

**COAL EXPLORATION TARGET EVALUATION FOR THE COAL
AUTHORITY UNDERGROUND COAL GASIFICATION LICENCE
CA11/UCG/0024/S AT POINT OF AYR, FLINTSHIRE**

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COAL EXPLORATION TARGET EVALUATION FOR THE COAL AUTHORITY UNDERGROUND COAL GASIFICATION LICENCE CA11/UCG/0024/S AT POINT OF AYR, FLINTSHIRE

1 NOTICE

This report presents the preliminary geological assessment of a coal exploration prospect at Point of Ayr, Flintshire in the United Kingdom. Opinions are expressed as to the possible scale of the deposit, so that an appropriate geological exploration strategy can be developed. The term Exploration Target is used in this report. The figures presented are not Coal Resources or Reserves and are conceptual in nature as there has currently been insufficient exploration to define a Coal Resource and it is uncertain if further exploration will result in the development of a Coal Resource.

2 INTRODUCTION

Cluff Natural Resources plc (CNR) has acquired the Coal Authority Underground Coal Gasification (UCG) Exploration Licence for Point of Ayr, Ref. No. CA11/UCG/0024/S. The licence, issued on 15 January 2013 and expiring on 15 January 2018, covers an area of 6,953 ha with the licence boundary shown in Appendix 1. The licence occupies the mouth of the Dee Estuary, with the licence boundary set at the high tide mark from Point of Ayr to Greenfield on the Flintshire coast, and between Hoylake and West Kirby on the Wirral coast.

FWS Consultants Ltd (FWS) has been commissioned by CNR to assess and report on the Exploration Target in the Deeside UCG Exploration licence area, in the United Kingdom. This JORC-compliant Exploration Target report presents the geological data, methodology and results of the coal exploration target determined for this UCG exploration licence.

3 METHODOLOGY FOR DEFINING A JORC EXPLORATION TARGET

3.1 Definition

An Exploration Target, as outlined by the JORC Code 2012 (Ref. 13), is defined as:-

'An Exploration Target is a statement or estimate of the exploration potential of a mineral deposit in a defined geological setting where the statement or estimate, quoted as a range of tonnes and a range of grade (or quality), relates to mineralisation for which there has been insufficient exploration to estimate a Mineral Resource.'

To determine the conceptual quantities and grade of coal within the licence area, reference is given to published guidelines for the estimation of coal resources/reserves of the Geological Survey of Canada Paper 88-21 (Ref. 12). This classifies coal deposits in terms of their geological complexity (Geology Type) and presents methods for determining key quantification parameters including seam thickness, areal extent and bulk density, as defined below:-

Geology Type – *'Four categories of 'Geology Type' are proposed to address differences in the complexity of seam geometry within deposits. These differences may result both from*

sedimentary processes at the time of coal deposition and from subsequent deformation that may have folded and faulted the coal measures. Primary categories are termed low, moderate, complex and severe. The low category is further subdivided into A, B and C, based on the sedimentologically controlled complexity of seam geometry.’ (Ref. 12).

General definitions of these categories with suggested examples are outlined in Ref. 12. Under this classification, the Point of Ayr licence area would fall into the category of ‘moderate complexity’:-

‘Deposits in this category have been affected to some extent by tectonic deformation. They are characterised by homoclines or broad, open folds (wavelengths greater than 1.5 km) with bedding generally less than 30°. Faults may be present, but are relatively uncommon and generally have displacement of less than ten metres.’ (Ref. 12).

Information on seam thickness, bulk density and areal extent are needed in order to calculate Exploration Target ranges. The following definitions are proposed by the Survey for the determination of these parameters:-

Data Point – *‘For the determination of seam thicknesses, a data point constitutes a surface outcrop at which the roof and floor of a seam are exposed and true thickness can be determined or estimated. A subsurface borehole intersection where the seam is completely penetrated, or observations from underground workings where the seam is completely exposed.’ (Ref. 12).*

The data points used for the Point of Ayr licence are records of underground workings obtained from the Coal Authority Mining Records Office and borehole data obtained from 58 legacy wells (Table 1, Appendix 2 and Appendix 5).

Bulk Density – The *in situ* bulk density of the seam, determined for the whole seam and clean coal, has been estimated from legacy British Coal/NCB exploration data from 18 boreholes (Appendices 3 and 4).

Areal Extent and Depth– The method of determining the areal extent of the coal seams utilising available exploration data is dependent on Geology Type (Ref. 12).

‘In deposits of low and moderate complexity, coal seam configuration may be determined utilising contour maps of seam elevation generated by direct interpolation/extrapolation of available data.’ (Ref. 12).

Contour maps of the depths Below Ordnance Datum (BOD) for target seams in the Point of Ayr Licence were generated using the Surfer v. 10 software package that uses a combination of true and false points in an iterative process to generate a statistically robust predication of depth contours. ‘True’ point data were obtained from mine plans and borehole intersections, whereas ‘false’ or estimated points, were placed to constrain the likely depth of seams in areas with little or no data coverage. A map of the true and false data points used in the modelling process is given in Drawing 1865OD017 and a full list of these data points is given in Appendix 6. The seam thicknesses and separations used to calculate depths and areas are given in Appendix 9.

3.1.1 Exploration Target Ranges

Exploration Target ranges are calculated on an *in situ* basis with no recovery factors applied.

4 GEOLOGICAL DATABASE

The distribution of available data is clustered in particular geographical locations centred on the former collieries within the licence area, with particularly sparse data coverage in the Northern licence and Wirral coast (Drawing 1865OD013). The geological database on which this evaluation is based (i.e. offshore) includes the following regional and local information:-

4.1 Maps and Cross-Sections

The key regional geological map of the licence area is the 1:50,000 bedrock map of Liverpool and the Wirral (Ref. 1 and Drawing 1865OD015). The accompanying southwest–northeast geological cross-section (line 1) across the mouth of the estuary gives the best available interpretation of the underlying structure (Drawing 1865OD038) and likely depth of Coal Measures beneath the Dee Estuary. The following British Geological Survey (BGS) 1:10,000 geological maps of the Dee Estuary coastal stretches were used in the identification of key structures that may control seam depth in the area; SJ28NW (Hoylake), SJ28SW (Thurstaston), SJ27SW (Flint), SJ27NW (Bagillt), SJ18SW (Point of Ayr), SJ18SE (Mostyn) and SJ17NE (Holywell). In addition, two schematic tunnel cross-sections at Mostyn and Bagillt collieries (Ref. 3) were referred to for structural interpretations in the south of the licence area (Appendix 7).

4.2 Well Data

Borehole data detailed in Table 1 and Drawing 1865OD013 is a combination of Open Source and confidential data that was obtained from the Coal Authority and the BGS' GeoIndex (Ref. 2) website. Confidential well data were obtained from the Department of Energy and Climate Change (DECC) via IHS for the Mostyn Quay 1 borehole.

The vast majority of well data relates to the former colliery at Point of Ayr, with a lesser number of boreholes relating to Mostyn colliery. The distribution of boreholes extends northwest to southeast along the Flintshire coast part of the licence area (Drawing 1865OD013). These data comprised scanned logs of 34 historical boreholes, mostly relating to the Point of Ayr colliery and penetrating between one and three coal seams. Key boreholes that penetrate multiple seams and significant thicknesses of Lower and Middle Coal Measures along the Flintshire coast are the deep boreholes in the Dee Estuary (Salisbury Bank, Hoyle Bank and Dee Estuary No. 1) and Point of Ayr colliery boreholes 1/85, 5/85 and No 4, (Drawing 1865OD013). Details of all boreholes used in this report, plus summary vertical sections based on shafts from the Rhewl Pit (Mostyn), Sir Roger's Pit (Bagillt) and Marsh Pit (Flint), all along the Flintshire coast, are given in Appendix 2.

Nineteen boreholes were obtained that related to Neston colliery, which is situated approximately 10 km east of Englefield colliery and is the only major mining area on the Wirral coast. There are no deep borehole data available within the licence for the Wirral coast. The closest deep borehole is at Heswall, approximately 5 km southeast of the licence boundary, where it intersects the Wirral coastline (Drawing 1865OD013).

Well data are not available for the Central Dee Estuary or Northern Licence (Drawing 1865OD013).

The Liverpool Bay 1 borehole lies offshore approximately 8 km northeast of the Wirral coast part of the Licence area (Drawing 1865OD013). The logs for this confidential borehole were not obtained, but the geophysical summary was obtained from the UK Onshore Geophysical Database (UKOGL; Ref. 5) to identify seismic picks in seismic line SW85-027 (see section 4.3). The well penetrates the full sequence of Permo-Triassic sediments, which overlie undifferentiated Carboniferous Coal Measures and Millstone Grit before ending in Namurian shales (likely Bowland Shales) at 2054.6 m BOD. The borehole summary from UKOGL is given in Appendix 2.

In addition to the Liverpool Bay 1 borehole, the Salisbury Bank and 4/85 (No. 4) wells were used in seismic line interpretation. The 4/85 borehole penetrates Permo-Triassic sediments overlying the Carboniferous Warwickshire Formation and Middle Coal Measures, ending in Lower Coal Measures at 900 m BOD. The Salisbury Bank borehole penetrates Permo-Triassic sediments overlying a significant thickness of Warwickshire Formation, and ends just below the upper boundary of the Middle Coal Measures at 942 m BOD.

4.3 Seismic Survey Information

Seven seismic lines project into the licence area: SW85-039.1; SW85-046; SW85-071; SW85-073, SC87-04; SC87-05 and SC87-12 (Drawing 1865OD037). In addition, seismic lines SW85-027, SW85-041 and SC87-07 lie outside of the licence area in Liverpool Bay. Migrated sections of seismic data for the ten lines were obtained from the UK Onshore Geophysical Database (UKOGL) (Ref. 5). Seismic picks were identified for key horizons picked from the closest deep boreholes to the seismic lines; the Salisbury Bank (seismic line SW85-073), No. 4 (SW85-071) and Liverpool Bay 1 (SW85-027 and SW85-041) boreholes. In the absence of Two Way Travel Time (TWTT), seismic velocity or density information for these three wells, approximate depth/TWTT relationships that are consistent with the Pennine Coal Measures (through comparison with other UKOGL boreholes in northern England) were applied in-house to identify the approximate depth to key reflectors. It should be stressed that this exercise gives an approximation of the depths of key reflectors. Consequently the depths quoted in this section were used as a check for the contour modelling described in Section 7.1.1, but were not used as parameters in the modelling process due to the inherent errors involved in this type of rough seismic interpretation. All seismic lines referred to in this report are presented in Appendix 8.

The Liverpool Bay 1 borehole lies approximately 8.5 km northwest of the licence area and provides a reference point for the depths to key stratigraphical horizons to the east of the licence area. The SW85-027 and SW85-041 seismic lines lie close to the Liverpool Bay 1 borehole, which penetrates the full sequence of Permo-Triassic and Coal Measures, ending in the Bowland Shales. The following picks were identified from the Liverpool Bay 1 well and extended, where possible, across the other four other seismic lines in the licence area:-

- Base Mercia Mudstone (TWTT = 160 m/sec [290 m])
- Base Sherwood Sandstone (TWTT = 475 m/sec [860 m])
- Base Manchester Marl (TWTT = 525 m/sec [950 m])
- Base Collyhurst Sandstone (TWTT = 575 m/sec [1045 m])
- Base undifferentiated Coal Measures (TWTT = 820 m/sec [1500 m])

- Base Millstone Grit (TWTT = 1170 m/sec [2040 m])
- The borehole ends in Namurian shales at 2054.6 m BOD

The 4/85 (No. 4 borehole) lies approximately 2 km north of the SW85-071 seismic line and identified seismic reflectors at the base Permian (TWTT = 70 m/sec [140 m]) and the base Warwickshire Formation (TWTT = 250 m/sec [460 m]). A reflector was not associated with the base of the Middle Coal Measures, but from well data in 4/85 the boundary is predicted to lie at TWTT = 433 m/sec (789 m). Borehole 4/85 ends in Lower Coal Measures TWTT = 494 m/sec (900 m). It should be noted that this borehole is intersected by one of the basin-bounding faults with a significant offset and poor seismic resolution in the area of the borehole location. Consequently only limited extrapolation of the seismic picks from the 4/85 borehole was possible.

The Salisbury Bank borehole is situated approximately 1 km north of the SW85-073 seismic line and was used to identify picks for the base Permian (TWTT = 202 m/sec [370 m]). The Warwickshire Formation is noted in the borehole to underlie the Permian unconformity but there is no reflector between the Warwickshire Formation and Middle Coal Measures; this boundary is defined by the Warras Marine Band and is predicted to lie at TWTT = 514 m/sec (935 m). The Salisbury Bank borehole ends in the Middle Coal Measures just below the Warras Marine Band at TWTT = 1193 m/sec (940 m).

Seismic line SW85-027 (Appendix 8; Drawing 1865OD031) provides the best resolution of deep strata and structures. The depth resolution of the other seismic lines markedly decreases westwards towards the Dee Estuary. Seismic line SW85-073 (Appendix 8; Drawing 1865OD036) in the Flintshire coast part of the licence is the poorest quality migrated section, from which no interpretation was possible without further reprocessing.

Seismic lines SC87-04, SC87-05 and SC87-012 encroach on the easternmost point of the licence area on the Wirral coast and, in the absence of well data for this part of the licence, provide an estimate of depths and structural complexity. The seismic lines suggest that the Permo-Triassic sedimentary pile extends down to depths of approximately 1000 to 1100 m. Based on the No. 4 (4/85) borehole, which provides the most detailed log of the sequence, interception of the top of the Middle Coal Measures would be expected at 1400 to 1500 m, in line with the findings with the BGS regional cross-section (Ref. 1). FWS is satisfied that the in-house interpreted seismic lines broadly support the results of the contour modelling process outlined in Section 7.1.1.

4.4 Mine Plans

All of the available mine plans within the licence area were obtained from the Coal Authority Mining Records Office and are included as digital data (on a CD), along with a summary, in Appendix 5. In total, 78 mine plans were obtained, as detailed in Appendix 5, from the Point of Ayr, Mostyn, Hanmer and Englefield collieries along the Flintshire coast (Drawing 1865OD013) for the following seams:-

- Five Yard (Main)
- (Mostyn) Two Yard
- Three Yard
- Durbog

- Stone
- Hard Five Quarter
- Soft Five Quarter
- Badger
- Bychton Two Yard

Drawing 1865OD030 shows the areas within, and adjacent to, the licence area where mine abandonment plans have been obtained and the number of mine plans per colliery are given in Appendix 5; Table 1. The quality of the mine plans varied greatly, with the most detailed available at Point of Ayr. The majority of plans for the other collieries were much older (late 1800s) and contained only limited information on seam characteristics, depth and geographical reference.

4.5 Coal Quality Data

Coal quality data were obtained for 18 boreholes summarised in Table 1 through the BGS Deep Mine Archive, with the full dataset presented in Appendices 3 and 4. The data cover whole seam analyses for the Five Yard, Three Yard, Two Yard, Durbog, Stone and Bychton Two Yard seams and main leaf or partial seam analyses for all the above plus Hard Five Quarter.

4.6 Publications

Published information on the stratigraphy and palaeoenvironment, palaeontology and basement structures is contained in Refs. 6, 7, 9 and 11, and more detailed accounts of the Coal Measures were referred to in Refs. 3 and 8 to 10. Additional information on the UK coalfields is given in Ref. 4, and generic information on coal quality is referred to in Ref. 12.

5 ENVIRONMENTAL CONSIDERATIONS

5.1 Hydrogeology

The bedrock geology of the coastline surrounding the Dee Estuary is subject to a number of regional and local aquifer designations (Drawing 1865OD026); the Triassic Sherwood Sandstone Group is designated a Principal Aquifer along the entire section of coast on the Wirral side of the estuary and the overlying Mercia Mudstone Group has a Secondary B Aquifer designation. On the Flintshire coast of the estuary, the Carboniferous limestone is a Principal Aquifer and the Coal Measures themselves have a Secondary A designation.

Superficial aquifers are not as extensive (Drawing 1865OD027), with Secondary A Aquifers skirting the coast at Point of Ayr and Hoylake.

5.1.1 Conservation

The entire Dee Estuary as far as the high tide mark is covered by the following statutory protection orders (Drawing 1865OD028); Site of Special Scientific Interest, Special Protection Area, Ramsar and Special Area of Conservation. The coastal areas around Point of Ayr and Hoylake are also covered by these. Little Hilbre Island is designated as a Local Nature Reserve.

6 GEOLOGICAL SETTING

6.1 Palaeogeographical Setting

The Dee Estuary lies at the southern end of the Permo-Triassic East Deemster Basin, a regional graben system separating the major East Irish Sea and Cheshire Basins, which is superimposed on a southern extension of the Carboniferous Bowland Basin. Following the Caledonian orogeny during the late Devonian and Dinantian, the Bowland and eastern Irish Sea areas were subject to a period of rifting in response to regional extension (Refs. 7 and 14). This was followed by regional thermal subsidence during the Namurian and Westphalian, during which time major prograding delta sequences from the north kept pace with subsidence, creating a shallowing-up sedimentary sequence with periodic marine submergence that is recorded in the Namurian Millstone Grit and Westphalian Coal Measures. The northwards-advancing Variscan front during the later Westphalian and into the Stephanian likely resulted in the reactivation of the N-S trending, early Carboniferous basement faults. This Variscan uplift and erosion at the end Carboniferous was followed by the unconformable deposition of Permian red beds. The region was subsequently subject to multiple phases of Mesozoic and Tertiary tectonism, including basin subsidence during the Permian and Triassic and late Cretaceous and Alpine uplift and inversion (Refs. 6 and 7).

6.2 Stratigraphy

The principal stratigraphical units from surface to the top of the target Middle Coal Measures (MCM) comprise a variable thickness (0 to 1300 m) of Permian and Triassic red beds, represented by the Triassic Sherwood Sandstone (1120 to 1220 m) and Permian Manchester Marl (0 to 50 m) and Collyhurst Sandstone (50 to 75 m). Rocks of Permian and Triassic age are not present onshore along the Flintshire coast part of the licence area, first appearing across a faulted boundary beneath the Dee Estuary (Drawing 1865OD015), initially in thicknesses of ~170 m near the fault, thickening eastwards across the Dee Estuary to ~1300 m on the Wirral coast (Ref. 1 and Drawing 1865OD038).

The Warwickshire Group is present across much of the offshore licence area in thicknesses of 0 to 645+ m. It is unconformably overlain by the Permo-Triassic sediments and overlies the Middle Coal Measures (MCM) (Ref. 1). The Upper Coal Measures (UCM) are not recognised in the licence area. The Warwickshire Group is removed by the Permo-Triassic unconformity in the Flintshire coast part of the licence (Drawing 1865OD013 and 015), or else concealed beneath the unconformity in the Northern, Central Dee Estuary and Wirral coast parts of the licence area (1865OD038).

Both MCM and Lower Coal Measures (LCM) are generally present across the entire licence area, ranging in total thickness from 280 to 375 m, with MCM ranging from 200 to 220 m thick (Ref. 1 and Ref. 14). The MCM and upper portion of the LCM is absent in the Heswall borehole to the east of the licence area (Drawing 1865OD013), likely a result of faulting in the vicinity of the borehole. The absence of MCM is not noted in any other offshore boreholes and the LCM was mined at Neston colliery approximately 4 miles southeast of the Heswall borehole (Drawing 1865OD013). Consequently the absence of part of the productive Coal Measures sequence at Heswall is considered to be a local feature and unlikely to reflect the occurrence of MCM across the licence area. LCM are present across the entire licence area ranging in thickness from

~140 m to ~245 m (Heswall borehole from top of observed LCM to the *G. Subcrenatum* Marine Band and Ref. 14).

Underlying the Coal Measures is the Namurian Millstone Grit, the bottom of which is not proved in the licence area but may attain thicknesses of 150 to 170 m. Ref. 1 predicts that the Millstone Grit is present throughout the licence area.

6.2.1 Millstone Grit (Namurian)

Subsidence during the late Namurian was countered by eustatic sea level rise and high sediment supply from prograding delta sequences, creating a broadly shallowing-up sequence. This sequence is reflected in the Millstone Grit, a thick sequence of grey to buff-coloured, conglomeratic to fine grained, feldspathic sandstones, and brown laminated siltstones and mudstones. The base of the unit has not been encountered in local boreholes, however the top is proved in the Heswall borehole at 1012.54 m, which ends in 'a hard coarse grit with some sandy shales containing plants remains' (Ref. 10). The Mostyn Quay 1 borehole on the Flintshire coast also ends in ca. 160 m of siltstones and fine sandstones of the Gwespar Sandstone (the local name for the Millstone Grit).

6.2.2 Pennine Coal Measures (Westphalian A and B)

The LCM and MCM represent the productive coal measures in the licence area. The typical stratigraphy in the Coal Measures shows progressively a shallowing system beginning with deep marine shales and mudstones that pass vertically into interbedded siltstones, mudstones and sandstones with increasing terrestrial-derived organic content. The sequence culminates in coal seams that represent an emergent environment. Coal development is typically followed by a return to deep water marine sedimentation, resulting in a series of cyclic sequences largely driven by high sediment supply set against marked eustatic fluctuations (Ref. 11).

Fourteen regionally extensive coal seams are shown in Drawing 1865OD014, seven of which show a thickness consistently >1.5 m of clean coal; the Five Yard, Three Yard, Two Yard, Durbog, Stone, Hard Five Quarters and Bychton Two Yard seams. These seams are present along the length of the Flintshire coast in the licence area, where they were worked to varying extents at the Point of Ayr, Mostyn, Hanmer and Englefield collieries within the licence area. These target seams straddle the MCM – LCM boundary in the middle of the productive Coal Measures sequence.

In addition, the following non-target seams have been worked along the Flintshire coast; Three Quarter and Cannel Coal of the MCM at Mostyn and Hanmer collieries, and the Badger, Soft Five Quarter, Brassey and Yard Coals at Hanmer and Englefield collieries. All of these seams lie near the top or bottom of the productive Coal Measures and, where present, generally do not consistently attain the thicknesses required for UCG. The lowest coal in the Lower Coal Measures is the Chwrelau (Little) Coal and was not worked in the licence area.

6.2.3 Warwickshire Group (Westphalian C and D)

The Warwickshire Group is a sequence of red, purple and grey mudstone (Etruria Formation, Westphalian C) which contains increasing amounts of sandstone moving up-sequence into the Salop and Halesowen Formations (Westphalian D) (Drawing 1865OD014). The base of the Etruria

Formation overlies the MCM onshore at Greenfield on the Flintshire Coast (Ref. 1) and strikes northwest where it is truncated against the Permo-Triassic unconformity approximately 2.5 km offshore to the north of Greenfield (Ref. 1). Approximately 570 m of red-green mottled mudstones with subordinate sandstones are reported in the Salisbury Bank borehole (Drawing 1865OD013), suggesting that the Warwickshire Group is present in significant thicknesses beneath much of the Dee Estuary. This is supported by the BGS cross-section (Ref. 1 and Drawing 1865OD038).

Lithologies fitting the description and stratigraphic position of the Warwickshire Group are described in the Dee Estuary No. 1 borehole (Drawing 1865OD013) but are identified as Upper Coal Measures or 'red measures'.

6.2.4 Post Carboniferous Cover

The Coal Measures are variably truncated by a marked angular unconformity at the base of the Permian, which is overlain by a thick sequence of conglomeratic to fine grained red sandstone with subordinate mudstones. Permian and Triassic sediments are juxtaposed against the Coal Measures across the Eastern Boundary Fault (Drawing 1865OD015; section 6.3.2), in the Flintshire coast and Northern parts of the licence area (Drawing 1865OD013). Significant thicknesses are noted on the downthrown east side of this fault, which appear to thicken eastward moving away from the fault as evidenced by the No 4 (169 m), Salisbury Bank (368 m), and Heswall (723 m) boreholes.

The area is covered by varying thicknesses of superficial cover ranging from approximately 20 m to 85 m. They are thickest beneath the Dee Estuary but thin moving onshore as recorded by the Salisbury Bank (60 m), Dee Estuary No. 1 (84 m) and Heswall (18 m) boreholes (Drawing 1865OD013).

6.3 Structural Geology

6.3.1 Overview

The Dee Estuary lies at the southern end of the Permian to Triassic East Deemster Basin, a regional graben system separating the East Irish Sea and Cheshire Basins that, in turn, are superimposed on the Carboniferous southwest Pennine Basin (Drawings 1865OD039 and 040). The licence area also lies on the northern margin of the Welsh Massif (in this area termed the Clwydian Platform), where Carboniferous strata form a basement high (Drawing 1865OD039) along the Flintshire coast (Ref. 7), accounting for the position of the majority of collieries on this side of the Dee Estuary. Fault blocks formed during the initial rifting of the Pennine Basin during the Carboniferous were subsequently reactivated during the Permian and Triassic, thus exerting a structural control on basin formation at this time. Section 6.3.2 outlines the principal fault trends in the licence area and their likely effect on the geometry of coal seams.

6.3.2 Faulting

The BGS 1:10,000 and 1:50,000 geological maps identify two main fault trends in the licence area, both of which are associated with faulting at various scales. The principal fault trend is oriented north-south, with major controlling structures (the Eastern Boundary Fault, Hilbre Fault and Kirby Fault) spaced at 1.5 to 5.5 km (Drawing 1865OD015 and 1865OD038). The Eastern

Boundary Fault is associated with around 500 m of down-to-east displacement (Ref. 1 and boreholes Hoyle Bank, No. 4 and Salisbury Bank). The Hilbre Fault with a possible down-to-west throw of ~250 m (Drawing 1865OD038 and seismic lines SW85-71 and 46 [Appendix 8]). A similar down-to-west displacement of ~250 m is suggested for the West Kirby Fault based on Drawing 1865OD038.

On the Flintshire coast of the Dee Estuary, Carboniferous strata are cut by north-south trending normal faults spaced at 600 m to 1300 m, with displacements in the order of 10s of metres as evidenced from mine plans at Point of Ayr. The Flintshire coast is also cut by a lesser number of east-west trending normal faults spaced at 600 m to 700 m, which swing to northeast-southwest trending around Mostyn (Drawing 1865OD013). The displacement on these faults is not known. Areas of high resolution mapping [e.g. 316,000E, 376,000N to 318,500E, 376,000N] identify areas of minor normal faults spaced at 50 m to 100 m, again with unknown displacement.

On the Wirral coast, the same fault orientations are noted as for the Flintshire coast, but the surface is apparently not as intensely faulted. Exceptions to this are areas of high resolution outcrop mapping near West Kirby [322,500E, 386,000N], Thurstaston Common [324,500E, 384,500N] and the town of Heswall [326,000E, 382,000N] which identify 50 to 100 m spaced approximately east-west trending faults with unknown offset.

The underlying structure beneath the Dee Estuary in the licence area is not well defined beyond the identification of major faults shown in Drawing 1865OD038. Based on the observation of Carboniferous-age faulting in the Coal Measures of the Flintshire coast, it is suggested that the concealed Coal Measures under the Dee Estuary and Wirral coast will show a similar fault pattern. This is supported by seismic line SW85-027 to the northeast of the licence area (Drawing 1865OD037 and Appendix 8), which indicates that faulting is present offshore on spacings of approximately 700 m to 2500 m.

6.3.3 Permo-Triassic Unconformity

Permian and Triassic sediments are noted to have a near horizontal, east to northeast dip (1865OD038), with the depth of Permo-Triassic cover varying in the Dee Estuary from 368 m at Salisbury Bank to 724 m at the Heswall borehole. The thickening in the Permo-Triassic sedimentary pile agrees with the BGS' interpretation of a gently east to northeast dipping unconformable boundary, where some of the thickness variation may be attributable to faulting. Geological mapping (Ref. 1) suggests the removal of part of the MCM sequence to the east and northeast of Mostyn colliery. Significant removal of MCM along the Permo-Triassic unconformity is considered unlikely outside of this area, due to the predominantly shallower dip of the unconformity relative to the Coal Measures, as illustrated in Drawing 1865OD038.

6.4 Coal Geology

6.4.1 Seam Thickness and Continuity

The general stratigraphy of the MCM and LCM of the Flintshire Coalfield is summarised in 1865OD014. Seven seams, detailed below, were identified as potential targets for UCG, based on their good lateral continuity and average seam thickness that includes >1.5 m of clean coal. Average and representative seam thicknesses were taken from mine plans (Appendix 5) and

boreholes (Table 2 and Appendix 2) at the Point of Ayr, Mostyn, Bagillt, Flint and Neston collieries (Drawing 1865OD013) to constrain the range of seam thicknesses across the licence area. It should be noted that the most detailed mine plans and borehole data are sourced exclusively from Point of Ayr colliery. Mine plans from Mostyn, Hanmer and borehole summaries from Bagillt, Mostyn, Flint and Neston collieries are sourced from older data, and give a more simplistic view of coal seams at these collieries compared to Point of Ayr. There are no coal seam data available for the Wirral coast part of the licence area. The regional approximately northwest to southeast variation in coal seam thickness in the licence area is shown in Drawing 1865OD016. Readers should refer to Drawing 1865OD013 for an overview of colliery locations and borehole locations. Unless otherwise stated, all quoted thickness refer to the whole seam including dirt partings.

Five Yard or Main Seam (MCM) – One of the most consistent coal seams in the licence area, which retains a whole seam thickness of approximately 3 m along the Flintshire coast between the nearshore/onshore Point of Ayr and Flint collieries. The seam thickness becomes variable moving offshore to the north of Point of Ayr colliery, with whole seam thickness here ranging from 2.24 to 4.78 m^ψ. The seam is absent at Neston colliery to the southeast of the licence, where only LCM seams were worked (Ref. 3). The seam is typified by one main leaf, usually between 1.80 and 2.20 m thick, bound above and below by at least two thin leaves (1 to 96 cm) and separated by partings ranging from 1 to 44 cm^ψ.

Three Yard (MCM) – A thick but variable seam, which is thickest offshore to the north of Point of Ayr (up to 6.45 m whole seam^λ) and steadily thins southeast along the Flintshire coast to 2.13 m at Bagillt. The seam was also absent at Neston colliery. The majority of coal is contained within one main leaf that varies from 2.70 m to 3.96 m thick at Point of Ayr. The rest of the variation in whole seam thickness is attributed to the variable presence of minor coal leaves and partings above and below the main leaf. The whole seam will typically contain between two and four dirt partings, which vary in thickness from 2 to 128 cm but are generally less than 50 cm thick. An exception is a 3.52 m thick parting in 1/85, which separates the top and main leaves (measuring 2.5 m and 3.63 m respectively) and suggests that significant partings may be present in this seam on a local scale. The minor leaves, which can vary from 3 to 59 cm thick, are more likely to be inferior, dirty or cannel coal.

[Mostyn] Two Yard (MCM) – The average whole seam is thickest at Point of Ayr (3.11 m) but thins markedly to the southeast along the Flintshire coast through Mostyn (1.83 m) and Bagillt (0.83 m)^α collieries. At Flint colliery, the whole seam is 2.08 m thick with coal split between two thin leaves totalling 58 cm and separated by 1.50 m of measures. Offshore to the north and northwest of Point of Ayr, the seam generally retains a whole seam thickness of approximately 2.5 to 3.5 m^β. The Two Yard seam is 1.96 m thick at Neston colliery, suggesting that seam thinning is less significant offshore than is observed along the Flintshire coast.

^ψ Based on 1/85, No. 4, 5/85, 6/85 and 7/91 boreholes.

^λ Based on 1/82, 1/83, 1/85, 2/85, 4/85, 6/85 and 9/91 boreholes. The Three Yard seam is faulted out in 5/85.

^α Based on mine plans from Point of Ayr and borehole data from Rhewl Pit (Mostyn) and Bagillt (Sir Roger's Pit) and Marsh Colliery, Flint⁸.

^β Based on 1/88, 1/72, 1/77, 1/83, 3/78, 1/85, 2/85, 4/85, 5/85, 6/85 and Hoyle Bank boreholes.

The seam is typically divided into a main and thinner leaf, separated by a one or two partings measuring 15 to 46 cm.

Durbog (LCM) – The average whole seam thickness is greatest in the nearshore Point of Ayr colliery (approximately 4.5 m) and thins southeast along the Flintshire coast to around 1 m thick at Bagillt and continues thinning towards Flint colliery. There is also a suggestion of thinning offshore to the north of Point of Ayr, where the seam apparently thins from ~4.52 m in the nearshore to between 3 and 3.5 m offshore. The Durbog is the main seam mined at Neston colliery, where it is 3.22 m thick, suggesting that seam thickness is maintained beneath the estuary.

The seam typically comprises one or two main leaves (>1.0 m each) separated by a dirt parting less than 30 cm thick. Additional minor leaves are present above and below the main leaf, which are usually between 15 and 80 cm thick and separated by partings between 26 and 38 cm thick^χ.

Stone (LCM) – A variable seam, thickest offshore to the north of Point of Ayr and thinning to the southeast as far as Mostyn colliery before thickening again towards Bagillt and Flint colliery to the southeast of the licence area. Offshore to the north Point of Ayr, the seam also exhibits variable thicknesses ranging from 2.3 to 5.3 m (not enough data is available elsewhere in the licence area to assess the extent of this thickness variation). The seam is slightly thinner at Neston, with a whole seam thickness of 2.18 m in line with the thicknesses seen at Bagillt.

Coal in the Stone seam is usually spread across two to four leaves, separated by dirt partings between 10 and 44 cm, although a notable parting in excess of 1 m is noted in the lower part of the seam in boreholes 2/85 and 5/85.

The thickness pattern in the Stone seam in the licence area suggests two areas of greatest thickness in the northwest and southeast of the licence, with a thinner, but still workable thickness of coal occupying the central licence area. It should be noted that, based on borehole observations, this seam may also be subject to thickness variations on smaller scales.

Hard Five Quarter (LCM) – As with the Stone seam, the Hard Five Quarter seam undergoes a regional thinning in the central part of the licence area before thickening again towards the southeast. The seam is thickest offshore to the north of Point of Ayr, with whole seam thickness of 5.89 m, thinning to 2.96 m at Mostyn, 1.36 m at Bagillt and 1.42 m at Neston but may thicken to around 2.40 m at Flint (uncertain seam correlation in the literature)^α.

Seam thickness is highly variable, ranging from 1.38 to 6.23 m in the offshore boreholes^μ at Point of Ayr. This is due to variations in both coal leaf and parting thickness; coal in most boreholes is spread across two to four leaves, separated by partings between 9 and 48 cm. In addition, a significant seatearth parting (1.82 m thick) between the main leaf and a 60 cm thick top leaf is noted in the Point of Ayr mine plans, and washout sediments are noted in the upper portion of

^χ Based on 1/72, 3/85, 4/85, 5/85 and 6/85 boreholes.

^α Based on mine plans from Point of Ayr and borehole data from Rhewl Pit (Mostyn) and Bagillt (Sir Roger's Pit) and Marsh Colliery, Flint⁸.

^μ Based on 1/78, 1/89, PAUG/UG/12, 3/85, 4/85, 6/85 and Hoyle Bank boreholes.

the seam in borehole 3/85. A significant parting is not noted in the remaining offshore boreholes or in the Rhewl Pit well at Mostyn, suggesting that a thick parting is localised to nearshore Point of Ayr. The potential for localised thick partings should, however, be noted for this seam.

Bychton Two Yard (LCM) – The seam retains a relatively constant thickness of approximately 2 m along the Flintshire coast from offshore Point of Ayr to Mostyn, where it begins to thin southeast towards Bagillt. Coal in the Bychton Two Yard is contained within two leaves and separated by a 22 to 23 cm dirt parting^p, indicating continuity in seam composition between Point of Ayr and Mostyn. However the wider presence of the seam in the south and east of the licence area remains uncertain, as it is not proved in boreholes south of Mostyn, which mostly end at the Hard Five Quarter seam.

6.4.2 Coal Quality

Coal quality data for whole seam, whole seam minus dirt and clean coal were available from 17 boreholes, all from the Point of Ayr colliery. No coal quality data are available for the Point of Ayr licence outside of Point of Ayr. Tables 3 and 4 present average coal quality values weighted by sample thickness for whole seam and main leaf/whole seam minus dirt respectively. Full Proximate analyses were only available for the main leaf coal; consequently all moisture (air dried), volatile matter (air dried), fixed carbon (air dried) and mineral matter (air dried) analyses relate to main leaf data only. Only single analyses are available for main leaf Durbog and Hard Five Quarter. The following section outlines the characteristic coal quality for each of the seams, with all data quoted as averages weighted by sample thickness. The full dataset used in the calculation of the weighted averages detailed in Table 3 and 4 can be found in Appendices 3, 4 and 4.1.

Specific Gravity (SG) – SG data were available for whole seam and main leaf samples. Weighted average whole seam SG values generally increase moving down the seam sequence, reflecting a more significant dirt content in the Stone, Hard Five Quarters and Bychton Two Yard compared with seams higher in the sequence. As expected, main leaf weighted SG averages are lower than the whole seam analyses and range from 1.33 (Bychton Two Yard) to 1.38 (Five Yard).

Ash Content - Ash content is roughly proportional to SG, with whole seam ash analyses ranging from approximately 7% (Three Yard) to 30% (Hard Five Quarter) and showing a general trend to higher ash contents in the lowest seams. Main leaf ash content is lower and shows a consistency across the seven seams, with weighted averages varying from 7% to 10%. Overall, the Three Yard exhibits the lowest ash content and the Stone seam the highest.

Total Sulphur – Whole seam sulphur content is relatively high, with all seams returning sulphur contents in excess of 1% (Tables 3 and 4).

Total Chlorine – Whole seam chlorine content varies from 0.08% in the Five Yard and Two Yard, to 0.28% in the Bychton Two Yard (Tables 3 and 4). Chlorine data were not available for the Durbog seam.

Grey-King Type – All seams have at least one analysis (whole seam, whole seam minus dirt or part main leaf) that returns coal type G, with a progression moving up-sequence (from lower to higher coal seams) from G only to G plus F, D or C (Table 3 and 4).

Swelling Number – Swelling number is generally high, with values greater than 6 returned for all seams except the Three Yard (Tables 3 and 4), which records swelling numbers between 3 and 5.

Coal Rank – Coal rank varies between samples of the same seam (Tables 3 and 4). All seams are high volatile, bituminous coals ranging from very weakly caking (802) to strongly caking (501).

Volatile Matter (main leaf only) – Remains fairly consistent across the seams, ranging from approximately 31.5% to 34.3% (weighted average). There is no apparent trend in ‘as received’ volatile matter moving through the sequence. The Stone seam returns the lowest volatile matter and the Three Yard the highest (Table 4).

Fixed Carbon (main leaf only) - Remains fairly consistent across the seams, ranging from approximately 54.3% to 57.8% (weighted average). There is no apparent trend in fixed carbon moving through the sequence. The highest value was returned from the Durbog seam but relates to a single analysis and similar or higher single analyses were also returned from the Five Yard, Three Yard, Two Yard, Stone and Bychton Two Yard seams.

Mineral Matter (main leaf only) – Mineral matter varies across all seams from 6.7% to 12.4% with no apparent trend moving up or down sequence (Table 4).

Calorific Value (main leaf only) – Calorific Values (CV) were acquired on an air-dried, dry mineral matter-free (d.m.m.f.), dry ash-free (d.a.f.), and net- and gross as received (n.a.r. and g.a.r) basis (Appendix 4.1). CV data on an air-dried basis were available for all seams and were used in this report to calculate the Coal-in-Place energy equivalent values discussed in Sections 7.2.4 and 7.2.5. Air dried CVs vary across all seven seams from 29,922 KJ/kg (Five Yard) to 32,340 KJ/kg (Durbog). The weighted average CV (air-dried) for all seams is given in Table 4 and detailed in full in Appendix 4.1.

6.5 Historical Workings

The Flintshire coast of the Dee Estuary has been worked onshore by deep mines and quarries, with some nearshore and offshore deep mining taking place beneath the Dee Estuary at the former Bagillt, Bettisfield, Englefield, Hanmer, Mostyn and Point of Ayr collieries (Drawing 1865OD030). There are no workings within the licence on the Wirral coast, however extensive offshore workings were carried out beneath the Dee Estuary at Neston, ~10 km to the SE of the licence area (mine plans not obtained). The most extensive workings in the licence are at Point of Ayr colliery, which was originally sunk in the 1880s and closed in 1996, being the last working deep mine in the Flintshire Coalfield.

7 ESTIMATION OF THE CONCEPTUAL EXPLORATION TARGET TONNAGES

Following compilation of data from the former mines of the Dee Estuary section of the North Wales Coalfield and compilation of borehole and seismic cross-section data from sources such as the BGS and the Coal Authority, FWS has prepared an estimate for the conceptual Exploration Target tonnages of coal from which resources might eventually be developed for UCG within the Point of Ayr licence.

The parameters given for coal to be considered as having potential for UCG were:-

- Depth of coal seams to be considered as exploration targets should be between 500 and 1500 m below the surface.
- Coal seams >1.5 m in thickness.
- 100 m buffer zones either side of marked faults.
- A 250 m internal buffer zone created inside the licence boundary within which no development would take place.

No parameters have been specified to FWS for coal quality considerations.

7.1 Methodology

The principal consideration as to whether coal located beneath the Point of Ayr licence might eventually become a UCG resource has been defined by the depth at which it occurs. CNR have stated depth parameters of -500 m to -1500 m as described above. A model was therefore developed for the structural contours on the seam floors to interpret which areas within the licence may contain coal seams at that depth range.

The definition of areas of coal potentially located within the defined depth parameters has involved the use of computer/statistical modelling to model available coal seam base data for the areas within, and close to, the licence. This included data from the former mine workings at Point of Ayr, Mostyn and Englefield. These mines were located along the Flintshire coast part of the Point of Ayr licence (Drawing 1865OD013). A map showing the extent of the former workings of the main collieries which mined coal from within the Point of Ayr licence is presented in Drawing 1865OD030. The former workings of the Point of Ayr colliery were the most recent and the most extensive and extended a lateral distance undersea of over 1 km into the western-most corner of the licence area.

Borehole data have also been used where it has been available and of sufficient quality (Appendix 2). Thus data from the NCB boreholes at Hoyle Bank (SJ18NW1), 'No.4' (4/85) and Salisbury Bank (SJ18NE1) have been used for the location and prediction of seam depths. However, seam thickness information used in the estimation of coal tonnages (see later) has been based on seam thicknesses taken from mine plans and literature from the Point of Ayr and Mostyn collieries as these thicknesses are believed to be the most appropriate representation of seam thicknesses for the licence area.

BGS map data from the 1:50 000 scale geological map for the Dee (Sheet 96, Ref. 1) have been used to assist in the prediction of the depth BOD of the MCM and LCM interface based on the published geological cross-section which crosses the northern half of the licence (Drawings 1865OD015 and 038). It has been assumed by FWS that this cross-section has been derived from BGS geophysics (seismic and gravity data), which is in addition to the publicly available data.

The surface geological map at 1:50 000 scale was also used to provide outcrop information for the position of the MCM, LCM and other geological units within the area. These data were entered into the contouring model.

Based on the amount of data available overall, it was decided to use the Hard Five Quarters and Durbog seams as planes of reference for the prediction of the other target seams' positions. The

base of the Hard Five Quarters seam was considered to be the depth ‘reference’ against which all other seam base depths were estimated.

7.1.1 Modelling of the Contours of the Base of the Hard Five Quarters Coal Seam

The statistical modelling/contouring software package “Surfer” (version 10) was used to model and predict the depth contours of the base of the Hard Five Quarters coal seam as it would be interpreted to occur below the Dee licence.

The software was employed because it is able to contour the depth values of known (‘true’) and extrapolated (‘false’) points for coal seam intersections. It also allows the user to enter the position of faults which act as controls on the contouring algorithm. This, therefore, provides a more realistic interpolation by accounting for the influence of geological structure. Depending upon the contouring algorithm used and the spacing of the data, this can result in a good representation of the structural position of a modelled horizon. However, as with any computerised modelling, the model is only as good as the information entered into it.

‘True’ point data for the Hard Five Quarters seam base was gathered from coal seam plans from the Point of Ayr colliery and also from plans from the Englefield colliery. Where depths in the workings were available in feet, they were converted to metres using the conversion 1 foot = 0.305 m. For the sake of this exercise, it was assumed that all historical measurements in feet in the older collieries were measured as a depth below the Ordnance Datum. However, it is likely this was not the case for all of the data, particularly for data from the Englefield colliery, so this will add an error to the seam depth estimates in these areas.

The true depth points of observation for the base of the Hard Five Quarters seam were used where it was intersected in the No. 4 borehole and from the Hoyle Bank (SJ18NW1) borehole. An estimated depth to the base of the Hard Five Quarters seam was made at the Salisbury Bank (SJ18NE1) borehole by extrapolation from a logged marine band (the Warras Marine Band) and comparison with the standard sequence in the No. 4 borehole.

‘False’ points for the contouring model were generated based on depths to the MCM – LCM interface taken from various points measured along the BGS geological cross-section (Ref. 1; Drawing 1865OD038). The depth to the actual seam base at these points was assumed by knowledge that the Durbog seam is within 5 m of the MCM – LCM interface and then extrapolation down by 58 m (the seam base separation taken from Point of Ayr mine plans) to the base of the Hard Five Quarters seam. The false points taken from along the geological cross-section were positioned to ensure depth estimates were made either side of major faults marked on the surface geological map and cross-section.

A further series of ‘false’ points were generated using the MCM – LCM contact marked on the 1:50 000 geological map in the southern corner of the Dee licence (Ref. 1). Depths of the base of the Hard Five Quarters seam at the Englefield colliery were extrapolated along the MCM – LCM boundary shown on the surface geological map in order to provide better control of the contouring in this area.

A list of the depth intersections for the Hard Five Quarters seam and the series of ‘false’ points created for the contour modelling is presented in Appendix 6. Their locations are also shown on the location plan Drawing 1865OD017.

7.1.2 Modelling Parameters

A Maximum Curvature algorithm was chosen to generate the contours as this is the most appropriate algorithm to deal with widely spaced data points. The basic Maximum Curvature default settings for the contouring were used:-

- Maximum Residual: 1.9
- Maximum Iteration: 100,000
- Anisotropy Ratio: 1
- Relaxation Factor: 1
- Internal Tension: 0
- Boundary Tension: 0

A Surfer fault file was created to load in the position of the major faults which had been digitised into the GIS from the 1:50 000 geological map (Ref. 1).

Once the parameters and data had been loaded into the software, the programme was run to create a 'grid' (.grd) file representing the contoured data.

The resulting grid file of the contoured depths and fault line locations for the Hard Five Quarter coal seam base was then plotted in Surfer to examine the contour model. The contour model was reviewed against the seam data to ensure the gridding parameters were correctly representing the data points. Once satisfactory, the Surfer contour file was exported to create an ESRI 'Shapefile' which was then added as a layer to the GIS. The resulting contour map is shown in Drawing 1865OD017.

The contour model provides coverage consistent with the inputted available point data. However, the areas east of what FWS has named as the Hilbre Fault (Drawing 1865OD015) is an exception. A lack of available point data for the modelling has resulted in some gaps in the contouring east of the Hilbre fault. For these areas, the contours that have been generated in the model have been extrapolated manually to give depth estimates.

7.1.3 Digitisation of Depth Classification Areas for each Seam

The modelling of the seam contours results in an estimation for the depth of the seam base of the Hard Five Quarters seam across the majority of the Dee licence. The target depths for UCG were stipulated as between -500 m and -1500 m BOD. A further classification of seam depths of below -1500 m was also added.

The average slope of the contours across the south and central sectors of the licence was calculated using trigonometry to be 18°NNE. This dip was used to calculate the *plan view* separation between each coal seam base, using the Hard Five Quarters seam as the main seam base reference. The relative plan positions of the remaining coal seam bases were then calculated using trigonometry based on their vertical separation and then drawn relative to the -500 m and -1500 m contours of the Hard Five Quarters seam.

The interpreted positions of each seam base at its -500 m and -1500 m contour thus formed the limits of a depth classification for each coal seam. These depths were checked against the seismic lines described in Section 4.3 and were found to broadly agree with FWS's in-house

interpretation of the depth of key seismic picks. The outlines for each depth classification on each seam were digitised in the GIS to generate polygons to represent the *plan area* of each seam depth classification. The process was repeated to define the plan areas for the greater than -1500 m seam depths. The area of each polygon was calculated using the GIS.

The position of the faults and their buffers together with the boundaries of the depth classifications have resulted in the creation of seven depth-related plan sub-areas which have been designated a letter A to G for convenience. Figures showing the resulting areas for each of the -500 to -1500 m and >-1500 m classifications for each coal seam in the sequence is shown in Drawing 1865OD018 to Drawing 1865OD024.

A summary of the plan areas which have been calculated for each coal seam is presented below in Table 5.

TABLE 5: THE CALCULATED AREA OF EACH DEPTH CLASSIFICATION FOR INDIVIDUAL COAL SEAMS IN THE MINE SEQUENCE BASED ON THE MODELLED SEAM BASE DEPTH OF THE HARD FIVE QUARTERS COAL SEAM

Coal Seam	Plan Area (sq. m)						
	A	B	C	D	E	F	G
	-500 to -1500 m	-500 to -1500 m	Deeper than -1500 m	Deeper than -1500 m	-500 to -1500 m	- Deeper than -1500 m	-500 to -1500 m
Five Yard	3,720,649	19,016,844	10,713,642	2,779,082	2,011,524	215,428	208,538
Three Yard	3,775,135	18,813,819	11,709,940	2,869,789	1,913,825	215,428	208,538
Two Yard	3,821,574	18,704,851	12,439,107	3,058,239	1,725,255	215,428	208,538
Durbog	3,838,024	18,474,933	13,387,707	3,075,062	1,699,083	215,428	208,538
Stone	3,916,763	18,459,363	13,889,370	3,052,989	1,703,267	215,428	208,538
Hard Five Quarters	4,007,020	18,357,977	14,488,608	3,119,062	1,622,452	215,428	208,538
Bychton Two Yard	4,092,348	18,224,433	16,240,237	3,394,297	1,376,531	215,428	208,538

7.2 Estimation of Exploration Target Tonnages

The plan areas described in Section 7.1 have been used to generate Exploration Target coal tonnages. However, there are several factors which have been taken into consideration during the estimation of these target tonnages. Such factors include the variation in coal seam thickness, discounting of coal tonnages due to the possible absence of coal due to the Permo-Triassic unconformity, and extra losses due to unrecognised faulting. A discussion of these factors leading up to the estimation of exploration target tonnage ranges is made in the following sections.

7.2.1 Coal Seam Thicknesses Used in the Modelling

The data used for coal seam thickness have been taken from the mine plans for the Point of Ayr. Their use assumes the mine plan seam sections have been developed from coal seam measurements and are fairly representative.

In the use of coal seam thickness values for the calculation of tonnages, only ‘clean coal plies’ have been counted. For each named seam, these have been treated to be a single coal seam *only if any partings/dirt bands present between the plies are less than 0.5 m in thickness and providing the cumulative thickness of the plies is greater than 1.5 m*. The reason for this is that it will be the coal that is reacted in the gasification cell (and ultimately supplies the gas/energy produced). Although the partings may contain organic matter which can be gasified, not counting any such partings as contributing to the coal seam thickness provides an element of conservatism to the calculation of overall coal tonnage and hence the overall energy-mass balance.

Thus the coal seam thicknesses used in the tonnage calculations presented in this section are for clean coal and the thickness will differ slightly from those reported in Section 6.4.1 which present the total seam thickness including partings.

No information is available to quantify any variations in seam thickness heading across the Dee Estuary to the northeast from these former collieries towards West Kirby/Hoylake. As a result of this uncertainty, a variation allowance in seam thickness of +/- 10% has been factored into the final tonnage estimates.

The seam thickness and specific gravity data based on the Point of Ayr colliery and borehole data used in the tonnage estimates is summarised in Table 6 (also see Appendix 9 and Drawing 1865OD016).

TABLE 6: SUMMARY OF COAL SEAM THICKNESSES AND DENSITY TAKEN FROM COMPILED DATA AND USED IN THE CALCULATION OF POTENTIAL COAL TONNAGES FOR THE IDENTIFIED DEPTH-CLASSIFIED AREAS

Coal Seam	Clean Coal Thickness Values (m) Used to Calculate Tonnages	Clean Coal Specific Gravity
Five Yard	3.05	1.38
Three Yard	3.10	1.34
Two Yard	2.92	1.37
Durbog	3.99	1.34
Stone	4.18	1.37
Hard Five Quarters	3.35*	1.34
Bychton Two Yard	1.75	1.33

* The figure of 3.35 m thickness for the Hard Five Quarters has been used here because it is believed that if the greater thickness intersected in borehole No. 4 is used, significant bias would be added to the tonnage calculations as this does not appear to be representative of the thickness of the clean coal plies encountered at the Point of Ayr Colliery or at Mostyn.

7.2.2 Unconformity-related Coal Losses

As referred to in Section 6.3.3, the Permo-Triassic unconformity appears to locally cut the Middle Coal Measures obliquely. The presence of the unconformity may have no effect on the presence of coal seams at depths below the -500 m contour within the licence area. However, as a conservative approach, we have assumed an overall tonnage loss of 5% for the Five Yard seam and 2% for the Three Yard seam, due to the predicted partial removal of these two coal seams at the Permo-Triassic unconformity.

7.2.3 Losses Due to Faulting

In defining the depth-classified areas, allowance has already been made for the major faults crossing the licence as shown on the 1:50 000 geological map by placing a 100 m buffer either side of the marked fault.

However, as discussed in Section 6.3.2, it is likely that there will be more faulting within the deeper Carboniferous Coal Measures sequences than is manifested in the Permo-Triassic rocks at surface and shown in the BGS 1:50,000 geological map (Ref. 1). Such faulting would have a negative effect on the tonnage areas available for UCG resources. To take this factor into account, we have applied an arbitrary discount factor of 10% to the tonnage estimates for the coal losses due to unrecognised faulting.

7.2.4 Estimation of Exploration Target Tonnes of Coal for Seam Depths of -500 m to -1500 m

The estimation of the Exploration Target Tonnes for coal seam depths of between -500 m and -1500 m (areas A, B, E and G in Drawings 1865OD018 to 1865OD024), taking into account the factors described in Sections 7.2.1 to 7.2.3, is presented in Appendix 10 and summarised in Table 7.

TABLE 7: SUMMARY OF DISCOUNTED LOWER AND UPPER RANGES FOR EXPLORATION TARGET COAL TONNAGES FOR SEAMS AT DEPTHS AT BETWEEN -500 m AND -1500 m

Coal Seam	Lower Estimated Tonnage Target for Seam Depths -500 m to -1500 m	Upper Estimated Tonnage Target for Seam Depths -500 m to -1500 m
Five Yard	80,034,984	101,044,254
Three Yard	80,557,597	101,087,759
Two Yard	78,280,525	97,850,656
Durbog	103,598,194	129,497,742
Stone	111,269,813	139,087,266
Hard Five Quarters	86,892,629	108,615,786
Bychton Two Yard	44,505,245	55,631,556
	585,138,985	732,815,019

The weighted average Calorific Values (air dried), outlined in Section 6.4.2, were applied to the tonnages calculated in Table 7 to give the Coal-in-Place energy equivalent for each seam, as shown below in Table 8 and in Appendix 12.

TABLE 8: ESTIMATES OF COAL-IN-PLACE ENERGY FOR EACH OF THE TARGET SEAMS IN THE DEPTH INTERVAL -500 m TO -1500 m

Coal Seam	Lower Estimated contained energy for seam depths -500m to -1500m (Joules)	Upper Estimated contained energy for seam depths -500m to -1500m (Joules)
Five Yard	2.39E+18	3.02E+18
Three Yard	2.50E+18	3.13E+18
Two Yard	2.36E+18	2.95E+18
Durbog	3.35E+18	4.19E+18
Stone	3.35E+18	4.19E+18
Hard Five Quarters	2.69E+18	3.36E+18
Bychton Two Yard	1.39E+18	1.73E+18
	1.80E+19	2.26E+19

Tables 7 and 8 show that within the Point of Ayr licence area, an Exploration Target Tonnage for coal seams expected to occur at between -500 m and -1500 m depth would be in the range of between **585 million and 733 million tonnes with Coal-in-Place energy equivalent values of 18 to 23 exajoules¹**.

It should be noted that this range of coal tonnages does not take into account the actual down-dip area of tonnage as the data available has only been sufficient to estimate the tonnage areas using their *plan areas*. However, simply by trigonometry, if the dip of the seams was maintained as 18°NNE across the licence, the seam surface area may possibly increase by approximately 5%.

It should be further emphasised that this is a conceptual Exploration Target tonnage. The lack of 'true' points of observation for the coal seams' depths and thicknesses (and coal quality) within the licence area means that without further exploration, it is not possible to classify these conceptual tonnages into resources which comply to any of the *Measured, Indicated or Inferred* resource classifications set out in the JORC (etc.) resource estimation codes and it is uncertain whether further exploration will result in a Coal Resource.

¹ 1 exajoule = 10¹⁸ joules

7.2.5 Estimation of Exploration Target Tonnages of Coal for Seam Depths of Greater than 1500 m

The estimation of the Exploration Target Tonnages for coal seam depths below -1500 m O.D. (areas C, D and F in Drawings 1865OD018 to 1865OD024, taking into account the factors described in Sections 7.2.1 to 7.2.3), is presented in Table 9 and in Appendix 10.

TABLE 9: SUMMARY OF DISCOUNTED LOWER AND UPPER RANGES FOR EXPLORATION TARGET COAL TONNAGES FOR SEAMS AT DEPTHS GREATER THAN 1500 m

Coal Seam	Lower Estimated Tonnage Target for Seam Depths >1500 m	Upper Estimated Tonnage Target for Seam Depths >1500 m
Five Yard	46,158,089	57,697,612
Three Yard	49,167,266	61,459,082
Two Yard	50,285,905	62,857,381
Durbog	71,337,318	89,171,648
Stone	78,604,626	98,255,783
Hard Five Quarters	64,006,310	80,007,887
Bychton Two Yard	36,960,629	46,200,787
	396,520,144	495,650,180

The weighted average Calorific Values (air dried), outlined in Section 6.4.2, were applied to the tonnages calculated in Table 9 to give the Coal-in-Place energy equivalent for each seam, as shown in Table 10 and in Appendix 12.

TABLE 10: ESTIMATES OF COAL-IN-PLACE ENERGY FOR EACH OF THE TARGET SEAMS FOR DEPTHS >1500 m

Coal Seam	Lower Estimated contained energy for seam depths >1500 m (Joules)	Upper Estimated contained energy for seam depths >1500 m (Joules)
Five Yard	1.38E+18	1.73E+18
Three Yard	1.52E+18	1.90E+18
Two Yard	1.52E+18	1.89E+18
Durbog	2.31E+18	2.88E+18
Stone	2.37E+18	2.96E+18
Hard Five Quarters	1.98E+18	2.47E+18
Bychton Two Yard	1.15E+18	1.44E+18
	1.22E+19	1.53E+19

Tables 9 and 10 show that within the Point of Ayr licence area, the conceptual Exploration Target Tonnage for coal seams expected to occur at depths between -1500 m and -2000 m would be in the range of between **397 million and 496 million tonnes with Coal-in-Place energy equivalent values of 12 to 15 exajoules.**

8 SUMMARY AND CONCLUSIONS

This report presents a series of estimates for the range of Exploration Target coal tonnages located within CNR's Point of Ayr licence. The estimates are reported in accordance with the JORC Code and estimated by a Competent Person as defined by that code. The figures presented are not Coal Resources or Reserves and are conceptual in nature as there has currently been insufficient exploration to define a Coal Resource and it is uncertain if further exploration will result in the development of a Coal Resource.

The licence occupies part of the North Wales Coalfield, but only a small proportion of the licence area had been mined before the coalfield was abandoned and the last mine was flooded in 1996.

Seven seams form the Target. Each contains dirt bands and the assessment is made only on the clean coal plies and only when dirt partings separating the plies are less than an arbitrary 0.5 m thickness.

The coals are expected to be high volatile, bituminous, weakly to strongly caking; usually <10% ash (air dried basis) and 1.5 to 2.5% total sulphur.

The summary Exploration Target tonnages for Point of Ayr licence CA11/UCG/0024/S are given in Tables 11 and expressed in millions of tonnes (Mt), with Coal-in-Place equivalent energy expressed in exajoules (EJ) (Table 12). These Exploration Target tonnages and associated energy estimates are based on information from the seven target seams that satisfy the seam thickness, depth and stand-off criteria as outlined by CNR and incorporate discount factors described earlier.

TABLE 11: SUMMARY OF EXPLORATION TARGET TONNAGES FOR COAL SEAMS IN THE POINT OF AYR LICENCE

Seam Depth (m)	Lower Estimated Tonnage Coal Target (Mt)	Upper Estimated Tonnage Coal Target (Mt)
-500 to -1500	585	733
>-1500	397	496
Total Exploration Target tonnage (Mt)	982	1,229
Rounded Totals	980	1,230

TABLE 12: SUMMARY OF COAL-IN-PLACE ENERGY FOR THE TARGET COAL SEAMS WITHIN EACH DEPTH CLASSIFICATION IN THE POINT OF AYR LICENCE

Seam Depth (m)	Lower Estimated Total Coal-In-Place Energy (EJ)	Upper Estimated Total Coal-In-Place Energy (EJ)
-500 to -1500	1.80E+19	2.26E+19
>-1500	1.22E+19	1.53E+19
Total	3.03E+19	3.79E+19

9 COMPETENT PERSON'S STATEMENT

The information in this report that relates to UCG Exploration Targets, together with any related assessments and interpretations, have been verified by and approved for release by Dr F W Smith FIMMM., CEng, CSci., a qualified geologist and full-time employee of FWS Consultants Limited ("FWS"), Environmental and Geological Consultants. Dr Smith, who is a Fellow of the Institute of Materials, Minerals and Mining (IMMM), has sufficient experience which is relevant to the style of mineralisation and type of deposit under consideration and to the activity which he is undertaking to qualify as a Competent Person for the purposes of the AIM Rules. Dr Smith and FWS consent to the inclusion of the information contained in this report and the respective references to them in the form and context in which they appear.

N HENWOOD
SENIOR CONSULTANT

DR F W SMITH
DIRECTOR

10 REFERENCES

- 1 British Geological Survey. 2006 Liverpool. England and Wales Sheet 96. Bedrock Geology, 1:50,000 Geology Series (Keyworth, Nottingham: British Geological Survey).
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- 12 Hughes, J.D., Klaztel-Mudry, L. and Nikols, D.J., 1989. A Standardised Coal Resource/Reserve Reporting System for Canada. Geological Survey of Canada Paper 88-21.
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TABLE 1: SUMMARY OF MINE PLANS OBTAINED FROM THE COLLIERIES OF THE FLINTSHIRE COALFIELD

SEAM	POINT OF AYR	MOSTYN	HANMER	ENGLEFIELD
Five Yard	1	1	0	1
Three Yard	5	2	0	0
Two Yard	10	4	1	0
Durbog	5	4	1	1
Stone	7	1	2	0
Hard Five Quarter	9	2	1	1
Bychton Two Yard	1	4	1	0
Other*	0	4	3	4

* Relates to seams of insufficient thickness to target but includes Cannel, Three Quarters, Blue Cannel, Bottom Brassey, Yard, Badger, Soft Five Quarters and plans of whole mine workings.

TABLE 2: LIST OF KEY BOREHOLES AND GRID REFERENCES

BOREHOLE	EAST	NORTHING	DEPTH (m)	COAL QUALITY DATA
5/85	310630	386888	516.15	yes
4/85	312938	388283	900	yes
6/85	311706	387884	546	yes
7/91	312362	385963	88.39	yes
3/96	311962	385884	n/a	yes
1/82	313860	386510	n/a	yes
1/83	312100	386625	124	yes
2/85	310590	388402	561	no
9/91	312362	385963	63.4	yes
1/61	313380	385701	40.3	no
1/72	312567	385667	109.5	no
1/77	312109	386332	60.96	yes
3/78	312082	386939	75.6	yes
2/78	312082	386939	75.6	yes
3/85	309894	387424	448.3	yes
1/91	313181	386310	38.7	yes
1/89	312360	387100	39.5	no
1/69	312836	386247	39.7	yes
PAUG/UG/12	313542	384035	29.9	no
1/78	313480	384356	91.2	yes
3/82	312382	385696	132.6	yes
PAUG/UG/49	313294	384611	135.6	no
1/85	311492	386947	372.5	yes
1/86	313285	386472	56.4	yes
Hoyle Bank	311482	388772	668.8	no
Salisbury Bank	315420	385330	942	no
Dee Estuary No 1	323370	378460	189.8	no
Neston	329000	376300	141.4	no
Heswall	325260	381610	1024.7	no
Mostyn Quay 1	315636	380921	778.8	no
Collinge 1	341429	371112	1362	no
BH 2	325341	377746	78.33	no
BH2A	325386	377759	271	no
BH 3	326288	375927	237.4	no
BH 4	328078	375015	169.6	no
BH 5	328576	375211	75.7	no
BH 6	328304	374762	83.8	no
BH 7	328011	374488	125.5	no
BH 9	328080	374091	125.9	no
BH 10	328845	375209	81.1	no
BH 11	328555	374867	69.2	no

BOREHOLE	EAST	NORTHING	DEPTH (m)	COAL QUALITY DATA
BH 12	327844	374805	247.5	no
BH 13	327726	375414	164.6	no
BH 14	328122	374838	90.2	no
BH 15	328340	375084	89.6	no
BH 16	328494	375499	86.2	no
BH 17	328568	375682	48	no
BH 18	328022	374675	34.7	no
BH 19	328592	375638	37.1	no
PA/UG/882	313108	386026	77.7	no
3/61	313109	385679	45.2	no
4/61 (591)	313222	385680	95.7	no
2/61	313236	385056	72.1	no
PA/UG/886	313345	385899	90.85	no
PA/UG/887	313152	385848	117.4	no
9/21	313280	385177	79.2	no
Liverpool Bay 1	322632	396984	2054.6	no
Liscard and Seaview Road Pumping Station	330290	392420	246	no

Coordinates given in British National Grid.

TABLE 3: SUMMARY OF WHOLE SEAM COAL QUALITY DATA

SEAM	NO SAMPLES	AVERAGE THICKNESS (cms)	SPECIFIC GRAVITY (LUMP COAL)	ASH (%)	TOTAL S (%)	TOTAL CI (%)	GREY-KING*	B.S. SWELLING NUMBER*	RANK*
Five Yard	6	243.17	1.42	14.82	2.40	0.08	C, D, G	1.5 to 7.5	501, 702
Three Yard ¹	4	325.00	1.34	6.85	1.24	0.13	D, F, G	3 to 5	702, 802
Three Yard ²	1	323.00	1.34	8.29	1.09	0.13	D, F, G	3 to 5	702, 802
Two Yard	4	302.25	1.44	18.67	1.91	0.08	D, F, G	3.5 and 8.5	501, 701, 702
Durbog ¹	1	286.00	1.35	8.3		n/a	G	8.5	501
Durbog ²	1	452.00	1.43	14.37	2.22	n/a	G	8.5	501
Stone	3	332.37	1.47	19.86	2.04	0.23	F, G	2.5 to 7.5	501, 601, 701
Hard Five Quarters ³	1	392.00	1.46	18.65	1.80	0.11	G	6.5	702
Hard Five Quarters ⁴	1	589.00	1.60	30.50	1.53	0.11	G	6.5	702
Bychton Two Yard	3	217.33	1.52	28.12	2.15	0.28	G	4.5 and 7	502, 601

¹ Only one whole seam analysis.

² Only one whole seam analysis. Empirical whole seam coal quality calculated by reconstructing the seam with partings from the mine plan and inserting weighted parting analyses.

³ No whole seam data available. Empirical whole seam coal quality calculated by reconstructing the seam with partings from the mine plans and inserting weighted parting analyses. Top leaf above thick parting/washout horizon ignored.

⁴ No whole seam data available. Empirical whole seam coal quality calculated by reconstructing the seam with partings from the mine plan and inserting weighted parting analyses. Calculations include the thick parting/washout horizon and the topmost leaf.

* Range of values obtained from whole seam and, whole seam minus dirt and main leaf analyses (text in bold from whole seam analyses).

TABLE 4: SUMMARY OF MAIN LEAF COAL QUALITY DATA

Seam	No samples	Average sample thickness (cm)	Specific Gravity (lump coal)	Proximate Analysis (%)				Mineral Matter (dry basis %)	Total S (a.d.b.) %	Total Cl (a.d.b.) %	Calorific Value (Air-Dried) (KJ/kg)	B.S Swelling Number	Gray-King Coke type
				Moisture	Volatile matter (less moisture)	Fixed Carbon	Ash						
Five Yard	7	216	1.38	3.10	32.50	54.47	9.93	11.44	2.30	0.20	29,922	1.5, 4.5, 6, 7.5	C, D, G
Three Yard	4	325	1.34	3.37	34.25	55.56	6.82	6.68	1.22	0.19	30,975	3, 4, 5	D, F, G
Two Yard	3	249	1.37	3.02	31.92	55.13	9.93	12.41	1.84	0.21	30,133	3.5, 8.5	D, F, G
Durbog	1	283	1.34	2.1	33.1	57.8	7	9.4	2.49	0.39	32,340	8.5	G
Stone	4	288	1.37	2.66	31.48	55.64	10.22	7.38	2.16	0.26	30,135	2.5, 5, 7.5	F, G
Hard Five Quarters	1	299	1.34	2.7	33.8	54.3	9.2	11	2.01	0.11	30,912	6.5	G
Bychton Two Yard	3	150	1.33	2.65	33.75	55.81	7.79	10.09	2.04	0.39	31,185	4.5, 7	G

NOTES / KEY



- POINT OF AYR** Site of former colliery
- Boreholes (Appendix 2)
- Point of Ayr Licence
- Point of Ayr Named Sub-areas
- Point of Ayr Licence 250m Internal Buffer
- Line of Geological Cross-section

CLIENT

Cluff Natural Resources plc

DRAWING TITLE

Location of Boreholes and
BGS Geological Cross-Section

PROJECT TITLE

Point of Ayr UCG Project

STATUS

FINAL

PROJECT NUMBER

1865

DRAWN BY

IH

DATE

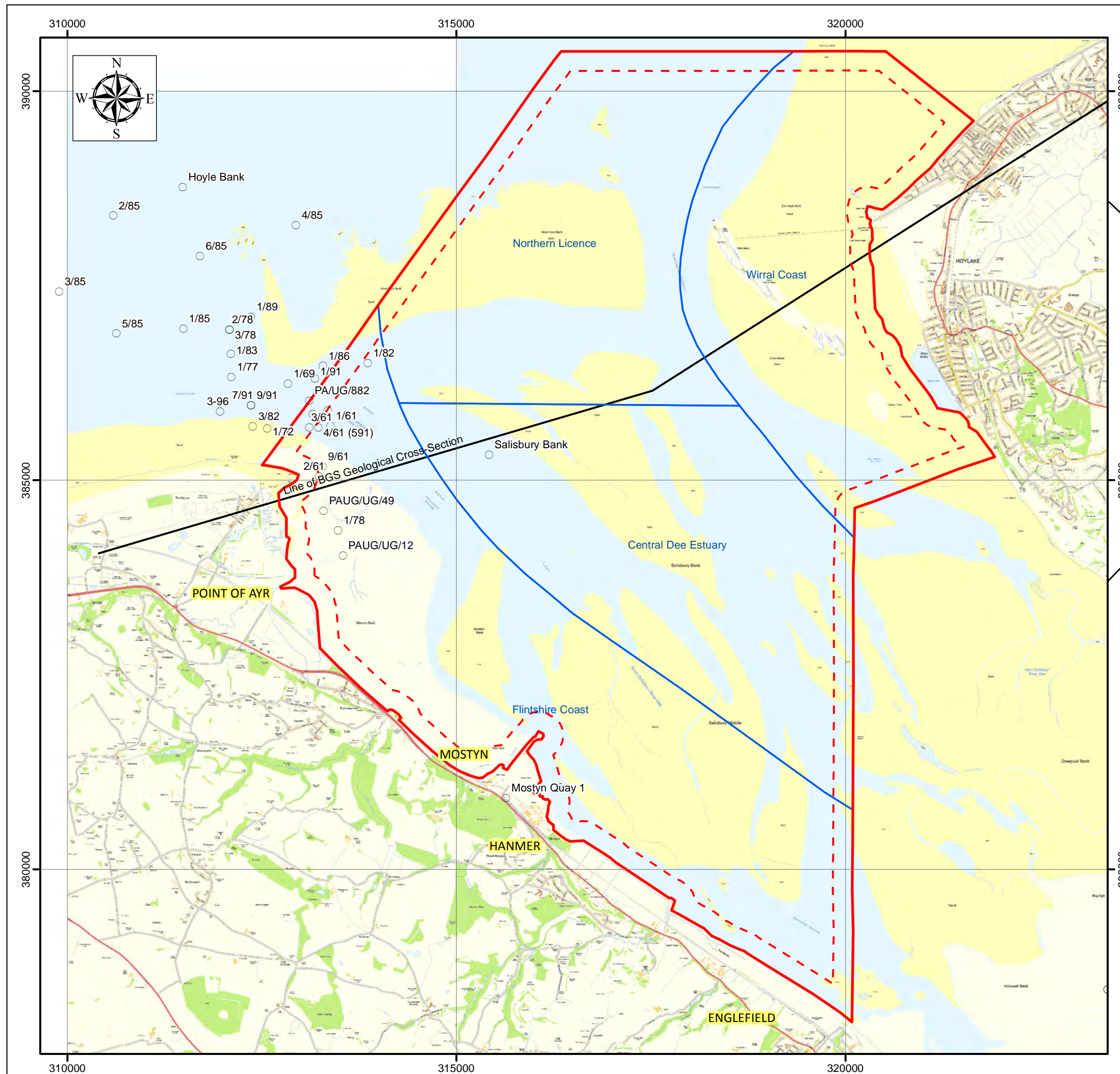
18th November 2014

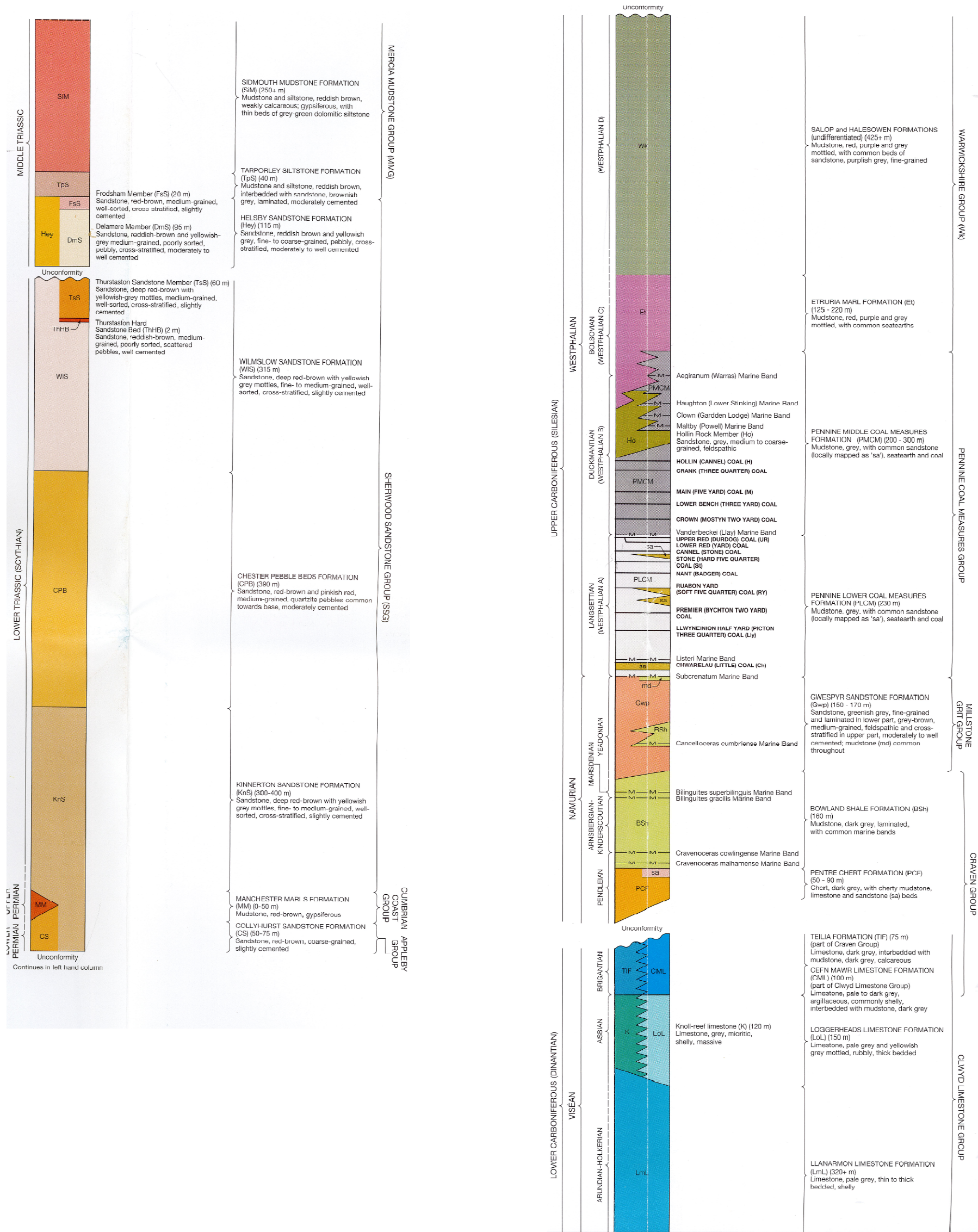
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DRG. No.

1865OD013





Source: England and Wales Sheet 96 (Liverpool). 2006. British Geological Survey.

NOTES / KEY	DRAWING TITLE REGIONAL STRATIGRAPHY OF THE DEE AND THE WIRRAL	CLIENT CLUFF NATURAL RESOURCES plc	FWS Environmental & Geological Consultants Merrington House Merrington Lane Industrial Estate Spennymoor Co Durham DL16 7UT Tel: 01388 420633 admin@fwsconsultants.com www.fwsconsultants.com
	PROJECT TITLE POINT OF AYR UCG PROJECT	STATUS FINAL	
		DRAWN BY KW	DATE Oct 2014
		SCALE NOT TO SCALE	DRG. No. 1865OD014

NW

SE



Merrington House
Merrington Lane Industrial Estate
Spennymoor
Co Durham
DL16 7UT

Tel: 01388 420633
admin@fwsconsultants.com www.fwsconsultants.com

NOTES / KEY

- Coal
- Cannel (where noted)
- 1.23 Seam, leaf or measures Thickness (measures in red)
- p Total parting thickness within seam (where available)
- * Composite log of Neston and Shaft No 1, Wirral Colliery

All thicknesses given in metres

CLIENT
CLUFF NATURAL RESOURCES plc

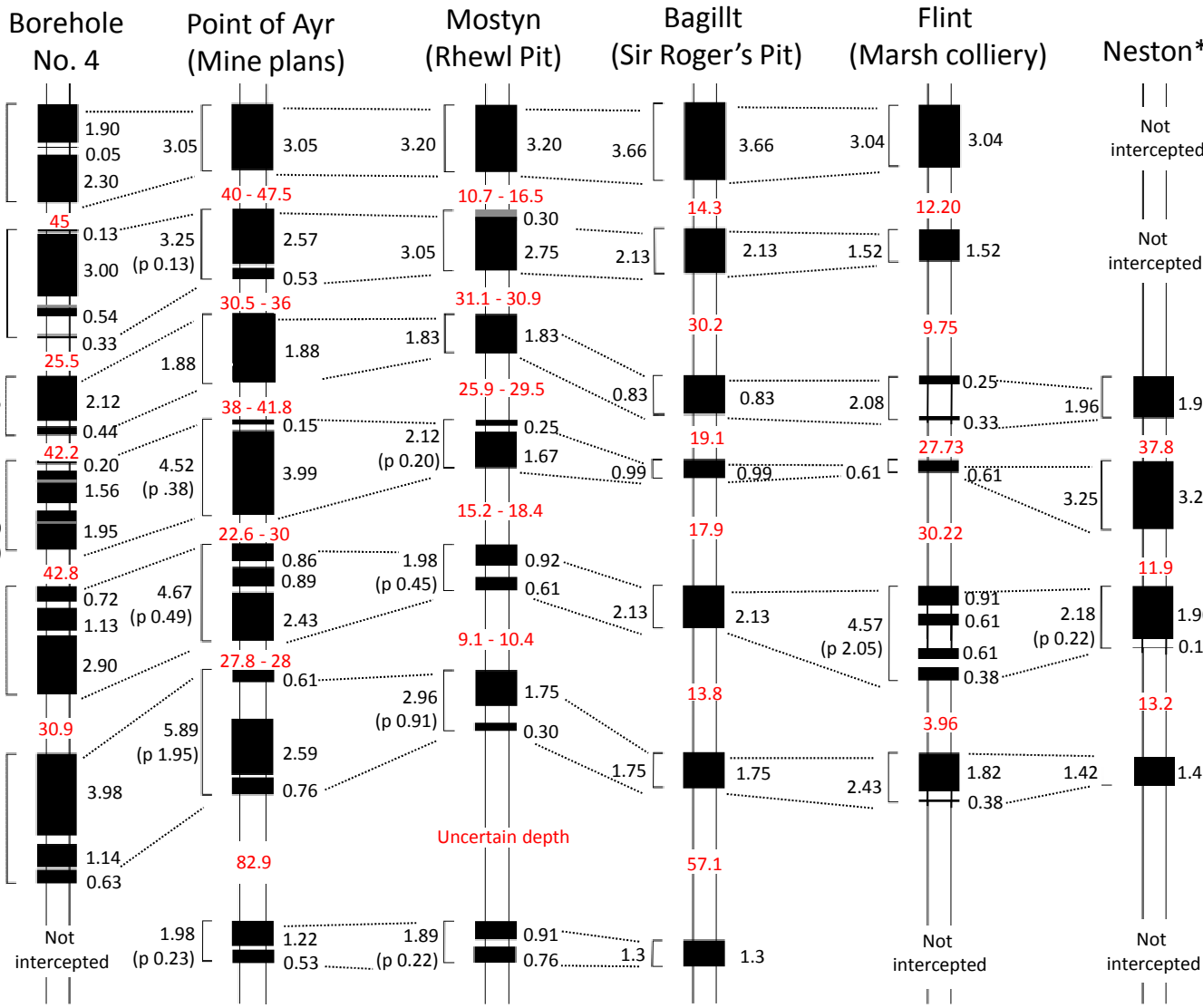
DRAWING TITLE
THICKNESS VARIATIONS IN TARGET SEAMS

PROJECT TITLE
POINT OF AYR UCG PROJECT

STATUS FINAL	PROJECT NUMBER 1865
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DRAWN BY NH	DATE Nov 2014
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SCALE NOT TO SCALE	DRG. No. 1865OD016
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NOTES / KEY

- Point of Ayr Licence
- Point of Ayr Licence 250m Internal Buffer
- 500 Surfer Modelled Seam Base Depth Contours for the Hard Five Quarters Seam (with metres below O.D.)
- Fault
- Boreholes
- Points Used For HFQ Seam Base Depth Estimation**
 - + Extrapolated 'False' Point (Appendix 6)
 - + 'True' HFQ Seam Base Intersection Point (Appendix 2)
- Point of Ayr Former Colliery

CLIENT

Cluff Natural Resources plc

DRAWING TITLE

Contour Modelling of the Depth to the Base of the Hard Five Quarters Coal Seam

PROJECT TITLE

Point of Ayr UCG Project

STATUS

FINAL

PROJECT NUMBER

1865

DRAWN BY

IH

DATE

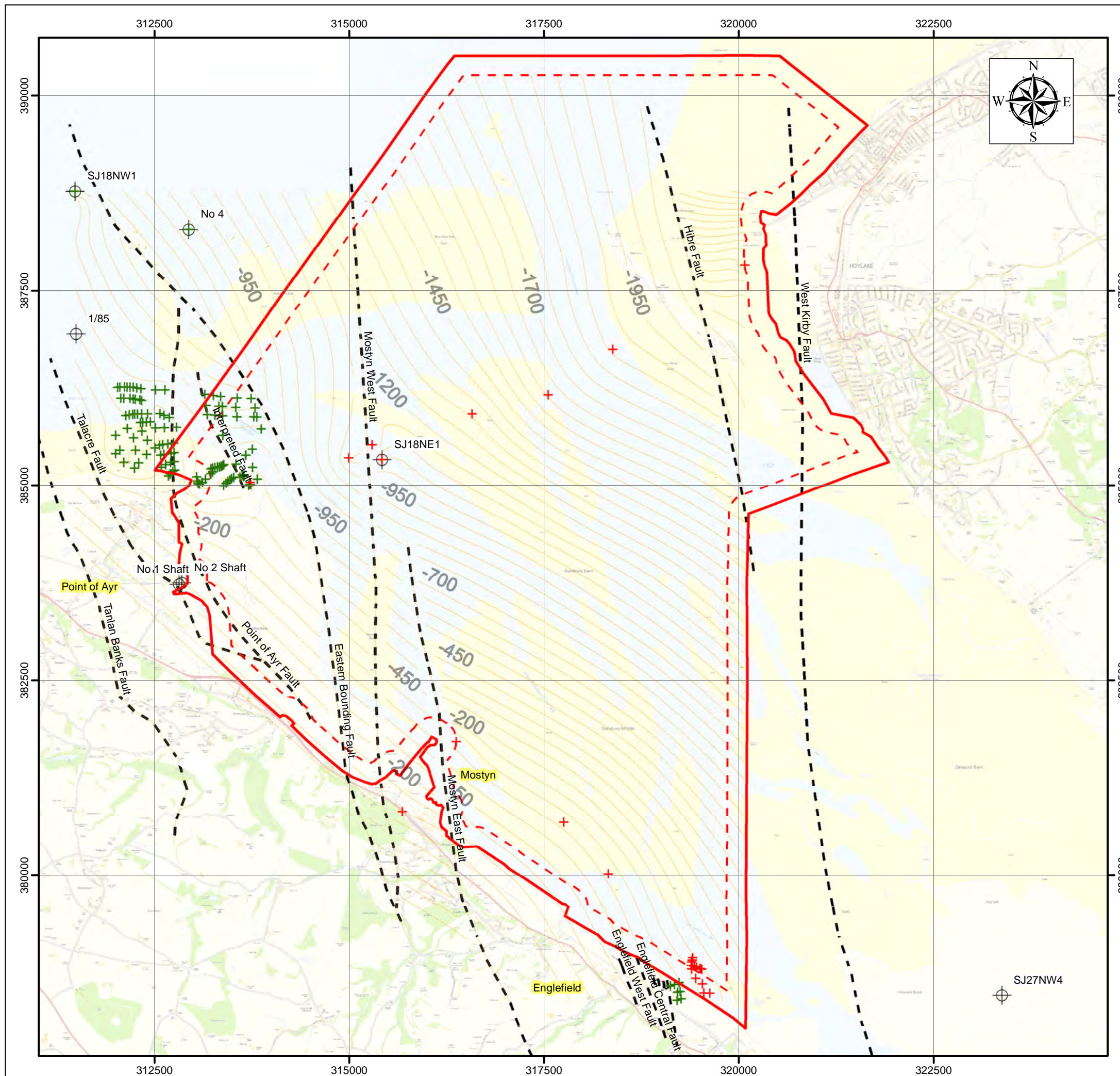
27th November 2014

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DRG. No.

1865OD017



NOTES / KEY

- Point of Ayr Licence
- Point of Ayr Licence 250m Internal Buffer
- Fault and 100m Buffer
- Boreholes
- Point of Ayr Former Colliery

Key to Coal Seam Tonnage Areas

- Five Yard Seam Tonnage Areas**
Area Classification - Areas A to G
- 500 to -1500 metres
 - Below -1500 metres

Coordinate System: British National Grid
Projection: Transverse Mercator
Datum: OSGB 1936
False Easting: 400,000,0000
False Northing: -100,000,0000
Central Meridian: -2,0000
Scale Factor: 0,9996
Latitude Of Origin: 49,0000
Units: Meter

CLIENT

Cluff Natural Resources plc

DRAWING TITLE

Interpreted Depth-Classified Areas
for the Five Yard Seam

PROJECT TITLE

Point of Ayr UCG Project

STATUS

FINAL

PROJECT NUMBER

1865

DRAWN BY

IH

DATE

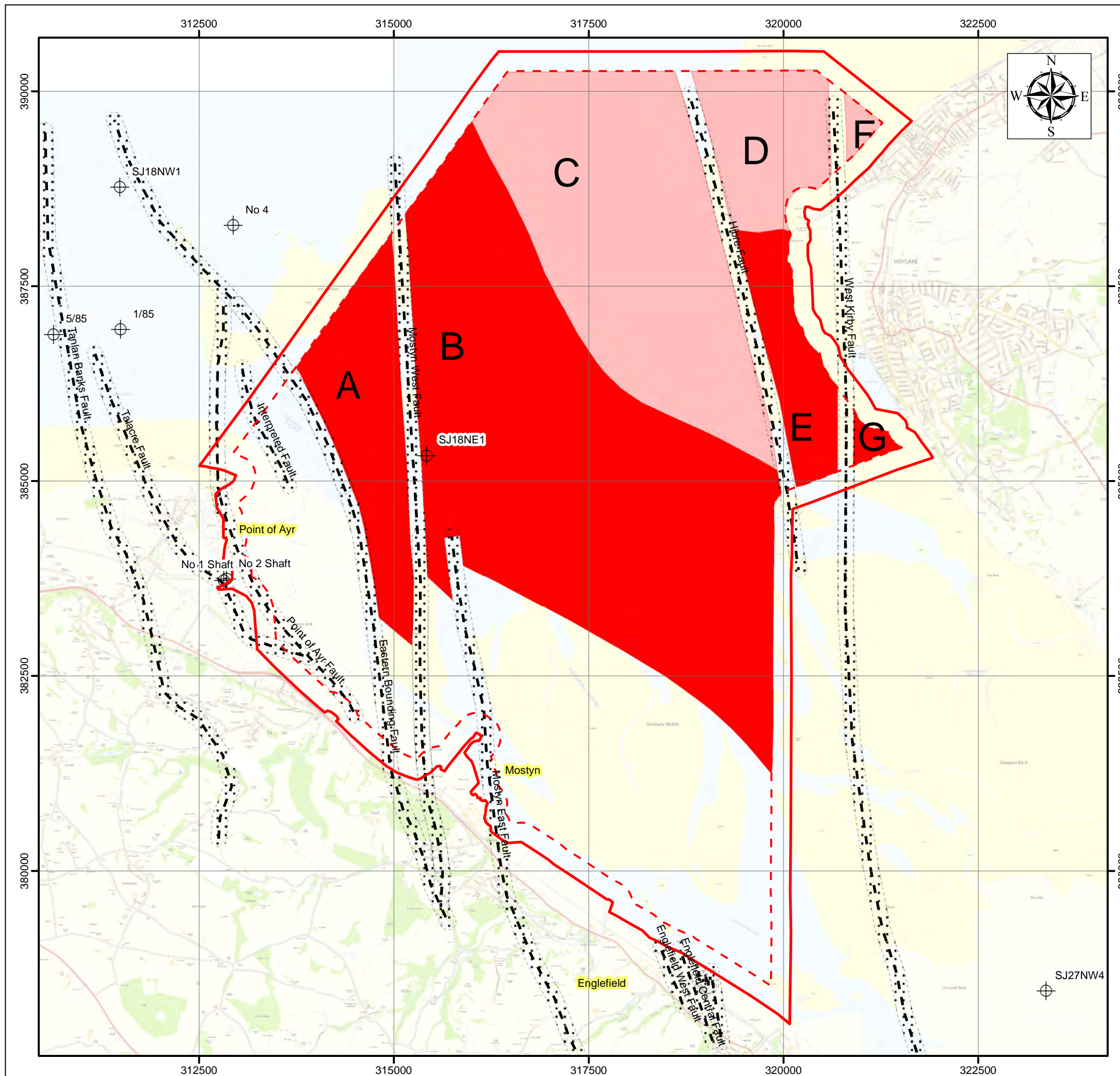
27th November 2014

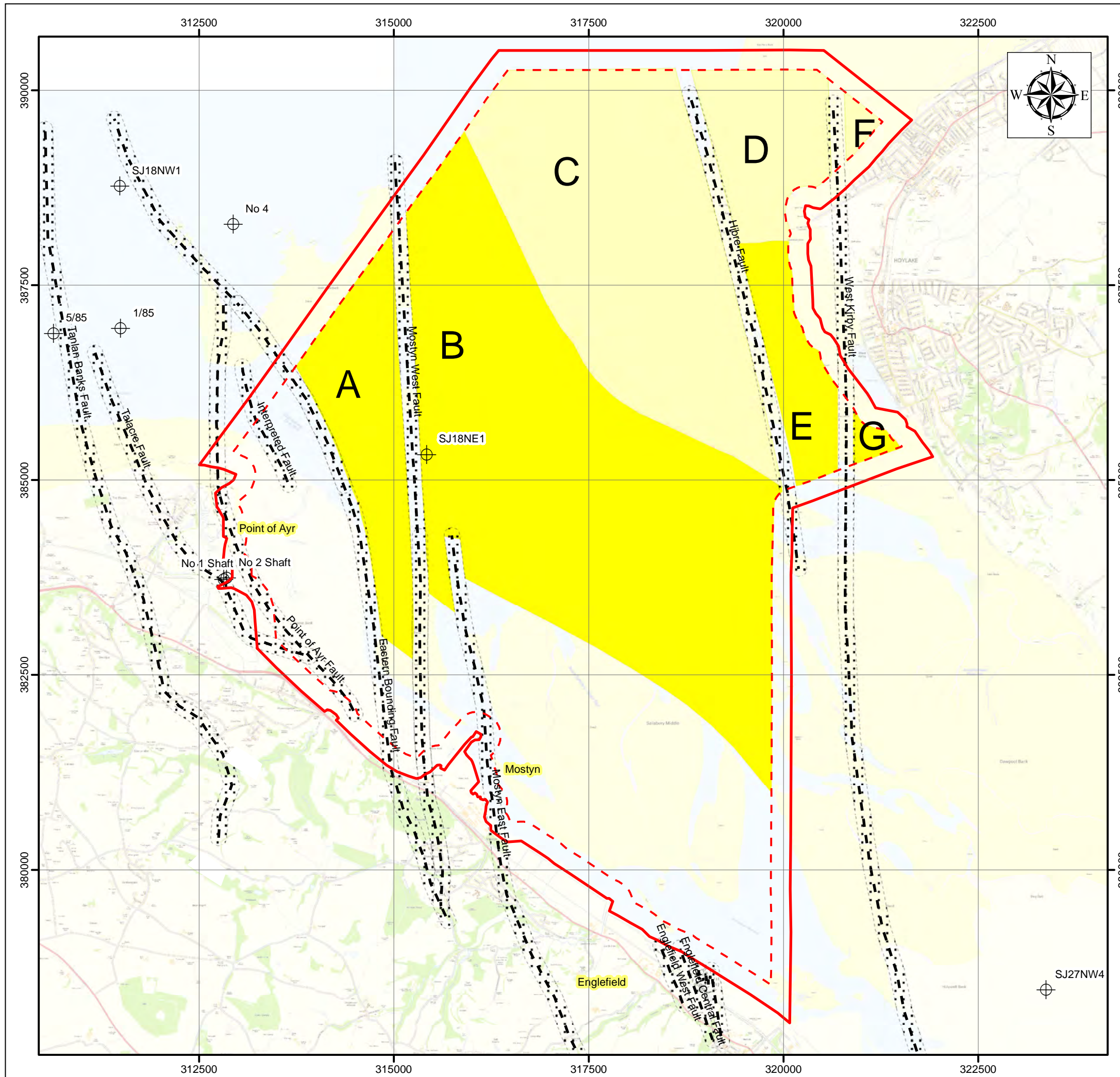
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DRG. No.

1865OD018





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NOTES / KEY

- Point of Ayr Licence
- Point of Ayr Licence 250m Internal Buffer
- Fault and 100m Buffer
- Boreholes
- Point of Ayr Former Colliery

Key to Coal Seam Tonnage Areas
Three Yard Seam Tonnage Areas
Area Classification - Areas A to G
 -500 to -1500 metres
 Below -1500 metres

Coordinate System: British National Grid
 Projection: Transverse Mercator
 Datum: OSGB 1936
 False Easting: 400,000.0000
 False Northing: -100,000.0000
 Central Meridian: -2.0000
 Scale Factor: 0.9996
 Latitude Of Origin: 49.0000
 Units: Meter

CLIENT

Cluff Natural Resources plc

DRAWING TITLE

Interpreted Depth-Classified
Areas for the Three Yard Seam

PROJECT TITLE

Point of Ayr UCG Project

STATUS

FINAL

PROJECT NUMBER

1865

DRAWN BY

IH

DATE

27th November 2014

SCALE

1:50,000

DRG. No.

1865OD019

NOTES / KEY

- Point of Ayr Licence
- Point of Ayr Licence 250m Internal Buffer
- Fault and 100m Buffer
- Boreholes
- Point of Ayr Former Colliery

Key to Coal Seam Tonnage Areas

- Two Yard Seam Tonnage Areas**
Area Classification - Areas A to G
- 500 to -1500 metres
 - Below -1500 metres

Coordinate System: British National Grid
Projection: Transverse Mercator
Datum: OSGB 1936
False Easting: 400,000,0000
False Northing: -100,000,0000
Central Meridian: -2.0000
Scale Factor: 0.9996
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Units: Meter

CLIENT

Cluff Natural Resources plc

DRAWING TITLE

Interpreted Depth-Classified
Areas for the Two Yard Seam

PROJECT TITLE

Point of Ayr UCG Project

STATUS

FINAL

PROJECT NUMBER

1865

DRAWN BY

IH

DATE

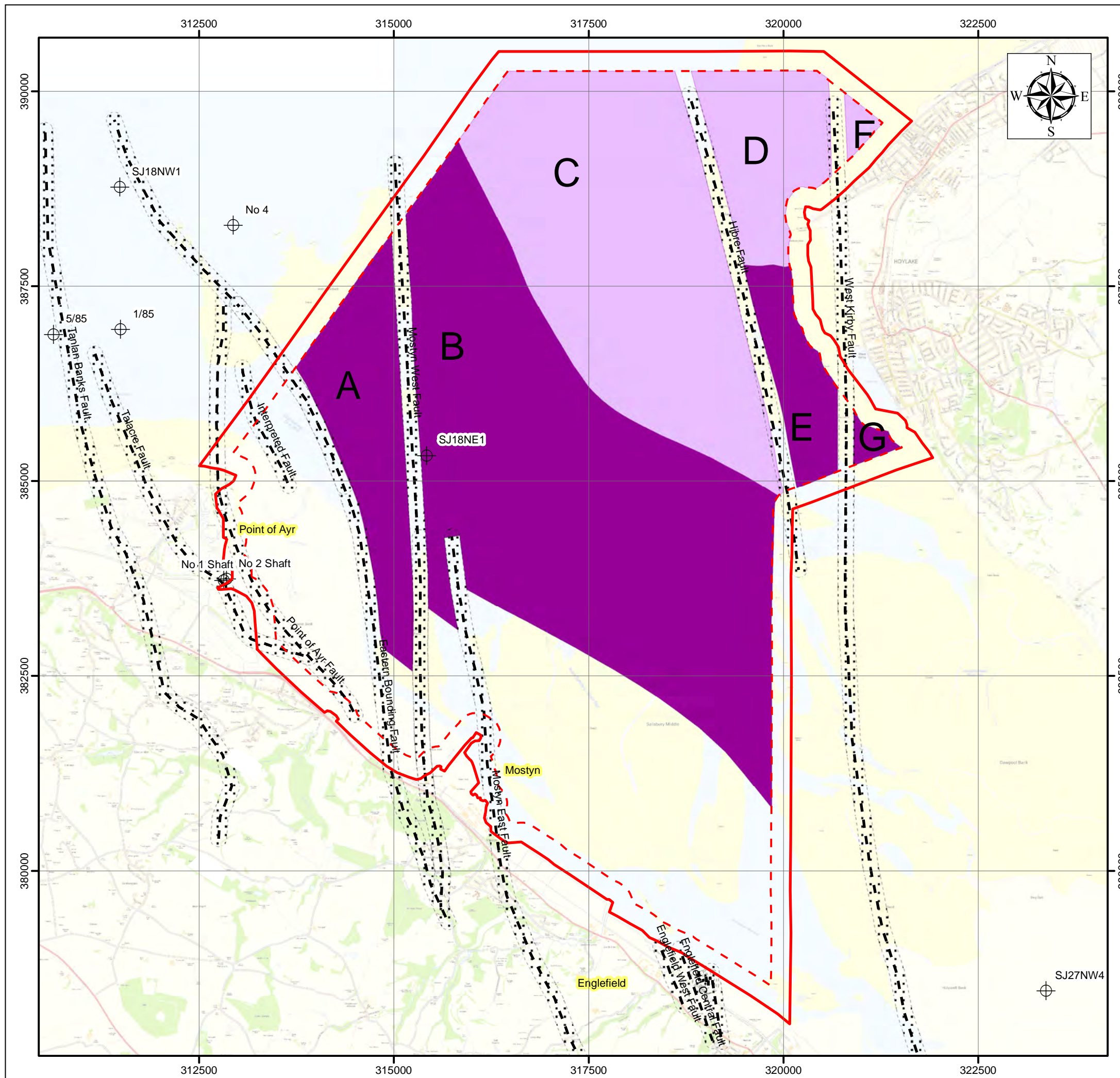
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SCALE

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DRG. No.

1865OD020



NOTES / KEY

- Point of Ayr Licence
- Point of Ayr Licence 250m Internal Buffer
- Fault and 100m Buffer
- Boreholes
- Point of Ayr Former Colliery

Key to Coal Seam Tonnage Areas

- Durbog Seam Tonnage Areas**
Area Classification - Areas A to G
- 500 to -1500 metres
 - Below -1500 metres

Coordinate System: British National Grid
Projection: Transverse Mercator
Datum: OSGB 1936
False Easting: 400,000,0000
False Northing: -100,000,0000
Central Meridian: -2,0000
Scale Factor: 0,9996
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Units: Meter

CLIENT

Cluff Natural Resources plc

DRAWING TITLE

Interpreted Depth-Classified
Areas for the Durbog Seam

PROJECT TITLE

Point of Ayr UCG Project

STATUS

FINAL

PROJECT NUMBER

1865

DRAWN BY

IH

DATE

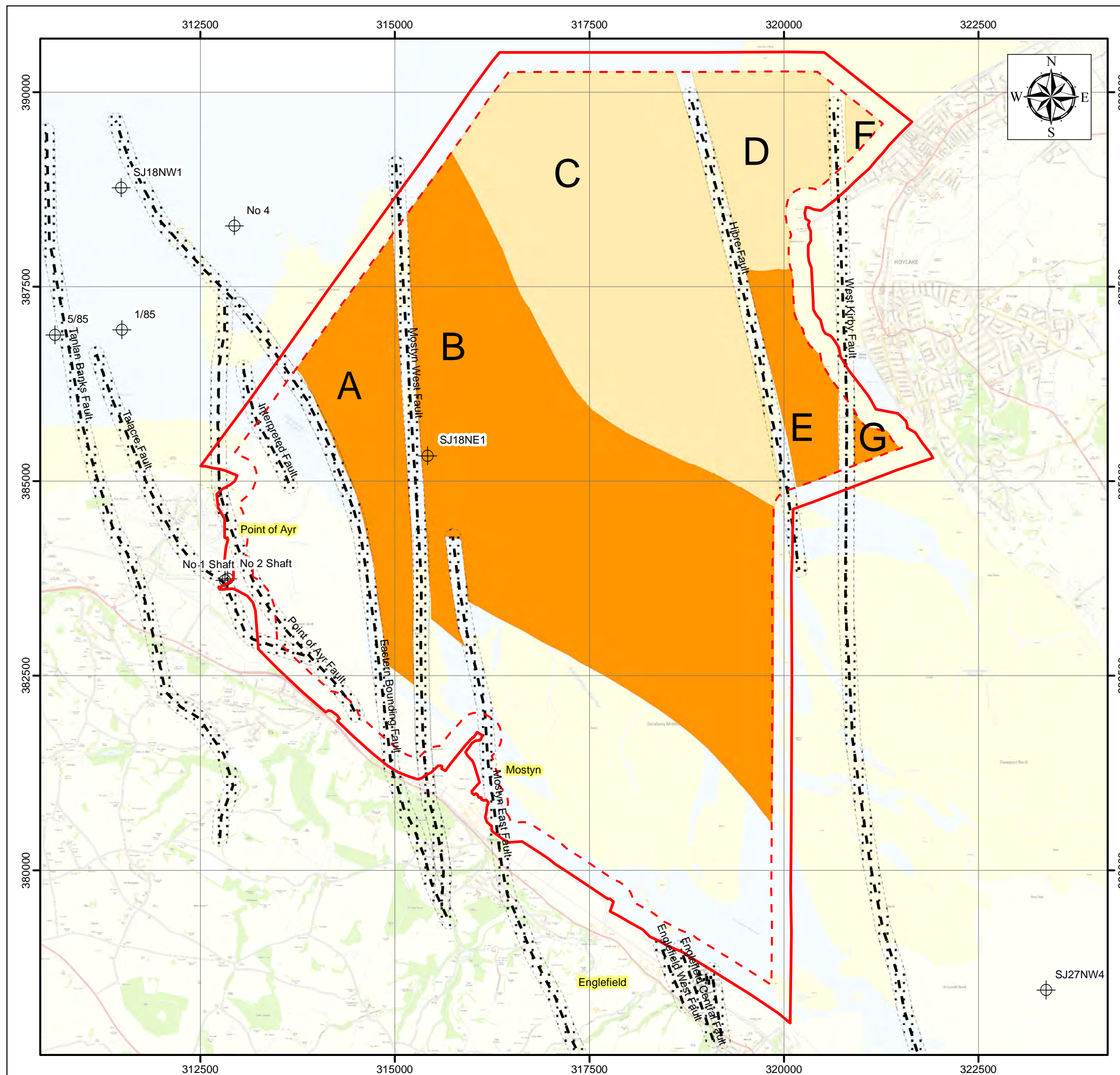
27th November 2014

SCALE

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DRG. No.

1865OD021



NOTES / KEY

- Point of Ayr Licence
- Point of Ayr Licence 250m Internal Buffer
- Fault and 100m Buffer
- Boreholes
- Point of Ayr Former Colliery

Key to Coal Seam Tonnage Areas

- Stone Seam Tonnage Areas**
Area Classification - Areas A to G
- 500 to -1500 metres
 - Below -1500 metres

Coordinate System: British National Grid
Projection: Transverse Mercator
Datum: OSGB 1936
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False Northing: -100,000,0000
Central Meridian: -2,0000
Scale Factor: 0,9996
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Units: Meter

CLIENT

Cluff Natural Resources plc

DRAWING TITLE

Interpreted Depth-Classified
Areas for the Stone Seam

PROJECT TITLE

Point of Ayr UCG Project

STATUS

FINAL

PROJECT NUMBER

1865

DRAWN BY

IH

DATE

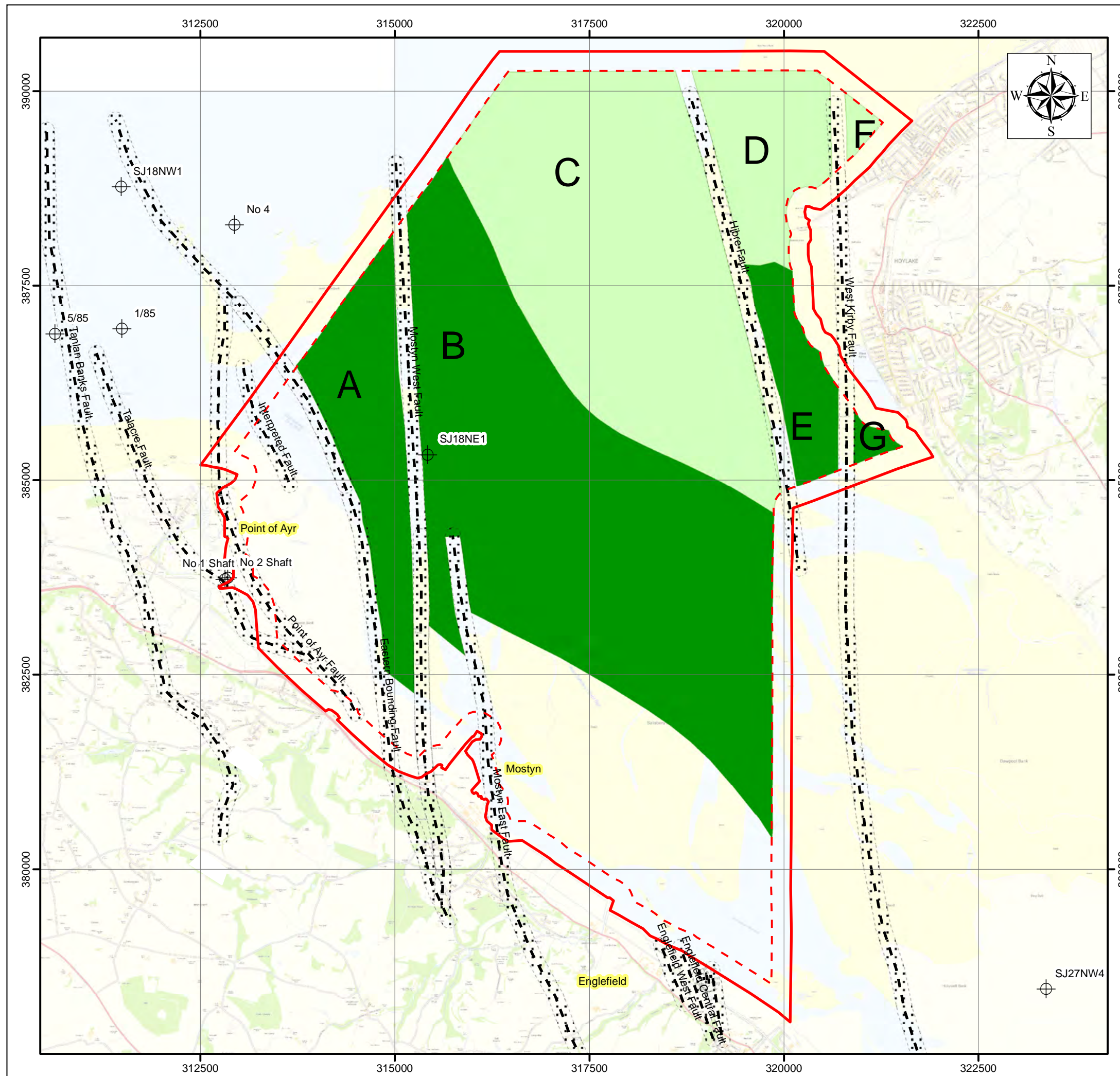
27th November 2014

SCALE

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DRG. No.

1865OD022



NOTES / KEY

- Point of Ayr Licence
- Point of Ayr Licence 250m Internal Buffer
- 500 Surfer Modelled Seam Base Depth Contours for the Hard Five Quarters Seam (with metres below O.D.)
- Fault and 100m Buffer
- Boreholes
- Point of Ayr Former Colliery

- Key to Coal Seam Tonnage Areas**
Hard Five Quarter Seam Tonnage Areas
Area Classification - Areas A to G
- 500 to -1500 metres
 - Below -1500 metres

Coordinate System: British National Grid
Projection: Transverse Mercator
Datum: OSGB 1936
False Easting: 400,000,000
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Central Meridian: -2,0000
Scale Factor: 0.9996
Latitude Of Origin: 49.0000
Units: Meter

CLIENT

Cluff Natural Resources plc

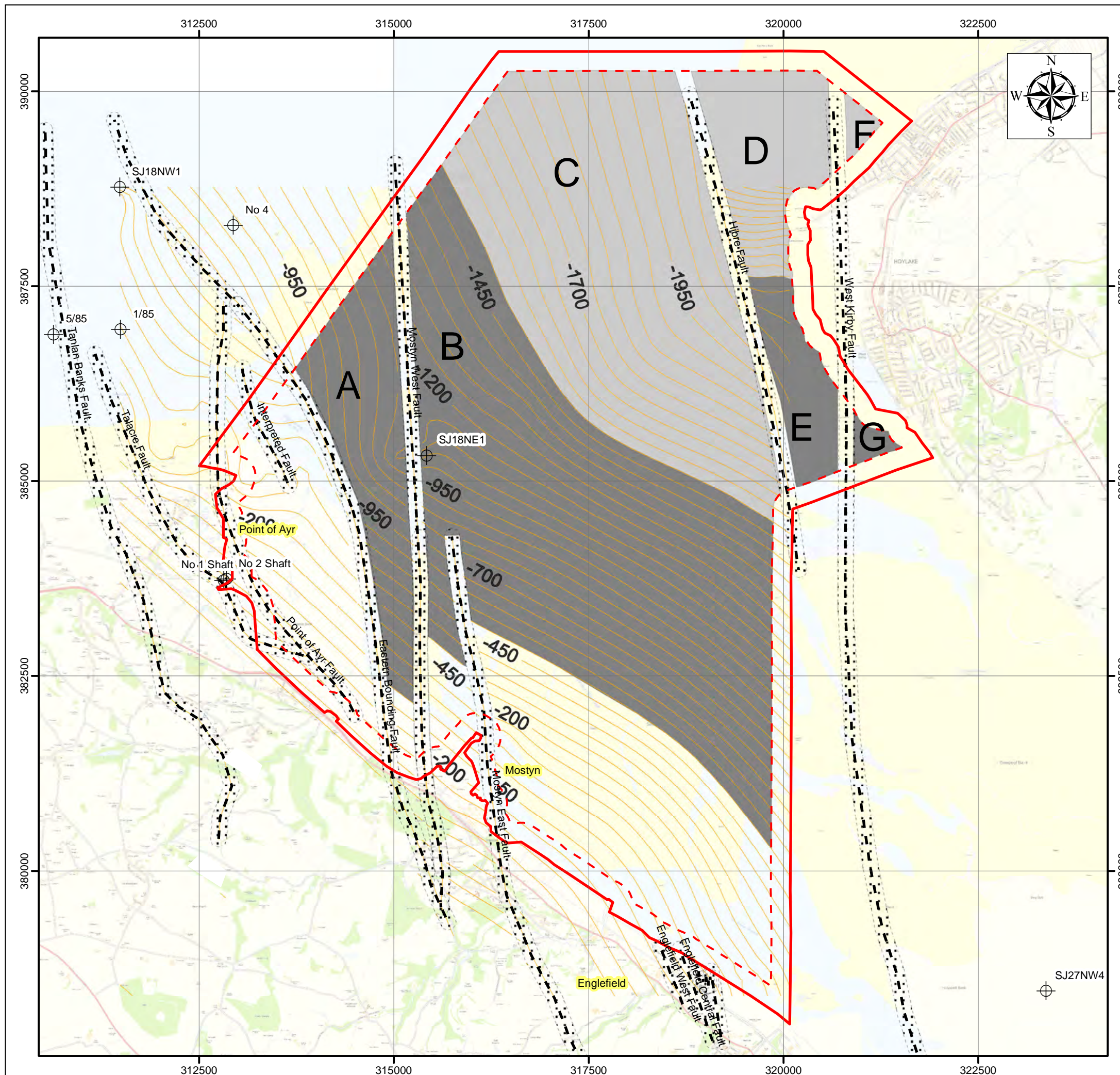
DRAWING TITLE

Interpreted Depth-Classified Areas
for the Hard Five Quarters Seam

PROJECT TITLE

Point of Ayr UCG Project

STATUS FINAL	PROJECT NUMBER 1865
DRAWN BY IH	DATE 27th November 2014
SCALE 1:50,000	DRG. No. 1865OD023



NOTES / KEY

- Point of Ayr Licence
- Point of Ayr Licence 250m Internal Buffer
- Fault and 100m Buffer
- Boreholes
- Point of Ayr Former Colliery

Key to Coal Seam Tonnage Areas

- Bychton Seam Tonnage Areas**
Area Classification - Areas A to G
- 500 to -1500 metres
 - Below -1500 metres

Coordinate System: British National Grid
Projection: Transverse Mercator
Datum: OSGB 1936
False Easting: 400,000,0000
False Northing: -100,000,0000
Central Meridian: -2.0000
Scale Factor: 0.9996
Latitude Of Origin: 49.0000
Units: Meter

CLIENT

Cluff Natural Resources plc

DRAWING TITLE

Interpreted Depth-Classified Areas
for the Bychton Two Yard Seam

PROJECT TITLE

Point of Ayr UCG Project

STATUS

FINAL

PROJECT NUMBER

1865

DRAWN BY

IH

DATE

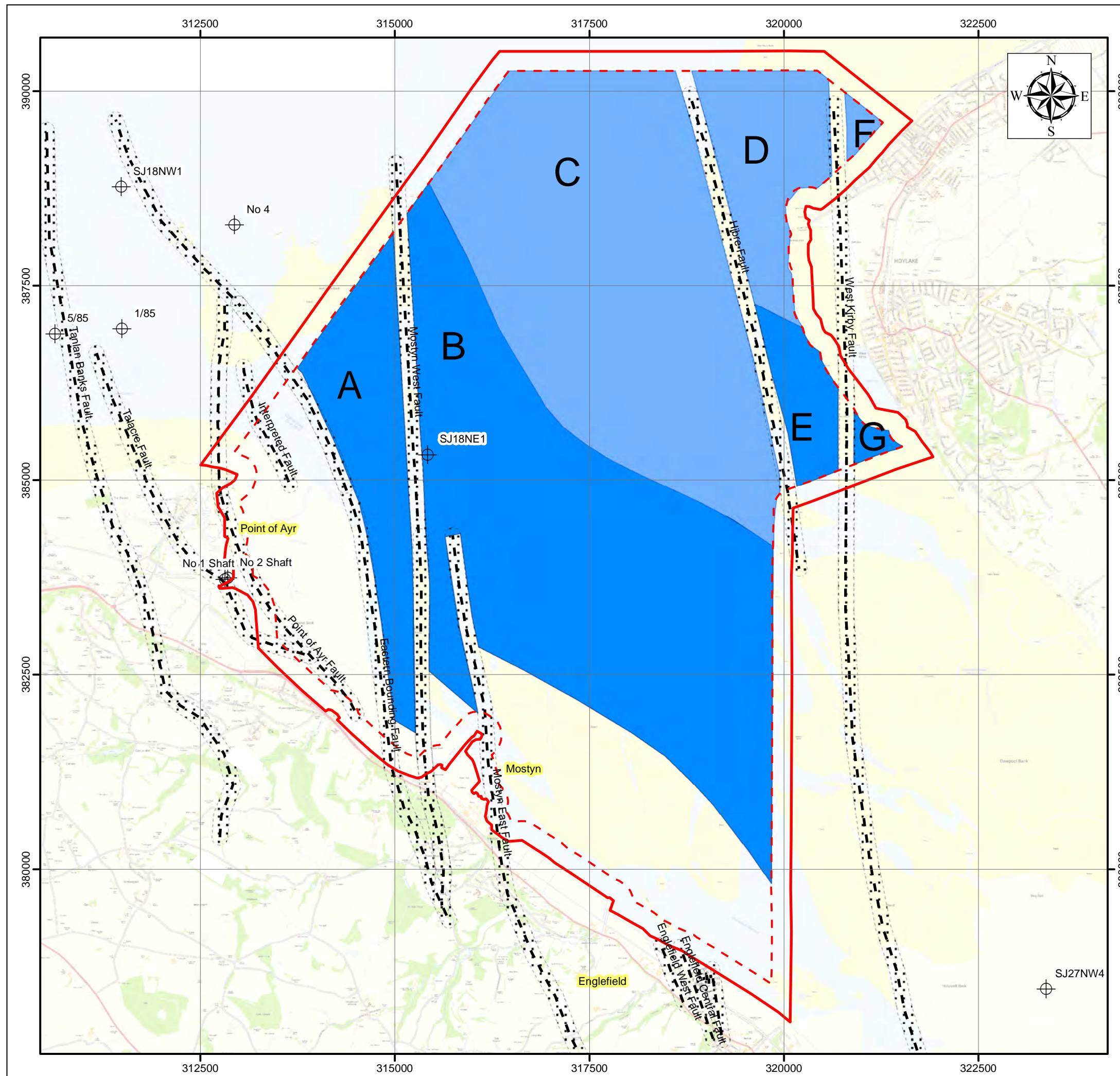
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SCALE

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DRG. No.

1865OD024



NOTES / KEY

- Point of Ayr Licence
- Point of Ayr Licence 250m Internal Buffer
- 500 Surfer Modelled Seam Base Depth Contours for the Hard Five Quarters Seam (with metres below O.D.)
- Fault and 100m Buffer
- Boreholes
- POINT OF AYR** Site of Former Colliery

Key to Coal Seam Tonnage Areas (-500m to > -2000m depth)

- Five Yard Seam Tonnage Areas
- Three Yard Seam Tonnage Areas
- Two Yard Seam Tonnage Areas
- Durbog Seam Tonnage Areas
- Stone Seam Tonnage Areas
- Hard Five Quarters Seam Tonnage Areas
- Bychton Seam Tonnage Areas

CLIENT

Cluff Natural Resources plc

DRAWING TITLE

Interpreted Depth-Classified Areas for the Bychton Two Yard to the Five Yard Seam

PROJECT TITLE

Point of Ayr UCG Project

STATUS

FINAL

PROJECT NUMBER

1865

DRAWN BY

IH

DATE

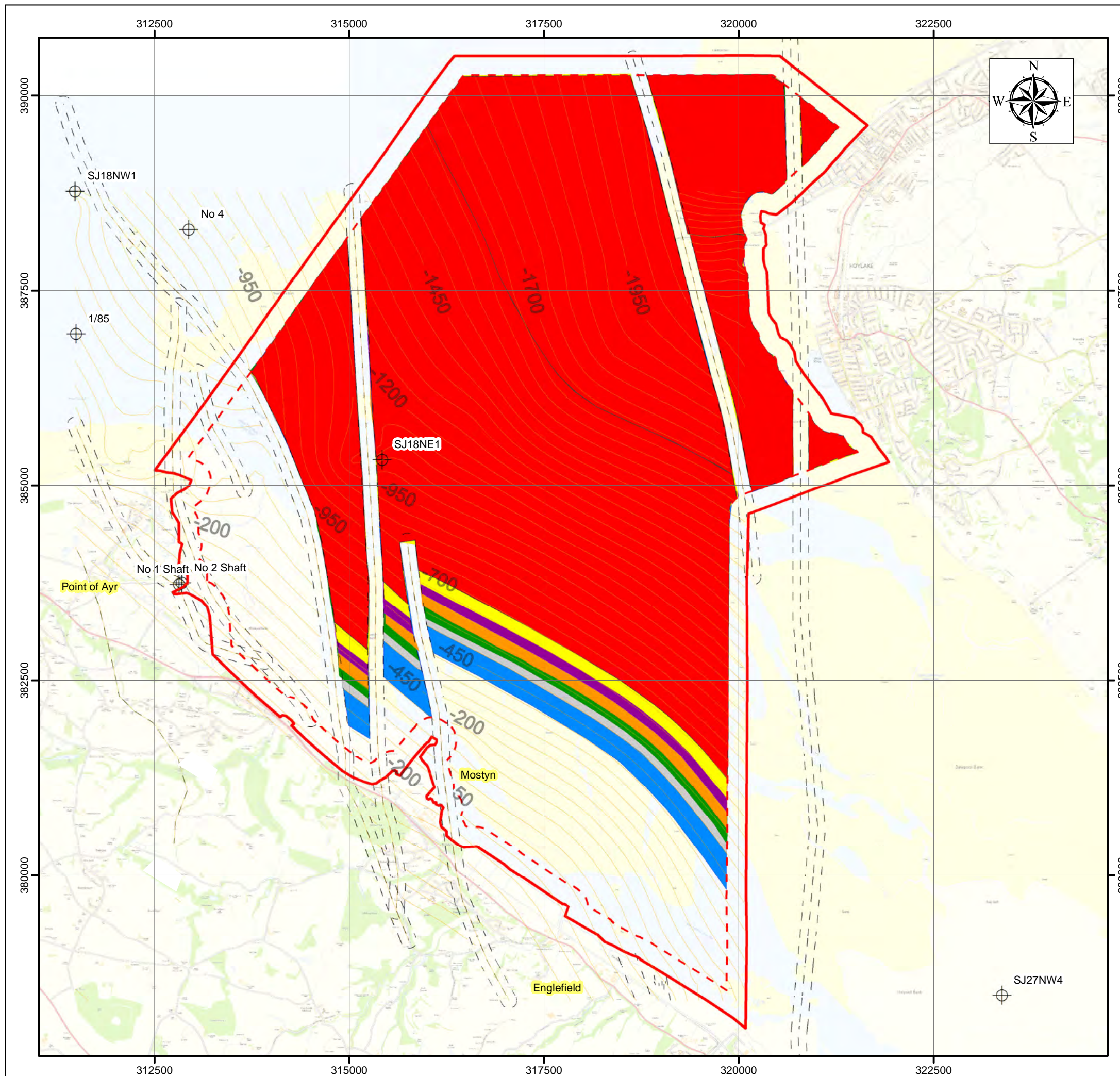
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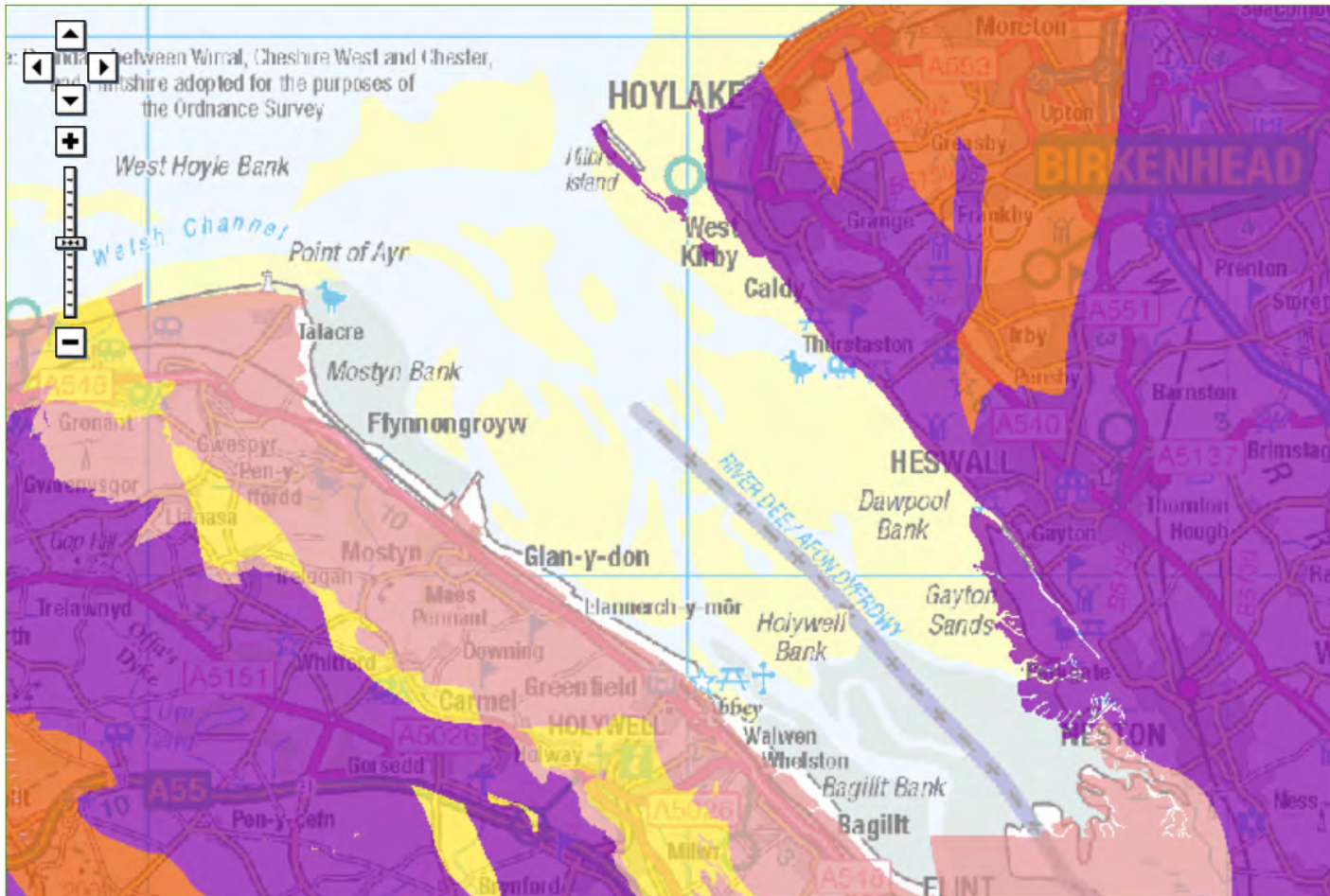
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1865OD025





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NOTES / KEY

- Principal aquifer
- Secondary A
- Secondary B
- Secondary (undiff.)

Source: Environment Agency

CLIENT

CLUFF NATURAL RESOURCES plc

DRAWING TITLE

BEDROCK AQUIFERS SURROUNDING THE DEE ESTUARY

PROJECT TITLE

POINT OF AYR UCG PROJECT

STATUS

FINAL

PROJECT NUMBER

1865

DRAWN BY

NH

DATE

Nov 2014

SCALE

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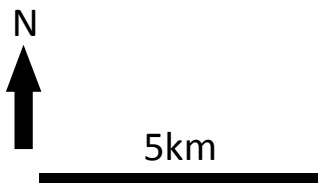
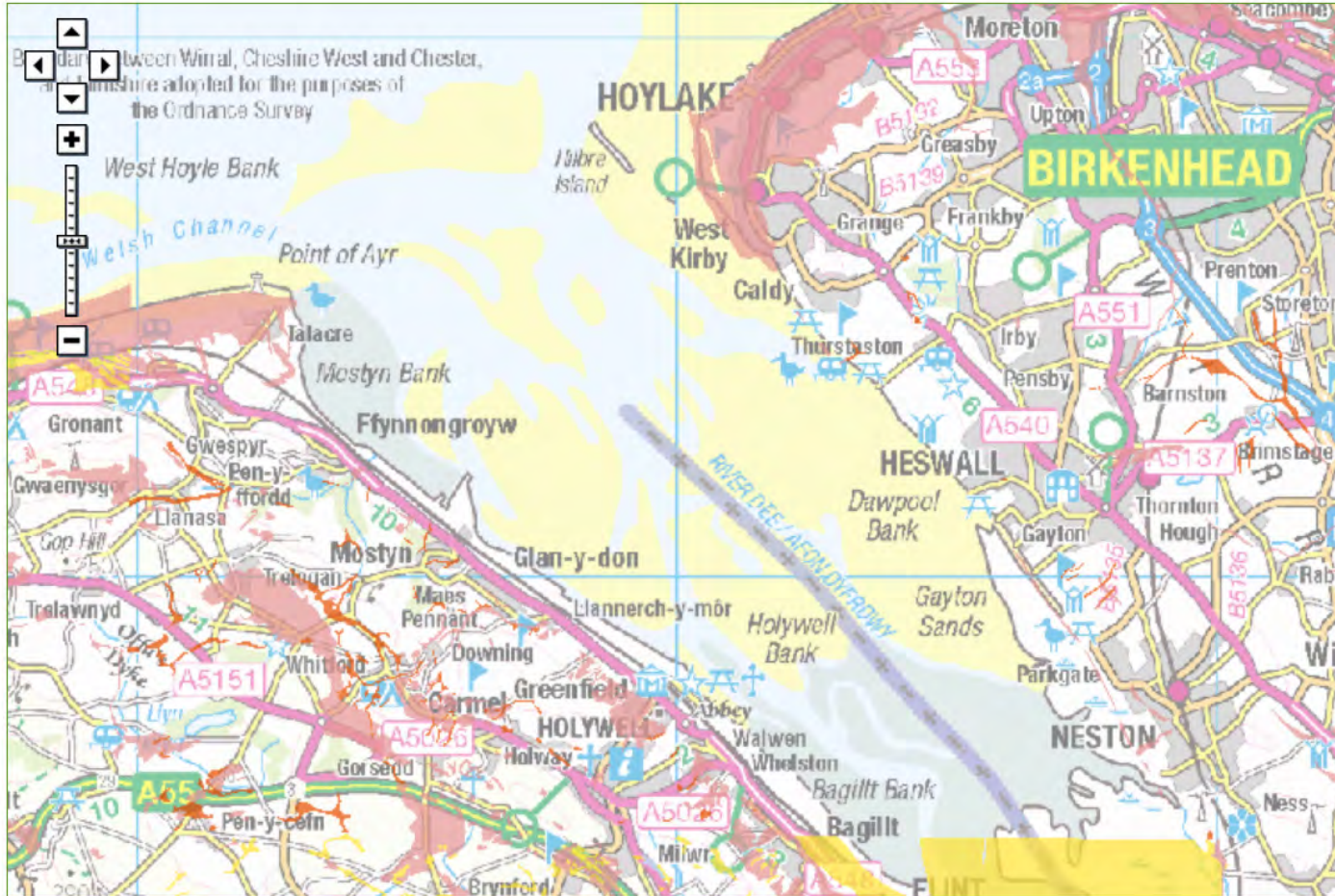
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NOTES / KEY

- Principal aquifer
- Secondary A
- Secondary B
- Secondary (undiff.)

Source: Environment Agency

CLIENT

CLUFF NATURAL RESOURCES plc

DRAWING TITLE

SUPERFICIAL AQUIFERS SURROUNDING THE DEE ESTUARY

PROJECT TITLE

POINT OF AYR UCG PROJECT

STATUS

FINAL

PROJECT NUMBER

1865

DRAWN BY

NH

DATE

Nov 2014

SCALE











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1865OD027

NOTES / KEY

POINT OF AYR Location of former colliery

-  Point of Ayr Licence
-  Point of Ayr Licence 250m Internal Buffer
-  Point of Ayr - Two Yard Seam Workings
-  Point of Ayr - Durbog Seam Workings
-  Point of Ayr - Stone Seam Workings
-  Point of Ayr - Hard Five Quarter Seam Workings
-  Mostyn - All Worked Areas (NCB plans)
-  Mostyn - Bychton Two Yard Seam Workings
-  Hanmer - All Worked Areas (NCB plans)
-  Englefield - All Workings

Note: the mine plans are available in Appendix 2

CLIENT

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DRAWING TITLE

The Locations of Former Colliery Workings Within the Licence Area

PROJECT TITLE

Point of Ayr UCG Project

STATUS

FINAL

PROJECT NUMBER

1865

DRAWN BY

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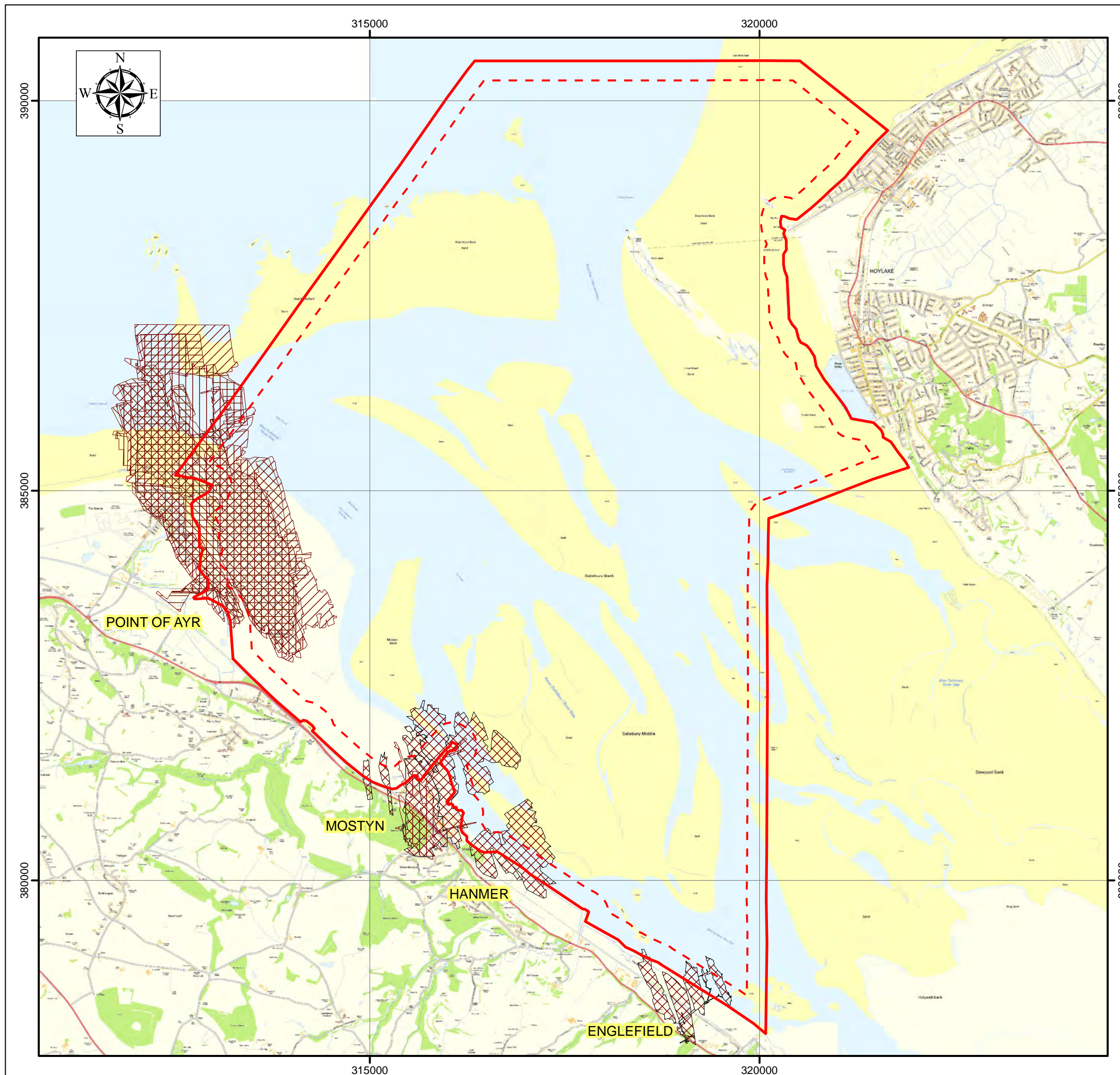
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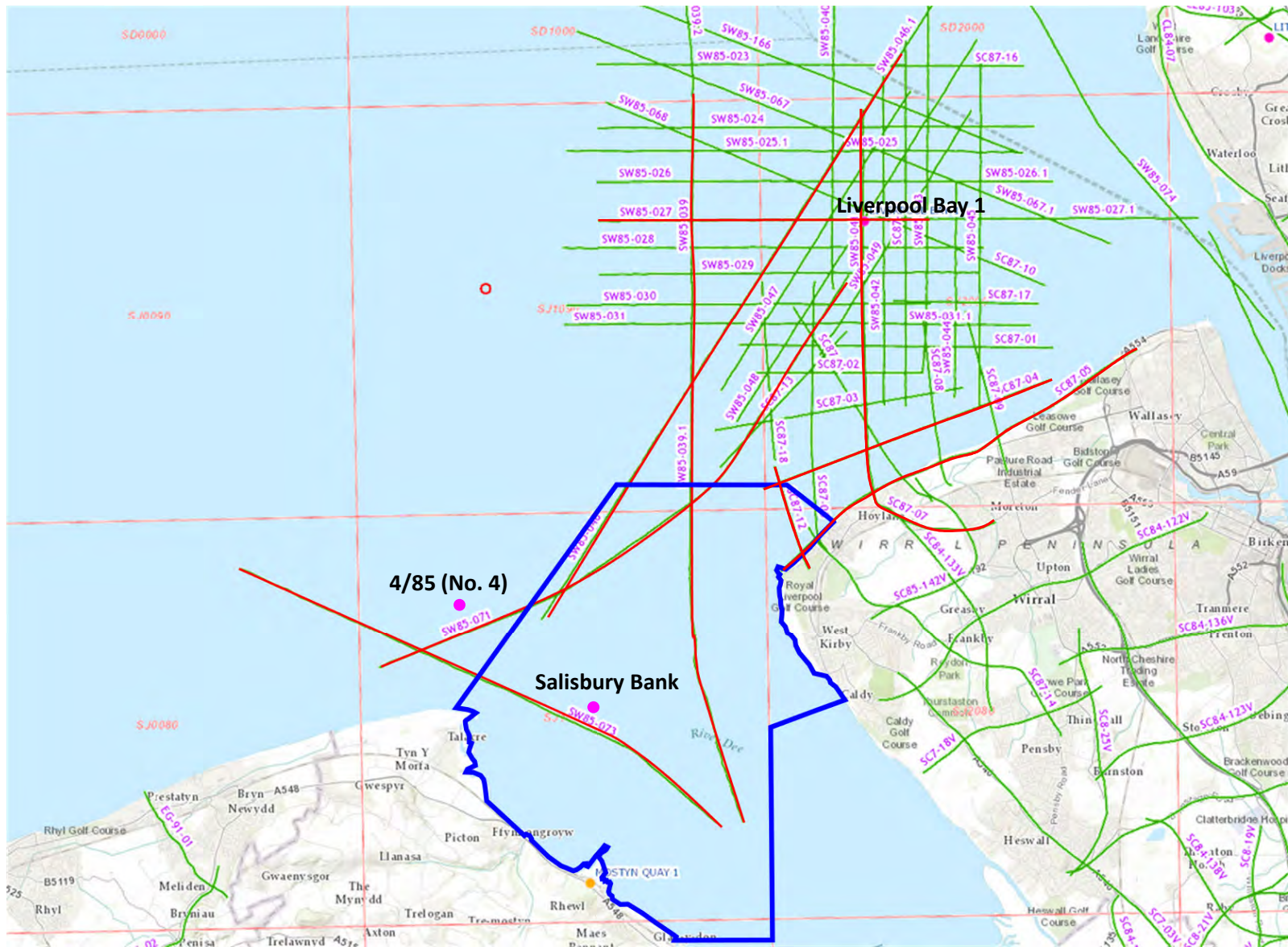
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1865OD030





10 km

Source: UKOGL

NOTES / KEY

- Licence area
- Key seismic line
- Key borehole

DRAWING TITLE

MAP SHOWING LOCATIONS OF SEISMIC LINES AND LIVERPOOL BAY 1 BOREHOLE

PROJECT TITLE

POINT OF AYR UCG PROJECT

CLIENT

CLUFF NATURAL RESOURCES plc

STATUS
FINAL

PROJECT NUMBER
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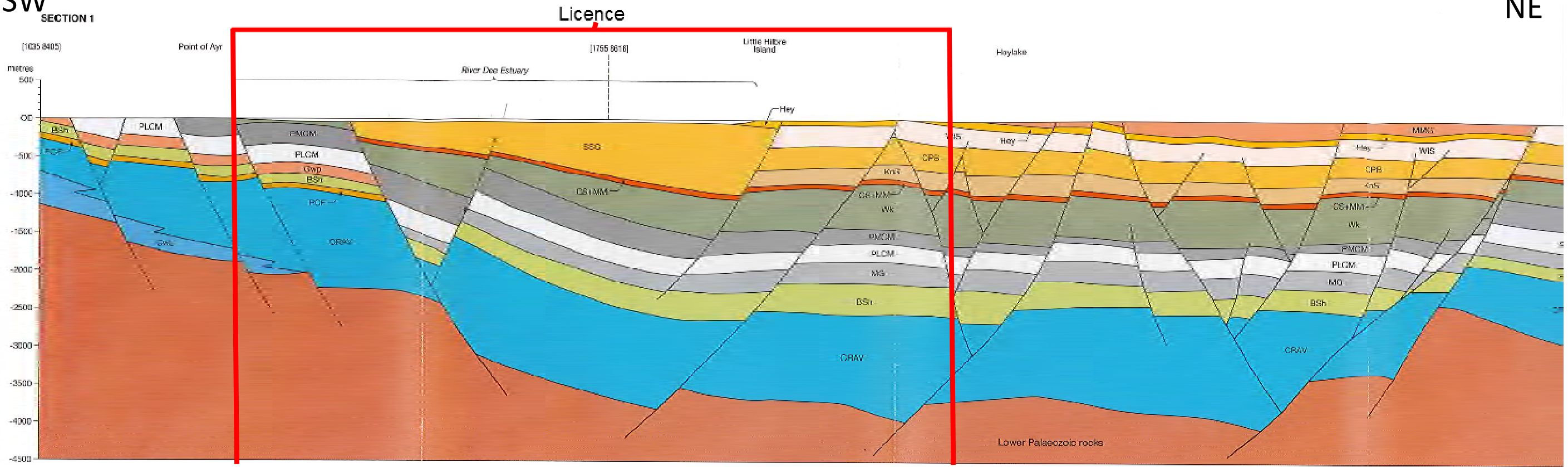
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SW
SECTION 1

NE



- | | | |
|---|----------------------------------|---|
| SSG Sherwood Sandstone Group | PMCM Middle Coal Measures | BSh Bowland Shale Formation |
| MM/CS Manchester Marl and Collyhurst Sandstone | PLCM Lower Coal Measures | CRAV Craven Group (Carboniferous Limestone) |
| Wk Warwickshire Group | MG Millstone Grit | Undifferentiated Lower Palaeozoic (mostly Silurian) |

Scale:



NOTES / KEY

Source: England and Wales Mapsheet 96 (Liverpool). 2006. British Geological Survey

DRAWING TITLE

CROSS SECTION ACROSS THE DEE ESTUARY AND THE WIRRAL

PROJECT TITLE

POINT OF AYR UCG PROJECT

CLIENT

CLUFF NATURAL RESOURCES plc

STATUS

FINAL

PROJECT NUMBER

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DRAWN BY

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DATE

November 2014

SCALE

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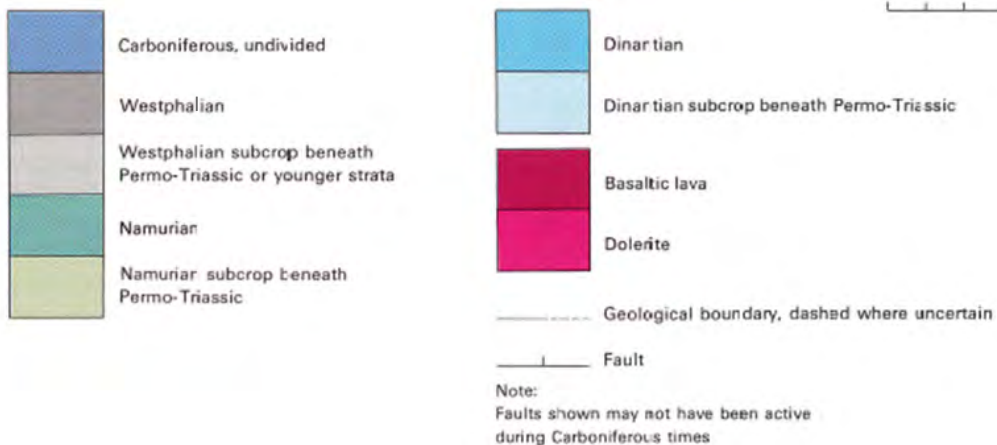
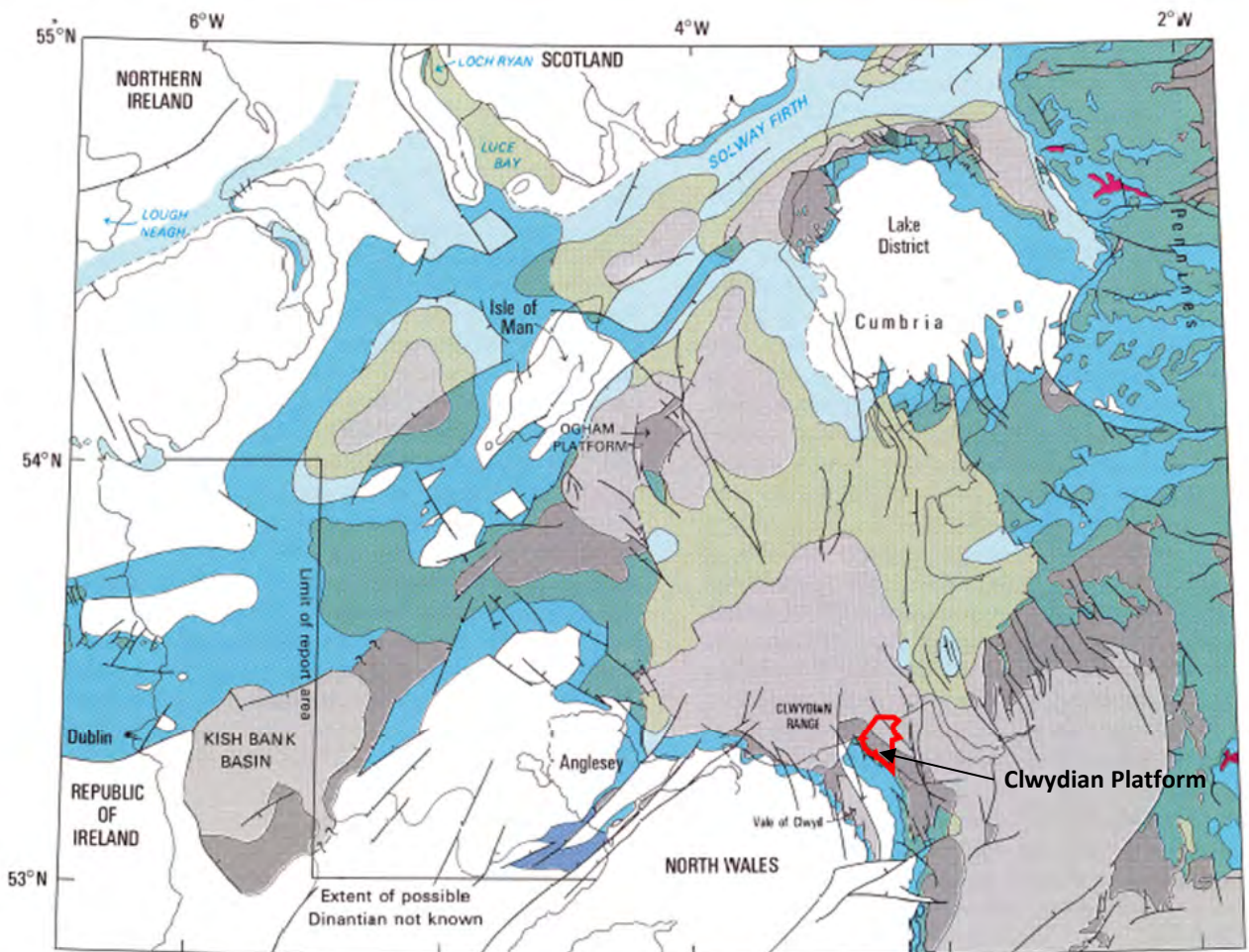
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1865OD038

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NOTES / KEY



Dee Estuary and Flintshire coalfield

Source: Jackson *et al* (1995).

DRAWING TITLE
DISTRIBUTION OF CARBONIFEROUS STRATA IN AND AROUND THE EAST IRISH SEA BASIN

PROJECT TITLE
POINT OF AYR UCG PROJECT

CLIENT
CLUFF NATURAL RESOURCES

STATUS
FINAL

DRAWN BY
TD

SCALE
AS SHOWN

PROJECT NUMBER
1865

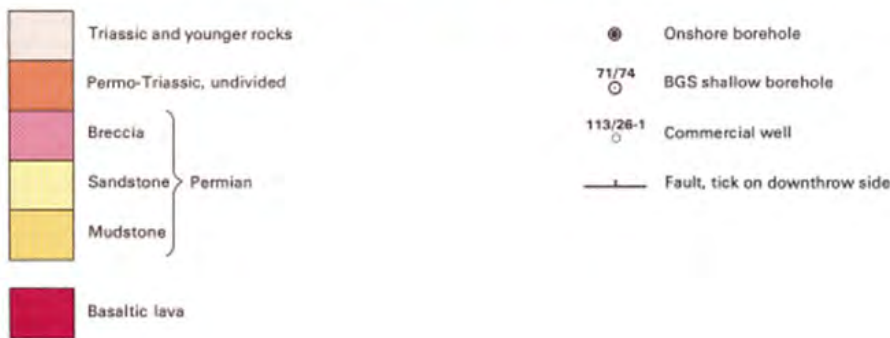
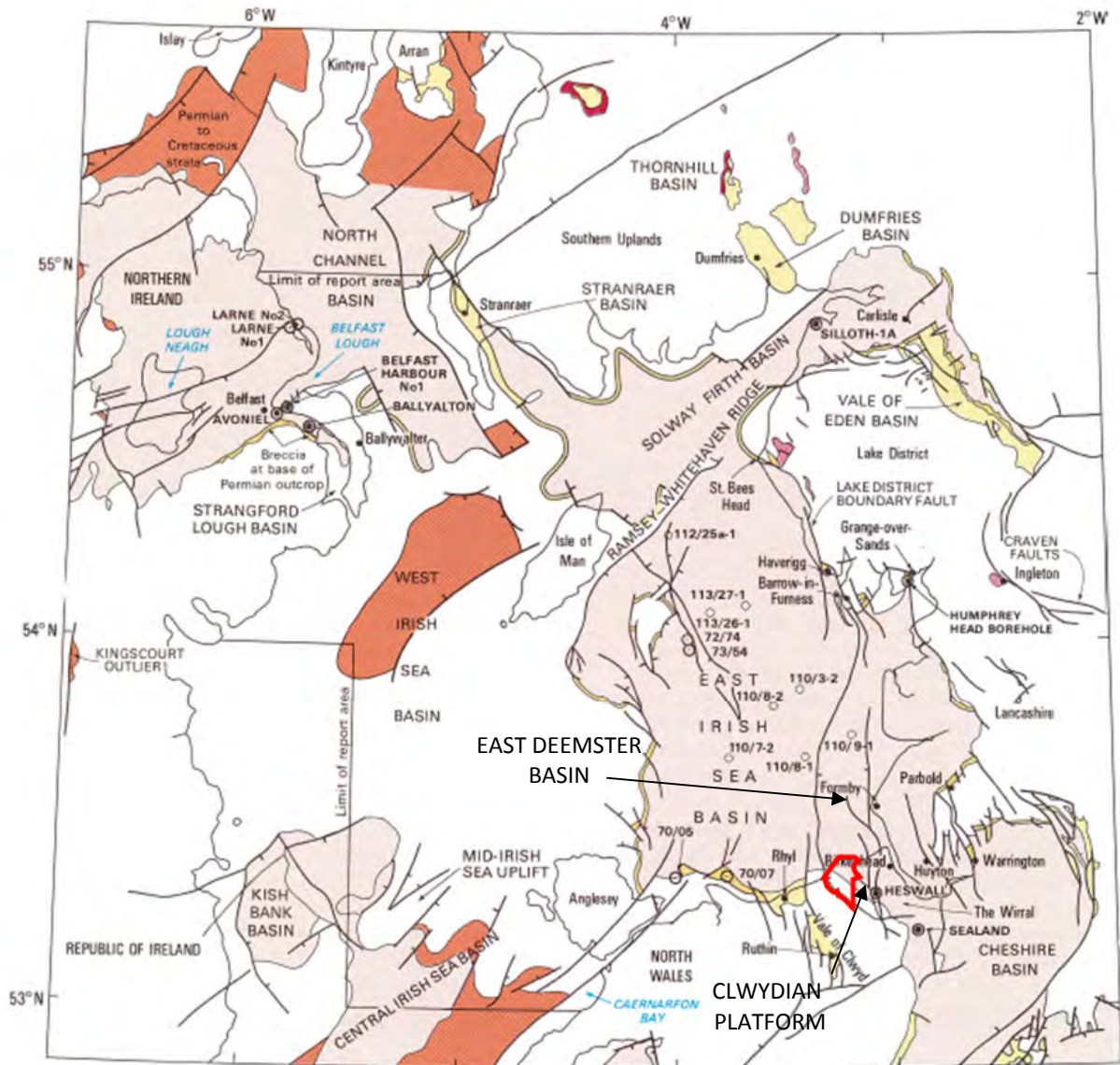
DATE
Nov 2014

DRG. No.
1865OD39

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NOTES / KEY

Dee Estuary and Flintshire coalfield

Source: Jackson *et al* (1995).

DRAWING TITLE
DISTRIBUTION OF PERMIAN AND TRIASSIC STRATA IN AND AROUND THE EAST IRISH SEA BASIN

PROJECT TITLE
POINT OF AYR UCG PROJECT

CLIENT
CLUFF NATURAL RESOURCES

STATUS FINAL	PROJECT NUMBER 1865
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DRAWN BY TD	DATE Nov 2014
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