COAL ASSESSMENT REPORT TITLE PAGE AND SUMMARY

TITLE OF REPORT: **Coal Assessment Report for the Willow Creek coal lease -- Volume 6: Willow Creek Mine, 2020 infill drilling**

TOTAL COST: **$156,945.01**

AUTHOR(S): **C.G. Cathyl-Huhn P.Geo, March 7, 2021**

SIGNATURE(S):

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

YEAR OF WORK: **2020-2021 lease term** (anniversary March 31)

PROPERTY NAME**: Willow Creek**

COAL LICENSE(S) AND/OR LEASES ON WHICH PHYSICAL WORK WAS DONE:
Coal Lease 389294

MINERAL INVENTORY MINFILE NUMBER(S), IF KNOWN: **93O.008**

MINING DIVISION: **Liard**

NTS / BCGS**: NTS 93O/9 / BCGS 93O.059, 93O.060, 93O.069, and 93O.070**

LATITUDE: **55° 36’ 00" North**; LONGITUDE: **122° 12’ 50" West** (at centre of work)

UTM Zone: **10N** EASTING: **549540** NORTHING: **6161855**

OWNER(S): **Conuma Resources Limited**

MAILING ADDRESS: **200-235 Front St. (P.O. Box 2140), Tumbler Ridge, BC, V0C 2W0**

OPERATOR(S) [who paid for the work]: **Conuma Coal Resources Limited**

MAILING ADDRESS: **200-235 Front St. (P.O. Box 2140), Tumbler Ridge, BC, V0C 2W0**

REPORT KEYWORDS (lithology, age, stratigraphy, structure, alteration, mineralisation, size and attitude). **coal, Gething Formation, Gaylard Member, thrust faults**

REFERENCES TO PREVIOUS ASSESSMENT WORK AND ASSESSMENT REPORT NUMBERS:
Coal Assessment Reports 984, 986, 988, 1001, and 1048 (primary references); also 490, 526, 667, 861, 936, 937, 952, 966, and 972; Petroleum Reports 582, 746, 863, and 1161.

SUMMARY OF TYPES OF WORK IN THIS REPORT		EXTENT OF WORK (in metric units)	ON WHICH TENURES
GEOLOGICAL (scale, area)			
	Ground, mapping	**nil**	n/a
	Photo interpretation	**nil**	n/a
GEOPHYSICAL (line-kilometres)			
	Ground (Specify types)	**nil**	n/a
	Airborne	**nil**	n/a
	(Specify types)		
	Borehole -- ***geophysical logs in all 4 holes***		
	Gamma-density (logged within drill rods)	**nil**	n/a
	Compensated gamma-density-caliper-resistivity	**249.3 m in 4 holes**	389294
	Deviation	**214 m in 4 holes**	389294
	Gamma-neutron (logged within drill rods)	**nil**	n/a
	Gamma-neutron	**250.11 m in 4 holes**	389294
	Dipmeter	**228.99 m in 4 holes**	389294
	Sonic	**nil**	n/a
	Spectral gamma-ray (KUT-log)	**nil**	n/a
	Others	**nil**	n/a
	Core drilling (spot-coring only; total of 74.66 m)	**250.8 m in 4 holes**	389294
	Non-core (rotary) drilling	**nil**	n/a
SAMPLING AND ANALYSES			
Total number of samples		**42 samples**	389294
	Proximate (with sulphur)	**28 analyses**	389294
	Ultimate	**nil**	n/a
	Apparent specific gravity	**nil**	n/a
	Ash chemistry (reported as oxides)	**nil**	n/a
	Ash fusibility	**nil**	n/a
	Petrographic	**nil**	n/a
	Vitrinite reflectance	**nil**	n/a
	Light transmission (oxidation test)	**5 analyses**	389294
	Caking (Free Swelling Index determination)	**29 analyses**	389294
	Coking	**nil**	n/a
	Wash tests (single-point, at 1.5 s.g.)	**29 analyses**	389294
PROSPECTING (scale/area)		**nil**	n/a
PREPARATORY/PHYSICAL			
Line/grid (km)		**nil**	n/a
Trench (number, metres)		**nil**	n/a
Bulk sample(s):		**nil**	n/a

Sections 6 and 7, and Appendix B remain confidential under the terms of the Coal Act Regulation and have been removed from the public version.

https://www.bclaws.gov.bc.ca/civix/document/id/complete/statreg/251_2004

Frontispiece: Geotech Drilling's Fraste multipurpose drilling rig DR-3, advancing down to core-point with an air-hammer, situated at a location atop mine bench of Willow Creek Mine's pit 4N2, on August 8, 2020. View is northwestward from a vantage-point atop the pit's southeastern highwall. [*RC 5468b/20.jpg*]

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2 Introduction

The Willow Creek coal lease, although held as one tenure, has been in recent years been explored and developed as three geographically (and to some extent tectonically) distinct blocks, although these blocks do not have independent identities as mineral tenures in their own right:

- Willow Creek Mine block, the subject of the present study, previously-reported in Coal Assessment Reports (CARs) 988, 1001, and 1048;
- Willow West block, situated along the southwestern bank of Willow Creek, and thus lying to the west of Willow Creek Mine, previously reported in CAR-984; and
- Willow South block, situated along the northeastern bank of Willow Creek, and thus lying to the southeast of Willow West, previously reported in CAR-986.

The present volume is the sixth in a series of reports concerning portions of the Willow Creek coal lease, covered by Crown tenure 389294. Previous volumes have focussed on the Willow South and Willow West exploration activities, previous work at Willow Creek Mine itself, and archival presentation of borehole data from exploration conducted at the mine in 1997. The present report discusses results of year-2020 infill drilling, conducted to investigate coal-quality trends and geological structure (both of tectonic and sedimentological origin) within the 4N2 area of Willow Creek Mine.

2.1 Arrangement of this report

This report's text and **Appendix A** discuss year-2020 infill diamond core-drilling, associated non-coring air-hammer drilling, and associated downhole geophysical surveys. **Appendix B** presents raw-coal and float-1.5 results of coal-quality sampling and consequent proximate analyses of diamond-drill cores. **Appendix C** presents lithological interpretations of geophysical logs, core descriptions, and associated summary sheets for each of the year-2020 boreholes.

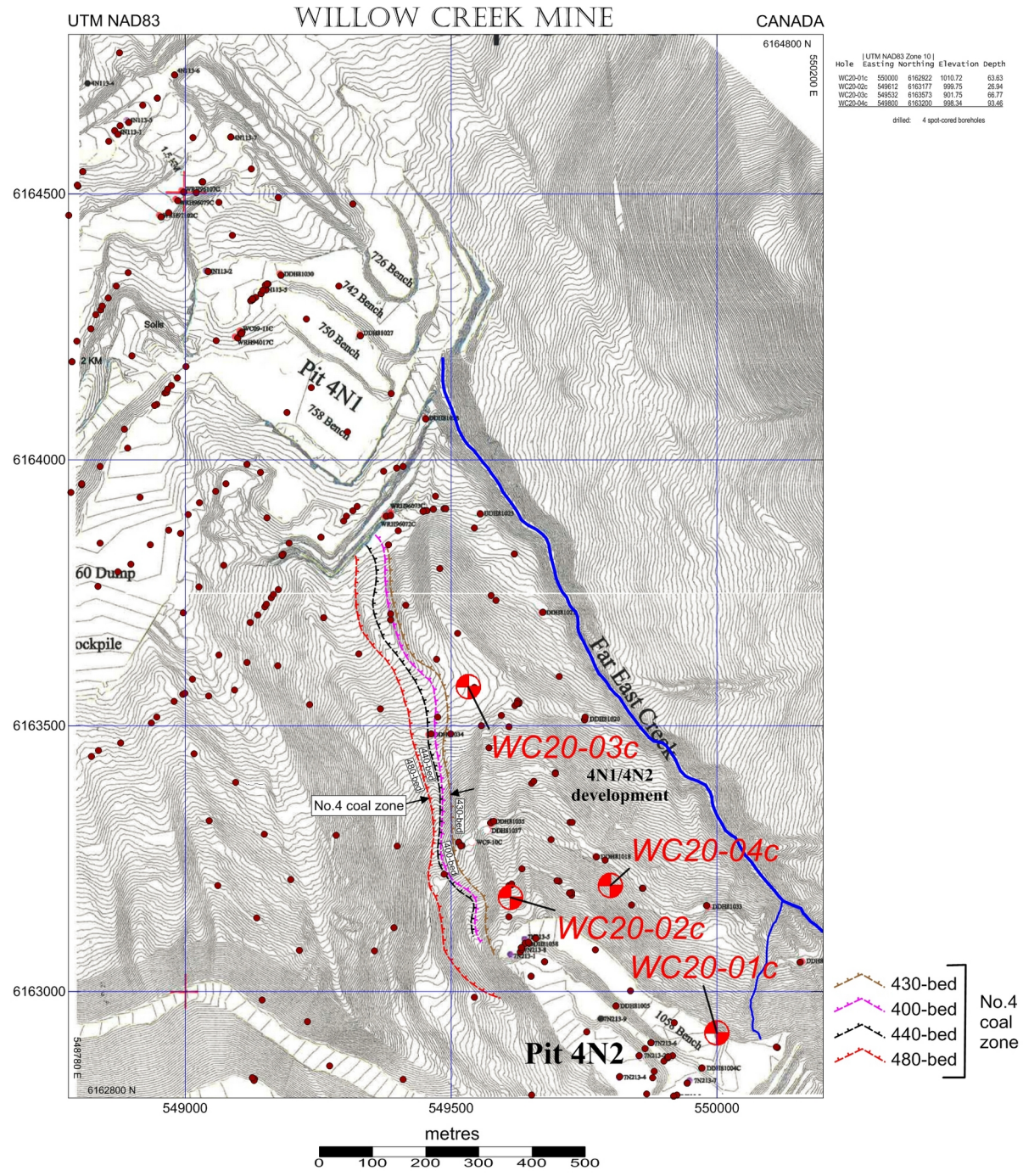
2.2 Distinction of historic and current work

Historic work comprises drilling of 763 boreholes (a majority of which were non-coring rotary-holes) and ancillary downhole geophysical surveys, as previously reported in Coal Assessment Reports 984, 986, 988, 1001, and 1048. Historic work was conducted between 1980 through 2018.

Current work (**Table 3-1**) comprises summer-2020 drilling of 4 boreholes (all of which were hammered down to predetermined core-points, and thence spot-cored with diamond coring bits) and an ancillary programme of downhole geophysical surveys (as documented in **Appendix A** of this report).

The total number of boreholes now known to have been drilled at Willow Creek Mine is 767. Borehole records, which are presented in **Appendix C**, are filed in the geological archives of Willow Creek Mine. Diamond-drill core samples (minus the coals and associated rock partings, which have been sampled) are stored at the mine's core-shack, situated within the 7N area of the mine.

All of this work was done within the mine's permitted disturbance boundary, specifically within the 4N2 development area of the mine (as shown in detail within **Map 2-1**). Results of this infill work are being incorporated into a geological model and an updated mine plan, being prepared by third-party consultants



Symbolic legend:

- Historic boreholes (pre-2020 work)
- Current boreholes (2020 work)

UTM Grid North
NAD83 Zone 10

Drawing: Willow-Mine-drilling-2020R_210131a.srf/jpg
Scale: as shown Reference: WC20-boreholes.dat/xls
Projection / grid: UTM NAD83 Zone 10, in metres
Drawn: C.G.Cathyl-Huhn P.Geo(BC) Lic.Geol(WA) RMSME
Date: 31 January 2021

Conuma Resources Limited

Map 2-1: Willow Creek Mine year-2020 infill drilling -- final programme map

2.3 Regulatory basis of report

This report has been compiled and submitted by Conuma Resources Limited (Conuma), 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.

2.3.1 Tenure description

Willow Creek Mine occupies the northeastern portion of the Willow Creek coal lease (Tenure 389294), within the Liard Mining District of northeastern British Columbia, situated within the eastern half of map-area 93O/9 of Canada's National Topographic System.

Table 2-1: Tenure details of the Willow Creek coal lease

Tenure Number	Map	Block	Units	Date Acquired	Area (hectares)	Former coal lease number
389294 (84 units)	93O/9E	B	61, 62, 63, 64, 71, 72, 73, 74, 81, 82, 83, 84, 85, 86, 87, 88 91, 92, 93, 94, 95, 96, 97, 98	March 31, 1998	6151	Coal Lease 15
	93O/9W	F	1, 2, 11, 12, 21, 22, 31, 32 41, 42, 51, 52, 61, 62, 63, 64 71, 72, 73, 74, 83, 84, 93, 94			
	93O/9E	G	3, 4, 5, 6, 7, 8, 9, 10, 13, 14, 15, 16, 17, 18, 19, 20, 25, 26, 27, 28, 29, 30, 35, 36, 37, 38, 39, 40, 47, 48, 49, 50, 57, 58, 59, 60			
Totals:	1 tenure		84 units		6,151 hectares	

Note: 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 NAD 27 surveys, and translated into NAD 83 coordinates for purposes of mapping.

The aggregate area of the Willow Creek coal lease is 6151 hectares. Tenure 389294 was granted by the Crown on March 31, 1998 (as listed in **Table 2-1**). Annual reporting and rental-payment anniversary dates are therefore March 31. The Willow Creek Mine block is an informal operational subdivision of the coal lease, with no formal stand-alone identity within the Crown mineral-tenure system of British Columbia. The outline of the Willow Creek Mine block is depicted upon **Map 2-2** and **Map 2-3** of the present report.

2.4 Situation and current drilling objectives

The objective of current work was to increase Conuma's level of understanding of coal quality and geological structure within the 4N2 area of Willow Creek Mine, and to assess whether FSI values of the 4-zone coals were a function of elevation within the mine.

Current work has consisted of diamond-drilling, geophysical logging, and coal-quality studies of 4-zone coal within the 4N2 area of Willow Creek Mine. Coal quality studies including proximate analysis, determination of total sulphur, caking (FSI) tests, and tests for oxidation by optical means.

2.5 Coal production history

Willow Creek Mine's coals have been extensively worked by open-pit operations, commencing in year-2001 and proceeding with some interruptions thereafter. Pine Valley Mining, Western Canadian Coal, and Walter Energy were former operators of the mine, prior to Conuma's acquisition of the mine in the late summer of 2016.

2.5.1 Mine operation under Conuma ownership

Mining operations recommenced in July 2018, and were again curtailed in February 2019, and most recently restarted in December 2020.

The mine has most recently been working within its 4N1 and 4N2 mining areas, which had previously been worked by Walter Energy. Workshops and other requisite support facilities (including administrative, environmental, quality-control, and technical offices) exist at Willow Creek Mine. A coal-washery and railcar-loader with railway-sidings are also present.

2.5.2 Production statistics

During the overall period of operation, Willow Creek Mine has produced slightly more than 6.05 million run-of-mine (ROM) tonnes of coal, at a strip ratio of 9.35 cubic metres/ROM tonne. Breakdown by year and material type is presented as **Table 2-2**.

Table 2-2: Production statistics by year and material type

	Bank cubic metres			Tonnes		
Year	Total mined	Waste	Coal	Total mined	Waste	Coal
2001	186,690	160,000	26,690	452,031	416,000	36,031
2002	215,811	180,000	35,811	516,345	468,000	48,345
2003	0	0	0	0	0	0
2004	1,594,963	1,412,000	182,963	3,918,200	3,671,200	247,000
2005	5,748,955	5,219,615	529,339	14,285,608	13,571,000	714,608
2006	4,779,093	4,328,231	450,861	11,862,062	11,253,400	608,662
2007	0	0	0	0	0	0
2008	1,249,000	1,212,000	37,000	3,201,150	3,151,200	49,950
2009	0	0	0	0	0	0
2010	6,415,816	6,078,157	337,659	16,259,048	15,803,208	455,840
2011	6,285,249	5,594,582	690,667	15,478,314	14,545,913	932,401
2012	16,228,129	15,245,144	982,985	40,964,404	39,637,374	1,327,030
2013	7,942,988	7,433,970	509,018	20,015,496	19,328,322	687,174
2014	1,727,828	1,581,502	146,326	4,309,445	4,111,905	197,540
2015	0	0	0	0	0	0
2016	0	0	0	0	0	0
2017	0	0	0	0	0	0
2018 (Jul-Dec)	n/a	5,907,000	n/a	n/a	n/a	549,000
2019 (Jan-Feb)	n/a	2,186,000	n/a	n/a	n/a	197,000
2020 (Dec)	n/a	n/a	n/a	n/a	n/a	n/a
Totals		**56,538,201**				**6,050,081**

Notes: data to end of 2014 compiled by Allen Baron, P.Eng. Figures for years prior to 2010 were taken from annual reports. Year-2018 and 2019 data provided by Sal Bafaro and by Lukas Klemke P.E.

2.6 Geological setting of Willow Creek Mine

Near-surface sedimentary rocks within and adjacent to the Willow Creek Mine block are of Lower Cretaceous age, comprising (from youngest to oldest) the basal formations of the Fort St. John Group, and the entirety of the Bullhead Group. The older and stratigraphically-lower Minnes Group is inferred to underlie the Willow Creek Mine block, but it is not mapped at outcrop at any point, and it likely has not yet been reached by coal-exploration drilling within the block, although oil and gas wells have drilled through these rocks.

The regionally-extensive coal-measures of the Gates and Boulder Creek formations have not been drilled at Willow Creek. Coal has, however been extensively drilled (in both historic and current boreholes) within the Gaylard Member (Gibson,1992a) of the Gething Formation of the Bullhead Group (**Map 2-3**).

2.6.1 Stratigraphic summary

Other than the coals which have been the principal focus of exploratory activities within the Willow Creek Mine block, associated sedimentary rocks comprise conglomerates, sandstones, siltstones, mudstones, carbonaceous mudstones, concretionary or banded ironstone, and very thin (centimetres to decimetres) but distinctive bands of igneous tuff (Kilby, 1984a; 1985). Marine mudstones and siltstones occur within the Fort St. John Group (Wickenden and Shaw, 1943; Hughes, 1963), most notably within the Moosebar and Hulcross formations. Furthermore, the local occurrence of bioturbated mudstones and siltstones in the basal half of the Gething Formation's Gaylard Member hints at the presence of marine conditions, there too, during deposition. The facies of the remainder of the Gaylard Member, of the overlying Gates and Boulder Creek coal-measures, and also that of the underlying Cadomin and Bickford formations, is otherwise alluvial, fluvial, or deltaic.

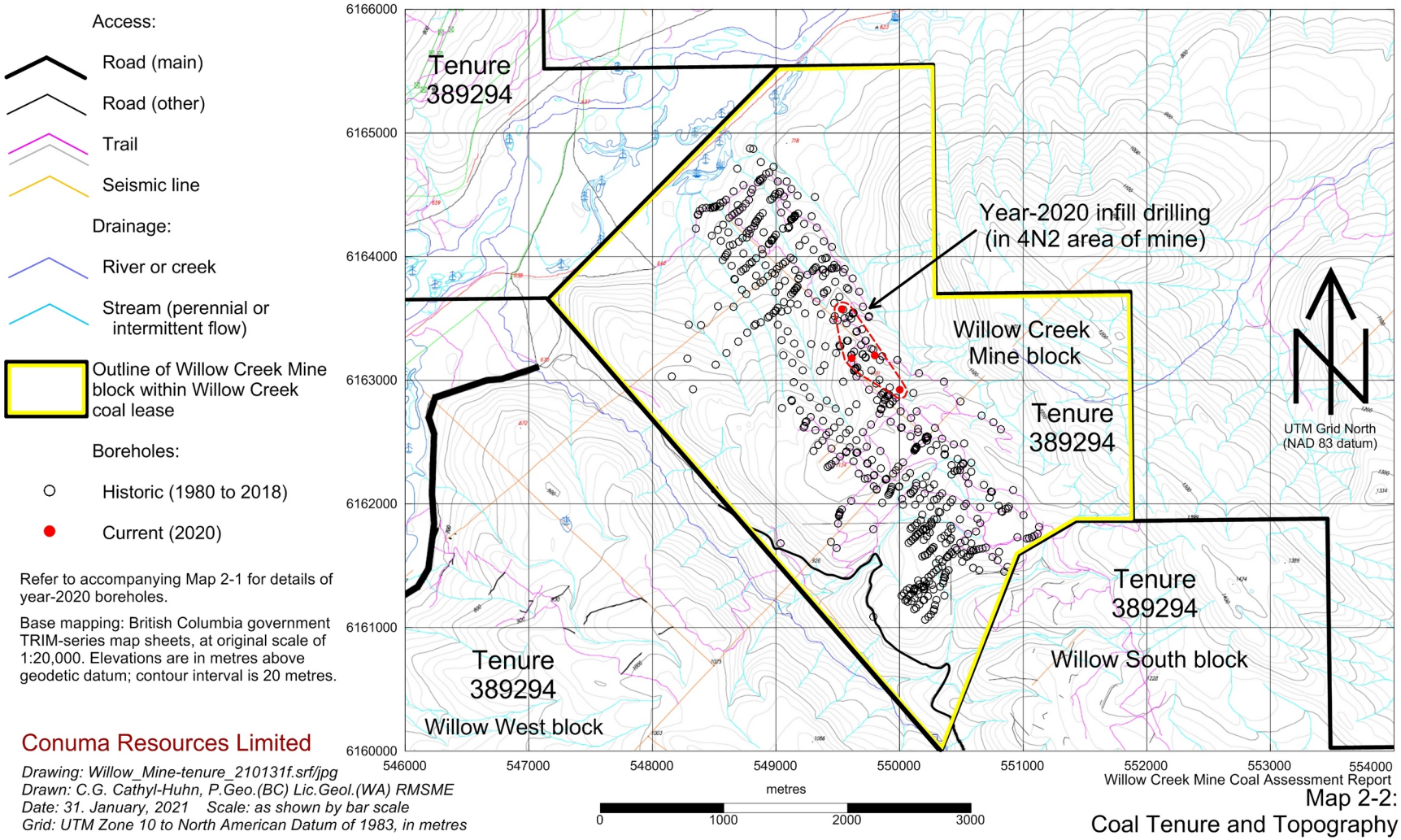
2.6.2 Deformational summary

Bedrock within the Willow Creek Mine block is moderately- to complexly-deformed, possibly more-so than is the case in the adjoining Willow West and Willow South blocks (James, 1998; Jordan and Acott, 2005; Cathyl-Huhn *et al.*, 2015a; 2015b). Southwest-verging thrust-faults, some of which may be folded, and associated northwest-striking, southwest-verging folds predominate at Willow Creek Mine, consistent with a structural setting within a passive-roof duplex system.

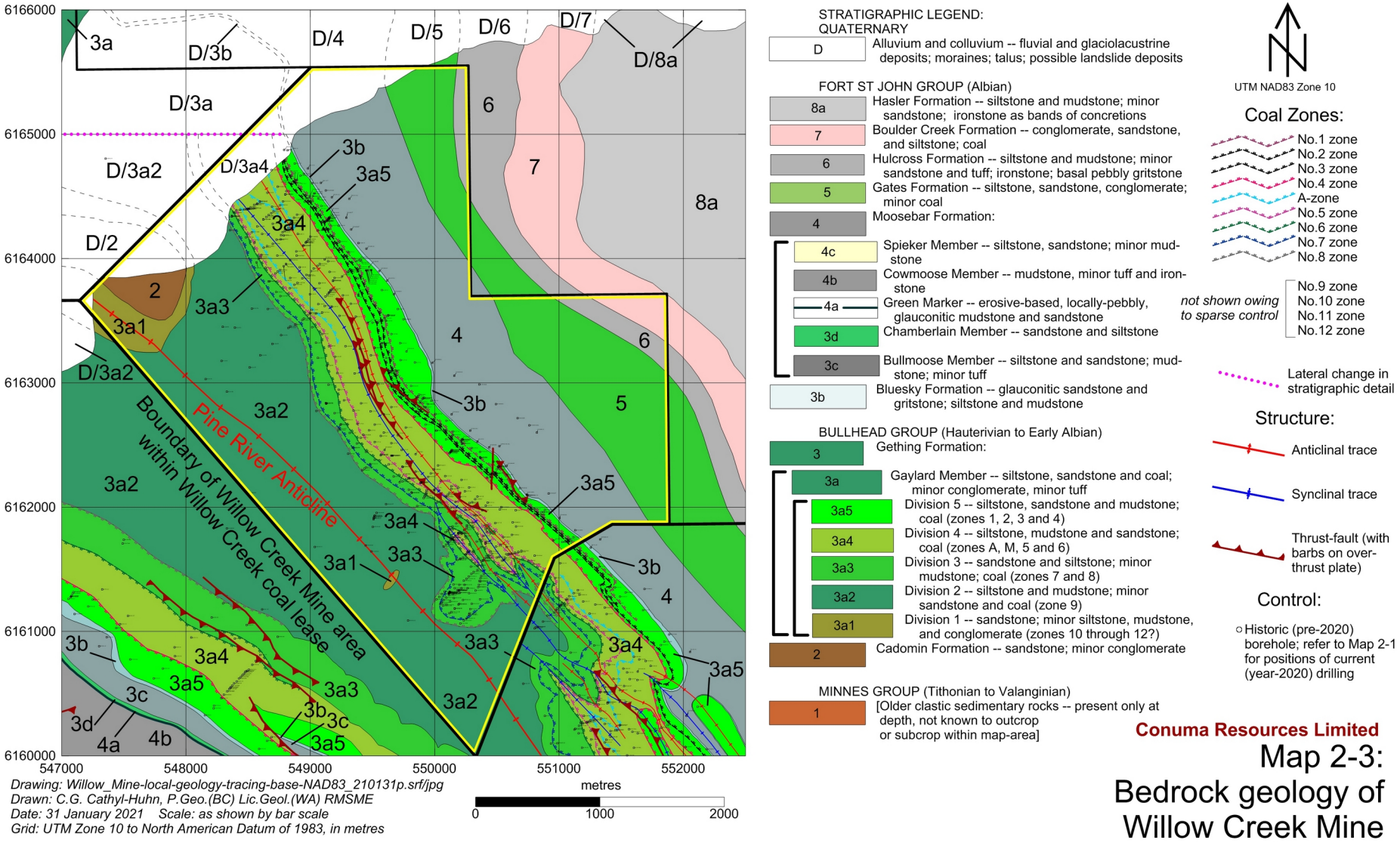
Folding of the southwest-verging near-surface thrust-faults, and refolding of some of the folds and faults, is very likely due to tectonic ramping of younger, underlying, northeast-verging thrust-faults, as suggested by oilfield seismic surveys. The opposing vergences of the shallow and deep structures is consistent with the triangle-zone structure which is well-established to be present within the Pine Pass area (McMechan, 1985; Lingrey, 1996).

2.6.3 Nomenclature and context of coal zones

Within the Gaylard coal-measures, numerous coal zones have been found by historic and current drilling at Willow Creek Mine. Coal zones are numbered in downward succession from the No.1 (near the top of the coal-measures) through No.12, following a long-established schema (McKechnie, 1955). As well, a coal zone at the immediate top of the coal-measures has been given the local name of Bird Seam, although this coal is by no means correlative with the Bird Seam as previously-recognised (Wallis and Jordan, 1974) in other coal properties of northeastern British Columbia.



Map 2-2: Coal Tenure and Topography



Map 2-3: Bedrock geology of Willow Creek Mine block

2.6.3.1 Topological nomenclature of split coal beds

Most of the coal zones at Willow Creek Mine comprise one or more laterally-persistent 'major' coal beds, often associated with laterally-branching subseams, locally designated as 'splits', 'stringers' and 'stringer plies' (defined in **Table 2-3** and graphically summarised in **Table 5-1**). Individual coal beds and subseams range in thickness from a few decimetres to several metres.

Table 2-3: Comparison of topological terminology for split coal beds

Topological term	Coal zone	Major coal bed	First-order subseam	Second-order subseam	Third-order subseam
Local term			'Split'	'Stringer'	'Stringer ply'

2.6.3.2 Informal stratigraphic subdivisions of the Gaylard coal-measures

At Willow Creek Mine, the Gaylard coal-measures may be conveniently subdivided into five informal divisions (**Table 4-1**), numbered in upward succession from Division 1 at the base of the Gaylard, to Division 5 at the top of the Gaylard.

Drilling has established that the thickest, and possibly more laterally-extensive, coals occur within Divisions 3, 4, and 5 of the Gaylard Member, at Willow Creek Mine. All four of the year-2020 boreholes solely intersected coal-measures of Division 5.

Table 2-4: Informal subdivisions of the Gaylard coal-measures

Formation	Member	Map-unit	Lithology	Division	Sub-unit	Characteristic lithology and coal zones
Gething Fm.	Gaylard Mb.	3a	Numerous fining-upward cycles of sandstone, siltstone, mudstone and coal (zones 'Bird' and 1 through 12); minor tuff; local concentration of sandstone beds; 260 to 360? metres thick	Div 5	3a5	Siltstone, sandstone, mudstone and coal (zones 'Bird' and 1 through 4); minor tuff as very thin bands
				Div 4	3a4	Siltstone and mudstone; coal (zones A, 5 and 6)
				Div 3	3a3	Sandstone; minor siltstone and mudstone; coal (zones 7 and 8)
				Div 2	3a2	Siltstone and mudstone; minor sandstone and coal (zone 9)
				Div 1	3a1	Basal sandy unit: sandstone and siltstone; minor coal (zones 10 to 12 -- correlations tentative)
Cadomin Fm.		2	Gritty to pebbly, siliceous sandstone and sandy conglomerate with distinctive 'blocky' gamma-log response; minor siltstone and coal; 2.5 to 14? m thick; erosional base			

2.7 Location and access

Chetwynd town, located on Highway 97 and situated approximately 50 kilometres northeast of Willow Creek Mine, is the closest incorporated settlement to Willow Creek Mine (**Map 2-4**). Chetwynd's population was reported as 2,633 persons in the year-2006 census. In the context of more-distant communities within British Columbia, the Willow Creek Mine coal property is located 130 kilometres south of Fort St John, 95 kilometres west of Dawson Creek, and 315 kilometres northeast of Prince George. Vancouver is situated 730 kilometres to the south-southwest of the property. Commercially-scheduled aircraft flights connect Vancouver to Fort St. John and Dawson Creek. A municipal airstrip is maintained at Chetwynd for non-scheduled use, chiefly by chartered helicopters.

2.7.1 Coal-loading facility and railway connections

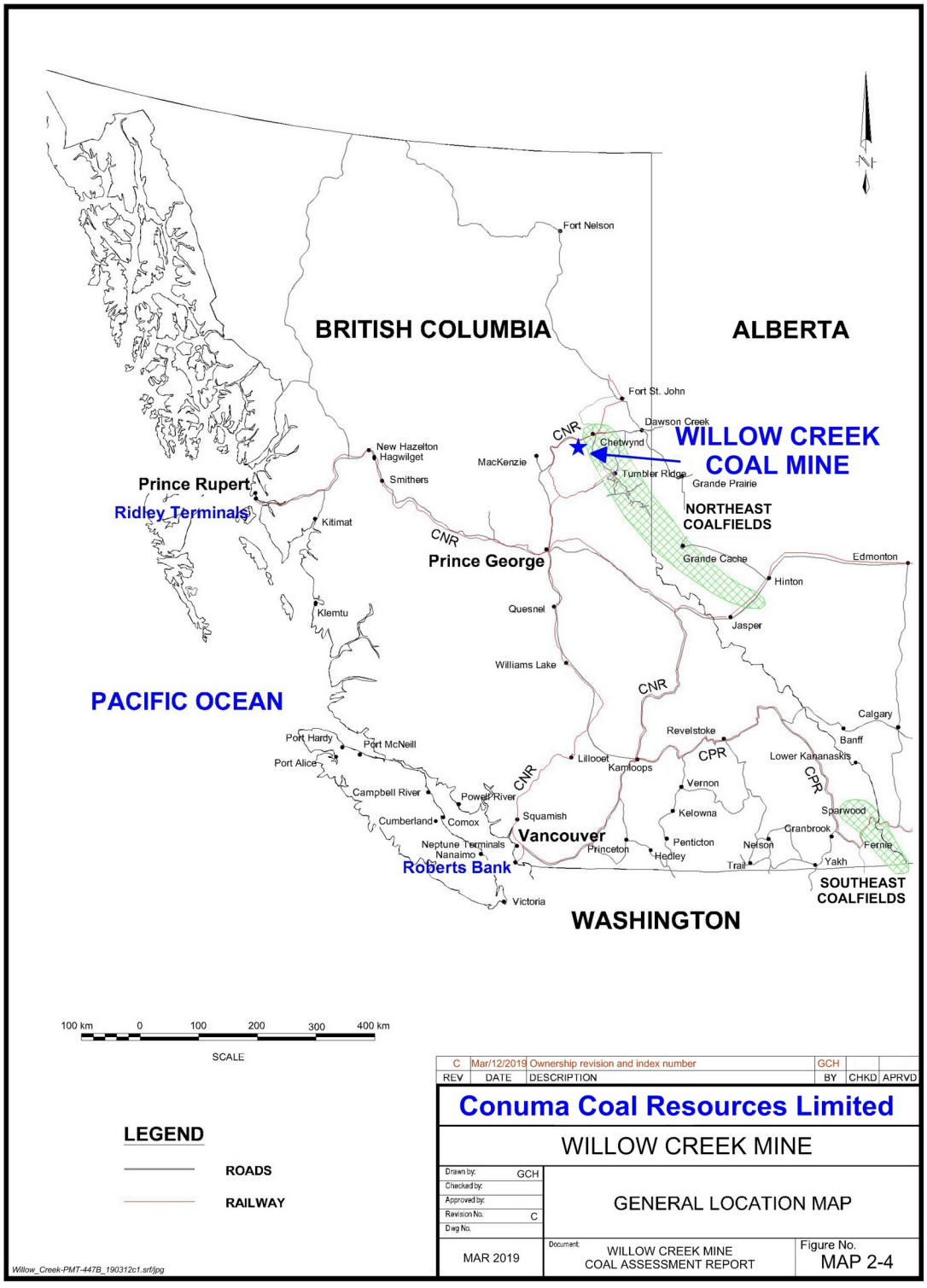
A coal-loading facility is situated on the southern bank of the Pine River, 2 kilometres to the northwest of Willow Creek Mine. This load-out site, which fills railway cars with coal produced from Brule Mine and from the Willow Creek coal washery, allows rail access to ports along the Pacific Coast of Canada, and elsewhere within the North American railway network. CN Rail are the operator of the former BC Rail line to which the load-out site is connected.

2.8 Climate

The nearest climate station to Willow Creek Mine is at Chetwynd, with 'cool continental' climate of 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 between 84 to 91 days, and about 30 foggy days are expected per year. The me4an 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.

2.9 Landforms and forest cover

The Willow Creek Mine block lies within the Inner Foothills of the Rocky Mountains. Topography comprises deeply-dissected, steep-sided, rounded hills and mountains, with elevations ranging from 635 to 1345 metres above sea level. Topographic contours at 20-metre intervals, based upon provincial government mapping (TRIM map-sheets 93O.059 and 93O.069), are shown in **Map 2-2**.



Map 2-4: General location map

The Willow Creek Mine block as a whole is variably-forested, chiefly with lodgepole pine, trembling aspen, balsam poplar, white and black spruce, and tamarack. The property lies within Tree Farm Licence 48, part of the Dawson Creek Timber Supply Area. Some cut-blocks have been operated for timber harvesting within the Willow Creek Mine block. As well, areas of forest cover (including a substantial portion of the mine's 4N1/4N2 development area) have been cleared in preparation for mine development. As a result, forest cover exhibits a range of ages and states of maturity, from juvenile to senescent.

2.9.1 Biogeoclimatic ecosystem classification

Willow Creek Mine lies within the Sub-Boreal Interior ecoprovince, within which are three biogeoclimatic ecosystem classification variants:

- Boreal White and Black Spruce moist warm Peace variant (*BWBSmw1*),
- Sub-boreal Spruce wet cool Finlay-Peace variant (*SBSwk2*), and
- Englemann Spruce Subalpine Fir moist very cold Bullmoose variant (*ESSFmv2*).

2.10 Acknowledgements and statement of professional responsibility

Thanks are due to many past and present workers:

- Allen Baron, P.Eng., senior mining engineer at Willow Creek Mine;
- Jerry Holmes, P.Geo., Apex Geoscience's drilling project manager;
- Dr. Peter Jones, at International Tectonic Consultants, who for many years has offered insights into the structural geology of the Mink-Brazion coalfield, including the Pine River Anticlinorium and the associated triangle-zone structure;
- Vesko Karadzic, P.Geo., formerly Conuma's mine geologist at Willow Creek Mine, who commenced the reconstruction of the structural and quality models of the mine, as well as caring for the mine's geological archives; and
- John Stokmans, Laura Avery LeMay, and Katherine Voyle Evans, former mine geologists at Walter Energy, for stimulating discussions of the geological structure and mining conditions at Willow Creek.

The author accepts professional responsibility for data and conclusions presented within this report.

3 Exploration

Both historic (pre-2020) and current (year-2020) coal exploration has been done by various parties within the Willow Creek Mine segment of the Willow Creek coal lease. The majority of the work is of historic vintage. In all, 763 historic and current boreholes (**Table 3-1**) are known to have been drilled between the years 1980 and 2020. Earlier (1946 to 1951) government-sponsored diamond-drilling is known to have occurred (as reported by McKechnie, 1955), but has not yet been accurately-located within the Willow Creek Mine block.

3.1 History of coalfield development

The following discussion is adapted in part from an unpublished report (Ryan, 2010) on behalf of Unicorn International Mines Group Inc.

Coal was first discovered in the Peace River District in 1793, by Alexander MacKenzie's exploring expedition (MacKenzie, 1801). Prior to 1980, less than 100,000 tonnes of coal were mined at all locations within northeastern British Columbia (Ryan, 2002).

At a location on Hasler Creek, situated about 17 kilometres southeast of Willow Creek Mine, the Hasler Creek Coal Company commenced small-scale underground coal-mining in 1943, continuing through 1944 and 1945. At this time, considerable geological mapping and some prospecting were undertaken within the Pine River Anticlinorium, including the Willow Creek Mine area (Wickenden and Shaw, 1943, Spivak, 1944; reviewed by Stott, 1973).

From 1946 onward to 1951, British Columbia's former Department of Mines conducted a government-funded diamond-drilling and trenching programme of the then-known coal deposits near the Pine River valley (McKechnie, 1955). This programme entailed extensive drilling within the Willow Creek Mine block. Summary records were published in McKechnie's report. Detailed logs of these boreholes have not yet been located, although they might eventually be found within the working files of the British Columbia Geological Survey Branch, or within the manuscript records collection held by the British Columbia Archives.

From the late 1950s onward, several oil companies undertook structural and stratigraphic mapping within and adjacent to Willow Creek Mine. Two reports prepared on behalf of Triad Oil by Dr. Peter Jones (1960; 1963) are the most useful of those reports which are publicly-available, as they incorporate detailed structural and stratigraphic mapping. Oil-company work culminated in the drilling of several deep exploratory wells, all of them being outside the mine's operating area.

Government-sponsored academic surveys were carried on concurrently. In 1963, Dr. John Hughes compiled a Ph.D. dissertation for McGill University, concerning structural geology and tectonics of the Pine River valley, including the Willow Creek Mine area (Hughes, 1963). Dr. Hughes' work was sponsored by the then-extent British Columbia Department of Mines, leading to the publication of two provincial Geological Survey Bulletins (Hughes, 1964; 1967).

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 rapid increase in crude oil prices, and concomitant increase in coal prices. These price increases were followed in short order by 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.

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).

3.2 Historic (years-1980 through 2018) exploration

The bulk of historic exploratory work at Willow Creek Mine has been by means of drilling, although considerable trenching and test-pitting was also done, especially within coal outcrops exposed during the construction of access trails and drill pads. A continuous miner (an underground coal-cutting and loading machine) was transported to the property from the Sukunka Mines in 1981, but it remains unclear whether it was ever put into use to drive adits into the property although such work was planned (A.S. Marton, personal communication, 1981).

Historic work has been documented within coal-assessment reports and unpublished technical reports prepared by third parties (Marton, 1981; Marton and Jones, 1981; Anonymous, 1997; James; 1998; Jordan and Acott, 2005) and by Walter Energy (Cathyl-Huhn, 2015b; Cathyl-Huhn *et al*., 2015c). By the late 1990s, the structure and general characteristics of the Willow Creek coals were sufficiently well-understood, to appreciate that the coal-measures were complexly-folded and faulted, and that principal structures had a southwestern vergence (in contrast to the usual northeastern structural vergence of the Peace River coalfields).

Locations of historic boreholes are generally well-established by means of surveying, initially established in terms of local (minesite) coordinate systems (*vide* **Section 3.2.2**, and **Table 3-2**, below), but subsequently translated into Universal Transverse Mercator (UTM) coordinates referred to the older NAD27 (North American Datum of 1927) or the modern NAD83 (North American Datum of 1983) metrologies.

A conspicuous exception concerns the locations of numerous year-1997 boreholes from which cores were aggregated to form drilled bulk-samples for coking tests (Anonymous, 1997). These boreholes' positions are only known in general terms, from graphic symbols presented on a small-scale drilling plan. The reason for the lack of surveyed coordinate data for these holes is unknown.

The substantial majority (**Table 3-1**, below) of historic boreholes were drilled by means of non-coring rotary methods. Rotary-drilled holes were generally shallower than diamond-cored boreholes. Drilling of the property in 1980-81 was entirely by means of coring, in keeping with the need to establish stratigraphy and structural style through the examination of cores (A.S. Marton, personal communication, 1980).

The numerous boreholes drilled in years-1980 through 1996 are documented in maps and data tables within coal-assessment reports (Marton, 1981; Marton and Jones, 1981; James, 1998).

More recent historic work, by Western Coal and by Walter Energy, has also been documented within Walter Energy's coal-assessment reports (*vide* Cathyl-Huhn, 2015b; Cathyl-Huhn *et al.*, 2015c).

Table 3-1: Statistical summary of historic and current drilling

Year in which drilled	Core drilling		Rotary drilling		All boreholes	
	Total holes	Total metres	Total holes	Total metres	Total holes	Total metres
historic drilling						
1980	3	854.70	0	nil	3	854.70
1981	43	11,240.30	0	nil	43	11,240.30
1994	3	107.91	54	2,694.29	57	2,802.20
1996	55	2,041.76	145	4,781.04	200	6,822.80
1997	73	2,052.30	67	3,119.88	140	5,172.18
1999	16	299.95	24	627.83	40	927.78
2001	5	708.80	15	576.20	20	1,285.00
2005	0	nil	28	1,975.40	28	1,975.40
2007	3	201.16	74	8,079.65	77	8,280.81
2008	3	475.30	50	5,887.68	53	6,362.98
2009	13	380.00	25	1,983.15	38	2,363.15
2010	5	493.05	1	13.00	6	506.05
2011	0		7	1,024.35	6	1,024.35
2013	14	1,083.83	0		14	1,083.83
2018	27	3,676.59	10	1,022.94	37	4,699.53
totals	263 core	23,615.65	500 rotary	31,785.41	763 overall	55,401.06
current drilling						
2020	4	250.80	0	0	4	
totals	4 core	250.80	0 rotary	0	4 overall	
all years	*267 core*	*23,866.45*	*500 rotary*	*31,785.41*	*767 overall*	*55,651.86*

3.2.1 Cross-reference to historic borehole positions and depths

Positions and depths of pre-2018 boreholes are presented in Tables 3-2 and 3-3 of the year-2015 coal assessment report for Willow Creek Mine (Cathyl-Huhn *et al*., 2015c). Positions and depths of year-2018 boreholes are presented in Table 3-3 of the year-2019 coal assessment report (CAR-1048, Cathyl-Huhn, 2019).

3.2.2 Coordinate transformation from minesite grid to UTM (NAD83 Zone 10)

Prior to 2008, most exploration activities were surveyed in terms of a local mine grid, for convenience in locating boreholes along cross-section lines. Although the mine grid is no longer in active use, mathematical transformations are required to bring earlier work into present-day terms of the UTM grid system used in governmental base-mapping. The following notes summarise the transformation algorithm.

Table 3.2: Coordinate transformation notes

Minesite grid	
Origin east 14652.254	Origin north 14950.671
UTM grid	
Transformed east 534954.317	Transformed north 6146860.561
Rotation -46º 55' 52.918088"	
Scale factor 0.99946605	Elevation adjustment -2.623 metres

3.3 Current (year-2020) in-mine drilling

Conuma conducted a four-hole programme of large-diameter core-drilling within the Willow Creek Mine block in the summer of 2020. Drilling contractor for this work was Geotech Drilling Services (using one mobile Fraste combination hammer / diamond coring rig).

The goal of the year-2020 drilling was to assess the hypothesis that 4-zone coal-quality would improve at deeper elevations within the 4N2 mining area of Willow Creek Mine, with the secondary objective of infilling structural details of the coals.

Individual borehole depths ranged from 26.94 to 93.46 metres, with overall depth of 250.80 metres. Of these boreholes, all were spot-cored, constructed by:

- installing 254 mm surface casing in a 267 mm hole,
- air-hammering a 222 mm open-hole down to a predetermined core-point, and thence
- coring (150 mm core diameter) in a 222 mm hole, to final depth.

Initially, three boreholes were planned, but careful attention to accumulated length of core-drilling allowed for a fourth hole to be drilled whilst remaining in-budget.

Three of the four drill sites were situated on existing benches of the 4N2 working area of Willow Creek Mine. The remaining site was situated on an existing forestry trail between working areas 4N2 and 4N1. No new trails, nor drill pads, were required to be built.

Table 3-3 (given below) and **Table A-1** (within **Appendix A**) present positional details and depths of the year-2020 boreholes. Positions are given in terms of Zone 10 of the UTM grid, relative to the North American Datum of 1983 (NAD 83). Lithological interpretation, including name assignments of coal beds, are presented as **Table A-2,** within **Appendix A**.

Plate 1: Fraste DR-3 drilling rig set-up for coring. From left to right: skid-steer loader, track-mounted supply/workshop van, track-mounted drill with integral rod rack and rod-handling manipulator, core in core-boxes (with one box containing overbored length of solid rock core), and trailer-mounted air-compressor. [*RC 5485a/20.jpg*]

Table 3-3: Details of current boreholes

Borehole ('c' indicates cored hole)	Surveyed borehole position (metres: UTM NAD83 Zone 10)			Drilled depth (metres)		Borehole orient-ation (degrees)	
	Easting	Northing	Elevation	Non-cored (267 / 222 mm hole)	Cored (150 mm size in 222 mm hole)	Azimuth	Dip
WC20-01C	550000.0	6162922.0	1010.72	46.22	17.41 (TD 63.63)	0	-90
WC20-02C	549612.0	6163177.0	999.75	10.24	16.70 (TD 26.94)	0	-90
WC20-03C	549532.0	6163573.0	901.75	46.11	20.66 (TD 66.77)	0	-90
WC20-04C	549800.0	6163200.0	998.34	73.57	19.89 (TD 93.46)	0	-90
		totals	4 boreholes	176.14	74.66 (TD 250.80)		

Note: borehole orientation was set-up to be vertical at commencement of drilling. TD: total depth. TL: total length. All positions, lengths, and depths are in metres. Surveyed positions of boreholes were as laid-out by the mine's engineering department, using staff-mounted GPS instrument.

An inventory of coal and rock samples is presented as **Table B-1**, and coal-quality results are presented as **Tables B-2** and **B-3**, within **Appendix B**.

Year-2020 core-drilling solely sampled coals within the No.4 coal zone, ranging from the uppermost samples of 430-bed, through the main sequence of 401-bed and 400-bed, and down to the lowermost samples of 442-bed. Stratigraphically-higher coals were hammered-through in some of the boreholes, but therefore not cored and thus only observed in geophysical logs (as presented in **Appendix A**).

Core-descriptions, reconciled to density logs, are presented in **Appendix C**. The variability in thickness and stratigraphic proximity (or local absence) of the thinner coals is noteworthy. Core recovery was generally excellent, the geophysical logs are of good quality, and it is therefore unlikely that any coals were erroneously noted as being absent.

3.3.1 Borehole geophysics

Downhole geophysical logging of all four year-2020 boreholes was done by Century Wireline Services (based out of Red Deer, Alberta, but operating from a hotel in Chetwynd), using a truck-mounted logging unit with draw-works and generator-derived power supply. A standard coal-industry suite of logs was run:

- Gamma/caliper/resistivity/compensated density (9239C tool);
- Gamma/neutron (9067 and 9058A tools);
- Deviation/verticality (9058A tool); and
- Dipmeter (9411A tool), in water-filled portions of boreholes.

Efforts were made to keep the boreholes topped-up with water for purposes of during geophysical logging. This was only moderately successful, as the strata were sufficiently fractured (in some cases, blast-damaged?) that rapid water-loss was an issue.

Geophysical logs were plotted at 1:100 vertical scale. Digital copies of downhole geophysical logs are presented in **Appendix A**, with an inventory of logs given as **Table A-1**. The digital logs are presented in LAS (Log ASCII Standard, as promulgated by the Canadian Well Logging Society) format, in TIF (Tagged Image File) format, and as PDF (Portable Document Format) files.

- LAS files can readily be imported into, and manipulated by, geophysical-processing software such as *LAS Viewer* or *WellCAD*, whereas
- TIF files may be opened by the native *Microsoft Windows* image-viewer, or by image-processing programmes such as *Photoshop*, and
- PDF files are suitable for printing via plotter, or as sectionalised images via an appropriately-capable printer.

Plate 2: Century Wireline geophysical logging unit, with extended-reach sheave-boom and overhead storage tubes for wireline sondes. To left are trailer-mounted air-compressor and flat-deck truck with water tank. [*RC5473a/20.jpg*]

3.4 Comments on validity of exploratory work

Historic and current drilling at Willow Creek Mine, comprising 55,651.86 metres' total length (**Table 3-1**), is regarded as having validly tested the coal potential of the coal-measures of the Gaylard Member of the Gething Formation, such that a revised structural and quality models can be compiled, and that resource estimates of coal-in-place can be undertaken with reasonable confidence.

Stratigraphic variations in coal quality (notably, in the characteristic caking propensities of the various coal beds) between coal zones are reasonably-well established by existing drilling and analytical work. However, understanding of spatial variations of coal quality within individual coal beds, or closely-associated coal beds within a given coal zone, is hampered by the absence of positional data for numerous historic boreholes, which would otherwise be useful in refining the spatial variations of coal quality.

Coal-resource and coal-reserve estimation are discussed in detail within **Section 7** of the this report.

4 Review of coalfield geology

This chapter of the report is updated from the discussion presented in Coal Assessment Report No. 1048 (Cathyl-Huhn, 2019). Discussion proceeds from regional setting to local scale.

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.

4.1 Regional structural setting

Most of the Jura-Cretaceous sediments were derived from orogenically-uplifted landmasses lying to the southwest of the Rocky Mountain Foreland Basin. 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 variably-effective source of sediment into the Foreland Basin (Cant and Stockmal, 1989; Cant, 1996; Cant and Abrahamson, 1996).

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's 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 folded thrusts is therefore essential to understanding the structural geology of the Foothills coal deposits of northeastern British Columbia.

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 Willow Creek Mine property) to a gently-folded frontal regime (within the Outer Foothills, five to ten kilometres to the northeast of Willow Creek Mine).

4.2 Regional stratigraphic setting

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, were J.E. Hughes (1964, 1967), D. Stott (1968, 1973, 1981, 1998), P.McL.D. Duff and R.D. Gilchrist (1981), and D.W. Gibson (1992).

The strata at Willow Creek Mine comprise Lower Cretaceous rocks of the Fort St. John and Bullhead groups, and older Jurassic to Lower Cretaceous rocks of the Minnes Group (**Table 4-1**). Almost all of the block is covered with coal-measures of the Gaylard Member of the Gething Formation, which forms the upper part of the Bullhead Group, or by the marine rocks of the overlying Bluesky and Moosebar formations, which form the basal part of the Fort St. John Group.

Fort St. John Group rocks are present only along the northeastern fringe of the Willow Creek Mine block, owing to substantial erosion. Minnes Group rocks are present only in the subsurface at Willow Creek Mine, inasmuch as the Bullhead Group rocks are at no point completely stripped-away by erosion (**Map 2-3**).

4.2.1 The Gething-Bluesky controversy and its resolution

Considerable stratigraphic controversy (as expressed in works of Hughes and Stott, studied further by Oppelt (1988), and to some extent resolved by Gibson's 1992a report) has revolved around the stratonymy and chronological 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. Hughes' previous stratonymy, comprising the Crassier and Beaudette groups, is now formally deprecated, although it is still being used by some industrial geologists.

At the latitude of the Willow Creek Mine block, and within the Pine Pass area in general, only the Gaylard Member of the Gething Formation is known to contain coal of potentially-mineable thickness.

Owing to the southwestward back-stepping of the Gething paleodelta complex at Willow Creek Mine, the Bluesky is here-recognised as a formation in its own right (homotaxial with the more-extensive Bluesky strata of the Deep Basin of the Alberta Syncline), and the Bullmoose and Chamberlain members (elsewhere part of the Gething Formation) are both considered to be members of the Moosebar Formation, as neither the Bullmoose rocks nor the Chamberlain rocks manifest any non-marine indicators. Supra-Gething rocks (from the Bluesky Formation upwards) are assigned to the Fort St. John Group, following Stott's work.

4.3 Local structural geology

Structural geology of the Willow Creek Mine area would be difficult to decipher on the sole basis of bedding attitudes within exposed bedrock, owing to the isolated nature of the outcrops, other than those formed by temporary or longer-lived open-pit walls. Current-day understanding of local structural geology comes from boreholes through faulted coal-measures, supplemented by bedrock alongside roads and trails. An additional source of structural information, albeit indirectly-so, is from the interpretation of landforms as visible in aerial photographs and on detailed topographic maps, although this indirect observation is locally hampered by Drift cover.

Map 2-3 depicts, in general terms, our understanding of bedrock structure at property scale. Willow Creek Mine comprises a series of moderately-tight southwest-verging folds, overlain and bounded to the northeast by a northeast-dipping monoclinal panel of coal-measures and cover rocks, dislocated by southwest-verging thrust-faults. The Willow Creek Mine block occupies the leading (northeastern) limb and central duplex zone of the Pine River Anticlinorium, which in turn lies within a regional-scale triangle zone (McMechan, 1984; 1985;

Lingrey, 1996). Willow Creek Mine's coal-measures appear to occupy a shallower structural position within the triangle-zone than those of the Willow South or Willow West blocks.

Within the 4N2 mining area (the site of year-2020 drilling, as well as most of the year-2018 drilling), the upper portion of the Gaylard coal-measures appears to form a consistent northeast-dipping homoclinal panel of strata. This panel is broken and to some extent dislocated by metre- to dekametre-scale southwest-verging thrust-faults (as seen in **Plate 6**). Faulting is visible as contorted and shattered zones within the rocks.

Faults, as interpreted from downhole duplication of geophysical-log response patterns, have been subdivided into three levels-of-assurance:

- Fault, established -- where there is a demonstrable repeat of log-response or of cored lithologies, interpreted to be associated with a consistently-developed coal bed
- Fault, probable -- where there appears to be a repeat of a minor coal, or of a characteristic sequence of non-coal strata
- Fault, possible -- where there appears to be a local thickening or duplication of stratal pattern, generally-associated with borehole breakout(s), but the interpretation is not robust-enough to justify classification as 'probable'.

This tripartite structural classification follows practice developed by geologists of BP Coal, working in the late 1970s and early 1980s on their then-operated Sukunka coal property (Andrew Bowler, personal communication, 1977).

Bedding-plane shearing is pervasive within incompetent strata such as dirty coals or coaly mudstones, and some of this shearing might be associated with bedding-parallel faulting.

4.3.1 Tectonostratigraphic coherence

Normal stratigraphic sequences are generally preserved at Willow Creek Mine, despite the thrust-faulting of the rocks and concomitant folding and tectonic stacking. Overturned strata are rare.

4.4 Local stratigraphy

Based largely upon the interpretation of downhole geophysical logs of coal-exploration boreholes and natural-gas wells, the local stratigraphic sequence (as shown in **Table 4-1**) has been identified within and adjacent to the Willow Creek Mine block.

Relationships between the various rock-units that occur within and adjacent to the Willow Creek Mine block are shown on the geological map (**Map 2-3**) accompanying this report. **Map 2-3** presents the bedrock geology as understood in 2018 (effectively unchanged in 2020), incorporating results of 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 generally-discontinuous nature of bedrock exposures, and paucity of documented stratigraphic and structural fieldwork.

4.4.1 Stratigraphic identity of rocks drilled in 2020

In 2020, all of the drilled rocks, including coal, were within Division 5 (map-unit 3a5) of the Gaylard coal-measures.

Table 4-1: Table of formations, members, and subdivisions

Group/Formation/Member			Map-unit		Lithology and thickness	
Quaternary Drift			D		Alluvium; lodgement till; moraines; talus; glaciolacustrine silts, up to ? 150 m thick within Pine Valley.	
Fort St. John Group	Hasler Fm.		8a		Siltstone and mudstone; minor sandstone; ironstone as bands of concretions; at least 180 m thick	
	Boulder Creek Fm.		7		Sandstone and siltstone; conglomerate; coal; 75 to 95 m	*Presence of coal not yet proven within Willow Creek Mine block*
	Hulcross Fm.		6		Siltstone and mudstone; minor sandstone and tuff; basal pebbly gritstone; erosional base; 120 to 130 m thick	
	Gates Fm.		5		Siltstone, sandstone and conglomerate; minor coal; 190 to 230 m thick	*Presence of coal not yet proven within Willow Creek Mine block*
	Moosebar Fm. 165 to 280 m thick	Spieker Mb.	4	4c	Siltstone, sandstone; minor mudstone; 60 to 90 m thick	*May be locally structurally-thickened due to internal thrust-induced telescoping, or repeated outright by thrusting. Possible detachment zones at base of Cowmoose Member and Bullmoose Member.*
		Cowmoose Mb.		4b	Mudstone; minor tuff and ironstone; erosive-based basal glauconitic grit; 80 to 100 m thick	
		Green Marker		4a	Locally-glauconitic siltstone and sandstone; nil to *ca.* 3 m thick	
		Chamberlain Mb.		3d	Sandstone and siltstone; 3 to 6 m thick	
		Bullmoose Mb.		3c	Siltstone and sandstone; mudstone; minor tuff; 100 to 120 m thick	
	Bluesky Fm.		3b		Glauconitic sandstone and gritstone; siltstone and mudstone; 1 to 8 m	
Bullhead Group	Gething Fm.	Gaylard Mb.	3a	3a5	Numerous fining-upward cycles of sandstone, siltstone, mudstone and coal (zones 'Bird' and 1 through 12); minor tuff; local concentration of sandstone beds; 260 to 360? metres thick	Siltstone, sandstone, mudstone and coal (zones 'Bird' and 1 through 4); minor tuff
				3a4		Siltstone and mudstone; coal (zones A, 5 and 6)
				3a3		Sandstone; minor siltstone and mudstone; coal (zones 7 and 8)
				3a2		Siltstone and mudstone; minor sandstone and coal (zone 9)
				3a1		Basal sandy unit: sandstone and siltstone; minor coal (zones 10 to 12 -- correlations tentative)
	Cadomin Fm.		2		Gritty to pebbly, siliceous sandstone and sandy conglomerate with distinctive 'blocky' gamma-log response; minor siltstone and coal; 2.5 to 14? m thick; erosional base	
Minnes Gp.	Bickford Fm.		1		Siltstone, sandstone, conglomerate, and mudstone; minor coal; 285 to 300 m thick	*present only at depth beneath the property*
	Monach Fm.				Sandstone and conglomerate; siltstone; 210 to 260 m thick	
	Beattie Peaks Fm.				Siltstone, sandstone and mudstone; minor coal; 285 to 350 m thick	
	Monteith Fm.				Quartzite and sandstone; minor siltstone; 340 to 425 m thick	

Rock-units are discussed in detail below, in order from youngest (generally nearest the ground surface) to oldest. Localised inversions of stratigraphic position have been induced by stratal shuffling consequent upon thrust-faulting, but the overall stratigraphic relations remain readily-recognisable, owing to distinctive geophysical and lithological characteristics of the various rock-units.

4.5 Drift (map-unit D)

Unconsolidated sediments, inferred to be of Quaternary age, form a patchy blanket at the ground surface throughout the Willow Creek Mine portion of the Willow Creek coal lease. For reasons of clarity, Drift is not mapped as a separate entity within **Map 2-3**, except along the floor of the Pine River valley.

The most pervasive Drift cover consists of glacial till, usually less than 10 metres thick within the upland areas of the property. Patches of sandy, gravelly and bouldery alluvium are present within stream channels. McKechnie (1955) noted the presence of possibly-glaciolacustrine silt deposits within the southeastern portion of the Willow South area; although an extension of such deposits into Willow Creek Mine area is considered likely, the extent of such deposits has yet to be assessed in detail, owing to lack of lithological records in Drift-penetrating boreholes.

The Pine River valley is inferred to be floored and possibly flanked by valley-filling alluvial, glacial, and glaciolacustrine sediments. By inference with results of sparse drilling in other valleys within the Foothills of northeastern British Columbia, such deposits are inferred to be locally more than 150 metres thick.

In the course of the year-2020 drilling, Drift (5.4 metres thick) was only encountered in borehole WC20-03, insofar as the other three boreholes were collared upon mine benches.

4.6 Fort St. John Group (map-units 8a, 7, 6, 5, 4, and upper part of map-unit 3)

The uppermost of the Early Cretaceous rocks of the Fort St. John Group have been completely removed by erosion at Willow Creek Mine. Most of this erosion is likely to have occurred during a prolonged episode of regional uplift during the Tertiary era (Cant and Stockmal, 1989), followed by further glacial scouring during the Quaternary era, and continuing through fluvial down-cutting to the present time.

Within the Group, the remainder of its constituent formations remain at least locally-present within the Willow Creek Mine map-area. From top down, these are the basal half of the Hasler Formation, and the entirety of the Boulder Creek, Hulcross, Gates, Moosebar and Bluesky formations.

4.6.1 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 northeast of the Willow Creek Mine block. The Hasler Formation is not interpreted to form bedrock within the boundaries of the block, but its basal portion (at least 180 metres thick) is mapped as forming bedrock within the northeastern corner of the mapped area of **Map 2-3**, completely outside the property's extent.

The Hasler Formation comprises marine siltstone, overlain by dark grey to black marine mudstone with occasional bands of sideritic concretions. The complete, undeformed thickness of the formation is approximately 335 to 365 metres (Wickenden and Shaw, 1943).

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 (Wickenden and Shaw, *op.cit*., page 6). This gritstone is not recognised as a mappable

horizon, owing to its thin nature and the lack of borehole intersections.

4.6.2 Boulder Creek Formation (map-unit 7)

The Boulder Creek Formation, of late Middle Albian age (Gibson, 1992b) forms prominent cliffs in the upland area, along and immediately to the northeast of the Willow Creek Mine block's northeastern boundary. The Boulder Creek Formation is the uppermost of the three formations (Boulder Creek, Hulcross, and Gates) formerly covered by the now-superseded Commotion Formation of Wickenden and Shaw (1943).

Regionally, the Boulder Creek formation consists of three members:

- Paddy Member -- coarse clastic rocks, minor thin coal;
- Walton Creek Member -- dominantly-fine clastic rocks, thin tuff bands, thin and thick coal;
- Cadotte Member -- coarse clastic rocks.

Within the vicinity of Willow Creek Mine, the Paddy Member appears to be absent. It is not clear whether the absence is due to non-deposition or to post-depositional erosion.

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 of the formation, while fine-grained rocks are concentrated in the overlying Walton Creek Member (Gibson, 1992b). The uppermost regionally-mapped division of the Boulder Creek Formation, comprising the conglomerate of the Paddy Member, is not recognised within the Willow Creek Mine area.

The overall thickness of the Boulder Creek Formation is tentatively inferred to be 75 to 95 metres at Willow Creek Mine, of which the basal 30 to 45 metres comprises the Cadotte Member and the overlying 45 to 50 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.

4.6.2.1 Walton Creek Member

The Walton Creek Member of the Boulder Creek Formation comprises 45 to 50 metres of generally-recessive siltstone, variably-carbonaceous, locally root-penetrated mudstone and variably-thick coal beds.

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.

4.6.2.2 Cadotte Member

The Cadotte Member of the Boulder Creek Formation comprises 30 to 45 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.

4.6.3 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 band along the northeastern margin of the Willow Creek Mine block. The thickness of the Hulcross Formation at Willow Creek Mine is estimated to be 120 to 130 metres, based on borehole data and measured outcrop sections from nearby properties, as reported by Gibson (1992b). 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.

4.6.4 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.

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 Willow Creek Mine, the Gates coal-measures are present along the northeastern margin of the property. No boreholes have yet penetrated the Gates Formation at or near Willow Creek Mine, and hence its coal potential is unknown in detail, although expected to be low on account of the well-established northward diminishment of coal content within the formation.

. Regionally, the Gates Formation may be readily subdivided into three members: the uppermost, dominantly fine-grained Notikewin coal-measures (90 to 120 metres thick?), the medial, dominantly coarse-grained conglomeratic Falher coal-measures (50 to 90 metres thick?), and the basal Torrens sandstone (30 to 40 metres thick?). The Notikewin, Falher and Torrens members can be reasonably-distinguished in the logs of oil and gas wells drilled to within the Highhat gasfield, situated to the southeast of Willow South, but these units cannot be easily mapped separately without the aid of detailed aerial imagery, so no attempt has been made to depict them separately on **Map 2-3**.

The Gates Formation is inferred to be 190 to 230 metres at Willow Creek. 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.

4.6.5 Moosebar Formation (map-units 4c, 4b, 3d, and 3c)

The Moosebar Formation, of early Albian age (Stott, 1968) forms the basal part of the Fort St John Group. At and near Willow Creek Mine, the Moosebar Formation has a typical stratigraphic thickness of at least 165 metres (Wickenden and Shaw, 1943, page 4) and perhaps 240 to 280 metres, although the latter figure likely indicates substantial structural thickening due to thrust-induced telescoping of the Moosebar rocks.

The Moosebar Formation comprises an overall coarsening-upward sequence, consisting of several lesser coarsening-upward cycles of mudstone passing upward to sandy siltstone. A basal pebbly, locally-glauconitic gritstone (the informally-designated Green Marker) occurs within the middle of the formation in some sections. Very thin (a few millimetres to a few decimetres) bands of tuff form conspicuous marker bands, generally concentrated within the basal 30 metres of the formation (Kilby, 1984a; 1985).

At Willow Creek Mine, the Moosebar Formation is inferred to form bedrock along the block's northeastern side, flanking the Gething coal-measures exposed within the northeastern limb of the Pine River Anticlinorium (**Map 2-3**).

Regionally, deep exploratory drilling for natural gas targets allows the recognition of five lithological subdivisions (from top down, the Spieker and Cowmoose members, the Green Marker, and the Chamberlain and Bullmoose members) within the Moosebar Formation of the Willow Creek Mine area. All but the uppermost of these subdivisions are present and recognisable in pit-slope exposures at Willow Creek Mine, although one (the Green Marker, map-unit 4a) is consistently too thin to be mappable as anything other than a single line at the scale of **Map 2-3**.

Owing to the sparse extent of drilling within the Moosebar Formation, and the lack of detailed borehole records, no attempt has been made to map the subdivisions of the formation within the Willow Creek Mine block *per se*, although such mapping has been accomplished within the adjoining Willow West block.

4.6.5.1 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 at Willow Creek Mine is estimated to be 60 to 90 metres, possibly being locally thickened through thrust-induced structural telescoping.

The Spieker Member's existence at the latitude of the Willow Creek coal lease is established by drilling within the western part of the Willow West area (Cathyl-Huhn, 2015c), outside the extent of **Map 2-3**. The Spieker Member is also likely to be present within the northeastern part of the Willow Creek Mine block, but beyond the area which has been tested by drilling.

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 appears to coincide with an upward increase in the silt content of the rocks, and a

concomitant passage from dark greyish-black to medium grey rock colour. The immediate base of the Spieker Member is in some sections marked by one or two metres of distinctly-sandy siltstone.

4.6.5.2 Cowmoose Member (map-unit 4b)

At and near Willow Creek Mine, the Cowmoose Member of the Moosebar Formation comprises 80 to 100 metres of rubbly-weathering, massive, dark greyish-black to black mudstone, punctuated by occasional bands crowded with ironstone concretions, and several very thin (a few millimetres to a few decimetres) but laterally-persistent and visually-prominent bands of light olive drab to white tuff. The tuff bands are useful as local structural markers (Duff and Gilchrist, 1981; Kilby, 1984a; Jordan and Dawson, 1988). The Cowmoose mudstones are sparsely-bioturbated, and locally contain sparse to abundant burrow-fillings, irregular blebs and euhedral crystals of pyrite, indicative of overall anoxic depositional conditions. Pyrite is particularly abundant near the base of the Cowmoose Member.

The name ‘Cowmoose’ was introduced by Cathyl-Huhn and Singh (2014) as an informal and pragmatic stratigraphic name, for the purposes of former mine-owner Walter Canadian Coal Partnership's coal-assessment studies. These rocks had been previously referred to as the ‘basal mudstone member’ of the Moosebar Formation or simply as the ‘mudstone member’ (Duff and Gilchrist, 1981).

The recommended type-section of the Cowmoose Member (Cathyl-Huhn and Singh, 2014) is on the northeastern face of Cowmoose Mountain, situated between Sukunka River and the western fork of Bullmoose Creek. Within the Willow Creek Mine block, the Cowmoose Member is locally exposed in road-cuttings and shale-pits along access roads within the northeastern fringe of the block.

Without recourse to cored sections or gamma-neutron logs, isolated exposures of the Cowmoose Member would be quite similar in weathering-habit to, and thus difficult to distinguish from, the basal part of the older Bullmoose Member. The Cowmoose Member is locally thickened to over 200 metres by thrust-induced structural telescoping (Cathyl-Huhn *et al.*, 2015).

The age of the Cowmoose Member is Early Albian (as noted for the mudstones of the Moosebar Formation by Stott, 1968). The basal contact of the Cowmoose mudstones over the underlying Green Marker is gradational to abrupt, and generally easily-recognised on geophysical logs.

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, and the downward appearance of distinctively-greenish glauconitic sediments.

4.6.5.3 Green Marker (map-unit 4a)

The Green Marker is a thin but regionally-persistent zone of erosive-based, pebbly, intensely-bioturbated, commonly-glauconitic sandstone, siltstone and mudstone. The Green Marker comprises zero to perhaps 3 metres of variably-glauconitic siltstone or chert-rich lithic arenite, locally containing stringers or lenses of gritstone or pebble-

conglomerate. Owing to its minimal thickness, the Green Marker is depicted as a single line upon **Map 2-3**.

The Green Marker is locally altogether absent; hence its minimum thickness of 'nil' as given in **Table 4-1**. At Willow Creek, glauconite development within this unit is patchy, in contrast with its more obvious presence in other areas.

Earlier reports (Wallis and Jordan, 1975; Jordan and Dawson, 1978) denoted this zone as the Bluesky Formation, on the grounds of its lithologic similarity to the typical Bluesky rocks of the Alberta Syncline and Deep Basin, but that correlation is now understood to be incorrect. Although the lithology of the Green Marker is superficially similar to that of the older Bluesky 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 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 may at least locally be erosional.

4.6.5.4 Chamberlain Member (map-unit 3d)

At Willow Creek Mine, the Chamberlain Member of the Moosebar Formation is a geophysically-distinctive (moderately-low gamma-log responses) unit within the Moosebar, comprising a few (3 to perhaps 6) metres of rocks with a low to moderate gamma-ray count, consistent with the regionally-known Chamberlain lithologies of interbedded sandstone and siltstone.

In contrast with the Chamberlain sections drilled in the Sukunka area (to the southeast of Willow Creek Mine), no coal has been found within the Chamberlain Member at Willow Creek Mine. Regionally, the Chamberlain Member is well-established as thinning to the east and northeast; it is locally altogether absent within oil and gas wells drilled at Highhat Mountain (a few tens of kilometres east of Willow Creek Mine), and in those wells the Cowmoose mudstones appear to directly overlie the Bullmoose siltstones.

Although in its type area at Sukunka Colliery and Bullmoose Mountain, the Chamberlain Member was defined by Gibson (1992a) as the uppermost member of the Gething Formation, in the Willow Creek area the Chamberlain's much-reduced thickness and apparent non-coal-bearing nature support its being more properly assigned to the Moosebar Formation.

The Chamberlain Member is not known to contain diagnostic fossils; it has therefore been assigned an Early Albian age by Gibson (1992) on the basis of fossils found within the overlying Cowmoose Member of the 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 lowest thick sandstone. The Chamberlain-Bullmoose contact possibly rises stratigraphically, to the north and east (Cathyl-Huhn *et al.*, 2015), but available drilling does not suffice to confirm nor contradict this supposition.

4.6.5.5 Bullmoose Member (map-unit 3c)

The Bullmoose Member of the Willow Creek Mine block comprises 100 to 120 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 Bullmoose Member comprises the youngest (stratigraphically-highest) rocks programmed to be mined in Pit 4N2 of Willow Creek Mine. The Bullmoose, in keeping with its turbiditic aspect, contains no workable coal.

Plate 3: Southeastern highwall of 4N2 pit, as seen prior to resumption of mining in autumn of 2018. Forested slopes are underlain by siltstones, with minor bands of ironstone and tuff, of the basal two-thirds of the Bullmoose Member of the Moosebar Formation. Cleared hillside to right is underlain by interbedded siltstone, sandstone, coal and variably-carbonaceous mudstone of the Gaylard Member of the Gething Formation. Closely-associated 400, 401, and 410 coals come to the ridgeline at the extreme right of the photograph. Bedding forms a northeastward homoclinal panel of strata, at dips of 30 to 32 degrees. [*RC4849/18.jpg*]

The geophysical log response of the Bullmoose Member is very distinct, as compared with the overlying Chamberlain Member and the underlying Bluesky Formation. Bullmoose rocks have characteristically-higher natural-gamma log responses than their bounding rock-units. On the other hand, the Bullmoose Member is difficult to distinguish from the younger Cowmoose Member.

The Bullmoose Member is well-exposed in the southeastern highwall of the 4N2 open-pit workings (as shown in **Plate 4**). The Bullmoose is inferred to form extensive areas of bedrock along the northeastern margin of the Willow Creek Mine block, extending into the adjoining Willow South block (**Map 2-3**).

As mentioned above, the Bullmoose lacks 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 originally suggested and locally-recognised by Duff and Gilchrist (1981), within those areas (for example, the deep subsurface under Highhat Mountain, southeast of the Willow Creek Mine block) where the overlying Chamberlain Member is absent. Geophysical logs of the Bullmoose Member show a characteristic high-gamma response at two horizons situated a few tens of 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, with the underlying Bluesky Formation, 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 original stratigraphic thickness of the Bullmoose is approximately 100 to 120 metres at Willow Creek Mine, although thicker sections (likely structurally-thickened by thrust-induced telescoping of the strata) are suspected to exist

4.6.6 Bluesky Formation (map-unit 3b)

The Bluesky Formation is a transitional unit between marine and non-marine facies. Accordingly, there has been considerable debate within the geological literature -- starting with Stott (1968), and further discussed by Kilby (1984b) and Legun (1990) -- as to the Bluesky's stratigraphic affinities. In the present report, the Bluesky is considered to constitute a formation in its own right, bounded above by the Moosebar Formation, and beneath by the Gething Formation, following earlier workers (*cf.* Legun, 1990 and James, 1998). Further to the south within the Mink-Brazion coalfield, the Bluesky is considered to be a member within the Gething Formation.

The Bluesky Formation generally consists of coarsening-upward cycles of interbedded mudstone, siltstone, and sandstone. The top of the Bluesky is characteristically marked by a glauconitic horizon, a few decimetres thick, comprising abundant fine-grained, green glauconite within sandy mudstone and argillaceous, locally-pebbly, sandstone. The base of the Bluesky (shown in **Plate 4**) is marked by a distinctive erosive-based chert- and quartz-pebble conglomerate up to a metre thick, grading to argillaceous sandstone with few randomly-distributed chert and quartz pebbles. The conglomerate horizon's presence has been noted on numerous historic borehole records at Willow Creek Mine.

Plate 4: Geologist's hand marks erosional contact of greenish-grey, glauconitic Bluesky pebbly gritstone over uppermost Gaylard sandy siltstone. Rusty-weathering habit of Bluesky rock suggests potential for acid rock drainage. [*RC4945/18.jpg*]

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 the Willow Creek area (Gibson, 1992a). The Bluesky Formation, as-drilled at and near Willow Creek Mine, is 1 to 8 metres thick. The age of the Bluesky is not directly known, but inferred to be late Early Albian on the basis of the ages of its bounding strata. The basal contact of the Bluesky Formation within the underlying Gething Formation is almost always erosional, locally with substantial downward scour into the older Gething rocks. Scour is locally evidenced by the absence of the Bird Seam coal of the uppermost Gaylard coal-measures

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

Both formations of the Bullhead Group -- the Gething and the older Cadomin -- are present at Willow Creek Mine, with the Gething containing all known potentially-mineable coal beds.

The four year-2020 boreholes were solely drilled within the Gething Formation.

4.7.1 Gething Formation (map-unit 3a)

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 Mink-Brazion coalfield, including the Willow Creek Mine block. At the latitude of Willow Creek Mine, the overlying (and therefore younger) Chamberlain paleodelta is presumed to have been 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 (Hughes, 1964).

During historic (pre-2020) as well as current (year-2020) drilling within the Willow Creek Mine block, nearly every coal-exploration borehole has intersected some section of the Gething Formation. However, the formation's thickness can only be indirectly estimated from this work, owing to lack of drilling into the underlying Cadomin Formation, as well as the block's pervasive structural complexity.

At local scale, the basal contact of the Gething Formation with the underlying Cadomin Formation is inferred to be abrupt to possibly erosional (Cant, 1996). At Willow Creek Mine, the Gething/Cadomin contact has been 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 Cadomin beds.

At regional scale, the two formations are inferred to interfinger (Stott, 1968; Gibson, 1992a).

4.7.1.1 Gaylard Member

Only one member (the Gaylard Member) is recognised within the Gething Formation at Willow Creek Mine, the overlying Bullmoose and Chamberlain rocks being here assigned to the Moosebar Formation, instead of to the Gething Formation as has been the case in property studies of areas lying further to the southeast.

4.7.1.2 Subdivisions of the Gaylard Member (map-units 3a1 through 3a5)

Table 4-1 (given above) summarises the subdivisions of the Gaylard Member. Major coal zones and other lithologies used as division markers are:

- No.4 coal zone, marking the base of Division 5;
- No.6 coal zone, marking the base of Division 4;
- No.8 coal zone, marking the base of Division 3;
- Heterolithic, mainly silty, strata forming Division 2; and
- Dominantly-sandy strata, comprising Division 1.

4.7.1.3 Sedimentological and cyclothemic details

The Gaylard Member consists mainly of non-marine sedimentary rocks within the Willow Creek Mine block, although the presence of at least one coal zone with slightly-elevated sulphur content suggests that some marine influence may have occurred. The coal zone in question, No.8, lies within Division 3 of the Gaylard Member.

The Gaylard Member consists principally of many vertically-stacked, locally erosive-based, fining-upward bed-sets, such as are typical of fluvial and deltaic depositional settings. A typical cyclic succession of Gaylard 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, Gaylard cycles are capped by coal beds, or by laterally-correlative carbonaceous to coaly mudstones. Coals vary in thickness: some are too thin (less than 40 to 50 cm) or too dirty, to be considered potentially-mineable, whereas other coals locally coalesce to form thick conjoint zones up to 4 metres thick. The individual component coal beds of these conjoint zones are readily-traceable on gamma-density logs, and they thus may be interpreted to maintain their identity as discrete sedimentation-units despite their bounding coal-on-coal contacts.

Coals frequently contain partings of siltstone or variably-carbonaceous mudstone, sometimes of tuff (the 'tonstein' bands of Kilby, 1984a and 1985), and rarely of nodular or banded ironstone. Splitting and lateral coalescence of coals is interpreted to represent the near-isochronous interaction between peat accumulation in wetlands, avulsive processes within nearby river distributaries, and concomitant crevasse-splay sedimentation atop the coeval coal-forming wetlands (Banerjee and others, 1996).

Gamma-log responses of the Gaylard sandstones (within and between these cycles) are typically 'ragged' in detail, occasionally capped by an upward-increasing 'bell-shaped' log response. In contrast, the siliceous sandstones and conglomerates within the underlying Cadomin Formation display distinctly 'blockier' responses than those of the Gaylard sandstones.

4.7.1.4 Discussion concerning the thickness of the Gaylard Member

The thickness of the Gaylard Member is not directly known at Willow Creek Mine, owing to the lack of completely-drilled sections, and the pervasive presence of incompetent structures comprising folds and both small- and large-scale thrust-faults within the Gaylard's coal-measures. From incomplete, but apparently minimally-disturbed, sections the Gaylard is established to be at least 260 metres thick at Willow Creek Mine, and possibly up to 360 metres thick. Yet-greater thickness has not yet been ruled-out.

In contrast, within the nearby Highhat gasfield (15 kilometres to the southeast of Willow Creek Mine), complete sections of the Gething Formation are 475 to 720 metres thick (Cathyl-Huhn, 2015a), although some of that thickness is made up by marginal-marine deposits which are considered to be homotaxial with the basal part of the Moosebar Formation as found at Willow Creek Mine.

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 now-deprecated Dresser Formation of the Crassier Group *sensu* Hughes (1964).

Regionally, 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 coal, several tens of metres thick overall.

The Cadomin Formation may be distinguished from the sandier parts of the Gaylard Member, upon the bases of the Cadomin Formation's greater lateral continuity, the Cadomin's distinctly-'blocky' gamma-log response, and the frequent (but not universal, *cf.* Cant and Abrahamson, 1996) presence of an intervening zone of fine-grained coal-measures strata.

Again regionally, the base of the Cadomin marks a northeastward-deepening angular unconformity, cutting down into successively-older rocks of the Minnes Group (Stott, 1973).

Locally, it remains uncertain whether the Cadomin Formation has been reached by any of the historic or current boreholes at Willow Creek Mine. By comparison with nearby properties, the Cadomin's basal contact with the underlying Bickford Formation of the Minnes Group is presumed to be erosional, with considerable local scour into the older sediments. The thickness of the Cadomin Formation at Willow Creek Mine is unknown, on account of lack of deep drilling. The estimated thickness of 2.5 to ca. 14 metres, as given in **Table 4-1** above, is derived from studies of the Gething and Cadomin formations within the adjoining Willow South coal property.

4.8 Minnes Group (map-unit 1)

The Minnes Group comprises 1000 to 1200 metres of clastic sedimentary rocks of latest Jurassic and earliest Cretaceous age, forming a poorly-exposed deltaic/shelfal/basinal complex which is overlain by the Bullhead Group. Four formations are locally recognised within the Minnes Group. From top down, they are the Bickford (equivalent to most of the now-deprecated Brenot Formation of Hughes, 1964), the Monach, the Beattie Peaks, and the Monteith formations (Stott, 1981; 1998). Coal is known to at least locally occur in all four of the Minnes Group's formations (Chowdry, 1980), but only the Bickford Formation is inferred to occur at reasonable depths within the Willow Creek Mine block, and therefore to be a credible (albeit thus-far apparently-untested) target for coal exploration.

5 Coal

As discussed above in **Section 4**, the Gaylard Member contains numerous coal beds, some of which are sufficiently thick and apparently laterally-continuous to constitute reasonable exploratory and mining targets, within the Willow Creek Mine block.

Plate 5: Bird coal bed, approximately a metre thick, as exposed in the southeastern highwall of the 4N2 open-pit workings. Coal bed comprises alternating blocky and sheared mushy bands. Note the bright yellow sulphate bloom on the weathered surface of the coal. Above is about 3 metres of silty sandstone and pebbly sandstone of the uppermost Gaylard Member, in turn erosionally-overlain by dark-weathering Bluesky gritstone. Top of exposed section is Bullmoose siltstone with centimetre- to decimetre-thick bands of conspicuously light-weathering tuff. [*RC4841/18.jpg*]

5.1 Regional correlations of major Gaylard coals

Regional correlations of Gaylard coals are here proposed, although not examined in detail:

- The variably-sulphurous 'Bird' zone at Willow Creek Mine (shown in **Plate 6**) may be correlative with the Lower Gething A zone at Sukunka Colliery. It is definitely not correlative with the type Bird Seam at Sukunka, which instead lies near the top of the Chamberlain Member of the Gething Formation.
- No.4 zone at Willow Creek Mine may be correlative with the Brenda Seam at Hasler Creek, Hudette F zone at Mink Creek and Hudette, Seam C60 (the Conuma 'A' coal zone) at Burnt River, and the Lower Gething B zone at Sukunka Colliery;

- No.6 zone at Willow Creek Mine may be correlative with the Upper Seam (Conuma 'B' zone) at Burnt River; and
- No.7 zone at Willow Creek Mine may be correlative with the Lower Seam (Conuma 'C' zone) at Burnt River.

Coals of the Gaylard Member at Willow Creek Mine, and their enclosing sedimentary rocks, were deposited during Hauterivian to late Early Albian time, between 112 and 133 million years ago, on the basis of plant-fossil and foraminiferal zonations, as presented by Gibson (1992a).

5.2 Local naming scheme for Gaylard coals

Table 5-1 depicts the conceptual stratigraphic hierarchy of coal zones, coal beds, and lesser subdivisions of coal beds, at Willow Creek Mine. Coal zones are numbered downwards from the Bird at the immediate top of the Gaylard Member, and then proceeding downward from the No.1 zone to the No.4 zone, then the A zone, followed by the No.5 through No.12 zones. The No.12 zone is postulated to lie close to the base of the Gaylard Member.

Each coal zone contains at least one major coal bed, and numerous subordinate and associated 'splits', 'stringers' and 'stringer plies'. Designations of the various major and minor coal beds have evolved with time from McKechnie's (1955) original concept of a series of numbered coal beds, into a more complex scheme of subordinate relationships. A system of split numbering was established by James (1998), who assigned odd terminal digits to subordinate coals lying above a major coal bed, and even terminal digits to those lying below a major coal bed.

5.2.1 Caveat concerning coal bed designations

The system of coal-bed designation presented within **Table 5-1** is not intended to imply that major ('0' terminal-digit) coal beds are invariably and completely split into subordinate beds. Furthermore, not all 'stringers' necessarily originate as laterally-continuous extensions of major coal beds. Considerable work likely remains to fully-establish splitting and coalescent relationships of the Gaylard Member coals at Willow Creek Mine, and within the Willow Creek coal lease in general.

5.3 Coals intersected by current boreholes at Willow Creek Mine

Correlatable coal intersections within the four year-2020 boreholes are collated as **Table C-1** within **Appendix C** of this report, wherein they have been given identifying codes, such as '410' or '442'. These codes have been assigned in aid of generating digital deposit models, subject to explicit hierarchical rules (presented graphically as **Table 5-1**) denoting their postulated 'parent-child' relationships as the various coal zones and coal beds are interpreted to split and possibly rejoin laterally.

The positions of faults are given within **Table C-1**. It should not be presumed that all faults have yet been found, as it is likely to be more difficult to identify bedding-parallel faults in the absence of core (given that the usual cues of missing or repeated sections of strata may be absent).

Within the core logs (also presented in **Appendix C** of this report), faults have been classified into their level-of-assurance as 'established', 'probable', and 'possible'.

Table 5-1: Hierarchy of coals and carbonaceous zones at Willow Creek

Formation	Member	Division	Coal Zone	Cored in 2020	Major Bed	'Split' -- first-order subseam	'Stringer' -- second-order subseam	'Stringer Ply' -- third-order subseam
Gething	Gay-lard	Divis-ion 5	**Bird**		Bird			
			No.1		190 (rare)			
					170			
					150			
					130			
						/ 111		
					110	--110		
						/ 101		
					100	--100		
			No.2			/ 201		
					200	--200 (?)		
						\ 202		
					203 (rare)			
			No.3		330 (rare)			
					310			
						/ 301		
					300	--300		
					320			
					340	--340		
						\ 342		
					360			
			No.4	yes	430			
				yes				/ 411
				yes			/ 410	--410
				yes		/ 401	--401	--401
				yes	400	--400	--400	--400
				yes			\	\ 402
				yes			\ 420	--420
				absent				\ 422
				yes	440	--440	--440	
				yes			\ 442	
					460			
					463			
					480	--480		
						\ 483		
		Division 4				/ A71		
					A7	--A7		
						\ A72		
								/ A55 (rare)
							/ A53	--A53
						/ A51	--A51	
					A5	--A5		
						/ A3		
					A1	--A1		
							/ A03 (?)	
						/ A01	--A01 (?)	
					A0	--A0		
						\ A02		
					A2 (?)			
			No.5		550			
					530			
						/ 511		
					510	--510		

Table 5-1: Hierarchy of coals and carbonaceous zones at Willow Creek (continued)

Formation	Member	Division	Coal Zone	Cored in 2020	Major Bed	'Split' -- first-order subseam	'Stringer' -- second-order subseam	'Stringer Ply' -- third-order subseam
						/ 501		
					500 (?)	--500 (?)		
Gething Formation (contin-ued)	Gaylard Member (contin-ued)	Divis-ion 4 (contin-ued)	**No.5** (con-tin-ued)			\ 502		
					520			
					540			
					560			
					580			
		Divis-ion 3	**No.6**		670			
					650			
						/ 631		
					630	--630		
					610			
						/ 601		
					600	--600		
						\ 602 ?		
					620			
					640			
			No.7		770			
					750			
						/ 731		
					730	--730		
						/ 703		
						/		/ 712 ?
						/	/ 710	--710
						/ / 701	--701	
					700	--700		
						\ 702		
						/ 721		
					720	--720		
						\ 722		
					740			
					760			
			No.8		830			
					810			
					800	--800		

						\ 802		
					820			
		Division 2	**No.9**					
					900	--900		
						\ 920 ?		
					980			
Gething (continued)	Gaylard (continued)	Division 1	**No.10**		1090			
					1070			
						/ 1003		
						/	/ 1010	
						/ / 1001	--1001	
					1000	--1000		
					1020			
					1060			
					1080			

Table 5-1: Hierarchy of coals and carbonaceous zones at Willow Creek (concluded)

Formation	Member	Division	Coal Zone	Cored in 2020	Major Bed	'Split' -- first-order subseam	'Stringer' -- second-order subseam	'Stringer Ply' -- third-order subseam
Gething (continued	Gaylard (continued	Division 1 (cont'd)	**No.11**			/ 1101		
					1100	--1100		
						\ \ 1102	--1102	
						\	\	/ 1121 (?)
						\	\ 1120 (?)	--1120
						\		\ 1122 (?)
						\ 1104		
			No.11		1140			
					1160			
					1180			
						/ 1210 (?)		
			No.12		1200	--1200		
						\ 1220 (?)		

Note: table compiled from Willow Creek Mine year-2001 through year-2020 drilling. Drilling of coal zones No.9 through No.12 is sparse; existence of No.12 zone in any of the year-2001 or more recent boreholes is not adequately established. Assignment of coal zone 12 to the Gething Formation is speculative, and merits further critical consideration. (?) indicates uncertainty of correlation. Symbols \ and / denote postulated splitting relationships.

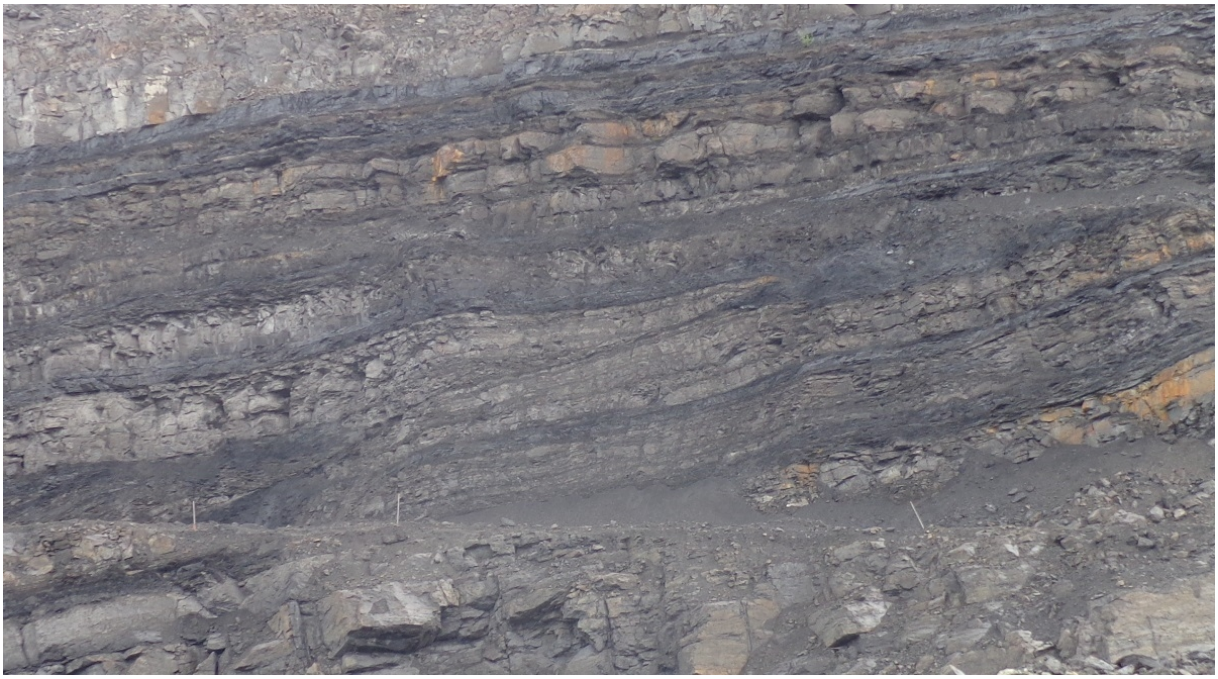


Plate 6: Southwestward-verging thrust fault duplicating silty sandstone beds beneath 442-bed coal within No.4 coal zone. Silty sandstone is about 1.2 metres thick. Left side of thrust displays ramp/ramp geometry, progressing updip to ramp/flat geometry, and then appearing to follow floor of 442-bed. Above 442-bed coal are coals of 440-bed, 420-bed, rusty-weathering siltstone, 400 and 401-beds (with light-weathering ?tuff band as parting), capped by 410-bed coal. Exposure is near southwest corner of 4N2 highwall. [*RC5493a/20.jpg*]

8 Reclamation

Drilling at Willow Creek Mine in year-2020 required no construction work, inasmuch as three of the year-2020 boreholes were drilled from locations atop mine benches, and the fourth was drilled on an existing forestry trail within an area which had been cleared of timber.

As per usual practice, the drill sites were cleared of equipment, supplies and trash prior to demobilisation of the drilling rigs. Boreholes were marked with flagged wooden-stake tripods. No other reclamation work was required.

9 Statement of costs

'Current work' at Willow Creek Mine, for purposes of the present report, comprises exploratory work done during the 2020-2021 tenure term, incorporating allocated costs (derived from agreed unit-costs covered by purchase orders) up to the compilation date (January 31, 2021). No additional invoices are expected to be received.

Work consisted mainly of drilling, by means of diamond-drilling (coring) and air-hammer (non-coring) methods (as referenced in **Table 3-3**). All of the boreholes were logged by means of downhole geophysical surveys (as discussed in **Appendix A** of this report). Analytical work (see **Appendix B**) was done on core samples recovered from the diamond-drilled basal portions of the boreholes.

Costs given below in **Table 9-1** (given on the following page) are net of Goods and Services Tax (GST). In aid of planning future work, unit costs per metre have been determined via division of invoiced cost by relevant total metreages of drilling.

Overall cost of current work is estimated to have been $110,487.79.

Drilling cost analysis: **Table 9-1**

Year / activity	Mobe/demobe and rig moves between sites		Casing (in 254-mm hole)		Air-hammering down to core point (in 222 mm hole)		Diamond core drilling (150 mm core in 222 mm hole)		Drill support (daywork, standby, vehicles, subsistence)		Consumables		Cost totals
	metres	cost	metres	cost	metres	cost	metres	cost	metres	cost	metres	cost	
2020/ 2021	250.8	$17,201.25	16.72	$3,895.76	159.85	$29,092.70	74.23	$33,106.58	250.8	$26,049.50	250.8	$1,142.00	$110,487.79
Totals	250.8	$17,201.25	16.72	$3,895.76	159.85	$29,092.70	74.23	$33,106.58	250.8	$26,049.50	250.8	$1,142.00	$110.487.79
Unit cost	$68.59 / metre		$233.00 / metre		$182.00 / metre		$446.00 / metre		$103.87 / metre		$4.55 / metre		$440.54 / metre

Cost breakdown by activity for the 2020-2021 reporting period: **Table 9-2**

Year / activity	Mud-rotary drilling (including mobe/demobe of rig, casing and bit charges, and consumables))		Core drilling (including mobe/demobe of rig, subsistence, casing and bit charges, hammering down to core point, consumables, and catwork in support of rig moves)		Geophysical logging (including mobe/demobe of logging unit, subsist-ence, and crew rotation costs		Lab analysis (in-house)		Roadwork (in support of drilling, and for trail deactivation)		Consultants (geological supervision and core-logging), including subsistence, crew rotations, and consumables)		Cost totals
	metres	cost	metres	cost	metres	cost	metres	cost	metres	cost	metres	cost	
2020/2021	0	0	250.8	$110,487.79	250.8	$30,330	250.8	0	250.8	0	250.8	$16,127.22	$156,945.01
Totals	0	0	250.8	$110,487.79	250.8	$30,330	250.8	0	250.8	0	250.8	$16,127.22	$156,945.01
Unit cost	n/a		$440.54 / metre		$120.93 / metre		$0 / metre		$0 / metre		$64.30 / metre		$625.78 / metre

Notes: unit costs are on per-metre drilled length basis, by division of the costs by the length of drilling. No roadwork was done. Overall unit cost is based on all net costs divided by all metres drilled.

Personnel estimate: 60 total person-days of direct employment upon the work programme.

9.1 Contractor list

The following contractors provided goods or services in support of the year-2020 drilling programme:

- Apex Geoscience -- consulting geology and project management, led by Jerry Holmes P.Geo.;
- Century Wireline Services -- geophysical logging of 4 boreholes, by geophysical engineer Dave Simmons;
- Geotech Drilling Services -- air-rotary and diamond core drilling of 4 boreholes, by Fraste rig DR-3 with crew;
- Robertson Manufacturing -- custom-made core boxes, billed through Geotech Drilling.

9.1.1 Contractor and equipment performance

Contractor performance was good, with the exception that Geotech Drilling Services did not bring a full set of replacement parts for the drilling rig, and the core-barrel's wireline and overshot assemblies were in poor condition.

During mobilisation, the core-barrel was shipped to site whilst lacking a critical ball-bearing which served as part of a check-valve. The part was creatively replaced with a child's large toy marble purchased at a retail shop in Chetwynd.

Although core-recovery with a 1.5-metre wireline core-barrel was generally good, coal core was dropped and lost from one hole, and some difficulty was encountered with breaking-off sandstone cores. This difficulty in turn led to overboring of the core during the beginning of the subsequent coring runs.

Core-boxes were solidly-constructed, and provided with rope-handles on their ends (which made handling of filled boxes substantially easier). However, the boxes were constructed with 1.52-metre (5-foot) side pieces, which yielded an internal length of 1.48 metres, which was shorter than the length of the core-barrel, and made no allowance for the thickness of wooden depth-marker blocks. Longer boxes (perhaps 1.83-metre / 6-foot length) would have allowed for depth blocks and stick-ups of core.

Geophysical logging services were provided in a timely, efficient, and safe manner by Century Wireline's geophysical engineer Dave Simmons. No functional equipment problems were encountered, and there were no downhole operational difficulties such as sticky ground.

10 References

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11 Conclusions

In all, 763 historic boreholes, totalling 55,401.06 metres' length, have been drilled during years-1980 through 2018 within the Willow Creek Mine block of the Willow Creek coal lease. An additional 4 current boreholes (here-reported for the first time), with overall length of 250.8 metres, were drilled on the property in year-2020. Overall drilling totals to date are 767 boreholes and 55,651.86 metres. This total does not include earlier drilling (at locations not yet confirmed by site surveys, and for which logs are as-yet unavailable) of boreholes by the British Columbia Department of Mines (reported by McKechnie, 1955) in years-1946 through 1951.

Drilling at Willow Creek Mine is regarded as sufficient to support the determination of coal-resources to current Canadian geometric standards (Hughes *et al.*, 1989), provided that an updated structural model is assembled, and an updated coal-quality model is constructed, in order to support the distinction of coking-coal, PCI coal, and possibly also thermal-coal within the deposit. This modelling work is now being undertaken by third-party consultants.

Estimated current exploratory cost to date (from April 1, 2020 through to March 7, 2021, and anticipating no further costs incurred prior to the tenure's anniversary date of March 31, 2021), are $156,945.01, at a unit cost of $625.78 / metre.

Willow Creek Mine is regarded as being a property of merit.

12 Statement of qualifications

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

a) I am currently employed on a full-time basis as Chief Geologist by Conuma Resources Limited, in their Canadian regional office in 200-235 Front Street (PO Box 2140), Tumbler Ridge, British Columbia, V0C 2W0 Canada, with permanent domicile at 2719 Dunsmuir Avenue (P.O. Box 40), Cumberland, British Columbia V0R 1S0 Canada.

b) This certificate applies to the current report, titled *Coal Assessment Report for the Willow Creek coal lease -- Volume 6: Willow Creek Mine, 2020 infill drilling*, dated March 7, 2021.

c) I am a member (Professional Geoscientist, Licence No.20550) of the Association of Professional Engineers and Geoscientists of British Columbia, a founding Registered Member of the Society for Mining, Metallurgy and Exploration (SME, Member No.518350), and a Life Member of the Canadian Institute of Mining, Metallurgy, and Petroleum (CIM). I hold British Columbia certification as a Mine Supervisor (No.835247, valid until May 31, 2023). I have worked as a colliery geologist in several countries for 42 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 reports and tech-nical 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 visits to Willow Creek Mine were in the summer of 2020, to oversee and direct the here-reported drilling and geophysical logging programme in my capacity as Chief Geologist.

f) I am the author of this report, titled *Coal Assessment Report for the Willow Creek coal lease - Volume 6: Willow Creek Mine, 2020 infill drilling*, dated March 7, 2021, concerning the Willow Creek Mine block of the Willow Creek coal property.

g) As of the date of the writing of this report, I am not independent of Conuma Resources Limited, pursuant to the tests in Section 1.4 of *National Instrument 43-101*.

“original signed and sealed by”
Dated this 7th day of March, 2021.

C.G. Cathyl-Huhn P.Geo. (BC) RMSME
British Columbia Mine Supervisor No.835247

Geophysical logs and borehole statistics: **Appendix A**

Geophysical logging and the pertinent statistics of the current (year-2018) boreholes at Willow Creek Mine are summarised in **Table A-1** (commencing on the following page). Copies of the geophysical logs are submitted as digital files, in LAS, TIF, and/or PDF formats. as explained below.

LAS and TIF are the primary digital formats within which geophysical logs are customarily (in modern practice) provided by borehole-logging service companies. PDF is a secondary format.

Geophysical logs are obtained by lowering a self-contained cylindrical sonde to the bottom of a borehole (or as close to the bottom as is safely practicable, given borehole wall stability conditions), and then drawing the sonde upward by means of a cable which contains power and data-transfer conductors. Depth reference on each log is based upon readings of a depth transponder connected to the geophysical logging system's draw-works. A very small amount of cable stretch may occur, depending upon the weight and diameter of each sonde; this accounts for slight variations in reported depths of log measurements as compared from one log suite to another.

Ordinarily, geophysical logs are run within boreholes once the drilling rods have been withdrawn. This practice allows for measurement of borehole diameter with a caliper instrument, and further allows for the effective collection of properly-calibrated log measurements. In some occasions, logs may be run within the drill rods, owing to concerns regarding borehole stability; these logs may or may not be subsequently be re-run with the rods withdrawn, again depending upon borehole conditions.

Positional and elevation data for boreholes are given in metres. Depths given on all geophysical logs are also given in metres, below the datum points mentioned in the headers of each log. Downhole depths reached by individual logging suites will vary, according to the length of each sonde, and also according to the source/detector geometry (and hence the measurement reference point) of each sonde. Geophysical log depth is therefore typically slightly less than driller's reported depth of each hole.

Inventory of boreholes and geophysical logs **Table A-1**

Borehole details (suffix 'C' denotes cored borehole)						Geophysical logs run and depths reached (metres)											
Borehole	Surveyed borehole position (metres: UTM NAD83 Zone 10)			Drilled depth (metres)		Gamma-density through drill rods		Compensated gamma-density-resistivity-caliper		Devia-tion	Gamma-neutron through drill roads	Gamma-neutron		Dipmeter	Sonic		
	Easting	Northing	Elevation	Cored (150 mm)	Non-cored (222 mm)	Century 9068 tool		Century 9239C tool		Century 9412A tool	Century 9067 tool	Century 9057A tool		Century 9411A tool	Century 9325A tool		
						Log base	Log top	Log base	Log top	Log base	Log base	Log top	Log base	Log top	Log base	Log top	Log base	Log top
WC20-01c	550000	6162922	1010.72	17.41 (TD 63.63)	46.22	not run		63.16	0	62	not run		62.22	0	63.32	18.48	not run	
WC20-02c	549612	6163177	999.75	16.70 (TD 26.94)	10.24	not run		26.58	0	26	not run		26.58	0	26.72	1.00	not run	
WC20-03c	549532	6163573	901.75	20.66 (TD 66.77)	46.11	not run		66.38	0	66	not run		66.40	0	66.53	1.00	not run	
WC20-04c	549800	6163200	998.34	19.89 (TD 93.46)	73.57	not run		93.18	0	93	not run		92.50	0	93.43	0.53	not run	
				74.66	176.14	not run		4 holes	249.30	4 holes	not run		4 holes	247.70	4 holes	228.99	not run	

Abbreviations: TD -- total depth (in metres); rdg - reading (on log, in metres); all log depths are taken from log headers, with exception of deviation log, whose base is taken as deepest depth calculation

Appendix C:
Lithological data tables, borehole summary sheets, and core descriptions

The author of this report, assisted by Jerry Holmes PGeo, logged and sampled the year-2020 cores.

Standard data-entry forms were used. These forms included directions on descriptive format. The logging forms were printed at tabloid (11 x 17 inches, approximately 279 x 432 mm) landscape format, on waterproof 'Rite-in-the-Rain' paper, allowing for all-weather large-format hand-written data entry, and for reproduction and scanning on commonly-available office equipment.. Core logs were subsequently transcribed into a portable computer driven by a power inverter in the field vehicle.

Summary sheets of borehole construction details were compiled in the office, once core logs were completed. Core logs and summaries are presented below.

Hardcopy geophysical logs were consulted during detailed logging; this was found to be a helpful means of determining the location, extent, and apparent lithology of core-loss zones. As well, coal beds were split open with a wood chisel, thus exposing to view the banding within the coals. The CSIRO 'dull-bright' descriptive scheme was used for coals, and the NCB mudstone descriptive scheme (mudstone / silty mudstone / carbonaceous mudstone / coaly mudstone / canneloid mudstone) was used for fine-grained muddy rocks.

A four-component interpretive model (coal / dirty coal / coaly rock / carbonaceous shale), with density-log boundaries of 1.5, 1.7, and 1.9 gm/cc was used for log interpretation, including as a field check of core descriptions. Interpreted lithologies and coal correlations for each borehole are presented below as **Table C-1**.

Core logs focused on describing the rock type and physical state of the cores, including documentation of recovered thicknesses of core with respect to lithological boundaries, core box ends, and drillers' depth blocks. Furthermore, sample intervals were marked-up within the core logs.

Apparent thicknesses of coal and rock were measured by means of a folding centimetre-scale ruler, parallel to the centreline of cores. Apparent dips were measured by means of a protractor relative to perpendicular planes at 90 degrees to core axis. Cosines of apparent dips were used to determine true stratigraphic thicknesses of coals and partings, as recorded in the sample inventory (presented above as **Table B-1** within **Appendix B**).

Table C-1: Lithological data table (sheet 1 of 9)				
WC20-01c	metres			
From	To	Apparent	Lithology	Name
0.00	4.05	4.05	R	
4.05	4.35	0.30	CBSH	
4.35	4.60	0.25	C	201
4.60	5.55	0.95	DC	201
5.55	6.05	0.50	R	
6.05	6.35	0.30	CBSH	
6.35	6.85	0.50	C	202
6.85	7.20	0.35	CR	202
7.20	7.55	0.35	C	202
7.55	7.65	0.10	DC	202
7.65	8.60	0.95	R	
8.60	8.70	0.10	CBSH	
8.70	9.05	0.35	R	
9.05	9.20	0.15	CBSH	
9.20	13.30	4.10	R	
13.30	13.45	0.15	CBSH	
13.45	14.55	1.10	R	
14.55	14.90	0.35	CBSH	
14.90	15.90	1.00	R	
15.90	16.15	0.25	CBSH	
16.15	16.65	0.50	R	
16.65	17.30	0.65	CBSH	
17.30	17.50	0.20	CR	
17.50	17.95	0.45	DC	310
17.95	18.10	0.15	CBSH	
18.10	18.20	0.10	CR	
18.20	18.50	0.30	CBSH	
18.50	18.75	0.25	R	
18.75	19.30	0.55	CBSH	
19.30	19.50	0.20	DC	300
19.50	20.07	0.57	C	300
20.07	20.30	0.23	CR	
20.30	22.45	2.15	R	
22.45	22.65	0.20	CBSH	
22.65	23.00	0.35	R	
23.00	23.35	0.35	CBSH	
23.35	23.70	0.35	R	

Table C-1: Lithological data table (sheet 2 of 9)				
From	To	Apparent	Lithology	Name
23.70	23.90	0.20	CBSH	
23.90	24.15	0.25	CR	
24.15	24.60	0.45	C	320
24.60	24.80	0.20	DC	320
24.80	25.05	0.25	CBSH	
25.05	27.00	1.95	R	
27.00	27.10	0.10	CBSH	
27.10	27.50	0.40	R	
27.50	27.80	0.30	CBSH	340
27.80	27.95	0.15	CR	340
27.95	28.15	0.20	CBSH	340
28.15	28.30	0.15	CR	340
28.30	28.75	0.45	CBSH	340
28.75	31.30	2.55	R	
31.30	31.40	0.10	CBSH	342
31.40	31.70	0.30	R	342
31.70	31.95	0.25	CBSH	342
31.95	50.25	18.30	R	
50.25	50.50	0.25	R	411
50.50	50.58	0.08	C	411
50.58	52.20	1.62	R	
52.20	52.54	0.34	R	410
52.54	52.80	0.26	R	
52.80	53.00	0.20	CR	
53.00	53.25	0.25	C	401
53.25	53.38	0.13	CR	401
53.38	54.05	0.67	C	401
54.05	54.14	0.09	CR	
54.14	54.43	0.29	C	400
54.43	54.64	0.21	DC	400
54.64	54.74	0.10	C	400
54.74	54.99	0.25	DC	400
54.99	55.74	0.75	C	400
55.74	55.83	0.09	DC	400
55.83	55.95	0.12	C	400
55.95	56.17	0.22	DC	400
56.17	56.20	0.03	CR	400

Table C-1: Lithological data table (sheet 3 of 9)				
From	To	Apparent	Lithology	Name
56.20	56.58	0.38	CBSH	400
56.58	56.61	0.03	C	400
56.61	56.95	0.34	DC	400
56.95	57.08	0.13	CR	
57.08	57.55	0.47	R	
57.55	57.68	0.13	IRST	
57.68	58.07	0.39	R	
58.07	58.31	0.24	C	420
58.31	61.41	3.10	R	
61.41	61.78	0.37	CBSH	
61.78	61.97	0.19	DC	440
61.97	62.05	0.08	CR	
62.05	62.13	0.08	R	
62.13	62.18	0.05	C	442
62.18	62.21	0.03	ASH	442
62.21	62.37	0.16	DC	442
62.37	62.53	0.16	C	442
62.53	63.58	1.05	R	
WC20-02c	metres			
From	To	Apparent	Lithology	Name
0.00	2.00	2.00	R	
2.00	2.20	0.20	CBSH	360
2.20	2.30	0.10	R	360
2.30	2.45	0.15	CBSH	360
2.45	14.09	11.64	R	
14.09	14.32	0.23	CBSH	410
14.32	14.67	0.35	CR	410
14.67	15.95	1.28	CBSH	
15.95	16.00	0.05	CR	
16.00	16.22	0.22	C	401
16.22	16.37	0.15	DC	401
16.37	16.91	0.54	C	401
16.91	16.95	0.04	CR	401
16.95	17.08	0.13	C	401
17.08	17.10	0.02	FAULT	
17.10	17.26	0.16	R	

Table C-1: Lithological data table (sheet 4 of 9)				
From	To	Apparent	Lithology	Name
17.26	17.71	0.45	CBSH	
17.71	17.81	0.10	DC	401
17.81	18.26	0.45	C	401
18.26	18.44	0.18	DC	401
18.44	18.46	0.02	FAULT	
18.46	18.69	0.23	DC	401
18.69	18.72	0.03	C	401
18.72	18.79	0.07	DC	401
18.79	19.32	0.53	C	401
19.34	19.36	0.02	FAULT	
19.36	19.70	0.34	DC	401
19.70	20.09	0.39	C	401
20.09	20.37	0.28	DC	401
20.37	20.74	0.37	C	401
20.74	20.86	0.12	DC	401
20.86	21.24	0.38	C	401
21.24	21.32	0.08	DC	401
21.32	21.50	0.18	C	401
21.50	21.56	0.06	CR	
21.56	21.66	0.10	C	400
21.66	21.70	0.04	DC	400
21.70	21.81	0.11	C	400
21.81	21.95	0.14	DC	400
21.95	22.08	0.13	C	400
22.08	22.18	0.10	CR	400
22.18	22.78	0.60	C	400
22.78	23.13	0.35	CR	
23.13	23.33	0.20	DC	402
23.33	23.42	0.09	CR	
23.42	23.45	0.03	CBSH	
23.45	23.52	0.07	CR	
23.52	24.00	0.48	R	
24.00	24.15	0.15	CBSH	
24.15	24.39	0.24	C	420
24.39	26.96	2.57	R	

Table C-1: Lithological data table (sheet 5 of 9)				
WC20-03c	metres			
From	To	Apparent	Lithology	Name
0.00	5.40	5.40	DRIFT	DRIFT
5.40	12.25	6.85	R	
12.25	12.90	0.65	C	300
12.90	13.05	0.15	DC	300
13.05	13.25	0.20	CR	
13.25	13.85	0.60	R	
13.85	14.00	0.15	CBSH	320
14.00	14.25	0.25	CR	
14.25	16.75	2.50	R	
16.75	17.45	0.70	CBSH	340
17.45	23.50	6.05	R	
23.50	24.00	0.50	CBSH	360
24.00	24.10	0.10	R	360
24.10	24.45	0.35	CBSH	360
24.45	26.25	1.80	R	
26.25	26.35	0.10	FAULT	
26.35	27.80	1.45	R	
27.80	28.10	0.30	CBSH	340
28.10	28.45	0.35	R	
28.45	29.40	0.95	CBSH	342
29.40	35.75	6.35	R	
35.75	36.70	0.95	CBSH	360
36.70	47.06	10.36	R	
47.06	48.05	0.99	CBSH	
48.05	48.31	0.26	C	430
48.31	48.40	0.09	CR	
48.40	52.60	4.20	R	
52.60	52.63	0.03	CBSH	
52.63	53.31	0.68	DC	410
53.31	53.72	0.41	CR	
53.72	54.44	0.72	R	
54.44	54.61	0.17	CBSH	
54.61	54.74	0.13	R	
54.74	55.30	0.56	CBSH	
55.30	56.05	0.75	C	401
56.05	56.17	0.12	CR	

Table C-1: Lithological data table (sheet 6 of 9)				
From	To	Apparent	Lithology	Name
56.17	56.48	0.31	DC	400
56.48	57.63	1.15	C	400
57.63	57.67	0.04	CBSH	400
57.67	57.82	0.15	DC	400
57.82	58.05	0.23	C	400
58.05	58.20	0.15	DC	420
58.20	58.66	0.46	C	420
58.66	58.70	0.04	ASH	420
58.70	58.90	0.20	C	420
58.90	59.13	0.23	R	
59.13	59.58	0.45	CBSH	
59.58	59.84	0.26	R	
59.84	60.20	0.36	CBSH	
60.20	60.85	0.65	R	
60.85	61.15	0.30	C	440
61.15	61.32	0.17	CBSH	440
61.32	61.40	0.08	C	440
61.40	61.45	0.05	R	440
61.45	61.48	0.03	C	440
61.48	61.59	0.11	R	440
61.59	61.69	0.10	DC	440
61.69	61.89	0.20	C	440
61.89	62.05	0.16	CBSH	
62.05	63.60	1.55	R	
63.60	63.90	0.30	DC	442
63.90	67.14	3.24	R	
WC20-04c	metres			
From	To	Apparent	Lithology	Name
0.00	8.00	8.00	R	
8.00	8.25	0.25	CR	
8.25	8.50	0.25	C	150
8.50	8.60	0.10	DC	150
8.60	8.75	0.15	C	150
8.75	8.90	0.15	DC	150
8.90	9.15	0.25	CBSH	
9.15	9.50	0.35	R	

Table C-1: Lithological data table (sheet 7 of 9)				
From	To	Apparent	Lithology	Name
9.50	10.20	0.70	CBSH	
10.20	11.40	1.20	R	
11.40	11.55	0.15	DC	
11.55	12.60	1.05	R	
12.60	12.75	0.15	CBSH	
12.75	13.80	1.05	R	
13.80	13.95	0.15	CBSH	
13.95	14.35	0.40	CR	130
14.35	15.00	0.65	R	
15.00	15.15	0.15	CBSH	
15.15	16.30	1.15	R	
16.30	16.65	0.35	CBSH	
16.65	17.10	0.45	R	
17.10	17.25	0.15	CBSH	
17.25	17.65	0.40	R	
17.65	17.85	0.20	CBSH	
17.85	18.00	0.15	R	
18.00	18.25	0.25	CR	
18.25	18.60	0.35	C	111
18.60	18.75	0.15	CBSH	
18.75	19.75	1.00	R	
19.75	20.00	0.25	CR	
20.00	20.40	0.40	C	110
20.40	21.35	0.95	R	
21.35	21.50	0.15	CBSH	
21.50	22.50	1.00	R	
22.50	22.70	0.20	CR	
22.70	24.20	1.50	C	101
24.20	26.10	1.90	C	100
26.10	26.40	0.30	CR	
26.40	26.55	0.15	CBSH	
26.55	26.90	0.35	CR	
26.90	28.95	2.05	R	
28.95	29.20	0.25	CBSH	
29.20	30.85	1.65	R	
30.85	31.00	0.15	CR	
31.00	31.15	0.15	CBSH	

Table C-1: Lithological data table (sheet 8 of 9)				
From	To	Apparent	Lithology	Name
31.15	31.40	0.25	CR	
31.40	32.05	0.65	C	201
32.05	32.35	0.30	CR	
32.35	34.35	2.00	R	
34.35	34.85	0.50	C	202
34.85	35.00	0.15	CBSH	202
35.00	35.25	0.25	CR	202
35.25	35.50	0.25	C	202
35.50	36.00	0.50	CBSH	
36.00	42.90	6.90	R	
42.90	43.30	0.40	CBSH	
43.30	44.15	0.85	R	
44.15	44.50	0.35	CR	
44.50	47.15	2.65	R	
47.15	47.35	0.20	CBSH	
47.35	47.80	0.45	C	300
47.80	47.90	0.10	DC	300
47.90	48.15	0.25	C	300
48.15	48.40	0.25	CBSH	
48.40	51.85	3.45	R	
51.85	52.20	0.35	CBSH	
52.20	52.40	0.20	R	
52.40	52.60	0.20	CBSH	
52.60	52.80	0.20	DC	320
52.80	52.95	0.15	CBSH	
52.95	55.80	2.85	R	
55.80	56.20	0.40	CBSH	340
56.20	56.60	0.40	CR	340
56.60	57.20	0.60	R	
57.20	57.90	0.70	CBSH	342
57.90	69.00	11.10	R	
69.00	69.15	0.15	CBSH	360
69.15	73.35	4.20	R	
73.35	73.50	0.15	CBSH	
73.50	79.98	6.48	R	
79.98	80.01	0.03	CBSH	
80.01	80.79	0.78	R	

Table C-1: Lithological data table (sheet 9 of 9)				
From	To	Apparent	Lithology	Name
80.79	80.81	0.02	FAULT	
80.81	82.15	1.34	R	
82.15	82.24	0.09	CR	
82.24	82.38	0.14	CBSH	
82.38	82.60	0.22	C	410
82.60	83.37	0.77	CBSH	
83.37	83.80	0.43	R	
83.80	84.81	1.01	C	401
84.81	87.65	2.84	C	400
87.65	88.19	0.54	C	420
88.19	88.21	0.02	FAULT	
88.21	88.55	0.34	C	401
88.55	88.58	0.03	DC	400
88.58	89.23	0.65	C	400
89.23	89.41	0.18	DC	400
89.41	91.21	1.80	C	400
91.21	91.37	0.16	DC	400
91.37	92.00	0.63	C	400
92.00	92.11	0.11	DC	420
92.11	92.45	0.34	CBSH	420
92.45	92.67	0.22	C	420
92.67	93.11	0.44	ASH	
93.11	93.15	0.04	DC	442
93.15	93.31	0.16	C	442
93.31	93.67	0.36	CBSH	

Abbreviations:

ASH -- Possible tuff band
C Coal (density log 1.50 gm/cc or less)
CBSH Carbonaceous shale (density log >1.90 gm/cc)
CR Coaly rock (density log >1.70<1.90 gm/cc)
DC Dirty coal (density log >1.50<1.70 gm/cc)
FAULT Fault: Established / Probable / Possible
IRST Possible ironstone band (anomalous high density)
R Rock, undifferentiated

All depths and thicknesses given in metres, along borehole axis (thus apparent thicknesses as opposed to true stratigraphic thicknesses).

Note: beds 340, 342, and 360 are primarily CBSH.

Interpretations by C.G. Cathyl-Huhn PGeo.

Summary of Willow Creek WC20-01c borehole

Drilled for: Conuma Coal Resources Limited
Purpose: to recover core samples of Willow Creek No.4 coal zone

Exact site: UTM (NAD83 Zone 10) coordinates:
Easting: 550000.0 m
Northing: 6162922.0 m
Elevation: 1010.72 m

Planned pad reference: 20/LD — Survey source: minesite GPS
Elevation at collar: 1010.72 m

Commenced: 6 August 2020 — Completed: 9 August 2020
Drilled by: Cody Daiziel, Kaia Lamarre, and Jordan Seath
Company: Geotech Drilling Services — Rig type: Fraste, tracked

Geophysical logs by: David Simmons
Company: Century Wireline Services (Red Deer, Alberta)
Logs run: Gamma/Density/Caliper/Resistivity, Gamma/Neutron, Deviation, Dipmeter

Geological supervision by: Jerry Holmes PGeo.
Company: Apex Geoscience
Tenure: Willow Creek coal lease — Area: 4N2

Cores examined by: C.G. Cathyl-Huhn PGeo. — Number of core runs: 12
Geophysical interpretation by: C.G. Cathyl-Huhn PGeo. — Number of core boxes: 12

Core and hole sizes:

Depth (m):	Diameter of core (mm)	Nominal hole diameter (mm)
0 to 7.62	254 mm casing	267 mm
7.62 to 46.22 m	222 mm hole (air hammer)	222 mm
46.22 to 63.63 m	150 mm core	222 mm

Drilling issues:

Core barrel lacking internal ball-bearing for check-valve. Replaced with toy marble.

WC20-01c-summary_200818b.doc

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact (*e.g. *abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
===== Core No.1 rec. 0.56/0.62 ===== Core No.2 rec. 1.59/1.53 overbore 6 cm				Siltstone / sandstone laminite (95:5) - dark grey muddy siltstone and medium grey very fine-grained sandstone, Core ground at top; churned base.	Top of Box 1 DD 46.23 0.56 DD 46.85 0.21	0.77	46.22 46.99	30 deg. in middle, 26 deg. at base
				Siltstone - dark grey, sandy, hard, with patchy bioturbation; abrupt base.	0.33 Box 1/2 0.60	0.93	47.92	
				Siltstone - dark grey, very sandy, hard; slightly ferruginous, slumped; abrupt base.	0.38	0.38	48.30	
===== Core No.3 rec. 1.48/1.52			trace to 1%	Siltstone - dark grey, muddy; abrupt base.	0.07 DD 48.38 0.41 Box 2/3	0.48	48.78	
				Siltstone / sandstone laminite (70:30 grading down to 95:5 at base) - dark grey siltstone and medium grey, very fine- to fine-grained, locally-rippled sandstone; sparsely-rooted in part; gradational base.	0.68	0.68	49.46	30 to 35 deg.
===== Core No.4 rec. 1.56/1.53				Siltstone - medium brownish-grey, slightly ferruginous, locally slumped or churned, with coalified stump at base' abrupt base.	0.39 DD 49.90 0.32 Box 3/4 0.08	0.79	50.25	32 deg.
				----- **Roof of 411 coal bed (horizon only)** ----- Mudstone - dark brownish-grey, slightly carbonaceous, rooty; abrupt base,	0.25	0.25	50.50	
				COAL - bright, crushed and badly broken; probably coalified stump; abrupt base. ----- **Floor of 411 coal bed (horizon only)** -----	0.08	0.08	50.58	
				(Core loss - rock)		(0.20)	(50.78)	
===== Core No.5 rec. 1.11/1.52				Mudstone - medium brownish-grey, slightly silty, rooty and top; grades down to sandy muddy siltstone at base; abrupt base.	0.79 DD 51.43 Box 4/5 0.33	1.12	51.90	

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact (*e.g. *abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
				Mudstone - medium grey, silty; gradational base.	0.07	0.07	51.97	
				Mudstone - medium to dark brownish grey, slightly carbonaceous; abrupt base.	0.23	0.23	52.20	
				----- **Roof of 410 coal bed (horizon only)** ----- Mudstone - dark brown to black, variably-carbonaceous, rooty, soft; gradational base. ----- **Floor of 410 coal bed (horizon only)** -----	0.34	0.34	52.54	26 deg,
				Mudstone - dark brownish-grey, silty, moderately hard; sheared at base.	0.14	0.14	52.68	
===== Core No.6 rec. 1.20/1.53				(Core loss - rock) (Core loss - coaly rock) Mudstone - black, coaly; slightly sheared; broken; abrupt base.	DD 52.95 Box 5/6 0.16	(0.12) (0.04) 0.16	52.80 52.84 53.00	
				----- **Roof of 401 coal bed** ----- COAL - bright banded, slightly sheared, broken; abrupt base.	0.25	0.25	53.25	
	Sample 3812			Mudstone - black, coaly, soft; abrupt base.	0.13	0.13	53.38	
				COAL - dull and bright, platy to blocky, slightly sheared, broken; sheared base.	0.60	0.60	53.98	44 deg.
				COAL - dull banded, intensely sheared and pulverised, soft; abrupt base. ----- **Floor of 401 coal bed** -----	0.07	0.07	54.05	27 deg.
	Sample 3813			Mudstone - black, coaly, intensely sheared and pulverised, very soft and sticky.	0.09	0.09	54.14	
				----- **Roof of 400 coal bed** ---- (Core loss - coal)		(0.29)	54.43	
===== Core No.7 rec. 1.40/1.52				COAL - dull banded, dirty, badly broken; abrupt base.	DD 54.48 Box 6/7 0.21	0.21	54.64	
				COAL - dull and bright, broken; abrupt base.	0.10	0.10	54.74	
				COAL - dull, dirty, intensely sheared, soft, coherent; abrupt base.	0.25	0.25	54.99	
				COAL - bright banded, platy to flaky, sheared and broken; abrupt base.	0.75	0.75	55.74	
				COAL - dull banded, dirty, sheared; coherent.	0.09	0.09	55.83	

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact (*e.g. *abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
===== Core No.8 rec. 1.46/1.53	Sample 3814			(Core loss - coal)	DD 56.00 Box 7/8	(0.12)	55.95	
				COAL - dull banded, dirty, slightly sheared; abrupt base.	0.22	0.22	56.17	
				Mudstone - black, coaly, moderately soft; gradational base.	0.03	0.03	56.20	
				Mudstone - dark brown, carbonaceous, moderately soft, rooty; abrupt base.	0.38	0.38	56.58	
				COAL - bright, crushed; abrupt base.	0.03	0.03	56.61	
				COAL - dull banded, dirty, sheared; flaky to platy; abrupt base. ----- **Floor of 400 coal bed** -----	0.34	0.34	56.95	19 deg.
				(Core loss - coaly rock)		(0.13)	57.08	
				Mudstone - medium to dark brownish-grey, slightly silty; sparsely-rooted; ground out at base.	0.40	0.40	57.48	
===== Core No.9 rec. 1.45/1.52	Sample 3815			(Core loss - rock)	DD 57.53 Box 8/9	(0.07)	57.55	
				Mudstone - dark brownish-grey, silty, slightly ferruginous, dense; abrupt base. Possible ironstone band.	0.13	0.13	57.68	
				Mudstone - dark brownish-grey, silty, slightly carbonaceous; abrupt base.	0.39	0.39	58.07	
	Sample 3816			----- **Roof of 420 coal bed** ----- COAL - dull and bright, crushed, badly broken. ----- **Floor of 420 coal bed** -----	0.24	0.24	58.31	
===== Core No.10 Rec. 1.44/1.53				Mudstone - medium to dark brownish-grey, slightly silty, sparsely-rooted; sheared base.	0.69 DD 59.05 Box 9/10 0.70	1.39	59.70	21 deg.
				(Core loss - rock)		(0.09)	59.79	
				Mudstone - dark brownish-grey, variably-carbonaceous, rooty, coarse coalified plant trash; gradational base.	0.41	0.41	60.20	
				Siltstone - dark grey to brownish-grey, muddy, rooted at top; abrupt base.	0.33			

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact (*e.g. *abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
===== Core No.11 Rec. 1.44/1.52					DD 60.58 Box 10/11 0.25	0.58	60.78	35 deg.
				Mudstone - dark brownish-grey to dark brown, variably-carbonaceous, rooty; abrupt base.	0.63	0.63	61.41	
				Mudstone - dark brown to black, carbonaceous; sparsely rooted at top; abrupt base.	0.37	0.37	61.78	
	Sample 3817			----- **Roof of 440 coal bed** ----- COAL - dull banded, dirty, hard. ----- **Floor of 440 coal bed** -----	0.19	0.19	61.97	18 deg. at top
				(Core loss - coaly rock)		(0.08)	62.05	
===== Core No.12 Rec. 1.45/1.53					DD 62.10 Box 11/12			
				(Core loss - rock)		(0.08)	62.13	
	Sample 3818			----- **Roof of 442 coal bed** ----- COAL - dull banded, hard.	0.05	0.05	62.18	
				Mudstone - dark grey, gritty, possible ash band; erosional base.	0.03	0.03	62.21	
				COAL - dull and bright, dirty, hard, fusain-rich at top; abrupt base.	0.16	0.16	62.37	
				COAL - bright banded, hard; abrupt base. ----- **Floor of 442 coal bed** -----	0.16	0.16	62.53	
===== End of hole				Mudstone - dark grey, slightly carbonaceous, occasional rootlets; base not recovered.	1.05 DD 63.63 End of hole	1.05	63.58	30 deg.

Summary of Willow Creek WC20-02c borehole

Drilled for: Conuma Coal Resources Limited
Purpose: to recover core samples of Willow Creek No.4 coal zone

Exact site: UTM (NAD83 Zone 10) coordinates:
Easting: 549612.0 m
Northing: 6163177.0 m
Elevation: 999.75 m

Planned pad reference: 20/LA
Elevation at collar: 999.75 m
Survey source: minesite GPS

Commenced: 9 August 2020
Completed: 10 August 2020
Drilled by: Cody Daiziel, Kaia Lamarre, and Jordan Seath
Company: Geotech Drilling Services
Rig type: Fraste, tracked

Geophysical logs by: David Simmons
Company: Century Wireline Services (Red Deer, Alberta)
Logs run: Gamma/Density/Caliper/Resistivity, Gamma/Neutron, Deviation, Dipmeter

Geological supervision by: Jerry Holmes PGeo.
Company: Apex Geoscience
Tenure: Willow Creek coal lease
Area: 4N2

Cores examined by: C.G. Cathyl-Huhn PGeo.
Geophysical interpretation by: C.G. Cathyl-Huhn PGeo.
Number of core runs: 11
Number of core boxes: 11

Core and hole sizes:

Depth (m):	Diameter of core (mm)	Nominal hole diameter (mm)
0 to 1.53	254 mm casing	267 mm
1.53 to 10.24 m	222 mm hole (air hammer)	222 mm
10.24 to 26.94 m	150 mm core	222 mm

Drilling issues:

None reported.

WC20-02c-summary_200819a.doc

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact (*e.g. *abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
===== Core No.1 rec. 1.49/1.45				Sandstone - very fine- to fine-grained, light to medium grey, abundant silty streaks, flaseroid, sparsely-rippled; gradational base.	Top of Box 1 DD 10.24 0.53	0.53	10.25 10.78	
===== Core No.2 rec. 1.51/1.52 ===== Core No.3 rec. 1.47/1.53 overbore 1 cm				Siltstone - dark grey, very sandy, with occasional fine plant trash, locally slumped; abrupt base.	0.96 DD 11.69 Box 1/2 1.51 DD 13.21 Box 2/3 0.84	3.31	14.09	20 deg.
	not sampled			----- **Roof of 410 coal bed (horizon only)** ----- Mudstone - dark brown to black, carbonaceous; abrupt base.	0.23	0.23	14.32	16 deg.
				Mudstone - black, coaly, with occasional thick bright coal bands; broken and ground.	0.12	0.12	14.44	
				(Core loss - coaly rock)		(0.07)	14.51	
				Mudstone - black, canneloid, low density; blocky, broken; abrupt base.	0.12	0.12	14.63	
				Mudstone - black, coaly; gradational base. ----- **Floor of 410 coal bed (horizon only)** -----	0.04	0.04	14.67	
===== Core No.4 rec. 1.19/1.52				Mudstone - dark brown to brownish-grey, carbonaceous; slightly silty at base; abrupt base.	0.12 DD 14.74 Box 3/4 1.16	1.28	15.95	17 deg. at base
				Mudstone - black, coaly, intensely sheared, flaky; very soft.	0.03	0.03	15.98	
===== Core No.5 rec. 1.48/1.53				(Core loss - coaly rock)	DD 16.26	(0.02)	16.00	

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact (*e.g. *abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
	Sample 3801			----- **Roof of 401 coal bed** ----- (Core loss - coal)		(0.22)	16.22	
				Coal - dull, dirty, sheared and broken; platy to flaky.	0.15 Box 4/5	0.15	16.37	
				Coal - dull and bright, sheared, platy; abrupt base.	0.54	0.54	16.91	
				Mudstone - black, coaly, intensely sheared and powdery; abrupt base.	0.04	0.04	16.95	
				Coal - dull and bright, platy, slightly sheared; broken. ----- *Fault, probable (forming base of partial 401 coal bed)*-----	0.14	0.14	17.09	Fault dip 40 deg.
	Sample 3802			(Core loss - rock)		(0.01)	17.10	
				Mudstone - dark grey to black, slightly carbonaceous, rooty.	0.16	0.16	17.26	30 deg.
				Mudstone - black, carbonaceous, with occasional thick bright coal bands; platy to blocky, sheared and slicked.	0.45	0.45	17.71	
===== Core No.6 rec. 0.97/1.52	Sample 3803			----- **Roof of 401 coal bed** ----- Coal - dull, dirty, platy, intensely sheared, with glossy slips.	0.10 DD 17.79 Box 5/6	0.10	17.81	
				Coal - dull and bright, intensely sheared, flaky.	0.45	0.45	18.26	
				Coal - dull, dirty, intensely sheared, platy to flaky. ----- *Fault, probable (forming base of partial 401 coal bed)*-----	0.19	0.19	18.45	
	Sample 3804			(Core loss - dirty coal)		(0.01)	18.46	
				Coal - dull, dirty, intensely sheared, platy to flaky.	0.23	0.23	18.69	
				Coal - dull and bright, broken.	0.03	0.03	18.72	
				Coal - dull banded, dirty, glossy, slips, broken.	0.07	0.07	18.79	
===== Core No.7 rec. 1.49/1.53				(Core loss - coal)	 DD 19.31 Box 6/7	(0.54)	19.33	
				----- *Fault, probable* -----				

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact (e.g. abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
				(Core loss - dirty coal)		(0.04)	19.37	
				Coal - dull, dirty, intensely sheared and broken.	0.33	0.33	19.70	
				Coal - dull, platy to flaky, sheared and glossy.	0.39	0.39	20.09	
				Coal - dull, dirty, hard, blocky to platy, slightly sheared, listric slips.	0.28	0.28	20.37	
				Coal - dull, blocky, slightly sheared, with oblique slips at 30 deg.	0.37	0.37	20.74	
===== Core No.8 rec. 1.27/1.52	Sample 3805			Coal - dull, dirty, dense, blocky.	0.12 DD 20.84 Box 7/8	0.12	20.86	11 deg.
				(Core loss - coal)		(0.05)	20.91	
				Coal - dull, sheared and broken.	0.33	0.33	21.24	
				Coal - dull, dirty, slightly sheared.	0.08	0.08	21.32	
				Coal - dull and bright, sheared and broken. ----- **Floor of 401 coal bed** -----	0.18	0.18	21.50	
	Sample 3806			Mudstone - black, coaly.	0.06	0.06	21.56	
				----- **Roof of 400 coal bed** ----- Coal - dull, blocky, broken.	0.10	0.10	21.66	
				Coal - dull, dirty, sheared at top and base.	0.04	0.04	21.70	
				Coal - bright banded, crushed.	0.11	0.11	21.81	
	Sample			Coal - dull, dirty, coherent, intensely sheared.	0.14	0.14	21.95	
	3807			Coal - dull, platy to blocky, slightly sheared.	0.13	0.13	22.08	
				Mudstone - black, coaly, platy to blocky, slightly sheared.	0.10	0.10	22.18	
===== Core No.9 rec. 1.42/1.53				(Core loss - coal)	DD 22.36 Box 8/9	(0.20)	22.38	
				Coal - dull, platy to blocky, sheared and broken. ----- **Floor of 400 coal bed** -----	0.40	0.40	22.78	
	Sample			Mudstone - black, coaly, with abundant thin bright coal bands.	0.35	0.35	23.13	14 deg.

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact (e.g. abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
	3808							
	Sample 3809			----- **Roof of 402 coal bed** ----- Coal - dull, dirty, blocky, slightly sheared and broken. ----- **Floor of 402 coal bed** -----	0.20	0.20	23.33	
				Mudstone - black, coaly, flaky, very soft; intensely sheared.	0.09	0.09	23.42	
				Mudstone - dark brown to black, carbonaceous, platy.	0.03	0.03	23.45	
				Mudstone - black, coaly, flaky to platy, intensely sheared, glossy.	0.07	0.07	23.52	
===== Core No.10 rec. 1.29/1.52	Sample 3810			Mudstone - dark brown to brownish-grey, slightly carbonaceous, rooty; abrupt base.	0.28 DD 23.89 Box 9/10 0.20	0.48	24.00	20 deg.
				Mudstone - black, carbonaceous, finely-laminated.	0.05	0.05	24.05	
				(Core loss - carbonaceous mudstone)		(0.10)	24.15	
	Sample 3811			----- **Roof of 420 coal bed** ----- Coal - dull, blocky, slightly sheared ----- **Floor of 420 coal bed** -----	0.24	0.24	24.39	11 deg.
				(Core loss - rock)		(0.24)	24.63	
===== Core No.11 rec. 1.53/1.53				Mudstone - dark brownish-grey, silty, slightly carbonaceous, sparsely-rooted at top; churned base.	0.80 DD 25.41 Box 10/11 0.37	1.17	25.80	11 deg.
===== End of hole				Siltstone - medium to dark brownish-grey; broken at base.	1.16 DD 26.94	1.16	26.96 End of hole	

Summary of Willow Creek WC20-03c borehole

Drilled for: Conuma Coal Resources Limited
Purpose: to recover core samples of Willow Creek No.4 coal zone

Exact site: UTM (NAD83 Zone 10) coordinates:
Easting: 549532.0 m
Northing: 6163573.0 m
Elevation: 901.75 m

Planned pad reference: 20/LC — Survey source: minesite GPS
Elevation at collar: 901.75 m

Commenced: 10 August 2020 — Completed: 13 August 2020
Drilled by: Cody Daiziel, Kaia Lamarre, and Jordan Seath
Company: Geotech Drilling Services — Rig type: Fraste, tracked

Geophysical logs by: David Simmons
Company: Century Wireline Services (Red Deer, Alberta)
Logs run: Gamma/Density/Caliper/Resistivity, Gamma/Neutron, Deviation, Dipmeter

Geological supervision by: Jerry Holmes PGeo.
Company: Apex Geoscience
Tenure: Willow Creek coal lease — Area: 4N2

Cores examined by: C.G. Cathyl-Huhn PGeo. — Number of core runs: 15
Geophysical interpretation by: C.G. Cathyl-Huhn PGeo. — Number of core boxes: 15

Core and hole sizes:

Depth (m):	Diameter of core (mm)	Nominal hole diameter (mm)
0 to 6.10	254 mm casing	267 mm
6.10 to 46.11 m	222 mm hole (air hammer)	222 mm
46.11 to 66.77 m	150 mm core	222 mm

Drilling issues:
None reported.

WC20-03c-summary_200819a.doc

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact* (e.g. *abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
===== Core No.1 rec. 0.83/0.83 ===== Core No.2 rec, 1.32/1.52				Siltstone - medium grey, muddy, locally churned, occasional coalified plant trash; abrupt base.	DD 46.11 0.81	0.81	46.25 47.06	
				Mudstone - dark brown to black, carbonaceous, platy; broken at top; abrupt base.	0.02 DD 46.95 0.35 Box 1/2 0.62	0.99	48.05	45 deg. 33 deg. at base
	Sample 3819			**----- Roof of 430 coal bed -----** Coal - dull and bright, splintery; gradational base. Does not part freely at base. **----- Floor of 430 coal bed -----**	0.26	0.26	48.31	
===== Core No.3 rec. 1.37/1.53	Sample 3830			Mudstone - black, canneloid, low-density, blocky to platy fracture habit.	0.09 DD 48.47	0.09	48.40	
				Siltstone - medium brownish--grey, muddy, sparsely-rooted; gradational base.	0.27 Box 2/3 0.16	0.43	48.83	35 deg.
				Siltstone - medium to dark grey, sandy, moderately hard; abrupt base; core jumbled at base.	1.05	1.05	49.88	28 deg.
				(Core loss - rock)		(0.46)	50.34	
===== Core No.4 rec. 1.40/1.52 ===== Core No.5 rec. 1.39/1.53				Mudstone - dark grey to brownish-grey, silty, churned, with occasional rootlets; abrupt base.	0.16 DD 50.00 1.40 DD 51.52 0.70	2.26	52.60	
				Mudstone - dark grey to black, carbonaceous, with abundant thin bright coal bands; platy; abrupt base. Does not part freely at base.	0.03	0.03	52.63	

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact* (e.g. *abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
				----- Roof of 410 coal bed ----- Coal - dull, dirty, intensely sheared, crushed, powdery to microblocky.	0.66	0.66	53.29	
===== Core No.6 rec. 1.43/1.52	Sample 3820			(Core loss- dirty coal) **----- Floor of 410 coal bed -----**	DD 53.05 Box 5/6	(0.02)	53.31	
	Sample 3821			Mudstone - black, canneloid, sheared in top half; broken and ground.	0.41	0.41	53.72	21 deg. at base
				Mudstone - dark brownish-grey to dark grey, slightly carbonaceous.	0.72	0.72	54.44	
				Mudstone - dark brown, carbonaceous, blocky.	0.17	0.17	54.61	
===== Core No.7 rec. 1.33/1.53				Mudstone - dark brownish-grey, brecciated, with calcite veinlets.	0.13 DD 54.57 Box 6/7	0.13	54.74	
				Mudstone - dark brown, carbonaceous, with occasional rootlets.	0.56	0.56	55.30	22 deg.
	Sample 3822			**----- Roof of 401 coal bed -----** (Core loss - coal)		(0.41)	55.71	
				Coal - dull banded, slightly sheared, powdery to platy , broken. **----- Floor of 401 coal bed -----**	0.34	0.34	56.05	
	Sample			Mudstone - black, coaly, with abundant thin bright coal bands, slightly sheared; abrupt base.	0.07	0.07	56.12	30 deg.
	3823			Mudstone - black, canneloid, blocky to splintery fracture habit.	0.05	0.05	56.17	
===== Core No.8 rec. 1.54/1.52	Sample 3824			**----- Roof of 400 coal bed -----** Coal - dull, dirty; sheared.	0.31 Box 7/8 DD 56.10	0.31	56.48	
				Coal - dull banded, sheared and flaky.	0.36	0.36	56.84	27 deg.
				Coal - dull lustrous, hard, with widely-spaced bedding-plane slips.	0.79	0.79	57.63	30 deg.

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact* (e.g. *abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
				Mudstone - dark brown, carbonaceous, platy.	0.04	0.04	57.67	
				Coal - dull, dirty, flaky, sheared.	0.15	0.15	57.82	
	Sample			Coal - dull and bright, lustrous, slightly sheared, broken.	0.18	0.18	58.00	
	3831			Coal - dull, powdery.	0.02	0.02	58.02	
===== Core No.9 rec. 0/0.50				(Core loss - coal)	DD 57.62 Box 8/9	(0.03)	58.05	
				(Driller reports 50 cm lost core in this run)				
===== Core No.10 rec. 1.53/1.70				**----- Floor of 400 coal bed and roof of 420 coal bed -----** Coal - dull and bright, dirty, crushed and flaky.	DD 58.12 0.08	0.08	58.13	
				Coal - dull banded, dirty, hard.	0.07 Box 9/10	0.07	58.20	
	Sample			Coal - dull and bright, sheared, flaky to powdery.	0.13	0.13	58.33	
	3825			Coal - dull lustrous, splintery fracture habit; broken.	0.06	0.06	58.39	
				Coal - dull banded, blocky, broken.	0.27	0.27	58.66	19 deg.
				Mudstone - black, sandy; probable ash band.	0.04	0.04	58.70	20 deg.
				Coal - dull banded, sheared, with oblique slips at 44 deg.	0.14	0.14	58.84	19 deg.
				Coal - dull lustrous, broken. **----- Floor of 420 coal bed -----**	0.06	0.06	58.90	
				Mudstone - dark brown, silty, slightly carbonaceous, rooty at top; abrupt base.	0.23	0.23	59.13	

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact* (e.g. *abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
===== Core No.11 rec. 0.88/0.85	Sample 3826			Mudstone - dark brown, carbonaceous; core spun into plates at base of Box 10. (Core loss - rock) Mudstone - dark brown, carbonaceous.	0.45 DD 59.82 Box 10/11 0.36	0.45 (0.26) 0.36	59.58 59.84 60.20	 35 deg.
===== Core No.12 rec. 1.28/1.52	Sample 3827			Siltstone / sandstone laminite (90:10) - dark brownish-grey siltstone and medium grey, very fine- to fine-grained sandstone; slightly ferruginous, moderately hard.	0.52 DD 60.67 Box 11/12 0.13	 0.65	 60.85	
	Sample 3828			**----- Roof of 440 coal bed -----** Coal - dull banded, platy.	0.05	0.05	60.90	
				(Core loss - coal)		(0.25)	61.15	
				Mudstone - dark brown, carbonaceous, with coalified stump; wood imprint at base; abrupt base.	0.17	0.17	61.32	
				(Core loss - coal)		(0.02)	61.34	
	coalified log?			Coal - bright, abrupt base.	0.06	0.06	61.40	
				Mudstone - medium to dark brown, silty, slightly carbonaceous; abrupt base.	0.05	0.05	61.45	35 deg.
				Coal - bright.	0.03	0.03	61.48	
				Mudstone - medium to dark brown, rooty, with root nodules.	0.11	0.11	61.59	
				Coal - dull banded, dirty.	0.10	0.10	61.69	
				Coal - dull and bright, sheared, flaky to platy. **----- Floor of 440 coal bed -----**	0.20	0.20	61.89	
				Mudstone - dark brown to black, carbonaceous, rooty at top, abundant thin bright coal bands in top 3 cm,; silty at base; gradational base.	0.16	0.16	62.05	22 deg.

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact* (e.g. *abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
===== Core No.13 rec. 1.38/1.53				Siltstone - dark brownish-grey, with sandy flaseroid lenses at top, muddy at base; abrupt base.	0.22 Box 12/13 DD 62.19 0.76	0.98	63.03	30 deg. at base
				Mudstone - medium grey, slightly brownish, sheared, calcite veinlets; abrupt base.	0.09	0.09	63.12	
				Mudstone - dark brownish-grey, silty, sparsely rooted; erosional base.	0.48	0.48	63.60	
===== Core No.14 rec. 1.75/1.52	Sample 3829			**----- Roof of 442 coal bed -----** Coal - dull banded, dirty, platy to flaky, slightly sheared.	0.05 DD 63.72 Box 13/14	0.05	63.65	
				Coal - dull, dirty, platy, broken and ground.	0.14	0.14	63.79	
				(Core loss - dirty coal) **---- Floor of 442 coal bed ----**		(0.11)	63.90	
				Mudstone - dark brownish-grey, silty; abrupt base.	0.08	0.08	63.98	
				Siltstone/sandstone laminite (80:20) - medium brownish-grey siltstone and medium grey, fine-grained laminated sandstone; abrupt base.	0.33	0.33	64.31	24 deg.
===== Core No.15 rec. 1.31/1.53				Mudstone - medium to dark brownish-grey, slightly carbonaceous, sparsely rooted, with root nodules; sheared and slicked in middle.	1.20 DD 65.24 Box 14/15 0.51	1.71	66.02	
				Ironstone - medium brown, silty, very hard, nodular texture; abrupt base.	0.15	0.15	66.17	
===== End of hole				Mudstone - dark grey, silty, platy to blocky, becomes sandy at base; slightly sheared. (Core loss - rock)	0.65 DD 66.77	0.65 (0.32)	66.82 67.14 End of hole	29 deg.

WC20-03c-log

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Summary of Willow Creek WC20-04c borehole

Drilled for: Conuma Coal Resources Limited
Purpose: to recover core samples of Willow Creek No.4 coal zone

Exact site: UTM (NAD83 Zone 10) coordinates:
Easting: 549800.0 m
Northing: 6163200.0 m
Elevation: 998.34 m

Planned pad reference: 20/LE — Survey source: minesite GPS
Elevation at collar: 998.34 m

Commenced: 13 August 2020 — Completed: 15 August 2020
Drilled by: Cody Daiziel, Kaia Lamarre, and Jordan Seath
Company: Geotech Drilling Services — Rig type: Fraste, tracked

Geophysical logs by: David Simmons
Company: Century Wireline Services (Red Deer, Alberta)
Logs run: Gamma/Density/Caliper/Resistivity, Gamma/Neutron, Deviation, Dipmeter

Geological supervision by: Jerry Holmes PGeo.
Company: Apex Geoscience
Tenure: Willow Creek coal lease — Area: 4N2

Cores examined by: C.G. Cathyl-Huhn PGeo. — Number of core runs: 15
Geophysical interpretation by: C.G. Cathyl-Huhn PGeo. — Number of core boxes: 14

Core and hole sizes:

Depth (m):	Diameter of core (mm)	Nominal hole diameter (mm)
0 to 1.50	254 mm casing	267 mm
1.50 to 73.57 m	222 mm hole (air hammer)	222 mm
73.57 to 93.46 m	150 mm core	222 mm

Drilling issues:

None reported.

WC20-04c-summary_200819a.doc

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact* (e.g. *abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
===== Core No.1 rec. 0.48/0.61					DD 73.57 0.48	Top of core	73.74	
				Mudstone - dark brownish-grey, silty, locally churned or slumped; gradational base.		0.48	74.22	
===== Core No.2 rec. 1.61/1.52					DD 74.18 0.12	0.12	74.34	30 deg.
				Siltstone - dark grey, muddy, locally churned, sparsely rooted; abrupt base.	0.64	0.64	74.98	
===== Core No.3 rec. 1.36/1.53				Mudstone - dark brownish-grey to dark grey, silty, locally slightly carbonaceous, locally churned; abrupt base.	0.14 Box 1/2 0.71 DD 75.70 0.70 Box 2/3 0.22	1.77	76.75	
===== Core No.4 rec. 1.71/1.52				Siltstone/sandstone laminite (85:15) - dark grey muddy siltstone and medium grey, very fine- to fine-grained, sparsely-rippled sandstone; rooty at top; abrupt base.	0.44 DD 77.23 0.79 Box 3/4 0.02	1.25	78.00	26 deg.
				Siltstone - dark brownish-grey to dark grey, thin- to medium-bedded, fining-upward gradation from silty to slightly-carbonaceous, muddier phases; abrupt base.	0.60	0.60	78.60	
===== Core No.5 rec. 1.24/1.32				Mudstone - dark brownish-grey, slightly carbonaceous, slightly silty; abrupt base. Does not part freely at base.	0.30 DD 78.75 0.42 Box 4/5 0.17	0.89	79.49	
				Mudstone - black, silty, dense, with oblique slip near top; broken at top; abrupt base.	0.49	0.49	79.98	40 deg.
				Mudstone - black, carbonaceous, platy, slightly sheared; broken.	0.03	0.03	80.01	
====== Core No.6 rec. 1.76/1.69				Mudstone - black, silty, slightly carbonaceous, with thin bright coal bands at top.	0.13 DD 80.07	0.13	80.14	17 deg.
				Sandstone/siltstone laminite (85:15) - very fine- to fine-grained sandstone and medium grey siltstone; locally convolute-laminated, rooty at top; brecciated in basal 4 cm. ----- *Fault, probable* -----	0.66 Box 5/6	0.66	80.80	32 deg.
				Sandstone - fine- to medium-grained, light grey, rippled, with sparse silty laminae; abrupt base.	0.60	0.60	81.40	

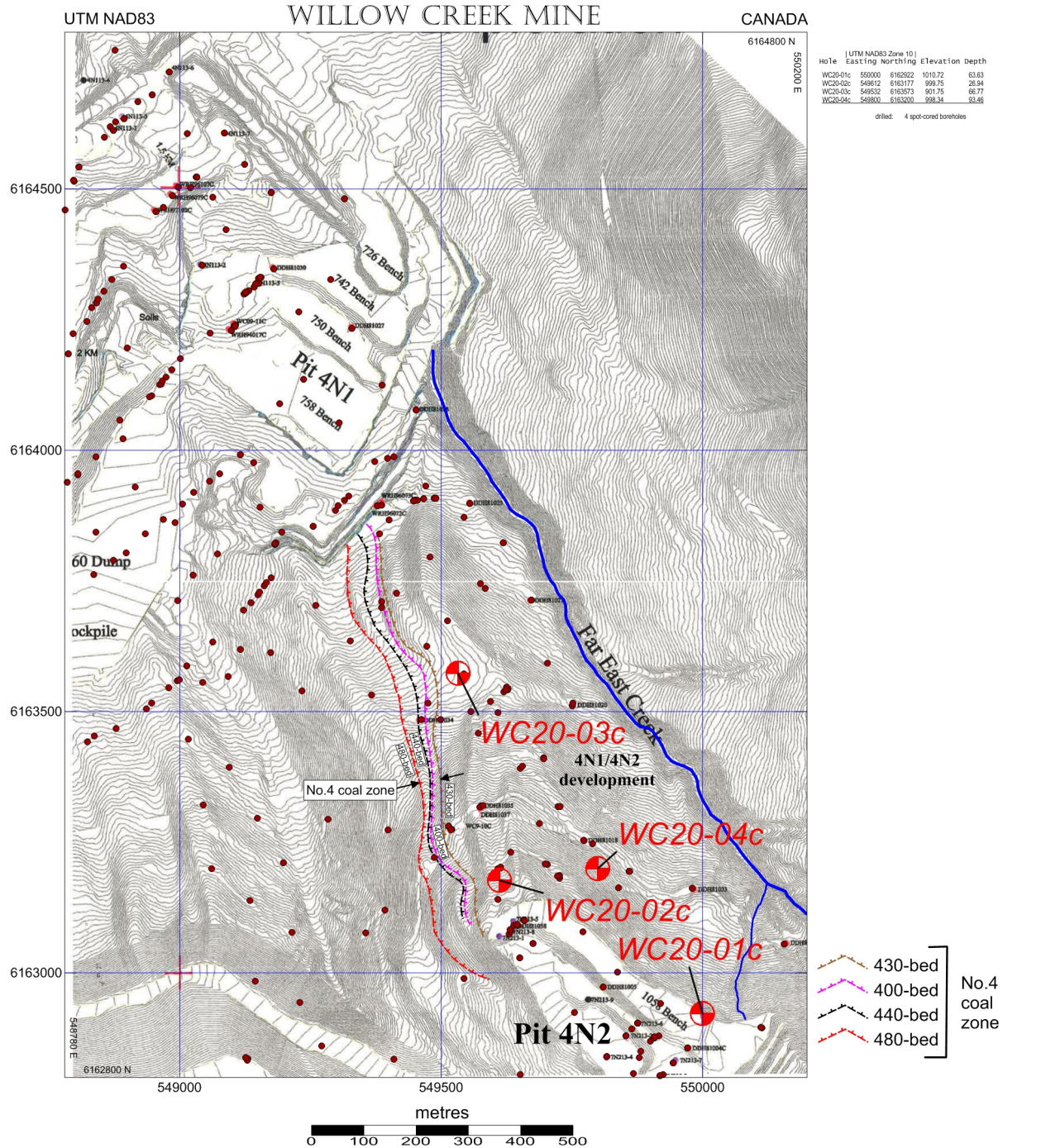
Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact* (e.g. *abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
				Siltstone - medium to dark grey, very sandy; core broken and jumbled at base; abrupt base.	0.38	0.38	81.78	
===== Core No.7 rec. 1.26/1.57				Siltstone - dark grey, muddy, broken; grades down to very fine- to fine-grained, light grey, laminated sandstone at base; abrupt base.	0.12 DD 81.76 Box 6/7 0.25	0.37	82.15	10 deg,
				Mudstone - black, coaly, with abundant thin bright coal bands; broken; abrupt base. (Core loss - coaly mudstone)	0.08	0.08 (0.01)	82.23 82.24	
				Mudstone - black, carbonaceous; abrupt base.	0.14	0.14	82.38	
	Sample 3832			----- **Roof of 410 coal bed** ----- Coal - dull banded, dirty in part, blocky, badly broken. ----- **Floor of 410 coal bed** -----	0.22	0.22	82.60	
	Sample 3833			(Core loss - carbonaceous mudstone) Mudstone - dark brown, carbonaceous, with silty laminae; abrupt base.	0.47	(0.30) 0.47	82.90 83.37	30 deg.
				Mudstone - black, laminated, dense; scoured base.	0.10	0.10	83.47	
===== Core No.8 rec. 1.08/1.52				Mudstone - dark brownish-grey, silty, slightly carbonaceous, with coalified stump at base,	DD 83.33 Box 7/8 0.33	0.33	83.80	24 deg.
	Sample 3834			----- **Roof of 401 coal bed** ---- (Core loss - coal) Coal - dull banded, intensely sheared, flaky and crushed.	0.53	(0.46) 0.53	84.26 84.79	
				Coal - dull lustrous, platy. ----- **Floor of 401 coal bed** -----	0.02	0.02	84.81	
===== Core No.9 rec. 0/1.53	Sample 3835			----- **Roof of 400 coal bed** ----- Coal - dull, platy to blocky; badly broken. (Core loss - coal)	0.18 DD 84.85	0.18 (1.53)	84.99 86.52	
===== Core No.10 rec. 0.63/1.25				(Core loss - coal)	DD 86.38 Box 8/9	(0.50)	87.02	
				Coal - dull, possibly dirty; intensely sheared and pulverised, incoherent, wet; trace of gas.	0.14	0.14	87.16	

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact* (e.g. *abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
				Coal - dull and bright, platy, badly broken.	0.08	0.08	87.24	
	Sample 3836			Coal - dull and dull banded; a mixture of intensely sheared and pulverised coal with slightly sheared, platy to blocky coal. Platy to blocky material is 10% of recovered core. ----- **Floor of 400 coal bed** -----	0.41	0.41	87.65	
===== Core No.11 rec. 0.60/1.11				----- **Roof of 420 coal bed** ----- (Core loss - coal)	DD 87.63 Box 9/10	(0.12)	87.77	
	Sample 3837			(Core loss - coal) Coal - dull, intensely sheared and pulverised, incoherent, sloppy, wet, with 5% platy chunks of dull coal. ----- **Floor of 420 coal bed** ----- ----- *Fault, established* -----	0.33	(0.10) 0.33	87.87 88.20	
	Sample 3838			----- **401 coal bed (top portion faulted-out)** ----- Coal - dull banded, powdery to flaky, damp, sheared, with 10% platy chunks of sheared dull coal. (Core loss - coal) ----- **Floor of 401 coal bed** -----	0.27	0.27 (0.08)	88.47 88.55	
===== Core No.12 rec. 1.12/1.40				----- **Roof of 400 coal bed** ----- (Core loss - dirty coal)	DD 88.74 Box 10/11	(0.03)	88.58	
	Sample			Coal - dull banded, intensely sheared, powdery to flaky.	0.65	0.65	89.23	
	3839			Coal - dull, dirty, slight brownish tinge, intensely sheared, pulverised, very soft.	0.18	0.18	89.41	
===== Core No.13 rec. 0.83/0.27				Coal - dull lustrous, slightly to intensely sheared, powdery to platy, moist.	0.29 DD 90.14 Box 11/12	0.29	89.70	40 deg.
				Coal - dull, sheared and badly broken, mostly powdery to flaky, with occasional platy chunks to 3 cm thick.	0.70	0.70	90.40	
===== Core No.14 rec. 0.87/1.53	Sample 3840			Coal - dull lustrous, slightly sheared, crushed and broken, flaky to platy. (Core loss - coal)	0.13 DD 90.41 Box 12/13	0.13 (0.64)	90.53 91.17	
				Coal - dull, powdery.	0.04	0.04	91.21	
				Coal - dull, dirty, platy, broken.	0.16	0.16	91.37	

Core runs / total recovered length	*Samples / facies / environment*	*Ferm Code*	*Visual estimate of pyrite content*	*Core description: lithology – grain-size, colour, modifiers, minor constituents, sedimentology, palaeontology, tectonic features, physical condition, basal contact (*e.g. *abrupt./gradational/polished/erosional/ground out).*	*Recovery (metres), core boxes and DD (marker blocks*	*Thickness (metres) as interpreted from geophysics*	*Depth to base (metres)*	*Apparent bedding dip (BCN angle)*
				Coal - dull, slight brownish tinge, powdery. **----- Floor of 400 coal bed -----**	0.63	0.63	92.00	
===== Core No.15 rec. 1.30/1.52	Sample 3841			**----- Roof of 420 coal bed ------** (Core loss - dirty coal) Mudstone - dark brown to black, carbonaceous, rooty, dense, jumbled and broken at base. (Core loss - coal) **----- Floor of 420 coal bed -----**	 0.04 DD 91.94 Box 13/14 0.30	 (0.11) 0.34 (0.22)	 92.11 92.45 92.67	
				Siltstone - dark grey, with conspicuous light brown streak, thin-bedded, blocky; possible ash band.	0.44	0.44	93.11	16 deg.
	Sample 3842			**----- Roof of 442 coal bed -----** Coal - dull, dirty, fusainous, badly broken.	0.04	0.04	93.15	
				Coal - dull banded, sheared, powdery to flaky. **----- Floor of 442 coal bed -----**	0.16	0.16	93.31	
===== End of hole				Mudstone - dark brown to black, carbonaceous, medium-bedded, rooty.	0.36 DD 93.46 End of hole	0.36	93.67	24 deg. at top

WC20-04c-log_200816c.doc

WC20-01c-02c-03c-04c-log-letter_210127g.doc



Symbolic legend:

- Historic boreholes (pre-2020 work)
- Current boreholes (2020 work)

UTM Grid North
NAD83 Zone 10

Conuma Resources Limited

Map 2-1: Willow Creek Mine year-2020 infill drilling -- final programme map

Drawing: Willow-Mine-drilling-2020R_210131a.srf/jpg
Scale: as shown Reference: WC20-boreholes.dat/xls
Projection / grid: UTM NAD83 Zone 10, in metres
Drawn: C.G.Cathyl-Huhn P.Geo(BC) Lic.Geol(WA) RMSME
Date: 31 January 2021

Access:

Road (main)

Road (other)

Trail

Seismic line

Drainage:

River or creek

Stream (perennial or intermittent flow)

Outline of Willow Creek Mine block within Willow Creek coal lease

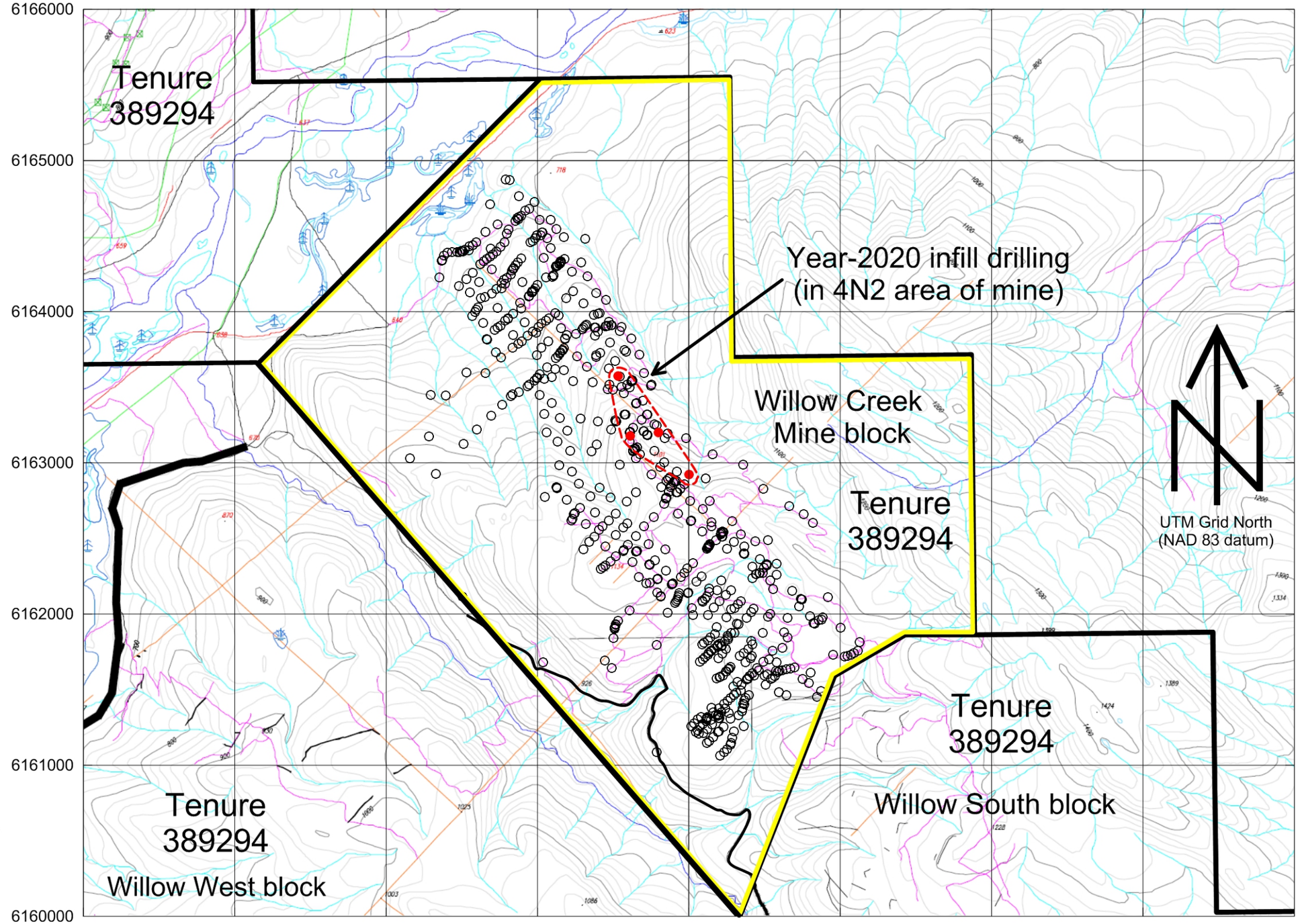
Boreholes:

Historic (1980 to 2018)

Current (2020)

Refer to accompanying Map 2-1 for details of year-2020 boreholes.

Base mapping: British Columbia government TRIM-series map sheets, at original scale of 1:20,000. Elevations are in metres above geodetic datum; contour interval is 20 metres.



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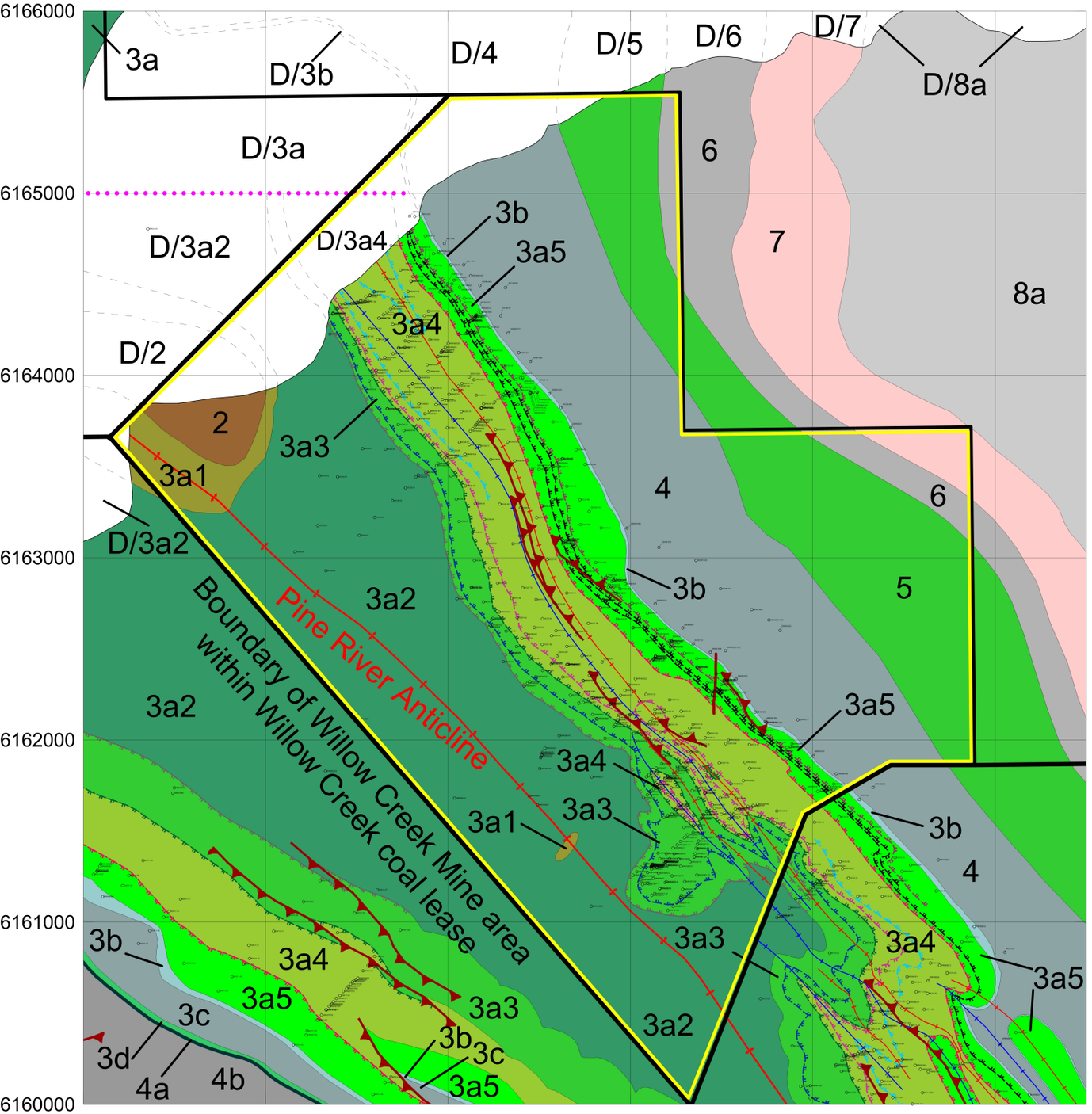
Drawing: Willow_Mine-tenure_210131f.srf/jpg
Drawn: C.G. Cathyl-Huhn, P.Geo.(BC) Lic.Geol.(WA) RMSME
Date: 31. January, 2021 Scale: as shown by bar scale
Grid: UTM Zone 10 to North American Datum of 1983, in metres

Willow Creek Mine Coal Assessment Report

Map 2-2:
Coal Tenure and Topography



Drawing: Willow_Mine-local-geology-tracing-base-NAD83_210131p.srf/jpg
Drawn: C.G. Cathyl-Huhn, P.Geo.(BC) Lic.Geol.(WA) RMSME
Date: 31 January 2021 Scale: as shown by bar scale
Grid: UTM Zone 10 to North American Datum of 1983, in metres

STRATIGRAPHIC LEGEND:

QUATERNARY

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

FORT ST JOHN GROUP (Albian)

8a — Hasler Formation -- siltstone and mudstone; minor sandstone; ironstone as bands of concretions

7 — Boulder Creek Formation -- conglomerate, sandstone, and siltstone; coal

6 — Hulcross Formation -- siltstone and mudstone; minor sandstone and tuff; ironstone; basal pebbly gritstone

5 — Gates Formation -- siltstone, sandstone, conglomerate; minor coal

4 — Moosebar Formation:

- 4c — Spieker Member -- siltstone, sandstone; minor mudstone
- 4b — Cowmoose Member -- mudstone, minor tuff and ironstone
- 4a — Green Marker -- erosive-based, locally-pebbly, glauconitic mudstone and sandstone
- 3d — Chamberlain Member -- sandstone and siltstone
- 3c — Bullmoose Member -- siltstone and sandstone; mudstone; minor tuff

3b — Bluesky Formation -- glauconitic sandstone and gritstone; siltstone and mudstone

BULLHEAD GROUP (Hauterivian to Early Albian)

3 — Gething Formation:

- 3a — Gaylard Member -- siltstone, sandstone and coal; minor conglomerate, minor tuff
  - 3a5 — Division 5 -- siltstone, sandstone and mudstone; coal (zones 1, 2, 3 and 4)
  - 3a4 — Division 4 -- siltstone, mudstone and sandstone; coal (zones A, M, 5 and 6)
  - 3a3 — Division 3 -- sandstone and siltstone; minor mudstone; coal (zones 7 and 8)
  - 3a2 — Division 2 -- siltstone and mudstone; minor sandstone and coal (zone 9)
  - 3a1 — Division 1 -- sandstone; minor siltstone, mudstone, and conglomerate (zones 10 through 12?)

2 — Cadomin Formation -- sandstone; minor conglomerate

MINNES GROUP (Tithonian to Valanginian)

1 — [Older clastic sedimentary rocks -- present only at depth, not known to outcrop or subcrop within map-area]

UTM NAD83 Zone 10

Coal Zones:

- No.1 zone
- No.2 zone
- No.3 zone
- No.4 zone
- A-zone
- No.5 zone
- No.6 zone
- No.7 zone
- No.8 zone

not shown owing to sparse control

- No.9 zone
- No.10 zone
- No.11 zone
- No.12 zone

Lateral change in stratigraphic detail

Structure:

Anticlinal trace

Synclinal trace

Thrust-fault (with barbs on over-thrust plate)

Control:

○ Historic (pre-2020) borehole; refer to Map 2-1 for positions of current (year-2020) drilling

Conuma Resources Limited

Map 2-3:
Bedrock geology of Willow Creek Mine