

# PEDL074 Somerset

Report by Douglas RP Goodwin for GeoMet Operating Inc for Geomet UK Ltd

## Licence Area

PEDL074: 400 km<sup>2</sup> - blocks ST55, ST56, ST65 and ST66

## Target

Lower and Middle Coal Measures at depths between 500 and 5,000 ft (152-1,525 m) (see Overlay 1 for 1"=1 mile geologic map). Together the Lower and Middle Coal Measures are 2,000 to 2,500 ft (610-762 m) thick with the Middle Coal Measures averaging about 1,600 ft (488 m) and the Lower Coal Measures about 600 ft (183 m).

The Somerset coalfield consists of the northern Pensford and the southern Radstock synclines separated by the east-west trending Farmborough Fault Belt. Only in the southern part of the Radstock Syncline have coals of the Lower and Middle Coal Measures been worked, mainly at the Newbury and Vobster collieries in the southeast and in the New Rock and Moorewood pits to the southwest. Only in the eastern part of Pensford Syncline have coals of the Lower and Middle Coal Measures been worked, at the Globe Pit in the Newton St Loe area in the 19th century.

North of and contiguous with the Somerset Coalfield is the southern portion of the Bristol Coalfield, an area known as the Kingswood Anticline. Middle and Lower Coal Measures crop out here and have been extensively mined, both at the surface and underground. Despite complex folding and major faulting some 20 seams, ranging from 0.3 to 2 m thick, have been extensively worked. Some of these workings continue for a short distance onto PEDL074.

One kilometer west of the northwest corner of PEDL074 is the eastern edge of the Nailsea Syncline. Coal workings here were abandoned between 1880 and 1890 because of heavily watered measures and the *inferior quality* of the 12 recorded coals seams of the Lower and Middle Coal Measures. Only two seams, each about 1 m thick, were mined to any extent. A veneer of Lower or Middle Coal Measures may be present beneath Triassic sediments and connect the Nailsea and Somerset coalfields at the northwest corner of the licence.

Lower and Middle Coal Measures Age: Westphalian A-C/Middle Carboniferous/about 320-335 m.y.

Lower and Middle Coal Measures Depths: 0-2,800+m/0-9,000+ft

(Dr. D. P. Creedy of Wardell Armstrong in his 1999 report titled "Coalbed Methane - R & D Needs of the UK" estimates coal depths in Bristol/Somerset at 0-2,200 m. The maximum basin depth/thickness figure quoted above agrees with the British Geological

Survey's estimate in the 1993 report titled "An Evaluation of CBM Potential in Great Britain.")

Prospective Part of Licence

Area with no Coal Measures: 95 km<sup>2</sup>/23.75 % (Overlay 1)

Area with target Coal Measures below 5,000 feet: 136 km<sup>2</sup>/34 % (Overlay 1)

Area with target Coal Measures above 500 feet: 14 km<sup>2</sup>/3.5 % (Overlays 1 and 4)

Urban areas: 20 km<sup>2</sup>/5 % (Overlay 3)

Mined areas not already excluded by urbanization and coal depths: 10 km<sup>2</sup>/2.5 % (Overlay 2)

Net prospective and developable area with target coals between 500 and 5,000 feet: 125 km<sup>2</sup>/12,500 hectares/31.25 % (Overlay 4)

(The preliminary estimate from Appendix B of the licence application for PEDL074 was 25,000 hectares of probable and possible productive area. This more detailed screening for CBM prospectivity yields one half the original estimate.)

## **Gas Content**

No gas content data are available for Somerset. Creedy in his 1999 report titled "Coalbed Methane - The R & D Needs of the UK" estimates an average gas content of 0.1 m<sup>3</sup>/ton for Bristol/Somerset coals. This figure is not based on any measurements. If this estimate is accurate, then this licence is not prospective for CBM development.

Methane is recorded from the Lower and Middle Coal Measures in the Nettlebridge Valley area (southeasternmost PEDL074) and at Kingswood and Easton (just north of PEDL074) (Preston, 1871). Collieries with firedamp (methane) explosions resulting in death include the following mines working the target coals in the vicinity of the southeast corner of PEDL074: Stratton, Newbury, Vobster, Old Vobster and Edford. The sole mention of firedamp ignition in Somerset mines working the Upper Coal Measures was in Kilmersdon in 1759. Kilmersdon is situated 3+ km north of the southeast corner of PEDL074, not far from the Nettlebridge Valley and at the northern edge of a major structure that continues at a low angle to the south, the Southern Overthrust. Historically naked light working (using open flames for illumination) was almost universal in Somerset mines targeting Upper Coal Measures due to the lack of firedamp.

In the absence of gas content data, coal rank analyses will substitute to define CBM prospectivity in PEDL074.

## **Lower and Middle Coal Measures Rank**

Medium volatile bituminous (mvb) to low volatile bituminous (lvb) within PEDL074 (See graphs on following page.)

In general, volatile content of the dry, ash-free bituminous coal is higher, ranging from 31 to 34 % (hvAb), north of the Kingswood anticline. Volatile content decreases to 25-28 % in the Kingswood anticline and continues to decrease southward toward the deepest portion of the Somerset coalfield near Pensford. Overall data are sparse and no Middle and Lower Coal Measures rank data are available for the basin center. However, Upper Coal Measures coals from Pensford Colliery show the highest rank in Bristol/Somerset, with volatiles ranging from 22 to 30 %; borderline lvb to mvb coals are evident 4,000-6,000 feet (1,220-1,820 m) above the target seams in the Pensford-Bromley area. Lower and Middle Coal Measures seams nearest the basin center in the Winford boreholes 4-5 km west of Pensford-Bromley have daf volatile contents ranging from 16 to 20 % - the lowest reported in Bristol/Somerset coalfield. Finally, at the south edge of Somerset basin, volatiles range from 24 to 28 % in seams from Ston Easton No. 1 and 2 boreholes. As expected, coal maturation on the perimeter of Somerset coalfield is less than for coals nearer the depositional center. (Overlay 4)

In British coal basins one of the most important factors controlling the amount of preserved adsorbed methane in coals appears to be the degree of syn- and post-depositional basin uplift and erosion. While enough methane to saturate the coals was probably generated during infilling of Upper Carboniferous coal basins, extensive degasification appears to have taken place during the end-Carboniferous Variscan orogeny. Subsequent Permo-Triassic reburial of coal sequences appears to have been insufficient to significantly replenish adsorbed methane over much of Great Britain. For this reason and due to significant mining of the Upper Coal Measures in the center of Somerset basin, the Upper Carboniferous coals are not considered a primary CBM target in PEDL074. At this stage of exploration, the most prospective area for siting coreholes targets Middle and Lower Coal Measures seams that might still retain their original adsorbed methane.

D.P. Creedy in a 1988 paper titled "Geological Controls on the Formation and Distribution of Gas in British Coal Measure Strata" plots the relationship between methane content and volatile matter content for a range of British coals. His dataset suggests that coals with volatile contents of 30 % would be expected to range from 7-15 m<sup>3</sup>/t methane and those with 20% volatiles might range from 12-18 m<sup>3</sup>/t methane. In addition Creedy reports that in-seam methane content gradients typically range from 0.1 to 0.01 m<sup>3</sup>/t per 100 m depth in British coalfields. Raw data for this paper were drawn from a seam gas content database containing some 4000 results of gas content measurement on samples of coal core from surface exploration boreholes. Therefore, these figures may provide general guidance for gas contents of target Somerset coals near their methane sorption capacity.

Somerset volatile content data are presented in Appendix 1 as these are not collated elsewhere in published reports.

## Target Coal Thickness

Coal thickness data have been tabulated for PEDL074 in a spreadsheet file titled "Somerset coals" and a paper copy is attached here as Appendix 2. Data for Lower and Middle Coal Measures are sparse and have been plotted with select Upper Coal Measures mining data on Overlay 4.

Because of structural problems and variations in borehole depths, coal data have been plotted as a percent of section rather than as a numeral thickness for each data point. This allows easier calculation of gas reserves.

## Potential Gas Reserves

First order gas reserves estimates have been calculated using coal thickness and average gas contents data for methane-saturated coal based on Creedy's plotted relationship of methane content vs volatile content for British coals. (It should be noted that these numbers are *highly* optimistic.) Volatile content data are plotted on Overlay 4 to suggest field-scale trends in coal rank. Prospective developable areas were also outlined and three areas were identified (see overlay). The areal extent of these three regions is 108 km<sup>2</sup>, less than the 125 km<sup>2</sup> previously estimated, because an additional 17 km<sup>2</sup> was deemed undevelopable for practical purposes during final review of data for reserve calculations.

### Area 1

Area 1 is situated in the northeast corner of the licence. It is isolated from the remaining prospective region by Bristol urbanization and the central Somerset coalfield where, to the southwest, the base of the target coals ranges from 5,000 feet to 9,000 feet in depth.

Area: 4 km<sup>2</sup>

Depths: 0-5,000 ft (0-1,524 m)

Thickness of Upper Coal Measures (UCM) % coal: 2.0%

Thickness Lower and Middle Coal Measures (L+MCM) % coal: 1.8%

Average thickness of Area 1 Coal Measures: 3,500 ft/1,067m

UCM estimated gas contents: "8 m<sup>3</sup>/t"

L+MCM estimated gas contents: "13 m<sup>3</sup>/t"

Coal density: 1.35 tons/m<sup>3</sup> (for all areas)

Assume 100% methane as gas composition for all areas.

Assume the surface 500 feet (152 m) of Coal Measures are not prospective for all areas.

Area 1 calculated methane reserves:

$3,000,000 \text{ m}^2 \times 610 \text{ m} \times 0.018 \text{ L+MCM coal} \times 1.35 \text{ t coal/m}^3 \times 13 \text{ m}^3 \text{ CH}_4/\text{m}^3 = 0.58 \times 10^9$

$11,000,000 \text{ m}^2 \times 762 \text{ m} \times 0.018 \text{ L+MCM coal} \times 1.35 \text{ t coal/m}^3 \times 13 \text{ m}^3 \text{ CH}_4/\text{m}^3 = 2.64 \times 10^9$

$11,000,000 \text{ m}^2 \times 228 \text{ m} \times 0.02 \text{ UCM coal} \times 1.35 \text{ t coal/m}^3 \times 8 \text{ m}^3 \text{ CH}_4/\text{m}^3 = 0.54 \times 10^9$

Area 1 total reserves:  $3.8 \times 10^9 \text{ CH}_4 \text{ m}^3 / 0.27 \times 10^9 \text{ CH}_4 \text{ m}^3/\text{sq km}$

The maximum number of wells at 32 hectares/wells is 44. This area is too small and isolated and does not merit drilling a corehole.

## Area 2

Area 2 is situated in the western half of the licence, north of the western extension of the Farmborough Fault Belt that separates this area from Area 3. It is the largest of the three prospective regions. Negatives include the results of the Dundry borehole (v. little coal) that are *assumed to be unrepresentative* of the region and proximity to villages of the best site for a corehole. One positive: the highest coal rank reported in Somerset occurs in the Winford wells.

Area:  $54 \text{ km}^2$

Depths: 0- 5,000 ft (0-1,524 m)

UCM % coal: 2.2% L+MCM % coal: 1.3%

Average thickness: 1,500 ft (457 m) above 2,500 ft (762 m) 3,750 ft (1,143 m) between 2,500 and 5,000 ft (762 and 1,524 m)

Area ranging in depth from 500 to 2,500 ft (M+LCM only):  $35 \text{ km}^2$

Area ranging in depth from 2,500 to 5,000 ft (All CMs):  $19 \text{ km}^2$

UCM estimated gas content: "8 m<sup>3</sup>/t"

L+MCM estimated gas content: "16 m<sup>3</sup>/t"

Area 2 calculated methane reserves:

$35,000,000 \text{ m}^2 \times 328 \text{ m} \times 0.013 \text{ L+MCM coal} \times 1.35 \text{ t coal/m}^3 \times 16 \text{ m}^3 \text{ CH}_4/\text{m}^3 = 3.2 \times 10^9$

$19,000,000 \text{ m}^2 \times 762 \text{ m} \times 0.013 \text{ L+MCM coal} \times 1.35 \text{ t coal/m}^3 \times 16 \text{ m}^3 \text{ CH}_4/\text{m}^3 = 4.1 \times 10^9$

$19,000,000 \text{ m}^2 \times 328 \text{ m} \times 0.022 \text{ UCM coal} \times 1.35 \text{ t coal/m}^3 \times 8 \text{ m}^3 \text{ CH}_4/\text{m}^3 \text{ coal} = 1.5 \times 10^9$

Area 2 total reserves:  $8.8 \times 10^9 \text{ CH}_4 \text{ m}^3 / 0.16 \times 10^9 \text{ CH}_4 \text{ m}^3 / \text{km}^2$

Both areas 2 and 3 are transected by east-west thrust faults and north-south normal faults and continuity of coals in the subsurface is a major concern. The less competent L+MCM mudstone-dominant strata have generally been squeezed and contorted between more competent rocks, sequences dominated by sandstone and/or limestone, that have also been folded and faulted but to a lesser degree. The Triassic apron along the northern edge of the Mendip Hills probably covers a thrust fault of early Carboniferous rocks overriding less competent Coal Measures for the width of

PEDL074. The throw on such thrust faults generally diminishes westward from the Radstock area where offset can exceed 1,000 feet. Hole siting in Somerset must avoid known faults and target larger fault blocks.

This area can accommodate drilling 168 wells on a 32 hectare well spacing. A prospective location to drill a 5,000 ft corehole, designated "A" on Overlay 4, is 1.5 km northeast of Chew Valley Lake and 1 km east of Chew Magna.

### Area 3

Area 3 is situated south and southwest of the central part of Radstock basin and north-northeast of the Mendip Hills. Mines working the southeasternmost portion of this area produced gassy coal over many centuries of operations. Siting a corehole in Area 3 involves less geologic risk regarding the presence of methane. Thus, this area is considered more prospective than Area 2.

Area: 40 km<sup>2</sup>

Depths: 0-5,000 ft (0-1,524 m)

UCM % coal: 2.5% L+MCM % coal: 2.5%

Average thickness: 1,500 ft (457 m) above 2,500 ft (762 m) 4,000 ft (1,220 m) between 2,500 and 5,000 ft (762 and 1,524 m)

Area ranging in depth from 500 to 2,500 ft (152-762 m) (M+LCM only): 9 km<sup>2</sup>

Area ranging in depth from 2,500 to 5,000 ft (762 to 1,524 m) (All CMs): 31 km<sup>2</sup>

UCM estimated gas content: "8 m<sup>3</sup>/t"

L+MCM estimated gas content: "13 m<sup>3</sup>/t"

Area 3 calculated methane reserves:

$9,000,000 \text{ m}^2 \times 328 \text{ m} \times 0.025 \text{ L+MCM coal} \times 1.35 \text{ t coal/m}^3 \times 13 \text{ m}^3 \text{ CH}_4/\text{m}^3 = 1.3 \times 10^9$

$31,000,000 \text{ m}^2 \times 762 \text{ m} \times 0.025 \text{ L+MCM coal} \times 1.35 \text{ t coal/m}^3 \times 13 \text{ m}^3 \text{ CH}_4/\text{m}^3 = 10.4 \times 10^9$

$31,000,000 \text{ m}^2 \times 328 \text{ m} \times 0.025 \text{ UCM coal} \times 1.35 \text{ t coal/m}^3 \times 8 \text{ m}^3 \text{ CH}_4/\text{m}^3 \text{ coal} = 2.7 \times 10^9$

Area 3 Total:  $14.4 \times 10^9 \text{ CH}_4 \text{ m}^3 / 0.36 \times 10^9 \text{ CH}_4 \text{ m}^3 / \text{km}^2$

In addition to being less risky for siting a corehole, the Area 3 estimated resource density is more than twice that in Area 2. Area 3 can accommodate about 125 wells. A central and prospective site for an Area 3 corehole is about 1.5 km east of Hinton Blewitt (Location "B" on Overlay 4).

### Methane resource for PEDL074

- 1) Best Case Maximum estimated at  $2.7 \times 10^{10}$  CH<sub>4</sub> m<sup>3</sup> as calculated above over a 108 km<sup>2</sup> area (27% of licence)
- 2) If the sandstone-dominant shallow UCMs have 0 m<sup>3</sup> CH<sub>4</sub>/t above 5,000 ft: Estimated at  $2.2 \times 10^{10}$  CH<sub>4</sub> m<sup>3</sup>
- 3) Worst case If UCMs have no gas and L+MCMS have 50% of estimated gas content: Estimated at  $1.1 \times 10^{10}$  CH<sub>4</sub> m<sup>3</sup>

An assumed recovery factor of 50% would cut the resource estimate by one half to yield an estimate of producible gas.

#### Average resource density

Best Case:  $0.25 \times 10^9$  CH<sub>4</sub> m<sup>3</sup>/ km<sup>2</sup>  
Worst Case:  $0.10 \times 10^9$  CH<sub>4</sub> m<sup>3</sup>/ km<sup>2</sup>

Maximum number of 700-5,000 ft wells at full development of prospective acreage is about 300.

Confidence in the gas content figures in making this estimate are not high as no gas content data are available for Somerset coalfield. This is a major reason to core and further assess the CBM potential of PEDL074.

## **Appendix 1. Bristol-Somerset Coal Seam Volatile Contents**

Data for Lower and Middle Coal Measure seams (from north to south) in the Harry Stoke (6-9 km north of PEDL074) and Kingswood (4 km north of PEDL074) areas:

Five Coals, Great Vein and Gillers Inn seams from about 1200 feet in Harry Stoke B borehole [6321 7816] UK coordinates: 31-34 % volatiles, 4-10 % ash and 1-1.5 % sulfur  
"Clean" seams between 1,400 and 2,100 feet in Harry Stoke B borehole:

33 % volatiles, 6.8-9.4 % ash and ?sulfur

Gillers Inn Seam from about 2500 feet in Harry Stoke C borehole [6504 7677]:

25 % volatiles, "low ash and sulfur"

Two Feet Seam at Speedwell Colliery [6323 7442] from about 1,100 feet:

28 % volatiles, 7-9 % ash and 1-1.2 % sulfur

Ashton Great Vein of Ashton Park Borehole [5633 7146] from about 500 feet?:

25 % volatiles, 6 % ash, <1 % sulfur

Data for Upper Coal Measures within PEDL074:

7.5" seam at 467 feet in Hursley Hill No. 1 Borehole [6180 6565]:

30.3 % volatiles, 11.5 % ash, 3.6 % sulfur

16" seam at 1146 feet in Hursley Hill No. 1 Borehole:

26% volatiles, 8.1 % ash, 3 % sulfur

9.5" seam at 1593 feet in Hursley Hill No. 1 Borehole:

26 % volatiles, 14 % ash, 6.3 % sulfur

2" seam at 1725 feet in Hursley Hill No. 1 Borehole:

26 % volatiles, 13.6 % ash, 2.0 % sulfur

7" seam at 1791 feet in Hursley Hill No. 1 Borehole:

24 % volatiles, 5.7 % ash, 1.3 % sulfur

27" seam (Pensford 2?) at 1883 feet in Hursley Hill No. 1 Borehole:

25 % volatiles, 15.9 % ash, 5 % sulfur

8" seam at 1886 feet in Hursley Hill No. 1 Borehole:

22 % volatiles, 12.5 % ash, ? sulfur

28" seam (Pensford 3?) at 1889 feet in Hursley Hill No. 1 Borehole:

23 % volatiles, 7.2 % ash, 1.5 % sulfur, 15,660 Btu/lb

9" seam at 1897 feet in Hursley Hill No. 1 Borehole:

24.6 % volatiles, 4.9 % ash, 1.3 % sulfur

7.5" seam at 1920 feet in Hursley Hill No. 1 Borehole:

23.6 % volatiles, 14 % ash, 2.2 % sulfur

Data for Lower and Middle Coal Measures (from north to south) within PEDL074:

66" seam from Ashton Group of coals at 259 feet in Winford No. 1 [5573 6375] and 261 feet in Winford 1a (drilled a few feet away to resample this coal):

17.2-19.5 % volatiles (15.9 % dafcc), 5.7-8.2 % ash, 0.8-0.9 % sulfur (poor sample recovery - recored in 1a borehole)

24" seam from 736 feet in Winford No. 2 [5636 6343]:

15.2 % volatiles dafcc, 4.1 % ash, 0.78 % sulfur (poor sample recovery)

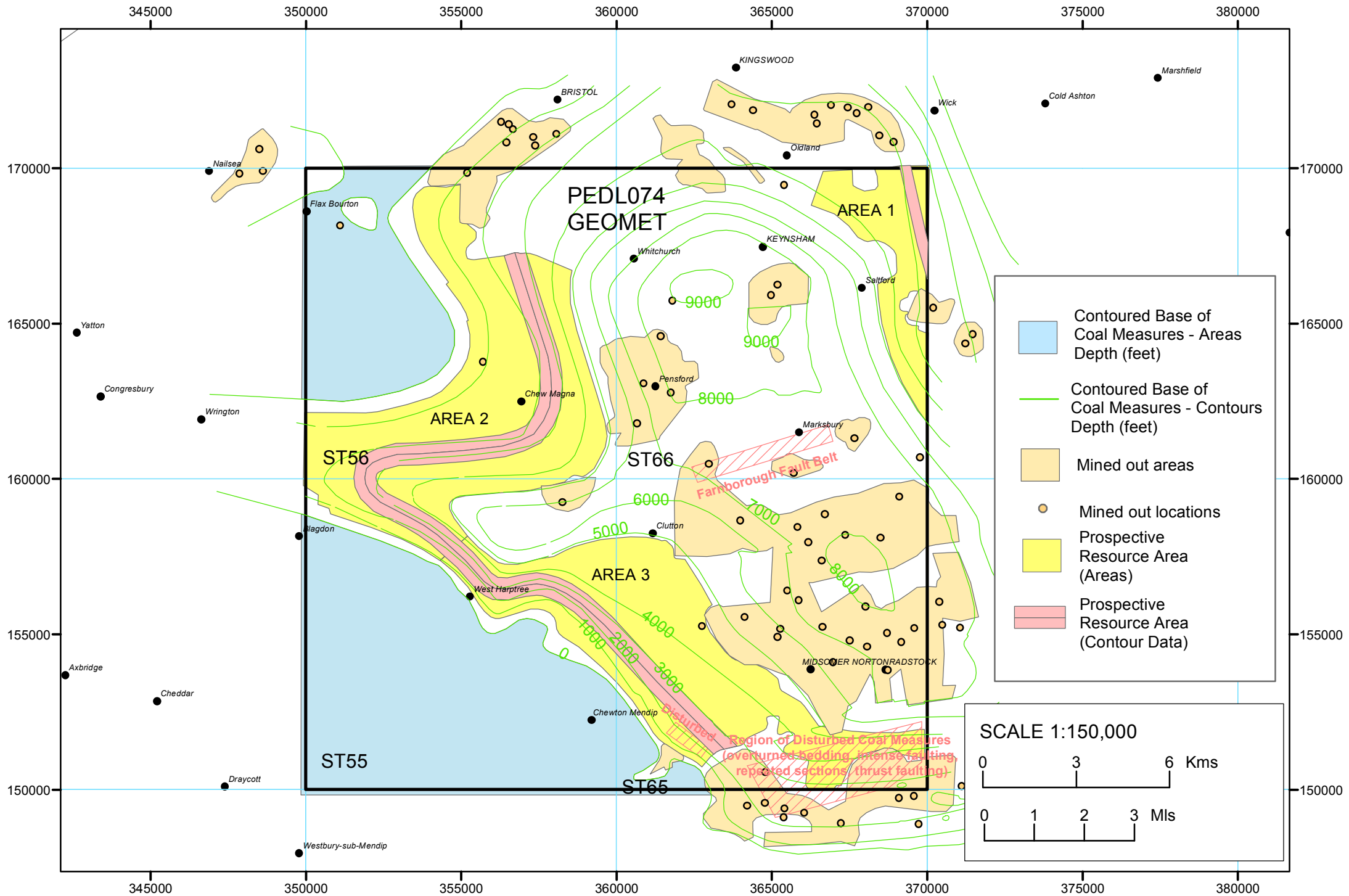
9" seam from 811 feet in Winford No. 2:



18.1 % volatiles dafcc, 5.2 % ash, 0.94 % sulfur (poor sample recovery)  
100" ? seam at 871 feet in Winford No. 2:  
15.0 % volatiles dafcc, 9.1 % ash, 0.88 % sulfur (poor sample recovery)  
18-24" seam at 928 feet in Winford No. 2:  
16.8 % volatiles daf, 6.8 % ash, 0.95 % sulfur (poor sample recovery)  
24 " seam at 950 feet in Winford No. 2:  
16.7 % volatiles daf, 8.8 % ash, 1.0 % sulfur (poor sample recovery)  
42" seam in Kingswood Group from 1023 feet in Winford No. 2:  
17.2-19.5 % volatiles (17.1 % dafcc), 9.5-9.9 % ash, 1.3-1.8 % sulfur; 15,410 Btu/lb  
(good rec.)  
39" seam from 1394 feet in Winford No. 2:  
19.1 % volatiles daf, 16.1 % ash, 1.2 % sulfur

(N.B. In the following two holes strata were commonly contorted and steeply dipping.)

21 ft 3 in seam at 904 feet (Main or Callows ?) in Ston Easton No. 1 Borehole [6225 5174]:  
"medium volatile", 6.6-20.1 % ash, 0.8-2.8% sulfur  
29 ft 3 in seam at 937 feet (Main or Callows ?) in Ston Easton No. 1 Borehole:  
23.9 % volatiles dafcc, 10.7 % ash, 1.0 % sulfur  
29" seam at 1065 feet (Perrink ?) in Ston Easton No. 1 Borehole:  
25 % volatiles, 6.9-7.4 % ash, 1.4-2.3 % sulfur, high carbonates, 15,200 Btu/lb  
21" seam at 256 feet in Ston Easton No. 2 Borehole [6211 5158]:  
24.5 % volatiles dafcc, 13.5 % ash, 0.9 % sulfur (weathered)  
6" seam at 287 feet in Ston Easton No. 2 Borehole:  
27.5 % volatiles dafcc, 11.6 % ash, 2.6 % sulfur  
"3" seam at 417 feet in Ston Easton No. 2 Borehole:  
26.5 % volatiles dafcc, 7.7-18.1 % ash, 1.35 % sulfur  
23" seam at 499 feet in Ston Easton No. 2 Borehole:  
25.4 % volatiles dafcc, 4.6 % ash, 1.2 % sulfur  
10" seam at 503 feet in Ston Easton No. 2 Borehole:  
25.2 % volatiles dafcc, 6.5 % ash, 1.9 % sulfur  
7 ft 5 in seam at 558 feet in Ston Easton No. 2 Borehole (50 % coal):  
24.7 % volatiles dafcc, 7.6-18 % ash, 1 % sulfur



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