Opencast Coal Reserves at Springhill

by B. Ward

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by

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TABLE OF CONTENTS

LIST OF FIGURES

(Figures 1 to 4 are found in back cover pocket)

TABLE OF CONTENTS

LIST OF TABLES

OPENCAST COAL RESERVES AT SPRINGHILL

1. INTRODUCTION

At the request of the Nova Scotia Department of Mines an exploration programme to delineate potential opencast coal reserves in the Springhill area was carried out under the supervision of Wimpey Laboratories Limited. The investigation included a desk study of available data, particularly old mine plans, and a drilling programme to prove intact seams away from the worked areas. This report gives the borehole records and test results, a discussion of the geology and a delineation of potential opencast sites.

The comments made and opinions expressed in this report are based on the results of research into old mining records and abandonment plans, previous borehole information and the ground conditions disclosed by the present investigation. In view of the structural complexity of the area, in particular the faulting, it is probable that undisclosed variations in ground conditions will occur between or away from the boreholes.

2. LOCATION AND DESCRIPTION OF SITE

The site is centered around the town of Springhill in Cumberland County, Nova Scotia, at approximately 45° 38' N, 64° 04' W, and covers an area of about 7 1/2 square miles. It includes the outcrops of all the known coal seams in the central Springhill area and is shown on Figure 1 which is based on the geological map by Copeland (1958). It is divided into five areas of geographical and geological convenience, as shown on Figure 1.

The town is built largely in Area D on the northwest flank of a hill, the highest part of which reaches an elevation of about 650 feet to the north of Area C and east of Area D. A ridge extends towards the southwest passing through the southeast section of Area A. On the southeast side of this ridge the land falls away to the Black River and Maccan River valleys at elevations below 400 feet. The Black River cuts across the centre of Areas B and C draining to the northeast and the Maccan River drains to the southwest from Area A. To the west of the hill and ridge the land levels off at an elevation of about 400 feet.

Area A is generally open land in the northern part with peripheral dwellings along the roads and wooded in the southern part; however, a large part of the latter is occupied by the Penitentiary. Area B includes agricultural and pasture land to the east and west with evergreen woods and blueberry fields in the central part. Area C is open land in the western part, generally given to blueberry cultivation, running into dense mixed woods in the east.

Most of the town is in Area D including the slope entrances of the major mines which are located in what is now the Springhill Industrial Park. Apart from the dwellings and occasional commercial building the land is generally derelict with deciduous woods to the west and north. A significant portion of Area D is occupied by an old coal dump that has been burning for at least 40 years. Area E is dense mainly deciduous woods.

3. GEOLOGY

The strata investigated belong to the Cumberland Group of the Upper Carboniferous Period. The coal-bearing zone appears on the geological map as a crescent curving from a position just east of Springhill Junction, to the north of Area E, through Areas D and A and continuous southwest through Leamington and Mapleton. Areas B and C are contained within an easterly projection from the crescent. Above and below the coal-bearing zone in the succession of strata are red beds with sandstones and conglomerates.

The general succession of the major coal seams in the central part of the mined area is given by the Report of the Royal Commission, McInnes, et. al. (1958), as follows:

Seam	Thickness	Approximate Interval
No. 3	10'0"	
		280'
No. 1 Upper	4'0"	
		30'
No. 1 Lower	4'0"	
		70'
No. 2	9'0"	
		45'
No. 4	3'5"	
		533'
No. 5	3'7"	
		66'
No. 7	5'0"	
		90'
No. 6	5'6"	

Only the Nos. 1, 2, 3, 6 and 7 Seams have been mined. Many thinner seams occur between Nos. 2 and 7 Seams, the most significant being the Nos. 4 and 5 Seams. Above the No. 3 Seam are several thin seams including the Golden Seam. Higher still in the succession is a group of thin seams outcropping to the southwest of the area investigated; included in this are the Barlow, Dan McLeod, Harrisson and Canning Seams. The Sandrun Seam shown on Figure 1 to the northeast of Springhill, also outside the area of investigation, is a solitary seam in a separate area of deposition.

The structure of the Springhill coal field is generally presented as an anticline plunging to the southwest at some 10° to 20°. The northern limb of the anticline is Area D where the strata dip fairly uniformly to the west-northwest at 30° to 35° near the surface levelling out at depth. Further to the north, in Area E, the dips increase to as much as 65°.

Areas B and C form the southern limb of the anticline with dips of about 25°. A zone of severe tectonic disturbance extends along the axis of the anticline. Area A, the nose of the anticline, is characterized by much faulting; however, mining records indicate that most of the faulting and strata disturbance die out with depth. To the east of Areas B and C the outcrops swing south as they approach the nose of a plunging syncline. Like Area A, the nose of the syncline is characterized by much faulting.

The thickest and most easily mined coal on all seams occurs on the northern limb in Area D. Along the strike to the north and around the nose of the anticline to the east the coals deteriorate in thickness and quality.

4. MINING METHODS AND HISTORY

Coal was traditionally mined at Springhill using the bord and pillar method. The main slopes for haulage and ventilation were driven down the dip of the seam with levels along the strike away from the slopes. The levels were joined by tunnels known as inclines driven up the dip at intervals to provide circulation. Bords were driven parallel to the levels from the inclines and also up dip between the inclines to break up the coal seam into pillars usually 40 to 50 feet square. When the levels had reached their farthest viable distance from the slope the pillars would then be removed starting at the farthest and retreating towards the slope.

The alternative method which replaced bord and pillar workings, except at shallow depths, was the longwall extraction method introduced into the Springhill mines during the 1920's. In this method the incline joining the levels became the coal face which was advanced at its full width between levels away from the main slopes. The roof was allowed to crush down behind the working area as the face advanced, access being maintained along the old levels by means of extensive support.

A major problem of coal mining at depth in Springhill was the high strength of roof and floor strata which tended to resist a gradual closure behind the worked areas. Stresses, therefore, accumulated until relieved by sudden and violent movements. The resulting movements in the working area in which the floor would rise, the walls close in and coal would be ejected violently from the face, were known as "bumps" and were a serious hazard to mining. In order to reduce these effects the deeper mines at Springhill used a retreating longwall method where the levels were driven to their farthest point and the coal face worked from there back towards the main slope.

Coal was first dug in the Springhill area in the early part of the nineteenth century by local inhabitants. A monopoly on coal extraction in Springhill was secured by the General Mining Association from 1826 to 1879 when it was relinquished to the Springhill and Parrsboro Railway Company. The Cumberland Railway and Coal Company took over in 1884 and ran the coal mining operations, albeit under the management of the Dominion Ccal Company after 1911, until the last of the major mines was closed in 1959.

The coal seams of economic importance were the Nos. 1, 2, 3, 6 and 7; their nomenclature reflecting the historical order of working and not the stratigraphic succession. The major mines are as follows, the location of the main slopes being given on Figure 1.

No. 1 Mine worked the No. 1 Seam via the No. 1 Slope from 1872 to 1896 when it was closed due to fire. It was reopened in 1897 and worked via the No. 2 Slope and cross-measure tunnels until 1913. The working was entirely bord and pillar and although the early mine plans were lost through fire, it appears that the pillars were extracted. The No. 1 Mine suffered a disastrous coal dust explosion in 1891 that caused the deaths of 125 people.

The No. 2 Mine worked the No. 2 Seam via the No. 2 Slope from 1873 to 1958. The earlier workings were bord and pillar with total extraction of pillars. Shallow workings extended to the north into Area E where coal was taken out via the Aberdeen Slope. In 1925 the mining method was changed to retreating longwall. This was the deepest of the Springhill mines reaching a vertical depth of 4,340 feet from the surface. It was closed following a disastrous bump on 23rd October 1958 in which 75 people were killed.

No. 3 Mine worked the No. 3 Seam from 1887 to 1916 when it was closed because of "fire and flood". The main slope was the No. 3 Slope but additional points of entry were the Rapid Transit Slope at the north end of the workings and the Syndicate Slope at the south end. The workings were bord and pillar with total extraction of pillars. Cross-measure tunnels connected the No. 3 Seam with the Nos. 1 and 2 Seams.

Nos. 6 and 7 Mines worked the Nos. 6 and 7 Seams respectively. Entry was by the Nos. 6 and 7 Slopes located at the north end of Area D. Both mines were of limited extent and relatively short-lived, opening in 1920 with the No. 7 Mine closing in 1933 and the No. 6 Mine in 1936. Working was for the greater part by bord and pillar with longwall extraction at depth. The pillars were only extracted below the second level. Cross-measure tunnels connected the mines.

No. 4 Mine worked both the No. 6 and 7 Seams. This mine was opened in 1936 following the closure of the No. 6 Mine but was never connected to either the No. 6 Mine or the No. 7 Mine workings. Entry was by the No. 4 Slope that shared the same bankhead tipple facilities as the No. 2 Slope. The No. 4 Slope was a 35° pitching rock tunnel that intercepted the No. 7 Seam at a depth of about 1,560 feet. A cross-measure escape tunnel connected to the No. 2 Seam at this level and other cross-measure tunnels at deeper levels connected to the workings in the No. 6 Seam. All workings were longwall with the shallowest level being some 550 feet below ground level. This was also a deep mine having reached a vertical depth of 3,486 feet when mining ceased after a coal dust explosion on 1st November 1956 that killed 39 people.

The closure of the No. 2 Mine in 1959 following the disaster in 1958 effectively marked the end of the coal mining era for Springhill even though several small mines were subsequently working during the 1960's. These were short-lived operations working from already existing slopes. They included the Syndicate Mine which worked the No. 3 Seam from the Syndicate Slope, the Tingley Slope in Rogers Field in Area C which worked the No. 7 Seam and the McCarthy Slope on the southern limb of the anticline which worked what was believed to be the No. 2 Seam. Mine plans are not available for either the McCarthy Slope or for two other small mines, one in Area D working the No. 1 Seam just east of the coal dump and referred to as the "New Mine", and the Ross and Tabour Slopes working the No. 2 Seam in the north part of Area A. The approximate locations of these small mines are indicated on Figure 2.

As well as the mines already noted there were a number of earlier pits and a great number of unauthorized, or bootleg, pits worked principally during times of economic hardship. Such undocumented workings are known to be concentrated in the wooded area immediately west of the McCarthy Slope and in the wooded area on the nose of the syncline in Areas B and C. Bootleg pits were also worked along the outcrops of the main seams in Areas A and D. Such operations continued as late as the 1950's in the No. 3 Seam near Coal Mine Brook and the No. 2 Seam at the north end of Area D and into Area E.

5. PREVIOUS GEOLOGICAL WORK

Geological mapping of the Springhill Coalfield has been carried out by various authors since 1874 although some reports were unpublished. Copies of various geological maps were provided by the Department of Mines, Stellarton, for use in this investigation. These included a manuscript version of Fletcher's map of the early 1900's (on a scale of 1 inch to 400 feet) and several coal company and Geological Survey of Canada maps. The most recent publication is the memoir by Copeland (1958), and his outcrop map, reproduced in Figure 1, was used to plan this investigation. Reference is also made to Copeland for a description and bibliography of previous geological work.

Many boreholes have been drilled in the area over the years, several of which commenced at depth within the coal mines. Apart from a few individual borings the main documented drilling programmes were carried out by the Cumberland Railway and Coal Company and the Nova Scotia Department of Mines. The surface boreholes of the former, numbered 1 to 35, were drilled during the period 1910 to 1913, with numbers 36 and 37 being drilled from 1935 to 1936. The approximate locations of these boreholes that lie within the area investigated are given on Figure 2.

Also shown is the approximate location of the underground borehole No. X11, drilled in 1928 from the No. 2 Seam up into the No. 3 Seam for drainage purposes.

The Department of Mines undertook their major drilling operation in 1959 following the closure of the No. 2 Mine. Drilling was concentrated in two areas - the southern part of Area A (boreholes 1W to 20W) and the southern part of Area D (boreholes 1E to 17E). Two holes were drilled in 1960 close to the line of the Syndicate Slope prior to its re-opening. These were originally called 1 and 2 but following the precedent of the Geological Survey of Canada they are marked 21W and 22W on Figure 2.

Other Department of Mines boreholes have subsequently been drilled, for example, 23W to 26W to the west of Area A from 1961 to 1962, DDNS-SH-3, 4 and 5 in Area E in 1976 and DDH1 to 5 immediately east of the coal dump in 1969. The last-mentioned series have not been included in the present investigation because of doubts about their location; the others lie outside the area covered by Figure 2.

6. METHOD OF INVESTIGATION

6.1 General

The initial stage of the investigation comprised an examination of available information on the Springhill coalfield including geological maps, borehole records and mine plans. The results of this desk study are given in the Preliminary Report (1977), in which the site was divided into four areas, the present Area E being included in Area D. The outcrop of each of the major coal seams was plotted and divided into sections according to accessibility in order to exclude reserves beneath major roads and structures. The potential opencast reserve for each accessible length was calculated for a 10:1 stripping ratio which disregarded superficial deposits. The maximum possible opencast reserve for the central Springhill area was estimated at 3.1 million short tons. An estimated 12,000 feet of drilling was considered necessary to prove this reserve.

A drilling programme was commenced that ran, in part, concurrently with the production of the Preliminary Report (1977). It soon became clear, however, that the original geological map (Fig. 1) was optimistically simple. So much effort had to be expended in locating the coal seams that the original concept of drilling at regular intervals along the strike of each coal seam was abandoned and the emphasis changed to exploratory drilling. As the core recovery in the coal was in any case proving to be less than satisfactory, the borehole diameter was reduced to improve drilling efficiency with coal seam thicknesses being obtained from the geophysical logs. It was assumed that additional drilling would be carried out at larger diameter specifically to recover core samples once the coal seam outcrop pattern had been determined. An account of the major part of the drilling programme is given in the Interim Report (1977).

As a general rule drilling was stopped at about 250 feet in each borehole if coal was not encountered. This was because at greater depths (and therefore over greater stratigraphic distances) variations in the thickness and disposition of coals and other correlative rocks reduces the confidence in the calculations. Also the maximum depth of any opencast pit would probably not be much greater than 250 feet. Because of the exploratory nature of the drilling it was not possible to preposition boreholes, hence each borehole was located with respect to information obtained from the previous one.

It was proposed to locate the coal outcrops by trenching as this would provide a more rapid and accurate method than drilling and would also provide more information about the surficial deposits. No use was made of trenching, however, due to the cessation of field work with the termination of the drilling programme.

A fundamental problem during the investigation was the lack of suitable topographic maps of the areas around Springhill. The town and its immediate environs are covered by both 1 inch to 200 feet and 1 inch to 400 feet topographic maps but since most of the drilling was outside these areas, the setting out was based on aerial photographs enlarged to an approximate scale of 1:5,000. The base plan used during the course of the investigation was drawn largely from Fletcher's early geological map.

The findings of the Interim Report (1977) indicated a need for a fundamental revision of the geological map. Not only were coal seams difficult to locate because of undisclosed faulting, but were in some cases apparently absent altogether. Another detrimental factor that became apparent was the thickness of superficial deposits which in many cases was such that the 10:1 stripping ratio would be exceeded before reaching the coal. The revised estimate of opencast coal reserves in the areas investigated was thus reduced to about 0.75 million short tons.

As a result of this drastic reduction, with little prospect of further exploration uncovering substantial reserves, it was concluded that the Springhill coalfield would be unable to meet the short term demand of the Halifax power station following its conversion to coal-burning. On this criterion the drilling programme was abruptly and prematurely terminated by the Department of Mines on 29th November 1977, following the completion of WB38.

6.2 Drilling

A total of 38 boreholes were sunk during the period 21 June to 29 November 1977, ranging in depth from 97 feet to 282 feet. The work commenced using a single drilling rig, however, a second and third were subsequently employed. The total footage was 8,401, broken down as follows:

Month	No. of Rigs	No. of Holes Drilled	Footage
June	1	1	218
July	1	4	1,035
August	2	7	1,731
September	2	8	1,565
October	3	9	1,838
November	3	9	2,014
		38	8,401

The drilling rigs, which were all supplied by the Department of Mines, were skid-mounted and used wireline coring equipment and water flush. Drilling was openhole without coring until rockhead was reached beneath the superficial deposits and weathered bedrock. The drilling was originally NQ size, giving a core diameter of 1 7/8 inches from a 3 inch borehole, but subsequently reduced to BQ size giving a core diameter of 1 7/16 inches from a borehole of approximate diameter 2 1/2 inches. Each borehole was backfilled with cement upon completion.

The locations and depths of the boreholes were determined by Wimpey Laboratories Limited.

6.3 Surveying

The ground levels and coordinates of the boreholes were determined by a surveyor from the Department of Mines, and this information is given on each borehole record. The ground levels are based on the Canadian Geodetic Datum (CGD). The coordinate system used in this report is the 6° Transverse Mercator (UTM) projection, this being the grid of the available topographic maps of Springhill. Coordinates for both the 6° and 3° TM projections as well as the computed latitudes and longitudes of the boreholes are listed in Appendix 2.

6.4 Core Logging

The logging of the rock core was carried out mainly by engineering geologists of Wimpey Laboratories Limited in general accordance with the recommendations of the 1970 Working Party Report of the Engineering Group of the Geological Society. Several of the boreholes were logged by a geologist from the Department of Mines (WB2, 14, 20 and 21).

The borehole records in Appendix 4 give the descriptions, depths, thicknesses and levels of the strata encountered. They also give information on core recovery and rock quality defined as follows:

TCR	Total core recovery	- The length of the total amount of core sample recovered as a percentage of the length of the core run.
SCR	Solid core recovery	- The length of core recovered as solid cylinders as a percentage of the length of the core run.
RQD	Rock quality designation	- The length of core recovered as solid cylinders each more than 4 inches long as a percentage of the length of the core run.

6.5 Geophysical Logging

Each borehole (except WB20 and 25) was geophysically logged by Nova Scotia Research Foundation using natural gamma and gamma-gamma (density) techniques prior to withdrawing the drilling rods. These logs were produced as an instantaneous trace from a pen recorder representing a vertical scale of 1 inch to 4 feet which is the same scale used for the lithological log on the borehole record. A slave recorder was employed to give a duplicate copy of each log for site use. This allowed immediate use of the logs for assessing the strata and planning the next borehole position whilst the final copies were being drawn up by Nova Scotia Research Foundation in Dartmouth.

The gamma-gamma log gives a picture of the rock density and is thus particularly useful for picking up coal seams due to their relatively low density. It is, however, potentially ambiguous as it also records drilling washouts or cave-ins in the side of the borehole as strata of low density. This problem is generally resolved by comparison with the natural gamma log which is not particularly affected by such washouts.

The natural gamma logs of the Springhill boreholes reflect changes in strata in considerable detail and thus allow for precise definition of lithological units when used in conjunction with the lithological descriptions of the rock core.

Both natural and induced gamma logs are recorded as counts per second and thus only give a qualitative representation of the relative lithology or density. Absolute values of rock density cannot be determined from such logs unless they have been previously calibrated against density determinations.

7. SAMPLING AND TESTING

The coal seams were sampled by dividing the coal core into one foot lengths if recovery was complete, or taking whatever was there in the case of poor recovery. Each sample was then split lengthways, one half being retained in the core box the other half being taken for testing. The number and extent of each coal sample is indicated on the borehole records.

The coal tests were arranged by the Department of Mines and carried out by the Federal Department of Energy, Mines and Resources Laboratory at Sydney. The tests included moisture, ash and sulphur content determinations on each sample and volatile and fixed carbon determinations on selected samples.

The results of the coal tests are given in Appendix 3.

8. GEOLOGICAL INTERPRETATION OF DRILLING PROGRAMME

8.1 General

The results of the geological interpretation of the borehole data are shown on Figure 2. The coal seam outcrops are determined by projection to ground level from the borehole interceptions, no account being taken of the thickness of superficial deposits or topographic variation between boreholes. The dip values given on Figure 2 are computed values from borehole intercepts not those recorded during the logging of core. The fault positions and orientations are conjectural within the limitations imposed by borehole spacing. In general faults have been located at the midpoint between the boreholes that indicate the presence of a fault hence the map is likely to be modified as further evidence becomes available.

All coal thicknesses given in this section are, unless otherwise stated, "as drilled", and not the true stratigraphic thickness corrected for dip. All depths quoted for coal seams refer to the base of the coal.

8.2 Area A

Area A is bounded by the Leamington Road, McGee Street and Herrit Road and covers the structurally complex nose of the anticline.

Drilling commenced with WB1 but due to temporary difficulties in obtaining permission to enter land the drilling rig was moved into Area B. WB1 was placed to intercept the No. 1 Seam on the south side of the Syndicate fault. A 7 foot 9 inch coal seam (true thickness 5 ft. 3 in.) was encountered at 53 feet 6 inches but with a high dip of 48 1/2°.

East of the Penitentiary in Area B, three coal seams were intercepted in WB3 that did not fit into the existing geological picture, hence the following nomenclature was adopted:

Coal	Thickness	Interval Between Coal Seams
F	1'0"	
		77'6"
A	6'0"	
		43'6"
B	4'0"	
		28'3"
C	4'6"	
		160'0"
D	1'2"	
		129'0"
E	10"	

The thicknesses and intervals are derived from WB2, WB3 and WB5. Seams F, D and E are persistent marker horizons in Area B.

Coals A, B and C were traced across Area B from WB6 to WB15 and found to coincide with the outcrop of the Nos. 1 and 2 Seams given by Copeland. In Area A, however, it was apparent that the Copeland map required modification. Accordingly, the records of boreholes drilled by the Department of Mines in 1959 were examined in detail commencing with a correlation of the seams where they crossed Herrit Road. The interpretation of these boreholes is shown on Figure 2.

The correlation of Coals A, B and C across Area A is shown on Figure 3 plotted to a datum on the base of Coal C. In the area of boreholes 36, 2W and WB1, which is more or less on the axis of the anticline, there is a complexity of faulting such that a complete geological map cannot be achieved. Spanning this zone, however, the correlation is continued into the area of the No. 3 Seam workings. Coal A thus correlates, as indicated on Figure 3, with the No. 3 Seam in boreholes 21W and 22W. A continuation of this correlation into the central part of the worked coalfield is provided by the underground borehole X11.

Coal A shows a general reduction in thickness around the nose of the anticline from 14 feet 9 1/2 inches in 22W to 6 feet 0 inches in WB3. Coal B is a subordinate unnamed seam 1 foot to 2 feet thick in the worked part of the coalfield but increasing to 4 feet 0 inches east of 20W. Coal C is also a subordinate unnamed seam, probably split in the worked part of the coalfield as indicated by borehole X1I, but having an average thickness of about 3 feet 9 inches in Area A. Coal F, the first seam overlying Coal A, is not generally of economic importance in Areas A and B but does, however, provide a persistent marker horizon.

Coal D persists west of Herrit Road with a thickness of 7 inches in 5W and 8 inches in 4W. However, when again intercepted, in 17W, it has a total thickness of 11 feet 6 inches. A coal of similar thickness was apparently encountered at a depth of 80 feet 10 inches in 3WA. The interval between Coals A and D in 17W is 229 feet 6 inches.

It is concluded therefore that Coal D is the No. 1 Seam which, east of boreholes 17W and 3WA, enters a zone of impoverished coal formation.

Coal E is intercepted in boreholes 4W, 5W and 5WA where it is 2 inches, 3 inches and 5 inches thick respectively. Coal E is stratigraphically at the level of the No. 2 Seam, hence it is concluded that the No. 2 Seam, recorded in boreholes 10, 6E and 17E in the north part of Area A with a total thickness of 11 feet 3 inches to 12 feet 9 inches, also enters a zone of non-deposition as the outcrop crosses the anticlinal axis.

Copeland indicates a zone of "washout" in the Nos. 1 and 2 Seams, the northern limit of which swings to the east parallel to the strike in Area B on the assumption that it is the No. 2 Seam that correlates across Area B to the McCarthy Slope. It is suggested that this zone of non-deposition, as it crosses the axis of the anticline, swings from a southeast to an east-northeast trend so that its northern limit passes to the south of 17W and 3WA but north of 3WB, 3WE and 5WA. This would imply that the present structure results largely from superimposition of northeast-southwest folds on west-dipping strata rather than a simple tilting or plunging to the west of a preformed anticline.

It is to be noted that unlike other coalfields in Nova Scotia correlation of seams in the Springhill coalfield by spore analysis has unfortunately not proved successful. Hence the proposed correlation of Coals A, D and E with the Nos. 3, 1 and 2 Seams is based entirely on detailed lithological comparison, stratigraphic interval and the correlation of natural gamma geophysical logs.

8.3 Area B

Area B extends east from Herrit Road to the nose of the syncline and was planned to cover the outcrops of the Nos. 1 and 2 and overlying seams along the southern limb of the anticline.

Drilling commenced with WB2 and progressed east along the strike to WB7 beyond which was a wooded area of difficult access. The seams were intercepted west of Black River Road in WB11 and again followed to the east until lost presumably by faulting in WB17. The continuity of the seams across the intervening hilly, wooded area around the McCarthy Slope was demonstrated by tracing the seams west from WB19 to WB26.

The correlation of Coals A, B and C in Area B, which is derived not only from comparison of the lithological logs as given in the borehole records, but also from examination of the geophysical logs, is shown on Figure 3. This often removes ambiguity that arises when only one type of log or record is available. The geophysical logs in fact provide the reason for plotting Figure 3 on the base of Coal C, for in each borehole the natural gamma log indicates a change of radioactive level at this point. This change is to some extent reflected in the lithology which shows a predominance of silty mudstones and siltstones below Coal C with mudstones and sandstones above.

Figure 3 shows that Coal A is significant as far east as WB7, where it increases locally to 5 feet 6 inches, thereafter deteriorating in thickness. Coal A was not actually proved in WB15 due to the poor core recovery; however, the geophysical logs suggest the presence of shaly coal or coaly shale at the position indicated.

WB7 shows the thickest development of coal in Area B and also the smallest stratigraphic interval between the seams. WB5, which is not shown on Figure 3, intercepts the three seams downdip from WB6 and also shows a reduced separation between seams. East of WB7 an influx of thick sandstones appears between Coals A and B increasing their separation from 29 feet 6 inches in WB7 to a maximum of 82 feet 9 inches in borehole 33. The sandstones decrease in thickness east of borehole 33 with WB15 showing gradation into siltstone.

Coals B and C persist throughout Area B and are the coals apparently worked from the McCarthy Slope. WB11 was stopped before reaching Coal C due to a cross correlation of Coal F with Coal A and is not shown on Figure 3.

Coal D is shown outcropping north of WB2 and WB29 on Figure 2 with correlative evidence suggesting its position north of WB6. It is believed to be represented by a 1 foot 3 inch seam in borehole 32 but complications of faulting in that area prevent reliance on outcrop projection. A comparison of both lithological and natural gamma logs provide a correlation between WB17 and WB29 which suggests the 6 inch seam at 113 feet in WB17 is Coal D. Thus Coals B and C are presumably displaced south of WB17 by faulting. This correlation could not be made during the drilling programme when only the geophysical logs were available.

Coal E is intercepted near the bottom of WB2 where it is represented by two thin seams totalling 9 to 12 inches of coal. WB29 was not quite deep enough to reach Coal E, which presumably is subsequently displaced by faulting to the north side of the Black River Road.

East of WB17 where the coal seams swing south around the nose of the syncline, the much-bootlegged outcrops may be a continuation of Coals B and C. This is suggested by previous geological maps that continue the No. 2 Seam from the McCarthy Slope into this area. On the other hand, it may be that they are not Coals B and C but a re-emergence of Nos. 1 and 2 Seams (Coals D and E) outside the zone of non-deposition.

Boreholes WB31, WB33 and WB38 were drilled in an attempt to locate the Golden Seam. WB31 and WB38 were drilled a short distance south of alleged outcrops on the north side of the Rodney Road. WB35 was drilled to provide complete stratigraphic coverage upwards from Coal A and also to pick up the Golden Seam if, like the others, it was displaced north by faulting. WB33 only went to 130 feet but was specifically located halfway between an old bootleg pit and a coal occurrence in a well and would have intercepted the suspected coal seam if it had been consistent between the two points.

Although several groups of thin seams from 1 to 6 inches thick were noted in WB31 and WB35 there was no indication of any significant coals. WB31, WB33 and WB38 were, however, characterized by dark red-brown or mottled dark red and grey mudstones not seen in strata lower down the succession (except for a single 3 foot layer in WB4 and two layers totalling 5 feet 3 inches in WB35). Strata of this type were found in WB27 and WB30 in Area D at approximately the same stratigraphic position above the No. 3 Seam.

Hacquebard and Donaldson (1964) indicate that the Golden Seam west of Area A is 4 feet 2 inches coal plus shale some 210 feet above the No. 3 Seam. A 9 inch coal seam was intercepted in WB5 at 217 feet above Coal A, but if this is correlated with the Golden Seam, it places the outcrop a long way north of the position shown on Figure 1. It is considered that WB5, WB4 and WB35 provide complete stratigraphic coverage for at least 500 feet above the No. 3 Seam and although, as mentioned above, several thin seams occur at higher levels than the 9 inch coal there are no significant coal seams in that part of the succession. It is concluded therefore that the Golden Seam is unlikely to occur as a mineable seam in Area B.

8.4 Area C

Area C was designated to cover the Nos. 6 and 7 Seams on the southern limb of the anticline. The existing geological maps indicated an extensive strike length and it was planned to intercept the seams at the west end and trace them to the east. WB8 and WB9 were drilled for this purpose but failed to encounter coal. It was therefore assumed that the west end of the strike length was not a simple pattern as shown on Figure 1, but that the complex faulting in the axial region in Area A persisted east into Area C.

The drilling rig was then moved to Victoria Street, which afforded a convenient north-south access, on the assumption that this would be sufficiently far to the east to be clear of the axial faulting. WB10, WB12, WB14 and WB16 were drilled which, together with 9E, gave a stratigraphic coverage that should have located the Nos. 6 and 7 Seams where they were shown to cross Victoria Street. However, the boreholes only encountered a 3 inch coal in WB10, 9 inch shaly coal in WB14, and a 12 inch coal in WB16.

The strata tended to be broken up making drilling difficult, as was the case with the Department of Mines boreholes drilled in 1959. The drilling rig was then moved further east to drill another north-south profile. In this instance WB18, WB20 and WB22 also displayed a lack of coal. WB20, like the earlier 7E, was aborted because of severe drilling conditions caused by broken strata and running sand.

Finally WB24 and WB28 were drilled to intercept coals whose outcrop was marked on Fletcher's geological map. However, only coal laminae and partings were encountered. It was concluded therefore that the Nos. 6 and 7 Seams did not occur as indicated on the geological map and no further attempts were made to locate them by drilling.

It was being conjectured by this stage in the drilling programme that the coals encountered in Area B represented the No. 3 Seam. The Nos. 1 and 2 Seams were thus suspected of outcropping immediately to the south of WB10. Hence WB32 and WB37 were drilled to check this by completing the stratigraphic coverage to the south. WB32 is quite close to 9EA which had suffered from poor core recovery to the extent that redrilling was warranted. However, nothing more than coal laminae and a 3 inch seam were encountered.

A layer of bituminous or carbonaceous mudstone that is distinctively less radioactive than the adjacent rocks provides a means of correlating WB29, WB37 and WB17 from the geophysical logs. On this basis the relict No. 1 Seam, Coal D, is expected to outcrop at the position of WB37 having been masked by the superficial deposits in that hole. This would imply downfaulting to the east of Coal D somewhere between WB6 and WB23. Coal E is thus probably represented in WB37 by the mudstone with coaly layers at 107 feet 6 inches.

As well as the general lack of coal, the strata in Area C are also noteworthy for a virtual absence of sandstone, being composed for the greater part of silty mudstones and siltstones. Also significant is the relative abundance of thin limestones, varying from argillaceous to crystalline but apparently unfossiliferous, and less frequent occurrence of calcarenites.

Detailed investigation of the geophysical logs in conjunction with the lithological records provides inter-borehole correlation, albeit tenuous, indicating that the strike pattern across Area C follows that of Area B. It appears that the strike is east-west between WB9 and WB32, turning east-northeast on the east side of the fault shown on Figure 2, and reverting to east-west somewhere between WB22 and WB28. The structure of Area C is however much more complicated than Area B as indicated by the variation in dip recorded in the boreholes. The mean dip of boreholes 29, 28 and 4E, all of which encountered the Nos. 6 and 7 Seams, varied from 12° to 18°; WB16 had a mean dip of 19 1/2°. To the south of these boreholes in a band from 8E to WB12 the dip is closer to 35°. Further east the dip between WB20 and WB22 is on average 22 1/2°.

Copeland (1958) explains the termination of the No. 6 Seam outcrop in Rogers Field by a westward trending fault zone, so that the outcrop is ".... displaced 2,000 ft. westward with a throw on the southern side of 400 ft.". Clearly this cannot be the case as a downthrow to the south would displace the outcrop to the east. Stratigraphically the No. 6 Seam is expected to outcrop at the position of WB16 (on the basis of the No. 1 Seam outcropping at WB37 as discussed above) and this, plus the occurrence of coal in the less steeply dipping strata south of Rogers Field, suggests the outcrop is displaced westward by no more than 500 feet. This of course implies that the fault downthrows to the north. It is suggested that the fault shown on Figure 2 is probably the first of several in the axial zone, the cumulative affects of which cause relatively little displacement of outcrop. The existence of other faults is shown by the coal intersections in boreholes 28 and 4E, for example, which indicate the presence of a fault downthrowing east by 260 feet between these boreholes.

It is concluded that although the Nos. 6 and 7 Seams are present south of Rogers Field (in the area that includes boreholes 28, 29 and 4E) they are inexplicably absent in the greater part of Area C that was investigated. WB16 is particularly enigmatic and must presumably have been drilled in an isolated downfaulted block, as may have been the case with borehole 2W in the axial zone in Area A.

The Nos. 6 and 7 Seams are, however, believed to outcrop along the east-west section of a tributary of the Black River to the east of WB22 and WB28. Evidence of a series of old bootleg pits and mines can be found in this area, one of which was known as Lloyds Slope. Figure 2 shows the approximate location of Lloyds Slope according to Fletcher's map. Inspection of the area indicated the presence of at least two seams striking east to southeast with dips from 12° to 18°. It is understood (Hacquebard, personal communication, 1977) that the coal section at Lloyds Slope is as follows:

coal	11 in.
shale	1 ft. 8 in.
coal	7 in.
coal + a little shale	3 ft. 10 in.

The structural complexity and severe topography around the Black River suggest that proving the outcrop east across the Black River would be impracticable. Nevertheless, it was proposed to move a drilling rig into the Lloyds Slope area, where structure and topography are more favourable, to investigate the strike length along the tributary and perhaps further to the east. The investigation was, however, terminated before this could be accomplished.

8.5 Area D

Area D is essentially the worked part of the coalfield and includes all the major Springhill mines. The Nos. 1, 2 and 3 Seams in this area have been worked along almost their entire strike length. Examination of the mine plans showed total extraction at shallow depths, and, in most areas, workings in close proximity to the surface. It is apparent that the greatest potential for coal reserves lies at the north and south extremities of the workings where either there were no workings at all or they did not approach the surface.

In the case of the Nos. 1 and 2 Seams the northern limit of workings extends beyond Area D and the southern limit, in the south part of Area D, appeared to be inaccessible for opencast mining without relocation of roads and dwellings. The No. 3 Seam outcrop, however, is generally sufficiently far to the west to avoid such restrictions.

Drilling commenced with WB25 in an attempt to delineate the intact coal left between the workings and the surface in the No. 3 Seam in the area south of the burning coal dump. Unfortunately WB25 was placed just east of the outcrop thus missing the seam. This indicated a need for greater precision in borehole location than could be achieved hence drilling was abandoned in favour of trenching. It was considered that trenching would provide a cheap and rapid method of locating the outcrop, after which boreholes could be accurately located to intersect the coal down-dip. The site investigation was, however, terminated before this method could be tried.

WB34 was drilled primarily to obtain a geophysical and lithological record of the strata directly overlying the No. 3 Seam. This provided a comparison with boreholes in Area B and assisted in correlating Coal A with the No. 3 Seam.

WB27 and WB30 were drilled in an abortive attempt to locate the Golden Seam based on outcrops in Coal Mine Brook shown on the geological maps. No coal, apart from 1 inch shaly coal in WB30, was found and the mudstones encountered were for the most part dark red-brown or mottled dark red and grey in colour. The lithologies are similar to those recorded in WB31, WB33 and WB38. Similarities in the natural gamma log suggest a tenuous correlation between the sandstones in WB30 and WB31 at 231 feet 9 inches and 140 feet 9 inches respectively.

The workings in the No. 3 Seam do not extend as far to the north as those of Nos. 1 and 2 Seams hence there is a block of intact coal in the No. 3 Seams in the northern part of Area D. WB36 was drilled in this block immediately north of the workings and intercepted two coal seams, of thickness 4 feet 6 inches and 3 feet 6 inches, believed at first to be the two leaves of the split No. 3 Seam. The separation was 75 feet whereas the mine plans indicated that a separation of this order should only be expected at depths approaching 1,200 feet. A detailed examination of the geological logs plus the lithological log when it became available suggested that the lower coal (at a depth of 140 feet 6 inches) is in fact the upper leaf of the No. 3 Seam. The seam intercepted at 65 feet 6 inches then correlates with Coal F. WB36 was therefore inadvertently stopped a short way above the lower leaf of the No. 3 Seam and hence is inconclusive. Further boreholes were planned to follow the No. 3 Seam to the north but were not drilled due to the termination of the investigation.

The outcrops of the Nos. 6 and 7 Seams in Area D are for the most part in the built-up areas of the town which would preclude their extraction. One particular area of open land in the southern part of Area D is known as Rogers Field and is marked as such on Figure 2. The Tingley Mine in the No. 7 Seam is in this area. No drilling was planned for Rogers Field, however, because of the abundance of boreholes already drilled as shown on Figure 2.

8.6 Area E

This area covers the extension of the outcrops to the north, the demarcation with Area D being the point at which the dips exceed

35°. Only the No. 2 Seam was mined in this area, from the Aberdeen Slope, with the workings extending as far north as the highway shown on Figure 1. The dip in the No. 2 Seam varies from 35° in the south to almost 65° at the limit of the workings.

Although included within the original brief, Area E was subsequently given a low priority, its investigation being dependent on the results from Area D. As a consequence no drilling was carried out in Area E.

9. OPENCAST PIT DESIGN

9.1 Basic Method

A major influence on the viability of an opencast mine is the volume of overburden to be removed per unit volume of coal extracted. This ratio of volumes is termed the stripping ratio. For an opencast mine on dipping strata the stripping ratio increases as the depth of the pit increases down the dip. Conversely a predetermined stripping ratio will govern the maximum depth of the pit. For the purposes of this report arbitrary stripping ratios of 10:1, 12 1/2:1 and 15:1 by volume have been used in the computation of reserves.

The quantity of coal available for mining is given by a stripping ratio formula, the one used in this report, and its derivation, given in Appendix 1. The formula used is for the general case of multiple seam working from a single pit but it is also valid for single seam pits. Insertion of the parameters stripping ratio, coal seam thicknesses, vertical interval between seams, thickness of superficial deposits, dip of strata and high wall slope angle into the formula enables the depth of the proposed pit to be calculated. A further computation gives the volume of coal per unit length of the pit for that particular depth. The basic assumptions in using the stripping ratio formula are:

(1) the topography is flat,
(2) the pit is of infinite length (that is, the side slopes are ignored),
(3) the dip and thickness of the coal remains constant.

Use of a stripping ratio allows a two-dimensional approach which provides a means of rapid assessment for initial planning. The computed reserves given in this report should therefore only be considered as a first approximation because of the variability of the basic parameters. More reliable estimates are based on the floor areas of proposed pits, but require determination of base of coal contours, coal and possibly ash isopachs and a realistic outcrop pattern based on topographic contours.

The tonnages have been calculated from the volumes on the assumption that one cubic yard of coal is equivalent to 2,240 pounds. They represent the total amount of unwashed coal available for the given stripping ratio. No attempt has been made to work on the basis of net tonnages of clean coal because of the limited information on ash contents. It should also be noted that the stripping ratio takes no account of cost factors such as the method of excavation of the overburden or control of the groundwater inflow.

9.2 Slope Stability

The opencast mines will be excavated down dip to give a pit floor at the dip of the strata and a high wall cut at the maximum angle within constraints of safety and interference to the works from slope failures. In the high wall the strata will dip downwards back from the face thus presenting the safest disposition of the bedding planes regarding slope failure. If, however, footwall slopes are cut into the pit floor causing the bedding planes to daylight in the slope a serious risk of translational sliding failure will be incurred. The risk will be particularly great in areas of high groundwater levels or artesian conditions.

In terms of rock strength visual examination during logging indicated the strata to be mainly moderately strong to strong with some 45 per cent of the total rock drilling being in the strong category. Compressive strength determinations McInnes, et. al. (1958) show very high values for the various strata including the mudstones. The overburden rock is thus much stronger than would normally be expected of Pennsylvanian strata. Slope collapse through mass failure of the rock is not considered likely in strata of such high strength. However, as the joint measurements indicated the majority of the joints were high angle, with dips from 60° to 90°, there is the increasing probability of local instability on any slopes exceeding 60°. Slopes angled greater than 60° are not therefore recommended without detailed geotechnical work to ascertain the joint distribution and groundwater conditions.

A factor likely to cause local instability is the occurrence of random extensive individual joints or faults which are not usually apparent from stereographic analysis of joint patterns. These may either form planes of sliding if they dip directly out of the slope or may form unstable rock wedges at places where they intersect. They are likely to be more of a problem on the side walls where they may form unstable rock wedges by utilizing the bedding planes as one of the two sliding surfaces. The structural complexity of the Springhill geology suggests that this sort of local slope instability could be of frequent occurrence. It is also possible that the tectonic development of the geological structure may have generated abnormally high horizontal stresses in the ground, remnants of which could still persist. These could adversely effect deeper excavations. As distribution of faults and major joints and states of stress are not generally known before excavation, any instability they may cause is usually dealt with during the course of the works, local slope failures being an acceptable part of opencast mining. It may be necessary for detailed investigation to be made in situations where high wall or side slope failure would prejudice adjacent structures or roads.

For the purposes of computing reserves in the potential opencast areas delineated in this report a high wall slope angle of 60° is assumed for slopes up to 200 feet high, with a reduction to 50° for slopes in the range 200 to 400 feet.

Cut slope angles in the superficial deposits will depend on the nature of the material and the groundwater conditions but are likely to be in the 25° to 35° range. No account is taken of the reduction in batter through the superficial deposits at the top of the high wall when computing reserves using the stripping ratio formula.

9.3 Additional Work

Whereas areas of potential opencast mining have been delineated in accordance with the brief it has not proved possible to substantiate the estimated reserves within the framework of this investigation. This was because of the variation over short distances of the quality and thickness of the coals, the complexity of the geology at a local level and the variable thickness of the superficial deposits.

Definition of the reserves in greater detail will thus require additional investigation. This will include boreholes at more closely spaced centres to delineate the geological structure and continuity of the seams and to provide sufficient core sample for assessing the quality of the coal. Trenches at close centres are likely to be necessary to locate the outcrops and provide information on the nature and thickness of the superficial deposits in this critical area. Computation of the tonnages and design of the mines will require adequate topographic map coverage.

Little information is available on the groundwater conditions as the boreholes were required to be backfilled with cement upon completion of drilling. This prevented determination of the standing water levels, although those cases of artesian groundwater resulting in overflow at the surface are noted on the relevant borehole records. Determination of the groundwater levels will necessitate the installation of standpipes or piezometers in certain of the additional boreholes and subsequent monitoring to determine seasonal fluctuation. Such information is a prerequisite to mine design as it affects both slope stability and mine drainage.

10. CALCULATION OF OPENCAST RESERVES

10.1 Area A

Area A tends to be divided by the east-northeast trending fault that passes through borehole 36. South of this fault the outcrops cross the axial zone of severe faulting. The complex geology of this zone is unlikely to be deciphered by drilling and holds little prospect for opencast reserves. The remaining part of the southern half shows a continuity of outcrop such that computation of reserves can be attempted.

The relevant parameters are:

Area: from the northeast-southwest fault south of borehole 2W to the Penitentiary.

Thickness of superficial deposits	29'0"	(mean of 2W & 3WE)
True thickness - coal A	4'6"	(mean of 3WB, 14W & 19W)
coal B	3'6"	(mean of 3WB & 4W)
coal C	4'0"	(mean of 3WB, 3WE & 4W)
Vertical interval coal C - coal B	42'0"	(mean of 3WB & 4W)
coal C - coal A	97'0"	(mean of 3WB & 4W)
Dip	14°	(by computation from 3WE & 14W)
High wall angle	50°	

Unfortunately, however, substitution in the formula indicates that because of the thickness of the superficial deposits the stripping ratio exceeds 12 1/2:1. This occurs whether 1, 2 or 3 seams are included in the pit design. This area only becomes a viable prospect for a stripping ratio of 15:1. The estimated reserve at this stripping ratio for a pit of maximum depth 215 feet, with a strike length of 720 feet and working all three coals is 205,000 short tons. The extent of this pit area is shown on Figure 2.

The Nos. 1 and 2 Seams are suspected of outcropping in the area of 3WA but are not likely to be extensive enough for opencast mining due to the faulting on the west side and the rapid deterioration in the zone of non-deposition to the east.

The northern half of Area A is essentially part of the northern limb of the anticline but being adjacent to the axial zone is structurally disturbed. No drilling was carried out in the area during this investigation but due to the suspected structural vagaries computation of reserves from available evidence will need substantiating by additional boreholes.

For the No. 3 Seam available reserves occur above the workings of the Syndicate Mine with an ash content, as indicated by tests on core from 1W and 21W, of about 22 per cent. Two pit areas, as shown on Figure 2, are considered:

Area: from 200 feet north of Syndicate Slope to the east-west fault passing through borehole 10.

Thickness of superficial deposits	11'6"	(mean of boreholes 1W & 10)

True thickness of coal	8'0"	(from 1W)
Dip	14 1/2°	(from Hacquebard & Donaldson 1965)
High wall angle	60°	

For a 10:1 stripping ratio the formula gives a maximum pit depth of 135 feet which would extend into the old workings. As the pillars were apparently drawn in the Syndicate Mine the pit depth is restricted to the top of the old workings at an approximate depth of 70 feet. The estimated reserve is based on a pit to this depth with a mean strike length of 900 feet, as shown on Figure 2, is 60,000 short tons. The stripping ratio would be about 6:1.

Area: from 200 feet south of Syndicate Slope to the east-northeast fault passing through borehole 36.

Thickness of superficial deposits	16'6"	(mean of boreholes 1W & 36)
True thickness of coal	8'0"	(from 1W)
Dip	16°	(from Hacquebard & Donaldson (1965)
High wall angle	60°	

For a 10:1 and 12 1/2:1 stripping ratios the formula gives maximum pit depths of 130 feet and 165 feet, both of which are above the level of the old workings. However, as the latter occurs within 100 feet of the workings little additional tonnage can be gained by considering deeper pits. From the extent of the pit areas as indicated on Figure 2 the estimated reserves are 70,000 and 105,000 short tons respectively for 10:1 and 12 1/2:1 stripping ratios.

These reserves in the No. 3 Seam are from both sides of the Syndicate Slope which would, together with the Miners' Museum, be left intact. The Black River Road, however, would have to be re-routed to accommodate the excavations. Further drilling at 400 feet or less will be necessary to prove the extension north and south of the Syndicate Slope as there is a possibility that the length of mineable near-surface coal could be restricted by undisclosed faults.

The two lower subordinate seams, Coals B and C, are possibly viable if extracted in conjunction with the No. 3 Seam, but insufficient knowledge of their disposition prevents further comment. Tests on Coal C from borehole 21W showed an ash content of 22.9 per cent.

The overlying Coal F shows a local thickening to a true thickness of 3 feet 9 inches in borehole 22W with tests showing an ash content of 13.2 per cent. It is however, sufficiently far removed from the No. 3 Seam to require a separate excavation and this would increase the stripping ratio to more than 10:1. Nevertheless viable reserves at higher stripping ratios appear likely in the following area:

Area: from borehole 21W to the east-northeast fault passing through borehole 36.

Thickness of superficial deposits	17'6"	(mean of 36 & 21W)
True thickness of Coal F	3'9"	(from 22W)
Dip	12 1/2°	(by computation from 1W, 7W & 22W)
High wall angle	60°	

At a stripping ratio of 12 1/2:1 the maximum pit depth is about 60 feet giving an estimated reserve of 25,000 short tons. A stripping ratio of 15:0 increases the maximum depth to 85 feet but this can only be realized at the southern end of the pit because of the proximity of dwellings along Leamington Road towards Millers Corner. The estimated reserves from the plan area shown on Figure 2 amount to 35,000 short tons.

The Nos. 1 and 2 Seams are known to outcrop in the northern half of Area A, the latter having been presumably worked from the Tabour and Ross Slopes. The outcrop pattern as shown on Figure 2 is probably an over-simplification and is likely to be complicated through undisclosed faulting. Furthermore the No. 2 Seam in boreholes 6E and 17E contained a substantial number of shale or mudstone layers in the lower part. Further drilling on a grid with centres of about 300 feet is therefore required to ascertain continuity of quality in the No. 2 Seam and to delineate outcrops. It may be necessary to excavate trenches in connection with the latter. Tests on the upper part of the No. 2 Seam from borehole 6E gave an ash content of 21.5 per cent.

Area: from the east-west fault passing through borehole 10 to the east-northeast trending fault passing through borehole 36.

Thickness of superficial deposits	20'0"	(from 17E)
True thickness No. 1 Seam	9'9"	(mean from 10 & 15)
No. 2 Seam	9'9"	(mean of 10, 6E and 17E)
Vertical interval	83'0"	(from 10)
Dip	21 1/2°	(by computation from 10 6E & 17E)
High wall angle	50° or 60°	

From the above parameters it is calculated that for a 10:1 stripping ratio a pit working both seams would have a maximum depth of 270 feet and yield some 630,000 short tons. The approximate proportions would be 230,000 tons from the No. 1 Seam and 400,000 tons from the No. 2 Seam. No account has been taken of depletion of reserves from the Tabour and Ross Mines in the No. 2 Seam. This potential reserve is likely to involve substantial interference to dwellings along Hall Street and probably Herrit Road depending on precise location of the outcrop. It is not therefore considered a viable pit design within the context of this report.

If, on the other hand, only the No. 1 Seam is mined such disturbance is much reduced. Reserves from the No. 1 Seam to the extent indicated on Figure 2 are estimated at 175,000, 230,000 and 255,000 short tons respectively for stripping ratios of 10:1, 12 1/2:1 and 15:1. The maximum pit depth in each case would be 155 feet, 200 feet (at 60°) and 220 feet (at 50°).

The viable reserves from Area A at the various stripping ratios are summarized in Table 1.

10.2 Area B

Only the No. 3 Seam and its subordinates, referred to as Coals A, B and C, present any prospect for opencast mining in Area B. The Golden Seam is insignificant, if it can be identified at all, and the Nos. 1 and 2 Seams although probably outcropping right across Area B appear only as marker horizons.

Figure 4 is a diagrammatic representation of the coal seam characteristics which incorporates the ash contents as determined from the coal tests on the core samples. Although shortcomings in core recovery in places may reduce the reliability of the test results, it is apparent from Figure 4 that the coals are not of good quality. In particular, Coal C invariably has an ash content in excess of 30 per cent and except for the areas around WB21 and WB23 is not considered a viable seam. Coal B, for the most part part, has an ash content in the range of 25 to 30 per cent rising above 35 per cent in places. Coal A is the best of the three with an ash content generally about 20 per cent but it too displays local deteriorations as in WB26.

No allowance has been made for the ash content in estimating the opencast reserves as the level of information does not justify it, hence all tonnages given below represent "as-dug", unwashed coal. The reserves are computed from the formula given in Appendix 1 using 10:1, 12 1/2:1 and 15:1 stripping ratios on a two-dimensional basis. No account is taken of topographic changes although the general fall of the land towards the Black River will tend to make estimates slightly conservative. In order to define reserves more accurately it will be necessary to augment the available information by additional drilling, sampling and testing based on the outcrop pattern established from this present investigation.

The reserves along the east-west strike of Coals A, B and C in Area B are assessed borehole by borehole to give the total estimated reserves shown in Table 1 as follows:

<u>WB3</u>

Thickness of superficial deposits	9'9" (mean of WB2, WB3 & WB29)		
True thickness of Coal A allow	4'0"		
Dip	23°		
High wall angle	60°		
Stripping ratio	10:1	12 1/2:1	15:1
Depth of pit	60 ft.	80 ft.	95 ft.
Quality of coal (short tons per ft. run)	19.91	28.83	34.33
Approximate tonnage	20,000	25,000	30,000

The extent of the pit is shown on Figure 2 with a strike length of 1,000 feet. Only Coal A is considered viable in WB3 and this should give reserves with an ash content of about 20 per cent. The tonnages given above are tentative estimates because of complications by the suspected faulting, although a strike fault as indicated could be advantageous by causing repetition of the coal seams. It will be necessary to define the faults more precisely and locate the outcrops by trenching in order to delineate the available strike length. Groundwater overflows were experienced in WB2 and WB29, thus artesian water conditions can be expected in excavations in this area.

<u>WB6</u>

Thickness of superficial deposits	10'3" (mean of WB6, WB7 & WB29)		
True thickness Coal A	2'0"		
Coal B	3'9"		
Vertical interval	33'9"		
Dip	25°		
High wall angle	60°		
Stripping ratio	10:1	12 1/2:1	15:1
Depth of pit	80 ft.	105 ft.	135 ft.
Quantity of coal (short tons per ft. run)	32.84	46.10	64.30
Approximate tonnage	25,000	35,000	50,000

The extent of the pit, working Coals A and B for a strike length of 800 feet is shown on Figure 2. The ash content of Coal A is likely to be about 20 per cent and that of Coal B about 25 per cent.

WB7

Thickness of superficial deposits	12'3" (mean of WB6, WB7 & WB26)		
True thickness of Coal A	5'0"		
Coal B	5'0"		
Vertical interval	29'6"		
Dip	25°		
Stripping ratio	10:1	12 1/2:1	15:1
High wall angle	60°	50°	50°
Depth of pit	155 ft.	180 ft.	225 ft.
Quantity of coal (short tons per ft. run)	123.28	148.52	195.80
Approximate tonnage	110,000	135,000	175,000

The extent of the pit working Coals A and B for a strike length of 900 feet is shown on Figure 2. The average ash content is likely to be between 20 and 25 per cent. Strike faults downthrowing north such as the one indicated between WB6 and WB5 that may occur within the pit area will have the effect of increasing the viable tonnage.

WB26

Thickness of superficial deposits	7'6" (mean of WB7, WB23 & WB26)		
True thickness of Coal B	4'3"		
Dip	25°		
Stripping ratio	10:1	12 1/2	15:1
Depth of pit	70 ft.	85 ft.	105 ft.
Quantity of coal (short tons per ft. run)	25.14	30.21	38.92
Approximate tonnage	15,000	20,000	25,000

Coal A shows a local deterioration at WB26 and ceases to be viable, therefore only Coal B is considered. The extent of the pit working Coal B only for a 700 foot strike length is shown on Figure 2. The ash content will probably be between 25 and 30 per cent.

WB23

Thickness of superficial deposits	10'9" (mean of 33, WB23 & WB26)		
True thickness of Coal B	4'6"		
Coal C	2'3"		
Vertical interval	8'0"		
Dip	25°		
High wall angle	60°		
Stripping ratio	10:1	12 1/2:1	15:1
Depth of pit	105 ft.	135 ft.	165 ft.
Quantity of coal (short tons per ft. run)	56.57	76.20	96.11
Approximate tonnage	40,000	50,000	65,000

No information on Coal A is available, but its stratigraphic distance from Coal B at this point may preclude the possibility of mining it in conjunction with Coals B and C. The extent of the pit working Coals B and C for a 700 foot strike length is shown on Figure 2. The ash content of 29.5 per cent for Coal B is based on incomplete core recovery, the geophysical log indicating the mean ash content may be between 20 and 25 per cent. The ash content of Coal C is 23.5 per cent.

WB21

Thickness of superficial deposits	14'3" (mean of 32, 33 & WB21)		
True thickness of Coal A	2'6"		
Coal B + C	4'6"		
Vertical interval	73'6"		
Dip	25°		
High wall angle	60°		
Stripping ratio	10:1	12 1/2:1	15:1
Depth of pit	60 ft.	105 ft.	145 ft.
Quantity of coal (short tons per ft. run)	18.47	46.10	74.22
Approximate tonnage	10,000	30,000	45,000

Although Coal A shows a return to a lower ash content of 17.8 per cent the limited thickness and the large stratigraphic separation from the other coals precludes its viability at a stripping ratio of 10:1. Thus the estimated tonnage of 10,000 is from a pit strike length of 650 feet, as indicated on Figure 2, working Coals B and C only. As these two coals are close together they are treated as one. At stripping ratios of 12 1/2:1 and 15:1 all three coal seams are worked. The ash content of the reserves in this area is probably not much over 20 per cent.

WB19-WB15

This section of the outcrop does not yield any viable reserves. Coal A has an ash content of just over 20 per cent in the section from WB19 to WB11 and Coal B has an ash content of 30 per cent from WB19 to WB13. The detrimental factor however is the superficial deposits which show a dramatic increase in thickness due to a gravel and boulder deposit in the area of WB11 and WB13.

10.3 Area C

No viable reserves were proved in Area C during this investigation. The Nos. 6 and 7 Seams are known to occur at depth in the area of boreholes 28, 29 and 4E in a block of relatively shallow-dipping strata. It is suspected, however, that due to its location in the axial zone of the anticline this area will be structurally complex. The potential for opencast reserves is thus reduced, and the problems of proving them increased. None of the other boreholes in Area C found any significant coal seams.

One area not covered by this investigation, but suspected of having potential opencast reserves, is along the east-west section of the Black River tributary at Lloyds Slope. The dip is relatively shallow varying from 12° to 18°, in sharp contrast to the hilly area around WB24, WB28 and the north-south sections of the Black River and its tributary, where dips approach 90°.

Several small pits and slopes that presumably worked the Nos. 6 or 7 Seams are present in the Lloyds Slope area. The location of Lloyds Slope itself is given on Fletcher's early geological map and marked accordingly on Figure 2. However, Lloyd's Slope could not be identified in the field at the time of this investigation. A rough estimate of the opencast reserves for a 10:1 stripping ratio is given as follows:

Thickness of superficial deposits	10'0" (based on field observation)
True thickness of coal	5'0" (from Lloyds Slope - see Section 8, Area C)
Dip	15° (mean of field readings & Fletcher's values)

High wall angle	60°
Depth of pit	75 ft.
Quantity of coal (short tons per ft. run)	45.71

Fletcher's map suggests a strike length of the order of 2,000 feet which would give an estimated reserve of 90,000 short tons. Because of the lack of information on the quality of the coal and reservations on the reliability of the figures for the strike length and superficial deposit thickness, confirmation of this estimate will require a drilling programme.

10.4 Area D

Only a limited amount of coal is present between the top level of the workings and the outcrop in the Nos. 1, 2 and 3 Seams. Moreover, the outcrops of the Nos. 1 and 2 Seam are for the most part under the built-up areas of Springhill. Those areas of accessible outcrop were usually the scene of bootleg mining operations. It is unlikely, therefore that the near-surface coal along the worked sections of the seams will be commercially viable.

It is believed that WB36, located in the zone of intact coal north of the No. 3 Seam workings, did not penetrate both leaves of the split No. 3 Seam. The upper seam in WB36, correlated with Coal F, showed a true thickness of 3 feet 9 inches and ash content of 10 per cent.

Thickness of superficial deposits	16'0" (WB36)		
True thickness of Coal F	3'9" (WB36)		
Dip	34° (WB36)		
High wall angle	60°		
Stripping ratio	10:1	12 1/2:1	15:1
Quantity of coal (short tons per ft. run)	-	11.39	17.09

Although this coal is not viable at a 10:1 stripping ratio it could yield some 10,000 or 20,000 short tons if the stripping ratio were raised to 12 1/2:1 or 15:1 for a pit length of some 1,200 feet.

The lower coal in WB36 with an ash content of 11.6 per cent is correlated with the upper leaf of the No. 3 Seam. With a true thickness of 2 feet 9 inches it is barely viable at a 15:1 stripping ratio. It is possible that the lower leaf with similar thickness and quality may occur within a short depth below this coal. If two such leaves occur with a 15 foot interval between them for example, it would allow extraction of the overlying Coal F in the same pit. For a stripping ratio of 15:1

and an available strike length of 1,200 feet reserves from all three seams could amount to 120,000 short tons. This estimate is speculative and would require additional boreholes to prove the existence and continuity of the seams over the mineable area.

The outcrops of the Nos. 6 and 7 Seams occur mainly beneath built-up areas of Springhill and only appear accessible in the Rogers Field area. The results of 1959 Department of Mines boreholes indicate that geological conditions vary across this area from north to south. Hence for the purpose of computation Rogers Field is divided into northern and southern halves.

Area: Rogers Field north, from borehole 22 to half way between boreholes 1E and 13E.

Thickness of superficial deposits	13'9"	(mean of 22, 23, 1E, 1EA & 13E)
True thickness of No. 7 Seam	4'6"	(mean of 22, 23, 1EB & 15E)
True thickness of intermediate coal	2'6"	(mean of 22, 23, 1EA, 1EB & 15E)
True thickness of No. 6 Seam	4'0"	(mean of 23 & 1EB)
Vertical interval No. 6-No. 7 Seams	86'9"	(mean of 23, 1EB & 15E)
No. 6 to intermediate coal	49'3"	(mean of 23, 1EB & 15E)
Dip	18°	(by computation)

Stripping ratio	10:1		12 1/2:1	15:1
Coal Seams	No. 6	No. 7	all 3 Seams	all 3 Seams
High wall angle	60°	60°	60°	50°
Depth of pit	50 ft.	65 ft.	180 ft.	220 ft.
Quantity of coal (short tons per ft. run)	17.23	29.11	181.94	245.74
Approximate tonnage	5,000	10,000	80,000	110,000

For a 10:1 stripping ratio only the Nos. 6 and 7 Seams, mined separately are viable, giving a total reserve of some 15,000 short tons for a 450 foot strike length. At higher stripping ratios multiple seam pits become viable and thus allow exploitation of the intermediate coal between the Nos. 6 and 7 Seams. Figure 2 shows the extent of the pit areas. The ash contents of the Nos. 6 and 7 Seams in this area appear to be in the range of 10 to 15 per cent, that of the intermediate coal is not known but is likely to be somewhat higher. No allowance has been made of the coal already extracted from Tingley's Mine in the above estimates.

Area: Rogers Field south, from halfway between boreholes 1E and 13E to borehole 3EA.

Thickness of superficial deposits	14'6" (mean of 23, 1E, 1EA, 2E, 3EA & 13E)		
True thickness of No. 7 Seam	2'9" (mean of 2E, 3E & 13E)		
intermediate Coal	2'9" (mean of 2E, 3E & 13E)		
No. 6 Seam	3'6" (mean of 2E, 3E & 3EA)		
Vertical interval No. 6-No. 7 Seam	76'3" (mean of 2E & 3E)		
No. 6 to intermediate coal	51'6" (mean of 2E & 3E)		
Dip	22° (by computation)		
High wall angle	60°		
Stripping ratio	10:1	12 1/2:1	15:1
Depth of pit	-	140 ft.	185 ft.
Quantity of coal (short tons per ft. run)	-	91.92	135.42
Approximate tonnage	-	45,000	70,000

Neither single seam pits nor multiple seam pits are viable at a 10:1 stripping ratio; however, for a strike length of 520 feet as shown on Figure 2 the latter could yield up to 70,000 short tons as indicated above. The ash contents of the Nos. 6 and 7 Seams appear somewhat higher in this area than the northern half of Rogers Field with a mean value of about 17 per cent. The intermediate coal was only tested in borehole 3E where the ash content was 24.1 per cent.

Total available reserves in Rogers Field are given in Table 1.

10.5 Area E

The coal seams in this area were not investigated during this present drilling program. Certain information is, however, available from the old mine plans. The Nos. 6 and 7 Seams are shown to be dipping at 54° and 43° respectively at the northern limit of the workings but are not viable for opencast mining because of a reduction in thickness. The No. 2 Seam remains 8 feet thick throughout most of the area and although the pillars were drawn it appears that sufficient coal was left above the first level to suggest the possibility of opencast mining. The dip varies from 50° to 60° for the most part but insufficient information is available on the thickness of superficial deposits to warrant any computation of reserves. No information is available regarding the near-surface conditions pertaining to the Nos. 1 and 3 Seams in Area E.

11. CONCLUSIONS

1) Because of the previously undisclosed complexity of the geology the original concept of a detailed evaluation of opencast reserves by drilling had to be changed to one of essentially exploratory drilling.

2) The results of this investigation have allowed delineation of potential opencast areas only.

3) The thickness of superficial deposits is often the governing factor in determining the viability of potential opencast areas; however, little reliable information is available concerning this aspect. Substantial investigation by trenching or soft-ground boring techniques is required to determine the variation in thickness along the coal outcrop and hence improve the accuracy of reserve calculations.

4) The estimated total potential opencase reserves of unwashed coal in the Springhill area based on the results of this investigation are as follows:

Stripping ratio	10:1	12 1/2:1	15:1
Tonnage (short tons)	540,000	850,000	1,250,000

5) A second stage of detailed investigation will be necessary to confirm these estimates by proving continuity of seam thickness and quality in each of the potential areas.

6) Excavation of the rock overburden will require blasting throughout.

7) Additional areas of potential opencast reserves not investigated during this present drilling program include:

Area C	Nos. 6 & 7 Seams	Lloyds Slope area
Area D	No. 3 Seam	North of workings
Area E	No. 2 Seam	Near-surface coal above workings

12. ACKNOWLEDGEMENTS

Acknowledgements are made to the Nova Scotia Department of Mines for providing office facilities at Springhill, for making available borehole records and mine plans, for supplying a geologist to assist with the site work, and also for providing drawing office and typing services during the production of this report.

TABLE 1

Estimated Opencast Coal Reserves at Springhill

Area	Seam	Location	Tonnage* per stripping ratio 10:1	12 1/2:1	15:1
A	Coals A, B & C	South of Black River Road	-	-	205,000
	No. 3	North of Syndicate Slope	60,000	60,000	60,000
	No. 3	South of Syndicate Slope	70,000	105,000	105,000
	Coal F	Borehole 21W	-	25,000	35,000
	No. 1	North of Black River Road	175,000	230,000	255,000
B	Coals A, B & C	Boreholes WB3 to WB21	220,000	295,000	390,000
D	Coal F	Borehole WB36	-	10,000	20,000
	Nos. 6 & 7	Rogers Field	15,000	125,000	180,000
	Totals		540,000	850,000	1,250,000

* short tons

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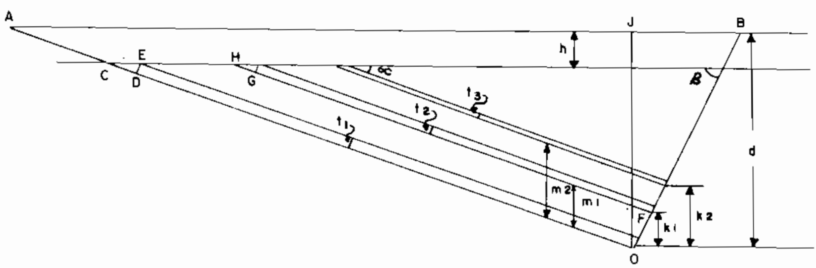
APPENDIX 1

DERIVATION OF STRIPPING RATIO FORMULA

APPENDIX 1

DERIVATION OF STRIPPING RATIO FORMULA

For a single depth opencast pit of infinite strike length on dipping strata an approximation of the stripping ratio for multiple seam working is derived as follows:



Maximum depth of pit to base of lowest coal seam	= d
Thickness of superficial deposit	= h
True thickness of coal seams	= t_1, t_2 . . .
Vertical distance between base of lowest coal and base of each succeeding coal	= m_1, m_2 . . .
Dip of coal seams	= α
Slope angle of high wall	= β

Volume of coal, Vc, = OD x t_1 + FG x t_2 + ... neglecting feather-edge of coal CDE

$$= (OC - CD) \times t_1 + (FH - HG) \times t_2 + \ldots$$

$$= \left(\frac{(d - h)}{\sin\alpha} - \frac{t_1}{\tan\alpha}\right) t_1 + \left(\frac{(d - h - k_1)}{\sin\alpha} - \frac{t_2}{\tan\alpha}\right) t_2 + \ldots$$

$$= \frac{(d-h)}{\sin\alpha} t_1 + \frac{(d-h)}{\sin\alpha} t_2 + \frac{(d\ \ h)}{\sin\alpha} t_3 - \frac{1}{\sin\alpha}(k_1 t_2 + k_2\ t_3) - \frac{1}{\tan\alpha}(t_1^2 + t_2^2 + t_3^2)$$

now k = OF sin

and $OF = \frac{m_1 \cos\alpha}{\sin(\alpha+\beta)}$

hence $k_1 = \frac{m_1 \cos\alpha \sin}{\sin(\alpha+\beta)}$

$$\therefore\ Vc = \frac{(d-h)}{\sin\alpha}(t_1 + t_2 + t_3) - \frac{\sin\beta}{\tan\ \sin(\alpha+\beta)}(m_1\ t_2 + m_2 t_3) - \frac{1}{\tan\alpha}(t_1^2 + t_2^2 + t_3^2) \quad ..(1)$$

Volume of overburden, Vo = OAB - Vc

$$= OAJ + OBJ - Vc$$

$$= \frac{\frac{1}{2}.d^2}{\tan\alpha} + \frac{\frac{1}{2}.d^2}{\tan\beta} - Vc$$

$$= \frac{1}{2}.d^2(\cot\alpha + \cot\beta) - Vc$$

Stripping ratio, $R = \frac{Vo}{Vc}$

$$R = \frac{\frac{1}{2}.d^2(\cot\alpha + \cot\beta) - Vc}{Vc}$$

$$\therefore\ Vc.R = \frac{1}{2}.d^2(\cot\alpha + \cot\beta) - Vc$$

$$Vc(R+1) = \frac{1}{2}.d^2(\cot\alpha + \cot\beta)$$

$$\therefore\ Vc = \frac{d^2(\cot\ + \cot\ )}{2(R+1)} \quad \text{------------ (2)}$$

substituting equation (1) in equation (2) gives

$$\frac{(d-h)}{\sin\alpha}(t_1 + t_2 + t_3) - \frac{\sin\beta(m_1\ t_2 + m_2 t_3)}{\tan\alpha \sin(\alpha+\beta)} - \frac{1}{\tan\alpha}(t_1^2 + t_2^2 + t_3^2) = \frac{d^2(\cot\alpha + \cot\beta)}{2(R+1)}$$

which becomes a quadratic in terms of d

$$d^2\frac{(\cot\alpha + \cot\beta)}{2(R+L)} - \frac{d(t_1 + t_2 + t_3)}{\sin\alpha} + \frac{h}{\sin\alpha}(t_1 + t_2 + t_3) + \frac{\sin\beta}{\tan\alpha \sin(\alpha+\beta)}(m_1 t_2 + m_2 t_3) + \frac{1}{\tan\alpha}(t_1^2 + t_2^2 + t_3^2) = 0$$

this is solved to get d which is then substituted in equation (2) to get the volume of coal per unit run of strike.

APPENDIX 2

SURVEY INFORMATION

APPENDIX 2

SURVEY INFORMATION

Borehole	Coordinate System			
	UTM 6°		3° TM	
	E	N	E	N
1	1 365 841.3	16 579 678.5	1 109 049.2	16 583 104.6
2	1 367 574.4	16 578 161.6	1 110 810.8	16 581 620.0
3	1 367 533.7	16 577 568.0	1 110 781.2	16 581 025.6
4	1 368 947.4	16 577 106.1	1 112 203.6	16 580 590.2
5	1 369 014.1	16 577 596.5	1 112 261.1	16 581 081.8
6	1 369 018.5	16 578 089.7	1 112 256.3	16 581 575.2
7	1 369 878.7	16 578 030.5	1 113 117.6	16 581 532.1
8	1 369 153.5	16 580 041.0	1 112 354.8	16 583 529.1
9	1 368 924.4	16 579 596.2	1 112 134.0	16 583 080.0
10	1 371 160.8	16 579 824.5	1 114 366.2	16 583 350.2
11	1 373 423.5	16 578 630.5	1 116 651.4	16 582 198.4
12	1 371 172.1	16 580 717.5	1 114 360.8	16 584 243.4
13	1 374 225.8	16 578 706.6	1 117 452.3	16 582 289.6
14	1 371 196.7	16 580 098.2	1 114 397.0	16 583 624.5
15	1 374 790.5	16 578 838.2	1 118 014.6	16 582 431.7
16	1 370 973.3	16 580 924.4	1 114 158.1	16 584 446.6
17	1 375 429.1	16 578 579.4	1 118 654.7	16 582 364.9
18	1 372 572.2	16 580 829.5	1 115 758.9	16 584 381.6
19	1 372 828.9	16 578 594.0	1 116 057.5	16 582 150.8
20	1 372 421.9	16 581 261.5	1 115 600.5	16 584 810.8
21	1 372 208.1	16 578 576.6	1 115 437.0	16 582 121.8
22	1 372 676.7	16 580 470.8	1 115 870.1	16 584 024.9
23	1 371 331.1	16.578 549.4	1 114 560.4	16 582 078.2
24	1 374 447.8	16 581 075.9	1 117 630.0	16 584 663.2
25	1 365 557.9	16 582 608.8	1 108 710.9	16 586 029.7
26	1 370 851.7	16 578 139.1	1 114 088.7	16 581 658.9
27	1 364 508.5	16 584 287.8	1 107 630.0	16 587 689.2
28	1 374 286.9	16 581 258.9	1 117 465.7	16 584 843.2
29	1 368 221.5	16 578 101.7	1 111 459.0	16 581 572.2
30	1 364 806.0	16 584 046.9	1 107 932.1	16 587 453.8
31	1 367 961.3	16 576 207.5	1 111 234.3	16 579 673.1
32	1 370 857.6	16 579 566.9	1 114 067.8	16 583 086.9
33	1 368 520.4	16 576 250.9	1 111 792.6	16 579 727.0
34	1 365 284.0	16 582 939.0	1 108 430.8	16 586 354.8
35	1 368 920.9	16 576 707.1	1 112 184.6	16 580 190.7
36	1 367 650.6	16 587 573.3	1 110 710.8	16 591 033.7
37	1 371 362.8	16 579 197.9	1 114 580.0	16 582 727.3
38	1 371 124.6	16 576 127.4	1 114 399.2	16 579 652.2

borehole	latitude	longitude
1	45 37 54.60450	64 4 25.33869
2	45 37 39.85325	64 4 0.66111
3	45 37 33.98610	64 4 1.12282
4	45 37 29.61088	64 3 41.14138
5	45 37 34.46152	64 3 40.29443
6	45 37 39.33329	64 3 40.32397
7	45 37 38.86102	64 3 28.20742
8	45 37 58.61951	64 3 38.78724
9	45 37 54.19732	64 3 41.92912
10	45 37 56.74336	64 3 10.49493
11	45 37 45.24414	64 2 38.42796
12	45 38 5.56252	64 3 10.50080
13	45 37 46.09945	64 2 27.15034
14	45 37 59.44992	64 3 10.03995
15	45 37 47.47057	64 2 19.22611
16	45 38 7.57994	64 3 13.33757
17	45 37 46.77456	64 2 10.22396
18	45 38 6.84954	64 2 50.81376
19	45 37 44.80745	64 2 46.78912
20	45 38 11.09600	64 2 53.00894
21	45 37 44.55570	64 2 55.52308
22	45 38 3.32152	64 2 49.27716
23	45 37 44.17377	64 3 7.86200
24	45 38 9.52470	64 2 24.45808
25	45 38 23.50280	64 4 29.88118
26	45 37 40.05984	64 3 14.53257
27	45 38 39.94396	64 4 44.97189
28	45 38 11.31120	64 2 26.75587
29	45 37 39.34661	64 3 51.54351
30	45 38 37.60409	64 4 40.73702
31	45 37 20.60815	64 3 54.85035
32	45 37 54.16012	64 3 14.71488
33	45 37 21.11035	64 3 46.99075
34	45 38 26.72728	64 4 33.79930
35	45 37 25.66750	64 3 41.43948
36	45 39 12.80327	64 4 1.35259
37	45 37 50.58147	64 3 7.53515
38	45 37 20.22990	64 3 10.32084

APPENDIX 3

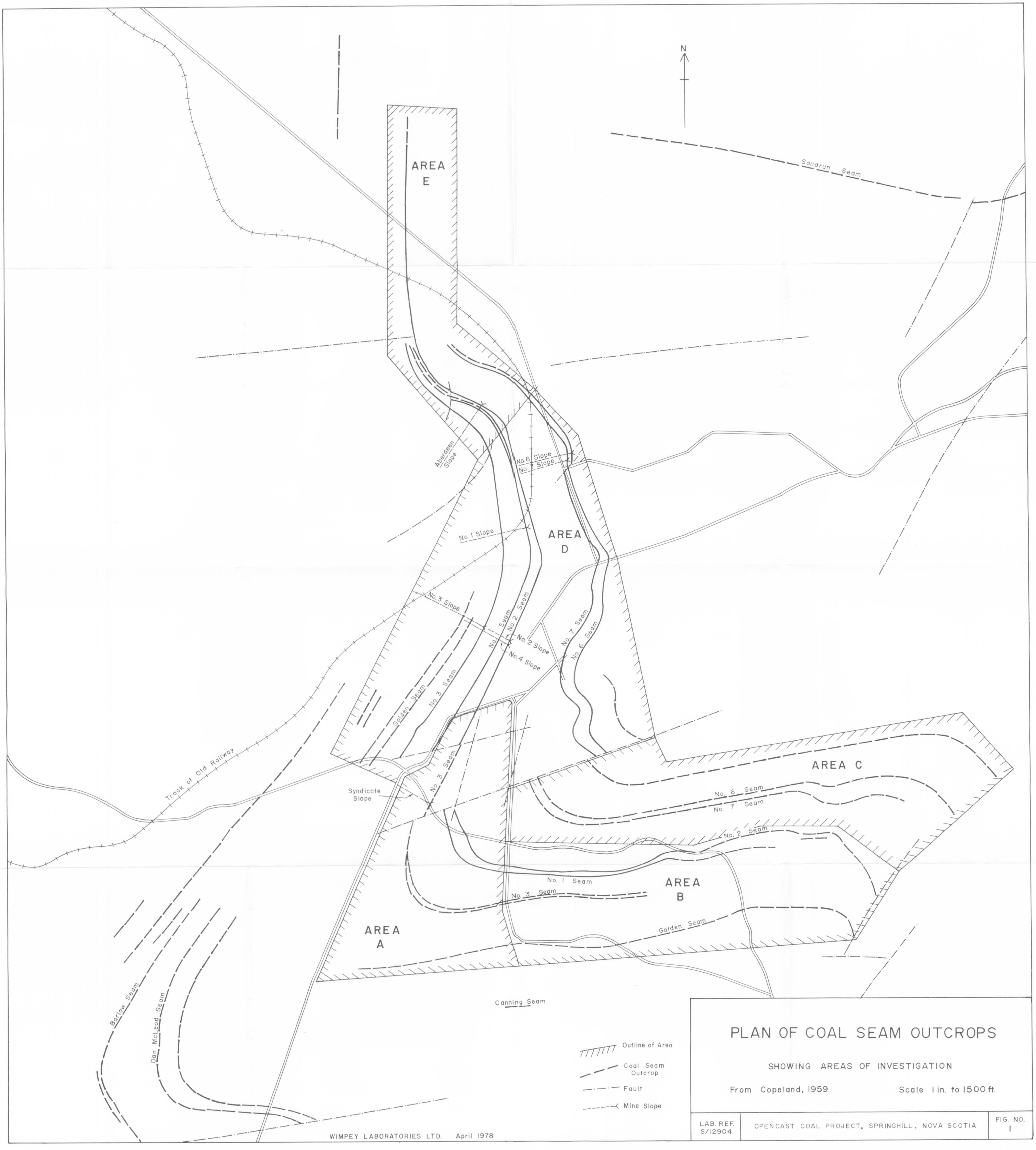
TEST RESULTS

APPENDIX 3

TEST RESULTS

Borehole No.	Sample No.	Depth of Sample	Moisture %	Ash %	Sulphur %	Volatite %	Fixed Carbon %
WB1	B0101	43'9" - 47'6"	2.3	17.8	3.9	29.4	50.6
	B0102	49'6" - 50'6"	2.7	10.1	1.7		
	B0103	50'6" - 51'6"	2.8	8.7	1.6	32.3	56.1
	B0104	51'6" - 52'6"	3.1	7.1	1.8		
	B0105	52'6" - 53'6"	2.1	18.1	1.9	29.5	50.2
WB3	B0301	42'0" - 43'0"	1.6	38.3	2.5		
	B0302	43'0" - 44'0"	1.6	41.4	1.9		
	B0303	44'0" - 45'0"	1.8	18.4	3.0	32.4	47.4
	B0304	84'9" - 86'0"	1.5	35.9	3.6		
	B0305	89'0" - 90'3"	1.4	31.8	3.8		
	B0306	113'0" -114'0"	1.7	33.5	3.0		
	B0307	115'0" -115'9"	1.6	43.3	2.6		
	B0308	116'0" -116'6"	1.7	40.4	2.8		
	B0309	116'9" -117'6"	1.5	47.3	3.7		
	B0310	117'6" -118'6"	1.5	6.4	2.5		
WB5	B0501	226'0" -227'0"	1.3	22.2	1.5	31.6	45.0
	B0502	228'6" -229'0"	1.0	25.4	1.9		
	B0503	229'0" -230'0"	1.6	12.5	1.3	33.9	52.0
	B0504	230'0" -231'0"	1.2	19.4	2.3		
	B0505	231'0" -231'9"	1.4	13.4	3.8		
	B0506	232'6" -233'6"	1.4	15.6	4.2	34.4	48.6
	B0507	238'0" -239'0"	1.1	34.4	2.0		
	B0508	241'0" -241'9"	0.9	47.5	3.0		
	B0509	242'0" -242'9"	1.1	29.3	2.2		
	B0510	259'6" -260'6"	1.3	18.8	2.6		
	B0511	263'0" -264'0"	1.1	48.2	2.3		
	B0512	264'0" -264'9"	0.9	42.5	2.9		
WB6	B0601	102'9" -103'6"	1.3	19.4	2.3	27.8	51.5
	B0602	103'10"-105'0"	0.8	46.7	3.0		
	B0603	105'0 -106'0"	0.9	36.1	2.5		
	B0604	106'0" - 106'9"	0.9	44.3	2.5		
WB7	B0701	87'3" - 88'9"	1.8	15.3	1.9		
	B0702	90'3" - 94'3"	1.4	30.0	1.5		
	B0703	119'9" -113'9"	1.2	27.0	2.8		
	B0704	118'3" -118'9"	1.2	28.9	4.0		
	B0705	119'0" -119'9"	1.3	32.2	1.6		
	B0706	121'3" -122'0"	1.5	39.0	3.2		
	B0707	122'0" -123'0"	1.0	27.1	2.3		
	B0708	123'0" -123'9"	1.6	12.7	2.3		
	B0709	130'9" -131'9"	1.2	39.2	2.0		
	B0710	132'0" -133'0"	1.3	46.9	2.0		
	B0711	133'0" -134'9"	1.2	40.8	1.5		
WB11	B1101	137'0" -137'9"	1.4	20.0	1.6		
	B1102	141'3" -142'0"	1.2	40.0	2.2		
	B1103	142'0" -143'0"	1.7	11.4	3.0		
	B1104	143'0" -144'0"	1.6	19.4	3.2		
WB13	B1301	127'3" -128'0"	1.4	13.3	2.7		
	B1302	128'0" -129'0"	1.4	25.8	2.8		
	B1303	129'0" -130'0"	1.3	48.0	2.5		
	B1304	130'0" -131'0"	1.2	35.9	2.4		
	B1305	131'0" -132'0"	1.7	21.5	1.5		

Borehole No.	Sample No.	Depth of Sample	Moisture %	Ash %	Sulphur %	Volatite %	Fixed Carbon %
	B1306	133'3" -134'0"	1.2	21.0	2.9		
	B1307	135'0" -136'3"	1.2	37.0	0.8		
	B1308	149'0" -150'0"	1.4	38.4	2.4		
WB15	B1501	87'0" - 88'0"	1.3	29.0	1.5		
	B1502	88'0" - 89'0"	1.0	53.6	0.8		
	B1503	89'0" - 90'0"	1.1	31.5	2.7		
	B1504	90'0" - 90'9"	0.7	28.8	0.7		
	B1505	95'3" - 96'3"	1.3	23.8	3.4		
	B1506	97'3" - 98'3"	0.9	39.3	4.3		
	B1507	98'3" - 99'3"	1.0	45.1	3.4		
WB19	B1901	50'3" - 51'3"	1.3	20.7	3.3		
	B1902	52'3" - 53'9"	1.5	19.7	2.6		
	B1903	118'6" -120'3"	1.0	33.4	2.1		
	B1904	121'3" -122'9"	1.0	24.7	2.0		
	B1905	124'0" -125'0"	1.0	40.0	2.2		
	B1906	125'0" -126'6"	1.0	47.7	2.4		
WB21	B2101	71'3" - 72'6"	2.5	17.8	1.7		
	B2102	74'0" - 74'9"	2.8	13.0	1.7		
	B2103	74'9" - 75'6"	2.4	22.7	1.4		
	B2104	140'9" -142'0"	2.3	32.9	2.0		
	B2105	142'0" -142'9"	2.2	18.5	3.6		
	B2106	144'3" -145'0"	2.4	22.5	3.5		
	B2107	145'0" -145'9"	2.5	19.7	2.8		
	B2108	145'9" -146'6"	3.2	9.4	2.6		
	B2109	148'3" -149'0"	3.1	16.0	2.6		
WB23	B2301	46'9" - 47'3"	1.0	21.0	4.1		
	B2302	47'6" - 49'9"	0.7	36.7	3.4		
	B2303	54'3" - 55'3"	1.0	21.5	1.6		
	B2304	56'3" - 57'9"	0.8	25.1	2.9		
WB26	B2601	59'3" - 60'0"	1.5	49.8	1.2		
	B2602	116'6" -117'0"	2.0	34.9	1.6		
	B2603	119'6" -120'6"	2.0	25.0	6.4		
	B2604	120'6" -121'9"	1.8	32.7	1.6		
	B2605	127'0" -128'0"	1.8	31.1	3.1		
	B2606	128'0" -129'0"	1.6	55.0	5.1		
	B2607	129'0" -130'0"	1.4	53.4	3.0		
	B2608	130'0" -130'9"	1.8	24.2	3.6		
WB36	B3601	61'9" - 65'6"	3.1	10.3	1.6	32.7	53.8
	B3602	138'0" -140'6"	2.8	11.6	1.6	32.7	52.8



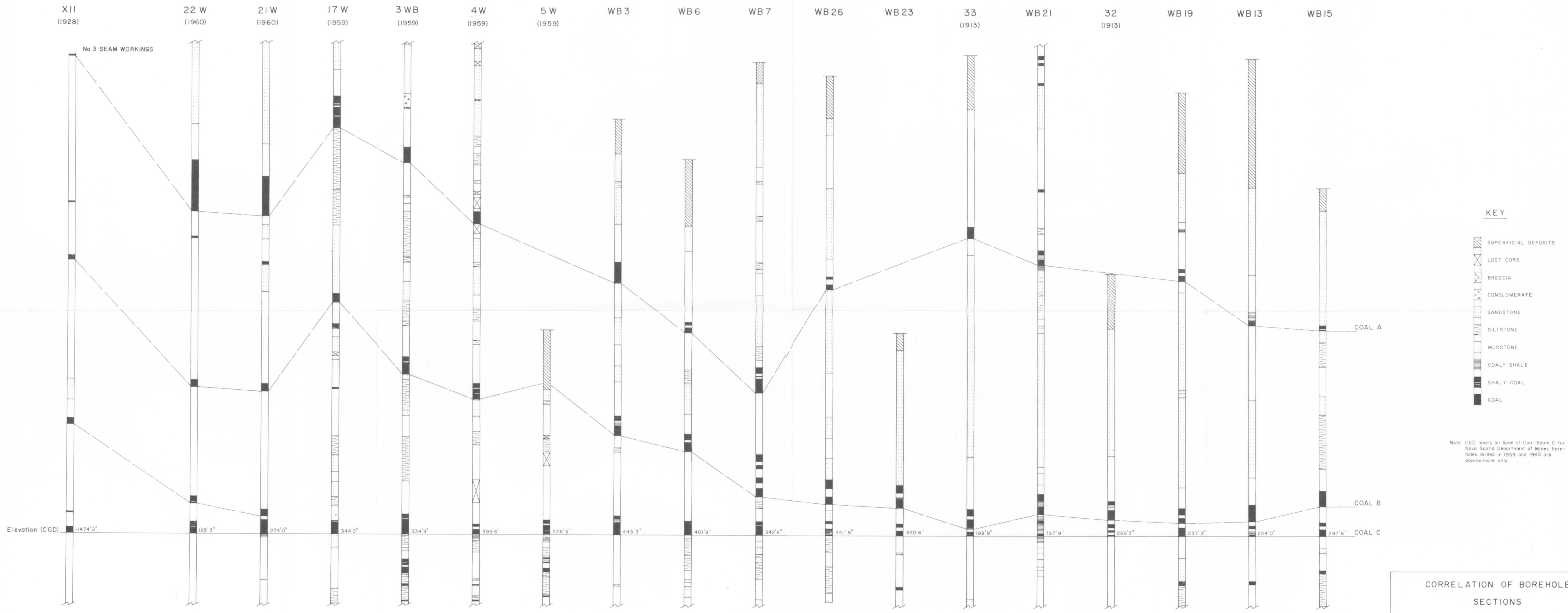
PLAN OF COAL SEAM OUTCROPS

SHOWING AREAS OF INVESTIGATION

From Copeland, 1959 — Scale 1 in. to 1500 ft.

LAB. REF. S/12904	OPENCAST COAL PROJECT, SPRINGHILL, NOVA SCOTIA	FIG. NO. 1


TRUE NORTH
MAGNETIC NORTH
DECLINATION 23°00' IN 1965
Main Street
No. 1 Slope
No. 3 Slope
No. 2 Slope
No. 4 Slope
No. 3 Seam
No. 2 Seam
No. 1 Seam
No. 7 Seam
No. 6 Seam
Track of old railway
Mills Brook
Old Coal Dump
Coal Mine Brook
New Mine Slope
Rogers Field
Tobiur & Ross Slopes
Hall Street
Herrit Road
McGee Street
Athol Road
Millers Corner
Syndicate Slope
Leamington Road
Black River Road
Black River
Smith Brook
McCarthy Slope
Lloyds Slope
Limit of penitentiary land
Penitentiary
Rodney Road
Potential Opencast Areas with estimated tonages
Stripping ratio 10:1
Strippig ratio 15:1
Boreholes:-
Cumberland Railway and Coal Company
Nova Scotia Dept. of Mines
Wimpey Laboratories Ltd.
coal seam outcrop
fault
major mine slope
small mine entrance
LOCATION OF POTENTIAL OPENCAST AREAS
Scale 1 in. to 800 ft.
Grid is based on Universal Transverse Mercator Projecton (UTM)
LAB REF S/12904
OPENCAST COAL PROJECT, SPRINGHILL, NOVA SCOTIA
FIG. NO. 2
WIMPEY LABORATORIES LTD April 1978



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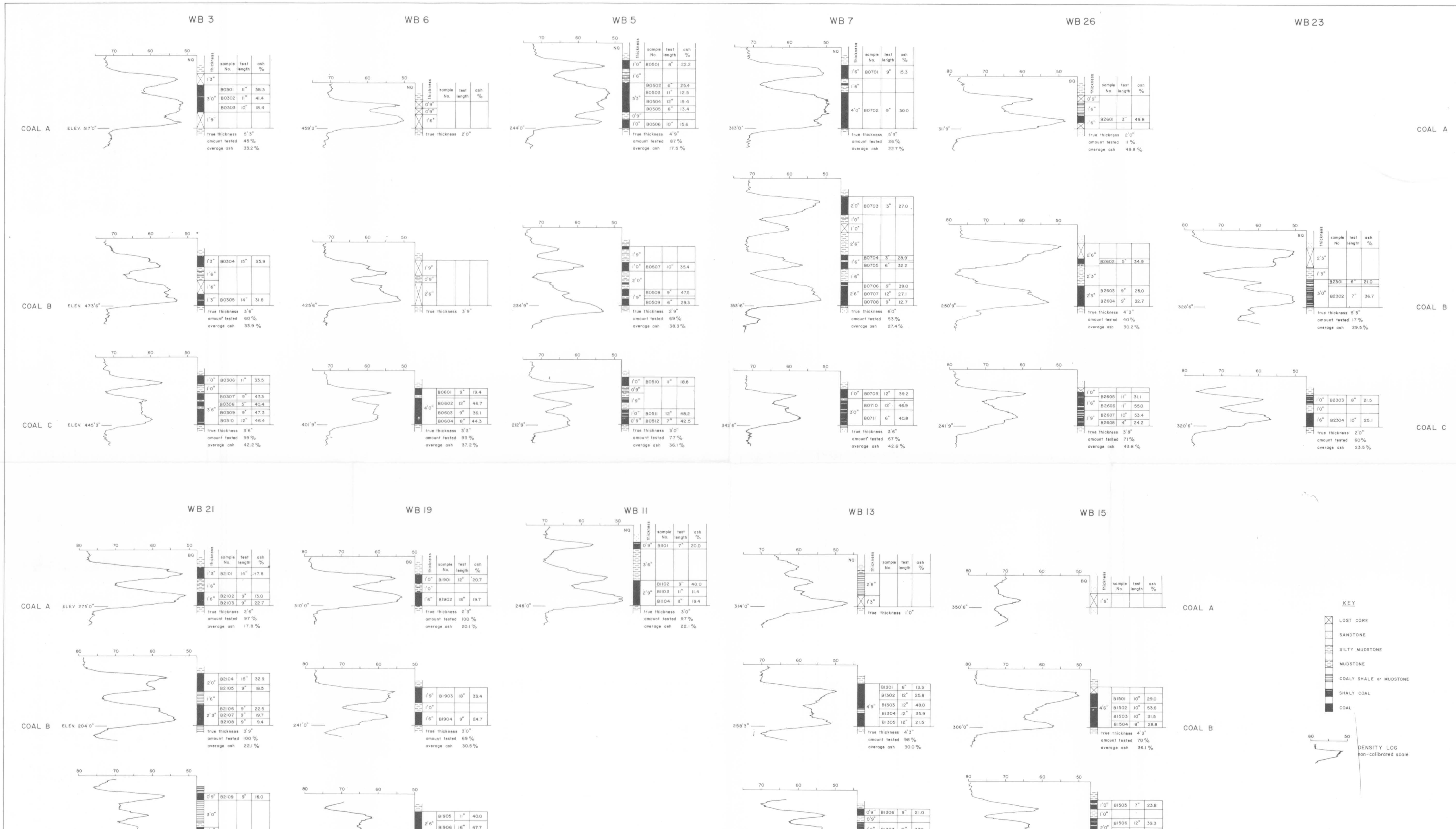
CORRELATION OF BOREHOLE SECTIONS

Vertical scale: 1" = 20'
Not to scale horizontally

LAB. REF.		FIG. NO.
S/12904	OPENCAST COAL PROJECT, SPRINGHILL, NOVA SCOTIA	3



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J.D.D.

DIAGRAM OF COAL SEAM CHARACTERISTICS

Vertical scale of coal sections 1 in. to 8 ft.

LAB REF.		FIG. NO.
S/12904	OPENCAST COAL PROJECT, SPRINGHILL, NOVA SCOTIA	4