# COAL ASSESSMENT REPORT TITLE PAGE AND SUMMARY

**TITLE OF REPORT: Coal assessment report for the Mink North coal property, British Columbia**

**TOTAL COST: $22,101**

AUTHOR(S): **C.G. Cathyl-Huhn**

SIGNATURE(S):

NOTICE OF WORK PERMIT NUMBER(S)/DATE(S):

YEAR OF WORK: **2012**

PROPERTY NAME**: Mink North**

COAL LICENSE(S) AND/OR LEASES ON WHICH PHYSICAL WORK WAS DONE:
**Coal Licence 418535**

MINERAL INVENTORY MINFILE NUMBER(S), IF KNOWN:

MINING DIVISION: **Liard**

NTS / BCGS**: NTS 93P/5W, 93O/8E, and 93 O/9E**

LATITUDE: **55° 28' 26" North**; LONGITUDE: **121° 58' 18" West** (at centre of work)

UTM Zone: 10N EASTING: **565000** NORTHING: **6148000**

OWNER(S): **Walter Canadian Coal Partnership**

MAILING ADDRESS: **800-668 West Hasting Street, Vancouver, BC, V6B 1P1**

OPERATOR(S) [who paid for the work]: **Walter Canadian Coal Partnership**

MAILING ADDRESS: **800-668 West Hasting Street, Vancouver, BC, V6B 1P1**

REPORT KEYWORDS (lithology, age, stratigraphy, structure, alteration, mineralization, size and attitude). **coal, Bullhead Group, Gething Formation, Gaylard Member, Bluesky Member, Bullmoose Member, Chamberlain Member, Moosebar Formation, Gates Formation, Hulcross Formation, Boulder Creek Formation, Walton Creek Member, anticlines, synclines, thrust faults**

REFERENCES TO PREVIOUS ASSESSMENT WORK AND ASSESSMENT REPORT NUMBERS: **Coal Assessment Reports 524, 525, 537, 583, 584, 585, 586, 587, 588, 667, 888; Petroleum Report 863**

| SUMMARY OF TYPES OF WORK IN THIS REPORT | | EXTENT OF WORK (in metric units) | ON WHICH TENURES |
|---|---|---|---|
| GEOLOGICAL (scale, area) | | | |
| | Ground, mapping | **nil** | |
| | Photo interpretation | **nil** | |
| GEOPHYSICAL (line-kilometres) | | | |
| | Ground<br>(Specify types) | **nil** | |
| | Airborne | **nil** | |
| | (Specify types) | | |
| | Borehole | | |
| | Gamma, Resistivity | **nil** | |
| | Resistivity | **nil** | |
| | Caliper | **nil** | |
| | Deviation | **nil** | |
| | Dip | **nil** | |
| | Others **Gamma-Neutron in 1 borehole** | **99.2 m** | **418535** |
| | Core | **nil** | |
| | Non-core **(rotary) in 1 borehole** | **102.1 m** | **418535** |
| SAMPLING AND ANALYSES | | | |
| Total # of Samples niil | | | |
| | Proximate | **nil** | |
| | Ultimate | **nil** | |
| | Petrographic | **nil** | |
| | Vitrinite reflectance | **nil** | |
| | Coking | **nil** | |
| | Wash tests | **nil** | |
| PROSPECTING (scale/area) | | **nil** | |
| PREPARATORY/PHYSICAL | | | |
| Line/grid (km) | | **nil** | |
| Trench (number, metres) | | **nil** | |
| Bulk sample(s) | | **nil** | |

# 1 Table of contents

1.1 List of tables



1.2 List of figures

## 1.3 List of maps



*Mink_North_150219a2.doc*

# 2 Introduction

The Mink North coal property comprises 8,808 hectares of Crown coal licenses, situated within the Brazion coalfield of northeastern British Columbia. This report presents results of one year-2012 borehole (designated as MCE 12-11) drilled close to the property's southern boundary, placed within the context of a geological compilation map and supporting discussion of structural and stratigraphic geology.

The borehole was drilled by a rotary (non-coring) method. Accordingly, no samples of the intersected coals were available for analysis. Furthermore, difficult hole conditions required that downhole geophysical logs could only be acquired from within the drill rods, using a narrow-diameter gamma-neutron sonde. Geophysical logs of MCE 12-11 are presented in **Appendix A** of this report.

Near-surface sedimentary rocks within and adjacent to the Mink North coal property are of Lower Cretaceous age, comprising (from youngest to oldest) the Hasler, Boulder Creek, Hulcross, Gates, Moosebar, Gething, Cadomin and Bickford formations (**Figure 2-1**; **Map 2-3; Table 3-1**). Younger rocks, of the Cruiser and Goodrich formations, are also outlined on the map, but these rocks solely lie to the north and east of the property's boundary.

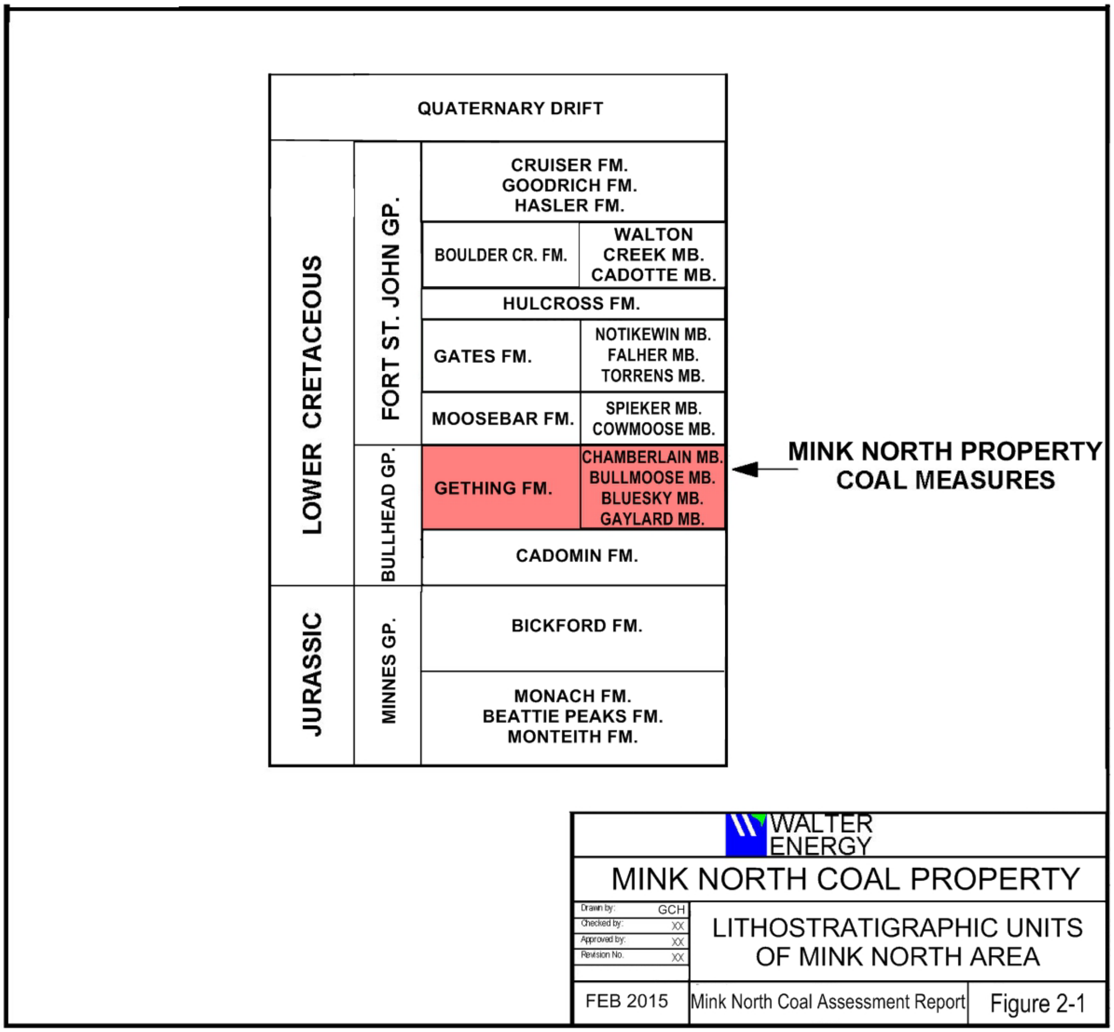
The Gething Formation contains the great majority of known potentially-mineable coal beds. Very limited amounts of mineable coal may also occur within the Boulder Creek Formation, and minor thin, unmineable, coals are known from the Gates and Cadomin formations. Coal potential of the Bickford Formation is unknown in detail, although expected to be low on account of its limited outcrop extent.

Associated sedimentary rocks comprise conglomerates, sandstones, siltstones, mudstones, carbonaceous mudstones, concretionary ironstone and tuff. Marine mudstones and siltstones occur within a marine tongue (the Bullmoose Member) near the top of the Gething Formation, and also within the Cruiser, Hasler, Hulcross and Moosebar formations. The facies of the thin, sandy, uppermost Chamberlain Member of the Gething is likely also marine. The facies of the basal coal-bearing Gaylard Member of the Gething Formation, and also of the underlying Cadomin and Bickford formations, are dominantly fluvial.

Bedrock within the Mink North coal property is structurally-complex. Closely-spaced, tight, northwest-striking, northeast-verging folds predominate at Mink North. These folds are most commonly associated with northeast-verging thrust-faults, which themselves are likely to be folded owing to passive deformation above subsequent underlying thrusts.

Within the Gaylard coal-measures, numerous coal zones have been found by very sparse drilling at Mink North. Coal beds range in thickness from a few decimetres to several metres. Historic drilling has established that thicker, and possibly more laterally-extensive, coals occur in the upper hundred or so metres of the Gaylard Member. Owing to the very wide spacing between historic and current boreholes at Mink North, no attempt is here made to correlate the Gaylard Member coals, save that the coals intersected in current borehole MCE 12-11 may readily be correlated with those found in several boreholes nearby within the adjoining Mink Creek coal property (as reported by Sultan and Cathyl-Huhn, 2014)

Extensive drilling will be required in order to define any exploitable coal resources at Mink North. One historic underground coal mine, the Hasler Mine, is located on the southeast bank of Hasler Creek, about a kilometre north of, and therefore outside, the Mink North property boundary. Other than that old mine, the closest coal-mining operations are at Walter Energy's Brule Mine, situated several kilometres southeast of the Mink North property.




*Mink_North-Figure-2-1.srf/jpg*

## 2.1 Scope of report

This report is submitted by Walter Canadian Coal Partnership (WCCP) in keeping with the provisions of the *Coal Act* and the *Coal Act Regulation*, with respect of exploratory activities on Crown coal tenures within British Columbia.

This report documents exploratory work completed on WCCP's Mink North coal property, situated within the Brazion coalfield, in northeastern British Columbia. WCCP acquired the Mink North coal licenses directly from the provincial Crown in 2014 (as tenures 418530, 418531, 418532, 418533, 418534, 418535, 418539, 418540, 418541, 418542, and 418543). Details of these tenures are presented as **Table 2-1**.

WCCP's fieldwork was conducted in year-2012, with the drilling of the one current borehole at Mink North. No further physical work has been done at Mink North, other than passing examination of coal exposures and associated rock outcrops within road-cuts along the Falling Creek Connector Road (**Map 2-3**). Estimated thicknesses of lithostratigraphic units at Mink North are based upon results of drilling, and upon analysis of map patterns. Measured sections of the strata have not been obtained, owing to incomplete exposure and structural complexity.

**Table 2-1:** Tenures comprising the Mink North coal property

| Tenure Number | Map | Block | Units | Date Acquired | Area (hectares) | Owner |
|---|---|---|---|---|---|---|
| 418530 (18 units) | 93O/8<br>93P/5 | I<br>L | 71,72,73,74,81,82,83,84, 91,92,93,94<br>79,80,89,90,99,100 | June 6, 2014 | 1320 | WCCP |
| 418531 (20 units) | 93O/8<br>93P/5 | I<br>L | 41,42,43,44,45,46,51,52,53,54, 55,56,61,62,63,64<br>59,60,69,70 | June 6, 2014 | 1468 | WCCP |
| 418532 (14 units) | 93O/8<br>93P/5 | I<br>L | 21,22,23,24,31,32,33,34<br>29,30,39,40,49,50 | June 6, 2014 | 1028 | WCCP |
| 418533 (12 units) | 93P/5 | L | 25,26,27,28,35,36,37,38, 45,46,47,48 | June 6, 2014 | 881 | WCCP |
| 418534 (12 units) | 93P/5 | L | 55,56,57,58,65,66,67,68, 75,76,77,78 | June 6, 2014 | 881 | WCCP |
| 418535 (12 units) | 93P/5 | L | 21,22,23,24,31,32,33,34, 43,44,53,54 | June 6, 2014 | 881 | WCCP |
| 418539 (12 units) | 93O/9 | A | 1,2,3,4,5,6,11,12, 13,14,15,16 | June 6, 2014 | 880 | WCCP |
| 418540 (4 units) | 93P/5 | K | 29,30,39,40 | June 6, 2014 | 294 | WCCP |
| 418541 (4 units) | 93P/5 | L | 41,42,51,52 | June 6, 2014 | 294 | WCCP |
| 418542 (4 units) | 93P/5 | L | 63,64,73,74 | June 6, 2014 | 294 | WCCP |
| 418543 (8 units) | 93P/5 | L | 85,86,87,88,95,96,97,98 | June 6, 2014 | 587 | WCCP |
| Totals: | 11 tenures | | 120 units | | 8,808 hectares | |

*Note: WCCP is Walter Canadian Coal Partnership. Map sheets listed are within the National Topographic System. Blocks and Units refer to the British Columbia Coal Tenures Grid System, whose unit cells are based upon original NAD 27 surveys.*

## 2.2 Situation and objectives

The Mink North coal property is located in the Peace River region of northeastern British Columbia (**Map 2-1**), an area which has seen considerable coal-exploration activity since the late 1960s.Walter Energy Inc., and predecessor and associated firms, have for some years operated metallurgical-coal mines to the north (Willow Creek Mine) and to the southeast (Brule and Dillon mines) of the Mink North property.

From the 1970s onward, the Mink North area has been mapped and drilled for coal. This historic exploration has generally been conducted at reconnaissance scale, with helicopter-supported geological traversing followed by sparse programmes of exploratory drilling (**Maps 2-2** and **2-3; Table 2-2**). In addition to the coal-industry work, the oil and gas industry has been moderately active within the Mink North area, mainly via the acquisition of seismic-reflection survey data along widely-spaced cross-section lines. A few oil and gas wells have been drilled as 'exploratory wildcat' tests, as listed in **Table 2-3**. Most of the oil and gas drilling has been conducted outside the bounds of the Mink North property, with just one well (Talisman Sukunka c-47-L/93-P-5, under provincial Well Authorisation 10615) drilled within the property.

In contrast with Walter Energy's other nearby coal properties, the Mink North coal property is still at a preliminary stage of exploration, with insufficient data to support the estimation of coal resources to current Canadian standards (*vide* Hughes *et al*, 1989).

## 2.3 Property description

The Mink North coal licenses are located within the Liard Mining District of northeastern British Columbia. The property comprises eleven Coal Licences, granted by the provincial Crown in June of 2014 (as tenures 418530, 418531, 418532, 418533, 418534, 418535, 418539, 418540, 418541, 418542, and 418543). Details of these tenures are presented above as **Table 2-1**.

The Mink North property is situated within map-areas 93P/5, 93O/8 and 93O/9 of Canada's National Topographic System. The aggregate area of the property is 8,808 hectares, covering 120 units within the provincial mineral-tenure grid system.

## 2.4 Location and access

Chetwynd town, located on Highway 97 and situated 54 kilometres northeast of the property, is the closest incorporated settlement to Mink North (**Map 2-1**). Chetwynd’s population was reported as 2,633 persons in the year-2006 census.

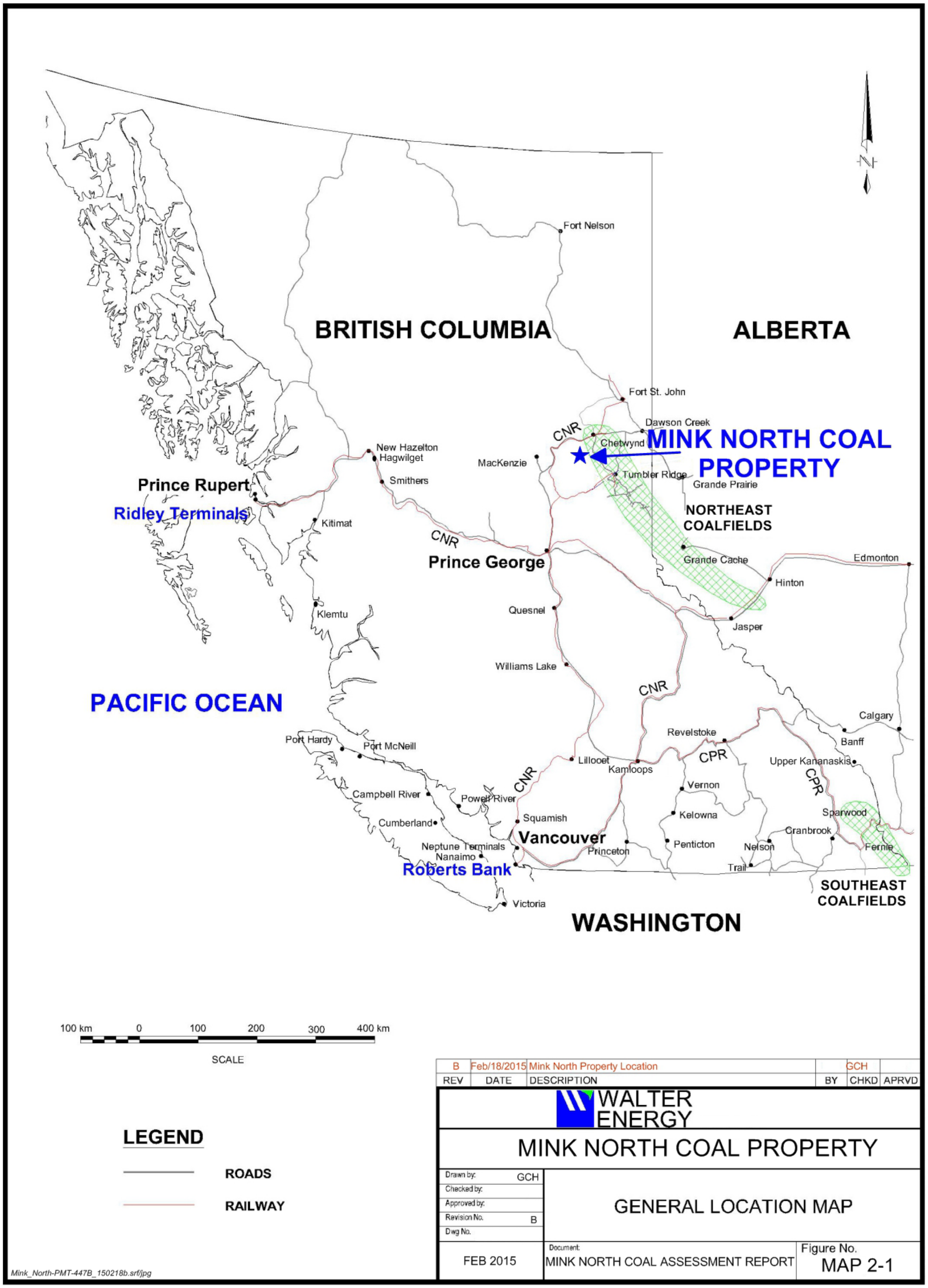

BRITISH COLUMBIA
ALBERTA
Fort Nelson
Fort St. John
Dawson Creek
Chetwynd
MINK NORTH COAL PROPERTY
Tumbler Ridge
Grande Prairie
NORTHEAST COALFIELDS
Grande Cache
Hinton
Edmonton
Jasper
CNR
New Hazelton
Hagwilget
Smithers
MacKenzie
Prince Rupert
Ridley Terminals
Kitimat
Prince George
Quesnel
Klemtu
Williams Lake
PACIFIC OCEAN
Port Hardy
Port McNeill
Revelstoke
Calgary
Banff
CPR
Upper Kananaskis
Lillooet
Kamloops
Vernon
Campbell River
Powell River
Squamish
Kelowna
Sparwood
Cumberland
Vancouver
Cranbrook
Neptune Terminals
Nanaimo
Princeton
Penticton
Nelson
Fernie
Roberts Bank
Trail
Victoria
SOUTHEAST COALFIELDS
WASHINGTON
N
100 km 0 100 200 300 400 km
SCALE
LEGEND
ROADS
RAILWAY
B Feb/18/2015 Mink North Property Location GCH
REV DATE DESCRIPTION BY CHKD APRVD
WALTER ENERGY
MINK NORTH COAL PROPERTY
Drawn by: GCH
Checked by:
Approved by:
Revision No. B
Dwg No.
GENERAL LOCATION MAP
FEB 2015
Document: MINK NORTH COAL ASSESSMENT REPORT
Figure No. MAP 2-1
Mink_North-PMT-447B_150218b.srf/jpg

**Table 2-2:** Historic (pre-2010) coal exploration boreholes

| Borehole | Coal Assessment Report | metres | | UTM NAD 83 coordinates | | tenure / outside property |
|---|---|---|---|---|---|---|
| | | elevation | total depth | Easting | Northing | |
| H-1 | see note | | 146.76 | 563073 | 6151723 | outside |
| H-2 | see note | | 107.59 | 563300 | 6151198 | outside |
| H-3 | see note | | 121.16 | 562796 | 6152049 | 418539 |
| H-4 | see note | | 259.38 | 563457 | 6152395 | outside |
| H-5 | see note | | 180.75 | 563424 | 6151485 | outside |
| H-6 | see note | | 164.90 | 563990 | 6152129 | outside |
| H-6A | see note | | 73.91 | 563990 | 6152129 | outside |
| H-7 | see note | | 193.24 | 563087 | 6150830 | 418530 |
| H-9 | see note | | 349.91 | 564128 | 6152360 | outside |
| DH 7507 | 584 | 1219 | 343 | 565921 | 6143624 | 418533 |
| DH 7508 | 584 | 1097 | 362 | 558326 | 6151698 | 418539 |
| DH 7509 | 584 | 1097 | 151 | 565332 | 6150028 | 418543 |
| DH 7611 | 585 | 822 | 51 | 562948 | 6151418 | 418539 |
| PP 7701 | 585 | 1097 | 143 | 564496 | 6150638 | 418530 |
| PP 7702 | 585 | 1097 | 91 | 564586 | 6150688 | 418530 |
| PP 79-01 | 587 | 990 | 266 | 561773 | 6152411 | 418539 |
| PP 79-02 | 587 | 1040 | 231 | 569923 | 6147221 | 418541 |
| PP 79-03 | 587 | 1475 | 316 | 570923 | 6146336 | 418541 |
| PP 79-04 | 587 | 1415 | 158 | 570248 | 6144956 | 418535 |
| PP 79-05 | 587 | 1220 | 259 | 563323 | 6145321 | 418532 |
| PP 79-06 | 587 | 885 | 233 | 563183 | 6152426 | outside |
| PP 79-07 | 587 | 850 | 244 | 562823 | 6151521 | 418539 |
| DDH 81-100 | 681 | 923 | 245.3 | 572178.3 | 6150564.9 | outside |
| DDH 81-102 | 681 | 1380 | 160 | 568011.6 | 6150175.5 | outside |
| RDH 81-104 | 681 | 1233 | 281.9 | 572663.5 | 6147602.5 | outside |
| DDH 81-105 | 681 | 971 | 238.3 | 570960.8 | 6149506.6 | outside |
| RDH 81-107 | 681 | 1297 | 342.9 | 572773.6 | 6146442.8 | outside |
| DDH 81-108 | 681 | 1204 | 617.2 | 566940.6 | 6151908.7 | outside |
| RDH 82-100 | 682 | 1274 | 122.4 | 572598.0 | 6146934.1 | outside |

**Table 2-2:** Historic (pre-2010) coal exploration boreholes (concluded)

| Borehole | Coal Assessment Report | metres | | UTM NAD 83 coordinates | | tenure / outside property |
|---|---|---|---|---|---|---|
| | | elevation | total depth | Easting | Northing | |
| FC 82-9 | 524 | 1258 | 200 | 558777 | 6145311 | 418531 |
| HH 82-1 | 537 | 1437 | 26 | 570333 | 6145076 | 418535 |
| HH 82-1A | 537 | 1428 | 41 | 570313 | 6145046 | 418535 |
| HH 82-2 | 537 | 1112 | 33 | 571263 | 6143036 | outside |
| FC 83-14 | 535 | 1335 | 336 | 558878 | 6149456 | outside |
| FC 83-21 | 535 | 1390 | 325 | 564395 | 6144166 | 418532 |
| 05RCPR01 | 888 | 865 | 27.43 | 562708 | 6151507 | 418539 |
| 05RCPR01A | 888 | 865 | 262.13 | 562703 | 6151505 | 418539 |
| 05RCPR02 | 888 | 930 | 259.08 | 561784 | 6151459 | 418539 |
| 05RCPR08 | 888 | 1040 | 259.08 | 568701 | 6146461 | 418535 |
| 05RCPR08A | 888 | 1040 | 103.7 | 568708 | 6146469 | 418535 |
| 05RCPR09 | 888 | 1204 | 245.4 | 567573 | 6146014 | 418533 |
| 05RCPR10 | 888 | 1118 | 121.92 | 568118 | 6146187 | 418535 |
| DH09-01 | see note | 977.28 | 184.09 | 571044.9 | 6148897.4 | outside |
| DH09-02 | see note | 1232.95 | 288.95 | 572672.7 | 6147614.2 | outside |
| MCE 12-11 | Current (year-2012) borehole -- see Table 3-1 | | | | | 418535 |

*Notes: H-series boreholes are discussed in general terms within McKechnie's year-1955 report. A search for detailed records is underway at time of this writing. Positions given are approximate, and should be checked against detailed records as and when available. Borehole DH09-01 and DH09-02 are discussed in Morris and Engler's year-2010 report.*

**Table 2-3:** Cross-reference to oil and gas wells

| Well name at time of drilling | Well authorisation number | UTM NAD 83 coordinates | | Within/outside property |
|---|---|---|---|---|
| | | Easting | Northing | |
| Skelly Getty CS Commotion a-23-D/93-P-12 | WA 3915 | 569363.4 | 6152878.1 | outside to northeast |
| Talisman Sukunka b-11-L/93-P-5 | WA 9363 | 570635.2 | 6142857.6 | outside to south |
| Talisman Sukunka c-47-L/93-P-5 | WA 10615 | 565827.8 | 6146028.8 | within |
| Talisman Highhat b-91-L/93-P-5 | WA 12875 | 570308.9 | 6150213.8 | outside to northeast |

**Table 2-4:** Cross-reference to coal assessment reports

| Company | Authority | Coal Assessment Report Number |
|---|---|---|
| Esso Resources | Waters, 1981 | 522 |
| Esso Resources | Klatzel-Mudry *et al*, 1982 | 524 |
| Esso Resources | Klatzel-Mudry *et al*, 1984 | 525 |
| Kennecott Canada Exploration | Hovis *et al*, 2006 | 888 |
| Norcen Energy | Newson, 1980a | 587 |
| Pan Ocean Oil | Dyson, 1975 | 584 |
| Pan Ocean Oil | Dyson, 1977 | 585 |
| Shell Canada Resources | Waters, 1981 | 522 |
| Walter Canadian Coal Partnership | Sultan and Cathyl-Huhn, 2014 | [not yet assigned] |

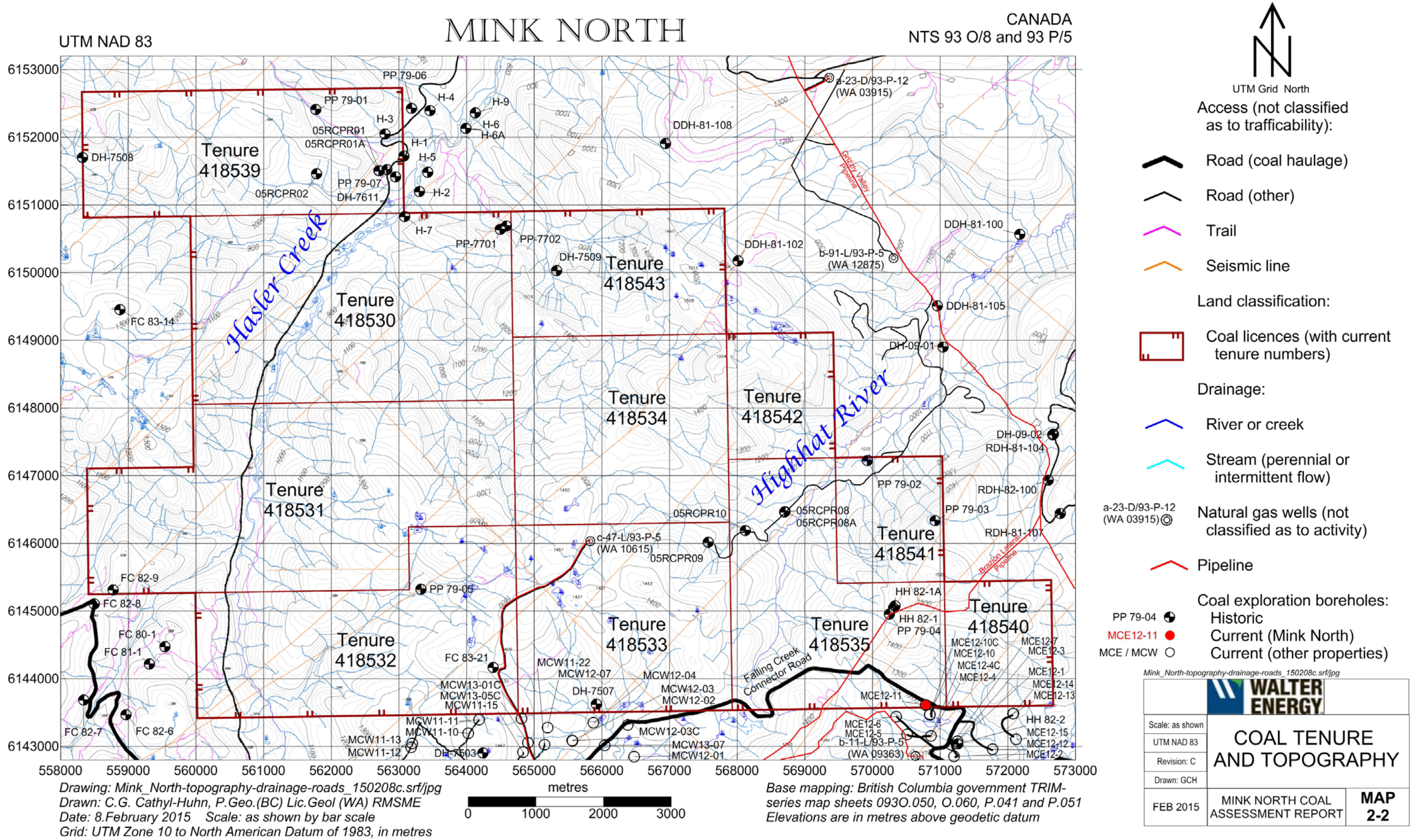
In the context of more-distant communities within British Columbia, the Mink North coal property is located 135 kilometres south of Fort St John, 100 kilometres west of Dawson Creek, and 310 kilometres east of Prince George. Vancouver is situated 725 kilometres to the south-southwest of the property. Commercially-scheduled aircraft flights connect Vancouver to Fort St. John.

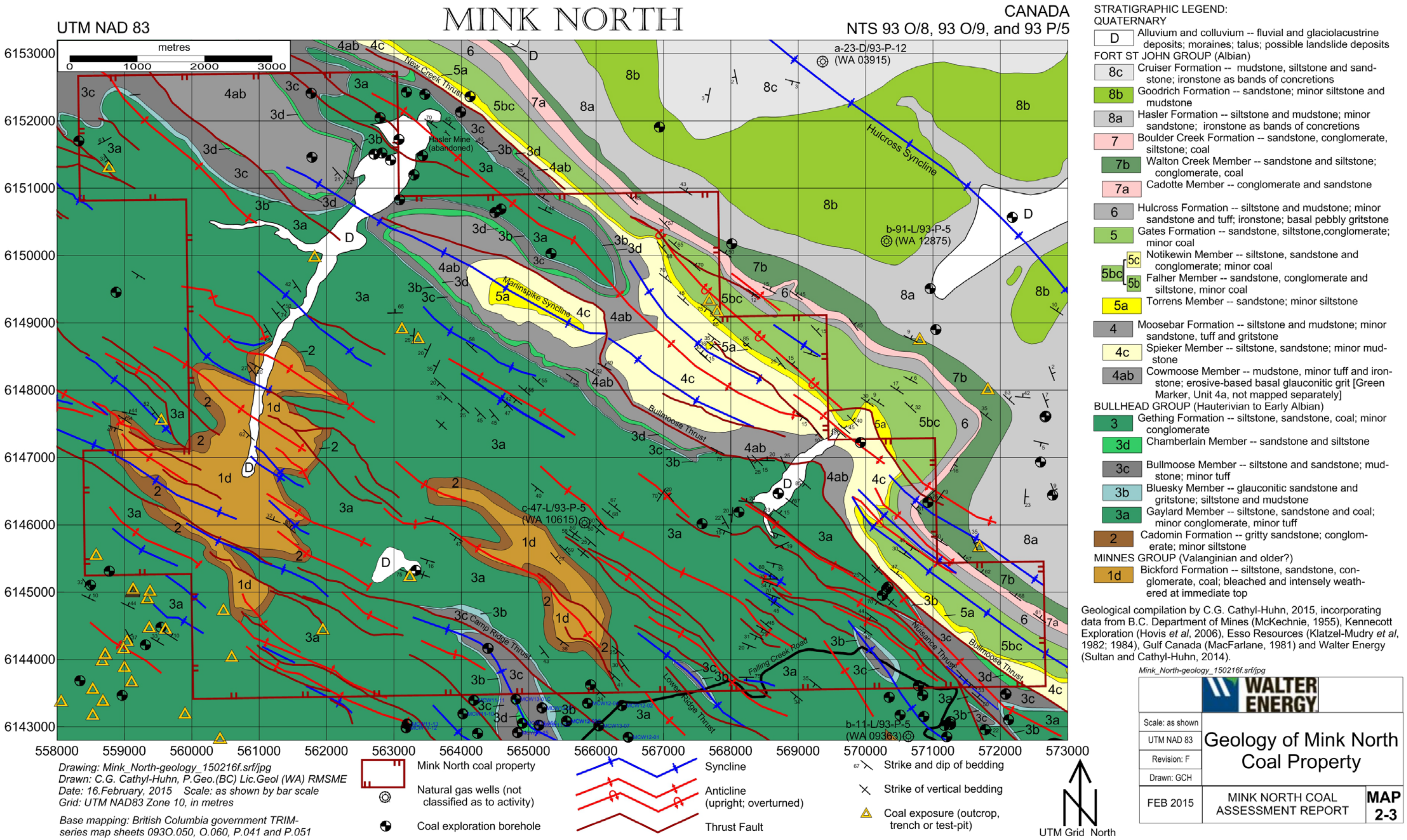
Primary access to the property from Chetwynd is via paved provincial highway BC-97, which intersects the Hasler Creek Forest Service Road (FSR), 24 kilometres west of Chetwynd. Southward 28 kilometres along the Hasler Creek FSR is a junction with the Falling Creek Connector Road (the FCCR).

The FCCR generally follows the southern boundary of the Mink North coal property, as shown in **Map 2-2** and **Map 2-3**. Alternate access to the property is provided by Sukunka FSR, an all-weather gravel road, extending along the eastern bank of the Sukunka River. The Sukunka FSR is accessible from Chetwynd via highways BC-97 and BC-29. At 16.5 kilometres along the Sukunka FSR, the Blind Creek Road (a non-status industrial road) crosses Sukunka River on a high-capacity bridge, and extends generally westward along the southwestern bank of Blind Creek, meeting the FCCR from the southeast after 21.5 kilometres.

## 2.5 Climate

The nearest climate station to Mink North is the town of Chetwynd, whose climate is 'cool continental', with frigid winters and warm summers. Average annual rainfall and snowfall at Chetwynd are 306 millimetres and 169 centimetres respectively. The average frost free period ranges 84 to 91 days, and about 30 days with some fog are expected per year. The mean daily temperature at Chetwynd is 15.4 C in July and -10.7 C in January. Winter temperatures below -40C are not uncommon, with the coldest weather occurring in January and February of most years.


MINK NORTH
UTM NAD 83
CANADA
NTS 93 O/8 and 93 P/5
UTM Grid North
Access (not classified as to trafficability):
Road (coal haulage)
Road (other)
Trail
Seismic line
Land classification:
Coal licences (with current tenure numbers)
Drainage:
River or creek
Stream (perennial or intermittent flow)
a-23-D/93-P-12 (WA 03915)
Natural gas wells (not classified as to activity)
Pipeline
Coal exploration boreholes:
PP 79-04 Historic
MCE12-11 Current (Mink North)
MCE / MCW Current (other properties)
Mink_North-topography-drainage-roads_150208c.srf/jpg
WALTER ENERGY
Scale: as shown
UTM NAD 83
Revision: C
Drawn: GCH
COAL TENURE AND TOPOGRAPHY
FEB 2015
MINK NORTH COAL ASSESSMENT REPORT
MAP 2-2
Tenure 418539
Tenure 418530
Tenure 418531
Tenure 418532
Tenure 418543
Tenure 418534
Tenure 418533
Tenure 418542
Tenure 418535
Tenure 418541
Tenure 418540
Hasler Creek
Highhat River
Falling Creek Connector Road
Grizzly Valley Pipeline
Brazion Lateral Pipeline
6153000
6152000
6151000
6150000
6149000
6148000
6147000
6146000
6145000
6144000
6143000
558000
559000
560000
561000
562000
563000
564000
565000
566000
567000
568000
569000
570000
571000
572000
573000
metres
0
1000
2000
3000
Drawing: Mink_North-topography-drainage-roads_150208c.srf/jpg
Drawn: C.G. Cathyl-Huhn, P.Geo.(BC) Lic.Geol (WA) RMSME
Date: 8.February 2015 Scale: as shown by bar scale
Grid: UTM Zone 10 to North American Datum of 1983, in metres
Base mapping: British Columbia government TRIM-series map sheets 093O.050, O.060, P.041 and P.051
Elevations are in metres above geodetic datum


MINK NORTH
UTM NAD 83
CANADA
NTS 93 O/8, 93 O/9, and 93 P/5
metres
0 1000 2000 3000
STRATIGRAPHIC LEGEND:
QUATERNARY
D Alluvium and colluvium -- fluvial and glaciolacustrine deposits; moraines; talus; possible landslide deposits
FORT ST JOHN GROUP (Albian)
8c Cruiser Formation -- mudstone, siltstone and sandstone; ironstone as bands of concretions
8b Goodrich Formation -- sandstone; minor siltstone and mudstone
8a Hasler Formation -- siltstone and mudstone; minor sandstone; ironstone as bands of concretions
7 Boulder Creek Formation -- sandstone, conglomerate, siltstone; coal
7b Walton Creek Member -- sandstone and siltstone; conglomerate, coal
7a Cadotte Member -- conglomerate and sandstone
6 Hulcross Formation -- siltstone and mudstone; minor sandstone and tuff; ironstone; basal pebbly gritstone
5 Gates Formation -- sandstone, siltstone, conglomerate; minor coal
5bc 5c Notikewin Member -- siltstone, sandstone and conglomerate; minor coal
5b Falher Member -- sandstone, conglomerate and siltstone, minor coal
5a Torrens Member -- sandstone; minor siltstone
4 Moosebar Formation -- siltstone and mudstone; minor sandstone, tuff and gritstone
4c Spieker Member -- siltstone, sandstone; minor mudstone
4ab Cowmoose Member -- mudstone, minor tuff and ironstone; erosive-based basal glauconitic grit [Green Marker, Unit 4a, not mapped separately]
BULLHEAD GROUP (Hauterivian to Early Albian)
3 Gething Formation -- siltstone, sandstone, coal; minor conglomerate
3d Chamberlain Member -- sandstone and siltstone
3c Bullmoose Member -- siltstone and sandstone; mudstone; minor tuff
3b Bluesky Member -- glauconitic sandstone and gritstone; siltstone and mudstone
3a Gaylard Member -- siltstone, sandstone and coal; minor conglomerate, minor tuff
2 Cadomin Formation -- gritty sandstone; conglomerate; minor siltstone
MINNES GROUP (Valanginian and older?)
1d Bickford Formation -- siltstone, sandstone, conglomerate, coal; bleached and intensely weathered at immediate top
Geological compilation by C.G. Cathyl-Huhn, 2015, incorporating data from B.C. Department of Mines (McKechnie, 1955), Kennecott Exploration (Hovis et al, 2006), Esso Resources (Klatzel-Mudry et al, 1982; 1984), Gulf Canada (MacFarlane, 1981) and Walter Energy (Sultan and Cathyl-Huhn, 2014).
Mink_North-geology_150216f.srf/jpg
WALTER ENERGY
Scale: as shown
UTM NAD 83
Revision: F
Drawn: GCH
Geology of Mink North Coal Property
FEB 2015
MINK NORTH COAL ASSESSMENT REPORT
MAP 2-3
Drawing: Mink_North-geology_150216f.srf/jpg
Drawn: C.G. Cathyl-Huhn, P.Geo.(BC) Lic.Geol (WA) RMSME
Date: 16.February, 2015 Scale: as shown by bar scale
Grid: UTM NAD83 Zone 10, in metres
Base mapping: British Columbia government TRIM-series map sheets 093O.050, O.060, P.041 and P.051
Mink North coal property
Natural gas wells (not classified as to activity)
Coal exploration borehole
Syncline
Anticline (upright; overturned)
Thrust Fault
Strike and dip of bedding
Strike of vertical bedding
Coal exposure (outcrop, trench or test-pit)
UTM Grid North
Hasler Mine (abandoned)
New Creek Thrust
Hulcross Syncline
Marlinspike Syncline
Bullmoose Thrust
Camp Ridge Thrust
Lower Ridge Thrust
Nuisance Thrust
Falling Creek Road
a-23-D/93-P-12 (WA 03915)
b-91-L/93-P-5 (WA 12875)
c-47-L/93-P-5 (WA 10615)
b-11-L/93-P-5 (WA 09363)
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## 2.6 Landforms and forest cover

The Mink North property lies within the Inner Foothills of the Rocky Mountains. Topography comprises deeply-dissected, steep-sided, rounded hills and mountains, with elevations ranging from 815 to 1554 metres above sea level. Topographic contours at 20-metre intervals, based upon provincial government mapping, are shown in **Map 2-2**. The property is heavily forested, chiefly with pine and spruce, and low-level scrub. Satellite imagery indicates that a considerable proportion of the valley-slope areas have been logged, with cutblocks at various stages of regrowth.

## 2.7 Acknowledgements and professional responsibility

Thanks are due to Dr. Muzaffer Sultan at Walter Energy, and Dr. Peter Jones at International Tectonic Consultants, for thought-provoking discussions of stratigraphy and structural geology respectively. Sara McPhail and David Richardson, at the B.C. Ministry of Natural Gas Development, assisted in locating details of natural-gas wells. Blake Snodsmith at Walter Energy provided a TRIM base-map, from which the topographic base of **Map 2-2** was derived.

Gwyneth Cathyl-Huhn accepts professional responsibility for data and conclusions presented within this report.

# 3 Exploration

Both historic (pre-2010) and current (post-2010) coal exploration has been done by various parties at and near the Mink North coal property. The vast majority of the work is historic in nature, having largely been sponsored by the coal departments of various oil companies during the period up to and immediately after the oil price escalation of the early 1980s.

## 3.1 History of exploration

The following discussion is adapted mainly from an unpublished report for Unicorn International Mines Group Inc. (Ryan, 2010).

Coal was first discovered in the Peace River District in 1793, by Alexander MacKenzie's exploring expedition. Prior to 1980, less than 100,000 tonnes of coal were mined at all locations within northeastern British Columbia (Ryan, 2002).

Within the vicinity of the Mink North coal property, small-scale mining (by the Hasler Creek Coal Company) commenced at Hasler Creek in 1943, and continued through 1944 and 1945. The Northern Alberta Railways took 4,500 short tons of coal for use in their locomotives serving their Dawson Creek railroad division (Spivak, 1944, Stott, 1973).

In the late 1950s, several oil companies undertook structural and stratigraphic mapping within and adjacent to the Mink North coal property, and within the Brazion coalfield generally. A report done for Triad Oil, by Dr. Peter Jones (1960) is the most useful of those reports which are publicly-available.

The expansion of steel production in mid-1960s stimulated exploration for metallurgical coking coal. By the mid-1970s within northeastern British Columbia, most of the land with coal potential had been acquired by mining companies, or by oil and gas companies seeking to enter the coal industry as a means of diversification. Initial development interest was along the existing railway (then known as the British Columbia Railway) which passed through Pine Pass and thus connected Chetwynd and Dawson Creek with then-existing ports along British Columbia's western coast.

Interest in coal development increased with the signing of a joint government-industry agreement between Japan and Canada, to develop new coal mines, highways, railways, other infrastructure, and a workers' townsite at Tumbler Ridge. Shipments of northeastern British Columbia coal through a new port at Ridley Island (near Prince Rupert, British Columbia) commenced in 1984, and have continued to the present day, albeit at currently-reduced levels.

Owing to its relative isolation at the time, the Mink North coal property did not receive as much exploratory attention as other, more accessible, parts of the northeastern British Columbia coalfields. As the oil and gas industry and the forestry industry extended their industrial road networks westward from Sukunka River and southward from Pine River, it became easier to bring drilling rigs into the Mink North area. This increased access accounts for the sparse extent of historic geological studies (**Table 2-4**) and historic coal-exploration drilling at and near Mink North (**Table 2-2**).

In all, 25 historic boreholes (as reported in previous coal-assessment reports and a B.C. Department of Mines bulletin), totalling 4800 metres' length, have been drilled within the Mink North coal property.

### *3.1.1 Regional exploratory context*

The earliest coal exploration within the Brazion coalfield was conducted in the Falling Creek area between 1946 and 1951 by the Coal Division of the then-extant British Columbia Department of Land and Forests, to estimate mineable coal reserves near the proposed railway route through Pine Pass and into the Peace River District (McKechnie, 1955; Dyson, 1975a). The program consisted of geological mapping, trenching and 14,830 metres of diamond-drilling. The work was mainly conducted in the Noman Creek and Willow Creek areas (several kilometres northwest of Mink North), although nine boreholes were also drilled near the Hasler Mine, situated on the southeast bank of Hasler Creek, just beyond the northeastern border of the Mink North property. Two of the Hasler Mine boreholes (H-3 and H-7) were drilled within the property (as shown on **Map 2-2**).

Pan Ocean drilled ten additional boreholes in 1974-1975 (Dyson, 1975) to test the coal bearing sequence at widely scattered locations across the remainder of their coal licenses. Two of these holes (PP 75-03 and PP 75-07) are located within or very near to the southern boundary of the Mink North property. These two boreholes demonstrated that greater prospects for potentially-mineable coal deposits lay within the upper portion of the Gething Formation's Gaylard Member.

During 1976 and 1977, Pan Ocean drilled three more boreholes (PP 76-11, PP 77-01 and PP 77-02), in an attempt to select a site for a test adit. The holes intersected coal seams, but adits were not successful due to overburden and faulting (Dyson, 1977).

Subsequently, acting under a joint venture agreement with Pan Ocean, Norcen Energy carried out exploration in 1979. The exploration program included geological mapping at a scale of 1:10,000 and the drilling of seven more boreholes with a cumulative coring length of 1,700 metres (Newson, 1980a).

The Norcen / Pan Ocean licenses were relinquished, and thereupon acquired and then in turned relinquished by Manalta Coal. Esso Resources thereupon reacquired the property in May 1980 (Waters, 1981).

Shell Canada Resources acquired the Highhat River property in 1982 (White, 1983). The property covers a part of Pan Ocean's former Pine Pass Property which was dropped in 1981.

Esso continued mapping and drilling in 1982 (Klatzel-Mudry *et al.*, 1982). Fourteen drill holes were completed. All of these boreholes (in the FC-82 series) lie within Walter Energy's Hudette coal property, which is adjacent to and westward of the Mink North coal property.

In 1983, eight more boreholes were drilled, with depths ranging from 77 to 384 metres. The purpose of the 1983 drilling was to intersect the Moosebar/Gething contact (as then understood by coal-industry workers) to use as a datum for coal-bed stratigraphy. One borehole (FC 83-21), lies within the southwestern corner of the Mink North property. Esso's exploration halted in 1984 as coal market declined.

Exploration activity resumed in 2004, when Kennecott Exploration Company (Hovis *et al*, 2006) carried out geological mapping and drilling within a group of coal licences which covered most of what is now the Mink North property. Kennecott's geological mapping was limited to outcrops in the road cuts of logging roads, although they also used LIDAR imagery to project faults and folds across their property (as extensively used to compile **Map 2-3** of the present report). Kennecott drilled fourteen boreholes in 2004 and 2005, of which seven lie within the Mink North property (as shown on **Map 2-2** and set forth in **Table 2-2**).

### *3.1.2 Governmental investigations*

The geology of Hasler Mine and its vicinity was mapped and reported by Spivak (1944), for the Geological Survey of Canada. A further review of the geology and coal deposits of the Hasler Mine area, based upon an extensive programme of mapping, diamond-drilling and trenching, was subsequently conducted by the British Columbia Department of Mines, and reported by McKechnie (1955).

In the early and mid-1960s, post-graduate geological research and structural modelling was undertaken by J.E. Hughes (1963), under the sponsorship of the provincial Department of Mines and Petroleum Resources. Subsequent reports on reconnaissance-scale stratigraphic and structural analysis, and a regional geological synthesis, were published in the middle and late 1960s (Hughes, 1964; 1967).

The Geological Survey of Canada published a regional-scale structural synthesis (McMechan, 1984), consisting of a map and cross-section at a scale of 1:250,000, followed by a journal article concerning the geometry of thrust-faults (McMechan, 1985).

In 1990 and 1991, staff of the British Columbia Geological Survey Branch mapped the Mink North property and surrounding area at a scale of 1:50,000 (Hunter and Cunningham, 1991; Cunningham and Sprecher, 1992). Two stratigraphic studies of the relationship between the Gething, Bluesky and Moosebar formations were published by provincial government staff, incorporating results from numerous coal-exploration boreholes (Kilby, 1984a; Legun, 1990). A compilation map of the geology of the Peace River coalfields on a scale of 1:200,000 was subsequently published by Legun (2003).

## 3.2 Current exploration

Walter Energy Inc. conducted a small exploration programme within the Mink North coal property, during year-2012. One borehole (MCE 12-11) was drilled within the southeastern corner of the area now covered by Coal Licence 418535, effectively as a northward extension of a larger drilling programme within Walter Energy's nearby Mink Creek coal property (as reported by Sultan and Cathyl-Huhn, 2014).

### *3.2.1 Year-2012 drilling*

Western Coal, and subsequently Walter Canadian Coal Partnership (WCCP), drilled numerous boreholes within their Mink Creek coal property in years 2011, 2012 and 2013 (Sultan and Cathyl-Huhn, 2014). However, only one borehole was drilled within the lands currently covered by the Mink North coal property: borehole MCE 12-11, drilled in 2012 (**Table 3-1**). The purpose of the drilling was to test the Gething Formation for potentially-mineable coal seams, and to assess the lateral continuity of the coal beds. To this end, borehole MCE 12-11 was a successful test of the upper part of the Gething Formation, although the clarity of its results is hampered by the limited suite of downhole geophysical logs (**Table 3-2**) that were run within the borehole.

**Table 3-1**: Current (year-2012) drilling at Mink North

| Borehole | Easting | Northing | Elev-ation | Total depth | Azimuth | Dip | Casing depth | Commenced (day/month/ year) | Completed (day/month/ year) | Geophysical logs run? |
|---|---|---|---|---|---|---|---|---|---|---|
| MCE12-11 | 570783.83 | 6143614.08 | 1189.4 | 102.1 | 040 | -60 | 3.08 | 19-Aug-12 | 22-Aug-12 | Yes |

**Table 3-2**: Geophysical logs run in current borehole

| Borehole | Easting | Northing | Elev-ation | Total depth | Gamma/Caliper/ Resistivity/Density | Gamma/ Neutron | Gamma/ Density | Deviation | Dipmeter | Notes |
|---|---|---|---|---|---|---|---|---|---|---|
| MCE 12-11 | 570783.83 | 6143614.08 | 1189.42 | 102.10 | | 99.44 | | | | Logged thru rods |

Borehole MCE 12-11 was drilled from a pad situated adjacent to the Falling Creek Connector Road, immediately north of the southern boundary of Coal Licence 418535 within the Mink North coal property.

### *3.2.2 Borehole geophysics*

Downhole geophysical logging was done by Century Wireline Services within the one year-2012 borehole (MCE 12-11). Owing to unstable borehole conditions, only one narrow-diameter sonde was run within the boreholes drill-rods::

- Gamma/neutron (9057A tool).

Copies of resultant downhole geophysical logs are presented in **Appendix A**, with an inventory of logs given above as **Table 3-3** (also repeated as **Table A-1** within **Appendix A)**.

### *3.2.3 Current coal-quality work*

No coal samples were taken from the strata intersected by the one current borehole (MCE 12-11) drilled at Mink North. Accordingly, no analytical work was done.

#### *3.2.3.1 Cross-reference to historic coal-quality work*

Numerous historic coal samples were taken from trenches, test-pits, natural outcrops, and cores recovered from historic boreholes. Details of these samples, and their associated analytical results, are reported within the various coal assessment reports produced by previous operators of the Mink North coal property.

# 4 Geological setting

The coalfields of northeastern British Columbia are hosted by marine and non-marine clastic sediments of Jurassic, Cretaceous and earliest Tertiary age. These rocks form a series of thick sequences of molasse and flysch, all of which was deposited into the Rocky Mountain Foreland Basin of Western Canada.

The basin is bounded by the mobile crustal terranes of the Cordilleran Orogen to the west, and the cratonic rocks and Palaeozoic cover sequences of the Canadian Shield to the east.

Most of the Jura-Cretaceous sediments were derived from orogenically-uplifted landmasses lying to the southwest of the basin, although patterns of sedimentation were to some extent influenced by occasional vertical movements of underlying structures within the cratonic basement rocks, chief amongst which was the Peace River Arch (Stott, 1968).

During Late Mesozoic and Early Cenozoic time, the Cordilleran Orogen underwent two main phases of deformation: the Late Jurassic to earliest Late Cretaceous Columbian Orogeny, and the Late Cretaceous to Oligocene Laramide Orogeny (Douglas *et al*, 1970). Both of these orogenies were driven by transpressional crustal movements along the outboard (western) edge of the North American continent. In each case, orogenic activity was driven by the collision of northward-moving exotic crustal terranes, which in turn caused compressive strains within the previously-accreted western margin of the continent. Northeast-directed overthrusting of Palaeozoic rocks caused episodic uplift of the Cordilleran Orogen, in turn providing a ready source of sediment into the Foreland Basin.

## 4.1 Regional structural setting

The present-day Rocky Mountains are the most visible manifestation of Columbian and Laramide overthrusting, which gradually proceeded northeastward, with successively-younger thrusts tending to break through the Foreland rocks at successively-deeper stratigraphic levels. As successively-younger thrusts developed, they generated passive folding within overlying, previously-deformed rocks. Overlying, older thrusts were therefore passively folded along with their adjoining strata. Recognition of this folding is essential to understanding the structural geology of the Mink North property and its surroundings.

From southwest to northeast, the Cordilleran fold-thrust belt gradually changes structural styles (Thompson, 1979) from a thrust-dominant regime(within the mostly-Palaeozoic carbonate-clastic rocks of the Rocky Mountain Main Ranges and Front Ranges) to a mixed fold-thrust regime (within the Inner Foothills, including the Mink North property) to a gently-folded frontal regime (within the Outer Foothills, five or more kilometres to the northeast of Mink North).

## 4.2 Regional stratigraphic setting

Regional stratigraphic nomenclature within the coalfields of northeastern British Columbia has undergone considerable revision during the past fifty years. Principal workers, whose reports were used as primary references for the present report, are J.E. Hughes (1964, 1967), D. Stott (1968, 1973, 1981, 1998), P.McL.D. Duff and R.D. Gilchrist (1981), and D.W. Gibson (1992a, 1992b).

The stratigraphic sequence within the northwestern part of the Brazion coalfield (including Mink North) consists of Lower Cretaceous sediments of the Fort St. John and

Bullhead groups, and Jurassic to Cretaceous rocks of the Minnes Group (**Figure 2-1**; **Table 4-1**). All but the uppermost part of the Minnes Group is confined to the deeper subsurface at Mink North, with the uppermost Minnes rocks being only seen within deeply-eroded stratigraphic 'window' areas.

The Fort St John Group within the Mink North area is nearly completely-represented within a panel of steeply-dipping beds associated with the frontal monocline of the Inner Foothills of the Rocky Mountains (**Map 2-3**).

Most of the stratigraphic controversy to date has revolved around the identity and stratigraphic topology of rocks underlying and overlying the coal-measures of the Gething Formation. In this report, the Gething Formation, as well as immediate sub-Gething rocks, are assigned to the Bullhead Group, following Stott’s extensive regional work.

Within the Brazion and Sukunka-Quintette coalfields, Gibson (1992a) divided the Gething Formation into four members. From top down, these are the Chamberlain, Bullmoose, Bluesky, and Gaylard Members. Within the Mink North coal property, only the Gaylard Member is definitely known to contain coal of potentially-mineable thickness, although within the nearby Burnt River property (McClymont, 1981; Cathyl-Huhn and Avery, 2014b), the Chamberlain Member also appears to be coal-bearing.

Supra-Gething rocks are assigned to the Fort St. John Group, following Stott’s work as subsequently modified by Gibson (1992b).

## 4.3 Local structural geology

Structural geology of the Mink North area would be difficult to decipher on the sole basis of bedding attitudes within exposed bedrock, owing to the paucity of outcrops. Much of our understanding of local structural geology comes from borehole intersections of coal-measures and associated younger non-coal-bearing rocks, supplemented by exposures of bedrock along the banks of major streams and in road-cuts.

An additional source of structural information, albeit indirect, is from the interpretation of landforms as visible in bare-earth LIDAR images, aerial photographs and on detailed topographic maps, although this indirect observation is locally hampered by Drift cover.

**Map 2-3** depicts the current understanding of bedrock structure. The Mink North property is tightly folded and frequently disrupted by northeast-verging thrust faults. A regionally-throughgoing northeast-verging thrust fault (the Bullmoose Thrust) crosses the northeastern margin of the property, and therefore is interpreted to underlie most of the property's extent. To the northeast of the Bullmoose Thrust, and therefore structurally beneath it (and possibly thus of younger age), a 1- to 2-kilometre wide belt of steeply-dipping, complexly-folded, locally-overturned strata marks the leading edge of the frontal monocline which forms the boundary between the Inner Foothills structural domain (comprising most of the Mink North property) and the adjoining, northeasterly, Outer Foothills structural domain.

Despite the local intensity of deformation, normal stratigraphic sequences are generally preserved at Mink North, with the exception of imbricate stacks of overthrust strata occasionally intersected by coal-exploration boreholes and by oil and gas wells. Structural thickening of the strata (most notably the Gaylard coal-measures) is ascribed to thrust-induced tectonic shortening.

Overall northeast-verging shortening of 25 to 35% is indicated by map patterns, but this estimate has not been rigorously checked.

## 4.4 Local stratigraphy

Based largely upon geophysical log interpretation, the following stratigraphic sequence (as shown in **Table 4-1**) has been identified within and adjacent to the Mink North coal property.

Relationships between the various rock-units that occur within and adjacent to the Mink North coal property are shown on the geological map (**Map 2-3**) accompanying this report. **Map 2-3** incorporates results of current drilling and geological fieldwork, together with historic drilling and geological mapping done by others, as cross-referenced in **Section 10** of this report. Geological contacts shown on the map are approximate to inferred, owing to the locally-thick Drift cover and the generally-discontinuous nature of bedrock exposures.

Owing to Drift cover and pervasive forest cover, complete stratigraphic sections of the bedrock formations are not exposed. Most of the outcrop data was recorded from isolated exposures, generally along the FCCR or along newly-built exploration trails, as the rocks were exposed during construction.

Map-units are discussed in detail below, in order from youngest (generally nearest the ground surface) to oldest. Localised inversions of stratigraphic position, owing to thrust-faulting, or overturned bedding, are possible, but the overall stratigraphic relations remain readily-recognisable, owing to distinctive geophysical characteristics of the various units.

## 4.5 Drift (map-unit D)

Unconsolidated sediments, of Quaternary age, form an extensive blanket at the ground surface throughout the Mink North coal property.

The most pervasive Drift cover consists of glacial till, usually less than 5 metres thick but locally more than 35 metres thick. As well, LIDAR imagery (provided by Hovis *et al*, 2006) shows a series of elevated straths along the more northerly, downstream reaches of Hasler Creek. On the basis of their geomorphology, these straths are interpreted to be dissected terraces of glaciolacustrine sediments, although this interpretation has not been field-checked by Walter Energy staff.

An isolated mesa capped by Torrens Member sandstone, situated southeast of Hasler Creek, shows stepped, locally-chaotic topography at its western end. This area is interpreted to be underlain by large-scale slide blocks of sandstone, although again this interpretation has yet to be field-checked.

## 4.6 Fort St. John Group (map-units 8c through 4a)

An incomplete section of the Fort St. John Group is present at Mink North, owing to the group's top contact having been stripped off by erosion during Tertiary uplift of the rocks, and further scouring by glaciers during the Quaternary era.

**Table 4-1:** Table of formations and subdivisions

<table>
<tr><th colspan="3">Group/Formation/ Member</th><th>Map-unit</th><th colspan="2">Lithology and thickness</th></tr>
<tr><td colspan="3">Quaternary Drift</td><td>D</td><td colspan="2">talus, colluvium, alluvium; glaciolacustrine deposits; moraines</td></tr>
<tr><td rowspan="12">Fort St. John Group</td><td colspan="2">Cruiser Fm.</td><td>8c</td><td colspan="2">siltstone and mudstone; minor sandstone; >50 m thick</td></tr>
<tr><td colspan="2">Goodrich Fm.</td><td>8b</td><td colspan="2">sandstone and siltstone; 250 to 300 m thick</td></tr>
<tr><td colspan="2">Hasler Fm.</td><td>8a</td><td colspan="2">siltstone and mudstone; minor sideritic concretions; 250 m thick.</td></tr>
<tr><td rowspan="2">Boulder Creek Fm.</td><td>Walton Creek Mb.</td><td>7b</td><td colspan="2">siltstone, sandstone, conglomerate and coal; 120 to 130 m thick</td></tr>
<tr><td>Cadotte Mb.</td><td>7a</td><td colspan="2">conglomerate and sandstone; 10 to 25 m thick.</td></tr>
<tr><td colspan="2">Hulcross Fm.</td><td>6</td><td colspan="2">marine mudstone, siltstone and sandstone; minor tuff and sideritic concretions; thin basal grit; 102 to 123 m thick</td></tr>
<tr><td rowspan="3">Gates Fm.</td><td>Notikewin Mb.</td><td>5c</td><td colspan="2">sandstone, siltstone, mudstone; minor coal; 95 to 138 m thick</td></tr>
<tr><td>Falher Mb.</td><td>5b</td><td colspan="2">sandstone, conglomerate, siltstone; minor coal; 50 to 95 m thick</td></tr>
<tr><td>Torrens Mb.</td><td>5a</td><td colspan="2">sandstone; minor siltstone; 21 to 47 m thick</td></tr>
<tr><td rowspan="2">Moosebar Fm.</td><td>Spieker Mb.</td><td>4c</td><td colspan="2">numerous fining-upward cycles of marine siltstone and sandstone, within an overall coarsening-upward sequence; 30 to 70 m thick</td></tr>
<tr><td>Cowmoose Mb.</td><td>4ab</td><td colspan="2">marine mudstone; minor tuff and ironstone; basal pebbly glauconitic sandstone (Unit 4a: ‘Green Marker’); 50 to 80 m thick</td></tr>
<tr><td rowspan="5">Bullhead Group</td><td rowspan="4">Gething Fm.</td><td>Chamberlain Mb.</td><td>3d</td><td colspan="2">marine sandstone and siltstone; pinchout to northeast; nil to 10 m thick</td></tr>
<tr><td>Bullmoose Mb.</td><td>3c</td><td colspan="2">marine siltstone and mudstone; minor sandstone and tuff; 110 m thick.</td></tr>
<tr><td>Bluesky Mb.</td><td>3b</td><td colspan="2">glauconitic pebbly sandstone, turbiditic siltstone and mudstone; pebbly mudstone and conglomerate; 7 to 30 m thick.</td></tr>
<tr><td>Gaylard Mb.</td><td>3a</td><td colspan="2">fining-upward cycles of sandstone, siltstone , mudstone and coal; minor conglomerate; 460 to 485 metres thick</td></tr>
<tr><td colspan="2">Cadomin Fm.</td><td>2</td><td colspan="2">gritty sandstone and conglomerate with distinctive 'blocky' log response; minor siltstone; 25 to 35 m thick</td></tr>
<tr><td rowspan="4">Minnes Gp.</td><td colspan="2">Bickford Fm.</td><td>1d</td><td colspan="2">siltstone, sandstone, mudstone and coal; 285 to 300 m thick.</td></tr>
<tr><td colspan="2">Monach Fm.</td><td>1c</td><td>sandstone and conglomerate; siltstone</td><td rowspan="3">present only at depth; unstudied; not on map</td></tr>
<tr><td colspan="2">Beattie Peaks Fm.</td><td>1b</td><td>siltstone, sandstone and mudstone; minor coal</td></tr>
<tr><td colspan="2">Monteith Fm..</td><td>1a</td><td>quartzite and sandstone; minor siltstone</td></tr>
</table>

### *4.6.1 Cruiser Formation (map-unit 8c)*

The Cruiser Formation is the uppermost formation within the Fort St. John Group. The Cruiser comprises approximately 105 metres of dark grey mudstone with frequent interbeds of siltstone and occasional interbeds of fine-grained, silty sandstone. Bands of discoidal to spheroidal sideritic concretions occasionally occur. The formation's age, on the basis of marine fossils, ranges from Late Albian to Cenomanian. Only the basal 50 or so metres of the formation is present within the northeastern corner of the area covered by **Map 2-3**; this part of the formation is therefore considered to be of Late Albian age. The basal contact of the Cruiser Formation with the underlying Goodrich Formation is abrupt (Stott, 1968), and possibly disconformable.

### *4.6.2 Goodrich Formation (map-unit 8b)*

The Goodrich Formation comprises approximately 250 to 300 metres of medium- to thick-bedded, locally cliff-forming sandstone, with frequent interbeds of siltstone and mudstone. The Goodrich Formation forms mesas in the northeastern part of the area covered by Map 2-3, entirely outside the northeastern boundary of the Mink North coal property. The Goodrich is of Late Albian age, as established by its molluscan fauna (Stott, 1968). The basal contact of the Goodrich Formation with the underlying Hasler Formation is gradational.

### *4.6.3 Hasler Formation (map-unit 8a)*

The Hasler Formation, of late Middle Albian to Late Albian age (Gibson, 1992b) forms subdued slopes within the upland area between Hasler Creek and Highhat River, along the northeastern margin of the Mink North property. The Hasler comprises marine siltstone, overlain by marine mudstone with occasional bands of sideritic concretions. The undeformed thickness of the Hasler is approximately 250 metres, locally thickened by structural telescoping to 365 metres.

A few centimetres to decimetres of erosive-based cherty gritstone commonly mark the Hasler Formation's abrupt basal contact with the underlying Boulder Creek Formation.

### *4.6.4 Boulder Creek Formation (map-units 7b and 7a)*

The Boulder Creek Formation, of late Middle Albian age (Gibson, 1992b) forms prominent cliffs in the upland area between Hasler Creek and Highhat River, along and immediately to the northeast of the Mink North property's northeastern boundary.

Regionally, conglomerate and sandstone are the predominant lithologies of the Boulder Creek Formation, but the Walton Creek Member of the formation also contains fine-grained rocks including siltstone, root-penetrated, variably-carbonaceous mudstone, and coal, some of which attains thicknesses of interest for underground mining.

Conglomerate and sandstone are concentrated in the basal Cadotte Member (map-unit 7a) of the formation, while fine-grained rocks are concentrated in the overlying Walton Creek Member (map-unit 7b). The uppermost regionally-mapped division of the Boulder Creek Formation, comprising the conglomerate of the Paddy Member (map-unit 7c), is not recognised within the Mink North study area.

The overall thickness of the Boulder Creek Formation is inferred to be 140 to 150 metres at Mink North, of which the basal 10 to 25 metres comprises the Cadotte Member and the overlying 120 to 130 metres comprises the Walton Creek Member. The basal contact of the Boulder Creek Formation with the underlying Hulcross Formation is abrupt to erosional at local scale, and likely to be interfingering at regional scale.

#### *4.6.4.1 Walton Creek Member (map-unit 7b)*

The Walton Creek Member of the Boulder Creek Formation comprises 120 to 130 metres of generally-recessive siltstone, variably-carbonaceous, locally root-penetrated mudstone and variably-thick coal beds (MacFarlane, 1981; Gibson, 1992b; Morris and Engler, 2010), of which two or three appear to be laterally-continuous within Anglo-Pacific Group Plc's Trefi coal property (which adjoins the Mink North property to the northeast). Two outcrops of Walton Creek coal are known to occur within the northeastern margin of the Mink North property (as mapped by MacFarlane, 1981, and as shown on **Map 2-3** of the present report), but details of their thickness and quality are not known. The swale-forming fine-grained rocks of the Walton Creek Member are punctuated by cliff-forming lenses of sandstone, gritstone and pebble-conglomerate, inferred to be channel-fills.

Gibson (1992b) considered the Walton Creek Member to be of probable Late Albian age, based on angiosperm flora. The basal contact of the Walton Creek Member with the underlying Cadotte Member is generally abrupt, and regarded by Gibson (*op. cit.*) as being conformable.

#### *4.6.4.2 Cadotte Member (map-unit 7a)*

The Cadotte Member of the Boulder Creek Formation comprises 10 to 25 metres of cliff-forming sandstone and pebble-conglomerate with rare thin interbeds of siltstone. The Cadotte generally coarsens upward, with its sandstones being at its base and its conglomerates being in its middle and at its top. Other than isolated coalified logs, the Cadotte Member is devoid of coal. The basal contact of the Cadotte Member with the underlying Hulcross Formation is generally abrupt and therefore considered to be conformable at local scale (Gibson, 1992b), although it may intertongue at regional scale.

### ***4.6.5 Hulcross Formation (map-unit 6)***

The Hulcross Formation, of middle Albian age within the Early Cretaceous (Stelck and Leckie, 1988) comprises thinly-interbedded, locally-concretionary grey siltstone, fine-grained sandstone and dark grey mudstone with occasional very thin but extremely-persistent interbeds of soft, light grey to white tuff (Kilby, 1985; Gibson, 1992b) and rare thin stringers of coal. Sideritic concretions are commonly found in isolated, laterally-persistent bands.

Within the area covered by **Map 2-3**, the Hulcross Formation forms a recessive-weathering band along the northeastern corner of the Mink North property

The thickness of the Hulcross Formation at Mink North is estimated to be 102 to 123 metres. The formation’s immediate base is characteristically marked by a thin (generally less than a metre thick) erosive-based bed of pebbly sandstone or gritstone, lying erosionally upon the underlying strata of the Notikewin Member of Gates Formation.

### *4.6.6 Gates Formation (map-unit 5)*

The Gates Formation, of late Early Albian age within the Early Cretaceous, comprises thin to thick interbeds of sandstone, siltstone, conglomerate, and shale, locally accompanied by coal beds. The Gates Formation was formerly considered as a member within the Commotion Formation, and that usage prevailed in earlier governmental surveys and coal-industry exploration reports (Stott, 1968). Coals of the Gates Formation, and their enclosing sedimentary rocks, were deposited on the shoreline of the Clearwater Sea (part of the Western Interior Seaway) between 108.7 and 111.0 million years ago, as part of an extensive complex of coastal plains, deltas and estuaries collectively known as the Gates Delta.

At Mink North, the Gates coal-measures are present along the northeastern margin of the property, with an isolated outlier of basal non-coal-bearing sandstone situated within a syncline, about two kilometres to the southwest of the main Gates outcrop belt.

The Gates Formation may be readily subdivided into three members: the uppermost Notikewin coal-measures, the medial Falher coal-measures, and the basal Torrens sandstone. The Notikewin and Falher members can be reasonably-distinguished in borehole records and the logs of oil and gas wells, but they cannot be easily mapped separately without the aid of detailed aerial imagery, so they have been mapped together as composite map-unit 5bc on **Map 2-3**. The Torrens Member, however, can be readily mapped, and it is thus shown as map-unit 5a. Only one coal-exploration borehole (PP 79-03) has tested the Gates coal-measures at Mink North (as shown on **Map 2-2**), finding several very thin coals within the Notikewin and Falher members.

The Gates Formation is inferred to be 190 to 230 metres thick within the area covered by **Map 2-3**. The nature of its contact with the underlying Moosebar Formation appears to be abrupt at local scale, but likely to be interfingering at the regional scale.

#### *4.6.6.1 Notikewin Member (map-unit 5c)*

The Notikewin Member at Mink North consists of 95 to 138 metres of thin-bedded siltstone, variably-carbonaceous mudstone, and thick-bedded but generally-lenticular sandstone and rare conglomerate. The Notikewin Member, along with the underlying Falher Member of the Gates Formation, outcrops along the northeastern margin of the Mink North property.

Coal forms a minor component of the Notikewin Member, typically as very thin beds, 60 or fewer centimetres thick. No potentially-mineable coals are yet known from the Notikewin Member at Mink North.

The basal contact of the Notikewin Member with the underlying Falher Member is abrupt, and probably disconformable on a regional scale.

#### *4.6.6.2 Falher Member (map-unit 5b)*

The Falher Member at Mink North consists of 50 to 95 metres of thickly-interbedded sandstone, conglomerate and siltstone, with minor coal. The Falher Member outcrops along the northeastern margin of the Mink North property. As is the case in the Notikewin Member, only a few very thin coal beds are present within the Falher Member, typically 50 or fewer centimetres thick. No potentially-mineable coals are yet known from the Falher Member at Mink North.

The basal contact of the Falher Member with the underlying Torrens Member is abrupt, and possibly interfingering at a regional scale.

#### *4.6.6.3 Torrens Member (map-unit 5a)*

The Torrens Member at Mink North consists of 21 to 47 metres of medium- to thick-bedded, erosionally-resistant, cliff-forming sandstone with minor interbedded siltstone. As is the case in most other parts of the Peace River coalfields, the Torrens Member lacks coal, other than as rare isolated accumulations of drifted coaly plant trash. The Torrens forms a distinctive 'rimrock' along the northeastern fringe of the property, and it also caps an isolated mesa within the core of the Marlinspike Syncline, about two kilometres further to the southwest.

The basal contact of the Torrens Member with the underlying Spieker Member of the Moosebar Formation appears to be abrupt, drawn at the base of the dominantly-sandy section. This contact is likely to be interfingering at a regional scale.

### 4.6.7 Moosebar Formation (map-unit 4)

The Moosebar Formation, of early Albian age (Stott, 1968) forms the basal part of the Fort St John Group. At and near the Mink North property, the Moosebar Formation has a typical stratigraphic thickness of 190 metres (Cathyl-Huhn and Avery, 2014a).

The Moosebar Formation comprises an overall coarsening-upward sequence, comprised of several lesser coarsening-upward cycles, of mudstone passing upward to sandy siltstone. A basal pebbly, locally-glauconitic gritstone occurs at the immediate base of the formation in some sections. Very thin (a few millimetres to one or two decimetres) bands of tuff form conspicuous marker bands within the basal 30 metres of the formation (Kilby, 1984a; 1985).

Within the Mink North property, the Moosebar is inferred to form bedrock within a narrow strip along the property's northeastern side, and also within a more extensive area in the property's northern end.

No substantial surface sections of the Moosebar are known from within the property, but the formation has been partially intersected within several coal-exploration boreholes. These partial sections are supported by complete (albeit possibly structurally-thickened) Moosebar sections in two natural-gas wells (a-23-D and b-91-L) situated close beyond the property's northeastern boundary.

Drilling is sufficient to allow the recognition of two regionally-extensive lithological subdivisions (the Spieker and Cowmoose members) within the Moosebar Formation of the Mink North area.

#### *4.6.7.1 Spieker Member (map-unit 4c)*

The Spieker Member of the Moosebar Formation (Duff and Gilchrist, 1981), of early Albian age (Stott, 1968), comprises thinly-interbedded, coarsening-upward units of siltstone and very fine sandstone, within an overall coarsening-upward sequence. Bioturbation is pervasive and intense within the Spieker Member, which is interpreted to have formed as shallow-water turbidites within a proximal shelf setting in advance of the northward-prograding Gates paleodelta. The undeformed thickness of the Spieker Member is 30 to 70 metres, locally thickened (through thrust-induced structural telescoping?) to 175 metres, as in oil and gas well a-23-D.

The basal contact of the Spieker Member with the underlying Cowmoose Member is abrupt, generally drawn at the base of an upward decrease in natural gamma radiation, which coincides with an upward increase in the silt content of the rocks. The basal Spieker is in some sections marked by one or two metres of distinctly-sandy siltstone.

#### *4.6.7.2 Cowmoose Member (map-unit 4b)*

At and near Mink North, the Cowmoose Member of the Moosebar Formation, of early Albian age (Stott, 1968), consists of dark grey to black mudstone, with occasional thin but laterally-persistent (centimetre- to decimetre-scale) bands of tuff, and infrequent bands of concretionary ironstone. Without recourse to cored sections or gamma-neutron logs, the Cowmoose Member is superficially similar (and therefore difficult to distinguish in isolated exposures) from the basal part of the older Bullmoose Member of the Gething Formation.

The undeformed thickness of the Cowmoose Member is 50 to 80 metres, locally significantly-thickened to over 200 metres by thrust-induced structural telescoping. The basal contact of the Cowmoose Member with the underlying Green Marker (an informal lithostratigraphic unit previously designated as the 'Bluesky-S unit' by Kilby, 1984b) is abrupt, being readily recognised as a downward decrease of gamma-log counts.

#### *4.6.7.3 Green Marker (map-unit 4a)*

The basal contact of the Moosebar Formation with the underlying Chamberlain Member of the Gething Formation is marked by the Green Marker (Cathyl-Huhn and Avery, 2014c), a thin but laterally-persistent zone of erosive-based, pebbly, intensely-bioturbated, commonly-glauconitic sandstone, siltstone and mudstone. The Green Marker is generally a few decimetres to a metre thick, although its drilled thickness is locally greater than 24 metres, possibly due to structural telescoping.

Although the lithology of the Green Marker is superficially similar to that of the Bluesky Member of the Gething Formation, these two glauconite-bearing zones are stratigraphically distinct, both in space and in time (Kilby, 1984b; Legun, 1990). Kilby's (*op. cit.*) 'Bluesky-S unit' corresponds to the beds currently mapped as the Green Marker, whereas his older and stratigraphically-lower 'Bluesky-N' unit corresponds to beds here mapped as the Bluesky Member of the Gething Formation.

The basal contact of the Green Marker with the underlying Chamberlain Member, or with the Bullmoose Member where the Chamberlain is absent, is characteristically abrupt and at least locally erosional.

## 4.7 Bullhead Group (map-units 3 and 2)

A complete section of the Bullhead Group is present within the northeastern margin of the Mink North coal property, where the overlying rocks of the Fort St. John Group have protected the Bullhead rocks from erosion. Throughout much of the property, however, lesser thicknesses of

Bullhead strata are present, owing to erosional truncation, although considerable structural telescoping and concomitant thickening of thrust-faulted strata has taken place.

### 4.7.1 *Gething Formation (map-unit 3)*

The Gething Formation, of Hauterivian to late Early Albian age (Gibson, 1992a), comprises thin to thick interbeds of siltstone, sandstone, mudstone and coal, with lesser amounts of gritstone, pebble-conglomerate, ironstone and tuff.

The Gething Formation originated as a complex of non-marine to shallow-marine sedimentary deposits, laid down by meandering and braided streams and rivers within a widely-extensive belt of coastal deltas and an intervening marine-influenced bay, of which the basal delta (the coal-bearing Gaylard paleodelta) extended throughout the Brazion coalfield, and the Falling Creek area in general, including the Mink North coal property. An overlying delta (the younger Chamberlain paleodelta) is only represented by a thin, non-coal-bearing, fringe of sandy/silty delta-front to prodeltaic deposits (Gibson, 1992a)

The Gething Formation forms the top of the Bullhead Group (Stott, 1968, as used in the present report), and of the Crassier Group (*sensu* Hughes, 1964, as observed in the adjoining Mink Creek coal property by Sultan and Cathyl-Huhn, 2014). Within and adjacent to the Mink North coal property, the Gething Formation is 475 to 720 metres thick, although some of that thickness is made up by marginal-marine deposits between deltaic lobes. Local structural telescoping has thickened the Gething to at least 800 metres (as seen in oil and gas well c-47-L).

During the current investigation of the Mink North coal licenses, almost every coal-exploration borehole has intersected some section of the Gething Formation, but a complete lithological section of the formation cannot yet be established from this work, since none of the boreholes have reached the underlying Cadomin Formation. Complete sections of the Gething are available from records of two off-property oil and gas wells (a-23-D and b-91-L), and partial sections (lacking the top part of the Gething) are available from wells a-67-L and b-11-L (as listed in **Table 2-3** and **Table 4-1**).

The basal contact of the Gething Formation with the underlying Cadomin Formation is abrupt to possibly erosional at the local scale (Cant, 1996) and interfingering at the regional scale (Stott, 1968; Gibson, 1992a), drawn at the top of a bed of coarse-grained, often gritty and occasionally pebbly sandstone which may laterally grade into more typical pebble-conglomerate or multi-storey sandstone characteristic of the underlying sub-Gething beds.

#### *4.7.1.1 Stratigraphic subdivisions of the Gething Formation*

The presence of a thick, fine-grained, marine sub-unit within the Gething Formation was first recognised in the early 1970s by coal-exploration geologists working within the Sukunka area, on the eastern bank of Sukunka River, about 20 kilometres southeast of the Mink North property (Wallis and Jordan, 1974). The mid-Gething marine band was subsequently found by boreholes drilled in the Rocky Creek area, about 15 kilometres south of the Mink North property (Chowdry, 1980).

In 1992, the Geological Survey of Canada published a stratigraphic and sedimentological review of the Gething Formation (Gibson, 1992a), drawing upon coal-exploration results to propose a fourfold subdivision of the Gething Formation. From top downward, Gibson recognised four members:

- Chamberlain Member: marine and non-marine sandstone and siltstone, locally containing coal of mineable thickness;
- Bullmoose Member: marine siltstone, mudstone and sandstone, lacking coal;
- Bluesky Member: marine sandstone, conglomerate, siltstone and mudstone, lacking coal, but characteristically containing glauconite at its top; and
- Gaylard Member: non-marine siltstone, sandstone and mudstone, with numerous coal beds, some of which are of mineable thickness.

#### *4.7.1.2 Chamberlain Member (map-unit 3d)*

The Chamberlain Member within the Mink North area comprises a few (3 to perhaps 20) metres of very thinly- to thinly-interbedded, sparsely to moderately bioturbated very fine-grained sandstone and siltstone, with occasional bands of silty mudstone. In contrast with the Chamberlain sections drilled in the Sukunka area (25 kilometres to the southwest of Mink North), no coal has been found within the sections of the Chamberlain drilled thus far at Mink North. The Chamberlain Member appears to thin to the northeast; it is locally altogether absent within oil and gas wells drilled at Highhat Mountain (beyond the property's boundary), and in those wells the Cowmoose mudstones appear to directly overlie the Bullmoose siltstones. Mink North thus appears to be close to the expected northward limit of recognisable Chamberlain Member.

The Chamberlain Member is not known to contain diagnostic fossils; it has therefore been assigned an Early Albian age by Gibson (1992a) on the basis of fossils found within the overlying Moosebar Formation.

The basal contact of the Chamberlain Member with the underlying Bullmoose Member is gradational by interbedding, being drawn at the base of the Chamberlain’s sandstone. The Chamberlain-Bullmoose contact possibly rises stratigraphically, to the north and east, but available drilling does not suffice to confirm nor contradict this supposition.

#### *4.7.1.3 Bullmoose Member (map-unit 3c)*

The Bullmoose Member comprises about 110 metres of thinly-interbedded, recessive-weathering mudstone, siltstone and minor sandstone of turbiditic aspect, forming several fining-upward sequences within an overall coarsening-upward sequence.

The geophysical log response of the Bullmoose Member is very distinct, as compared with the overlying Chamberlain Member and the underlying Bluesky Member. **Table 4-2** (presented below) summarises drilled intersections of the Bullmoose Member at and near the Mink North property, within the context of the adjoining Chamberlain, Bluesky and Gaylard members of the Gething Formation, and the Cowmoose Member of the Moosebar Formation.

The Bullmoose Member is inferred to form extensive areas of bedrock within broad synclinal troughs situated along the northeastern fringe of the Mink North property, and the Bullmoose is also inferred to be preserved within the central cores of three tight synclines along the property's southern boundary.

The Bullmoose Member does not contain any coal, other than isolated coalified logs and coarse, poorly-preserved ‘plant trash’, likely of drifted origin. The Bullmoose does, however, contain abundant molluscan fossils, including *Pecten (Entolium)* cf. *irenense* McLearn (Gibson, 1992a) and *Yoldia kissoumi* (Duff and Gilchrist, 1981), which, although not age-diagnostic, are locally-characteristic of the unit.

The Bullmoose Member likely corresponds with the ‘Lower Silty Member’ of the Moosebar Formation, as suggested by Duff and Gilchrist (1981), within those areas (for example, the deep subsurface under Highhat Mountain, northeast of the Mink North property) where the overlying Chamberlain Member is absent.

Geophysical logs of the Bullmoose Member show a characteristic high-gamma response at two horizons situated 30 to 40 metres above the Bullmoose/Bluesky contact. These gamma ‘spikes’ are interpreted to be thin bands of tuff, each of them one to two decimetres thick, with the lower of the two bands being more persistent. These bands provide a regionally-extensive geophysical marker throughout the Falling Creek region (Kilby, 1984a).

The basal contact of the Bullmoose Member with the underlying Bluesky Member is drawn at the top of the underlying glauconitic sandy mudstone. In geophysical logs, the Bullmoose/Bluesky contact is readily recognised as a rapid downward change in log response to higher resistivity response, lower natural-gamma counts, and higher API neutron counts. This downward change is interpreted to correspond with a rapid downward passage from fine-grained mudstone of the basal Bullmoose, to the sandy mudstone and sandstone of the uppermost Bluesky.

The Bullmoose Member is of late Early Albian age (Gibson, 1992a). The thickness of the Bullmoose is typically about 110 metres at Mink North, although much thicker sections seen in oil and gas wells lying to the northeast of the property (189 and 237 metres respectively in wells b-91-L and a-23-D at Highhat Mountain, as given in **Table 4-2**) suggest that some lateral thickening, perhaps further complicated by structural telescoping, is possible.

#### *4.7.1.4 Bluesky Member (map-unit 3b)*

The Bluesky Member is a transitional unit between marine and non-marine facies. Accordingly, there has been considerable debate within the geological literature (as cogently summarised by Stott, 1968, and further discussed by Kilby (1984b) and Legun (1990), as to whether it properly belongs with the Gething Formation or the Moosebar Formation.

**Table 4-2**: Drilled thickness of key Moosebar and Gething lithostratigraphic units at and near Mink North

| Borehole (Drift) | Cowmoose Member | | Green Marker | | Chamberlain Member | | Bullmoose Member | | Bluesky Member | | Gaylard Member | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | top | thickness | top | thickness | top | thickness | top | thickness | top | thickness | top | thickness |
| a-23-D (unknown) | 1312.47 m | 78.03 m | absent? | nil? | absent? | nil? | 1390.50 m | 237.44 m | 1627.94 m | 25.75 m | 1653.69 m | 459.18 m (to Cadomin) |
| b-11-L (ca. 0 m) | | | | | | | | | | | starts | >266 m (to Cadomin) |
| c-47-L (ca. 21 m) | | | | | | | | | | | starts | >801 m (to Cadomin) |
| b-91-L (unknown) | 1038.0 m | | | | | | 1182.1 m | 189.3 m | 1371.4 m | 28.7 m | 1400.1 m | 485.9 m (to Cadomin) |
| H-3 | *no data* | | | | | | | | | | starts? | |
| H-7 | *no data* | | | | | | | | | | starts? | |
| DH 7503 (1.28 m) | | | | | | | | | | | starts | >272.13 m |
| DH 7507 (22.56 m) | | | | | | | | | | | starts | >202.35 m (to Cadomin) |
| DH 7508 (29.63 m) | | | | | | | | | | | starts | >332.47 m |
| DH 7509 (31.70 m) | | | | | | | | | | | starts | >120.09 m |
| DH 7611 (21.4 m) | | | | | | | | | | | starts | >30.42 m |
| PP 77-01 (5.43 m) | | | | | | | | | | | starts | >137.83 m |
| PP 77-02 (6.77 m) | | | | | | | | | | | starts | >84.67 m |
| PP 79-01 (19.4 m) | | | | | | | starts | > 41.3 m | 60.7 m | 7.9 m | 68.6 m | >197.4 m |
| PP 79-02 (17.0 m) | 116.5 m | 50.6 m | 167.1 m ? | 24.5 m ? | 191.6 m | >9.3 m | faulted out | | | | | |
| PP 79-03 (1.28 m) | not reached | | | | | | | | | | | |
| PP 79-04 (11.46 m) | | | | | | | | | | | starts | >146.02 m |
| PP 79-05 (34.5 m) | | | | | | | | | | | starts | >224.65 m |

**Table 4-2**: Drilled thickness of key Moosebar and Gething lithostratigraphic units at and near Mink North (concluded)

| Borehole (Drift) | Cowmoose Member | | Green Marker | | Chamberlain Member | | Bullmoose Member | | Bluesky Member | | Gaylard Member | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | top | thickness | top | thickness | top | thickness | top | thickness | top | thickness | top | thickness |
| PP 79-07 (13.3 m) | | | | | | | | | | | starts | >230.3 m |
| FC 82-9 (6.4 m) | | | | | | | | | | | starts | >194.6 m |
| FC 83-14 (3.83 m) | | | | | | | | | | | starts | >332.28 m |
| FC 83-21 (4.60 m) | | | | | | | starts | >23.75 m | 28.35 m | 19.4 m | 47.75 m | >277.55 m |
| 05RCPR01 (>27.43 m) | borehole did not reach rockhead | | | | | | | | | | | |
| 05RCPR01 A (27.4 m) | | | | | | | | | | | starts | >234.73 m |
| 05RCPR02 (12.5 m) | starts? | >72.7 m | absent? | nil? | 85.2 m ? | 3.7 m ? | 88.9 m ? | 110.2 m ? | 199.1 m | 8.4 m | 207.5 m | >51.58 m |
| 05RCPR08 (32.5 m) | | | | | | | | | | | starts | >226.58 m |
| 05RCPR08A (33.8 m) | | | | | | | | | | | starts | >69.9 m |
| 05RCPR09 (4.5 m) | | | | | | | | | | | starts | >240.9 m |
| 05RCPR10 (2.8 m) | | | | | | | | | | | starts | >119.12 m |

*Note: figures shewn (thus) are drilled depths to rockhead in metres. Figures shewn >thus are thicknesses of incomplete intersections, owing to the top and/or base of the unit having not been encountered by drilling.*

In areas lying ten or more kilometres to the north and east of the Mink North property, where the Bullmoose and Chamberlain members of the Gething Formation can no longer be recognised, the Bluesky is customarily mapped as a formation in its own right, bounded above by the Moosebar Formation, and beneath by the Gething Formation (Legun, 1990). At Mink North, following the usage of Gibson (1992), the Bluesky is considered as a member within the Gething Formation.

The Bluesky Member of the Gething Formation, generally consists of coarsening-upward cycles of interbedded mudstone, siltstone, and sandstone. Thin to medium interbeds of sandstone and mudstone give parts of the Bluesky a banded appearance. The top of the Bluesky is characteristically marked by a glauconitic horizon. The glauconitic zone, where observed in the nearby Mink Creek property, is 40 to 57 centimetres thick (Sultan and Cathyl-Huhn, 2014), and contains abundant fine-grained, green glauconite within sandy mudstone and argillaceous, locally-pebbly, sandstone.

Regionally, the basal contact of the Bluesky Member with the underlying Gaylard Member is characterized by chert- and quartz-pebble conglomerate up to a metre thick, grading to argillaceous sandstone with few randomly-distributed chert and quartz pebbles.

The erosive-based Bluesky sediments likely represent the initial transgressive deposits of an early tongue of the Clearwater Sea, which shortly after deposition of the Bluesky had transgressed to a southerly limit several hundred kilometres southeast of Mink North (Gibson, 1992a).

The Bluesky, as-drilled within and adjacent to the Mink North property, is 8 to 30 metres thick. The age of the Bluesky Member is not directly known, but inferred to be late Early Albian on the basis of the ages of its bounding strata.

#### *4.7.1.5 Gaylard Member (map-unit 3a)*

The Gaylard Member is the basal unit of the Gething Formation, comprising dominantly (or entirely?) non-marine sedimentary rocks within the Mink North coal property.

The Gaylard Member consists principally of many vertically-stacked, locally erosive-based, fining-upward bedsets, such as are typical of fluvial and deltaic depositional settings. A typical cyclic succession of Gething sediments commences with basal sandstone (rarely basal gritstone or pebble-conglomerate), passing upward through coarse- to fine-grained sandstone, siltstone, variably-carbonaceous mudstone, rooty seatearth mudstone and coal. Most, but not all, Gething cycles are capped by coal beds. Coals frequently contain partings of siltstone or variably-carbonaceous mudstone, tuff (the 'tonstein' bands of Kilby, 1984a and 1985) and rarely of ironstone.

Gamma-log response of the siliceous sandstones and conglomerates within the underlying Cadomin Formation are distinctly 'blockier' than those of the Gaylard sandstones, which tend to display upward-increasing gamma-ray log responses consistent with fining-upward sediments.

Nearly all of the known coal occurrences within the Mink North property are hosted by the Gaylard Member of the Gething Formation, with a few coal showings within the Bickford, Gates and Boulder Creek formations. At the adjoining Mink Creek coal property (Sultan and Cathyl-Huhn, 2014), the Gaylard Member contains at least nineteen readily-correlatable coal zones. Drilling at Mink North is not yet sufficient to allow for a commensurate enumeration of the Gaylard coal zones therein, although at least five coal zones were encountered in the single year-2012 borehole at Mink North.

Coals of the Gaylard Member at Mink North, and their enclosing sedimentary rocks, were deposited between 112 and 133 million years ago (Gibson, *ibid.*), on the basis of regional plant-fossil and foraminiferal zonations. The Gaylard's age (Gibson, 1992a) is Hauterivian to late Early Albian.

The Gaylard Member is bounded by the overlying transitional and marine sediments of the Bluesky Member, and the underlying non-marine (fluvial braidplain?) facies of the Cadomin Formation. Different facies within the Gaylard Member (such as channel-filling sandstone, sandy/silty point-bar sediments, carbonaceous mudstone, or coal) may be readily interpreted as various components of a deltaic complex.

Within the Mink North coal property, the internal subdivisions of the Gaylard Member -- as are readily mapped at Brule Mine, and to a lesser extent within the intervening Mink Creek coal property -- are not yet considered to be mappable given the scattered, discontinuous bedrock exposures and widely-spaced drilling. At Mink North, the lower third of the Gaylard Member does, however, contain thicker and more closely-spaced sandstones. Furthermore, as has been seen within the more closely-drilled Mink Creek coal property, thick coal beds tend to be more numerous and more closely-spaced within the upper fifth of the Gaylard Member at Mink North, and it may eventually prove practicable to recognise a tripartite lithostratigraphic subdivision of the Gaylard based upon vertical changes in its distribution and relative proportions of coal and sandstone.

The thickness of the Gaylard Member is known only from oil and gas wells, as none of the coal-exploration boreholes have intersected a complete section of the Gaylard within or near the Mink North property. The thickness of the Gaylard is thus indicated to be 460 to 485 metres, locally greatly thickened (to at least 800 metres in oil and gas well c-47-L) by thrusting and concomitant structural repetition, although some of this thickening may reflect oblique well trajectories with respect to bedding orientation.

The basal contact of the Gething Formation with the underlying Cadomin Formation is abrupt to possibly erosional at the local scale (Cant, 1996) and interfingering at the regional scale (Stott, 1968; Gibson, 1992a), drawn at the top of a bed of coarse-grained, often gritty and occasionally pebbly sandstone which may laterally grade into more typical pebble-conglomerate or multi-storey sandstone characteristic of the underlying sub-Gething beds.

### *4.7.2 Cadomin Formation (map-unit 2)*

The Cadomin Formation immediately underlies the Gething Formation, forming the basal part of the Bullhead Group (Stott, 1968). As such, the Cadomin Formation includes strata which may alternatively be assigned to the Dresser Formation of the Crassier Group *sensu* Hughes (1964).

The Cadomin Formation comprises one or more thick beds of coarse-grained, gritty to pebbly sandstone and pebble-conglomerate (McLean, 1977) with occasional lenses of siltstone and pebbly gritstone, and rare thin lenses of dirty coal. The Cadomin Formation thus resembles the basal sandstone unit (Division 1, as seen at Brule Mine) of the Gaylard Member, and its distinction from the overlying Gaylard sandstones rests mainly upon the Cadomin Formation's greater lateral continuity, and its distinctly-'blocky' geophysical-log response.

At Mink North, the Cadomin Formation is estimated to be 25 to 35 metres thick. Its basal contact with the underlying Bickford Formation of the Minnes Group is erosional, with considerable local scour into the older sediments. Regionally, the base of the Cadomin marks a northeastward-deepening angular unconformity, cutting down into successively-older rocks of the Minnes Group (Stott, 1973).

## 4.8 Minnes Group (map-unit 1)

The Minnes Group comprises clastic sedimentary rocks of latest Jurassic and earliest Cretaceous age, forming a poorly-exposed deltaic/shelfal/basinal complex which is overlain by, and therefore largely concealed by, the Bullhead Group.

Four formations are locally recognised within the Minnes Group. From top down, they are the Bickford Formation (equivalent to most of the now-deprected Brenot Formation of Hughes, 1964), the Monach Formation, the Beattie Peaks Formation, and the Monteith Formation (Stott, 1981; 1998). Coal is known to occur in all four of the Minnes Group's formations (Chowdry, 1980), but only the Bickford Formation is exposed at ground surface within the Mink North coal property, and therefore readily-accessible to exploration.

### *4.8.1 Bickford Formation (map-unit 1d)*

The Bickford Formation (named for Mount Bickford, near Pine Pass) consists of non-marine sandstone, siltstone, mudstone and coal, with a total thickness of 285 to 300 metres (Chowdry, 1980). Channel-filling conglomerates, up to 11 metres thick, locally occur near the top of the formation (Stott, 1998). The uppermost few metres of the formation, immediately beneath the base of the Cadomin Formation, is typically bleached and altered to a distinctively-soft, very light grey to white layer of clay-rich sediment.

Coals of potentially-mineable thickness were reported (Chowdry, 1980; Kalkreuth, 1982) from the Bickford Formation (coeval with the Brenot Formation) within the Rocky Creek coal property (south of Mink North), on the basis of extensive drilling during the early 1980s, but the Brenot Formation has yet to be drilled at Mink North (other than in oil and gas wells), and its local coal potential is therefore unknown.

# 5 Coal

The Gething Formation contains several coal seams, at least some of which are sufficiently thick to constitute reasonable exploratory targets, within the Mink North coal property. No attempt is here made to correlate these coals, although past workers have made reasonable progress in that direction.

The Boulder Creek, Gates and Bickford formations also are known to contain coal, albeit generally of subeconomic thickness, within boreholes drilled close outside of the property boundaries. The Boulder Creek and Gates formations both also have been observed (in historic work, as shown on **Map 2-3**) to contain isolated coal outcrops, although little is known of their thickness.

## 5.1 Coals within the current borehole at Mink North

**Table 5-1** presents a listing of Gaylard Member coals encountered in the one current borehole (MCE 12-11, drilled in year-2012) at Mink North. These coals are correlated, at a fair level of confidence, with like-named coals encountered by closely-spaced boreholes drilled within the adjoining Mink Creek coal property (*vide* Sultan and Cathyl-Huhn, 2014).

**Table 5-1**: Coal intersections in current borehole MCE 12-11

| Borehole | From | To | Drilled thick-ness | Lithology | Seam | True thick-ness | Remarks |
|---|---|---|---|---|---|---|---|
| MCE12-11 | 30 | 33.5 | 3.5 | Coal | A | 3.43 | Owing to unstable borehole conditions, only a gamma-neutron log was run within the drill rods. |
| | 41 | 42 | 1 | Coal | B | 0.98 | |
| | 64 | 68.5 | 4.5 | Coal | C | 4.41 | |
| | 76.7 | 79 | 2.3 | Coal | D | 2.28 | |
| | 82 | 83 | 1 | Coal | E | 0.99 | |
| | 87 | 88 | 1 | Coal | E | 0.99 | |
| | 90.5 | 90.7 | 0.2 | Coal | Coal | 0.20 | |

*Note: coal bed intersections interpreted by M. Sultan, as presented in Mink Creek coal assessment report (Sultan and Cathyl-Huhn, 2014). Depths and thicknesses are given in metres. Coal identified simply as 'Coal' has not been correlated to named coal beds.*

# 6 Coal quality

No coal-quality data were obtained during the year-2012 drilling at Mink North, owing to the single borehole having not been cored.

## 6.1 Note concerning historic coal-quality data

A considerable volume of coal-quality data, including some petrographic data, were obtained in the course of historic exploration at Mink North. These historic data have not yet been subjected to a meta-analysis of their trends, although such a study would clearly be useful to any future evaluation of the Mink North coal property.

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# 7 Coal-resource estimation

At its present density of drilling, Mink North has not yet been sufficiently-explored to support coal-resource estimation. Further exploration would be needed before any consideration could be given to the recognition of measured or indicated coal resources.

# 8 Reclamation

Drilling at Mink North during year-2012 was confined to one drill pad adjacent to the Falling Creek Connector Road. As per usual practice, the drill site was cleared of equipment, supplies and trash prior to removal of the drilling rig, and appropriate revegetation seed mix was applied to the site.

# 9 Statement of costs

'Current work' within the Mink North coal property, for purposes of the present report, comprises exploratory work done in year-2012. Work done was minimal, comprising the drilling of one borehole adjacent to an existing access road, using rotary (non-coring) methods. The borehole was geophysically logged, but no samples were taken for analysis.

For the year-2012 work, exploratory costs are not readily available from exploration department files. Year-2012 costs are therefore estimated, based on provincial average unit costs, following the methodology used in Coal Assessment Report No.936 for the nearby Brule property (Cathyl-Huhn and Avery, 2014a).

**Table 9-1** presents the resultant estimated cost breakdown for work at Mink North.

**Table 9-1**: Estimated exploratory cost breakdown by activity

| | Year-2012 | | | |
|---|---|---|---|---|
| Item/year | Quantities | Average unit costs | Estimated costs | Total costs |
| Rotary-drilling | 102.1 metres | $201.34/metre | $20,355 | $20,355 |
| Core-drilling | nil | $210.34/ metre | nil | nil |
| Geophysical logging | 99.44 metres | $17.56/ metre | $1,746 | $1,746 |
| Roadwork | nil | $23.30/ metre | nil | nil |
| Analytical work | nil | $79.63/ metre | nil | nil |
| | | Totals | $22,101 | $22,101 |

Notes: unit costs are on per-metre drilled length basis, derived from provincial average unit-costs (see Bouchard (2011) report on behalf of Natural Resources Canada. Geophysical log metreage is slightly lower than drilled metreage, as the borehole could not be logged to its total depth.

# 10 References

The following reference materials were used in the compilation of this report, with citations given at relevant points within the report's text. All coal-assessment reports here cited are available in digital versions via the British Columbia Geological Survey Branch's webspace, with the exception that year-2014 reports are still confidential at the time of this writing.

**Bienia, A.**

1982: Trefi coal project 1982 exploration program geological report; *Norwest Resource Consultants Ltd.*, unpublished report PR-Trefi 82(1)A, dated December 1982; *British Columbia Geological Survey Branch*, Coal Assessment Report 682.

**Bouchard, G.**

2011: Mineral exploration, deposit appraisal, and mine complex development activity in Canada, 2010 and 2011; *Natural Resources Canada*, online document accessed via *http://www.nrcan.gc.ca/mining-materials/exploration/13814#t5a*

**Cant, D.J.**

1996: Sedimentological and sequence stratigraphic organization of a foreland clastic wedge, Mannville Group, Western Canada; *Journal of Sedimentary Research*, volume 66, number 6 (November 1996), pages 1137 to 1147.

**Cathyl-Huhn, C.G. and Avery, L.R.**

2014a: Coal assessment report for the Brule lease, British Columbia, Canada; *Walter Canadian Coal Partnership*, unpublished report dated July 17, 2014; *British Columbia Geological Survey Branch*, Coal Assessment Report 936.

2014b: Coal assessment report for the Burnt River coal property, British Columbia; *Walter Canadian Coal Partnership*, unpublished report dated July 17, 2014; *British Columbia Geological Survey Branch*, Coal Assessment Report 937.

2014c: Coal assessment report for the EB Main coal property, British Columbia; *Walter Canadian Coal Partnership*, unpublished report dated December 18, 2014; *British Columbia Geological Survey Branch*, Coal Assessment Report [not yet catalogued].

**Chowdry, M.A.**

1980: B.C. Government report on the North East B.C. thermal coal exploration program, 1980; *BP Exploration Canada Limited*, unpublished report PR – Sukunka 80(1)A, dated December 31, 1980; *British Columbia Geological Survey Branch*, Coal Assessment Report No. 667, 807 pages.

**Cunningham, J.M. and Sprecher, B.**

1992: Geology of the Le Moray Creek and Carbon Creek areas, northeastern British Columbia; NTS 93 O-8, 15; *British Columbia Geological Survey Branch*, Open File Map 1992-12.

**Douglas, R.J.W., Gabrielse, H., Wheeler, J.O., Stott, D.F. and Belyea, H.R.**

1970: Geology of Western Canada: Chapter VIII; in Douglas, R.J.W. (editor), Geology and Economic Minerals of Canada, *Geological Survey of Canada*, Economic Geology Report, volume 1, pages 366 to 488.

**Duff, P.McL.D. and Gilchrist, R.D.**
1981: Correlation of Lower Cretaceous coal measures, Peace River coalfield, British Columbia; *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Paper 1981-3, 31 pages.

**Dyson, P.**
1975: Pine Pass coal project, N.E. British Columbia; Paul Dyson Consultants, unpublished report PR - Pine Pass 75(1)A, dated October 1975, on behalf of Pan Ocean Oil Ltd.; *British Columbia Geological Survey Branch*, Coal Assessment Report No. 584.

1977: Pine Pass coal project, northeast British Columbia: 1976 - 1977; Paul Dyson Consultants, unpublished report PR - Pine Pass 77(1)A, dated December 1977, on behalf of Pan Ocean Oil Ltd.; *British Columbia Geological Survey Branch*, Coal Assessment Report No. 585.

**Flynn, B.P.**
1980: Trefi coal project geological report; *Gulf Canada Resources Inc.*, unpublished report PR-Trefi 80(1)A; *British Columbia Geological Survey Branch*, Coal Assessment Report No.680.

**Gibson, D.**
1992a: Stratigraphy, sedimentology, coal geology and depositional environments of the Lower Cretaceous Gething Formation, northeastern British Columbia and west-central Alberta; *Geological Survey of Canada*, Bulletin 431, 127 pages.

1992b: Stratigraphy and sedimentology of the Lower Cretaceous Hulcross and Boulder Creek formations, northeastern British Columbia; *Geological Survey of Canada*, Bulletin 440, 111 pages.

**Hovis, S.T., Crawford, J. and Coombes, S.F.**
2006: Assessment report for the Falling Creek coal property, Peace River District; unpublished report dated January 3, 2006, on behalf of Kennecott Canada Exploration Inc.; *British Columbia Geological Survey Branch*, Coal Assessment Report No. 888.

**Hughes, J.D., Klatzel-Mudry, L. and Nikols, D.J.**
1989: A standardized coal resource/reserve reporting system for Canada; *Geological Survey of Canada*, Paper 88-21.

**Hughes, J.E.**
1963: The Peace and Pine River Foothills (structures and tectonics); *McGill University*, unpublished Ph.D. dissertation dated September 1963.

1964: Jurassic and Cretaceous strata of the Bullhead succession in the Peace and Pine River Foothills; *British Columbia Department of Mines and Petroleum Resources*, Bulletin 51.

1967: Geology of the Pine Valley, Mount Wabi to Solitude Mountain, northeastern British Columbia; *British Columbia Department of Mines and Petroleum Resources*, Bulletin 52.

**Hunter, D.J. and Cunningham, J.M.**
1991: Geology of the Burnt River and Gwillim Lake (southwest half) areas, northeastern British Columbia, NTS 93P/5, 93P/6; *British Columbia Geological Survey Branch*, Open File Map 1991-4.

**Jones, P.B.**

1960: Geological field work in the North Monkman group of permit areas, British Columbia, 1959; *Triad Oil Co. Ltd*., unpublished report T.R. 152 dated April 1960; *British Columbia Ministry of Energy and Mines*, Petroleum Resources Branch Assessment Report No. 863.

**Kalkreuth, W.D.**

1982: Rank and petrographic composition of selected Jurassic - Lower Cretaceous coals of British Columbia, Canada; *Bulletin of Canadian Petroleum Geology*, volume 30, number 2 (June, 1982), pages 112 to 139.

**Kilby, W.**

1984a: Tonsteins and bentonites in northeast British Columbia ((3O, P, I); in Geological Fieldwork 1983; *British Columbia Geological Survey Branch*, Paper 1984-1, pages 95 to 107.

1984b: The character of the Bluesky Formation in the Foothills of northeastern British Columbia (93O, P, I); in Geological Fieldwork 1983; *British Columbia Geological Survey Branch*, Paper 1984-1, pages 108 to 112.

1985: Tonstein and bentonite correlations in northeast British Columbia (93O, P, I; 94A); in Geological Fieldwork 1984; *British Columbia Geological Survey Branch*, Paper 1985-1, pages 257 to 277.

**Klatzel-Mudry, L., Horgan, J. and Hallas, D.**

1982: Geology of the Falling Creek property; unpublished report PR - Falling Creek 82(1)A, on behalf of Esso Resources Canada Ltd.; *British Columbia Geological Survey Branch*, Coal Assessment Report No. 524.

**Klatzel-Mudry, L., Horgan, J., Hallas, D. and Wright, B.**

1984: Geology of the Falling Creek property; unpublished report PR - Falling Creek 83(1)A, on behalf of Esso Resources Ltd.; *British Columbia Geological Survey Branch*, Coal Assessment Report No. 525.

**Legun, A.S.**

1990: Stratigraphic trends in the Gething Formation (NTS 93P/1 to 8 and 93I/14, 15); *British Columbia Ministry of Energy, Mines and Petroleum Resources*, Open File 1990-33.

2003: Coalbed methane geology of the Peace River District - NE BC, NTS (Parts of 94A&B; 93I, O&P); *British Columbia Geological Survey Branch*, Geoscience Map 2003-2.

**MacFarlane, D.W.**

1981: Geological report: Trefi Project 1981 exploration program; *Gulf Canada Resources Inc.*, unpublished report PR-Trefi 81(1)A, dated November 1981; *British Columbia Geological Survey Branch*, Coal Assessment Report No.681.

**McClymont, B.I.**

1981: Burnt River coal property 1981 exploration report; *Teck Corporation*, unpublished report PR – Burnt River 81(1)A, dated December 1981; *British Columbia Geological Survey Branch*, Coal Assessment Report No.490.

**McKechnie, N.D.**

1955: Coal reserves of the Hasler Creek - Pine River area, British Columbia; *British Columbia Department of Mines*, Bulletin 36.

**McLean, J.R.**

1977: The Cadomin Formation: stratigraphy, sedimentology, and tectonic implications; *Bulletin of Canadian Petroleum Geology*, volume 25, number 4, pages 792 to 827.

**McMechan, M.E.**

1984: Geology and cross-section, Dawson Creek, British Columbia; *Geological Survey of Canada*, Map 1858A, scale 1:250,000

1985: Low-taper triangle-zone geometry: an interpretation for the Rocky Mountain Foothills, Pine Pass – Peace River area, British Columbia; *Bulletin of Canadian Petroleum Geology*, volume 33, number 1 (March 1985), pages 31 to 38.

**Morris, R.J. and Engler, R.F.**

2010: Resource estimate for the Trefi coal property; *Moose Mountain Technical Services*, unpublished report dated 18 March 2010, on behalf of Anglo-Pacific Group Plc; accessed via *http://www.anglopacificgroup.com/i/pdf/TrefiTechnicalReportMar10.pdf*, on February 19, 2015.

**Newson, A.C.**

1980a: Pine Pass coal project, 1978, N.E. British Columbia; *Norcen Energy Resources Ltd.*, unpublished report PR - Pine Pass 79(2)A; dated January, 1980; *British Columbia Geological Survey Branch*, Coal Assessment Report No. 587.

**Ryan, B.**

2002: Coal in British Columbia; British Columbia Ministry of Energy and Mines and Responsible for Core Review, website accessed December 17, 2014 via *http://www.empr.gov.bc.ca/Mining/Geoscience/Coal/CoalBC/Pages/default.aspx*

2010: Technical report: Hasler Creek coal property, unpublished report on behalf of *Unicorn International Mines Group Inc*., dated March 1st, 2010; 77 pages.

**Spivak, J.**

1944: Geology and coal deposits of Hasler Creek area, British Columbia; *Geological Survey of Canada*, Paper 44-7.

**Stelck, C.R. and Leckie, D.A.**

1988: Foraminiferal inventory and lithologic description of the Lower Cretaceous (Albian) Hulcross Shale, Monkman area, northeastern British Columbia; *Canadian Journal of Earth Sciences*, volume 25, pages 793 to 798.

**Stott, D.F.**

1968: Lower Cretaceous Bullhead and Fort St. John groups, between Smoky and Peace rivers, Rocky Mountain Foothills, Alberta and British Columbia; *Geological Survey of Canada*, Bulletin 152, 279 pages.

1973: Lower Cretaceous Bullhead Group between Bullmoose Mountain and Tetsa River, Rocky Mountain Foothills, Northeastern British Columbia; *Geological Survey of Canada*, Bulletin 219, 228 pages.

1981: Bickford and Gorman Creek, two new formations of the Jurassic-Cretaceous Minnes Group, Alberta and British Columbia; *Geological Survey of Canada*, Paper 81-1B, pages 1 to 9.

1998: Fernie Formation and Minnes Group (Jurassic and lowermost Cretaceous), northern Rocky Mountain Foothills, Alberta and British Columbia; *Geological Survey of Canada*, Bulletin 516, 516 pages.

**Thompson, R.I.**
1979: A structural interpretation across part of the northern Rocky Mountains, British Columbia, Canada; *Canadian Journal of Earth Sciences*, volume 16, pages 1228 to 1241.

**Wallis, G.R. and Jordan, G.R.**
1974: The stratigraphy and structure of the Lower Cretaceous Gething Formation of the Sukunka River coal deposit in B.C.; *CIM Bulletin*, volume 67, number 743 (March 1974), pages 142 to 147.

**Waters, B.L.M.**
1981: Geology of the Falling Creek licences; *Esso Resources Ltd.*, unpublished report PR - Falling Creek 80(1)A, dated July 1981; *British Columbia Geological Survey Branch*, Coal Assessment Report No. 522.

**White, A.**
1983: Highhat River coal property, N.E. British Columbia, 1982 geological report; unpublished report PR - Highhat River 82(1)A, dated April 1983, on behalf of Shell Canada Resources Ltd.; *British Columbia Geological Survey Branch*, Coal Assessment Report No. 537.

# 11 Conclusions

Coal occurrences, of potentially-workable thickness, occur within the Mink North coal property. Most of the thick coals are contained within the upper portion of the Gaylard Member of the Lower Cretaceous (Hauterivian to Early Albian) Gething Formation.

Exploration to date has been sparse, on account of difficult access and structural complexity. Rocks at Mink North have been tightly-folded, and broken by numerous thrust faults. which themselves are likely to have been folded. Given the structural complexity of the area, insufficient work has yet been done to allow the assessment of coal resources within the property.

In all, 25 historic boreholes (as reported in previous coal-assessment reports and a B.C. Department of Mines bulletin), totalling 4800 metres' length, have been drilled within the Mink North coal property. One 'current' borehole (here-reported for the first time), with a total depth of 102.1 metres, was drilled on the property in year-2012.

Estimated exploratory costs to date, covering year-2012 activities, are $22,101. The Mink North coal property is regarded as being a property of merit, warranting further study of coal-quality trends.

# 12 Statement of qualifications

I, C.G. Cathyl-Huhn P.Geo.(BC) Lic.Geol.(WA) RMSME, do hereby certify that:

a) I am currently employed on a full-time basis by Walter Canadian Coal Partnership, a subsidiary of Walter Energy, in their Northeast British Columbia office in Tumbler Ridge, British Columbia.

b) This certificate applies to the current report, titled *Coal Assessment Report for the Mink North coal property, British Columbia*, dated February 19, 2015.

c) I am a member (Professional Geoscientist, Licence No.20550) of the Association of Professional Engineers and Geoscientists of British Columbia, licensed as a geologist (Licence No.2089) in Washington State, and a founding Registered Member of the Society for Mining, Metallurgy and Exploration (SME, Member No.518350). I have worked as a colliery geologist in several countries for over 36 years since my graduation from university.

d) I certify that by reason of my education, affiliation with professional associations, and past relevant work experience, having written numerous published and private geological reports and technical papers concerning coalfield geology, coal-mining geology and coal-resource estimation, that I am qualified as a Qualified Person as defined by Canadian *National Instrument 43-101* and a Competent Person as defined by the Australian *JORC Code*.

e) My most recent visit to the Mink North coal property was in the summer of 2014.

f) I am an author of this report, titled *Coal Assessment Report for the Mink North coal property, British Columbia*, dated February 19, 2015, concerning the Mink North coal property.

g) As of the date of the writing of this report, I am not independent of Walter Canadian Coal Partnership and Walter Energy, pursuant to the tests in Section 1.4 of *National Instrument 43-101*.

"original signed and sealed by"

Dated this 20th day of February, 2015. C.G. Cathyl-Huhn P.Geo. Lic.Geol. RMSME

# **Appendix A**: Geophysical logs

Geophysical logging and the pertinent statistics of the one current (MCE 12-11, year-2012) borehole are summarised in **Table A-1**. A copy of the geophysical log is submitted as digital files accompanying this report, in both LAS and TIF format. Note that only a minimal suite of logs (natural gamma and neutron) were obtained, owing to poor ground conditions necessitating the running of geophysical tools inside drilling-rods.

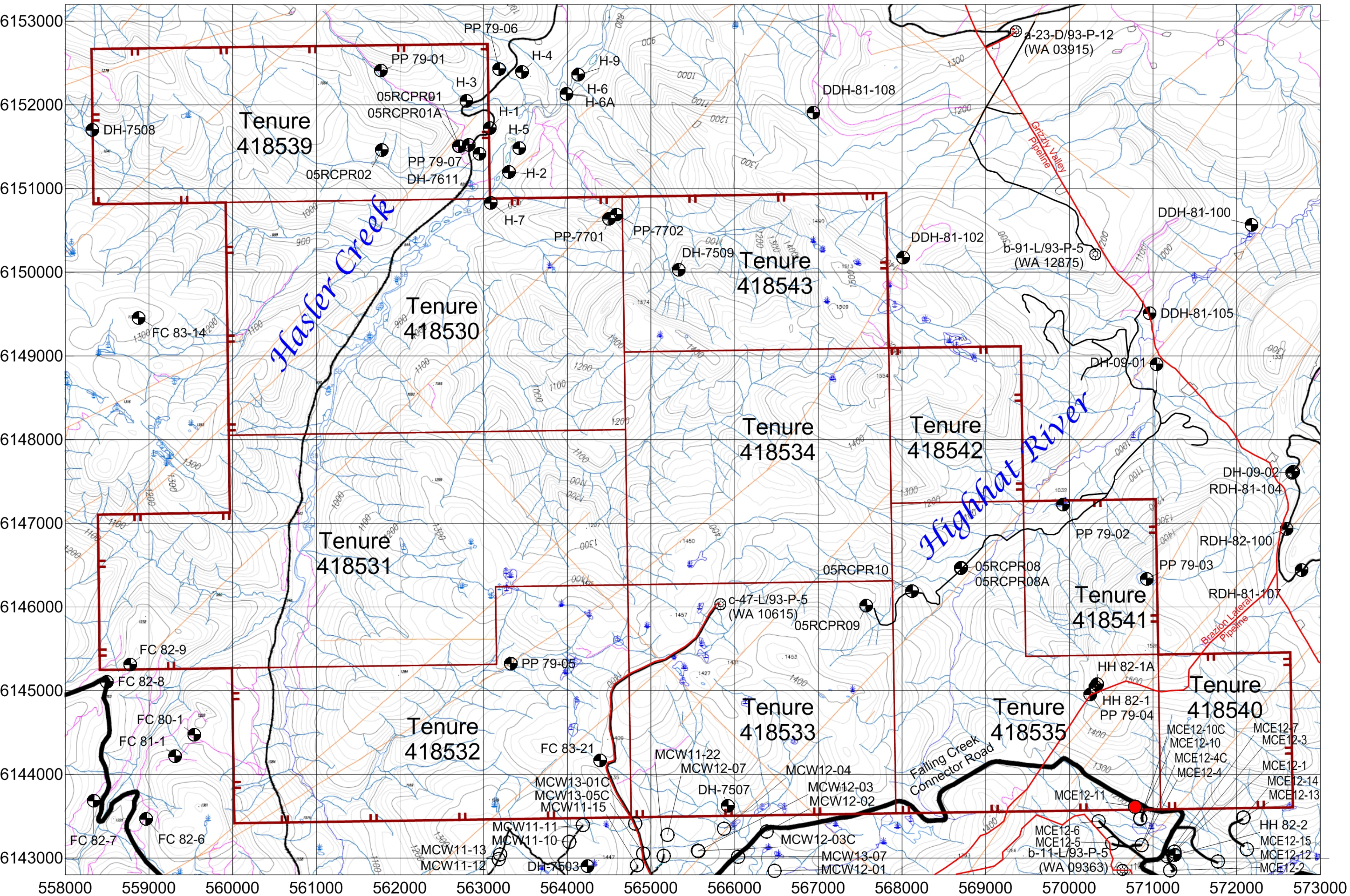
**Table A-1**: Geophysical logs run in borehole MCE 12-11

| UTM NAD83 (Zone 10) | | Elevation, depth and logging lengths given in metres | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Easting | Northing | Elevation | Total depth | Gamma/ Caliper/ Resistivity / Density | Gamma/ Neutron | Gamma/ Density | Deviation | Dipmeter |
| 570783.83 | 6143614.08 | 1189.42 | 102.1 | | 99.44 (thru rods) | | | |

# MINK NORTH

UTM NAD 83

CANADA
NTS 93 O/8 and 93 P/5




Drawing: Mink_North-topography-drainage-roads_150208c.srf/jpg
Drawn: C.G. Cathyl-Huhn, P.Geo.(BC) Lic.Geol (WA) RMSME
Date: 8.February 2015 Scale: as shown by bar scale
Grid: UTM Zone 10 to North American Datum of 1983, in metres

Base mapping: British Columbia government TRIM-series map sheets 093O.050, O.060, P.041 and P.051
Elevations are in metres above geodetic datum

UTM Grid North

Access (not classified as to trafficability):

- Road (coal haulage)
- Road (other)
- Trail
- Seismic line

Land classification:

- Coal licences (with current tenure numbers)

Drainage:

- River or creek
- Stream (perennial or intermittent flow)

a-23-D/93-P-12 (WA 03915) Natural gas wells (not classified as to activity)

Pipeline

Coal exploration boreholes:

- PP 79-04 Historic
- MCE12-11 Current (Mink North)
- MCE / MCW Current (other properties)

Mink_North-topography-drainage-roads_150208c.srf/jpg

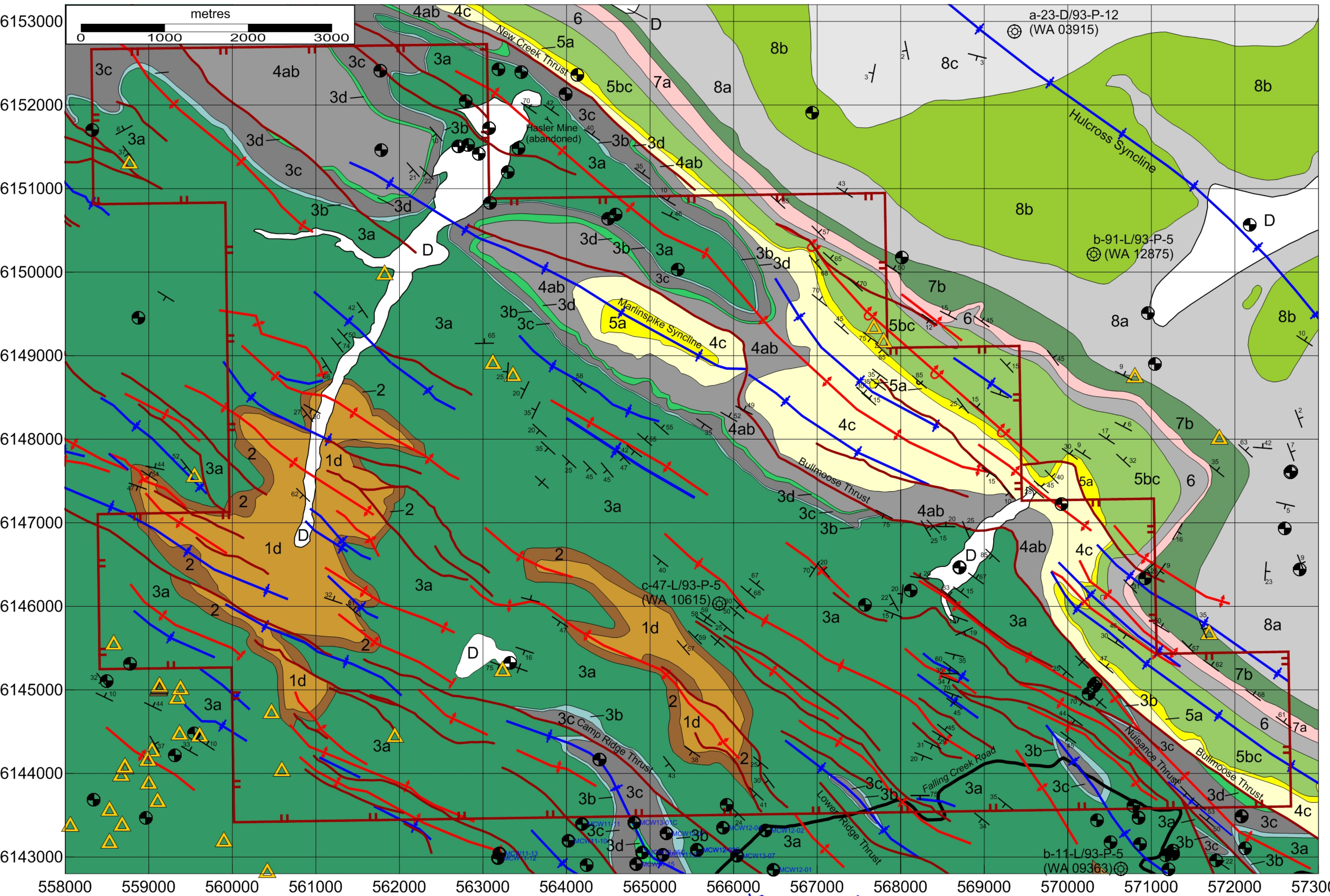
WALTER ENERGY

| | |
|---|---|
| Scale: as shown | COAL TENURE AND TOPOGRAPHY |
| UTM NAD 83 | |
| Revision: C | |
| Drawn: GCH | |
| FEB 2015 | MINK NORTH COAL ASSESSMENT REPORT — MAP 2-2 |

# MINK NORTH

UTM NAD 83

CANADA
NTS 93 O/8, 93 O/9, and 93 P/5




STRATIGRAPHIC LEGEND:

QUATERNARY

- D — Alluvium and colluvium -- fluvial and glaciolacustrine deposits; moraines; talus; possible landslide deposits

FORT ST JOHN GROUP (Albian)

- 8c — Cruiser Formation -- mudstone, siltstone and sandstone; ironstone as bands of concretions
- 8b — Goodrich Formation -- sandstone; minor siltstone and mudstone
- 8a — Hasler Formation -- siltstone and mudstone; minor sandstone; ironstone as bands of concretions
- 7 — Boulder Creek Formation -- sandstone, conglomerate, siltstone; coal
  - 7b — Walton Creek Member -- sandstone and siltstone; conglomerate, coal
  - 7a — Cadotte Member -- conglomerate and sandstone
- 6 — Hulcross Formation -- siltstone and mudstone; minor sandstone and tuff; ironstone; basal pebbly gritstone
- 5 — Gates Formation -- sandstone, siltstone, conglomerate; minor coal
  - 5bc: 5c — Notikewin Member -- siltstone, sandstone and conglomerate; minor coal
  - 5bc: 5b — Falher Member -- sandstone, conglomerate and siltstone, minor coal
  - 5a — Torrens Member -- sandstone; minor siltstone
- 4 — Moosebar Formation -- siltstone and mudstone; minor sandstone, tuff and gritstone
  - 4c — Spieker Member -- siltstone, sandstone; minor mudstone
  - 4ab — Cowmoose Member -- mudstone, minor tuff and ironstone; erosive-based basal glauconitic grit [Green Marker, Unit 4a, not mapped separately]

BULLHEAD GROUP (Hauterivian to Early Albian)

- 3 — Gething Formation -- siltstone, sandstone, coal; minor conglomerate
  - 3d — Chamberlain Member -- sandstone and siltstone
  - 3c — Bullmoose Member -- siltstone and sandstone; mudstone; minor tuff
  - 3b — Bluesky Member -- glauconitic sandstone and gritstone; siltstone and mudstone
  - 3a — Gaylard Member -- siltstone, sandstone and coal; minor conglomerate, minor tuff
- 2 — Cadomin Formation -- gritty sandstone; conglomerate; minor siltstone

MINNES GROUP (Valanginian and older?)

- 1d — Bickford Formation -- siltstone, sandstone, conglomerate, coal; bleached and intensely weathered at immediate top

Geological compilation by C.G. Cathyl-Huhn, 2015, incorporating data from B.C. Department of Mines (McKechnie, 1955), Kennecott Exploration (Hovis *et al*, 2006), Esso Resources (Klatzel-Mudry *et al*, 1982; 1984), Gulf Canada (MacFarlane, 1981) and Walter Energy (Sultan and Cathyl-Huhn, 2014).

*Mink_North-geology_150216f.srf/jpg*

*Drawing: Mink_North-geology_150216f.srf/jpg*
*Drawn: C.G. Cathyl-Huhn, P.Geo.(BC) Lic.Geol (WA) RMSME*
*Date: 16.February, 2015 Scale: as shown by bar scale*
*Grid: UTM NAD83 Zone 10, in metres*

*Base mapping: British Columbia government TRIM-series map sheets 093O.050, O.060, P.041 and P.051*

- Mink North coal property
- Natural gas wells (not classified as to activity)
- Coal exploration borehole
- Syncline
- Anticline (upright; overturned)
- Thrust Fault
- 67 Strike and dip of bedding
- Strike of vertical bedding
- Coal exposure (outcrop, trench or test-pit)

UTM Grid North

WALTER ENERGY

| | | |
|---|---|---|
| Scale: as shown | Geology of Mink North Coal Property | |
| UTM NAD 83 | | |
| Revision: F | | |
| Drawn: GCH | | |
| FEB 2015 | MINK NORTH COAL ASSESSMENT REPORT | MAP 2-3 |