3. PROJECT DESCRIPTION

3.1 INTRODUCTION

This chapter provides a description of the various components of the Murray River Coal Project (the Project). The geologic and exploration background discussions (Sections 3.2 to 3.5) provide a description of the major geologic strata from surface down to the coal, identifying key geotechnical and geochemical considerations that have been addressed in Project design, as well as the basis for definition of the mineral resource. Key design and planning criteria (Section 3.6) are outlined for major Project components (underground mine and surface facilities), followed by a description of the development sequence through Construction, Operation, Decommissioning and Reclamation, and Post-closure (Sections 3.7 to 3.10).

The Project Description is derived from a number of key documents. Coal exploration and resource estimation was completed by a team of coal mining experts, the results of which were compiled by No. 173 Prospecting Party of China National Administration of Coal Geology. In October 2011, Shenyang Design & Research Institute of Sino-coal International Engineering Group (Shenyang) prepared a Prefeasibility Study on the Project. The senior management of HD Mining updated the information in the Prefeasibility Study and the revised information related to underground mine design has been incorporated into the Project Description. Design of the Coal Preparation Plant was completed by Taggart Engineering, and design of the Coarse Coal Reject piles was completed by Ausenco.

Table 3.1-1 provides a summary of key Project statistics, which are described in more detail later in the chapter. The Project has a design capacity of approximately 4.8 million tonnes of saleable coal per annum (Mtpa), with 6.0 Mtpa ROM coal.

Table 3.1-1. Project Overview Statistics

Statistic	Engineering Design
Production Rate	
Underground Mine ROM coal	6.0 Mtpa
Saleable coal	4.8 Mtpa
Life of Mine	25 years
Total proven minable reserve	261.6 million tonnes
Underground Mine Development	
Mining Method	Retreating Longwall Mining
Production Decline	
Head Elevation (masl)	837.5
Dip (°)	16
Bottom Elevation (masl)	255
Length (m)	2,128
Hoist	Conveyor Belt (1.6 m width)

(continued)

Table 3.1-1. Project Overview Statistics (continued)

Statistic	Engineering Design
Underground Mine Development ***(cont'd)***	
Service Decline	
Head Elevation (masl)	786.1
Dip (°)	16
Bottom Elevation (masl)	358
Length (m)	1,547
Hoist	Single-drum with rail cars
Ventilation Shaft	
Head Elevation (masl)	848
Dip (°)	90
Bottom Elevation (masl)	358
Length (m)	490
Underground Transportation	
Main Level (masl)	255
Sublevel (masl)	358
Coal	Conveyor belt
Personnel and materials	Rubber Tired Vehicle
Coal Seam Blocks	4
Mine Ventilation	Exhausting System
Coal Processing	
Coal Preparation Plant	
Raw coal processed	6.0 Mtpa
Coal produced	4.8 Mtpa
Coal products	Clean coal, middlings
Processing methods	50~1.0 mm: Heavy media cyclones; 1.0~0.25 mm: Teetered-bed Slime Sediment Separator; 0.25~0 mm: Flotation
Coal Rejects	Two stockpiles of co-mingled coal reject (coarse and fine); total storage of 17.4 million m^3
Rail Loadout	5.5 km single linear track , parallel to existing track, within CN Rail right-of-way; generally 1 train of 116 rail cars per day
Utilities	
Electricity	152×10^6 kWh/year
Natural gas	18.4 Mm^3/year
Diesel	468,400 L/year
Employees during Construction	
Underground mine	270 (avg.) / 450 (peak)
Coal Processing Site	150 (avg.) / 210 (peak)

(continued)

Table 3.1-1. Project Overview Statistics (completed)

Statistic	Engineering Design
Employees during Operation	
Underground mine	643
Coal Processing Site	140
Capital cost	$668 M
Annual Operating cost (avg)	$425 M
Construction Period	**3 years**
Underground mine	3 years (includes 6 months mobilization)
Coal Processing Site	2 years
Projected Start of Construction	**April 2015**
Projected Start of Commissioning	**June 2017**
First saleable coal product	July 2017
Date of full production	October 2017

Figure 3.1-1 summarizes the Project development phases and anticipated timelines. HD Mining has approval to mine a 100,000 tonne Bulk Sample. Site preparation for the Bulk Sample was initiated in 2012. Mining activity is currently underway, and is expected to take two years to complete. Construction of the mine and coal processing facilities will take approximately three years, followed by 25 years of Operation. Decommissioning and Reclamation of the site is expected to take approximately three years, followed by a Post-closure of active monitoring and management, which is assumed to last 30 years. While actual mine life will depend on many factors driven by world market conditions, the exploration program has proven a large resource that can support a long-term mine.

3.2 MINERAL TENURE, EXPLORATION, AND PERMITTING HISTORY

3.2.1 Mineral Tenure

The Murray River property consists of 57 coal licences covering an area of 160 km^2. The proposed underground mine and surface facilities described within this Application/EIS are within 19 of the licence areas in the southeast portion of the licence block (Figure 3.2-1 and Table 3.2-1) with a total area of 37.45 km^2. As part of the *Mines Act* permitting process, HD Mining International Inc. (HD Mining) will seek to convert these licences to a coal lease.

3.2.2 Exploration History

Previous exploration in the area was conducted by various major oil and gas companies in the 1970s (Lortie 2010), Quintette Coal Limited (Quintette) and more recently in 2006 and 2007 by Kennecott Coal Exploration Inc. (Kennecott). The exploration programs in the 1970s were generally regional in nature, comprised of widely spaced seismic lines and drilling of a small number of primarily oil and gas wells. These programs helped Quintette and Kennecott identify target areas for more detailed coal exploration and eventual mining. The target seams for the Project are part of the Gates Formation (Fort Saint John Group).

Figure 3.1-1
Project Phases

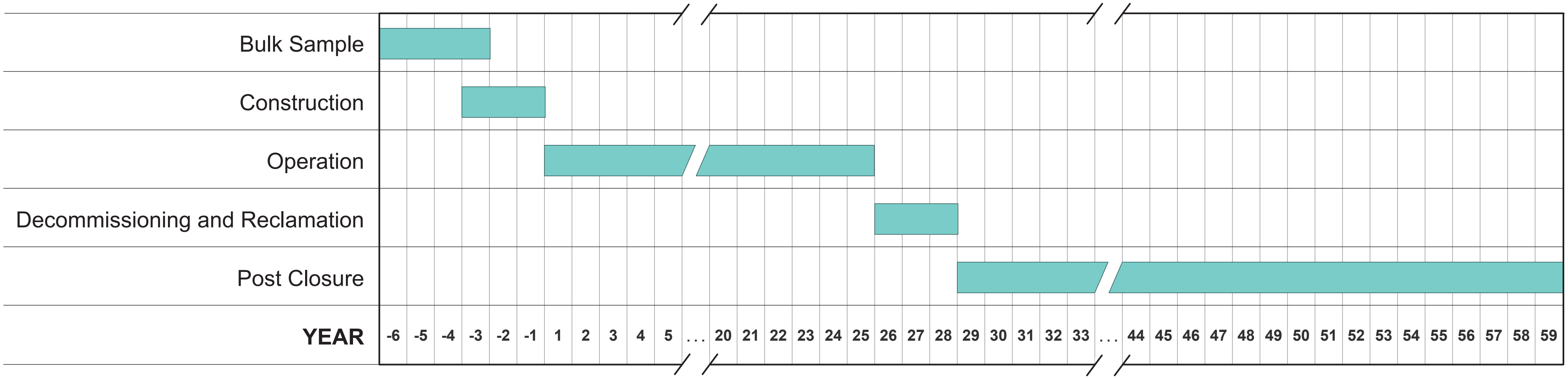
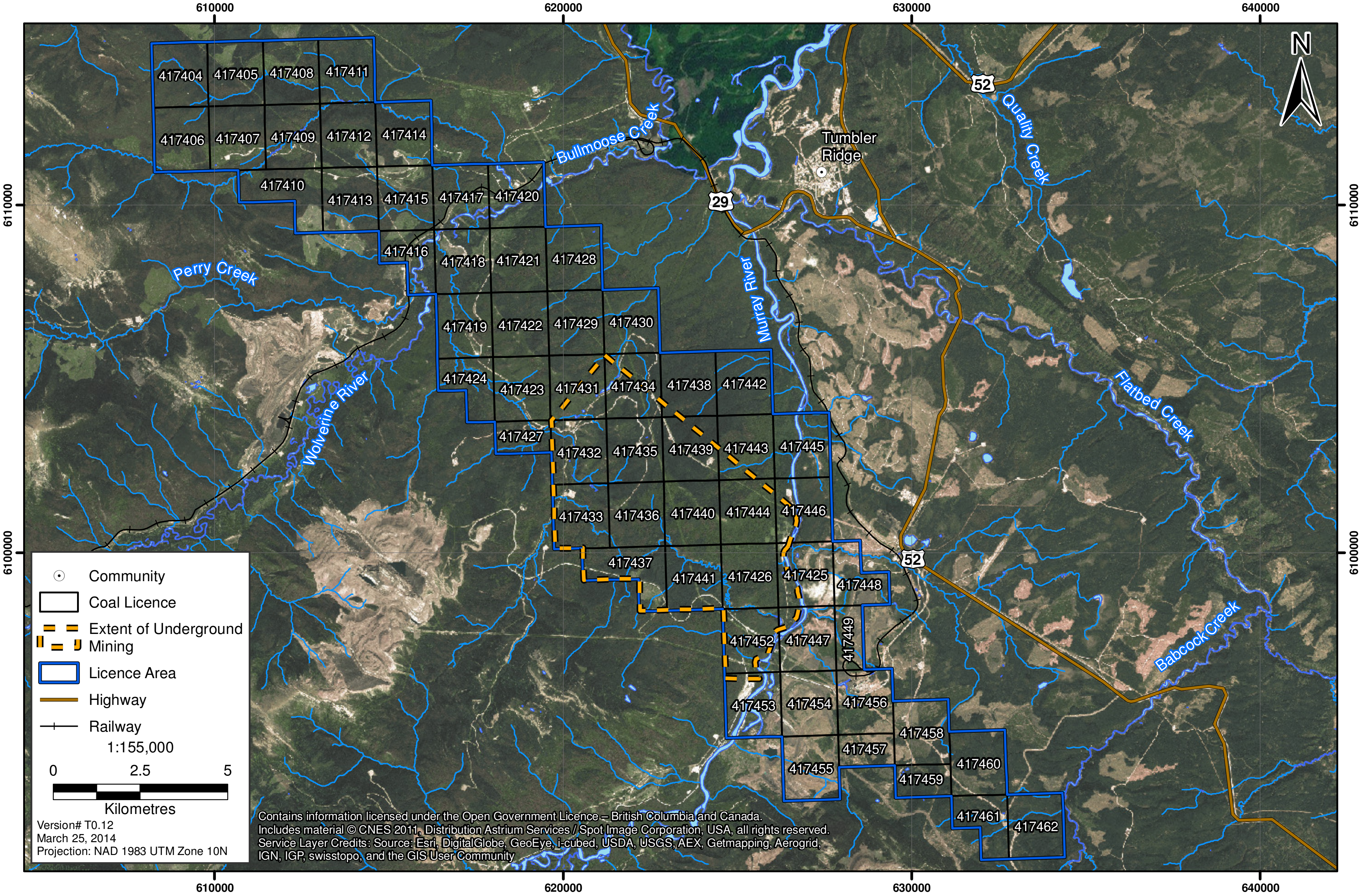


Figure 3.2-1
Murray River Property Coal Licences and Proposed Underground Mining Area



Version# T0.12
March 25, 2014
Projection: NAD 1983 UTM Zone 10N

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Table 3.2-1. Murray River Property Coal Licences

Tenure Number	Map Number	Status	Area
417404	093P014	Good Standing until 2014.05.08	296 ha
417405	093P014	Good Standing until 2014.05.08	296 ha
417406	093P014	Good Standing until 2014.05.08	296 ha
417407	093P014	Good Standing until 2014.05.08	296 ha
417408	093P014	Good Standing until 2014.05.08	296 ha
417409	093P014	Good Standing until 2014.05.08	296 ha
417410	093P014	Good Standing until 2014.05.08	296 ha
417411	093P014	Good Standing until 2014.05.08	296 ha
417412	093P014	Good Standing until 2014.05.08	296 ha
417413	093P014	Good Standing until 2014.05.08	296 ha
417414	093P014	Good Standing until 2014.05.08	296 ha
417415	093P014	Good Standing until 2014.05.08	296 ha
417416	093P005	Good Standing until 2014.05.08	222 ha
417417	093P015	Good Standing until 2014.05.08	296 ha
417418	093P005	Good Standing until 2014.05.08	296 ha
417419	093P005	Good Standing until 2014.05.08	297 ha
417420	093P015	Good Standing until 2014.05.08	296 ha
417421	093P005	Good Standing until 2014.05.08	296 ha
417422	093P005	Good Standing until 2014.05.08	297 ha
417423	093P005	Good Standing until 2014.05.08	297 ha
417424	093P005	Good Standing until 2014.05.08	223 ha
417425	093P005	Good Standing until 2014.05.08	297 ha
417426	093P005	Good Standing until 2014.05.08	297 ha
417427	093P005	Good Standing until 2014.05.08	149 ha
417428	093P005	Good Standing until 2014.05.08	296 ha
417429	093P005	Good Standing until 2014.05.08	297 ha
417430	093P005	Good Standing until 2014.05.08	297 ha
417431	093P005	Good Standing until 2014.05.08	297 ha
417432	093P005	Good Standing until 2014.05.08	297 ha
417433	093P005	Good Standing until 2014.05.08	297 ha
417434	093P005	Good Standing until 2014.05.08	297 ha
417435	093P005	Good Standing until 2014.05.08	297 ha
417436	093P005	Good Standing until 2014.05.08	297 ha
417437	093P005	Good Standing until 2014.05.08	297 ha
417438	093P005	Good Standing until 2014.05.08	297 ha
417439	093P005	Good Standing until 2014.05.08	297 ha
417440	093P005	Good Standing until 2014.05.08	297 ha
417441	093P005	Good Standing until 2014.05.08	297 ha
417442	093P005	Good Standing until 2014.05.08	297 ha

(continued)

Table 3.2-1. Murray River Property Coal Licences (completed)

Tenure Number	Map Number	Status	Area
417443	093P005	Good Standing until 2014.05.08	297 ha
417444	093P005	Good Standing until 2014.05.08	297 ha
417445	093P005	Good Standing until 2014.05.08	297 ha
417446	093P005	Good Standing until 2014.05.08	297 ha
417447	093I095	Good Standing until 2014.05.08	297 ha
417448	093P005	Good Standing until 2014.05.08	223 ha
417449	093I095	Good Standing until 2014.05.08	149 ha
417452	093I095	Good Standing until 2014.05.08	297 ha
417453	093I095	Good Standing until 2014.05.08	297 ha
417454	093I095	Good Standing until 2014.05.08	297 ha
417455	093I095	Good Standing until 2014.05.08	297 ha
417456	093I095	Good Standing until 2014.05.08	297 ha
417457	093I095	Good Standing until 2014.05.08	149 ha
417458	093I096	Good Standing until 2014.05.08	297 ha
417459	093I096	Good Standing until 2014.05.08	149 ha
417460	093I096	Good Standing until 2014.05.08	297 ha
417461	093I096	Good Standing until 2014.05.08	223 ha
417462	093I096	Good Standing until 2014.05.08	298 ha

Note:
Shading indicates coal licences that overlap with proposed underground mine and/or surface facilities.

Kennecott's exploration program is the only known coal-specific exploration program previously conducted within the Murray River licence area. It consisted of one rotary (Lane 2006) and three core holes (BC MEMNG 2006) (two others were abandoned), surface mapping and interpretation of two seismic lines. Because of difficulties encountered during drilling, only one core hole was completed through the Gates Formation.

Du Pont completed two holes in 1979 west of the Murray River property as a preliminary investigation of the Gates Formation coal seams. One hole did not penetrate into the zone on contact between upper Gates and Hulcross formations due to the interception of a postulated fault zone (Du Pont of Canada Exploration Ltd. 1980).

In 2009, Canadian Dehua International Mines Group Inc. obtained the Murray River coal property. Detailed exploration consisting of 12 drill holes was carried out in 2009 and 2010, focusing on the central part of the property (about 37.45 km^2). HD Mining took over responsibility for the exploration program in August 2010, and additional exploration was performed on the property. In total, 20 holes (17,850 m) have been drilled; two of the holes were tested for hydrogeologic properties.

3.2.3 Permitting History

As part of exploration of the coal deposit, HD Mining has received the following approvals from the BC Government to mine a 100,000 tonne bulk sample:

- Coal Exploration Permit CX-9-44 (BC Ministry of Energy, Mines, and Petroleum Resources):
    - initially issued in December 2010, and
    - amended in March 2012 to approve the Bulk Sample program;
- Occupant Licence to Cut (BC MFLNRO):
    - issued in May 2011 to support exploration activities;
- Approval AE105825 under the BC Environmental Management Act (BC MOE):
    - issued in February 2012, authorizes temporary discharge of effluent from the Murray River Bulk Sample initial surface preparation construction activity;
- Approval AE105878 under the BC Environmental Management Act (BC MOE):
    - issued in March 2012, authorizes discharge of effluents from the Murray River Bulk Sample construction and operation activities; and
- Permit 106666 under the BC Environmental Management Act (BC MOE):
    - issued in October 2013, replacing Approval AE105878; authorizes discharge of effluents from the Murray River Bulk Sample construction and operation activities.

The purpose of the Bulk Sample program is to test the coal for use as a coking coal and to perform coal washability testing. The raw coal mined for the bulk sample will be shipped by train directly to the port in Prince Rupert for testing to be completed overseas.

In 2012 and into 2013, HD Mining completed surface preparations to mine the bulk sample. Following approval of mining equipment, underground development of a decline began in January 2014. Permitted infrastructure associated with the Bulk Sample is divided between two areas: the North (shaft) area and the South (decline) area.

The North (shaft) area includes:

- a shaft;
- topsoil storage;
- a waste rock pile; and
- water management facilities, including a sediment pond and discharge structure to M20 creek.

The South (decline) area includes:

- a decline portal;
- a decline conveyor;
- a truck loading area;
- topsoil storage; and
- water management facilities, including a sedimentation pond and discharge infiltration galleries.

Plates 3.2-1 to 3.2-3 outlines the current extent of infrastructure associated with Bulk Sample. Construction of the shaft has not yet commenced.

Plate 3.2-1. Decline Site – view to decline portal (left), office portable, settling tanks (front right), truck loading area (center right), June 2014.

Plate 3.2-2. Decline Site – view to sedimentation pond (back left), topsoil stockpile (back center), gravel storage (center right), June 2014.

Plate 3.2-3. Shaft Site – view from access road to waste rock storage pad (left), sedimentation pond (right), topsoil stockpile (back right), August 2013.

3.3 GEOLOGY

3.3.1 Regional Setting

The Murray River property is located within the Peace River Coalfield (PRC) in the eastern foothills of the Canadian Rocky Mountains of northeastern BC. The western margin of the Foothills Belt is classified as the easternmost major thrust fault that emplaced Paleozoic strata over Mesozoic strata. The eastern margin is a series of echelon thrust faults that separate the Foothills from the gently dipping strata of the Alberta Plateau (Holland 1976). The Foothills Belt is characterized by folded and faulted Mesozoic sediments. The deformation within the Foothills Belt is variable – mostly decreasing in complexity toward the eastern margin. Deformation within the Rocky Mountains involves complicated folding and faulting. Regional axes for folding and faulting trend northwest, dipping to the southeast. In the Foothills Belt, dips tend to be 20° or less with local folds and undulations significantly modifying this value.

In the PRC there are two main coal-bearing units: the Gates Formation and the Gething Formation (British Columbia Geological Survey n.d.). Both Lower Cretaceous units were subjected to varying degrees of burial prior to the Laramide deformation and mountain-building episodes that took place approximately 40 to 70 million years ago when the Pacific and North American plates collided. The Laramide Orogeny increased the overall maturity of the coal seams. Based on drill core information from the neighbouring Quintette mine (immediately adjacent north of the Murray River Forest Service Road), coal seams of the Gates Formation can be comprised of up to 10 separate seams and the average cumulative thickness of the coal seams is as high as 17 metres.

3.3.2 Stratigraphy

The regional geology and stratigraphy of the PRC is provided in Figure 3.3-1 and Figure 3.3-2. Descriptions of the formations are provided below. The information is sourced primarily from Johnson (1985). Additional detail can be found in Appendices 3-A and 3-B.

3.3.2.1 Moosebar Formation

The basal sequence of the Moosebar Formation is a dark grey to black marine shale with sideritic concretions, bentonite, and siltstone. The upper parts comprise banded or fissile sandy shale, very fine-grained sandstone, and sandstone intercalated shale. This transition is a pro-deltaic (highstand systems tract) transition from marine sediments to the massive continental sandstones that mark the overlying Gates Formation. The Bluesky Member is a chert pebble conglomerate that is found locally at the base of the Moosebar Formation.

3.3.2.2 Gates Formation (Fort St. John Group)

The Gates Formation conformably overlies the Moosebar Formation. The lower portion of the formation is termed the Quintette or Torrens member and consists of massive, light gray, medium-grained sandstone, with minor carbonaceous and conglomeratic horizons.

Figure 3.3-1
Regional Geology of NE British Columbia

ERM

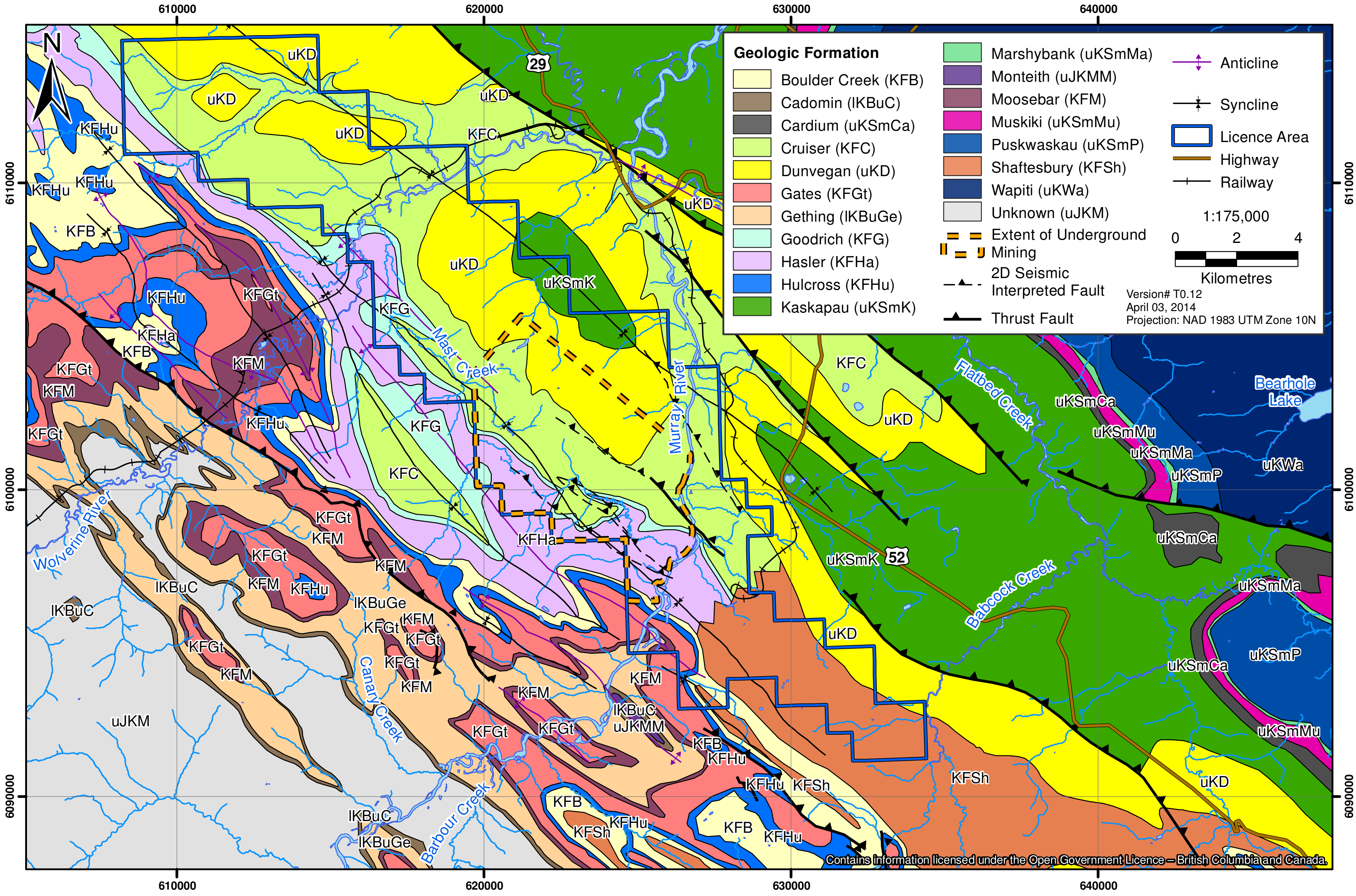
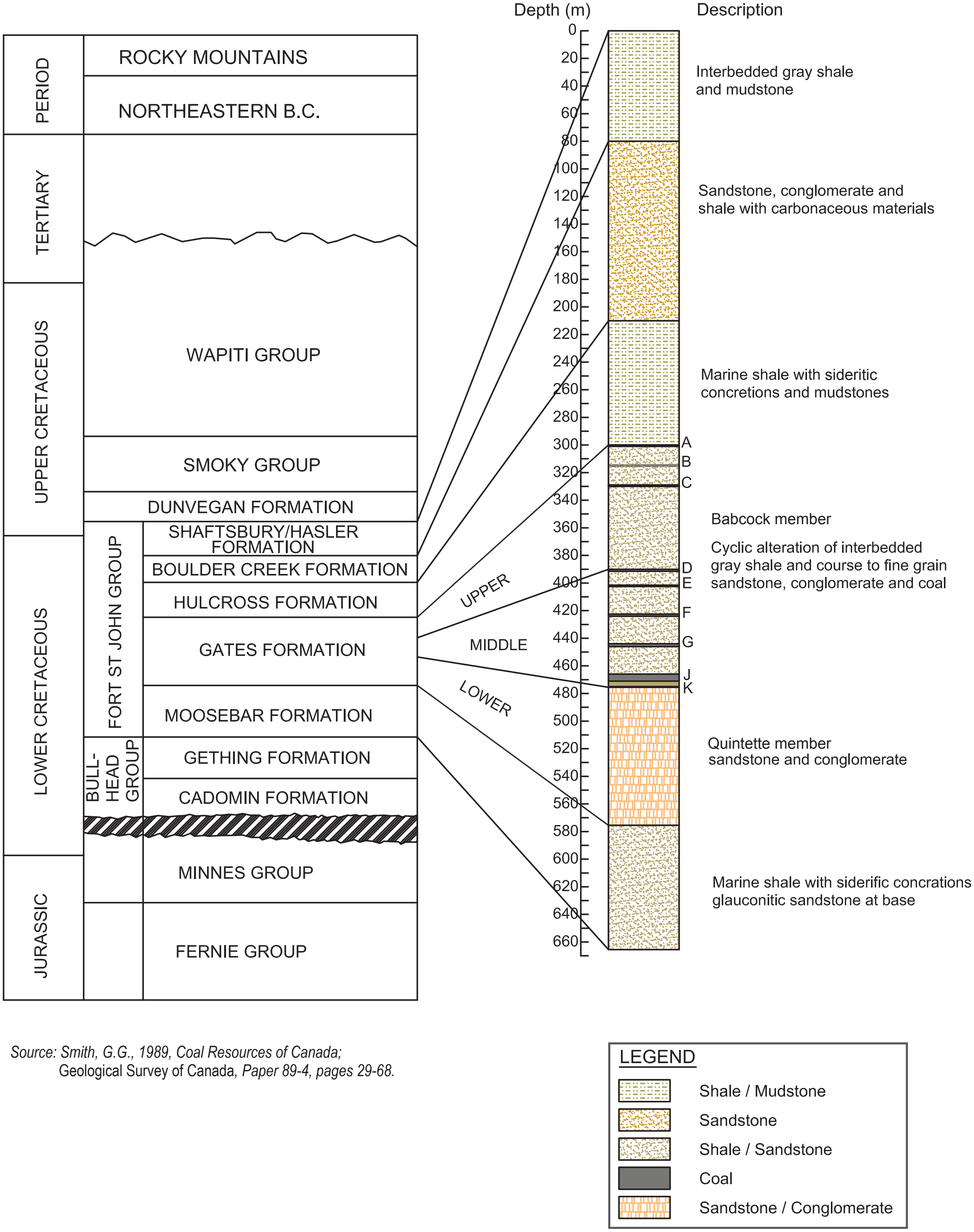


Figure 3.3-2

Regional Stratigraphic Section of Upper Jurassic - Tertiary Units of NE British Columbia



Source: Smith, G.G., 1989, Coal Resources of Canada;
Geological Survey of Canada, *Paper 89-4, pages 29-68.*

The Quintette member is overlain by several cyclical sequences of coal deposition that occur over a stratigraphic interval of approximately 80 m collectively referred to as the Middle Gates. Each cycle normally begins with laminated, medium- to fine-grained sandstone at the base, transitioning to carbonaceous shale and coal. Coal seams are thickest and more continuous in the lowermost cycle: the D through K seams are economical to mine. Individual coal seams within the higher cycles may coalesce to form a single seam, e.g., the G and I seams are typically referred to as the G/I seam.

The lower portion of the Upper Gates is massive, medium- to coarse-grained sandstone and overlain by a predominantly shale sequence containing two to three poorly developed coal seams (A to C) intercalated with sandy shale and very fine sandstone. A very thin bed of chert pebbles with ferruginous cement marks the contact of the Upper Gates with the overlying marine sediments of the Hulcross Formation.

3.3.2.3 Hulcross Formation

The Hulcross Formation is comprised predominantly of dark grey marine shale approximately 100 metres thick. The base of the Formation is more homogeneous and arenaceous, and can contain sideritic concretions. The upper portion of the Formation is dominated by thinly laminated interbeds of siltstone and very fine-grained sandstone. A few kaolinitic beds have also been observed. The Hulcross Formation is usually distinguished from the Moosebar Formation by the absence of glauconitic sandstones at the base of the Hulcross.

3.3.2.4 Boulder Creek Formation

The Boulder Creek Formation is a 130 to 200 metre thick sequence of shale, greywacke, and conglomerate that conformably overlies the Hulcross Formation. The Boulder Creek Formation is a coarsening upward sequence with massive conglomerate and conglomeratic sandstone in the upper portions of the Formation and alternating medium- to fine-grained sandstones and shale in the middle of the Formation (Du Pont of Canada Exploration Ltd. 1980).

3.3.2.5 Hasler Formation

The Hasler Formation is predominantly dark grey marine shale with sideritic concretions and a minor sandstone and pebble conglomerate component; the basal layer is frequently pebbly (British Columbia Ministry of Energy and Mines 2011).

Above the Hasler Formation, the Goodrich and Cruiser Formations form the uppermost units in the Fort St. John Group. According to regional geology maps, the Hasler, Goodrich, and Dunvegan formations comprise the majority of bedrock outcrop on the property.

3.4 MINERAL RESOURCES AND RESERVES

HD Mining has undertaken a strict and methodical assessment of the resource to plan their development of the Project. A team of coal mining experts was brought together to review the exploration data collected and to develop a resource estimate. The results of this analysis were compiled by No. 173 Prospecting Party of China National Administration of Coal Geology (July 2011; Appendix 3-A). The following resource information has been extracted from their report.

In general, the coal seams within the proposed mining area have moderate structural conditions. The seams dip to the northeast and at more than 30° in the flanks of the fold in the west of the region. The coal seams with mining value occur in the Gates and Gething formations. There are nine coal seams developed in the Gates Formation, which are labeled alphabetically from top to bottom (A to K). There are also seven coal seams developed in the Gething Formation (from top to the bottom: Superior, Trojan, Lower Trojan, Titan, Falls, Little Mogul, and Mogul). The F and J seams are the major workable coal seams of this area, with other seams providing locally mineable sources.

The resources estimate was based on the following industrial criteria:

- minimum mineable thickness of gas coal (blending coal for coking): 0.7 m;
- minimum mineable thickness of long flame coal: 0.80 m;
- maximum ash content of ROM coal (A_d): 40%;
- maximum sulfur content of ROM coal ($S_{t,d}$): 3%; and
- minimum calorific value of ROM coal ($Q_{net,d}$):17.0 MJ/kg.

3.4.1 Mineral Resources

Five coal seams were included in the estimation of resources: D, E, F, G/I, and J, which are demonstrated in Table 3.4-1.

Table 3.4-1. Resources Summary for Gates in the First Detailed Exploration Area

Classification Coal Seam	Area ($\times10^3$ m^2)	Measured Resources (Mt)	Indicated Resource (Mt)	Inferred Resource (Mt)	Total Resources (Mt)	Percentage of Measured/ Total
D	29,923	–	25.8	49.2	75.0	–
E	24,652	–	–	84.8	84.8	–
F	39,434	71.4	31.0	75.8	178.2	40%
G/I	36,915	–	27.5	46.0	73.6	–
J	39,735	121.9	36.5	115.5	273.9	45%
Subtotal		**193.3**	**120.9**	**373.9**	**688.1**	**28%**

The mineral resources estimate for the Gates Formation in the first detailed exploration area includes:

- total coal resource: 688 million tonnes;
- measured resource: 193 million tonnes;
- indicated resource: 121 million tonnes; and
- inferred resource: 374 million tonnes.

The mineral resources and reserves estimate in this report comply with the Specification for Coal and Peat Exploration (DZ/T0215-2002) issued by the People's Republic of China Ministry of Land and Resources issued on December 17, 2002. Definitions for the various categories are provided below.

Measured resources: The detailed exploration has satisfied the requirements for this category. Geological study has been completed, but a feasibility study has not yet been completed. The economic viability is between the economic and sub-marginal economic ranges.

Indicated resources: The assessment has been limited to geological study, with no feasibility study or pre-feasibility study yet. The economic viability is between the economic and sub-marginal economic ranges. The resources estimate has a high level of credibility, but the feasibility assessment has a low level of credibility.

Inferred resources: Only geological study has been completed. The economic viability is between the economic and sub-marginal economic ranges. The credibility of both the resources estimate and feasibility assessment is low level.

The sum of measured resources and indicated resources is 314.2 million tonnes, which is 45.66% of total resources. This total can be converted to mineral reserves. A modifying factor of 0.8 is taken into account in the conversion from inferred resources to mineral resources/reserves. The total coal resources/reserves are then 613.3 million tonnes.

3.4.2 Mineral Reserves

The total proven extractable reserve for basic engineering design is 261.6 million tonnes after the deductions of coal pillars and mining loss, which is the defined resource for the basic engineering design. The reserves summary is demonstrated in Table 3.4-2.

3.5 GEOCHEMICAL CHARACTERIZATION

Geochemical baseline studies have been carried out at the Project since 2010, as detailed in Appendix 3-B. The geochemical program focused on the characterization of coal and reject material from the target coal seams (D, E, F, G/I, and J), as well as characterizing the waste rock that will be excavated during the construction of access shafts and declines.

The scope of the geochemical program was to generate and interpret geological and geochemical data to provide an assessment of the metal leaching (ML) and acid rock drainage (ARD) potential for the various geologic materials. The geochemical program was designed to support development of ML/ARD and selenium management plans (Chapter 24), and predictive surface water quality modelling (Appendix 8-E).

The geochemical characterization program included overburden, waste rock, and coal that will be excavated or disturbed during development and mining operations. For the purposes of this summary, the program is divided into waste rock and coal.

Waste rock refers to material that will be excavated during the development phase of the mine program, such as the construction of the shaft and declines. This includes:

- all rock above the Middle Gates Formation D seam; and
- interburden material between Middle Gates Formation coal seams.

Table 3.4-2. Proven Minable Reserves Summary of Engineering Design

		Permanent Coal Pillars Loss					Designed Protective Coal Pillars				
Seams	Industrial Resources/ Reserves	Pillars for Mine Boundary	Pillars for Fault	Pillars for Natural Gas Pipelines	Subtotal	Designed Reserves	Surface Facilities	Major Tunnels	Subtotal	Mining Loss	Designed Proven Minable Reserves
D	65.17	0.9	4.8	27.4	33.1	32.1	1.7	2.0	3.7	5.7	22.7
E	69.96	1.0	5.5	30.1	36.7	33.3	2.0	2.1	4.1	5.8	23.4
F	163.02	1.3	6.6	51.2	59.1	103.9	2.4	2.6	5.0	19.8	79.1
G/I	64.35	0.8	4.0	24.5	29.2	35.2	1.4	1.6	3.0	6.4	25.8
J	250.85	1.9	9.9	93.3	105.1	145.7	3.6	3.9	7.4	27.7	110.6
Subtotal	**613.40**	**6.2**	**35.9**	**221.1**	**263.2**	**350.2**	**11.0**	**12.2**	**23.3**	**65.4**	**261.6**

Note:
Unit = million tonnes

Coal material refers to all material from the Middle Gates Formation coal seams D, E, F, G/I, and J. This includes:

- raw, run-of-mine (ROM), coal;
- clean coal and middlings;
- coarse coal reject (CCR) and non-coal rock from the roofs, partings, and floors of the coal seams; and
- fine coal reject (tailings).

3.5.1 ML/ARD Assessment Methods

Geochemical characterization of materials sampled from drill core and bench-scale coal processing was completed using standard ML/ARD assessment techniques (Price 2009). The criterion used to determine ML/ARD potential for the Project is the ratio of modified Sobek neutralization potential (NP) to the sulphide acid potential (AP; calculated from the sulphide sulphur content of the sample), the sulphide net potential ratio (SNPR). Ratios greater than or equal to 2.0 are considered low potential and material is classified as not potentially acid-generating (non-PAG). Ratios less than 2.0 are considered higher potential, and material is classified as potentially acid-generating (PAG). These classifications are consistent with the approved Waste Rock Management Plan as per CX-9-44 for the Bulk Sample.

The testing program included the following analyses:

- ARD potential through acid-base accounting (ABA), including neutralization potential by the modified Sobek and standard Sobek methods (Price 2009);
- solid phase elemental analysis through whole rock (X-ray fluorescence; XRF) and trace element chemistry (inductively coupled plasma - mass spectrometry; ICP-MS);
- mineralogical composition of select samples (X-ray diffraction with Rietveld refinement; XRD) and petrographic analysis (polished thin sections by reflected and transmitted light microscopy);
- leaching tests by a modified version of the shake flask extraction (SFE; Price 2009); and
- kinetic tests, including:
  - laboratory humidity cell tests (HCTs; Price 2009), and
  - on-site waste rock field leach barrels (FLBs).

3.5.1.1 Waste Rock

A total of 176 drill core samples of waste rock and overburden were collected between 2010 and 2013, including samples from the Hasler, Boulder Creek, Hulcross, and Gates formations (Appendix 3-B). The distribution of samples by formation is presented in Table 3.5-1, along with the different analytical techniques performed on waste rock samples.

Table 3.5-1. Summary of Number of Samples and Analytical Methods for Characterization of Waste Rock at Murray River

Formation	Acid-base Accounting	Elemental Abundance	Whole Rock XRF	Rietveld XRD	Optical Mineralogy	Shake Flask Extraction	Humidity Cell	Field Leach Barrel
Overburden	7	7	3	-	-	4	-	-
Hasler	45	45	24	6	3	5	3	1
Boulder Creek	30	30	22	5	1	7	1	1
Hulcross	31	31	22	4	3	9	3	1
Upper Gates	32	32	9	2	2	11	2	1
Middle Gates Interburden	22	22	10	-	-	10	-	-
Below Middle Gates J Seam	9	9	1	-	-	5	-	-
Total	**176**	**176**	**91**	**17**	**9**	**51**	**9**	**4**

- indicates analysis not performed for indicated formation.
Samples include testing from 2010 to December 2013.

Waste rock will be excavated for construction of the shafts and declines. Material will be stored in a waste rock storage area at the Shaft site, with some material stored at the CCR site or underground, as outlined in Section 3.6.2.13. The ML/ARD waste rock sampling program focused on characterizing the different formations that will be exposed and stored at surface.

3.5.1.2 Coal

A total of 156 samples of coal material were collected for analysis between 2010 and 2013, including 11 raw coal, 11 clean coal, 115 CCR, and 19 fine reject samples (Appendix 3-B). Samples were collected from all seams to be targeted for mining, although some samples were composited between seams due to limited available mass of material. Table 3.5-2 summarizes the distribution of samples by coal seam and the analytical methods used for characterization of raw and clean coal, and coarse and fine rejects.

During mining operations, raw coal will be transported from the mining face via conveyors through the underground workings, up the decline to the surface. At the surface, raw coal will be stockpiled prior to processing at the coal preparation plant (CPP). At the CPP, raw coal will be crushed, and then flow through a series of sizing and gravity separation processes. From there, clean coal and middlings will be directed to the rail loadout and transported off site. Oversized reject material will be co-mingled with thickened and dewatered fine reject material produced from the flotation cells, and stored in the CCR pile. The mine plan is described in more detail in Section 3.6.

3.5.2 ML/ARD Assessment

This section summarizes the results of static, short-term shake flask extraction leachate, and kinetic testing of waste rock and coal at the Project. More detailed results, incorporating summary tables and graphs, are presented in the *Murray River Coal Project: Geochemistry Baseline Report* (Appendix 3-B).

Table 3.5-2. Summary of Number of Samples and Analytical Methods for Characterization of Coal at Murray River

Coal Seam	Acid-base Accounting	Elemental Abundance	Whole Rock XRF	Rietveld XRD	Optical Mineralogy	Shake Flask Extraction	Humidity Cell
Raw Coal							
D Seam	4	4	-	-	-	-	-
E Seam	1	1	-	-	-	-	-
F Seam	3	3	1	1	-	-	1
G/I Seam	2	2	-	-	-	-	-
J Seam	1	1	-	-	-	-	-
Clean Coal and Middlings							
D Seam	2	2	1	1	-	2	1
E Seam	2	2	1	1	-	2	1
F Seam	3	3	-	-	-	3	-
G/I Seam	-	-	-	-	-	-	-
J Seam	3	3	-	-	-	1	-
D-E Seam†	1	1	-	-	-	1	-
Coarse Coal Reject							
D Seam	28	28	10	8	1	4	3
E Seam	14	14	2	2	1	1	2
F Seam	27	27	9	4	-	4	2
G/I Seam	18	18	7	3	-	2	2
J Seam	27	27	9	4	1	7	2
E-F Seam†	1	1	-	1	-	1	1
Fine Reject							
D Seam	4	4	-	1	-	-	-
E Seam	3	3	-	1	-	-	-
F Seam	4	4	-	1	-	-	-
G/I Seam	3	3	1	1	-	-	1
J Seam	4	4	1	1	-	-	1
D,E,F,J Seam†	1	1	-	1	-	-	1
Total	**156**	**156**	**42**	**31**	**3**	**28**	**18**

† Composite sample from multiple seams
- indicates analysis not performed

3.5.2.1 Waste Rock

Static Tests

Static testing included ABA testing, solid phase elemental analysis, and mineralogical composition by Rietveld XRD and optical microscopy. All identified lithologies were sedimentary, as described in Section 3.3, and as a result lithologies were differentiated by grain size. Samples were categorized in drill logs as mudstone, siltstone, sandstone, and conglomerate, with the majority of samples collected and analysed classified as mudstone. Conglomerate samples were predominantly located in the Boulder Creek Formation. The geochemical characterization of waste rock was determined to be more dependent on formation than lithology, as mudstone and siltstone samples from the Hasler and Hulcross formations contained higher sulphide and lower NP values than samples of the same grain size in the Gates Formation.

The majority of minerals identified were quartz, feldspar, and hydrated aluminosilicates, such as illite and muscovite.

Paste pH values of samples were dominantly neutral to alkaline. Sulphur was present typically as sulphide sulphur, with pyrite the dominant sulphide mineral. The highest sulphide sulphur concentrations (up to 2.7% sulphide sulphur) were observed in mudstone and siltstone from the Hasler and Hulcross formations, and conglomerate from the Boulder Creek and Gates formations.

High carbonate mineral content and NP values were observed in most Gates Formation samples. Mineralogical analysis by Rietveld XRD determined the bulk of carbonate mineral content to comprise dolomite-ankerite, with calcite and siderite also observed. Siderite was mostly identified in samples from the Boulder Creek Formation.

Various methods were used to assess NP in waste rock. Due to the presence of iron carbonates such as siderite and ankerite, inorganic carbon values typically overestimated the NP. Of the different methods employed to determine NP, inorganic carbon NP corrected for iron carbonate content had the strongest correlation with NP values measured by the modified Sobek method. The results suggested a good quantification of NP by both the modified Sobek and iron carbonate corrected inorganic carbon NP methods.

Approximately 50% of waste rock samples submitted for ABA testing were classified as PAG, corresponding to approximately 59% of the expected mass of waste rock. Variability between formations was high. The formations with the highest potential for ARD were the Hasler Formation (86.7% of samples classified as PAG) and the Hulcross Formation (90.3% of samples classified as PAG). Boulder Creek Formation samples had a moderate potential for ARD (30.0% of samples classified as PAG), and samples from the Gates Formation had a low potential for ARD (18.5% of samples classified as PAG). Overburden also had a low proportion of PAG samples, with one sample classified as PAG out of seven samples collected.

The relationship between NP and AP showed that sulphur content in waste rock samples has a stronger influence over SNPR values than the NP. This relationship was most apparent in the Boulder Creek Formation, where a sulphide sulphur cut-off of 0.1% was identified, above which value samples were typically PAG. The exception is the Hulcross Formation, in which sulphide sulphur values were relatively consistent across a range of SNPR values.

Solid phase elemental abundance results were compared to average crustal abundances in sandstone and shale. The analysis identified the potential for elevated selenium in samples of overburden and the Hulcross Formation, with a median measured selenium concentration of 1.4 ppm in the Hulcross

Formation. Elevated cadmium concentrations were identified in the Gates Formation, and elevated silver in all formations.

Short-term Leachate Tests

Short-term SFE leachate tests were performed on 51 samples of overburden and waste rock material. Dissolved aluminum, arsenic, selenium, and vanadium concentrations were above BC 30-day mean or maximum water quality dissolved or total guidelines for multiple samples from each formation. Dissolved chromium, iron, and antimony concentrations were also above guidelines in several samples. Overall, the formations with the most elements with concentrations above BC guidelines were the Boulder Creek and Upper Gates formations.

Some elements elevated in SFE leachate were also elevated in solid phase. This included selenium, which was elevated in both solid phase and leachate for overburden and Hulcross Formation samples; and silver, which was elevated in both phases in samples from the Hasler, Hulcross, and Upper Gates formations.

Kinetic Tests

The metal release rates due to primary weathering for the major waste rock formations were assessed by nine ongoing laboratory kinetic humidity cell tests and four ongoing field leach barrels. Of the seven PAG humidity cells, three mudstone humidity cells from Hasler Formation have become acid-leaching, with laboratory lag times of approximately one to three years, and one humidity cell of Boulder Creek Formation conglomerate has become acid-leaching with a laboratory lag time of approximately 0.8 years. The remaining three PAG cells, from the Hulcross Formation, are predicted to become acid-leaching within the next six months. Two non-PAG humidity cells from the Upper Gates Formation are not predicted to become acid-leaching.

Laboratory HCT results were used to calculate lag times to the onset of acidic leachate in waste rock, based on the rates of sulphate production and NP consumption. Laboratory humidity cell leach rates and lag times were scaled for use as inputs for water quality modelling, allowing for predictions of surface and seepage water quality from waste rock storage areas and other infrastructure during Operations and Post-closure. The effects on surface water quality are assessed in Chapter 8, and the water quality model is presented in Appendix 8-E. As part of water quality modelling, sensitivity analyses were completed to bracket the geochemical variability that may be observed in waste rock, as well as variability due to imperfect segregation.

Steady state selenium leach rates in waste rock humidity cells were approximately correlated with sulphide sulphur content, and did not correlate with initial selenium content. The highest selenium leach rates were observed in the acidic Boulder Creek Formation humidity cell (HC4). The Selenium Management Plan is presented in Section 24.10.

In field barrel leachate, dissolved aluminum, arsenic, chromium, copper, iron, selenium, and zinc concentrations frequently exceeded BC guidelines under neutral leaching conditions.

3.5.2.2 Coal

Static Tests

The same static tests used for waste rock samples were applied to coal samples. Results were analysed by seam, by material, and by mine block. No significant trends in spatial variability were identified between samples of different mine blocks within the same coal seams.

Paste pH values of coal samples were typically near-neutral to alkaline. Sulphur content and NP were variable among seams, and as a result the ML/ARD potential of the coal seams was variable. Sulphur was present typically in sulphide sulphur form, with pyrite the dominant sulphide mineral. Sulphide sulphur concentrations were below 1.0% in the majority of samples. Sulphur concentrations were typically highest in D seam, and were higher in fine coal reject than CCR or raw coal.

Calcite, dolomite-ankerite, and siderite were all identified as carbonate minerals present in coal seams. Dolomite was typically more abundant than calcite, and siderite was most abundant in J seam samples. Inorganic carbon concentrations, carbonate mineral content, and NP values were typically highest in G/I seam, and lowest in E seam.

Similarly to waste rock, the modified Sobek and iron carbonate corrected inorganic carbon NP methods were determined to be the most appropriate methods for quantification of NP in coal samples.

Approximately 46% of coal samples were classified as PAG, corresponding to approximately 44% of the total mass of coal to be mined, for an estimated total mass of 64.7 Mt of PAG raw coal. The coal seams with the highest potential for ARD were D seam (an estimated 6.1 Mt of material classified as PAG) and E seam (60.0% of samples classified as PAG, for an estimated PAG mass of 14.7 Mt). F and J seams had a moderate potential for ARD, with 35.1% and 45.7% of samples, respectively, classified as PAG. G/I seam had the lowest potential for ARD (17.4% of samples classified as PAG). The largest mass of coal will be mined from J seam under the current mine plan, with 75.1 Mt of J seam projected to be mined, of which 40.8 Mt are estimated to be non-PAG.

As was observed in waste rock, sulphide content of coal samples appears to have a stronger influence over SNPR values than the NP. The exception is in G/I seam, which has a narrow range of sulphide sulphur concentrations and a much stronger control by NP on SNPR than other seams. Samples from seams other than G/I were typically PAG at sulphide sulphur values above 0.3%.

Variability between seams was typically greater than variability between different materials (such as raw coal and coarse reject) within the same seam, with the most significant intra-seam variation identified between clean coal and other materials. A comparison of average values of sulphide sulphur and modified NP per seam determined a correlation coefficient of 0.8 between raw coal and CCR.

Solid phase elemental abundance results indicated the potential for elevated silver, cadmium, and selenium in all coal seams.

Short-term Leachate Tests

A total of 28 coal samples were submitted for SFE leachate tests. Dissolved aluminum, arsenic, selenium, and vanadium had concentrations above BC dissolved or total guidelines in all coal seams. Dissolved cadmium and antimony concentrations were also frequently elevated. E seam samples had the highest number of elements with concentrations above guidelines, and G/I seam samples had the fewest elevated elements.

Selenium concentrations were elevated in both solid phase and leachate for all seams, and cadmium concentrations were elevated in both phases in samples from D, E, F, and J seams.

Kinetic Tests

The metal release rates for primary weathering of Murray River coal materials were assessed by eight ongoing laboratory kinetic humidity cell tests. As of May 2014, a further 10 humidity cell tests had been running for 10 weeks. No Project coal humidity cells had produced acidic leachate at this time. Estimated lag times based on waste rock humidity cells and other regional coal projects predict currently running PAG E seam and J seam CCR humidity cells will become acid-leaching with lag times of 4.9 to 8.7 years. Currently running D and F CCR and raw coal humidity cells are not predicted to become acid-leaching. Lag time predictions will be further refined with the onset of acidic conditions in the new humidity cells, several of which are PAG.

Laboratory humidity cell leach rates and lag times were scaled for use as inputs for water quality modelling, allowing for predictions of surface and seepage water quality from raw coal and CCR storage areas during Operation and Post-closure, as presented in Appendix 8-E.

Fine reject and CCR humidity cells typically had higher sulphate leach rates than raw coal or clean coal humidity cells. Selenium leach rates correlated with initial selenium concentrations in coal samples, but not with initial sulphide sulphur content. Selenium loadings in coal humidity cells were initially high, and decreased over the first 20 to 30 weeks of leaching before reaching a steady state. The Selenium Management Plan is presented in Section 24.10.

3.5.3 ML/ARD Potential, Management, and Mitigation

3.5.3.1 Waste Rock

The ML/ARD potential of waste rock was variable, due to the significant variation in sulphur content and NP among waste rock formations. ARD potential of waste rock is summarized by formation in Table 3.5-3, with estimated masses of PAG and non-PAG rock calculated from the masses of proposed waste rock.

The Hasler and Hulcross formations have the highest ML/ARD potential. Waste rock from the Boulder Creek Formation showed the most variability in carbonate and sulphide content, with PAG samples predominantly composed of mudstone and conglomerate material with high sulphur content and low carbonate. Sandstone and siltstone samples from the Boulder Creek Formation were typically non-PAG with high SNPR values.

Table 3.5-3. Waste Rock Acid Rock Drainage Potential Summary

Formation	Overburden	Hasler	Boulder Creek	Hulcross	Gates Formation	
Mass proposed waste rock (kt)	31	238	42	43	129	
Number ABA Samples	7	45	30	31	32[1]	22[2]
ARD Potential†						
PAG Proportion	14.3%	86.7%	30.0%	90.3%	18.5%	
Non-PAG Proportion	85.7%	13.3%	70.0%	9.7%	81.5%	
Estimated PAG Mass (kt)	4.5	206	12.6	38.7	23.9	
Estimated Non-PAG Mass (kt)	26.8	31.7	29.5	4.1	105	

† ARD potential is based on SNPR, where SNPR ≥ 2.0 = non-PAG, SNPR < 2.0 = PAG

[1] *Upper Gates Formation samples*

[2] *Middle Gates Formation interburden samples*

Waste rock from the Gates Formation, where the coal seams are hosted, typically had a low potential for acid generation, excluding wall and parting material directly in contact with the seams. Overall, as the declines are constructed, the earliest waste rock to be excavated will have the highest ML/ARD potential. The largest mass of PAG waste rock will be from the Hasler Formation. Waste rock that is classified as PAG (predominantly the Hasler, Boulder Creek, and Hulcross formations) will be hauled to the waste rock storage area at the Shaft site, and covered by non-PAG material.

As discussed in Section 3.5.2.1, leachate results from laboratory humidity cell testing indicated lag times to the onset of acid leaching to be between one and four years in the PAG waste rock units. These lag times assume year-round leaching under room temperatures, and therefore should be scaled appropriately to determine leach rates under site-specific conditions in the waste rock pile. As the waste rock pile will be completed and closed following completion of the Production Decline in the first year of Operation, ARD is not expected from the waste rock pile. Field leach barrels operating on site for three years are currently not producing acid drainage.

Management and Mitigation

Management of waste rock at the Project will be consistent with the approved Waste Rock Management Plan for the Bulk Sample collection, as detailed in the *Murray River Bulk Sample: Waste Discharge Permit Application Technical Assessment Report* (Rescan 2011). Based on the results of geochemical characterization during baseline studies, the stratigraphic formations that will be excavated were operationally classified as PAG or non-PAG. Waste rock from the Hasler, Boulder Creek, and Hulcross formations was operationally defined as PAG material, while overburden material and waste rock from the Upper and Middle Gates formations were defined as non-PAG.

Waste rock material generated during the Bulk Sample work and the construction of the Production Decline will be segregated based on these operational definitions. Waste rock that is operationally classified as PAG will be hauled to the waste rock storage area at the Shaft Site. Waste rock from the formations classified as non-PAG will be placed on temporary stockpiles and sampled for ABA and SFE. Once analytical results have been received, this material will be segregated by ARD potential. PAG material will be disposed of to the waste rock pile, and non-PAG material will remain at the

Coal Processing Site for use as fill and cover material in the CCR piles. Some non-PAG waste rock may be used for fill material and grading of the Shaft Site.

Once the Production Decline is completed, the waste rock facility will be closed and reclaimed. The waste rock pile will be covered in a till layers and a clay liner or geomembrane to prevent water infiltration into the pile.

Waste rock produced during Operation will remain underground, or be transported to the Coal Processing Site and used as fill and cover material in the CCR piles. Material that is expected to be PAG, based on operational classifications, data collected for the geochemical inventory, and additional geochemical sampling, will be preferentially stored underground.

Waste rock sampling and analysis for a geochemical inventory is currently ongoing as part of the permitted Bulk Sample program, and will assist with further refinement of the operational classifications of waste rock.

The management and mitigation of ML/ARD from the waste rock storage area is further detailed in the ML/ARD Management Plan (Section 24.7).

3.5.3.2 Coal

Acid rock drainage potential of coal material is summarized by coal seam in Table 3.5-4, with estimated masses of PAG and non-PAG rock calculated from the masses of proposed coal to be mined.

Table 3.5-4. Coal Acid Rock Drainage Potential Summary

Seam	D	E	F	G/I	J
Mass proposed coal (kt)	9,000	13,600	42,000	8,200	75,100
Number ABA Samples	37	20	37	23	35
ARD Potential†					
PAG Proportion	67.6%	60.0%	35.1%	17.4%	45.7%
Non-PAG Proportion	32.4%	40.0%	64.9%	82.6%	54.3%
PAG Mass (kt)	6,080	8,160	14,700	1,430	34,300
Non-PAG Mass (kt)	2,920	5,440	27,300	6,770	40,800

† ARD potential is based on SNPR, where SNPR ≥ 2.0 = non-PAG, SNPR < 2.0 = PAG

Overall, coarse and fine reject material from D and E seams contains the highest potential for ML/ARD. F and J seam samples had a moderate to low potential for acid generation, and G/I seam samples had a low potential for acid generation. CCR, tailings, and raw coal material had a moderate potential for metal leaching, while clean coal samples had a low potential for metal leaching.

As discussed in Section 3.5.2.2, leachate results from laboratory humidity cell testing indicated lag times to the onset of acid leaching to be between 4.9 and 6.7 years in PAG samples of CCR, while non-PAG samples are not expected to become acid leaching. These lag times assume year-round leaching under room temperatures, and therefore should be scaled appropriately to determine leach rates under site-specific conditions in the CCR piles and the raw coal stockpiles.

Management and Mitigation

Raw coal will be stored in two stockpiles at the Coal Processing Site in advance of coal handling and preparation. Once raw coal has passed through the CPP, clean coal and middlings will be stockpiled near the rail loadout station prior to removal from the Project site. Coarse and fine reject will be co-mingled and stored in two CCR piles. CCR North will be operated for the first 14 years during Operation, and CCR South will serve for the next 11 years of Operation. Coal stockpiles and CCR piles will have liners to prevent chemical loading to groundwater from the piles.

Samples will be collected from the raw coal stockpiles and analysed for ABA and SFE, and a geochemical inventory of raw coal material will be maintained. As discussed in Section 3.5.2.2, raw coal and CCR results were well-correlated, and therefore geochemical analyses of material in raw coal stockpiles will guide placement of material in the CCR piles. As raw and clean coal stockpiles have expected maximum turnover times of two weeks, ARD is not expected from those stockpiles, based on leach rates and lag times from laboratory humidity cell testing.

To manage and mitigate ML/ARD from coarse and fine rejects, the CCR piles will be lined with a geomembrane liner, and PAG and non-PAG rejects will be co-deposited using blending. The reducing environment in the piles, with high moisture and organic carbon content and low permeability, will limit the availability of oxygen for the oxidation of sulphides, and likely promote selenium attenuation and retention in the pile.

Material from D and E seams contains the highest potential for ML/ARD. As these seams are predominantly scheduled to be mined in the five years of the current mine plan, PAG material from these seams will be placed at the toe of the CCR North pile, and subsequently will be encapsulated with net neutralizing reject and waste rock, reducing the potential for ML/ARD. Median NP and sulphide sulphur values for each seam were weighted by the proportion of material from each seam in the CCR piles, and used to calculate SNPR values in the two CCR piles. The progressive change in total SNPR of each CCR pile is summarized in Table 3.5-5, indicating that net neutralizing conditions will exist in CCR North after the first five years of mining, with the progression of mining from the PAG D and E seams to predominantly non-PAG coal seams. Based on currently estimated laboratory humidity cell lag times, the first five years of mining will not be long enough for the material in CCR North to become acid-generating. ARD is not expected from the CCR South pile.

The CCR North and CCR South piles will be closed and reclaimed at the end of Years 14 and 25, respectively. The piles will be covered with a layer of non-PAG fine reject to serve as a low permeability liner (Section 3.9.4.1). Topsoil will be spread over the fine reject cover, and re-vegetated. The fine reject and topsoil cover will have sufficient water storage capacity for both annual precipitation and snowmelt, and will therefore effectively limit infiltration to the CCR piles.

Additional sampling and analysis of coal materials during the permitted Bulk Sample program will assist with continued geochemical characterization of coarse and fine rejects and refinement of the management strategy for the CCR piles. The details of management, monitoring, and mitigation of ML/ARD from the raw and clean coal stockpiles and the CCR piles are presented in the ML/ARD Management Plan (Section 24.7).

Table 3.5-5. Annual Change in Sulphide Net Potential Ratio of the CCR Piles

CCR North Pile		CCR South Pile	
Mine Year	Annual Total SNPR	Mine Year	Annual Total SNPR
1	1.7	15	4.7
2	1.7	16	3.8
3	1.8	17	3.5
4	2.0	18	3.4
5	2.0	19	3.3
6	2.0	20	3.3
7	2.1	21	3.2
8	2.2	22	3.2
9	2.3	23	3.2
10	2.3	24	3.2
11	2.4	25	3.1
12	2.4		
13	2.6		
14	2.8		

3.6 DESIGN AND PLANNING

3.6.1 Overview

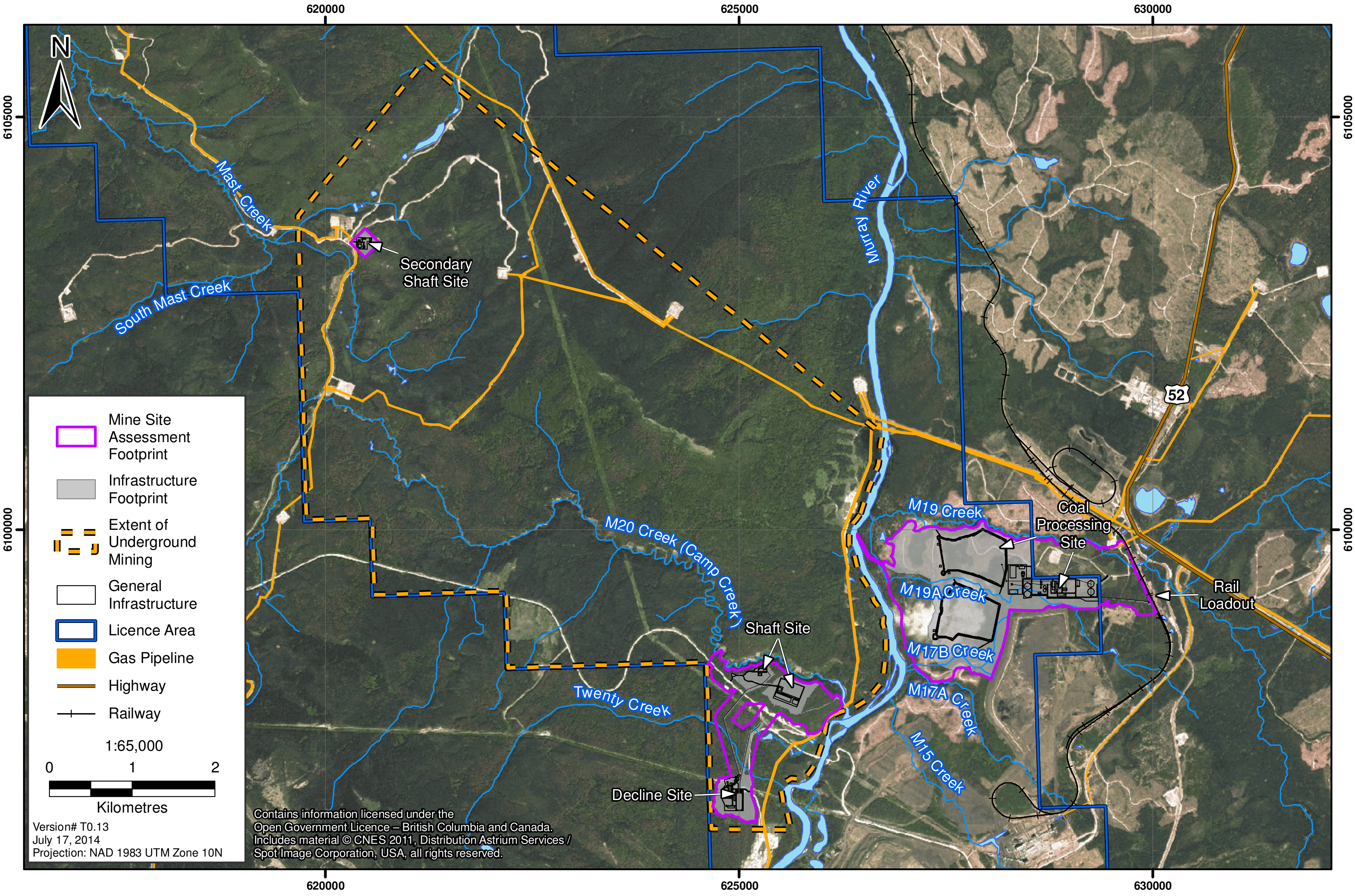
In October 2011, Shenyang Design & Research Institute of Sino-coal International Engineering Group (Shenyang) prepared a Prefeasibility Study on the Project. The senior management of HD Mining updated the information in the Prefeasibility Study and the revised information has been incorporated into the Project Description

The Project is located 12.5 km southwest of the town of Tumbler Ridge, BC. Tumbler Ridge is accessible via Highways 29, 97, and 52. The Project is accessed from Highway 52 (Heritage Highway), and the existing Quintette / Murray River Forest Service Road.

Total saleable coal production of 4.8 Mtpa is planned, with underground mine capacity of 6.0 Mtpa of ROM. As outlined in Section 3.4.2, the extractable mineral reserve is 261.6 Mt. However, at this report, the proposed life of mine will be 25 years with total mined reserve of 210 Mt, leaving one coal block as reserved for further exploration and developed after 25 years.

The proposed Project site general layout is shown in Figure 3.6-1, and the underground mine development plan is delineated in Figure 3.6-2. The site is divided into five (5) areas: Decline Site, Shaft Site, Coal Processing Site, Secondary Shafts Site, and Underground Mine. Table 3.6-1 summarizes the main Project components relative to these five areas.

Figure 3.6-1
General Project Layout - Surface Facilities



Version# T0.13
July 17, 2014
Projection: NAD 1983 UTM Zone 10N

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Figure 3.6-2
Underground Mine Development

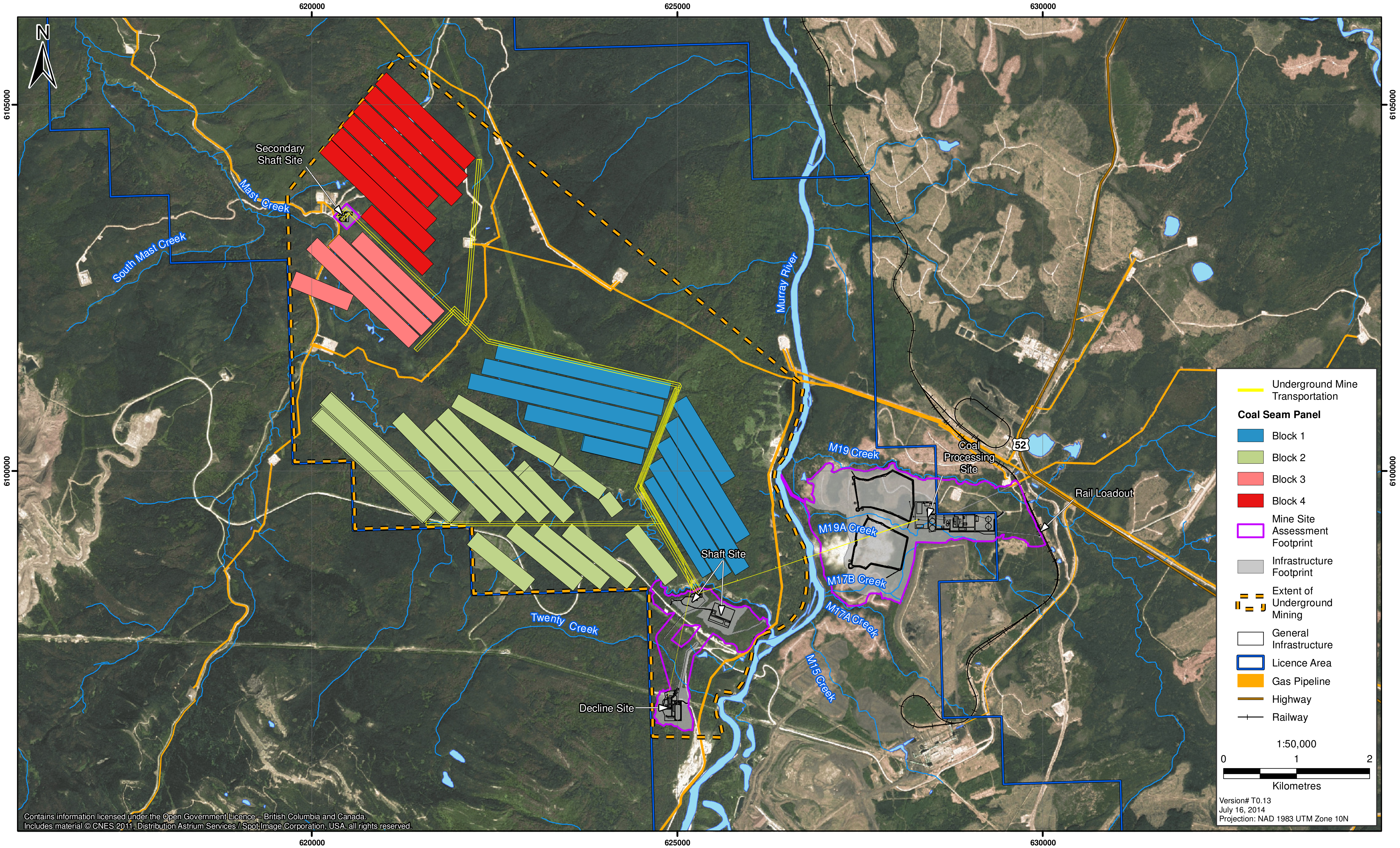

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Table 3.6-1. Project Components

Project Component	Decline Site	Shaft Site	Coal Processing Site	Secondary Shafts Site	Underground Mine
Underground mine and associated works (e.g., main access shaft, ventilation shaft for return air, ramps, portals, tunnels)	-	-	-	-	X
Waste rock storage facilities	-	X	-	-	-
Overburden and soil storage areas	X	X	X	X	-
Coal rejects storage area	-	-	X	-	-
Equipment and fuel storage areas and facilities	X	X	X	-	X
Maintenance, administration and warehouse facilities	X	-	X	-	X
Coal handling and preparation facilities (e.g., washing plant)	-	-	X	-	-
Coal conveyors	-	-	X	-	X
Rail loadout	-	-	X	-	-
Contact water collection ditches, sedimentation pond(s) and water management structures, including a discharge pipeline	X	X	X	-	-
Non-contact water diversion ditch network and sedimentation pond(s)	X	X	X	-	-
Water supply facilities (e.g., groundwater extraction well)	X	-	X	-	-
Sewage treatment and disposal facilities	X	-	X	-	-
Electricity transmission line connecting to the existing BC Hydro grid and related infrastructure	X	-	-	-	-
Natural gas pipeline connecting to existing infrastructure and related sub-station infrastructure	-	-	X	-	-

The above-listed Project components will be permanent throughout the life of the Project. On-site accommodation for mine employees will not be required as all employees will live off site in Tumbler Ridge.

3.6.2 Underground Mine

3.6.2.1 Coal Seams

Seven main coal seams (B, C, D, E, F, G/I, and J) were identified during exploration (Appendix 3-A). The main workable coal seams of the mine are seams D, E, F, G/I, and J. Seams D and E are thin or moderately-thick, F and J are moderately thick, whereas G/I is very thin and therefore not targeted. The total distance between the coal seams is 80 to 120 m. In order to achieve the mine's production capacity, seams F and J are designed as the main mining seams, and seams D and E are the auxiliary mining seams.

Coal Seam D

Seam D is the first workable seam. The roof rock is generally mudstones overlain by conglomerate. The seam is continuous with good quality coal, but the coal thickness can vary significantly from tens of centimetres to more than 5 m. The average thickness is 2.12 m.

Coal Seam E

Seam E is located 15 to 30 m below seam D. The interburden between seams D and E is siltstones and fine-grained sandstones. Seam E thickness ranges from several centimetres to 8 m, with an average thickness of 2.32 m.

Coal Seam F

Seam F lies about 20 m beneath seam E. It is a continuous, thick coal seam of good quality. There are most likely multiple-layer sub-seams within this seam. The thickness is between 0.67 m and 7.07 m with an average of 3.46 m.

Coal Seam G/I

The G and I seams are typically referred to as the G/I seam, as the two seams are often coalesced. This seam is continuous, stable and partly workable at a variety of thickness from 0.40 m to 3.52 m. The average thickness of this seam is 1.60 m.

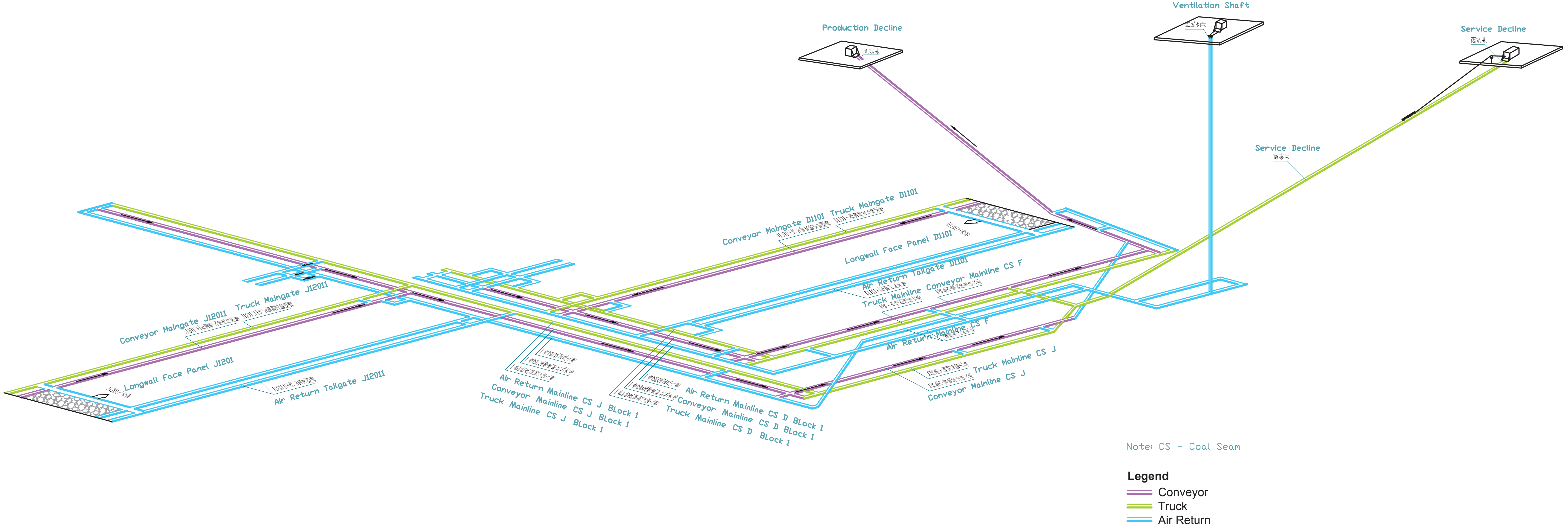
Coal Seam J

Seam J is 20 m underneath Seam G/I. It is also the thickest and most widely distributed seam. The thickness is from 2.60 m to 9.20 m with an average of 6.19 m.

3.6.2.2 Access and Egress

Initially, two declines and a shaft will be constructed to provide access to the coal seams from surface (Figure 3.6-3 and Table 3.6-2). The decline being constructed for the Bulk Sample (Decline Site) will continue to be used for the full mine development. It will serve as the main entry for personnel and materials, as well as a fresh air intake. The shaft planned for the Bulk Sample (Shaft Site) will also continue to be used for the full mine development, serving as the return air shaft for ventilation. A new Production Decline will be constructed from the east side of the Murray River (Coal Processing Site) down toward the base of the shaft. The Production Decline will be the primary means of hauling coal to the surface for processing. It will also provide an alternative route for transport of personnel and materials, and serve as a fresh air intake. Later in the mine life, two more ventilation shafts will be sunk (Secondary Shafts Site): one for fresh intake air; another one for return air.

Figure 3.6-3
Mine Access and Egress



Source: Shenyang Institute.

Table 3.6-2. Characteristics of Shafts and Declines

Items		Production Decline	Service Decline	Ventilation Shaft	Secondary Air Intake Shaft	Secondary Air Return Shaft
Coordinates (m)	North (Y)	6,099,337	6,096,923	6,098,170	6,103,504	6,103,489
	East (X)	628,292	624,871	625,092	620,409	620,459
Head elevation (masl)		837.5	786.1	+848	+1,102	+1,102
Azimuth (°)		72°00'00"	191°59'41"	-	-	-
Dip (°)		16°00'00"	16°00'00"	90°00'00"	90°00'00"	90°00'00"
Level elevation (m)	Initial	＋255	＋358	＋358	+252	+252
	Final	＋255	＋358	＋358	+252	+252
Length (m)	Initial	2,128	1,547	490	850	850
	Final	2,128	1,547	490	850	850
Diameter (net width) (m)	Net Value	5.5	5.5	6.5	6.5	6.5
	Excavated	6.3/5.72/5.65 [1]	6.3/5.72/5.65	8.1/7.7	8.0/7.5	8.0/7.5
Cross section (m^2)	Net Value	19.6	19.6	33.2	33.2	33.2
	Excavated	25.2/22.2/22.2	25.2/22.2/22.2	51.5/46.5	50.3/44.2	50.3/44.2
Support	Materials	Reinforced Concrete / Bolts Shotcrete/Steel Arches	Steel Arches / Bolts Shotcrete	Reinforced Concrete / Concrete	Reinforced Concrete / Concrete	Reinforced Concrete / Concrete
	Thickness (mm)	400/110/75	400/110/75	800/600	750/500	750/500
Equipment		Belt Conveyor	-	-	-	-

[1] *Cross section dimensions vary based on rock type: top soil and glacial till/weathered bed rock/stable bed rock.*

Cross sections of the Production Decline are provided in Figure 3.6-4 and Figure 3.6-5. The decline will extend 2,128 m down to Coal Seam F. The portal elevation of the decline will be 837.5 metres above sea level (masl) sloping at 16º, and the bottom elevation will be at 255 masl. The decline will be approximately 360 m below Murray River where they would intersect. The decline will be 5.5 m wide, which provides sufficient space for a 1.6 m wide belt conveyor and a roadway for maintenance vehicles. It will serve as the coal transportation travelway as well as a primary means of emergency exit.

The Service Decline (Figure 3.6-6 and Figure 3.6-7) portal elevation will be 786.1 masl, also sloping at 16º, and 1,547 m long. It will also be 5.5 m wide in cross section and will serve as the primary means of access and egress for the mine.

The Shaft will be 6.5 m in diameter (Figure 3.6-6 and Figure 3.6-8), and 490 m deep. It is worthwhile to note that the original Bulk Sample plan was for a shaft diameter of 9.4 m. With the inclusion of the Production Decline, hoisting is no longer required at the shaft, and ventilation requirements are reduced, allowing for a smaller diameter.

The two secondary ventilation shafts at the Secondary Shafts Site are planned to be sunk at Year 15 of Operation. They will also be 6.5 m in diameter, but as the coal seams are deeper to the north, will extend 850 m deep.

3.6.2.3 Underground Operations Hub

An Underground Operations Hub will be constructed at level +358 masl near the bottom of the Ventilation Shaft and connected with Production Decline via tunnels. It will include areas such as a large equipment assembly shop, truck maintenance shop, central underground mine power substation, main drainage pump station, water sump, first aid facility, equipment/tools room, waiting room, dispatch room, firefighting materials, and equipment warehouse. The layout of the hub is illustrated in Figure 3.6-9.

3.6.2.4 Longwall Mining

HD Mining plans to use the long wall mining method to extract the coal. Longwall mining is designed to maximize extraction rates while maintaining worker safety. This contemporary method has been used for many years at mines around the world, including HD Mining's operating mines in China. Section 4.2 provides additional description of longwall mining in comparison to other methods of underground mining.

Longwall mining is an underground coal mining method where a long wall of coal is mined in a single slice typically 0.6 to 1.0 m thick. An individual Panel of coal that is being mined is typically 1 to 5 km long and 200 to 400 m wide (Figure 3.6-10). Gate roads are driven to the back of each panel before longwall mining begins. The gate road along one side of the Panel providing fresh air and containing the coal clearance conveyor is called the Maingate (or headgate); the road on the other side which carries return (used) air is called the Tailgate.

The Mainlines are the main entry system connecting the declines, shafts and the production areas. Mainline entries are normally a set of three parallel tunnels, consisting of a coal conveyor belt roadway (Conveyor Mainline), a material and personnel transportation roadway (Truck Mainline), and an exhausted return airway (Air Return Mainline). Gate roads are driven off the Mainlines to the back of each Panel before longwall mining begins.

In underground developments where long-term access is required (e.g., Mainlines, head gate, tail gate), roof bolting will be the predominant type of roof support. Based on geotechnical assessment, other methods such as steel arches may be used in areas where additional support is required. At the longwall face, where relatively short-term access is required, hydraulic shield supports will be used (see Section 3.6.2.6).

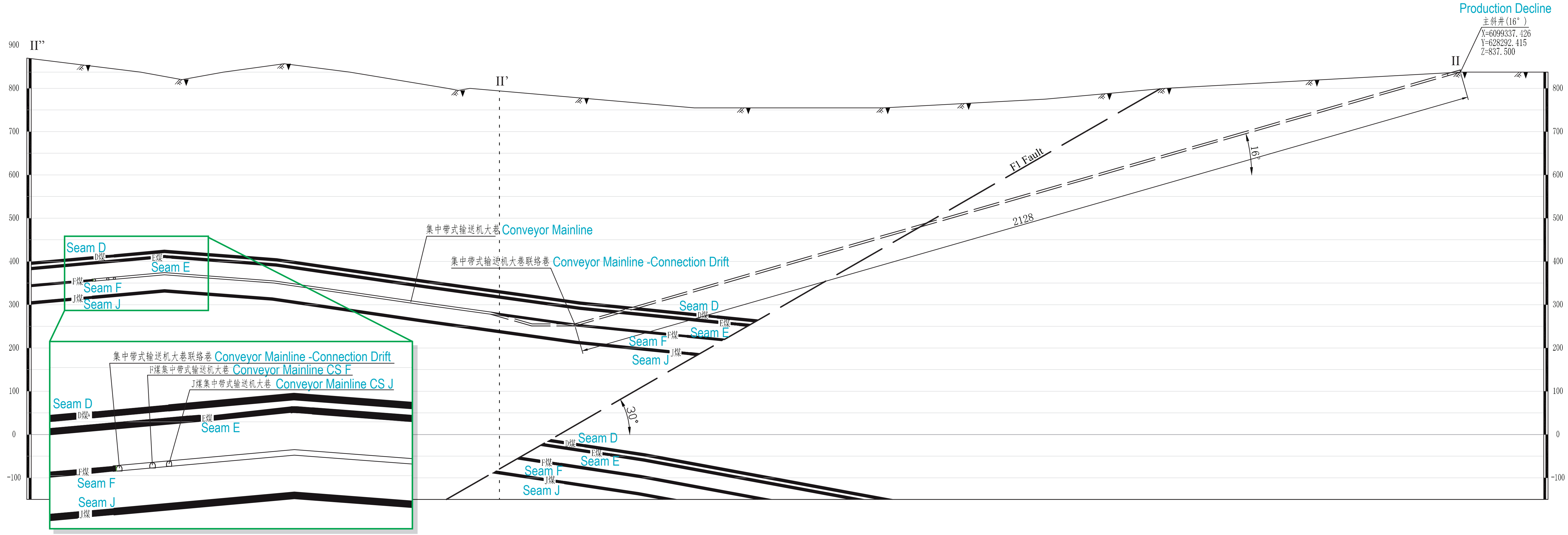
The longwall face is mined back toward the Mainline in retreat fashion. The cavity that is created behind the longwall face is called the gob (also called goaf). For safety reasons, personnel and equipment do not access the gob. Figure 3.6-11 provides a schematic of the principles of typical longwall mining.

For the Project, the mine layout has been designed based on the following general criteria:

- centerline distance between the mainline entries: 25 m;
- coal pillars outside mainline entries: 50 m width;
- coal pillars between Panels: 10 m width in each side;

Figure 3.6-4

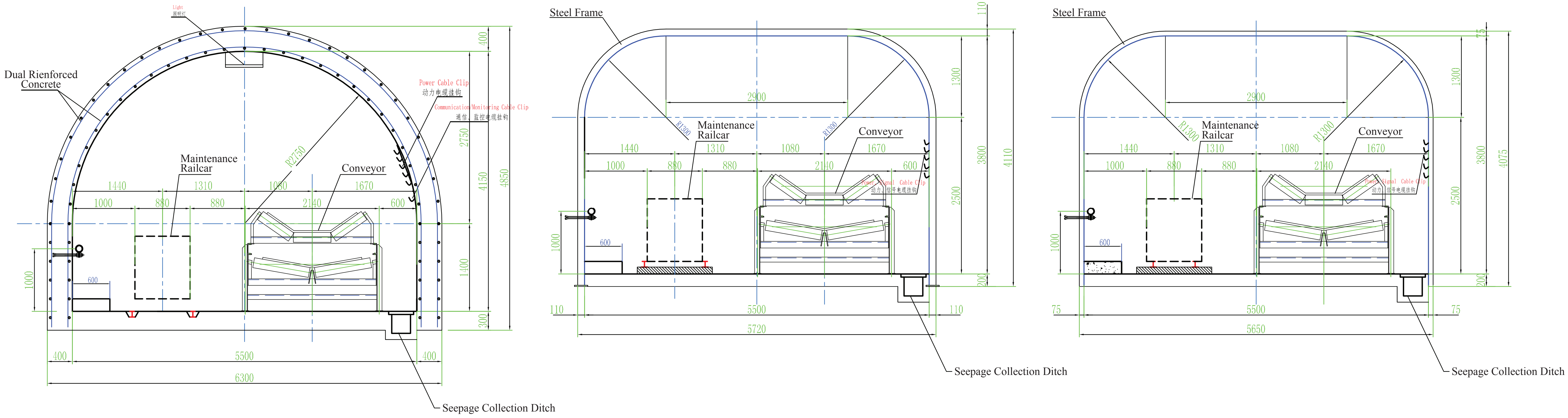
Longitudinal Profile of Production Decline



Source: Shen Yang Institute.

Figure 3.6-5

Cross Sections of Production Decline



Cross Section of Service Decline - Top Soil and Till
副斜井表土及冰渍层断面图

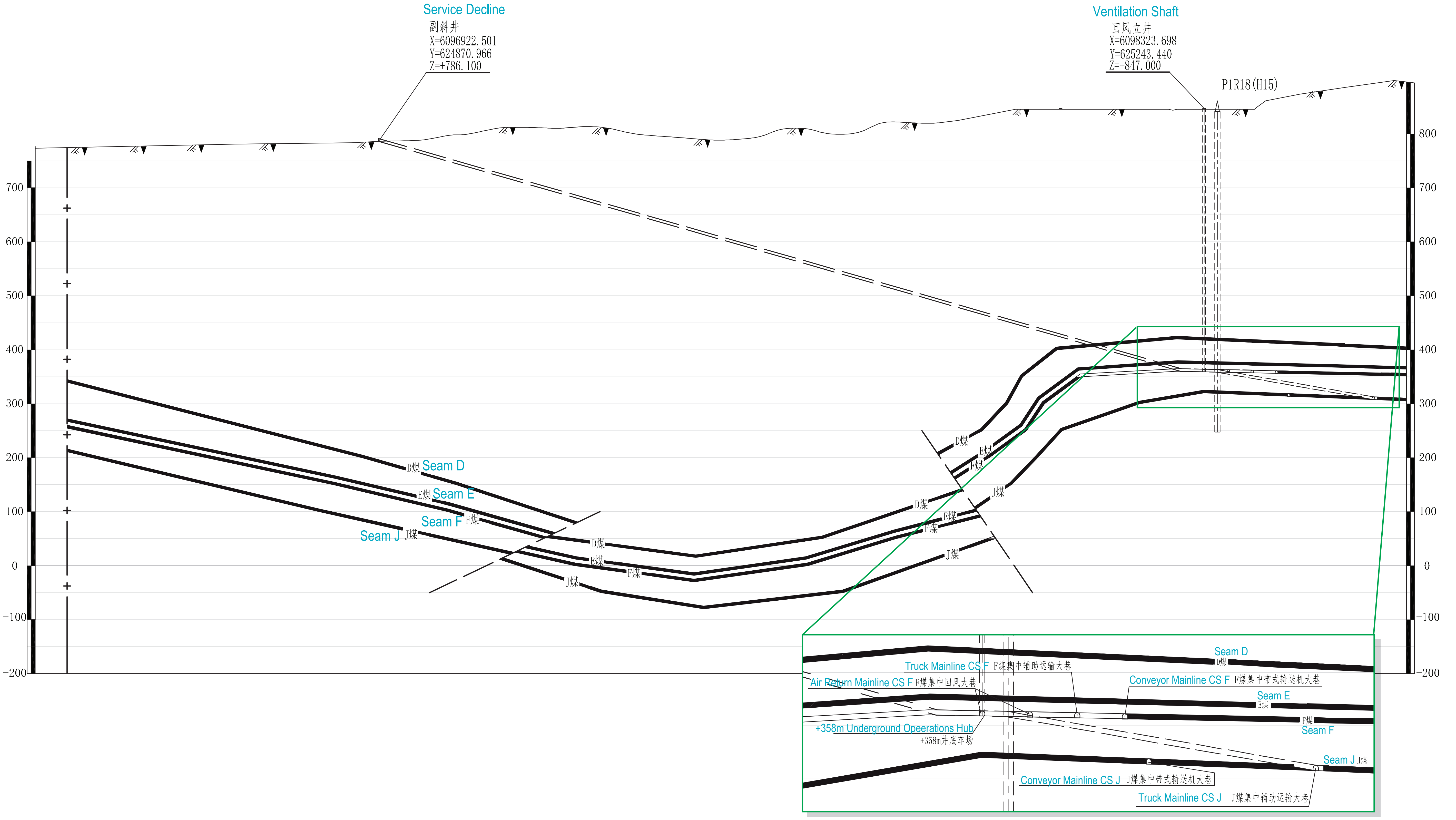
Cross Section of Service Decline - Weathered Bedrock
副斜井基岩风化带断面图

Cross Section of Service Decline - Stable Bedrock
副斜井稳定基岩断面图

Source: Shenyang Institute.

Figure 3.6-6

Longitudinal Profile of Service Decline and Ventilation Shaft

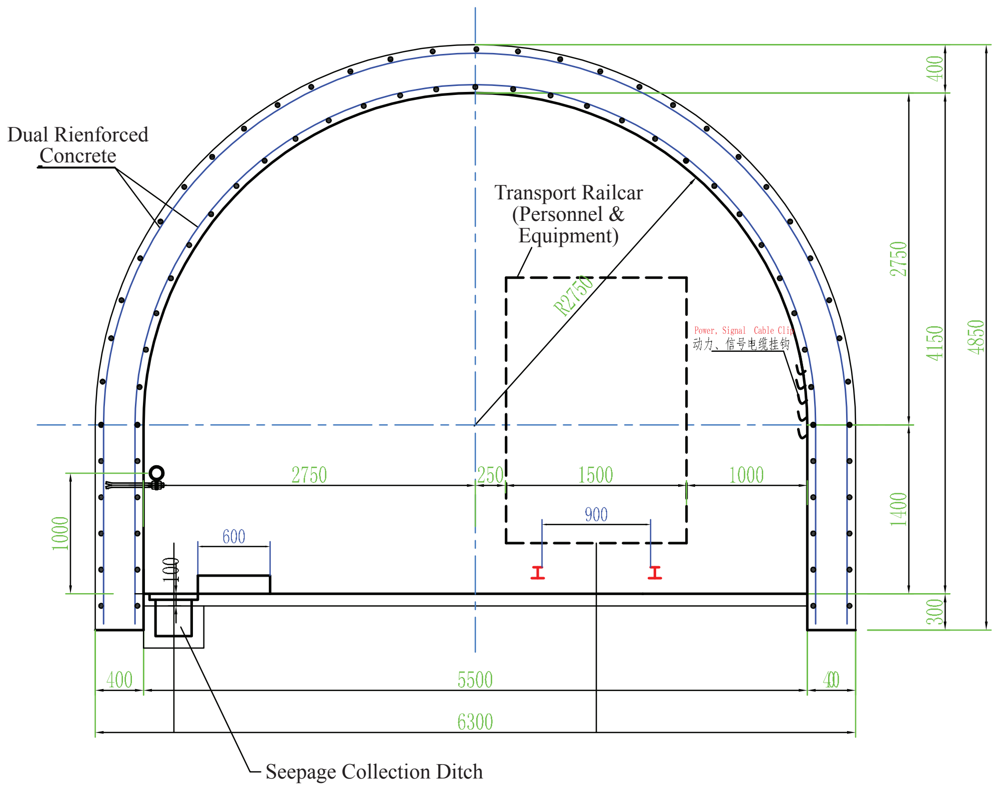


Source: Shen Yang Institute.

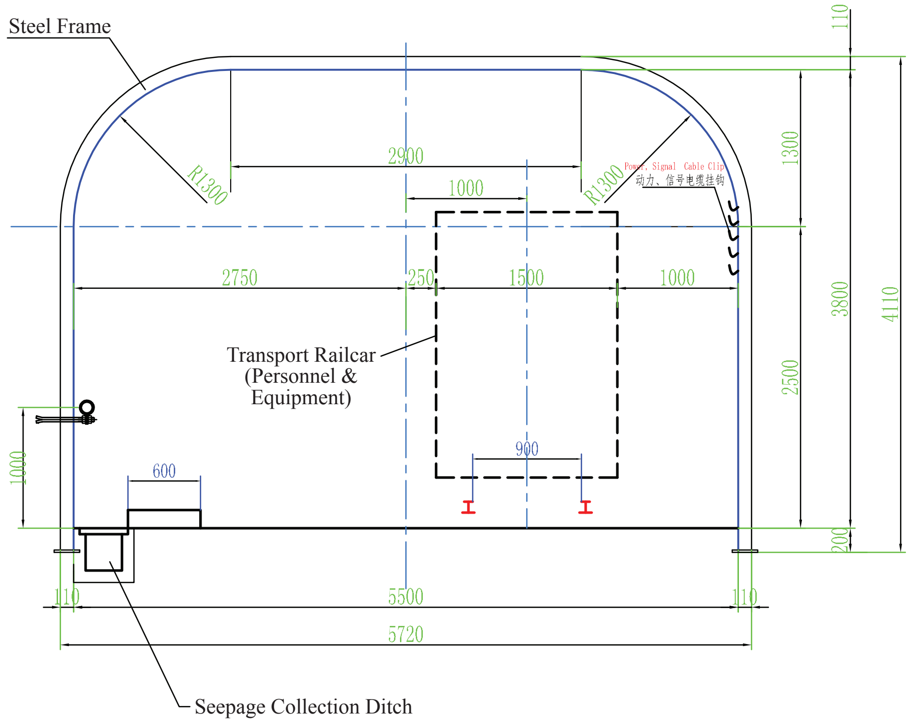
Figure 3.6-7

Cross Section of the Service Decline

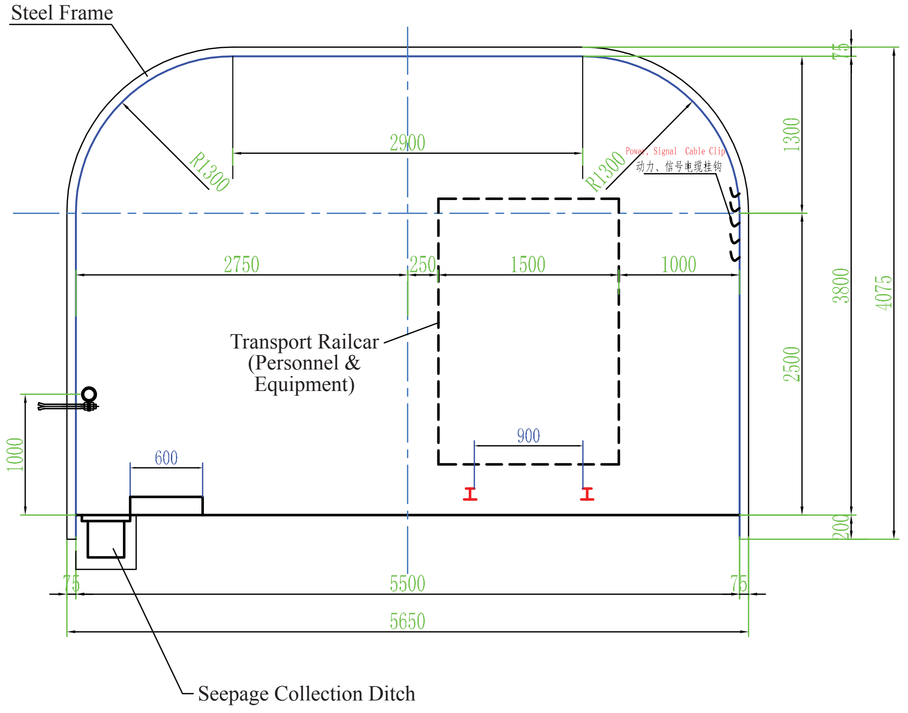
Cross Section of Service Decline - Top Soil and Till
副斜井表土及冰渍层断面图



Cross Section of Service Decline - Weathered Bedrock
副斜井基岩风化带断面图



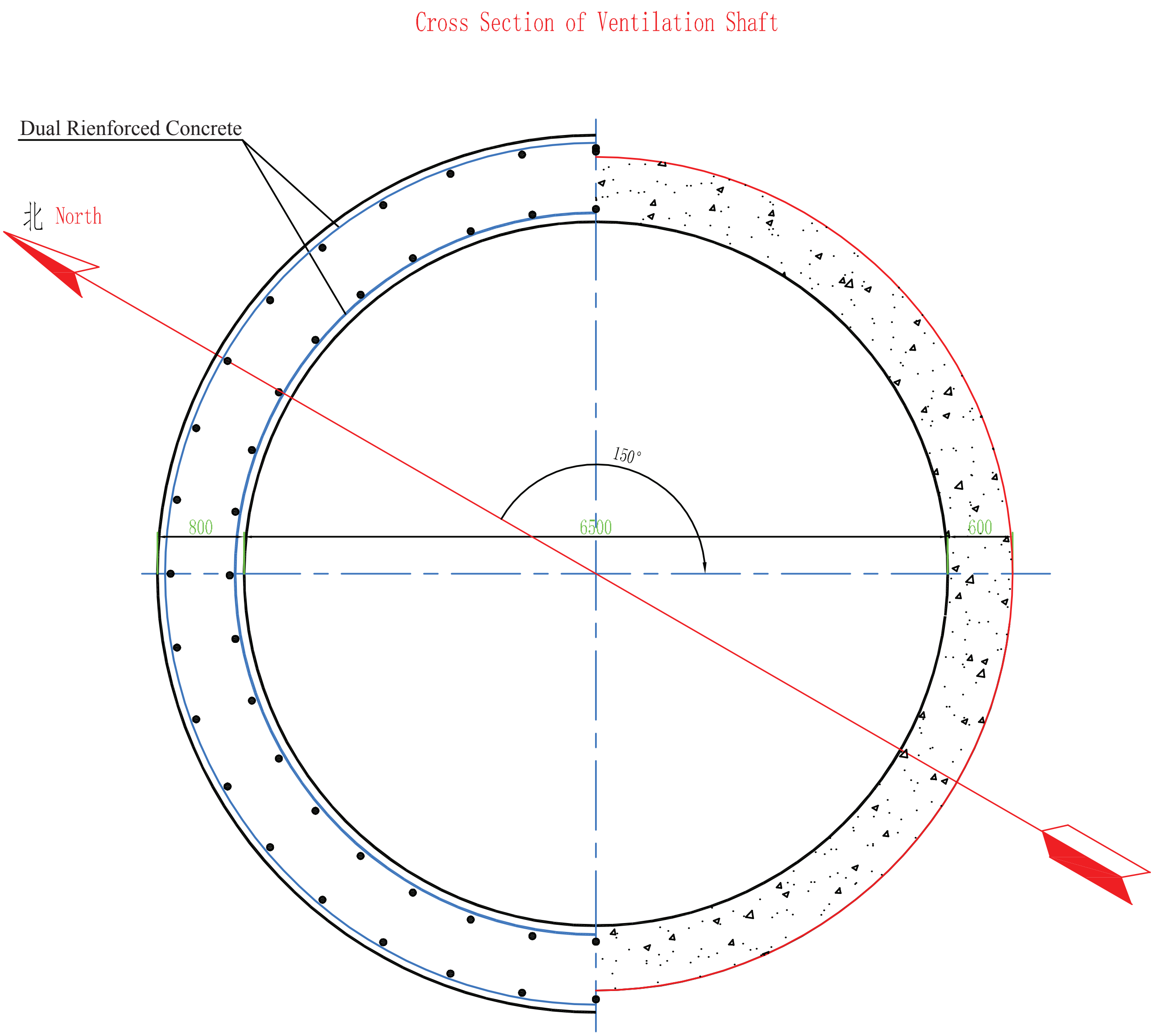
Cross Section of Service Decline - Stable Bedrock
副斜井稳定基岩断面图



Source: Shenyang Institute.

Figure 3.6-8

Cross Section of the Shaft



- centerline between adjacent gateways: 25 m, with coal pillar 20 m width;
- panel width: 220 m; and
- panel length: dependant on coal seam conditions, and range from 800 m to 3,000 m.

Two retreating longwall mining methods will be employed. The typical longwall (TL) mining method will be used for thinner coal seams (e.g., < 4.5 m), and longwall top coal caving (LTCC) mining method for thick coal seams (e.g., > 4.5 m).

The TL mining panel layout is illustrated in cross section in Figure 3.6-12 (A). The coal is mined in web cuts moving into and out of the diagram. Hydraulic shields are used to hold up the roof at the active mining face. The roof materials then collapse behind the shields, creating the gob.

The long wall top coal caving (LTCC) is a special type of longwall mining method applicable to very thick seams where good quality coal would otherwise be left behind. As demonstrated in Figure 3.6-12 (B), the lower section of the seam is cut by a conventional longwall set-up except that the longwall supports have a longer rear canopy extending past the base into the gob. The extended canopies have a sliding door fitted into them. An additional conveyor is attached to the rear of the hydraulic shields and runs directly below the canopy openings. As the working face moves forward, the coal left above the section cut by the machine falls onto the extended canopies. The sliding doors in the canopies are sequentially opened, and the coal falls through onto the rear mounted conveyor.

3.6.2.5 Murray River Mine Layout

The underground area has been divided into four large coal Blocks (Figure 3.6-13), with each Block consisting of 10 to 30 panels in all levels of coal seams. Each block is divided into two wings on either side of the Mainlines. The current underground mine layout includes a total of four Blocks and 84 panels. Where multiple seams are planned to be mined vertically, mining will begin at the shallowest seam (e.g., D Seam), and work downwards.

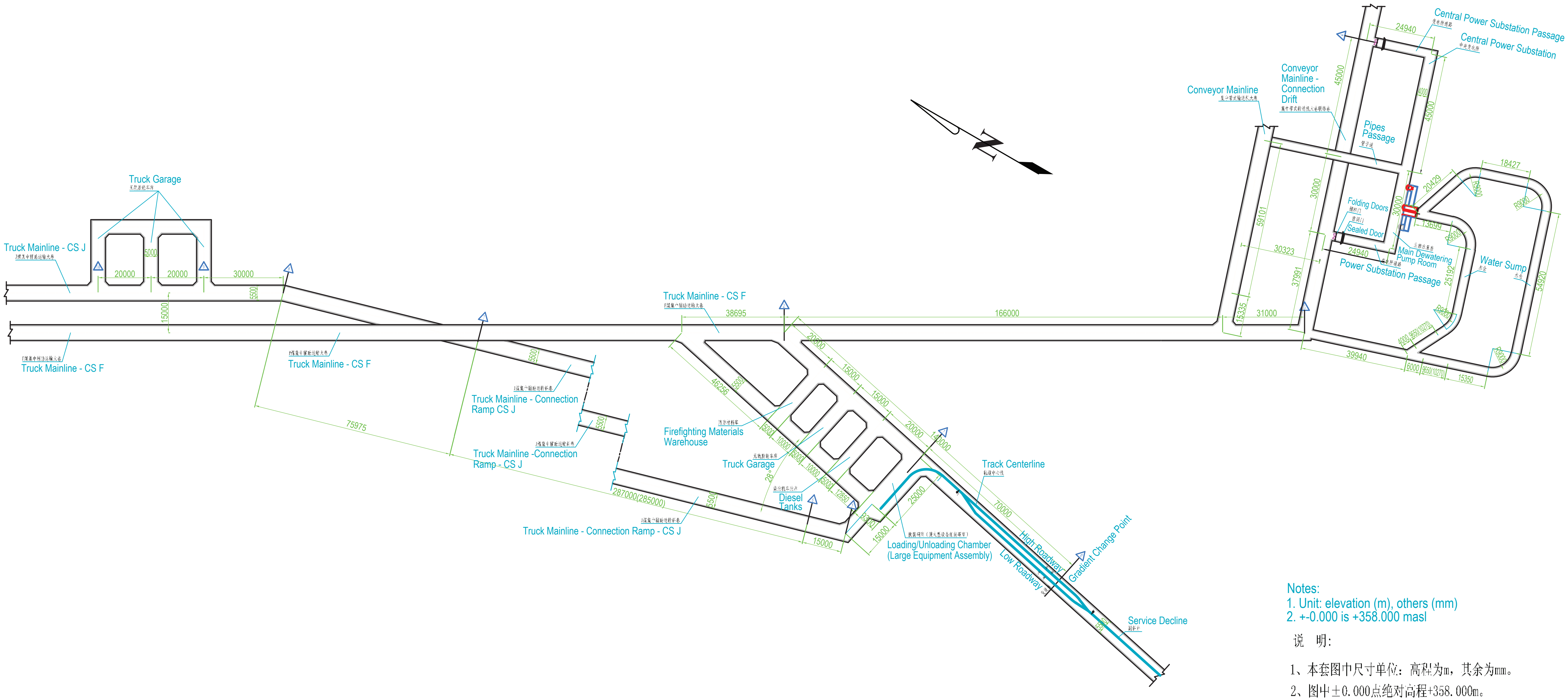
The 6 Mtpa ROM coal mining capacity will be achieved by simultaneously mining two longwall working faces throughout the 25 year life-of-mine. Mining will start with two panels in Block 1: Panel J1201 and Panel D1101. Table 3.6-3 summarizes the details of these two Panels when they are operated at the designed capacities.

Table 3.6-3. Properties of Panels J1201 and D1101+D1102

Panel	Average Coal Seam Thickness (m)	Coal Density (t/m³)	Average Partings Thickness (m)	Partings Density (t/m³)	Average Working Height (m)	Panel Width (m)	Mining Schedule (m/a)	Recovery Rate (%)	Production Capacity (Mtpa)
J1201	4.6	1.36	0.5	2.53	5.1	220	2,640	93	3.75
D1101 + D1102	1.9	1.38	0.2	2.53	2.1	220	3,696	95	2.24

Figure 3.6-9

Plan View of Underground Operations Hub



Notes:
1. Unit: elevation (m), others (mm)
2. +-0.000 is +358.000 masl

说　明:

1、本套图中尺寸单位：高程为m，其余为mm。

2、图中±0.000点绝对高程+358.000m。

Source: Shenyang Institute.

Figure 3.6-10

Typical Longwall Mining Panel Layout and Sequencing (Plan View)

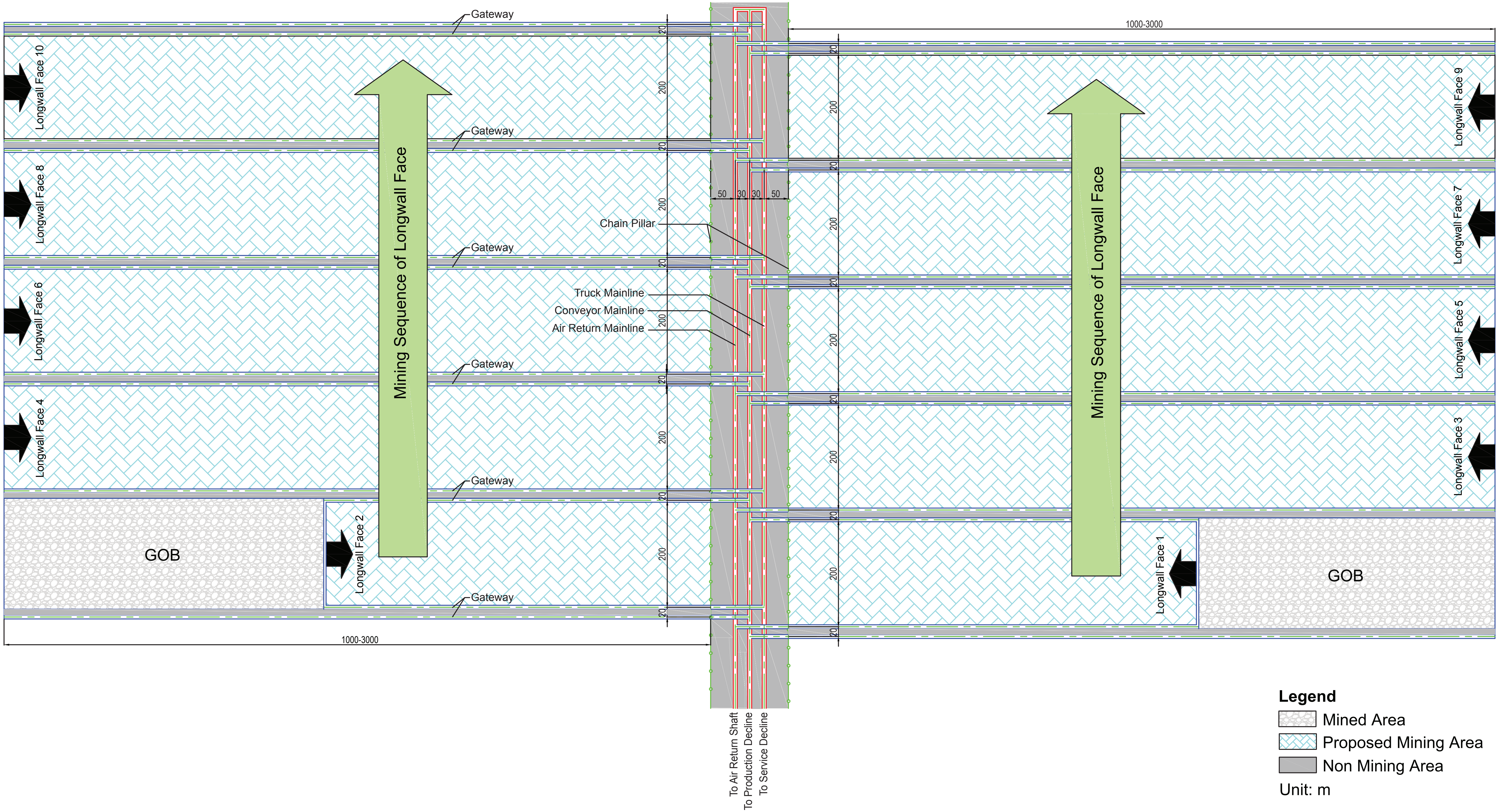


Figure 3.6-11

Typical Longwall Mining Panel Layout (Isometric View)

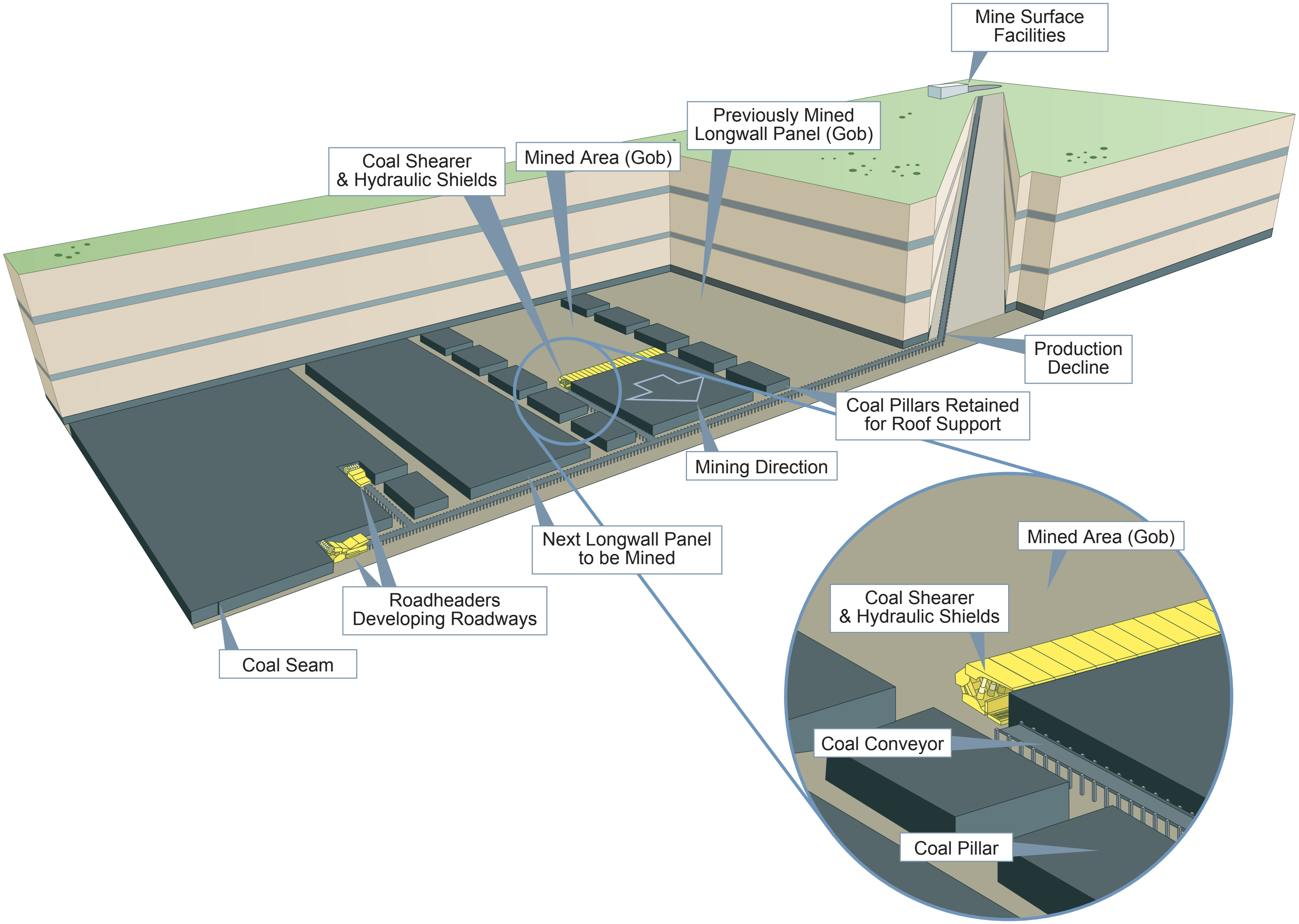
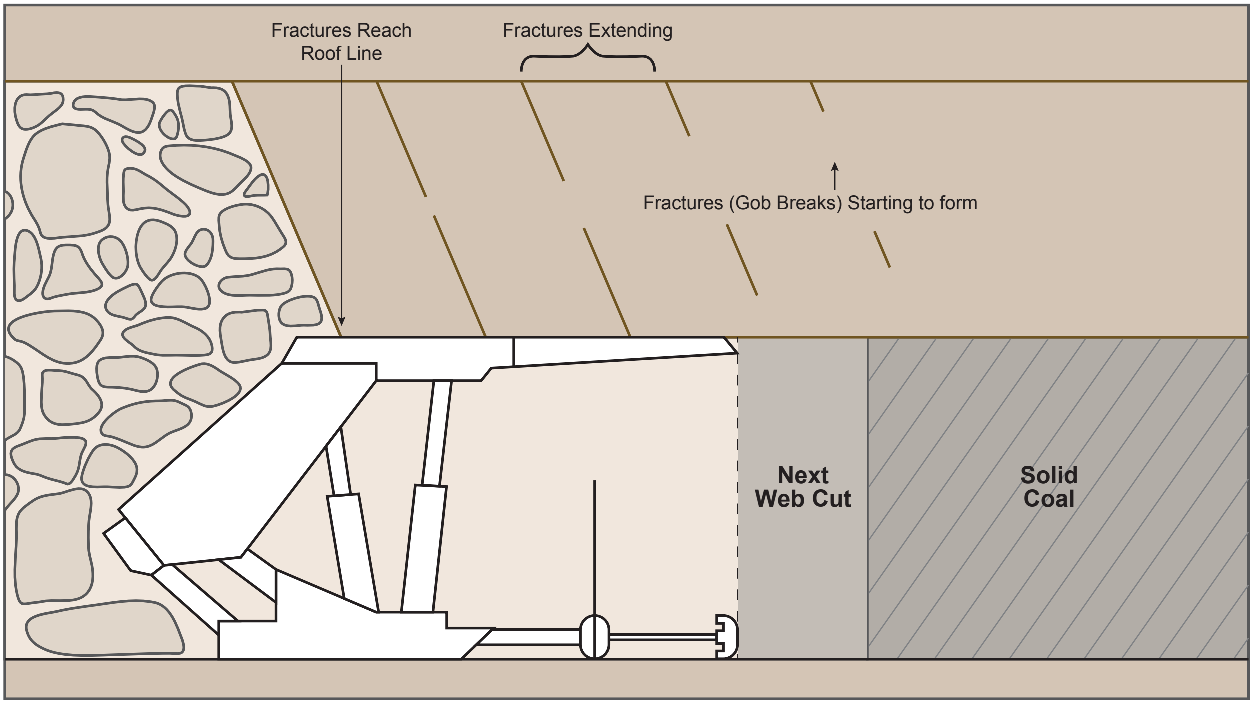


Figure 3.6-12

Principles of Longwall Mining Methods

a) Typical Longwall (TL) Mining Method



b) Longwall Top Coal Caving (LTCC) Method

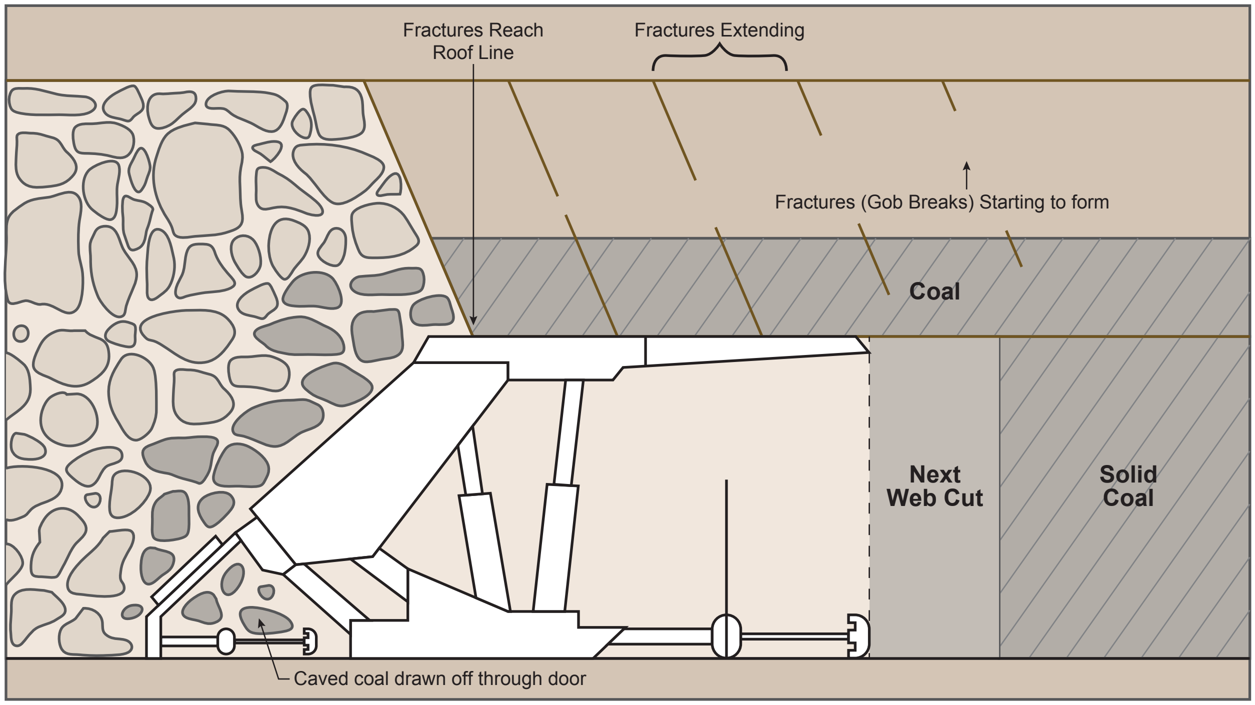
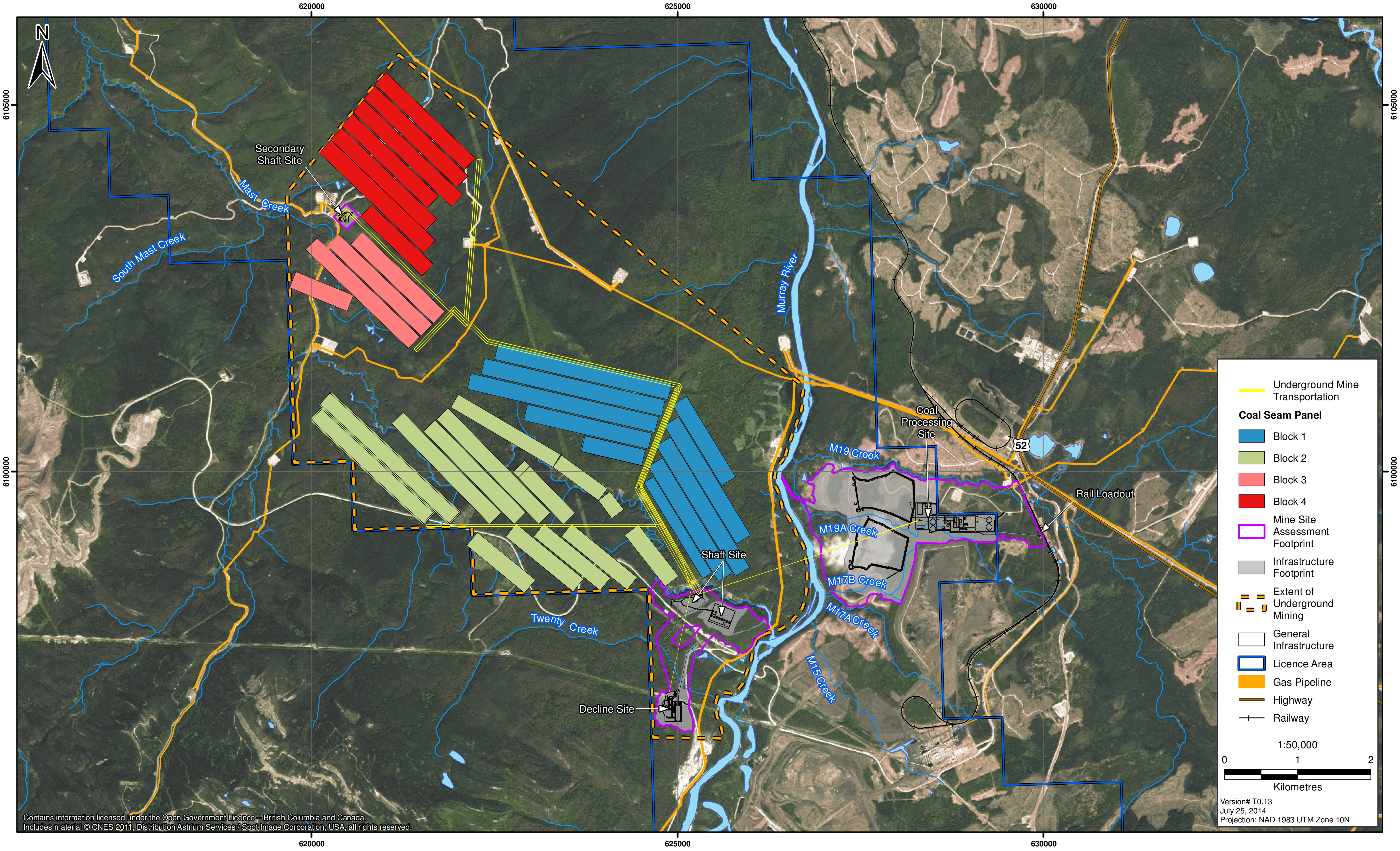


Figure 3.6-13
Coal Blocks Plan View



Version# T0.13
July 25, 2014
Projection: NAD 1983 UTM Zone 10N

3.6.2.6 Mine Equipment

Longwall Mining

As illustrated in Figure 3.6-14, the major equipment required for longwall mining includes:

- Shearer;
- Hydraulic Shields;
- Armored Face Conveyor (AFC);
- Elevating Conveyor (Beam Stage Loader or BSL) and Crusher; and
- Extensible Belt Conveyor.

Shearer

A coal shearer can continually cut the coal from the coalface. A typical coal shearer is illustrated in Plate 3.6-1. It comprises a main body, cutter drum, ranging arm, and cowl. Ranging arms allow for vertical adjustment to follow the coal seam. The cutting drums are fitted with 40 to 60 cutting picks.

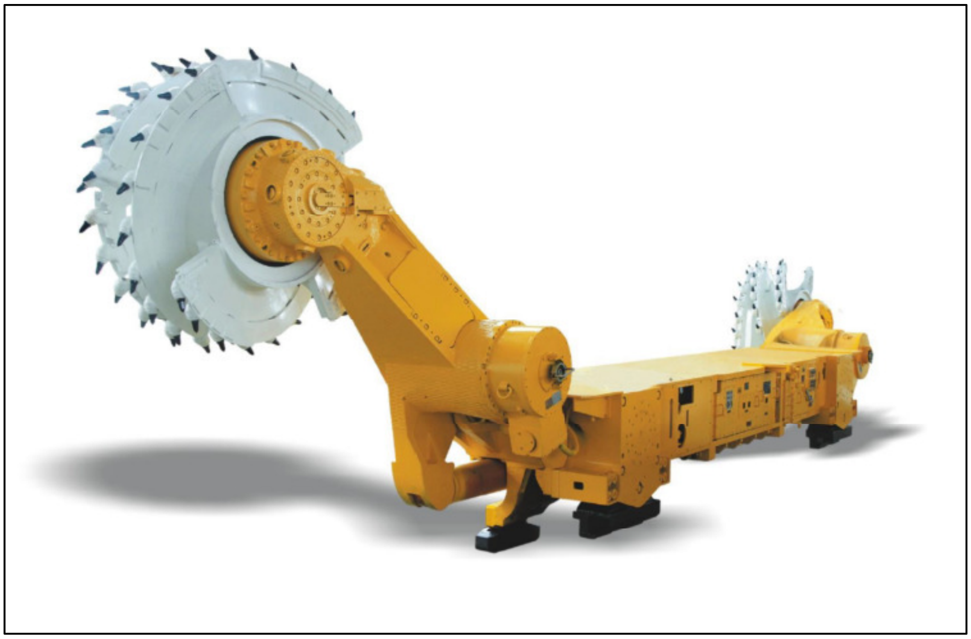
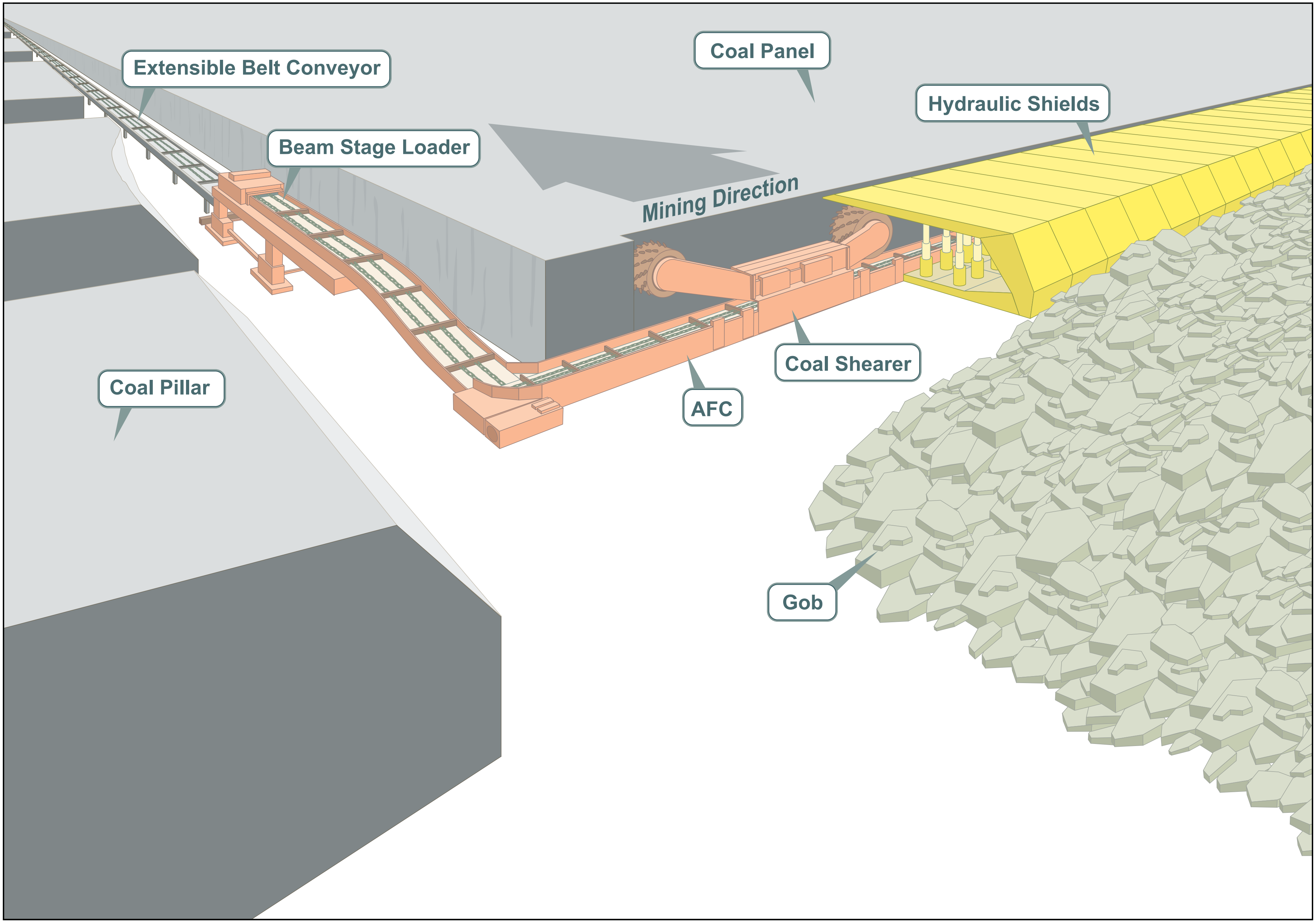


Plate 3.6-1. Typical coal shearer.

Two longwall faces will be mined simultaneously throughout the mine life. A key difference between the two faces will be the capacity of the shearers. Shearer #1 (TL) will be capable of mining coal seam heights from 1.6 m to 2.8 m, and achieving a production rate of 2.25 Mtpa. Shearer #2 (LTCC) will be capable of mining coal seam heights from 2.1 m to 6 m, achieving a production rate of up to 4 Mtpa.

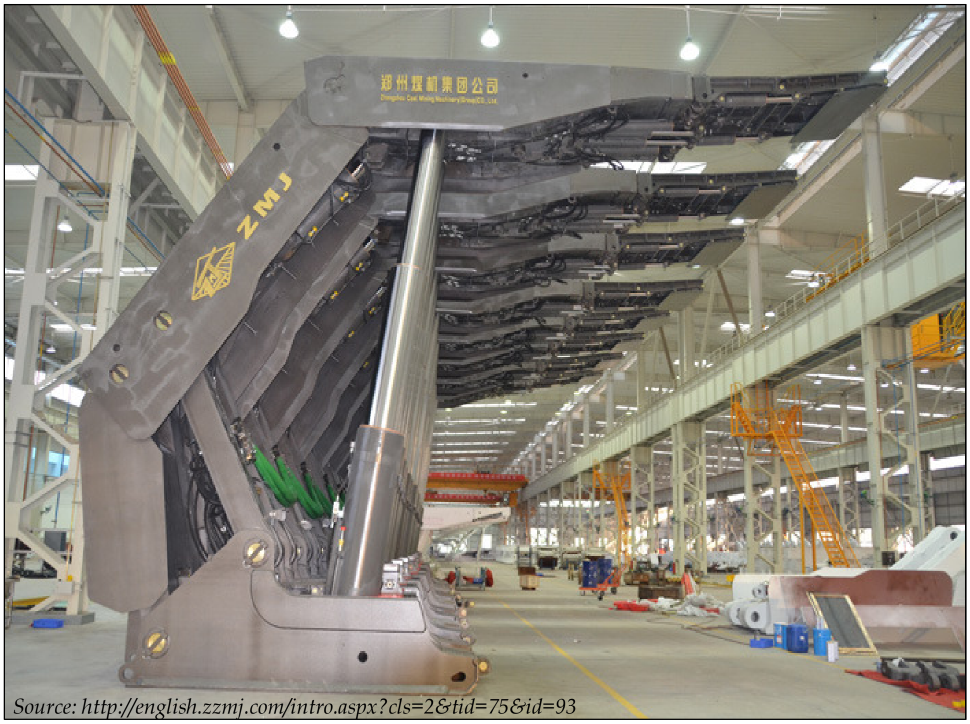
Figure 3.6-14

Perspective View of Longwall Mining System



Hydraulic Shields

Hydraulic shields are used to hold the roof up near the active coal face to allow safe mining. An example is illustrated in Plate 3.6-2. Shields are complex pieces of equipment, with remote control or automated operation, requiring electronic control and monitoring. They are designed to operate through a range of heights to accommodate variations in working heights and possibly some degree of unplanned loss of roof or floor. It is also necessary that they can be closed down low enough to allow transport around the mine.



Source: http://english.zzmj.com/intro.aspx?cls=2&tid=75&id=93

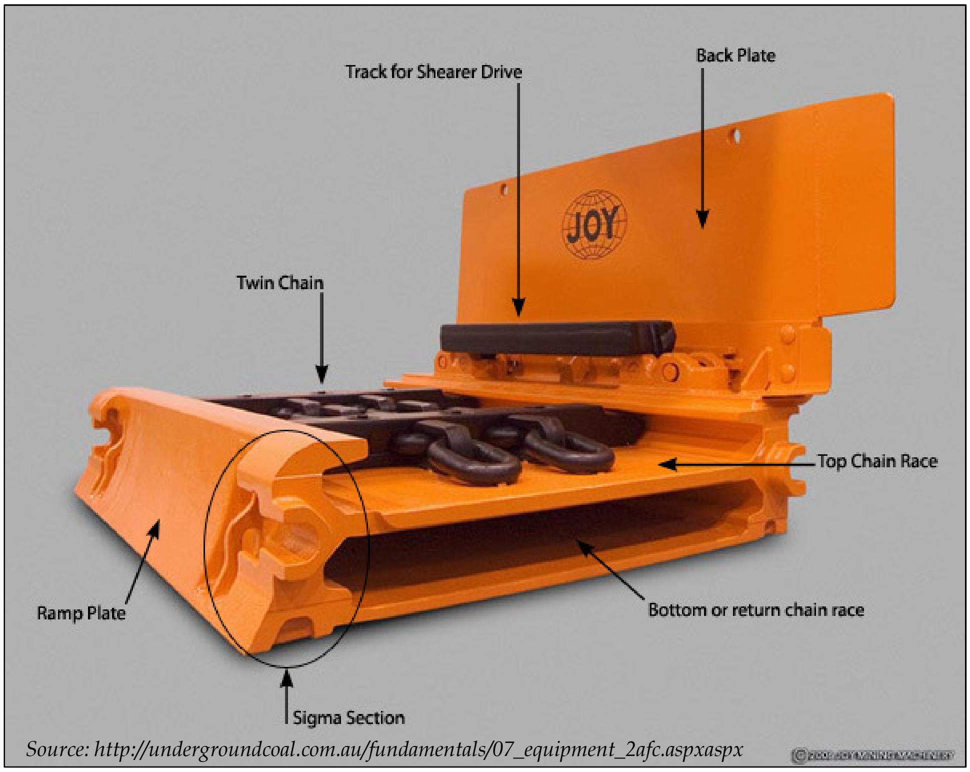
Plate 3.6-2. Typical hydraulic shield.

The purpose of the roof supports on a longwall face is not to prevent roof movement, but to control it so that the immediate roof remains essentially intact where the coal is cut and within the area of the face where personnel have to work. Two different sizes of hydraulic shields will be used, one to support the TL shearer, and one for the LTCC shearer. The shields will have supporting heights of 1.4m to 2.8 m (TL) and 1.7 to 3.2 m (LTCC), and a working resistance of 6,200 kN (TL) and 9,000 kN (LTCC). Each individual shield is 1.5 m wide.

Armored Face Conveyor

Once the coal is cut, it is moved from the face to the maingate by an Armoured Face Conveyor (AFC). The AFC is a one-sided trough scraper conveyor, the second side of the trough being formed by the coal face. Cut coal falls into the trough which has an endless chain with scraper flights attached running along the base plate. The coal is dragged along the base plate by the flights.

To provide a degree of horizontal and vertical articulation in the AFC along the face, the AFC consists of many individual sections joined together with flexible couplings, these sections are known as "pans" as shown in Plate 3.6-3. The flexibility allows the AFC segments to be moved in differing amounts along the face so that short lengths can be pushed towards the face forming a bend.



Source: http://undergroundcoal.com.au/fundamentals/07_equipment_2afc.aspxaspx

Plate 3.6-3. Typical AFC pan.

Apart from the AFC's primary function of removing the cut coal from the face, its structure is used for other purposes:

- the edges of the base are used as tracks for the shearer to run on; and
- troughs and attachments are mounted on the back plates to carry fixed and trailing cables and hoses.

Elevating Conveyor (Beam Stage Loader or BSL)

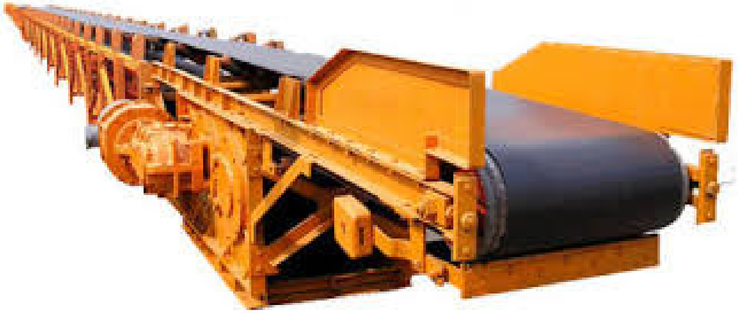
When the coal has been hauled to the maingate, it then has to be transferred through a 90° turn, and loaded onto the maingate conveyor. This function is carried out by the "Elevating Conveyor", which runs from the maingate drive to the maingate conveyor (belt). The elevating conveyor has a change of elevation (a vertical curve) along its length in order to discharge coal onto the maingate conveyor. A crusher is mounted on the conveyor to reduce the size of mined coal to improve loading and transport. Plate 3.6-4 shows a typical beam stage loader and crusher.

Extensible Belt Conveyor

The extensible belt conveyor (Plate 3.6-5) transports the coal down the maingate and onto the Mainline conveyor. It is extensible as its length needs to match the longwall face as it retreats back toward the Mainline.

Source: http://www.chinacoal.com/n42752/n239584/n239608/n239636/n239704/c291258/content.html

Plate 3.6-4. Beam stage loader.



Source: http://www.yphwgs.com/ProductShow.asp?ID=103

Plate 3.6-5. Extensible belt conveyor.

Mine Development

Mine development work is the drivage and preparation of all first workings (e.g., mainlines and gate roads) in advance of panel mining. Mine development will be completed with a road header (Plate 3.6-6). The rate of advance will depend on rock type. It is anticipated that a rate of 400 m per month will be achieved in coal; 350 m per month in half rock-half coal; and 260 m per month in rock. Each roader header will be supported and equipped with:

- belt conveyor (~1,000 mm);
- extensible belt conveyor;
- pneumatic roof bolter; and
- ventilation fan.

Source: http://ycft-machinery.en.alibaba.com/product/273265571-214845232/EBZ200_Roadheader.html

Plate 3.6-6. Typical road-header.

Underground Transportation and Hoist

The underground transportation system consists of coal conveyance and personnel/materials transportation. Figure 3.6-15 outlines a schematic diagram of the proposed underground transportation system.

Two conveyor lines will be used for the transportation of coal underground from the two mining faces. For example, as outlined in Figure 3.6-15:

- Line 1: ROM coal will be transported along the maingate belt conveyor in Block 1, and then transferred to the Seam J Mainline conveyor. Coal from the Seam J Mainline conveyor will be unloaded onto the Production Decline conveyor through a discharge chute, and then transported to the surface.
- Line 2: ROM coal will be transported from maingate belt conveyor to Seam D Mainline conveyor in Block 1, where it will be transferred to Seam F Mainline conveyor. Coal from the Seam F Mainline conveyor will then be unloaded onto the Production Decline conveyor through a discharge chute, and transported to the surface.

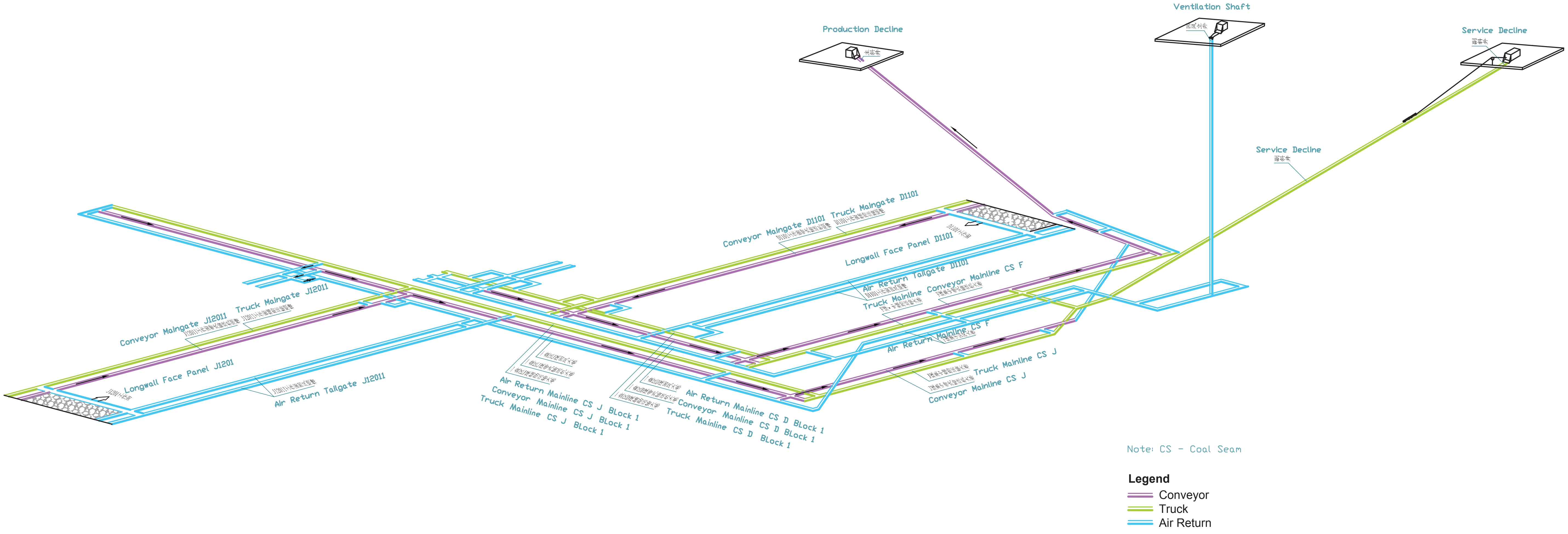
A maintenance railcar will parallel the conveyor belt in Production Decline, with a hoist installed in the head house.

A single drum hoist with a series of railcars will be installed in the Service Decline to transport materials, equipment and personnel between the surface and underground.

Underground, a variety of rubber-tired vehicles (trucks) will also be equipped to transport the major equipment, materials, parts, and personnel. All the trucks will be diesel-powered and properly certified and approved for use in underground coal mines in British Columbia.

Figure 3.6-15

Schematic Diagram of the Underground Transportation System



Note: CS - Coal Seam

Source: Shenyang Institute.

3.6.2.7 Explosives

Most of the mining, including the main tunnel systems, will be within the coal seams, where use of explosives is not necessary. Small amounts of explosives may be required when constructing the Production Decline, excavating rock tunnels, and when mining between coal seams. Explosives will not be stored on site. When blasting is required, a local blasting company will be contracted to provide the necessary explosives and conduct the blasting. Strict safety procedures will be in place to ensure that areas are clear before any blasting occurs. All blasting will be conducted by qualified persons in a manner consistent with the Health, Safety and Reclamation Code for Mines in British Columbia (the Code; BC MEMPR 2008).

3.6.2.8 Ventilation System

A main exhaust ventilation system will be provided to ventilate the entire mine and maintain air quality standards set by the provincial government for worker safety.

During mine development and initial production, the total air flow for the underground mine ventilation will be 180 m^3/s. A central-past ventilation system will be used and mainly service Blocks I and II, as shown in Figure 3.6-16. Intake (fresh) and return airways will be separated. Longwall mining faces will employ U-shape ventilation, with intake airways located at the maingate and return airways at the tailgate at each end of the working faces. Both declines will be used for fresh air intakes, while the shaft will be used for exhausted air return. The development working faces will use auxiliary fans for ventilation enhancement.

After about 15 years of Operation when activity begins in Blocks III and IV, two more shafts for ventilation will be sunk at the west site (Secondary Shafts Site) for those two Blocks: one for air intake; another one for return air. A parallel ventilation method will be employed from that point forward.

The main ventilation fans will be installed adjacent to the shaft head. Two explosion-proof contra-rotating axial fans will be installed, one for operation and another one for backup. Two electrical motors will run each fan. The fans' engineering design criteria are:

- Airflow: 180 m^3/s;
- Negative pressure: 180 to 2,200 Pa;
- Working elevation: 2,826 m.

Due to the depth of mining, and geothermal gradients, air temperatures in the underground mine will be consistent year-round. However, during the winter months, the ventilation air will be heated by natural gas to avoid freezing of water and utility lines within the intakes. The intake air flow from the Production Decline will be 40 m^3/s and from the Service Decline will be 140 m^3/s. The fresh air demands for different areas are: 32 m^3/s for Seam J working face, 25 m^3/s for Seam D working face, 40 m^3/s (4×10 m^3/s) for development working faces, and 83 m^3/s for truck exhaust dilution and others.

The underground mine is also designed with an air reversing ventilation system in case of a mine fire.

3.6.2.9 Coalbed Gas

Overview

Coalbed Gas (CBG, or Coal Bed Methane, coal mine methane), is a form of natural gas composed of methane, higher hydrocarbons, nitrogen and other gases contained predominantly within coal beds (seams) and to a lesser extent within coal bearing rocks. The gas is liberated when pressure above or surrounding the containing seams and rocks is reduced. The release of the gas from the mined coal continues at a decreasing rate through mining, transportation, processing and shipment to the customer. CBG must be actively managed within the mine, as it presents a safety hazard otherwise.

Coal Seams

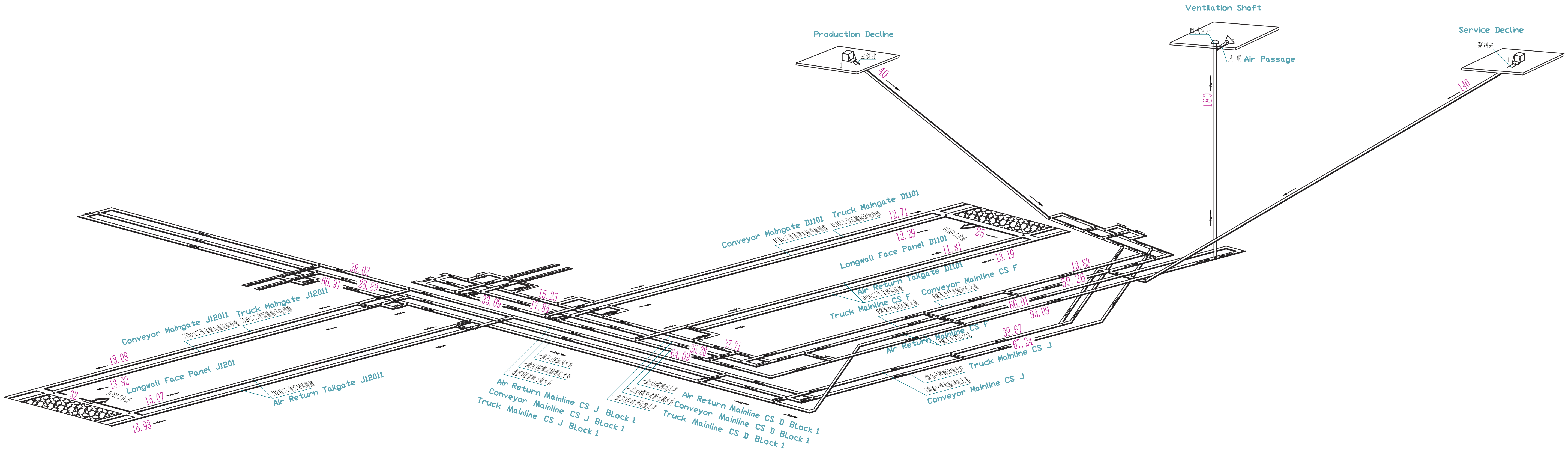
Exploration drilling results show that the coal seams of the Project contains CBG. CBG surveys have been undertaken by No. 173 Prospecting Party of China National Administration of Coal Geology, China Coal Technology and Engineering Group Shenyang Design and Research Institute, and HD Mining. The results are demonstrated in Table 3.6-4. The coal seams are bio-CBG coal beds and some areas may have high CBG content. Therefore the mine has been designed as a high content CBG mine.

Table 3.6-4. Coalbed Gas (CBG) Content Survey Results

Seam	No	Bore Hole	Lost CBG Content (m^{3}/t)	Desorption CBG Content (m^{3}/t)	Residual CBG Content (m^{3}/t)	Total CBG Content (m^{3}/t)
D	1	P1C46-K1	/	/	/	6.56
	2	DD-79-2-K2	/	/	/	2.87-10.80
	3	6DDMR03-K3	/	/	/	10.54-10.80
	4	07MR0006-K4	/	/	/	8.91-9.63
	5	P2C20-H12	2.17		4.41	6.58
	6	H20-1	0.96	3.54	5.11	9.61
F	1	P1C46-K1	/	/	/	6.21-9.65
	2	6DDMR03-K3	/	/	/	10.11-10.94
	3	P2C20-H12	3.07		4.17	7.24
	4	H17 -03(1)	4.111	1.5286	5.25	10.89
	5	H11-03(2)	1.25	0.95	6.05	8.24
	6	H20-3	1.01	2.41	6.35	9.77
	7	H20-4	0.66	3.35	7.55	11.56
J	1	P1C46-K1	/	/	/	8.28-10.63
	2	DD-79-2-K2	/	/	/	10.7
	3	6DDMR03-K3	/	/	/	10.06-11.14
	4	H2-02	1.63	1.42	5.59	8.64
	5	H11-04(3)	2.23	1.93	5.07	9.22
	6	H20-5	1.46	2.71	8.41	12.58
	7	H20-6	1.20	4.82	11.88	17.89

Figure 3.6-16

Schematic Diagram of the Underground Mine Ventilation System



Units: m³/s

Source: Shenyang Institute.

CBG Drainage, Monitoring and Management

Monitoring of underground air quality is a key aspect of maintaining a safe working environment. Air quality monitors will be mounted on key pieces of underground equipment and will be connected with the mine production safety monitoring system. CBG content in the ventilation airflow will be monitored and reported in real-time at the surface control center.

The specific approach to managing CBG will be adaptive and site specific, as it will depend on actual conditions observed underground. However, in general, CBG management will employ an inter-connected drainage system to collect CBG and vent it to the surface via the ventilation shaft. Common methods that will be used are described below.

A schematic diagram of the coal seam pressure and CBG drainage method is demonstrated in Figure 3.6-17 (A). From the air return side of the panel, a series of 200 m deep boreholes will be drilled parallel to the coal seam dip at 30 m intervals. All holes will be connected onto the CBG drainage pipeline. This method will be used during active mining. The coal working face pressure will crack the coal ore body ahead of the face, and further increase the permeability for CBG drainage.

Figure 3.6-17 (B) illustrates a typical gob drainage method. Pipes will be installed through the gob area and attached to a pipeline as above. A vacuum may be applied to these pipes to assist in gas removal.

Particularly in Seam J, where CBG density is higher, the roof CBG drainage method will be employed as a supplement to the coal seam pressure and CBG drainage method. Boreholes will be drilled in the roof or roof strata above Seam J, paralleling the return airway, as shown in Figure 3.6-17 (C).

The current design for the CBG system includes four CBG drainage pumps (two for operation and two for backup), and a 400 mm diameter CBG pipeline installed throughout the mine.

There is uncertainty with predicting methane emissions associated with underground coal mining, and limited data available to compare these values to other underground coal mines in Canada. HD Mining will carry out monitoring at the site once Construction begins. Depending on the volume of methane emitted, mitigation measures will be put in place to ensure methane emissions are minimized. Possible mitigation measures include flaring, catalytic oxidiser systems, or capture and use. Good practice post-drainage techniques can typically capture 50% to 80% of the total gas from a longwall district (UN 2010).

3.6.2.10 Spontaneous Combustion, and Explosion

Overview

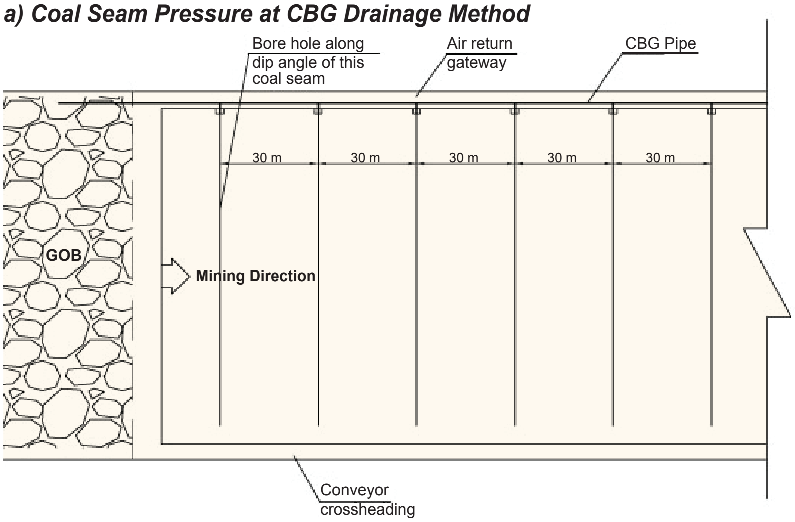
Spontaneous Combustion

When exposed to air all coal will oxidize (at varying rates). Oxidation is an exothermic process that produces heat and may result in spontaneous combustion under specific conditions. Many seams will not reach this point. Coal seam heatings can also be caused by oxidation of waste organic matter, such as oils and greases, under the right conditions.

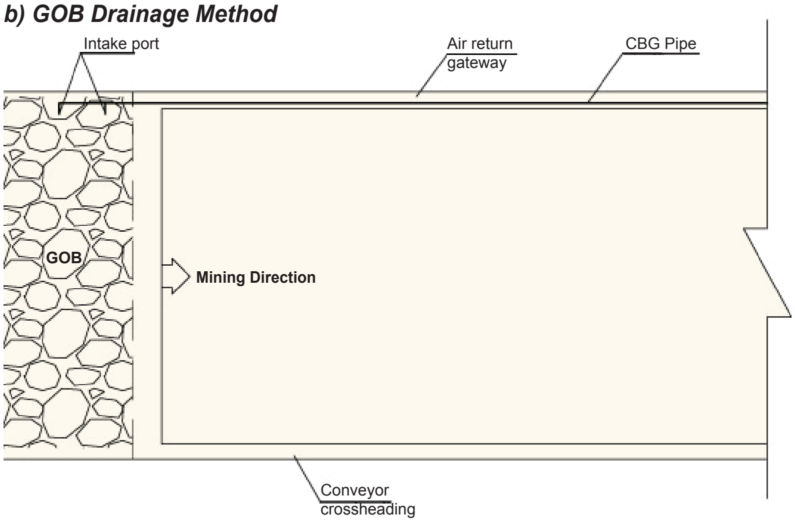
Figure 3.6-17

Coal Seam Pressure and CBG Drainage Method

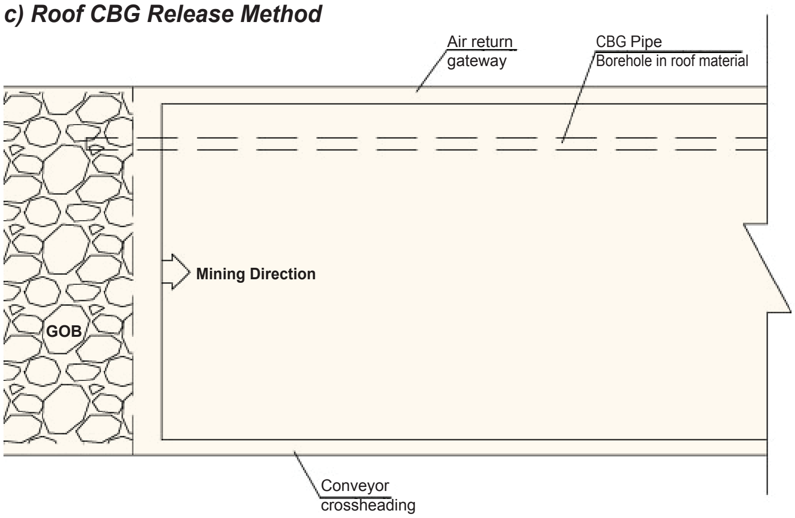
a) Coal Seam Pressure at CBG Drainage Method



b) GOB Drainage Method



c) Roof CBG Release Method



Source: Shenyang Institute.

When spontaneous combustion does occur, there is an initial stage where the temperature is rising but no burning is yet taking place. This stage is known as a "heating". Over time, the heating will develop into a fire if conditions do not alter. Apart from the increase in temperature, a heating can be detected by gases produced, notably carbon monoxide.

In most parts of a mine the air flow is sufficient to remove the heat produced and prevent development of a heating. Risks are higher in areas where there is sufficient air flow to provide a supply of oxygen but insufficient to provide enough cooling to prevent a heating. Such locations may be in areas of fractured coal with a pressure differential across them (e.g., between intakes and returns), in piles of cut or broken coal placed in unventilated locations, and especially in the gob.

Particular care is required in sealing old areas. When ventilation is cut off there is a risk that a heating will occur. It is important for the atmosphere in such an area to be monitored and for the mine to be evacuated while the atmosphere is within the explosive range.

Environmental monitoring systems in the mine will include extensive monitoring of air returns adjacent to gobs, particularly for carbon monoxide and oxygen. Inspections of return areas require particular attention to indicators of heating, including increased temperatures, odours, and "sweating" of strata.

A written underground mine air quality management plan will be prepared prior to mine development and will be adapted over time as further experience is gained. The plan will include monitoring and inspection, and actions to address identified concerns.

Explosion

Gas explosion and coal dust explosion are two potential conditions within underground coal mines. The majority of explosions in coal mines have been initiated by the ignition of CBG. This can be even more violent if the shock wave raises combustible dust into the air such that it can be ignited by the flame of the burning CBG.

Project Coal Seams

Analysis of core from the exploration program surveyed coal dust explosiveness and coal spontaneous combustion potential. The analysis conducted in seams D, F and J is summarized in Table 3.6-5 and Table 3.6-6. All seams are susceptible to spontaneous combustion and explosion. The minimum stone dust rate required to suppress coal dust explosion is 50%.

Table 3.6-5. Explosiveness of Coal Dust

Seam	Bore Hole	Moisture (%)	Ash (%)	Volatile Matter (V_{ad}) (%)	Volatile Matter (V_{daf}) (%)	Flame Length (mm)	Minimum Stonedust to Suppress Coal Dust Explosion (%)	Explosiveness
D	P2R5 (H5)	0.57	7.49	22.39	24.35	50	50	Yes
F	P2R5 (H5)	0.62	7.40	21.15	22.99	50	50	Yes
J	P2R5 (H5)	0.58	6.82	22.29	24.07	50	50	Yes

Table 3.6-6. Coal Spontaneous Combustion

Seam	Bore Hole	Moisture (%)	Ash (%)	Volatile Matter (V_{daf})	True Relative Density (tonnes/m^3)	Oxygen Absorption (cm^3/g)	Spontaneous Combustion Degree	Spontaneous Combustion
D	P2R5 (H5)	0.57	7.49	24.35	1.34	0.64	II	Yes
F	P2R5 (H5)	0.62	7.40	22.99	1.34	0.61	II	Yes
J	P2R5 (H5)	0.58	6.82	24.07	1.35	0.60	II	Yes

Monitoring and Management

Dust suppressing and mitigation measures will be implemented throughout the mine. This will primarily be accomplished with sprinkler systems installed throughout the mine to maintain a moisture content greater than 30% (by weight) on the walls, roof and floor, consistent with HSRC requirements.

Water Barriers consisting of plastic troughs full of water suspended at roof level will also be used as a secondary measure to manage combustion and explosion risk. A number of water troughs and water bags will be placed in mainline entries, roadways, gateways and airways, and attached to roof supports. The troughs are constructed from foam or a similarly weak material so that they will disintegrate when subjected to a shock wave. The tunnel cross section becomes filled with water droplets when the water is released, suppressing and extinguishing the flames, and preventing further propagation.

Table 3.6-7 summarizes planned water barriers' size, water volumes and locations in the first two panels of the underground mine.

Table 3.6-7. Water Barriers Size and Location for Panel D1101 and J1201

Water Barrier Location	Total Water Volume (L)	Water Volume per Barrier (L)	Total Barriers	Barrier Length (m)	Location Numbers
Panel D1101: conveyor maingate, air return tailgate	37,440	60	624	288	12
Panel D1101: truck maingate	13,440	60	224	104	4
Panel J1201: conveyor maingate, air return tailgate	43,200	60	720	336	12
Panel J1201: truck maingate	15,360	60	256	120	4
Seam J (F):air return mainline, truck mainline or connection ramps ,	104,000	80	1,300	494	13
Seam J (F):conveyor mainline or connection ramps	36,000	80	450	170	5
Seam D: air return mainline or connection ramps	54,400	80	680	256	8
Seam D:conveyor mainline and cross-cut	18,000	80	225	84	3

3.6.2.11 *Fire Safety*

The underground mine will be equipped with a fire safety system. Fire water pipe networks and hydrants will be installed in related tunnels and chambers. All mainline tunnels will be shotcreted with bolt mesh and panel mining areas will be sealed after mining. Fire-proof doors will be installed to protect critical areas underground, including the water pump station and the power substation. A firefighting equipment and materials warehouse will be constructed in the Underground Operation Hub and equipped with firefighting tools and materials, such as high-expansion foam fire extinguisher, fire extinguishing grenades, and foam and dry chemical fire extinguishers.

Nitrogen gas will be injected into underground mined gobs and areas with higher fire potential. With nitrogen application, the oxygen content within the gob will be less than 7% for fire protection, while less than 3% for combustion suppression. Mobile nitrogen gas generators will be provided in intake airways in working coal faces. The capacity of the nitrogen gas generators will be about 2,114 m^3/h.

3.6.2.12 *Water Management*

It is recognized that at this stage in Project planning, there is a high degree of uncertainty associated with estimating groundwater inflow rates into the underground mine. Through analysis of core logs and hydrogeologic testing, and using methods consistent with the Specifications for Coal, Peat Exploration (DZ/T0215-2002, 2002), HD Mining's engineering team has estimated inflow rates for the purpose of designing an adequate pumping system. This estimate produced two scenarios:

- normal ground water inflow: 365 m^3/h (8,760 m^3/d); and
- maximum ground water inflow: 548 m^3/h (13,152 m^3/d).

The approach has built-in factors of safety, and, based on experience, is expected to produce a conservatively high estimate of inflow rate, which is appropriate for use when designing pumping capacities (Chapter VI of Appendix 3-A; Appendix 3-H).

ERM Rescan has developed a 3-dimensional groundwater model of the mine (Appendix 7-B), which has also produced estimates of groundwater inflow to the underground mine. The 3-dimensional model is calibrated to observed water levels in wells installed above the proposed mining area. Through sensitivity analysis, three estimates of inflow were derived (based on a steady state model, constructed to simulate the mine dewatering of the all four mining blocks simultaneously to their maximum extents):

- base case: 1,891 m^3/d;
- upper case: 6,002 m^3/d; and
- uppermost case: 12,748 m^3/d.

It is believed that these estimates bracket the range of long-term average inflow rates that may be encountered underground, and forms the basis of water balance analysis and planning that is described in Section 3.6.3.8, and feeds into the effects assessments (Chapters 6-19).

Regardless of the actual inflow rate that is observed, it will be managed in a consistent manner. A central water sump and a main water pump station will be constructed in the Underground Operation Hub. A treatment system will be used to help settle suspended particulates within the sump. Approximately 2,075 m^3/d of seepage from the mine sump will be circulated back within the mine through the sprinkler system and for general fire water and dust suppression purposes. Groundwater inflow in excess of underground demand will be pumped to surface via water pipes in the Production Decline.

The engineering design criteria for underground sump and pumping system are:

- Normal ground water inflow: 365 m^3/h (8,760 m^3/d);
- Maximum ground water inflow: 548 m^3/h (13,152 m^3/d);
- Ground surface elevation: +847 masl;
- Underground sump elevation: +350 masl;
- Pumping height: 497 m;
- Water pipeline length: about 3,500 m; and
- Pressure Head in underground water treatment facility: 15 m.

Three centrifugal water pumps are planned, each with a capacity of 540 m^3/h at a head of 603 m. During normal operation, one pump will run for operation, the second will be for backup and the third one for maintenance. The total drainage time is 15.7 hours to pump out all the groundwater produced during 24 hours under the normal inflow scenario. During the maximum inflow scenario, two pumps will be in operation, with one for backup. The total drainage time for this scenario is 11.8 hours to pump out the maximum groundwater produced during 24 hours.

Two water pipelines will be installed in the Production Decline: one for operation and another one for backup during normal operation; two for operation during the maximum seepage scenario.

Pump rooms and water sumps are included in the panel design. Groundwater from the panels will flow into the water sumps and then be pumped into the central water sump at the Underground Operation Hub.

Three centrifugal water pumps will be used at each panel, each with a capacity of 336 m^3/h at a head of 310 m. During normal operation, one pump is for operation, the second for backup, and the third for maintenance. Total drainage time is about 12 hours to pump out all the groundwater produced during 24 hours in the panel. During maximum inflow, two for operation and one for backup, and the total drainage time is about 17 hours to pump out the maximum groundwater produced during 24 hours.

The engineering design criteria of pumps at panels are:

- Normal ground water inflow: 163 m^3/h;
- Maximum ground water inflow: 245 m^3/h;

- Maximum head: 250 m; and
- Water pipeline length: 3,300 m.

Early in the mine life, it will not be possible to store excess seepage water underground. However, as mining progresses, there may be opportunity to store some excess seepage in mined out panels (e.g., gob). Given that mining sequence is planned to start at the shallowest coal and work deeper, storage of water underground would need to be carefully evaluated to ensure safety is maintained. Factors that need to be taken into consideration include (but are not limited to):

- orientation of the coal seam relative to the mainlines (e.g., upgradient or downgradient);
- sequence of panels to be mined within a Block;
- coal seam being mined relative to others planned in the Block (e.g., multiple seam mining); and
- connectivity of Blocks within the mine layout.

Current water management planning does not account for storage of excess groundwater inflow. This is seen as a future opportunity that could be used to help optimize water management and reduce potential effects to the surface water system.

3.6.2.13 Waste Rock

Waste rock (coal gangue, refuse, rejects), which is the commercially worthless waste rock, material surrounding/mixing/overlying the coal seams, will be produced from access drivage and tunnelling, shaft excavation, working faces collapse and caving gobs during Construction and Operation of the mine.

Approximately 52,000 m^3 of waste rock will be generated during the Bulk Sample work when the Service Decline and Ventilation Shaft are established. This material will be hauled out from the Service Decline and transported 3.4 km by trucks to the waste rock storage area at the Shaft site.

An additional 47,000 m^3 of waste rock will be generated to construct the Production Decline, for a total of 141,000 m^3 of waste rock combined between Bulk Sample and Construction (see Table 3.7-1).

There will be two types of waste rock from the construction of the Production Decline. The potentially acid generating waste rock will be hauled 10 km by trucks to the waste rock storage area at the Shaft Site. The remaining waste rock will be used at the Coarse Coal Reject (CCR) storage area.

About 48,500 tonnes of waste rock will be produced each year from development activities during the Operation. This material will be transported by mainline coal conveyor to the coal processing plant, and conveyed onto the CCR after processing.

3.6.2.14 Subsidence

The Nature of Subsidence

The removal of any material from beneath the earth's surface influences the stress state of the surrounding ground which responds with related deformation and displacements of the material. As the volume of material removed increases, the amount of deformation of the ground around it also increases. The overlying rock moves towards and into the empty volume at a rate dependent on the active stresses and the nature of the rock. If the empty volume is large enough in relation to its depth, the deformations and displacements may eventually propagate up to the surface causing subsidence. Removal of oil, gas, and groundwater, as well as mining, may cause the surface above to subside. The subsidence movements may generate small seismic events rarely strong enough to cause damage. Subsidence movement has both vertical and lateral components and can be continuous (smooth) or discontinuous (stepped or cracked) depending on specific mining and geological conditions.

An important feature of surface subsidence is that it is always greater in areal extent than the workings which cause it. The disturbance spreads up and outwards from the edge of the workings at an "angle of draw" which ranges from zero to 45 degrees or more depending on the inclination of the seam and the nature of the overburden.

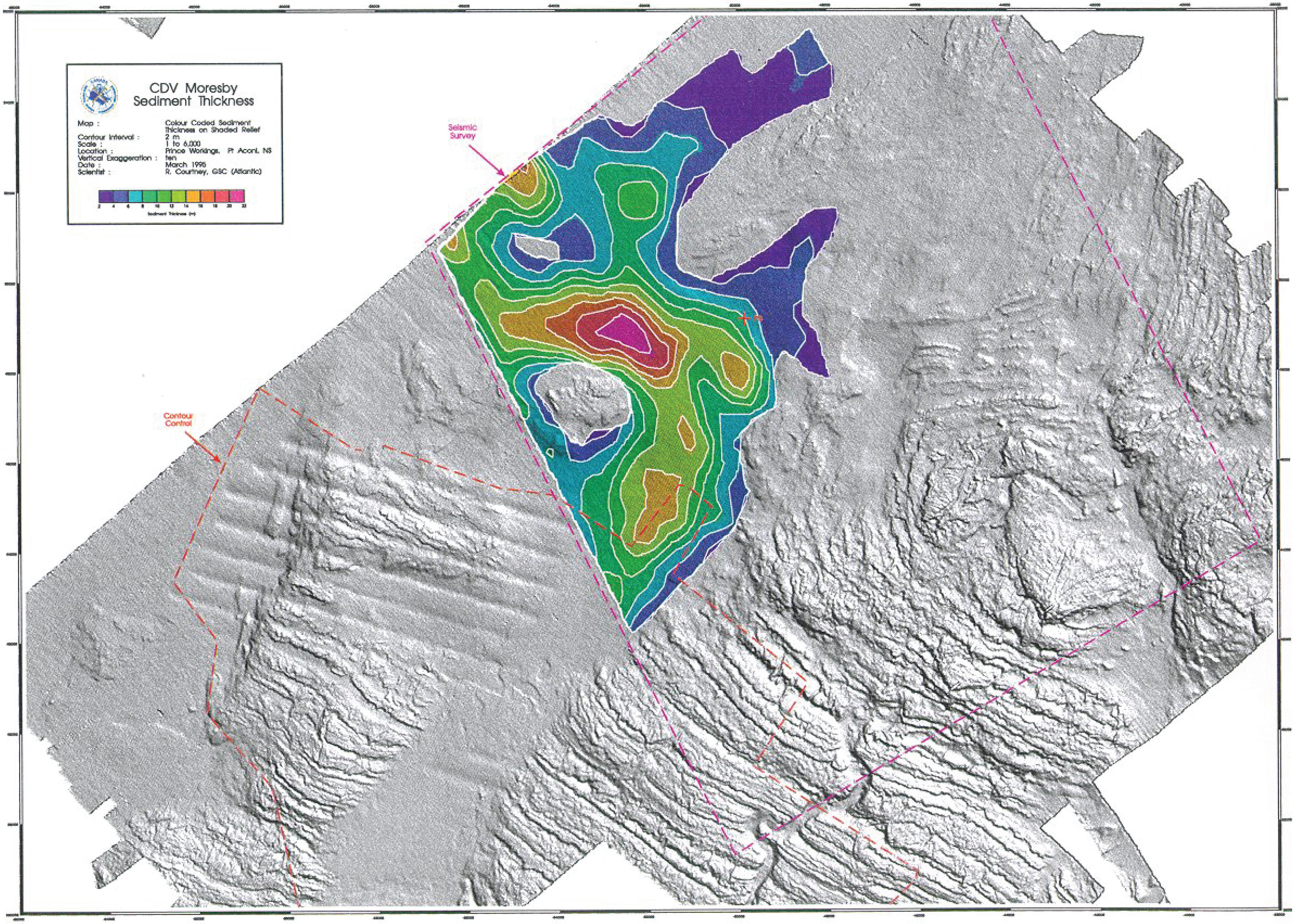
Longwall mining creates long, rectangular voids in the coal seam into which the roof collapses (the gobs). In order to ensure stability, longwall panels are worked from the top seam to the bottom seam with the panels superimposed on each other. After the first (top) seam is mined, the roof collapses. When subsequent lower seams are mined in sequence the overlying gobs collapse into the underlying workings. Superimposing the subsidence from a number of seams results additional movement at the surface. The magnitude of the movement depends on the total thickness of coal extracted, the nature and thickness of the rock layer between each seam and the areal extent of the workings in relation to their depth.

Subsidence is often very difficult to visualize on land because of surface features which tend to obscure it. Figure 3.6-18 shows the results of a high-definition survey of the seafloor above an underground longwall coal mine in Nova Scotia. On the left hand side of the Figure the long, narrow parallel subsidence troughs developed over longwall panels are clearly visible in the seafloor. The extracted width of each panel was about 160 m, and between 2.0 and 2.5 m of coal was extracted from a depth of between 200 and 300 m resulting in total subsidence at the centre of each trough of between one and two metres.

While the physical movement of the surface can cause large structures to tilt, it is the strain generated as the original surface stretches to accommodate its new shape that is usually the cause of most of the damage.

Figure 3.6-18

The Expression of Subsidence Troughs Resulting from Longwall Mining on Seafloor Sediment off the Coast of Nova Scotia



Subsidence Prediction Methods

Subsidence as a consequence of coal mining has been recognized since the 17th Century when its effects on surface structures and features were noticed. Since then many theories have been developed regarding its occurrence and many methods proposed to predict its magnitude and extent. However, the uncertainties over the nature and behaviour of the heterogenous materials overlying the coal seams has so far defeated any attempts to predict the effects of subsidence on the surface with engineering accuracy.

Arguably, the least effective type of prediction model is the theoretical numerical model which seeks to quantify the properties of the materials involved and the nature of the extraction and then to calculate the subsidence effects using classical materials theory.

A slightly better estimate is usually obtained from empirical methods of subsidence prediction which use as a basis the results of subsidence monitoring programs conducted in a particular area or environment. The variation in the measured response of the surface to the mining parameters of extraction width, height, length and depth (and sometimes the properties of the overlying strata themselves) are then expressed as fitted curves which can be applied to proposed excavations. Modern computers make the automation of these calculations quite simple.

Empirical methods have been found to be reasonably accurate in the areas and under the conditions in which they were developed, but less accurate when they are applied away from their observational base. Because they depend on smoothed and fitted data they tend not to be as accurate when the terrain is heavily contoured and the geological structure is complex.

Despite these shortcomings, subsidence models can make reasonable estimates of the amounts of subsidence which might be experienced and where the subsidence will occur, allowing critical areas to be identified and mitigation to be developed.

Mitigation of Subsidence Effects

Once a mine is proposed and the extraction parameters have been developed, subsidence modeling can be used to provide an estimate of the effects that might be experienced over the workings. In almost all jurisdictions it is the responsibility of the mining company to ensure that their operation does not cause harm on the surface and to mitigate and make good any losses arising from the subsidence.

The prevention of damage arising from ground movement associated with longwall mining also applies to mine infrastructure. Sufficient distance must be left as a buffer between panels, shafts, declines and geological disturbances to protect the integrity of the mine and ensure the safety of the workforce.

In heavily populated areas, or in areas with a high level of human infrastructure, there will often be a need to mitigate the effects of subsidence on the overlying surface to prevent the development of hazards and damage to valuable infrastructure. In central Europe, the UK and the eastern USA there are many examples of mine plans having to be altered or mitigation of effects planned to prevent the development of hazards or excessive damage to infrastructure. In cases where only minor damage is expected, it is often more economical to remediate subsidence damage after it has occurred.

Usually this can be accomplished with minimal alteration to mining plans and only a small degree of inconvenience to the surface owners.

In the case of the Project, the areal extent of the planned extent of mining is quite large and the mineable seams are overlain by a number of watercourses, variable topography and mainly linear infrastructure features such as roads, powerlines and gas lines (Figure 3.6-19). HD Mining has built mitigation measures into the mine plan to minimize the potential for effects on the environment and to other land users and stakeholders as a result of subsidence. These mitigation measures take the form of "exclusion zones" within which mining is not permitted to protect surface features and infrastructure. Figure 3.6-19 shows the extent of the exclusion zones at seam level around the features they are protecting.

The features protected by exclusion zones include features both within the mine (individual mining panels within blocks; main mine access roadways between mining blocks; geological faults; declines and shafts) and on the surface (mining licence boundary; rivers and major watercourses; natural gas production well-heads; gas pipelines).

Underground, the exclusion zones are measured in the plane of the seam. They serve to protect underground structures from the adverse effects of mining and ensure the safety of the workforce. The distances are based on mining best practise and experience.

At the surface, the exclusion zones get larger as the depth of mining increases. The disturbance spreads up and outwards from the edge of the workings at an "angle of draw", which ranges from zero to 45 degrees or more to the vertical depending on the inclination of the seam and the nature of the overburden. The angle of draw represents the limit of observable subsidence movement, not the limit of damage to surface features, which are capable of absorbing a certain amount of movement without consequence.

Underground exclusion zones are 10 m wide around individual panels (resulting in a block of coal 20 m wide left between panels) and 50 m each side of main access roads and geological faults. Because shafts and declines extend from the seam to the surface, the exclusion zone varies in width with depth.

Surface exclusion zones include 30 m inside the mine licence boundary and variable exclusion zone widths around gas well-heads, gas lines and watercourses depending on the depth to the mine workings below them.

In all cases if two exclusion zones apply, the largest is the one which is maintained.

As listed in Table 3.4-2, within the current mine plan, the total coal resource held within the exclusion zones ("pillars") will be about 304 Mt, or about 50% of the total coal resource of 613 Mt. This total includes about 6 Mt for mine boundary and rivers, 36 Mt for faults, 221 Mt for natural gas pipeline, 11 Mt for other surface infrastructure and 12 Mt for major mainline entries and roadways.

<u>Prediction of Subsidence effects on the Murray River Property</u>

The current mine plan is a conservative approach to minimize adverse effects on existing infrastructure. Throughout the mine life, HD Mining will monitor subsidence, and based on those results, will work to optimize the mine plan and maximize extraction. HD Mining will establish a communication protocol to engage other tenure holders and address potential overlaps and conflicts in advance of mining activity.

As a first step in the process, Xtraction Science and Technology (XST) of Bethel Park, PA, USA was commissioned to study the potential impacts of subsidence across the mine area (Appendix 3-C). XST used a semi-empirical prediction method based on data collected from across the USA implemented as a computer based model, CISPM-W. The work was conducted at West Virginia University by the engineer who helped develop the model.

As with any model, CISPM-W has its limitations. It is calibrated for US mining conditions, which are typically flat, shallow longwalls of limited height and largely against single seam extractions. Multiple dipping seams at depth with thicknesses up to 7 m are rarely encountered in the US and are poorly represented, if at all, in their subsidence databases. Compared to most US coalfields, the rocks in the Murray River area are strong and the geological structure is complicated by parallel faults with large displacements which are known to act as a focii for subsidence movements.

The XST work provided detailed subsidence assessments for the first three years of longwall production as well as subsidence estimates for the end of the mine life for three cases thought to represent the most severe subsidence effects at surface. Subsidence effects over the two proposed declines were not predicted as the openings are not large enough to produce measurable effects at the surface. By the same token, the bulk sample extraction area consisting of tunnels in the coal seam separated by large pillars and maintained through the life of the mine will not generate surface subsidence.

Initial longwall production is from D Seam and J Seam in Block 1 (Figure 3.6-20). In D seam the depth of working is about 500 m and the seam thickness is 2.5 m. In J Seam the depth of working is about 900 m and the seam thickness is 4.5 m.

On completion of the D Seam and J Seam workings in Block 1, the maximum subsidence is predicted to be 1 m and 1.4 m over D Seam and J Seam respectively.

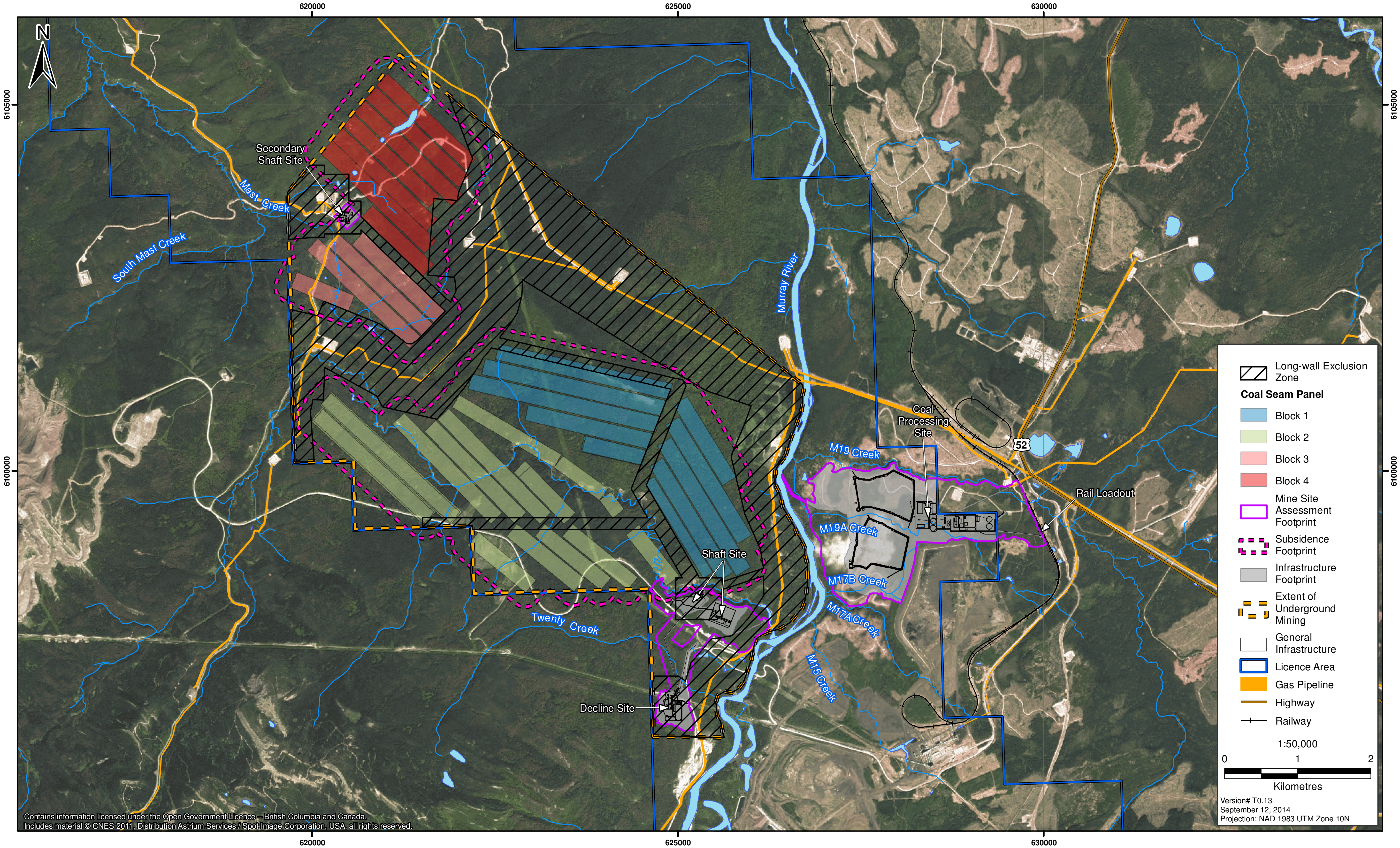
The critical subsidence parameter used to assess surface damage is the tensile strain generated as the ground surface stretches to accommodate the new shape. Strains are expressed as a ratio of extension over original length and a tensile strain of 10 mm per metre is recorded as 1E-03 (compressive strains are negative). When working below lake beds or the sea, tensile strains of more than 7E-02 are considered potentially hazardous.

Figure 3.6-20 is a page extracted from the Subsidence Engineer's Handbook published in 1975 by Britain's National Coal Board. It describes the degree of damage to be expected due to a tensile strain exerted on a surface structure.

After reviewing the surface features in the vicinity of the Project the only man-made structures which might be affected are: gas pipelines, gas well-heads, power line pylons and gravel roads.

The panel layout has taken into consideration the potential effects of mining on surface gas well-heads and gas pipelines by determining and applying exclusion zones as described above.

Figure 3.6-19
Mine Layout and Long-wall Exclusion Zones



Version# T0.13
September 12, 2014
Projection: NAD 1983 UTM Zone 10N

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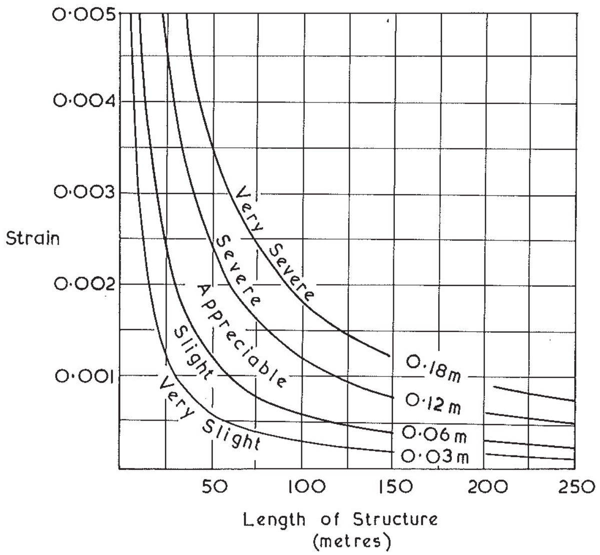
Figure 3.6-20
Classification of Subsidence Damage



Source: Subsidence Engineer's Handbook (1975) by Britain's National Coal Board.

TABLE of **National Coal Board Classification of Subsidence Damage**

Change of Length of Structure	Class of Damage	Description of Typical Damage
Up to 0.03 m	1. Very slight or negligible	Hair cracks in plaster Perhaps isolated slight fracture in the building, not visible on outside.
0.03 m – 0.06 m	2. Slight	Several slight fractures showing inside the building. Doors and windows may stick slightly. Repairs to decoration probably necessary.
0.06 m – 0.12 m	3. Appreciable	Slight fracture showing on outside of building (or one main fracture). Doors and windows sticking; service pipes may fracture.
0.12 m – 0.18 m	4. Severe	Service pipes disrupted. Open fractures requiring rebonding and allowing weather into the structure. Window and door frames distorted; floors sloping noticeably; walls leaning or bulging noticeably. Some loss of bearing in beams. If compressive damage, overlapping of roof joints and lifting of brickwork with open horizontal fractures.
More than 0.18 m	5. Very severe	As above, but worse, and requiring partial or complete rebuilding. Roof and floor beams lose bearing and need shoring up. Windows broken with distortion. Severe slopes on floors. If compressive damage, severe buckling and bulging of the roof and walls.

The major power line affected by the Project comprises three conductors on a twin-upright T structure. Three uprights are used at turning points. These poles will rotate from vertical in a pattern depending on their location with respect to the undermining. Apart from requiring additional guying, the effects on these structures are expected to be minimal. Because the distance between the tops of the poles may change there may be some increases in line tension or sagging, which will need to be monitored to prevent breakage or grounding.

There are no gravel service roads overlying Block 1, which is where longwall extraction will be located for the first three years of production. Because of their construction, gravel roads in the area generally are unlikely to be badly affected by subsidence, and any cracking or crumpling can be remediated by routine grading. HD Mining will notify road owners/users and other stakeholders when roads are to be undermined. Sign postings (e.g., "Road Liable to Subsidence") and reduced speed limits are effective safety controls. HD Mining expects that additional maintenance costs will be to their account. Complicating factors such as changes in gradient of drainage ditches and potential damage to culverts will be assessed closer to the anticipated undermining. These can be assessed in the light of experience with subsidence development during Block 1 mining.

In addition to the effects of subsidence on man-made infrastructure and facilities, there must be consideration of the potential effects of subsidence on natural features such as water-courses, marshes, wetlands, slopes and other features. Prediction of the amount of subsidence occurring due to longwall extraction and its expression in association with seam dips and surface topography is impossible without site specific experience from the Block 1 mining, although results from the XST work suggests that vertical displacements above multiple thick panels in some areas of the property could be as much as could add up to as much as 9 m.

Combined with complex seam and surface topology, the nature of surficial materials and the expression of major faults on the surface will present challenges to successful effects prediction. Fortunately, mining is planned to proceed seam by seam to depth, which will allow any subsidence effects to be generated gradually and will allow early identification of potential problem areas and the design and implementation of mitigation strategies. Potential effects of subsidence to Valued Components (e.g., terrain stability, water quantity, wetlands, etc.) are considered in Chapters 6 through 19.

Subsidence Monitoring and Analysis

HD Mining recognizes the need to develop a project-specific predictive capability for the effects of subsidence above the workings in order to confirm design assumptions and to predict mitigation requirements. In order to do this, HD Mining is planning to monitor surface subsidence using one or more of several potential methods:

- Traditional survey transits of surface monuments or benchmarks at regular intervals before, during and after their undermining. The monuments or benchmarks will be constructed to eliminate, a far as possible, non-subsidence effects such as slope instability and frost heave and will be installed along existing linear infrastructure (transmission rights-of-way, roads, pipelines) or along cut lines established for the purpose. The distance between benchmarks will be approximately 30 m. They will be established to collect the best possible data for future analysis.

- High-resolution airborne Lidar surveying can be used to monitor changes in surface elevation by comparing pre-mining digital terrain models with data collected at various stages over the life of the mine. Lidar data can detect the ground surface through tree cover and is conducted from aircraft, which makes it an especially useful technique in mountainous, forested terrain found at Murray River. However, it is costly, so would be used infrequently and be correlated with surface survey methods.
- Satellite radar imagery has been used to detect subsidence effects over wide areas and the data is available from commercial aggregators. The resolution and precision of satellite data is less than airborne Lidar but it will be useful in later stages when full subsidence development has occurred.

HD Mining will collate and analyse the subsidence data and to develop empirical models calibrated to local conditions. The results and the analyses will be reported regularly to the Ministry of Energy and Mines. As confidence in prediction methods increases, subsidence effects will be re-evaluated and mitigation planned and completed where required.

3.6.3 Surface Facilities

3.6.3.1 Introduction

Surface facilities for the Project will occur at four locations:

- Decline Site;
- Shaft Site;
- Coal Processing Site; and
- Secondary Shafts Site.

The general surface facilities layout is outlined in Figure 3.6-1.

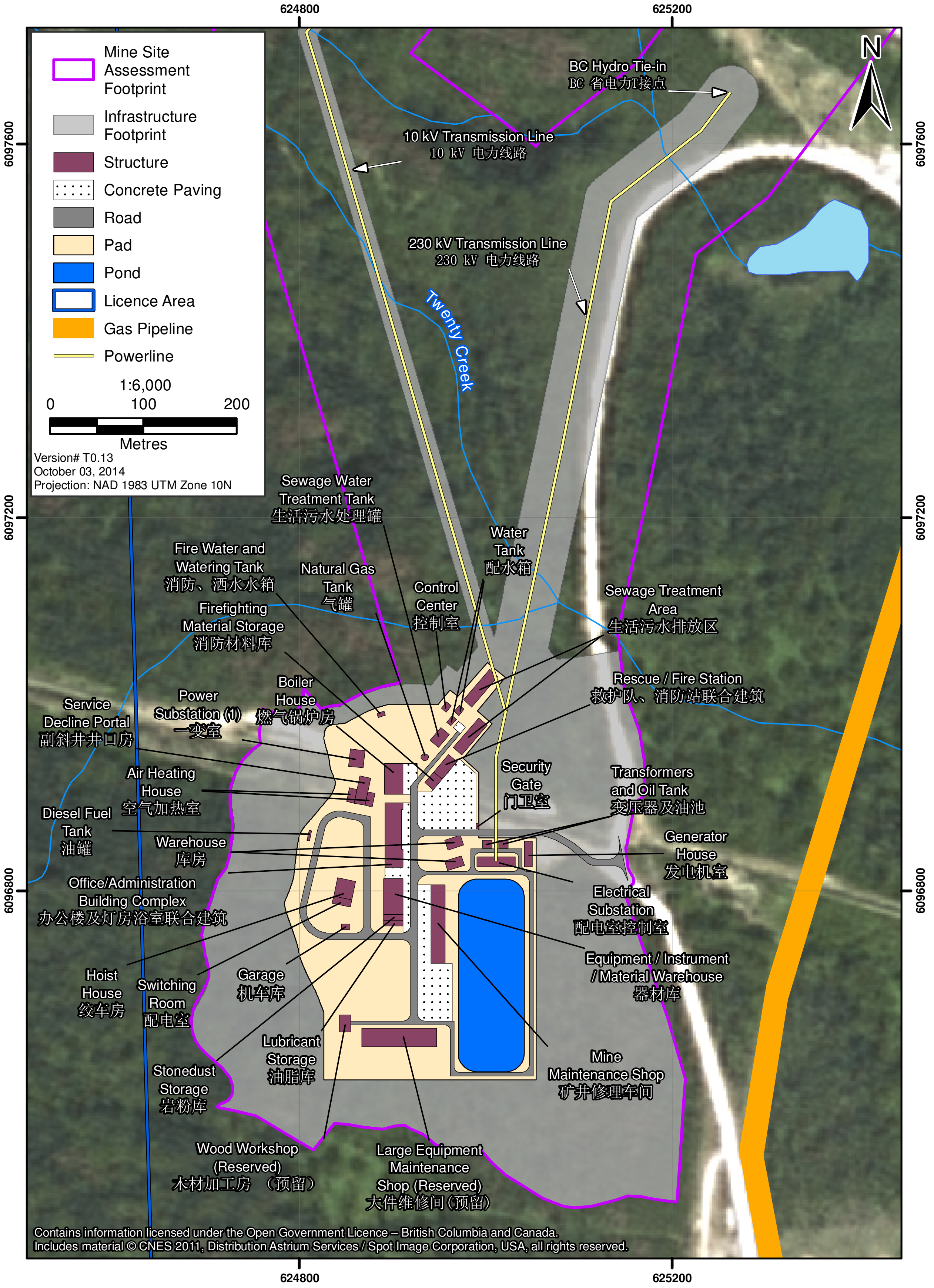
3.6.3.2 Decline Site

Facilities at the Decline Site (Figure 3.6-21) will include:

- Service Decline portal;
- Hoist house;
- Equipment assembly and maintenance shops;
- Warehouse complex;
- Rescue/fire station;
- Mine dry;
- Generator house;

Figure 3.6-21

Decline Site Layout



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- Electrical Substation;
- Natural gas storage tanks;
- Fuel station;
- Natural gas storage tank;
- Water well;
- Wood workshop;
- Boiler house;
- Intake air heating house;
- Office/Administration buildings complex;
- Sewage treatment tanks and disposal area; and
- Sedimentation pond.

3.6.3.3 Shaft Site

Facilities at the Shaft Site (Figure 3.6-22) will include:

- Roads and site access;
- Ventilation fans;
- Electrical and switching house;
- CBG drainage pump station;
- Waste rock storage area;
- Topsoil stockpile;
- Sedimentation pond; and
- Water discharge pipeline to M20 Creek.

As described in Section 3.2.3, the waste rock storage area has been permitted as part of Bulk Sample activities. Details regarding the design of the waste rock storage area are provided in Appendix 3-G, and information related to ML/ARD management of waste rock materials is described in Section 3.5.3.1. The design and storage capacity of the waste rock storage area as designed for Bulk Sample is able to support the full mine development.

3.6.3.4 Coal Processing Site

Primary facilities at the Coal Processing Site (Figure 3.6-23) will include:

- Production Decline portal ;
- Coal Preparation Plant (CPP):
  - a range of conveyors and transfer towers,

Figure 3.6-22
Shaft Site Layout

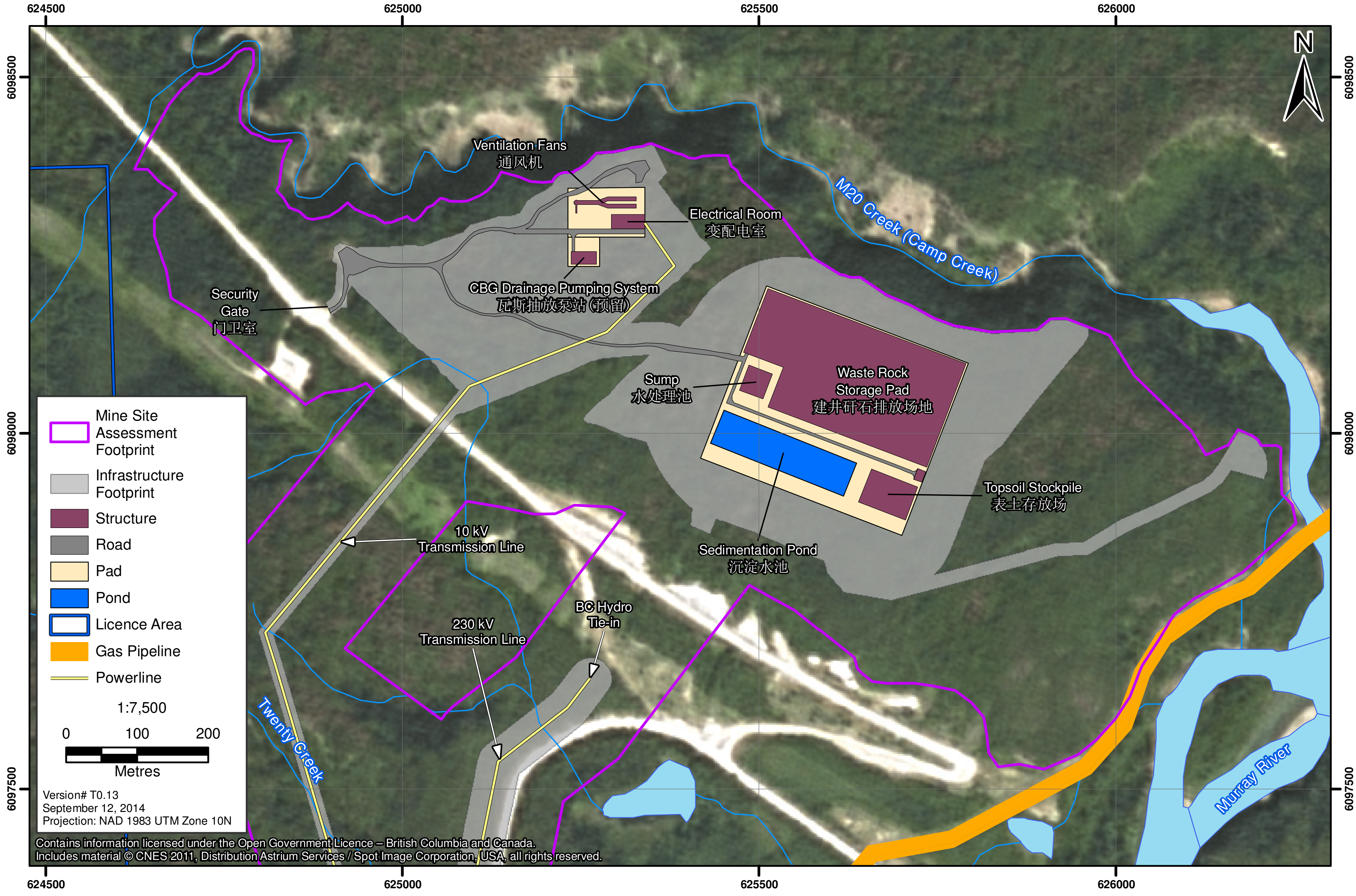

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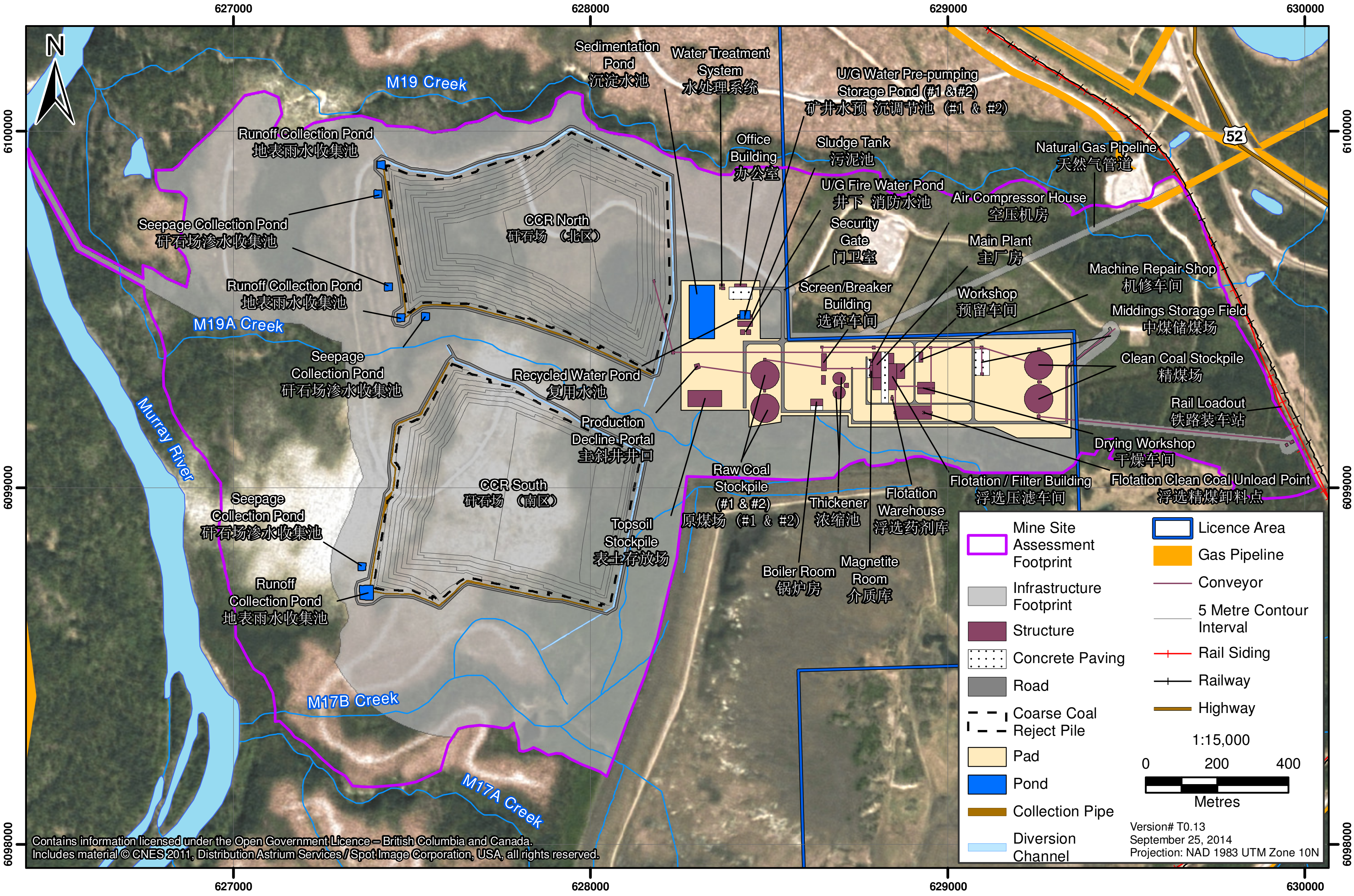
Figure 3.6-23
Coal Processing Site Layout



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September 25, 2014
Projection: NAD 1983 UTM Zone 10N

  - screening and crushing plant,
  - coal preparation main plant,
  - thickeners,
  - flotation and filtration plant, and
  - drying plant;
- Stockpiles:
  - ROM coal stockpiles (x2),
  - clean coal stockpiles,
  - middling coal stockpile,
  - flotation clean coal stockpile, and
  - top soil stockpiles;
- Coarse Coal Rejects (CCR) piles:
  - North Pile, and
  - South Pile;
- Rail Loadout;
- Support buildings:
  - power substation and distribution building,
  - maintenance workshop,
  - boiler room,
  - air compressor building,
  - flotation reagents storage, and
  - office/administration building; and
- Water Management Infrastructure:
  - water well and supply pipelines,
  - sewage water treatment plant,
  - potable water treatment plant,
  - underground mine fire water pond,
  - sludge tanks,
  - sedimentation pond, and
  - TSS treatment system.

Production Decline Portal

The Production Decline Portal is located between coal preparation plant and coarse coal rejects piles at the Coal Processing Site. The portal is designed with elevation of 837.5 masl and 16^{o} dip. The 2,128 m long decline will primarily transport ROM coal to surface from the mine. The ROM coal from mainline conveyor will be discharged onto another conveyor belt through a head hopper, and then be directed to the raw coal stockpiles. The decline will also be used for fresh air intake to the mine, as well as an evacuation exit in emergency.

In addition to the portal, the head house also consists of air heating room and electrical switching room. Three drive motors will be installed to hoist the mainline conveyor in Production Decline, and a 32 t crane will also be equipped here for the purpose of assembly and maintenance.

Coal Preparation Plant (CPP)

Preliminary design of the CPP has been completed by Taggart Engineering (Appendix 3-D). Figure 3.6-24 and Figure 3.6-25 outline the process-flow diagram and material flowsheet for the Coal Preparation Plant (CPP). Run-of-Mine coal (ROM coal or raw coal) will enter the plant, be crushed, and then flow through a series of sizing processes, including: vibrating screens, heavy media cyclones, teetered-bed separator, flotation cells, centrifuges, and press filters.

Raw coal will be crushed and separated into two streams through the deslime screens and crushing plant. The over-screen stream (1 to 50 mm) will be processed by a pre-washing system and produce clean coal, middlings and coarse rejects after a series of screens and Heavy Media Cyclones (HMC).

Deslime screen underflow (< 1.0 mm), will be pumped into classifying cyclones. Underflow coal slime (0.25 to 1.0 mm) will be further processed into clean coal and middlings (0.25 to 1.0 mm) after classifiers, cyclones, teetered-bed separator, sieve-bend screen, and slime centrifuge. Rejects from the teetered-bed separator will be dewatered, then mixed with HMC rejects and directed to the Coarse Coal Rejects piles. The classifying cyclone overflow slurry will be the fine coal slime (< 0.25 mm).

Fine coal slurry comprises overflow of classifying cyclone, undersize of sieve-bend screen and effluent from the slime centrifuge. It will be directed into the flotation cells, filter, and thickener, and produce flotation clean coal and fine rejects (tailings). Flotation clean coal will be mixed into the clean coal for external sale. Underflow from the thickener will be pumped via slurry agitators into press filters. The resulting filter cake will be fine coal rejects, which will be comingled with the coarse coal reject and conveyed to the CCR storage area.

Four streams will be produced through the Coal Preparation Plant (Figure 3.6-24):

1. Clean coal will be transported to the clean coal storage area, and then be directed to the rail loadout.
2. Middling coal will be transported to the middling storage area, and then be directed to the rail loadout.
3. Flotation clean coal will be temporarily stored at the flotation clean coal storage. This material will be dried – by evaporation during the summer, and via a drying plant during the winter months – then directed to the clean coal storage area.
4. Rejects – two streams of rejects will be generated (coarse and fine); they will be comingled and conveyed to the coal rejects pile and stockpiled.

No water discharge is planned from the Coal Preparation Plant. All water contained in the coal fines will be clarified and recycled within the system. Water will be lost via evaporation from the clean coal drying plant, and will be transported off site as moisture content within the coal product. Make-up water requirements to the system (up to 2,450 m^3/d) will be supplied from CCR seepage collection and from excess underground groundwater inflows. Additional details regarding water management and water balance at the Coal Processing Site are outlined in Section 3.6.3.8.

Coal Stockpiles

Several open outdoor coal stockpiles are in place for the temporary storage of raw coal and coal products (Table 3.6-8).

Table 3.6-8. Coal Stockpiles

No.	Stockpile	Diameter (m)	Height (m)	Average Particle Size (mm)	Moisture Content (%)	Turnover Time	Note	Maximum Capacity ($\times 10^3$ tonnes)
1	Raw Coal #1	80	36	30	7	3 days	open	60
2	Raw Coal #2 (reserved)	80	36	30	7	3 days	open	60
3	Clean Coal #1	80	36	8	11	3 days	open	60
4	Clean Coal #2 (reserved)	80	36	8	11	3 days	open	60
5	Flotation Clean Coal Stockpile	104*48 (L*W)	8.5	0.2	24	2 weeks	open	42
6	Middling Coal Stockpile	114*42 （L*W）	9.5	8	15	2 weeks	open	45

Two raw coal piles, each 80 × 36 m (diameter × height), are located at west side of the Coal Processing Site in advance of coal handling and preparation. They will provide a maximum of 6 days turnover storage capacity (120,000 tonnes). Raw coal mined during Construction, prior to commissioning of the processing plant will be stored at these stockpiles.

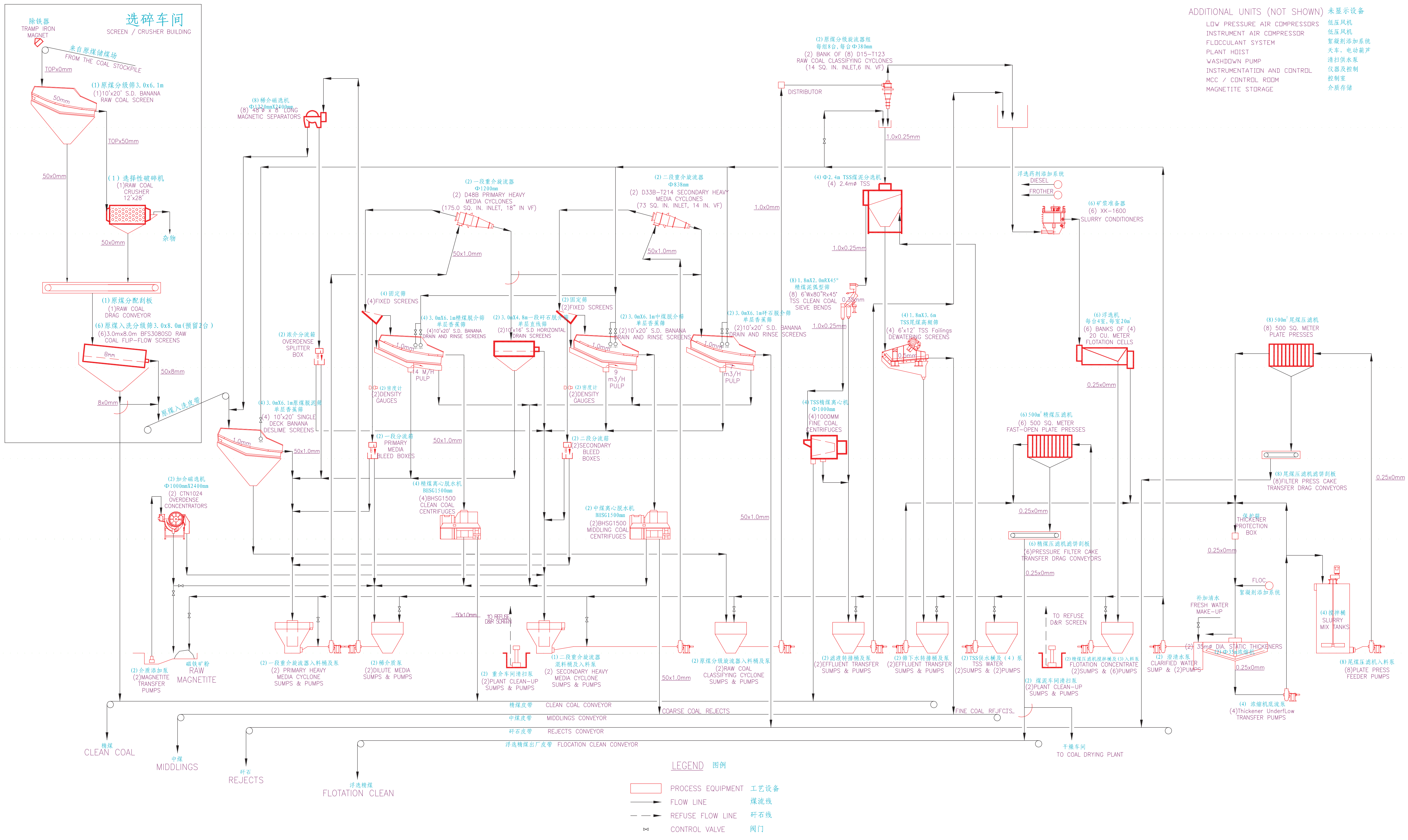
Two clean coal piles, also 80 × 36 m each, are located at the east side of the Coal Processing Site, close to the rail loadout station for coal delivery.

A rectangular middling coal pile, 114 × 42 × 9.5 m (length × width × height), will have two weeks turnover storage capacity (45,000 tonnes).

A rectangular flotation clean coal pile, 104 × 48 × 8.5 m (length × width × height), will have two weeks turnover storage capacity (42,000 tonnes). This stockpile will be used during summer months to allow the flotation clean coal to be dried naturally (by evaporation). During winter months, the fine coal cake is conveyed directly from pressure filter to the drying plant, bypassing this stockpile. Once the desired moisture content is achieved, the flotation clean coal is combined with the clean coal for delivery.

Figure 3.6-24

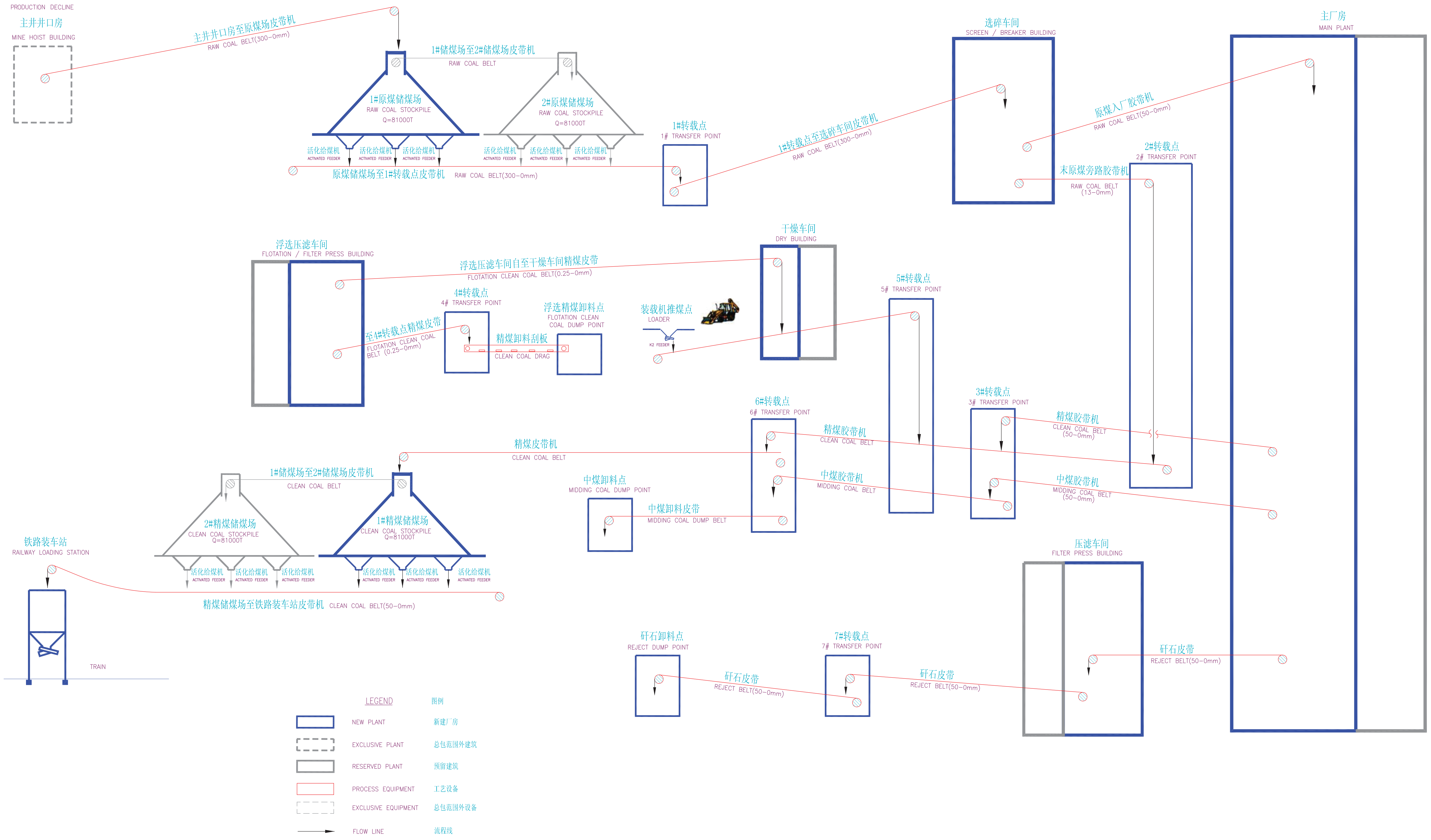
Flow Chart of Coal Preparation Plant



Source: Taggart Engineering.

Figure 3.6-25

Material Flowsheet of Coal Preparation Plant



Source: Taggart Engineering.

Coarse Coal Rejects (CCR) Piles

The co-mingled rejects from the Coal Preparation Plant will be directed to a Coarse Coal Reject (CCR) area. Material will be transported to the CCR on an extensible conveyor, and then re-worked by dozers in 8 to 10 m lifts. Two piles within the CCR site are currently planned (CCR North and CCR South), with the toe of the piles set back from riparian areas of M19, M19A and M17B creeks (Figure 3.6-26).

Geotechnical investigation and design of the CCR piles have been completed by Ausenco (Appendix 3-E). As outlined in the Ausenco report, the geotechnical investigation included 7 boreholes, 10 test pits, and a laboratory test program (42 samples) that included: gradation, Atterberg limits, and specific gravity; Proctor; permeability and consolidation; and tri-axial and large direct shear.

The general design criteria for the CCR piles include:

- Capacity of CCR Piles: 17.4 million cubic metres
- Exterior Embankment Slopes: 2.5:1
- Interior Embankment Slopes: 2:1
- Coarse Coal Reject Moisture Content: 10% to 15%
- Fine Coal Reject Moisture Content: 25%
- Coarse Coal Reject Transport: Conveyor
- Fine Coal Reject Transport: Conveyed co-mingled with the CCR
- Internal Disposal Method: co-disposal

The CCR piles layout is depicted in Figure 3.6-26 to 3.6-32. There will be two CCR piles to accommodate all the coal rejects during 25 years of Operation. CCR North will serve for the first 15 years and CCR South is planned for the remaining 10 years.

Based on the analysis completed, a geomembrane liner (2.0 mm LLDPE) is planned for both piles. The thickness of the geomembrane is based on the planned depth of coal reject weight on top of the overliner-geomembrane and laboratory testing of similar systems.

Seepage collection piping on top of the geomembrane will consist of 150-mm perforated dual wall (smooth interior and corrugated exterior) HDPE laterals placed every 50-meters in a herring bone pattern across the liner, oriented to positively flow from the natural ridges to the main collectors. The laterals will drain and connect to perforated 300-mm dual wall HDPE headers that drain to small external transition ponds (15 m by 15 m). The collection pipes will sit within a 2 m thick blanket drain of coarse reject material will be used to promote drainage and prevent development of a phreatic surface within the pile. The seepage collection layouts for these two piles are outlined in Figures 3.6-29 to 3.6-32.

Based on modelling of seepage through the pile and depth to water table, it is expected that the piles will have 98% capture efficiency (with allowance for minor installation defects in the geomembrane).

Slope stability analyses were conducted to determine the factors of safety for the given slope geometry of the respective coal reject stockpiles. These results are compared against the Dump Stability Rating (DSR) scheme from the Investigation and Design Manual Interim Guidelines (BC MWRPRC, 1991). The piles are classified as Class II, Low Hazard. In accordance with provincial guidelines and standard industry practice, the minimum acceptable factor of safety for waste facilities under static conditions is 1.3 for short-term operating conditions and 1.5 after reclamation and abandonment. A factor of safety under seismic conditions of less than 1.0 may be acceptable provided that calculated deformations resulting from seismic loading are not significant.

Slope stability analyses for the coal reject piles for the ultimate configuration were undertaken. The most critical section were analysed for each pile and the computed factors of safety for the two piles are included in Appendix 3E. The lowest factors of safety for CCR North are 1.87 (static) and 1.52 (pseudostatic) and for CCR South are 1.53 (static) and 1.15 (pseudo-static). These factors are acceptable under the conditions laid out in the DSR scheme. The final factors of safety at closure exceeds the minimum factor of safety of 1.5 for structures after reclamation and abandonment and is thus acceptable, all factors of safety are in excess of the minimum factor of safety of 1.3 for short-term operating conditions.

Rail Loadout

The rail loadout will support mine production of 4.8 Mtpa saleable coal.

Instead of a looped rail loadout similar to what is utilized by Peace River Coal and Quintette, a single linear track is planned that parallels the existing CN Rail line (Figure 3.6-33). The track will be constructed within existing CN Rail right-of-way.

Rail track and geometry have been designed to CN Rail standards. The track will have a total length of 5,500 m. The loadout will be located at the mid-point of the track. This design allows for a full train length to be loaded on a level grade as it moves through the loadout, with the empty rail cars being pulled up the 0.5% grade.

Annual rail operating days will be 330 days. Each train will have the capacity to carry 116 rail cars and will be driven by five locomotives.

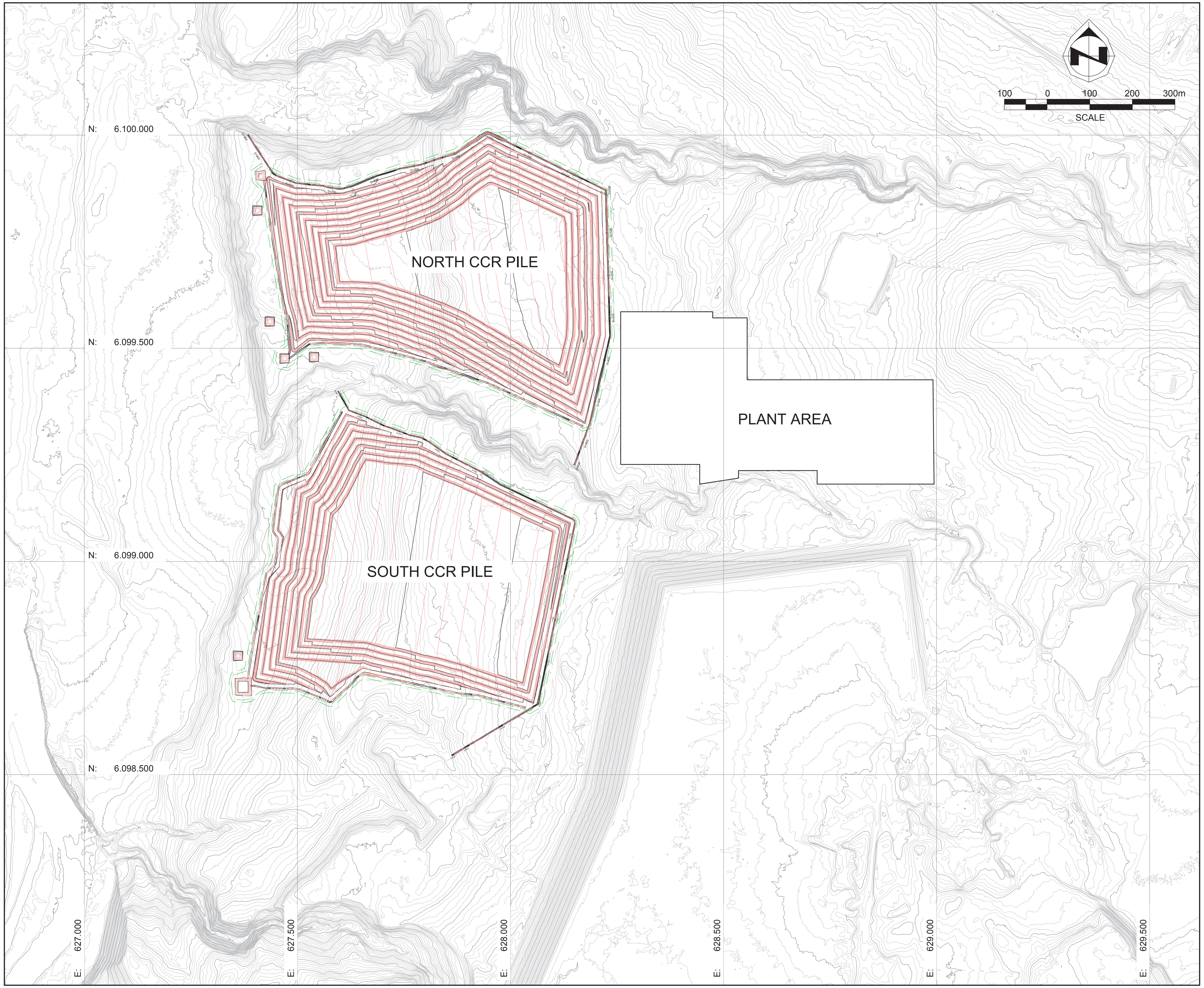
Clean coal will be conveyed from the processing plant to the loadout on a continuous basis throughout the operating hours at the plant. The average conveyor throughput will be approximately 3,000 t/h based on 4 hours per day plant operations.

Ancillary facilities at the rail loadout will include: a small office, an electrical substation for incoming power supply and medium/low voltage power distribution.

Support Buildings

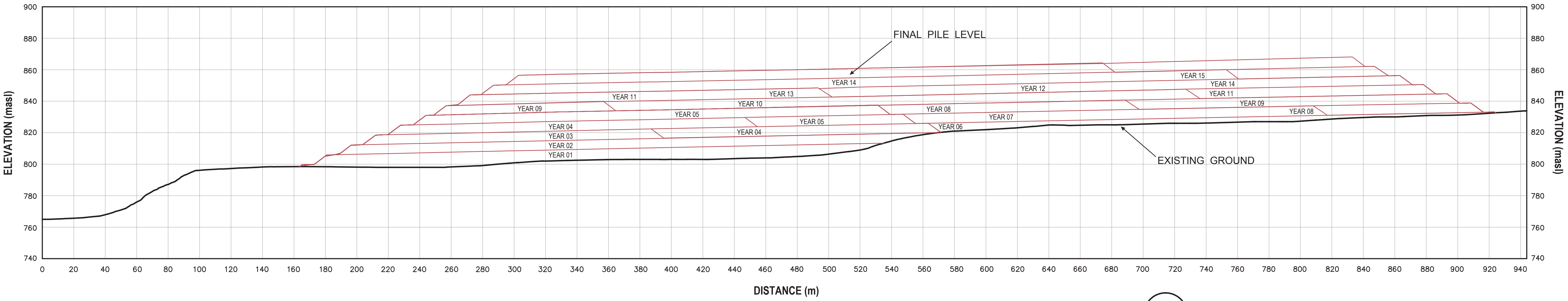
Other infrastructures in Coal Processing Site also include facilities and infrastructures, such as water well and supply pipelines, fuel station, natural gas pipeline and storage facility, rainfall diversion ditches, parking lots, and conveyors from coal product storage to the Rail Loadout.

Figure 3.6-26
CCR Piles General Arrangement

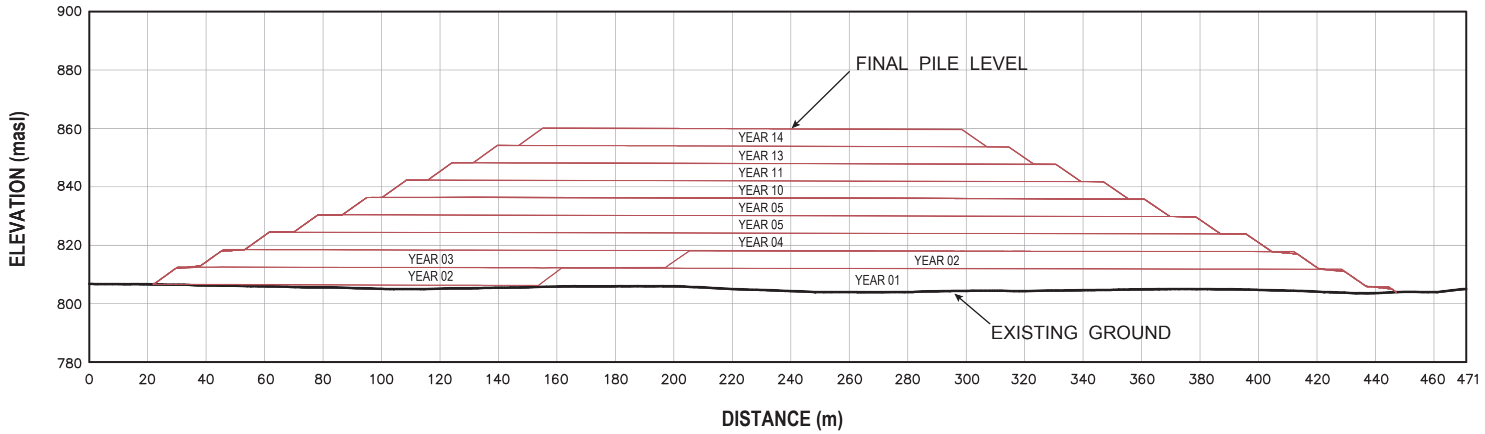


Note: Contours every 1 metre.
Source: Ausenco International.

Figure 3.6-27
CCR North Pile Cross Sections



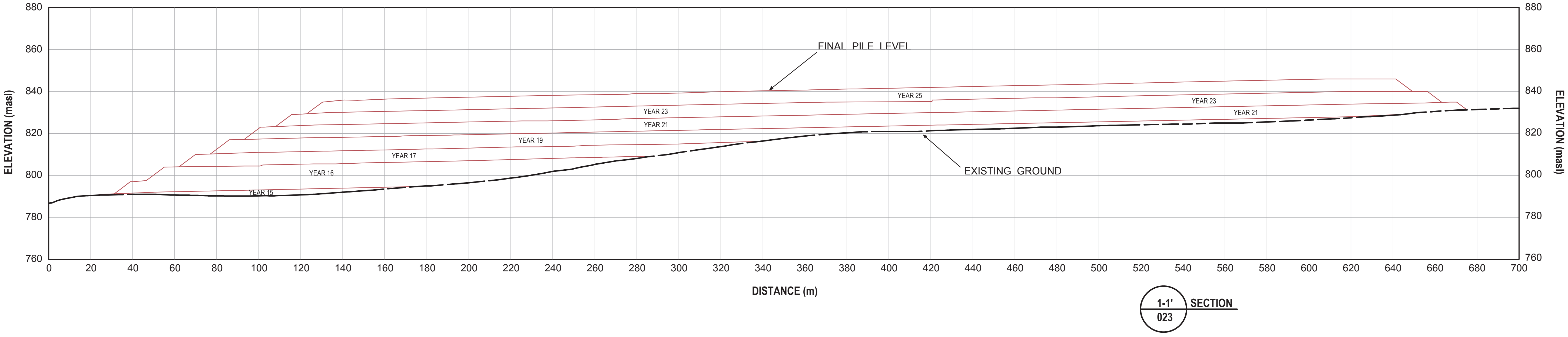
1-1'
005
SECTION

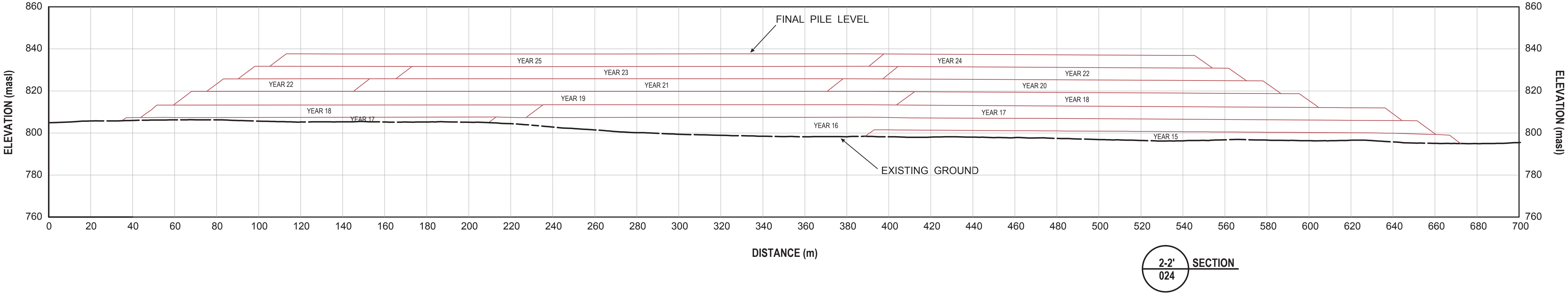


2-2'
005
SECTION

Source: Ausenco International.

CCR South Pile Cross Sections

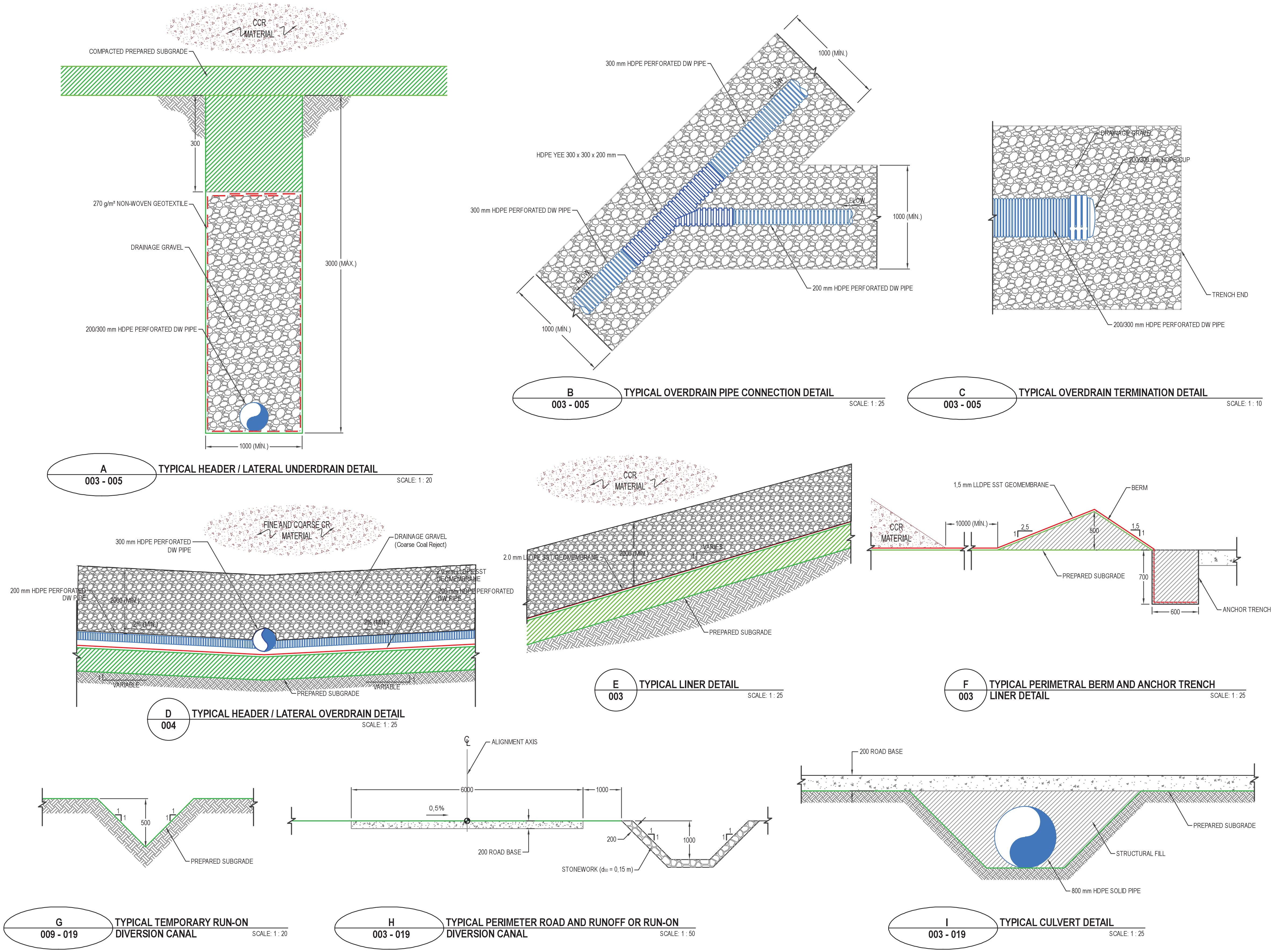




Source: Ausenco International.

Figure 3.6-29

CCR Overdrain System Details



LEGEND

🟩	PREPARED SUBGRADE
🟥	1,5 mm LLDPE SST GEOMEMBRANE
🟥	270 g/m² NON-WOVEN GEOTEXTILE
▼	WATER TABLE LEVEL
▨	EXISTING GROUND
▨	STRUCTURAL FILL
▨	LOW PERMEABILITY SOIL LINER
▨	ROAD BASE
▨	STONEWORK

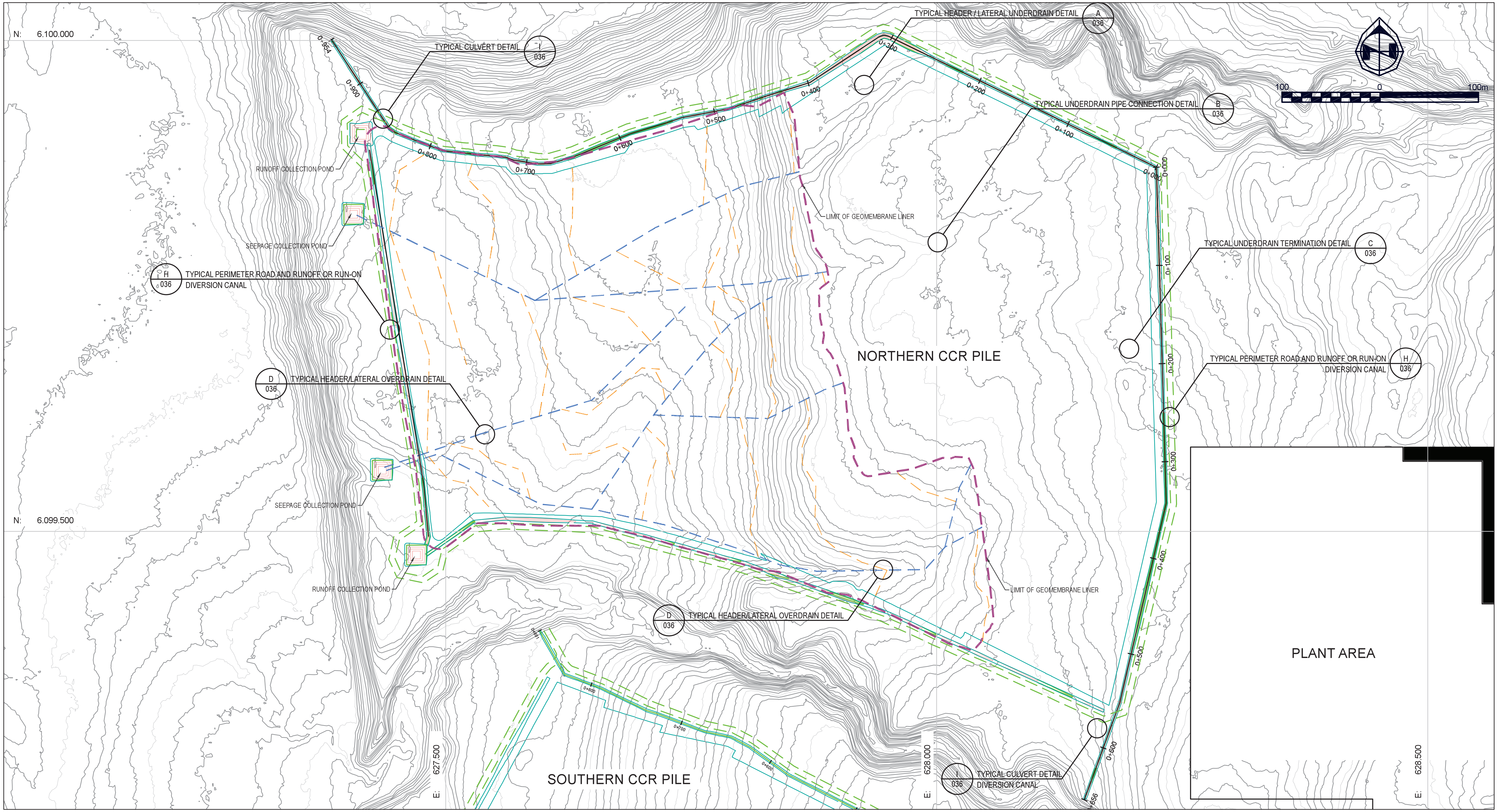
NOTES:

1. LLDPE = LINEAR LOW DENSITY POLYETHYLENE
   HDPE = HIGH DENSITY POLYETHYLENE
   SST = SINGLE-SIDED TEXTURE
   DW = DUAL WALL
2. UNSUITABLE MATERIAL FOUND DURING CONSTRUCTION SHALL BE REMOVED AND REPLACED BY COMPACTED STRUCTURAL FILL, OR EXCAVATED UNTIL FOUNDATION LEVELS AS INDICATED IN THIS DRAWING AND/OR REQUIRED BY THE ENGINEER.
3. THE CUT SLOPE SHALL BE EXCAVATED IN ACCORDANCE WITH THE SAFETY REQUERIMENTS, GROUND CONDITIONS, AND AS DETERMINED AND APPROVED BY THE ENGINEER.
4. IF DURING UNDERDRAIN INSTALLATION THE ENGINEER DETERMINES THE GROUND CONDITIONS ARE SUITABLE, BEDDING LAYER PLACEMENT MAY BE ELIMINATED. EXCAVATIONS SHALL BE REVIEWED AND APPROVED BY THE ENGINEER BEFORE RE-STARTING THE WORKS.
5. ALL PIPE CONNECTIONS AND ACCESORIES FOR THE UNDERDRAIN AND LINER DRAIN SYSTEM SHALL BE PROVIDED BY THE PIPE MANUFACTURER.
6. DRAINAGE GRAVEL SHALL MEET THE TECHNICAL SPECIFICATIONS. LIKEWISE, THE PLACEMENT PROCEDURES SHALL FOLLOW THE GUIDELINES OF THIS DOCUMENT.
7. THE PERIMETER ANCHOR TRENCH FILL SHALL BE DONE BY UTILIZING COMPACTED MATERIAL WITH NO GRAVEL EXCESS.
8. THE 1,5 mm LLDPE SST GEOMEMBRANE SHALL BE DEPLOYED WITH THE TEXTURED SIDE ADJACENT SUBGRADE.

Source: Ausenco International.

Figure 3.6-30

CCR North
Overdrain System - Phase 1



MAJOR CONTOUR

MINOR CONTOUR

300 mm HDPE DW PIPE FOR OVERDRAIN

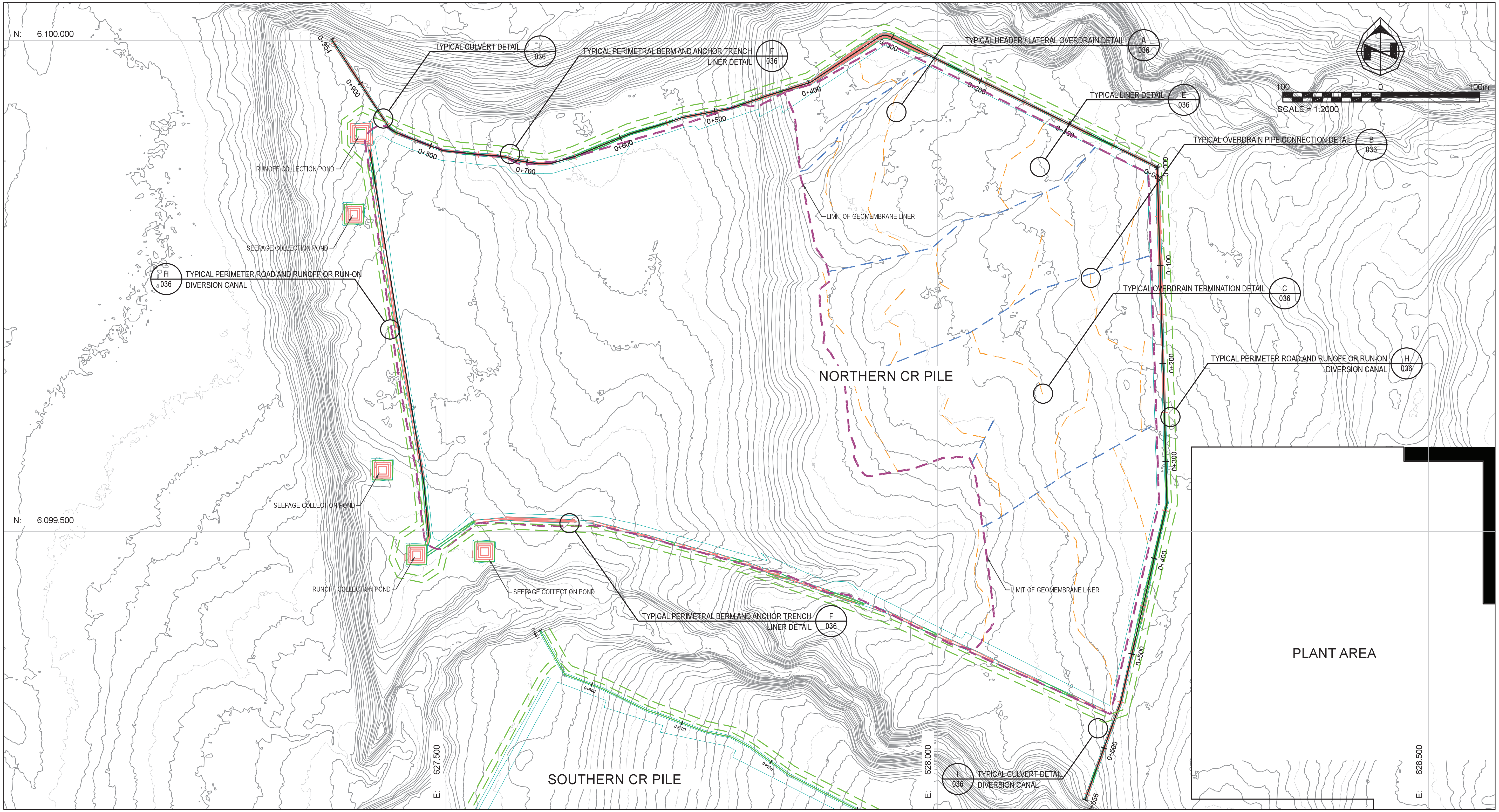
200 mm HDPE DW PIPE FOR OVERDRAIN

PERIMETER ROAD

LIMIT OF GEOMEMBRANE LINER

Note: Contours every 1 metre.
Source: Ausenco International.

Figure 3.6-31
CCR North
Overdrain System - Phase 2

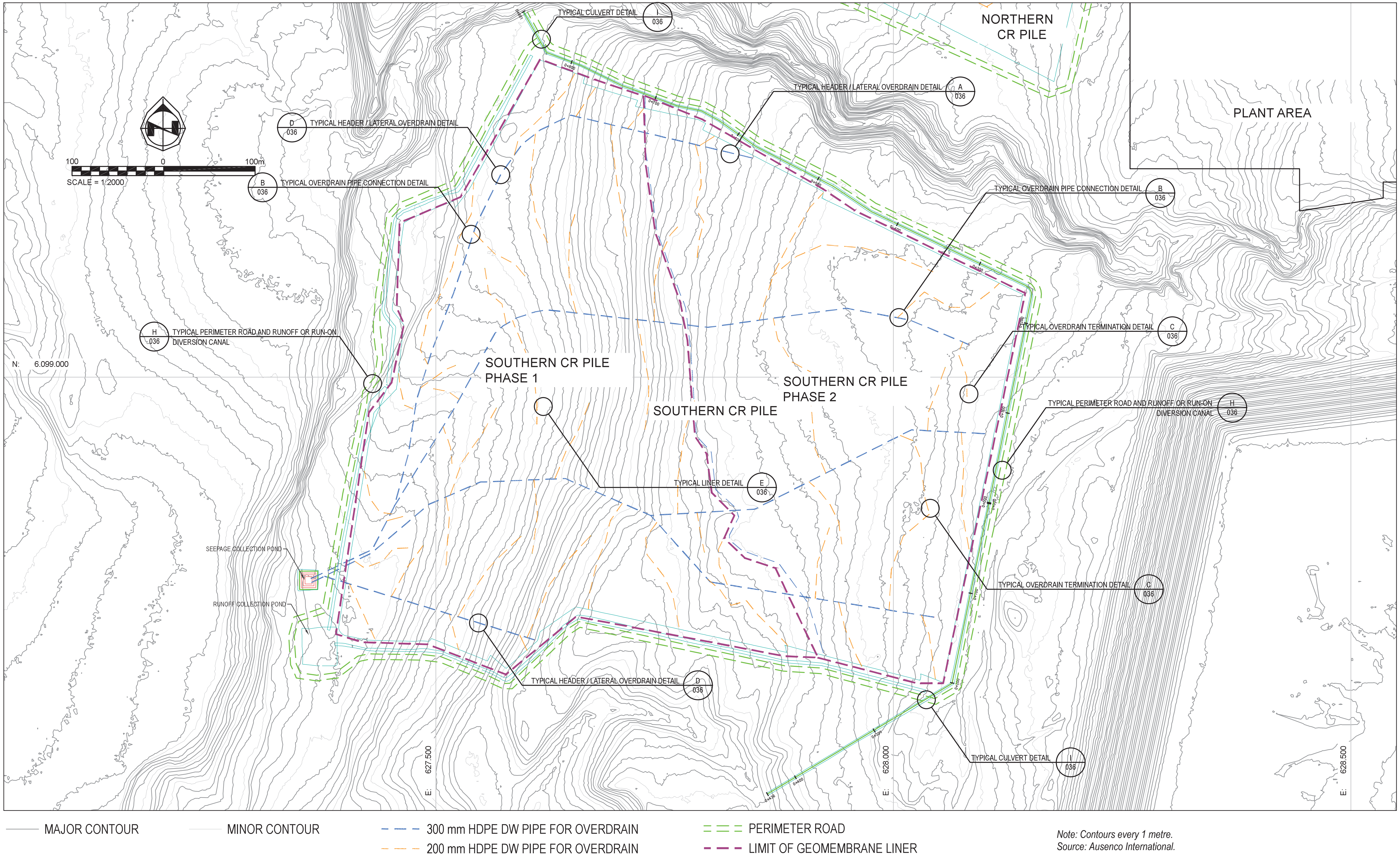


- MAJOR CONTOUR
- MINOR CONTOUR
- 300 mm HDPE DW PIPE FOR OVERDRAIN
- 200 mm HDPE DW PIPE FOR OVERDRAIN
- PERIMETER ROAD
- LIMIT OF GEOMEMBRANE LINER
- 300 mm HDPE NON PERFORATED OVER DRAIN PIPE

Note: Contours every 1 metre.
Source: Ausenco International.

Figure 3.6-32

CCR South Overdrain System

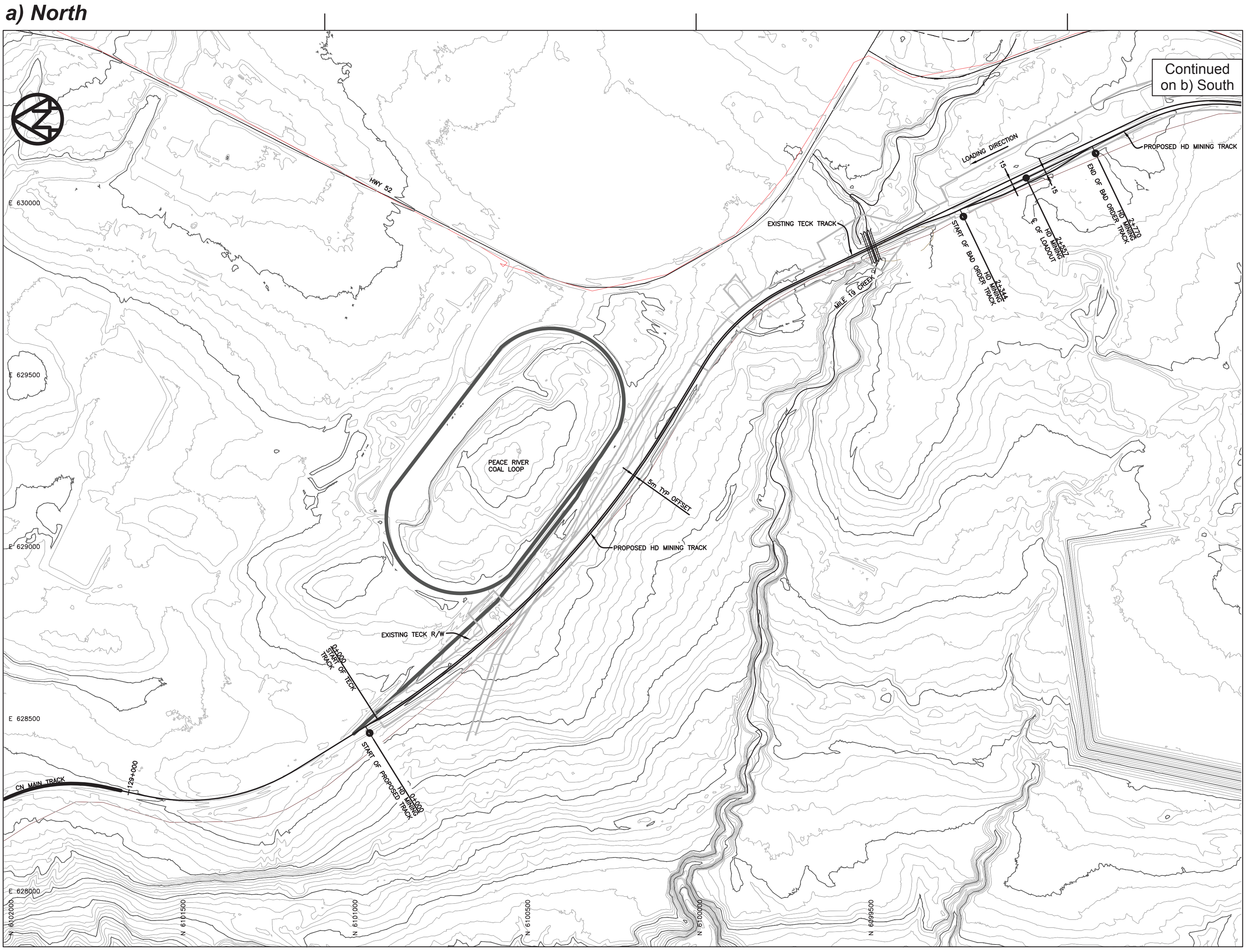


Note: Contours every 1 metre.
Source: Ausenco International.

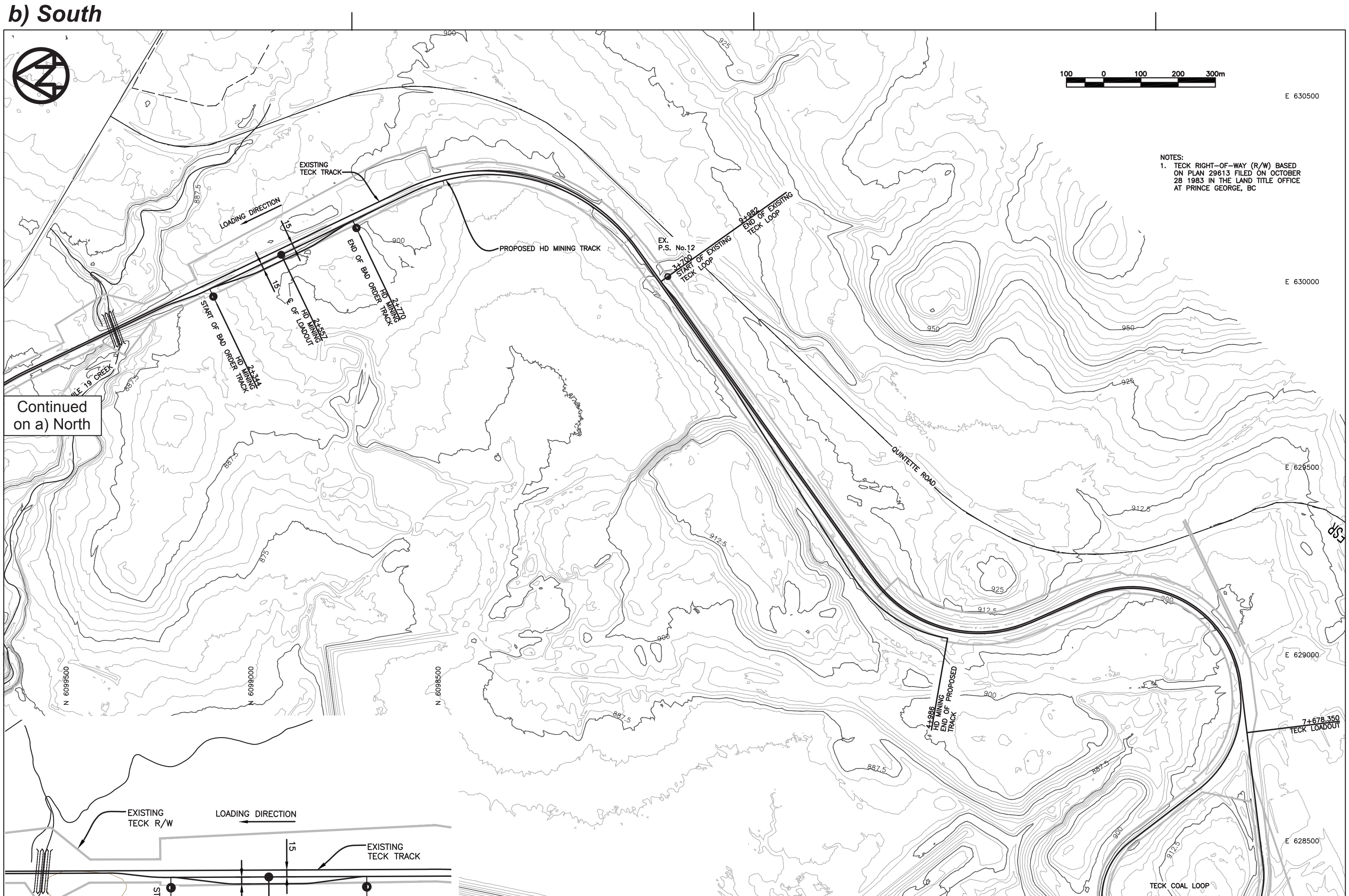
Figure 3.6-33

Rail Loadout
Site Plan

a) North



b) South



Source: Ausenco International.

Water Management Infrastructure

Potable/sanitary water will be supplied by a water well at the Coal Processing Site. Where necessary it will be treated through a treatment system to achieve the necessary quality for human consumption, and serve the administrative office, shower, boilers, fire water, plant watering, etc. It is anticipated that an ozone/UV potable water treatment package will be employed.

The sanitary sewage will be discharged into the disposal area after treatment in accordance to the BC regulation (see Section 3.6.3.10).

Groundwater inflow to the underground mine will be pumped to the CPP Pond. Some of this water will be used as process water for the coal preparation plant. Excess groundwater inflow water will be discharged into the environment in compliance with permit requirements.

Seepage from all raw and processed coal stockpiles will be collected in sumps at each coal stockpile area, and pumped to the CPP pond.

Seepage from CCR piles will be collected in the seepage ponds adjacent to the piles and pumped back to the coal preparation plant as supplement water for the process, or to the CPP Pond.

See Section 3.6.3.8 for further details on water management and water balance.

The non-contact runoff will be directed into the M19A Creek and M19 Creek through the perimeter runoff trenches and ditches system.

3.6.3.5 Secondary Shafts Site

As illustrated in Figure 3.6-34, facilities at the Secondary Shafts Site will include:

- Intake Air Shaft;
- Return Air Shaft;
- Ventilation Fans;
- Electrical House;
- Air Heating House; and
- Site Access roads.

This site will be constructed after 15 years into Operation.

3.6.3.6 Roads and Access

The existing road network will be used to access the site, including Murray River FSR, Mast Road, and the access from HWY 52 to the Coal Processing Site. HD Mining will secure road use agreements to support this use.

Internal roads leading to the Decline Site, Shaft Site and Coal Processing Site, respectively will be connected to the existing forest roads (Figure 3.6-35).

Figure 3.6-34
Secondary Shaft Site

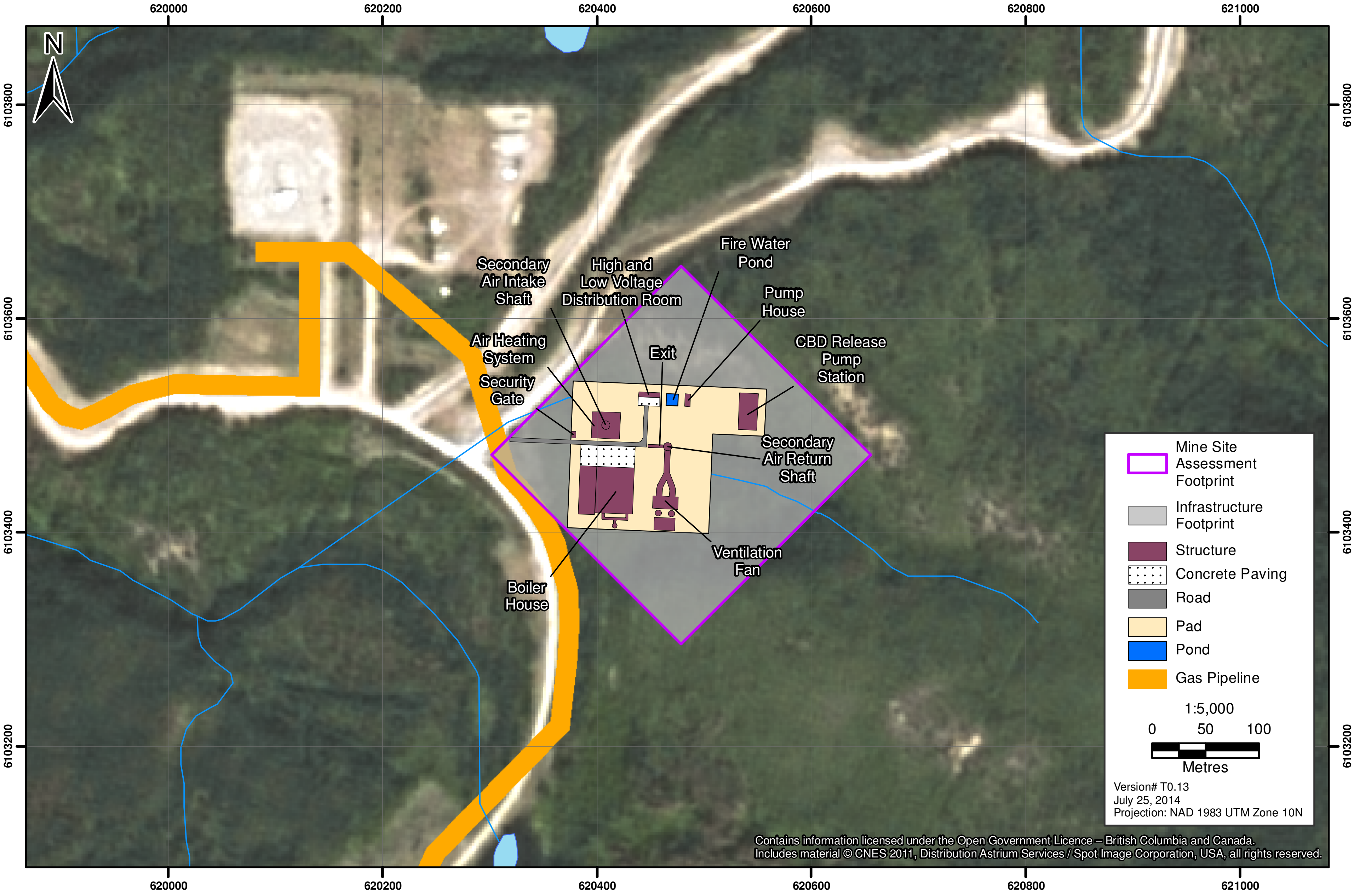


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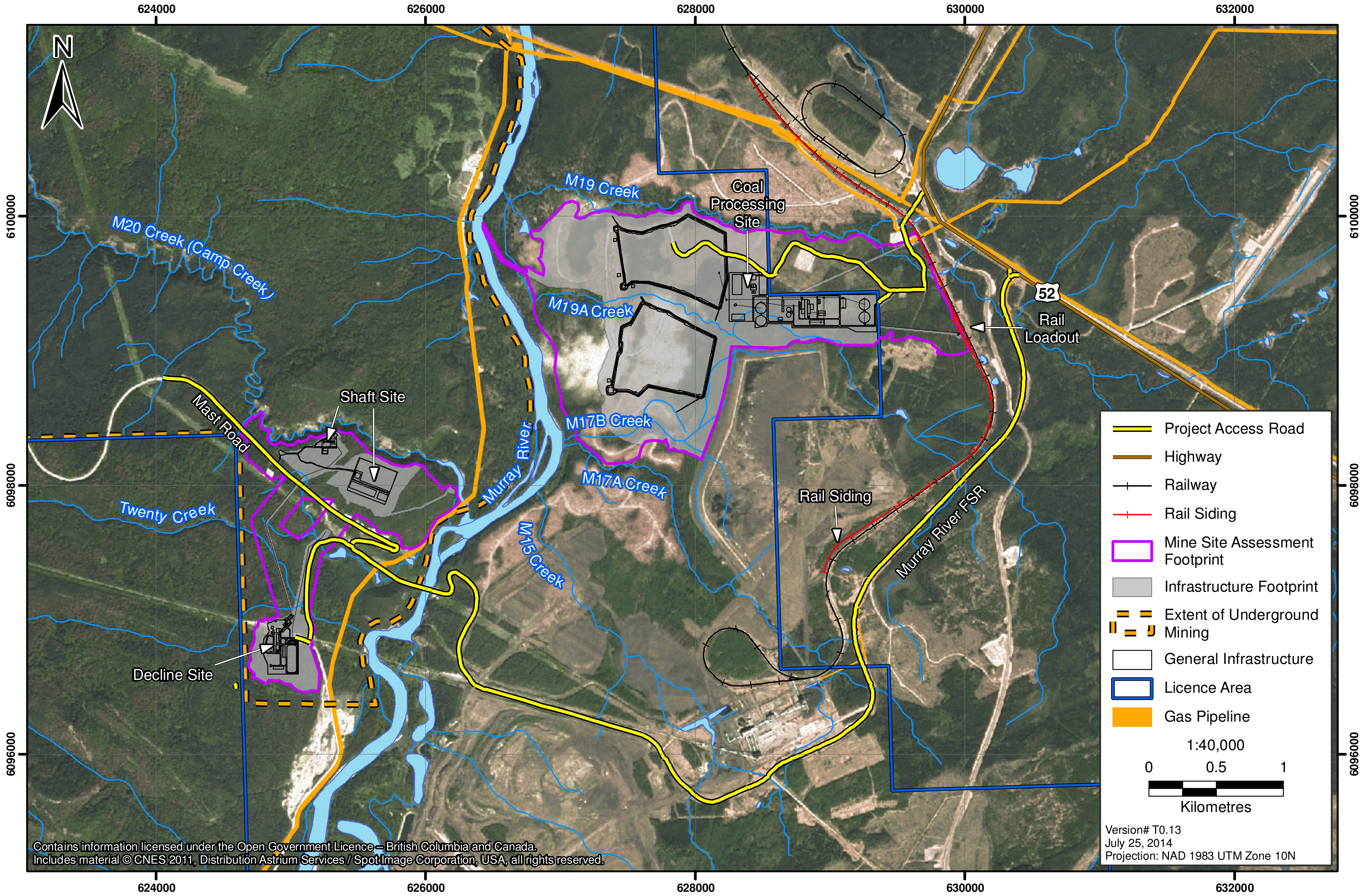
Figure 3.6-35
Access Road and Surface Transportation System

ERM



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3.6.3.7 Utilities

Electricity

BC Hydro has an existing 230 kV power line that runs within 1.3 km of the Decline Site (see Figure 3.6-36). HD Mining has engaged BC Hydro to develop a tie into this system.

HD Mining will construct an 1.3 km 230 kV line from the BC Hydro tie-in to a substation/distribution hub at the Decline site, which will direct power around surface sites and to an underground substation, where it will be distributed to each working area along roadways/gateways.

Power to the Shaft Site will be connected to a secondary substation via a 10 kV line from the main power substation at the Decline Site.

Power to the Coal Processing Site will be routed through the underground mine and up the Production Decline to a substation located on surface near the portal.

There will be two principal transformers in the surface main power substation. Each one is capable of servicing the entire mine; however, they will operate simultaneously during normal operation.

The total equipment electrical load is estimated at 59,509 kW for the underground mine and 15,877 kW for the Coal Processing Site. The total equipment working load is 53,271 kW for the underground mine and 15,572 kW for the Coal Processing Site. The total annual power requirement is about 152 x 10^6 kWh.

Four 2,400 kW, 10.5 kV diesel generators will be equipped in the main power substation for emergency backup in the case of BC Hydro power outage. The generators will provide service only for ventilation fans, principle water pumps, CBG drainage, and other priority power users.

Natural Gas

HD Mining has engaged Pacific Northern Gas (PNG) to supply natural gas from their existing network (Appendix 3-F). A short pipeline (approximately 800 m) will be installed to supply the Coal Preparation Plant for coal drying and boilers. Natural gas will also be required to run the boilers at the Decline Site. A natural gas tank is located in the Decline Site with the capacity to supply 15 days of mine operation consumption. The tank will be refilled through regular truck delivery.

The total annual natural gas requirement is estimated to be about 18.4 Mm^3/yr.

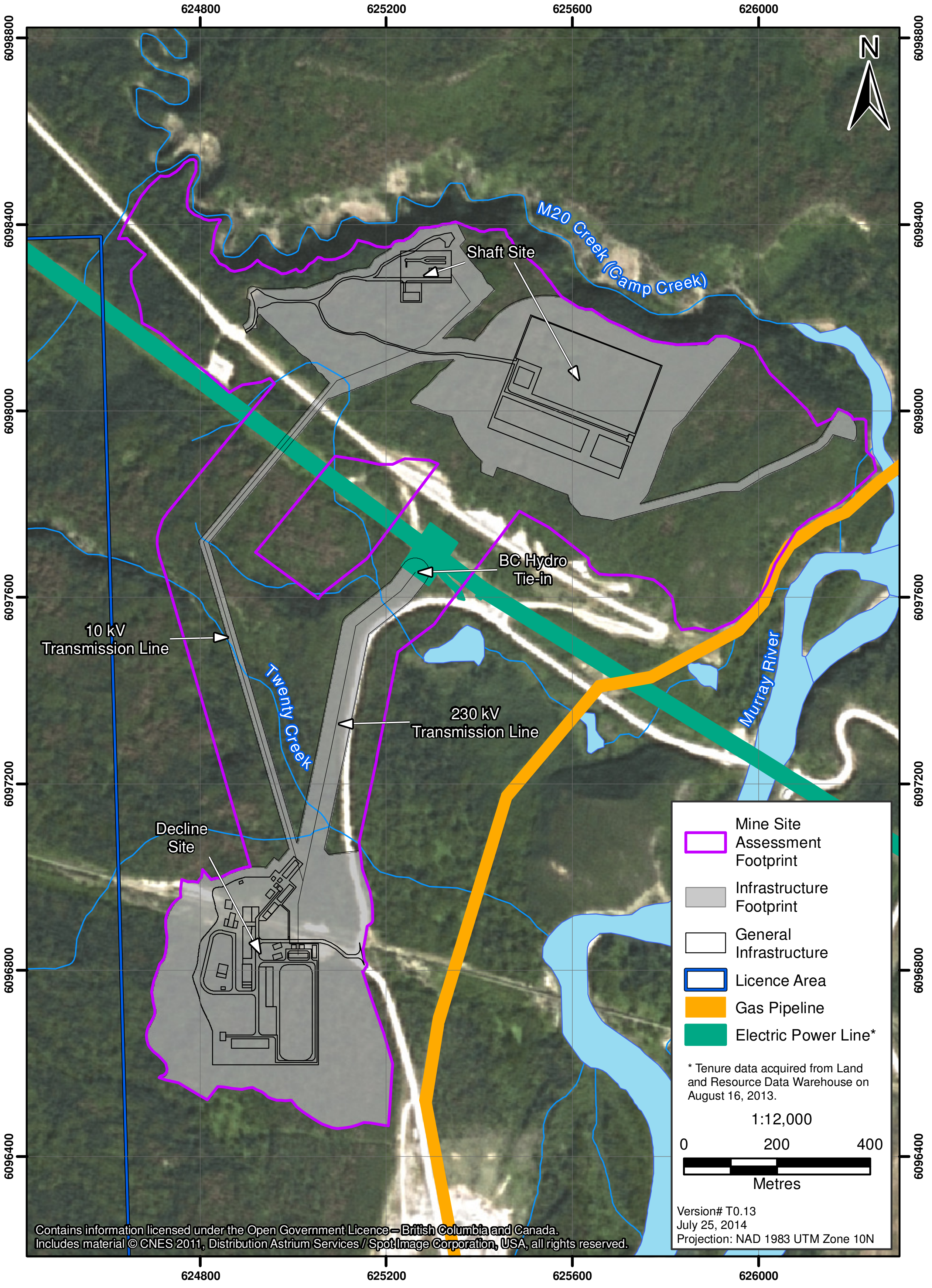
Fuel Storage and Handling

The total annual diesel requirement is estimated at about 468,400 liters. Diesel will be primarily used for the vehicles and equipment of coal processing and underground mining.

Diesel storage tanks will be installed at the Decline Site to serve the diesel equipment and vehicles on site. In addition, a fuel station, equipped with a 15,000 liters horizontal storage tank, will be constructed at the Decline Site to support the diesel vehicles in the underground mine and surface operation.

Figure 3.6-36

Electricity Tie-in Location with BC Hydro



* Tenure data acquired from Land and Resource Data Warehouse on August 16, 2013.

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Two separate 30 m^3 buried tanks will be installed at CPP site for the flotation reagents storage of kerosene and octanol respectively.

Communication

Two standalone operation and control centers will be set up for the underground mine and coal processing operation. These two centers will be located in the office/administration complex buildings at the Decline Site and Coal Processing Site, respectively.

An integrated mine communication system consisting of an administration/operation communication system, and a wireless system will be used.

A cable digital program-controlled telephone switching system will be established to serve the administration, surface facilities operation and underground mine production. It will have the capacity to accommodate more than 500 digital phone sets and will be connected with the local municipal telephone system.

A mine WiFi system will be installed to support the underground mobile personnel, such as drivage, maintenance, and safety inspection, and for emergency use.

Furthermore, a set of emergency mine rescue wireless communication devices and an underground mine broadcast system are also planned.

3.6.3.8 Water Balance and Water Management

Water Balance

A water balance model for the Project was developed using a monthly time-step (Appendix 8-E). The model schematics are presented in Figure 3.6-37a-c. Water balance volumes during the Construction, Operation, Decommissioning and Reclamation, and Post-closure are presented in Appendix 8-E, and summarized in the following sections.

Underground Mine

It is recognized that there is a high degree of uncertainty associated with estimating rates of inflow to the underground mine. As described in Section 3.6.2.12, three estimates were derived: low (1,891 m^3/d); moderate (6,002 m^3/d); and high (12,748 m^3/d). For the purposes of water balance modelling, the moderate estimate was used as the base case scenario.

Inflow to the underground mine will be collected in a central water sump that is equipped with a main water pump station. Under the base case scenario, up to 6,002 m3/d of groundwater will enter the underground mine, 162 m^3/d of which will be lost to evaporation. Underground water demand increases over the mine life based on the length of mainlines that need to be active and maintained with a sprinkler system for general fire and dust suppression purposes. Up to 2,075 m3/d of groundwater will be circulated back within the mine for this purpose. At full production rate, it is estimated that 1,376 m3/d of water will be stored as moisture in raw coal, and conveyed to the surface (Figure 3.6-37b).

Figure 3.6-37a

Water Balance Model Schematic

a) Construction

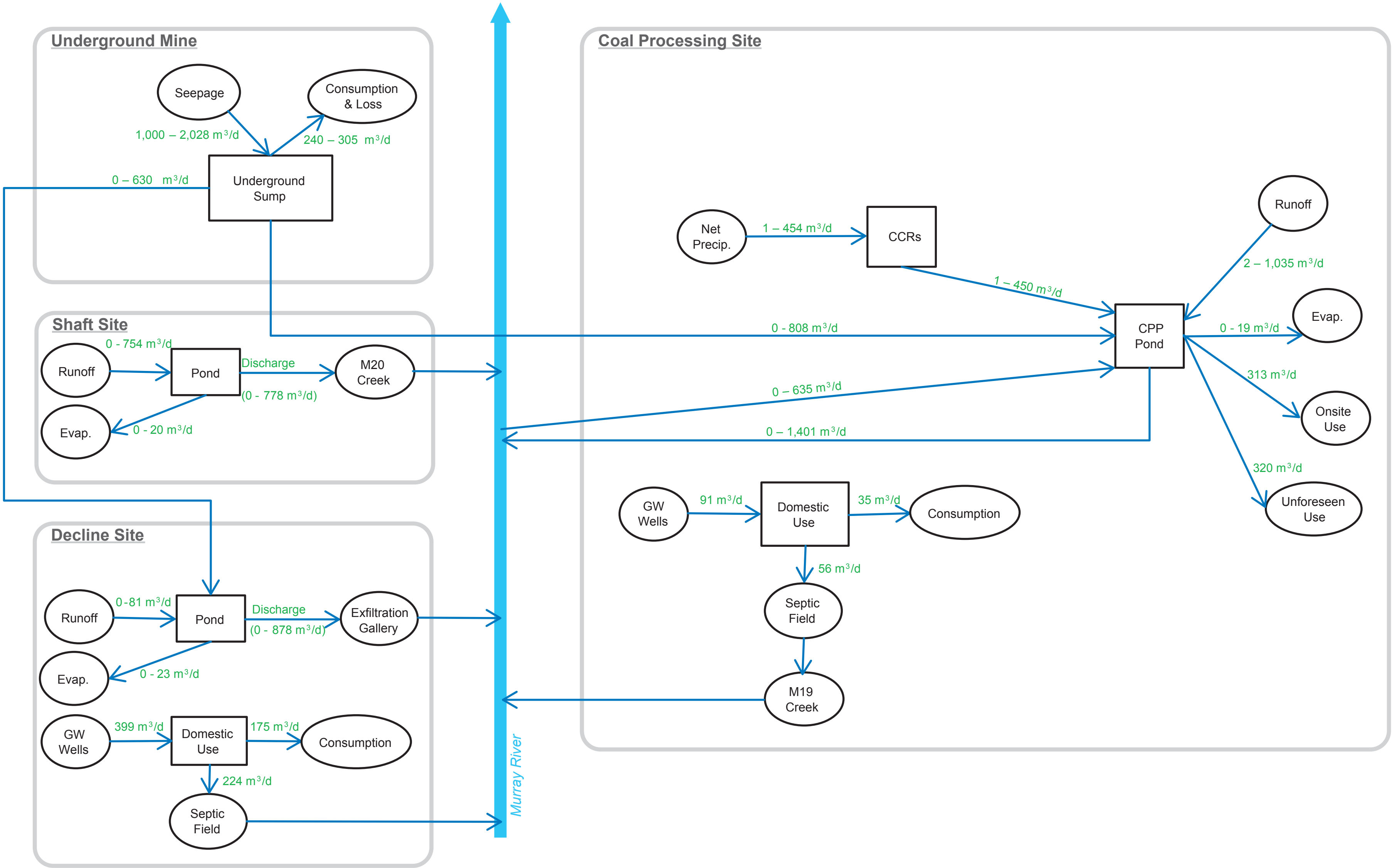


Figure 3.6-37b

Water Balance Model Schematic

b) Operation

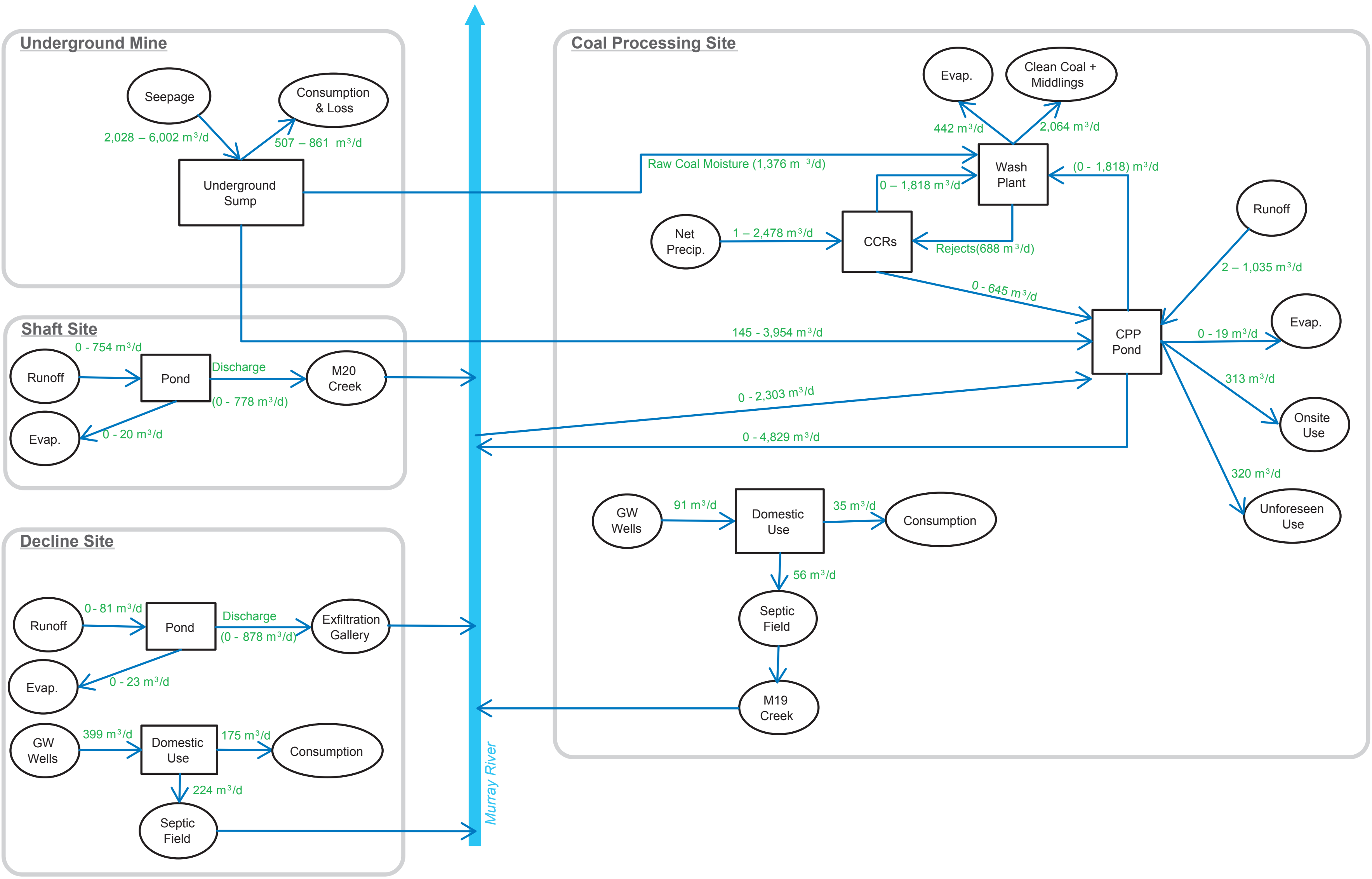
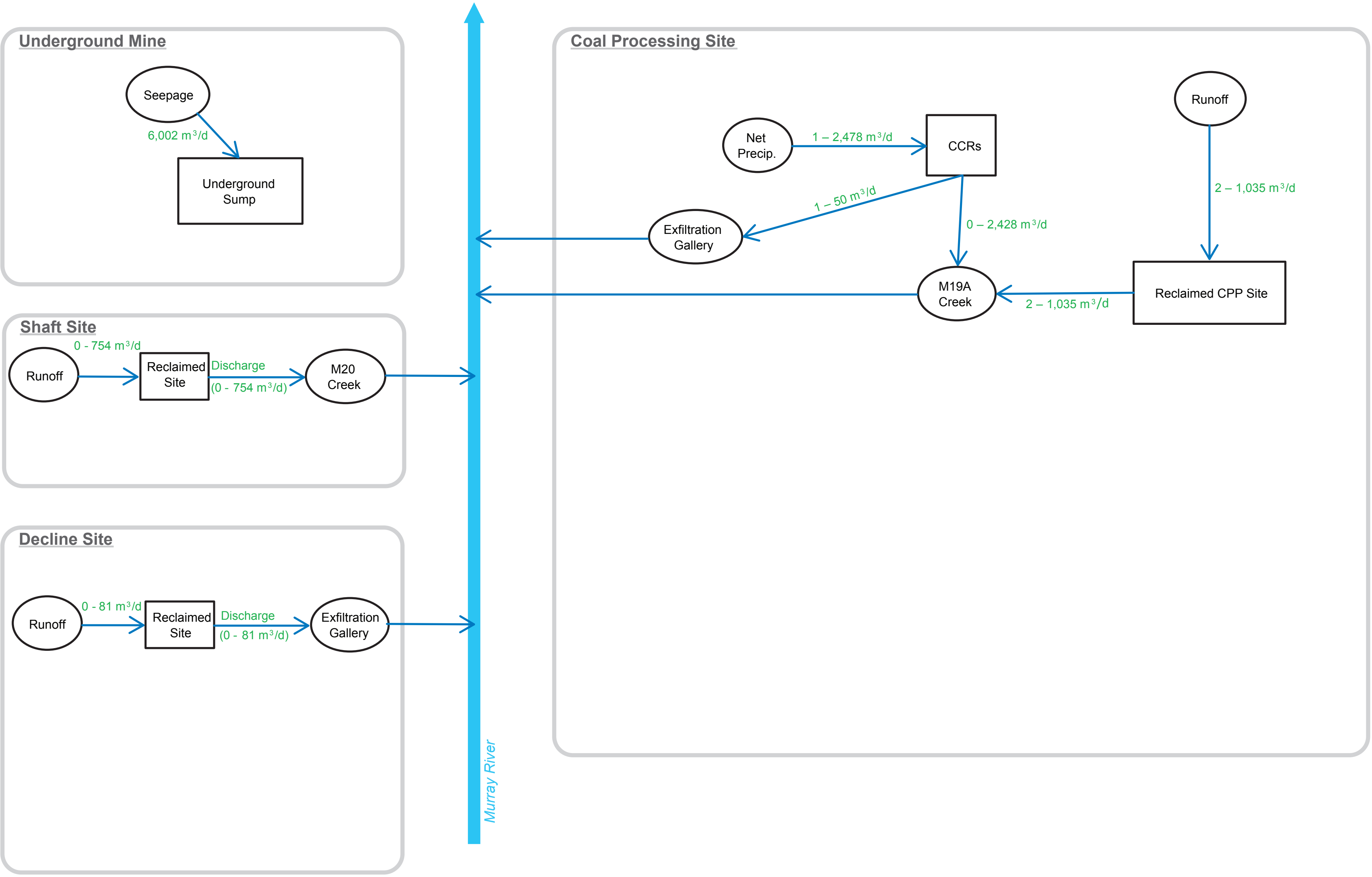


Figure 3.6-37c
Water Balance Model Schematic

c) Closure



For the low inflow scenario, the underground mine will be at water deficit conditions. Water withdrawal from Murray River (up to 1,275 m^3/d) would be required to support for underground activities in this scenario. At an inflow rate of 2,237 m^3/d or greater, the underground mine will not be at water deficit conditions.

During the first year of Construction, excess groundwater inflows will be pumped to the Decline Site pond, consistent with current water management during Bulk Sample. Once construction of the Production Decline is complete, excess groundwater inflows will be pumped to the Coal Processing Site for the remainder Construction and during Operation. Water will not be pumped to the surface once mining is complete (Decommissioning and Reclamation and Post-closure).

Current water management planning does not account for storage of excess water (underground or on surface). This is seen as a future opportunity that could be used to help optimize water management and reduce potential effects to the surface water system.

Decline Site

During the first year of Construction, excess groundwater inflows will be pumped into the Decline Site pond. The pond outflow will be discharged on the ground via an exfiltration gallery. This water will eventually reach Murray River. After the first year of Construction, the Production Decline will be complete, and groundwater inflows will be pumped into the Coal Preparation Plant (CPP) pond instead of the Decline pond. In the water balance model, the Decline pond is decommissioned at the end of the first year of Operation.

Groundwater wells will provide 399 m^3/day of water for domestic use from which 225 m^3/day will be discharged to a septic field as domestic sewage.

Shaft Site

A waste rock storage area and sedimentation pond have been constructed at the Shaft Site as part of Bulk Sample. During Construction and the early part of Operation, surface runoff from the waste rock pile will report to the Shaft Site pond. The pond outflow will be discharged to M20 (Camp) Creek (Figure 3.6-37a).

The waste rock pile is planned to be reclaimed after the end of Construction. In the water balance model, the Shaft Site pond is decommissioned at the end of the second year of Operation, after which seepage and runoff will naturally flow to M20 Creek.

Coal Processing Site

During mining, the Project will process approximately 148 Mt of coal in the 25 years of Operation. The mass of coal rejects per year is approximately 30% of the total coal mined each year. The coal rejects are split with 70% in the coarse fraction (coarse coal rejects; CCR) and 30% in the fine fraction (tailings). Coarse and fine coal rejects will be comingled and stored sub-aerially in two stockpiles within the Coal Processing Site. CCR North will be in operation from Year 1 through Year 14 and the CCR South will be in operations from Year 15 through Year 25. Diversion ditches around the CCR North will divert non-contact water to M19 Creek and M19A Creek (a tributary of M19 Creek). For the CCR South, non-contact water will be diverted to M19A Creek and M17B Creek.

As described in Section 3.6.3.4, the base of the CCR piles are designed with a geomembrane liner and overdrain system. It is expected that more than 98% of the effective precipitation (i.e., rainfall plus snowmelt minus evaporation) on CCR piles will be captured by the seepage collection system either as surface runoff or seepage through the piles. The seepage collection system will drain contact water into a collection sump. Contact water in this sump will be pumped to the Coal Preparation Plant, and excess water, beyond the Coal Preparation Plant need, will be pumped into the CPP pond.

The CCR North and CCR South piles will be covered and re-vegetated at the end of Years 15 and 25, respectively. It is assumed that only 2% of annual effective precipitation will infiltrate this cover, and 98% will run off the surface. After the end of mining (i.e., Year 25), surface runoff from the reclaimed CCR piles is rerouted to M19A Creek, and infiltrated water will be recharged to groundwater through exfiltration galleries.

On-site groundwater wells will provide 91 m^3/day of water for domestic use from which 56 m^3/day will be domestic sewage, which will be discharged to the environment along with excess groundwater inflows.

There will be six stockpiles in the coal processing area, two for raw coal and four for coal product. Raw coal and clean will stockpiles will have a maximum capacity of 60 kt each with a turnover time of 3 days. The flotation clean coal and middling coal stockpiles will have maximum capacities of 42 kt and 45 kt, respectively, with two-week turnover times. Runoff from the stockpiles will be directed to the CPP pond. Diversion ditches around the plant area will divert non-contact water to M19A Creek.

The Coal Preparation Plant requires 3,194 m^3/day of water to replace the volume of water that leaves the plant as clean coal and middlings moisture (2,064 m^3/day), reject moisture (688 m^3/day), and evaporation loss (442 m^3/day). This demand is supplied by raw coal moisture (1,376 m^3/day), water collected from the CCR seepage system (variable volume), and makeup water from the CPP pond (variable volume; Figure 3.6-37b).

The CPP pond will be used as the water source for wash plant make-up water, onsite uses (313 m^3/day), and unforeseen uses (320 m^3/day). Total water uses from the CPP pond are variable during Operation, particularly because make-up water needs for the wash plant are variable. During Operation, depending on the time of year, and the underground inflow rate, the CPP pond may be in either a positive balance status (i.e., excess water from the pond is discharged into the Murray River) or a negative balance status (i.e., water from Murray River is pumped to the CPP pond to be used in the wash plant). Positive balance occurs during spring/summer, when snowmelt runoff from the CCR piles combines with excess underground inflows to provide sufficient input to the wash plant. Discharge rates from the CPP Pond to Murray River are expected to increase over time (consistent with inflow rates), and range from 800 to 4,800 m^3/d (0.01 m^3/s to 0.55 m^3/s; Figure 3.6-38). Negative balance occurs during the fall/winter. Withdrawal rates are estimated to range from 1,200 to 2,100 m^3/d (0.014 m^3/s to 0.024 m^3/s) during the first 10 years of mining, decreasing over time (Figure 3.6-39).

Figure 3.6-38

CPP Pond Discharge to Murray River during Different Phases of the Project

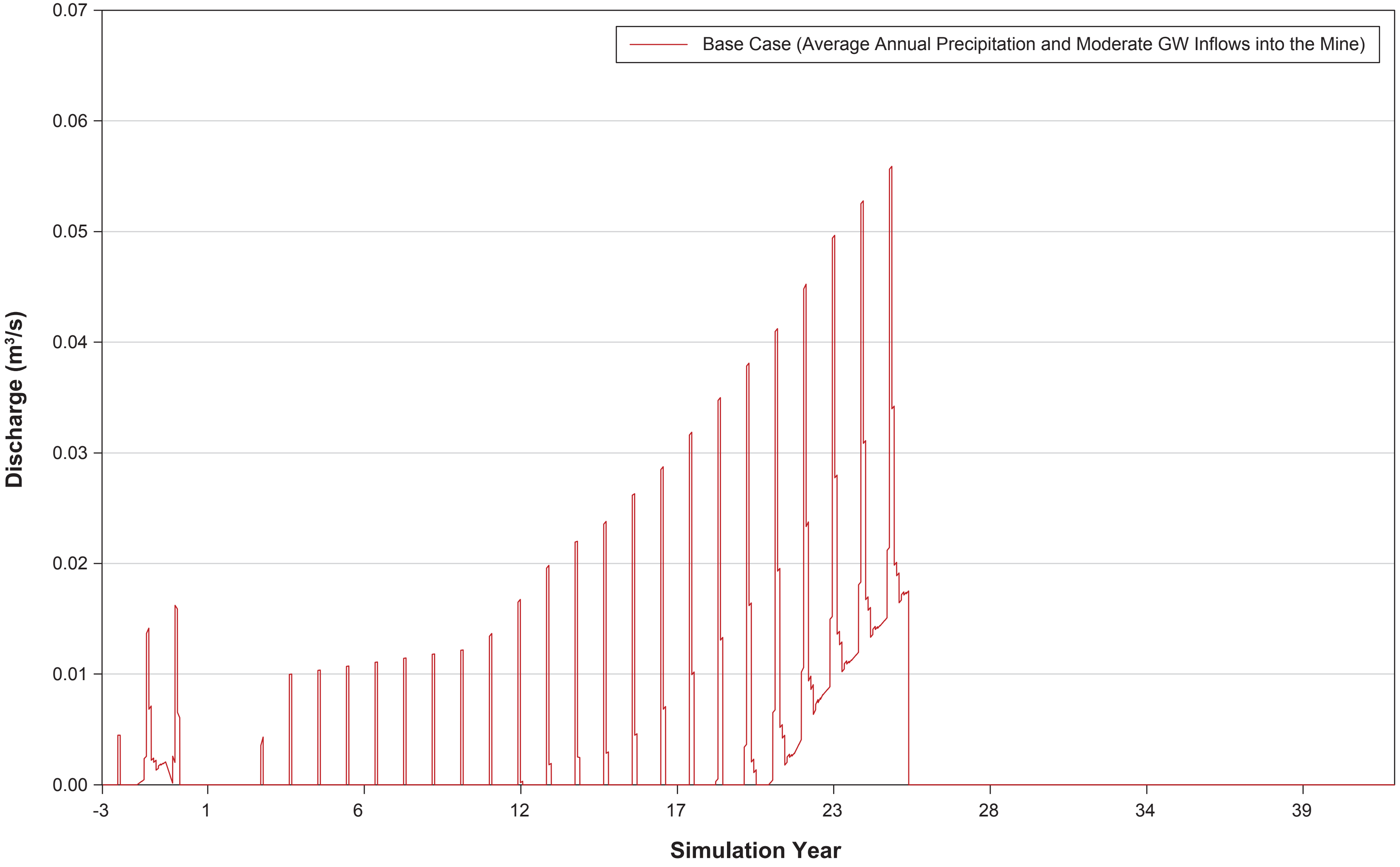
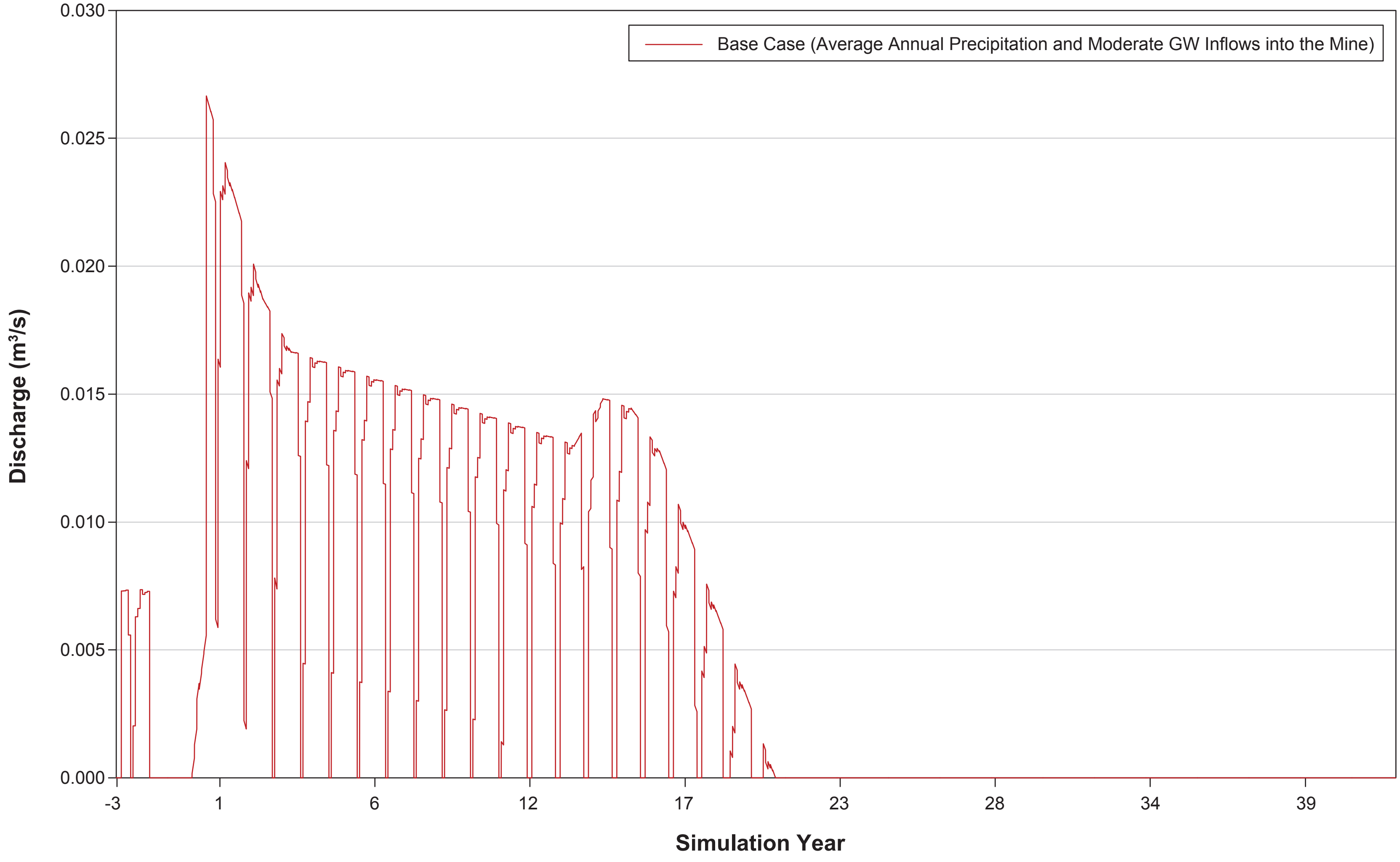


Figure 3.6-39

Murray River Water Withdrawal for CPP Pond during Different Phases of the Project



Intake and Discharge Infrastructure

Figure 3.6-40 provides a conceptual diagram of the approach to the collection and distribution of water between the Coal Preparation Plant, CCR piles, and Murray River. Intake works will be required at the Murray River to provide up to 2,100 m^3/d of make-up water to the Coal Preparation Plant during periods of the year. Water will only be pumped from the river when the CPP Pond cannot supply the required demand.

The intake works will be located on the right bank of the river at the same location as proposed discharge outfall. Simultaneous intake and discharge at the river is not anticipated. Intake works will include screening that is consistent with DFO guidelines to prevent entrainment or impingement of fish (DFO 1995). A buried pipe will carry water from the river up to the primary pond of the CCR runoff/seepage collection system at the toe of CCR North.

Multiple seepage and runoff collection ponds at the periphery of CCR North and South (once in use) will convey flow to a primary pond (which will also receive the make-up water from Murray River). Water from this primary pond will be pumped up to the Coal Preparation Plant for direct use in the wash plant. During periods of excess water (e.g., during snowmelt), flow from the primary pond will be redirected to the CPP Pond.

The CPP Pond will serve as the main collection point for water near the CPP. Excess groundwater inflow to the underground mine will be pumped up the Production Decline to the CPP Pond. Also, surface runoff (contact water) from all areas within the Coal Processing Site is collected in the CPP pond.

During periods of low or no pumping from the CCR seepage system, make-up from the CPP Pond will be pumped to the wash plant.

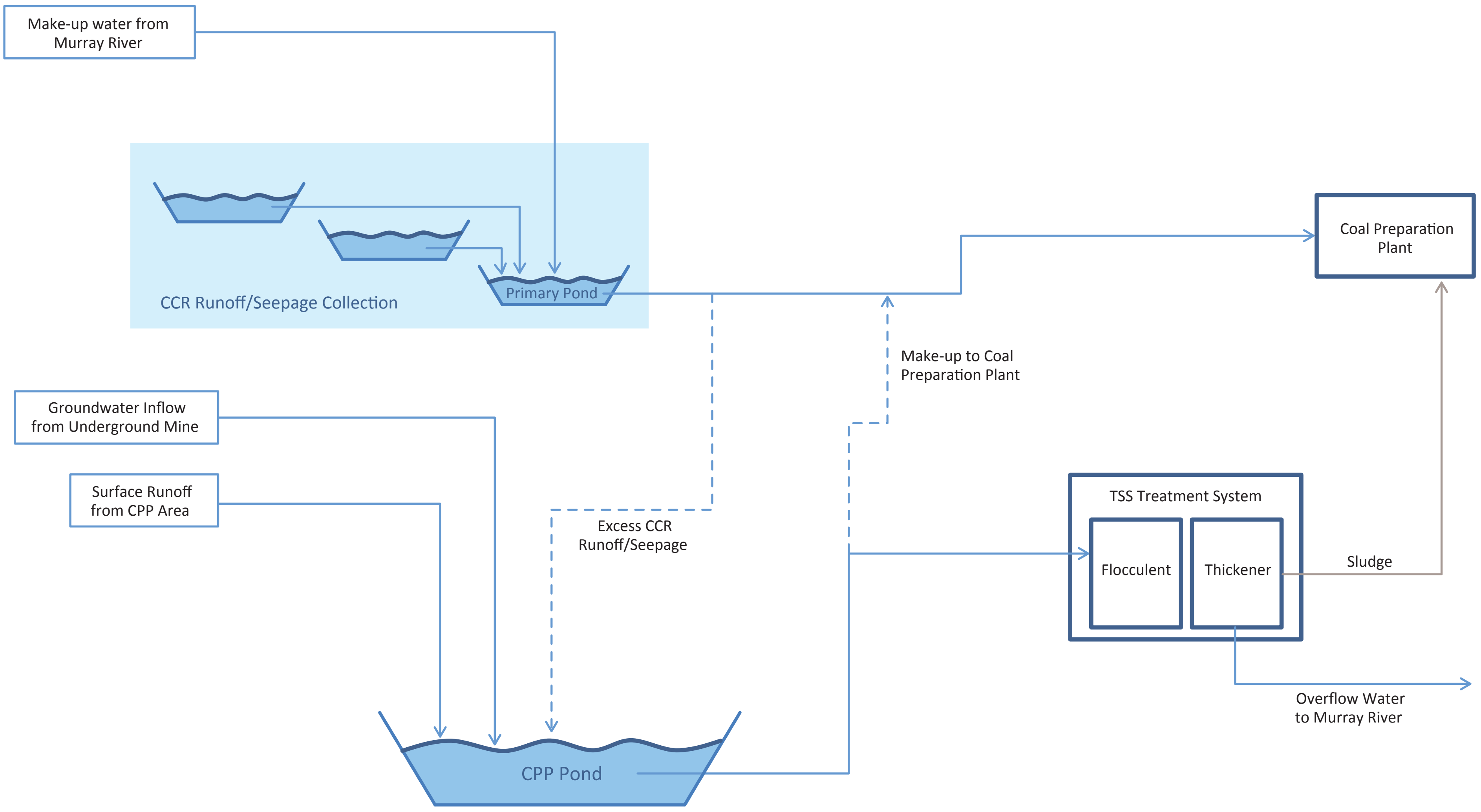
During periods with excess water in the CPP Pond, the water will be discharged to Murray River.

Prior to discharge, water will be treated to remove TSS to meet permit criteria. Current water quality predictions (Appendix 8-E) show that the CPP pond water can be discharged to Murray River without treatment for dissolved parameters. If these predictions do not hold valid during next stages of the Project design, or during the monitoring program, additional water treatment can be added to the system.

The TSS sources will largely be coal-based (underground inflow, CCR seepage, stockpile runoff). As illustrated in Figure 3.6-38, discharge to the river is seasonally (snow-melt) driven; only during the last 10 years of mining do underground inflows increase to the point that year-round discharge from the CPP Pond is required. It is anticipated that suspended solids in the water column will be very fine grained, and will not readily settle by gravity. The TSS treatment facility will include flocculent dosing and a thickener. For the Bulk Sample, water is currently being treated with a flocculent called Hydrex; testing has also been successful with Magnafloc. However, this has all been in overburden rocks. As the Bulk Sample progresses into the coal seams, further testing will confirm the most appropriate flocculent product and optimal dose rate.

Figure 3.6-40

Conceptual Diagram of the Collection and Distribution of Water between the Coal Preparation Plant, CCR Piles, and Murray River



Underflow from the thickener will be fed into the CPP slurry mix tank feeding the fine reject filter press, and will end up in the CCR piles. Assuming inflow to the treatment plant has a TSS of 2,500 mg/L (a conservative estimate), and that it is removed down to 50 mg/L prior to discharge, based on the flow rates from Figure 3.6-38, the total annual mass of solids that would be generated as thickener underflow ranges from 20 to 1,200 tonnes per year, which is an insignificant component of the total fine tailings generated annually.

Treated effluent will flow in a buried pipe back down to Murray River, discharging to the river from the right bank.

To assess mixing of effluent discharge into Murray River from the Coal Processing Site, a MIKE3 hydrodynamic model was developed. The results of the mixing model were used to identify the optimal effluent discharge location (Figure 3.6-41). Details of the model approach, assumptions, and sensitivity analyses are provided in Appendix 8-F.

The MIKE3 mixing model evaluated a nominal effluent discharge rate of 100 L/s under low flow conditions in the Murray River (5 m^3/s) that are equivalent to a 7-day low flow with a 10-year return period (7Q10). The results of the mixing model indicate that optimal mixing occurs at the inner bend of the east bank adjacent to the Coal Processing Site; therefore, the proposed CPP pond discharge was sited at this location.

3.6.3.9 Heat, Hot Water, and Boiler Houses (HVAC)

There will be two boiler houses at surface. At the Decline Site, a boiler system is required to provide heat and hot water for the Service Decline ventilation, and the buildings and facilities within the Decline Site. Four gas-fired boilers will produce hot water to heat the buildings equipped with steel radiators in place. Ten electric forced air space heaters in an air heating room will generate warm air for the Service Decline ventilation during winter months.

At the Coal Processing Site, three gas-fired boilers will provide hot water to heat the buildings. Three electric forced air space heaters in an air heating room will generate warm air for Production Decline portal ventilation during the winter months.

In addition, there will be two electric air space heaters in the hoist house of Service Decline to protect the winch mooring rope entrances.

3.6.3.10 Waste Management

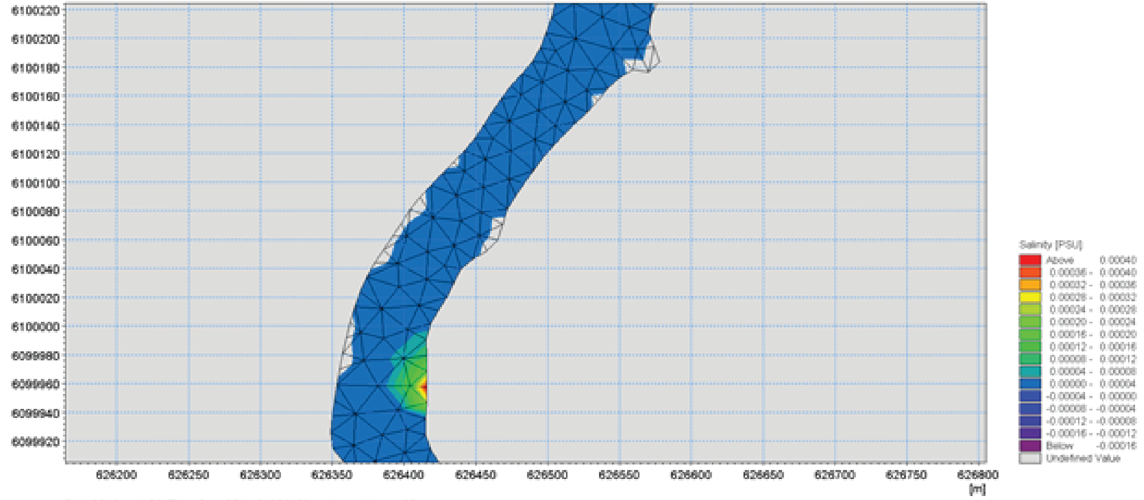
Temporary Storage

It is anticipated that approximately 550 tonnes of general waste will be produced each year during Operation. All recyclable and waste material will be segregated and stored in appropriate bins/ receptacles. A registered waste management company(s) will be contracted to haul waste off site to appropriate management facilities. More details regarding waste management are outlined in Chapter 24.

Figure 3.6-41

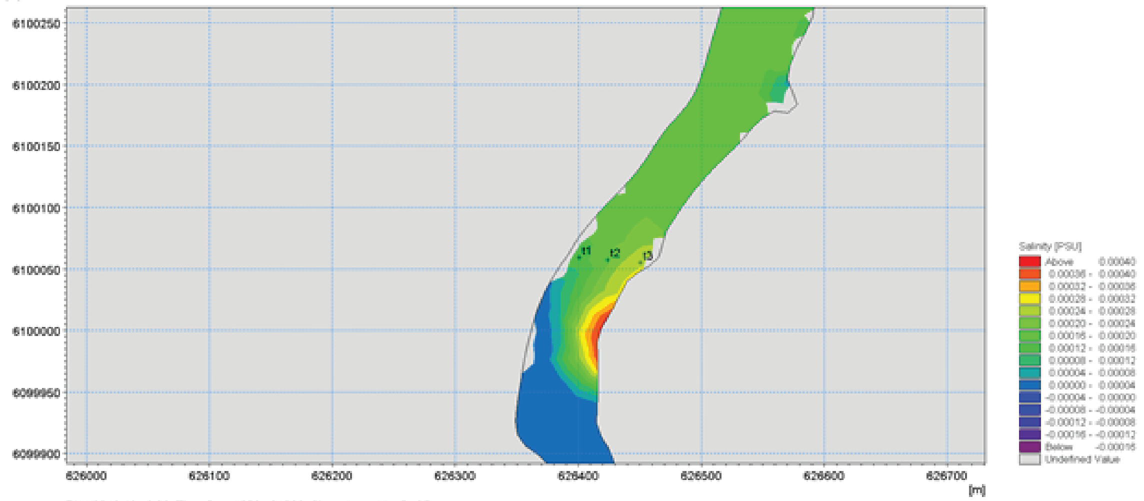
Mixing Associated with Effluent Discharge to Murray River at Low Flow Conditions

a) Surface concentrations 1 s after Injection of Effluent



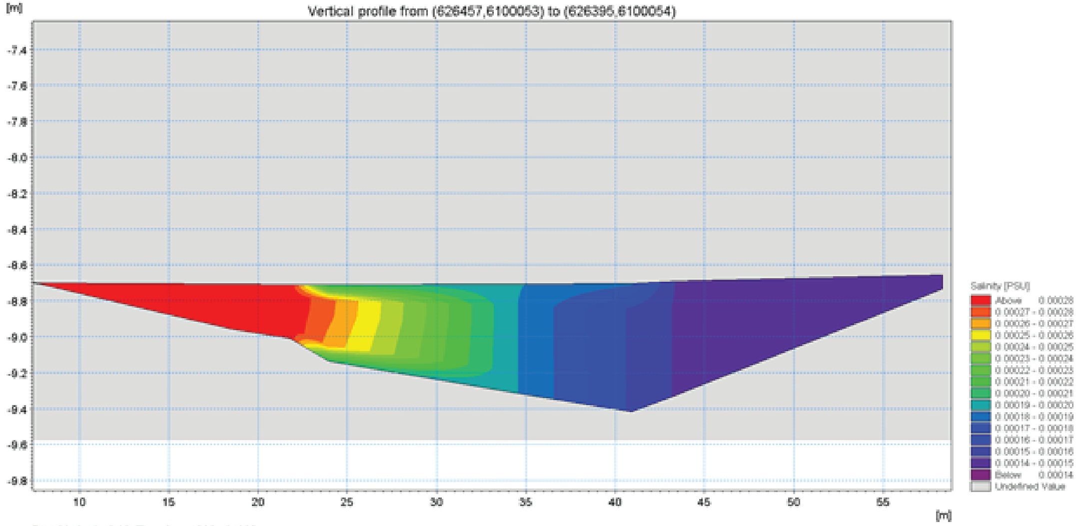
7/11/2013 4:11:00 Time Step 251 of 1000. Sigma Layer No. 1 of 5.

b) Surface concentrations at Equilibrium



7/11/2013 16:40:00 Time Step 1000 of 1000. Sigma Layer No. 5 of 5.

c) Cross-section 100 m downstream of Discharge Location at Equilibrium



7/11/2013 16:40:00 Time Step 1000 of 1000.

Hazardous Materials

Hazardous waste materials, such as spoiled processing reagents and used batteries, laboratory waste, oil and lubricants will be generated throughout the life of the Project, from construction to decommissioning. These materials will be anticipated in advance; segregated, inventoried, and tracked in accordance with federal and provincial legislation and regulations such as the federal *Transportation of Dangerous Goods Act (1992)*. A separate secure storage area will be established with appropriate controls to manage spillages. Hazardous waste will be labeled and stored in appropriate containers for shipment to approved off-site disposal facilities.

Non-hazardous Materials

Waste management will involve the segregation of waste into appropriate management channels. Project waste collection and disposal facilities will include specific areas for recyclable materials and general wastes. Waste materials will be transported off site for disposal at existing licensed facilities.

Sewage

Sewage management for the Project will be consistent with the requirements of the *Environmental Management Act* (2003) and its Municipal Wastewater Regulation (BC Reg. 87/2012).

Decline Site

A sewage treatment facility has been installed at the Decline Site to support Bulk Sample activities. The current system is a Type 2 treatment plant with a daily design flow of 17,000 L/d (registered under Northern Health). The current treatment plant tanks have capacity for up to 68,000 L/d; however, the septic field is currently only sized for 17,000 L/d. A trash compartment settles out most of the solids, fats/oils/grease, and effluent is then pumped to a reactor tank. Treated effluent subsequently is pumped to a septic field, which includes 14 distal pressure lines installed below grade.

For full mine development, in order to support the mine dry for the full work force, the size of the sewage treatment system and septic field will be increased to a daily design flow of 225 m^3/d (225,000 L/d). As part of water management for Bulk Sample activities, an exfiltration gallery has been installed and used for discharge of treated water to ground. Discharge rates to the exfiltration gallery have regularly been in excess of 225 m^3/d, and as such, ground conditions are expected to be capable of supporting a septic field of this size.

Coal Processing Site

A similar Type 2 sewage treatment facility and septic field is planned for the Coal Processing Site. Based on the balance of employees between the Decline Site and the Coal Processing Site, the system at the Coal Processing Site is planned for up to 56 m^3/d (56,000 L/d).

3.6.3.11 Lighting

Given that there will be activity at the Project around the clock, lighting will be required. The Project is located in a relatively remote area, as such, existing ambient light levels (diurnally and seasonally) are expected to be consistent with natural ambient conditions for a location at 55° north latitude. The principle objective for the outdoor lighting design will be to use strategically located, downward-directed lights to provide the lighting required to ensure safe working conditions, while keeping "light pollution" to the minimum. To minimize energy consumption, lighting fixture selection will include the use of the most energy efficient type for each purpose (e.g., fluorescent, metal-halide, LED, high-pressure sodium, etc.). Where possible, lighting will be controlled through a centralized timer or photocell system with manual override.

3.7 PROJECT PHASE: CONSTRUCTION

3.7.1 Development Schedule

HD Mining is currently advancing development of a Bulk Sample on site. Permitted Bulk Sample activity has included site preparation at the Decline Site and Shaft Site, and will extend through completed construction of the Service Decline and the Ventilation Shaft.

The Construction phase for full mine development includes establishment of all site surface infrastructure, as well as the underground mine development to the point that longwall mining can commence. Figure 3.7-1 summarizes the schedule for the major Project components during Construction. The total Construction period will be approximately three years (including six months site preparation and mobilization). It is important to note that planning and optimization of the construction schedule is ongoing; however, the schedule presented is considered reasonable for the purposes of the Application/EIS.

Figure 3.7-2 illustrates the Project layout at the end of Construction.

3.7.2 Site Preparation

HD Mining has developed infrastructure at the Decline Site and Shaft Site to support the Bulk Sample. While some minor modifications will be required within the existing sites, these sites are already established, and little site preparation is expected to allow these sites to continue to be used during Construction of the full mine development. Therefore, site preparation work during Construction will largely focus on the Coal Processing Site. Site preparation for the Secondary Shafts Site will occur approximately 15 years into the mine life, and is considered as an activity during Operation.

At the Coal Processing Site, initial site preparation will require clearing the land surface within the CPP site and the CCR North footprint areas. Topsoil and subsoil will then be stripped from the surface and stored in stockpiles around the perimeter of the site. This material will be used for reclamation purposes during Decommissioning and Reclamation. Topsoil and subsoil will remain segregated throughout the process to ensure the quality of the soils is not degraded for future use.

In addition, site preparation activities during Construction will include:

- engineering design review by construction contractors;
- temporary construction infrastructure such as access roads, power, water supply, drainage, site grading;

Figure 3.7-1
Project Construction Schedule

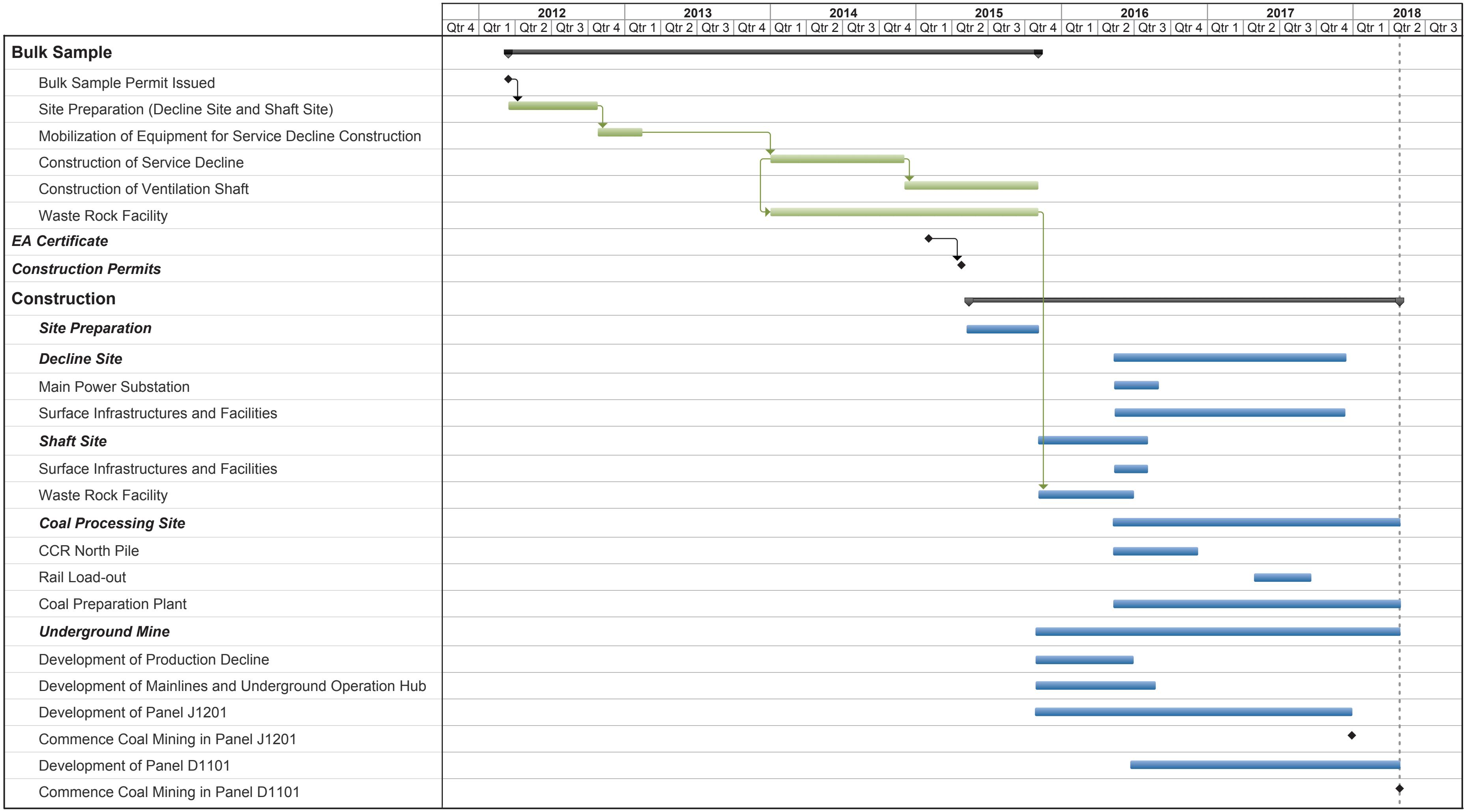
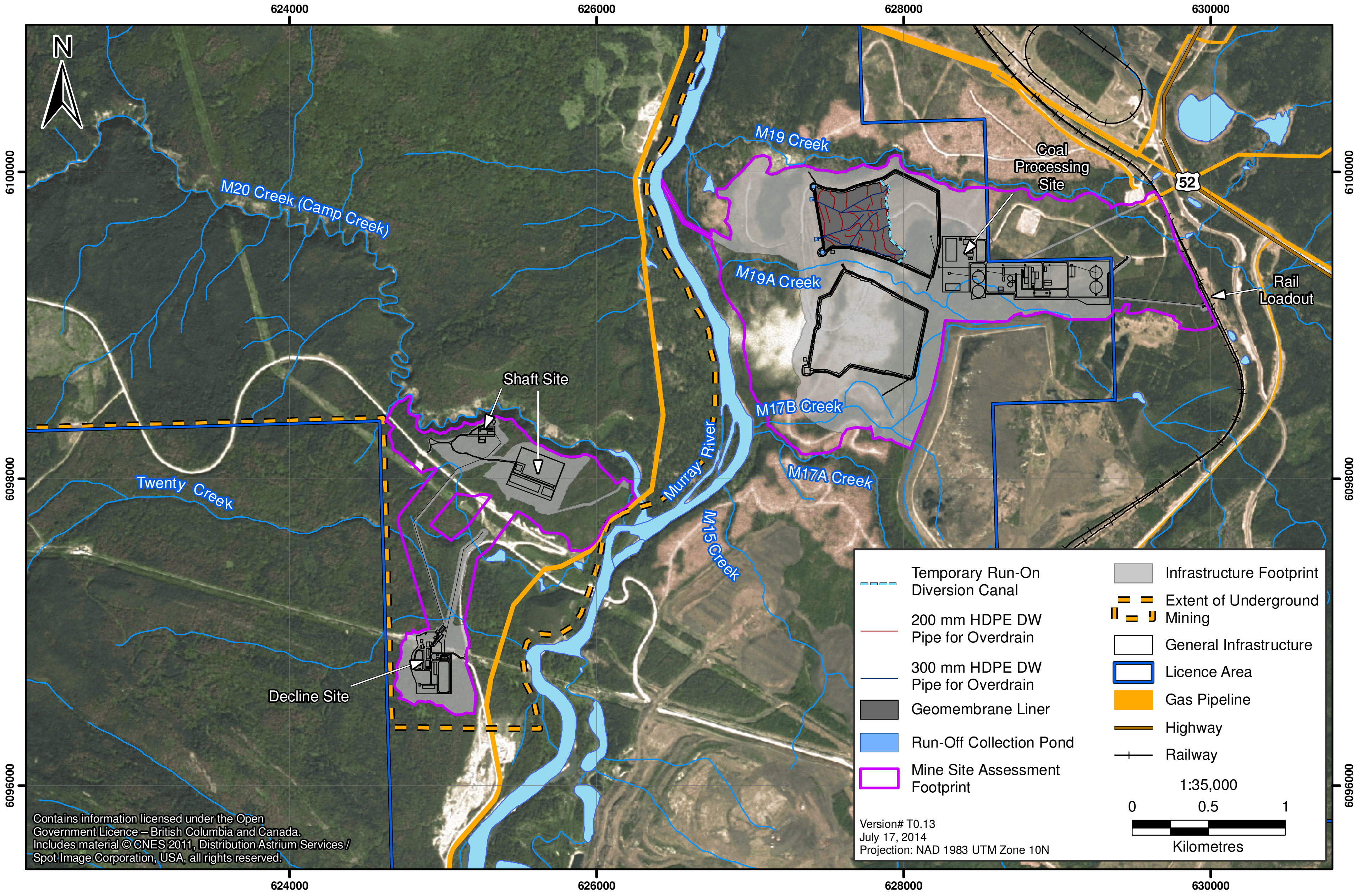


Figure 3.7-2
Project Layout at End of Construction



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- hoist house, air compressor house, lighting, washroom, mine dry, fuel station, boiler houses, maintenance shop, office building, cafeteria, warehouse, etc.;
- temporary surface transportation and waste rock stockpiling system;
- concrete batch plant, water pump house;
- training for construction staff;
- materials and equipment pre-ordering, non-standard equipment fabricating; and
- other temporary infrastructure on site.

Murray River will be the water supply source during Construction. Water management infrastructure will consist of embankments, ditches, sedimentation ponds, water treatment facilities, groundwater wells, and site drainage, including a system of diversion channels to divert contact and non-contact water.

Site preparation is planned to be completed within six months.

3.7.3 Underground Mining

3.7.3.1 Main Infrastructure and Facilities of the Underground Mine

The main underground infrastructure and facilities to be completed during Construction will include but not be limited to:

- Production Decline;
- Underground Operation Hub;
- mainline entries (to Block 1);
  - conveyor roadways,
  - truck roadways,
  - airways;
- connection drifts;
- connection ramps;
- electromechanical installations:
  - ventilation fans,
  - air heating system,
  - underground power substation, and
  - switching house.

3.7.3.2 Mine Development Methods and Schedule

For the underground mine construction, development through the overburden, weathered rock, stable rock, and coal seams for the declines, shaft, mainline entries, roadways and gateways are similar. The excavation methods depend upon the type of materials encountered during the tunnel construction.

Near the surface, the topsoil, subsoil, till and other unconsolidated material will be removed by excavators and bulldozers until bedrock is reached. Weathered rock (Protodyakonov coefficient of rock strength $f \leq 10$), will be excavated by a road-header. The conventional drill and blast method will be deployed in the stable and hard rock ($f \geq 10$) section.

Utility lines (water supply pipeline, water drainage pipeline, compressed air line, and communications/monitoring cables) will be suspended along the side of the tunnels, supported on a steel frame work attached to the tunnel rib.

Roof support and ground control will be employed while tunneling. The support will be by a combination of rock bolts, mesh, and shotcrete. The ground control will use rock bolts augmented by shotcrete, cable bolts and/or steel arches depending upon the rock property index values.

The anticipated monthly shaft sinking and decline tunneling schedule will be:

- Production Decline:
  - roadheader: 200 m, and
  - drill and blast: 120 m;
- rock drifts (level tunnels):
  - roadheader: 300 m, and
  - drill and blast: 200 m;
- rock ramps (inclined tunnels):
  - road header: 200 m, and
  - drill and blast: 120 m;
- coal tunnels (roadheader): 400 m; and
- rock chambers (drill and blast): 1,500 m^3.

There will be total four construction teams working simultaneously for the mine development (Figure 3.7-3 and Figure 3.7-4).

Total underground mine construction will require approximately three years (Figure 3.7-4). Because the Service decline and Ventilation Shaft will be completed during the Bulk Sample period, the Production Decline and Underground Operation Hub will be excavated first and scheduled to be completed within 14 months. Following that, the connection will be established between the Production Decline, Service Decline, Ventilation Shaft, and Underground Operation Hub. This will provide more space for further mine development.

The mainlines (conveyor, truck and return airway) in coal seams J and F will be constructed once access is available. It is anticipated to be completed in 6 months.

Development activity around Panel J1201 will begin as early as possible in Construction. Development will primarily consist of driving the three mainlines (Conveyor, Truck, and Air Return) about 1,600 m each, and then four gateways about 2,800 m each. This development is expected to require 11 months. It is planned to achieve coal mining within 32 months from the start of Construction.

Development activities around Panel D1101 will include three mainlines in seam F with a ranging from 1,300 m to 1,700 m; three mainlines in seam D about 1,000m in length; and four gateways about 2,200 m in length. This development is expected to require 15 months, with Panel D1101 ready to produce coal about 4 months behind panel J1201.

Once the two panels (J1201 and D1101) are developed and ready to be mined, this will mark the end of the Construction phase and the start of Operation.

3.7.3.3 Drivage Workload of Mine Development

During Construction, the total tunnel length will be about 44,000 m (830,000 m^3). Coal tunnels will represent 37,000 m (700,000 m^3) of this total, and rock tunnels will be about 7,000 m (140,000 m^3; Table 3.7-1).

The total waste rock from sinking the Production Decline will be approximately 47,241 m^3, as shown in Table 3.7-2.

Table 3.7-1. Drivage Bill of Quantities during Underground Mine Development

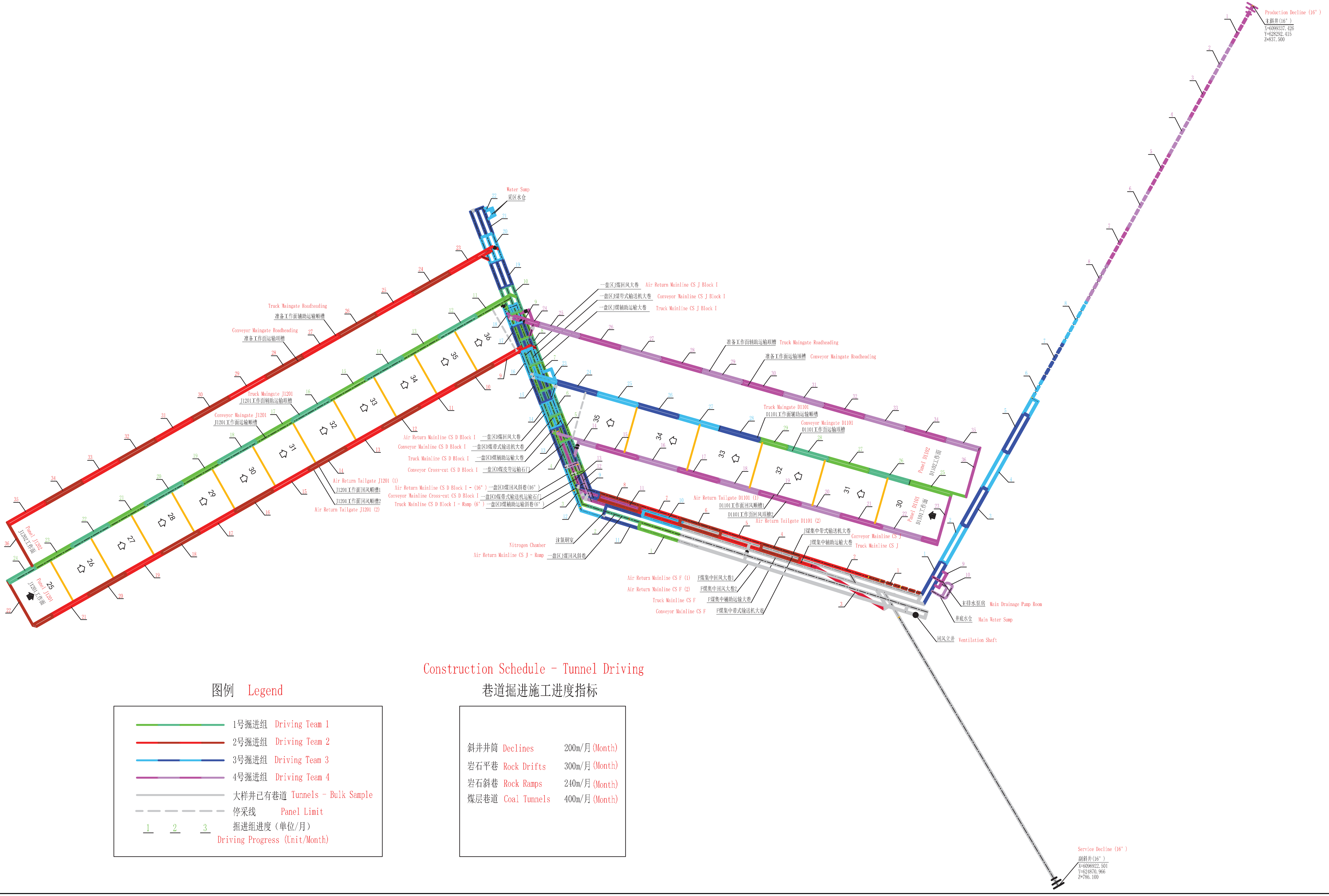
		Length(m)			Volume (m^3)		
No	Name	Coal Tunnel	Rock Tunnel	Subtotal	Coal Tunnel	Rock Tunnel	Subtotal
1	Production Decline	-	2,128	2,128	-	47,242	47,242
2	Underground operation hub and chambers	-	1,535	1,535	-	37,896	37,896
3	Mainline truck roadways and airways	17,622	1,064	18,686	355,547	21,733	377,281
4	Panel Gateways	19,455	1,610	21,065	329,210	26,646	355,856
5	Temporary works	-	600	600	-	8,040	8,040
6	**Total**	**37,077**	**6,892**	**44,104**	**690,863**	**140,718**	**831,581**

3.7.4 Decline and Shaft Sites

Some infrastructure has been completed during the Bulk Sample period, such as water sedimentation ponds, sewage treatment area, waste rock stockpile, etc. Other facilities will be built during the Construction stage to support the full mine capacity. These facilities will include decline and shaft collarhouses, main power substation, boiler house, mine dry, maintenance workshop, fuel station, office/administration complex buildings, miscellaneous warehouse complex, natural gas storage tanks, water wells, air heating houses, rescue and fire station.

Figure 3.7-3

Mine Development Plan (Construction)



Construction Schedule - Tunnel Driving

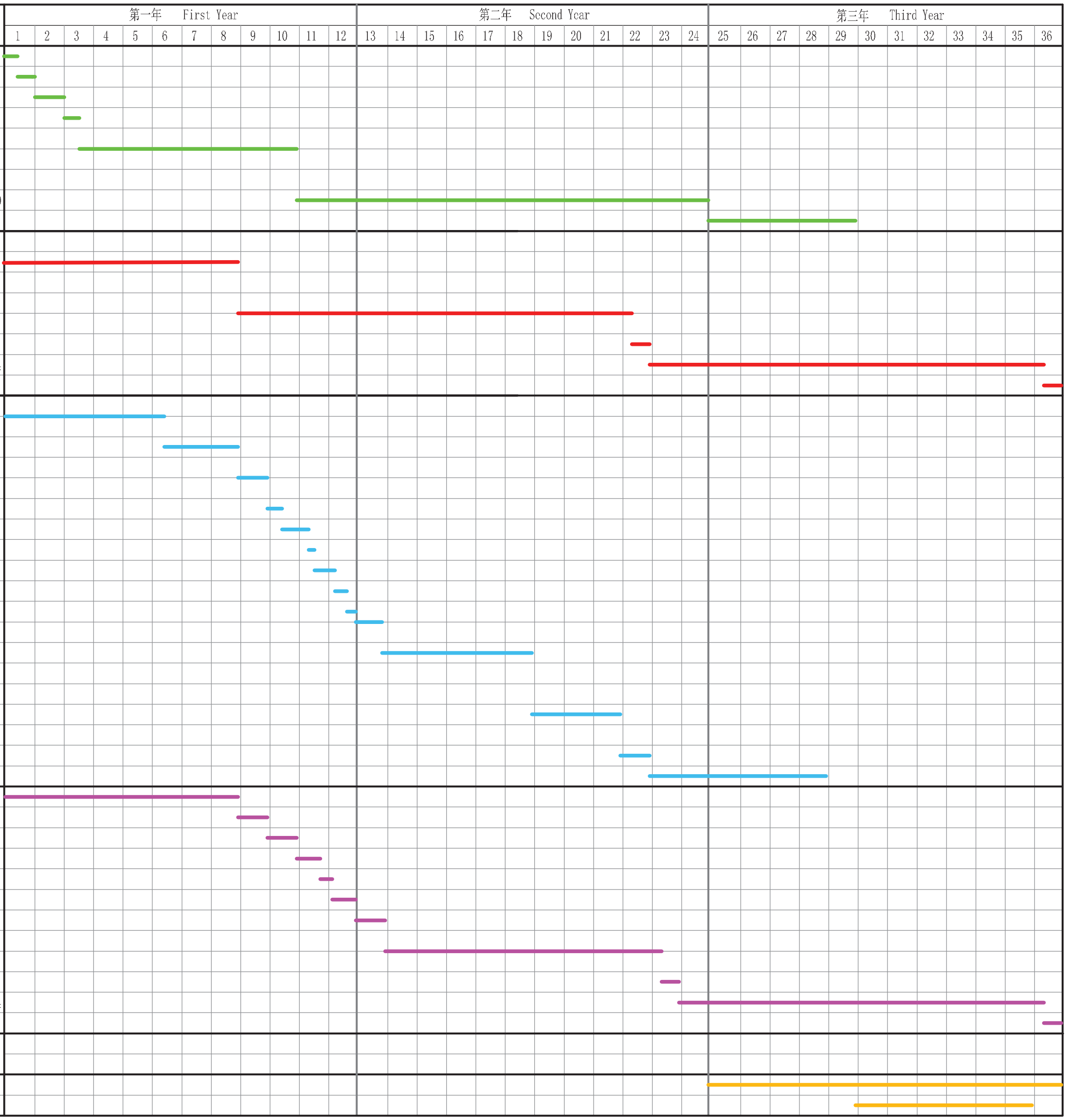
巷道掘进施工进度指标

斜井井筒	Declines	200m/月 (Month)
岩石平巷	Rock Drifts	300m/月 (Month)
岩石斜巷	Rock Ramps	240m/月 (Month)
煤层巷道	Coal Tunnels	400m/月 (Month)

Figure 3.7-4

Mine Development Schedule (Construction)

Items	Teams	工程名称	Workloads Unit	Workloads Quantity	Monthly Schedule m/month	Months
Air Return Mainline CS F (1)	一号掘进组 Driving Team 1	F煤集中回风大巷1	m	200	400	0.5
Air Return Mainline CS F (2)		F煤集中回风大巷2	m	256	400	0.6
Air Return Mainline CS J Block I - Connection Ramp (Rock)		一盘区J煤回风斜巷（岩石斜巷）	m	241	240	1.0
Air Return Mainline CS J Block I		一盘区J煤回风大巷	m	1155	400	2.9
Conveyor Mainline CS J Block I		一盘区J煤带式输送机大巷	m	955	400	2.4
Truck Mainline CS J Block I		一盘区J煤辅助运输大巷	m	955	400	2.4
Connection Tunnels		联络巷	m	80	400	0.2
Truck Maingate J1201		J1201工作面辅助运输/运输顺槽	m	5600	400	14.0
Conveyor Maingate J1201		D1101工作面辅助运输/运输顺槽	m	2000	400	5.0
Conveyor Mainline CS J (Rock)	二号掘进组 Team 2	J煤集中带式输送机大巷（岩巷）	m	214	240	0.9
Conveyor Mainline CS J (Coal)		J煤集中带式输送机大巷（煤巷）	m	1386	400	3.5
Truck Mainline CS J		J煤集中辅助运输大巷	m	1455	400	3.6
Air Return Tailgate J1201 (1)		J1201工作面回风顺槽1	m	2667	400	6.7
Air Return Tailgate J1201 (2)		J1201工作面回风顺槽2	m	2701	400	6.7
Open-off Cut of Panel J1201		J1201工作面开切眼	m	220	400	0.6
Roadheading of Truck/Conveyor Maingates J1202		准备工作面J1202辅助运输/运输顺槽	m	5360	400	13.4
Open-off Cut of Panel J1202		准备工作面J1202开切眼	m	220	400	0.6
Conveyor Mainline	三号掘进组 Driving Team 3	集中带式输送机大巷	m	1064	400	2.7
Truck Mainline		辅助运输巷	m	1100	400	2.8
Production Decline		主斜井	m	500	200	2.5
Truck Mainline CS J Block I		J煤集中/一盘区辅助运输大巷	m	200	400	0.5
Conveyor Mainline CS J Block I		J煤集中/一盘区带式输送机大巷	m	200	400	0.5
Conveyor Mainline CS F		F煤集中带式输送机大巷	m	200	400	0.5
Truck Mainline CS F		F煤集中辅助运输大巷	m	370	400	0.9
Nitrogen Chamber		注氮硐室	m	60	400	0.2
Air Return Mainline CS F (1)		F煤集中回风大巷1	m	285	400	0.7
Air Return Mainline CS D Block I - Connection Ramp (Rock)		一盘区D煤回风斜巷（岩石斜巷）	m	105	240	0.4
Air Return Mainline CS D Block I		一盘区D煤回风大巷	m	925	400	2.3
Truck Mainline CS D Block I		一盘区D煤辅助运输大巷	m	808	400	2.0
Conveyor Mainline CS D Block I		一盘区D煤带式输送机大巷	m	633	400	1.6
Connection Tunnels		联络巷	m	160	400	0.4
Air Return Mainline CS J Block I		一盘区J煤回风大巷	m	395	400	1.0
Conveyor Mainline CS J Block I		一盘区J煤带式输送机大巷	m	395	400	1.0
Truck Mainline CS J Block I		一盘区J煤辅助运输大巷	m	395	400	1.0
Water Sump and Pump Room (panels)		采区泵房/水仓				1.0
Conveyor/Truck Maingate D1101		D1101工作面辅助运输/运输顺槽	m	2400	400	6.0
Production Decline	四号掘进组 Driving Team 4	主斜井	m	1600	200	8.0
Main Drainage Pump Room		主排水泵房				1.0
Main Water Sump		水仓				1.0
Conveyor Mainline CS F		F煤集中带式输送机大巷	m	315	400	0.8
Truck Mainline CS F		F煤集中辅助运输大巷	m	153	400	0.4
Truck Mainline CS D Block I - Connection Ramp (Rock)		一盘区D煤辅助运输斜巷(岩石斜巷)	m	182	240	0.8
Conveyor Mainline CS D Block I - Cross-cut (Rock)		一盘区D煤皮带运输石门(岩石平巷)	m	300	300	1.0
Air Return Tailgate D1101 (1)		D1101工作面回风顺槽1	m	1904	400	4.8
Air Return Tailgate D1101 (2)		D1101工作面回风顺槽2	m	1850	400	4.6
Open-off Cut of Panel D1101		D1101工作面开切眼	m	220	400	0.6
Roadheading of Truck/Conveyor Maingates D1102		准备工作面D1102辅助运输/运输顺槽	m	4960	400	12.4
Open-off Cut of Panel D1102		准备工作面D1102开切眼	m	220	400	0.6
			Panel Length Unit	Panel Length Quantity	Monthly Schedule m/month	Months
Panel J1201		J1201工作面	m	2627	220	12
Panel D1001		D1101工作面	m	1832	308	6



Construction Schedule - Tunnel Driving 巷道掘进施工进度指标				
	斜井井筒 Declines	200m/月(Month)	岩石斜巷 Rock Ramps	240m/月(Month)
	岩石平巷 Rock Drifts	300m/月(Month)	煤层巷道 Coal Tunnels	400m/月(Month)

Table 3.7-2. Waste Rock from Sinking Production Decline, Service Decline, and the Shaft

Items	Stratum	Length（m）	Volume（m3）
Production Decline	Overburden	10	232
	Hasler	1,485	32,957
	Boulder Creek	245	5,439
	Hulcross	185	4,107
	Gates	203	4,507
Subtotal		2,128	47,242
Service Decline	Overburden	31	695
	Hasler	1,067	23,680
	Hulcross	77	1,709
	Gates	372	8,258
Subtotal		1,547	34,343
Shaft	Overburden	8	290
	Hasler	120	4,356
	Boulder Creek	129	4,682
	Hulcross	91	3,303
	Gates	142	5,154
Subtotal		490	17,786
Overall Total		**4,165**	**99,371**

3.7.5 Coal Preparation Plant

The construction of the CPP will commence along with the underground mine development. It will include the coal preparation plant, screening/crushing plant, thickeners, flotation and filtration plant, drying plant, a variety of conveyors, transfer towers, maintenance workshop, boiler house, water well, water treatment plant, sedimentation ponds, raw coal storage stockpiles, clean coal and middlings stockpiles, floatation clean coal stockpiles, top soil stockpiles, power substation and distribution building, flotation reagents house, air compressor house, fire water pond, office/administration complex building, and rail loadout. The total construction period will be approximately 25 months.

Construction of the plants, buildings, ponds, stockpiles, and warehouses complex will take approximately 19 months to complete. Construction on site follows a similar sequence:

- excavation of foundation area;
- installation of cast-in-place pilings;
- foundation construction (pile caps and pedestals);
- backfilling and underground services;
- structural steel erection;
- cladding and roofing; and

- electrical, instrumentation, equipment, mechanical and piping installations.

3.7.6 Coarse Coal Rejects

The first phase of the CCR North pile will be constructed during Construction (Figure 3.7-5). This will include installation of the geomembrane liner to cover an area that would support the first five years of mining. Site preparation will commence at the early stage of Construction. It will include topsoil and subsoil removal, earth work, grading, geomembrane liner installation and anchoring, overdrain pipe networks, runoff ditches, seepage collection ponds and pumping system.

3.7.7 Materials for Construction

A substantial amount of material will be transported to site to support construction activities. Table 3.7-3 summarizes the estimated total material requirements over the Construction period. Some of the aggregate material will be produced on site; some will be purchased from third party providers. Material physical and chemical characteristics will be confirmed prior to use on site, as necessary.

Table 3.7-3. Estimated Materials Supply Requirements for Construction

Description	Amount
Rock and Processed Materials	68,668 t
Concrete	31,524 t
Sands	64,218 t
Structural Steel	11,743 t
Construction Plant and Equipment	116 sets
Underground Mine Equipment	24,000 t
Coal Processing Equipment	5,450 t
Fuel	1,636,600 L

3.7.8 Product Storage and Shipping

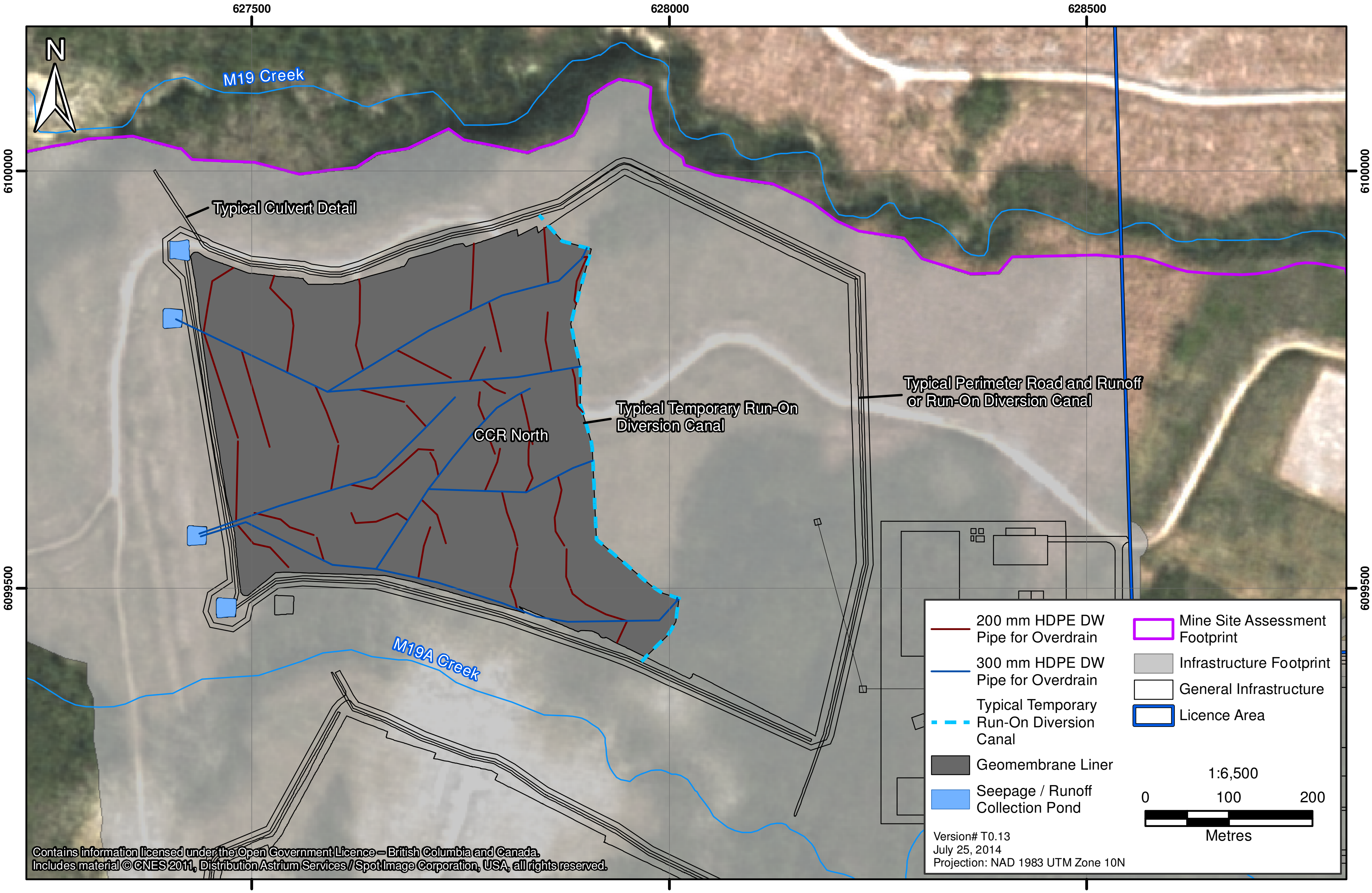
The two raw coal stockpiles will be completed at an early stage of Construction. During Construction, about 1 million tonnes (700,000 m^3) of ROM coal will be extracted while constructing the tunnels to reach the coal seams and panels (Table 3.7-1). This material will be hauled to, and temporally stored in, the raw coal stockpiles (120,000 tonne capacity). Prior to commissioning of the coal preparation plant, excess material will be sold from time to time.

3.7.9 Work Force and Goods and Services

3.7.9.1 Work Force

During underground mine construction, at peak activity, about 450 people will be employed. The average construction work force will be approximately 270 people. Given the scale of the Project it is expected that workers will be sourced from different geographic regions, including local residents in BC, residents from elsewhere in Canada, temporary foreign workers, and expatriates internationally. For construction of CPP, CCR, and Rail loadout, it will be conducted by various contractors.

Figure 3.7-5
CCR North at End of Construction



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3.7.9.2 Shifts

Underground mine development will be conducted for three eight-hour shifts per day. The surface construction of coal preparation plant, rail loadout, and other general surface infrastructures will be based upon two 8-hour shifts per day. They are conducted on a 365 days per year basis.

3.7.9.3 Transportation

All workers will be accommodated in Tumbler Ridge and commute daily between site and residence.

Materials and equipment will be brought to site by truck via the provincial and national road grid. Once the rail track is constructed and connected to the national rail system, it is possible that some materials and equipment will be transported via rail.

3.7.9.4 Goods and Services Sourcing

HD Mining will contract to a variety of goods and services providers, both locally and nationally. All contractors will be required to meet HD Mining Health, Safety, Environment, and Community (HSEC) standards, as well as meeting the requirements of the Code (BC MEMPR 2008).

3.8 PROJECT PHASE: OPERATION

3.8.1 Development Schedule

Operation of the underground mine and coal processing plant will be for 25 years. The major inputs for the Operation consist of fresh water, natural gas, electricity, diesel, and personnel. Outputs will consist primarily of clean coal, middlings, rejects. Table 3.8-1 lists the annual estimated inputs and outputs during the full Operation.

3.8.2 Underground Mining

Longwall mining will start from Block 1. This Block is 4.7 km long from east to west, and 1.3 km wide from north to south, with total area of 5.9 km^2. For the mine full production, two long wall working faces will be operated simultaneously. One will utilize the typical longwall mining method (TL) and another one will deploy the Longwall Top Coal Caving method (LTCC).

Mining will commence with two panels in Block 1: Panel J1201 and Panel D1101 after the mine development is completed. In every Block, mining will occur from top coal seam (Seam D) downward crossing through E, F, G/I, and J. The panels in each block will be excavated in accordance with the mine production plan. The annual mine production plan by blocks and panels is illustrated in Figure 3.8-1 and Table 3.8-2. Figure 3.8-2 to Figure 3.8-6 demonstrate the mining layout and sequence per coal seam through Operation.

Table 3.8-1. Estimated Inputs and Outputs during 6 Mtpa Operation

	Amount per tonne ROM Coal		Annual Amount	
Operation Inputs		Unit		Unit
Underground Mining				
Cement, sands and gravels	55.16	$\times 10^{-4}$ m^3	33,096	m^3
Timbers/woods	275	$\times 10^{-4}$ m^3	165,000	m^3
Steel	4.62	$\times 10^{-4}$ tonnes	2,772	tonnes
Fresh Water	0.0242	m^3	145.5	$\times 10^3$ m^3
Electricity	15.6	kWh	93,600	MWH
Natural Gas	1.11	m^3	6.655	$\times 10^6$ m^3
Diesel	0.01265	L	75,900	L
Coal Processing and Loadout				
Heavy medium – Magnetite	1.5	kg	9,000	Tonnes
Reagents				
(Kerosene)	60	g	360	Tonnes
(Octanol)	90	g	540	Tonnes
(Polyacrylamide)	22	g	132	tonnes
(Polymerization aluminum chloride)	60	g	360	tonnes
Fresh Water	0.0055	m3	33.2	× 103 m^3
Electricity	9.7	kWh	58,200	MWH
Natural Gas	1.95	m^3	11.724	× 106 m^3
Diesel	0.06542	L	392,500	L
Clean Coal (incl. Flotation clean coal)	0.7267	tonnes	4.3602	× 106 tonnes
Middling Coal	0.0793	tonnes	0.4758	× 106 tonnes
Coal Rejects	0.1940	tonnes	1.2125	× 106 tonnes
Solid Waste	0.0917	kg	550	tonnes

3.8.3 Coal Preparation Plant

As discussed in Section 3.6.3.4 and Table 3.8-1, raw coal will be processed through the CPP to produce saleable coal and rejects. During the full Operation, it will have a relatively steady demand for electricity, natural gas, water, reagents, etc.

Every year, about 4.8 million tonnes of clean coal and middling coal will be continuously conveyed to their respective storage areas in the CPP.

Materials of heavy mediums and flotation reagents will be used for CPP operation, such as magnetite, kerosene, octanol, polymerization aluminum chloride, polyacrylamide, etc. The annual consumption of those reagents are 9,000, 360, 540, 360, 132 tonnes, respectively.

Table 3.8-2. Mine Annual Production by Coal Seams and Blocks

	Block 1					Block 2					Block 3					Block 4					Subtotal
Year	D	E	F	G/I	J	D	E	F	G/I	J	D	E	F	G/I	J	D	E	F	G/I	J	(Mt)
1	2.24				3.75																5.99
2	2.24				3.75																5.99
3	0.74	0.83	0.89		3.53																5.99
4		1.48	3.59			0.76															5.83
5			3.59			2.24															5.83
6			2.44		1.2	0.29	1.95														5.88
7					3.75		0.92	1.32													5.99
8					3.75			2.24													5.99
9					3.56			2.24		0.19											5.99
10								2.24		3.75											5.99
11								2.24		3.75											5.99
12								2.24		3.75											5.99
13								0.22	2.02	3.75											5.99
14									2.24	3.75											5.99
15									2.24	3.75											5.99
16										3.75							2.19				5.94
17										0.83			2.73				2.19				5.75
18													3.5				2.19				5.69
19													2.98		0.58		1.73	0.44			5.73
20															3.84			2.07			5.91
21															3.42			2.07		0.41	5.9
22																		2.07		3.74	5.81
23																		1.97		3.74	5.71
24																		1.47		3.74	5.21
25					1.71													1		2.57	5.28

Note: Unit = Million Tonnes

Figure 3.8-1

Longwall Mining Sequence

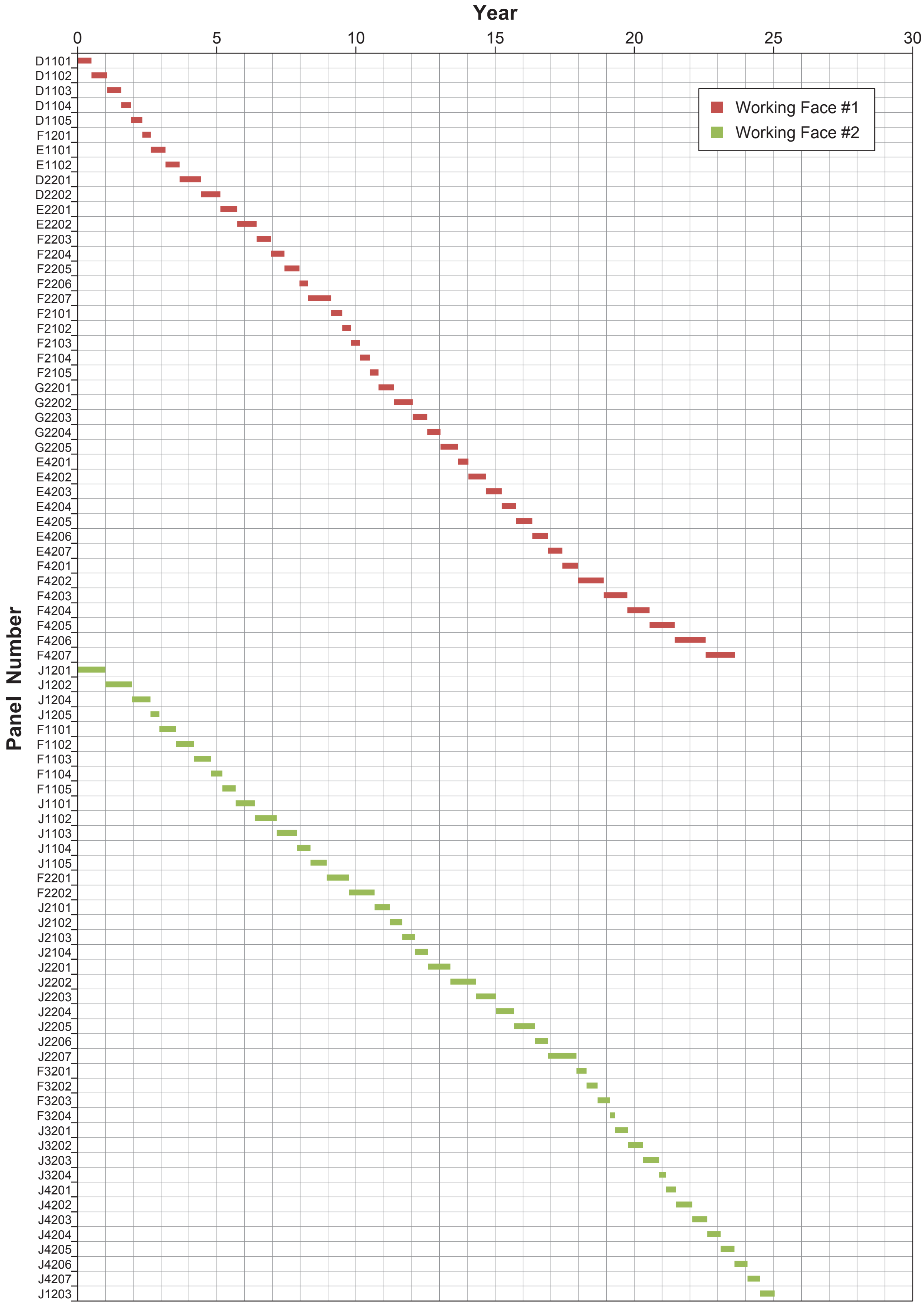

Figure 3.8-2
Underground Mine Layout - D Seam

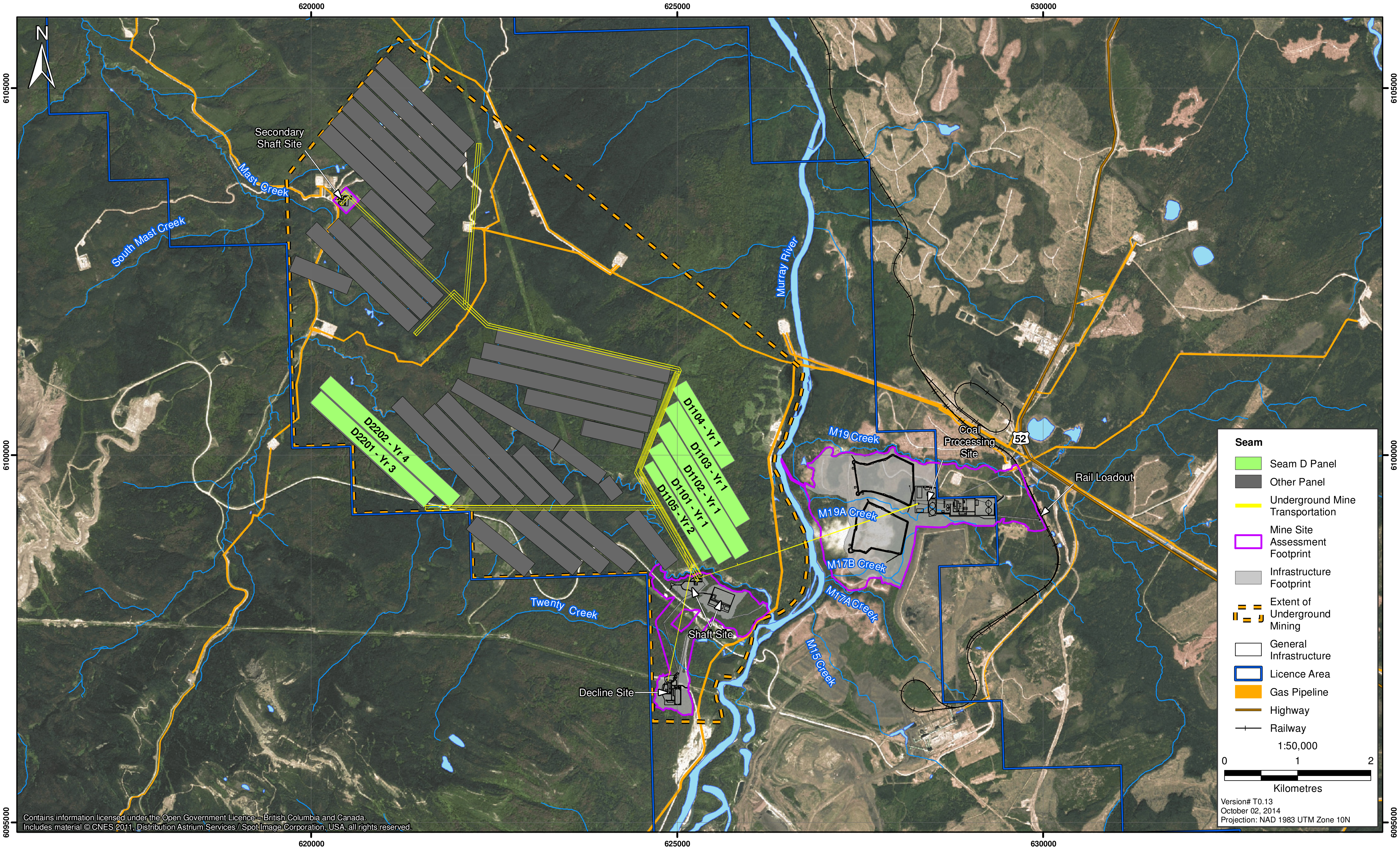

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Figure 3.8-3
Underground Mine Layout - E Seam

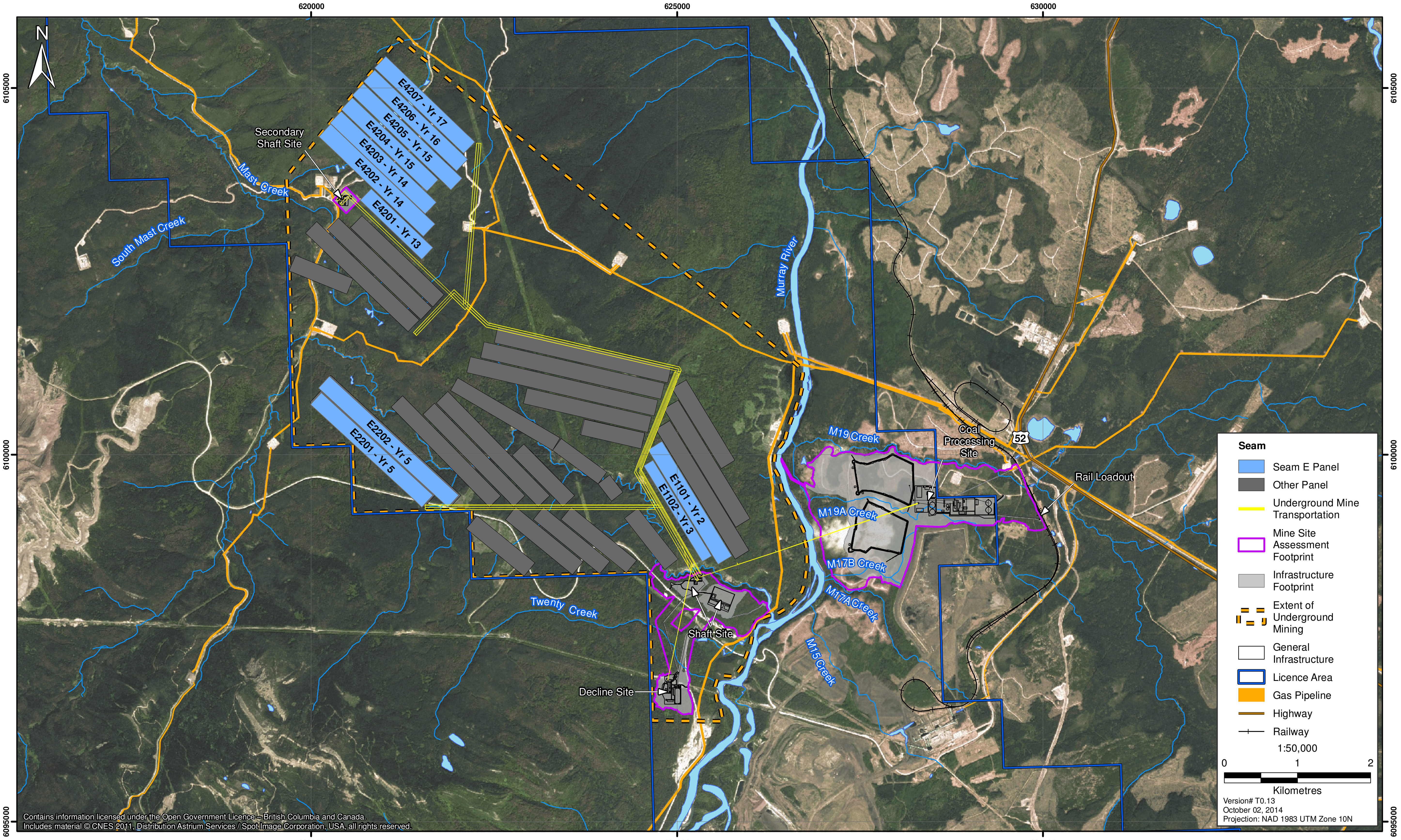

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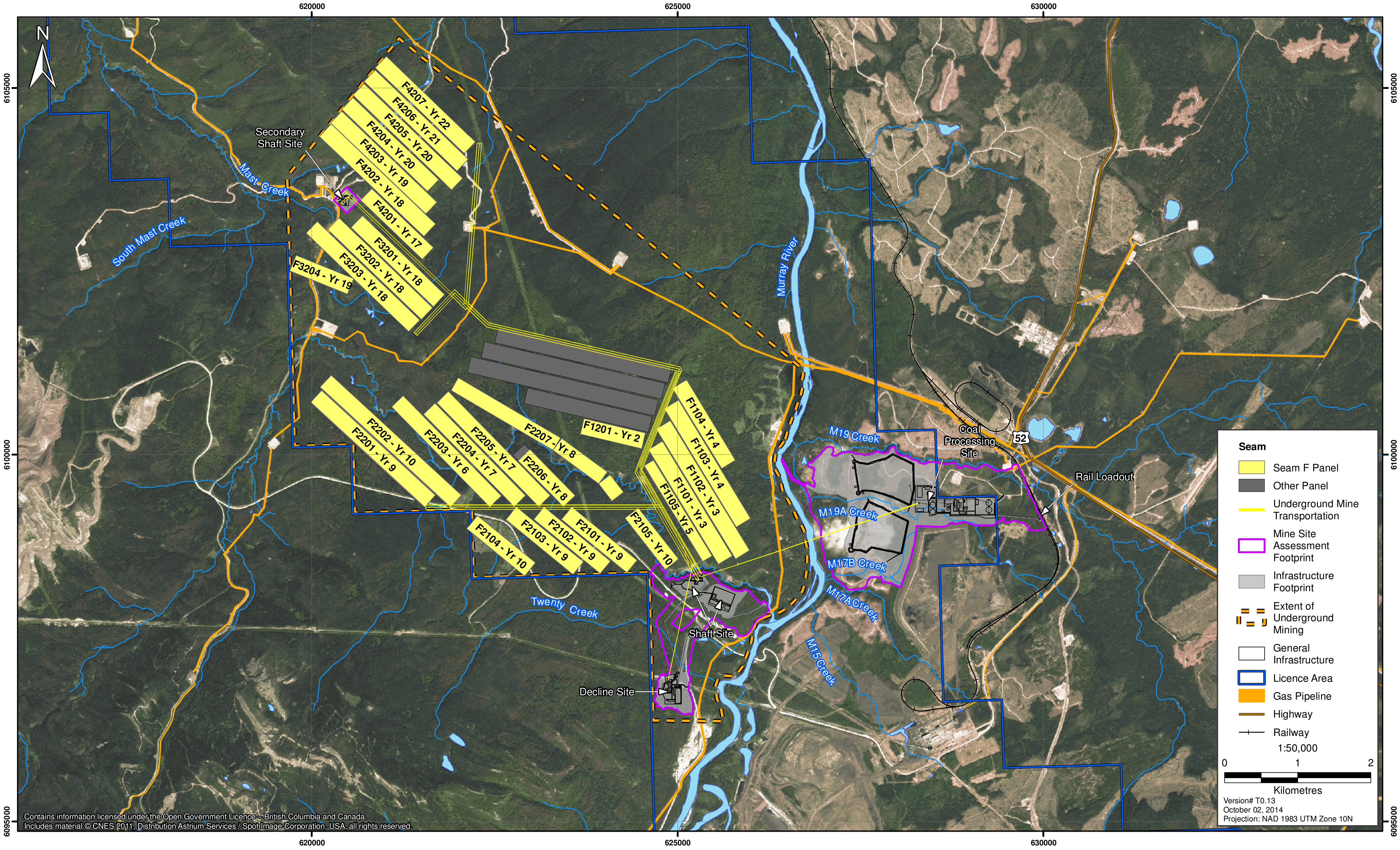
Figure 3.8-4
Underground Mine Layout - F Seam



Seam

🟨	Seam F Panel
■	Other Panel
—	Underground Mine Transportation
▭	Mine Site Assessment Footprint
▨	Infrastructure Footprint
▭	Extent of Underground Mining
▭	General Infrastructure
▭	Licence Area
🟧	Gas Pipeline
—	Highway
┼	Railway

1:50,000

0 1 2

Kilometres

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Figure 3.8-5
Underground Mine Layout - G\I Seam

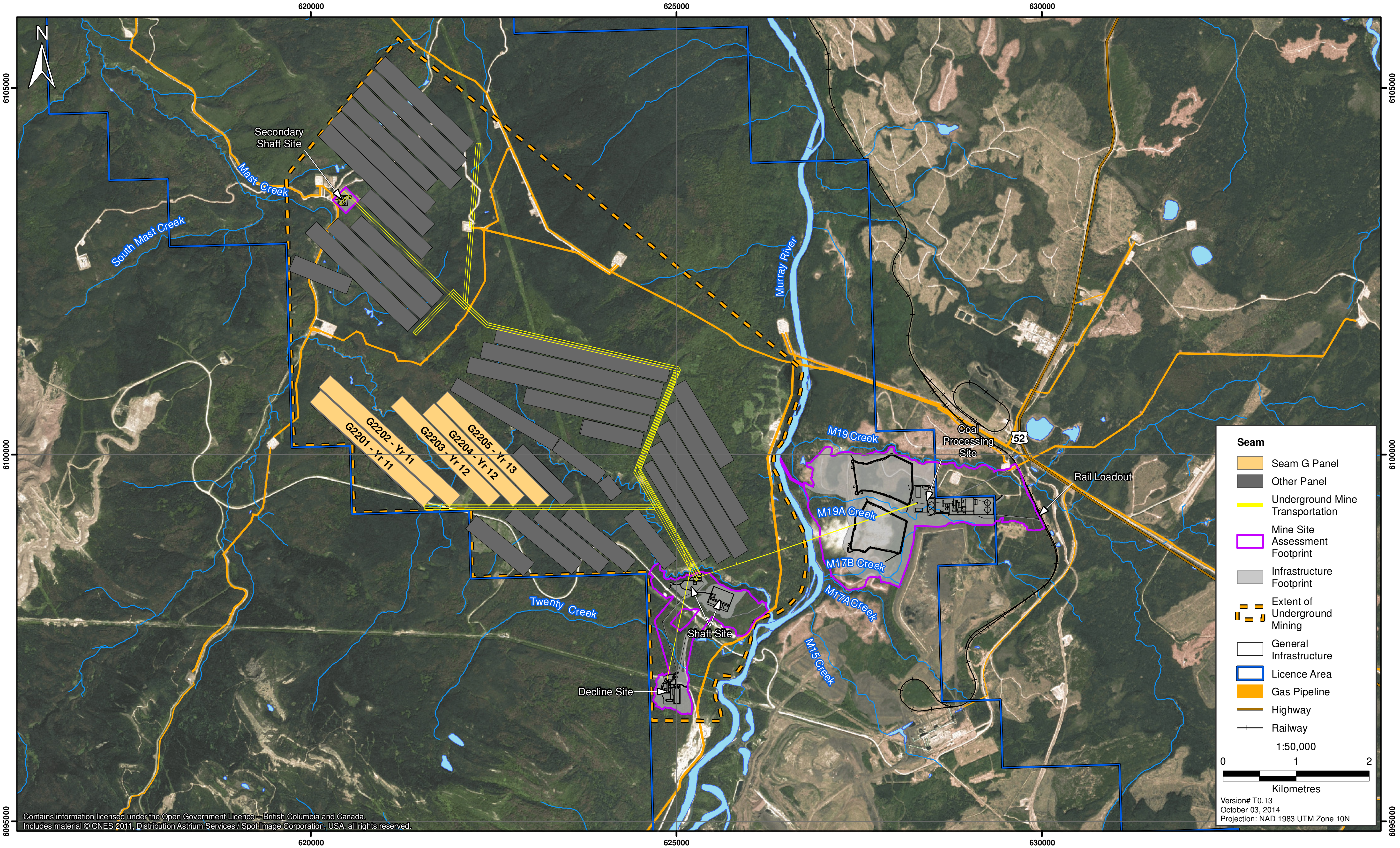

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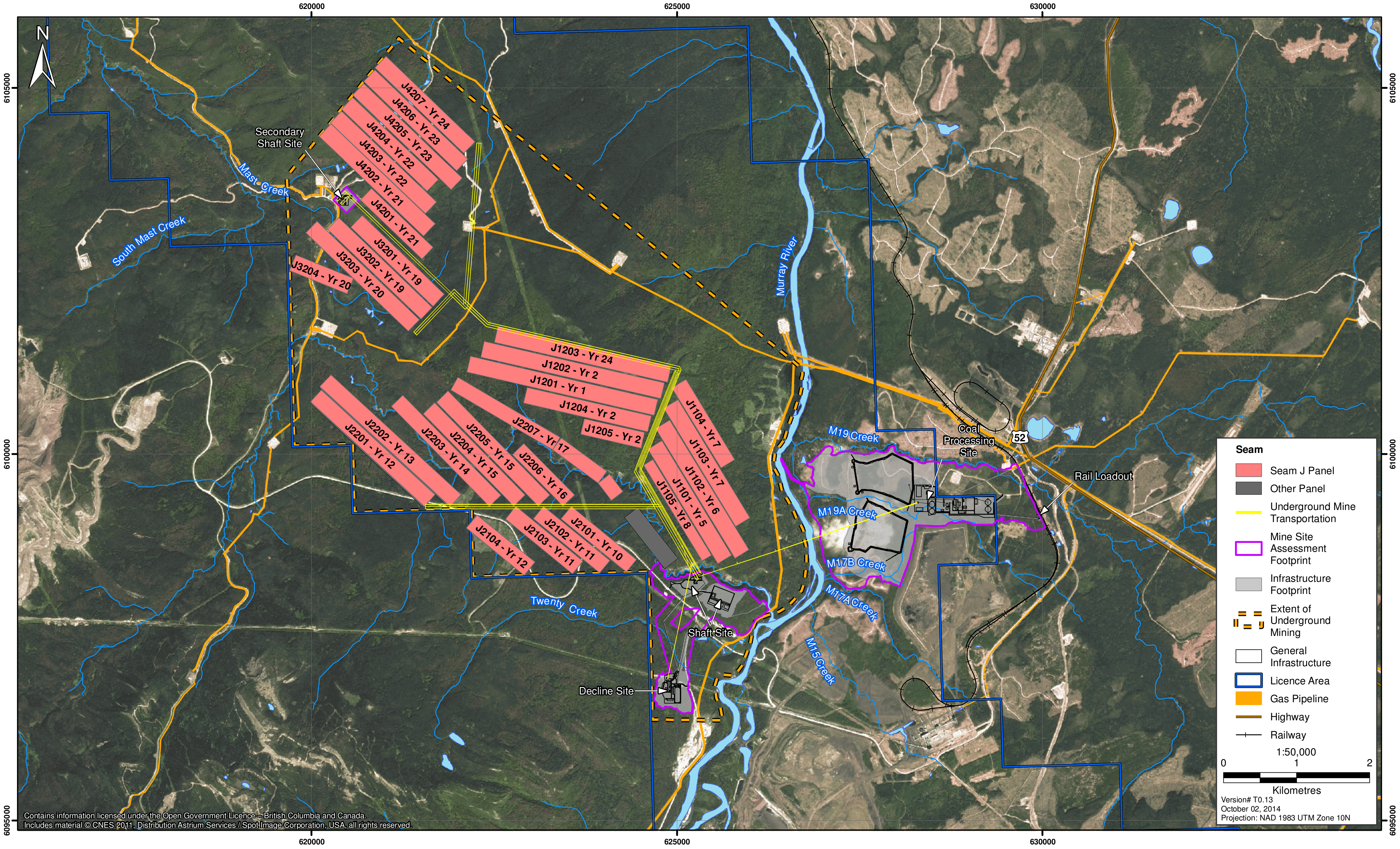
Figure 3.8-6
Underground Mine Layout - J Seam



3.8.4 Coarse Coal Rejects

The rejects from the Coal Preparation Plant will be directed to a Coarse Coal Reject (CCR) area on an extensible conveyor, and then re-worked by dozers in 8 to 10 m lifts. The CCR North pile will be used for the first 14 years during Operation to accommodate approximate 9.92 Mm^3 coal rejects. And then CCR South pile will serve the next 11 years for about 7.06 Mm^3 coal rejects. The stacking sequence of CCR piles development for CCR North and CCR South, respectively, are illustrated in Figure 3.8-7 and Figure 3.8-8.

Annual rejects output will be approximately 0.7 Mm^3.

3.8.5 Product Storage and Shipping

The coal product storage area will be located in the east of Coal Processing Site. As listed in Table 3.6-8, three independent coal storage facilities will be assigned to the two saleable coal products, respectively, clean coal, middling coal. Flotation fine clean coal will be mixed into the clean coal after dried. The coal products will be directed to the rail loadout by a series of belt conveyors, where they will be discharged into the train for shipment to markets.

Unit trains will have approximately 116 railcars, each with the capacity to carry approximately 95 metric tonnes. For a 4.8 Mtpa saleable (6 Mtpa ROM) coal operation, 1.2 trains will be loaded each day on average.

3.8.6 Utilities

Energy for mining and coal processing activities will be supplied through a combination of electricity, natural gas, and diesel fuel. Energy demand during 6 Mtpa ROM coal Operation is summarized in Table 3.8-3.

Table 3.8-3. Estimated Energy Demand during Operation

Source	Energy Demand	
Electricity		
Underground Mining	93,600	MWh/y
Coal Processing and Surface Facilities	58,200	MWh/y
Electricity Total	151,800	MWh/y
Natural Gas		
Underground Mining	6,655,700	m^3/y
Coal Processing Drying	4,536,000	m^3/y
CPP Surface Facilities heating	7,188,480	m^3/y
Natural Gas Total	18,380,180	m^3/y
Diesel		
Underground Mining	75,900	L/y
Coal Processing and Ground Vehicle	392,500	L/y
Diesel Total	468,400	L/y

3.8.7 Air Emissions

Air emissions will primarily be from fuel combustion by vehicles and equipment, CBG drainage, and operation of the Coal Preparation Plant.

The main air emissions during Operation will be from gas-fired boilers, the surface coal washing and drying system, CCR and waste rock transportation, sub-transfer, and stockpiles. Gas-fired boilers will be operated only in cold seasons, and to be scheduled 24 hours per day during 208 days every year. The coal drying plant is planned to run 16 hours per day, 189 days per year. The diesel generators will only be operated as back-up. These emission sources have been incorporated into air quality modelling for the Project (Appendix 6-B).

3.8.8 Work Force and Goods and Services

3.8.8.1 Work Force

It is anticipated that the Project will provide approximately 780 direct employment opportunities during the Operation.

Underground Mine

The mine is planned to operate year-round. It is anticipated that the mine will employ approximately 643 workers for the underground mine (Table 3.8-4).

Table 3.8-4. Total Workforce in Underground Mine

No.	Workforce	Attendance				Backup Coefficient	Total
		Nights	Days	Afters	Subtotal		
1	Workers	160	173	166	499	1.05	524
1.1	Underground	152	155	155	462	1.05	485
1.2	Surface	8	18	11	37	1.05	39
2	Administration staff	10	63	10	83	1.0	83
Subtotal of production workers		**170**	**236**	**176**	**582**		**607**
3	Service staff	8	15	13	36	1.0	36
Total		**178**	**251**	**189**	**618**		**643**

Examples of typical underground operating and maintenance positions include:

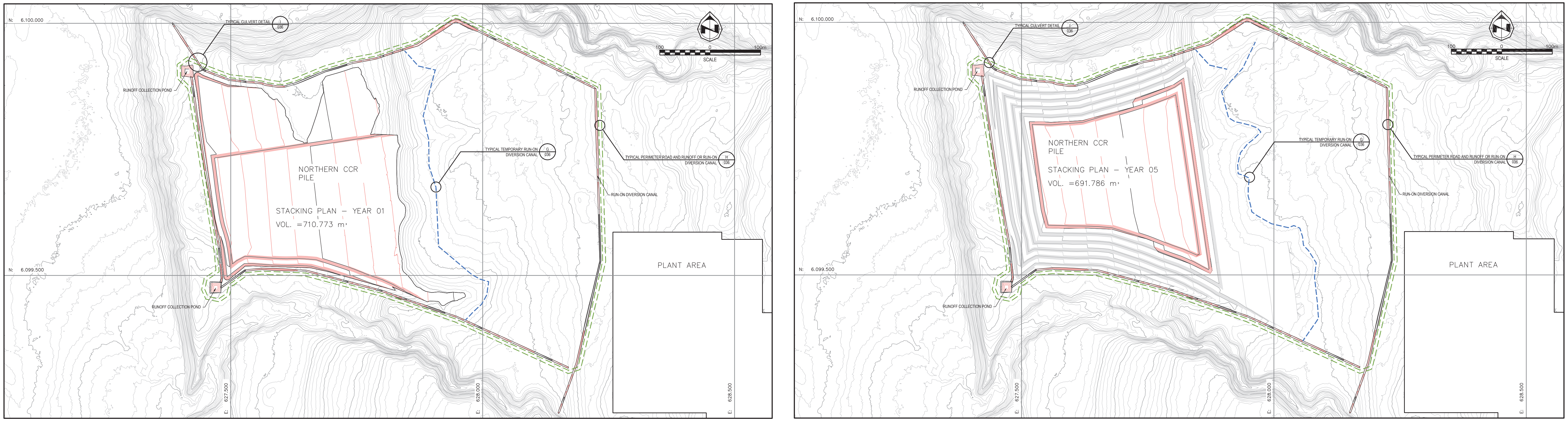
- Shift lead;
- Fire lead;
- Equipment Operators;
  - Shearers,
  - Chain conveyors,
  - Crushers,

Figure 3.8-7

CCR North Pile Stacking Sequence

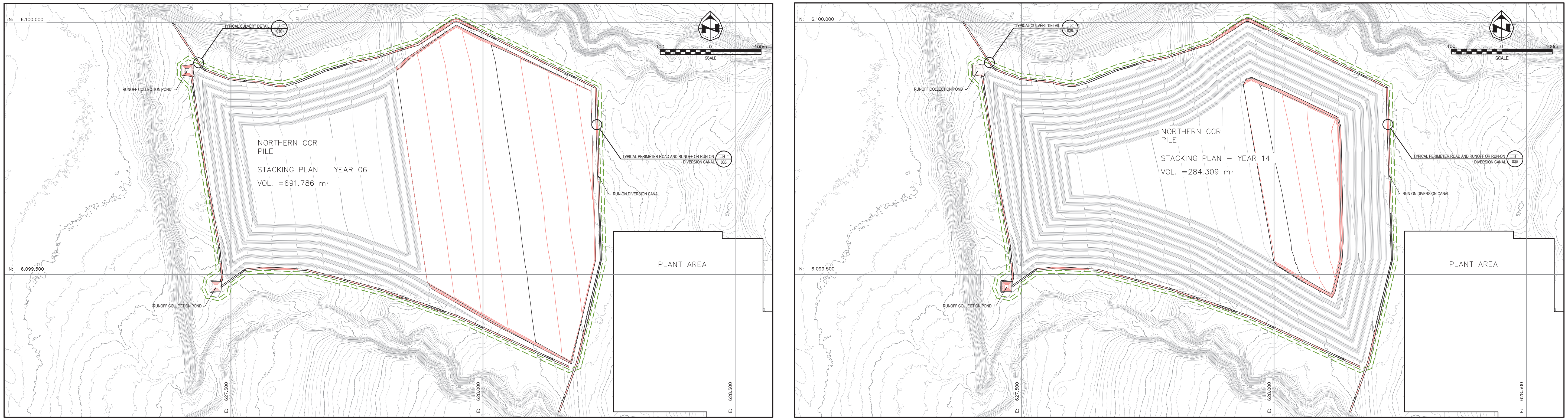
Year 1

Year 5



Year 6

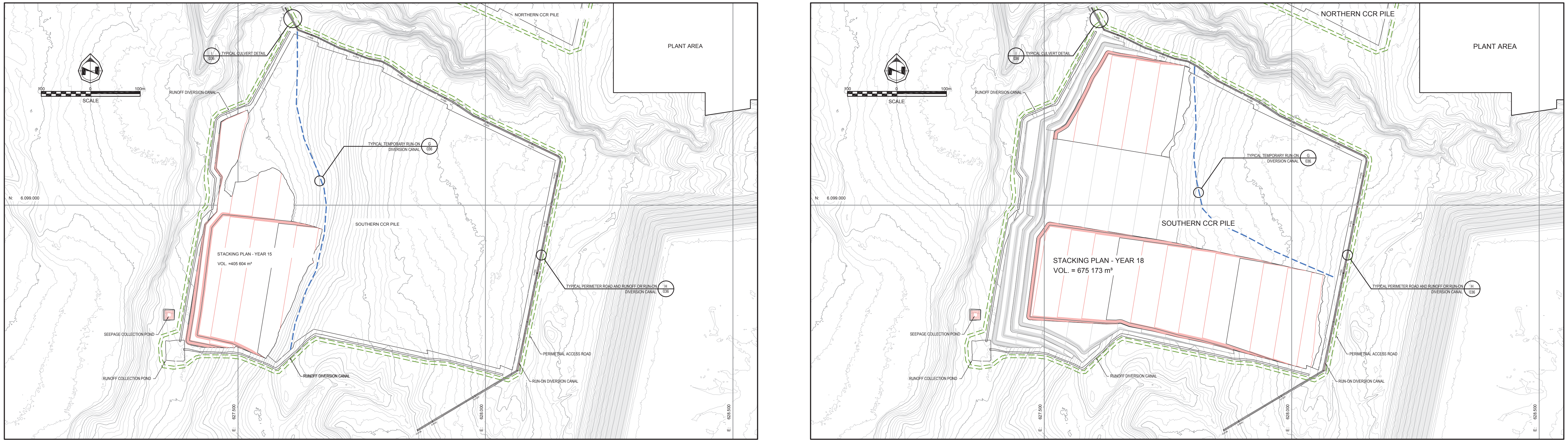
Year 14



Note: Contours every 1 metre
Source: Ausenco International.

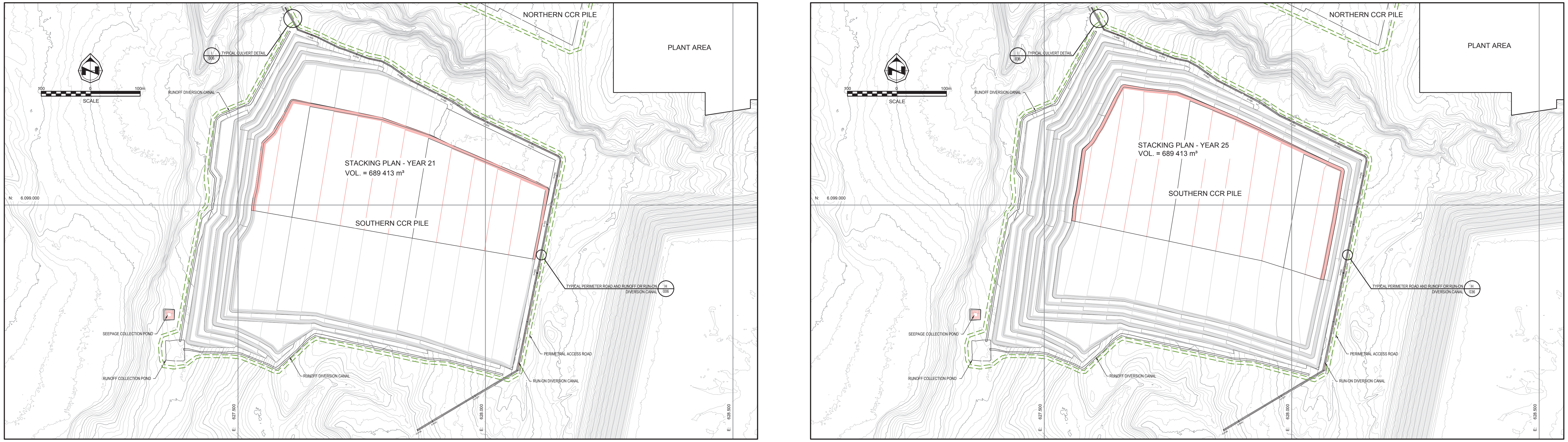
Figure 3.8-8

CCR South Pile
Stacking Sequence



Year 15

Year 18



Year 21

Year 25

Note: Contours every 1 metre.
Source: Ausenco International.

  - Hydraulic shields,
  - Pumps,
  - Road headers,
  - Bolters,
  - Belt conveyors, and
  - Hoists;
- Electricians (underground);
- Mechanics and maintenance workers (underground);
- Blasters;
- Drillers; and
- Labourers (underground).

Mine operating and maintenance personnel will work a schedule that meets applicable provincial laws and regulations. The maximum scheduled shift underground will be eight hours.

Other Positions

Other typical positions that will be required include:

- Mine manager;
- Geologists;
- Engineers;
- Water treatment operators;
- Coal Preparation Plant operators;
- Rail loaders;
- Equipment operators (surface);
- Electricians (surface);
- Mechanics (surface);
- Welders (surface);
- Labourers (surface); and
- Administrative support.

Workforce Employment Strategy

There is currently a shortage of skilled underground mine workers in the Canadian mining sector (Government of Canada 2013). In particular, there is a shortage of workers trained and experienced to safely undertake longwall coal mining. For its Bulk Sample program, HD Mining has received an approved labour market opinion (LMO) from Human Resources and Skills Development Canada (HRSDC) for the use of 201 Temporary Foreign Workers (TFWs) for a two-year period.

It is anticipated that TFWs would also be required to fill a portion of the positions during full mine operation. These workers will typically come from China, and will have experience working with the specific pieces of longwall mining equipment that will be utilized at the site. It is the goal of HD Mining that over time, the skills of the TFWs will be transferred to local Canadians; however this transfer will take time. HD Mining has made a transition plan of 10 years to train the Canadian workers to operate and maintenance the longwall mining and coal processing activities (Table 3.8-5).

Table 3.8-5. Employment Strategy

Year	TFWs	Local Canadians	Year	TFWs	Local Canadians
1	477	306	7	189	594
2	429	354	8	141	642
3	381	402	9	93	690
4	333	450	10	45	738
5	285	498	11	0	783
6	237	546			

3.8.8.2 Shifts

The Project (underground and surface) will be run three eight-hour shifts per day, two operation shifts, and one maintenance shift. The underground mine and surface operation will be operated upon a 330 day per year basis.

3.8.8.3 Transportation

During the full operation, the major consumed materials and supplies will be diesel, cement, sand, timber and steel, as well as heavy medium and flotation reagents for CPP operation. The annual supplies will be approximately 33,000 m^3 of cement, sands and gravels, 165,000 m^3 of timbers, 3,000 tonnes of steel, and 12,000 tonnes of reagents and other materials.

All materials, equipment and personnel will be hauled into the project site from Highway 52, and the existing Forest Service Road.

Natural gas will be delivered by pipeline directly to the CPP and electricity will be available from the nearby BC Hydro electrical network.

All workers will dwell in Tumbler Ridge and commute daily between site and residence via shuttle buses.

Clean coal and middling coal will be shipped off site via the rail system. The material will be loaded at the onsite railway loadout station connected to the CN rail system.

Some of the materials and equipment, such as diesel, reagents, wearing parts, maintenance supplies, etc., may also be brought to site by truck via the provincial and national road grid.

3.8.8.4 Goods and Services Sourcing

HD Mining will contract to an array of goods and services providers, both locally and nationally. All contractors will be required to meet HD Mining Health, Safety, Environment, and Community (HSEC) standards.

3.9 PROJECT PHASE: DECOMMISSIONING AND RECLAMATION

Closure and reclamation activities will occur throughout the mine life, as particular Project components or activities are completed. At the end of mine life, a focussed period of Decommissioning and Reclamation is planned to occur over approximately a three-year period. Continued Post-closure monitoring beyond this period is discussed in Section 3.10.

The following is a description of the regulatory and environmental setting related to mine closure in BC; the end land use objectives for the site which determine the reclamation planning; the activities that will be carried out to decommission the mine and reclaim it; a high level cost estimate to carry out these activities, and other components including temporary closure.

3.9.1 Regulatory Framework

As with all industrial activity, mine closure is subject to a number of different acts and regulations provincially and federally (e.g., the *Canada Water Act* (1985), the *Fisheries Act* (1985), and the *Canadian Environmental Protection Act* (1999), the BC *Water Act* (1996), the *Environmental Management Act* (2003), and the *Coal Act* (2004). However, closure planning is primarily driven by the BC *Mines Act* (1996a), and the Code (BC MEMPR 2008), which require mining operations to carry out a program of environmental protection and reclamation to ensure that, upon termination of mining, land, watercourses, and cultural heritage resources will be returned to a safe and environmentally sound state and to an acceptable end land use. A plan outlining the details of the proposed work including information, particulars and maps established by the regulations or the Code (Section 10.1) is required. The *Mines Act* (1996a) and are administered by the Ministry of Energy and Mines (MEM). The Chief Inspector of Mines has the ultimate legislative authority for all issues pertaining to the *Mines Act* (1996a) and the Code.

Proponents of mining projects are required to obtain a permit from the MEM prior to commencing any work on a mine site, in accordance with Section 10 of the *Mines Act* (1996a). HD Mining has approval to mine a 100,000 tonne Bulk Sample under Coal Exploration Permit CX-9-44 (amended in March 2012 for the Bulk Sample; see Section 3.2.3 for the permitting history). As a condition of issuing a permit, the Chief Inspector may require a security for mine reclamation and to provide for protection from, and mitigation of, damage to, watercourses and cultural heritage resources affected by the mine (Section 10.4). The objective of BC's reclamation security policy is to provide reasonable assurance that the provincial government will not have to contribute to the costs of reclamation and environmental protection if a mining company defaults on its obligations. In the case of a company default, the security should allow Government to successfully manage the environmental issues at the mine site, complete any outstanding reclamation requirements, and continue to monitor and maintain the site for as long as is required (BC MEM 2009). In general, MEM reviews the reclamation security at a mine site every five years, or whenever significant changes occur at the mine. The security can increase or decrease depending upon assessed liability at the time and financial factors, such as real return bond yields. At the environmental assessment stage, a high-level cost estimate is required to help the government and project stakeholders evaluate the merits of the project. More detailed costing is undertaken to support the *Mines Act* permit application and to set the appropriate financial security at the start of Construction.

3.9.2 Closure and Reclamation Objectives

3.9.2.1 Context

Part 10 of the Code focuses on reclamation and closure. Section 10.7 identifies reclamation standards. Section 10.7.4 (Land Use) indicates: "The land surface shall be reclaimed to an end land use approved by the chief inspector that considers previous and potential uses." Section 10.7.5 (Capability) indicates: "Excluding lands that are not to be reclaimed, the average land capability to be achieved on the remaining lands shall not be less than the average that existed prior to mining, unless the land capability is not consistent with the approved end land use." Section 10.7.6 (Long Term Stability) states: "Land, watercourses and access roads shall be left in a manner that ensures long-term stability."

HD Mining's goal is to develop a conceptual Closure and Reclamation Plan for the Project that will meet the requirements of the Code and provide assurance to the province that the site will be left in a condition that will limit any future liability to the people of BC. The three objectives of the conceptual Closure and Reclamation Plan are to:

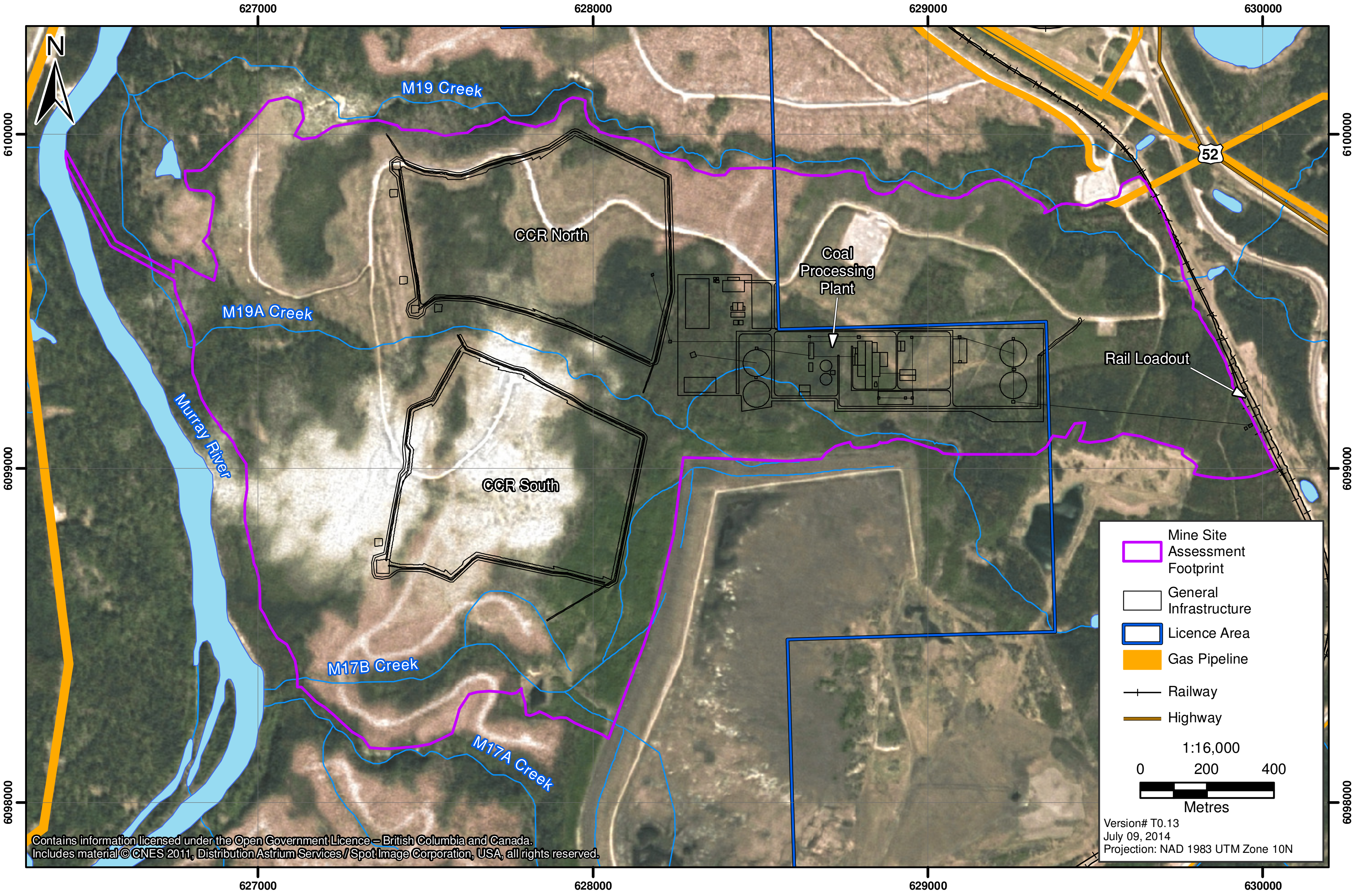
1. continue to ensure that aquatic resources are protected during closure activities and following closure;
2. provide stable landforms; and
3. where feasible, establish post-mine productive land use(s) similar to those present pre-mine.

3.9.2.2 Existing Conditions and Use

The pre-development land use and conditions form the basis for setting the end land use and capability objectives. The goal is to return the site to a use consistent with the pre-mine related land use. Information has been obtained from the environmental and socio-economic baseline studies, which were initiated in 2010 and have continued into 2014.

The Project is located in an area widely used for forestry and as a result, much of the area has been logged, including areas within the Coal Processing Site footprint (Figure 3.9-1). Four separate companies hold five forestry tenures. Canadian Forest Products Ltd. (Canfor) holds tree farm license (TFL) 48 which is comprised of five supply blocks in the western half of the Dawson Creek TSA; one of these blocks has Murray River as its eastern boundary. West Fraser Mills Ltd. holds a Forest Licence located in the southeastern and northeastern sections of the LSA, which grants a renewable right to harvest a percentage of the Dawson Creek TSA AAC. They also have BC Timber Sales cutblocks under a separate license on the northwestern portion of the LSA within the mining area. The southeastern edge of the LSA encompasses a Community Forest Agreement held by the Tumbler Ridge Community Forest Corp., which provides the exclusive right to harvest 20,000 m^3 annually for a period of 25 years, as well as the opportunity to manage and profit from other forest resources (BC MFLNRO 2011). The entirety of the LSA is covered by Tembec's Pulpwood Agreement Grant (a form of forest tenure that is no longer being issued), which provides a conditional right to harvest pulp quality timber where other sources are insufficient or uneconomic.

Figure 3.9-1
Coal Processing Site



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Version# T0.13
July 09, 2014
Projection: NAD 1983 UTM Zone 10N

The Project site is located in the Boreal White and Black Spruce (BWBS) biogeoclimatic (BEC) zone. Upland forests are characterized by trembling aspen, white spruce, lodgepole pine, subalpine fir, birch, and balsam poplar. Large expanses of low-lying terrain are muskeg (peat wetlands) characterized by scrub forest of black spruce and tamarack. The area has a history of natural disturbances such as wildfires, windthrow, and insect epidemics (notably pine beetle (*Dendroctonus ponderosae*)). Tree disease is widespread.

The forests also provide for wildlife habitat. A variety of wildlife habitats occur in the LSA that have been identified by provincial or scientific authorities as being important for wildlife in this area. These include habitat for caribou, moose, and elk; furbearers (e.g., fisher); raptors, including the northern goshawk which is reliant on closed canopy forests; waterbirds including five species of conservation concern (harlequin duck, surf scoter, horned grebe, red-necked phalarope, and Western grebe); songbirds including 3 species of conservation concern (barn swallow, black-throated green warbler and olive-sided flycatcher); and amphibians.

A total of 16 fish species have been documented within the Murray River and connecting tributary streams. Arctic Grayling, Brook Trout, Bull Trout, Burbot, Finescale Dace, Lake Chub, Longnose Dace, Longnose Sucker, Mountain Whitefish, Northern Pike, Rainbow Trout, and Slimy Sculpin were captured between 2010 to 2013 from the Murray River and tributary streams (ERM Rescan 2014).

Current land use in the LSA also includes recreation, aboriginal, and industrial use. Recreational activities within or near the LSA include: fishing, hiking, boating, and both residential and non-residential hunting. Aboriginal land use in the Project area includes: fishing, hunting, trapping and gathering of animal and plant resources.

Commercial activities within the LSA include: guide outfitting, trapping, mineral exploration, oil and gas, as well as forestry. The majority of the LSA overlaps with one guide-outfitters area, and a small portion of another. There are three trap lines that also run through the LSA. There are also 2 coal leases and 45 coal licences, 32 petroleum and natural gas leases, plus licences for ancillary developments (roads, power lines, aggregate quarrying) that are associated with forestry, mineral exploration, and petroleum and natural gas exploration (Rescan 2013b). The Murray River Forest Service Road and the Mast Creek Road provide access to the property and a 230 kilovolt (KV) powerline cuts across the site.

3.9.2.3 End Land Use Objective

The above information indicates that there are multiple users of the site and that these users can be accommodated in the future if the infrastructure areas are reclaimed, where practical, to a forest cover. This could support wildlife, recreation, aboriginal, and forestry operations. Therefore, the end land use objective is to revegetate the site to achieve a forest cover or a natural vegetative cover of herbs and shrubs, such as on the CCR piles, that will support the current land uses including wildlife habitat, trapping, hunting, recreational, and forestry activities.

3.9.3 Soil Handling Plan

Under Section 10.1.4 (h) of the Code, information is required on soil characterization as soils are required for successful reclamation. The reclamation plan must also include information on soil salvage and stockpiling of surface and overburden materials. A soils baseline program was conducted and the information collected has been used in the development of the soils handling plan.

Soils will only be salvaged in the footprint areas. The Shaft and Decline Sites were required for the Bulk Sample so the soils have been salvaged from these areas and are stockpiled (Plate 3.9-1). Some minor infrastructure modifications will be required within the Shaft and Decline Sites so additional soil salvage is planned (Figure 3.9-2). The following is a discussion of the assessment of the soils for reclamation purposes, salvage considerations, and the approaches to storing them.

Plate 3.9-1. Stockpiled soils in the Decline Site area.

3.9.3.1 Soil Assessment

The soils in the Project area have developed on morainal, glaciofluvial, colluvial, fluvial, and organic materials (Rescan 2013c). In some areas, glaciofluvial materials overlie till materials. To optimize effectiveness of reclamation in a given environment, the factors associated with soil quality, such as the physical properties (e.g., texture, coarse fragment content, soil structure) and chemical properties (e.g., organic matter content, nutrient status, and pH), must be adequate for plant establishment and for plants suited to the area. The suitability of soils for reclamation was assessed (Table 3.9-1) by reviewing the detailed profile descriptions of the sites checked during the soil mapping program. The chemical properties of the soils were assessed through laboratory analyses (Appendix 10-A) and were also inferred from vegetation occurring on site.

Figure 3.9-2

Areas Affected by the Bulk Sample Project

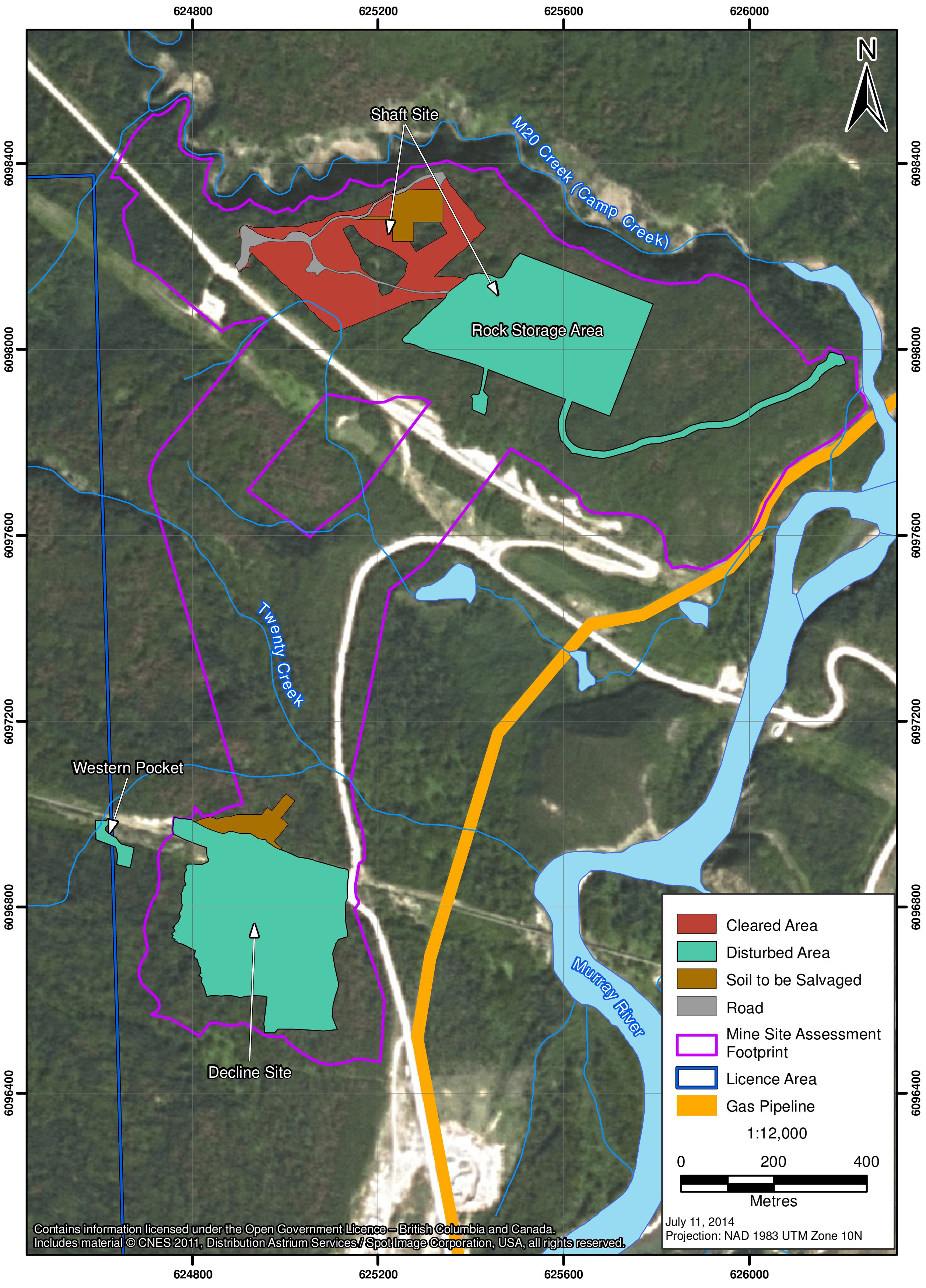

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Table 3.9-1. Soil Salvage Suitability

Parent Material	Soil Mapping Units	Depth of Organic Horizons (cm) Range	Total Thickness to C Horizon (cm)		Management Limitations		Salvage Suitability	Material Description
			90th percentile	Range	Soil (T=texture CF=% coarse fragment)	Landscape		
Colluvial	C4_B	9	62	-	coarse texture	steep slope	Good to Fair	50 cm available, may be coarse textured
Fluvial	F6_G, F6_G.p	2 - 12	-	16 - 27	texture: often fine or coarse	wet soils	Fair	25 cm available
Glaciofluvial veneers over till	FG/M2_B, FG/M4_B, FG/M3_BR.GL	5 - 13	39	15 - 48	sporadic: fine texture in a portion of soil profile	-	Good to Fair	35 cm available
Glaciofluvial blankets	FG2_B, FG4_B, FG3_BR.GL	5 - 14	48	27 - 50	common: coarse textures, high CF%	-	Good to Fair	35 cm available, may be limited by coarse texture or CF%
Morainal	M4-B, M3_BR.GL, M6-G	-	47	30 - 61	slightly limited by fine textures	-	Good	50 cm available, mainly good suitability, may be slightly limited by fine textures
Organic veneers over till	O|M5_B.g	15	50	-	slightly limited by fine textures	-	Fair	50 cm available, slightly limited by fine textures
Organic	O7_M	-	100	45 - 200	organic	-	-	usually deep > 100 cm, medium decomposition, salvage and store separately, good as an amendment material for reclamation

Based on the soil baseline studies (Appendix 10-A), the morainal materials generally consist of non-stratified material composed of a mixture of sand, silt, and clay with a heterogeneous mixture of sub-rounded to angular coarse fragments of different sizes (Plate 3.9-2). The soil textures vary widely (sandy to clayey), but most typically include clay loams and silty clay loams. These textures provide good moisture and nutrient capacities for vegetation establishment. The surface vegetation and roots also provide organic matter and nutrients to the surface soils. The soils developed on morainal materials in the Project area have a good suitability for reclamation purposes (Table 3.9-1). The finer textures may make these soils susceptible to compaction in high traffic areas when they are wet or if they are handled when wet. The subsoil will have similar textures but will be compacted. The subsoil materials may be suitable as a base material for the topsoil where covers are required such as on the CCR piles.

Plate 3.9-2. Morainal soils found near the Project footprint.

In the Project area, the glaciofluvial materials have been deposited as blankets or veneers. They mainly consist of sandy and silty materials with a considerable component of rounded or sub-rounded coarse fragments. These materials are well-sorted and often stratified. The glaciofluvial veneers deposited over gentle morainal slopes are characterized by relatively high coarse fragment content (average 48%). The surface soils have been affected by weathering and plant litter and roots which improves the soil structure and organic matter content. These soils have been rated as having a good to fair suitability for reclamation purposes. The subsoils generally have a low suitability for reclamation purposes as they have poor structure and organic matter content. The component of glaciofluvial materials that are predominantly very coarse textured have low moisture and nutrient holding capacities and are rated as not suitable for reclamation purposes.

Fluvial soils are similar to the glaciofluvial materials in that the textures can be variable. Similarly, the surface soils which have good structure and organic matter are rated as having a fair suitability for reclamation purposes. The subsoils generally have a low suitability for reclamation purposes because they have poor soil structure and are deficient in organic matter.

Colluvial materials are the products of mass-wasting, typically occurring on moderate to steep slopes. They are generally poorly sorted and contain a wide range of particle sizes. These materials can be non-stratified, non-compacted veneers covering morainal or glaciofluvial materials deposited on moderate to steep slopes. Coarse fragments consist mainly of sub-angular to angular gravels (1 to 60%) and up to 20% cobbles (Plate 3.9-3). These soils should be suitable for reclamation purposes as they are generally eroded morainal material so have moderately fine textures which provide good nutrient and moisture holding capacities. They have been rated as good to fair for reclamation purposes. Soils with coarse fragments >50% are not suitable for reclamation purposes.

Plate 3.9-3. Colluvial soils found near the Project footprint.

Organic deposits (Plate 3.9-4) occur in the CCR and the CPP footprints (Figure 3.9-3). These soils are made of organic materials and have formed in wet, depressional areas. They vary in decomposition from poorly decomposed, to medium, to well-decomposed depending on the degree of wetness. These soils are suitable as organic amendments for soils salvaged for reclamation purposes.

Plates 3.9-5 and 3.9-6 are typical soils found in the CCR area.

Plate 3.9-4. Organic soils found near the Project footprint.

Plate 3.9-5. Typical soils found in the North CCR pile footprint (Source: Ausenco 2014; Appendix 6).

Figure 3.9-3

Soil Mapping of the CCR Area

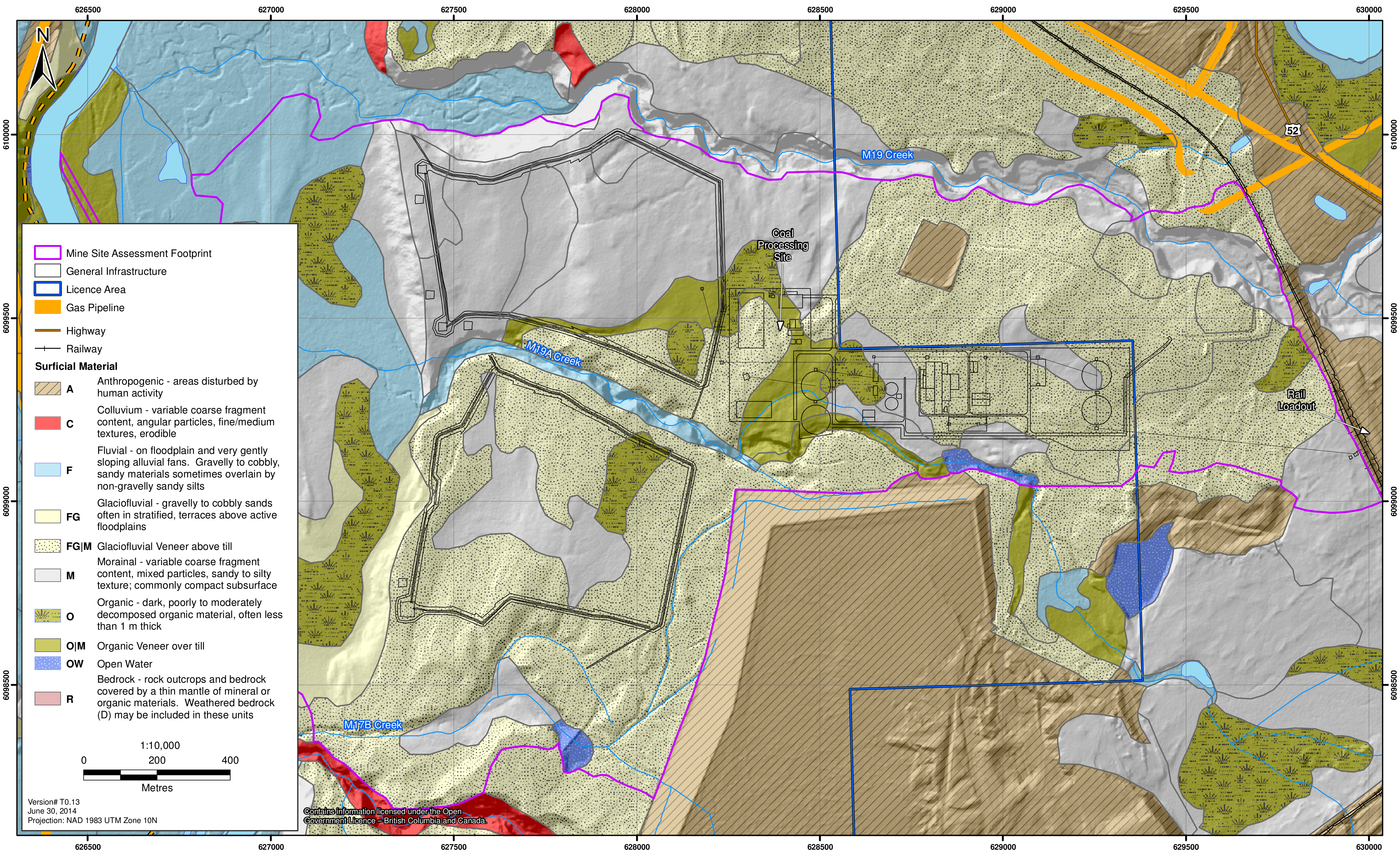


Plate 3.9-6. Typical soils found in the South CCR pile footprint (Source: Ausenco 2014; Appendix 6).

3.9.3.2 Soil Salvage

The soils will be salvaged only when an area will be required for the Project. They will be salvaged using a dozer. Efforts will be made not to salvage the soils when they are excessively wet or dry as this will degrade the soil structure. Trees and stumps will be removed prior to soil salvage. Soil salvage will include the groundcover and forest litter which will provide organic matter to the soils. The soils will be salvaged in two lifts, the topsoil (the surface 25 cm) and subsoil in areas where subsoil is required to provide sufficient soil for reclamation such as at the CCR area. The soils will be placed in a truck and transported to the storage area.

The organic soil deposits have low structural stability and therefore they will be salvaged when they are frozen, if possible. They will be transported to a separate stockpile until they are drained and have sufficient structural stability to be mixed with the subsoil or topsoil stockpiles.

The volume of soils to be salvaged has been estimated for each infrastructure footprint (Table 3.9-2). Approximately 176,683 m^3 will be salvaged from the CCR North footprint, 143,182 m^3 will be salvaged from the CCR South footprint, and 97,971 m^3 will be salvaged from the CPP area. An additional 12,525 m^3 of soil will be salvaged from the Shaft and Decline Sites and 7,780 m^3 of soil will be salvaged at the Secondary Shaft Site.

Approximately 10,295 m^3 of the soils salvaged from the CCR North footprint will be organic material; 6,407 m^3 of organic material will be salvaged from the CCR South footprint; and 27,505 m^3

of organic material will be salvaged from the CPP footprint area. This material will be handled and temporarily stored separately.

Table 3.9-2. Soil Salvage by Infrastructure Area

Infrastructure Areas	Materials	Total area (ha)	Total area (m^2)	Soil Salvage Depth (cm)	Volume (m^3)
Decline Site	Glaciofluvial	1.65	16,485	35	5,770
	Colluvial	0.68	6,777	50	3,389
Total					9,158
Secondary Shaft Site	Glaciofluvial	1.43	14,273	35	4,995
	Fluvial	0.13	1,311	25	328
Total					5,323
Shaft Site - West Side	Glaciofluvial/ morainal	0.96	9,621	35	3,367
Coal Processing Site - CCR North	Glaciofluvial/ morainal	1.93	19,300	35	6,755
	Morainal	31.93	319,265	50	159,632
	Organic	1.16	11,587	25	2,897
	Organic/morainal	2.96	29,594	25	7,398
Total			-		176,683
Coal Processing Site - CCR South	Glaciofluvial	8.12	81,240	35	28,434
	Glaciofluvial/ morainal	17.24	172,438	35	60,353
	Morainal	9.60	95,976	50	47,988
	Organic	2.56	25,626	25	6,407
Total			-		143,182
Coal Processing Site - Pad Area	Glaciofluvial/ morainal	16.46	164,581	35	57,603
	Morainal	2.57	25,724	50	12,862
	Organic	2.40	23,997	25	5,999
	Organic/morainal	8.60	86,024	25	21,506
Total					**97,971**

3.9.3.3 *Soil Stockpiling*

The topsoil will be stockpiled separately from the subsoil in order to not degrade the topsoil with the poorer quality subsoil. The soils will be stockpiled in lifts to provide structural stability to the piles. The piles will be no steeper than 2:1 (H:V). Care will be taken not to overly compact the soil. The final soil lift will be loosely spread to increase surface roughness.

The organic materials are subject to hydrophobicity (water repellency) if allowed to dry out and are also subject to wind erosion if they become desiccated. Therefore, they will be incorporated in the subsoil stockpiles as soon as possible. The stockpiles will then be re-vegetated with a native seed mix suitable to the Project area.

There will be some variability in the physical and chemical properties of the soils salvaged across the site and variability in the soil properties will occur due to moisture conditions during salvage and stockpiling. As well, variability in the physical conditions of the soils will occur during material handling and stockpile construction.

A suitable mixture could include:

- Alpine bluegrass (*Poa alpine*);
- Ticklegrass (*Agrostis scabra*);
- Mountain brome (*Bromus marginatus*);
- Blue wildrye (*Elymus glaucus*); and
- American vetch (*Vicia americana*).

The use of a seed mix will allow for the variability in the stockpiled soils such that some grasses will become better established in areas on the stockpiles where the soils are more suited to their requirements.

These grasses are suitable for erosion control. American vetch is a legume which supports the establishment of a sustainable vegetative cover.

The seed will be certified weed free and applied at 40 kg/ha. The propagules in the vegetation and litter included in the topsoil during salvage will result in increasing the complexity of the vegetated cover. The rough surface will provide seed catchment areas which will result in the seed staying in place and allowing it to germinate in place. The roughness at the surface will also reduce the potential of surface erosion on the stockpile slopes.

The various facilities are located primarily on level to gently sloping topography (Figures 3.9-4 and 3.9-5) so soil salvage has not been nor will be limited by steep slopes except in the Secondary Shaft Site where there are some areas with slopes greater than 70% (> 35°).

The soils will be stockpiled close to the areas where they will be used for reclamation but where they will not be disturbed by operational activities. CCR North pile will be constructed before CCR South. Therefore, the soils salvaged from CCR North will be stockpiled in the eastern portion of the CCR South footprint area as this will be the last area to be used for the reject material and the area is gently sloping (Figure 3.3-8).

These soils will be used to reclaim the CCR North when it is completed. The soils salvaged from CCR South will then be stockpiled on the reclaimed CCR North until it is required to reclaim CCR South.

3.9.3.4 Materials Balance

It is projected that there will be surplus of salvaged soil following reclamation of the Shaft Site as well as the Secondary Shaft site (Table 3.9-3). The surplus soils will be used for the reclamation of disturbed areas where additional soil may be required such as in working and laydown areas, gravelled areas that require additional soil, and existing road areas that will be reclaimed.

Figure 3.9-4

Slope Map of the Shaft, Decline and Secondary Shaft Site

ERM

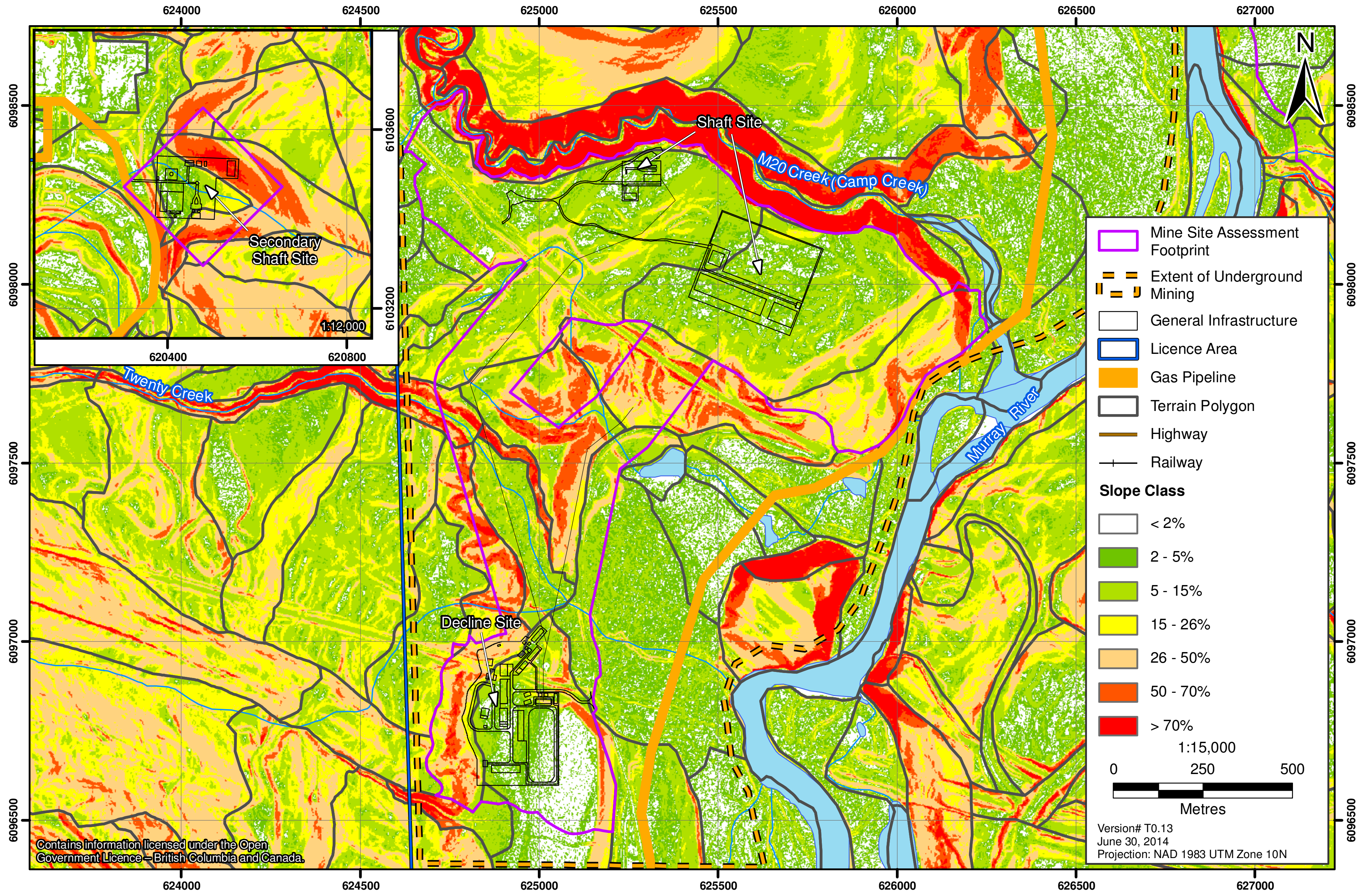


Figure 3.9-5
Slope Map of the Coal Processing Site

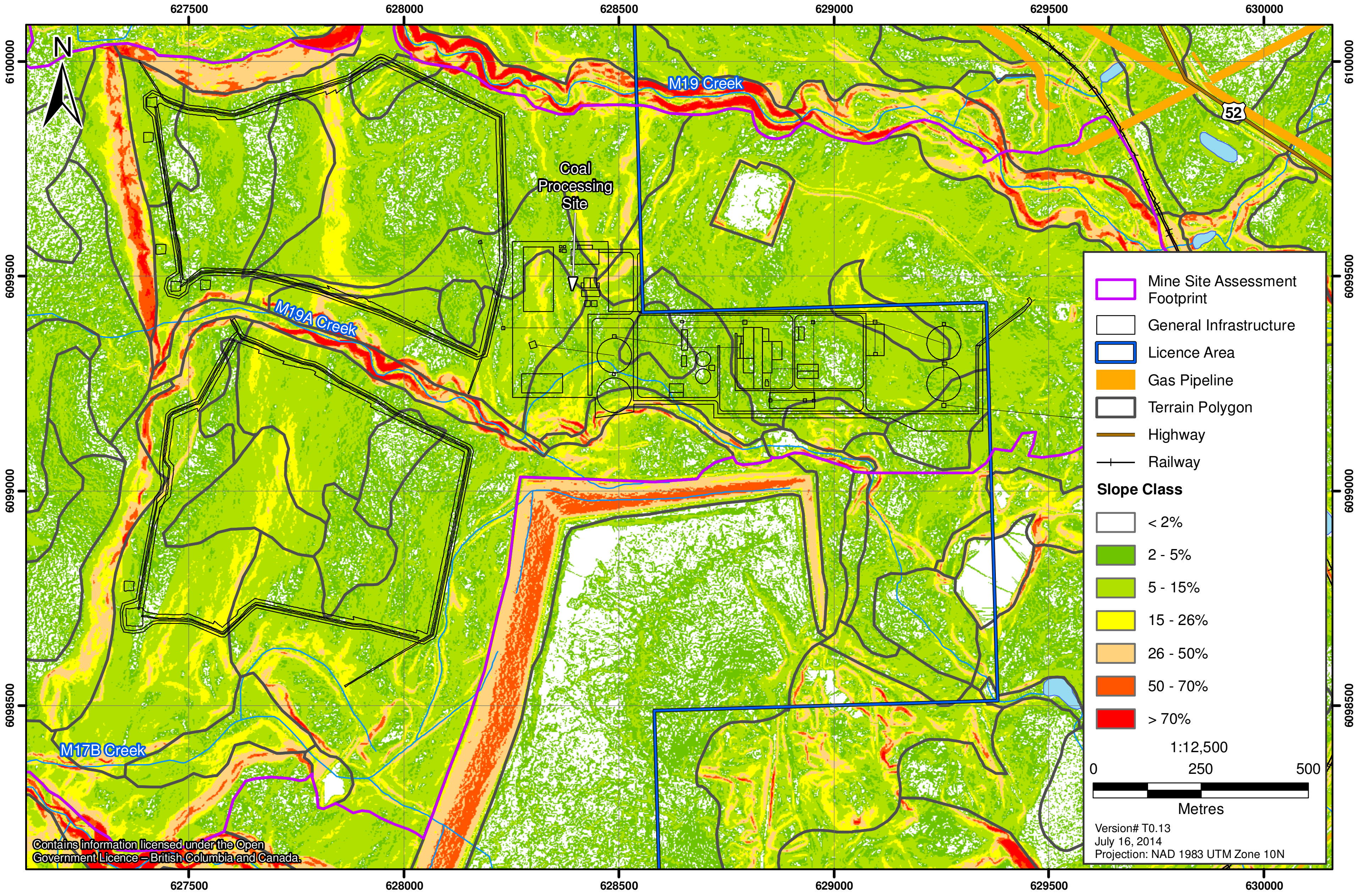


Table 3.9-3. Soils Balance for the Project

Infrastructure Component	Soils Salvaged (m^3)	Soils Required (m^2)	Area Depth (m)	Volume (m^3)	Net Volume (m^3) Available
Decline Site	20,000	88,700	0.25	22,175	-2,175
Shaft Site West	3,367	9,621	0.25	2,405	962
Shaft Site East	12,000	35,550	0.25	8,888	3,113
Waste Rock Pile	40,000	76,000	0.25	19,000	21,000
Secondary Shaft Site	5,323	20,498	0.25	5,125	199
CCR North	176,683	379,746	0.4	151,898	24,784
CCR South	143,182	348,700	0.4	139,480	3,702
CPP	97,971	297,158	0.4	118,863	-20,892

It is predicted that there may be a shortage of soil for reclamation purposes at the CPP site as a large part of the CPP site has been mapped with organic soils (Table 3.9-2) and only 25 cm of the organic material is planned for reclamation use to be incorporated as an amendment to the mineral soils. However, there will be a surplus of soils from the CCR footprints that will be retained to reclaim the CPP footprint area.

3.9.4 Decommissioning and Reclamation

General strategies for closure include removing infrastructure that is no longer in use, re-contouring, re-establishing watercourses, and reclamation. The activities that will be carried out to close and reclaim each of the infrastructure areas are described below.

3.9.4.1 Coarse Coal Reject Piles

Decommissioning

The coarse coal reject will be managed as dry disposal and therefore, it will be subject to infiltration of precipitation during Operation and into Post-closure. The CCR piles will be constructed with coarse and fine coal rejects that will be co-mingled during the construction of the piles. The fines will be dried to produce a filter cake. The material will contain approximately 40% gravel size, 28% sand size, and 33% finer material (Appendix 3E).

CCR North may contain reject that is potentially acid generating (PAG) in the first five years of mine production. The pile will be constructed over 14 years such that the upper portions of the pile will be constructed with non-PAG material. The Southern CCR pile is expected to be non-PAG and will be constructed over the next 11 years.

The piles will be constructed in 8 to 10 m lifts with benches between the lifts. The hydraulic conductivity of the co-mingled reject material has been predicted at 3.7×10^{-7} cm/s (Appendix 3E). As the piles are constructed, small drainage channels will be installed along the benches to capture runoff and convey it down to ponds.

At closure, the bench crests will be rounded and the faces re-shaped to final slopes of 2.5:1 (H:V) to improve stability and allow for reclamation of the piles (Figure 3.9-6).

Reclamation

As part of the water management of the CCR piles at closure, the surface of the piles will be covered with a 50 cm thick, compacted layer of fine coal reject. The goal of applying this layer is to reduce infiltration of precipitation into the CCR piles. The fine reject will serve as a low permeability liner. This material will be non-PAG and is predicted to have a saturated hydraulic conductivity of $5x\ 10^{-10}$ m/s (Appendix 3E).

Approximately 175,750 m^3 of fine reject will be required for the CCR North pile cover and 174,350 m^3 will be required for CCR South cover (Table 3.9-4). It is estimated that in Year 14, the last year that reject will be placed on CCR North, approximately 211,497 m^3 of fine reject will be generated (Appendix 3E). Of this, approximately 175,750 m^3 will be separated and stockpiled in a corner of the pile while the coarse coal reject and the remaining fines are placed on the pile. The stockpiled fines will then be re-worked to create the cover. Similarly, in the Year 25, approximately 205,142 m^3 of fine reject will be generated of which 174,350 m^3 will be stockpiled for use as cover material.

Table 3.9-4. Fine Reject and Topsoil Requirements for the CCR Pile Covers

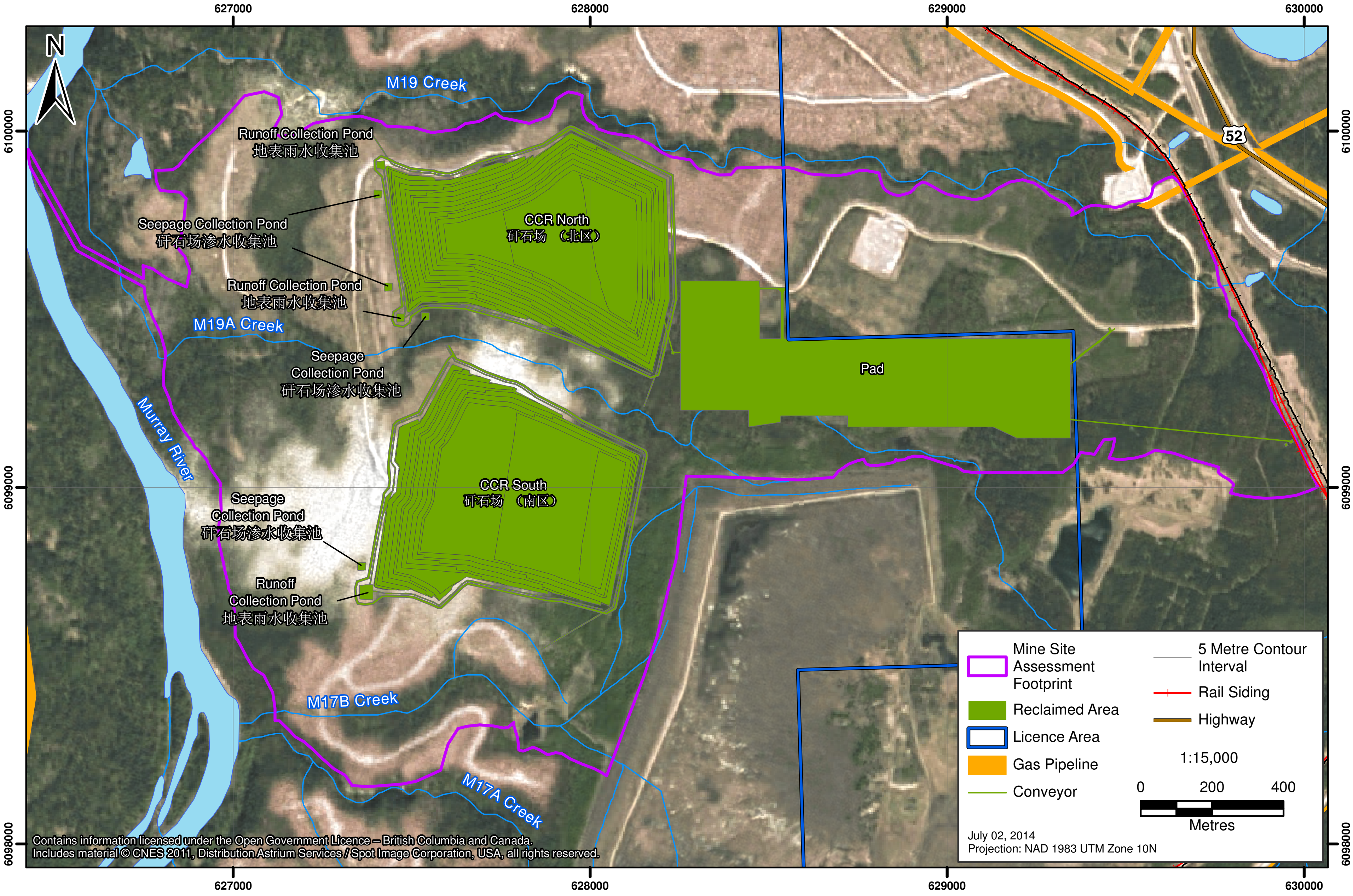
Stockpile	Surface Area (m^2)	Fine Reject Depth (m)	Fine Reject Volume (m^3)	Topsoil Depth (m)	Topsoil Depth (m^3)
CCR North	351,500*	0.5	175,750	0.4	140,600
CCR South	348,700*	0.5	174,350	0.4	139,480
Total	700,200		350,100		280,080

**Source: Ausenco 2014; Appendix 5*

Approximately 40 cm of topsoil will then be spread over the fine coal reject for re-vegetation. This soil layer will further reduce water infiltration into the CCR piles.

Based on a silt loam texture, the soil cover will have a water storage capacity of approximately 80 mm of water. The fine reject fraction will have a water storage capacity of approximately 100 mm. Therefore, the complex cover should have a water storage capacity of approximately 180 mm. The Project area is characterized by a continental climate with little precipitation, moderately warm summers, and cold winters. The mean annual precipitation for the Project site has been estimated at 515 mm (Appendix 8A). The heaviest precipitation typically falls as rainstorms during the summer. The majority of precipitation occurring from November through April falls as snow. Approximately 30% to 42% of the annual total precipitation occurs as snowfall, representing approximately 91 mm of precipitation. The snow will melt during May and June and the soil/fine reject cover should have sufficient storage for the water from the melted snow. The soil/fine reject cover may have some remaining water from the previous season; however, the cover should have the capacity to store this as well as the snow melt.

Figure 3.9-6
Coal Processing Site Post-closure



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Summer storms could also result in the saturation of the soil cover and the subsequent release of water depending on the amount of water in the soils prior to the storm event. The 10-year storm event has been predicted at 24 mm, at 41 mm for a 50-year event, and at 44 mm for a 100-year event (Appendix 8-A). The soil/reject cover should have capacity to store the water from these storm events as water will also be evaporating from the soil cover during the warmer months.

If there is additional water, it would be shed as surface runoff.

The soil cover will be applied loosely. This will provide for surface roughness that will reduce the potential for surface erosion and provide a seed bed for vegetation. The piles will be vegetated with a suitable native seed mixture, which could include:

- Alpine bluegrass (*Poa alpine*);
- Ticklegrass (*Agrostis scabra*);
- Mountain brome (*Bromus marginatus*);
- Blue wildrye (*Elymus glaucus*); and
- American vetch (*Vicia americana*)

These grasses are suitable for erosion control and the American vetch is a legume. The seed will be certified weed free and applied at 40 kg/ha. The blue wildrye will be short-lived but will establish rapidly providing for erosion control. The vegetation and litter included in the topsoil will result in increasing the complexity of the vegetated cover.

The vegetative cover will also capture moisture on the leaves and shoots increasing the potential for surface evaporation thereby reducing the amount of precipitation entering the soil cover. The plant roots will also take up soil moisture further reducing the potential for water moving deeper into the cover and into the pile.

The soil cover thickness of 40 cm should provide sufficient water storage capacity for the grasses as the soils are predicted to have a relatively high water storage capacity and roots are generally concentrated in the upper 20 cm of the soil.

The soils have an estimated saturated conductivity of 7.2×10^{-7} m/s, which is greater than the compacted fine reject layer lying below the soil cover. The difference in saturated conductivities between the soil and the fine reject layer may result in perching some water at the soil and fine fraction interface in some situations. This perched water could provide additional moisture to the soils and therefore the vegetation growing on the CCR piles. The water perched at the interface is not expected to have a detrimental effect on the plants as it is primarily below the most active rooting layer and the fine reject will be non-PAG. The soils will be checked during Post-closure for Se and other metals to ensure that the soil cover is not contaminated by contact with the compacted fine reject layer.

Trees will not be planted on the CCR piles to minimize the uprooting of the cover in the event of windthrow. Shrubs will include species such as mountain ash, blueberry, huckleberry, and red elderberry. These species and the grasses will provide browse for a range of wildlife occurring in the Project area. The grasses will also provide habitat for small mammals.

3.9.4.2 Coal Processing Plant

Decommissioning

The Coal Processing Plant (CPP) will include the coal preparation plant, screening/crushing plant, thickeners, flotation and filtration plant, drying plant, a variety of conveyors, transfer towers, maintenance workshop, boiler house, water well, a water treatment plant, a sedimentation pond, raw coal storage stockpiles, clean coal and middlings stockpiles, floatation clean coal stockpiles, topsoil stockpiles, a power substation and distribution building, a flotation reagents house, an air compressor house, a fire water pond, an office/administration complex building, and a rail loadout (Figure 3.6-23). These facilities are located on a cleared area which will occupy approximately 21.7 ha.

At the end of mining, each of components will be closed. Lubricants/oils will be drained from equipment such as generators, pumps, compressors, etc. These fuels will be placed in sealed containers and will be taken off site for disposal in a regulated facility. All chemicals and compounds such as flocculants and magnetite will be taken off site and sold or taken to a designated facility for disposal. All equipment will be removed from the buildings and taken off- site for resale, recycling, or disposal. This will include office, workshop, and processing equipment including the crusher, centrifuges, screens, cyclones, pumps, tanks, filter presses, conveyor belts, and any other equipment such as the water treatment system and sludge tank.

Once all equipment is removed, all portables will be taken off site. Structures, such as the screen breaker building, the workshop, machine repair workshop, the flotation warehouse, and all other buildings and surface structures will be dismantled. All building materials will be taken off site for recycling or disposal. Wood debris will be burned.

The sedimentation pond will be backfilled. Before backfilling is carried out, the liner of the sedimentation pond will be cut to ensure that a water table will not build up in the backfilled pond. Any remnant coal will be placed on CCR South before it is reclaimed. Concrete pads will be broken up and left in place or put in the Production Decline. The soil quality in the areas around the stockpiles will be assessed and remediated if required.

Reclamation

The CPP area will have a gravel surface in the high traffic areas and concrete paving will also occur in limited areas. The surfaces will be compacted. The area will be ripped to reduce compaction and to increase surface drainage. The salvaged soils that will have been stockpiled from the area will be loosely spread over the surface to a depth of approximately 40 cm. Care will be taken not to compact the soils. The area will be vegetated with the seed mix described above as well as native tree seedlings including hybrid white spruce and subalpine fir and native shrubs such as mountain ash, blueberry, huckleberry, and red elderberry. The tree seedlings will be planted at approximately 400 stems/ha.

The vegetation will provide browse for wildlife as well as habitat for small mammals. With time, the vegetation will become more complex and the trees will mature, providing wildlife habitat. These trees will also be suitable for commercial forestry.

3.9.4.3 Ditches and Ponds

Decommissioning

During Operation, diversion ditches will be constructed around the northern and eastern sides of the CCR piles to prevent non-contact surface water flowing through the base of the piles (Figure 3.6-23). These ditches will be approximately 0.7 m deep with a bottom width of 1 m and a top width of 2.4 m (Appendix 3E). During construction, the topsoil in the ditch footprint will be salvaged and placed in the soil stockpile. The deeper materials will be placed in a berm along the ditch. Ditches for collection of contact water that will run off from the surface of the CCR piles will be located on the south and western edges of the piles. The runoff will be directed to runoff collection ponds. Seepage water through the piles will be directed to collection pipes below the piles which drain into seepage collection ponds.

After the CCR piles have been reclaimed, the diversion ditches will be backfilled. The runoff collection ponds will be backfilled as the runoff over the reclaimed CCR piles will be directed to the surrounding environment. Seepage is expected to be low following the application of the cover and the establishment of vegetation on the CCR piles. Seepage that does occur will be directed to exfiltration galleries that will be constructed downslope of the seepage collection ponds to allow the water to flow slowly and seep into the ground.

Reclamation

All of the backfilled ditch and ponds will be covered with 25 cm of soil. Care will be taken to not compact the soils. These areas will then be re-vegetated (Figure 3.9-6) with the native grass mix described above at a rate of 40 kg/ha. With time, the vegetation will become more complex in the reclaimed ditches as seeds from surrounding areas will gradually enter the reclaimed areas. These areas will provide browse for wildlife and with time, tree and shrub seedlings will enter these areas providing wildlife habitat.

Native grasses and tree seedlings such as hybrid white spruce and subalpine fir will be planted in the reclaimed pond areas at approximately 400 stems/ha. With time, the trees will mature and provide wildlife habitat. The trees will also be suitable for commercial forestry. Shrubs such as such as blueberry, huckleberry, and red elderberry will also be planted in the pond areas. These are important wildlife browse species.

3.9.4.4 Decline Site

Decommissioning

The Decline Site has been developed for the Bulk Sample project. Current structures include portables, industrial size Quonsets, sea-cans, and some wooden structures (Plate 3.9-7). The decline portal (Plate 3.9-8) and a lined sediment pond approximately 1.43 ha in size have also been constructed (Plate 3.9-9). Additional infrastructure, including the main power substation and sewage treatment facility, mine dry and administration complex and equipment maintenance shops, will be constructed at the Decline Site to support Operation of the full mine (Figure 3.6-21).

Plate 3.9-7. Eastern view of the Decline Site area facing south (April 2014).

Plate 3.9-8. Western view of the Decline Site area facing south (April 2014).

Plate 3.9-9. Lined sediment pond in the southeastern part of the Decline Site area (April 2014).

At the end of mine life, the Decline Site will be closed. All fuel tanks will be emptied and the fuel taken off site for use or recycling. Fuel, water, and any other tanks on site will be taken off site for re-use or recycling. Lubricants and oils will be drained from all generators, transformers, and other equipment and will be placed in labelled, sealed containers and taken for disposal at a designated facility. The generators and other equipment will be taken off site for re-use, recycling, or disposal in a regulated facility. The power will be disconnected from all buildings and the electrical cables, transformers, switching gear, wiring, conductors, and towers will be removed from the site. All other equipment such as the boiler, hoists, heating equipment, office equipment, tools and equipment from the shops and used for vehicle maintenance, and materials stored around the site and in the various structures will be taken off site for disposal or recycling.

All buildings and storage areas (e.g., Quonsets, portables, and sea-cans) will be deconstructed and taken off site for re-use or recycling. The sewage treatment plant and associated piping will be removed from the site as well.

Once the sediment pond is no longer needed, it will be decommissioned. Any remaining water will be pumped out. The liner will be cut to ensure that water will drain freely. The pond will then be backfilled with the berm material around the pond in preparation for reclamation.

There is approximately 1 ha of concrete used in different areas of the site and this will be broken up and placed in the Service Decline.

The wooden sheds will be dismantled and will be removed offsite for recycling or disposal as appropriate. Wood associated with other infrastructure will also be removed offsite for recycling or disposal as appropriate.

Reclamation

Once all materials and structures have been removed from the site and the ponds and any ditches backfilled, reclamation will be carried out. Approximately 13.2 ha in the Decline Site will be reclaimed (Figure 3.9-7). Many of the areas will have been compacted during construction. The compacted areas will be ripped to improve surface drainage and to loosen the soil for the establishment of vegetation. Approximately 25 cm of the stockpiled soil will be loosely placed on the disturbed areas occurring on native surficial material. The existing soil will provide a base for the topsoil to support vegetation establishment. Areas with a gravel surface such as in the parking areas, will receive approximately 35 cm of soil to provide sufficient soil water capacity for plants.

The surface will be broadcast seeded with native seed which will include the following:

- Alpine bluegrass (*Poa alpine*);
- Ticklegrass (*Agrostis scabra*);
- Mountain brome (*Bromus marginatus*);
- Blue wildrye (*Elymus glaucus*); and
- American vetch (*Vicia americana*)

These grasses are suited to the area. American vetch is a legume and will support the sustainability of the vegetative cover. The seed will be certified weed free and applied at 40 kg/ha. The area will also be planted with native tree seedlings such as hybrid white spruce and subalpine fir, which are growing in the area and native shrubs such as mountain ash, blueberry, huckleberry, and red elderberry. The trees will be planted at approximately 400 stems/ha. The ecosystem will become more complex with time as the plants mature. The Decline Site area will be suitable as wildlife habitat and will develop into a forest which will support commercial forestry use when the trees mature.

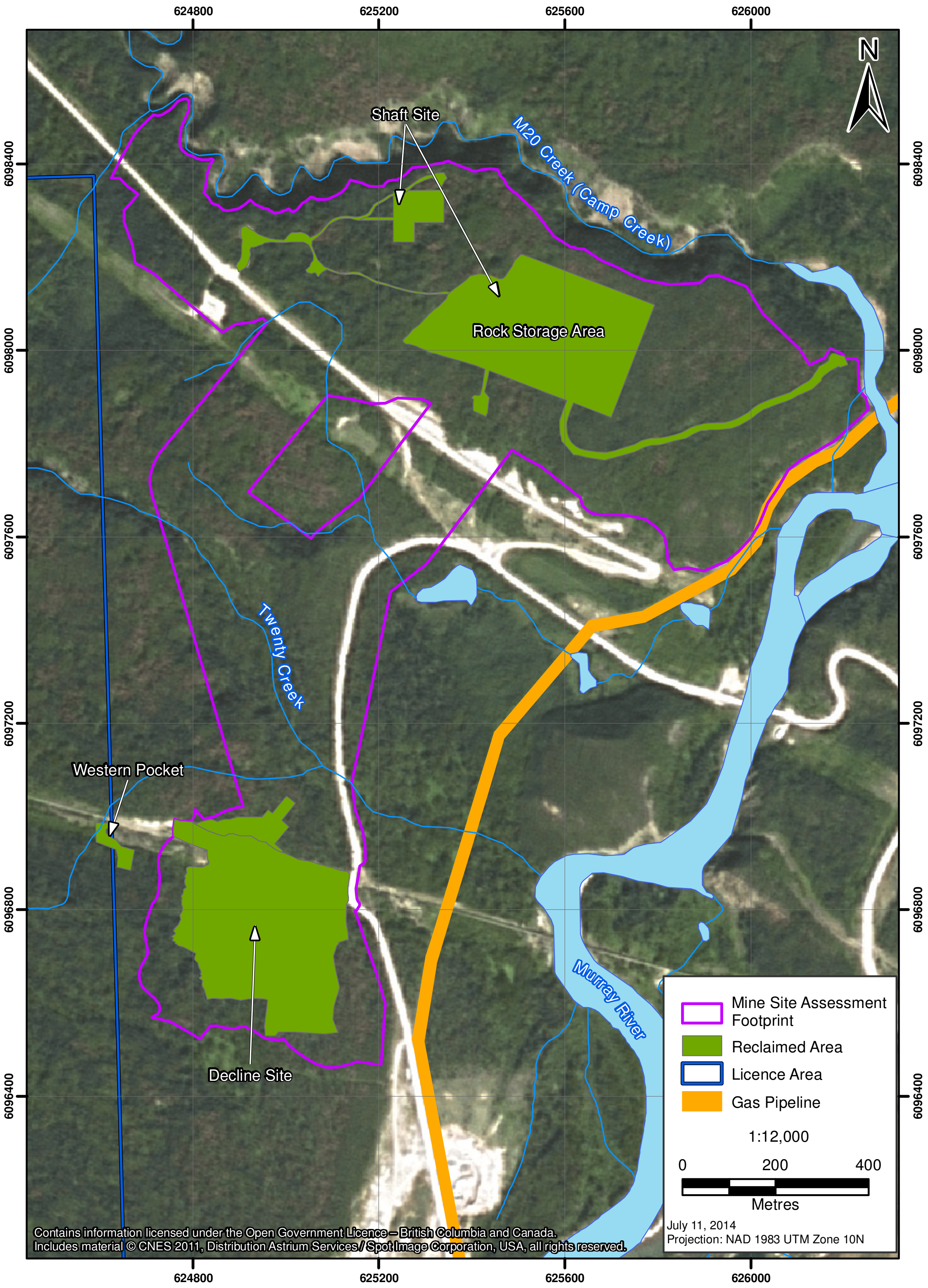
3.9.4.5 Underground Mine

Decommissioning

The underground mine infrastructure will include a system of conveyors (Plate 3.6-5), travelways, electromechanical installations, ventilation fans, an air heating system, power substations, a switching house, a large equipment assembly shop, a truck maintenance shop, a main drainage pump station, diesel tanks, a first aid facility, equipment/tools room, waiting room, dispatch room, firefighting materials, and equipment warehouse (see Figure 3.6-9). As well, large mining equipment such as coal shearers (Plate 3.6-1), hydraulic shields (Plate 3.6-2), AFC pans (Plate 3.6-3), and road headers (Plate 3.6-6) will be operated underground.

Figure 3.9-7

Shaft and Decline Sites Post-closure



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At closure, all fuels, oils, and lubricants will be drained from the mining equipment, transformers, pumps, and any other equipment. These materials will be placed in sealed containers and taken off site for disposal at a regulated facility. All smaller pieces of equipment will be removed such as first aid supplies, tools, pumps, fans, office equipment, and truck maintenance equipment. The large pieces of mining equipment, the conveyors, electrical cables, and any other equipment that is attached to the underground will be left in place.

The underground will be allowed to flood. Based on the predicted groundwater inflow rates from the groundwater model developed for the Project, it is estimated that it will take approximately 52 years for the underground workings to flood with water and another 40 years for water to return to the pre-mining groundwater level (Appendix 7B).

3.9.4.6 Production and Service Decline Portals

Decommissioning

The Production and Service Decline portals will be approximately 4.55 m high and 6.3 m wide (Figures 3.6-5 and 3.6-7) with internal dimensions of 4.15 m high and 5.5 m wide at the base. The entrance from the surface is a steel arch culvert with a concrete floor which occurs at an angle of 16° below ground (Plate 3.9-8).

At closure, the entrance will be sealed and backfilled to prevent humans and animals from entering. The underground will be checked to make sure no bats or other animals have entered the underground. Once the entrance is backfilled, the steel culvert will be covered with approximately 2 m of overburden to create a small hill on the landscape. The slope from the entrance area will be less that 2:1 (H:V). The material will be built up in lifts to ensure that the overburden will stay in place.

Reclamation

Once the portal is covered with overburden, approximately 25 cm of topsoil will be loosely spread over the area. The area will then be seeded with the native seed mix described above. This will provide for erosion control, browse for wildlife, and habitat for small mammals.

3.9.4.7 Shaft Site

Decommissioning

The Shaft Site will include a waste rock pile which has been partially constructed as part of the Bulk Sample and occupies 4.3 ha, a working area associated with it which occupies approximately 2.1 ha, a topsoil stockpile which occupies 0.4 ha, a sump which occupies 0.1 ha, and a lined sedimentation pond which receives seepage from the waste rock pile and which occupies 1.0 ha (Figure 3.6-22). A buried pipeline will carry water from the sediment pond to M20 Creek.

The Site will also include the main mine ventilation shaft opening, an electrical and switching building, ventilation fans, and a drainage and pumping station. These facilities will occupy approximately 1.7 ha.

The closure plan for the waste rock pile is consistent with what was originally proposed in the Technical Assessment Report (TAR) for the Bulk Sample. It includes designing the pile to shed water with slopes that allow for reclamation to be carried out. The top will be cambered and will have a 5% slope down from the top of the pile to achieve as much shedding of precipitation, as possible. Efforts will be made to minimize any depressions on the surface in order to reduce the potential for localized ponding. The side-slopes will be designed with a 3:1(H:V) slope from the surface of the waste rock pile which will also facilitate shedding of water off of the pile and allow the pile to be reclaimed.

The waste rock will be covered with 30 cm of till. The till layer will be compacted to reduce potential downward movement of water into the waste rock pile. This layer will be covered with a 30 cm thick layer of clay that will also be compacted to operate as a clay liner. If the clay is not available at closure, a geomembrane will be a used to prevent water infiltration into the pile. A 50 cm thick layer of till will then be spread on the surface. The bottom 25 cm of this till layer will be slightly compacted and the upper part will be loose to provide for rooting by vegetation. A 25 cm layer of topsoil will be loosely placed on the surface. Care will be taken not to compact the topsoil.

The 75 cm topsoil and till cover will have a relatively high water holding capacity of approximately of 158 mm further reducing the potential of precipitation infiltrating the cover and entering the waste rock material. The cover will have sufficient water holding capacity to support grasses and shrubs growing on it. As the vegetation grows and spreads, more precipitation will remain on the leaves allowing for increased evaporation, further reducing the amount of water that will infiltrate the waste rock pile.

The sediment pond will be closed following reclamation of the pile. When this occurs, any water remaining in the pond will be pumped out. The liner will be cut to ensure that water will drain freely and not perch after it is backfilled. The pond will then be backfilled with the berm material around the pond. It will then be reclaimed.

The parking and work areas around the waste rock pile will be compacted. These areas will be ripped to allow for surface drainage and to prepare the areas for reclamation. The sump will also be backfilled in preparation for reclamation.

At closure, the oils and lubricants will be drained from all pumps, transformers, and any other pieces of equipment at the site. These oils and lubricants will be taken off site for disposal at a regulated facility. The transformers and equipment in the switching house will be dismantled and taken off site for disposal.

The pumps and fans will be disconnected and the associated infrastructure will be dismantled and taken off site for re-use or recycling. Any mobile equipment and tools as well as supplies will be taken off site for disposal. The structures will then be removed such as the switching house, the pump station, and any other structures. These materials will be taken off site for disposal. Wood debris will be burned on site.

Reclamation

Once all materials have been removed and the site is prepared, the disturbed areas will be reclaimed (Figure 3.9-7). Approximately 25 cm of soil will be loosely spread over the disturbed surfaces where native surficial material still remains and 35 cm over areas where there is a gravel base such as in parking areas. The site surficial materials will provide a base for the topsoil and support the establishment of vegetation.

The topsoil areas will be vegetated with the native seed mix described above. Seeds from the adjacent forested and cleared areas will contribute to the vegetation on the reclaimed areas resulting in a more complex ecosystem with time, providing wildlife habitat.

3.9.4.8 Ventilation Shafts

Decommissioning

There will be three ventilation shafts for the Project including one at the Shaft Site and two at the Secondary Shaft Site. The three shafts will have the same internal and external diameter (Table 3.6-2; see Figure 3.6-8).

At closure, the shafts will be decommissioned. The ventilation fans and aboveground structures will be dismantled and taken off site for re-use, recycling, or disposal at a regulated facility. All portable equipment will be removed and taken off site. The infrastructure in the shaft such as electrical cables, stairs, or any other internal infrastructure will be left in place.

Closure of the shaft opening will involve the construction of a level, concrete pad over the opening. This pad will then be covered with 1m of overburden which will be slightly raised at the centre to allow for shedding of precipitation. This will result in a low level, mounded landform that can be reclaimed.

Reclamation

The areas around the various infrastructure at the Shaft Site will be compacted as these will be high use areas. They will be ripped to provide surface drainage and additional rooting depth below the topsoil cover. The prepared surfaces will be loosely covered with 25 cm of topsoil and re-vegetated with the native seed mix described above. These grasses will provide for erosion control, browse for wildlife, and habitat for small mammals.

3.9.4.9 Secondary Shaft Site

Decommissioning

The Secondary Shaft Site will occupy approximately 2 ha. It will include an intake and return shaft, a CBG release pump station, a high and low voltage distribution building, a ventilation fan, a boiler house, a fire water pond, and an air heating system (Figure 3.6-34).

At closure, oils and lubricants will be removed from equipment such as pumps, generators, and transformers. This equipment will be taken off site for recycling, re-use, or disposal at a regulated facility. The electrical cables, switching equipment, transformers, and any other equipment will be removed from the high and low voltage building. Similarly, the equipment in the CBG release pump station and the boiler house will be dismantled and all equipment removed and taken off site for disposal. The air heating system will be disconnected and all pumps and equipment will be removed the building and taken off site for disposal.

The buildings will generally be portables. These will be removed from the site. The fire water pond will be drained and backfilled with the bermed material around pond. The gate and fencing will be dismantled and taken off site for disposal.

Reclamation

Once the site is prepared, approximately 25 cm of topsoil will be loosely placed over the surface. As noted above, the existing surface materials will be ripped which will provide increased root depth as it will operate as base material for the topsoil cover. Approximately 35 cm of topsoil will be spread over the gravelled areas. The soils will be vegetated with the native seed mixture described above (Figure 3.9-8). The native grass mix will provide erosion control, browse for wildlife, and small mammal habitat. With time, the ecosystem will become more complex as seeds from adjacent vegetation will become established. This will develop into wildlife habitat with time.

3.9.4.10 Roads

Decommissioning

All mine infrastructure roads will be closed as soon as they are no longer required. All culverts will be removed to allow for a return of surface drainage. The culverts will be taken off site for disposal.

Reclamation

The road surfaces will be highly compacted. They will be ripped to improve surface drainage and reduce compaction in preparation for reclamation. Approximately 25 cm of soil will be loosely placed on the road bed areas. These areas will then be seeded with the native seed mix described above. The native grass mix will provide for erosion control and browse for wildlife. With time, the ecosystem will become more complex as seeds from adjacent vegetation will become established. The reclaimed road areas will become forested and provide wildlife habitat.

3.9.5 Progressive Reclamation

Progressive reclamation will be carried out during the Construction and Operation phases as soon as activities are completed in a particular area. Progressive reclamation reduces the potential for surface erosion, may reduce the potential for slope failure, reduces the establishment of invasive species, and allows for the opportunity to research various re-vegetation approaches that will allow for greater successful reclamation at closure. On-going monitoring of plant establishment will be used to assess the suitability and seeding rates of the various species. As reclamation is progressive, areas reclaimed early in the life-of-mine will be well established at closure.

Early reclamation will focus on laydown and traffic areas adjacent to the infrastructure which may be disturbed during construction activities. As soon as the infrastructure is completed, these adjacent areas will be reclaimed. High traffic areas will be ripped and topsoiled, if required. These areas can be re-vegetated with the native seed mix described above.

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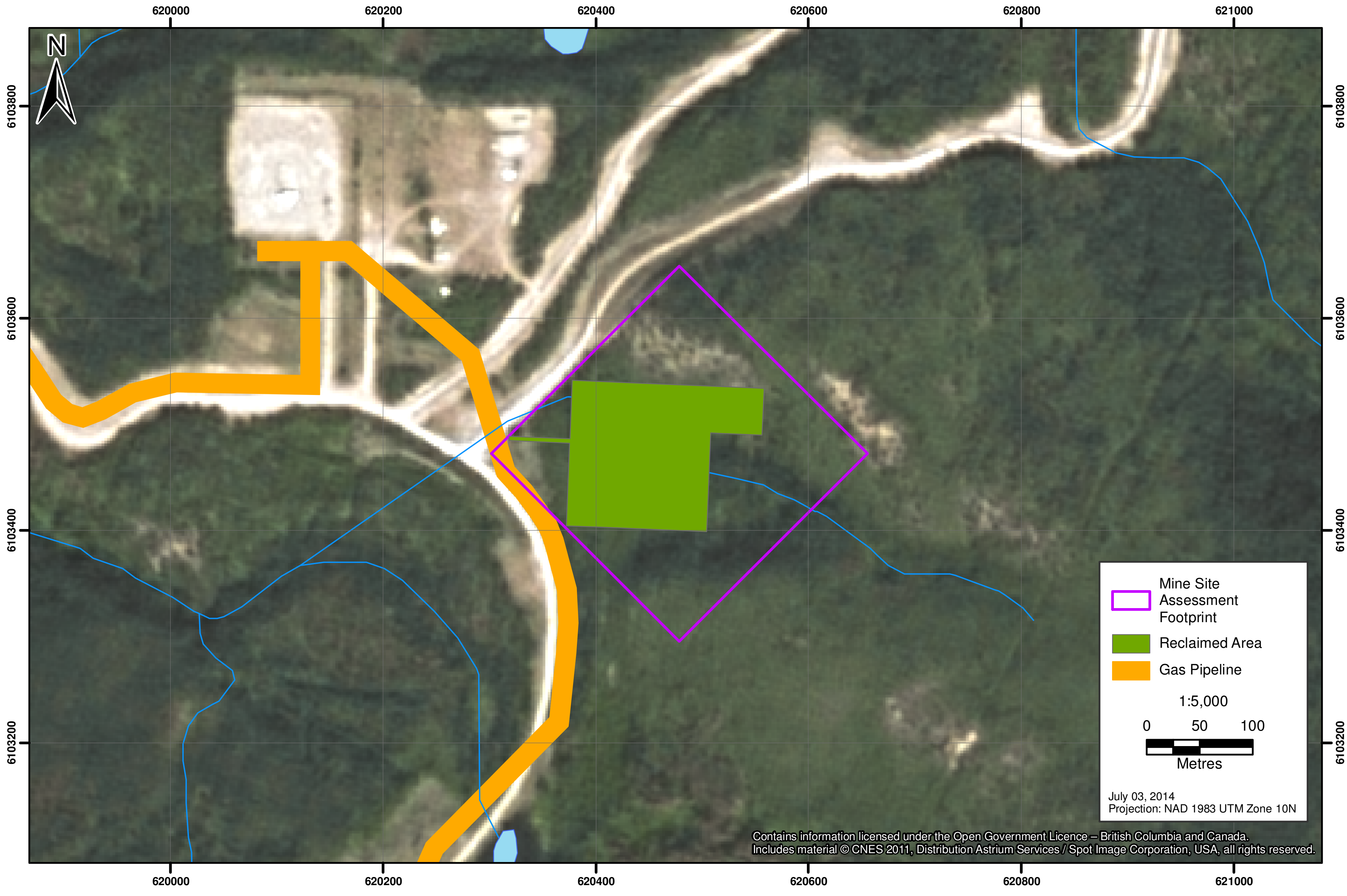
Figure 3.9-8
Secondary Shaft Site Post-closure



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Specific area where reclamation will occur during the mine life include the reclamation of the waste rock facility at the Shaft Site which is intended to be reclaimed during the first few years of Operation, once the Production Decline is completed and CCR North is operational. Similarly, reclamation of CCR North is planned in Year 15-16, once CCR South is operational.

3.9.6 Interim and Premature Closure

Part of planning of the Project includes planning for interim and premature closure. Interim and premature closure activities will be affected by the progress of the Project.

3.9.6.1 Interim Closure

At interim closure, personnel will be required on site to perform care and maintenance activities and to ensure that the site is secure. This includes the gates, the equipment left on site, the doors for the portals and shafts, and the underground mine.

Reclaimed areas will be checked to ensure that erosion is not occurring. The waste rock and CCR piles will be checked for stability. Sediment ponds and ditches will be checked to ensure that these facilities are operating properly. Underground groundwater inflows will be continuously pumped to surface during interim closure. This water will be pumped to the CPP Pond at the Coal Processing Site. It will be released if it meets permit criteria. As there would be no water demand from the coal wash plant, discharge rates to Murray River may increase during some periods. Opportunities to store water underground, or temporary water treatment systems would be investigated and established if required.

The underground working faces, gas sensors, and other infrastructure will be regularly inspected. Therefore, the ventilation system will be operated as necessary during interim closure.

3.9.6.2 Premature Closure

The activities that will be required for premature closure will be similar to those that will occur during the Closure phase. This includes ripping compacted areas, topsoil spreading, and re-vegetation. The portals and shafts will be closed as described above as well as CPP infrastructure. The waste rock pile will be closed as described above. The closure of the CCR piles requires a layer of fines that will be compacted to operate as a low permeability liner. The plan is to set aside fines near the end of the construction of the respective CCR piles sufficient to cover the CCR piles. Therefore, premature closing may require some continued mining in order to produce a sufficient volume of fines for the cover. If mining cannot continue to produce sufficient fines, the closure of the CCR pile may require the replacement of the fines with a geomembrane.

3.9.7 Work Force

The required work force for Decommissioning and Reclamation activities has not been directly estimated at this time. However, it is generally expected that it will be similar to that of Construction.

3.10 PROJECT PHASE: POST-CLOSURE

The Post-closure phase is projected to take 30 years. By this phase, all infrastructure will have been removed, the decline portals and the shaft openings should be closed, and the site reclaimed. Monitoring is the major activity occurring during this period.

The waste rock pile and the CCR piles will be checked for stability. This will take place annually for the first 10 years to make sure there are no signs of failure. They will be checked every five years following that period for 15 years to ensure they are stable.

The entrances to the declines will be checked annually for the first five years to make sure that the overburden/soil cover over the entrances are stable. The soils will be mounded over the shaft covers and will be assessed for cracking or slumping.

The reclaimed areas will be checked annually for the first three years to ensure that the vegetation has established and no surface erosion is occurring. The sites will also be checked annually for invasive plants. The invasive management plan that will be followed during the Operation phase will continue during the Post-closure phase. Invasive plants will be removed as soon as they occur and records will be kept on their location to ensure that remediation has been successful.

The water in the seepage collection ponds around the CCR piles will be checked annually for the first five years to assess the water quality. Changes in water quality may indicate failure in the covers or indicate more work is required on the covers.

Groundwater wells will be monitored annually to assess the progress of the flooding of the underground and the recovery of the water table.

Records on the monitoring program will be kept by a person designated by HD Mining. Once all monitoring is complete, the site roads required for monitoring will be reclaimed. These roads will be ripped and loosely covered with at least 25 cm of topsoil and seeded using the native seed mix described above.

3.11 CLOSURE COSTING

This section provides an estimate of closure and reclamation costs based on the approach to closure and reclamation described above. The costing estimate is consistent with the approach taken in the MEM spreadsheets used for bonding purposes.

The greater part of the Project will be developed in the early stages of the Project. The Secondary Shaft Site will be developed at about Year 15 as well as CCR South and these will be closed and reclaimed during the Closure phase. The closure of CCR North will occur at about Year 15. Reclamation of some disturbed areas will occur during the Operation stage once all infrastructure is in place. These progressively reclaimed areas are included in the estimation of areas to be reclaimed so are included in the cost estimate. Detailed costing of closure using the MEM spreadsheets will be developed as part of the bond development required for obtaining a Permit.

3.11.1 Closure Costing

The closure costs estimates are based on the closure activities proposed for each type of facility, as described. Separate costing has been developed for specific infrastructure such as the CCR piles (Table 3.11-1). The costs have been estimated for labour and equipment operation, reclamation that includes some labour and equipment operation costs built into the cost such as in soil handling, and materials such as concrete for closing the shaft openings. The total cost has been estimated at $20,049,700.

Table 3.11-1. Closure Cost Estimate

Infrastructure	Labour/Equipment Operation	Reclamation /Materials
Ventilation Shafts	$4,862,000	$22,100
Shaft Area	$378,700	$268,700
Secondary Shaft Site	$426,900	$218,900
Waste Rock Pile	-	$342,000
CCR North Pile	-	$1,370,900
CCR South Pile	-	$1,359,900
Underground	$861,300	-
Coal Processing Plant	$4,769,200	$832,000
Decline Site	$3,732,000	$230,100
Transmission Line	$375,000	-
Sub-Total	**$15,405,100**	**$4,644,600**
TOTAL	**$20,049,700**	

3.12 POST-CLOSURE MONITORING

Monitoring is required under Section 10.7.30 of the Code (BC MEMPR 2008) to demonstrate that reclamation and environmental protection objectives including land use, productivity, water quality, and stability of structures are being achieved. As well, the Mines Act and Environmental Management Act permits to be issued authorizing the construction, operation, and closure of the Project will both set out site-specific monitoring and reporting requirements for the Project. The results of the monitoring programs will be included in annual reports on reclamation and environmental monitoring (per Section 10.1.4 of the Code; BC MEMPR 2008). The monitoring will be carried out by a qualified environmental technician with an assistant. The following is a brief description of the Post-closure monitoring plan proposed for the Project.

3.12.1 Reclamation

Reclaimed areas will generally be monitored annually for the first three years following reclamation or until the vegetation is well established to ensure reclamation is successful. Bare areas greater than 1 m^2, areas with rill or gully erosion greater than 1 m^2, or areas showing signs of failure will be treated as soon as possible. Bare areas may indicate that the soils are compacted. Treatment may include roughening the surface to reduce surface compaction before reseeding. As well, fertilizer may be required to promote plant establishment where vegetation is sparse. Slope instability may require grading and re-vegetation.

The grass mix typically used will include a range of native species suited to the area. This will compensate for variation across the site such that plants will be established despite differences in microclimate, aspect, soil texture, soil fertility, and soil drainage. The species may be changed, however, to reflect the site conditions. For example, plants on coarse textured soils may be affected by insufficient moisture and may indicate that areas need to be re-seeded with more drought resistant species.

Native shrubs and tree seedlings will be planted in most areas to accelerate the development of a forested ecosystem and wildlife habitat. Plants will be checked for excessive browsing. These plants may need protection from browsing by wildlife. Early monitoring will therefore be required to ensure that plants are established and flourish to a suitable level to allow for the development of more complex vegetative communities. This will occur over time through the influence of wildlife use as well as natural seed dispersal from adjacent areas. Reclaimed sites will also be checked for noxious weeds. The locations of any areas requiring retreatment will be recorded to allow for future monitoring.

Re-vegetation efforts have been estimated at $5,000 per year for the first three years. This will include the cost of replacement seed, shrubs, and tree seedlings. Re-vegetation will be carried out by an environmental technician on the site.

Potential uptake of metals by vegetation is predicted by metal content in soils. The soils collected for reclamation will be mixed during the construction of the stockpiles. Any metal contaminated dust from Operation activities on the stockpiled soils will be mixed with the deeper and greater part of the soil volume in the soil stockpiles when the soils are required for reclamation. Therefore, metal contamination of reclaimed areas is not predicted to occur. However, soils from representative areas such as on the reclaimed CCR piles and the plant site will be checked for metals such as selenium prior to seeding and following re-vegetation for the first five years.

Approximately 20 surface soil samples (0-10 cm) will be collected annually from the waste rock soil cover, the soil covers of the CCR pile, and the reclaimed areas at the plant site. An additional 10 samples will be collected randomly across the site in the reclaimed areas. The samples will be tested for metals. Costs for analysis are estimated at approximately $5,000 per year for a total of $25,000 over the five-year period.

Including field labour and expenses, laboratory analysis, additional seed etc., and reporting, the total annual cost for the reclamation monitoring program has been estimated at $9,900.

3.12.2 Geotechnical Stability

The waste rock pile at the Shaft site and the CCR piles will continue to be monitored for stability during Post-closure in accordance with the Mines Act and Mines Act Permit. The piles will be checked for surface cracking and movement of materials. Any indication of instability will be remediated as soon as possible.

As well, the areas of the closed shaft openings will also be checked to ensure there are no indications of instability at the surface.

Including field labour and expenses, and reporting, the total annual cost for the reclamation monitoring program has been estimated at $3,400.

3.12.3 Surface Water Quality

Surface water quality will be monitored at sites with the potential to incur effects attributable to Project infrastructure, such as groundwater seepage. No discharge sampling requirements are anticipated during Post-closure. All water samples will be analyzed for a number of physio-chemical parameters, including anions, nutrients, total organic carbon, and total and dissolved metals.

Water quality sampling sites will be located downstream of infrastructure, with both near-field and far-field exposure to Project activities, so that a gradient of potential effects can be assessed. Reference sites will be located either upstream (if possible) or in unaffected watersheds with similar hydrological conditions. Water quality sampling will likely take place monthly for a period of five years, or as determined through consultation with the appropriate regulatory agency.

Laboratory fees per aquatic environment water quality sampling event are estimated as follows:

12 samples (including one duplicate and one field blank) = $4,200 per sampling event. Including field labour and expenses, analysis and reporting, the total annual cost for the water monitoring program has been estimated at $70,500.

3.12.4 Groundwater Monitoring

Groundwater monitoring during Post-closure will occur above the Underground Mine Zone and downslope of the CCR Piles.

Water levels above the Underground Mine Zone will be monitored to track the recovery of the water table via vibrating wire piezometers installed in several wells and/or within the closed shafts/declines.

As described in Section 3.12.3, surface water sampling of the CCR seepage and in M19A Creek will be conducted. At this time it is not anticipated that groundwater sampling of the area between the toe of the CCR piles and M19A Creek will be required. However, this can be completed if further investigation is necessary based on the results of the surface monitoring.

Annual costs (in 2014 dollars) for the groundwater level monitoring, including field labour, analysis and reporting, are estimated to be $20,000.

3.12.5 Annual Monitoring

The annual monitoring cost has been estimated at $103,840 per year for each area to be monitored (Table 3.12-1). These costs include field work, accommodation, travel, laboratory and other expenses, and report production and are based on the different monitoring requirements for each program as described above.

Table 3.12-1 Estimated Annual Monitoring Costs

Monitoring Area	Annual Cost
Reclamation	$9,900
Geotechnical Stability	$3,400
Water quality	$70,500
Groundwater	$20,000
Total	**$103,800**

REFERENCES

BC MOE. 2014. Ambient Water Quality guidelines for Selenium Technical Report Update. ISBN 978-0-7726-6740-3. http://www.env.gov.bc.ca/wat/wq/BCguidelines/selenium/pdfs/wqg-update-2014.pdf

Ausenco Services. 2014. HD Murray Mining International Ltd. *Murray River Project, Northern and Coarse Coal Reject Pile Design, 100102-01-RPT-01* Revision Number B. Vancouver, BC.

ERM Rescan. 2014a. *Murray River Coal Project: 2012 to 2013 Fisheries Baseline Report*. Prepared for HD Mining International Ltd. by ERM Rescan: Vancouver, British Columbia.

ERM Rescan. 2014b. *Murray River Coal Project: 2011 to 2013 Meteorology Baseline Report*. Prepared for HD Mining International Ltd. by ERM Rescan: Vancouver, British Columbia.

ERM Rescan. 2014c. *Murray River Coal Project: Groundwater Modelling Report*. Prepared for HD Mining International Ltd. by ERM Rescan: Vancouver, British Columbia.

Price, W. A. 2009. *Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. MEND Report 1.20.1*. Natural Resources Canada, Mine Environmental Neutral Drainage Program: Ottawa, ON.

Rescan. 2011. *Murray River Bulk Sample: Waste Discharge Permit Application Technical Assessment Report*. Prepared for HD Mining International Ltd. by Rescan Environmental Services Ltd.: Vancouver, BC.

Rescan. 2013a. *Murray River Coal Project: 2010 to 2012 Ecosystem and Vegetation Baseline Report.* Prepared for HD Mining International Ltd. by Rescan Environmental Services Ltd.: Vancouver, British Columbia.

Rescan. 2013b. *Murray River Coal Project: 2013 Non-traditional Land and Resource Use Baseline* Report. Prepared for HD Mining International Ltd. by Rescan Environmental Services Ltd.: Vancouver, British Columbia.

Rescan. 2013c. *Murray River Coal Project: 2012 Terrain and Soils Baseline Report*. Prepared for HD Mining International Ltd. by Rescan Environmental Services Ltd.: Vancouver, British Columbia.