RIVERSDALE
RESOURCES

Section B

Geology and Geotechnical

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B.0 GEOLOGY AND GEOTECHNICAL

The Crowsnest Pass region has been extensively mined since the early 1900s. Coal was extracted from underground mines on the Grassy Mountain property from 1913 at the Greenhill and Bellevue mines until 1968 and surface operations continued at a number of small open cut mines until 1975. Photos B.1 and B.2 provide examples of legacy open cuts located on Grassy Mountain as a result of previous mining activities. Coal rights for Grassy Mountain and the Bellevue property to the east are controlled by Benga Mining Limited (Benga). Exploration for the Grassy Mountain Coal Project (the Project) was focused on the northern part of the property, which is predominantly classified as Category 4. Exploration and development is permitted within Category 4, subject to normal approval procedures in accordance with the Coal Development Policy of Alberta.

Photo B.1: Example of Open Cut from Legacy Surface Mining on Grassy Mountain. Direction looking South towards Crowsnest Pass, Alberta.

Photo B.2: Example of Open Cut from Legacy Surface Mining on Grassy Mountain.

Three coal seams of economic importance have been identified at Grassy Mountain and occur within structurally deformed sediments of the late Jurassic to early Cretaceous age Kootenay Group. Target coal seams crop out for about 7 km along the limbs of north trending anticlines and synclines, transected by reverse faults with dips that can vary from horizontal to overturned but in general dip at about 30°. Fault offsets are common but fault-bounded plates generally retain normal stratigraphic thicknesses. These characteristics suggest that the Grassy Mountain coal deposits should be categorized as a "complex" geology type based on the GSC Paper 88-21 classification. A total of 450 holes exist in the current database.

Coal quality tests indicate that the coal at Grassy Mountain is medium volatile bituminous coal. Target coal horizons are known as Seam No. 1 (uppermost), Seam No. 2 and Seam No. 4 (lowest) (Table B.0.0-1). Seams No. 1 and No. 4 are zones of interbedded coal and claystone, Seam No. 2 is generally more uniform and less banded. Seam thickness is variable across the deposit due to depositional and structural modifications and localized thickening of coal seams, which may occur in the apex of folds and adjacent to reverse faults. Approximately 143 Mt of coal resources have been identified so far at depths of less than 400 m, comprising 93 Mt of Measured + Indicated and approximately 50 Mt of Inferred Resources.

Table B.0.0-1 Coal Resources Summary

Seam	Depth (m)	Typical Thickness (m)	Coal Resources (Mt)		
			Measured	Indicated	Inferred
Seam No. 1	< 400	4.0	14.5	0.7	7
Seam No. 2		10.0	41.0	2.6	24
Seam No. 4		8.0	32.8	-	21
Total			**88.3**	**3.3**	**52**
Total (Rounded)			**90**	**3**	**50**

B.1 Geological Setting

The Grassy Mountain deposit is within the Rocky Mountain Thrust Belt, approximately 7 km west of the surface trace of the Livingstone Thrust boundary fault and 10 km north of the town of Blairmore. Coal-bearing sediments occur within the Mist Mountain Formation of the Late Jurassic to Early Cretaceous age Kootenay Group (Figure B.1.0-1), which was strongly deformed during the Late Cretaceous Laramide Orogeny. This resulted in the development of north to northwest-trending folds and steeply dipping reverse faults, which locally caused the strata to be thrust upwards. Three coal seams of the Mist Mountain Formation, Seam No. 1, Seam No. 2 and Seam No. 4 crop out in three sub-parallel zones at Grassy Mountain, each zone separated by a major thrust fault.

B.1.1 Regional Geology

Three northwest trending coal-bearing belts to the east of the Rocky Mountains occur in Alberta and British Columbia (Smith *et al.*, 1994). The most western of these and the most structurally complex is the Front Ranges where the Grassy Mountain deposit lies. The stratigraphic succession represents a transition from marine to alluvial deposition which commenced during a period of uplift during the Columbian Orogeny of Late Jurassic age. Sediments were supplied to a foreland basin from a rising landmass to the west and south due to tectonic collision and terrane accretion. These sediments reach a maximum thickness west of the border between Alberta and British Columbia and progressively thin to the east (Gibson, 1983; Figure B.1.1-1). Later compressional deformation during the Laramide Orogeny produced a series of sub-parallel folds transected by reverse faults that dip steeply to the west. The stratigraphic sequence at the Grassy Mountain property characterized as, from top to bottom, the Blairmore Group, the coal-bearing Kootenay Group and the Fernie Group (Figure B.1.1-2 and Figure B.1.1-3).

- **The Blairmore Group** is of Cretaceous age and comprises two formations in the Grassy Mountain area, the Cadomin and the Gladstone formations.
  - **The Cadomin Formation** is a hard and typically massive white, grey and green alluvial conglomerate of well-rounded pebbles, cobbles and boulders of chert and quartzite that is resistive to erosion and is distinctive in the field (Photo B.3). This unit is up to 10 m thick at Grassy Mountain and an erosive surface below the base results in a variable position above Seam No. 1 (Figure B.1.1-4).
  - **The Gladstone Formation** is up to 100 m of fining upwards sequences with pale grey coarse to medium grained siliceous sandstone at the base and interbedded dark grey, green and red claystones, dark grey calcareous siltstone and fine grained sandstone towards the top.

Photo B.3: Contact between the Cadomin Formation and Mist Mountain. Formation in the West (left) and Centre (right) of Grassy Mountain

- **The Kootenay Group** is Late Jurassic and Early Cretaceous in age and consists of predominantly non-marine interbedded sandstone, siltstone, claystone, conglomerate and coal. This unit is 120 m to 200 m thick at Grassy Mountain and up to 450 m where sediments thicken to the west. The group is subdivided into three formations: the Elk Formation, the coal-bearing Mist Mountain Formation and the Morrissey Formation.

- **The Elk Formation** is a coarse sandstone and conglomerate sequence which conformably overlies the Mist Mountain Formation. Thin and laterally discontinuous coal seams of little economic importance are present in southeastern British Columbia but at Grassy Mountain a regional unconformity, which occurs below the overlying Cadomin Formation, has eroded the Elk Formation.
- **The Mist Mountain Formation** contains the three coal seams of economic importance at Grassy Mountain. The formation is a floodplain succession comprising up to 150 m of interstratified siltstone, claystone, sandstone, coal and conglomerate. The basal contact is conformable and abrupt where carbonaceous claystone, siltstone and coal units occur above the massive sandstone of the Moose Mountain Member. The formation is subdivided into the Adanac, Hillcrest and Mutz Members.
- **The Morrissey Formation** (lowermost) is a massive quartz sandstone deposit which is erosion-resistant and easily identified in the field. The basal Weary Ridge Member is acalcareous sandstone with rare siltstone and mudstone interbeds, which weathers to produce an orange brown colour. The uppermost Moose Mountain Member is a hard siliceous grey sandstone with interbeds of carbonaceous claystone and coal and weathers to a brownish-grey colour. The contact between the two members is abrupt and conformable elsewhere but only the upper Moose Mountain Member has been identified at Grassy Mountain.

- **The Fernie Group** is Late Jurassic in age and consists of up to 200 m of dark grey to black marine claystones that turn green in color when weathered. Local occurrences of phosphatic sandstone, limestone and cherty limestone occur towards the base of the group. The upper contact with the Kootenay Group is gradational with increasing sandstone and siltstone interbeds of non-marine origin known as the Passage Beds.

B.2 Deposit Geology

The Mist Mountain Formation is the main coal-bearing unit at Grassy Mountain and marks the transition from coastal to alluvial deposition in a prograding delta environment (Hughes and Sutton, 1975). The three members of the Grassy Mountain Mist Mountain Formation include:

- The Adanac Member consists entirely of Seam No. 4 and is a coaly unit up to 30 m thick, with numerous siltstone and claystone interbeds at the base of the Mist Mountain Formation.
- The Hillcrest Member is up to 30 m of fluvial channel sandstone deposits with interbedded siltstone and claystone that overlies the Adanac Member. Seam No. 3 has not been correlated to the Grassy Mountain deposit and has probably been removed by an erosional surface at the base of the Hillcrest Member.

- The Mutz Member is the stratigraphically uppermost unit of the Mist Mountain Formation and comprises up to 90 m of fluvial siltstone with minor interbedded claystone and coaly partings. Seams No. 1 and No. 2 occur at the top and base of this unit respectively.

Three coal zones within the Adanac and Mutz Members of the Mist Mountain Formation have been identified as potential mining targets (Figure B.1.1-2).

Cross sections have been provided through the deposit and can be found on Figures B.2.0-1 through to B.2.0-7. As illustrated on the section, the coal zones are relatively continuous between major reverse faults; however, the thickness and distribution of coal plies and rock partings within the coal seams is variable and changes often occur over relatively short distances (Figures B.2.0-8 to B.2.0-10). Variations within coal seams and interburden lithologies are partly due to the depositional environment and partly due to the effects of folding and faulting. Reverse faults can cause repetition of coal plies and partings and coal is commonly sheared and friable when adjacent to faults and tight folds.

B.2.1 Seam No. 1

Seam No. 1 is the uppermost unit of the Mutz Member and occurs across most of the deposit, but is locally absent where it has been eroded by a regional unconformity occurring beneath the Cadomin Formation. The position of Seam No. 1 in relation to the hard and resistant Cadomin Formation above is presented in Figure B.1.1-4. Seam No. 1 consists of several coal plies with an aggregate thickness up to 10 m within a stratigraphic interval 5 m to 20 m thick. The seam splits into three main coal plies with carbonaceous claystone and siltstone partings that can be correlated. However, thin coal bands within the plies may pinch out and be laterally discontinuous. The lowermost ply, 1A, is a carbonaceous, high ash and high density ply up to 2 m thick (average 0.6 m) that has been included in the geological model for structural control. The middle ply, 1B, is the thickest and most consistent ply up to 5 m thick, with an average thickness of 2.1 m. Please refer to the thickness isopach in Figure B.2.1-1. Raw ash ranges typically about 20% from 10% to 40%. The uppermost 1C ply is directly below the Cadomin Formation is typically 1.5 m thick (Figure B.2.1-2) and up to 4 m thick with raw ash approximately 25%. Sulphur content is consistent for plies 1B and 1C across the deposit and less than 1%, typically about 0.5%. Coking coal characteristics indicate that Seam No. 1 has potential to be an excellent metallurgical coal after beneficiation (Figure B.2.1-3).

The floor of Seam No. 1 is a 5 m – 30 m thick uniform and competent siltstone/claystone unit across most of the deposit. The interburden between Seam No. 1 and Seam No. 2 is a siltstone up to 50 m thick with interbedded sandstone and carbonaceous claystone interbeds. Structure contour maps have not been provided due to the various fault domains.

B.2.2 Seam No. 2

Seam No. 2 is the thickest and most consistent coal seam and can be identified and correlated throughout the deposit. The seam is the basal unit of the Mutz Member and consists of two coal plies, 2A and 2B, of approximately equal thickness. Seam No. 2 generally varies in thickness from 5 m to 15 m with a typical true thickness of 8 m (Figure B.2.2-1), but may be more than 25 m thick where it is structurally thickened. A stony coal band (2A0) approximately 0.5 m thick splits from the base of Seam No. 2 and has a tendency to pinch out randomly.

Seam No. 2 is a hard coal that contains very few stone bands (Photo B.4). Raw ash is about 20% and fairly consistent across the deposit, although contamination can occur adjacent to reverse faults. Sulphur content of Seam No. 2 is typically less than 1%. The results of coal and coke quality tests indicate that Seam No. 2 has excellent metallurgical properties after beneficiation (Figure B.2.2-2).

The floor lithology of Seam No. 2 is variable but usually comprises at least 1 m of claystone and/or carbonaceous mudstone which is underlain by the siltstone, claystone and sandstone interbeds of the Hillcrest Member. Sandstone is present locally in the immediate floor and thin carbonaceous or coaly bands can occur within 10 m of the base of the seam. Interburden thickness between Seam No. 2 and Seam No. 4 is between 5 m and 40 m but may vary due to structural and depositional characteristics.

Photo B.4: Seam No. 2 at Grassy Mountain

B.2.3 Seam No. 4

Seam No. 4 is equivalent to the Adanac Member and comprises three coal plies. The 4C (uppermost) and 4A plies are both in the order of 2 m to 5 m thick but may reach 10 m in places (Figures B.2.3-1 and Figure 2.3-3). The central 4B ply is typically about 1 m thick and up to 3 m in places (Figure B.2.3-2). Raw ash varies from 10% to 48%, typically 25%. Sulphur content is generally in the order of 0.5%. Coking coal characteristics indicate that Seam No. 4 has potential to be an excellent metallurgical coal after beneficiation (Figure B.2.3-4).

The floor of Seam No. 4 is often a competent claystone or siltstone between 0.5 m and 5 m thick. This unit locally pinches out and in some locations (*e.g.* RGOH3041 and RGSC0009) Seam No. 4 directly overlies more than 20 m of hard siliceous sandstone of the Moose Mountain Member.

B.2.4 Geological Structure

The Grassy Mountain deposit is structurally complex as a result of compressional deformation from the southwest during the Columbian (Jurassic) and the Laramide (Cretaceous) orogenies. Target coal seams occur in three main zones along the limbs of anticlines with axial planes that plunge to the north and within synclines formed on topographic highs (Figures B.2.0-1 through B.2.0-7). Anticlines are overturned in the north of the deposit and are transected by a series of reverse faults that generally dip steeply (up to 80°) to the west with associated drag folds. Major faults limit the extent of economic coal zones both laterally and at depth.

Fifteen reverse faults that dip to the west at 50° – 80° have been identified and modelled with throws between 5 m and 200 m. Fault displacement and axial dip appear to be variable along the fault planes. Small reverse faults occur as splays from the major faults and create imbricate structures in the southwest and north of the deposit. Faults cause repetition of coal seams (Figure B.2.4-1), drag folding adjacent to major faults (Photo B.5) and thickening of coal seams along the axial planes of folded strata, such as Seam No. 2 (Photo B.6). Due to the seam repetitions structure contours maps of the coal seams have not been provided.

Reverse faults and shear structures unable to be identified with the current drill hole spacing, are likely to exist throughout the deposit and these also cause thickening of coal seams (Photo B.7). Evidence of structural disturbance includes geophysical logs, lithology logs, outcrop observations such as brecciation, slickensides, iron oxide on fracture surfaces, caliper breakout, 'spikes' in the sonic log response and scattered dipmeter readings. The presence of reverse faults is often indicated by seam repetition or an increased thickness of a particular lithological unit. Disturbed zones that can occur over an interval of a few metres were recorded in historical descriptive logs as broken or sheared, breccia and slickensides.

Identification of reverse faults and adjacent zones of disturbance is important when assessing potential stability issues in the pit wall and floor and to identify structurally complex zones where faulting can affect coal product yields and coal quality characteristics through contamination and increased proportion of fines.

Bedding dips along fold limbs and between reverse faults varies considerably over relatively short distances and folds can locally produce rolls. In the west of the deposit, strata generally dip towards the west at 25° in the south up to 60° in the north. In the east of the deposit, seams occur along the east (up to 90° dip) and west (up to 45° dip) flanks of an anticline.

Photo B.5: Seam No. 4 Drag Fold Adjacent to a Major Fault

Photo B.6: Example of Thickening of Coal Seams along the Axial Planes of Folded Strata at Seam No. 2

Photo B.7: Seam No. 2 Reverse Fault

B.2.5 Deposit Type

Geological Survey of Canada Paper 88-21 (GSC 88-21) outlines criteria that may be used to classify coal deposits on the basis of "geology type" (degree of geological complexity) and "deposit type" (potential mining methods). Based on these criteria, Grassy Mountain is probably best classified as a complex, surface mineable deposit as the deposit has been subjected to relatively high levels of tectonic deformation with tight folds and steeply inclined or overturned limbs common. Individual fault-bounded plates generally retain normal stratigraphic sequences although coal seam thicknesses are commonly structurally thickened or thinned. Some areas of the Grassy Mountain deposit are considered 'severe' where extreme levels of tectonic deformation have resulted in steeply inclined and overturned folds with large fault displacements.

B.3 Exploration

Coal mining commenced at Grassy Mountain in 1909; however, exploration results from that period are not available. Five exploration campaigns to assess the potential for surface extraction of thermal and metallurgical coal products were conducted from 1971 to 2014 by Scurry Rainbow Oil Limited (Scurry – Rainbow), Consolidation Coal Company (Consol) and Riversdale Resources Limited (the parent company of Benga Mining Limited). Table B.3.0-1 shows the number of drill holes with data available. More than 60,000 m of exploration drilling has been carried out since 1970 (Figure B.3.0-1).

Table B.3.0-1 Summary of Exploration Activities

Year	Company	Drill Holes			Additional Exploration
		Number of Drill Holes	Metres Drilled	Drill Hole Series	
1970 - 1972	Scurry – Rainbow	35	6,065[1]	71DH01 – 71DH35	37 trenches 9 adits
1973	Consol and Scurry – Rainbow	164 (includes twinned core and redrilled holes)	12,050[1]	73CS001 – 73CS133	11 sidewall samples Field mapping
1974	Consol	201 (including redrilled holes)	21,795[1]	74GM001 – 74GM196	Field mapping 54 tonne bulk sample 34 channel samples

Table B.3.0-1 Summary of Exploration Activities

Year	Company	Drill Holes			Additional Exploration
		Number of Drill Holes	Metres Drilled	Drill Hole Series	
1975	Consol	34	4,270[1]	75GM01 – 75GM28 75GMT01 – 75GMT06	Field mapping
2013 - 2016	Riversdale Resources	83	15,930	RGSC0001 – RGSC0010 RGLD1001 – RGLD1013 RGOH3001 –RGOH3063	Field mapping Trench samples 9 tonne bulk sample

[1] Hughes and Sutton (1975)

B.3.1 Historical Exploration\Mining

The Crowsnest Pass area has a long history of underground mining and to a lesser degree, surface mining since the early 1900s (Figure B.3.1-1). Underground coal mines at Greenhill and Blairmore operated from 1909 until 1968 (Table B.3.1-1) and West Canadian extracted between 3 and 4 million tonnes of coal from several small pits in the Grassy Mountain property between 1947 and 1960 (Photo B.8) with historical remnants throughout the property (Photo B.9). Historical reports are inconsistent regarding the number of holes drilled and contain limited information regarding exploration procedures.

Table B.3.1-1 Historical Mine Production from the Grassy Mountain Property

AER Mine No.	Mine Type	Mine Name	Company	Lifespan	Production (k tonnes)
0193	Underground	Blairmore	West Canadian	1909 – 1919	423[1]
0396	Underground	Greenhill	West Canadian	1913 – 1968	14,072[1]
1745	Surface	Grassy Mountain	West Canadian	1956 - 1960	3,500[2]
1776/E	Surface	Grassy Mountain	Consolidated Coal	1974 - 1978	Unknown

[1] ERCB, 2010
[2] Hughes and Sutton (1975)

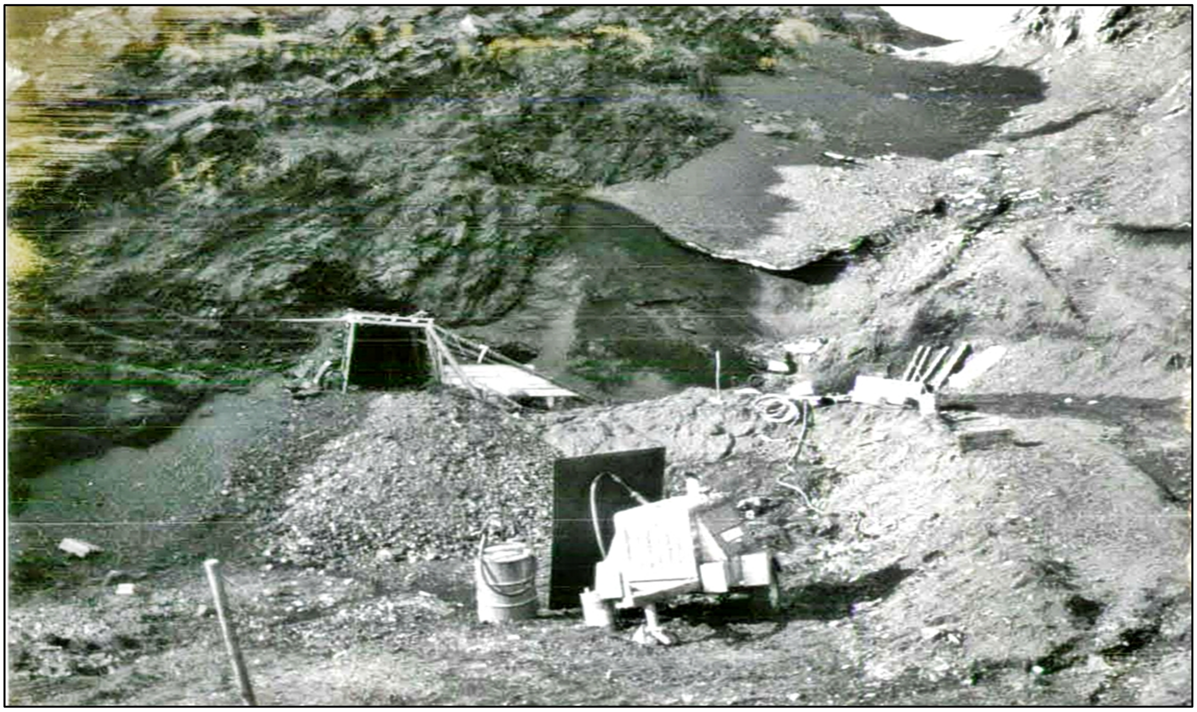


Photo B.8: Historical Image of the Grassy Mountain Strip Mine and Adit – 1971

Photo B.9: Entrance to Historical Greenhill Coal Mine

B.3.1.1 Scurry – Rainbow (1970 – 1972)

The Grassy Mountain coal property was acquired by Scurry – Rainbow in 1966. Exploration carried out between 1970 and 1972 included a comprehensive review of data acquired by West Canadian. 35 HQ size core holes (64 mm diameter) were drilled along section lines, nine adits were excavated and 37 trenches were cut. Coal quality data was obtained for most of the drill holes and five of the adits underwent pilot scale washability testing. Drill hole locations were not always surveyed and survey methods were not recorded.

B.3.1.2 Scurry – Rainbow/ Consol Joint Venture (1973)

Consol acquired a 50% interest in the property through a joint venture agreement with Scurry - Rainbow Oil in 1973. The 1973 exploration program consisted of extensive geological mapping and approximately 150 rotary holes were drilled on section lines to define the structural continuity of coal seams. Coal samples were obtained from 15 rotary holes by scraping the sidewall of the hole into a plastic sample tube, but this method was later rejected due to concerns about the representative nature of the samples. Instead 15 rotary holes had sections cored using a Valley Tool and Machine Co. (VTM) core barrel to produce 70 mm diameter core.

B.3.1.3 Consolidated Coal (1974 – 1975)

Consolidated Coal conducted two further phases of exploration in 1974 and 1975. A total of 330 exploration holes were reported to be drilled of which 235 can be located (including twinned core and redrilled holes). Infill drilling was designed to confirm earlier structural interpretations and provide coal quality information.

The 74GM hole series (1974) was reported to total 164 holes including 57 core holes. Data is available for eight HQ core holes and 30 VTM holes. In March 1974 a 54,000 tonne bulk sample was taken and 15,000 tonnes were processed at the Coleman Collieries coal preparation plant for production scale washability tests. The clean coal was shipped to Ontario Hydro for full scale carbonization analysis.

The 75GM series (1975) comprised 24 non-core holes, 10 HQ core holes (75GM04 to 75GM13) and six VTM holes (75GMT01 to 75GMT06). Data is available for all holes except six non-core holes which were drilled alongside the VTM holes to investigate the structure and coal quality characteristics of a proposed bulk sample pit to test from pilot scale washability and carbonization.

Geophysical logging of holes included natural gamma and gamma-gamma density logs. Downhole deviation was recorded for 30 holes. An assessment of coal oxidation was made by analysis of free swelling index (FSI) results of 21 near surface coal intersections. Low FSI values occurred in only four holes. Depth of oxidation appears to be generally less than 15 m.

B.3.2 Recent Exploration

Exploration was conducted from 2013 to 2016 by Riversdale Resources to improve resource definition and to assess the potential for open cut extraction as part of a feasibility assessment (Figure B.3.2-1). Prior to the start of exploration, historical data for each hole was reviewed individually and seam depths and thicknesses were validated and corrected to geophysical log depths as required. Correlations of coal seams were checked and exploration was designed to augment the historical data distribution. Field mapping was undertaken during all stages of exploration.

- Phase 1: Eight twinned non-core holes and large diameter holes (LD, 150 mm core diameter) and three PQ core holes (85 mm core diameter) were drilled to ascertain potential metallurgical coal quality characteristics.
- Phase 2: Geotechnical investigation for rock mass characteristics, pit stability and hydrogeological assessment was facilitated by seven HQ3 core holes that were packer tested during drilling. Selected holes had piezometers installed upon completion.
- Phase 3: Exploration drilling was designed to allow detailed resource definition, to augment coal quality information and provide detailed assessment of metallurgical coal characteristics.

Phase 4: Drill program included two bulk sample drill holes (additional assessment of metallurgical coal characteristics), twenty-three exploration drill holes designed to better understand geological structure near the limits of the proposed pit shell and three large diameter holes (LD, 150 mm core diameter) to improve understanding of the metallurgical coal quality characteristics in the first five to ten years of the life of mine. Recent exploration has improved confidence in the location of some of the historical drill holes in the geological model. Geological structural interpretation and deposit geometry has been confirmed with only minor adjustments to some fault planes. Coal quality information has validated and augmented the historical structural interpretation and in addition, provided an excellent assessment of coking characteristics and improved resource definition.

B.4 Data Acquisition

Different stages of earlier exploration (1971 - 1975) were variable in the level of detail and type of information recorded. Historical data is reasonably reliable for all holes which have geophysical logs and/or detailed lithological logging of core which is the majority of drill holes (approximately 90%). The standard suite of geophysical tools comprised gamma and gamma density tools with data recorded at a scale of 1 inch to 5 feet. Geophysical logs produced in 1971 also include the neutron log. Downhole deviation was recorded in 30 holes during 1974 and 1975.

Lithological drill logs from 1971 to 1975 include lithologies and details of core competency, core loss were commonly recorded. Some logs contain details of bedding dips, grain size and colour.

Lithological descriptions from 1975 were more detailed and included core recoveries for all coal units and geotechnical descriptions such as infill type in fractures and the Rock Quality Index.

Historical drill holes were surveyed on a local grid. Coordinates are available for the majority of holes but some are missing or indicate that the coordinate was taken from map data not from field survey. There is no record of the survey method or who provided the drill hole collar coordinates. A summary of the recent geological data acquired during the 2013 – 2016 feasibility study exploration program is presented in Table B.4.0-1.

Table B.4.0-1 Summary of Recent Data Acquired

Drilling Phase	Hole IDs	Hole Type	Purpose	Field Data		Geophysical Logs			Coal Quality	
				Field Logs	Geotech Logs	Density and Gamma	Verticality	Acoustic Scanner	Raw	Petrology
Phase 1	RGOH3001 - RGOH3008	Non-Core	Structure	☐	-	☐	Available for RGOH3001, RGOH3002, RGOH3006 and RGOH3007		-	-
	RGSC0001 - RGCS0003	PQ Core	Coal Quality and Structure	☐	☐	☐	☐	Not available for RGSC0001	☐	-
	RGLD1001 - RGLD1008	Large Diameter Core	Coal Quality	☐	☐	All holes	All holes except RGLD1007 and RGLD1008	-	All holes	All holes except RGLD1008 (Clean Coal)
Phase 2	RGSC0004 - RGCS0010	HQ Core	Geotechnical	☐	☐	☐	☐	☐	☐	-
Phase 3	RGOH3008 - RGOH3041	Non-Core	Structure	☐	-	All holes except RGOH3019, RGOH3037 and RGOH3039	All holes except RGOH3019, RGOH3037, RGOH3039, RGOH3040 and RGOH3041	Available for RGOH3009, RGOH3011 and RGOH3012	-	-
	RGLD1009 - RGLD1010	Large Diameter Core	Coal Quality	☐	☐	-	-	-	Available for RGLD1004, RGLD1009 and RGLD1010	-
	RGRF1501	Reverse Flood	Bulk Sample Coal Quality	☐	-	-	-	-	Carbonization Tests	

Table B.4.0-1 Summary of Recent Data Acquired

Drilling Phase	Hole IDs	Hole Type	Purpose	Field Data		Geophysical Logs			Coal Quality	
				Field Logs	Geotech Logs	Density and Gamma	Verticality	Acoustic Scanner	Raw	Petrology
Phase 4	RGOH3042 - RGOH3063	Non-Core	Structure	☐	-	All holes	All holes except RGOH3048 and RGOH3049	-	-	-
	RGRF1502 - RGRF1503	Reverse Flood	Bulk Sample Coal Quality	☐	-	☐	☐	-	Carbonization Tests	
	RGLD1011 - RGLD1013	Large Diameter Core	Coal Quality	☐	☐	-	-	-	☐	☐

B.4.1 Drilling

Exploration by Benga from 2013 to 2016 was conducted in four phases. Phase 1 (December 2013 to February 2014) provided a baseline assessment of deposit geometry and coal quality attributes and enabled validation of historical data. Phase 2 and Phase 3 (August to December 2014) were designed to expand the Phase 1 assessment, to identify geological features that may impact mine productivity and to investigate key specialist objectives (*e.g.*, geotechnical, hydrogeology, *etc.)* for feasibility assessment. Phase 4 was designed to expand on the work completed in Phase 2 and Phase 3, to identify geological features at the extremities of the proposed pit as well as better understand the metallurgical coal quality characteristics in the first five to ten years of the life of mine.

B.4.1.1 Phase 1

Eight large diameter (152 mm diameter) holes (Photo B.10) were drilled for structural and resource definition (RGLD1001 – RGLD1008). LD size core was required to obtain sufficient coal recoveries and sample mass, particularly in areas of structural complexity. Industry standard core recoveries (>95%) were generally achieved which improved confidence that the coal quality results are representative. All LD holes were preceded by a pilot hole of either PQ core size (85 mm diameter, RGSC0001) or 121 mm diameter open holes (RGOH3002 – RGOH3008).

Photo B.10: Large Diameter Drill Rig on Grassy Mountain

Two further PQ holes (RGSC0002 and RGSC0003) and one non-core hole (RGOH3001) were drilled for coal quality and structural assessment. The majority of holes were geophysically logged with a standard suite of sondes and four non-core holes were also logged with the acoustic scanner tool.

Upon completion, all holes were geologically and geotechnically logged and holes were grouted with concrete to the surface.

B.4.1.2 Phase 2

During Phase 2, seven HQ3 core holes were drilled as part of a geotechnical and hydrogeological assessment for pit design criteria (RGSC0004 – RGSC0010). Holes were cored from surface and terminated 20 m below Seam No. 4. All holes were geologically and geotechnically logged in detail. All holes were geophysically logged with both the standard suite of sondes and the acoustic scanner tool to aid identification of defect orientations for structural assessment. Holes were also utilized for hydrogeological baseline studies. Packer tests were carried out on all holes to define vertical water quality distribution and hydraulic conductivity. On completion of drilling, piezometers were installed in selected holes to measure ongoing changes in groundwater pressure.

B.4.1.3 Phase 3

Expansion of earlier structural and resource definition was undertaken during this phase. Two LD holes (RGLD1009 and RGLD1010) were drilled for coal quality analysis and 33 non-core holes (RGOH3009 - RGOH3041) drilled to assess structural continuity of coal seams and for groundwater observation (RGOH3035, RGOH3037 and RGOH3039). All holes were geologically and geotechnically logged and were geophysically logged where conditions allowed, with the acoustic scanner tool run in three holes. Holes were sealed to the surface upon completion with the exception of five holes that will be sealed during the next exploration campaign.

A 430 mm diameter hole (RGRF1501) was drilled (Photo B.11) using the reverse circulation flood method. The hole was drilled on the site of a LD hole (RGLD1010) with associated open hole (RGOH3012) to allow accurate determination of the roof and floor of the three target seams (Seam No. 1, Seam No. 2 and Seam No. 4). Cuttings were brought to surface by water and passed over a screen for de-watering and collected in plastic drums. The coal samples were sent to the ALS Laboratory Group (Maitland, Australia) for washability and carbonization testing.

Photo B.11: Example of Reverse-Flood Drilling and Product Conducted on Grassy Mountain.

B.4.1.4 Phase 4

Detailed work of earlier structural and resource definition was undertaken during this phase. Three LD holes (RGLD1011, RGLD1012 and RGLD1013) were drilled for coal quality analysis and 23 non-core holes (RGOH3042 - RGOH3063) drilled to assess structural continuity of coal seams and define coal resources at the extremities of the proposed pit. All holes were geologically and geophysically logged where conditions allowed. Holes were sealed to the surface upon completion.

Two 430 mm diameter holes (RGRF1502 and RGRF1503) were drilled using the reverse circulation flood method. The holes were drilled on the site of the previous reverse circulation hole to allow accurate determination of the roof and floor of the three target seams (Seam No. 1, Seam No. 2 and Seam No. 4). Cuttings were brought to surface by water and passed over a screen for de-watering and collected in plastic drums. The coal samples were sent to the ALS Laboratory Group (Maitland, Australia) for washability and carbonization testing.

B.4.1.5 Geological Logging

Field geologists responsible for drill rig supervision and lithological descriptions of the core and drill cuttings were employees of Riversdale Resources. Core holes were also geotechnically logged by Benga geologists during Phases 1 and 4 and geotechnical engineers during Phases 2 and 3. All core and chips were photographed, boxed and stored at the site core shed.

The visual base of weathering (BOW) was determined by geologists from direct observation of core or chip samples, and interpretation of historical data including lithology logs, geophysical logs, outcrop mapping and trench information. The resulting base of weathering surface at Grassy Mountain Property is approximately 7 m below the surface across most of the deposit with localised deeper areas up to 30 m (bottom of valley, near Blairmore Creek).

In addition to geological data, all drilling information was recorded including loss of circulation returns, water inflow and poor (soft fractured) strata conditions. Standing water levels were recorded by the geophysical loggers in all holes where possible.

Logging and sample data was entered using Prolog software to produce lithological graphics which were then used to reconcile the lithology depths and core recovery against the geophysical logs. Data was validated by excel functions and by comparison of the core with final corrected graphic logs during coal quality sampling. Final data is stored both digitally on the Riversdale Resources server and as hard copies at the Riversdale Resources office.

B.4.1.6 Geophysical Logging

Century Wireline Services were contracted for down-hole geophysical logging during 2013 and 2014. Holes were logged with a standard suite of tools where possible. This included:

- density, gamma, caliper;
- acoustic scanner;
- sonic;
- verticality;
- neutron;
- dip-meter; and
- resistivity.

Down-hole problems such as low water levels and hole stability issues (*e.g.*, blocked holes) sometimes prevented logging with the full suite of tools. Hard copies of all recent geophysical logs are stored at the Riversdale Resources office and all digital data is saved on the Riversdale Resources server.

The downhole geophysical logs listed above are used to correct lithological boundaries from field logging using geophysical signatures. This lithological correction assists in the correct assignment of core loss to the appropriate lithological horizon throughout the hole. Data from geophysical logs such as the sonic, dipmeter and caliper logs used in conjunction with field data such as geologist's notes and core photos can aid identification and interpretation of coal seam continuity and deposit geometry. The acoustic scanner tool generates a detailed image of the borehole wall and specialist interpretation allows defects to be oriented.

B.4.1.7 Outcrop and Field Mapping

Outcrop mapping occurred whenever new drill site preparation exposed bedrock. Historical field mapping has been integrated into the geological model where possible. Data such as bedding dip, dip direction/strike and rock type were recorded and surveyed with a hand held Garmin 60CSX GPS (typically accurate to less than 5 m except in areas of dense overhead cover).

B.4.1.8 Bulk Samples

Bulk sampling programs were undertaken during 2014 to provide sufficient coal mass for pilot scale sizing, washability and carbonization tests. An additional bulk sampling program was carried out in 2015. The location of the sample sites is shown in Figure B.3.2-1. Due to constraints with topography and bedding dips, bulk sample coal was obtained by two separate methods:

- Reverse-flood drilling: This supplied a one tonne sample of Seam No. 1, a three tonne sample of Seam No. 2 and a two tonne sample of Seam No. 4 from drill hole RGRF1501. All coal from RGRF1501 was sent to ALS in Australia. During 2015, two additional reverse-flood holes (RGRF1502 and RGRF1503) were drilled on the location of RGRF1501. These drill holes each yielded similar tonnages to the original RGRF1501.
- Test pit excavation: To provide the sample mass required for each seam by ALS, two tonnes of coal from Seam No. 1 and an additional one tonne sample from Seam No. 2 (Photograph B.12) were extracted from two separate test pits. Half the sample of Seam No. 1 (one tonne) was added to the reverse-flood coal for testing in Australia. The remaining sample was sent to Hazen, USA for testing. Initial field tests were substantiated by laboratory analysis at Birtley Coal and Minerals Testing Division (Birtley Coal, Calgary) to assess variations of key oxidation indicators such as light transmittance, FSI, moisture content and volatile matter. Once results indicated fresh coal, clean sections were cut from the face, sampled directly into lined barrels and weighed to ensure minimum mass requirements were met.

Photo B.12: Test Pit Excavation on Grassy Mountain at Seam No. 2

B.4.2 Coal Quality

Raw coal quality data is available for more than 650 samples in 114 holes drilled between 1971 and 1975. Historical raw coal quality data was validated using manual methods and regression analysis of density and ash content, coal sample depths were compared to geophysical log depths to validate ply thickness and recovery values and samples with excessive core loss (more than 20%) including partially sampled plies were excluded to avoid bias of the data.

Recent coal quality data was obtained from 10 core holes (seven HQ3 size and three PQ size), 13 LD holes (150 mm diameter) and three holes were drilled with reverse circulation flood method (430 mm diameter) to achieve suitable sample mass for bulk sample analysis. Drill core was sampled at site on a ply by ply basis and the analysis results were verified using manual methods and excel functions. Bulk samples from Seam No. 1, Seam No. 2 and Seam No. 4 were sent to ALS Maitland for bulk scale washability and carbonization testing.

The raw coal quality database (as received, adjusted to 5% moisture basis) at Grassy Mountain used to create the different quality grids (Ash, density, sulphur, *etc.*) contains 77 samples of Seam No. 2, 55 samples of Seam No. 1 and 49 samples of Seam No. 4 (Figure B.4.2-1).

The Grassy Mountain coal is bituminous possessing a volatile content and maceral content consistent with a high grade coking coal. The clean coal properties of the three seams are variable but are all amenable to blend construction which would maximize hard coking coal yield from the deposit (Table B.4.2-1). Seam No. 1 has higher volatile and vitrinite content which enhances plasticity while Seam No. 2 has moderately high reactives (combined vitrinite and partial semi fusinite content) and higher rank (lower volatile content) which will potentially aid coke strength. Seam No. 4 is similar in rank to Seam No. 2 though with slightly higher vitrinite content and thus has the potential to provide both plasticity and components enhancing coke strength.

Table B.4.2-1 Summary of Average Clean Coal Properties

Seam	Volatile Content (ad) %	Sulphur %	HGI	FSI	P %	Reactive Content %	Maximum Reflectance (Ro Max)[1]	Fluidity (Mddm)
No. 1	25.4	0.4 - 0.7	73 - 78	7	0.04	70	1.10	300 -1300
No. 2	22.1			3	0.04	60	1.20	10 – 200
No. 4	23.8			5	0.01	65	1.18	10 – 400

[1] Combined with the other rank indicator volatile content, all three seams fit centrally into the rank requirement for hard coking coal

B.4.2.1 Sample Testing

B.4.2.1.1 Historical Sample Testing

Historical coal quality data is available for 138 holes (drill core and sidewall samples), three channel samples, five adit samples and one 54,000 tonne bulk sample acquired between 1971 and 1975. Sample preparation and analytical procedures were different for each drilling program and coal seam recoveries were dependent on drilling methods with HQ size core generally producing 75% to 100% in coal. VTM core recoveries were limited to 50% to 70% due to broken core. Prior to 1975 standard practice was to exclude partings and carbonaceous units greater than 15 cm. Holes were drilled open until coal was intersected but this sometimes resulted in thin coal riders being cored and target seams being missed (Figure B.4.2-2). Samples were analyzed at a number of different laboratories, Cyclone Engineering Sales Limited (Cyclone), Coal Sciences and Minerals Testing (Birtley, Calgary), Metals Reduction and Energy Centre (MREC), B & I Testing Laboratories Limited (B&I, Edmonton), and Loring Laboratories Limited (Loring).

B.4.2.1.2 Recent Sample Testing

Riversdale drill programs undertaken during 2014, 2015 and 2016 provided samples for analysis from ten core holes (seven HQ3 size and three PQ size), 13 LD holes (150 mm diameter) and three reverse flood holes (430 mm diameter). Target seams from all holes with sufficient recovery were sampled on a ply by ply basis and dispatched by courier (Figure B.4.2-3). Test requirements recommended by Bob Leach (contract coal quality specialist) were sent digitally to the laboratory and a copy sent with the core samples. Samples from three PQ core holes (RGSC0001 - RGSC0003), two HQ core holes (RGCS0004 and RGCS0009) and three LD core holes (RGLD1011 – RGLD1013) were sent to Birtley Coal. LD core (RGLD1001 – RGLD1010) was tested at ALS Laboratory Group, Vancouver (BC, Canada). The bulk sample acquired from the reverse flood hole (RGRF1501, RGRF1502 and RGRF1503), supplemented with a one tonne test pit sample of Seam No. 1, was tested with full analysis at ALS Laboratory Group, Maitland (NSW, Australia). A smaller sample (one tonne of Seam No. 1 and one tonne of Seam No. 2) sourced from a set of test pits was analyzed at Hazen Research Inc. (Hazen, USA). Selected samples for petrographic analysis were sent to Pearson and Associates Pty Limited (Pearson) for maceral and reflectance analysis.

B.4.2.2 Sample Analyses

B.4.2.2.1 Historical Analysis

During all stages of exploration, the standard suite for raw coal and float sink analysis included proximate analysis (moisture, ash, volatile matter and fixed carbon content), sulphur content, calorific value (CV) and free swelling index (FSI). Variability of laboratory preparation and analytical procedure occurred throughout historical exploration and a summary is contained in Table B.4.2-2.

B.4.2.2.2 Recent Analysis

A schematic illustrating recent analytical procedures is shown in Figure B.4.2-4.

Table B.4.2-2 Summary of Historical Analytical Procedures

Year	No. of Holes / Bulk Samples	Description	Laboratory	Moisture basis	Crush Size (")				Screen Size						Analysis				Additional Coking Tests[1]
					2	1	3/4	1/4	1"	1/4"	8 M	28 M	100 M	200 M	Raw Coal	Fines	Float/ Sink	Froth Flotation	
1970 - 1972	10	HQ Core	Cyclone	Air-dry				☐				☐		☐	☐	☐	☐		
	1	Bulk Sample - Weathered	Cyclone	Unknown				☐						☐			☐		
	25	HQ Core	Birtley	Unknown			☐					☐			☐		☐	☐	
	5	Bulk Sample - Adits 1, 2, 3, 4 and 6	Birtley	Unknown			☐					☐			☐	☐	☐	☐	
	4	Bulk Sample - Adits 1, 2, 3 and 4	Cyclone	Unknown	☐				☐	☐	☐	☐	☐			☐	☐		
	4	Carbonization - Adits 2, 3, 4 and 6	MREC	N/A															
1973	20	VTM and HQ Core	B & I	Dry				☐				☐					☐		
	15	Sidewall - Crushed	B & I	Dry				☐				☐					☐		
1974	26	VTM and HQ Core	Loring	Air-dry				☐		☐		☐	☐		☐	☐	☐		☐
	22	VTM and HQ Core	Loring	Air-dry		☐				☐		☐	☐		☐	☐	☐		☐
	1	Bulk Sample - Test Pit	Birtley	Dry				☐				☐	☐		☐		☐	☐	☐
1975	16	VTM and HQ Core	Loring	Air-dry		☐				☐		☐	☐		☐	☐	☐		☐

B.5 Geological Model Development

B.5.1 Structural Model

The Grassy Mountain geological model was built in Minex ® Software (Version 6.2). The structural geological model used only drill hole data considered to be reliable and outcrop mapping/trenching to control the model. Non-core holes where coal seam intersections could not be confirmed with geophysical logs were excluded. Drill holes were deviated in the model where verticality data was available. Seam grids were extrapolated up to 300 m beyond the last data point.

Coal seam floor, roof and thickness were modelled from existing data using Minex growth algorithms. The raw coal quality model used data considered to be reliable following validation by Riversdale's geologist. Interpolation of coal quality data was modelled using inverse distance cubic functions. Raw coal quality grids including in-situ density were produced for each seam at a 5% in situ moisture basis. Coal tonnes were generated using the structural and quality models.

Grassy Mountain is a grid model with mesh size of 10 m and scan distance of 2,000 m. Grids were compared against drill hole data to ensure the model honours existing data. No assumptions were made regarding mining units and all seams and stony bands (Table B.5.1-1) that could potentially affect mine planning were also modelled.

Table B.5.1-1 Stratigraphic Intervals Modelled

Formation	Interval	Model Code	Description
Blairmore Group	Cadomin	CADOM	Conglomerate
Kootenay Group	Seam No. 1	1C2	Coal – Variable in thickness
		1C1	Coal – Variable in thickness
		1B2	Coal – Variable in thickness
		1B1	Coal – Variable in thickness
		1B0	Coal/Carbonaceous bands located below Ply 1B1
		1A2	Coal/Carbonaceous bands located below main package of Seam No. 1 – High density/ash
		1A1	Coal/Carbonaceous bands located below main package of Seam No. 1 – High density/ash
	Seam No. 2	2B	Coal – Top ply in main Seam No. 2

Table B.5.1-1 Stratigraphic Intervals Modelled

Formation	Interval	Model Code	Description
		2A	Coal
		2A0	Coal ply located below main package of Seam No. 2
	Seam No. 4	4D	Coal – Variable in thickness; can tend to be carbonaceous
		4C2	Coal
		4C1	Coal
		4B	Coal – Variable in thickness
		4A2	Coal
		4A1	Coal

B.5.2 Coal Quality Database

The coal quality database includes all available recent and historical data and the entire raw coal analysis database was used in the geological model with the exception of holes with excessive core loss (>20%) to avoid sample bias.

Validation of the raw coal quality database was carried out manually as well as using regression analysis of density and ash (Table B.5.2-1). Anomalous results including rotary chip and trench sample coal quality analysis were reviewed before removal from the regression. Historical data was mostly reported on a dry basis and data was assumed to be reported as dry when no moisture basis or inherent moisture values were specified in the report. This assumption will only produce a small error (less than 1%) in the event that a sample was air dried, as air dried moisture is typically <1%. Relevant parameters were adjusted to 5% moisture basis (using the Preston & Sanders equation) to simulate the effect of in situ moisture. Relative density was generated for all samples from a relationship with raw ash (on a dry basis).

Table B.5.2-1 Raw Quality Variables Modelled

Raw Quality Parameters	Model Suffix
In situ Ash (5% in situ moisture)	AS
In situ Sulphur (5% in situ moisture)	TS
Volatile Matter (5% in situ moisture)	VM
In situ Density (5% in situ moisture)	ID

Table B.5.2-1 Raw Quality Variables Modelled

Raw Quality Parameters	Model Suffix
Free Swell Index	CSN

In general, the raw coal quality data are reliable. However, due to different stages of historical drilling and sampling since 1971, the following issues were taken into consideration:

- Historical data included some sample intervals that encompass multiple coal plies as well as the rock partings that separate them. These stone intervals were extracted from samples using a default density of 2.2 g/cc resulting in a number of 'cleaner' coal samples separated by higher density and/or ash content rock and parting samples. New coal quality parameters (ash, volatile matter, sulphur content and in situ density) were created for all relevant plies in cases where rock partings were removed from large cross-ply samples.
- Unrecorded core loss in historical reports within the coal samples may overestimate or underestimate the actual quality of the coal intervals. Intervals with more than 20% core loss were not used in the geological model to avoid potential sample bias and samples that could have been contaminated (open hole chip cuttings and trench samples) were not included.
- Reliability of the model is directly related to the amount and quality of data available, some coal seams have few data points and the spread through the deposit is sparse making these grids less reliable (Table B.5.2-2).

The raw coal quality model was built using a tolerance on sample boundaries of 5 cm to avoid floor or roof stone being included in the seam composite. Low tolerance is possible in this model as the samples are adjusted to the seam picks.

Bulk samples from historical exploration are not included in the model due to a lack of reliable location.

Table B.5.2-2 Average Raw Coal Quality Characteristics

Seam (Ply)	Sample Range	In situ Quality at 5% Moisture (Raw)				CSN / FSI (Raw)
		Density %	Ash %	VM %	Sulphur %	
Seam No. 1 (1C2)	Mean Value:	1.49	26.9	20.8	0.59	2.8
	Maximum Value:	1.58	35.3	30.8	1.42	8.5
	Minimum Value:	1.37	14.5	18.2	0.28	1
	No. Samples:	30	31	31	27	29
Seam No. 1 (1C1)	Mean Value:	1.48	24.6	20.9	0.58	3.2
	Maximum Value:	1.58	35.3	24.5	1.42	7
	Minimum Value:	1.38	15.3	18.2	0.28	1
	No. Samples:	34	35	34	31	31
Seam No. 1 (1B2)	Mean Value:	1.44	22.5	21.6	0.58	4.1
	Maximum Value:	1.62	43.1	26.1	1.97	7.5
	Minimum Value:	1.32	9.6	17.5	0.25	1
	No. Samples:	47	48	46	43	43
Seam No. 1 (1B1)	Mean Value:	1.46	23.8	21.1	0.57	3.9
	Maximum Value:	1.63	43.1	25.4	1.06	7.5
	Minimum Value:	1.33	10.3	17.5	0.25	0.7
	No. Samples:	49	50	48	45	43
Seam No. 1 (1B0)	Mean Value:	1.46	23.1	21.3	0.57	4.9
	Maximum Value:	1.63	40.8	24.7	0.79	8
	Minimum Value:	1.33	10.8	18.2	0.37	1
	No. Samples:	15	15	15	13	15
Seam No. 1 (1A2)	Mean Value:	1.55	32.2	19	0.56	3.9
	Maximum Value:	1.7	46.7	24.5	0.95	7
	Minimum Value:	1.38	16	15.1	0.4	1
	No. Samples:	13	13	13	12	12
Seam No. 1	Mean Value:	1.55	32.6	19.3	0.59	3.8

Table B.5.2-2 Average Raw Coal Quality Characteristics

Seam (Ply)	Sample Range	In situ Quality at 5% Moisture (Raw)				CSN / FSI (Raw)
		Density %	Ash %	VM %	Sulphur %	
(1A1)	Maximum Value:	1.7	46.7	24.5	0.95	7
	Minimum Value:	1.35	12.4	15.1	0.4	1
	No. Samples:	13	13	13	12	12
Seam No. 2 (2B)	Mean Value:	1.43	21	20.2	0.34	2.5
	Maximum Value:	1.56	32.9	24	0.94	7
	Minimum Value:	1.31	12.1	14.8	0.1	1
	No. Samples:	80	85	80	76	75
Seam No. 2 (2A)	Mean Value:	1.43	21.2	20.1	0.37	2.5
	Maximum Value:	1.55	33.3	25	0.99	7
	Minimum Value::	1.31	12.1	14.8	0.12	1
	No. Samples :	94	99	94	89	86
Seam No. 2 (2A0)	Mean Value:	1.47	24.5	19.2	0.37	2.8
	Maximum Value:	1.57	34.5	23	0.6	6
	Minimum Value:	1.39	16.2	16.5	0.23	1
	No. Samples:	13	13	13	12	12
Seam No. 4 (4D)	Mean Value:	1.46	23.8	20.2	0.36	3.5
	Maximum Value:	1.62	38.9	23.3	0.58	7.5
	Minimum Value:	1.34	11.5	16.2	0.26	1
	No. Samples:	18	18	18	15	15
Seam No. 4 (4C2)	Mean Value:	1.45	22.2	20.4	0.35	2.7
	Maximum Value:	1.59	36.6	26.8	0.84	7.5
	Minimum Value:	1.33	10.2	17.7	0.14	1
	No. Samples:	49	49	48	45	40
Seam No. 4 (4C1)	Mean Value:	1.46	23.9	20.2	0.35	2.6
	Maximum Value:	1.59	36.6	25.2	0.52	5.5

Table B.5.2-2 Average Raw Coal Quality Characteristics

Seam (Ply)	Sample Range	In situ Quality at 5% Moisture (Raw)				CSN / FSI (Raw)
		Density %	Ash %	VM %	Sulphur %	
	Minimum Value:	1.39	16.2	17.6	0.16	0.8
	No. Samples:	47	47	45	41	38
Seam No. 4 (4B)	Mean Value:	1.46	23.2	20.3	0.52	3.9
	Maximum Value:	1.71	48.4	25.5	1.03	8
	Minimum Value:	1.33	10.4	15.6	0.27	1
	No. Samples:	24	24	24	22	20
Seam No. 4 (4A2)	Mean Value:	1.5	27	19.4	0.45	2.2
	Maximum Value:	1.82	54.1	22.2	0.87	6.5
	Minimum Value:	1.34	13.9	14.9	0.24	1
	No. Samples:	31	31	27	24	24
Seam No. 4 (4A1)	Mean Value:	1.49	26.8	19.5	0.45	2.3
	Maximum Value:	1.61	38.2	24.9	0.87	6.5
	Minimum Value:	1.34	13.9	16.3	0.24	1
	No. Samples:	36	36	32	29	28
Summary	**Mean Value:**	1.45	22.4	20.2	0.4	2.7
	Maximum Value:	1.82	54.1	30.8	1.97	8.5
	Minimum Value:	1.31	9.6	14.8	0.1	0.7
	No. Samples:	593	607	581	536	523

B.5.3 Data Validation

The Grassy Mountain drill hole database contains 450 drill holes which includes data acquired between 1970 and 1975. Drill hole and geophysical data prior to 1975 data is only available as PDF files and hard copies. Data was entered into excel by Benga geologists and was cross checked against original data. Historical data is considered reliable for all holes which have geophysical logs and/or detailed lithological logging, which includes the majority (about 90%) of cored holes.

The structural interpretation is based on extensive surface mapping of exposed faces, trenches, adits and the majority of available drill holes. Deviation data is only available for 30 drill holes prior to exploration in 2013. Although it is known that drill holes can deviate due to the geological structure, recent drilling results have confirmed previous structural interpretation.

Multiple stages of validation of the data were undertaken prior to, during and after modelling. The original drill hole database of coal seam depths and thicknesses were compared to geophysical logs to ensure that coal thickness determinations were consistent with industry standards. Differences were reviewed and if there was sufficient evidence to indicate an error, such as an inconsistent sample mass for a given volume, the sample length was corrected to the geophysical log depths and the core recovery updated.

Correlations of coal seams were validated for each drill hole using geophysical logs, hand drawn and model generated cross sections, contour plots and regression analysis of ash and density values.

The majority of drill holes had the collar location surveyed. These were verified as far as reasonably possible by comparison of the collar location against topography. Holes without collar survey data are considered less reliable.

The structural and coal quality models were internally audited by another MBGS modeller as standard procedure and was classified as suitable for coal resource estimation and mine planning.

B.6 Mineral Resources and Coal Quality

B.6.1 Resource Estimation Criteria

The Grassy Mountain resource estimate was carried out in Minex ® Software (Version 6.3.1) within a data shell constrained by depth and areal extent of drill holes. The deepest coal resources reported in the data shell were approximately 400 m deep. No coal quality cut-offs were applied. Resource estimation was carried out using vertical sided polygons within the data shell and limited on the outer sides by the data shell and pit shell (only in the west) and using in situ density. No assumptions were made regarding by-products.

Grassy Mountain coal resource confidence categories for Seam No. 1, Seam No. 2 and Seam No. 4 were derived on the basis of drill hole spacing, physical and quality continuity and general predictability of the coal seam nature and occurrence. A series of cross sections along drill holes over the whole deposit were generated using Minex and the resource classification was hand drawn in the cross sections by assessing any potential change of seam location, continuity and thickness from a different interpretation. The resource classification for each seam was transferred to plan view and digitize into Minex to generate vertical sided polygons limited by the data shell previously generated from all existing data.

Coal resources for all seams were estimated from the structural and quality model by depth increment from surface and cut to the modelled base of weathering.

B.6.2 Oxide Coal and Overburden

Sample data of oxidized coal was not included in coal quality model. The base of oxidation in drill holes was determined by visual observation of drill core/cutting by geologists, or by the results of coal quality tests. The thickness of oxidized coal was modelled and the limit of oxidation grid was subtracted from the topography grid for resource estimations. The base of oxidation is considered to be fairly uniform but small areas exist where oxidation is deeper, such as where coal seams have been left exposed to the environment by historical surface pits and adjacent to channels.

Topography was modelled from 1 m LIDAR data acquired in November 2013. The base of weathering and depth of unconsolidated material is modelled from geologist's interpretation from lithology logs, geophysical logs, coal outcrop and trench information. No coal resources are reported above the base of weathering.

The overburden at Grassy Mountain is variable due to the vast amount of historical activity that has modified the environment through mining, road building and drilling. Many areas are exposed with no overburden material whereas other areas have between 1 m and 10 m cover of soil and gravel.

B.6.3 Mineable Thickness

For the resource estimate no assumptions were made regarding selective mining of particular coal units. All coal seams and stony bands that could potentially affect the mining technique were modelled and all in-situ coal reported.

B.6.4 Bulk Density

Relative density was not always analyzed in historical data; however there was enough information of ash with relative density to obtain the missing values through an ash - density regression.

Recent samples were analyzed as received, as air-dried and as dried at the laboratory. Every sample was analyzed for density. The sample was weighed, air dried and re-weighed, crushed to pass nominal 12.5 mm. A subsample of 1/4 of the crushed sample was subject to relative density and proximate analysis as well as other coal quality analysis.

Relative density is adjusted to 5% in situ moisture basis.

B.6.5 Description of Resource Estimate Results

Coal resources for Grassy Mountain as at 31 July 2015 were reported in accordance with the 2012 JORC Code. Coal resources are reported at 5% moisture basis, cut-offs were not applied and the majority of the coal resources (>90%) are not extrapolated laterally or vertically beyond the last datum point. A portion of Inferred Resources (10 Mt) were extrapolated to a distance of up to 300 m to the crest of the planned pit shell in the western side. Coal seams are cut to the base of weathering (modelled from drill hole and trench data). The geological model used is identified as GM_0215. Coal resources at Grassy Mountain were estimated using Minex software (Version 6.3.1) within a 'data shell' that is constrained by the depth and areal extent of drill holes for most of the area with the exception of the western boundary where resources are limited by the Feasibility Study pit shell. Based on the results of the recent (2016) optimization study the mine license pit shell has been extended in the very south west corner into the legacy underground workings. Due to the minor impact on the reported coal resources this work was not revisited. Within the data shell coal resources were estimated both inside and outside the planned open cut pit to a maximum depth of 400 m below surface.

Measured, Indicated and Inferred criteria are as follows:

- Measured Resources – generally supported by drill holes that are up to approximately 200 m apart.
- Indicated Resources – occur in a narrow area along the strike on the eastern limb of the deposit. Resource classification is supported by outcrop mapping and by drill holes along strike approximately 500 m apart.
- Inferred Resources – supported by drill holes up to 800 m apart in the western structural block and 300 m apart in the more complex central synclinal zone.

Coal resources for Seams No. 1, No. 2 and No. 4 total 143 Mt are reported to a maximum depth of 400 m. The majority (134 Mt) of the resource is less than 200 m deep and approximately 90 Mt are classified as Measured Resources. Resource estimates are presented in Table B.6.5-1. Figures B.6.5-1 and B.6.5-2 illustrate the difference between the resource boundary limit (data shell on the figures) and the Feasibility Study proposed ultimate pit limit.

Table B.6.5-1 Grassy Mountain Coal Resources, 31 July 2015

Area	Seams	Depth Interval (m)	Typical Thickness (m)	Coal Area (km²)	Typical Raw Coal Quality (5% Moisture Basis)				Resource Classification (Mt)				
					Density (g/cc)	Ash (%)	Sulphur (%)	Volatile Matter (%)	Measured	Indicated	Measured + Indicated	Inferred	Total
INSIDE PIT	Seam 1	<100	4.1	2.2	1.49	26.9	0.6	20.5	10.8	0.4	11.2	3	14.2
		100 - 200	3.2	0.7	1.5	28.1	0.6	20.2	1.5	-	1.5	3	4.5
		200 - 300	2.6	0.2	1.49	27.7	0.7	21.0	0.1	-	0.1	1	1.1
		300 - 400	-	-	-	-	-	-	-	-	0	-	0
		Subtotal							**12.4**	**0.4**	**12.8**	**7**	**19.8**
	Seam 2	<100	9.8	1.9	1.44	22.1	0.4	20.2	20.1	1.5	21.6	7	28.6
		100 - 200	10.0	1.5	1.44	22.0	0.4	20.3	12.9	-	12.9	14	26.9
		200 - 300	10.2	0.2	1.45	22.7	0.4	20.1	0.7	-	0.7	2	2.7
		300 - 400	11.6	0.1	1.45	22.7	0.4	19.8	0.9	-	0.9	1	1.9
		Subtotal							**34.6**	**1.5**	**36.1**	**24**	**60.1**
	Seam 4	<100	7.9	1.3	1.47	24.5	0.4	19.9	9.1	-	9.1	6	15.1
		100 - 200	8.4	1.8	1.46	24.2	0.4	20.1	15.2	-	15.2	11	26.2
		200 - 300	7.8	0.1	1.48	25.6	0.3	20.1	0.6	-	0.6	2	2.6
		300 - 400	9.1	0.1	1.49	26.7	0.3	20.0	0.4	-	0.4	1	1.4
		Subtotal							**25.3**	**-**	**25.3**	**20**	**45.3**
	Total Coal Resources Inside Pit								**72.3**	**1.9**	**74.2**	**51**	**125.2**

Table B.6.5-1 Grassy Mountain Coal Resources, 31 July 2015

OUTSIDE PIT	Seam 1	<100	5.6	0.3	1.45	23.3	0.5	20.1	1.7	0.3	2	-	2
		100 - 200	3.4	0.1	1.47	25.1	0.5	20.3	0.4	-	0.4	-	0.4
		200 - 300	-	-	-	-	-	-	-	-	-	-	-
		300 - 400	-	-	-	-	-	-	-	-	-	-	-
		Subtotal							**2.1**	**0.3**	**2.4**	**0**	**2.4**
	Seam 2	<100	10.4	0.3	1.44	22.0	0.4	19.8	4.1	1.1	5.2	-	5.2
		100 - 200	11.2	0.2	1.44	22.2	0.3	19.9	2.3	-	2.3	-	2.3
		200 - 300	10.8	0.1	1.44	21.9	0.4	20.3	-	-	-	-	-
		300 - 400	-	-	-	-	-	-	-	-	-	-	-
		Subtotal							**6.4**	**1.1**	**7.5**	**0**	**7.5**
	Seam 4	<100	8.1	0.2	1.47	25.1	0.4	19.4	2.4	-	2.4	1	3.4
		100 - 200	7.6	0.4	1.47	24.7	0.4	19.5	5.0	-	5	-	5
		200 - 300	10.7	0.1	1.47	25.5	0.4	19.9	0.1	-	0.1	-	0.1
		300 - 400	10.1	0.1	1.49	27.1	0.3	19.9	-	-	-	-	-
		Subtotal							**7.5**	**0**	**7.5**	**1**	**8.5**
	Total Coal Resources Outside Pit								**16**	**1.4**	**17.4**	**1**	**18.4**
TOTAL COAL RESOURCES (INSIDE + OUTSIDE PIT)									88.3	3.3	91.6	52	143.6
TOTAL COAL RESOURCES (Rounded)									**90**	**3**	**93**	**50**	**143**

B.7 Mineral Reserves

B.7.1 Description of Reserve Modelling Constraints

For mineral reserve analysis, the in-situ Minex resource model was imported into Ventyx' Minescape software gridded seam format. The resource model included gridded structure and quality information for all modelled coal seam plies, where coal seam ply structure within the model is defined by in-situ seam roof and floor surfaces. Due to the complex nature of the geology, characterized by significant reverse faulting, the seam ply structure grids were modelled within 13 unique fault zones. In comparison, the Minex model coal quality grids were developed and imported as single individual coal ply surfaces, which extended across fault zones within the modelled resource extents. The quality model included ash content (%), sulfur content (%), volatile matter (%), and in-situ coal density (g/cc). All quality was modelled on a 5% as received moisture content basis. Each seam ply was modelled to a reasonable extent beyond the furthest seam intercept from exploration drilling.

The in-situ resource model was utilized as a basis for the reserve model through the application of the mine design criteria. These mine design parameters considered ply and interburden thickness to delineate mineable and non-minable material. Coal quality was used in conjunction with the ply thickness data to calculate ROM and product tonnages. The coal reserve model was subsequently converted to a block model format for economic analysis and pit targeting.

Pit targeting was completed using the Lerchs-Grossman optimization engine in Maptek's Vulcan software. Pit targeting indicated the pit extent with sufficient clean coal tonnage to support an economic mine life. In addition to containing a desirable tonnage, all mine rock from the optimized pit could successfully be disposed within the designated area. Pit access and detailed geotechnical parameters were applied to the target pit to validate the feasibility of the optimized pit and to create the ultimate pit. All reserves were calculated using the ultimate pit and the reserve model as described in Section B.7.3.

B.7.2 Description of Mine Design Criteria (Dilution, Recovery, Method) GM

Three surface mineable coal seams of the Kootenay Group, Seam No. 1, Seam No. 2 and Seam No. 4, are present within the Grassy Mountain Project area. Each coal seam group comprises approximately 3 to 8 individual coal plys separated by parting bands of varying thickness and extent. In-situ coal plys vary in thickness from less than 0.3 m up to 15 m. For mine planning purposes, the modelled individual coal plys were evaluated for development of coal seam working sections based on a minimum coal ply thickness and minimum separable parting thickness. The thickness criterion used to determine working sections is as follows:

- minimum single ply mineable coal thickness – 0.60 m;
- minimum removable parting thickness – 0.45 m; and
- minimum multi-ply mineable coal thickness – 0.30 m.

The criteria were applied to 160 m wide strips oriented perpendicular to the strike of the deposit using the average true thickness along the 160 m strike length for each ply interval within each fault block and vertical 15 m bench across the deposit.

All the plies within a given strip, fault block were sorted stratigraphically in down-hole order within each individual bench. The plies were then interrogated through application of the following tests on each coal and rock ply to determine if the ply was part of a mineable working section based on the minimum thickness described above:

1. Current coal ply thickness greater than 0.6 m – then set to mineable.
2. Current coal ply thickness between 0.30 m and 0.60 m with a mineable ply either above or below – then set to mineable.
3. Current ply interburden thickness less than 0.45 m with a coal ply both above and below that have thicknesses greater than 0.30 m – then set mineable.
4. Otherwise set to non-mineable.

This logic was then applied in a continuous loop until no further rock or coal plies met the criteria. All processed intervals were added to the working section and coded as either mineable or non-mineable. Any material coded as non-minable in the working section was categorized as mine rock. The working section logic is illustrated in Figure B.7.2-1.

Roof loss and floor dilution were applied to the top most and bottom most plys of the mineable working sections as defined above. Loss and dilution parameters were applied to the entire working section rather than on a ply-by-ply basis to allow coal plies internal to a working section to be taken fully without any additional loss or dilution. Only the contact areas on the top and bottom of the working section were subjected to loss and dilution adjustments using the parameters below:

- Roof loss on top of working section (roof dip greater than 35°) – 15 cm.
- Roof loss on top of working section (roof dip less than 35°) – 10 cm.
- Floor dilution on bottom of working section (floor dip greater than 35°) – 15 cm.
- Floor dilution on bottom of working section (floor dip less than 35°) – 10 cm.

Any coal categorized as roof loss was converted to mine rock and accounted for in the prime effective mine rock. ROM coal quality was re-calculated following the application of roof loss and floor dilution adjustments. Mineable rock partings (rock bands less than 0.45 m in thickness) within a working section were assumed to dilute the working section. The following qualities were assumed for both the floor dilution and non-separable parting dilution on a 5% moisture basis:

- Ash – 80%; and
- Density – 2.3 g/cc.

Using these assumed dilution qualities, ROM tonnages and ash contents were determined for the working sections. Using the supplied yield curve shown below, clean coal product tonnages were calculated based on the average ROM ash content of the nominated working section.

Seam No. 1 Product YieldF1.50 = -1.264 x ROM Ash % + 100.16
Seam No. 2 Product YieldF1.45 = -1.410 x ROM Ash % + 93.77
Seam No. 4 Product YieldF1.45 = -1.724 x ROM Ash % + 105.84

Product yields were based on washing Seam No. 1 coal at a float density of 1.50 g/cc, and Seam No. 2 and Seam No. 4 coal at a float density of 1.45 g/cc. Separable partings were removed in the pit prior to coal loading. Product tonnages are reported on a 10% total moisture (TM) basis. Product ash values are constant by seam on an air dried (ad) moisture basis as shown below:

- Seam No. 1 – 9.5% ad;
- Seam No. 2 – 9.7% ad; and
- Seam No. 4 – 9.8% ad.

B.7.3 Description of Reserve Model

Application of the mining parameters was done using a Microsoft Access database. Organization of the reserve model by working section, bench level, fault block number, and parent seam provided sufficient categorization to analyze all plys of the deposit. The mining section width and bench height of 160 and 15 m respectively were chosen to replicate the expected extraction advance for the truck and shovel mining method.

ROM calculations were performed on all unique combinations of working section, bench, fault block number, and parent seam. All in-situ rock and coal was processed and assigned to either the prime effective mine rock volume or clean product tonne classification. The reserve database was used to populate block model values with ROM and Product adjustments for pit optimization. Following the pit optimization and ultimate pit design, the database was used to calculate the reserve estimates for the ultimate pit.

B.7.4 Description of Error Checking

Benga Mining's on-site geology contractor, MBGS, gridded seam model was formatted as a Minex grid dump and had to be imported into Ventyx' Minescape software. A total volume check was performed upon receipt of the in-situ resource model from MBGS using the imported grids. The imported model was then processed by working section and bench for manipulation and processing in the reserve database. The in-situ quantities were sampled using the validated Minescape grid model. Continuous checks were performed within reserve database. Total volume and tonnage summaries were matched with the input totals following the minable in-situ adjustments, ROM, and product calculations had been made. Conservation of total volume and tonnage ensured all material was accounted for from in-situ to product within the reserve database.

B.7.5 Descriptions of Reserve Estimate Results

The reserve model database was used to estimate the reserves contained within the ultimate pit. All in-situ and ROM coal tonnages are assumed to have 5% as received moisture. Product tonnes are reported with a 10% total moisture content (TM). The pit has been divided into a number of Phases which is illustrated on Figure B.7.5-1. The reserve estimate, broken out by Phase can be found in Table B.7.5-1.

Table B.7.5-1 Mineral Reserve Summary by Phase

Phase	Seam No.	In-Situ Mine Rock Volume (000s BCM)	In-Situ Coal Tonnage (000s, 5% TM)	ROM Rock Volume (000s	ROM Coal Tonnage (000s, 5%	Product Coal Tonnage (000s, 10% TM)	Product Strip Ratio (BCM/CMT)
1	1	17,511	2,051	17,511	2,116	1,115	15.7
	2	8,387	5,740	8,387	5,791	3,245	2.6
	4	14,352	4,565	14,352	4,714	2,310	6.2
	U	5,956	-	5,956	-	-	0.0
	Sub-total	**46,207**	**12,357**	**46,207**	**12,621**	**6,670**	**6.9**
2	1	25,193	3,118	25,193	3,253	1,593	15.8
	2	12,437	6,655	12,437	6,723	4,154	3.0
	4	6,718	4,451	6,718	4,593	2,222	3.0
	U	10,277	-	10,277	-	-	0.0
	Sub-total	**54,624**	**14,224**	**54,624**	**14,568**	**7,970**	**6.9**
3	1	130,627	10,489	130,627	10,939	5,404	24.2
	2	52,017	28,766	52,017	29,108	17,819	2.9

Table B.7.5-1 Mineral Reserve Summary by Phase

Phase	Seam No.	In-Situ Mine Rock Volume (000s BCM)	In-Situ Coal Tonnage (000s, 5% TM)	ROM Rock Volume (000s	ROM Coal Tonnage (000s, 5%	Product Coal Tonnage (000s, 10% TM)	Product Strip Ratio (BCM/CMT)
	4	48,197	23,937	48,197	24,665	13,029	3.7
	U	52,291	-	52,291	-	-	0.0
	Sub-total	**283,132**	**63,192**	**283,132**	**64,712**	**36,252**	**7.8**
4	1	3,444	92	3,444	95	46	74.7
	2	474	372	474	379	238	2.0
	4	928	308	928	315	183	5.1
	U	396	-	396	-	-	0.0
	Sub-total	**5,242**	**772**	**5,242**	**790**	**467**	**11.2**
5	1	2,975	79	2,975	83	47	63.4
	2	1,000	538	1,000	549	336	3.0
	4	1,831	519	1,831	538	258	7.1
	U	1,224	-	1,224	-	-	0.0
	Sub-total	**7,030**	**1,136**	**7,030**	**1,169**	**641**	**11.0**
6	1	1,788	58	1,788	61	29	62.1
	2	2,037	415	2,037	425	253	8.0
	4	1,889	855	1,889	882	409	4.6
	U	2,845	-	2,845	-	-	0.0
	Sub-total	**8,558**	**1,328**	**8,558**	**1,368**	**691**	**12.4**
7	1	1,649	8	1,649	8	2	697.4
	2	2,015	752	2,015	771	444	4.5
	4	3,471	1,423	3,471	1,472	655	5.3
	U	1,423	-	1,423	-	-	0.0
	Sub-total	**8,558**	**2,183**	**8,558**	**2,252**	**1,101**	**7.8**
8	1	165,924	1,153	165,924	1,206	579	286.6
	2	44,581	24,395	44,581	24,716	14,760	3.0
	4	39,982	21,292	39,982	21,876	11,390	3.5
	U	35,812	-	35,812	-	-	0.0

Table B.7.5-1 Mineral Reserve Summary by Phase

Phase	Seam No.	In-Situ Mine Rock Volume (000s BCM)	In-Situ Coal Tonnage (000s, 5% TM)	ROM Rock Volume (000s	ROM Coal Tonnage (000s, 5%	Product Coal Tonnage (000s, 10% TM)	Product Strip Ratio (BCM/CMT)
	Sub-total	**286,299**	**46,840**	**286,299**	**47,799**	**26,729**	**10.7**
9	1	81,092	2,595	81,092	2,704	1,502	54.0
	2	30,167	10,489	30,167	10,631	6,182	4.9
	4	11,217	8,758	11,217	9,005	4,411	2.5
	U	11,156	-	11,156	-	-	0.0
	Sub-total	**133,632**	**21,841**	**133,632**	**22,340**	**12,095**	**11.0**
Subtotal	1	430,203	19,642	430,203	20,464	10,317	41.7
Subtotal	2	153,114	78,124	153,114	79,094	47,432	3.2
Subtotal	4	128,585	66,107	128,585	68,061	34,867	3.7
Subtotal	U	121,380	-	121,380	-	-	0.0
Grand Total		**833,281**	**163,873**	**833,281**	**167,619**	**92,616**	**9.0**

As shown in Table B.7.5-1, the ultimate pit contains approximately 163.9 Mt of in situ coal. When coal loss and OSD are applied, the estimated ROM coal tonnage totals 167.6 Mt. The estimated ROM coal comprises 20. 5 Mt of Seam No. 1 (12.2% of the total), 79.1 Mt of Seam No. 2 (47.2% of the total) and 68.1 Mt of Seam No. 4 (40.6% of the total) coal. The ROM coal is estimated to produce 92.6 Mcmt of hard coking coal when processed. Of this total, approximately 11.1% is Seam No. 1, 51.2% is Seam No. 2, and 37.7% is Seam No. 4.

B.7.6 Unrecovered Coal

The Grassy Mountain mine footprint is largely controlled by Blairmore Creek to the west and Gold Creek to the east and the geological structure of the economic coal seams between these creeks. The shape of the active mining pit has been modeled on a series of nested pit shells using an industry accepted Lerch-Grossman algorithm derived from a range of projected coal prices and calculated operating costs. The pit shell chosen for mine permitting and feasibility study purposes has been based on a coal price of US$100/t.

While trying to maximize the available area for open cut coal extraction, space needs to be assigned for external waste dumps to allow mining to proceed efficiently until sufficient area has been developed to provide for in-pit dumping. Additional space also needs to be set aside for the mine surface infrastructure and coal processing and handling.

The Grassy Mountain Project has two external waste dumps planned, one positioned in the northwest and one positioned in the south. The southern waste dump will be split to avoid relocating an existing powerline. Both of these waste dumps have been located to minimize sterilization of economic coal and both dumps over time will merge with the in-pit dumps to create a smooth convergent final landform.

The coal processing and infrastructure area has been located in the southwestern end of the deposit, which provides access to more favourable topography, avoids crossing Blairmore Creek, is directly adjacent to the initial area of mining and a facilitates a direct link to the CP railway in Blairmore. Detailed discussions around potential coal sterilization with respect to the locations of the NRDA, SRDA and Plant Site are contained in the following sections.

B.7.6.1 NRDA

The NRDA has been designed to sit adjacent to the northwestern end of the US$100/t pit shell. In this location, the coal seam sequence plunges steeply to the northwest resulting in a rapid increase in strip ratios. The geological knowledge in this area has been aided by several oil/gas holes located to the northwest along with a recent drill hole from February 2016. This information has been incorporated into the geological model.

All of the NRDA is located over coal seams with a cumulative thickness over Seams 1, 3 and 4 ranging from 14 to 20m. In this area, there are multiple (up to four) thrust faults and while the thrusts result in uplifted coal seams to the west as the seams dip towards Blairmore Creek, the throws are insufficient to lift the seams to economic strip ratios. Total depth to Seam 4 ranges from 270 m to 540 m. Coal contained under the footprint of the North Waste Dump is estimated at approximately 40 mt.

Analysis of east to west cross sections at 400 m spacing has shown that in-situ strip ratios are in excess of 8:1 bcm/rmt under the western (shallow) end of the disposal area. Seam dip under the area is in excess of 45 degrees which results in in-situ stripping ratios under the center of the dump increasing to over 15:1 bcm/rmt where the depth to the basal seam is in excess of 400m. This strip ratio and depth is well in excess of economic recovery based on the modeled costs and coal prices. On a clean basis, the ratio is over 27:1.

Please refer to the cross sections (Figures B.7.6-1 and B.7.6-2), which illustrate the depth of the coal, the current pit shell and the drilling information on which the model is based. Benga is confident that the drilling information in the area is sufficient to support the coal as modelled.

The topography under the NRDA is generally favourable due to the western side of the dump being tied into localised hills, and the crest of these provide a natural barrier between the dump and Blairmore Creek and it tributary.

In summary, while the NRDA does cover a coal resource it occupies a location that:

- contains coal seams that are well beyond an economic strip ratio;
- is conducive to supporting low cost mining operations while sufficient space is opened up for in-pit dumping; and
- has a topographical advantage providing a direct connection to the north end of the pit while having a natural barrier to Blairmore Creek and its tributaries.

B.7.6.2 SRDA

The South Rock Disposal Area has been designed to sit primarily between two structural limbs of the Grassy Mountain coal deposit; the eastern limb, which is very steeply dipping (dips ranging from 45 to 65 degrees) and contains limited resources and the western limb where mining operations are schedule to commence in 2019. The northern edge of this disposal area is designed to connect with the main geological syncline that links the eastern and western limbs. The southern limit of the waste dump is defined and limited by the rising topography and provides a logical point for the dump to connect with the existing surface.

The SRDA is largely located on the barren Fernie (Jurassic) and Rocky Mountain (Pennsylvanian) Groups. The coal-bearing Kootenay Group is located above topography (eroded) in this area so there is no chance of sterilizing any coal resources. Please refer to the cross sections on Figures B.2.0-1 and B.2.0-2 and the geology map Figure B.1.1-3.

The very steeply dipping seams located at the eastern portion of the SRDA were not considered for mining due to economic hurdles. Based on the economic pit shell assumptions described above, mining of the eastern limb is planned to terminate at 5,506,600 mN (Figure B.2.0-3). South of this point the aggregate coal seam thickness reduces from 16m to 6-7m, resulting in a rapid increase in strip ratios. It is estimated that approximately 0.39 mt of clean coal at a strip ratio of 17:1 bcm/cmt is affected by the SRDA over a strike length of 1.8 km and a depth of 50 m. By comparison the LOM average clean coal strip ratio is 9.2 bcm/cmt.

In this area, the coal seam sub-crops trend closer to Gold Creek (less than 500m) further limiting potential mining while maintaining a safe buffer between the pit high-wall and the creek.

An additional factor limiting the extension of mining of the eastern limb is that the LOM design needs to provide space for the South East Surge Dam, an important water management structure, capturing run-off from the southeast part of the deposit and protecting Gold Creek. The eastern limit of the South Waste Dump provides for this.

In summary, the South Waste Dump will sterilize some coal but its location and size takes into consideration:

- The amount of coal affected (0.39 clean metric tonnes) is relatively small.
- The strip ratio of the sterilized coal is significantly higher that the LOM average.
- Should the size of the South Rock Disposal Area be reduced to allow further mining of otherwise sterilized coal; the buffer space between the pit and Gold Creek and the space available for the South East Surge Dam will be compromised.

B.7.6.3 PLANT SITE

Riversdale's initial feasibility study contemplated the sterilization of any coal thought to be impacted by previous underground coal mining. As part of on-going optimization studies Riversdale has decided to push the southwestern pit limit further west into the previous underground mining area. Expanding the pit to the west allows for additional coal recovery with extremely short haul distances. The plan also enhances the development of the selenium attenuation zone in that a large zone is opened up earlier in the mine plan. Additional equipment will be added to the plant in order to handle the deleterious material expected to be associated with the coal when mining through the old workings (steel, timbers). Please refer to Figure B.7.6-3. This figure shows the pit limit from the Feasibility Study (original EIA submission) versus the slightly larger pit currently proposed. The increase in resources has been calculated at 8 million cmt at an incremental ratio of 6 bcm/cmt. The calculations assume that the underground maps accurately reflect the amount of historical resource extraction through this area.

Finding sufficient space with reasonably flat topography for a coal processing and infrastructure area is challenging for the Grassy Mountain Project. Much of the area is either covered by coal seams or needs to be reserved for initial out of pit dumps at the south and northeast limits of the pit.

In selecting the appropriate location for the coal processing and infrastructure area the following criteria was considered:

- minimizing sterilized coal;
- providing direct access for conveying product coal to the CP railway in Blairmore;
- providing direct access for employees without interacting with heavy mine vehicles;

- having sufficient space for the coal handling and processing facilities, the raw water dam, environmental protection dams and the mine infrastructure area (including office, ablution blocks, work shop, service area and warehouse);
- having reasonably flat ground given the hilly topography that is present at Grassy Mountain; and
- locating the facilities in an area that is visibly and audibly shielded from the local communities.

In consideration of these factors, the location selected was adjacent to the south end of the mine, adjacent to the revised mini pit where operations are scheduled to commence.

The remaining ROM resources directly under the coal processing and infrastructure area are estimated at approximately 7.5 mt. The average depth is 200 m with a cumulative coal thickness over Seams 1, 3 and 4 varying from 17.5 m to 30 m. Average ROM strip ratio is approximately 8:1 or 14.5:1 on a clean basis which is considered uneconomic based on the modeled pit shell.

Please refer to Figure B.7.6-3 which is a cross section showing:

- the pit shell as submitted in the original EIA;
- a revised pit shell which is included as part of this mine permit/mine licence application; and
- the location of the plant infrastructure.

B.8 Geotechnical Assessment

Riversdale has commissioned a number of geotechnical studies in support of the Mine Permit/Licence Application. Four geotechnical reports have been included in Appendix 9(a – d). The four reports are:

- Golder Associates (Golder), April 2016. Grassy Mountain Project Waste Dump and Infrastructure – Supplemental (2015) Geotechnical Program.
  This report should be referenced in regard to the plant infrastructure, surge and sediment ponds and the NRDA. Additional field work was recommended by Golder with respect to the SRDA. This work was completed by Terracon Geotechnique and has also been included.
- Golder, April 2015, Grassy Mountain Preliminary Pit Slope Stability Assessment
  This report was submitted as part of the original EIA/Mine Permit Application. It has been re-submitted for completeness.
- Golder, July 2016. Grassy Mountain Mini Pit Geotechnical Investigation and Pit Slope Stability Assessment
  The results of the optimization study indicated that expansion of the open pit into the legacy

underground workings provided a positive benefit to the project. Golder updated the preliminary pit slope assessment to include the additional field investigation completed in spring 2016.

- Terracon Geotechnique, July 2016. Geotechnical Site Investigation of Waste Storage Dumps and Water Impoundment Structures at Grassy Mountain Coal Project
  The optimization study indicated that there was a positive benefit to the project by avoiding the relocation of an existing 500 kV powerline that crosses the future SRDA. This report speaks specifically to the field program and stability analysis with respect to the modified (split into two halves) South Rock Disposal Area as well as preliminary stability analyses of various water management structures.

B.8.1 Surficial and Bedrock Geology

The Grassy Mountain Project site is located in southwestern Alberta in the Rocky Mountain foreland fold and thrust belt. As discussed in Sections B.1 and B.2, the rock within the Mist Mountain formation consists of interbedded mudstones, siltstones and sandstones along with thick, inter-bedded, bituminous coal seams. The formation is disconformably overlain by the Cadomin conglomerate. The Cadomin forms an erosional contact with the upper half of the Mist Mountain formation removed by erosion processes. The Blairmore group, which lies above the Cadomin conglomerate, is comprised of similar rock types such as sandstone, siltstone and mudstones.

The soil and weathered bedrock cover was not cored in the geotechnical boreholes. This unconsolidated material, usually colluvium and till soils, varies in thickness between 10 and 20 m from ground surface over the property. The colluvium and till has been generally described as fine to coarse grained silty sand along with some gravel, cobbles and boulders of detached weather rock.

B.8.2 Structural Controls

As shown on the geological cross sections (Figures B.2.0-1 through B.2.0-7), the Grassy Mountain open pit is situated within a succession of generally west-dipping thrust faults which trend in a north-south direction. The surface trace of the Livingstone Thrust Fault, which forms the boundary between the foothills and the front ranges of the Rocky Mountains, is located approximately 6.5 kilometres east of the proposed mine.

The Coleman Thrust Fault serves as the western border of the Grassy Mountain open pit. In between these two faults, the Kootenay Group has been subjected to folding and faulting. There are two major continuous faults located on site, the McConnell and Turtle Mountain, which divide the property into three structural geological domains. The domains, located from west to east are described below:

- Western Structural Domain: Sedimentary strata generally dip at 20° to 35° toward the west at the southern end of Domain 1, increasing to 40° to 60° at the northern end. The McConnell Thrust Fault forms the eastern boundary of the outcropping Mist Mountain in this domain.
- Central Structural Domain: Sedimentary strata generally dip at 25° to 50° toward the west-northwest, increasing to about 50° dip angle at the northern end of the Domain. The Turtle Mountain Thrust Fault separates the Central Domain from the Eastern Domain.
- Eastern Structural Domain: Sedimentary strata generally dip at 60° to 80° towards the east. This domain is characterised by an overturned anticline. The Turtle Mountain Thrust Fault defines the western boundary of this domain and is replaced by major folds in the north.

B.8.3 Description of Testing Programs

B.8.3.1 Pit Slope Stability Investigations

To date, there have been two pit slope stability investigations. The first program was in support of the Feasibility Study and the second was initiated to support the results of the Optimization Study and this mine permit/licence application.

Pit Slope Program 1

A geotechnical and hydrogeological field investigation program was carried out for the Project from August 5, 2014, through September 21, 2014. The field program consisted of the following activities:

- drilling of seven HQ-3, diamond-cored geotechnical drillholes;
- Geotechnical data collection including the geotechnical logging, rock core sampling, and point load strength testing;
- Hydrogeological testing in the seven drillholes; in total, 14 successful packer tests were conducted; and
- installation of three grout-in-place vibrating wire piezometer nests (RGSC-0004, RGSC-0005, and RGSC-0009).

A summary of the program is provided in Table B.8.3-1.

Table B.8.3-1 Summary of 2014 Pit Slope Program

Drillhole	Date Completed	Easting	Northing	Elevation	Length	Inclination	Azimuth	Piezometer Installation
		metres	metres	metres	metres	metres	degrees	
RGSC-0004	18-Aug-2014	685,490	5,506,218	1,755	173.71	70	100	Yes
RGSC-0005	24-Aug-2014	685,118	5,504,574	1,507	149	70	75	Yes
RGSC-0006	29-Aug-2014	685,577	5,507,161	1,825	161.21	90	-	No
RGSC-0007	6-Sep-2014	685,627	5,507,655	1,912	176.68	90	-	No
RGSC-0008	9-Sep-2014	686,638	5,507,638	1,955	87.45	90	-	No
RGSC-0009	16-Sep-2014	686,742	5,509,160	1,912	158.92	70	20	Yes
RGSC-0010	19-Sep-2014	686,807	5,510,108	1,774	170.92	90	-	No

Pit Slope Program 2

Program 2 was initiated based on recommendations from the preliminary assessment and to reassess the highwall stability of the expanded pit limit in the southwest corner. The results of the optimization study also caused the southwestern pit limit to move further west (referred to as the mini-pit in Golder's 2016 report). This required the mine/plant infrastructure to also move west. This program was carried out from May 15th through to May 27th, 2016. The field program consisted of the following activities:

- drilling of an additional three HQ-3, diamond-cored geotechnical drillholes;
- geotechnical data collection including the geotechnical logging, rock core sampling, and point load strength testing; and
- acoustic televiewer (ATV) surveys in the cored drillholes.

A summary of the program is provided in Table B.8.3-2.

Table B.8.3-2 Summary of 2016 Pit Slope Program

Drillhole	Date Completed	Easting	Northing	Elevation	Length	Inclination	Azimuth
		metres	metres	metres	metres	degrees	degrees
RGSC-0011	May 19, 2016	685504	5504648	1563	156.41	-90	0
RGSC-0012	May 24, 2016	685218	5504610	1527	139.72	-90	0
RGSC-0013	May 27, 2016	685567	5504637	1568	127.40	-90	0

B.8.3.2 Rock Disposal Areas & Infrastructure Field Investigations

This section addresses geotechnical engineering field work related to the rock disposal areas and plant infrastructure. There are two external (*i.e.*, not in-pit backfill) rock disposal areas: North Rock Disposal Area (NRDA) and the South Rock Disposal Area (SRDA). Disposal area stability rating and slope stability analysis have been performed for the external disposal areas. Preliminary plant site design parameters and recommendations are provided for deep and shallow foundations, general earthwork construction (cut and fill, backfill materials, and compaction), fill settlement and winter earthwork, frost protection, lateral pressures on buried structures, Mechanically Stabilised Earth (MSE) walls, slab on grade floors and guidelines for machine foundations.

A number of field investigations have been completed at the Grassy Mountain site over the last number of years. The programs have been a combination of test pits and standard penetration test (SPT) drilling using an auger drill rig.

Disposal Area and Infrastructure Program 1

Between August 7 and 15, 2014, 33 test pits were excavated by a private contractor using a track mounted John Deere 160G LC excavator. The test pit locations were selected by Riversdale based on recommendations from a prefeasibility Technical Report that proposed the external disposal area and plant infrastructure west of where they are currently planned.

The target depth for the test pits was bedrock refusal or to the reach of the excavator arm, approximately 5.0 metres below ground surface (m bgs). The depth range of the test pits was 1.3 m bgs to 5.2 m bgs.

Soil samples were retrieved from each major lithological unit from the spoil pile created by the excavator. A total of 26 samples were submitted to a geotechnical laboratory for evaluation and testing.

The texture of the overburden is diverse, ranging from soft to stiff silty clay to sand and gravel with occasional cobbles and boulders. The presence of boulders often made excavation difficult. Multiple test pits encountered groundwater resulting in side wall collapse and sloughing. Other pits contained unconsolidated sands and gravels that also resulted in sloughing side walls. Twelve test pits encountered sandstone/siltstone bedrock, with a depth range of 2 m bgs to 4 m bgs.

Two test pits encountered anthropogenic environmental issues:

- WD-SPT-3 – encountered debris suggesting the site is a former landfill; and
- WD-SPT-5 – encountered hydrocarbon stained soil.

The area of WD-SPT-3 was flat and contained no trees, further indicating that the site might be a former landfill.

A summary of the August 2014 test program has been included in Table B.8.3-3.

Table B.8.3-3 Summary of August 2014 Test Pit Program

Test Pit	Date Completed (D/M/Y)	Easting	Northing	Notes:
		metres	metres	
CCR-SPT-31	8/8/2014	683224	5504597	Bedrock at d = 2.3 m
CCR-SPT-35	8/8/2014	683979	5503977	-
CCR-SPT-36	8/8/2014	683828	5504424	-
CCR-TP-11	8/8/2014	683514	5504767	Bedrock at d = 1.7 m
CCR-TP-13	8/8/2014	683269	5504459	Bedrock at d = 4.1 m
CCR-TP-14	9/8/2014	683472	5503711	Bedrock at d = 4.3 m
CCR-TP-15	9/8/2014	683837	5503715	Sandstone at d = 2.1 - 2.2 m
CRR-SPT-33	8/8/2014	684289	5503961	-
SP-SPT-29	7/8/2014	685081	5505095	-
SP-SPT-30	7/8/2014	685044	5505507	-
SP-SPT-37	10/8/2014	684674	5504542	-
SP-SPT-38	10/8/2014	684595	5504199	-
SP-TP-10	10/8/2014	684893	5504984	-
SP-TP-16	10/8/2014	684527	5504586	Bedrock at d = 1.3 m

Table B.8.3-3 Summary of August 2014 Test Pit Program

Test Pit	Date Completed (D/M/Y)	Easting	Northing	Notes:
		metres	metres	
SP-TP-17	9/8/2014	684022	5504192	-
SP-TP-19	10/8/2014	684634	5504393	-
SP-TP-20	9/8/2014	684554	5504086	-
SP-TP-6	11/8/2014	684889	5505654	-
SP-TP-7	11/8/2014	685061	5505694	-
SP-TP-8	7/8/2014	685071	5505411	-
SP-TP-9	7/8/2014	685089	5505226	Steady seepage at d = 2.9 m
WD-SPT-1	11/8/2014	684959	5505839	Bedrock at d = 4.0 m
WD-SPT-11	14/8/2014	683648	5509468	-
WD-SPT-12	15/8/2014	684120	5510260	Bedrock at d = 0.5 - 1.9 m
WD-SPT-13	15/8/2014	684356	5510290	Bedrock at d = 2.0 - 2.2 m
WD-SPT-14	15/8/2014	684982	5510086	Bedrock at d = 1.7 - 2.7 m
WD-SPT-3	13/8/2014	684626	5507218	Terminated due to garbage. Suspected landfill in clearing surrounding test pit.
WD-SPT-4	13/8/2014	684545	5507460	-
WD-SPT-5	13/8/2014	684552	5507708	Oil staining present.
WD-SPT-6	13/8/2014	684386	5508137	-
WD-SPT-7	14/8/2014	684725	5508233	Sandstone at d = 3.7 - 4.1 m
WD-SPT-8	14/8/2014	685198	5508364	-
WD-SPT-9	13/8/2014	683930	5508492	Bedrock at d = 4.4 m

Disposal Area and Infrastructure Program 2

A track-mounted auger drill rig operated was contracted by Riversdale to perform standard penetration test (SPT) drilling between October 6 and 15, 2014. As for the test pits, the locations were based on the prefeasibility Technical Report that proposed the external disposal area and plant infrastructure on the west side of the property. The drillhole locations were primarily selected at locations where the test pits did not reach bedrock.

The target depth of the drillholes was bedrock or to a maximum of 11.1 m bgs. Drilling was performed using 152-mm (6-inch) solid stem auger or 254-mm (10-inch) hollow stem auger. Solid stem was initially attempted; however, if the drillhole was unstable and prone to collapse, the driller switched to hollow stem. The total depths of the drillholes ranged from 2.0 m bgs to 11.1 m bgs.

SPTs were conducted during drilling to quantify subgrade compactness/stiffness and to collect split spoon samples. If no sample was retained by the split spoon, the field engineer obtained a sample from the auger flight from the representative depth. SPTs and split spoon samples were collected approximately every 0.76 metres from ground to 6.1 m bgs and every 1.5 m from 6.1 m bgs to end of hole.

Samples retrieved from the split spoon were measured for recovery length and then immediately bagged and labelled. A total of 143 samples were collected and delivered to the geotechnical laboratory for further evaluation and testing.

The lithology of the overburden is diverse: soft to stiff silty clay to sand and gravel with occasional cobbles and boulders. Several drill holes encountered groundwater resulting in drill hole collapse. Two drill holes (WD-TP-4 and WD-TP-10) encountered boulders that caused auger refusal. Five drill holes encountered sandstone bedrock, with a depth range from 3.0 m bgs to 10.4 m bgs.

A summary of the October 2014 Auger Drill Hole program has been included in Table B.8.3-4.

Table B.8.3-4 Summary of October Auger Drill Hole Program

Drillhole	Date Completed (D/M/Y)	Easting	Northing	Notes
		metres	metres	
CCR-SPT-33	8/10/2014	684292	5503963	-
CCR-SPT-35	8/10/2014	684131	5503966	-
CCR-SPT-36	8/10/2014	683837	5504403	-
GC-12-A	8/15/2014	684249	5499635	Sandstone at d = 5.3m
GC-12-B	8/15/2014	684354	5499534	Sandstone at d = 3.0m
SP-SPT-29	10/10/2014	685077	5505080	Auger refusal at d = 4.7m
SP-SPT-30	10/10/2014	685048	5505486	-
SP-SPT-37	9/10/2014	684681	5504533	Sandstone at d = 7.0m
SP-SPT-38	9/10/2014	684586	5504213	-

Table B.8.3-4 Summary of October Auger Drill Hole Program

Drillhole	Date Completed (D/M/Y)	Easting	Northing	Notes
		metres	metres	
SP-TP-10	9/10/2014	684681	5504969	-
SP-TP-17	8/10/2014	684030	5504199	Sandstone at d = 5.2m
SP-TP-6	9/10/2014	684973	5505664	-
WD-SPT-11	15/10/2014	683648	5509460	-
WD-SPT-4	11/10/2014	684555	5507479	-
WD-SPT-5	14/10/2014	684549	5507721	Oil staining at d = 1.2 -2.6m
WD-SPT-6	14/10/2014	684353	5507888	Sandstone at d = 10.4m
WD-SPT-8	14/10/2014	684160	5508384	-

Disposal Area and Infrastructure Program 3

During July, and again in November of 2015, additional geotechnical field investigations were completed. Results of the Feasibility Study had caused the proposed locations of the ex-pit rock disposal areas along with the plant infrastructure to move. The work included drilling an additional 35 SPT boreholes along with the excavation of an additional 10 test pits. The SPT tests were largely in support of plant and mine infrastructure foundation assessments. The test pits were largely advanced in support of the NRDA and SRDA stability analysis. A summary of the SPT program is included in Table B.8.3-5. A summary of the test pit program is included in Table B.8.3-6.

Table B.8.3-5 2015 SPT Program

Hole Number	Easting	Northing	Hole Depth	Bedrock Depth	Groundwater Depth(1)	Borehole Type	Location
	metres	metres	m bgs	m bgs	m bgs		
BH15-01	684485	5508267	11.1	10.8	-	SPT	NW Surge Pond
BH15-02	684433	5508219	9.3	7.9	-	SPT	NW Surge Pond
BH15-03 (HA)	684668	5507425	0.2	0.2	-	Hand Auger	West Sed. Pond
BH15-04	684689	5507320	4.8	0.8	-	SPT	West Sed. Pond

Table B.8.3-5 2015 SPT Program

Hole Number	Easting	Northing	Hole Depth	Bedrock Depth	Groundwater Depth(1)	Borehole Type	Location
	metres	metres	m bgs	m bgs	m bgs		
BH15-05	685020	5504844	4.6	4.1	-(3)	SPT	SW Surge Pond
BH15-06	685006	5504753	3.1	2	-	SPT	SW Surge Pond
BH15-07	685722	5504831	8.5	8.5*	-	SPT	South Dump
BH15-08	683215	5504669	4	4.0*	0.8	SPT	South Dump
BH15-09	686010	5504224	10.7	-	8	SPT	South Dump
BH15-10	685581	5503838	10.7	10.7*	3.3	SPT	Plant Site
BH15-11	685604	5503630	4.6	1.6	-	SPT	Plant Site
BH15-12	685322	5504058	0.3	0.3	-	Auger	Plant Site
BH15-13	685231	5503989	4.7	-	-	SPT	Plant Site
BH15-14	685321	5503963	3.1	1.8	-	SPT	Plant Site
BH15-15	685125	5504243	0.2	0.2	-	Shovel	Plant Site
BH15-16	685122	5504021	15.4	-	-	SPT	Plant Site
BH15-17	685011	5504044	0.4	0.3	-	SPT	Plant Site
BH15-18	684983	5504043	0.3	0.3*	-	Shovel	Plant Site
BH15-19	685371	5504436	0.2	0.2	-	Shovel	Plant Site
BH15-20	685416	5504511	0.2	0.2	-	Shovel	Plant Site
BH15-21	685056	5503243	7	-	1.3	SPT	Plant Site
BH15-22	684990	5503754	9.6	-	8.1	SPT	Plant Site
BH15-23	684939	5503660	11.1	-	9	SPT	Plant Site
BH15-24	685015	5503975	0.8	0.8	-	SPT	Plant Site
BH15-25	685293	5503770	12.2	12.2*	6.8	SPT	Plant Site
BH15-26	685040	5503596	9.3	8.5	-	SPT	Plant Site
BH15-28	685060	5504386	2.6	2	-	SPT	Plant Site
BH15-29	687355	5510554	5	2.1	-	SPT	-
BH15-30	687396	5510663	11.1	9.1	-	SPT	-
BH15-31	687724	5508280	11.1	-	1.5**	SPT	NE Sed. Pond
BH15-32	687715	5508452	11.1	-	6.1**	SPT	NE Sed. Pond

Table B.8.3-5 2015 SPT Program

Hole Number	Easting	Northing	Hole Depth	Bedrock Depth	Groundwater Depth[1]	Borehole Type	Location
	metres	metres	m bgs	m bgs	m bgs		
BH15-40 (HA)[4]	684483	5508256	0.2	0.2	-	Hand	North Dump
PZ15-01a	684792	5503690	13.7	7.6	-	SPT and Coring with Piezometer	Plant Site
PZ15-01b	684792	5503690	6.9	N/A	-	Piezometer	Plant Site
PZ15-02a	684792	5503690	18.6	3.3*	-	Auger and Coring with Piezometer	Plant Site
PZ15-02b	684792	5503690	9.1	N/A	0.8	Piezometer	Plant Site

(1)Depth to water was measured at end of drilling and may not represent actual groundwater level

* Indicates inferred bedrock based on drilling conditions

** Indicates seepage

Table B.8.3-6 2015 Test Pit Program

Test Pit #	Easting (m)	Northing (m)	Depth (m bgs)	Bedrock Depth (m bgs)	Groundwater Depth (m bgs)	Test Pit Type	Location
TP15-01 (HA)	684483	5508256	0.5	0.5	-	Hand Auger	North Dump
TP15-01a	684716	5509309	4.7	-	-	Excavator	North Dump
TP15-02	685585	5509670	5.0	-	-	Excavator	North Dump
TP15-04	684624	5509110	5.3	-	-	Excavator	North Dump
TP15-05	684612	5508686	4.7	-	-	Excavator	North Dump
TP15-06	685531	5508645	5.0	-	-	Excavator	North Dump
TP15-07	684624	5508405	5.0	-	-	Excavator	North Dump
TP15-08	684488	5508303	5.0	-	-	Excavator	NW Surge Pond

Table B.8.3-6 2015 Test Pit Program

Test Pit #	Easting (m)	Northing (m)	Depth (m bgs)	Bedrock Depth (m bgs)	Groundwater Depth (m bgs)	Test Pit Type	Location
TP15-09	686257	5505343	5.0	-	-	Excavator	South Dump
TP15-10	686109	5505018	5.1	-	-	Excavator	South Dump
TP15-11	685892	5504323	5.0	-	-	Excavator	South Dump
TP15-14(HA)	686722	5503226	0.4	0.4	-	Hand Auger	South Dump
TP15-15(HA)	684544	5508292	0.4	0.4	-	Hand Auger	South Dump

Disposal Area and Infrastructure Program 4

Golder recommended additional drilling in support of the SRDA stability assessment. In addition, the Optimization Study, which was undertaken after the Feasibility Study, recommended that the SRDA be split in half to avoid the relocation of a 500 kV powerline which runs across the SRDA from east to west. An updated stability analysis was completed given the potential risk to this important piece of the provincial electrical grid. This work was completed by Terracon Geotechnique in May 2016. During this field program, additional geotechnical information was also gathered to support future dam safety applications for the sediment/surge ponds. A summary of the program is included in Table B.8.3-7. Ten geotechnical auger boreholes were completed using a track mounted drilling rig with two holes drilled by hand. To define the bedrock properties, core samples from five of the boreholes (GT16-01, 02, 03, 06 and 07) were retrieved using HQ diamond drilling equipment.

Table B.8.3-7 2016 Borehole Program

Drillhole	Easting	Northing	Elevation	Borehole Depth	Depth to Bedrock	Borehole Location	Bedrock Core	Piezo Installation
	metres	metres	metres	metres	metres			
GT16-01	685585	5503808	1,480	9.14	7.62	Raw Water Pond	Yes	
GT16-02	685587	5503635	1,493	7.62	4.57	Raw Water Pond	Yes	
GT16-03	686235	5503611	1,563	3.05	0.61	South Waste Dump	Yes	

Table B.8.3-7 2016 Borehole Program

Drillhole	Easting	Northing	Elevation	Borehole Depth	Depth to Bedrock	Borehole Location	Bedrock Core	Piezo Installation
	metres	metres	metres	metres	metres			
GT16-04	686120	5502814	1,717	0.46	0.46	South Waste Dump		
GT16-05	686668	5502929	1,739	0.76	0.76	South Waste Dump		
GT16-06	686727	5503578	1,592	2.29	0.76	South Waste Dump	Yes	
GT16-07	686617	5504451	1,554	6.10	3.05	South Waste Dump	Yes	Yes
GT16-08	687304	5504478	1,500	7.62	6.86	Southeast Surge Pond		
GT16-09	687345	5504670	1,504	10.06	9.45	Southeast Surge Pond		
GT16-10	687616	5506197	1,574	4.27	-	East Sediment Pond		
GT16-11	687766	5506182	1,570	10.67	9.14	East Sediment Pond		Yes
GT16-12	687733	5506379	1,575	4.57	3.35	East Sediment Pond		

A consolidated figure with the geotechnical investigation site locations from all the programs has been included in Figure B.8.3-1.

B.8.4 Pit Slope Laboratory Investigation

B.8.4.1 2014 Pit Slope Laboratory Work

During the 2014 field investigation, approximately 1,080 m of rock core from the Project was geotechnically logged. The following observations have been made with respect to the intact rock strength data.

B.8.4.1.1 Mist Mountain – Coal

The average estimated rock strength of coal from the 2014 drilling investigations was R1 (very weak). No laboratory unconfined compressive strength (UCS) testing was carried out on any coal samples from the Mist Mountain Formation.

B.8.4.1.2 Mist Mountain Formation

Laboratory UCS testing has been carried out on six samples of rock from the Mist Mountain Formation comprising sandstone, siltstone, or mudstone. The UCS of these samples ranged from 35.3 million Pascals (MPa) to 96.9 MPa, with an average of 61.5 MPa. Of the six samples, three tests were carried out on mudstones with an average UCS of 45 MPa, two tests on sandstone with an average UCS of 68.4 MPa and one test on a siltstone with a UCS value of 96.9 MPa. The average estimated rock strength of these rocks from the 2014 geotechnical logging was R2 (weak). However, the laboratory UCS test results indicate that the Mist Mountain rocks can exhibit high intact rock strengths (*i.e.*, R3 to R4 strength range) in the more competent siltstone and sandstone rock types.

B.8.4.1.3 Blairmore Group

Laboratory UCS testing has been carried out on four samples of Blairmore group, comprising two tests from the Cadomin conglomerate and two tests from the overlying Gladstone member. The UCS of these samples ranged from 93.5 MPa to 179.1 MPa, with an average of 128.2 MPa.

B.8.4.1.4 Moose Mountain Member

No laboratory UCS testing was carried out on any rock core samples from the Moose Mountain member of the Morrissey Formation. The average estimated rock strength of sandstone from the 2014 drilling investigations was R4 (moderately strong rock) and is generally consistent with the strengths encountered in the Moose Mountain located in the mines in the nearby Elk Valley.

B.8.4.2 Rock Mass Rating

An assessment of the overall quality of the rock masses that will be exposed in the Grassy Mountain Pit has been prepared using the Rock Mass Rating (RMR76) rock mass classification system (Bieniawski 1976) and based the data collected from the 2014 geotechnical drilling investigation.

The rock mass quality data have been divided based on the geological formations encountered at Grassy Mountain. The average RMR76 values were determined using a weighted average based on the variable geotechnical interval lengths (Table B.8.4-1).

Table B.8.4-1 Summary of Weighted Average RMR76 Classification Values

Dataset	Rock Type/Formation	RMR76 (Weighted Average)	Rock Mass Classification (RMR76)[1]
All Drillholes	Mist Mountain – Coal	25	Poor Rock
	Mist Mountain[2]	58	Fair Rock
	Blairmore Group	61	Good Rock
	Moose Mountain	62	Good Rock
	All Data	56	Fair Rock

Notes:

[1]RMR76 values were determined using a weighted average based on the variable geotechnical interval lengths.

[2]Mist Mountain Formation includes all rock types (mudstone, carbonaceous mudstone and siltstone) with the exception of the sandstone.

B.8.4.3 Discontinuity Characterization

The bedding in the Rocky Mountains has been observed to be continuous over hundreds of metres. Bedding spacing varies by rock type, with mudstones exhibiting spacing between 1 and 10 cm and more massive sandstones exhibiting fracture spacing between 1 and 3 m. Sedimentary strata also typically contain two prominent cross-joint sets (denoted JS1 and JS2 joint sets). One set typically strikes parallel or near-parallel to the bedding strike and dips orthogonal to the bedding. The second set typically strikes perpendicular to the strike of the bedding and to the first joint set. These cross-joint sets and bedding define an orthogonal fracture pattern, in that both joint sets are mutually perpendicular and are oriented perpendicular to the bedding. Golder commonly refers to these joints as the JS1 and JS2 joint sets, where the JS1 joint set strikes parallel to the strike of the bedding and the JS2 set strikes perpendicular to the strike of the bedding.

The Joint Condition Rating (JCR) is used to describe the small-scale surface characteristics of the joint discontinuities in the RMR76 rock mass classification system (Bieniawski 1976). A discrete numeric value between 0 and 25 is assigned based on the evaluation of the shape, roughness, and wall rock alteration of the discontinuity surface. The following observations have been made with respect to the interval JCR data:

- The logged interval JCR values are generally higher in the Blairmore Group and Moose Mountain rocks than the Mist Mountain Formation Rocks.

- The coal of the Mist Mountain was generally assigned an interval JCR value of 0 or 6. The average interval JCR logged in the remainder of the Mist Mountain formation rocks is 12, Moose Mountain is 12, and the Blairmore Group is 20.

B.8.5 Subsurface Conditions

Testing was completed on select overburden and bedrock samples collected during the test pit and drilling programs. Laboratory testing included Atterberg limits, water content, and particle size analysis.

B.8.5.1.1 North Rock Disposal Area

During the 2014 geotechnical program, two test pits were advanced within the footprint of the NRDA. An additional six test pits and two hand auger holes were advanced during the 2015 program. The conditions as described in the Golder report were as follows:

Topsoil - Organic Silt to Silty Sand Trace Organics: A surficial layer between 0.02 m and 0.6 m thick of dark brown to dark grey to black organic silt to sandy organic silt to silty sand, trace organics was encountered at ground surface at all investigation locations. Hand auger hole BH15-40 (HA) terminates in this layer after encountering bedrock at 0.2 m bgs. No laboratory testing was conducted on this material.

Silty Sand to Gravelly Sand: Silty sand to gravelly silty sand to gravelly sand was encountered underlying the organic silt in all investigation locations except TP15-07 and BH15-40 (HA). The brown non-cohesive deposit contains cobbles and boulders and is moist becoming wet below 2.9 m to 4.5 m bgs. The natural water content measured in samples described as wet are between 14% and 17%. The layer had a loose to compact consistency. TP15-01 (HA) terminated in this layer after encountering bedrock or a boulder at 0.5 m bgs. TP15-01 (HA), 02, 05 and 06 terminate in this layer after penetrating 4.1 m to 4.8 m and reaching target excavation depth. The thickness of this layer varies between 0.4 m and greater than 4.8 m.

Sandy Clayey Silt: Grey to brown sandy clayey silt, trace to some gravel was encountered in TP15-07 under the organic silt at 0.15 m bgs and in TP15-04 under the silty sand at 1.6 m bgs. The layer thickness ranged from 0.85 m to 3.3 m. Natural water content of 19% was measured in a sample from this deposit. The sandy clayey silt had a firm consistency. Cobbles/boulders were encountered in TP15-07.

Silty Clay to Sandy Silty Clay: Grey silty clay, some sand, trace gravel to sandy silty clay was encountered below the sandy clayey silt at 1.0 m to 4.9 m bgs in TP15-07 and TP15-04. Both test pits reached target excavation depth in this layer and terminated. Natural water content of 11% was measured in a sample from this deposit. The silty clay to sandy silty clay had a stiff consistency. Cobbles/boulders were encountered in TP15-07 in this layer.

Bedrock: Inferred bedrock and/or cobbles/boulders were encountered at 0.2 m to 0.4 m bgs in hand auger holes (TP15-01 (HA) and BH15-40 (HA)). Bedrock was encountered at 0.7 m bgs and 3.7 m bgs in the 2014 test pits and the excavators were able to excavate up to an additional 2.0 m into the weak sandstone/siltstone bedrock prior to refusal. The 2015 test pits did not encounter bedrock. Based on the investigation, bedrock is shallower from the centre to north east edge of the North External Dump.

Groundwater: Groundwater and/or seepage was not encountered

B.8.5.1.2 South Rock Disposal Area

During the 2015 geotechnical program, three test pits (TP15-09 to 11), two hand auger holes (TP15-14(HA) and 15(HA)) and three boreholes (BH15-07 to 09) were advanced within the footprint of the SRDA. During the spring of 2016, an additional five auger holes were drilled within the SRDA (GT16-03 – GT16-07).

Golder described the surficial conditions encountered in their 2015 report as follows:

Fill: Coal waste/soil fill was encountered at ground surface in BH15-07. The fill layer is 7.8 m thick and is described as dry, containing inferred cobbles/boulders. SPT values indicate a loose to dense relative density, with density increasing with depth. Laboratory testing was not conducted on samples of this material.

Organic Silt to Clayey Organic Silt: A surficial 0.1 m to 0.6 m thick layer of black to brown organic clayey silt to organic silt was encountered at all locations except BH15-07 and BH15-09. Laboratory testing was not conducted on samples of this material. Hand auger hole TP15-14(HA) terminated in this layer due to possible bedrock/boulders at 0.4 m bgs.

Sandy Clayey Gravel to Sandy Silt: A deposit of non-cohesive sandy clayey gravel to gravelly clayey sand to sand and gravel to gravelly silty sand to sandy silt colluvium was encountered in all boreholes, test pits and hand auger hole TP15-15 (HA). The deposit was encountered at ground surface or underlying either the organic silt to clayey organic silt at 0.05 m to 0.6 m bgs, except for BH15-07, where it is encountered below fill at 7.8 m bgs. The deposit is brown to grey, contains cobbles and inferred cobbles/boulders at multiple depths and SPT values indicate a compact to very dense relative density, generally increasing with depth. The natural water content varies between 5% and 20%, generally increasing with depth. The deposit is 0.4 m to 10.4 m thick. TP15-15 (HA) terminated in this layer due to possible bedrock/boulders at 0.4 m bgs. Only TP15-11 does not terminate in this material. All other boreholes and test pits terminated in this deposit either due to refusal (inferred bedrock) at 4.0 m to 10.7 m bgs or target excavation depth.

Silty Clay: Silty clay, some sand, containing boulders/cobbles was only encountered in TP15-11 (west side of South Dump – Figure 1). The dark grey silty clay layer has low plasticity and a firm to stiff consistency. The natural water content on a single sample was 10%. TP15-11 terminates in the silty clay after penetrating it for 3.5 m from 1.5 m bgs.

Bedrock: Bedrock was inferred at 0.4 m bgs in hand auger holes (TP15-14 (HA) and 15 (HA)) and bedrock was inferred at 4.0 m and 8.5 m bgs in boreholes (BH15-07 and 08). BH15-09 terminated due to refusal in very dense soil conditions at 10.7 m bgs and bedrock was not inferred at that location.

Groundwater: Groundwater was measured at 0.8 m bgs during drilling in BH15-08. Groundwater or seepage was not encountered at other investigation locations. The water levels in the open boreholes did not stabilize. Water levels are expected to fluctuate seasonally in response to changes in precipitation and snow melt.

Observed surficial conditions during the recently completed (May 2016) Terracon program were described as follows:

Topsoil: Low plastic, stiff, dry to moist silt and clay mixture with occasional fine to coarse grained sand was encountered at all five drilling locations. The maximum thickness (0.13m) of the topsoil was measured at GT16-07. No topsoil samples were collected.

Silt and Silty Clay: Beds of silt and silty clay were inferred at 0.05 m bgs to 0.6 m bgs at GT16-03; at 0.05 m bgs to 0.8 m bgs at GT16-06 and from 0.13 m bgs to 1.22 m bgs at GT16-07. SPT blow count numbers and laboratory testing suggest that the silt and silty clay are low plastic, very stiff to hard. The layer has occasional zones of sand and gravel. Silty clay was encountered in previous investigations in only one borehole.

Sand and Sandy Silt: Loose, dry to moist, homogeneous, fine grained sand and clayey sand, with trace to occasional gravel, was logged at 0.08 m bgs to 0.46 m bgs at GT16-04 and at 0.08 m bgs to 0.76 m bgs at GT16-05. Low plastic, loose, dry sandy silt with some gravel was recorded at 1.22 m bgs to 3.05 m bgs at GT16-07.

Bedrock: Hard, partially fractured/weathered fine grained, light to dark grey sandstone bedrock was encountered at 3.05 m bgs at GT16-03, at 0.46 m bgs at GT16-04, at 0.76 m bgs at GT16-05, at 0.76 m bgs at GT16-06 and at 3.05 m bgs at GT16-07.

B.8.5.1.3 Plant Site and other Infrastructure

Twenty-two boreholes were advanced around the plant site during the 2015 investigation. Subsurface conditions for the plant site infrastructure are inferred from the boreholes. Descriptions of the surface conditions encountered can be found in Section 3.4 of Golder's April 2016 Report in Appendix 9-D.

B.8.6 Design Criteria

B.8.6.1 Pit Slope Stability Considerations

Rock slope design procedures are intended to establish pit wall design criteria based on the anticipated failure modes, as determined by the expected site geologic and geotechnical conditions. In this context, instability in rock slopes can generally be classified according to two principal failure mechanisms:

- Structurally Controlled Failure Mechanisms: Structurally controlled failure in rock occurs as the result of sliding along pre-existing geologic discontinuities (*i.e.*, kinematic failures).
- Rock Mass Strength Failure: Slopes excavated in weak or heavily fractured rock masses, or very high slopes, can be susceptible to overall rock mass failure, which involves the development of pseudo-circular type failure zones through intact rock.

Structurally controlled failures can be further subdivided into the following types based on the pit slope type:

- structural controlled failure in benched highwall, footwall, and endwall rock slopes are planar failure, wedge failure, and toppling failure; and
- structurally controlled failure in unbenched footwall slopes are planar sliding failure, ploughing failure, bi-linear sliding failure, and buckling failure.

To reduce the probability of undercutting of bedding and subsequently expose structures that could result in multi-bench instabilities, a bench face angle which follows the bedding dip slope has to be adopted for benched and unbenched footwall slopes at Grassy Mountain. The magnitude and frequency of structurally controlled failures are directly related to the continuity of the structures along which sliding can occur. Structures that exhibit limited continuity, such as the cross joints at Grassy Mountain, may result in small bench-scale failures that are rarely of consequence to overall slope stability, but may affect access ramps or fixed equipment adversely. Conversely, larger scale failures can occur along continuous, through-going structures, such as bedding and major faults at Grassy Mountain. It is, therefore, these more continuous structures that are of primary concern to overall slope stability.

B.8.6.2 Pit Slope Design Recommendations

Design recommendations have been developed based on the expected stability performance of proposed pit slopes. A summary of the recommended pit slope design criteria is presented in Table B.8.6-1 for 15 m- bench heights. The recommendations for each of the respective pit walls are presented in Figures B.8.6-1 and B.8.6-2. Also, please refer to the figures found in Appendix I in Golder Associates report entitled *Grassy Mountain Preliminary Pit Slope Stability Assessment.* The complete report has been included in Appendix 9-B.

Based on the results of the spring 2016, pit slope drilling program and subsequent analysis Golder has recommended a minor modification to the 2015 design criteria for the highwall in the very southern end of the pit (Mini Pit). A weathered zone exists near the top of the highwall and varies in thickness from 8m to 42m thick. The recommended design criteria in the weathered zone are as follows:

- Bench Height: 30m (double bench)
- Bench Face Angle: 60 degrees
- Catch Bench Width: 12m
- Inter-ramp Angle: 47 degrees

Below the weathered zone the recommended design criteria are as follows:

- Bench Height: 30m (double bench)
- Bench Face Angle: 65 degrees
- Catch Bench Width: 12m
- Inter-ramp Angle: 49.1 degrees

B.8.6.3 Rock Disposal Areas – Analysis and Recommendations

B.8.6.3.1 Dump Stability Rating

A semi-quantitative system for assessing the relative potential for dump stability from the British Columbia Mined Rock and Overburden Investigation and Design Manual, Interim Guidelines, 1991 (Interim Guidelines, Table 5.1) was used to develop a Dump Stability Rating, which in turn provided guidance for the level of effort for investigation and design.

Table 8.6-2 below summarises the four classes of DSR values and recommends a level of effort for design, investigation and construction methods and monitoring (from Table 5.2 of the Interim Guidelines).

The North and South Dumps have a Dump Stability Class of 800 and 750 (Table 8.6-3 and Table 8.6-4).

Table B.8.6-1 Summary of Recommended Design Criteria and Slope Stability Considerations – 15 m Bench Heights

<table>
<tr><th rowspan="2">Pit</th><th rowspan="2">Pit Slope</th><th colspan="4">Bench Design Criteria</th><th rowspan="2">Bench Scale Stability Conditions</th><th rowspan="2">Overall Stability Considerations</th></tr>
<tr><th>Height (metres)</th><th>Bench Face Angle (degrees)</th><th>Catch Bench Width (metres)</th><th>Inter-ramp Angle (degrees)</th></tr>
<tr><td rowspan="6">Western Portions</td><td>Highwall</td><td rowspan="2">30</td><td rowspan="2">70</td><td rowspan="2">12</td><td rowspan="2">52.6</td><td rowspan="3">Benches expected to break back to and be controlled by the steeply dipping JS1 joints.</td><td rowspan="3">Highwall is expected to exhibit adequate overall stability. Limit-equilibrium overall stability analysis to confirm.</td></tr>
<tr><td>Southern and northern portions.</td></tr>
<tr><td>Central portions.</td><td>30</td><td>65</td><td>12</td><td>45.7</td></tr>
<tr><td>Footwall</td><td rowspan="2">45</td><td rowspan="2">Follow bedding dip angle.</td><td rowspan="2">8</td><td rowspan="2">Dependent on dip of bedding.</td><td rowspan="2">Footwall excavated as benched slope. Bench faces to be excavated along bedding dip to limit potential planar sliding mechanisms.</td><td rowspan="2">Footwall to be excavated as a benched configuration where bedding dips are inclined greater than 35 degrees. Bench slopes to be excavated along bedding dips to reduce the probability of exposing bedding structures. Limit-equilibrium stability analysis required to confirm overall slope stability.</td></tr>
<tr><td rowspan="2">Lower slope portions. Upper slope portions, Northeast lower slope portion.</td></tr>
<tr><td colspan="4">Unbenched, excavate along bedding.</td><td>Footwall to be excavated as an unbenched slope. See overall slope stability conditions.</td><td>Footwall to be excavated as an unbenched slope along competent Moose Mountain Sandstone where bedding dips are inclined at less than 35 degrees. Footwall expected to exhibit adequate overall stability providing that bedding is not undercut.</td></tr>
</table>

Table B.8.6-1 Summary of Recommended Design Criteria and Slope Stability Considerations – 15 m Bench Heights

<table>
<tr><th rowspan="2">Pit</th><th rowspan="2">Pit Slope</th><th colspan="4">Bench Design Criteria</th><th rowspan="2">Bench Scale Stability Conditions</th><th rowspan="2">Overall Stability Considerations</th></tr>
<tr><th>Height (metres)</th><th>Bench Face Angle (degrees)</th><th>Catch Bench Width (metres)</th><th>Inter-ramp Angle (degrees)</th></tr>
<tr><td rowspan="5">Central Portions</td><td>Highwall</td><td rowspan="2">15</td><td rowspan="2">60</td><td rowspan="2">10</td><td rowspan="2">38.8</td><td rowspan="2">Benches expected to break back to and be controlled by the steeply dipping JS1 joints.</td><td rowspan="2">Highwall is expected to exhibit adequate overall stability. Limit-equilibrium overall slope stability analysis to confirm.</td></tr>
<tr><td>Western slope.</td></tr>
<tr><td>Footwall</td><td rowspan="2">45</td><td rowspan="2">Follow bedding dip angle</td><td rowspan="2">8*</td><td rowspan="2">Follow bedding dip angle.</td><td rowspan="2">Footwall excavated as benched slope. Bench faces to be excavated along bedding dip to limit potential planar sliding mechanisms.</td><td rowspan="2">Footwall to be excavated as a benched configuration where bedding dips are inclined greater than 35 degrees. Bench slopes to be excavated along bedding dips to reduce the probability of exposing bedding structures. Limit-equilibrium stability analysis required to confirm overall slope stability.</td></tr>
<tr><td rowspan="2">Western and eastern slopes greater than 35 degree bedding dips.
Western and eastern slopes less than 35 degree bedding dips.</td></tr>
<tr><td colspan="4">Unbenched, excavate along bedding.</td><td>Footwall to be excavated as an unbenched slope. See overall slope stability conditions.</td><td>Footwall to be excavated as an unbenched slope along competent Moose Mountain Sandstone where bedding dips is inclined at less than 35 degrees. Footwall expected to exhibit adequate overall stability providing that bedding is not undercut.</td></tr>
</table>

Table B.8.6-1 Summary of Recommended Design Criteria and Slope Stability Considerations – 15 m Bench Heights

Pit	Pit Slope	Bench Design Criteria				Bench Scale Stability Conditions	Overall Stability Considerations
		Height (metres)	Bench Face Angle (degrees)	Catch Bench Width (metres)	Inter-ramp Angle (degrees)		
Eastern Portions	Highwall	15	60	11	37.3	Significant toppling failure mechanisms are expected. Benches expected to break back along steeply east-dipping bedding structures forming a ravel slope close to a 37 degree angle of repose.	Highwall is expected to exhibit adequate overall stability. Highwall is to form a talus slope of failure rock debris.
	Footwall	15	70	8	48.1	Footwall excavated as benched slope. Bench faces to be excavated along bedding dip to limit potential planar sliding mechanisms.	Footwall to be excavated as a benched configuration where bedding dips are inclined greater than 35 degrees. Bench slopes to be excavated along bedding dips to reduce the probability of exposing bedding structures.
-	Endwalls	30	70	10	55.1	Bench faces expected to break back to and be controlled by JS2 joints.	The endwall slope is expected to exhibit adequate overall slope stability.

Table B.8.6-2 Dump Stability Classes and Recommended Level of Effort for Investigation, Design and Construction

Dump Stability Class	Failure Hazard	Recommended Level of Effort for Investigation, Design, and Construction	Range of Dump Rating (DSR)
I	Negligible	Basic site reconnaissance, baseline documentation. Minimal lab testing. Routine check of stability, possibly using charts. Minimal restrictions on construction. Visual monitoring only.	<300
II	Low	Thorough site investigation. Test pits, sampling may be required. Limited lab index testing. Stability may or may not influence design. Basic stability analysis required. Limited restrictions on construction. Routine visual and instrument monitoring.	300 – 600
III	Moderate	Detailed, phased site investigation. Test pits required, drilling or other subsurface investigations may be required. Undisturbed samples may be required. Detailed lab testing, including index properties, shear strength and durability likely required. Stability influences and may control design. Detailed stability analysis, possibly including parametric studies, required. Stage II detailed design report may be required for approval/permitting. Moderate restrictions on construction (*e.g.*, limiting loading rate, lift thickness, material quality, *etc.*). Detailed instrument monitoring to confirm design, document behaviours, and establish loading limits.	600 – 1,200

Table B.8.6-2 Dump Stability Classes and Recommended Level of Effort for Investigation, Design and Construction

Dump Stability Class	Failure Hazard	Recommended Level of Effort for Investigation, Design, and Construction	Range of Dump Rating (DSR)
IV	High	Detailed, phased site investigation. Test pits, and possibly trenches, required. Drilling, and possible other subsurface investigations probably required. Undisturbed sampling probably required. Detailed lab testing, including index properties, shear strength, and durability testing probably required. Stability considerations paramount. Detailed stability analyses, probably including parametric studies and full evaluation of alternative probably required. Stage II detailed design report probably required for approval/permitting. Severe restrictions on construction (*e.g.*, limiting loading rates, lift thickness, material quality, *etc.*). Detailed instrument monitoring to confirm design, document behaviour, and establish loading limits.	>1,200

Table B.8.6-3 North Rock Disposal Area Stability Rating and Class

Factor	North Rock Disposal Area Stability Rating and Class		
	Description		Rating
Dump Height	100 - 200 m	100 – 200 m	100
Dump Volume	Medium	21.5 million BCM	50
Dump Slope	Flat	<26°	0
Foundation Slope	Unconfined	10° – 25°	50
Degree of Confinement	Moderately Confined	Convex slope, sidehill, no toe confinement	100
Foundation Type	Intermediate	Glacial/Colluvium Deposits	100
Dump Material Quality	Moderate	Coarse coal refuse (10% – 25% fines)	100
Method of Construction	Unfavorable	Descending construction, lifts >50 m thick	200
Piezometric & Climatic Conditions	Intermediate	Limited development of phreatic surface in dump possible	100
Dumping Rate	Slow	<0.1 m/day	0
Seismicity	Low	Seismic Zone 2, per Canadian NBC 1985	0
Dump Stability Rating			800
Dump Stability Class			Moderate

Table B.8.6-4 South Rock Disposal Area Rating and Class

Factor	South Rock Disposal Area Stability Rating and Class		
	Description		Rating
Dump Height	>200 m	>200 m	200
Dump Volume	Medium	21.5 million BCM	50
Dump Slope	Flat	<26°	0
Foundation Slope	Flat	10°	0
Degree of Confinement	Unconfined	Convex slope, sidehill, no toe confinement	100
Foundation Type	Intermediate	Glacial/Colluvium Deposits	100
Dump Material Quality	Moderate	Coarse coal refuse (10% – 25% fines)	100
Method of Construction	Intermediate	Mixed ascending and descending construction, lifts 25 m to 50 m thick	100
Piezometric & Climatic Conditions	Intermediate	Limited development of phreatic surface in dump possible	100
Dumping Rate	Slow	<0.1 m/day	0
Seismicity	Low	Seismic Zone 2, per Canadian NBC 1985	0
Dump Stability Rating			750
Dump Stability Class			Moderate

B.8.6.3.2 Rock Disposal Area Design Criteria

The minimum recommended design values for factor of safety (FOS) from British Columbia Mined Rock and Overburden Piles Investigation and Design Manual, Interim Guidelines, 1991 (Interim Guidelines, Table 6.4) are presented in Table B.8.6-5.

Table B.8.6-5 Minimum Design Factor of Safety

Stability Condition	Suggested Minimum Design Values for FOS	
	Case A	**Case B**
Stability of Dump Surface		
Short Term (During construction)	1.0	1.0
Long Term (Reclamation - abandonment)	1.2	1.1
Overall Stability (Deep Seated Stability)		
Short Term (During construction)	1.3 – 1.5	1.1 – 1.3
Long Term Static (Reclamation - abandonment)	1.5	1.3
Long Term Pseudo-static (Reclamation - abandonment)	1.1	1
Case A		
Low level of confidence in critical analysis parameters. Possibly unconservative interpretation of conditions, assumptions. Severe consequences of failure. Simplified stability analysis method (charts, simplified method of slices). Stability analysis method poorly simulates physical conditions. Poor understanding of potential failure mechanism(s).		
Case B		
High level of confidence in critical analysis parameters. Conservative interpretation of conditions, assumptions. Minimal consequences of failure. Rigorous stability analysis method. Stability analysis method simulates physical conditions well. High level of confidence in critical failure mechanism(s).		

Note: A range of suggested minimum design values are given to reflect different levels of confidence in understanding site conditions, material parameters, consequences of instability, and other factors

The North and South Dumps meet the requirements of Case A for the following reasons:

- A geotechnical investigation has not yet been performed for the two dump sites. Reasonable assumptions have been made for stratigraphy and material parameters; however, a site investigation is recommended to support final design.

- Potential failure of the South Dump towards the plant site, should a lengthy run out result, would have severe consequences. Depending on the final mining plan potential, failure and run out of the North Dump may only have minimal consequences.

B.8.6.3.2.1 Disposal Area Stability Analysis for Feasibility Study Dump Configurations

Stability analysis was performed on three cross sections: A, B and C (Figure B.8.6-3, B.8.6-4 and B.8.6-5). These cross sections were selected for analysis by inspection to be critical sections, based on dump height and foundation slopes. The overall slope angle of the spoil face of the dumps is 23°, which results in a FOS of 1.78, greater than the suggested minimum design value (Case A) in Table 8.6-5.

Stability analysis of the North and South Dumps was performed using the limit equilibrium software SLOPE/W (Version 17.7). The Morgenstern-Price method was selected for the analysis along with the Mohr-Coulomb failure criterion to identify potential failure surfaces and the associated factors of safety.

For the seismic stability analysis (pseudo-static cases), the 475-year design earthquake event was selected. A peak ground acceleration (PGA) of 0.056 g is associated with the in the 475-year event for the Grassy Mountain area (based on coordinates 49.69 North 114.4 West from 2010 National Building Code Seismic Hazard Calculation).

To model earthquake conditions, the pseudo-static method of analysis was used, which applies a horizontal force to the failure mass proportional to the design horizontal acceleration. To account for the non-rigid response of the foundation soils and waste rock, the horizontal seismic loading that was considered in the analysis was one-half the PGA. The foundation soils material strengths were reduced to 80% of the peak strength (Hynes-Griffin and Franklin 1984) to account for potential strain softening due to pore pressure generation during shaking.

Assumptions made for feasibility stage stability analysis of the North and South Rock Disposal Areas are the following:

- The foundation soil was assumed to be a compact cohesionless soil. The unit weight and friction angle used in the analysis were assumed based on parameters applied to similar soil conditions in the region. The assumed material parameters are presented in Table B.8.6-6. Any organic, weak, or fine grained materials are assumed to be removed prior to dumping waste rock.
- The depth to bedrock (thickness of the foundation soils) was assumed to be approximately 5 metres for the North Dump and 7 metres for the South Dump. Bedrock joints were assumed

to be oriented in a favourable manner; thus, failure surfaces were limited to within the foundation soils.

- Groundwater elevation was assumed to rise to approximately existing ground level underneath the toe and slopes of the dumps. Further upslope the groundwater elevation is assumed to be approximately coincident with bedrock elevation.

The results of the stability analysis are presented in Table B.8.6-7 with a comparison of the calculated factors of safety and the design factors of safety for long term overall stability.

Table B.8.6-6 Material Parameters for Stability Analysis

Material	Unit Weight (kN/^{3})	Friction Angle (°)	Cohesion (kPa)
Waste Rock	20	37	0
Foundation Soils	17	27	0
Foundation Soils (Pseudo-static)	17	22	0
Bedrock	Intact Rock Strength		

Table B.8.6-7 Summary of Slope Stability Analysis Results – Overall (Deep Seated) Stability

Section	Factor of Safety (Long-term)	Minimum Design of Factor of Safety (per Table B.8.5-5)	Factor of Safety (Pseudo-static)	Minimum Pseudo-static Factor of Safety (per Table B.8.5-5)
North Disposal Area Section A	1.5	1.5	1.1	1.1 – 1.3
South Disposal Area Section B	1.7		1.6	
South Disposal Area Section C	1.8		1.5	

B.8.6.4 Stability Analysis for Modified SRDA

As discussed previously, results of the Optimization Study have indicated that there is a cost/benefit analysis to avoiding the relocation of the 500 kV powerline. Given the potential risk to this existing infrastructure, the stability analysis was updated using the additional spring 2016 drill hole information and the updated SRDA configuration. Details of this recent work can be found in Section 6.5 of Terracon's July 2016 geotechnical report found in Appendix 9c. Stability profile locations for the SRDA can be found in Figure 2 in the appendix of this report along with the stability profiles themselves (profiles 5 and 6). A summary of the slope stability results can be found below in Tables B.8.6-8 and B.8.6-9.

Table B.8.6-8 Slope Stability Results - Profile 5

Condition	Minimum Target FoS	Minimum FoS	Failure Mode
Drained	1.5	1.6	Foundation
Drained with Seismic	1.1	1.1	Foundation

Table B.8.6-9: Slope Stability Results - Profile 6

Condition	Minimum Target FoS	Minimum FoS	Failure Mode
Drained	1.5	1.6	Foundation
Drained with Seismic	1.1	1.1	Foundation

In-pit portions of the disposal, areas have been designed so that the dump slopes, once re-sloped to 23 degrees for reclamation purposes, toe out below the crest elevation of the ultimate pit.

B.8.6.5 Pit and Dump Slope Monitoring

B.8.6.5.1 Pit Slope Monitoring

An observational pit slope design approach will be adhered to during pit excavation to include mapping and stability performance monitoring, as subsurface geology is exposed during mining.

B.8.6.5.2 Geologic Mapping

The recommended slope design criteria are based on the current understanding of the geology. In order to improve the understanding of the geology, routine geologic mapping will be carried out as the slopes are excavated. Particular attention will be paid to the following:

- the orientation and character of the systematic rock fabric and continuous structures with respect to the interpreted orientation, as the slope designs are based on the orientation of these features; and
- the presence and orientation of faults in the pit walls.

The potential adverse impacts of these structures on the stability of the slopes should be assessed as they are identified. Mapping techniques should include the use of conventional geology and geotechnical mapping, as well as remote techniques such as LiDAR or photogrammetry.

B.8.6.5.3 Slope Stability Monitoring

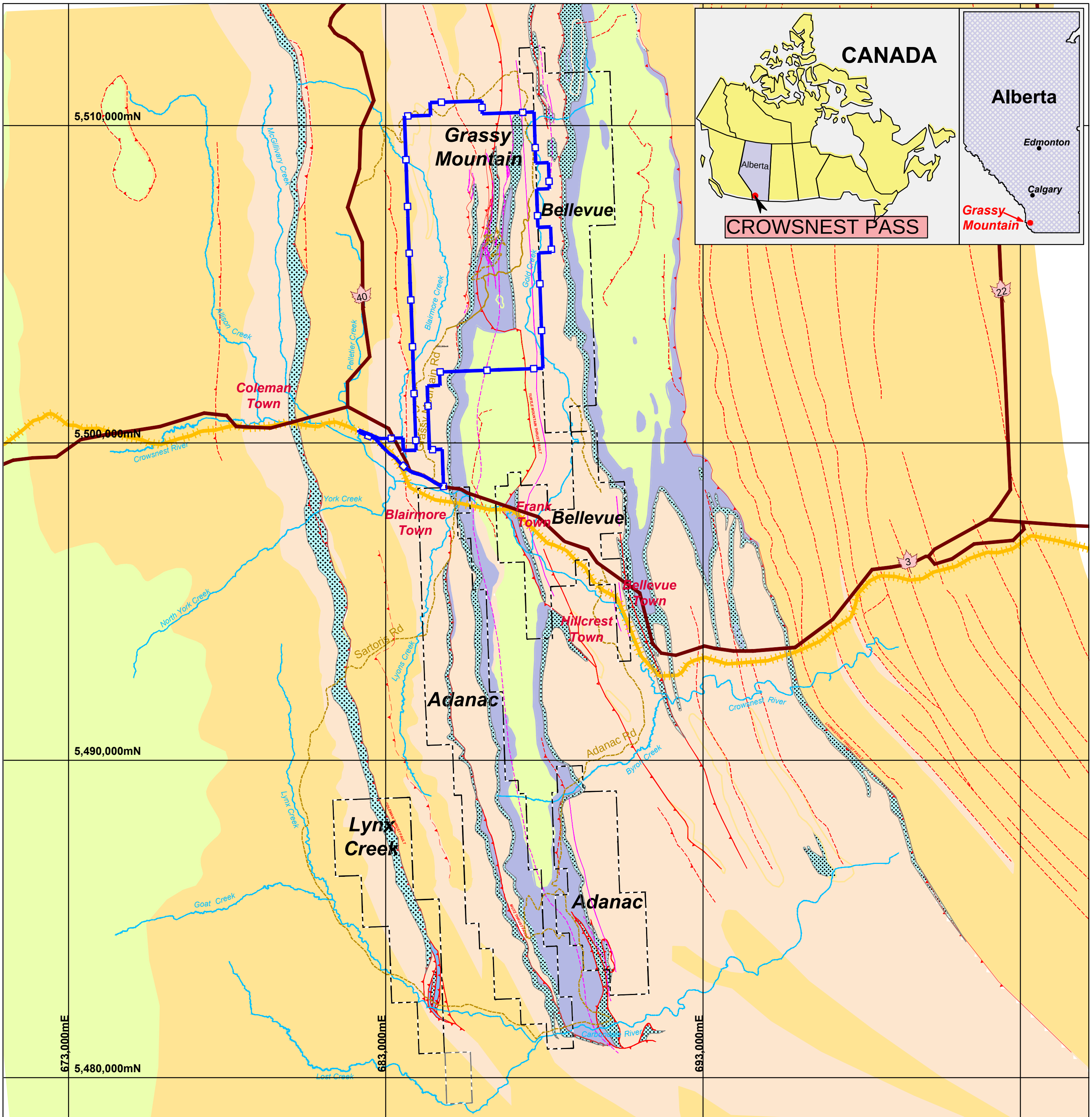
A major part of any the pit slope stability monitoring program is regular visual inspection of the bench faces and crest areas for early evidence of slope instability. The crest and benches should be examined for signs of cracking or instability at least once every 2 weeks, and more frequently during the spring runoff.

Slope stability instrumentation, including prisms, GPS, and radar monitoring may be required to be incorporated into a monitoring program. The monitoring frequency of prisms that may be installed on the slope will depend upon the stability of the slopes, the time of year, the rate of mining, and the nature of the mining being carried out along the slopes. Assuming the slopes are stable, prism monitoring should be carried out on a monthly basis, and increased as necessary should instability develop. The GPS and radar units provide continuous, ongoing monitoring.

B.8.6.5.4 Groundwater Monitoring

Vibrating Wire Piezometers (VWP) were installed in three drillholes (RGSC-0004, RGSC-0005, and RGSC-0009) following the completion of drilling. Permanent data loggers where connected to the VWPs to continuously record groundwater pressures. The data will be uploaded on a regular basis (*i.e.*, quarterly) to establish site groundwater trends prior to mining.

Figures



LEGEND

SURFACE FEATURES

- WATERCOURSE
- MAJOR ROAD
- ACCESS ROAD
- RAILROAD

GEOLOGY

- FAULT
- ANTICLINE
- SYNCLINE

LITHOLOGICAL UNITS

- PALEOZOIC
- CRETACEOUS
- BLAIRMORE GROUP
- **KOOTENAY GROUP** *(COAL BEARING)*
- FERNIE GROUP

LAND OWNERSHIP

- PROPOSED MINE PERMIT BOUNDARY
- RIVERSDALE COAL LEASES
  - *ADANAC*
  - *BELLEVUE*
  - *LYNX CREEK*

REFERENCE(S)

- GEOLOGICAL MAP OF ALBERTA. HAMILTON, W.N.; LANGENBERG, C.W.; PRICE, M.C.; CHAO, D.K., 1998.
- GEOLOGY AND MINERAL DEPOSITS OF THE CROWSNEST CORRIDOR. HAMILTON, W.N.; PRICE, M.C.; CHAO, D.K., 1998.
- MINING LEASE BOUNDARIES PROVIDED BY
- MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY
- MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

REGIONAL GEOLOGY

NOTES

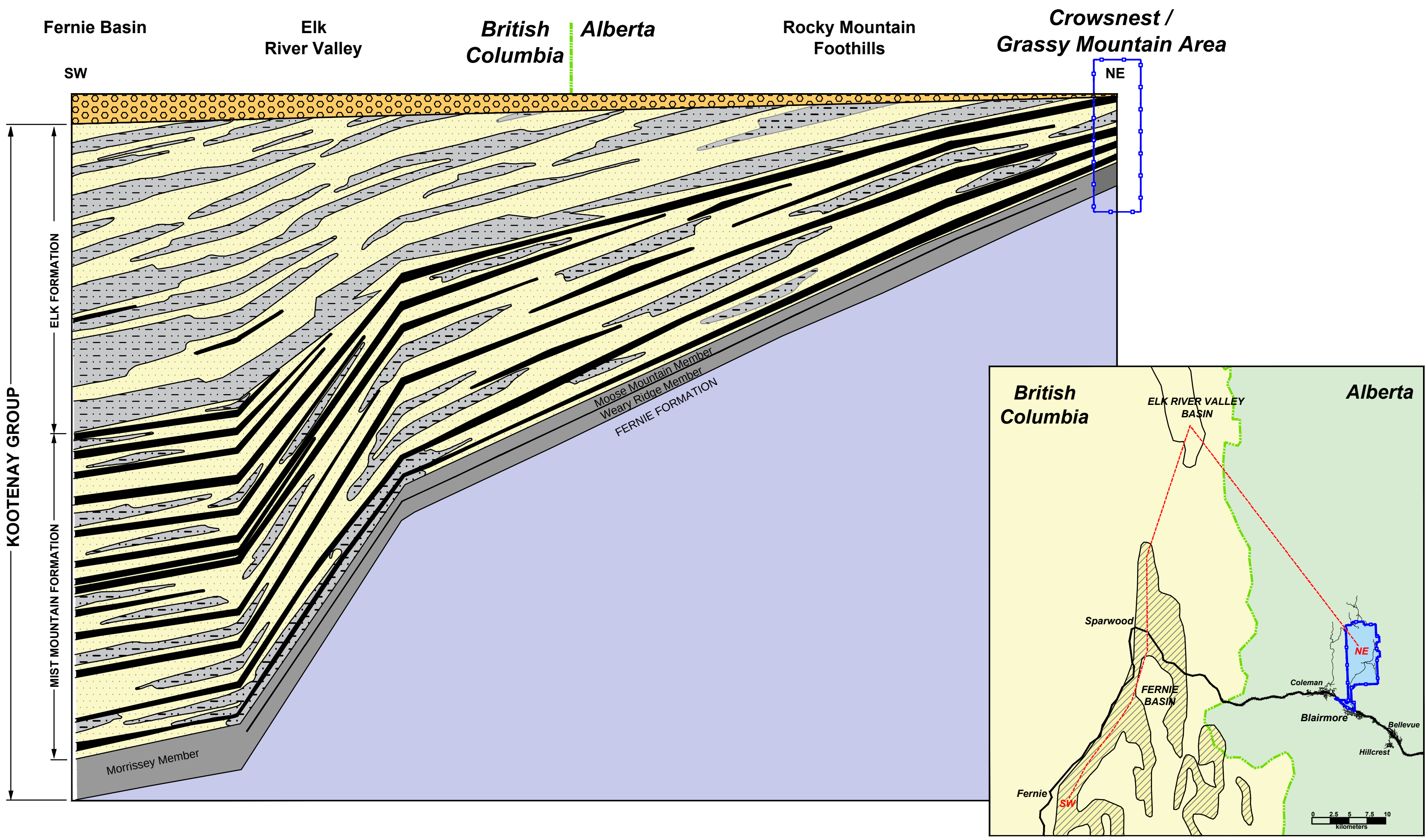
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 2 4 8
Kilometres

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM/CP
DATE: JUNE 14, 2016

FIGURE

B.1.0-1



LEGEND

GEOLOGICAL UNITS

- COAL
- CADOMIN FORMATION (CONGLOMERATE)
- SANDSTONE
- SILTSTONE

LAND OWNERSHIP

- PROPOSED MINE PERMIT BOUNDARY

COMMENT

- PROGRESSIVE THINNING OF SEDIMENTS FROM WEST TO EAST
- REGIONAL UNCONFORMITY OCCURING BELOW THE CADOMIN FORMATION HAS ERODED THE ELK FORMATION IN THE CROWSNEST AREA
- SIXTEEN COAL SEAMS AT ELKVIEW ARE REDUCED TO BASAL FOUR SEAMS PRESENT IN THE CROWSNEST AREA

NOTE(S)

1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS

REFERENCE(S)

- MINING LEASE BOUNDARIES PROVIDED BY
- MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY
- MILLENNIUM EMS SOLUTIONS (MEMS)
- GIBSON, D.W. 1983. STRUCTURE, STRATIGRAPHY, SEDIMENTARY ENVIRONMENTS AND COAL DEPOSITS OF JURA-CRETACEOUS KOOTENAY GROUP, CROWSNEST PASS AREA, ALBERTA AND BRITISH COLUMBIA, CSPG FIELD TRIP GUIDEBOOK NO. 4, 42P.

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

REGIONAL STRATIGRAPHIC CORRELATION

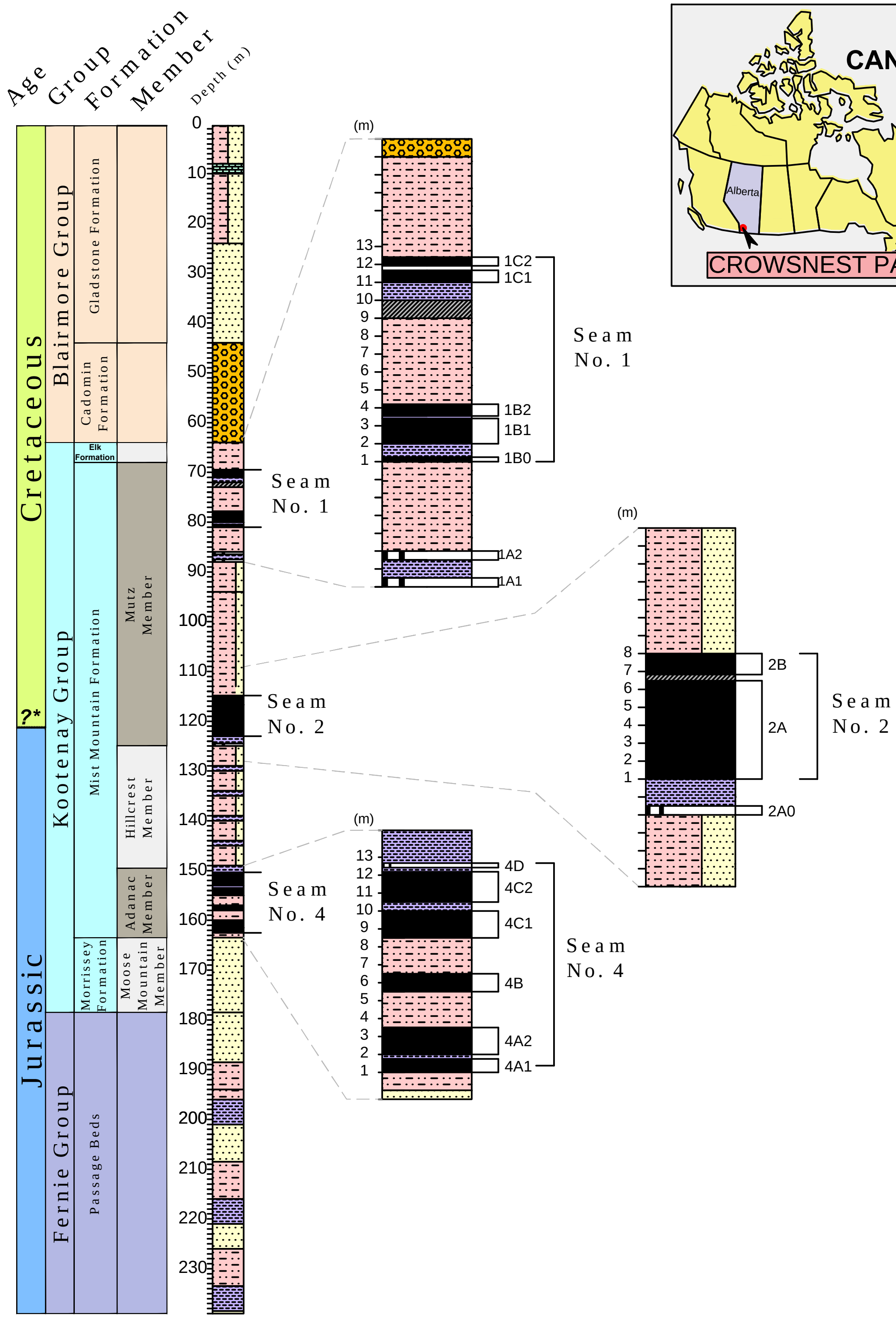
NOTES

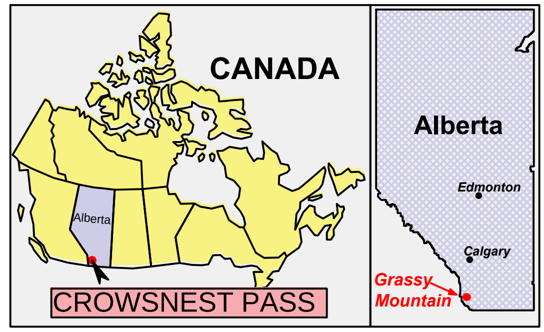
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM/CP
DATE: JUNE 14, 2016

FIGURE

B.1.1-1





LEGEND

LITHOLOGY

- COAL
- COAL STONY
- CARBONACEOUS CLAYSTONE
- CLAYSTONE
- CONGLOMERATE
- LIMESTONE
- SANDSTONE
- SILTSTONE

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. TYPICAL GRASSY MOUNTAIN SEAM SEQUENCE
3. SEAMS ARE FAIRLY VARIABLE AND DO NOT ALWAYS REPLICATE THE ABOVE EXAMPLE
4. *THE PRECISE POSITION OF THE JURASSIC-CRETACEOUS CONTACT IS UNKNOWN

REFERENCE(S)
GIBSON, 1983

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

TYPICAL STRATIGRAPHICAL COLUMN

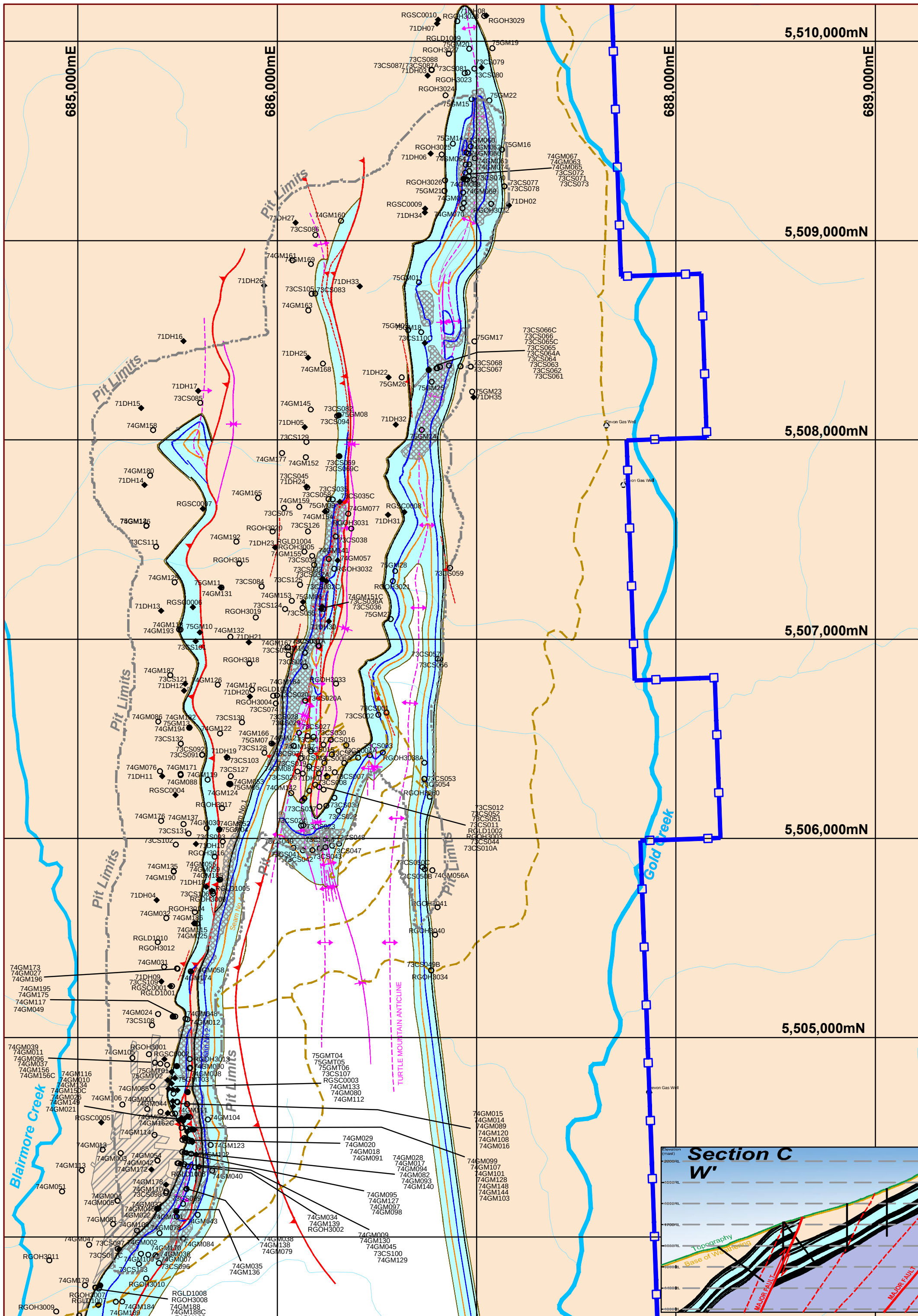
NOTES

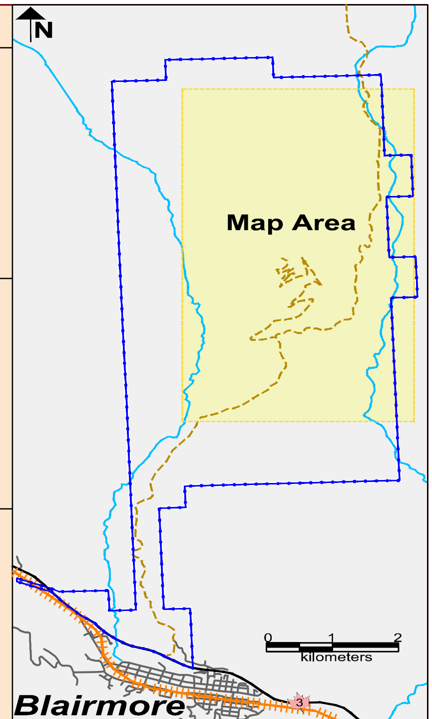
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

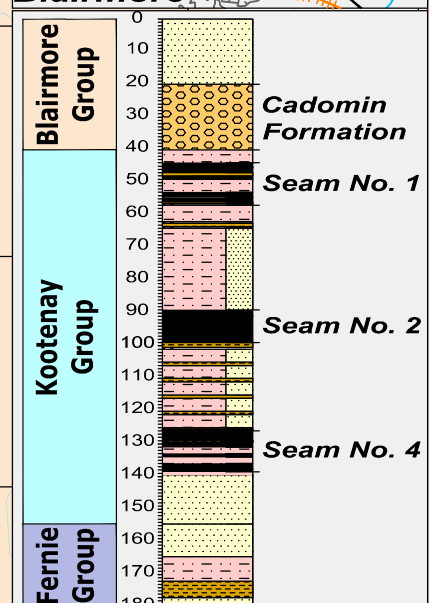
PROJECT: 14-00201-01
DRAWN BY: RS
CHECKED BY: JM/CP
DATE: AUGUST 19, 2015

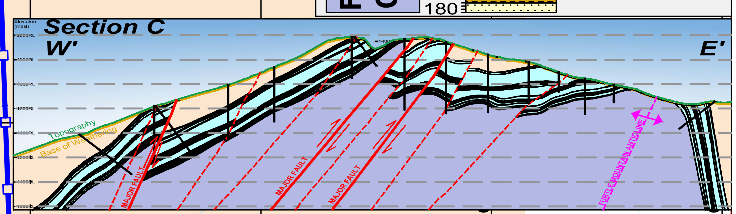
FIGURE

B.1.1-2









LEGEND

SURFACE FEATURES
- WATERCOURSE
- ACCESS ROAD
- SEAM NO.1 SUBCROP
- SEAM NO.2 SUBCROP
- SEAM NO.4 SUBCROP
- MAJOR FAULT (AT SURFACE)
- MINOR FAULT (AT SURFACE)
- ANTICLINE
- SYNCLINE

HISTORIC MINES*
- SURFACE
- UNDERGROUND

* SEAM NO. 1 & SEAM NO. 2

LAND OWNERSHIP
- PROPOSED MINE PERMIT BOUNDARY

DRILL HOLE
- CORED HOLE
- OPEN HOLE

GEOLOGICAL UNITS
- BLAIRMORE GROUP
- KOOTENANY GROUP
- FERNIE GROUP

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. SEAM ROOF SUBCROPS DISPLAYED

REFERENCE(S)
- UTM COORDINATES: NAD83, ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- GEOLOGY BY CONSOL (EXPLORATION SUMMARY MAP; 1988) AND RIVERSDALE RESOURCES 2013 & 2014

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

GEOLOGY MAP

NOTES

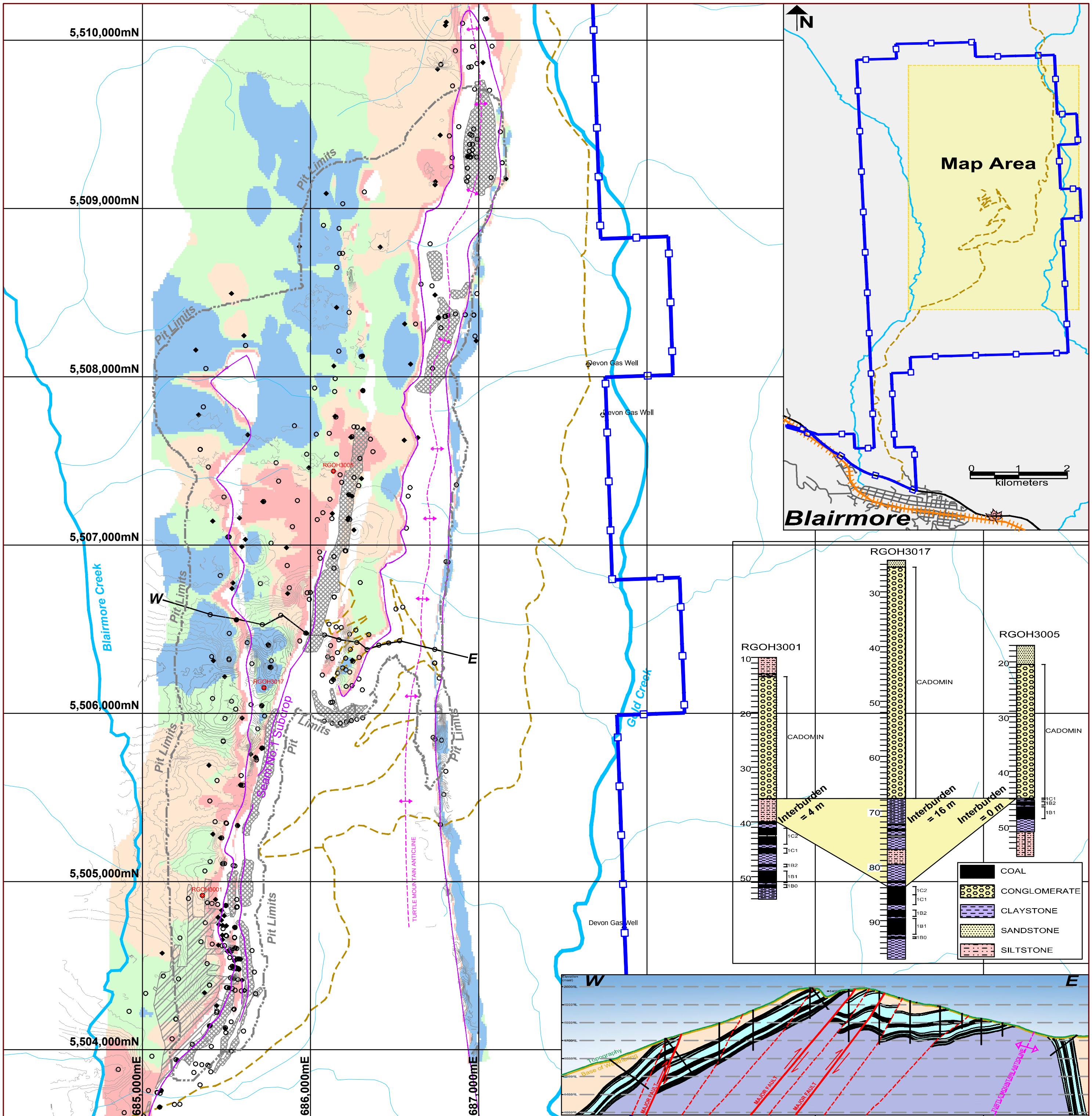
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 400 800 1600
Metres

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM/CP
DATE: JUNE 14, 2016

FIGURE

B.1.1-3



LEGEND

SURFACE FEATURES

- WATERCOURSE
- ACCESS ROAD
- ANTICLINE
- SEAM NO. 1 SUBCROP

HISTORICAL MINES*

- SURFACE
- UNDERGROUND

* SEAM NO. 1 & SEAM NO. 2

LAND OWNERSHIP

- PROPOSED MINE PERMIT BOUNDARY

DRILL HOLE

- ◆ CORED HOLE
- ○ OPEN HOLE

CADOMIN THICKNESS (m)

- <20
- 20 - 30
- 30 - 40
- 40 - 75

SEAM NO.1 TO CADOMIN FORMATION INTERBURDEN CONTOUR (1 m INTERVAL)

SEAM NO.1 TO CADOMIN FORMATION INTERBURDEN CONTOUR (0.5 m INTERVAL)

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. GEOLOGY FROM MINEX COMPUTER MODEL (GM_0215)

REFERENCE(S)
- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

CADOMIN FORMATION THICKNESS

NOTES

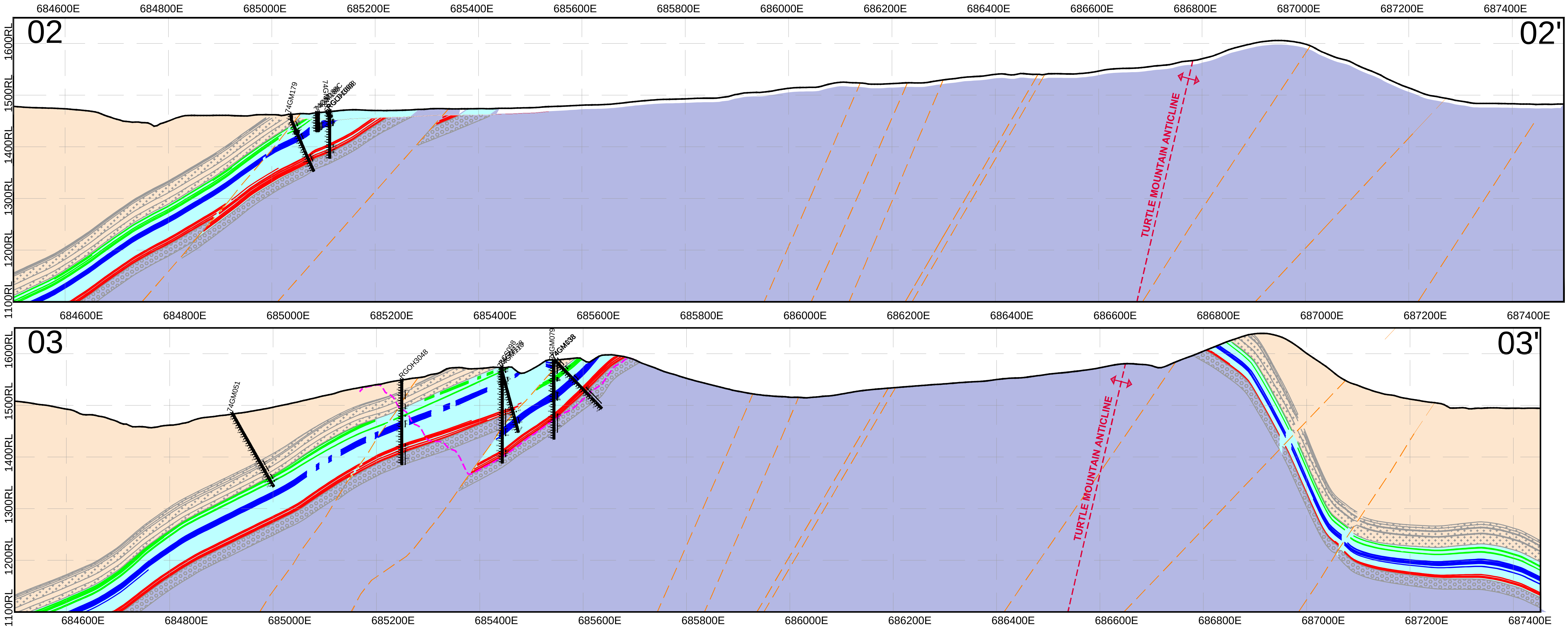
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

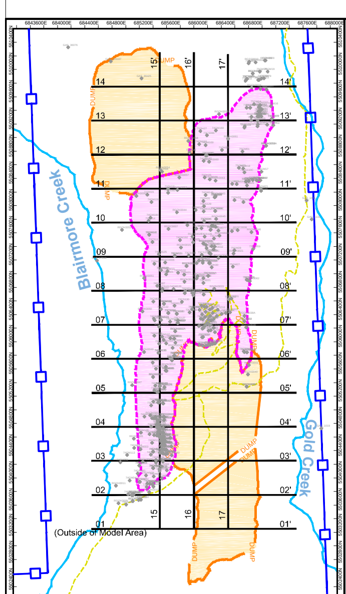
0 400 800 1600
Metres

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM/CP
DATE: JUNE 14, 2016

FIGURE

B.1.1-4





CROSS SECTION

- BLAIRMORE GROUP
- KOOTENANY GROUP
- FERNIE GROUP
- CADOMIN CONGLOMERATE
- SEAM NO.1
- SEAM NO.2
- SEAM NO.4
- MOOSE MOUNTAIN SANDSTONE
- FOLD - ANTICLINE
- REVERSE FAULT
- PROPOSED PIT

LOCATION PLAN

- WATERCOURSE
- ACCESS ROAD
- MINE PERMIT BOUNDARY
- PROPOSED PIT
- PROPOSED DUMP

NOTE(S)

1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS

REFERENCE(S)

- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- GEOLOGY BY CONSOL (EXPLORATION SUMMARY MAP; 1988) AND RIVERSDALE RESOURCES 2013, 2014, 2015 & 2016

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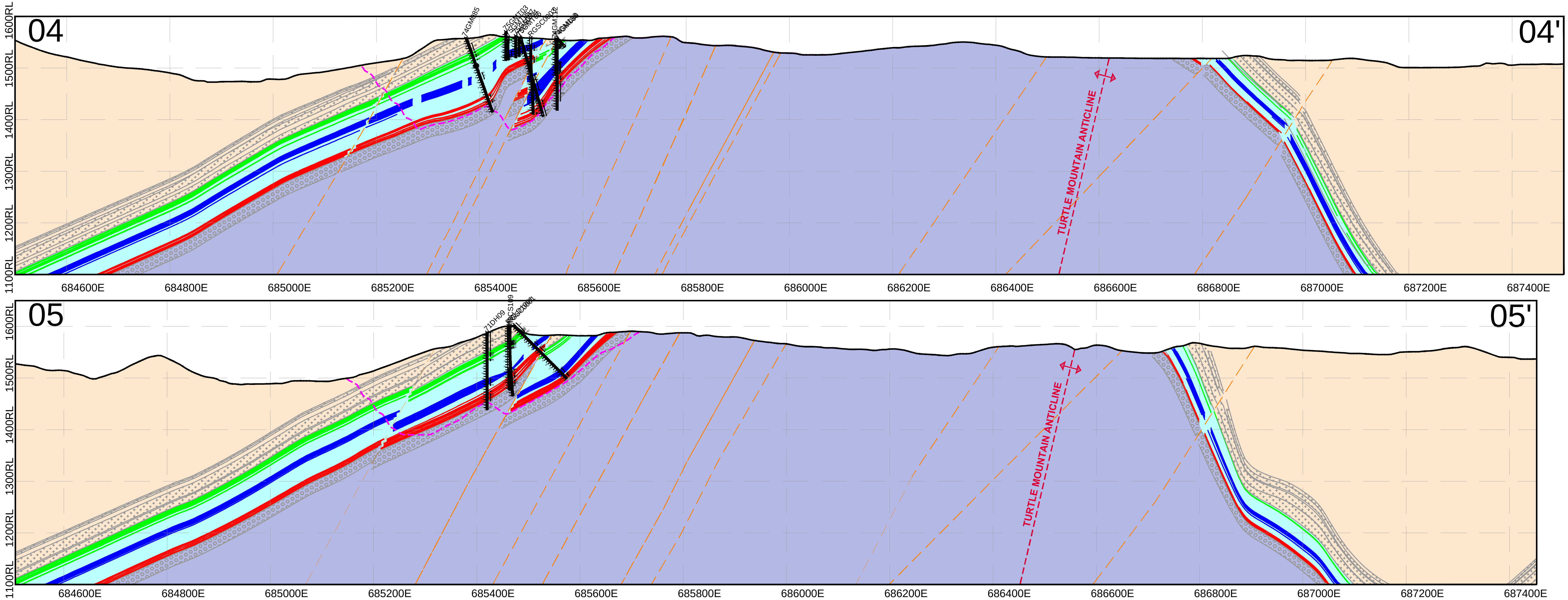
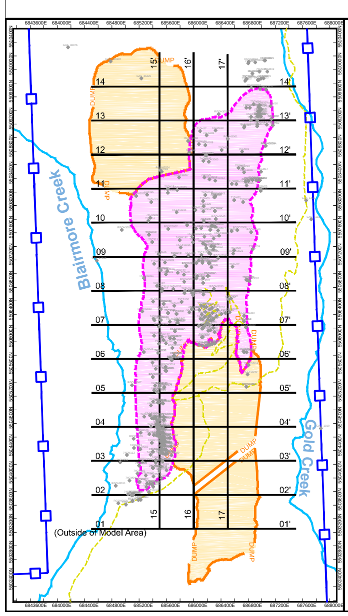
GRASSY MOUNTAIN COAL PROJECT
MINE LICENCE
ALBERTA, CANADA

Figure B.2.0-1
GEOLOGICAL CROSS SECTIONS 02 & 03

DRAWN BY: M.A
DATE: MAY 02, 2016





CROSS SECTION

- BLAIRMORE GROUP
- CADOMIN CONGLOMERATE
- KOOTENANY GROUP
  - SEAM NO.1
  - SEAM NO.2
  - SEAM NO.4
- FERNIE GROUP
- MOOSE MOUNTAIN SANDSTONE
- FOLD - ANTICLINE
- REVERSE FAULT
- PROPOSED PIT

LOCATION PLAN

- WATERCOURSE
- ACCESS ROAD
- MINE PERMIT BOUNDARY
- PROPOSED PIT
- PROPOSED DUMP

NOTE(S)

1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS

REFERENCE(S)

- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- GEOLOGY BY CONSOL (EXPLORATION SUMMARY MAP; 1988) AND RIVERSDALE RESOURCES 2013, 2014, 2015 & 2016

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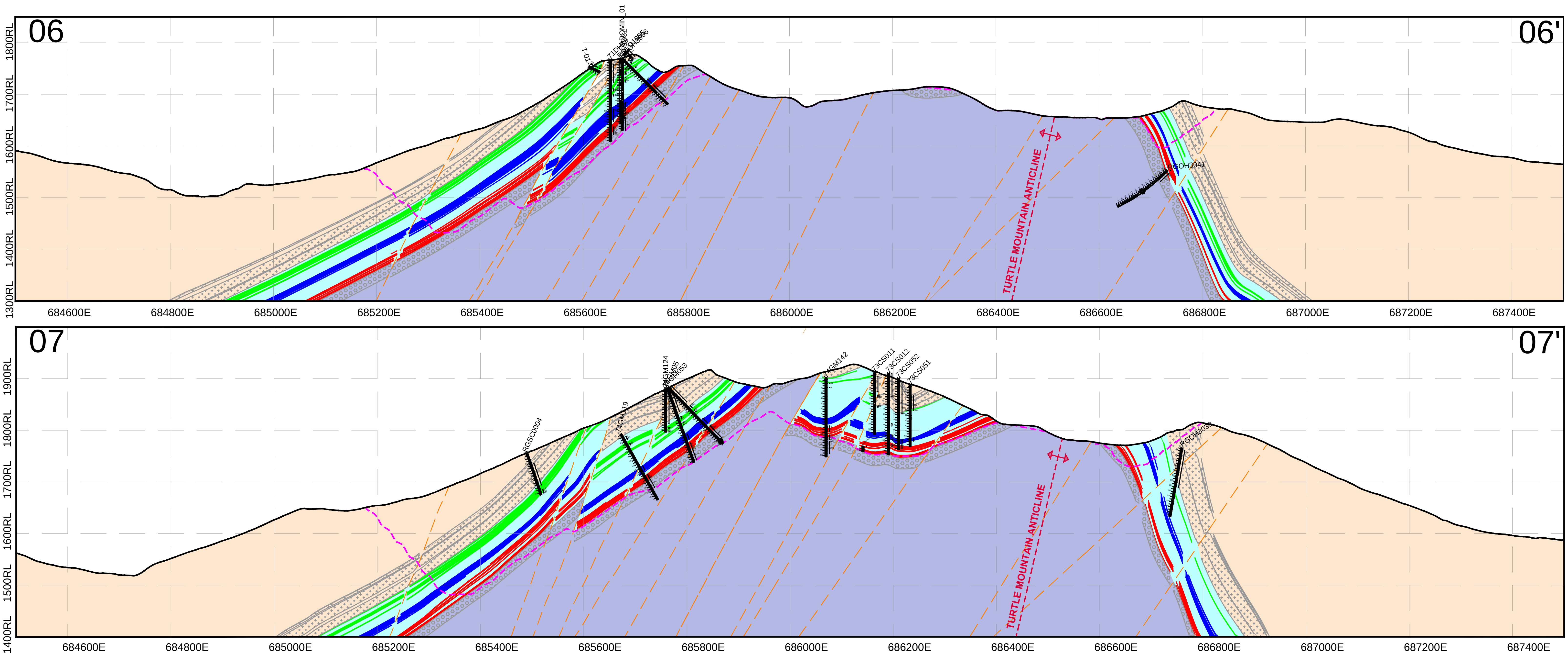
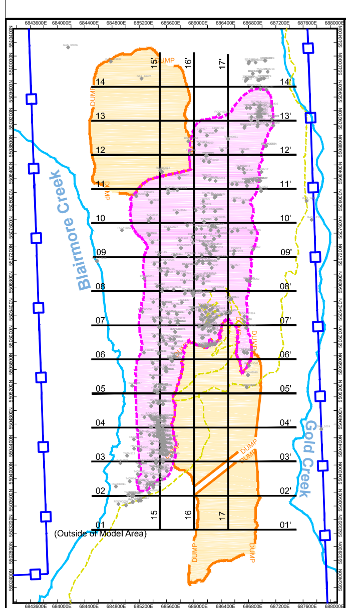
GRASSY MOUNTAIN COAL PROJECT
MINE LICENCE
ALBERTA, CANADA

Figure B.2.0-2

GEOLOGICAL CROSS SECTIONS 04 & 05

DRAWN BY: M.A
DATE: MAY 02, 2016





CROSS SECTION

- BLAIRMORE GROUP
- CADOMIN CONGLOMERATE
- KOOTENANY GROUP
  - SEAM NO.1
  - SEAM NO.2
  - SEAM NO.4
- FERNIE GROUP
- MOOSE MOUNTAIN SANDSTONE
- FOLD - ANTICLINE
- REVERSE FAULT
- PROPOSED PIT

LOCATION PLAN

- WATERCOURSE
- ACCESS ROAD
- MINE PERMIT BOUNDARY
- PROPOSED PIT
- PROPOSED DUMP

NOTE(S)

1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS

REFERENCE(S)

- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- GEOLOGY BY CONSOL (EXPLORATION SUMMARY MAP; 1988) AND RIVERSDALE RESOURCES 2013, 2014, 2015 & 2016

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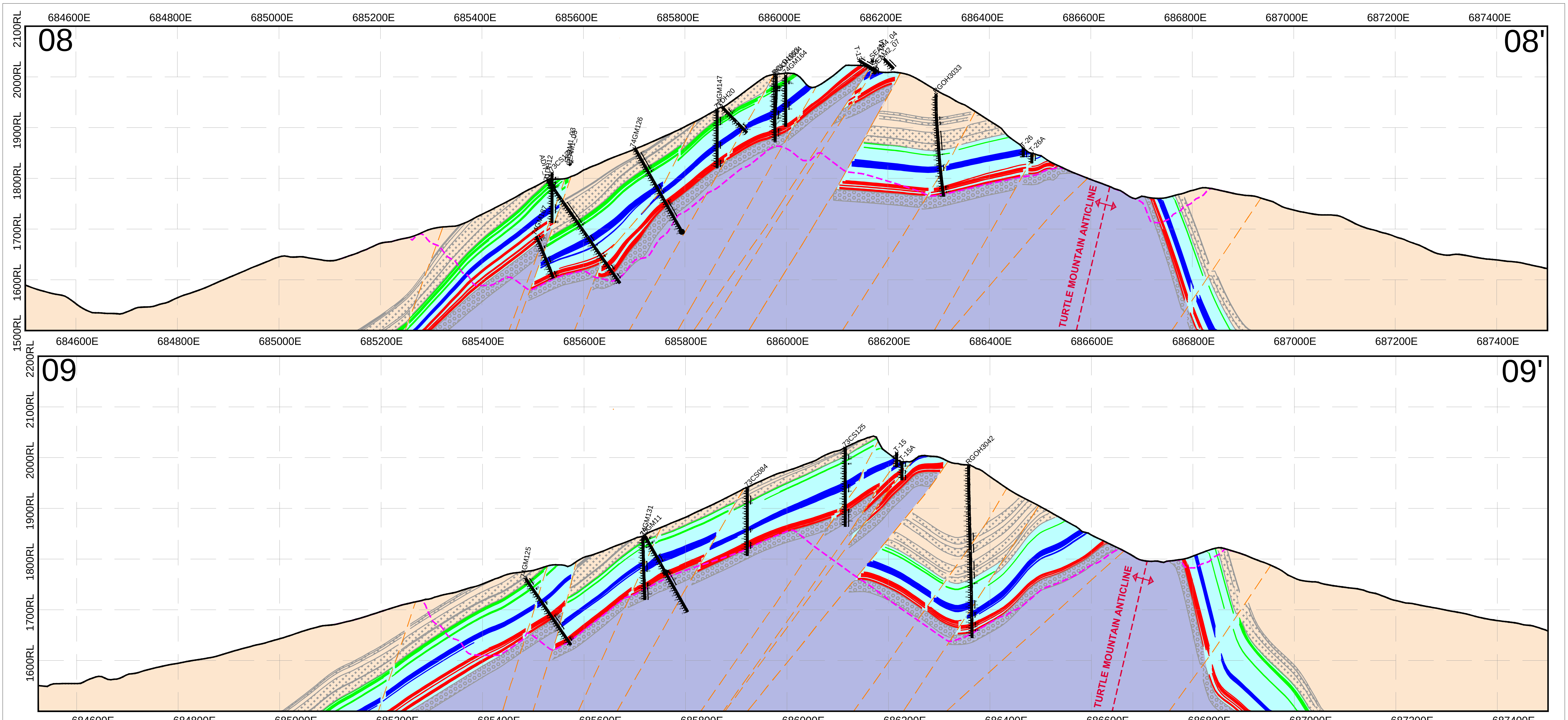
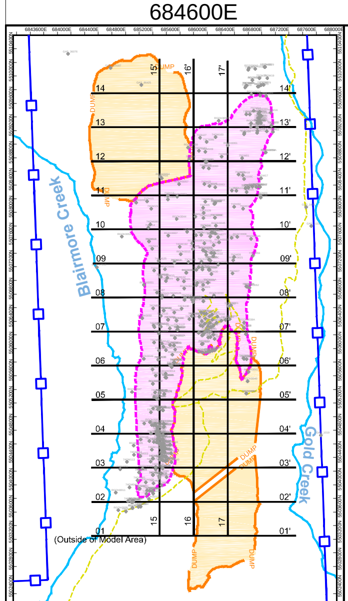
GRASSY MOUNTAIN COAL PROJECT
MINE LICENCE
ALBERTA, CANADA

Figure B.2.0-3
GEOLOGICAL CROSS SECTIONS 06 & 07

DRAWN BY: M.A
DATE: MAY 02, 2016





CROSS SECTION	**LOCATION PLAN**
BLAIRMORE GROUP	WATERCOURSE
KOOTENANY GROUP	ACCESS ROAD
FERNIE GROUP	MINE PERMIT BOUNDARY
CADOMIN CONGLOMERATE	PROPOSED PIT
SEAM NO.1	PROPOSED DUMP
SEAM NO.2	
SEAM NO.4	
MOOSE MOUNTAIN SANDSTONE	
FOLD - ANTICLINE	
REVERSE FAULT	
PROPOSED PIT	

NOTE(S)

1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS

REFERENCE(S)

- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- GEOLOGY BY CONSOL (EXPLORATION SUMMARY MAP; 1988) AND RIVERSDALE RESOURCES 2013, 2014, 2015 & 2016

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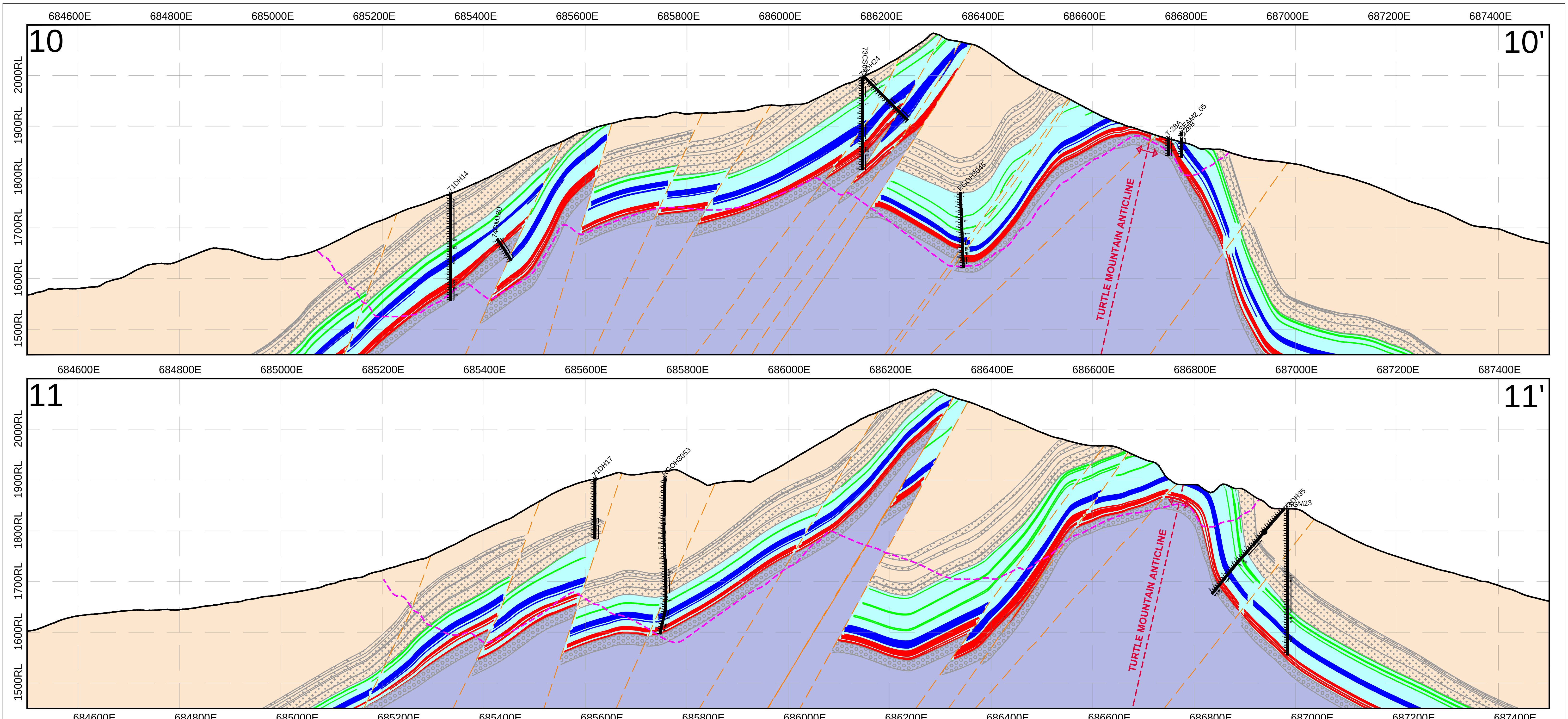
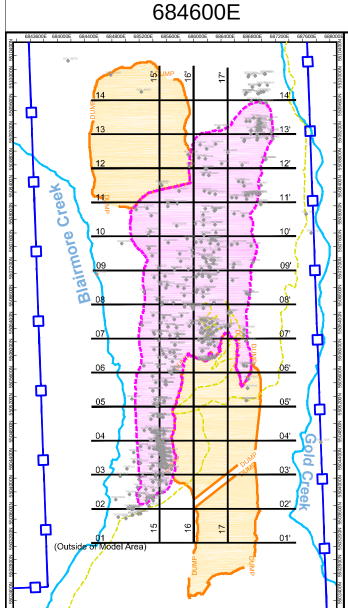
GRASSY MOUNTAIN COAL PROJECT
MINE LICENCE
ALBERTA, CANADA

Figure B.2.0-4
GEOLOGICAL CROSS SECTIONS 08 & 09

DRAWN BY: M.A
DATE: MAY 02, 2016





CROSS SECTION

- BLAIRMORE GROUP
- CADOMIN CONGLOMERATE
- KOOTENANY GROUP
  - SEAM NO.1
  - SEAM NO.2
  - SEAM NO.4
- FERNIE GROUP
- MOOSE MOUNTAIN SANDSTONE
- FOLD - ANTICLINE
- REVERSE FAULT
- PROPOSED PIT

LOCATION PLAN

- WATERCOURSE
- ACCESS ROAD
- MINE PERMIT BOUNDARY
- PROPOSED PIT
- PROPOSED DUMP

NOTE(S)

1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS

REFERENCE(S)

- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- GEOLOGY BY CONSOL (EXPLORATION SUMMARY MAP; 1988) AND RIVERSDALE RESOURCES 2013, 2014, 2015 & 2016

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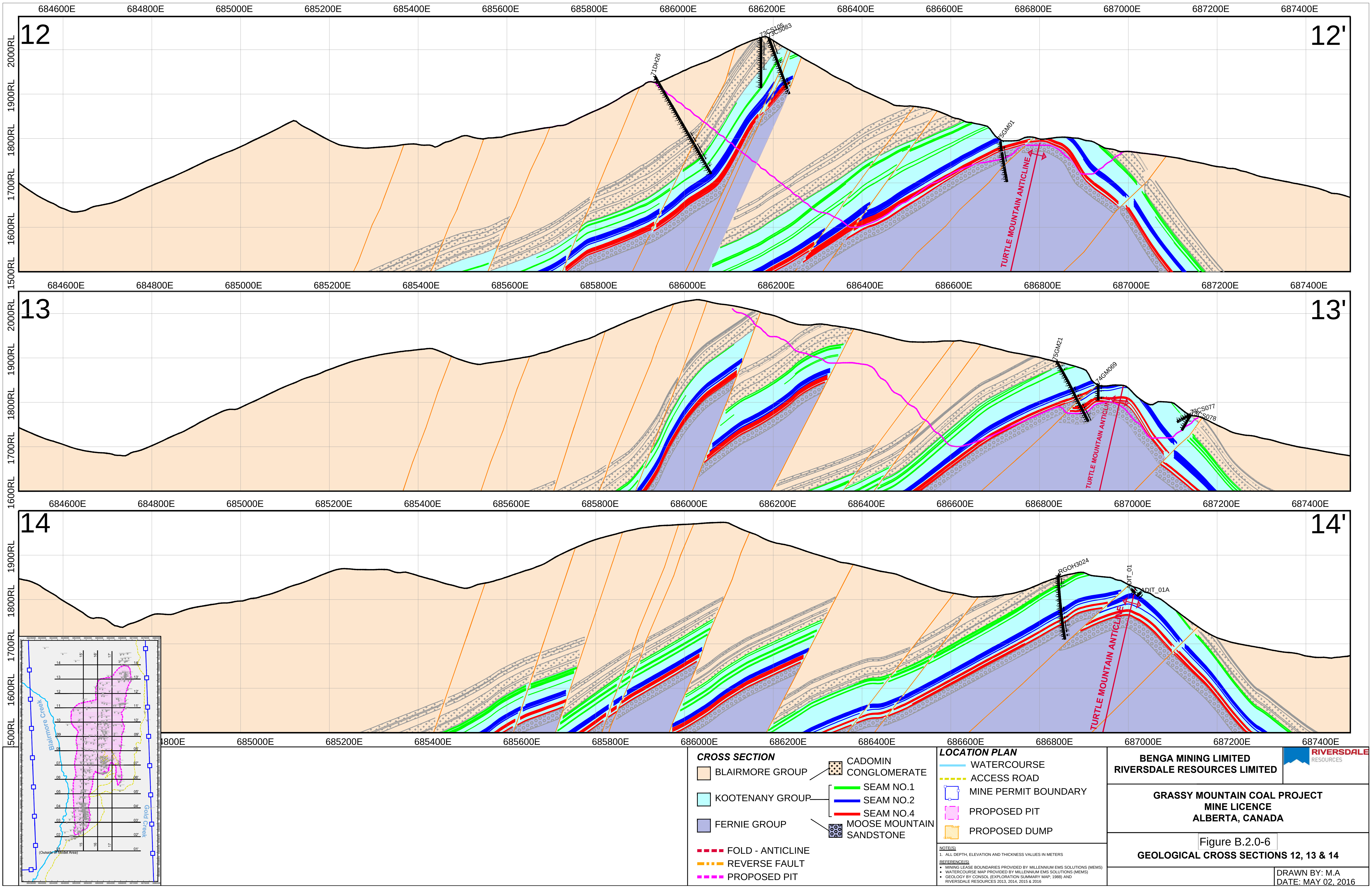
GRASSY MOUNTAIN COAL PROJECT
MINE LICENCE
ALBERTA, CANADA

Figure B.2.0-5

GEOLOGICAL CROSS SECTIONS 10 & 11

DRAWN BY: M.A
DATE: MAY 02, 2016


12
12'
13
13'
14
14'
684600E
684800E
685000E
685200E
685400E
685600E
685800E
686000E
686200E
686400E
686600E
686800E
687000E
687200E
687400E
1500RL
1600RL
1700RL
1800RL
1900RL
2000RL
71DH26
73CS105
73CS083
75GM01
75GM21
74GM069
73CS077
73CS078
RGOH3024
ADIT_01
ADIT_01A
TURTLE MOUNTAIN ANTICLINE
Blairmore Creek
Gold Creek
CROSS SECTION
BLAIRMORE GROUP
KOOTENANY GROUP
FERNIE GROUP
CADOMIN CONGLOMERATE
SEAM NO.1
SEAM NO.2
SEAM NO.4
MOOSE MOUNTAIN SANDSTONE
FOLD - ANTICLINE
REVERSE FAULT
PROPOSED PIT
LOCATION PLAN
WATERCOURSE
ACCESS ROAD
MINE PERMIT BOUNDARY
PROPOSED PIT
PROPOSED DUMP
NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
REFERENCE(S)
• MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
• WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
• GEOLOGY BY CONSOL (EXPLORATION SUMMARY MAP; 1988) AND RIVERSDALE RESOURCES 2013, 2014, 2015 & 2016
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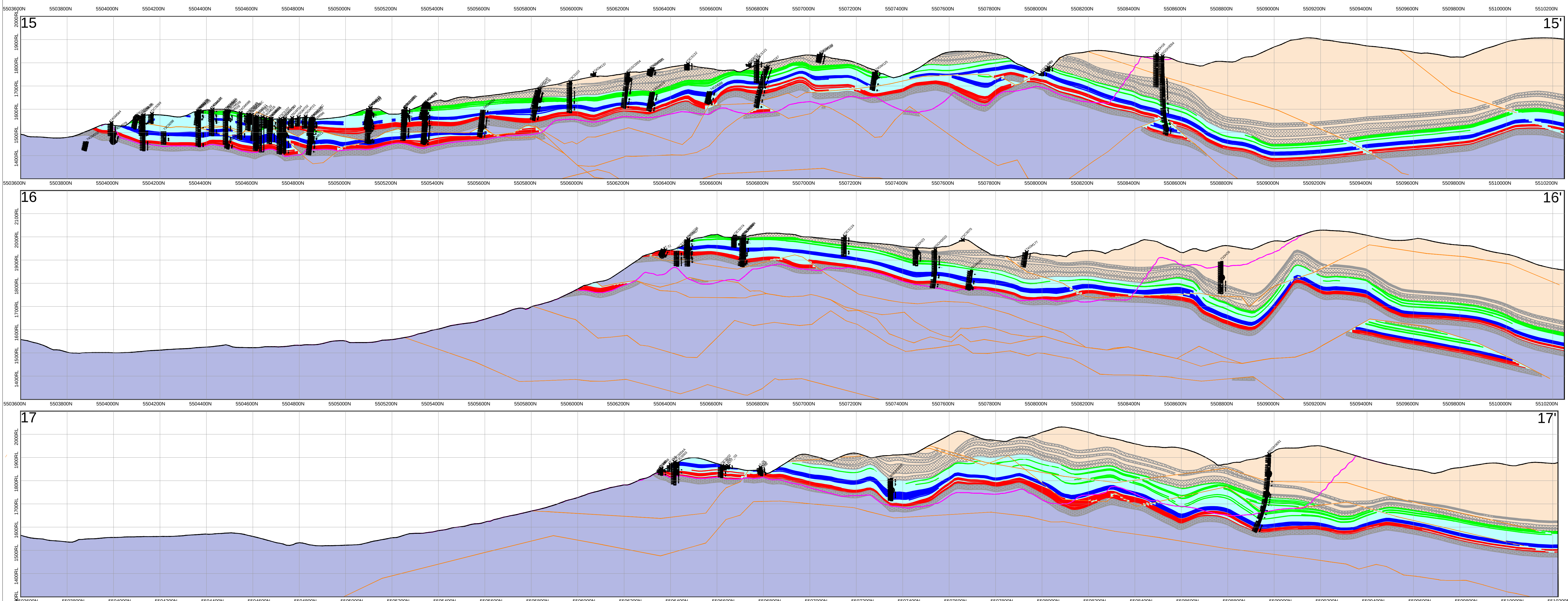
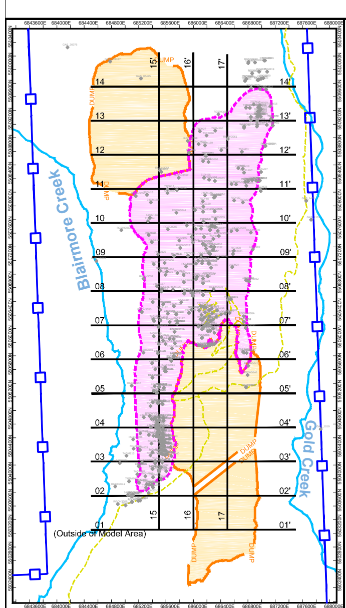
RIVERSDALE RESOURCES
GRASSY MOUNTAIN COAL PROJECT
MINE LICENCE
ALBERTA, CANADA
Figure B.2.0-6
GEOLOGICAL CROSS SECTIONS 12, 13 & 14
DRAWN BY: M.A
DATE: MAY 02, 2016





CROSS SECTION

- BLAIRMORE GROUP
- CADOMIN CONGLOMERATE
- KOOTENANY GROUP
- SEAM NO.1
- SEAM NO.2
- SEAM NO.4
- FERNIE GROUP
- MOOSE MOUNTAIN SANDSTONE
- FOLD - ANTICLINE
- REVERSE FAULT
- PROPOSED PIT

LOCATION PLAN

- WATERCOURSE
- ACCESS ROAD
- MINE PERMIT BOUNDARY
- PROPOSED PIT
- PROPOSED DUMP

NOTE(S)

1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS

REFERENCE(S)

- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- GEOLOGY BY CONSOL (EXPLORATION SUMMARY MAP; 1988) AND RIVERSDALE RESOURCES 2013, 2014, 2015 & 2016

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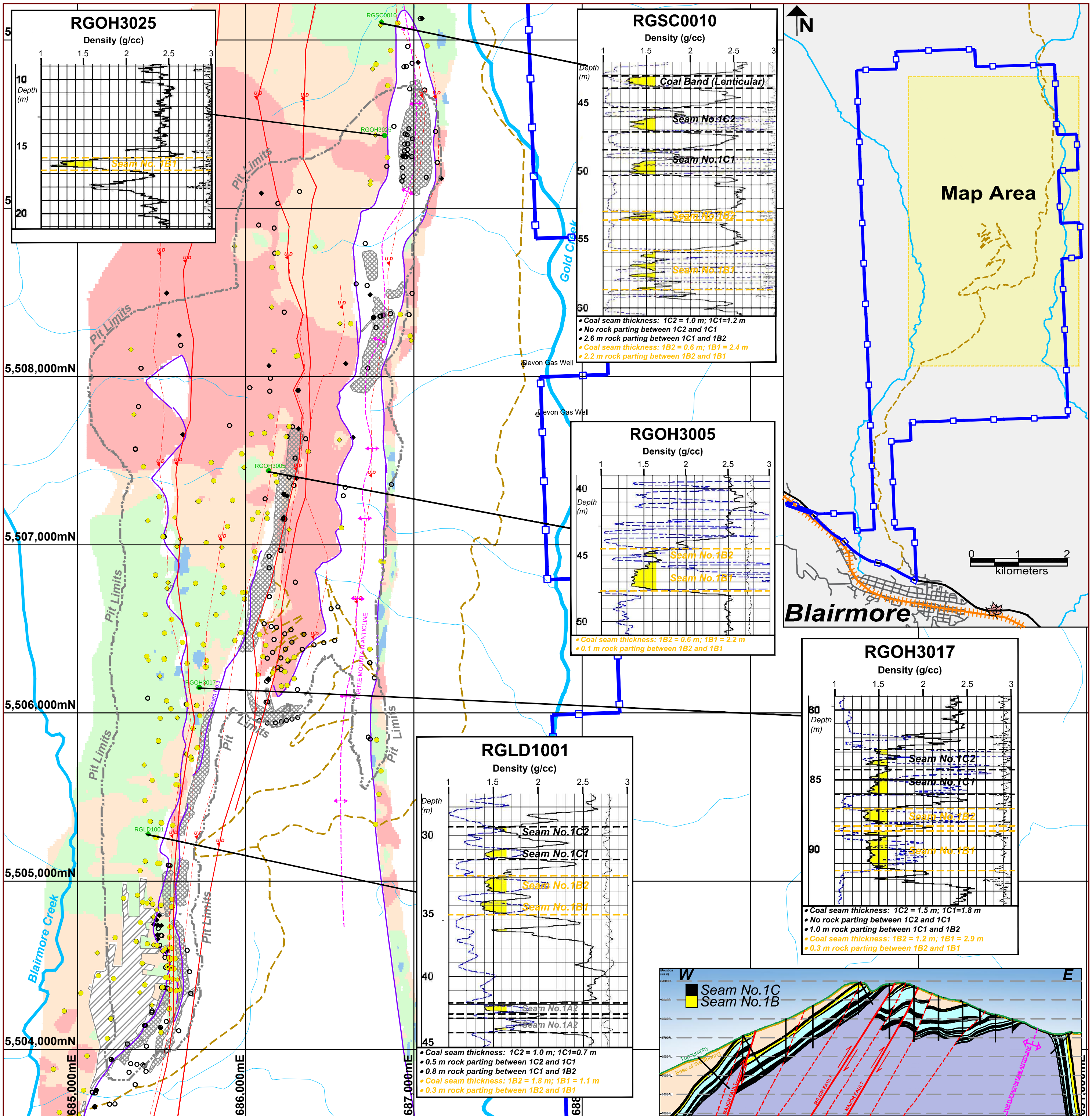
GRASSY MOUNTAIN COAL PROJECT
MINE LICENCE
ALBERTA, CANADA

Figure B.2.0-7

GEOLOGICAL CROSS SECTIONS 15, 16 & 17

DRAWN BY: M.A
DATE: MAY 02, 2016



LEGEND

SURFACE FEATURES
- WATERCOURSE
- ACCESS ROAD
- FAULT (MINOR) (AT SEAM NO.1 LEVEL)
- FAULT (MAJOR) (AT SEAM NO.1 LEVEL)
- ANTICLINE
- SEAM NO. 1 SUBCROP

HISTORICAL MINES*
- SURFACE
- UNDERGROUND

* SEAM NO. 1 & SEAM NO. 2

LAND OWNERSHIP
- PROPOSED MINE PERMIT BOUNDARY

DRILL HOLE
- CORED HOLE
- OPEN HOLE

DRILL HOLE INTERSECTING SEAM NO.1
- CORED HOLE
- OPEN HOLE

SEAM THICKNESS (m)
- <2
- 2-5
- 5-10
- >10

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. GEOPHYSICAL DENSITY LOGS FROM CENTURY WIRELINE SERVICES
3. GEOLOGY FROM MINEX COMPUTER MODEL (GM_0215)

REFERENCE(S)
- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

VARIABILITY OF SEAM No. 1

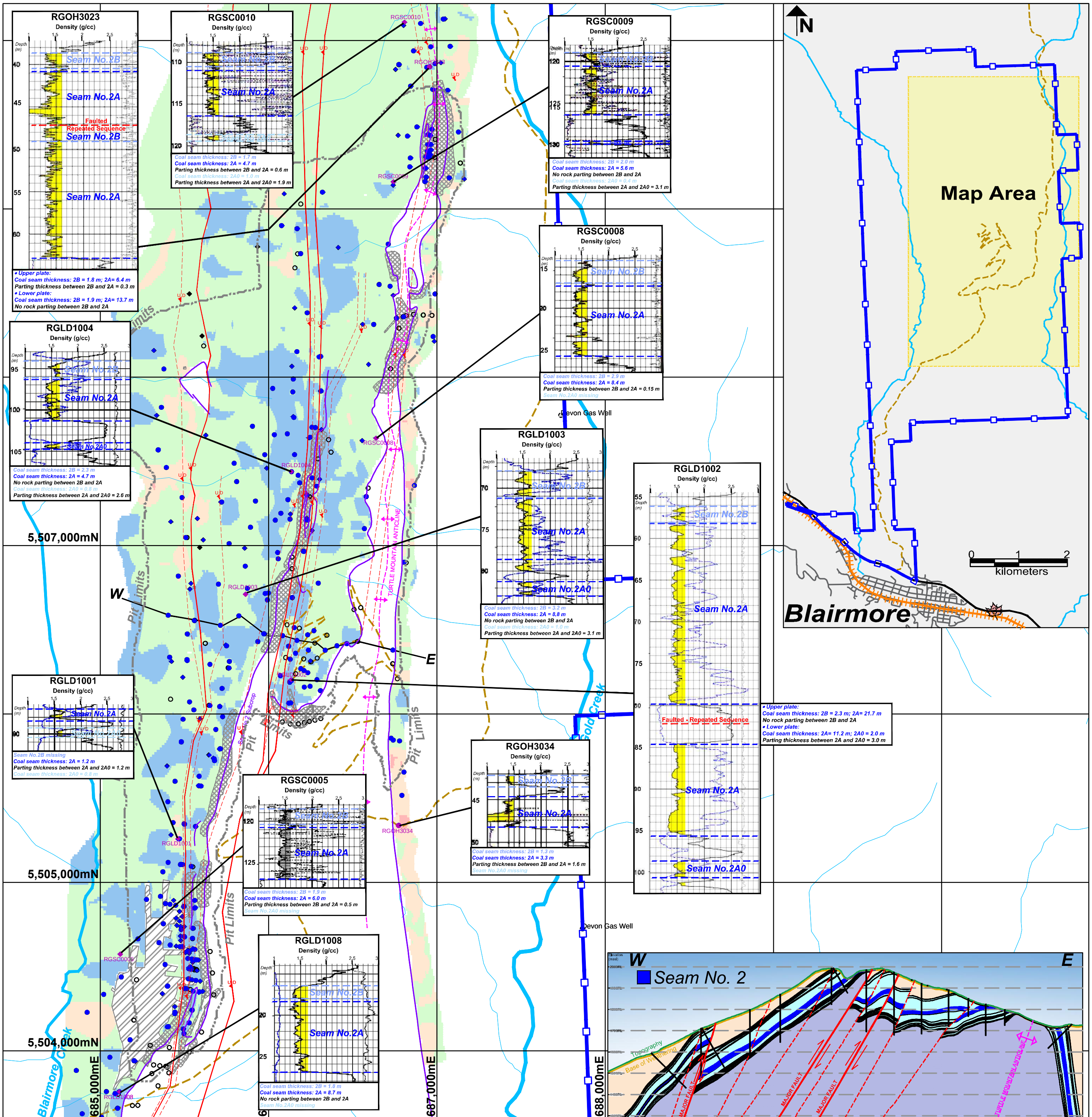
NOTES

Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 400 800 1600
Metres

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM
DATE: JUNE 14, 2016

FIGURE
B.2.0-8



LEGEND

SURFACE FEATURES
- WATERCOURSE
- ACCESS ROAD
- FAULT (MINOR) (AT SEAM NO.2 LEVEL)
- FAULT (MAJOR) (AT SEAM NO.2 LEVEL)
- ANTICLINE
- SEAM NO. 2 SUBCROP

HISTORICAL MINES*
- SURFACE
- UNDERGROUND

* SEAM NO. 1 & SEAM NO. 2

LAND OWNERSHIP
- PROPOSED MINE PERMIT BOUNDARY

DRILL HOLE
- CORED HOLE
- OPEN HOLE

DRILL HOLE INTERSECTING SEAM NO.2
- CORED HOLE
- OPEN HOLE

SEAM THICKNESS (m)
- <2
- 2-5
- 5-10
- >10

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. GEOPHYSICAL DENSITY LOGS FROM CENTURY WIRELINE SERVICES
3. GEOLOGY FROM MINEX COMPUTER MODEL (GM_0215)

REFERENCE(S)
- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

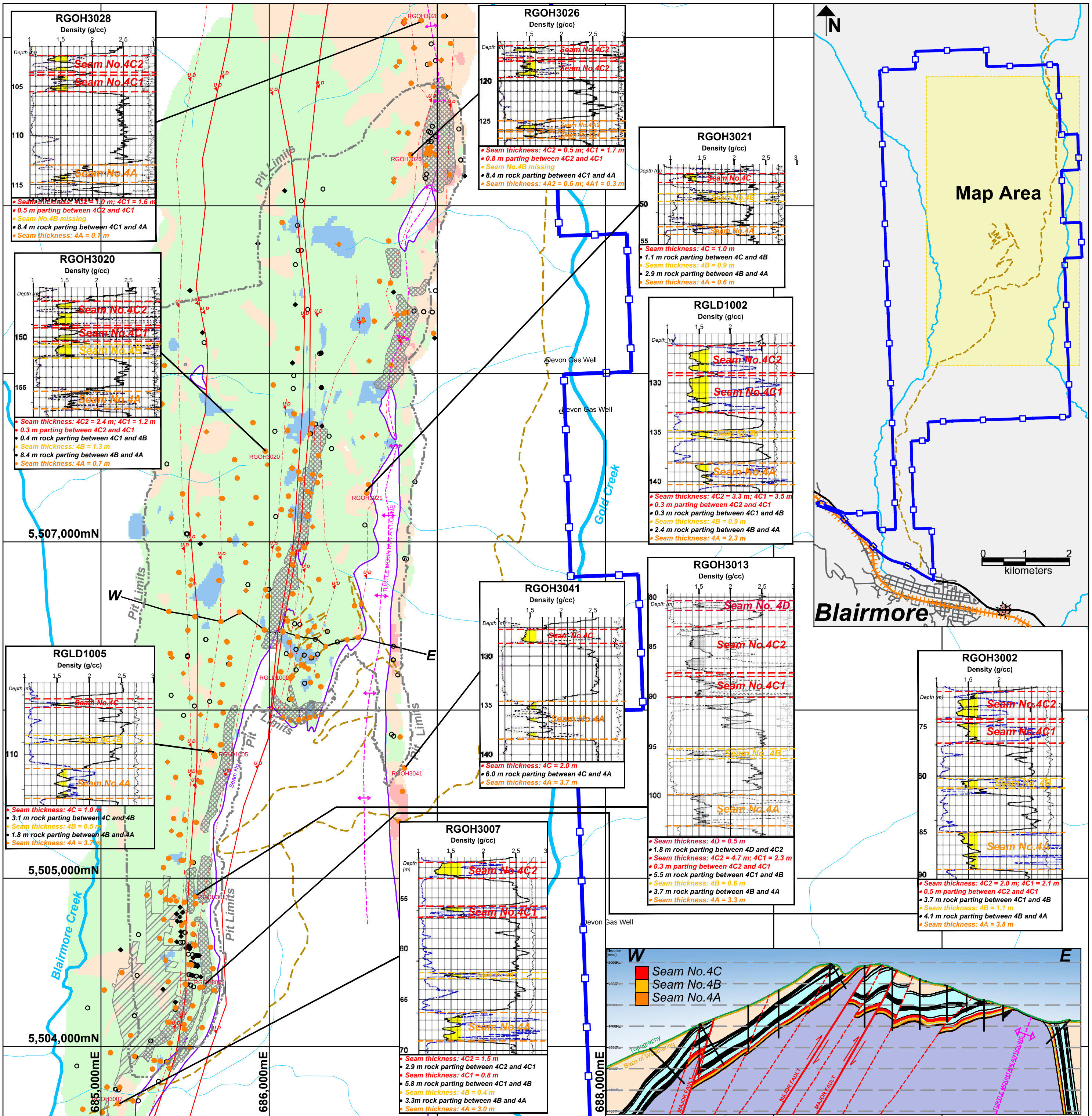
VARIABILITY OF SEAM No. 2

NOTES

Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 400 800 1600
Metres

PROJECT:	14-00201-01
DRAWN BY:	RS/SL
CHECKED BY:	JM
DATE:	JUNE 14, 2016
FIGURE	B.2.0-9



LEGEND

SURFACE FEATURES
- WATERCOURSE
- ACCESS ROAD
- FAULT (MINOR) (AT SEAM NO.4 LEVEL)
- FAULT (MAJOR) (AT SEAM NO.4 LEVEL)
- ANTICLINE
- SEAM NO. 4 SUBCROP

HISTORICAL MINES*
- SURFACE
- UNDERGROUND

* SEAM NO. 1 & SEAM NO. 2

LAND OWNERSHIP
- PROPOSED MINE PERMIT BOUNDARY

DRILL HOLE
- CORED HOLE
- OPEN HOLE

DRILL HOLE INTERSECTING SEAM NO.4
- CORED HOLE
- OPEN HOLE

SEAM THICKNESS (m)
- <2
- 2-5
- 5-10
- >10

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. GEOPHYSICAL DENSITY LOGS FROM CENTURY WIRELINE SERVICES
3. GEOLOGY FROM MINEX COMPUTER MODEL (GM_0215)

REFERENCE(S)
- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

VARIABILITY OF SEAM No.4

NOTES

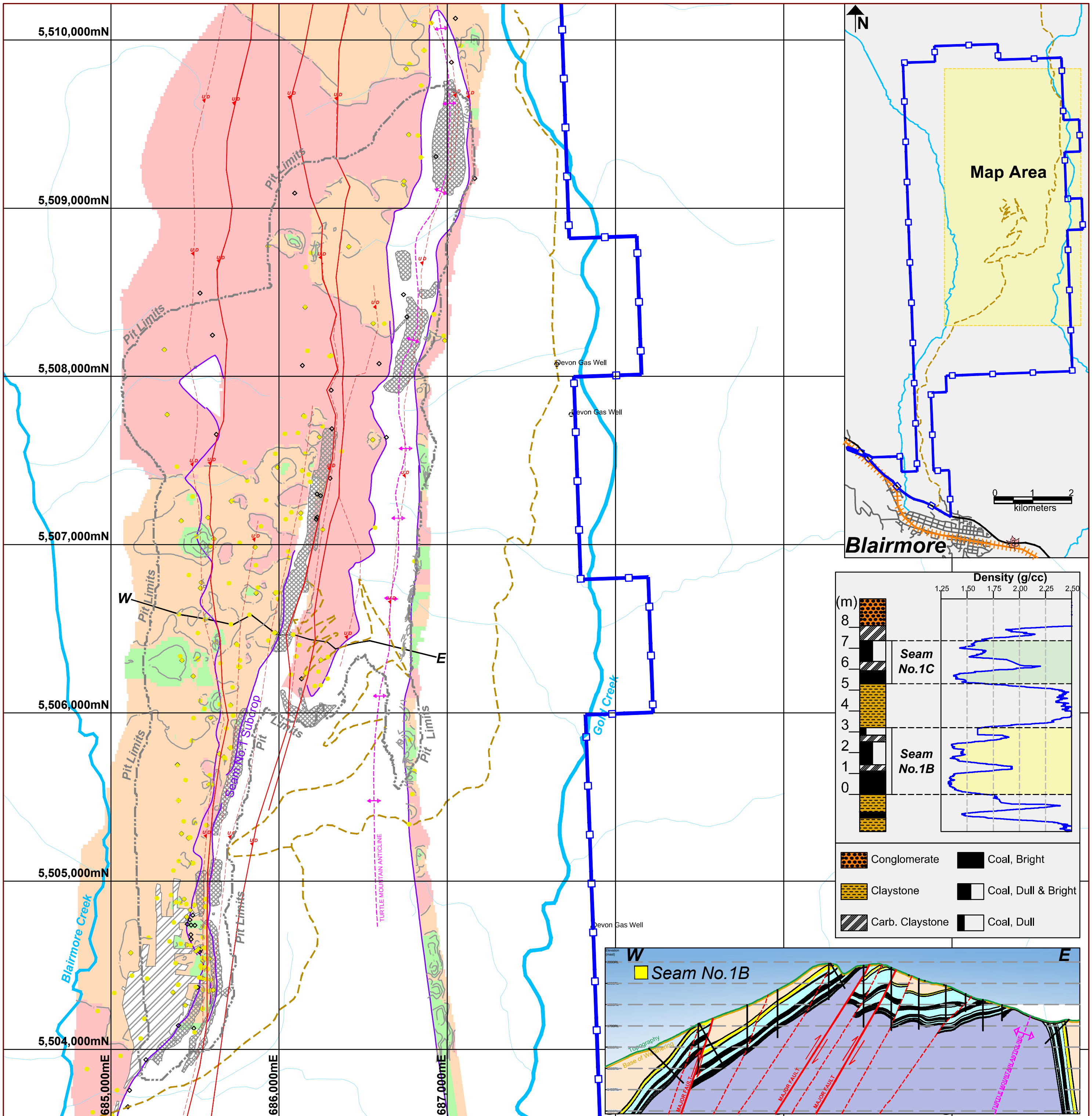
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 400 800 1600
Metres

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM
DATE: JUNE 14, 2016

FIGURE

B.2.0-10



LEGEND

SURFACE FEATURES
- WATERCOURSE
- ACCESS ROAD
- FAULT (MINOR) (AT SEAM NO.1 LEVEL)
- FAULT (MAJOR) (AT SEAM NO.1 LEVEL)
- ANTICLINE
- SEAM NO. 1 SUBCROP

HISTORICAL MINES*
- SURFACE
- UNDERGROUND

* SEAM NO. 1 & SEAM NO. 2

LAND OWNERSHIP
- PROPOSED MINE PERMIT BOUNDARY

THICKNESS CONTOUR (2 m INTERVAL)

DRILL HOLE
- CORED HOLE
- OPEN HOLE

DRILL HOLE INTERSECTING SEAM NO. 1B
- CORED HOLE
- OPEN HOLE

SEAM THICKNESS (m)
- <2
- 2 - 5
- 5 - 10

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. GEOLOGY FROM MINEX COMPUTER MODEL (GM_0215)

REFERENCE(S)
- UTM COORDINATES: NAD83, ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

SEAM 1B THICKNESS

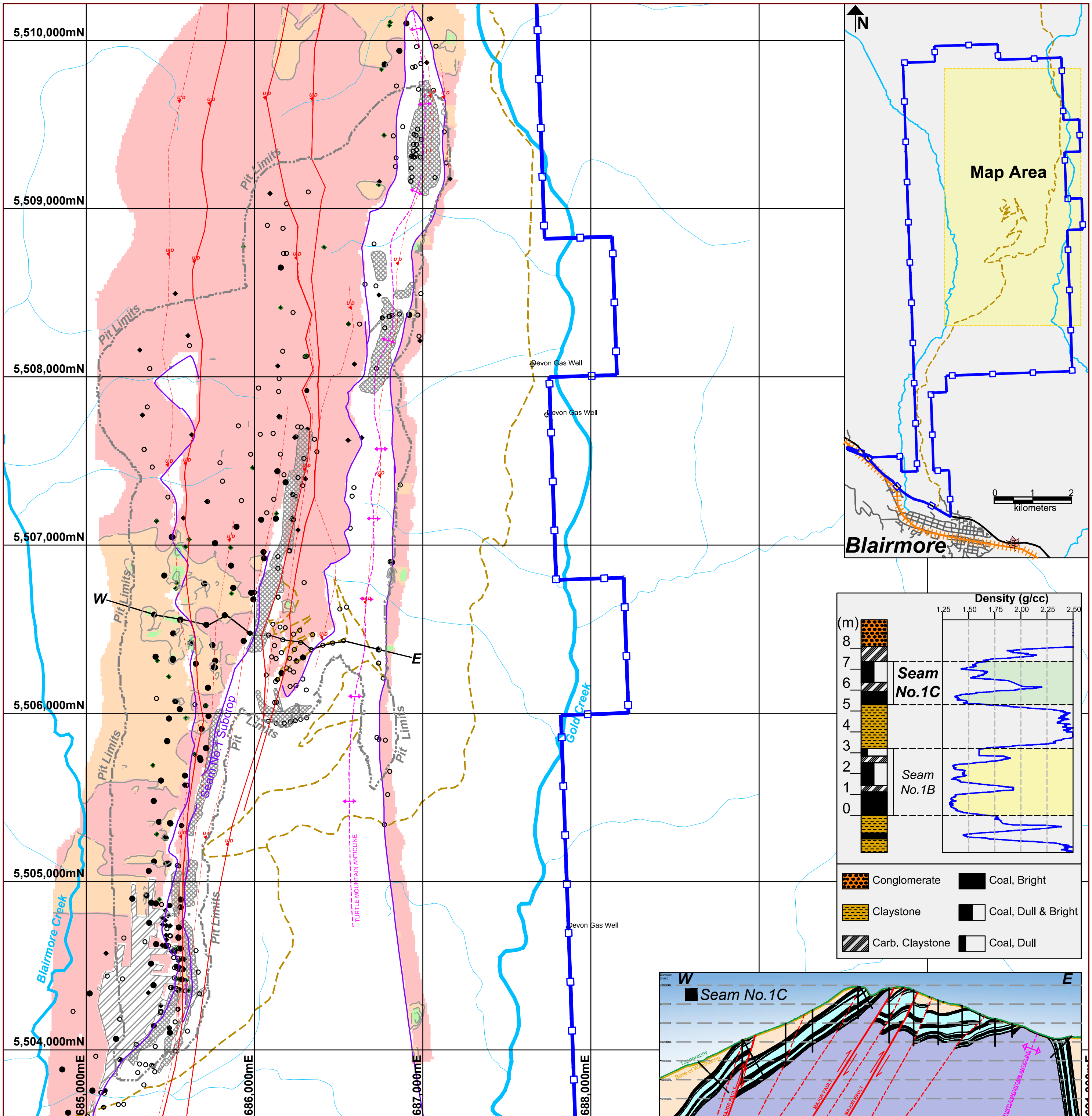
NOTES

Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 400 800 1600
Metres

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM/CP
DATE: JUNE 14, 2016

FIGURE
B.2.1-1



LEGEND

SURFACE FEATURES

- WATERCOURSE
- ACCESS ROAD
- FAULT (MINOR) (AT SEAM NO.1 LEVEL)
- FAULT (MAJOR) (AT SEAM NO.1 LEVEL)
- ANTICLINE
- SEAM NO. 1 SUBCROP

HISTORICAL MINES*

- SURFACE
- UNDERGROUND

* SEAM NO. 1 & SEAM NO. 2

LAND OWNERSHIP

- PROPOSED MINE PERMIT BOUNDARY

DRILL HOLE

- ◆ CORED HOLE
- ○ OPEN HOLE

DRILL HOLE INTERSECTING SEAM NO. 1C

- ◆ CORED HOLE
- ● OPEN HOLE

SEAM THICKNESS (m)

- <2
- 2 - 5
- 5 - 10

THICKNESS CONTOUR (2 m INTERVAL)

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. GEOLOGY FROM MINEX COMPUTER MODEL (GM_0215)

REFERENCE(S)
- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

SEAM 1C THICKNESS

NOTES

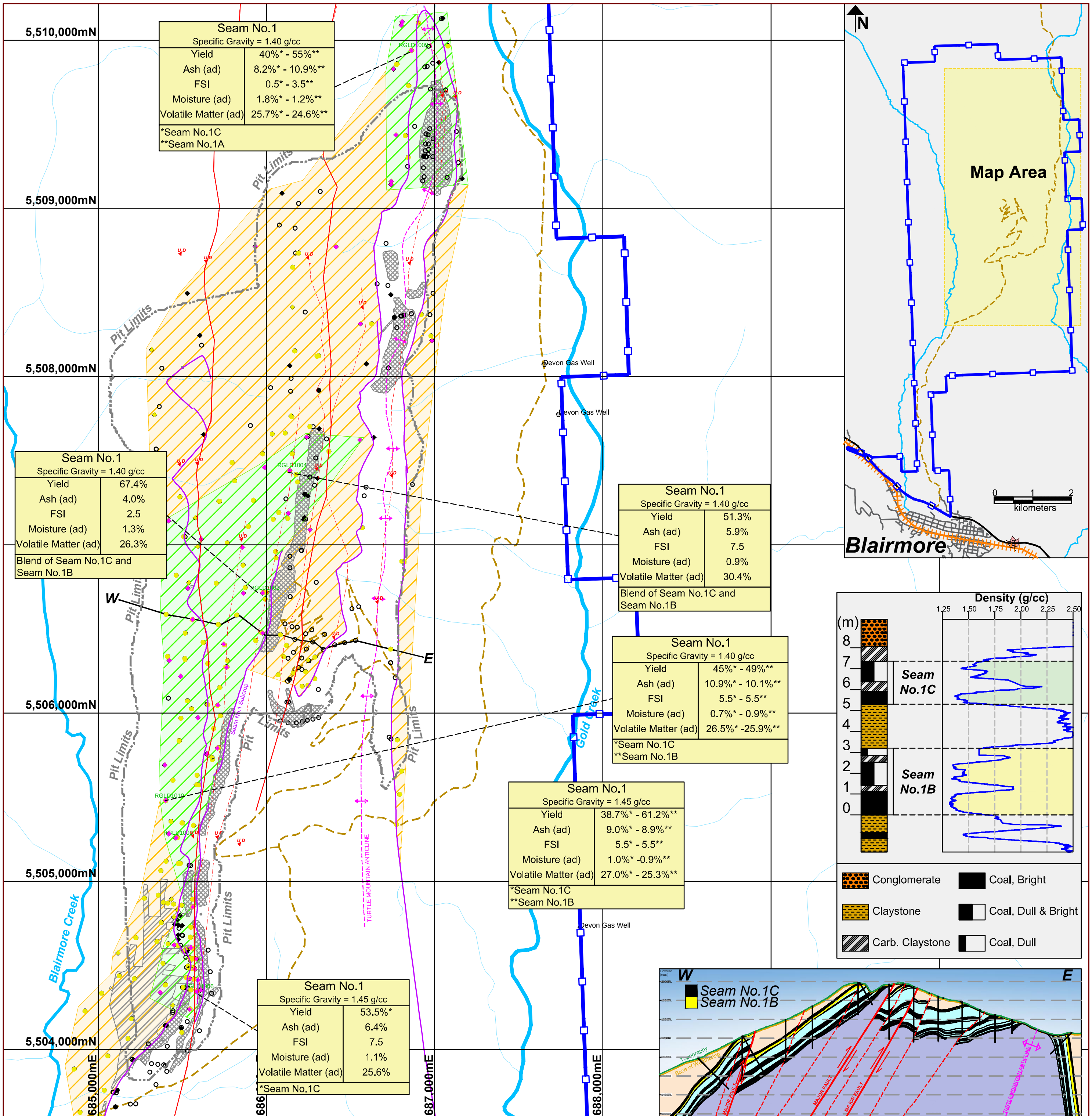
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 400 800 1600
Metres

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM/CP
DATE: JUNE 14, 2016

FIGURE

B.2.1-2



LEGEND

SURFACE FEATURES
- WATERCOURSE
- ACCESS ROAD
- FAULT (MINOR) (AT SEAM NO.1 LEVEL)
- FAULT (MAJOR) (AT SEAM NO.1 LEVEL)
- ANTICLINE
- SEAM NO. 1 SUBCROP

HISTORICAL MINES*
- SURFACE
- UNDERGROUND

* SEAM NO. 1 & SEAM NO. 2

LAND OWNERSHIP
- PROPOSED MINE PERMIT BOUNDARY

DRILL HOLE
- CORED HOLE
- OPEN HOLE

DRILL HOLE INTERSECTING SEAM NO.1
- CORED HOLE
- OPEN HOLE
- SEAM NO.1 RAW ANALYSIS

CONFIDENCE LEVEL
- GOOD
- MODERATE

-

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. ALL QUALITY AT 1.40 G/CC EXCEPT RGLD1001 (1.45 G/CC)
3. COAL QUALITY RESULTS FROM ALS VANCOUVER LAB
4. WASHED COAL RESULTS DISPLAYED IN AREA OF GOOD CONFIDENCE. RAW COAL DATA AVAILABLE AT ALL HIGHLIGHTED LOCATIONS IN AREAS OF GOOD AND MODERATE CONFIDENCE

REFERENCE(S)
- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

Seam 1 Wash Quality

NOTES

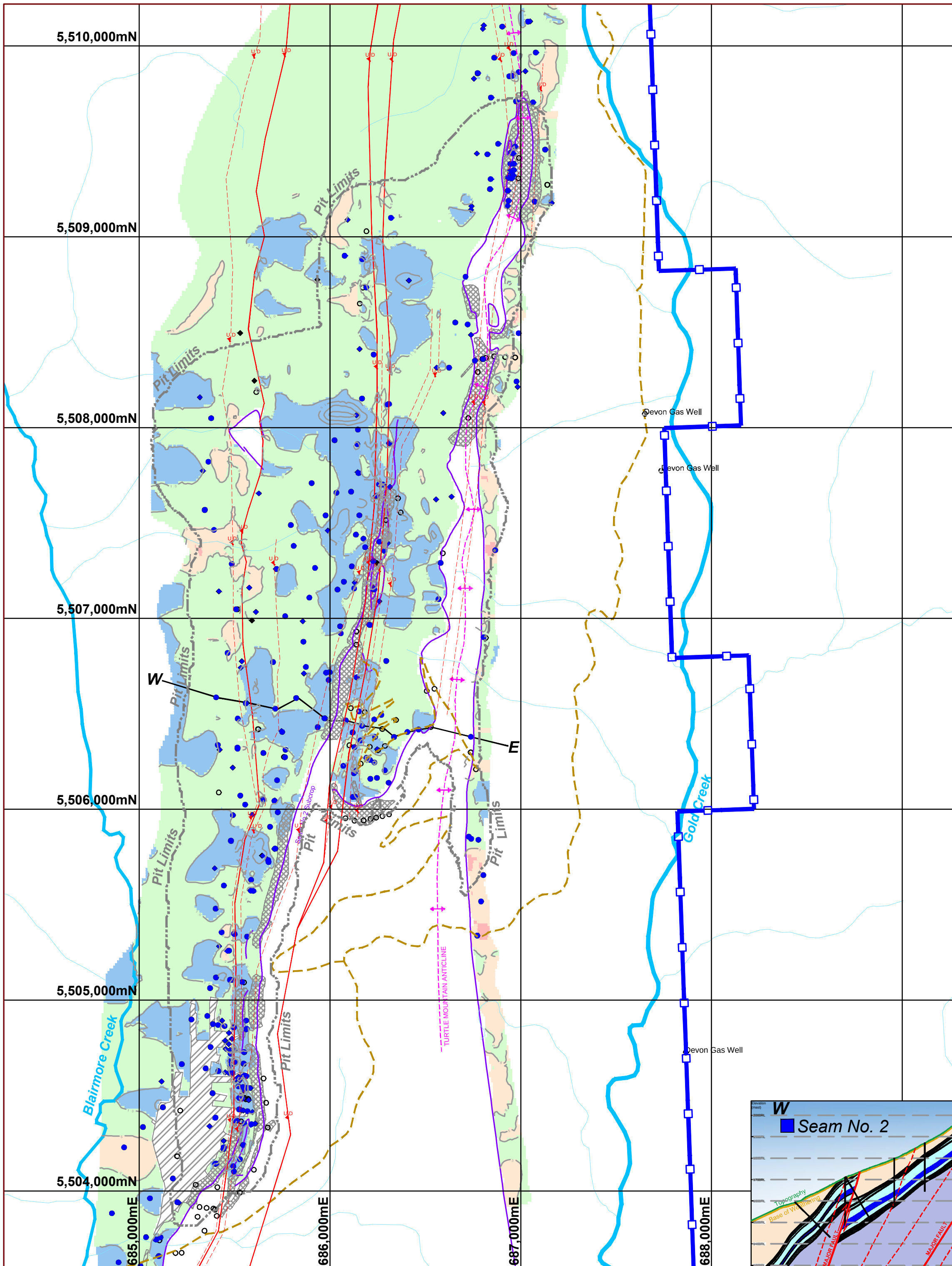
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

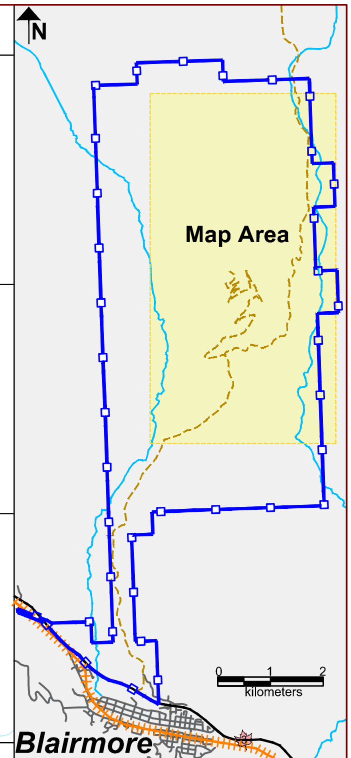
0 400 800 1600
Metres

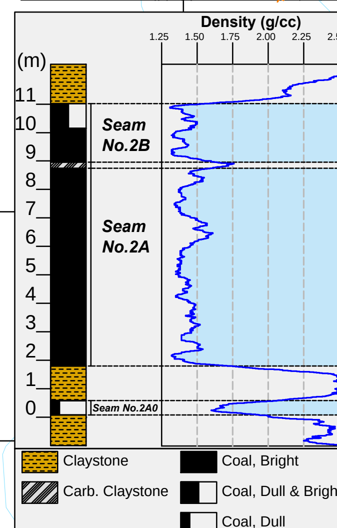
PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM/CP
DATE: JUNE 14, 2016

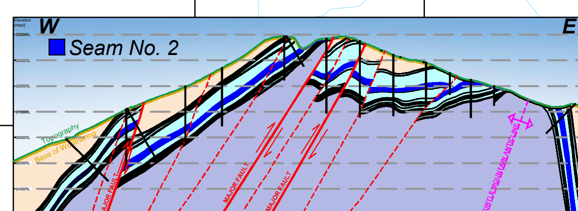
FIGURE

B.2.1-3









LEGEND

SURFACE FEATURES

- WATERCOURSE
- ACCESS ROAD
- FAULT (MINOR) (AT SEAM NO.2 LEVEL)
- FAULT (MAJOR) (AT SEAM NO.2 LEVEL)
- ANTICLINE
- SEAM NO. 2 SUBCROP
- THICKNESS CONTOUR (5 m INTERVAL)

HISTORICAL MINES*

- SURFACE
- UNDERGROUND

* SEAM NO. 1 & SEAM NO. 2

LAND OWNERSHIP

- PROPOSED MINE PERMIT BOUNDARY

DRILL HOLE

- ◆ CORED HOLE
- ○ OPEN HOLE

DRILL HOLE INTERSECTING SEAM NO. 2

- ◆ CORED HOLE
- ● OPEN HOLE

SEAM THICKNESS (m)

- <2
- 2 - 5
- 5 - 10
- >10

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. GEOLOGY FROM MINEX COMPUTER MODEL (GM_0215)

REFERENCE(S)
- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

SEAM 2 THICKNESS

NOTES

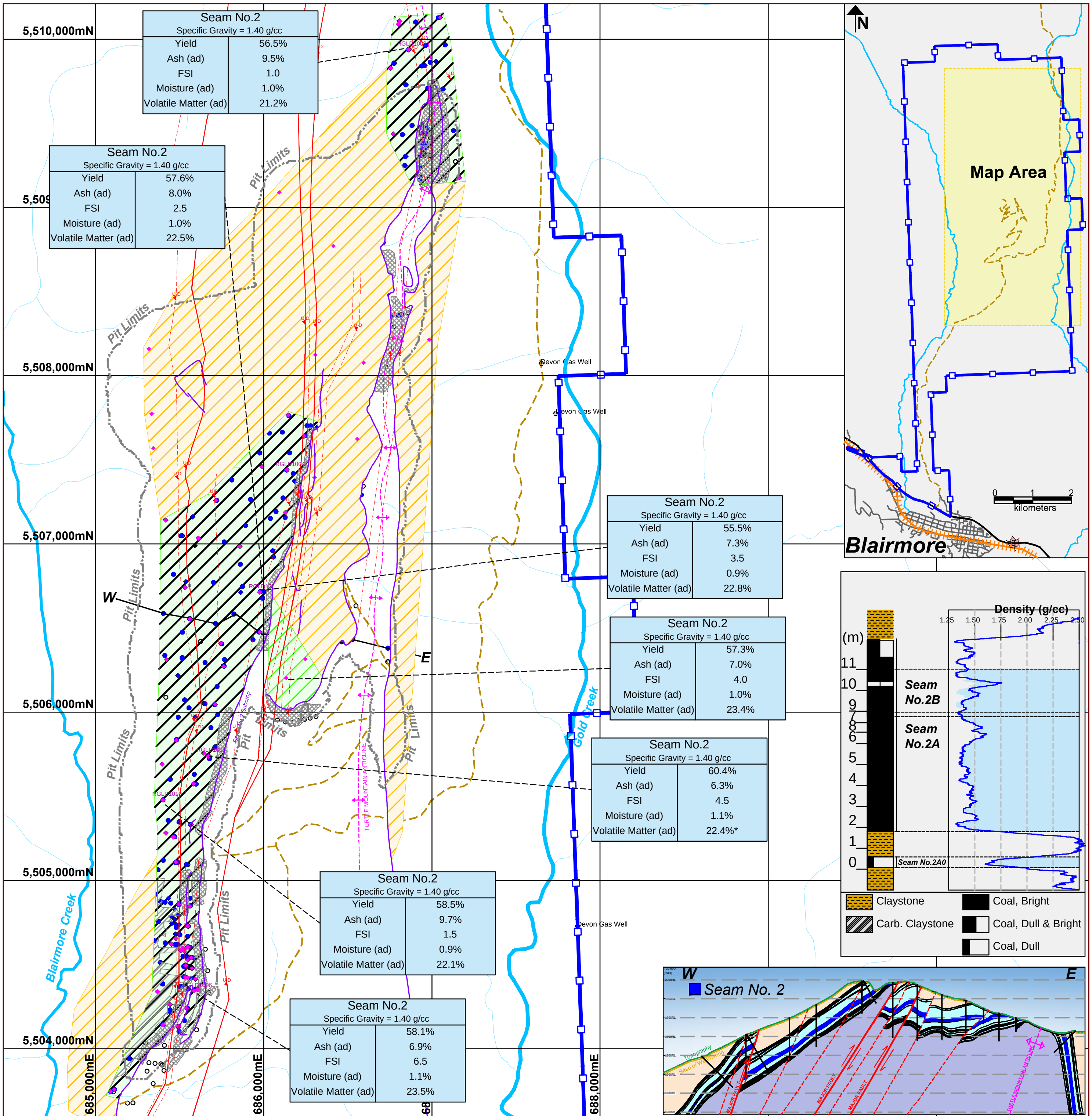
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 400 800 1600
Metres

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM/CP
DATE: JUNE 14, 2016

FIGURE

B.2.2-1



Seam No.2 — Specific Gravity = 1.40 g/cc

Yield	56.5%
Ash (ad)	9.5%
FSI	1.0
Moisture (ad)	1.0%
Volatile Matter (ad)	21.2%

Seam No.2 — Specific Gravity = 1.40 g/cc

Yield	57.6%
Ash (ad)	8.0%
FSI	2.5
Moisture (ad)	1.0%
Volatile Matter (ad)	22.5%

Seam No.2 — Specific Gravity = 1.40 g/cc

Yield	55.5%
Ash (ad)	7.3%
FSI	3.5
Moisture (ad)	0.9%
Volatile Matter (ad)	22.8%

Seam No.2 — Specific Gravity = 1.40 g/cc

Yield	57.3%
Ash (ad)	7.0%
FSI	4.0
Moisture (ad)	1.0%
Volatile Matter (ad)	23.4%

Seam No.2 — Specific Gravity = 1.40 g/cc

Yield	60.4%
Ash (ad)	6.3%
FSI	4.5
Moisture (ad)	1.1%
Volatile Matter (ad)	22.4%*

Seam No.2 — Specific Gravity = 1.40 g/cc

Yield	58.5%
Ash (ad)	9.7%
FSI	1.5
Moisture (ad)	0.9%
Volatile Matter (ad)	22.1%

Seam No.2 — Specific Gravity = 1.40 g/cc

Yield	58.1%
Ash (ad)	6.9%
FSI	6.5
Moisture (ad)	1.1%
Volatile Matter (ad)	23.5%

LEGEND

SURFACE FEATURES
- WATERCOURSE
- ACCESS ROAD
- FAULT (MINOR) (AT SEAM NO.2 LEVEL)
- FAULT (MAJOR) (AT SEAM NO.2 LEVEL)
- ANTICLINE
- SEAM NO. 2 SUBCROP

HISTORICAL MINES*
- SURFACE
- UNDERGROUND

** SEAM NO. 1 & SEAM NO. 2*

LAND OWNERSHIP
- PROPOSED MINE PERMIT BOUNDARY

DRILL HOLE
- CORED HOLE
- OPEN HOLE

DRILL HOLE INTERSECTING SEAM NO.2
- CORED HOLE
- OPEN HOLE
- SEAM NO.2 RAW ANALYSIS

CONFIDENCE LEVEL
- GOOD
- MODERATE

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. ALL QUALITY AT 1.40 G/CC EXCEPT RGLD1001 (1.45 G/CC)
3. COAL QUALITY RESULTS FROM ALS VANCOUVER LAB
4. WASHED COAL RESULTS DISPLAYED IN AREA OF GOOD CONFIDENCE. RAW COAL DATA AVAILABLE AT ALL HIGHLIGHTED LOCATIONS IN AREAS OF GOOD AND MODERATE CONFIDENCE

REFERENCE(S)
- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

SEAM 2 WASH QUALITY

NOTES

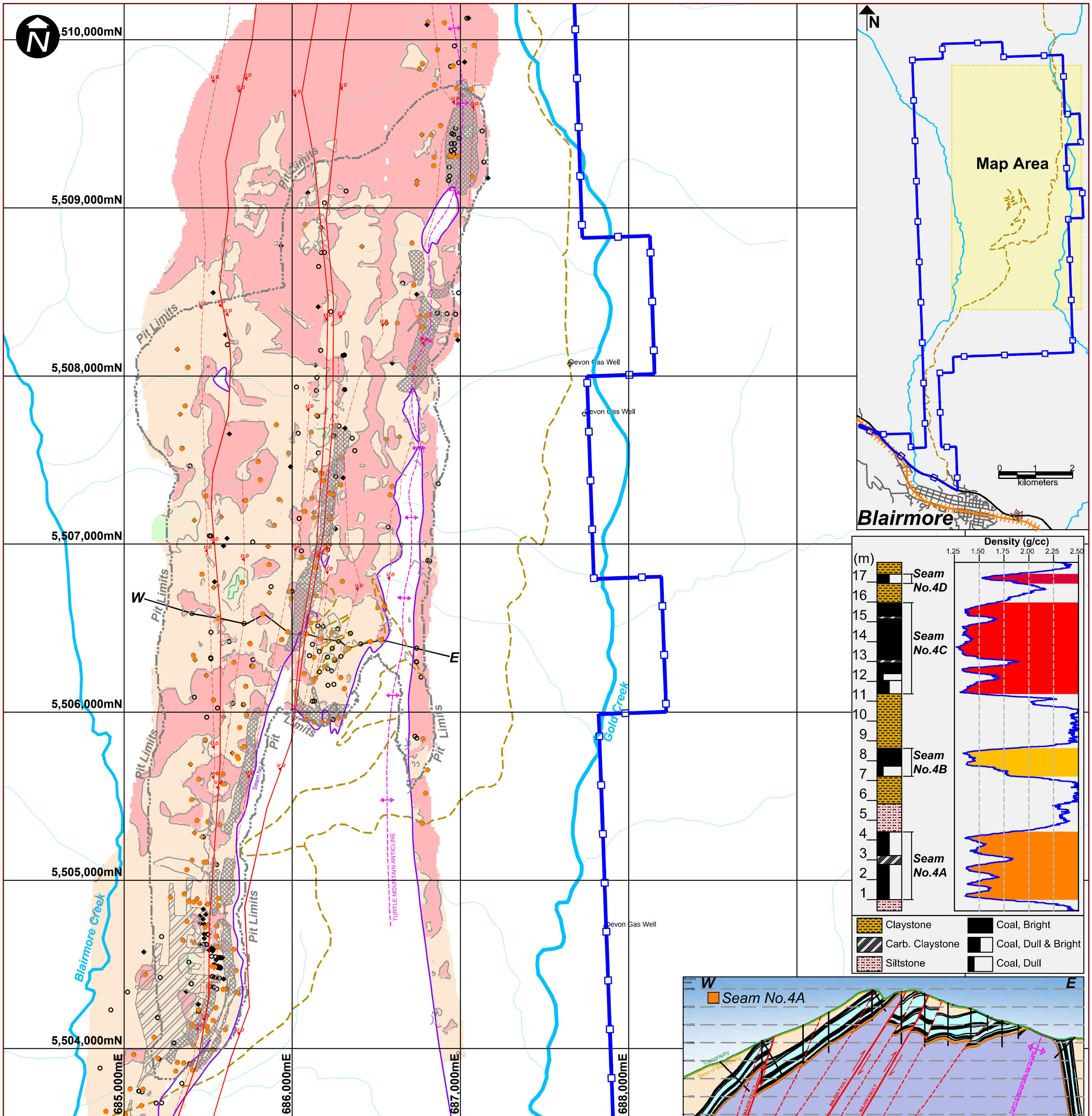
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 400 800 1600
Metres

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM/CP
DATE: JUNE 14, 2016

FIGURE

B.2.2-2



LEGEND

SURFACE FEATURES
- WATERCOURSE
- ACCESS ROAD
- FAULT (MINOR) (AT SEAM NO.4 LEVEL)
- FAULT (MAJOR) (AT SEAM NO.4 LEVEL)
- ANTICLINE
- SEAM NO. 4 SUBCROP
- THICKNESS CONTOUR (2 m INTERVAL)

HISTORICAL MINES*
- SURFACE
- UNDERGROUND

* SEAM NO. 1 & SEAM NO. 2

LAND OWNERSHIP
- PROPOSED MINE PERMIT BOUNDARY

DRILL HOLE
- CORED HOLE
- OPEN HOLE

DRILL HOLE INTERSECTING SEAM NO. 4A
- CORED HOLE
- OPEN HOLE

SEAM THICKNESS (m)
- <2
- 2 - 5
- 5 - 10

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. GEOLOGY FROM MINEX COMPUTER MODEL (GM_0215)

REFERENCE(S)
- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

SEAM 4A THICKNESS

NOTES

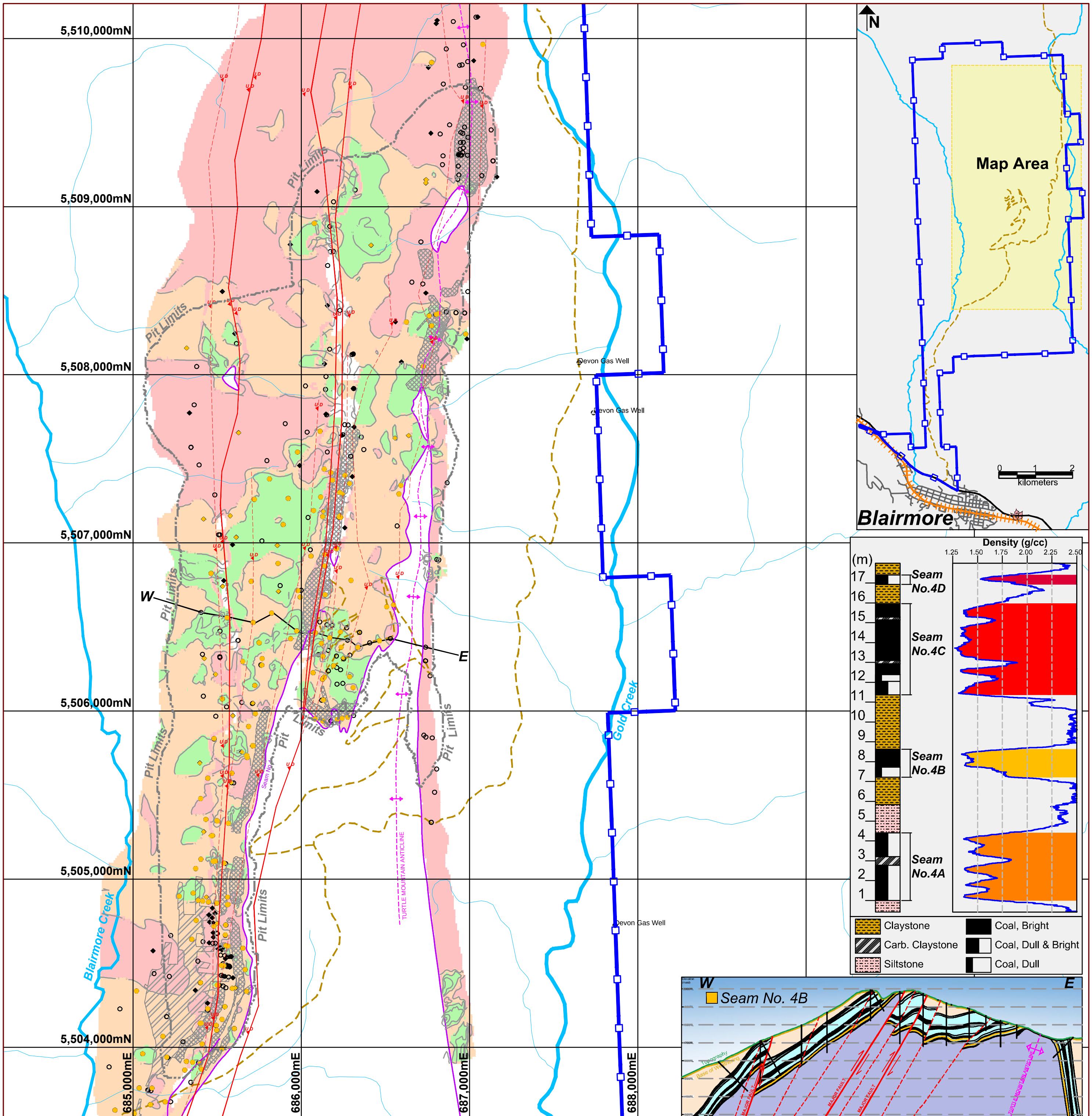
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 400 800 1600
Metres

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM/CP
DATE: JUNE 14, 2016

FIGURE

B.2.3-1



LEGEND

SURFACE FEATURES	HISTORICAL MINES*	DRILL HOLE	SEAM THICKNESS (m)
WATERCOURSE	SURFACE	CORED HOLE	< 0.5
ACCESS ROAD	UNDERGROUND	OPEN HOLE	0.5 - 1
FAULT (MINOR) (AT SEAM NO.4 LEVEL)	* SEAM NO. 1 & SEAM NO. 2		1 - 3
FAULT (MAJOR) (AT SEAM NO.4 LEVEL)	**LAND OWNERSHIP**	**DRILL HOLE INTERSECTING SEAM NO. 4B**	
ANTICLINE	PROPOSED MINE PERMIT BOUNDARY	CORED HOLE	
SEAM NO. 4 SUBCROP		OPEN HOLE	
THICKNESS CONTOUR (0.5 m INTERVAL)			

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. GEOLOGY FROM MINEX COMPUTER MODEL (GM_0215)

REFERENCE(S)
- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

SEAM 4B THICKNESS

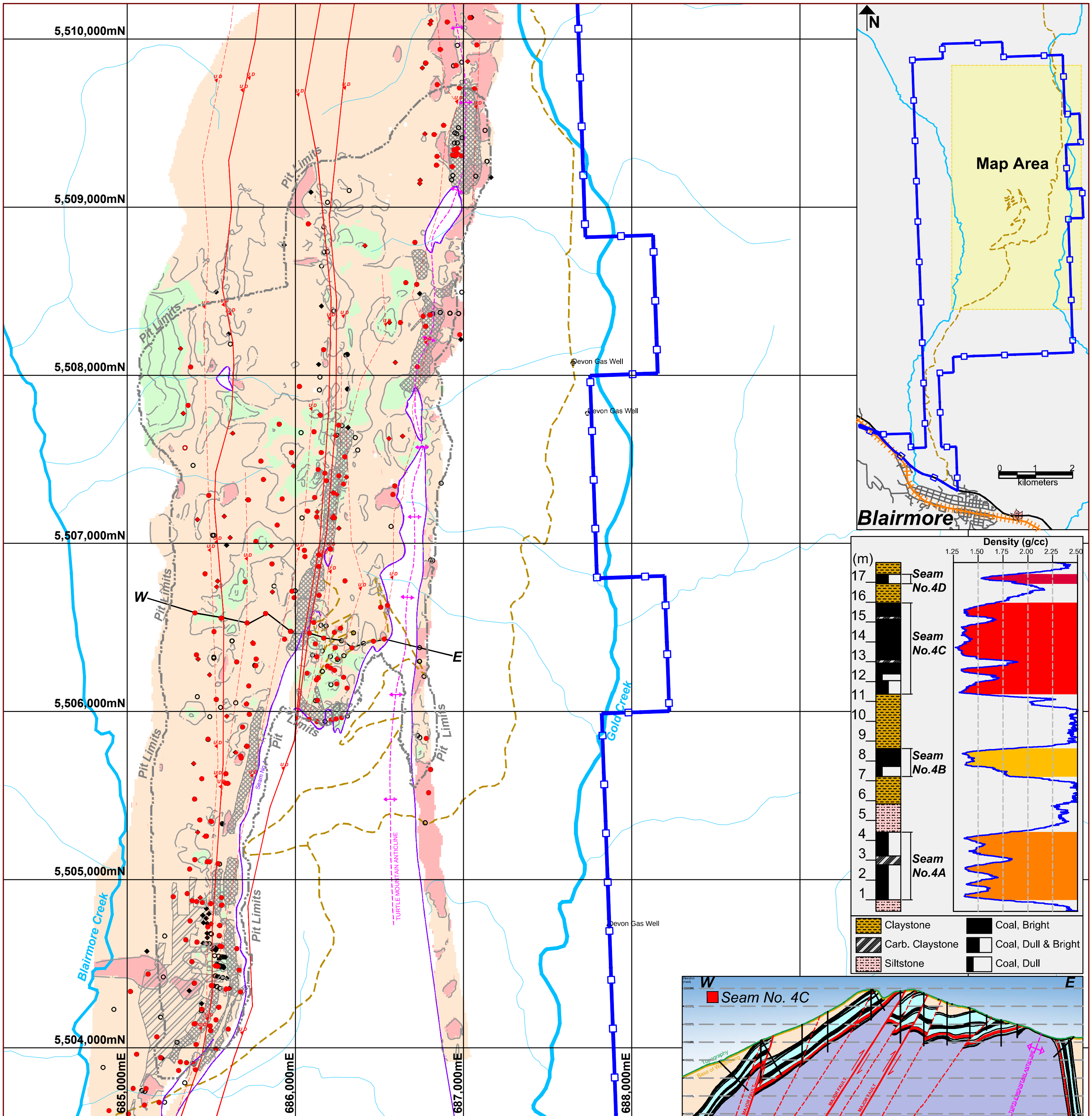
NOTES

Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 400 800 1600
Metres

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM/CP
DATE: JUNE 14, 2016

FIGURE
B.2.3-2



LEGEND

SURFACE FEATURES
- WATERCOURSE
- ACCESS ROAD
- FAULT (MINOR) (AT SEAM NO.4 LEVEL)
- FAULT (MAJOR) (AT SEAM NO.4 LEVEL)
- ANTICLINE
- SEAM NO. 4 SUBCROP
- THICKNESS CONTOUR (2 m INTERVAL)

HISTORICAL MINES*
- SURFACE
- UNDERGROUND

** SEAM NO. 1 & SEAM NO. 2*

LAND OWNERSHIP
- PROPOSED MINE PERMIT BOUNDARY

DRILL HOLE
- ◆ CORED HOLE
- ○ OPEN HOLE

DRILL HOLE INTERSECTING SEAM NO. 4C
- CORED HOLE
- OPEN HOLE

SEAM THICKNESS (m)
- <2
- 2 - 5
- 5 - 10

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. GEOLOGY FROM MINEX COMPUTER MODEL (GM_0215)

REFERENCE(S)
- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

SEAM 4C THICKNESS

NOTES

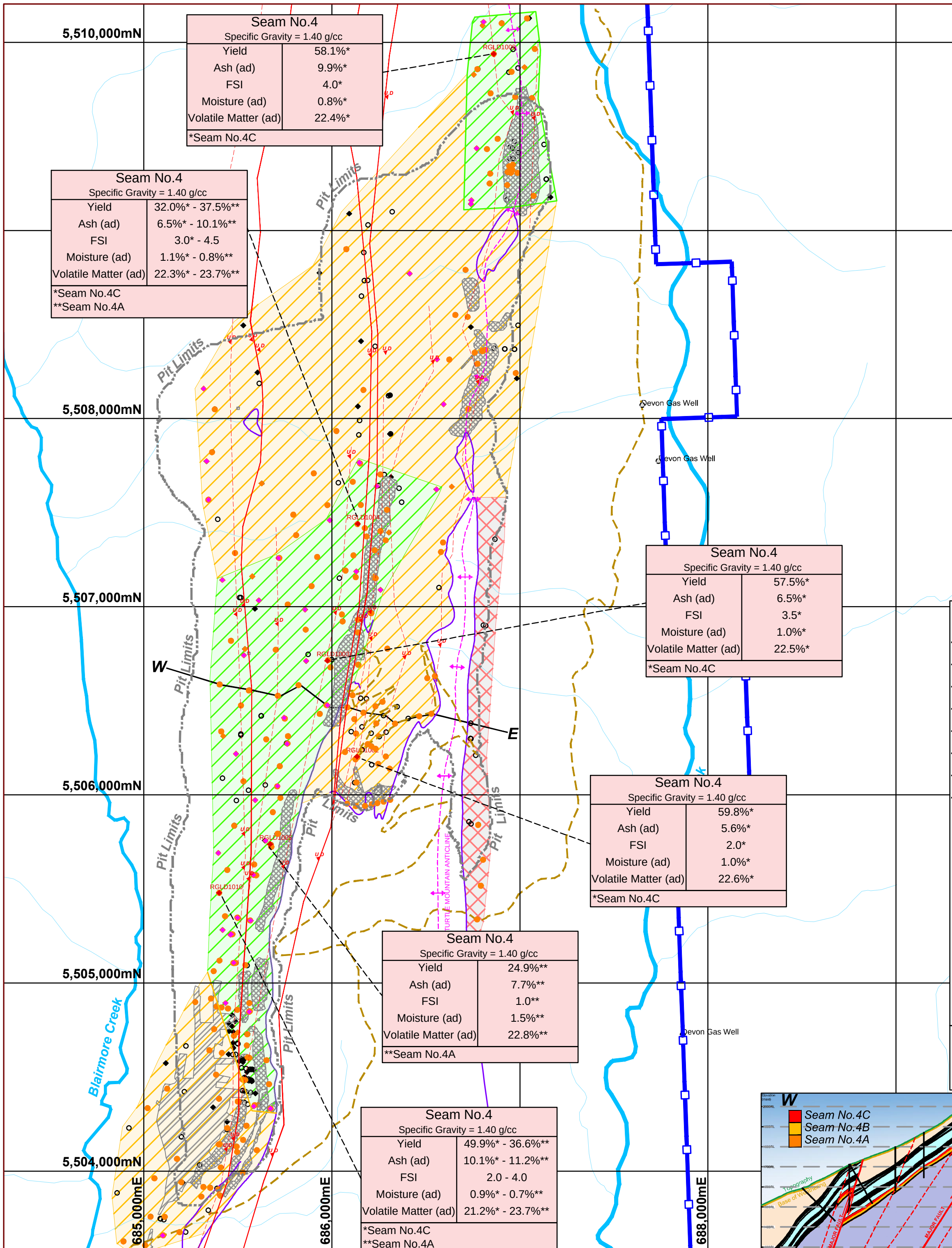
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 400 800 1600
Metres

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM/CP
DATE: JUNE 14, 2016

FIGURE

B.2.3-3



Seam No.4	
Specific Gravity = 1.40 g/cc	
Yield	58.1%*
Ash (ad)	9.9%*
FSI	4.0*
Moisture (ad)	0.8%*
Volatile Matter (ad)	22.4%*
*Seam No.4C	

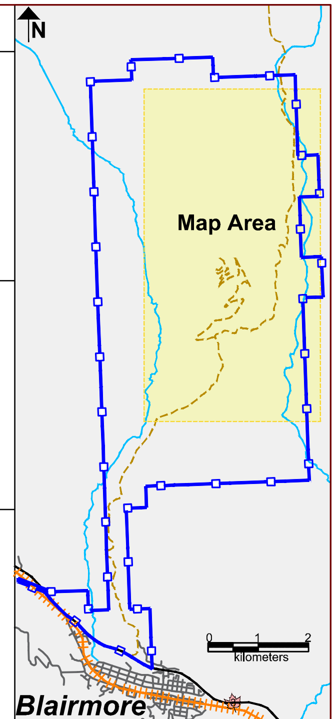
Seam No.4	
Specific Gravity = 1.40 g/cc	
Yield	32.0%* - 37.5%**
Ash (ad)	6.5%* - 10.1%**
FSI	3.0* - 4.5
Moisture (ad)	1.1%* - 0.8%**
Volatile Matter (ad)	22.3%* - 23.7%**
*Seam No.4C **Seam No.4A	

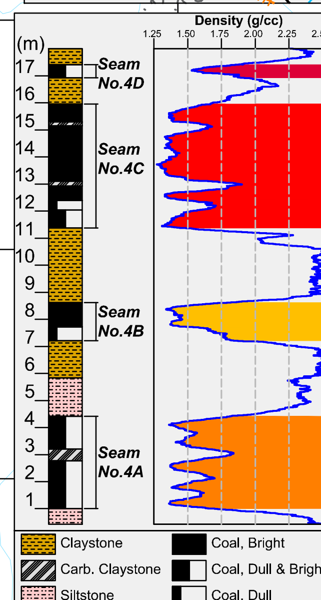
Seam No.4	
Specific Gravity = 1.40 g/cc	
Yield	57.5%*
Ash (ad)	6.5%*
FSI	3.5*
Moisture (ad)	1.0%*
Volatile Matter (ad)	22.5%*
*Seam No.4C	

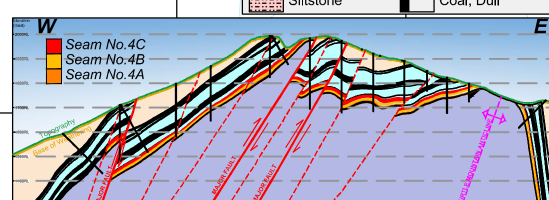
Seam No.4	
Specific Gravity = 1.40 g/cc	
Yield	59.8%*
Ash (ad)	5.6%*
FSI	2.0*
Moisture (ad)	1.0%*
Volatile Matter (ad)	22.6%*
*Seam No.4C	

Seam No.4	
Specific Gravity = 1.40 g/cc	
Yield	24.9%**
Ash (ad)	7.7%**
FSI	1.0**
Moisture (ad)	1.5%**
Volatile Matter (ad)	22.8%**
**Seam No.4A	

Seam No.4	
Specific Gravity = 1.40 g/cc	
Yield	49.9%* - 36.6%**
Ash (ad)	10.1%* - 11.2%**
FSI	2.0 - 4.0
Moisture (ad)	0.9%* - 0.7%**
Volatile Matter (ad)	21.2%* - 23.7%**
*Seam No.4C **Seam No.4A	







LEGEND

SURFACE FEATURES
- WATERCOURSE
- ACCESS ROAD
- FAULT (MINOR) (AT SEAM NO.4 LEVEL)
- FAULT (MAJOR) (AT SEAM NO.4 LEVEL)
- ANTICLINE
- SEAM NO. 4 SUBCROP

HISTORICAL MINES*
- SURFACE
- UNDERGROUND

* SEAM NO. 1 & SEAM NO. 2

LAND OWNERSHIP
- PROPOSED MINE PERMIT BOUNDARY

DRILL HOLE
- CORED HOLE
- OPEN HOLE

DRILL HOLE INTERSECTING SEAM NO.4
- CORED HOLE
- OPEN HOLE
- SEAM NO.4 RAW ANALYSIS

CONFIDENCE LEVEL
- GOOD
- MODERATE
- LOW

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. ALL QUALITY AT 1.40 G/CC EXCEPT RGLD1001 (1.45 G/CC)
3. COAL QUALITY RESULTS FROM ALS VANCOUVER LAB
4. WASHED COAL RESULTS DISPLAYED IN AREA OF GOOD CONFIDENCE. RAW COAL ANALYSIS WITH HIGHLIGHTED LOCATIONS IN AREAS OF GOOD AND MODERATE CONFIDENCE

REFERENCE(S)
- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

SEAM 4 WASH QUALITY

NOTES

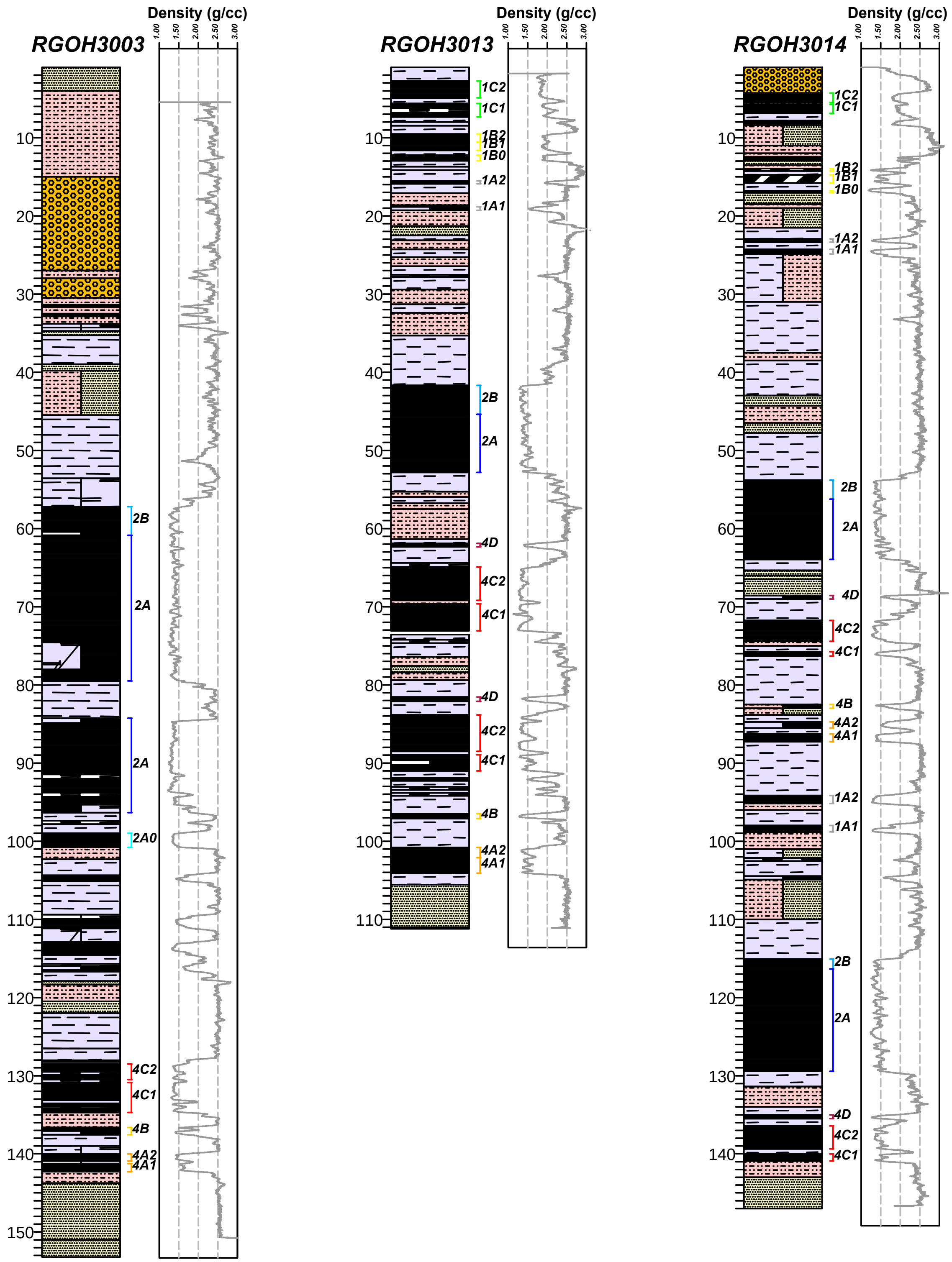
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 400 800 1600
Metres

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM/CP
DATE: JUNE 14, 2016

FIGURE

B.2.3-4



LEGEND

LITHOLOGY

- COAL
- CLAYSTONE
- CONGLOMERATE
- SANDSTONE
- SILTSTONE
- FAULT (REVERSE)
- GEOPHYSICAL DENSITY LOG (G/CC)

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. GEOPHYSICAL DENSITY LOGS FROM CENTURY WIRELINE SERVICES
3. GEOLOGY FROM MINEX COMPUTER MODEL (GM_0215)

REFERENCE(S)
- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

SEAM REPETITIONS

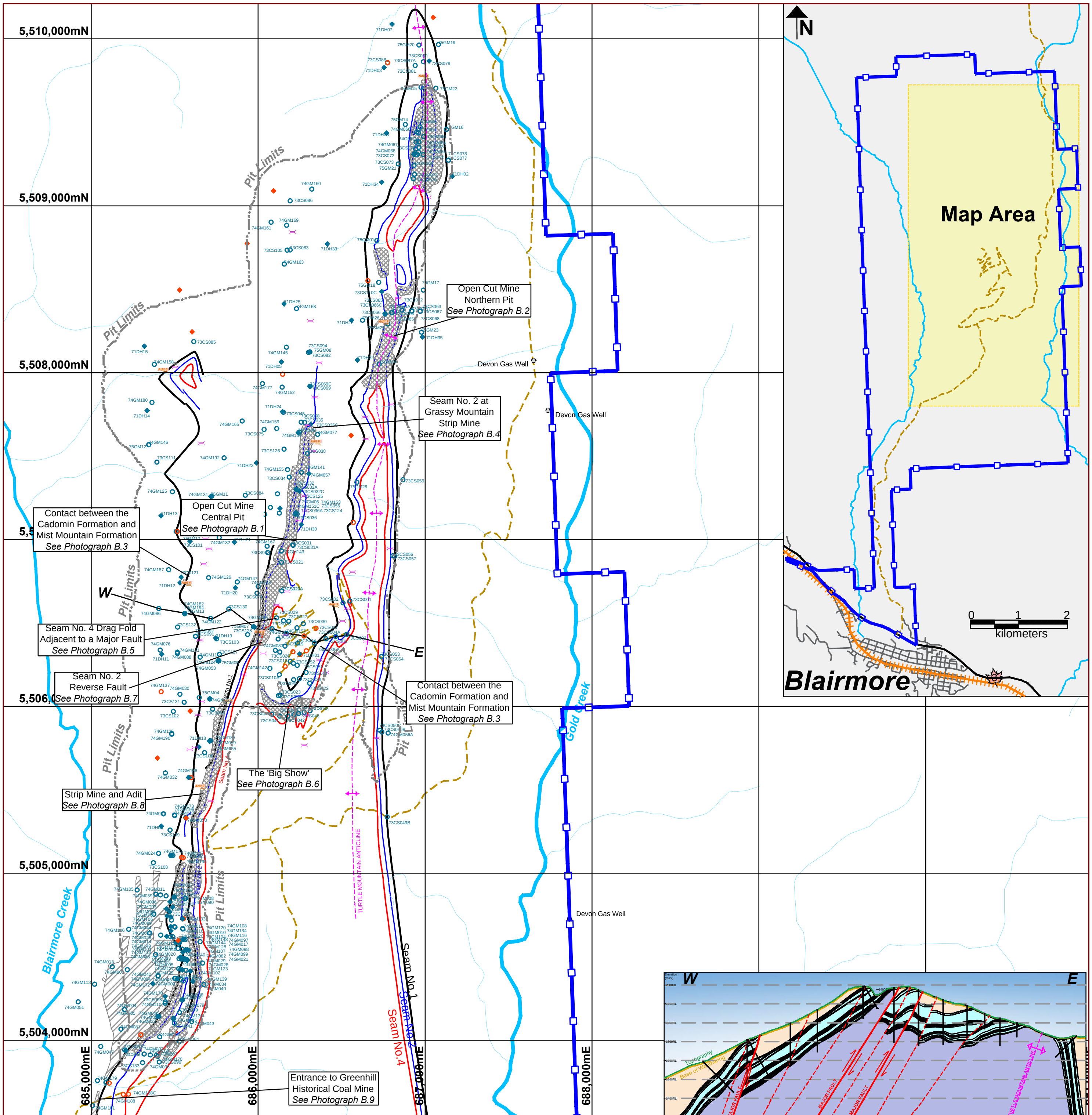
NOTES

Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 14-00201-01
DRAWN BY: RS
CHECKED BY: JM/CP
DATE: AUGUST 25, 2015

FIGURE

B.2.4-1



LEGEND

SURFACE FEATURES

- WATERCOURSE
- ACCESS ROAD
- ANTICLINE
- SEAM NO.1 SUBCROP
- SEAM NO.2 SUBCROP
- SEAM NO.4 SUBCROP

HISTORIC MINES*

- SURFACE
- UNDERGROUND

* SEAM NO. 1 & SEAM NO. 2

LAND OWNERSHIP

- PROPOSED MINE PERMIT BOUNDARY

DRILL HOLE (WITH GEOPHYSICS)

- CORED HOLE
- OPEN HOLE

DRILL HOLE (WITHOUT GEOPHYSICS)

- CORED HOLE
- OPEN HOLE

OTHER

- ADIT
- TRENCH

NOTE(S)

1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS

REFERENCE(S)

- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- ADIT AND TRENCH LOCATIONS FROM *GRASSY MOUNTAIN COAL-1971 INTERIM REPORT VOLUME 2 - EXPLORATION MAPS ABD ISO DRAWINGS*
- MAPPING BY *CONSOL (EXPLORATION SUMMARY MAP; 1988)*

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

HISTORICAL EXPLORATION PLAN

NOTES

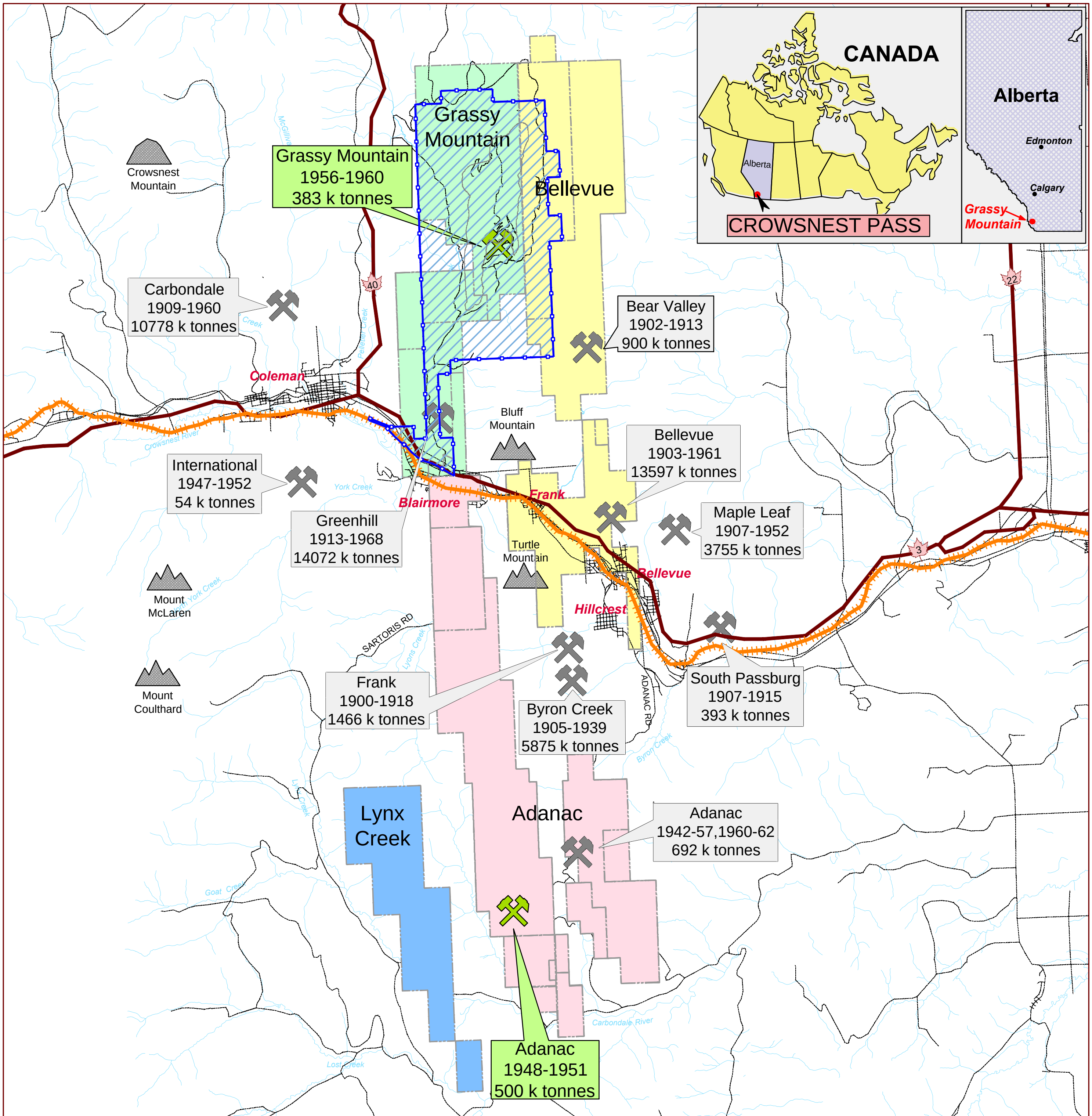
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 400 800 1600
Metres

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM
DATE: JUNE 14, 2016

FIGURE

B.3.0-1



LEGEND

SURFACE FEATURES

- MAIN ROAD
- MINOR ROAD
- RAILROAD
- WATERCOURSE
- MOUNTAIN

RIVERSDALE COAL TENURES

- ADANAC
- BELLEVUE
- GRASSY MOUNTAIN
- GRASSY MOUNTAIN PROPOSED MINE PERMIT BOUNDARY
- LYNX CREEK

HISTORIC MINES

- UNDERGROUND
- SURFACE

REFERENCE(S)

- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- GEOLOGICAL MAP OF ALBERTA. HAMILTON, W.N.; LANGENBERG, C.W.; PRICE, M.C.; CHAO, D.K., 1998.
- GEOLOGY AND MINERAL DEPOSITS OF THE CROWSNEST CORRIDOR. HAMILTON, W.N.; PRICE, M.C.; CHAO, D.K., 1998.

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

HISTORICAL MINING

NOTES

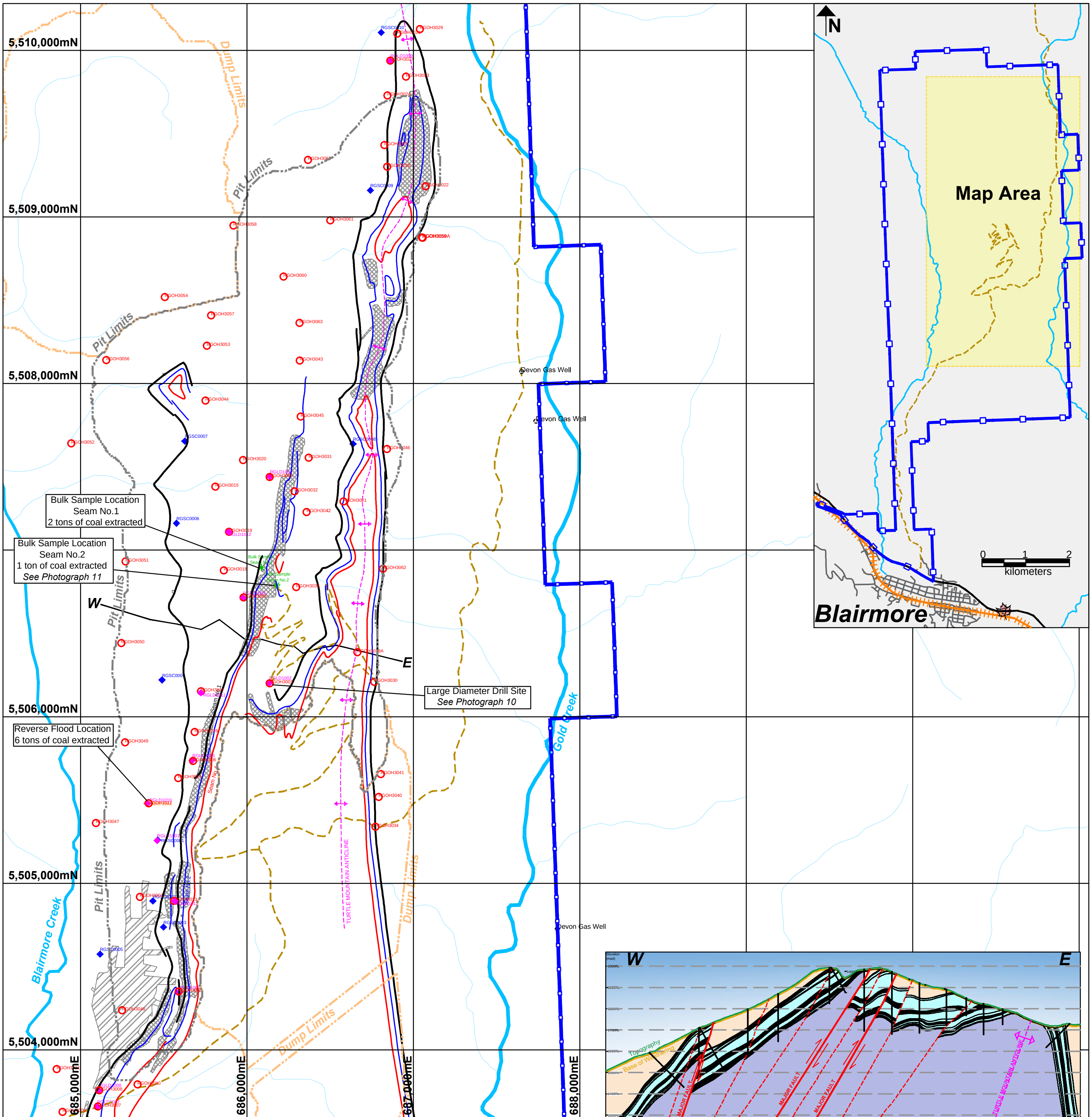
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM/CP
DATE: JUNE 14, 2016

0 2 4 8
Kilometres

FIGURE

B.3.1-1



LEGEND

SURFACE FEATURES

- WATERCOURSE
- ACCESS ROAD
- ANTICLINE
- SEAM NO.1 SUBCROP
- SEAM NO.2 SUBCROP
- SEAM NO.4 SUBCROP

HISTORIC MINES*

- SURFACE
- UNDERGROUND

* SEAM NO. 1 & SEAM NO. 2

LAND OWNERSHIP

- PROPOSED MINE PERMIT BOUNDARY

DRILL HOLE TYPE

- SLIM CORE 2.5" (RGSC)
- LARGE DIAMETER CORE 6" (RGLD)
- OPEN HOLE 3" (RGOH)
- REVERSE FLOOD 17" (RGRF)

TRENCH

- BULK SAMPLE LOCATION

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS

REFERENCE(S)
- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

RECENT EXPLORATION

NOTES

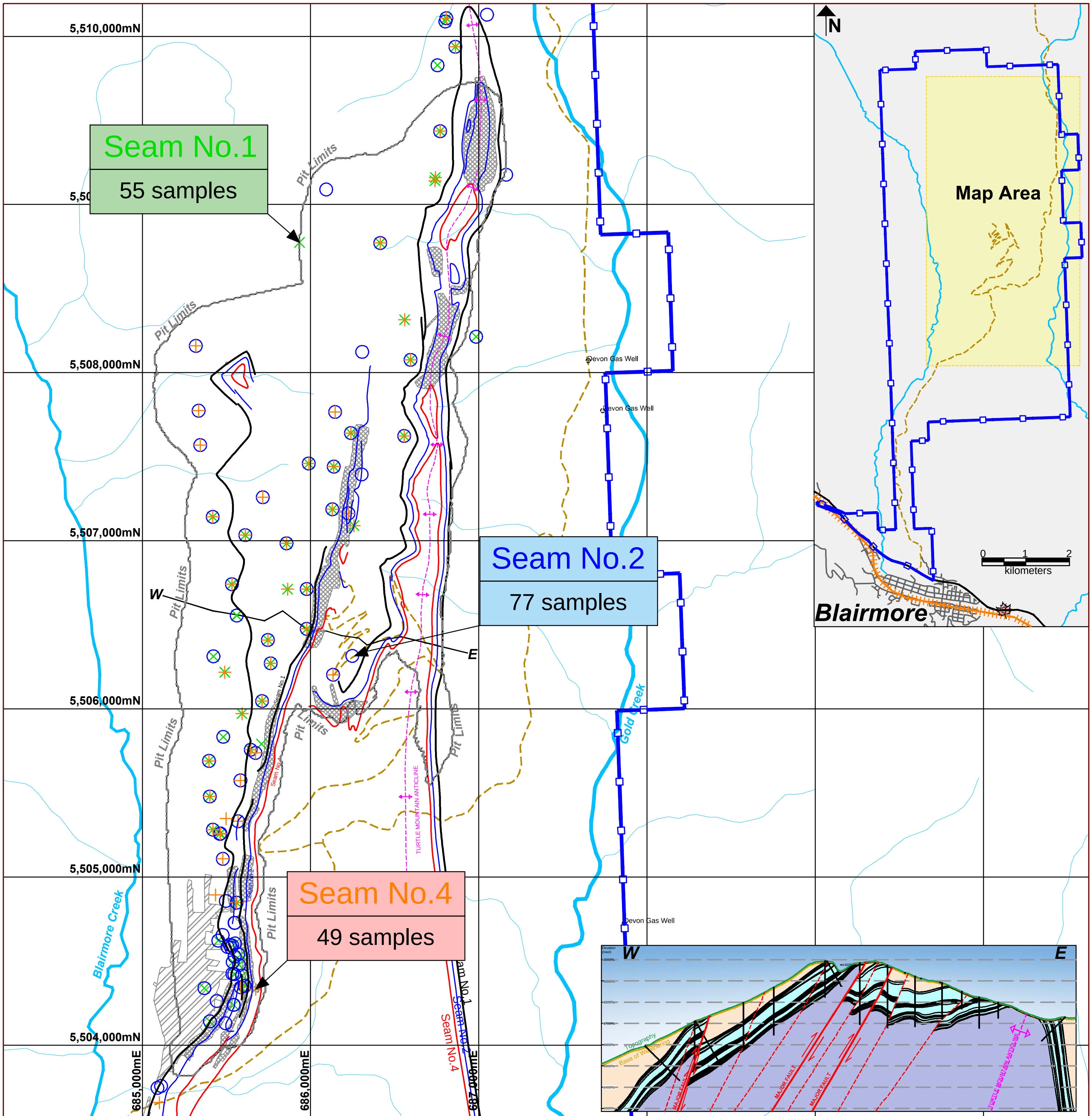
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM
DATE: JUNE 15, 2016

0 400 800 1600
Metres

FIGURE

B.3.2-1



LEGEND

SURFACE FEATURES
- WATERCOURSE
- ACCESS ROAD
- ANTICLINE
- SEAM NO.1 SUBCROP
- SEAM NO.2 SUBCROP
- SEAM NO.4 SUBCROP

HISTORIC MINES*
- SURFACE
- UNDERGROUND

* SEAM NO. 1 & SEAM NO. 2

LAND OWNERSHIP
- PROPOSED MINE PERMIT BOUNDARY

QUALITY SAMPLES
- SEAM No.1
- SEAM No.2
- SEAM No.4

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS
2. GEOLOGY FROM MINEX COMPUTER MODEL (GM_0215)

REFERENCE(S)
- DATUM/PROJECTION: UTM NAD 83 ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

RAW COAL QUALITY DISTRIBUTION

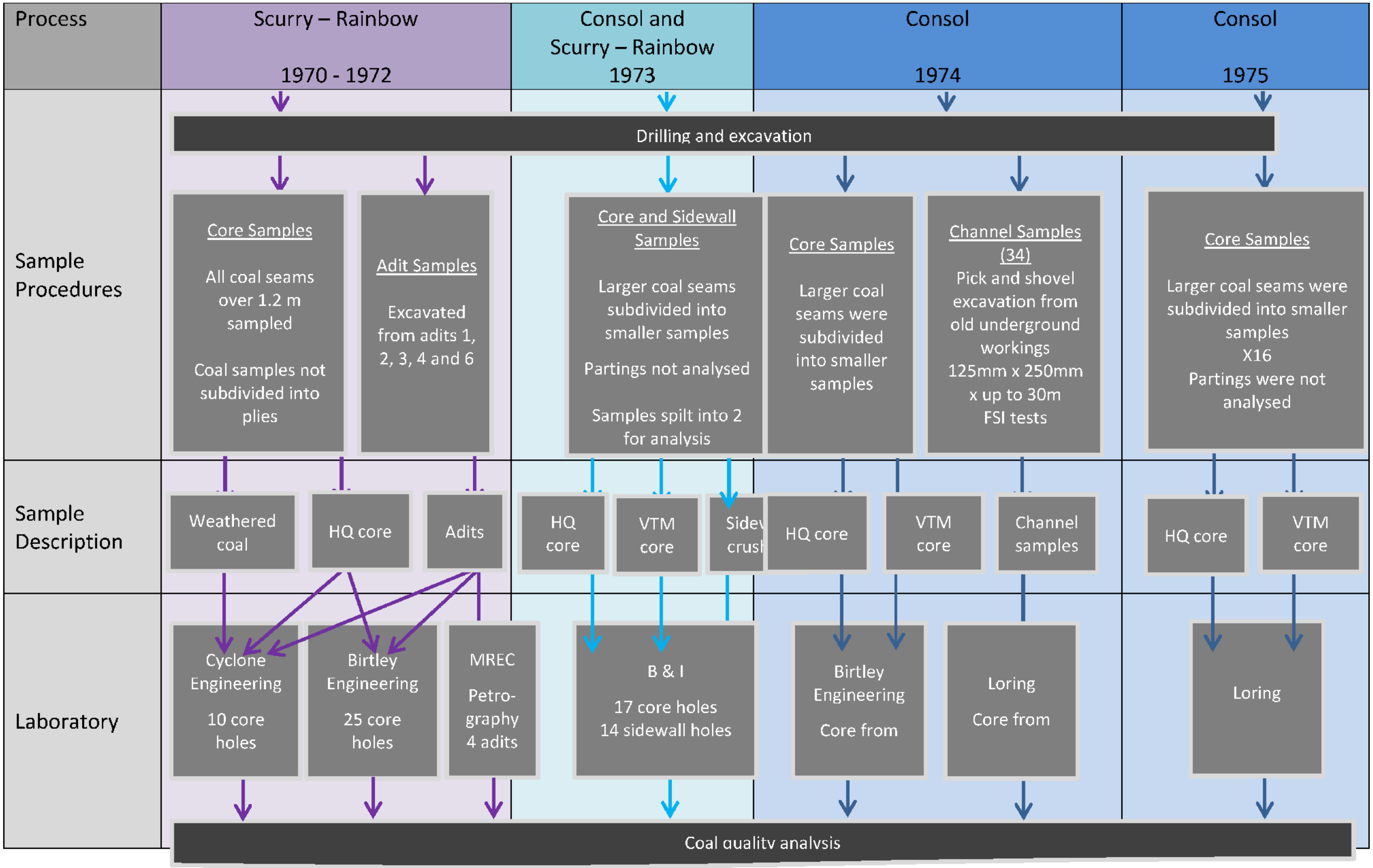
NOTES

Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 400 800 1600
Metres

PROJECT: 14-00201-01
DRAWN BY: RS/SL
CHECKED BY: JM/CP
DATE: JUNE 15, 2016

FIGURE
B.4.2-1



LEGEND: N/A

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

HISTORICAL SAMPLE TESTING

PROJECT: 14-00201-01

DRAWN BY: CP

CHECKED BY: JM

DATE: OCTOBER 14, 2015

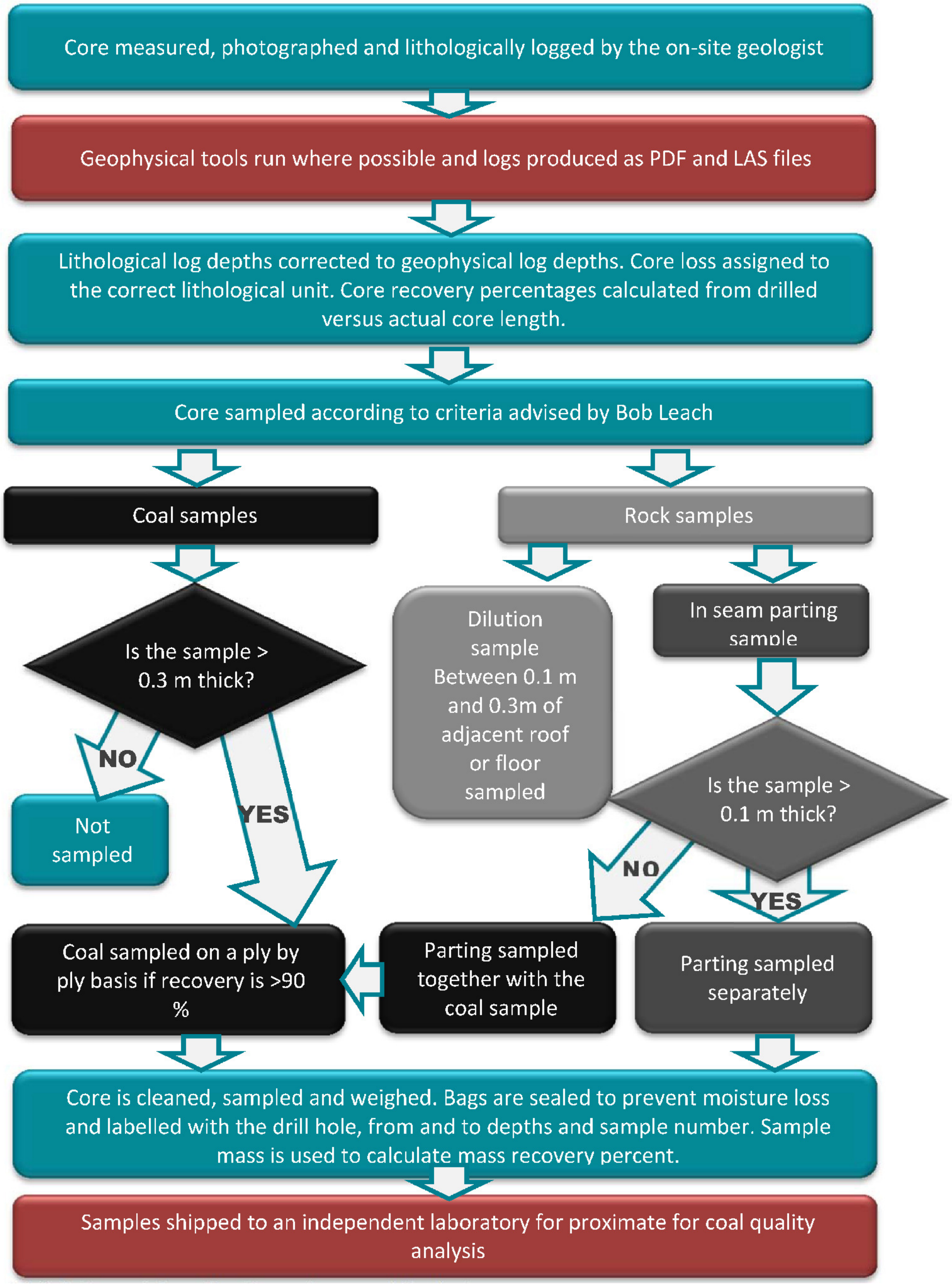
NOTES

MEMS, 2015

SCALE BAR: N/A

FIGURE

B.4.2-2



LEGEND: N/A

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

RECENT SAMPLING PROCEDURES AND ANALYSIS

NOTES

MEMS, 2015

PROJECT: 14-00201-01

DRAWN BY: CP

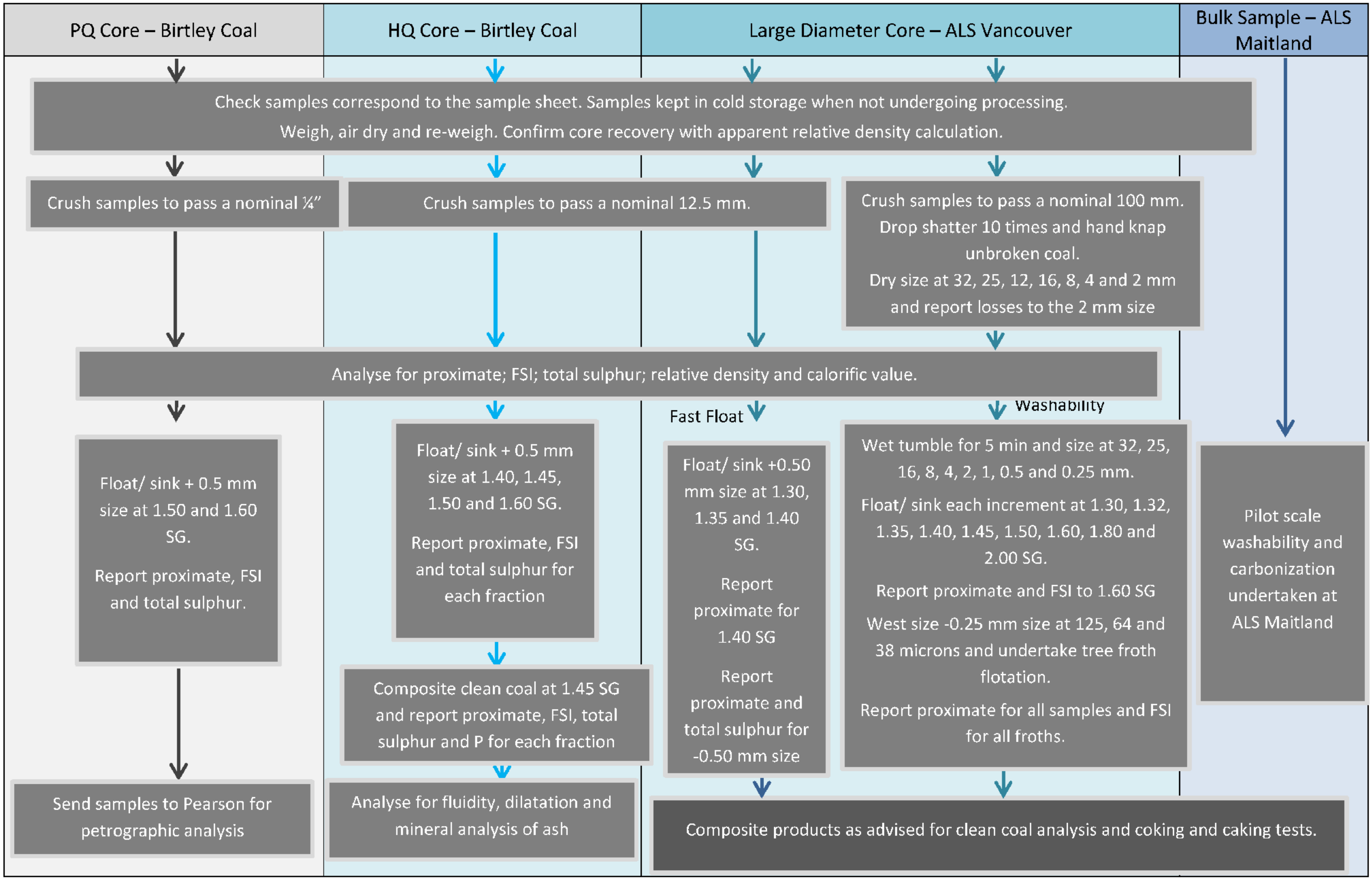
CHECKED BY: JM

DATE: OCTOBER 14, 2015

SCALE BAR: N/A

FIGURE

B.4.2-3



LEGEND: N/A

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

TITLE

RECENT ANALYTICAL PROCEDURES

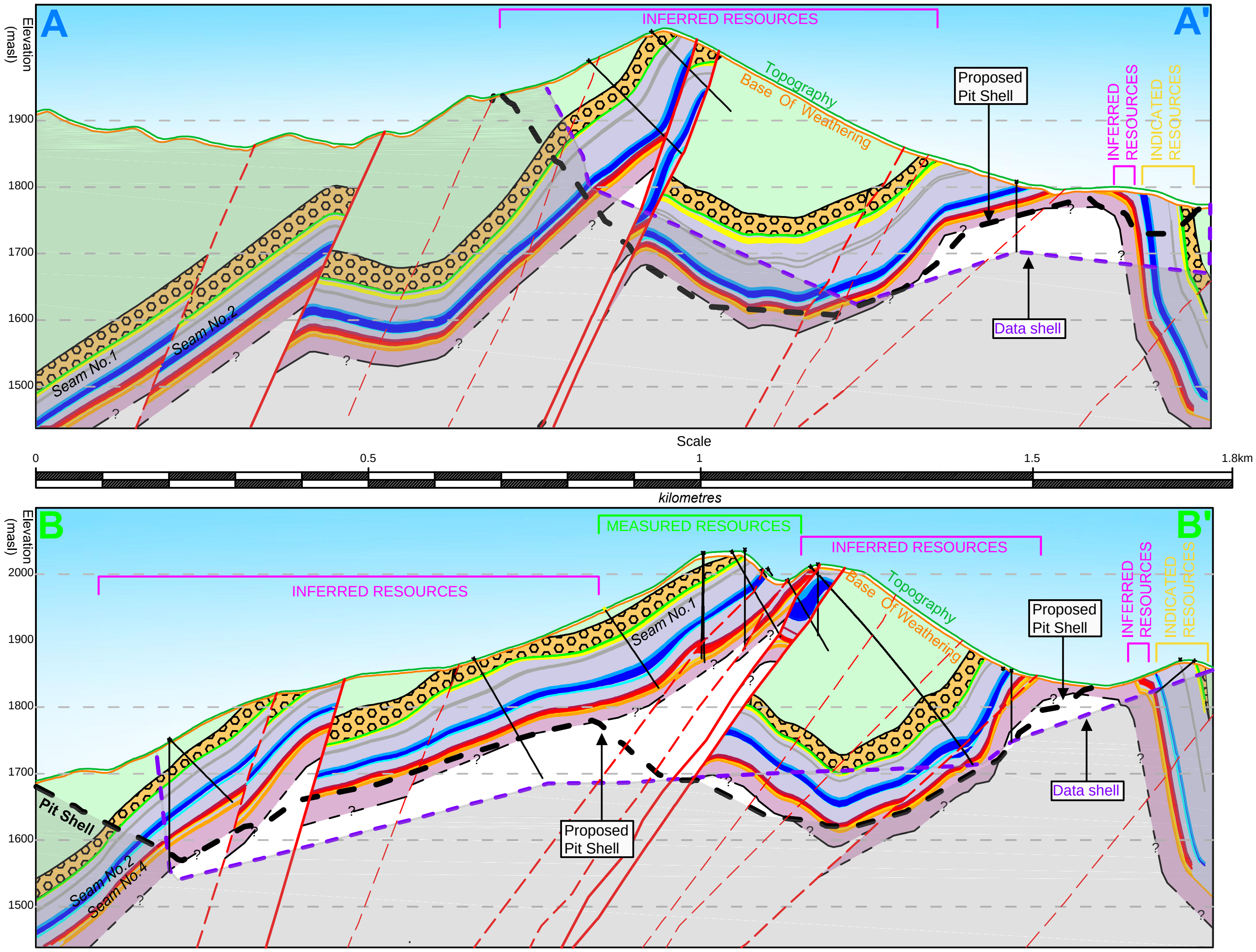
NOTES
MEMS, 2015

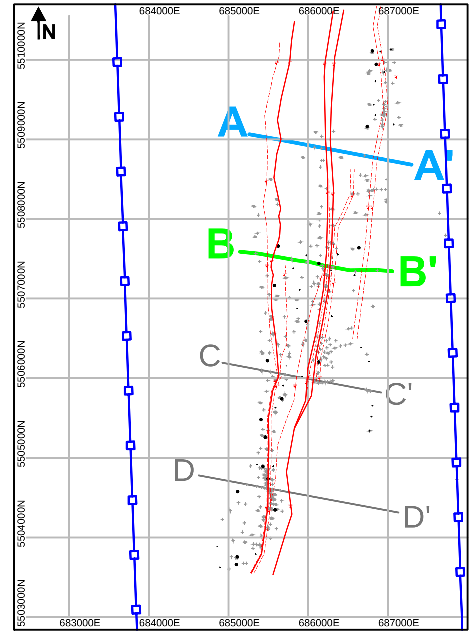
SCALE BAR: N/A

MILLENNIUM EMS Solutions Ltd.

PROJECT: 14-00201-01
DRAWN BY: CP
CHECKED BY: JM
DATE: OCTOBER 14, 2015

FIGURE
B.4.2-4





LEGEND

FAULT (MAJOR)

FAULT (MINOR)

DATA SHELL

PROPOSED PIT SHELL

GLADSTONE FORMATION

CADOMIN FORMATION

MIST MOUNTAIN FORMATION

SEAM NO.1

SEAM NO.2

SEAM NO.4

MORRISEY FORMATION

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS

REFERENCE(S)
- UTM COORDINATES: NAD83, ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- PIT BOUNDARY PROVIDED BY GOLDER MINING
- RESOURCE POLYGONS BY McELROY BRYAN GEOLOGICAL SERVICES (MBGS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

CROSS SECTION A & B

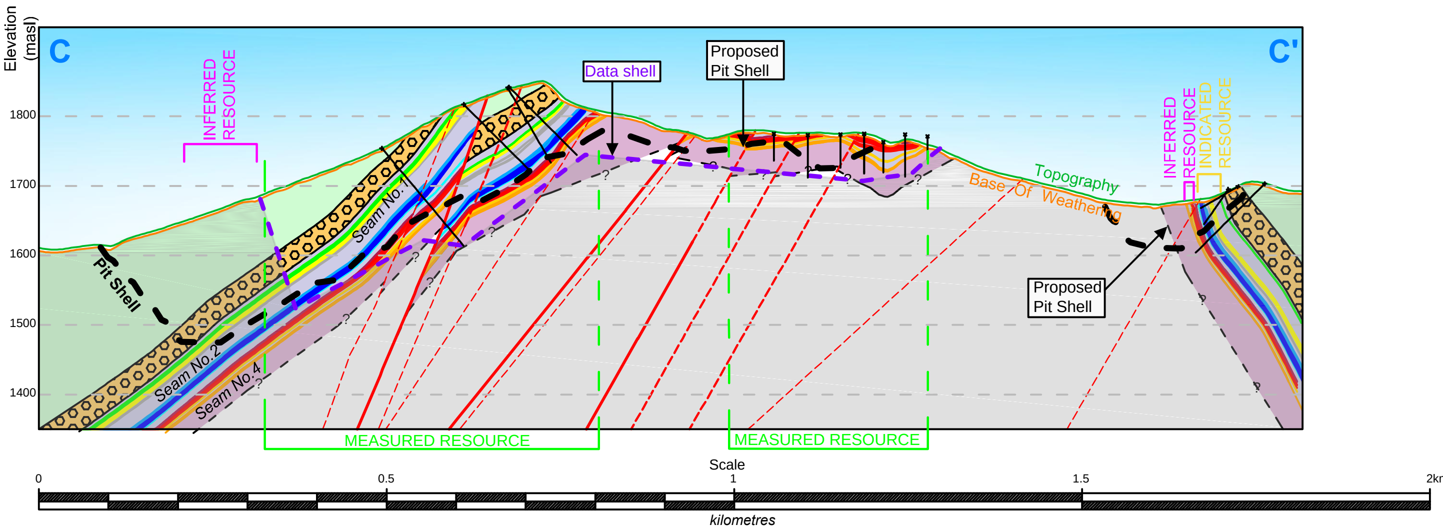
NOTES

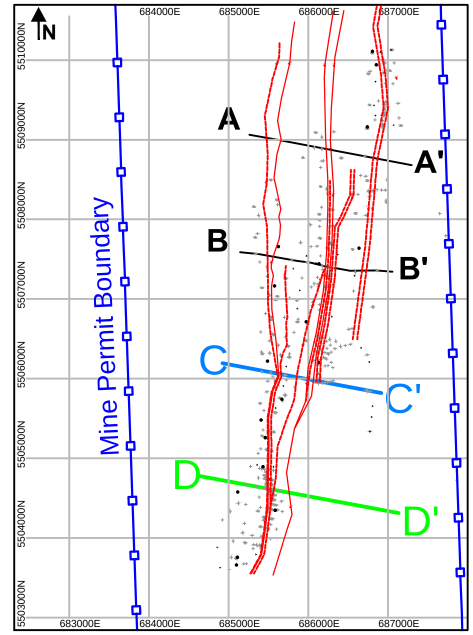
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

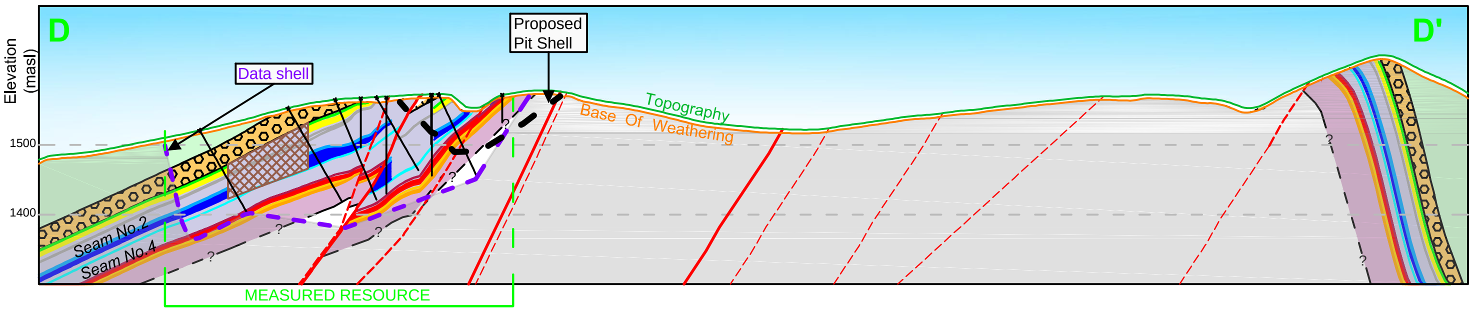
PROJECT: 14-00201-01
DRAWN BY: RS
CHECKED BY: JM/CP
DATE: AUGUST 25, 2015

FIGURE

B.6.5-1







LEGEND

- FAULT (MAJOR)
- FAULT (MINOR)
- DATA SHELL
- PROPOSED PIT SHELL
- HISTORICAL UNDERGROUND MINE
- GLADSTONE FORMATION
- CADOMIN FORMATION
- MIST MOUNTAIN FORMATION
  - SEAM NO.1
  - SEAM NO.2
  - SEAM NO.4
- MORRISEY FORMATION

NOTE(S)
1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS

REFERENCE(S)
- UTM COORDINATES: NAD83, ZONE 11
- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- PIT BOUNDARY PROVIDED BY GOLDER MINING
- RESOURCE POLYGONS BY McELROY BRYAN GEOLOGICAL SERVICES (MBGS)

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

CROSS SECTIONS C & D

NOTES

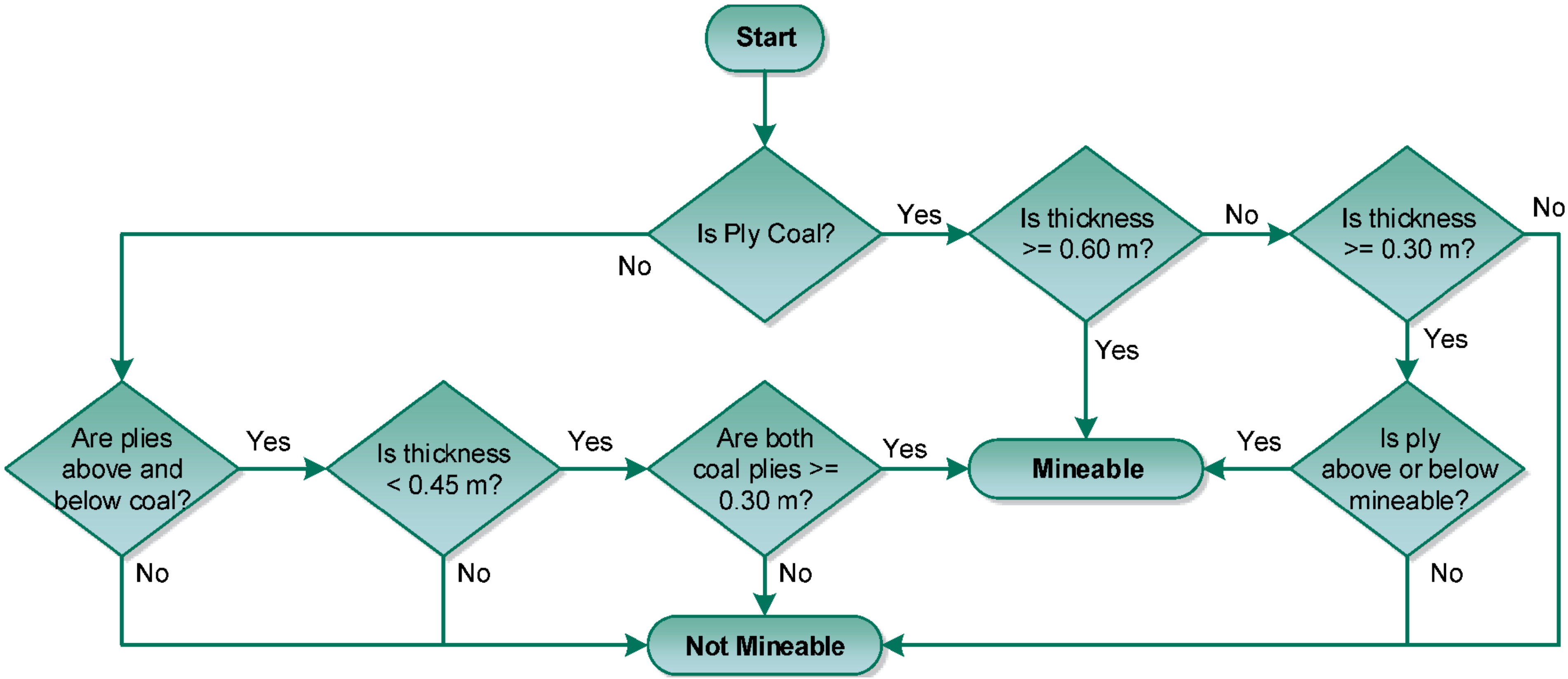
Original figure from McElroy Bryan Geological Services
Datum/Projection: UTM NAD 83 Zone 11

0 2 4 8
Kilometres

PROJECT: 14-00201-01
DRAWN BY: RS
CHECKED BY: JM/CP
DATE: AUGUST 25, 2015

FIGURE

B.6.5-2



Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Geology\Fig B.7.2-1 Working Section Defination Logic.mxd

LEGEND: N/A

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

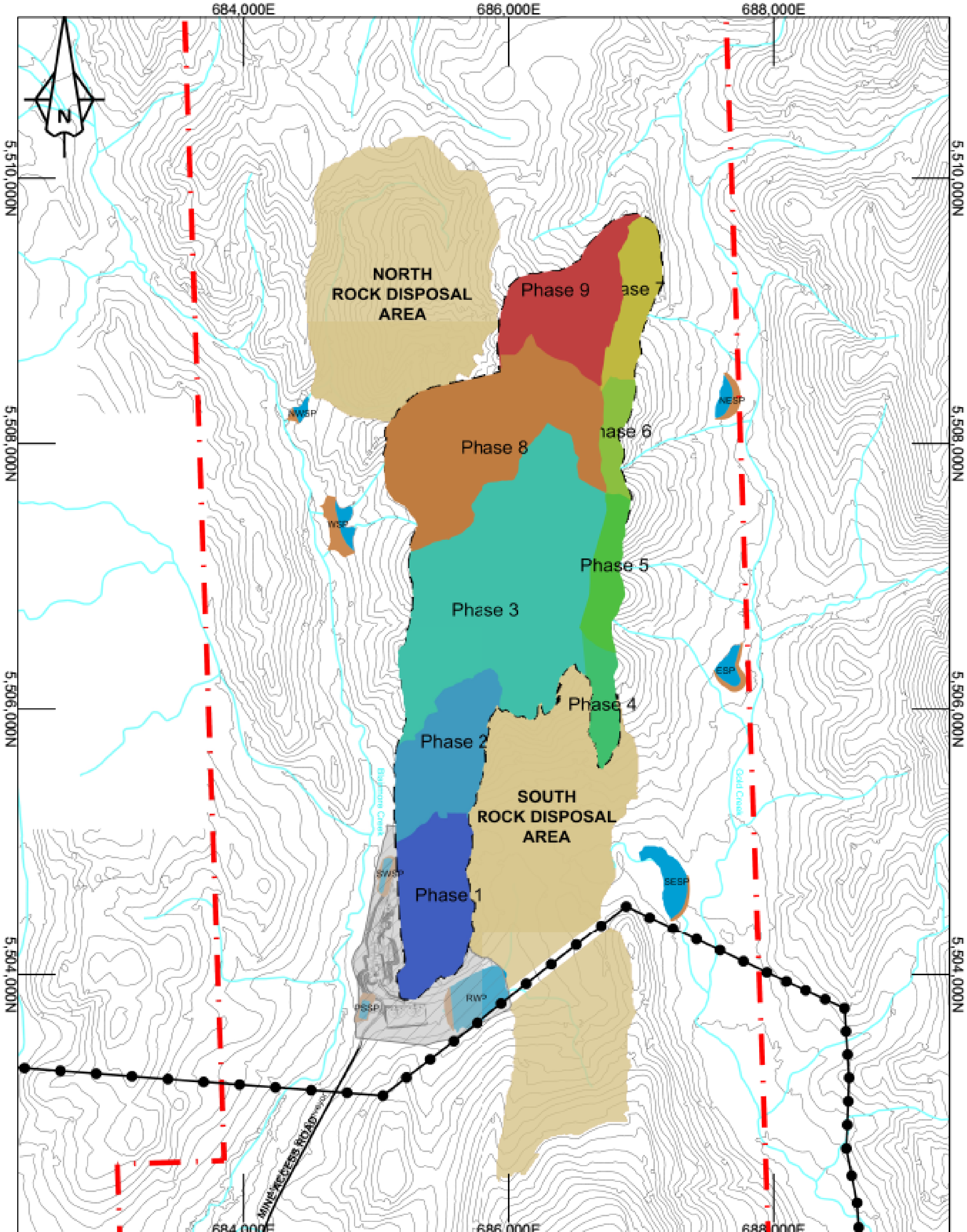
WORKING SECTION DEFINITION LOGIC

PROJECT: 14-00201-01
DRAWN BY: CP
CHECKED BY: JM
DATE: OCTOBER 14, 2015

NOTES
MEMS, 2015

SCALE BAR: N/A

FIGURE
B.7.2-1



LEGEND

- ACTIVE MINING AREA
- EXPOSED COAL SEAM
- ROCK DISPOSAL AREA
- DISTURBED AREA
- TOPSOIL STOCKPILE
- TOPSOIL REPLACEMENT & REVEGETATION
- POND
- DAM
- PLANT AND ADMINISTRATION AREA
- MINE PERMIT BOUNDARY
- DRAINAGE
- SURFACE CONTOUR
- HAULROAD
- EXISTING POWERLINE
- ULTIMATE PIT CREST

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

Deswik

TITLE

MINING PHASES

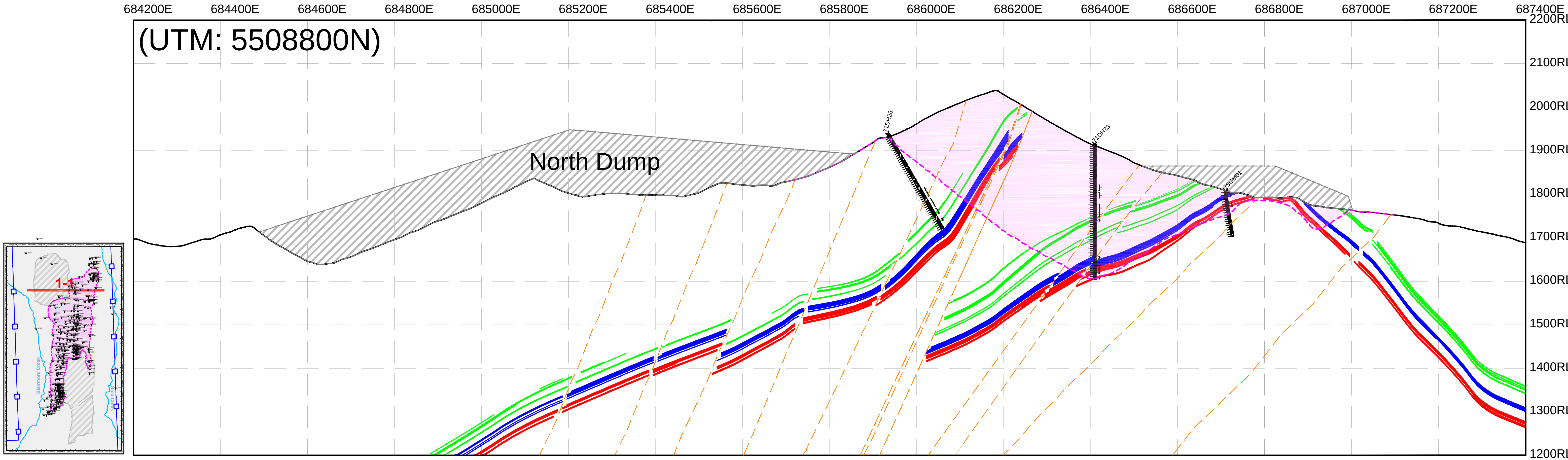
NOTES

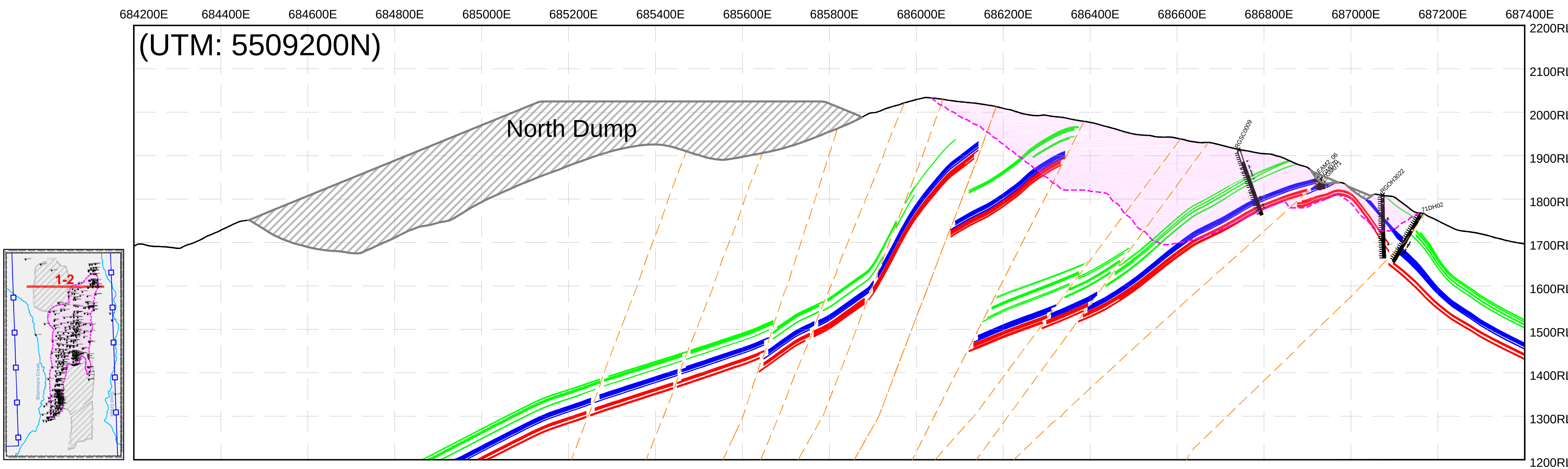
1.) Topographic LIDAR Data - Riversdale, 2015;
2.) Mine Plan Data - Deswik, 2015;
Datum/Projection: UTM NAD 83 Zone 11

0 500 1000 1500 2000 2500

PROJECT: RDR - 20150827
DRAWN BY: AG
CHECKED BY: MD
DATE: 05 May 2016

FIGURE B.7.5-1





Proposed Pit

Reverse Fault

Proposed Dump

Coal Seam No. 1

Coal Seam No. 2

Coal Seam No. 3

NOTE(S)

1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS

REFERENCE(S)

- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- GEOLOGY BY CONSOL (EXPLORATION SUMMARY MAP; 1988) AND RIVERSDALE RESOURCES 2013, 2014, 2015 & 2016

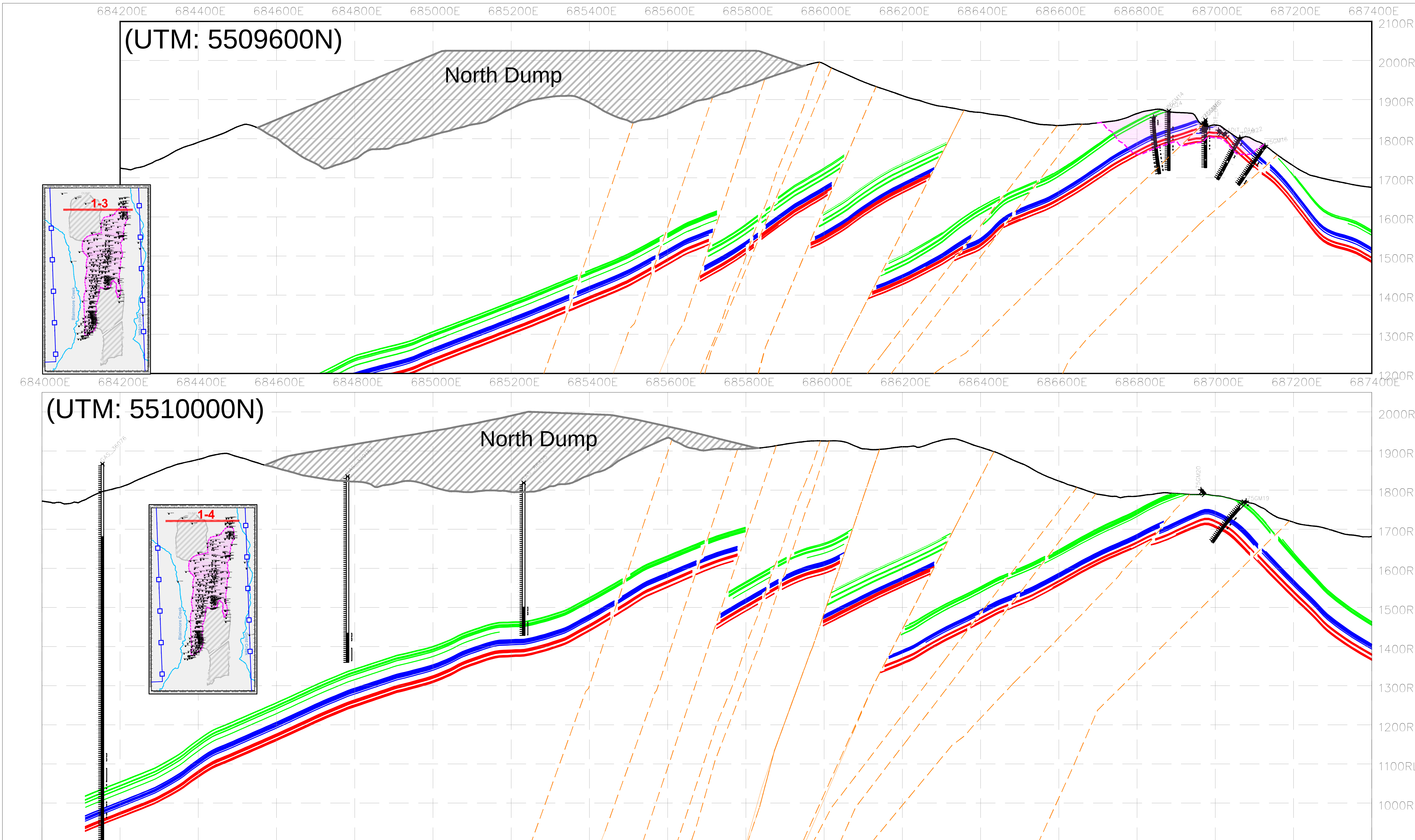
CLIENT
BENGA MINING LIMITED
RIVERSDALE RESOURCES LIMITED

RIVERSDALE RESOURCES

PROJECT
GRASSY MOUNTAIN COAL PROJECT
NRDA
ALBERTA, CANADA

TITLE
Figure B.7.6-1
GEOLOGICAL CROSS SECTIONS 1-1 & 1-2

DRAWN BY: M.A
DATE: MAY 02, 2016



Proposed Pit

Reverse Fault

Proposed Dump

Coal Seam No. 1

Coal Seam No. 2

Coal Seam No. 3

NOTE(S)

1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS

REFERENCE(S)

- MINING LEASE BOUNDARIES PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- GEOLOGY BY CONSOL (EXPLORATION SUMMARY MAP; 1988) AND RIVERSDALE RESOURCES 2013, 2014, 2015 & 2016

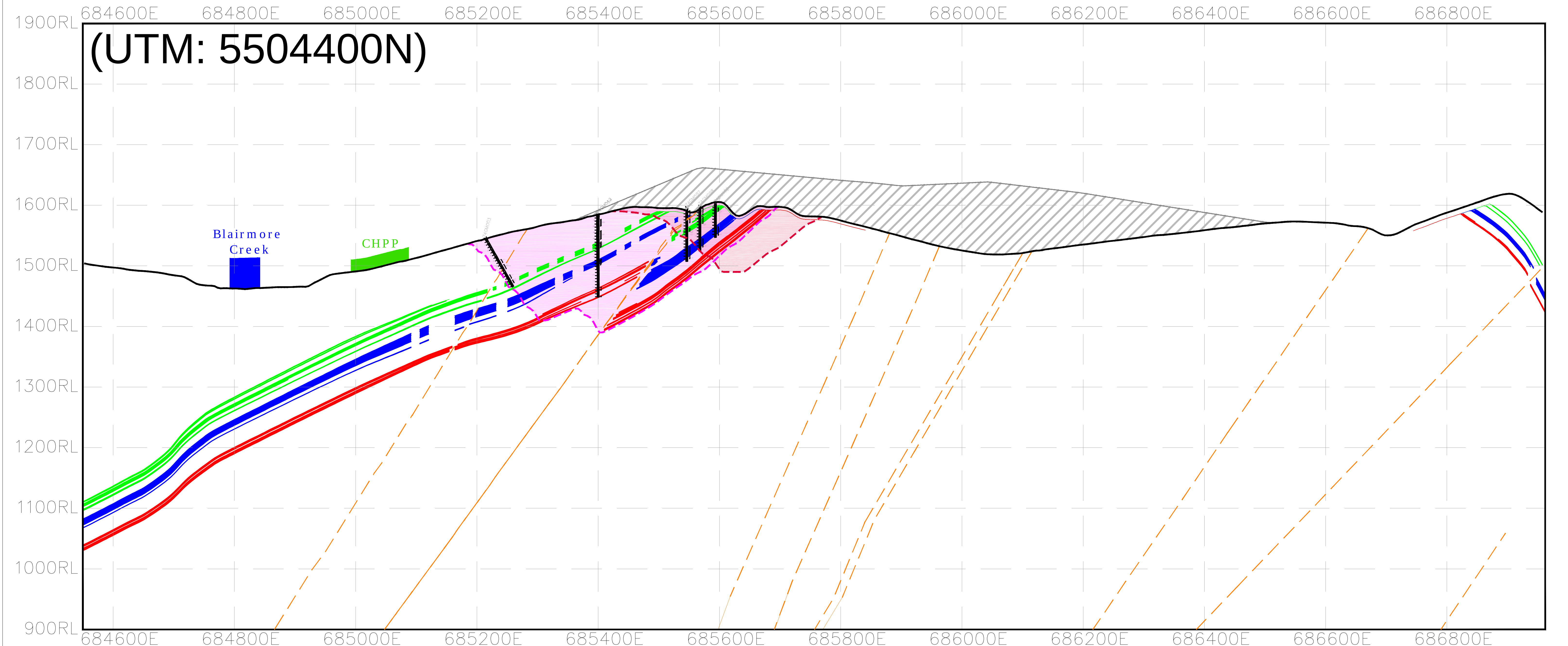
CLIENT
BENGA MINING LIMITED
RIVERSDALE RESOURCES LIMITED

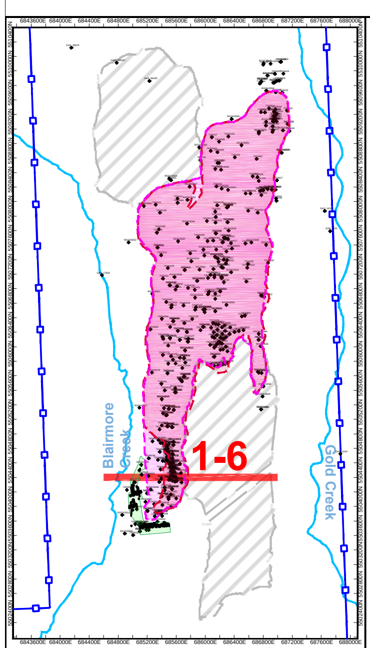
RIVERSDALE RESOURCES

PROJECT
GRASSY MOUNTAIN COAL PROJECT
NRDA
ALBERTA, CANADA

TITLE
Figure B.7.6-2
GEOLOGICAL CROSS SECTIONS 1-3 & 1-4

DRAWN BY: M.A
DATE: MAY 02, 2016





Pit Shell (Mine License)

Pit Shell (EIA)

Proposed Dump

Mine Permit Boundary

Reverse Fault

Coal Seam No. 1

Coal Seam No. 2

Coal Seam No. 3

NOTE(S)

1. ALL DEPTH, ELEVATION AND THICKNESS VALUES IN METERS

REFERENCE(S)

- PIT SHELLS PROVIDED BY GOLDER MINING (EIA) AND DESWIK (MINE LICENSE)
- WATERCOURSE MAP PROVIDED BY MILLENNIUM EMS SOLUTIONS (MEMS)
- GEOLOGY BY CONSOL (EXPLORATION SUMMARY MAP; 1988) AND RIVERSDALE RESOURCES 2013, 2014, 2015 & 2016

CLIENT

BENGA MINING LIMITED
RIVERSDALE RESOURCES LIMITED

RIVERSDALE RESOURCES

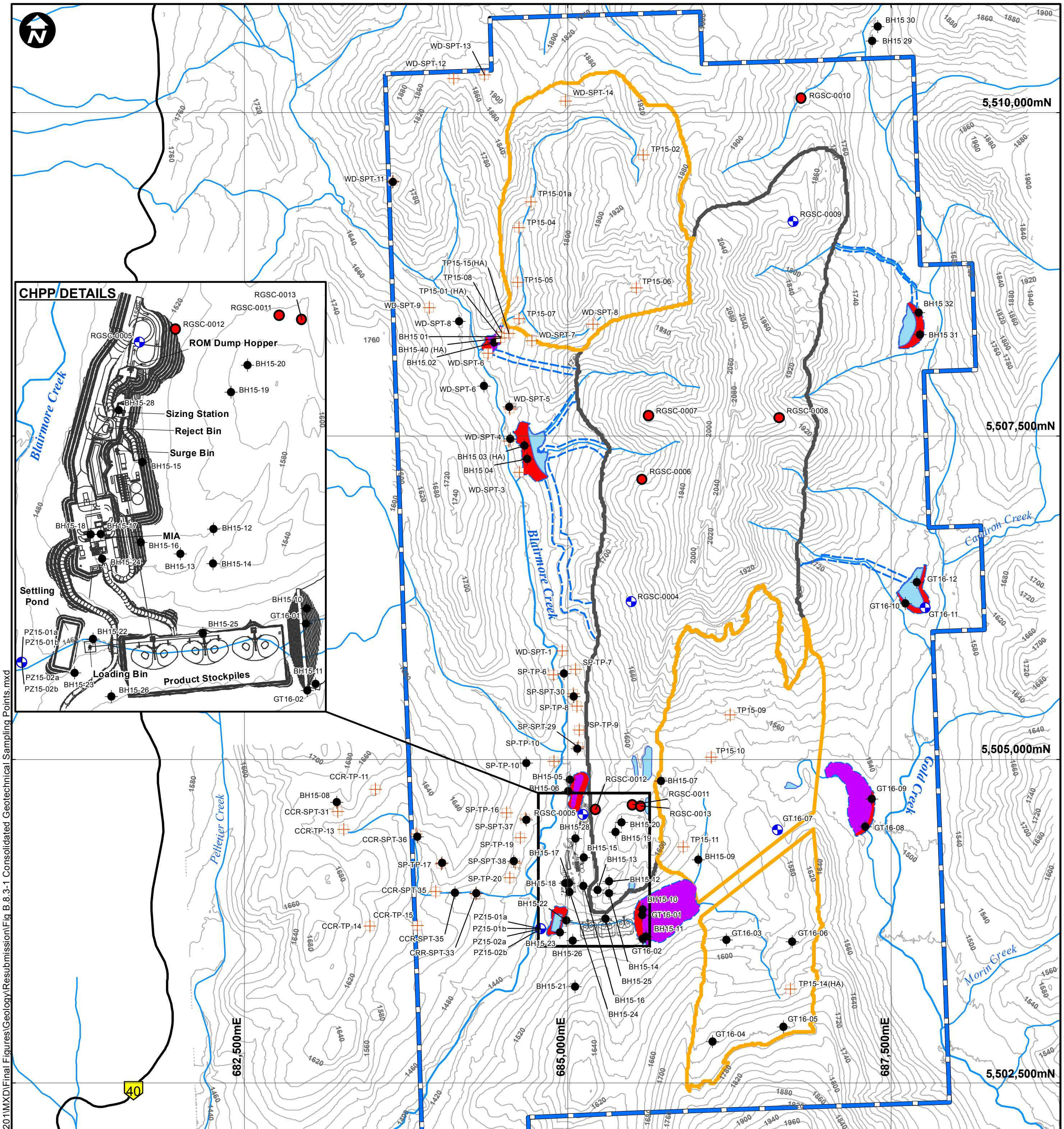
PROJECT

GRASSY MOUNTAIN COAL PROJECT
STERILIZATION QUESTION
ALBERTA, CANADA

TITLE

Figure B.7.6-3
Plant Site Sterilization

DRAWN BY: M.A
DATE: MAY 02, 2016



LEGEND

- Piezometer
- Borehole
- Corehole
- Test Pit
- Primary Highway
- Secondary Highway
- Existing Railway
- Contour (20m Interval)
- Surface Water Drainage
- Proposed Mine Permit Boundary
- Ultimate Pit Extent
- Ultimate Rock Disposal Area Extent
- Release Pond
- Dam
- Surge Pond (No Release)
- Ditches

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

CONSOLIDATED GEOTECHNICAL SAMPLING POINT MAP

NOTES

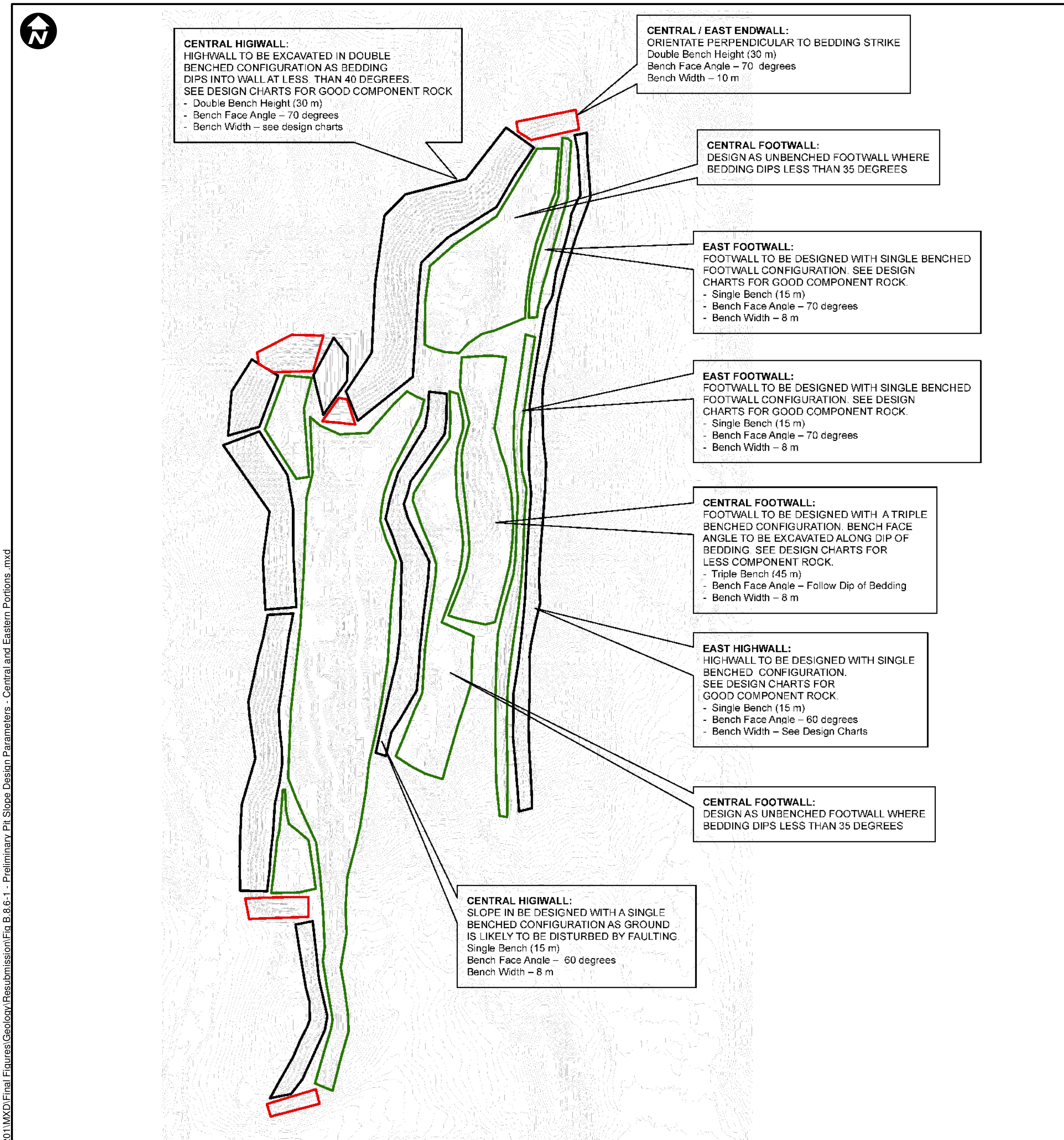
AltaLIS, 2016; NRCAN, 2015; Riversdale, 2016
Datum/Projection: UTM NAD 83 Zone 11

0 0.5 1 2
Kilometres

PROJECT: 14-00201-01
DRAWN BY: CP/SL
CHECKED BY: JM
DATE: JULY 05, 2016

FIGURE
B.8.3-1

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Geology\Resubmission\Fig B.8.3-1 Consolidated Geotechnical Sampling Points.mxd



LEGEND

- Highwall
- Endwall
- Footwall

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PRELIMINARY RECOMENDED PIT SLOPE DESIGN PARAMETERS - CENTRAL AND EASTERN PORTIONS

NOTES

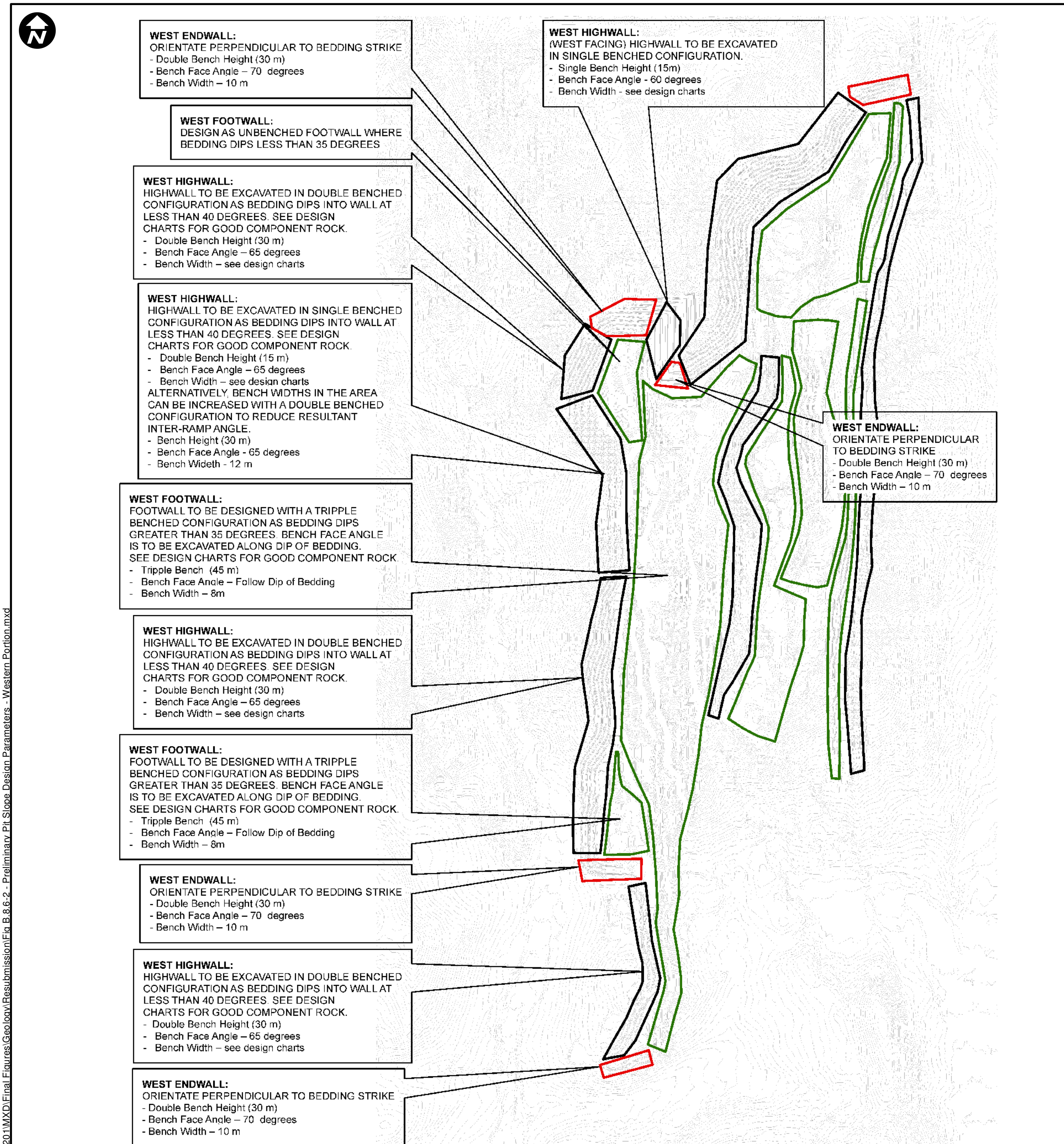
Golder Associates, 2015;
Datum/Projection: N/A

PROJECT: 14-00201-01
DRAWN BY: CP
CHECKED BY: JM
DATE: OCTOBER 05, 2015

0 1,000 2,000
Metres

FIGURE

B.8.6-1



LEGEND
- Highwall
- Endwall
- Footwall

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

PRELIMINARY RECOMENDED PIT SLOPE DESIGN PARAMETERS - WESTERN PORTION

NOTES

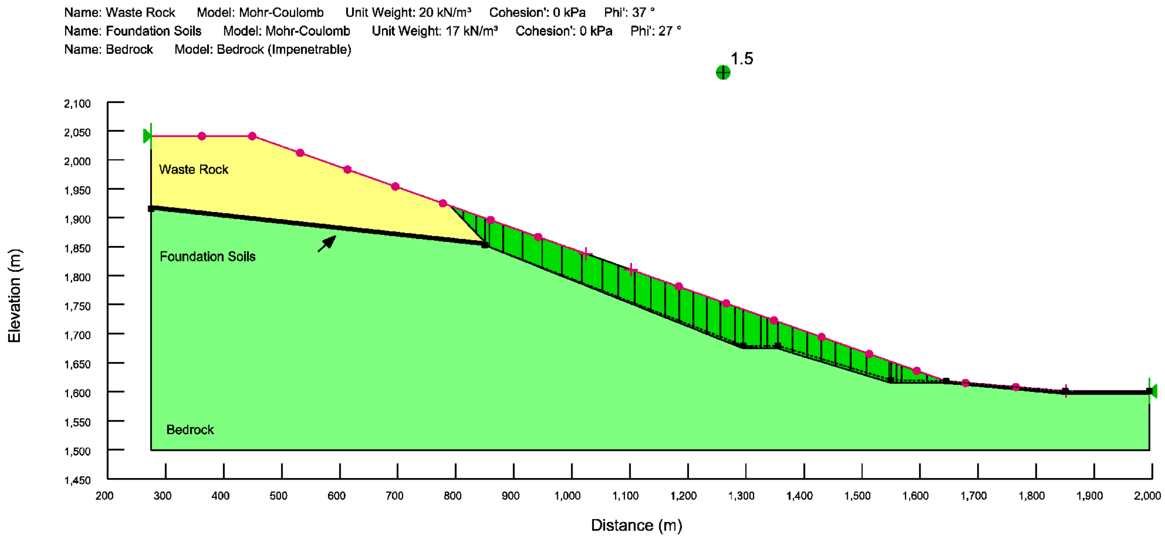
Golder Associates, 2015;
Datum/Projection: N/A

PROJECT: 14-00201-01
DRAWN BY: CP
CHECKED BY: JM
DATE: OCTOBER 05, 2015

0 1,000 2,000
Metres

FIGURE
B.8.6-2

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Geology\Resubmission\Fig B.8.6-2 - Preliminary Pit Slope Design Parameters - Western Portion.mxd



SCALE 1:10000 (A) STABILITY SECTION
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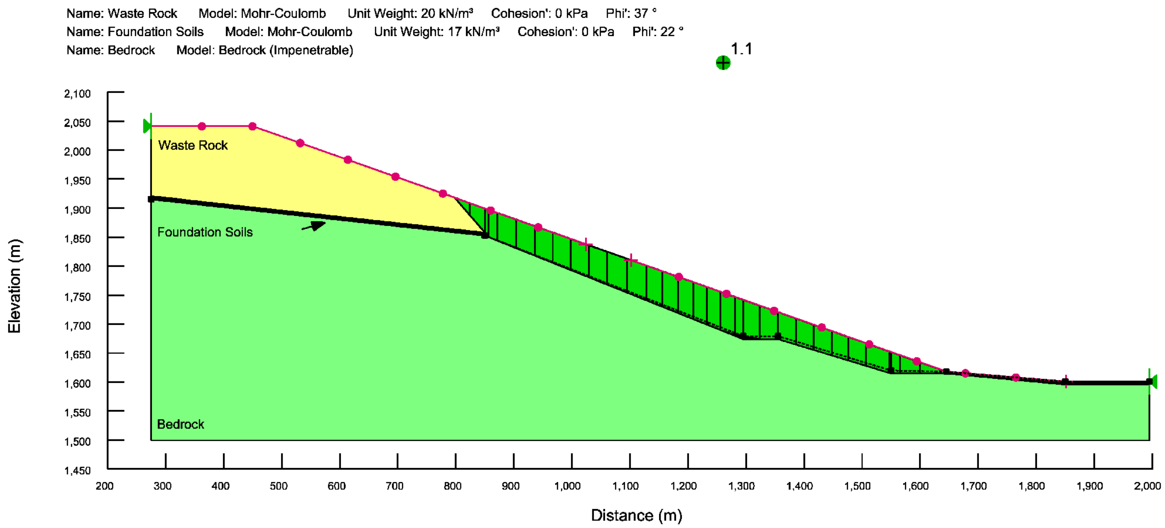

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PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

STABILITY SECTION A

PROJECT: 14-00201-01
DRAWN BY: CP
CHECKED BY: JM
DATE: OCTOBER 05, 2015

NOTES

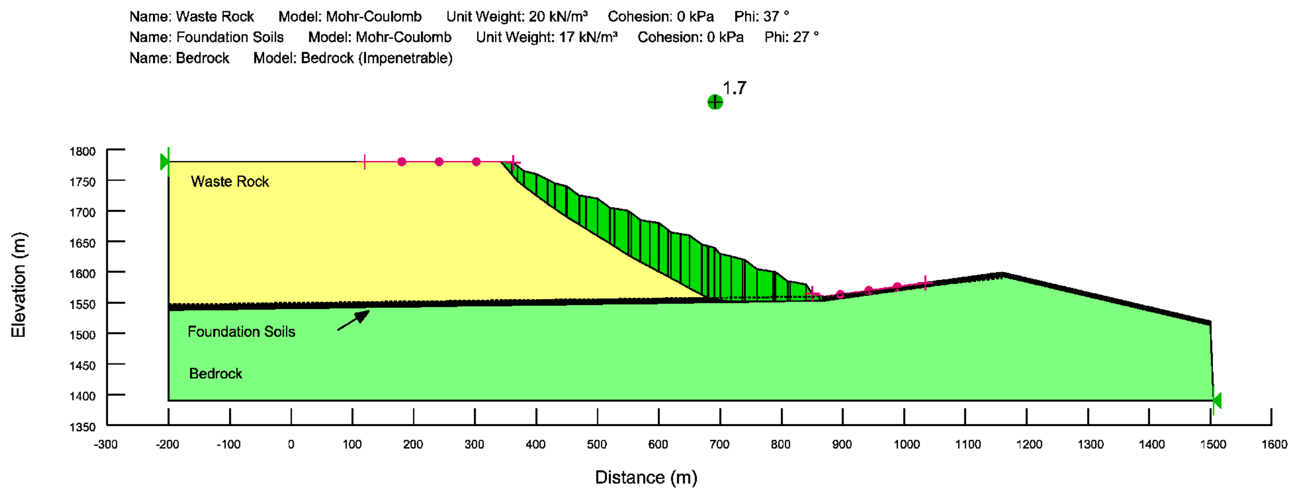
Golder Associates, 2015

0 250 500
Metres

FIGURE

B.8.6-3

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Geology\Resubmission\Fig B.8.6-3 Stability Section A.mxd



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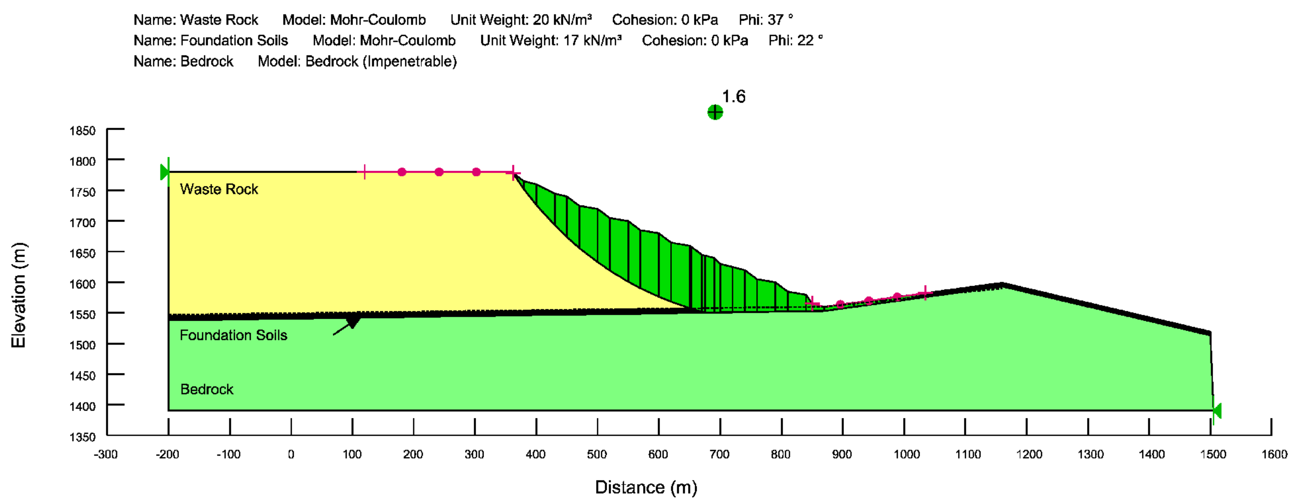


LEGEND: N/A

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

TITLE

STABILITY SECTION B

NOTES

Golder Associates, 2015

0 250 500
Metres

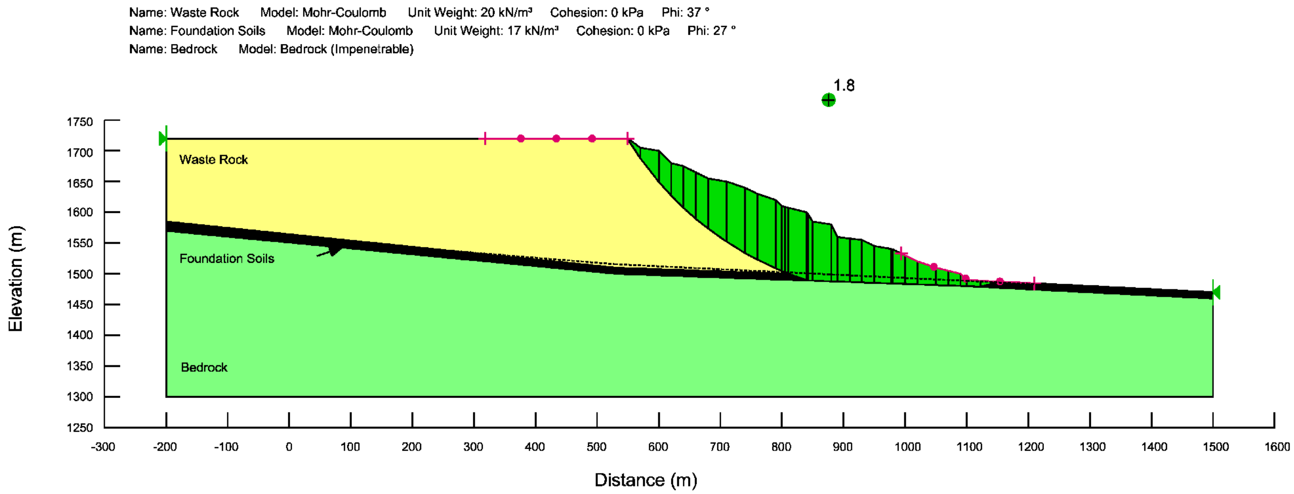
MILLENNIUM EMS Solutions Ltd.

PROJECT: 14-00201-01
DRAWN BY: CP
CHECKED BY: JM
DATE: OCTOBER 05, 2015

FIGURE

B.8.6-4

Document Path: K:\Active Projects 2014\AP 14-00201 to 14-00250\14-00201\MXD\Final Figures\Geology\Resubmission\Fig B.8.6-4 Stability Section B.mxd



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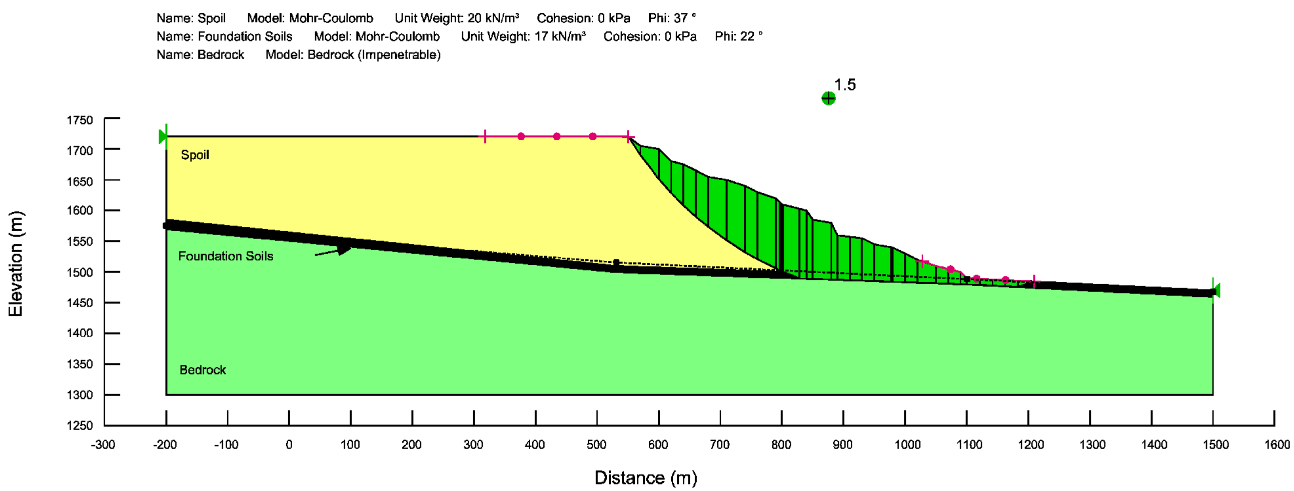

LEGEND: N/A

PROJECT

RIVERSDALE RESOURCES

GRASSY MOUNTAIN COAL PROJECT

MILLENNIUM EMS Solutions Ltd.

TITLE

STABILITY SECTION C

PROJECT: 14-00201-01
DRAWN BY: CP
CHECKED BY: JM
DATE: OCTOBER 05, 2015

NOTES

Golder Associates, 2015

0 250 500
Metres

FIGURE

B.8.6-5

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Appendix 9a

Grassy Mountain Mini Pit Geotechnical Investigation and Pit Slope Stability Assessment

Golder Associates Ltd., July, 2016

(Provided electronically on CD)

Appendix 9b

Grassy Mountain Preliminary Pit Slope Stability Assessment
Golder Associates Ltd., April 24, 2015
(provided electronically on CD)

Appendix 9c

Geotechnical Site Investigation of Waste Storage Dumps and Water Impoundment Structures at Grassy Mountain Coal Project

Terracon Geotechnique LTD., July, 2016

(provided electronically on CD)

Appendix 9d

Grassy Mountain Project Waste Dump and Infrastructure – Supplemental (2015) Geotechnical Program
Golder Associates Ltd., April 2016
(provided electronically on CD)