Report 74-8
COAL RESOURCES, HUSSAR-HANNA AREA, ALBERTA

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COAL RESOURCES,

HUSSAR-HANNA AREA, ALBERTA

Abstract

The coal resources of the Hussar-Hanna area, which lies between longitudes 111° 15′ and 113° 30′ west and latitudes 50° 45′ and 52° north, were examined chiefly by means of shallow testholes spaced at 2-mile intervals. Strippable coal (within 100 feet of surface) appears to be restricted to three fields where it has long been known; the largest of these, Sheerness, contains about 100 million tons of economically recoverable coal. Two useful marker beds are recognized in the coal-bearing Edmonton Formation. Tertiary gravels and glacial deposits obscure the coal so that outcrops are largely restricted to the walls of postglacial valleys.

INTRODUCTION

The Hussar-Hanna area (Figs. 1 and 2) is an L-shaped region lying between longitudes 111° 15′ and 113° 30′ west and latitudes 50° 45′ and 52° north. Within and adjacent to it lie the Drumheller, Sheerness, and Battle River coal fields, containing some of the largest coal deposits in Canada.

The Drumheller field, with large seams outcropping in the badlands along the Red Deer River, is well known through the work of Allan (1921) and Allan and Sanderson (1945); however, coal-bearing flatlands farther east are less well known. Accordingly, in 1962 Alberta Research[1] extended its exploratory coal testhole program (Campbell and Almadi, 1964) into the Hussar-Hanna area to search for near-surface coal deposits suitable for stripmining and large enough to support electric power producing plants.

This report summarizes data from the testhole program, from air photograph examination, and from outcrop examination in the period 1955-1967.

Testholes were drilled on a staggered 2-mile grid, 260 during the summer of 1962 and 4 in 1966. All were drilled with a standard truck-mounted seismic shothole rig, usually to a depth of 105 feet, logged by visual examination of cuttings collected at 5-foot intervals, and electric-logged for spontaneous potential and single-point resistance. The cutting-log indicated lithology while the electric-log determined depths and bed thicknesses.

Study was directed primarily to the flatland coal deposits forming a discontinuous band across the Hussar-Hanna area along the southeast and east foot

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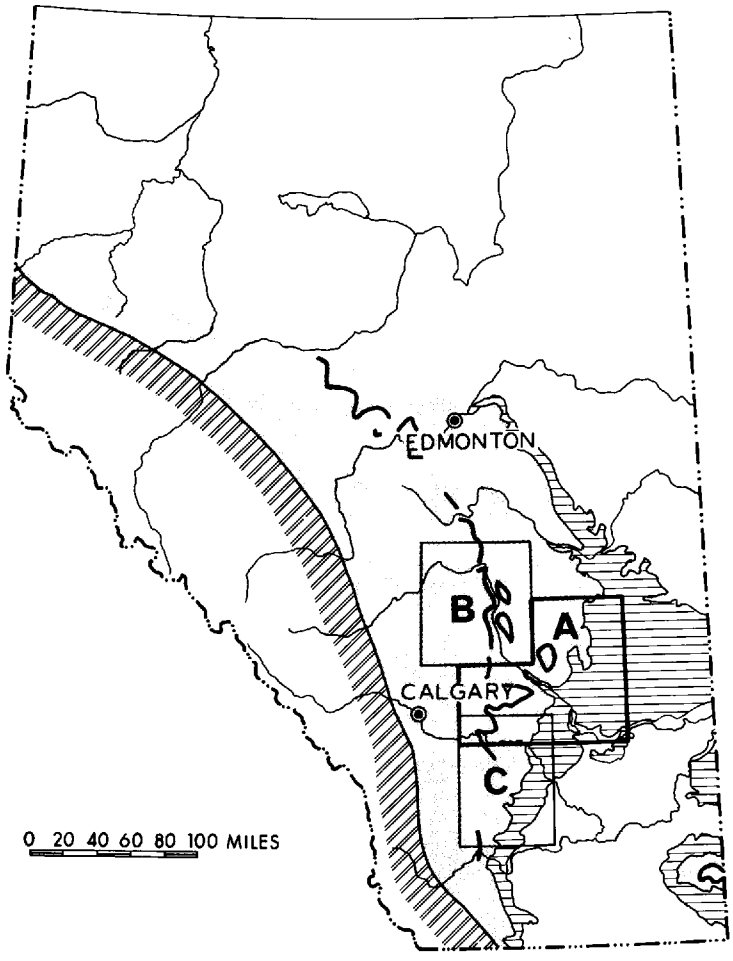
[1] Formerly Research Council of Alberta



LEGEND

Hussar-Hanna area ..... A

Central Red Deer River area ..... B

Vulcan-Gleichen area C

West boundary, Plains physiographic province .....

Edmonton and Paskapoo Formations and equivalents .....

Bearpaw Formation .....

Kneehills Member, Edmonton Formation and equivalents; approximate line of outcrop .....

FIGURE 1. Location of study area.

of the central chain of hills. Brief attention was also paid, for comparative purposes, to adjacent coal deposits in the Drumheller basin and the Hand Hills and to stratigraphy near Castor and the Battle River mines.

Previous Work

J. B. Tyrrell (1887), with his remarkably accurate map of central Alberta, initiated geological work in the Hussar-Hanna area. Allan (1921), Allan and Sanderson (1945), Campbell (1967), Elliott (1960), Irish (1967b, 1970), Irish and Harvard (1968), and Ower (1960) have continued study of the outcrops and coal deposits of the Red Deer River valley, while Allan (1936), Campbell (1962), Irish (1967a), and Lines (1963) examined the flatlands east of the Hand Hills.

Allan (1924, 1943), Campbell (1964), MacKay (1949), and Stansfield and Lang (1944) referred to the coal resources of Alberta as a whole from administrative, geological, and classificatory standpoints while Campbell and Almadi (1964) reported on coal resources of the area immediately south of the Hussar-Hanna area.

Glacial and surficial deposits, bedrock topography and groundwater resources of much of the Hussar-Hanna and adjacent areas have been studied by Borneuf (1972), Carlson (1969, 1970), Carlson *et al.* (1969), Craig (1957), Geiger (1968), Kunkle (1962), Stalker (1955), and Vanden Berg and Lennox (1969).

Geography

The Hussar-Hanna area is dominated by an irregular chain of hills extending from Hammer Hill in Tp. 23, R. 23[2] northeastward through the Wintering Hills and Hand Hills and north of Hanna to about Tp. 32, R. 14; and by the spectacular valley of the Red Deer River cutting at right angles across this chain (Fig. 6). East and southeast of the hill chain lies a flat lower prairie level, west and northwest lies a rolling prairie upland. Three basins, the Crowfoot, Drumheller, and Bullpound basins, well outlined by the 2,800-foot contour (Fig. 6), lie enclosed within the prairie upland and drain through the hill chain by way of restricted gaps. The largest of these, the Drumheller basin, exits between the Wintering and Hand Hills by way of a 1,200 foot deep constricted valley.

Access to most parts of the Hussar-Hanna area is facilitated by a relatively complete system of highways and local roads. Three lines of the Canadian Pacific Railway and two of the Canadian National Railways traverse the area; all towns and villages are situated on these.

Most of the Hussar-Hanna area lies within the prairie vegetation region. In the primitive state, tree growth was restricted to a few groves of cottonwood (*Populus*

[2] All survey locations given in this report are west of the 4th meridian.

balsamifera) along major watercourses, and extensive groves of aspen poplar (*P. tremuloides*) on the crests of the Wintering and Hand Hills. However, in the last 60 years since the beginning of settlement, aspen poplar has advanced southeastward across the area to the region of Sheerness and, in its new territory, is commonly an indicator of near-surface lithology; in the heavily drift-covered region northwest of Hanna, aspen tends to occupy the more sandy or gravelly locations while eastward and southward where the drift is very thin (e.g., near Sheerness), it occupies localities underlain by sandy and relatively pervious bedrock of Edmonton Formation type, shunning areas dominated by saline clay soils characteristic of the Bearpaw Formation.

Agriculture, the chief basis of local economy, varies in character largely with topography. On the steeper slopes of the Hand and Wintering Hills and on the lower saline flatlands of the east and southeast, grazing and herding dominate, while the higher prairies to the west and northwest support grain farms; indeed, this area contains some of the best wheat-producing districts of Canada.

Oil and gas production from such fields as Cessford, Chancellor, Countess, Drumheller, Hussar, and Wayne contributes materially to the economy of the area. In the past coal mining too was a major industry; in particular, Drumheller was one of the most important producers of Western Canada.

Acknowledgments

Coal survey operations of Alberta Research in the Hussar-Hanna area were supported financially by Calgary Power Limited and Canpac Minerals Limited (formerly Canadian Pacific Railway Natural Resources Division), members at that time of the *ad hoc* steering committee. I. S. Almadi conducted the field drilling and logging operations; A. Bosman, B. Untergasser, and Mrs. E. Nimmon compiled the data tables. The writer wishes to express his appreciation of the late Mr. G. L. Kidd of Drumheller who introduced him to the geology of the area. Finally, throughout the region, local informants too numerous to mention provided leads and valuable data on the distribution of coal.

GEOLOGY

Bedrock underlying the Hussar-Hanna area consists entirely of sedimentary strata, both marine and continental, that dip gently (regionally about 15-25 feet a mile) westward. Four rock units outcrop within the area; in ascending order these are the continental Oldman Formation, the marine Bearpaw Formation, and the continental, abundantly coal-bearing Edmonton Formation, all Late Cretaceous in age, and the continental, coal-bearing Paskapoo Formation, Late Cretaceous and Paleocene in age.

Figures 2, 3, and 4 indicate distribution and stratigraphic relationships of Bearpaw, Edmonton, and Paskapoo Formations in the study area.

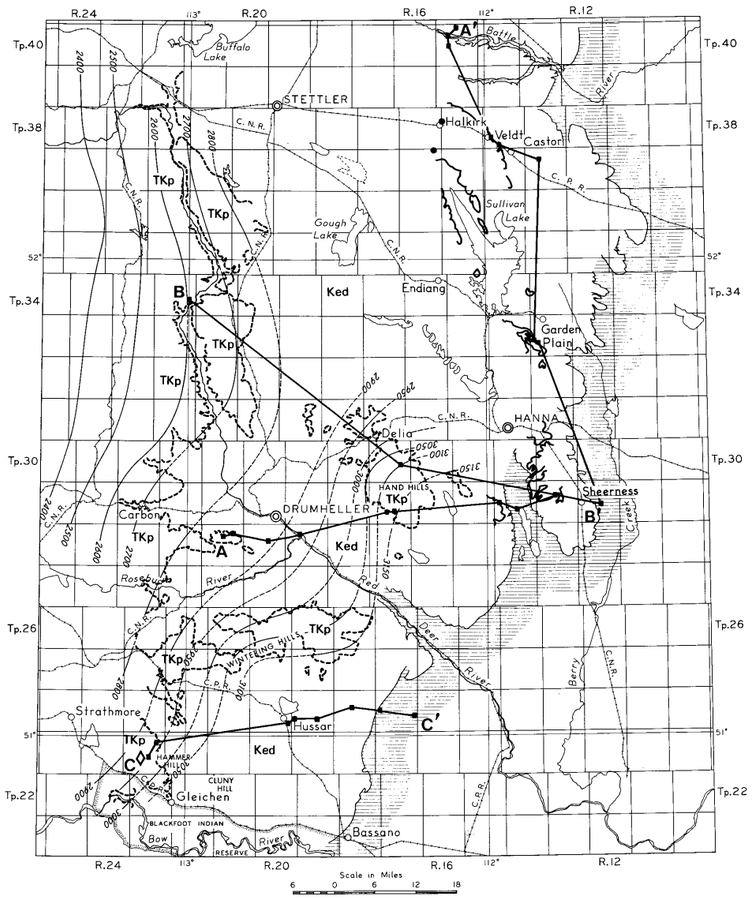


Figure 3. Generalized geology, Hussar-Hanna area and adjacent regions.

LEGEND

- Supplementary coal testhole (1966) ..... ●
- Datum point ..... ▪
- Hammer Hill tuff locality ..... ◊
- Paskapoo Formation ..... TKp
- Edmonton Formation ..... Ked
- Kneehills Member, Edmonton Formation .....
- Structure contour on Kneehills Member: actual, projected ..... ~2900~
- Garden Plain tuff .....
- Bearpaw Formation .....
- Line of structure section ..... A—A'

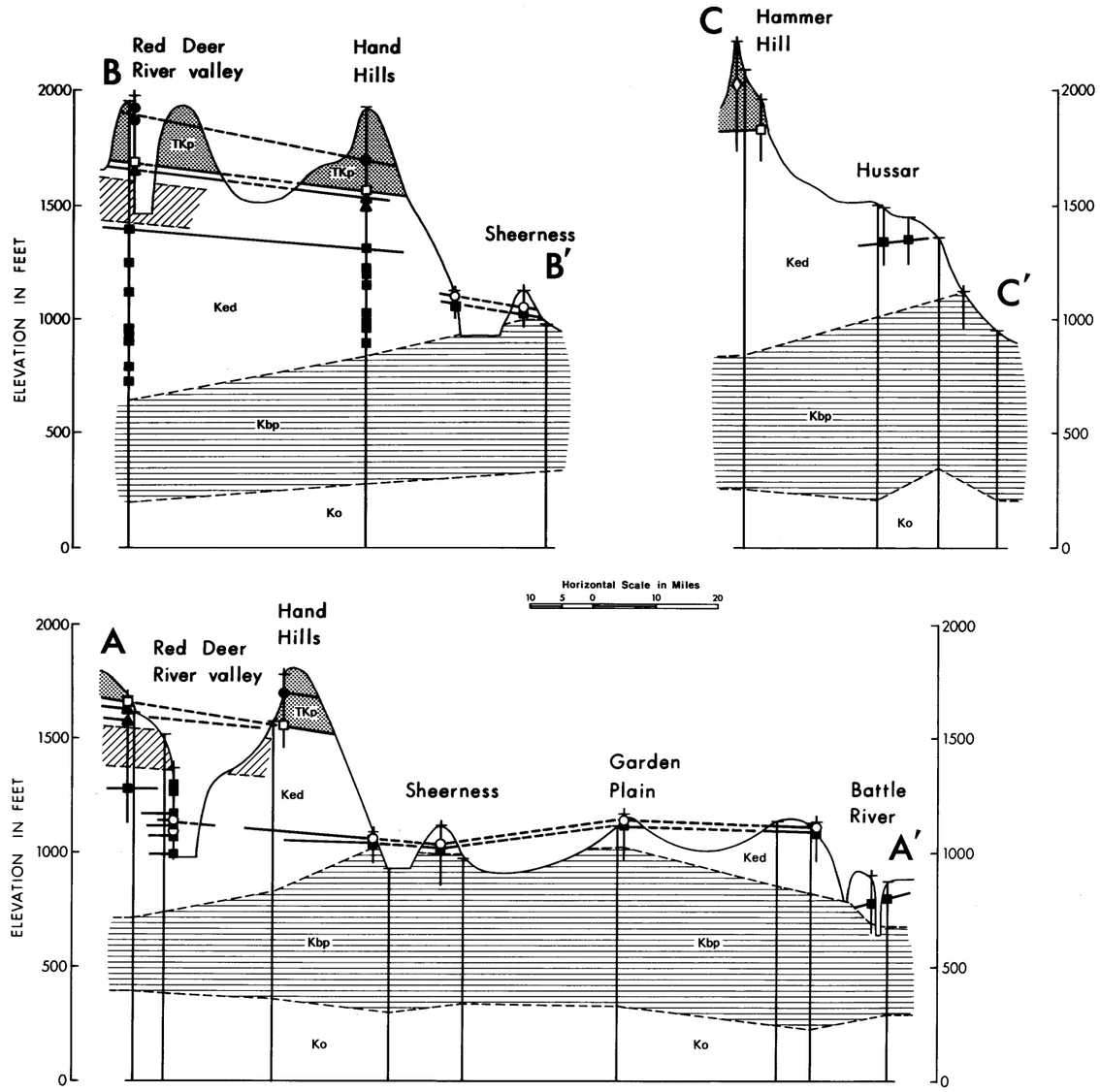


Figure 4. Structure cross sections.

LEGEND

Paskapoo Formation ..... TKp

Edmonton Formation ..... Ked

Member B, Edmonton Formation ("barren member") .....

Bearpaw Formation ..... Kbp

Oldman Formation ..... Ko

Ardley coal zone: subsurface; projected .....

Kneehills Member, Edmonton Formation: subsurface; projected .....

Carbon-Thompson coal zone: subsurface; projected .....

Garden Plain tuff and equivalents: subsurface; projected ..

Coal seam of Member A, Edmonton Formation: subsurface; projected .....

Hammer Hill tuff .....

Outcrop or coal mine .....

Oil or gas well or shallow testhole .....

Datum: 1000 feet above First White Speckled Shale

The Oldman Formation, which outcrops in the valleys of the Red Deer River and Berry Creek near Wardlow about Tps. 21-22, Rs. 10-12, contains little coal and consequently was not examined for this report.

The Bearpaw Formation, for the purposes of this report, is taken to include all thinly bedded, argillaceous strata at the base of the overlying Edmonton Formation that are dark grey as cutting samples, and grey, brownish or chocolate colored in outcrop and that give a uniformly low single-point resistance trace on an electric log; this definition encompasses both typical marine Bearpaw shale and brackish-water strata which Russell (1932) called Bassano Member.

Edmonton Formation

Most coal deposits within the study area occur within the Edmonton Formation (Edmonton Group of Irish, 1970), a complex rock unit with a transitional lower boundary and few reliable marker horizons. The formation, as early defined by Allan and Sanderson (1945), was subdivided in a workable manner by Ower (1960) into five "members," designated A to E in ascending order, all well exposed in the sharply incised valleys adjacent to the Red Deer River but usually difficult to distinguish elsewhere.

A significant discontinuity in fossil records has long been recognized about the top of Ower's Member D, the widespread and well-marked Kneehills Member (Bell, 1949; Snead, 1969; Sternberg, 1947; and others); Irish (1970) and Carrigy (1970), together recognizing a substantial lithologic break at the same level, transferred Ower's Member E to the overlying Paskapoo Formation with which it has a transitional, highly variable boundary (Carrigy, 1971). In this report, the Edmonton Formation is assumed to consist of strata lying between the top of the Bearpaw Formation and the top of the Kneehills Member.

Of the four members, A to D inclusive, left in the revised Edmonton Formation, Member B and Member D (the Kneehills Member) are barren, but the other two contain numerous coal seams.

Member A, the lower coaly member, is about 500 to 600 feet thick, about two-thirds of the total Edmonton Formation thickness, along the Red Deer River in the Drumheller basin; here Allan and Sanderson (1945) recognized and numbered in ascending order 10 relatively continuous coal seams. Elsewhere the member is difficult to measure but it appears to thin markedly on the east side of the Hand Hills and to thicken northward in the region of the Battle River and northwestward in the Central Red Deer River area (Campbell, 1967). Southeastward around Hussar and in the eastern part of the Crowfoot basin the member contains little coal but is believed to be as thick as in the Drumheller basin (Fig. 4).

Member C, the Carbon-Thompson coal zone, immediately underlies the Kneehills member and may reach 100 feet in thickness. Usually it contains one or

two well-marked coal seams of which the uppermost is occasionally interlensed with the base of the Kneehills. The zone occurs from the region of Standard (Tp. 25, R. 22) northward at least to Nevis (Tp. 38, R. 22). West of this line subsurface evidence indicates that coal deposits are relatively continuous, but eastward they appear to be thin and sporadic and reach their eastern limit in scattered occurrences along the south flank of the Wintering Hills (Tp. 25, R. 19) and at the north corner of the Hand Hills (Tp. 31, R. 17).

Volcanic Marker Beds, Edmonton Formation

Sanderson (1931) first recognized the volcanic ash-fall origin of the Kneehills Member and its correlation with the Whitemud and Battle Formations of southeastern Alberta and southern Saskatchewan. Subsequently Ower (1960), Elliott (1960) and others noted the value of the member as the most widespread, persistent, and recognizable stratigraphic marker in the Edmonton Formation. Throughout the Plains region of the province, coal zones are identified and traced largely on the basis of their position relative to the Kneehills Member.

Typically, the member is between 30 and 50 feet thick, consisting largely of uniform mauve weathering, thin bedded, highly bentonitic shale with beds of contrasting white weathering, highly bentonitic medium-grained sandstone either underlying the mauve shale or erratically interbedded with it. Thin discontinuous beds of hard phonolitic light grey tuff (often called "Kneehills Tuff") occur erratically within the mauve shale; usually near the top of the member (Campbell and Almadi, 1964)[3]

The Kneehills Member, being highly bentonitic, is recessive and outcrops only in special situations such as relatively recent river cuts or badlands; elsewhere it has slumped to an extreme degree (e.g., the west face of the Hand Hills) or has been distorted by glacial action to such an extent that it occurs only as a major component in hummocky moraine (e.g., the north face of the Wintering Hills). Outcrops of the member and slumped or glacially disturbed subcrops (estimated chiefly from air photographs) within the Hussar-Hanna area are shown in figures 2 and 3.

At seven localities in the eastern part of the study area (Sec. 22, Tp. 29, R. 13; Secs. 18-19, Tp. 29, R. 14; Sec. 6, Tp. 30, R. 13; Sec. 32, Tp. 30, R. 13; Sec. 18, Tp. 33, R. 13; Sec. 13, Tp. 33, R. 14; Sec. 23, Tp. 33, R. 14) and at two localities beyond the north boundary (Sec. 4, Tp. 36, R. 15; Sec. 8, Tp. 38, R. 14), outcropping rock assemblages appear remarkably like the Kneehills Member; each consists of an underlying coal seam, a "white sandstone," a "mauve shale," and

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[3] Because of the usual interlensing of the white sandstone with the mauve shale and the occasional interlensing of the underlying Carbon-Thompson zone coal seams with the sandstone, the proposal (Irish, 1970; Irish and Havard, 1968) to recognize the two different lithologies as two separate formations cannot be accepted.

erratically occurring indurated tuff beds. It was formerly believed (Campbell, 1962; Irish, 1965) that these outcrops did in fact belong to the Kneehills Member; however, on the basis of megaspores, it was determined that they lie stratigraphically much lower in the Edmonton Formation. Field relations indicate that all nine outcrops belong to the same horizon, and microscopic examination has shown that both the indurated bed and the unindurated "mauve shale" are indeed formed of volcanic ash. Since the best outcrop of this horizon occurs southwest of Garden Plain (Lsd. 5, Sec. 18, Tp. 23, R. 14) the rock unit is referred to in this report as the "Garden Plain tuff" (Figs. 2, 5, and 8).

Along the Red Deer River valley, a persistent concentration of volcanically derived benonite beds has been noted (Allan and Sanderson, 1945; Babet, 1966; Byrne, 1955; Byrne and Farvolden, 1959) about the middle of Member A, Edmonton Formation near seams 6 and 7, while the late G. L. Kidd (pers. comm.) correlated the Sheerness coal seam (Tp. 29, R. 13) approximately with seam 7. Thus the rock assemblage consisting of the Sheerness coal (and correlatives) and the Garden Plain tuff may reasonably be correlated with the middle part of Ower's Member A, Edmonton Formation, in the Red Deer River valley (Fig. 4).

As far as known, no coal seam has ever been exploited above the Garden Plain tuff in the eastern part of the Hussar-Hanna area.

Bentonitic rock assemblages similar in appearance to the Kneehills Member also occur higher in the section. One such, exposed on the west face of Hammer Hill (SE 1/4, Sec. 16, Tp. 23, R. 23) consists of mauve shale with a few stringers of indurated tuff and apparently lies about 210 feet stratigraphically higher than the Kneehills (Fig. 5). Another, in the valley of Kneehills Creek, was described by Folinsbee (*in* Ritchie, 1957) "250 feet above the Kneehills."

Lower Boundary, Edmonton Formation

The boundary between the Edmonton Formation and the underlying Bearpaw Formation is everywhere diachronous (Allan and Sanderson, 1945; Campbell, 1962; Campbell and Almadi, 1964; Kidd, 1929; Russell, 1932). In the Red Deer River valley between Drumheller and East Coulee, the numerous exposures in coal mines and canyon walls demonstrate the large-scale interlensing of the two formations.

The interval between the Garden Plain tuff (or its equivalent) and the top of the Bearpaw Formation varies greatly in thickness (Fig. 4); at Sheerness (Tp. 29, R. 13) and at the Hand Hills East mines (Tp. 29, R. 14) it is less than 60 feet, but it increases markedly westward to about 350 feet near Rosedale in the Drumheller basin (Tp. 28, Rs. 19-20) and increases northward to about 100 feet at Garden Plain (Tp. 33, R. 13), to about 250 feet near Castor and Veldt (Tp. 38, Rs. 13-14), and to about 400 feet at the Battle River coal mines (Tp. 40, R. 15).

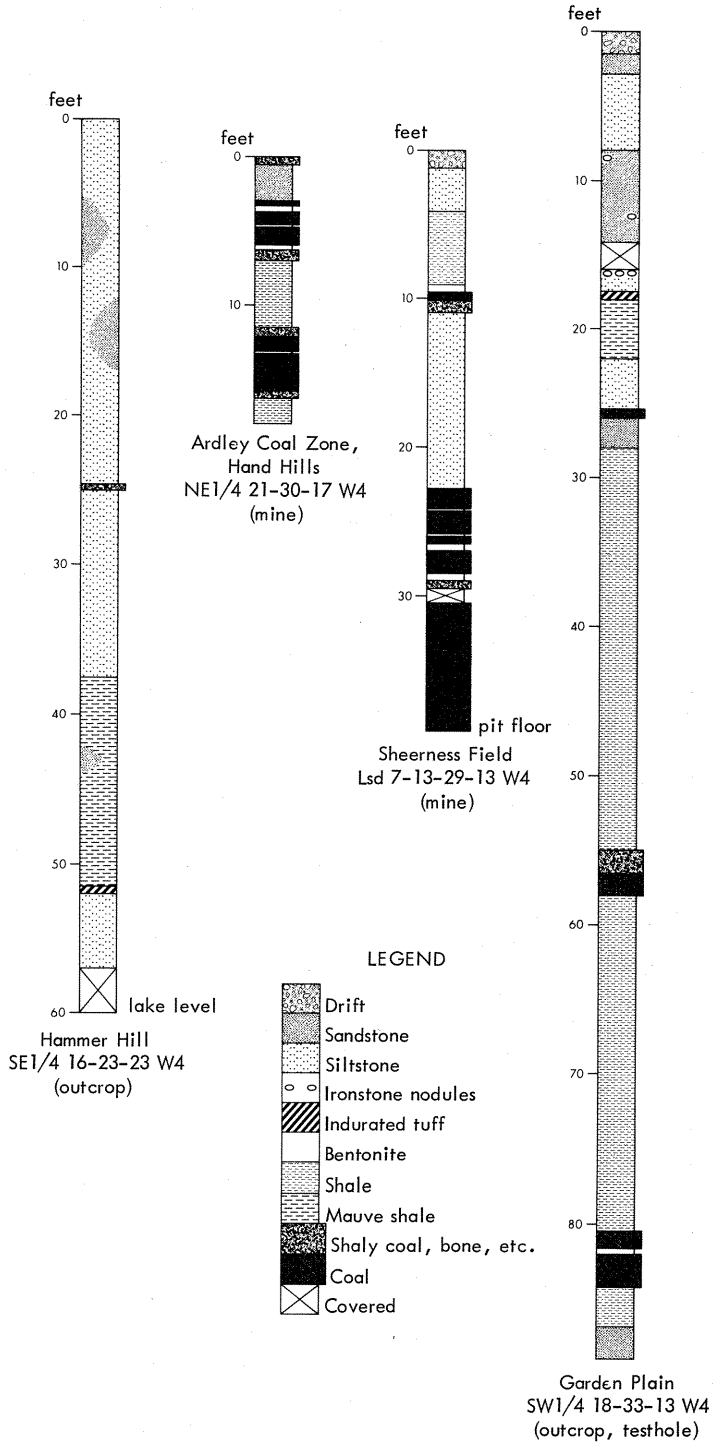

FIGURE 5. Typical stratigraphic sections.

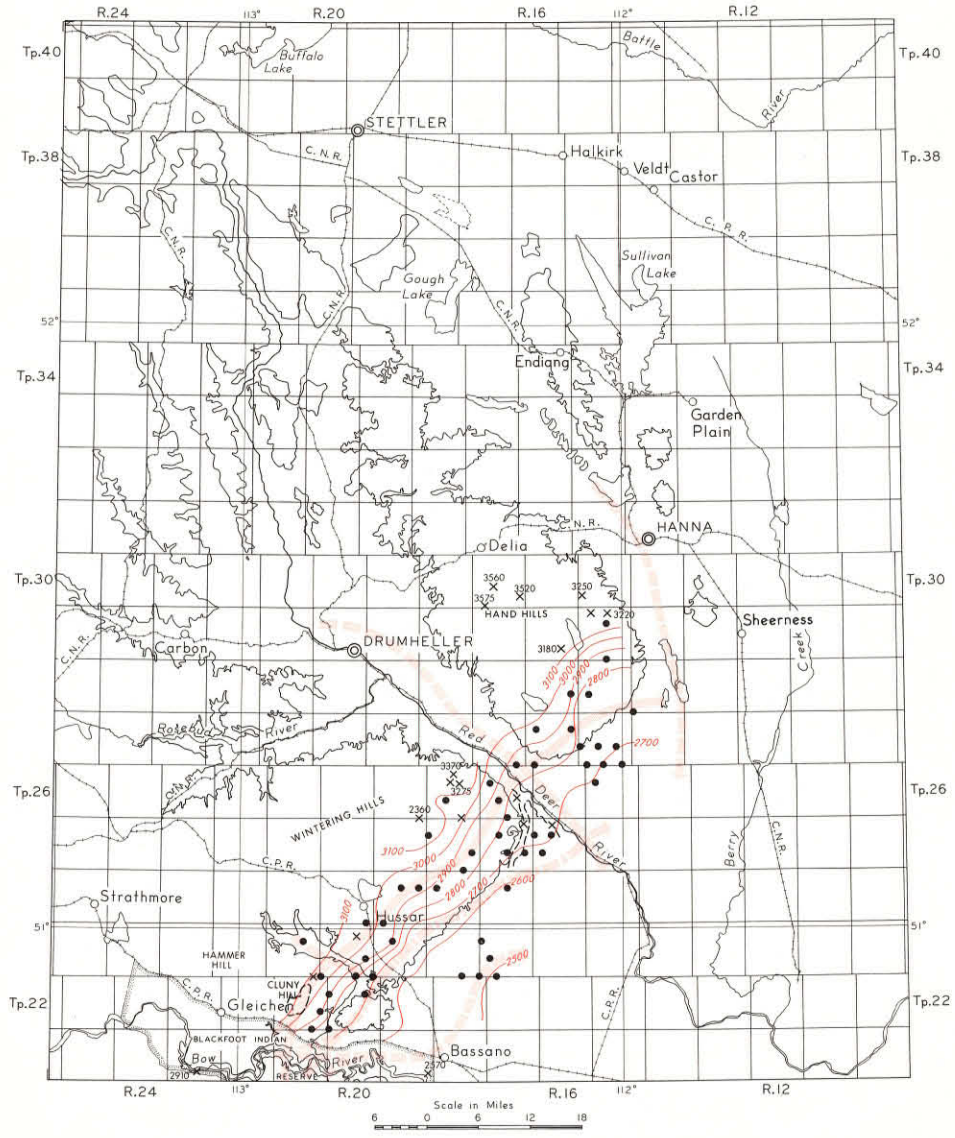

Figure 6. Preglacial gravel occurrences.

LEGEND

Testhole intersecting preglacial gravel .....•

Outcrop, preglacial gravel ..... ×—

Elevation in feet, top of preglacial gravel 3250

Postulated structure contour, top of preglacial gravel ... —2900—

Postulated major stream sequence:

- Oldest Bow River valley stage .....
- Middle Bow River valley stage .....
- Youngest preglacial Bow River valley stage .....

Topographic contour, 2800-foot .....

Thus the upper part of the Bearpaw Formation at Sheerness is the chronologic equivalent of the lower and middle parts of Member A, Edmonton Formation (Fig. 4), and the big coal seam mined on the Battle River appears to be stratigraphically lower and older than any seam exposed along the Red Deer River.

Paskapoo Formation

The Paskapoo Formation, which lies immediately above the Kneehills Member, Edmonton Formation, occupies the western part of the Hussar-Hanna area as far east as the crests of the Hand and Wintering Hills. Mostly it is composed of arenaceous sediments dominated by massive or thickly cross-bedded cliff-forming sandstones; however, in the Hand Hills and northwest of the study area the basal 100 to 200 feet of the formation consists of dominantly grey-weathering argillaceous coal-bearing strata that constitute Irish's (1970) Scollard Member (Ower's Member E, Edmonton Formation). About the middle of the Scollard Member lies the Ardley coal zone, a major energy resource well exposed in the Central Red Deer River area (Campbell, 1967) which reaches its southeastern limits in the Hand Hills.

Structure

Figure 3 shows structure contours in the western part of the Hussar-Hanna area and adjacent parts of the Central Red Deer River area drawn on the top of the Kneehills Member. Regionally, the member dips west-northwestward or westward, at about 15 to 20 feet a mile. Wherever local dips greatly depart from this direction or greatly exceed this angle (e.g., Garden Plain, about Tp. 33, R. 13) glacial bedrock deformation is suspected.

Geomorphology and Late Tertiary Geology

Surficial deposits and related landforms exercise a profound control over the ease with which coal may be detected and exploited; potentially coal-bearing bedrock, for instance, is always obscured to some extent by overlying glacial and postglacial deposits such as moraines, kames, and lake deposits. Within the Hussar-Hanna area, several surficial geologic features merit special attention.

(1) Gravel deposits which occur plentifully in the southeastern part of the study area (Fig. 6) offer an extremely difficult obstacle to exploratory drilling, and since they commonly carry large volumes of groundwater, may render economic stripmining impossible. Most gravels lack Shield-derived pebbles and consequently are believed to be preglacial in age. They appear to correlate with the numerous gravel occurrences in the Vulcan-Gleichen area from which Campbell and Almadi (1964) deduced the history of a large drainage system believed to be that of the ancestral Bow River.

Four arbitrary stages of the history were outlined:

(i) streams represented by the oldest and highest gravels in the Vulcan-Gleichen area and whose direction was not determinable;

(ii) first McGregor valley stage or oldest Bow River valley stage;

(iii) middle Bow River valley stage;

(iv) youngest preglacial valley stage.

The oldest unconsolidated sediments within the Hussar-Hanna area are the relatively flat-lying gravels and associated marl beds capping the Hand Hills in Tp. 30, R. 17, believed to be Late Pliocene in age (Russell, 1957, 1958). These and slightly younger (because lower in elevation) gravels on the east ridge of the Hand Hills (Tp. 30, R. 15) and on the summits of the Wintering Hills (Tp. 26, Rs. 18-19) are believed to correlate with deposits on Buffalo Hill in the Vulcan-Gleichen area which Campbell and Almadi (1964) placed in their Stage A of Bow River development.

Younger preglacial gravels form an essentially continuous sheet mantling the southeastern slopes of Cluny Hill, the Wintering Hills, and the Hand Hills with few erosional interruptions. This sheet, which in large areas, notably between Crowfoot Creek and the Red Deer River, constitutes a substantial aquifer (Carlson ***et al.*** 1969), is 5 to 25 miles wide and more than 60 miles long, and slopes southeastward at about 25 to 200 feet a mile. It is suggested that this is the product of a long process of gradual lateral southeastward migration or "slip-off" on a regional scale of the Ancestral Bow River, flowing northeastward. Stages B, C, and D of this stream may be traced more than 60 miles into the Hussar-Hanna area (Fig. 6).

(2) Three well-defined, broad, preglacial basins, the Crowfoot, Drumheller, and Bullpound basins, shown by the 2,800-foot contour line (Fig. 6), lie northwest of the central chain of hills. All the commercial coal deposits of the Drumheller field lie well below the preglacial basin floor and are accessible for exploitation only in the walls of postglacial valleys cut 200 to 300 feet in the basin floor by the present Red Deer River and its tributaries.

(3) Probably all bedrock within the Hussar-Hanna area has been glacially deformed to some extent. Severe bedrock deformation may be visible in air photographs (e.g., Sec. 32, Tp. 29, R. 13); it can be detected in testholes only if there is obvious lithologic inconsistency (e.g., gravel under coal). The Kneehills Member, particularly, appears to be drastically disturbed by ice action wherever it occurs close to the general ground level (e.g., Tp. 27, R. 20); the Garden Plain tuff also is commonly strongly deformed in outcrop.

The mineability of near-surface coal deposits is always affected to some extent by glacial distortion. At Sheerness (Tp. 29, R. 13) the coal seam occasionally is steep enough in the gentle folds to interfere with deployment of stripping shovels, while at Garden Plain (Tp. 33, R. 13) folding is sufficiently extreme that exploitation of the coal appears to be impossible at present.

(4) South and southeast of Standard in Tp. 24, Rs. 22-23, there lies a complex postglacial fluvial feature that partially obstructs exploration and exploitation of the Standard coal deposit. The following sequence of events appears to have taken place:

(i) Kneehills Member bedrock underlying a considerable area (and overlying the Carbon-Thompson coal zone) was strongly deformed by ice action;

(ii) the area was at least partially covered by deltaic deposits laid down by meltwater issuing from several successive spillways across the Wintering Hills in Tp. 24, R. 24, and Tp. 25, R. 23;

(iii) some of the deltaic deposits were reworked by wind to form dunes.

(5) The glacial and postglacial deposits of most of the Hussar-Hanna area have been described by Craig (1957) and Stalker (1955).

COAL

Probably the earliest coal mining activity within the Hussar-Hanna area took place near the mouth of Crowfoot Creek in Tp. 22, R. 20; soon after the main line of the Canadian Pacific Railway was built, coal was shipped from this location to Calgary. The prolific Drumheller field, first exploited after the building of the Canadian Northern Railway (now Canadian National) Edmonton-Calgary line about 1912-13, became one of the most productive coal mining regions of Western Canada in the 1920's and 1930's. The earliest known production in the eastern flatlands came from a small coal mine opened in 1913 near Garden Plain.

At present only three mines operate within the area, a large underground mine at East Coulee, a large strip-pit at Sheerness and a small strip-pit near Drumheller. However the distribution of the many former mines gives an indication of the distributrion of recoverable coal (Fig. 2; Campbell, 1967).

Most commercial coal deposits of the Hussar-Hanna area occur within Member A of the Edmonton Formation. Member C, the Carbon-Thompson coal zone, contains thick coal at a number of locations in the western portion of the area from Standard (Tp. 25, R. 22) to Carbon (Tp. 29, R. 23), and the Ardley coal

zone of the basal Scollard Member, Paskapoo Formation, a major energy resource in central Alberta, reaches its southeastern limit at higher elevations in the Hand Hills.

Within the study area, seven "coal fields" may be recognized where at least some coal has been mined and intersected in Alberta Research testholes; their locations and extent may be traced in figure 2.

An eighth field, about Tps. 21-23, Rs. 14-15, contains only negligible coal seams in the Oldman Formation and consequently was not considered in the present study.

Hussar

Scattered coal seams referable to Member A were intersected in numerous testholes near Hussar in Tp. 24, Rs. 18-21 and southward towards the short-lived Crowfoot Creek mines in Tp. 22, R. 20. However none of the coal occurrences exceeds 2 feet in thickness except in two testholes near the southeast end of Deadhorse Lake where 4-foot coal seams were found; furthermore, strata along the ridge south of Hussar are probably strongly distorted by ice action. It seems unlikely, therefore, that any economically strippable deposits exist in the Hussar field; no tonnage estimate is offered in this report.

Standard

Around the village of Standard, coal was mined for many years in the southeast part of Tp. 25, R. 22; three adjacent testholes intercepted coal, and a weathered seam outcrops in SE 1/4, Sec. 9, Tp. 25, R. 22. The coal, a single seam 4 to 5 feet thick under a relatively flat terrace at the foot of the Wintering Hills, lies 90 to 100 feet below the Kneehills Member (Fig. 2) and therefore represents the Carbon-Thompson coal zone. The seam is believed to underlie about 5 square miles with less than 60 feet of overburden and an additional 8 square miles with between 60 and 100 feet of overburden. Thus about ***20 million tons***[4] of strippable coal with less than 60 feet of overburden is probably present here together with an additional 30 million tons under less than 100 feet. Field limits and structure contours on the coal are shown in figure 2.

Carbon-Thompson zone coal was also intersected in six testholes east of Standard along the south base of the Wintering Hills in Tp. 25, Rs. 19-21; however, the seams are all thin (0.5 to 2 feet thick) and the terrain broken so that no mineable resources are to be expected in this region.

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[4] Tonnage estimates in this report are based on the assumption that approximately 1 million tons of coal are recoverable by stripmining from I square mile of coal 1 foot thick, about an 85 percent recovery factor.

Drumheller Basin

Some of the largest known coal deposits of the Alberta Plains lie in the valleys of the Red Deer and Rosebud Rivers and Kneehills Creek in Tps. 26-29, Rs. 18-23. Coal seams outcrop predominantly in the steep walls of the postglacial valleys; except at the immediate outcrop and in regions of rough badlands terrain, the known seams everywhere lie under heavy (200-500 feet) cover so that stripmining methods cannot economically be used in recovery. Consequently no testholes were drilled in the field and no tonnage estimates were made.

The field, once the most prolific coal field of the Alberta Plains with numerous large underground mines (Campbell, 1967), is geologically one of the best known as a result of the detailed description by Allan (1921) and Allan and Sanderson (1945). Considerable coal reserves lie within both Member A and the Carbon-Thompson coal zone although deposits in the former are much the larger; of the 10 seams recognized by Allan within Member A, numbers 1, 2, 5 and 7 are all, in places, economically mineable. Figure 2 shows structure contours, based largely on mine records, drawn on seams 1 and 2 (probably splits of a single seam — pers. comm. Mr. A. Hnatyshyn, Drumheller) between East Coulee and West Drumheller, and on seam 7 around Drumheller.

Sheerness

The second largest coal field of the Hussar-Hanna area is at Sheerness around the southeast part of Tp. 29, R. 13; here an irregular coaly lens, up to 20 feet thick, lies 15 to 45 feet below ground level. This Sheerness lens forms the southeast edge of an otherwise thin extended coal body which consists of 1 to 3 seams lying within a band of continental strata partially isolated by Bearpaw marine beds (Figs. 2 and 7). Only in the Sheerness lens is there coal thick enough to sustain commercial mining.

A section of the Sheerness lens is shown in figure 5, The main coaly sequence, 16 feet thick above the pit floor, rests directly on a bed of grey sandstone about 35 feet thick and is the lowest coal in the field; in miners' parlance it comprises a clean, blocky "lower seam" 8.5 feet thick and a much divided "upper seam." A third seam, very thin and commonly removed by erosion, lies 12 to 13 feet above the "upper seam."

Although the Sheerness coal lies close above the Bearpaw Formation (in the testhole at northeast corner Sec. 12, Tp. 29, R. 13, only 55 feet separate them), it lies close below the Garden Plain tuff (22 to 38 feet below it in the outcrop in Sec. 22, Tp. 29, R. 13) and is believed to be stratigraphically approximately equivalent to Member A, seams 5 to 7 at Drumheller. Tuff is also associated with the coal in outcrops in Secs. 5, 32, Tp. 30, R. 13.

Structurally, the extended coal body consists of two irregular domes separated by a syncline on the northwest side of the Sheerness lens (Fig. 7). Where exposed in strip pits, the lens exhibits gentle undulations striking northwest with crests at 100- to 300-foot intervals, 3 to 10 feet above the intervening troughs. Both the dome structures and the undulations as well as a series of rough arcuate ridges, concave towards the northeast, along the northeast edge of the coal body in Tp. 30, R. 13, are believed to result from glacial action.

Isopachs of clean coal, based on mine and testhole data, are shown in figure 7. The Sheerness lens, in an area of 13 square miles where the "lower seam" is 5 to 12 feet thick, contains about ***100 million tons*** of coal, all easily strippable. At present only the "lower seam" is commercially attractive, chiefly because of its low ash content (5-7 percent; Table 1); if the whole seam were mined, reserve tonnages would be significantly increased but average ash contents would be 25 to 30 percent and average ash-free calorific values would be appreciably lower because of deep weathering in the "upper seam."

Weathering of coal under the conditions of arid climate prevalent at Sheerness is an alkaline oxidation process of which the end products are humates. The "upper seam," and a few irregular patches of the "lower seam" called "rusty coal," are objectionable as fuel because of deep weathering and attendant reduced calorific value; however, humates may have a future as a non-fuel raw material for a number of relatively large-tonnage products such as drilling mud additives, tanning agents, and agricultural soil amendments. The Sheerness lens is one of the largest and most convenient sources of naturally occurring humates in Canada.

Hand Hills East

Along the eastern flanks of the Hand Hills, testholes intersected a number of thin coal seams at various elevations. At the western edge of Bullpound Creek valley in Tps. 28-29, R. 14, the lowest of these is 4 to 5 feet thick and, where exposed in badlands gullies, has been exploited by a number of small underground mines. This seam, lying close above the Bearpaw Formation and associated with a tuff assemblage considered to be the Garden Plain tuff, is correlated with the Sheerness seam in Member A, Edmonton Formation. Stripmining is not possible in this area since the thick lowest seam outcrops in rough terrain, and other seams are very thin. Structure contours on the lowest seam (Fig. 2) suggest broad bedrock distortion by glacial action.

The same coal zone at the small mines in Tps. 31-33, R. 16 is believed to be too thin and discontinuous to be economically attractive.

Hand Hills

Coal deposits in Tps. 29-30, R. 17 at higher elevations in the Hand Hills lie about 100 feet above the Kneehills Member and therefore represent the Ardley coal zone in the Paskapoo Formation, which here finds its southeastern limit.

Two small mines in Sec. 12, Tp. 31, R. 17 are believed to have exploited Carbon-Thompson coal, but no other occurrence of this zone is known in the area.

A reasonably reliable picture of Ardley coal occurrence and distribution in the Hand Hills has been derived from records of a number of small underground mines and from outcrops. The zone appears to dip gently northwestward approximately in the same attitude as the Kneehills Member (Fig. 2).

The Ardley zone contains lenses of coal 6 to 8 feet thick (Fig. 5) in the northwest part of the hills, but the topography is too rough and the overburden too thick for stripmining, and around Sec. 21, Tp. 30, R. 17, glacial deformation is an added obstacle to exploitation. Elsewhere in the hills the zone is believed to contain little or no coal since the outcrop in Sec. 10, Tp. 29, R. 17 contains only a few thin streaks and there is no local knowledge of appreciable seams.

Garden Plain

In Tps. 32-34, Rs. 13-14, a cluster of coal outcrops, testhole coal intersects, and abandoned coal mines occur in a band of smooth, gentle hills (Figs. 2 and 8). As discussed above, the coal here is believed to correlate approximately with the horizon of seams 5 to 7 of Member A in the Drumheller basin. The seams are difficult to trace and appear to be strongly folded and faulted by glacial action. The area is interpreted as having three coal seams contained in strata distorted to form two major serrated subparallel ridges, each 8 to 9 miles long, trending north-northwest (Figs. 2, 5, and 8).

Seams in the Garden Plain field range to 5 feet in thickness and in places have only 20 to 40 feet of overburden, so that they have attracted considerable industrial interest. Because of distortion and the low rank of the coal (Table 1), stripmining is not attractive at present, but coal lies near the surface under a 12 square mile area of sparse population and low land values so that, under suitable economic conditions, it will be possible to stripmine about ***50 million tons*** of coal here.

Analyses and Summary

Stansfield and Lang (1944) presented complete (proximate and elemental) analyses of coals produced in the Gleichen, Carbon, Drumheller, and Sheerness administrative coal areas. Table 1 gives more recent analyses carried out in the coal analytical laboratories, Alberta Research, of samples representing a number of coal deposits in the Hussar-Hanna area, but since composition is known to vary somewhat within individual deposits only proximate analyses and calorific values are included.

In general, coals of the westernmost parts of the study area (Standard field and western part of the Drumheller basin) are marginally Subbituminous A —

Table 1. Proximate analyses of mined coals

Location (W 4th Mer)			AFCM Basis				CM Basis		
Sec	Tp	R	H_2O	VM	FC	G.BTU	S	A	ASTM Classification
Standard Field									
11	25	22	18.7	34.7	46.6	10550	-	10.1	Subbituminous A
Drumheller Basin									
20	26	21	19.4	33.3	47.3	10500	-	7.4	Subbituminous A
29	26	21	20.0	33.6	46.4	10340	-	8.1	Subbituminous B
18	27	18	21.3	31.8	47.0	10050	-	5.9	Subbituminous B
22	28	18	22.9	31.4	45.6	9860	-	8.4	Subbituminous B
16	28	19	21.3	32.9	45.8	10220	-	8.1	Subbituminous B
11	29	20	21.5	32.5	46.0	10220	-	10.4	Subbituminous B
14	29	23	18.0	34.1	47.9	10870	-	8.4	Subbituminous A
Sheerness Field									
19	29	12	29.5	30.7	39.8	8850	-	7.1	Subbituminous C
12	29	13	29.5	30.1	40.4	8820	-	5.1	Subbituminous C
13	29	13	28.6	30.0	41.4	8740	-	5.7	Subbituminous C
Hand Hills Field									
21	30	17	25.2	30.2	44.7	9460	-	8.2	Subbituminous C
Garden Plain Field[1]									
-	32-33	13,14	31.4	30.5	38.1	8420	0.4	8.2	Subbituminous C

Abbreviations: AFCM - ash-free capacity moisture basis; CM - capacity moisture only basis; H_2O - capacity moisture percentage; VM - volatile matter percentage; FC - fixed carbon percentage; G.BTU - gross calorific value in BTU/lb; S - elemental sulphur percentage; A - ash percentage

[1]Data from Stansfield and Lang, 1944.

Subbituminous B in rank, those of the northeasternmost part (Garden Plain field) are marginally Subbituminous C — Lignite A in rank, while other coals lying between the two extremes are Subbituminous B or C.

Near-surface coal is found in eight "fields" within the Hussar-Hanna area, but only in the Standard, Sheerness, and Garden Plain fields are the setting and coal quantities sufficiently favorable to warrant making estimates of coal tonnages suitable for stripmining. These estimates are:

Standard field — about 20 million tons

Sheerness field — about 100 million tons

Garden Plain field — about 50 million tons.

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APPENDIX A

ALBERTA RESEARCH COAL TESTHOLES,

HUSSAR–HANNA AREA

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 31-22-17 2570; July 12th
0-20	Buff till
20-74	Dark grey till
74-96	Gravel
96-195	Bearpaw
	NE cor. 31-22-18 2674; July 11th
0-20	Buff till
20-105	Dark grey till
	NE cor. 33-22-18 2620; July 11th
0-30	Buff till
30-70	Dark grey till
70-84	Pea gravel
	NE cor. 35-22-18 2590; July 12th
0-15	Buff till
15-85	Dark grey till
85-92	Gravel
	NE cor. 31-22-19 2815; July 11th
0-5	Till
5-15	Gravel
15-105	Till

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 33-22-19 2790; July 11th
0-30	Buff till
30-105	Dark grey till
	NE cor. 35-22-19 2730; July 11th
0-20	Buff till
20-105	Dark grey till
	NE cor. 20-22-20 2875; July 10th
0-35	Buff till
35-105	Dark grey till
	NE cor. 22-22-20 2790; July 10th
0-115	Till
115-120	Sand & pea gravel
	NE cor. 24-22-20 2795; July 10th
0-105	Till

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 31-22-20 3005; July 9th
0-38	Buff till
38-47	Brown shale
47-48	Coal
48-105	Dark grey shale & hard stringers
	NE cor. 33-22-20 2800; July 10th
0-75	Till
75-105	Light grey shale
105-110	Gravel
110-120	Light grey shale
	NE cor. 35-22-20 2792; July 11th
0-70	Buff till
70-95	Pea gravel
	NE cor. 24-22-21 2930; July 10th
0-19	Till
19-24	Gravel
24-72.5	Light grey & brown shale
72.5-74	Coal
74-92	Brown shale
92-95	Siltstone
95-105	Light grey & green shale
	NE cor. 35-22-21 3100; July 9th
0-5	Buff till
5-20	Sand & gravel

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 7-23-17 2620; July 12th
0-30	Buff till
30-94	Dark grey till
94-95	Gravel
	NE cor. 7-23-18 2720; July 30th
0-25	Buff till
25-105	Dark grey till
	NE cor. 24-23-18 2600; Sept. 12th
0-15	Sand & gravel
15-45	Dark grey till
45-60	Gravel
60-105	Bearpaw
	NE cor. 33-23-18 2785; July 16th
0-45	Buff till
45-105	Dark grey till
	NE cor. 35-23-18 2725; July 16th
0-20	Buff till
20-105	Dark grey lake deposit
	NE cor. 9-23-19 2830; July 31st
0-15	Buff till
15-105	Dark grey till

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 11-23-19 2780; July 31st
0-30	Buff till
30-80	Dark grey till
80-105	Light grey lake deposit
	NE cor. 20-23-19 2965; July 31st
0-45	Buff till
45-50	Buff till & pea gravel stringers
50-60	Dark grey till
60-75	Gravel
	NE cor. 24-23-19 2790; July 30th
0-30	Buff till
30-75	Dark grey till
75-105	Dark grey lake deposit
	NE cor. 31-23-19 3010; Sept. 12th
0-20	Buff till
20-40	Gravel
40-50	Rusty silty shale
50-60	Light grey shale
60-95	Dark grey shale
95-105	Light grey shale & ss
	NE cor. 33-23-19 2997; July 27th
0-50	Buff till
50-60	Buff lake deposit
60-106	Dark grey till
106-120	Dark brown & light grey shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 35-23-19 2873; July 27th
0-30	Buff till
30-105	Dark grey till
105-150	Lake deposit
	NE cor. 7-23-20 2830; July 9th
0-90	Till
90-98	Brown shale
98-104	Light grey shale & ss
104-104.5	Coal
104.5-120	Brown shale & coal stringers
	NE cor. 11-23-20 2997; July 5th
0-30	Buff till
30-44	Gravel
44-65	Light grey & brown shale
65-72	Light grey s & p ss
72-80	Shale
80-83	S & p ss
83-92.5	Brown shale
92.5-94.5	Coal
94.5-95	Shale & bone
95-96.5	Coal
96.5-128	Brown shale
128-129.5	Coal
129.5-135	Brown shale
135-136.5	Coal
136.5-145	Brown shale
145-150	Light grey s & p ss

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 20-23-20 2810; July 4th
0-88	Buff till
88-122	Brown shale
122-131	S & p ss (well-cemented)
131-141	Shale
141-142	Coal
142-150	Brown shale
	NE cor. 22-23-20 3072; July 5th
0-80	Buff till
80-97	Brown shale
97-98	S & p ss
98-110	Light grey shale
110-115	Light green s & p ss
115-125	Brown shale
125-150	Light grey shale
	NE cor. 24-23-20 2920; July 5th
0-70	Buff & grey till
70-71	Fossil bed
71-90	Brown shale
91-92	Coal
92-101	S & p ss & ironstone
101-103	Coal
103-109	Brown shale
109-111	Coal
111-118	Brown shale
118-119.5	Coal
119.5-133	Brown shale
133-135	Coal
135-140	Brown shale
140-145	S & p ss
145-150	Brown shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 31-23-20 2822; July 9th
0-35	Buff till
35-50.5	Brown shale
50.5-52	Coal
52-67	Light grey s & p ss
67-69	Coal
69-105	Light grey & brown shale
	NE cor. 33-23-20 2924; July 4th
0-50	Buff till
50-78	Light grey shale
78-80	Ss
80-84	Light grey shale
84-86	Ss
86-106.5	Brown shale
106.5-111.5	Coal
111.5-118	Brown shale
118-122	Coal
122-129.5	Brown shale
129.5-131.5	Coal
131.5-150	Brown shale
	NE cor. 35-23-20 3065; July 6th
0-30	Buff till
30-45	Pea gravel
	NE cor. 9-23-21 2815; July 26th
0-61	Buff & dark grey till
61-62.5	Coal
62.5-85	Dark grey shale
85-90	Brown shale
90-95	Light grey s & p ss
95-105	Dark grey shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 11-23-21 2860; July 27th
0-5	Buff till
5-28	Brown shale
28-30	Coal
30-46	Light grey shale
46-48.5	Coal
48.5-62	Light grey shale
62-62.75	Coal
62.75-105	Light grey shale
	NE cor. 22-23-21 2765; July 27th
0-30	Buff till
30-60	Dark grey till
60-65	Sand
65-82	Dark grey shale
82-85	Light grey ss
85-105	Dark brown shale
	NE cor. 24-23-21 2785; July 9th
0-37	Buff till
37-45	Brown shale
45-51	Buff s & p ss
51-64	Brown shale
64-65	Ss
65-78	Brown & green shale
78-80	Coal
80-90	Light grey s & p ss
90-105	Brown shale
	NE cor. 35-23-21 2820; July 9th
0-40	Till
40-105	Dark grey to brown shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 11-23-22 2970; July 26th
0-5	Buff till
5-10	Brown silty shale
10-15	Light grey shale
15-20	Brown shale
20-55	Light grey s & p ss
55-60	Dark grey till (N.B.)
60-65	Light grey shale
65-70	Dark grey shale
70-105	Light grey shale
	NE cor. 20-23-22 2880; July 26th
0-15	Buff lake deposit
15-19	Shale
19-25	Light grey siltstone
25-60	Dark grey & brown shale
60-80	Light grey silty shale
80-85	Brown silty shale
85-105	Dark grey shale & hard siltstone stringers
	NE cor. 11-23-23 3040; July 26th
0-25	Buff till
25-35	Brown shale
35-85	Light grey silty shale
85-95	Dark grey shale
95-105	Dark brown shale
105-120	Light grey shale
	NE cor. 22-23-23 3095; July 26th
0-5	Buff till
5-45	Buff shale
45-55	Brown & dark grey shale - mauve shale
55-68	Light grey s & p ss
68-105	Dark grey silty shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 35-23-23 2930; July 25th
0-35	Buff till
35-45	Light grey & brown s & p ss
45-60	Dark grey & brown shale
60-70	Light grey s & p ss
70-85	Brown shale
85-90	Light grey silty shale
90-105	Brown shale & hard siltstone stringers @ 97 feet
	NE cor. 21-24-17 2665; Sept. 14th
0-40	Buff river sand
40-52	Gravel shield
52-80	Dark grey till
80-110	Gravel
110-115	Bearpaw
	NE cor. 32-24-17 2845; Aug. 1st
0-25	Buff till
25-105	Dark grey till
	NE cor. 8-24-18 2927; July 16th
0-30	Buff till
30-105	Dark grey till

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 19-24-18 2923; Sept. 13th
0-35	Buff till
35-52	Gravel
52-67	Brown shale
67-68.5	Coal
68.5-75	Dark grey shale
75-105	Light grey s & p ss
	NE cor. 21-24-18 2950; July 31st
0-30	Buff till
30-105	Dark grey till
	NE cor. 34-24-18 2920; Aug. 1st
0-20	Buff till
20-65	Dark grey till
65-75	Gravel
	NE cor. 36-24-18 2955; Aug. 1st
0-30	Buff till
30-105	Dark grey till
	NE cor. 8-24-19 2916; July 30th
0-15	Buff till
15-75	Dark grey till
75-95	Buff & dark grey till
95-99	Coal
99-104	Brown shale
104-108	Coal
108-135	Brown shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 10-24-19 2985; July 30th
0-20	Buff till
20-80	Dark grey shale
80-85	Light grey shale
85-88	Dark grey shale
88-89	Coal
89-105	Dark grey shale
105-106	Coal
106-110	Brown shale
110-115	Light grey silty shale
115-120	Brown shale
	NE cor. 12-24-19 2950; July 30th
0-5	Buff till
5-105	Dark grey lake deposit
	NE cor. 19-24-19 2945; July 31st
0-10	Buff till
10-36	Dark grey lake deposit
36-70	Light grey shale
70-75	Brown shale
75-82	Dark grey shale
82-84	Coal
84-105	Blind - possible coal @ 92,98 feet
	NE cor. 21-24-19 3040; July 17th
0-95	Buff till
95-96	Gravel

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 23-24-19 2990; July 16th
0-15	Buff till
15-55	Dark grey till
55-60	Gravel
	NE cor. 32-24-19 3082; July 17th
0-50	Buff till
50-58	Buff shale
58-66	Buff s & p ss
66-112	Brown & light grey shale
112-116	Ss
116-195	Light & dark grey shale
	NE cor. 8-24-20 2835; July 6th
0-20	Buff till
20-37	Brown shale
37-38	Coal
38-55	Dark grey shale
55-57	Siltstone, well-cemented
57-64	Light grey shale
64-65	Ss
65-70	Light grey to green shale
70-86	Light grey s & p ss
86-93	Shale
93-95	Coal
95-106	Brown shale
106-108	Coal
108-120	Brown shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 10-24-20 2935; July 4th
0-49	Buff till
49-50.5	Coal
50.5-62	Light grey shale
62-64	Light grey s & p ss
64-79	Light grey shale
79-90	Chocolate brown shale
90-95	Dark grey shale
95-140	Light grey shale
140-145	Dark grey shale & siltstone stringer @ 144 feet
145-150	Black shale
	NE cor. 12-24-20 2984; July 3rd
0-88	Buff till
88-160	Light grey to brown shale
160-164	Coal
164-165	Parting (shale or bone)
165-167	Coal
167-190	Grey bentonitic shale
190-195	Brown shale
	NE cor. 19-24-20 2850; Aug. 6th
0-32	Buff till
32-60	Dark grey shale, coal stringers .5 feet @ 60 feet
60-70	Light grey s & p ss
70-75	Light grey silty shale
75-90	Dark grey shale
90-100	Brown shale
100-105	Light grey silty shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 21-24-20 2965; Aug. 6th
0-40	Buff till
40-50	Light & dark grey shale
50-55	Light grey s & p ss
55-70	Dark grey shale
70-72	Ss
72-105	Dark grey shale
	NE cor. 36-24-20 2995; July 31st
0-30	Buff till & pea gravel stringers
30-50	Dark grey till
50-55	Reworked bedrock
55-70	Light grey silty shale & ironstone & s & p ss
70-105	Dark grey shale
	NE cor. 10-24-21 2885; July 9th
0-42	Buff till
42-105	Grey shale & hard stringers
	NE cor. 12-24-21 2888; July 6th
0-18	Buff till
18-55	Light grey shale
55-65	Brown shale
65-70	S & p ss
70-105	Light grey shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 19-24-21 2885; July 23rd
0-10	Buff till
10-30	Buff shale
30-40	Brown shale
40-70	Light grey silty shale
70-84	Light grey s & p ss
84-92	Light grey shale
92-94	Ss
94-105	Light grey silty shale
	NE cor. 21-24-21 2842; Aug. 6th
0-10	Buff till
10-40	Dark grey lake deposit
40-54	Brown s & p ss
54-55	Brown shale
55-65	Dark grey shale
65-75	Brown silty shale
75-85	Dark grey shale
85-90	Light grey silty shale
90-105	Dark grey silty shale
	NE cor. 23-24-21 2910; Aug. 6th
0-12	Buff till
12-40	Light buff & brown shale
40-45	Light grey shale
45-96	Dark grey shale
96-97	Coal
97-102	Light grey s & p ss
102-105	Brown shale
105-120	Dark grey silty shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 32-24-21 2883; July 24th
0-20	Buff till
20-30	Buff shale & siltstone stringers
30-35	Light grey silty shale
35-105	Dark grey shale & ss stringers
	NE cor. 36-24-21 2915; Aug. 6th
0-20	Buff till
20-28	Light grey shale
28-32	Light grey siltstone
32-80	Dark grey shale
80-85	Light grey s & p ss
85-105	Dark grey shale
	NE cor. 19-24-22 2950; July 24th
0-25	Brown shale - mauve
25-65	Light grey to brown silty shale
65-80	Light grey ss
80-105	Light grey shale
	NE cor. 21-24-22 2820; July 24th
0-15	Buff till & pea gravel stringers
15-40	Light brown shale
40-105	Light grey shale & ss stringers

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 23-24-22 2915; July 23rd
0-15	Buff till
15-45	Buff silty shale
45-105	Dark grey shale, ss stringers @ 64 feet
	NE cor. 32-24-22 2904; July 23rd
0-25	Buff till
20-25	Buff shale
25-30	Brown shale
30-50	Dark grey to brown shale
50-54	Dark brown shale
54-59	Coal
59-105	Light grey shale & hard stringer @ 102 feet
	NE cor. 34-24-22 2877; July 23rd
0-5	Buff till
5-20	Buff soft s & p ss
20-25	Buff shale
25-40	Dark grey to brown shale
40-60	Light grey shale
60-65	Light grey s & p ss
65-70	Light grey shale
70-75	Brown shale
75-105	Dark grey & brown shale
105-108	Brown shale
108-120	Light grey ss (well-cemented)

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 36-24-22 2875; July 23rd
0-15	Buff till
15-40	Light grey shale
40-45	Siltstone
45-50	Brown shale
50-105	Light grey shale
	NE cor. 12-24-23 2925; July 25th
0-40	Brown river sand
40-100	Dark grey lake deposit
100-105	Dark grey shale - mauve
	NE cor. 19-24-23 2970; July 25th
0-10	Buff lake deposit
10-15	Pea gravel stringers
15-30	Buff shale
30-35	Light grey shale
35-60	Light grey s & p ss
60-95	Dark grey shale - mauve
95-100	Light grey s & p ss
100-105	Dark grey shale
	NE cor. 21-24-23 2962; July 25th
0-5	Buff till
5-43	Buff shale
43-50	Dark grey s & p ss
50-105	Dark grey shale - mauve

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 23-24-23 2928; July 24th
0-10	Buff till
10-30	Buff silty shale
30-65	Dark grey shale
65-70	Brown shale
70-105	Dark grey & brown shale
	NE cor. 36-24-23 2930; July 25th
0-15	Sand & gravel
15-30	Till
30-60	Dark grey shale - mauve
60-65	Light grey shale
65-70	Light grey s & p ss
70-75	Brown shale & coal stringers
75-80	Light grey shale
80-105	Light grey s & p ss & hard stringers
	NE cor. 23-24-24 2975; July 25th
0-25	Sand & gravel
25-36	Light grey s & p ss
36-45	Dark grey shale
45-105	Light grey s & p ss & hard stringers
	NE cor. 7-25-16 2700; Aug. 1st
0-20	Buff till
20-60	Dark grey till
60-65	Gravel

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 9-25-16 2595; Aug. 2nd
0-15	Buff till
15-72	Brown lake deposit
72-86	Gravel
86-105	Till (poor sample)
105-130	Bearpaw
	NE cor. 20-25-16 2740; Aug. 2nd
0-20	Buff till
20-35	Gravel
	NE cor. 7-25-17 2905; Aug. 1st
0-25	Buff till
25-105	Dark grey till
	NE cor. 9-25-17 2810; Sept. 14th
0-20	Buff till
20-48	Dark grey till
48-72	Gravel
72-73	Coal
73-80	Brown shale
80-105	Light grey s & p ss
	NE cor. 11-25-17 2738; Aug. 1st
0-20	Buff till
20-80	Dark grey till
80-85	Gravel

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 20-25-17 2900; Aug. 2nd
0-15	Buff till
15-90	Dark grey till
90-100	Gravel
	NE cor. 24-25-17 2785; Sept. 13th
0-49	Buff till
49-68	Gravel
68-80	Dark grey shale
80-105	Light grey s & p ss
	NE cor. 31-25-17 2985; Aug. 3rd
0-50	Buff till
50-105	Dark grey till
	NE cor. 33-25-17 2860; Aug. 3rd
0-20	Buff till
20-70	Dark grey till
70-90	Sand & gravel
	NE cor. 11-25-18 2920; Aug. 3rd
0-55	Buff till
55-75	Dark grey till
75-80	Gravel
	NE cor. 24-25-18 2945; Aug. 3rd
0-30	Buff till
30-105	Dark grey till

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 7-25-19 3005; July 17th
0-20	Buff till
20-40	Dark grey till
40-45	Light grey shale
45-70	Dark grey shale
70-75	Brown silty shale
75-85	Light grey shale, with 1 siltstone stringer
85-105	Light grey shale
	NE cor. 9-25-19 3064; July 18th
0-30	Buff till
30-36	Light grey shale
36-39	Ss
39-51	Dark grey shale
51-53	Siltstone
53-60	Dark grey shale
60-69	Ss
69-105	Light grey shale
	NE cor. 20-25-19 3020; July 18th
0-15	Buff till
15-30	Dark grey till
30-40	Light grey s & p ss
40-45	Brown shale
45-60	Green shale
60-65	Brown shale
65-70	Grey siltstone
70-80	Dark grey shale
80-85	Brown shale
85-105	Light grey shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 22-25-19 3057; July 18th
0-11	Buff till
11-16	Coal
16-20	Coaly shale
20-54	Light grey shale
54-59	Ss
59-105	Light grey shale
	NE cor. 24-25-19 3170; July 18th
0-25	Buff till
25-45	Sand & gravel
45-60	Yellow clay
60-70	Brown shale
70-95	Bentonite, yellow to off white
	NE cor. 31-25-19 3035; July 18th
0-40	Buff till
40-48	Dark grey shale
48-58	Ss
58-142	Dark grey & brown shale
142-143	S & p ss
143-156	Brown shale
156-158	Ss
158-180	Light grey shale
180-190	Brown shale
	NE cor. 33-25-19 3095; July 19th
0-15	Buff till
15-30	Brown shale
30-45	Light grey shale
45-46.5	Coal
46.5-80	Dark grey & brown shale
80-82	Coal
82-105	Light grey shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 7-25-20 2985; July 20th
0-35	Buff till
35-105	Dark grey & brown shale
	NE cor. 9-25-20 2965; July 20th
0-20	Buff till
20-30	Sand & gravel
30-50	Buff till
50-55	Light grey s & p ss
55-90	Light grey shale
90-100	Brown shale
100-105	Light grey s & p ss
	NE cor. 22-25-20 3065; July 19th
0-15	Brown lake deposit
15-35	Brown till & gravel stringers
35-45	Dark grey lake deposit
45-70	Dark grey shale
70-72	Light grey s & p ss
72-105	Dark grey shale
	NE cor. 35-25-20 3020; July 19th
0-30	Till
30-50	Brown s & p ss
50-52	Coal
52-105	Dark grey shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 7-25-21 2905; July 20th
0-30	Buff till
30-53	Light grey shale
53-56	Light grey s & p ss
56-60	Green silty shale
60-105	Dark grey to brown shale
	NE cor. 9-25-21 3007; July 20th
0-50	Buff till
50-56	Brown shale
56-57.75	Coal
57.57-76	Light grey shale
76-78.5	Coal
78.5-85	Brown shale
85-88	Light grey ss
88-100	Light grey shale
100-105	Light grey siltstone
	NE cor. 11-25-21 3002; July 20th
0-30	Buff till
30-90	Dark grey till
90-100	Light grey shale
100-105	Dark grey shale
	NE cor. 20-25-21 3075; July 24th
0-78	Buff till
78-94	Mauve shale
94-116	Dark grey & brown shale
116-134	Light grey ss (white)
134-142	Light grey shale
142-144	Coal
144-154	Light grey s & p ss
154-158	Light grey silty shale
158-160	Coal
160-172	Dark grey shale
172-174	Ss
172-195	Light grey shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 22-25-21 3160; Aug. 6th
0-45	Buff till
45-52	Brown s & p ss - Paskapoo
52-60	Brown silty shale
60-75	Brown s & p ss
75-80	Dark grey s & p ss
80-85	Dark grey silty shale
85-105	Light grey s & p ss
	NE cor. 24-25-21 3100; July 27th
0-15	Buff till
15-50	Brown s & p ss - Paskapoo
50-52	Hard ss
52-65	Light grey shale
65-75	Black shale
75-90	Dark grey shale, coal .5 feet @ 88 feet
90-105	Dark brown & coaly shale
	NE cor. 9-25-22 2905; July 23rd
0-15	Buff till
15-35	Light grey shale
35-60	Dark grey to black shale & coal stringers
60-65	Light grey shale
65-67	Bone
67-72	Coal
72-90	Light grey shale
90-100	Light green shale & hard stringers
100-105	Light grey silty shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 11-25-22 2914; July 20th
0-10	Buff till & ss pebbles
10-20	Buff silty shale
20-25	Brown shale
25-30	Light grey soft s & p ss
30-40.5	Dark grey to brown shale
40.5-46.5	Coal
46.5-55	Dark grey shale & coal stringers
55-65	Light grey s & p ss
65-70	Green shale
70-105	Light green shale & siltstone stringers
	NE cor. 11-25-23 2882; July 25th
0-35	Brown shale ("mauve")
35-45	Light grey shale
45-88	Dark grey & brown shale
88-92	Ss
92-95	Light grey s & p ss
95-105	Light grey silty shale
	NE cor. 8-26-15 2653; Sept. 11th
0-15	Buff till
15-60	Dark grey shale - Bearpaw
	NE cor. 19-26-15 2630; Sept. 11th
0-15	Gravel
15-63	Light grey s & p ss
63-105	Dark grey shale - Bearpaw

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 32-26-15 2745; Sept. 11th
0-39	Buff till
39-72	Gravel
72-76	Dark grey shale
76-105	Light grey s & p ss
	NE cor. 34-26-15 2682; Aug. 13th
0-20	Buff till
20-30	Gravel
	NE cor. 36-26-15 2645; Aug. 13th
0-10	Buff till
10-24	Dark grey till
24-105	Dark grey shale - Bearpaw
	NE cor. 32-26-16 2765; Aug. 7th
0-5	Sand & gravel
5-30	Buff till
30-50	Dark grey till
50-56	Brown shale
56-56.5	Coal
56.5-84	Brown shale
84-86	Coal
86-87	Brown shale
87-88	Coal
88-105	Light grey s & p ss

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 34-26-16 2780; Aug. 7th
0-25	Buff till
25-35	Dark grey till
35-45	Brown shale
45-47	Ss
47-59	Brown shale
59-60	Coal
60-62	Brown shale
62-62.75	Coal
62.75-72	Dark grey shale
72-73	Coal
73-81	Brown shale
81-82.75	Coal
82.75-90	Brown & dark grey shale
90-105	Light grey s & p ss
	NE cor. 36-26-16 2785; Aug. 7th
0-15	Buff till
15-25	Light grey s & p ss
25-30	Dark grey & brown shale
30-30.5	Coal
30.5-50	Gravel
	NE cor. 8-26-17 2950; Aug. 3rd
0-30	Buff till
30-70	Dark grey till
70-94	Light brown lake deposit
94-100	Gravel
100-120	Dark grey s & p sand or ss

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 19-26-17 3035; Aug. 7th
0-40	Buff till
40-60	Sand & gravel
	NE cor. 34-26-17 2525; Aug. 7th
0-30	Buff till (sand)
30-130	Dark grey till
130-135	Cemented gravel
	NE cor. 36-26-17 2635; Aug. 7th
0-35	Buff till
35-45	Gravel
	NE cor. 8-26-18 3090; Aug. 3rd
0-16	Buff till
16-22	Gravel
22-25	Light buff s & p ss
25-30	Light buff to brown shale
30-60	Light grey silty shale
60-90	Light brown shale
90-105	Light grey silty shale
	NE cor. 19-26-19 3045; July 19th
0-10	Buff till
10-76	Grey lake deposit
76-82	Dark grey s & p ss
82-105	Green shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 12-26-20 3085; July 19th
0-15	Brown lake deposit
15-68	Dark grey lake deposit
68-96½	Light grey shale
96-98	Ss
98-105	Dark grey shale
	NE cor. 23-27-13 2615; Sept. 6th
0-20	Buff till
20-105	Dark till
	NE cor. 32-27-13 2594; Sept. 6th
0-25	Buff till
25-105	Dark grey till
	NE cor. 34-27-13 2650; Sept. 6th
0-10	Buff sand
10-40	Dark grey till
40-105	Dark grey shale - Bearpaw
	NE cor. 36-27-13 2658; Sept. 6th
0-10	Buff till
10-30	Dark grey till
30-105	Dark grey shale - Bearpaw
	NE cor. 32-27-14 2695; Aug. 9th
0-10	Buff till
10-15	Buff s & p ss
15-24	Light grey s & p ss
24-114	Dark grey shale
114-126	Light grey s & p ss
126-130	Brown silty shale
130-142	Dark grey silty shale
142-144	Ss
144-195	Dark grey shale - Bearpaw
	NE cor. 34-27-14 2615; Aug. 9th
0-10	Buff till
10-18	Sand
18-34	Dark grey till
34-48	Dark grey shale
48-70	Light grey s & p ss
70-150	Dark grey shale - Bearpaw
	NE cor. 36-27-14 2593; Aug. 9th
0-15	Buff till
15-135	Dark grey till
	NE cor. 8-27-15 2780; Aug. 8th
0-20	Buff till
20-45	Sand & gravel
45-48	Brown shale
48-50	Coal
50-105	Dark grey shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 10-27-15 2720; Aug. 13th
0-5	Buff till
5-15	Gravel
	NE cor. 12-27-15 2675; Aug. 13th
0-15	Buff till
15-23	Dark grey till
23-80	Light grey shale
80-80.5	Coal
80.5-90	Light grey shale
90-105	Dark grey shale
	NE cor. 19-27-15 2800; Aug. 13th
0-10	Buff till
10-60	Dark grey till
60-78	Shale
78-105	Light grey shale & s & p ss
	NE cor. 21-27-15 2780; Aug. 10th
0-20	Buff till
20-52	Dark grey till
52-86	Light grey shale
86-92	Light grey silty shale
92-96	Light grey s & p ss
96-98	Light grey silty shale
98-105	Light grey s & p ss

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 23-27-15 2712; Aug. 13th
0-10	Buff till
10-44	Dark grey till
44-49	Shale
49-80	Dark grey s & p ss & hard stringers
80-105	Light grey s & p ss & hard stringers
	NE cor. 32-27-15 2865; Aug. 10th
0-15	Buff till
15-30	Dark grey till
30-35	Dark grey shale
35-36.5	Coal
36.5-54	Light grey silty shale
54-60	Light grey s & p ss
60-69	Light grey shale
69-71	Coal
71-105	Dark grey shale
	NE cor. 34-27-15 2810; Aug. 9th
0-15	Buff till
15-70	Dark grey till
70-105	Brown & dark grey shale
	NE cor. 36-27-15 2777; Aug. 9th
0-20	Buff till
20-45	Sand & gravel

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 8-27-16 2890; Aug. 8th
0-30	Buff till
30-44	Light grey & brown shale
44-46	Coal
46-53	Light grey shale
53-54	Coal
54-77	Dark grey shale
77-79	Coal
79-82	Light grey siltstone
82-95	Dark grey & black coaly shale
95-100	Light grey ss
100-105	Brown shale
105-107	Coal
107-108	Shale
108-110	Coal
110-120	Brown & dark grey shale
	NE cor. 10-27-16 2855; Aug. 8th
0-20	Sand & gravel
20-30	Dark grey till
30-36	Dark grey shale
36-39	Coal
39-60	Dark grey shale
60-66	Light grey shale
66-68.5	Coal
68.5-88	Brown shale
88-120	Light grey s & p ss
	NE cor. 12-27-16 2820; Aug. 8th
0-20	Buff till
20-30	Gravel

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 19-27-16 3025; Aug. 8th
0-15	Buff till
15-60	Dark grey till
60-65	Gravel
	NE cor. 23-27-16 2900; Aug. 8th
0-15	Buff till
15-90	Dark grey till
90-100	Gravel
100-105	Dark grey & brown shale
	NE cor. 36-27-16 2885; Aug. 8th
0-20	Buff till
20-105	Dark grey till
	NE cor. 7-28-12 2685; Sept. 6th
0-10	Buff s & p ss
10-30	Brown shale
30-40	Dark grey s & p ss
40-105	Dark grey shale - Bearpaw
	NE cor. 31-28-12 2762; Sept. 5th
0-6	Buff till
6-12	Coal with 1.5 feet parting
12-105	Light grey s & p ss, lowermost 15 feet well cemented

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 33-28-12 2637; Sept. 5th
0-24	Buff till
24-32	Dark grey shale
32-36	Brown siltstone
36-55	Dark grey s & p ss
55-105	Dark grey shale - Bearpaw
	NE cor. 9-28-13 2637; Sept. 6th
0-20	Buff till
20-65	Dark grey till
65-105	Dark grey shale - Bearpaw
	NE cor. 20-28-13 2637; Sept. 6th
0-10	Buff till
10-50	Dark grey till
50-105	Dark grey shale - Bearpaw
	NE cor. 22-28-13 2710; Sept. 5th
0-5	Buff till
5-40	Light grey s & p ss
40-90	Dark grey silty shale
90-96	Light grey s & p ss
96-100	Dark grey shale
100-105	Light grey s & p ss

Depth (feet)	Location W 4th Mer. Top elevation (feet) Date
	NE cor. 24-28-13 2754; Sept. 6th
0-5	Buff sand or ss
5-25	Buff s & p ss
25-86	Light grey s & p ss
86-105	Dark grey to black silty shale
	NE cor. 31-28-13 2612; Sept. 5th
0-30	Buff till
30-100	Dark grey till
100-105	Light grey s & p ss
	NE cor. 33-28-13 2728; Sept. 5th
0-5	Buff till
5-13	Brown shale
13-16.5	Coal
16.5-26	Brown shale
26-37	Coal & 3 partings equal to 3 feet
37-70	Light grey s & p ss
70-90	Light grey shale
90-105	Dark grey shale
	NE cor. 35-28-13 2735; Sept. 5th
0-15	Buff till
15-31	Coal & 3 partings equal to 3 feet
31-86	Light grey s & p ss
86-105	Dark grey shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 7-28-14 2770; Aug. 14th
0-20	Buff till
20-60	Dark grey till
60-84	Dark grey & brown shale
84-105	Light grey shaly ss
	NE cor. 9-28-14 2645; Aug. 14th
0-10	Buff s & p ss
10-30	Light grey shale
30-105	Dark grey shale - Bearpaw
	NE cor. 20-28-14 2783; Aug. 14th
0-18	Buff till
18-30	Dark grey shale
30-40	Brown shale
40-45	Light grey shale
45-55	Brown shale
55-76	Dark grey to brown shale
76-79.5	Coal
79.5-88	Light grey s & p ss
88-105	Dark grey shale
	NE cor. 31-28-14 2770; Aug. 16th
0-15	Buff till
15-26	Light grey s & p ss
26-30	Dark grey shale
30-40	Light grey shale
40-45	Brown shale
45-57	Light green & dark grey shale
57-59	Coal
59-73	Brown shale
73-79	Light grey ss
79-82	Shale
82-87	Coal
87-104	Dark grey shale
104-116	Light grey s & p ss
116-144	Dark grey to brown shale
144-190	Dark grey s & p ss
190-200	Light green s & p ss
200-205	Dark grey ss
	NE cor. 7-28-15 2900; Aug. 9th
0-15	Buff till
15-105	Dark grey till & fresh water limestone @ 105 feet
105-120	Sand & gravel
	NE cor. 9-28-15 2850; Aug. 9th
0-30	Buff till
30-54	Dark grey till
54-61	Brown shale
61-63	Siltstone
63-66	Black shale
66-67	Siltstone
67-71	Black shale
71-75	Brown siltstone
75-96	Brown & dark grey shale
96-98	Coal
98-105	Brown shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 11-28-15 2815; Aug. 14th
0-15	Buff till
15-50	Dark grey till
50-75	Dark grey shale
75-80	Brown shale
80-90	Dark grey shaly ss
90-100	Dark grey shale
100-110	Light grey shaly ss
110-120	Dark grey sandy shale
	NE cor. 22-28-15 2853; Aug. 15th
0-15	Buff till
15-80	Dark grey till
80-96	Dark grey shale
96-97	Coal
97-105	Brown shale
105-110	Dark grey shale
110-120	Light grey s & p ss
	NE cor. 24-28-15 2830; Aug. 15th
0-10	Buff till
10-16	Brown shale ("mauve")
16-22	Light grey ss ("white")
22-64	Dark grey shale
64-68	Coal
68-75	Light grey shale
75-92	Dark grey shale
92-93.5	Coal
93.5-100	Dark grey shale
100-105	Light grey s & p ss
	NE cor. 33-28-15 2925; Aug. 15th
0-60	Buff & dark grey till, bottom 5 feet sand
60-90	Brown shale
90-105	Light grey silty shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 35-28-15 2865; Aug. 15th
0-15	Buff till
15-20	Buff s & p ss
20-30	Buff shale
30-68	Dark grey shale
68-69.5	Coal
69.5-80	Lost circulation
80-83	Coal
83-105	Lost circulation
	NE cor. 11-28-16 2974; Aug. 9th
0-5	Buff till
5-30	Dark grey till
30-40	Sand & gravel
40-68	Light green s & p ss
68-85	Dark grey shale
85-87.75	Coal
87.75-105	Dark grey & brown shale
	NE cor. 8-29-12 2712; Sept. 5th
0-5	Buff till
5-28	Buff ss
28-29.5	Coal
29.5-30	Dark brown shale
30-105	Light grey s & p ss
	NE cor. 12-29-13 2725; Sept. 5th
0-10	Buff till
10-14	Brown shale
14-30	Coal
30-65	Light grey s & p ss
65-85	Light grey s & p shaly ss
85-105	Brown to dark grey shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 19-29-13 2770; Sept. 6th
0-5	Buff sand or ss
5-10	Dark grey shale
10-15	Brown shale
15-20	Light brown shale
20-35	Black & dark grey shale
35-43	Light grey shale & siltstone stringers
43-46	Coal
46-66	Dark grey shale
66-70	Coal
70-80	Light grey s & p ss
80-100	Light grey silty shale
100-105	Dark grey shale
	NE cor. 21-29-13 2828; Aug. 30th
0-26	Brown shale
26-28	Coal
28-36	Brown shale
36-38	Coal
38-52	Dark grey shale
52-61	Light grey s & p ss
61-80	Dark grey to brown shale
80-86	Light grey s & p ss
86-98	Dark grey shale
98-100.5	Coal
100.5-105	Light grey-green shale
	NE cor. 32-29-13 2877; Sept. 10th
0-15	Buff till
15-63	Dark grey shale
63-64.5	Coal
64.5-90	Light grey & green shale
90-96	Dark grey shale
96-105	Light grey s & p ss

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 34-29-13 2750; Aug. 30th
0-15	Buff till
15-20	Brown shale
20-23	Coal
23-48	Light grey s & p ss
48-105	Dark grey shale - Bearpaw
	NE cor. 36-29-13 2686; Aug. 30th
0-17	Buff till
17-30	Buff s & p ss
30-100	Light grey-green s & p ss
100-105	Dark grey shale - Bearpaw
	NE cor. 19-29-14 2655; Aug. 15th
0-20	Buff till
20-30	Pea gravel
30-35	Buff till
35-40	Dark grey till
40-65	Dark grey & brown shale
65-80	Light grey s & p ss
80-90	Light grey silty shale
90-105	Light grey ss
	NE cor. 21-29-14 2585; Aug. 16th
0-30	Dark grey till
30-64	Till & lake silt
64-69	Gravel
69-113	Lake silt
113-117	Loose gravel
117-185	Lake sediments

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 23-29-14 2637; Aug. 29th
0-10	Buff till
10-55	Dark grey till
55-105	Dark grey silty shale - Bearpaw
	NE cor. 10-29-15 3050; Aug. 20th
0-105	Buff till, gravel & sand stringers
	NE cor. 12-29-15 2912; Aug. 15th
0-20	Buff till
20-44	Dark grey shale
44-46	Light grey ss
46-54	Shale
54-55.5	Coal
55.5-67	Dark grey shale
67-69	Coal
69-87	Dark grey shale
87-88.5	Coal
88.5-94	Dark grey shale
94-97	Coal
97-105	Dark grey shale
	NE cor. 21-29-15 3190; Aug. 20th
0-25	Buff till
25-35	Gravel & boulders

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 23-29-15 2932; Aug. 16th
0-30	Buff till
30-60	Buff to rusty shale
60-83	Dark grey shale
83-84.5	Coal
84.5-95	Dark grey shale
95-97	Dark grey s & p ss
97-105	Chocolate brown shale
105-110	Light grey s & p ss
110-113	Light grey shale
113-118	Coal
118-125	Light grey ss & green shale
	NE cor. 32-29-15 3065; Aug. 20th
0-10	Buff till
10-54	Dark grey lake deposit
54-105	Dark blue-grey silty shale
	NE cor. 34-29-15 2870; Aug. 17th
0-50	Buff till
50-60	Dark grey to brown shale
60-61.75	Coal
61.75-75	Dark grey shale
75-80	Light grey s & p ss
80-90	Dark grey shale
90-98	Light grey s & p ss
98-103	Coal
103-120	Dark brown shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 36-29-15 2680; Aug. 17th
0-50	Buff & dark grey till
50-65	Dark grey shale
65-70	Lost circulation 4 feet; drilled like coal
70-90	No samples, lost circulation
	NE cor. 20-30-12 2578; Aug. 30th
0-20	Buff till
20-105	Dark grey shale - Bearpaw
	NE cor. 31-30-12 2583; Aug. 22nd
0-14	Buff till
14-105	Dark grey shale - Bearpaw
	NE cor. 11-30-13 2710; Aug. 30th
0-30	Buff till
30-50	Buff s & p ss
50-105	Light grey to blue-green s & p ss
	NE cor. 20-30-13 2766; Sept. 10th
0-10	Buff till
10-31	Brown & dark grey shale
31-32	Coal
32-45	Light grey silty shale
45-57	Dark grey & brown shale
57-64	Light grey s & p ss
64-92	Light grey s & p ss & hard stringers
92-105	Dark grey shale
	NE cor. 24-30-13 2648; Aug. 30th
0-28	Buff till
28-35	Brown to dark grey shale
35-105	Dark grey shale - Bearpaw
	NE cor. 31-30-13 2750; Aug. 22nd
0-10	Buff till
10-20	Black shale
20-70	Light grey s & p ss
70-92	Dark grey shale
92-105	Light grey s & p ss
	NE cor. 33-30-13 2675; Aug. 22nd
0-5	Buff till
5-20	Brown shale
20-36	Dark grey shale
36-60	Light grey s & p ss
60-84	Dark grey silty shale
84-87	Ss
87-105	Dark grey silty shale - Bearpaw

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 35-30-13 2643; Aug. 22nd
0-10	Buff till
10-36	Blue-grey s & p ss
36-105	Dark grey shale - Bearpaw
	NE cor. 7-30-14 2615; Aug. 17th
0-15	Buff till
15-75	Dark grey till
75-90	Pea gravel
90-105	Lake deposit
	NE cor. 11-30-14 2690; Aug. 23rd
0-28	Buff till
28-90	Dark grey silty shale
90-105	Blue-grey s & p ss
	NE cor. 20-30-14 2620; Aug. 23rd
0-10	Sand & gravel
10-40	Dark grey till
40-105	Dark grey shale - Bearpaw
	NE cor. 22-30-14 2650; Aug. 23rd
0-25	Buff till
25-60	Sand & reworked bedrock

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 31-30-14 2647; Aug. 17th
0-25	Buff till
25-95	Dark grey till
95-105	Dark grey shale
	NE cor. 33-30-14 2687; Aug. 23rd
0-34	Buff till
34-86	Light grey s & p ss
86-105	Light grey shale
	NE cor. 35-30-14 2702; Aug. 22nd
0-10	Buff till
10-14	Brown shale
14-22	Buff s & p ss
22-40	Dark grey silty shale
40-94	Light green-grey s & p ss
94-105	Light green-grey silty shale
	NE cor. 7-30-15 3013; Aug. 20th
0-10	Buff till
10-22	Sand
22-85	Dark grey lake deposit
85-105	Dark grey shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 9-30-15 2870; Aug. 20th
0-30	Buff till
30-60	Dark grey till
60-79	Dark grey shale
79-84	Coal
84-99	Dark grey & brown shale
99-100.75	Coal
100.75-105	Dark brown shale
	NE cor. 11-30-15 2734; Aug. 20th
0-15	Buff till
15-55	Dark grey till
55-60	Dark grey shale
60-80	Brown shale
80-85	Coaly shale
85-95	Brown shale
95-96.5	Coal
96.5-105	Brown shale
	NE cor. 20-30-15 2822; Aug. 21st
0-30	Buff till
30-55	Dark grey till
55-60	Dark grey shale
60-62	Ss
62-72	Dark grey shale
72-74	Ss
74-90	Dark grey shale
90-100	Dark brown shale
100-120	Light grey ss

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 22-30-15 2723; Aug. 21st
0-30	Buff till
30-105	Dark grey lake deposit
	NE cor. 24-30-15 2650; Aug. 17th
0-20	Buff till
20-105	Dark grey till
	NE cor. 33-30-15 2770; Aug. 24th
0-10	Buff till
10-90	Dark grey till
90-105	Dark grey shale
	NE cor. 35-30-15 2665; Aug. 21st
0-30	Buff till
30-105	Dark grey till
	NE cor. 22-30-16 2920; Aug. 21st
0-15	Buff till
15-50	Dark grey till
50-55	Blue-green sand & shale
55-75	Dark grey shale
75-92	Light blue-grey silty shale
92-105	Dark grey to green s & p ss

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 24-30-16 2870; Aug. 21st
0-10	Buff sandy till
10-55	Dark grey till
55-59	Dark grey shale
59-61	Coal
61-75	Dark grey to brown shale
75-76.5	Coal
76.5-88	Light grey silty shale
88-89	Coal
89-105	Dark grey shale & ss stringers
	NE cor. 31-30-16 2915; Aug. 24th
0-15	Buff till
15-105	Dark grey shale
	NE cor. 33-30-16 2815; Aug. 24th
0-5	Buff till
5-45	Dark grey till
45-55	Dark grey shale
55-57	Coal
57-67	Light grey silty shale
67-68	Coal
68-100	Dark grey shale
100-105	Brown shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 35-30-16 2795; Aug. 24th
0-10	Sand & gravel
10-35	Buff till
35-57	Brown shale
57-58	Coal
58-80	Dark grey shale
80-81	Coal
81-105	Dark grey shale
	NE cor. 35-30-17 2985; Aug. 24th
0-10	Buff till
10-45	Dark grey till
45-73	Dark grey shale
73-78	Light grey s & p ss
78-105	Dark grey shale
	NE cor. 19-31-13 2762; Aug. 27th
0-10	Buff till
10-30	Brown shale
30-35	Dark grey shale
35-50	Light grey s & p ss
50-60	Coal stringers in brown shale
60-105	Dark grey shale
	NE cor. 21-31-13 2687; Sept. 10th
0-15	Buff till
15-25	Dark grey till
25-72	Dark grey s & p ss
72-105	Dark grey shale - Bearpaw

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 8-31-14 2683; Aug. 27th
0-25	Buff till
25-105	Dark grey till
	NE cor. 10-31-14 2675; Aug. 23rd
0-15	Buff till
15-73	Dark grey till
73-76	Dark grey shale
76-78	Ss
78-105	Dark grey silty shale
	NE cor. 12-31-14 2742; Aug. 23rd
0-15	Buff till
15-37	Brown coaly shale
37-75	Blue-grey s & p ss
75-80	Dark grey shale
80-105	Light grey s & p ss
	NE cor. 19-31-14 2690; Aug. 27th
0-35	Buff till
35-105	Dark grey till
	NE cor. 21-31-14 2740; Aug. 27th
0-30	Buff till
30-105	Dark grey till
	NE cor. 23-31-14 2740; Aug. 27th
0-30	Buff till
30-60	Dark grey till
60-105	Light grey s & p ss & hard stringers
	NE cor. 32-31-14 2750; Aug. 27th
0-30	Buff till
30-90	Dark grey till
90-95	Gravel stringer
95-105	Dark grey till
	NE cor. 34-31-14 2830; Aug. 28th
0-35	Buff till
35-105	Dark grey till
	NE cor. 36-31-14 2750; Aug. 27th
0-15	Sand & pea gravel
	NE cor. 7-32-12 2595; Aug. 30th
0-30	Buff till
30-42	Dark grey till
42-66	Dark grey shale
66-78	Light grey s & p ss
78-100	Light grey silty shale - Bearpaw
100-105	Dark grey shale

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 7-32-13 2800; Aug. 28th
0-15	Buff till
15-62	Dark grey shale
62-70	Light grey s & p ss
70-74	Dark grey shale
74-75	Coal
75-77	Brown & black coaly shale
77-94	Light grey-green s & p ss
94-105	Light grey-green silty shale
	NE cor. 9-32-13 2680; Aug. 28th
0-15	Buff till
15-20	Dark grey till
20-40	Buff s & p ss
40-60	Light grey s & p ss
60-65	Dark grey silty shale
65-75	Dark grey s & p ss
75-105	Dark grey silty shale
	NE cor. 20-32-13 2712; Aug. 29th
0-15	Buff till
15-20	Buff s & p ss
20-60	Dark grey shale
60-105	Light grey s & p ss

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 22-32-13 2650; Aug. 29th
0-10	Buff till
10-17	Buff s & p ss
17-21	Shale
21-30	Light grey s & p ss
30-34	Shale
34-42	Ss
42-105	Dark grey silty shale - Bearpaw
	NE cor. 31-32-13 2737; Aug. 29th
0-10	Buff till
10-38	Brown shale
38-40	Coal
40-41	Parting
41-45	Coal
45-98	Light grey s & p ss
98-105	Brown shale
	NE cor. 33-32-13 2697; Aug. 29th
0-20	Buff till
20-105	Light grey s & p ss
	NE cor. 11-32-14 2797; Aug. 28th
0-30	Buff till
30-105	Dark grey till

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 22-32-14 2812; Aug. 29th
0-30	Buff till
30-75	Dark brown till
75-105	Dark grey till
	NE cor. 24-32-14 2747; Aug. 28th
0-10	Buff till
10-15	Grey ss
15-39	Dark grey shale
39-40	Bone
40-44.5	Coal
44.5-50	Brown shale
50-74	Light grey s & p ss
74-85	Dark grey silty shale
85-90	Light grey silty shale
90-105	Dark grey shale
	NE cor. 35-32-14 2825; Aug. 29th
0-35	Buff till
35-40	Gravel
40-90	Dark grey till
90-93	Coal
93-105	Dark grey shale
	NE cor. 8-33-13 2730; Aug. 29th
0-5	Buff till
5-20	Buff s & p ss
20-105	Light grey s & p ss

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 10-33-13 2670; Aug. 29th
0-5	Buff till
5-15	Brown shale
15-50	Light grey s & p ss
50-105	Dark grey shale - Bearpaw
	NE cor. 10-33-14 2787; Aug. 29th
0-15	Buff till
15-34	Dark grey till
34-40	Shale
40-42.5	Coal
42.5-50	Brown shale
50-98	Dark grey shale
98-100.5	Coal
100.5-104	Dark grey shale
104-107	Coal
107-120	Dark grey shale
	NE cor. 12-33-14 2775; Aug. 29th
0-5	Buff till
5-6	Coal
6-36	Dark grey shale
36-38	Coal
38-60	Dark grey shale
60-61	Coal
61-62	Parting
62-65	Coal
65-70	Brown shale
70-105	Light grey s & p ss

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 21-33-14 2695; Sept. 10th
0-5	Buff till
5-20	Brown shale
20-22	Coal
22-25	Dark grey shale
25-30	Dark brown shale
30-42	Dark grey shale
42-44	Coal
44-45	Parting
45-48	Coal
48-50	Parting - shale
50-51.75	Coal
51.75-105	Dark grey s & p ss
	NE cor. 23-33-14 2752; Sept. 10th
0-15	Buff till
15-55	Dark grey till
55-80	Dark grey s & p ss
80-93	Dark grey shale
93-96	Coal
96-100	Brown shale
100-105	Light grey s & p ss
	NE cor. 34-33-14 2690; Sept. 10th
0-20	Buff till
20-25	Buff sand
25-35	Dark grey shale
35-40	Dark grey s & p ss
40-47	Dark grey shale
47-50	Coal
50-105	Light grey s & p ss

Depth (feet)	Location W 4th Mer. Top elevation (feet); Date
	NE cor. 9-34-14 2710; Feb. 9th, 1966
0-5	Till; few chips of coal
5-10	Well-sorted lake deposit
10-76	Shales & ss
76-77	Coal - bright & hard
77-79	Ss
	NE cor. 13-34-14 2805; Feb. 9th, 1966
0-10	Till pebbles
10-46.5	Shales, siltstones & ss
46.5-49	Coal
49-124	Shales, ss, bentonite & siltstone
124-125	Coal - soft
126.5-128	Coal - bright, fairly hard
138-148	Porous ss

SCALE

1 0 1 2 Miles

1000 500 0 1000 2000 3000 Meters

LEGEND

RIVER OR CREEK

INTERMITTENT CREEK

MARSH OR SWAMP

ROADS

HARD SURFACE ALL WEATHER

LOOSE OR STABILIZED SURFACE

LOOSE SURFACE

TRUCK TRAIL

SEISMOGRAPH LINE OR TRAIL

PIPE LINE

TRANSMISSION LINE

RAILWAY

SURFACE MINE

TOWNSITE

PARK BOUNDARY

GAS FIELD BOUNDARY

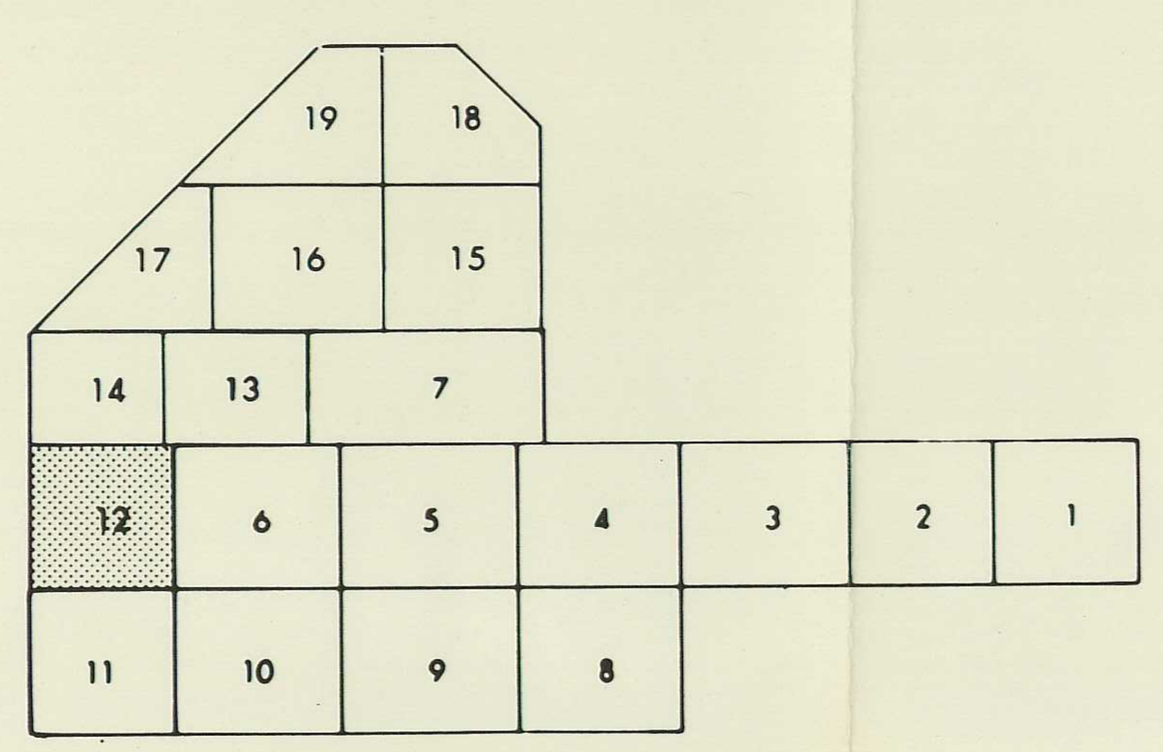
AIRSTRIP AIRSTRIP

WELL LOCATION

6520 SURVEYED PEAK

UNION LAND HOLDINGS

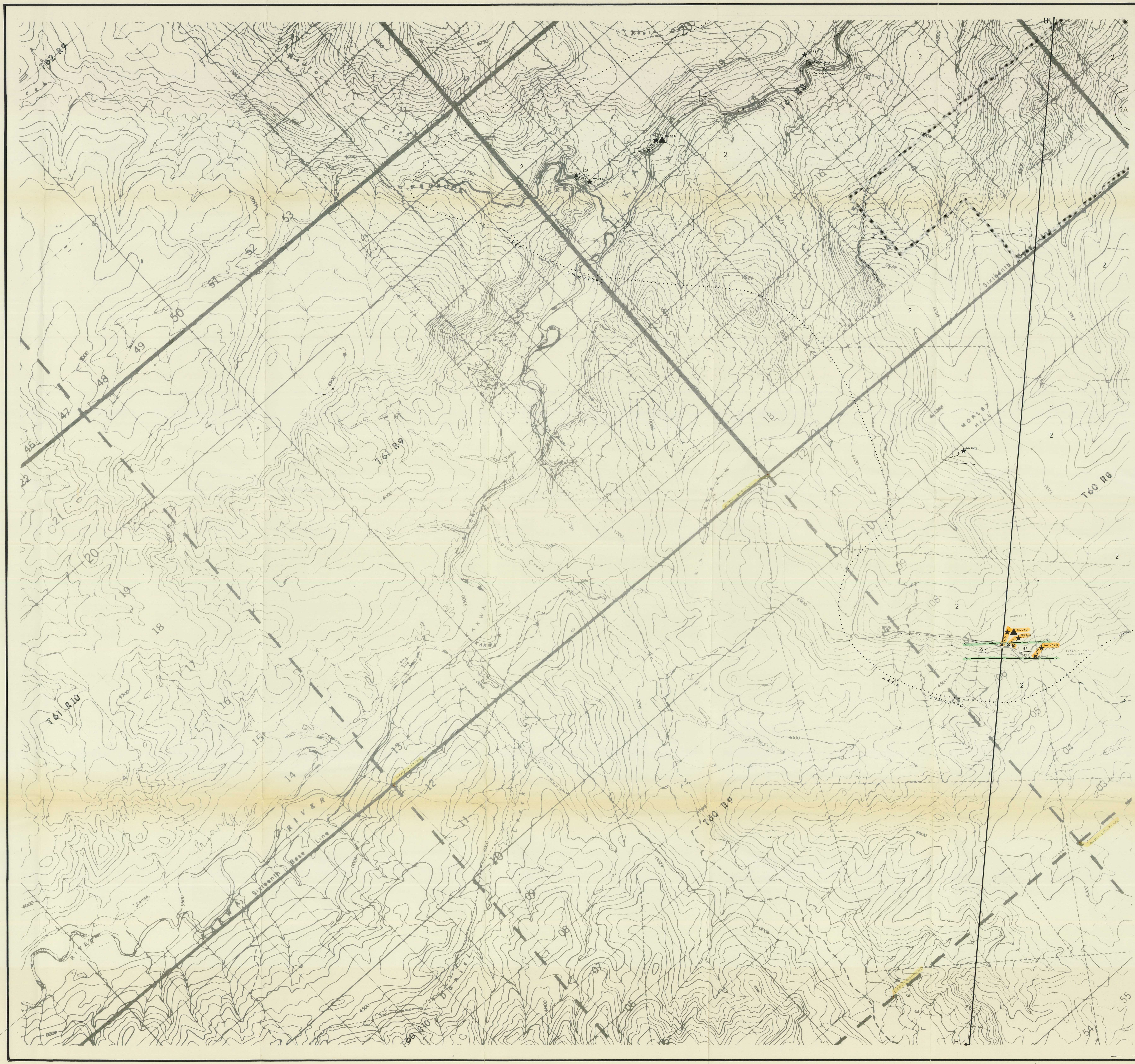
SHEET INDEX



MAGNETIC NORTH

TRUE NORTH

MAP SHEET 12



LEGEND

UPPER CRETACEOUS AND TERTIARY

3 PASKAPOO FORMATION

2 WAPITI FORMATION (May contain some undivided Smoky Group)

2A PEPPERS LAKE COAL ZONE

2B ENTRANCE CONGLOMERATE

2C HIGHWAY 40 COAL ZONE

1 SMOKY GROUP AND OLDER

Rock outcrop, outcrop area

Coal outcrop

Rock float, coal float

Shot hole with coal

Shot hole with rock chips

Bedding (horizontal, inclined, vertical, overturned, dip unknown) 15°, 80°

Joint (inclined, vertical) 30°

Fault (observed, interpreted, assumed)

Fault (inclined)

Fault (movement known) U D

Anticlinal axis (arrow indicates plunge)

Synclinal axis (arrow indicates plunge)

Photo linear

Lithological contact (observed, interpreted, assumed)

Formation boundary

Coal zone boundary (top)

Coal zone boundary (base)

Water well or flowing shot hole 35

Fossil locality F

Palynology sample analysed MW 105

Union Oil coal test hole (drilled, cased only) 74-35 74-46

Competitor coal test hole (no data, accompanying data) R 7101

Measured section

Line of cross-section A A'

Coal bulk sample analysed RB 105

REVISIONS

UNION	WEST OF SIXTH PROJECT ALBERTA
AUTHOR MICHAEL WOODLEY DATE JANUARY, 1981 SCALE 1 : 25.000 CONTOUR INTERVAL DRAWN BY L. H. APPROVED	MORLEY HILL AREA GEOLOGICAL MAP Sheet 12
UNION OIL COMPANY OF CANADA LIMITED CALGARY ALBERTA	FILE NO. C/WS/77 N.T.S. NO. 83 E, F, L EXHIBIT # 7

LEGEND

RCA testhole: coal thicker than 2 feet
coal trace
bedrock encountered, no coal
Kneehills Member intersected
drift only

Selected bedrock outcrop

Tuff outcrop, Hammer Hill

Lsd within which coal mine registered (to 1968)

Line of outcrop — subcrop, mined coal seam, approximate (excluding Drumheller Basin)

Limit of coal field (excluding Drumheller Basin)

Coal structure contour (approximate, projected) on top of:
Ardley coal zone
Carbon-Thompson coal zone
No. 7 seam (member A) or equivalent
No. 1-2 seams (member A)

Paskapoo Formation

Kneehills Member, line of outcrop — subcrop: approximate, projected

Area of glacially disturbed Kneehills Member

Garden Plain tuff, line of ourcrop — subcrop, approximate

Bearpaw Formation and older strata

Special areas (see Figures 7 and 8)

Topographic contour (interval 200 feet)

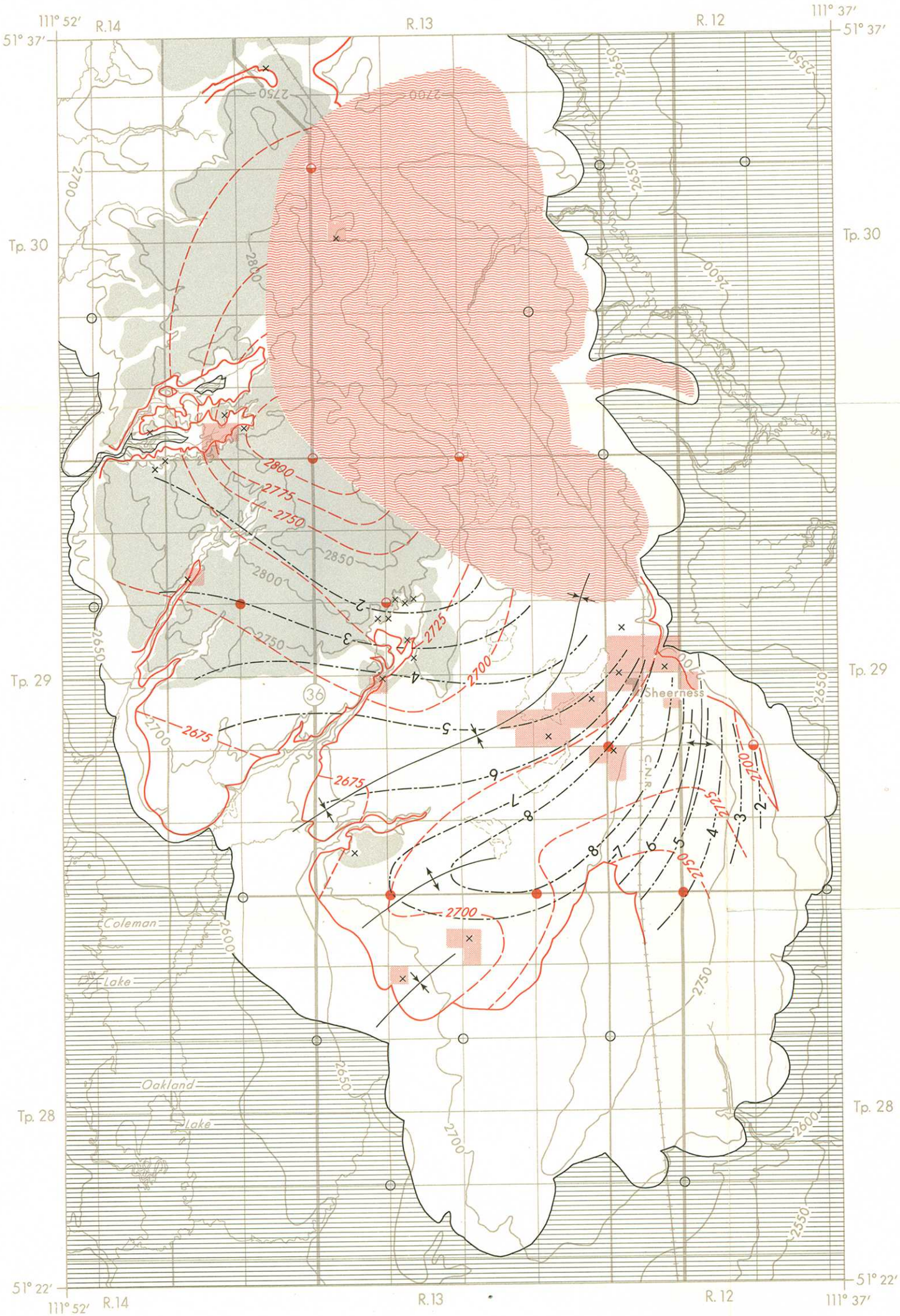
SCALE 1:250,000

Miles 5 0 5 10 15 20 Miles

Kilometres 5 0 5 10 15 20 25 30 Kilometres

FIGURE 2. GEOLOGY AND COAL OCCURRENCES, HUSSAR-HANNA AREA

To accompany Alberta Research Report 74-8
by J. D. Campbell



LEGEND

RCA testhole: coal thicker than 2 feet
coal trace
no coal
Bedrock exposure
Lsd within which coal mine registered (before 1968)
Area of extreme glacial bedrock deformation
Area underlain by Garden Plain tuff
Line of outcrop-subcrop, mined coal seam, approximate
Isopach of mined coal seam (feet) — 4
Structure contour on mined coal seam (interval 25 feet) — 2700
Axis of syncline; anticline
Bearpaw Formation

SCALE IN MILES
0 1 2 3 4

FIGURE 7. GEOLOGY AND COAL OCCURRENCES, SHEERNESS FIELD

To accompany AR Report 74-8
by J. D. Campbell

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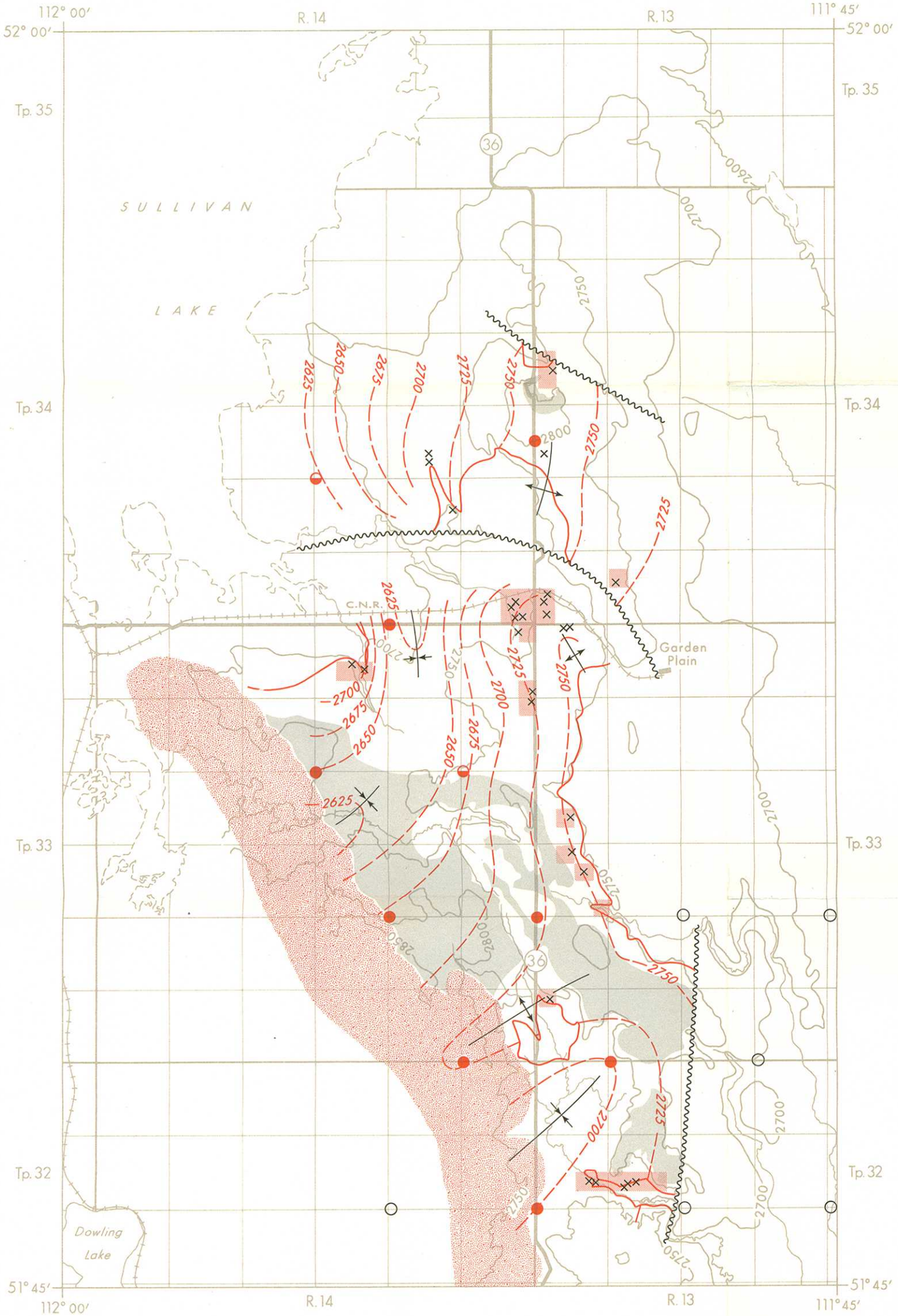

LEGEND

RCA testhole: coal thicker than 2 feet ●
coal trace ◒
no coal ○

Bedrock exposure ×

Lsd within which coal mine registered (before 1968)

Area of deep hummocky moraine

Area underlain by Garden Plain tuff

Line of outcrop-subcrop, mined coal seam, approximate

Structure contour on mined coal seam (interval 25 feet) 2700

Axis of syncline; anticline

Fault (attitude unknown)

SCALE IN MILES

0 1 2 3 4

FIGURE 8. GEOLOGY AND COAL OCCURRENCES, GARDEN PLAIN FIELD

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