APPENDIX 11

Methodology and notes on the determination of mineral matter

Departmental coal analyses data set

The data discussed in pages 49 to 58 in this record, and presented in Appendix 12, comprise a mix of:

- analysed values (Stage 1 and Stage 2), where a coal interval was sampled as a single interval (about 75 entries)

- analysed values of mass proportioned ply composites prepared in the laboratory for the determination of Specific Energy during Stage 2 testing

- calculated (mass proportioned) values in instances where a coal interval was sampled as multiple contiguous plies (about 120 entries).

Notes provided in the 'Comments' column of the table presented in Appendix 12 distinguish between these data types.

The data set also includes the analytical results of coal seams intersected in three GSQ Stratigraphic boreholes—GSQ Jericho 1, GSQ Hughenden 6 and GSQ Hughenden 7.

The table presented in Appendix 12 shows analysed results in normal type, while the italicised numbers depict calculated parameter values (mass proportioned basis) for 'full seam' composites using results from the individual plies. Analytical results for all composited 'full seam' intervals are shown in bold type and highlighted in yellow. For calculating composite values for each parameter, on a mass proportioned basis, the following general equation used was:

$$all\ plies\ in\ the\ composite = \frac{\sum (ply\ length \ \mathbf{x} \ ply\ raw\ coal\ relative\ density\ (RD) \ \mathbf{x} \ yield\ at\ F\ 1.90 \ \mathbf{x} \ parameter\ value\ )}{\sum (ply\ length \ \mathbf{x} \ ply\ raw\ coal\ RD \ \mathbf{x} \ yield\ at\ F\ 1.90\ )}$$

Values presented in red (Galilee NS 1, Galilee NS 2), indicate the analysis was undertaken on raw coal. These results have been excluded from the data set reviewed, since all other results were of the Floats 1.90 fraction.

In calculating the proximate analyses parameters for seam composites, from the individual ply results, the moisture, ash and volatile matter content values were first determined as the product of non-rounded numbers, then rounded to 3 significant figures. The Fixed Carbon value was then determined by subtraction of the sum of the other three rounded parameter values (Moisture, Ash and Volatile Matter—air dry basis) from 100 (per cent) and rounded to 3 significant figures to ensure the proximate analysis result for the calculated composite (air dry basis) totalled to 100 per cent.

For boreholes drilled initially in the program (Galilee NS 1 to NS 12R inclusive), calorific values reported by the laboratory in British Thermal Units (BTU) per pound (lb) were converted to the equivalent Specific Energy value (presented in Megajoules per kilogram—MJ/kg) by dividing the Calorific Value with a factor of 429.923. Also presented is the Specific Energy value expressed as kilocalories per kilogram (kcal/kg). The latter was derived by multiplying the Specific Energy of the coal expressed in MJ/kg by the factor 238.846.

Boreholes Galilee NS 1 to Galilee NS 15R inclusive were logged and sampled in imperial units. The factor used to convert measurements into metric units was to divide sample intervals in decimalised feet by a factor of 3.2808.

The core recovery listed has been taken from the coal sampling detail sheets and represents the estimated linear recovery. In most cases, the boreholes were fully cored and all holes were continuously cored through the coal bearing sections. Very few boreholes had downhole geophysical logs run in them.

For about 60 coal samples, with Stage 2 testing, both air dried moisture content and ash value determinations were undertaken a second time when the Specific Energy determination was undertaken. The moisture content determined at this later stage of testing is presented in the column headed "Specific Energy Analysis Moisture adb". In almost all cases, the moisture content determined during Stage 2 testing, was lower (in some cases significantly so) than the moisture content either determined with Stage 1 testing or calculated from the individual ply Stage 1 test results. While theoretically, this would allow for the Specific Energy value reported to be corrected to the moisture content determined during Stage 1 testing, this correction to the Specific Energy value, has not been undertaken for the data set used in the statistical presentation of results.

Unless determined in the laboratory and recorded in Appendix 12 as a 'reported' value, the Relative Density (RD) of the raw coal has been calculated using the mass balance percentages and relative densities determined from the floats (F) 1.90 and Sinks (S) 1.90 fractions.

Determination of mineral matter to different bases for the purpose of coal classification

For the coal analyses data set derived for the coal samples taken from the Departmental coal reconnaissance drilling program, in order to generally classify the coal using either the American Society of Testing and Materials (ASTM) current standard (D388-12; '*Standard Classification of Coals by Rank*'—herein referred to as the ASTM classification) or Seyler's Classification Chart—it was first necessary to determine the mineral matter content of the coal sampled and also calculate various coal parameters as reported, to different bases from the as reported basis.

The parameters required for the purpose of broadly classifying the coals were the Carbon and Hydrogen content values (determined from the Ultimate Analysis and reported on a dry, ash free basis), in addition to the Volatile Matter content and Specific Energy (Calorific Value) either reported or calculated on an air dry basis.

The procedure followed and formulae used were as follows:

Step 1

The mineral matter of the coal sample or composited samples was calculated to both an air dry basis (adb) and a dry basis (db) using the Parr Formula as follows:

(a) Mineral Matter (air dry basis) is estimated with the Parr formula as

$$1.08 * Ash\,(adb) + 0.55 * Total\,Sulphur\,(adb)$$

(b) Mineral Matter (dry basis) is estimated with the Parr Formula as

$$1.08 * Ash\,(db) + 0.55 * Total\,Sulphur\,(db)$$

For equation 1(b) above, conversion of the ash and sulphur values reported on an air dry basis (from proximate analysis) to a dry basis, is given by the equation

$$(c)\; Parameter\,db = Parameter\,(adb) * \frac{100}{100 - Moisture\,(adb)}$$

Step 2

Conversion of the Specific Energy (SE) reported on an air dry basis to a dry, mineral matter free (dmmf) basis, is given by the equation

$$\text{(a) } SE\ (dmmf) = SE\ (adb) * \frac{100}{100 - (Moisture\ adb + Mineral\ Matter\ adb)}$$

Equation 2(a) becomes

$$\text{(b) } SE\ (dmmf) = SE(adb) * \frac{100}{100 - (Moisture\ adb + [1.08 * (Ash\ adb) + 0.55 * (Total\ S\ adb)])}$$

Step 3

Fixed Carbon (FC) values reported with the proximate analysis results on an air dry basis were converted to a dry mineral matter free basis using the same formula as follows

$$\text{(a) } FC\ (dmmf) = FC(adb) * \frac{100}{100 - (Moisture\ adb + Mineral\ Matter\ adb)}$$

Equation 3(a) becomes

$$\text{(b) } FC\ (dmmf) = FC(adb) * \frac{100}{100 - (Moisture\ adb + [1.08 * (Ash\ adb) + 0.55 * (Total\ S\ adb)])}$$

In accordance with the ASTM classification system, Volatile Matter (VM) content, dry mineral matter free basis, was determined by subtraction of the calculated dry, mineral matter free Fixed Carbon value—given by equation 3(b), from 100 per cent—equation 3(c) below

$$\text{(c) } VM\ (dmmf) = 100 - FC\ (dmmf)$$

Note: For calculating dry, mineral matter free values of the low sulphur content Galilee Basin coal samples in this dataset, correction for sulphates of both the Fixed Carbon content and Ash values as outlined in the ASTM classification system (for higher sulphur content North American coals) was not undertaken:

The ASTM classification (page 4) gives the formula for the determination of Fixed Carbon to a dry, mineral matter free basis as

$$FC\ (dmmf) = \frac{100 * (FC - 0.15\ Total\ S)}{[100 - (Moisture\ adb + 1.08\ Ash\ adb + 0.55\ Total\ S\ adb)]}$$

The ASTM classification specifies that the Moisture, Ash and Sulphur values in this equation are to be on the inherent (air dry) moisture basis.

Step 4

Convert both the Hydrogen and Carbon values reported with the Ultimate Analyses on a dry, ash free basis to a dry, mineral matter free basis, is given by the equation

$$\text{(a) } H\ (dmmf) = H\ (daf) * \frac{100 - Ash\ db}{100 - Min\ Matter\ db}$$

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Equation 4(a) becomes

$$(b)\ H\ (dmmf) = H\ (daf) * \frac{100 - \text{Ash db}}{100 - (1.08 * \text{Ash db}) + (0.55 * \text{Total S db})}$$

Converting both the ash value and total sulphur value used in equation 4(b) to a dry basis, from the values reported on an air dry basis with the proximate analysis, this equation translates to

$$(c)\ H\ (daf)) * \frac{100 - \left(\text{Ash adb} * \frac{100}{100 - \text{Moisture adb}}\right)}{100 - \left[1.08 * \left(\text{Ash adb} * \frac{100}{100 - \text{Moisture adb}}\right) + \left(0.55 * \text{Total S adb} * \frac{100}{100 - Moisture\ adb}\right)\right]}$$

The same procedure and equations were used to convert the dry, ash free Carbon values reported with the Ultimate Analyses to a dry, mineral matter free basis.

Adjusting for Mineral Matter in coal— notes on the Parr Formulae and 'unit coal'

Perch & Russell (1949) describe the formulae developed by Parr & Wheeler (1910), by which ash as weighted in an analysis of a coal sample could be converted to the original mineral matter in the coal. According to Perch and Russell, coal corrected to the 'mineral-matter-free basis' was referred to originally by Parr and Wheeler as 'actual or unit coal' with the American Society of Testing and Materials (ASTM) subsequently preferring to designate this correction as 'mineral-matter-free'. The latter term is now universally applied to coal analyses that have been corrected in this way.

The formulae developed by Parr and Wheeler (referred to as 'the Parr Formulae') were derived using assumptions based on analytical data for North American coals. Perch and Russell (*op.cit.,* page 473) set out the Parr Formulae and the simplified 'Approximation Formulae' derived from them. A detailed derivation of the Parr Formulae is provided by Rees (1966, pages 20 to 24). The Parr Formulae and the system now adopted by the American Society of Testing and Materials (embodied in the ASTM coal classification system) use the calculated dry, mineral-matter free Fixed Carbon value to determine the dry, mineral-matter free Volatile Matter content, by subtraction of the value from 100 per cent.

Ward (1984, page 66) outlines an alternative approach. Since, as Ward explains, 'pure' coal (termed 'actual or unit coal' by Parr and Wheeler, page 2, Introduction) may be considered to consist solely of volatile matter and fixed carbon, in order to determine the corrected proportions of these two components in a sample of coal, it is necessary to first determine, and then adjust for, the total amount of mineral matter in the coal sample. The component parts that make up the volatile matter of coal comprise the volatile matter contributed to by the mineral matter (volatile mineral matter) and the volatile matter contributed to by the organic matter (Ward, 1984, figure 2.18, page 66).

Ward then provides the formulae used to determine the proportion of the total volatile matter attributed to the mineral-induced volatiles, and subsequently, using this value, the formula used to determine the percentage of volatile matter in the coal sample, in order to calculate to a dry, mineral-matter free basis.

This (indirect) method, however, requires that the coal sample is analysed for:

- forms of sulphur (to determine the percentage of pyritic sulphur)

- the percentage of carbonates

- the percentage of chlorine.

The percentage of volatile matter calculated to a dry, mineral-matter free basis using this method, is then used to determine the dry, mineral-matter free Fixed Carbon value by subtraction from 100 per cent.

Ward (1984, page 67) notes further, that the use of the ASTM classification has limitations and specifically excludes certain coals which have particularly unusual properties such as non-banded, volatile rich sapropelic coals—of the type (for example) found in the Surat and Clarence-Moreton basins.