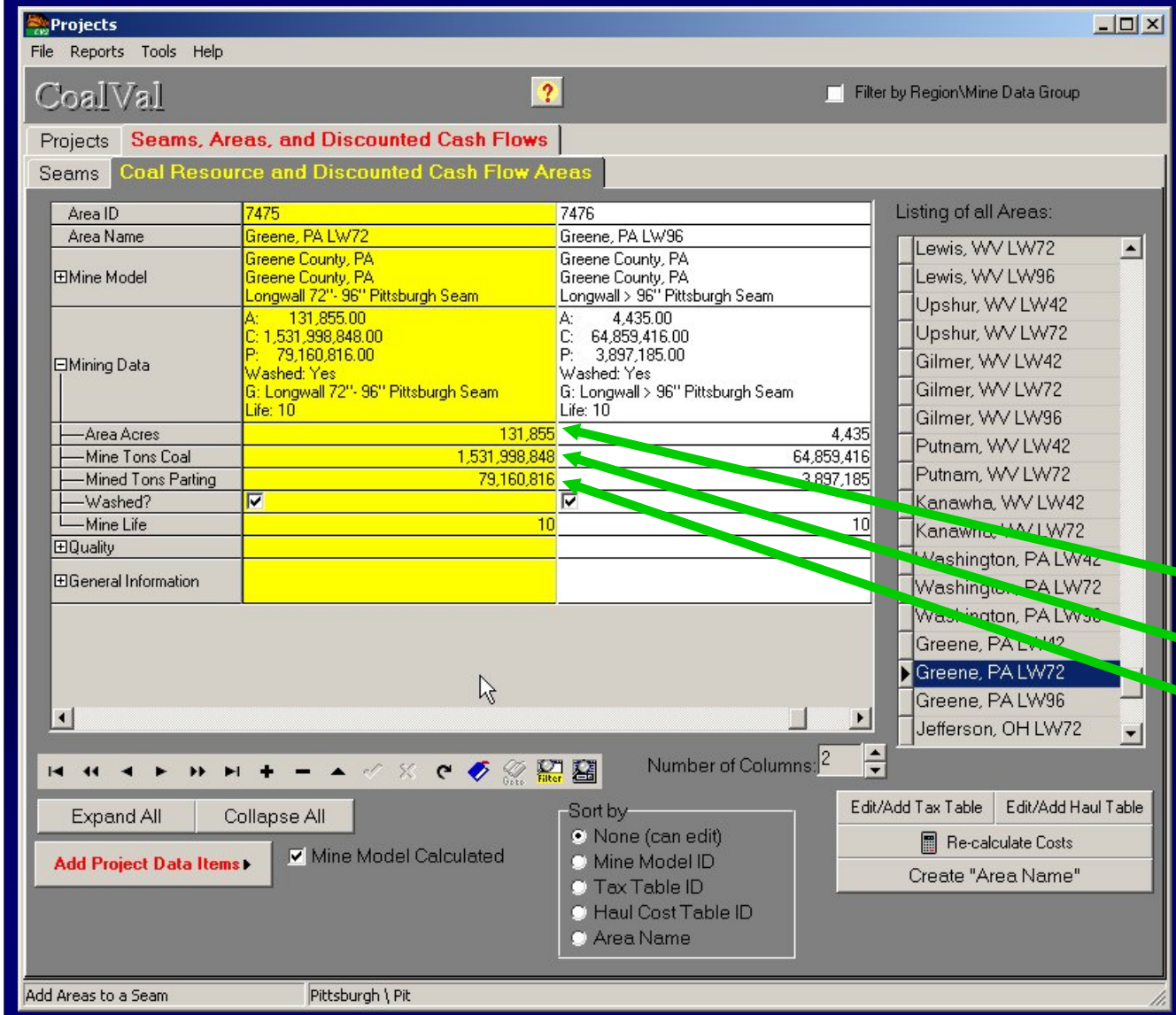


Figure 7. The availability of GIS coverages for land, restrictions, geology, etc. greatly facilitate the evaluation process.

Available Resource Areas Input into CoalVal



GIS study assigns coal to mine models.

Coal tons are imported by county into resource areas for each mine model.

Results from GIS are:

- Acreage
- *In Situ* Tons Coal
- *In Situ* Tons Parting

Figure 8. The first step in an economic evaluation is importing the coal volumes into CoalVal from the GIS mine models. This example is from an evaluation of the Pittsburgh coal bed in Pennsylvania, but the types of data imported are the same. CoalVal is scheduled for publication in 2006.

CoalVal - Mine Model Equipment

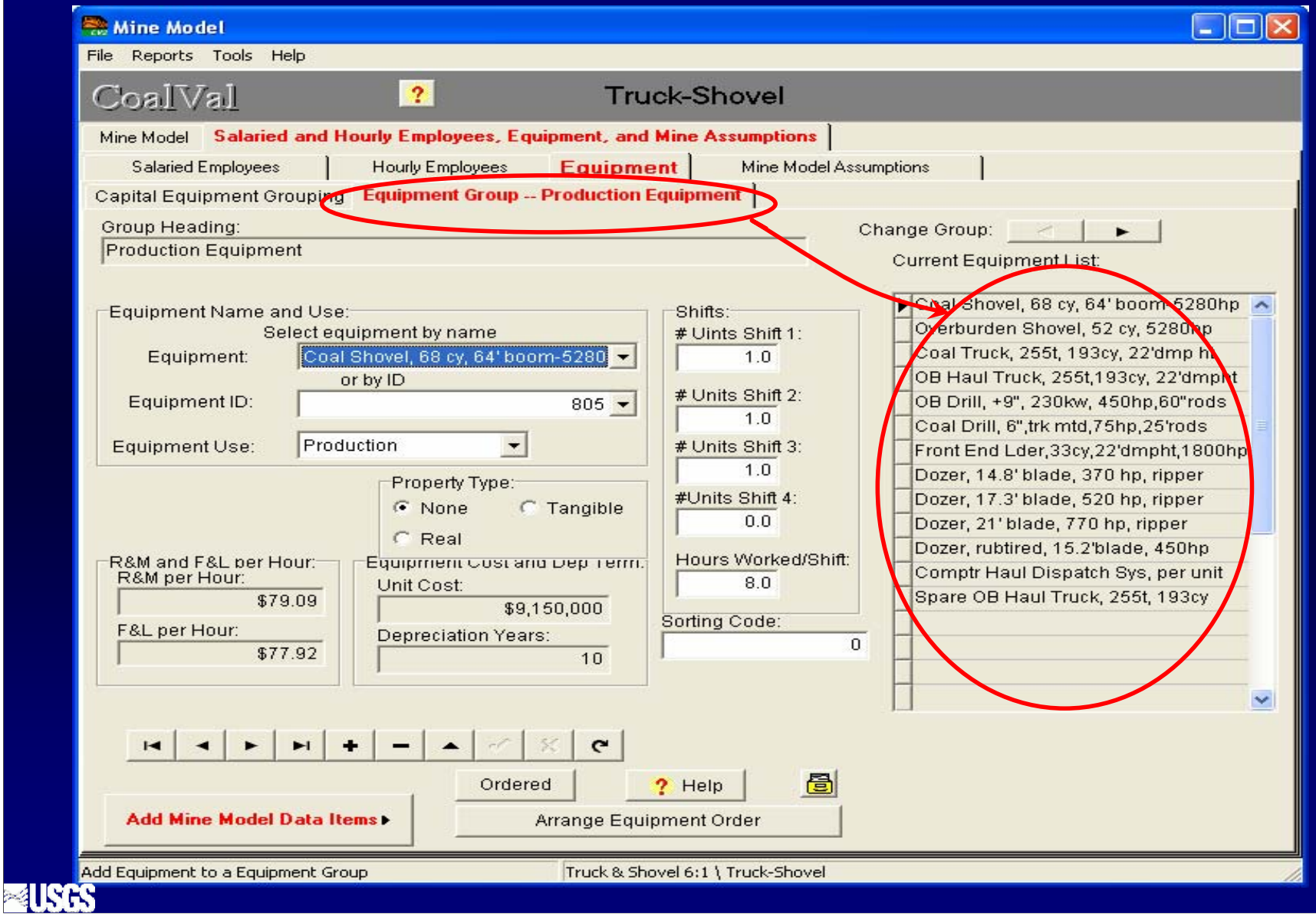


Figure 9. CoalVal provides a series of tables to add and cost out mine equipment.

CoalVal Mine Model Assumptions

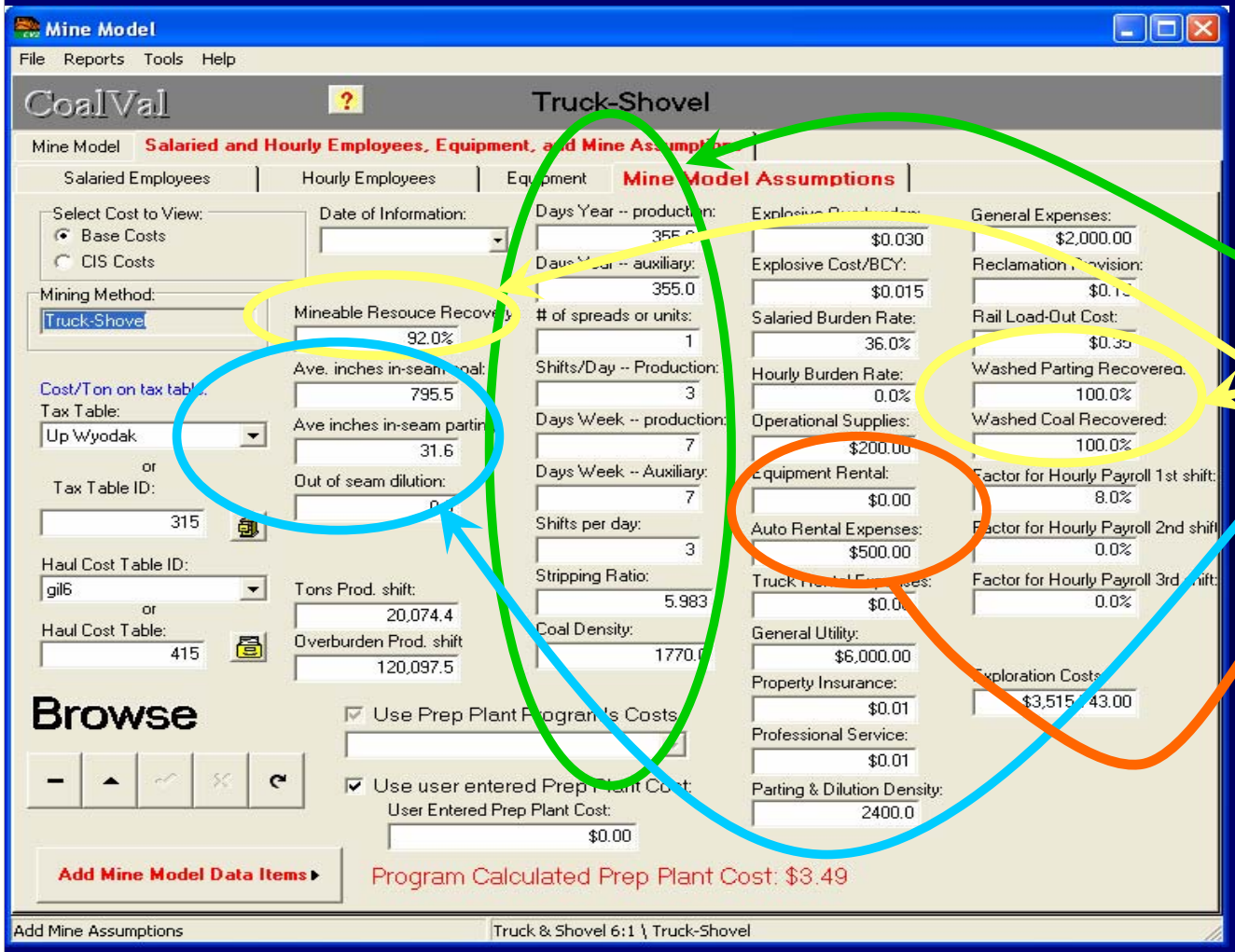


Figure 10. Mine models assumptions including productivity, dilution, and recovery rates are also entered. All data is based on published regional statistics and actual equipment pricing costs, as well as input from and verification of assumptions by coal mines in the region.

Mine Model Employees

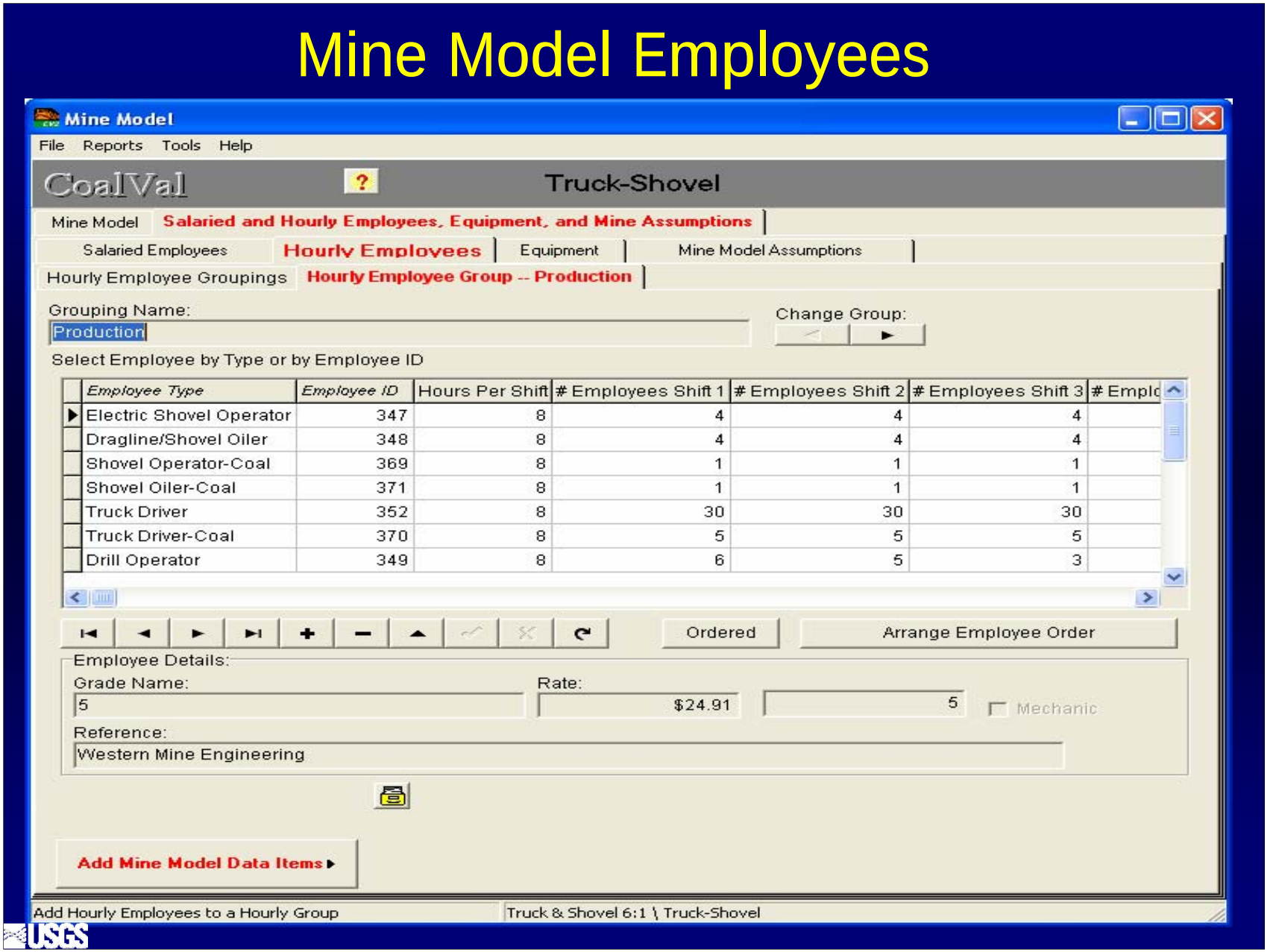


Figure 11. Input for the manpower table is also regionally-based from published labor statistics and mining company information. CoalVal will be published with all the basic tables completed as place markers; however, it will be the user's responsibility to supply current information.

CoalVal - Discounted Cash Flow Summary

Material Flow Tracking Summary

Resource ID	Mine Life	Coal FOB to Market	HurdleRate	Threshold Price
N. App. Basin: LW42"	10	422,133,400	10.00 %	$26.18

	Coal	Parting	Dilution	Total
In Place Tonnage				
In Place Total	642,789,824	29,590,659	53,801,199	726,181,682
from Whole LPUs	600,339,621	27,636,476	50,248,137	678,224,234
from Carry Over	42,450,203	1,954,184	3,553,062	47,957,448
Annual In Place Tonnage per LPU				
LW Part of LMU	3,772,545	173,668	315,760	4,261,974
CM Part of LMU	2,230,851	102,697	186,721	2,520,269
Totals	6,003,396	276,365	502,481	6,782,242
Annual Run of Mine Tonnage per LPU				
LW Part of LMU	2,867,134	131,988	239,978	3,239,100
CM Part of LMU	1,494,670	68,807	125,103	1,688,580
Totals	4,361,805	200,795	365,081	4,927,680
In Place Tonnage Carry Over (CO)				
LW Part of CO	26,675,786	1,228,013	2,232,750	30,136,550
CM part of CO	15,774,417	726,171	1,320,311	17,820,899
Recovered Carry Over				
LW Part of CO	20,273,598	933,290	1,696,890	22,903,778
CM Part of CO	10,568,859	486,535	884,608	11,940,002
Out of Wash Plant Carry Over				
Wash Plant Recovery Rate	89%	11%	11%	
LW Part of CO	18,043,502	99,862	181,567	18,324,931
CM Part of CO	9,406,285	52,059	94,653	9,552,997
Total	27,449,786	151,921	276,220	27,877,928
Out of Wash Plant to Market				
from whole LPU's	388,200,604	2,148,501	3,906,366	394,255,472
from Carry Over	27,449,786	151,921	276,220	27,877,928
Total	415,650,391	2,300,423	4,182,586	422,133,400

Fractional Report ☐

Number LPU's Based on User Entered Mine Life
10.71

Number LPU's Based on Calculated Mine Life
10.71

Calculated Mine Life
10

Mineable Resource Recover Rate (from mine model)

76%

67%

Mine Model Name:

Longwall 42"-72" Pittsburgh Seam

Quality

Revised BTU	12,178
BTU	13,670
RevisedSulfur	2.57 %
Sulfur	2.90 %
RevisedAsh	18.28 %
Ash	8.16 %

USGS

1

2/5/2005 3:18:44 PM

Figure 12. The final result of the economic evaluation is a report summing the number of tons at a threshold price (including a discounted rate of return) for each area and mine model for the entire project area.

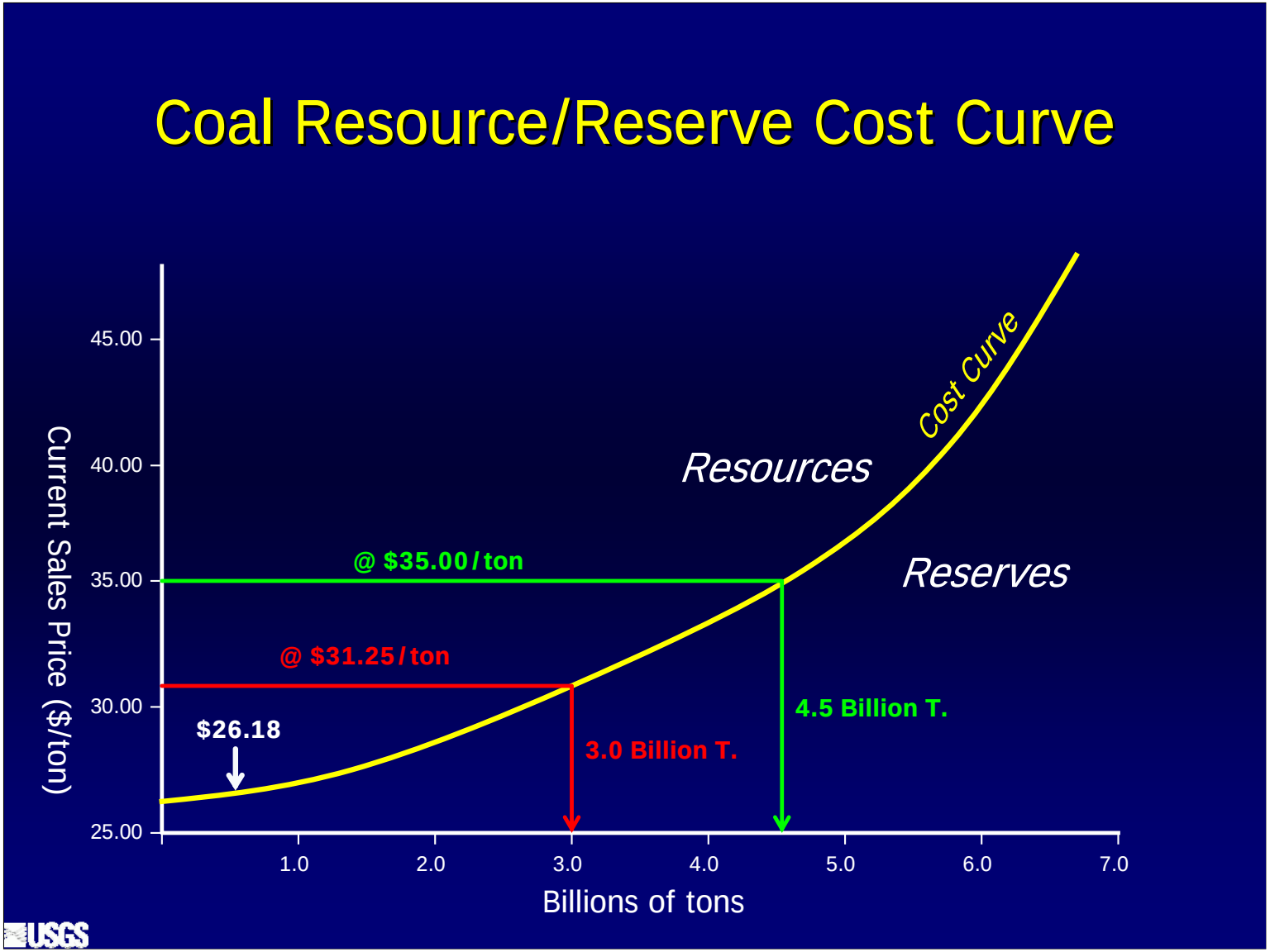


Figure 13. Once the cost of all the available tons are determined, a resource cost curve can be derived. Given a current sales price of $31.25/ton, about 3 billion tons would be economic. Any coal tons with a threshold price of $31.25 or less would be considered reserves. Thus, the block shown in fig. 12 at $26.18 falls into the reserves category. If the price were to increase to $35.00/ton, and additional 1.5 billion tons would added to the reserves category. It must be stressed, that the determination of reserves is an ongoing process that must be revalidated as market and mining costs, and other economic and technological factors change.

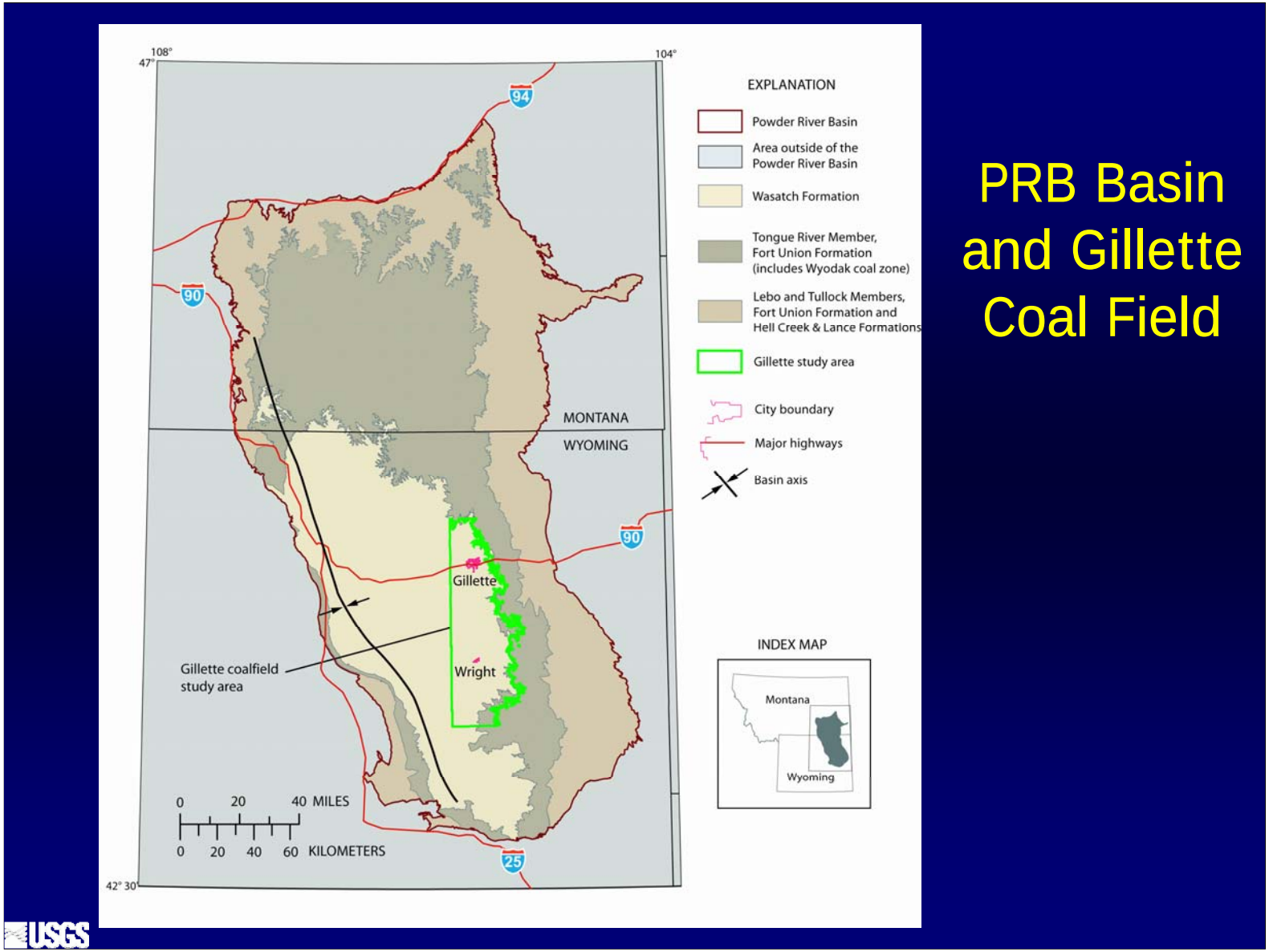


Figure 14. This is the location of the Gillette Coal Field, Wyoming where the initial PRB coal assessment project is starting. The Powder River Basin (PRB) represents the single most productive coal basin in the US, producing nearly 40% of the nation's coal. Just the Wyoming portion of the basin produced 403 million tons in 2005 (U.S. Bureau of Land Management, 2006). Furthermore, the announced additional coal development is significant. Peabody's new School Creek mine (60 miles south of Gillette) alone is expected to come on-line in late 2008 producing 30 million to 40 million short tons/yr (Platts Coal Outlook, 2006).

Current PRB Assessment Status

- Current Database:

Original	–	2,200 points
New oil & gas wells	–	2,330 points
New CBM wells	–	7,470 points
TOTAL	**–**	**12,000 points**

- Two Geologists for approximately one year
- About 4,000 points from WY Geological Survey
- Plan to complete Gillette coalfield assessment by Dec., 2006
- Assessment of the north and northwest portions of the PRB will begin following completion of the Gillette coal field evaluation.

USGS

Figure 15. The current USGS PRB assessment status. When completed, the resulting database should provide one of the most extensive drill hole compilations for the PRB available to the public. The slides in this next section represent preliminary assessment work and may be modified for the final report.

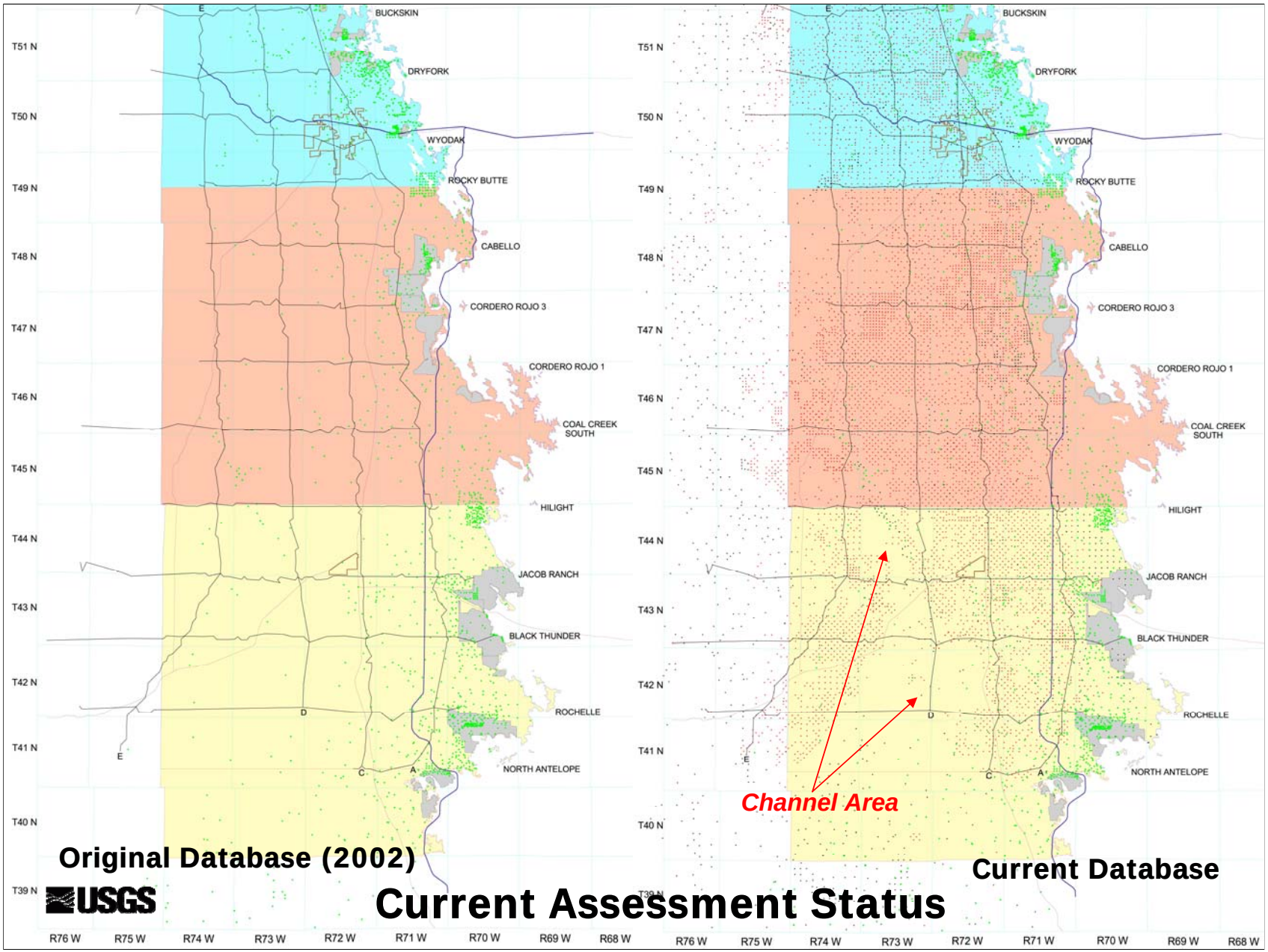


Figure 16. Comparison of the original Gillette coal field assessment coal assessment drill hole database (Ellis and others, 2002) to the current assessment database. The extensive drilling activity associated with coal bed methane (CBM) development has resulted in a relatively dense drilling pattern which, by itself, helps define the limits of a significant channel area where the coal beds are thin or absent.

Preliminary Assessment Results

- Minor changes in coal bed correlations
- Major down-dip channel will be a restriction to surface mining

USGS

Figure 17. The preliminary interpretation of the massive amount of new data has resulted in several significant findings. Both are related to the channel geometry defined by the substantial amount of new drilling information.

Previous Coal Bed Correlations

(USGS Miscellaneous Investigations Series, Map I-1959-B)

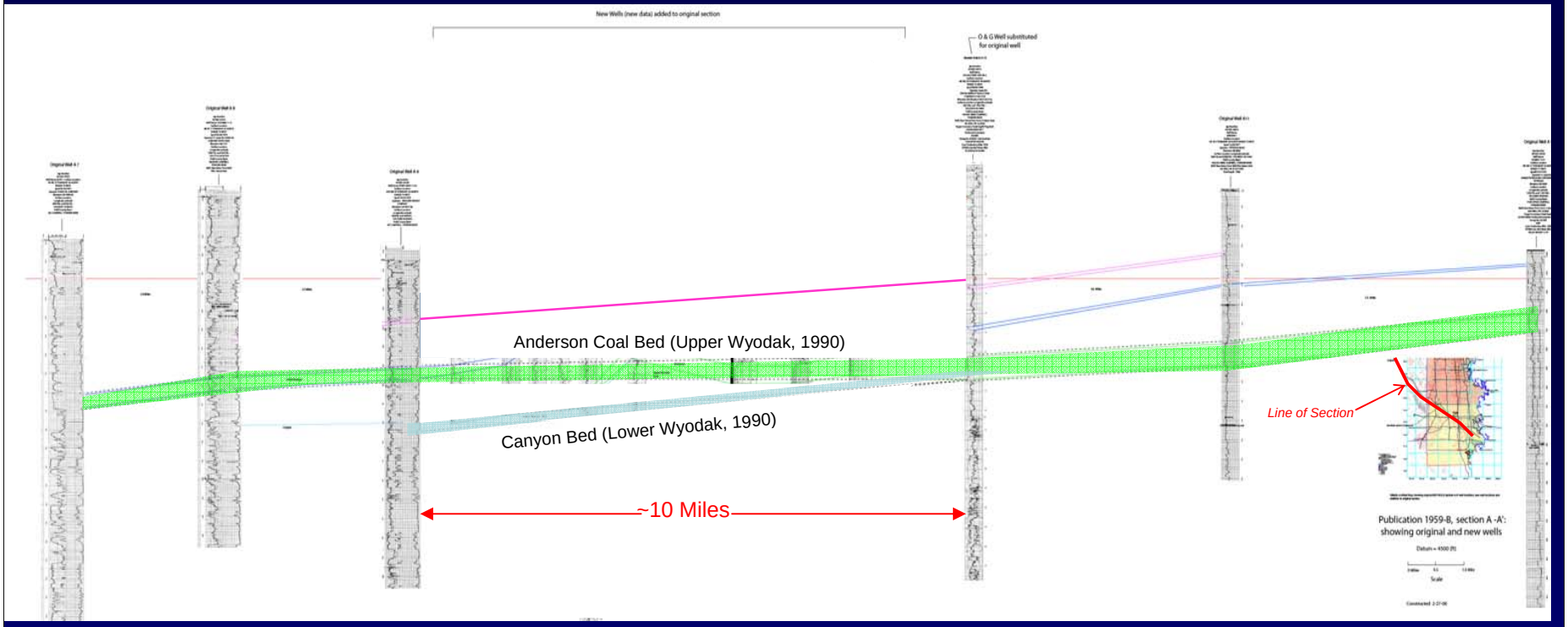


Figure 18. A portion of a published NW-SE cross section through the channel area based on widely-spaced well logs (Pierce, F. W., and others, 1990).

Correlation Changes with Infill Drilling

(USGS Miscellaneous Investigations Series, Map I-1959-B)

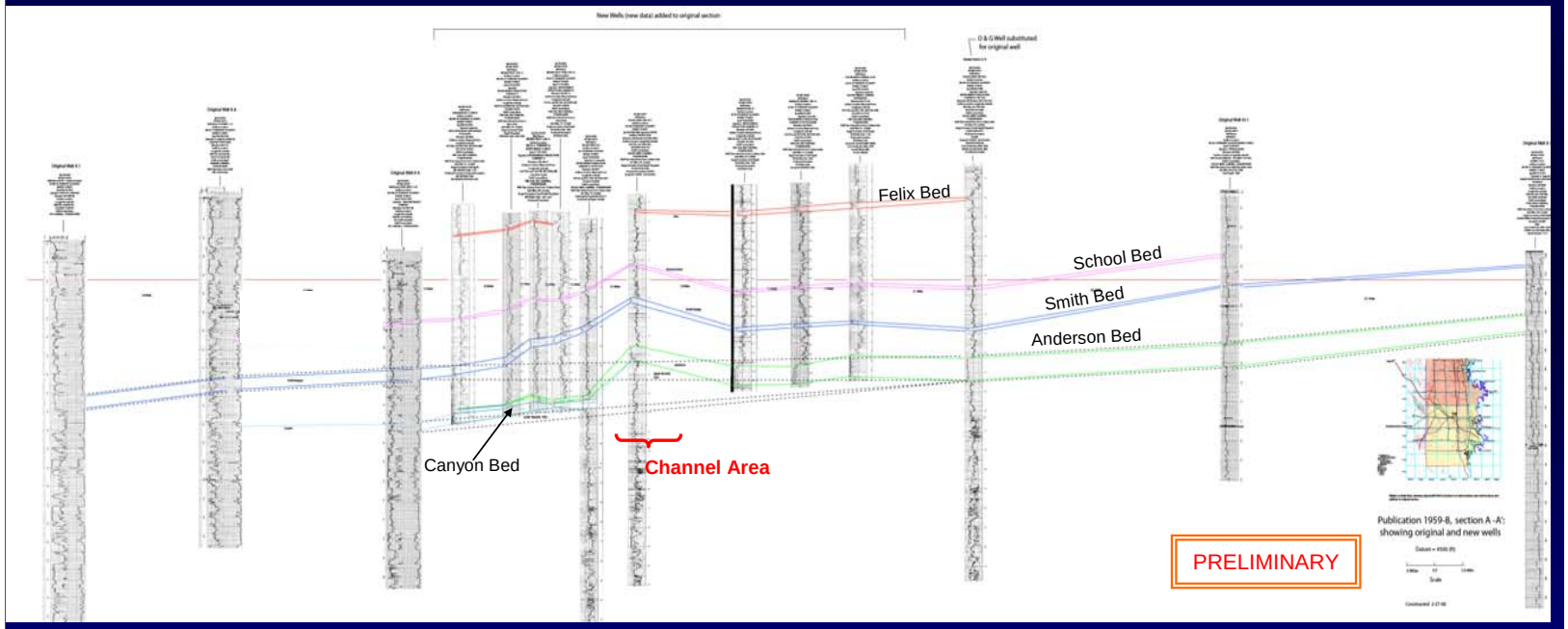


Figure 19. Closer-spaced drilling reveals minor revisions in the coal bed correlations. Dotted lines indicate previous correlations. The Anderson/Canyon coal beds, which are the major beds in the current mining areas of the Gillette coal field split, thin, and (or) are absent in and immediately adjacent to the channel areas. The Smith coal bed thickens rapidly west of the major channel area Both the Smith and the Anderson/Canyon beds are all part of the Anderson-Wyodak coal zone after Flores and others (1999).

Correlation Changes with Infill Drilling

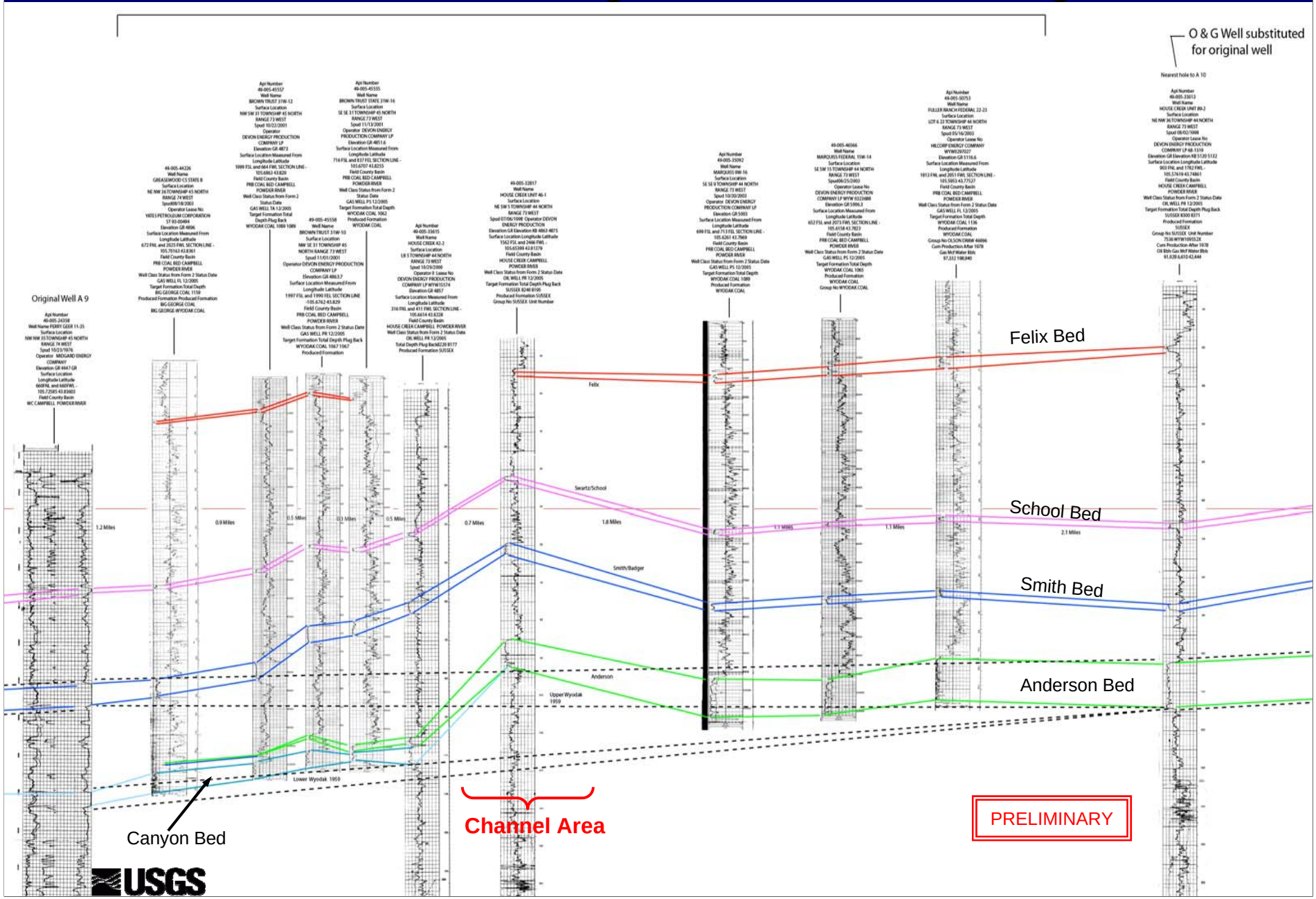


Figure 20. Expanded view of infill drilling (fig.19) showing greater detail for the geophysical logs.

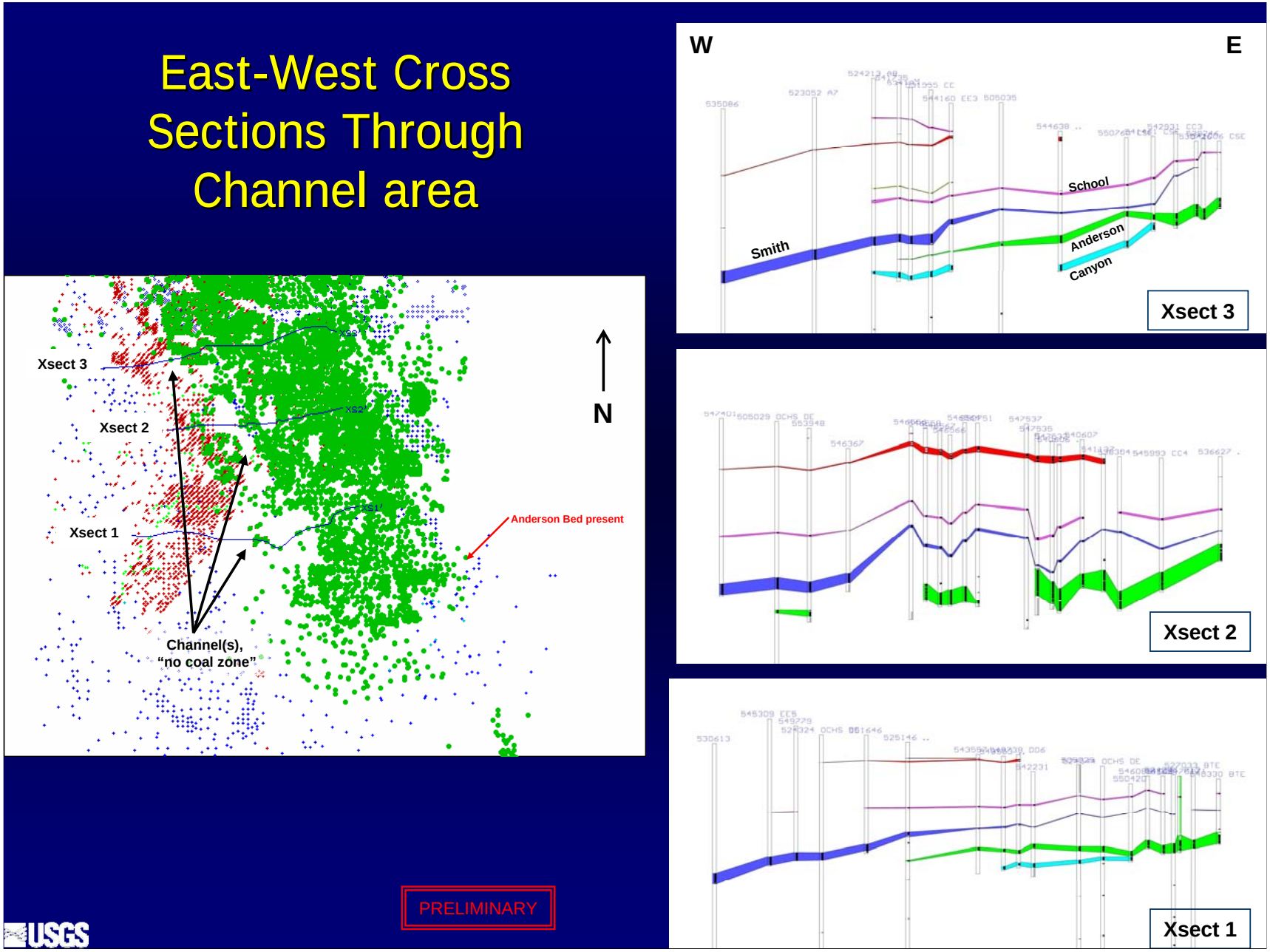


Figure 21. East-west cross sections through the channel confirm the scenario shown in figs. 19 and 20 where the Smith thickens and the Anderson/Canyon (Wyodak) beds are thin or absent westward. Drill holes with the Anderson bed present are displayed with a solid green dot to create a simple areal distribution map. Structural highs in the Smith coal can indicate the presence of an underlying Wyodak "no-coal zone" (Ashley, M., 2006).

Comparison of Anderson Bed - 2002 Study and Current Assessment

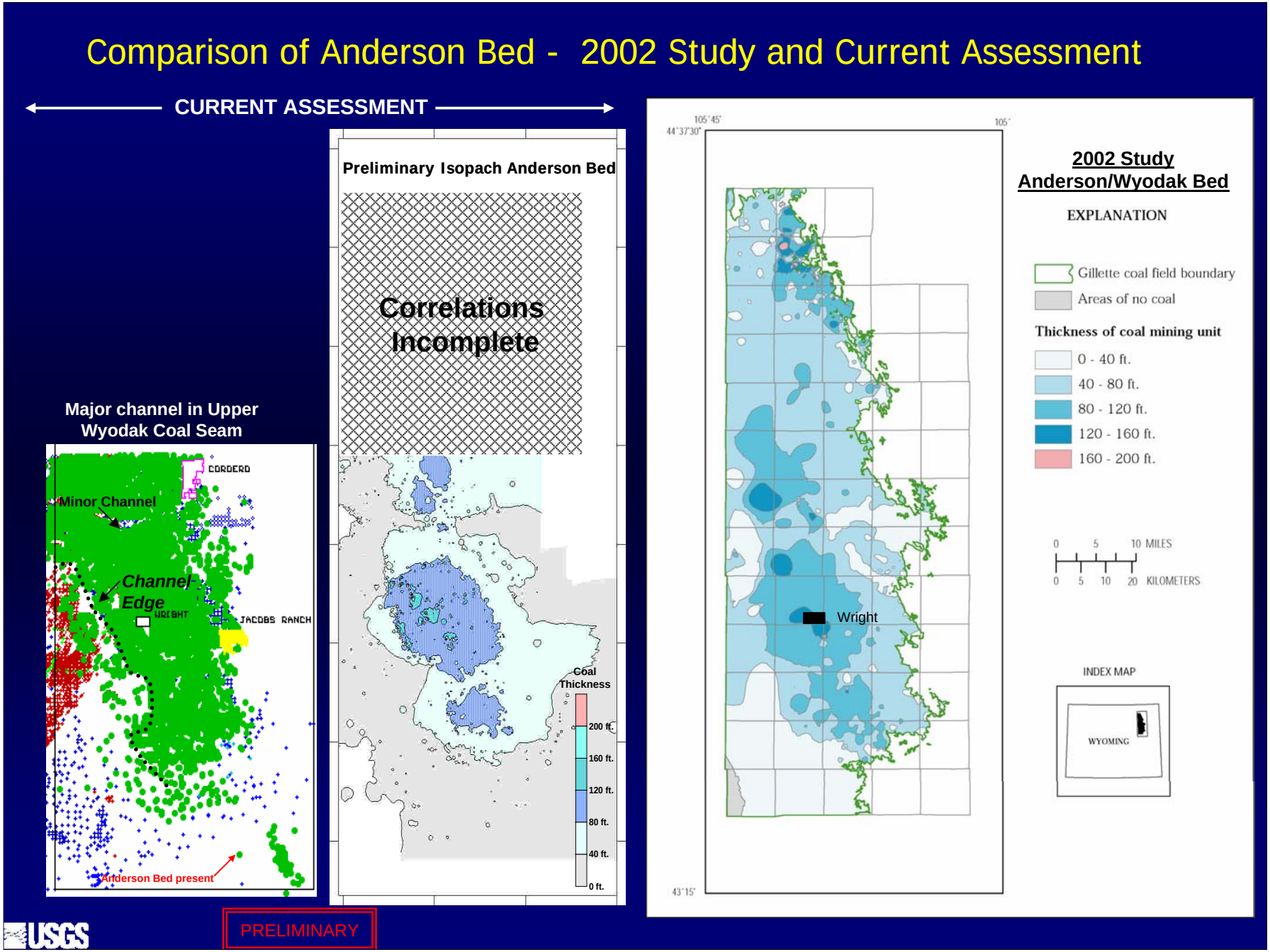
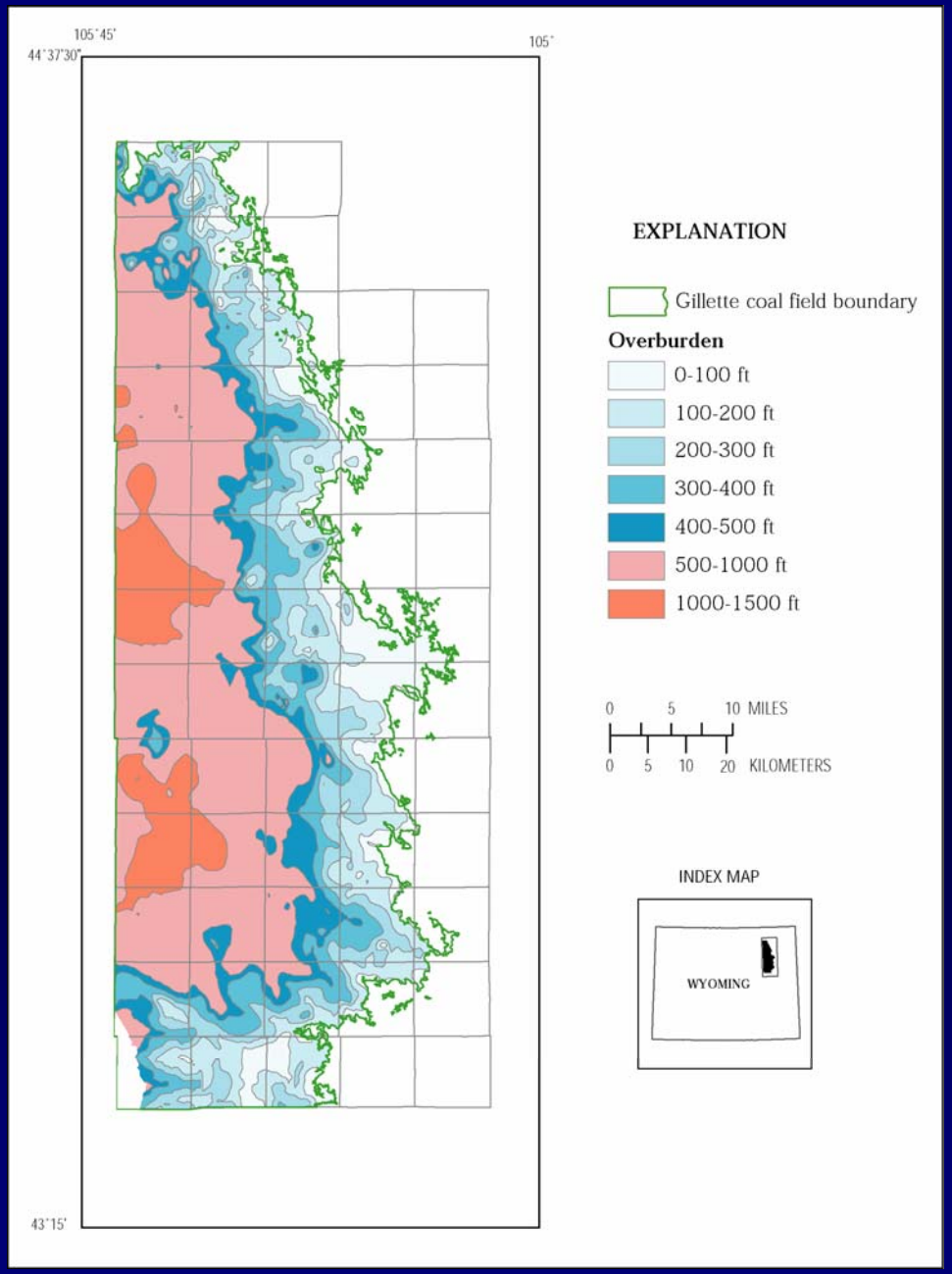


Figure 22. Comparison of a preliminary isopach map from the current assessment and that from Ellis and others, 2002. It is obvious that the total coal resources in the final assessment results will be impacted by improved delineation of the channel areas. The end results should provide a more realistic appraisal of the available coal resources.

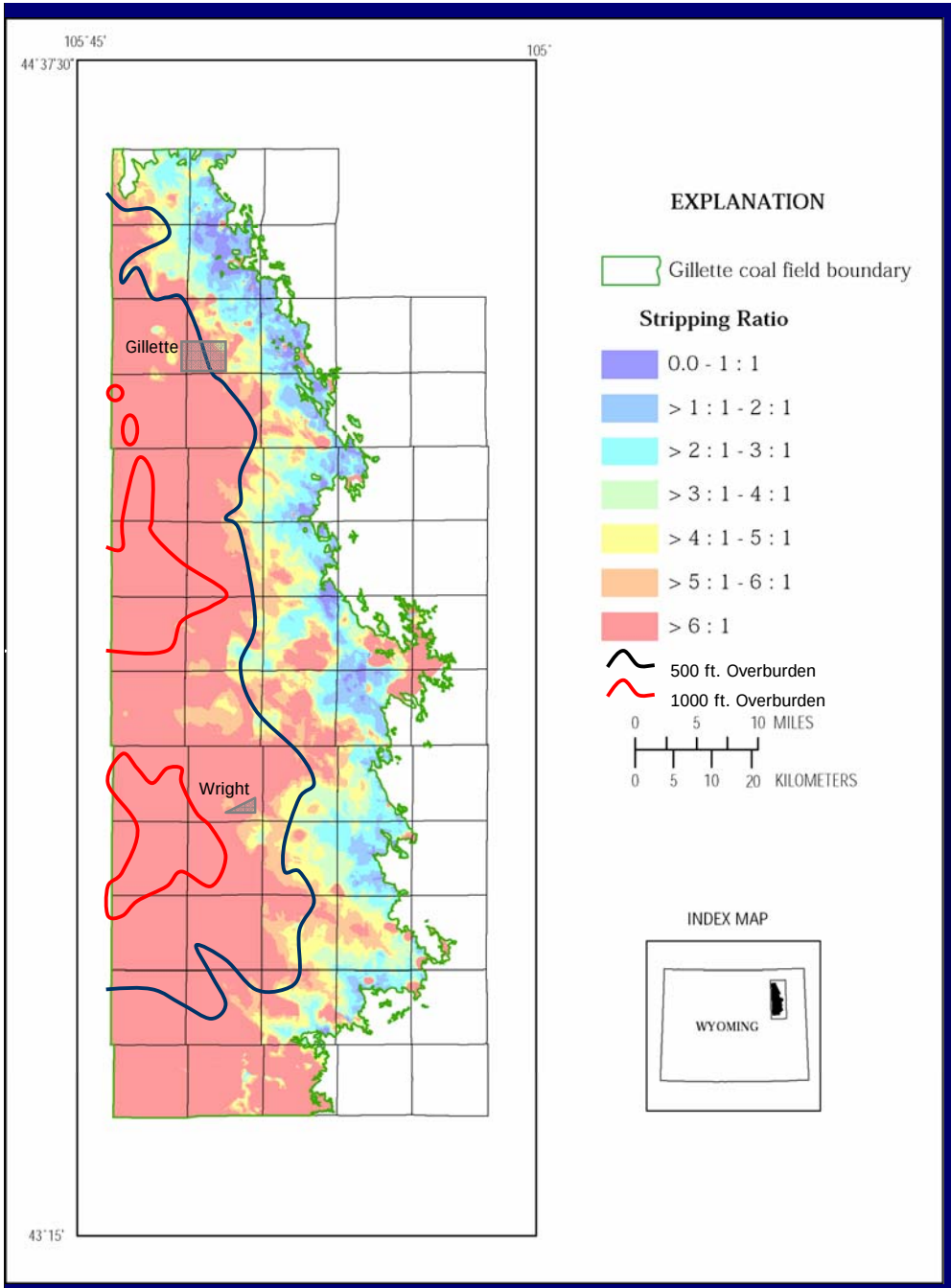


Overburden Isopach Gillette Coalfield (Upper Wyodak)

(2002 Study Anderson - Wyodak Bed)

USGS

Figure 23. Overburden isopach for the Anderson/Wyodak bed (Ellis and others, 2002). Fortunately, much of the major channel lies in areas of deeper cover in the western portion of the coal field.



Stripping Ratios Gillette Coalfield (Upper Wyodak)

(2002 Study Anderson - Wyodak Bed)

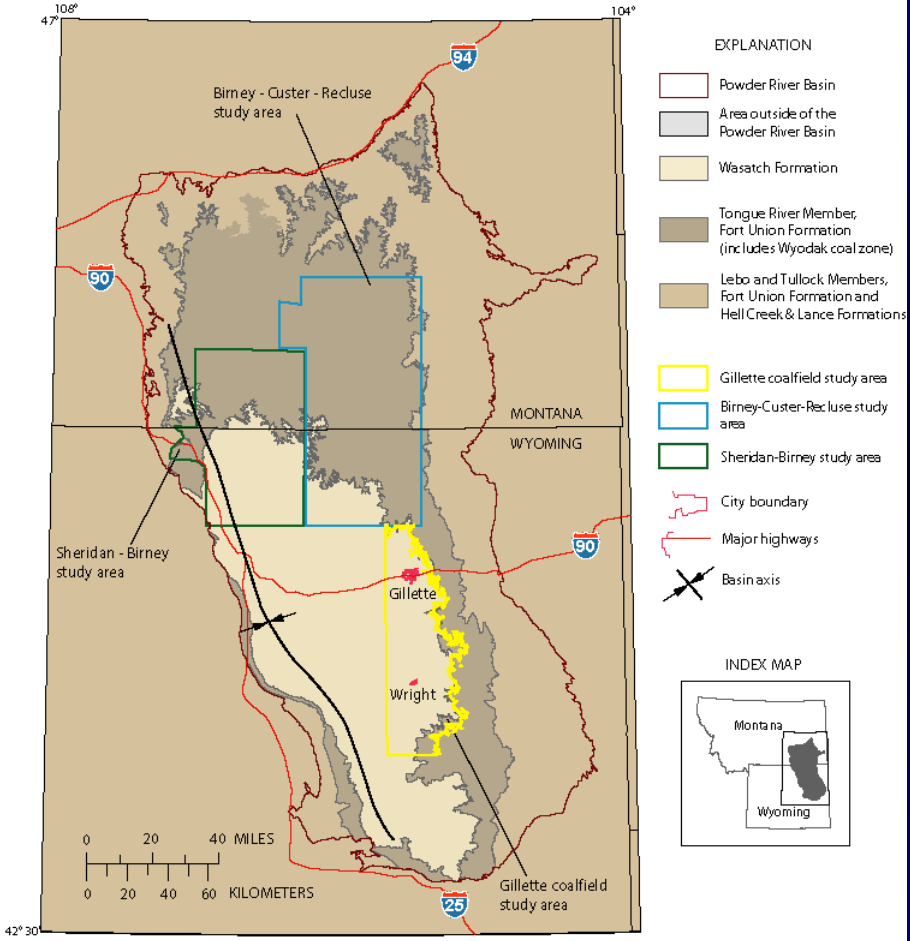
Current Assessment will include models down to 10:1 Stripping Ratio

USGS

Figure 24. Stripping ratio map for the Anderson/Wyodak bed (Ellis and others, 2002). We plan to conduct an economic evaluation of the Gillette coal field down to a 10:1 stripping ratio during the current coal assessment.

Powder River Basin Study Areas

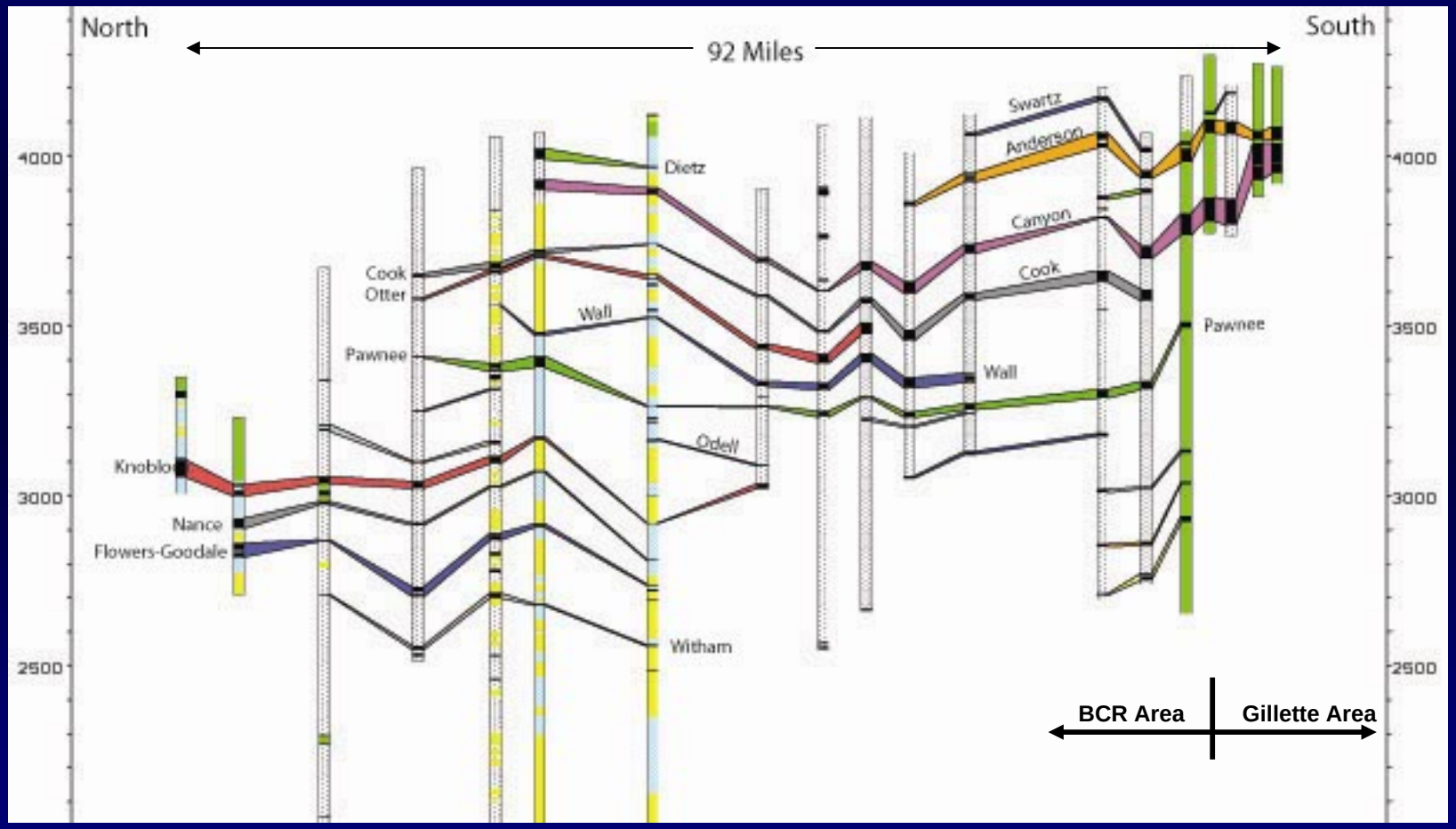
- Gillette coal field
- Birney-Custer-Recluse coal fields (BCR)
- Sheridan-Birney coal fields



USGS

Figure 25. Once the Gillette coal field portion of the PRB is completed, the assessment will move to the north and the northwest into the Birney-Custer-Recluse (BCR) and Sheridan-Birney coal fields.

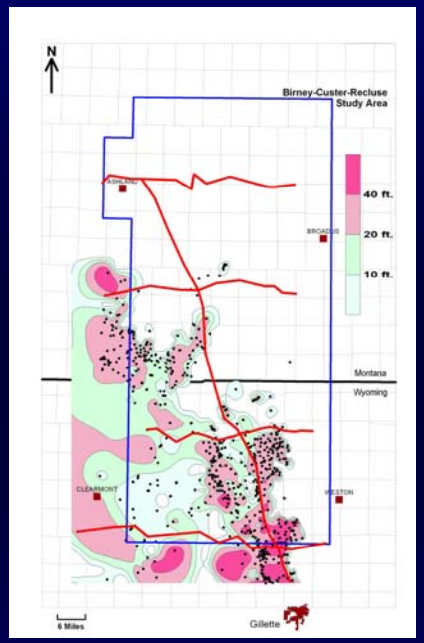
North-South Cross-Section
BCR Study Area



USGS

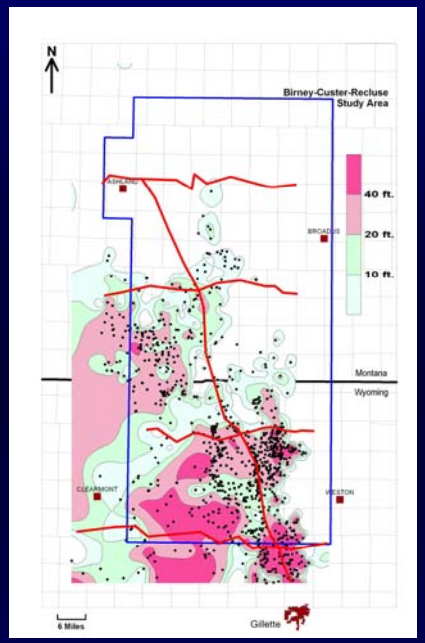
Figure 26. The coal beds including the Anderson and Canyon beds tend to thin northward from the Gillette coal field; however, more coal beds are generally present.

Major Coal Bed Distributions in the BCR



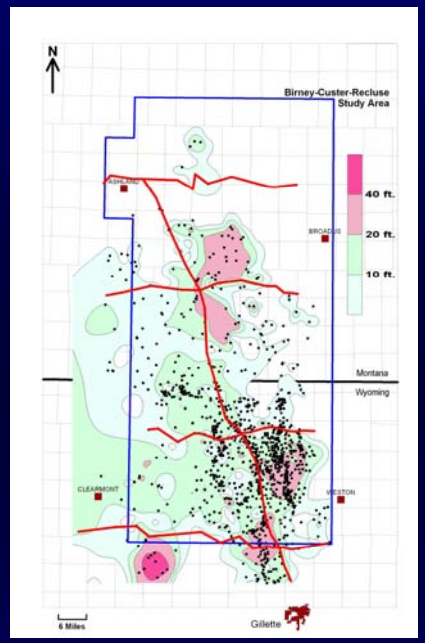
Anderson Isopach

- Maximum thickness = 86’



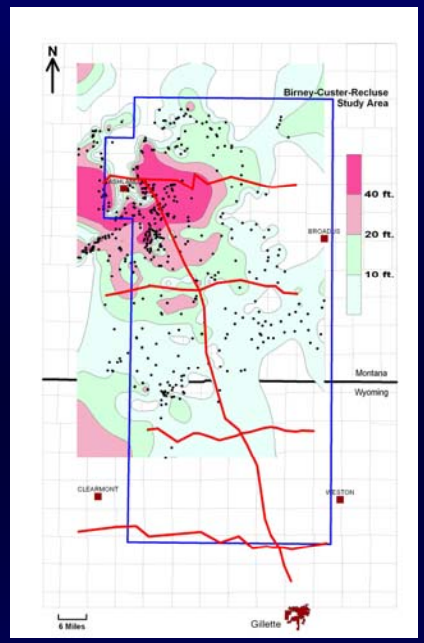
Canyon Isopach

- Maximum thickness = 98’
- Good extent
- Significant areas with thick coal



Pawnee Isopach

- Maximum thickness = 48’
- Good extent



Knobloch Isopach

- Maximum thickness = 79’
- Good extent
- Truncated to south

PRELIMINARY

USGS

Figure 27. Although the coal beds are generally not as thick and widespread as those in the Gillette coal field, significant coal resources are present in the BCR coal field.

PRB Coal Resource Assessment Summary

- Extensive CBM and additional oil and gas development, especially in the Gillette coal field, has provided an unprecedented amount of down-hole geological data.
- Better definition of channel/no-coal areas that form barriers to mining will be possible.
- These additional data will provide a more robust evaluation of the single most productive U.S. coal basin.
- The Gillette coal field assessment, including the mining economic evaluation, is planned for completion by the end of 2006.
- The geologic portion of the coal assessment work will shift to the northern and northwestern portions of the PRB before the end of 2006 while the Gillette engineering studies are finalized.

USGS

Figure 28. PRB Assessment Summary.

References

Ashley, M., 2006, Wyodak Coal, Tongue River Member of the Fort Union Formation, Powder River Basin, Wyoming: "No-Coal Zones" and Their Effects on Coalbed Methane Production; Search and Discovery Article #10094, http://www.searchanddiscovery.com/documents/2005/ashley/index.htm

Ellis, M. S., Molnia, C. L.. Osmonson, L. M., Ochs, A. M., Rohrbacher, T. J., Mercier, T., and Roberts, L. N. R., 2002, Evaluation of Economically Extractable Coal Resources in the Gillette Coal Field, Powder River Basin, Wyoming; U.S. Geological Survey Open-File Report 02-180, 48 p.

Flores, R.M., Ochs, A.M., Bader, L.R., Johnson, R.C., and Vogle, D., 1999, Framework geology of the Fort Union coal in the Powder River Basin; Chapter PF, *in* U.S. Geological Survey Professional Paper 1625-A, 40 p.

Pierce, F. W., Johnson, E.A., Molnia, C.L., and Sigleo, W.R., 1990, Cross-sections showing coal stratigraphy of the southeastern Powder River Basin, Wyoming: U.S. Geological Survey, Miscellaneous Investigations Series, Map I-1959-B.

Platts Coal Outlook, 2006; v. 30, No. 11, http://www.platts.com

Rohrbacher, T. J., Luppens, J. A., Osmonson, L. M., Scott, D. C., and Freeman, P. A., 2005, An external peer review of the U.S. Geological Survey energy resource program's economically recoverable coal resource assessment methodology—report and comments: U.S. Geological Survey Open-File Report 2005-1076, 21 p.

U.S. Bureau of Land Management, 2006, Powder River Basin Coal Production; http://www.wy.blm.gov/minerals/coal/prb/PRB_coalpro.htm

USGS

Figure 29. References