

***2 North / 3 North and 5 South
Groundwater Evaluation - Quinsam Mine***

June, 2011



Enterprise Geoscience Services Ltd.



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1. Introduction



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1. Introduction

Quinsam Coal Corporation (QCC), and its parent company Hillsborough Resources Ltd. have mined coal from the 2 North and 3 North mines located north of the Quinsam River. These workings are connected by the No. 8 Mains to the 5 South Mine that is located on the south side of the Quinsam River. All of these mines extract coal from the No. 1 Coal Zone. Coal that is mined from the mines is washed at the existing QCC coal processing facility and the clean coal is hauled to the barge loading facility near the City of Campbell River. Coarse reject washed from No. 4 Zone raw coal will be placed in underground mine voids in the barrier pillar and flooded to prevent acid generation and limit the rate of metal loading. Tailings that are produced from the 7 South mine are proposed to be placed in the 2 North Mine voids.

Quinsam Coal Corporation (QCC) submitted an application to the Ministry of Energy Mines and Petroleum Resources (MEMPR) to amend the current Mine Permit No. C-172 with the inclusion of the proposed 7 South mine development. Following the review of the application, specific comments were raised by Ministry of Natural Resource Operations (now Ministry of Energy and Mines (MEM)). These comments were provided in a mine inspection report as follows:

**Ministry of Natural Resource Operations – Report of Inspector of Mines,
November 10, 2010**

Future PAG CCR is proposed to be stored subaqueously in the River Barrier Pillar underground working, 4 South underground workings and 2 South pit. Future PAG tailings are proposed to be stored subaqueously in the 2 North underground working. Mines Act Permit amendments will be required for all of these changes to the mine waste handling. It is clear that subaqueous storage of geochemically reactive mine waste in underground workings requires further investigation prior to permitting, given recent events with acidic drainage conditions in the 4 South underground workings and the unknown potential for poor water quality at closure in other portions of the mine.

Order 6. The Mine Manager shall ensure that no further mine development work occurs above the elevation of the Quinsam River in the 5 South underground workings until a full hydrogeological and water quality assessment has been completed and submitted to the Chief Inspector.

Order 7. The Mine Manager shall ensure that as part of the updated closure plan due June 30, 2011 (or in conjunction with Mines Act Permit amendment

applications for underground waste storage; whichever is first), the effects to water quality from flooding of underground workings at closure are assessed (including 2N-5S workings).

An assessment of the geochemistry of the 2 North / 3 North and 5 South strata, geochemical source terms of the underground mine waters, existing and post-mining groundwater conditions (both physical and groundwater quality) and predictions of seepage rates and mass loadings from the 5 South and 2/3 North underground mines to receiving waters has been prepared for QCC. The assessment was conducted jointly by Lorax Environmental Services Ltd (Lorax) and Enterprise Geoscience Services Ltd. (EGSL).

2. Environmental Setting



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2. Environmental Setting

The Quinsam Coal Mine is located 20 km west of Campbell River and is currently developing the Middle Quinsam coal deposit at the northwest end of the Comox Coal Basin. This basin is hosted within Nanaimo Group sedimentary strata, which extend south to Mud Bay along the east coast of Vancouver Island (Figure 2-1).

The lower portion of the Comox Formation with a stratigraphic thickness of up to 200 metres is present in the Middle Quinsam area. At the base of the formation is the Benson member, a coarse grained unit consisting of conglomerate, sandstone and red beds. The Benson Member is overlain by the Cumberland and Dunsmuir members, which host the mineable coal reserves in the area (Figure 2-2). The Cumberland member is comprised of siltstones and mudstones and contains the No.1 and No.2 Coal Zones; it reflects a lower energy depositional environment consistent with a coastal swamp or lagoon. The upper Dunsmuir member reflects a higher energy fluvial or deltaic deposit and is comprised of medium to coarse grained sandstones, minor siltstone and the No. 3 through No. 5 Coal Zones (Gardner, 1999).

This groundwater evaluation focuses on mine areas where the No. 1 Coal Zone has been or is currently being developed. These areas include 2 North, 3 North, 5 South and the River Barrier Pillar (RBP) (Figure 2-3). The No. 1 Coal Zone was also mined in the 2 South and 3 South open pits, however these areas are not included in this analysis. Initial mining of the No. 1 Coal Zone occurred at the 2 North pit between 1986 and 1991. The main tailings facility was established in the south end of the resultant pit void in 1994. An underground test mine was developed in the 2 North area in 1990 which produced coal through 1991. In 1993, two new parallel portals into the 2 North underground were established in the toe of the 2 North open pit highwall; however, consistent production from the 2 North underground did not occur until 1999. The 2 North and 3 North areas were then consistently mined through the end of 2009 and have been largely depillared (Figure 2-3). In 2007, mining in 2 North advanced under the Quinsam River via the 8 Mains into the 5 South Phase 1 area. Phase 1 was mined until 2010 and has been depillared; 5 South Phase 2 continues to be mined today. Mining into the RBP adjacent to the 8 Mains commenced in the first quarter of 2011 and is ongoing.

The No. 1 coal seam ranges in thickness from less than 1 meter to as much as 5 meters, but generally averages between 2.4 and 4.6 meters (Gardner 1999). It is separated from a thin (0-0.6 m) rider seam by up to six meters of mudstone and/or siltstone but may be locally incorporated into the main No. 1 seam.

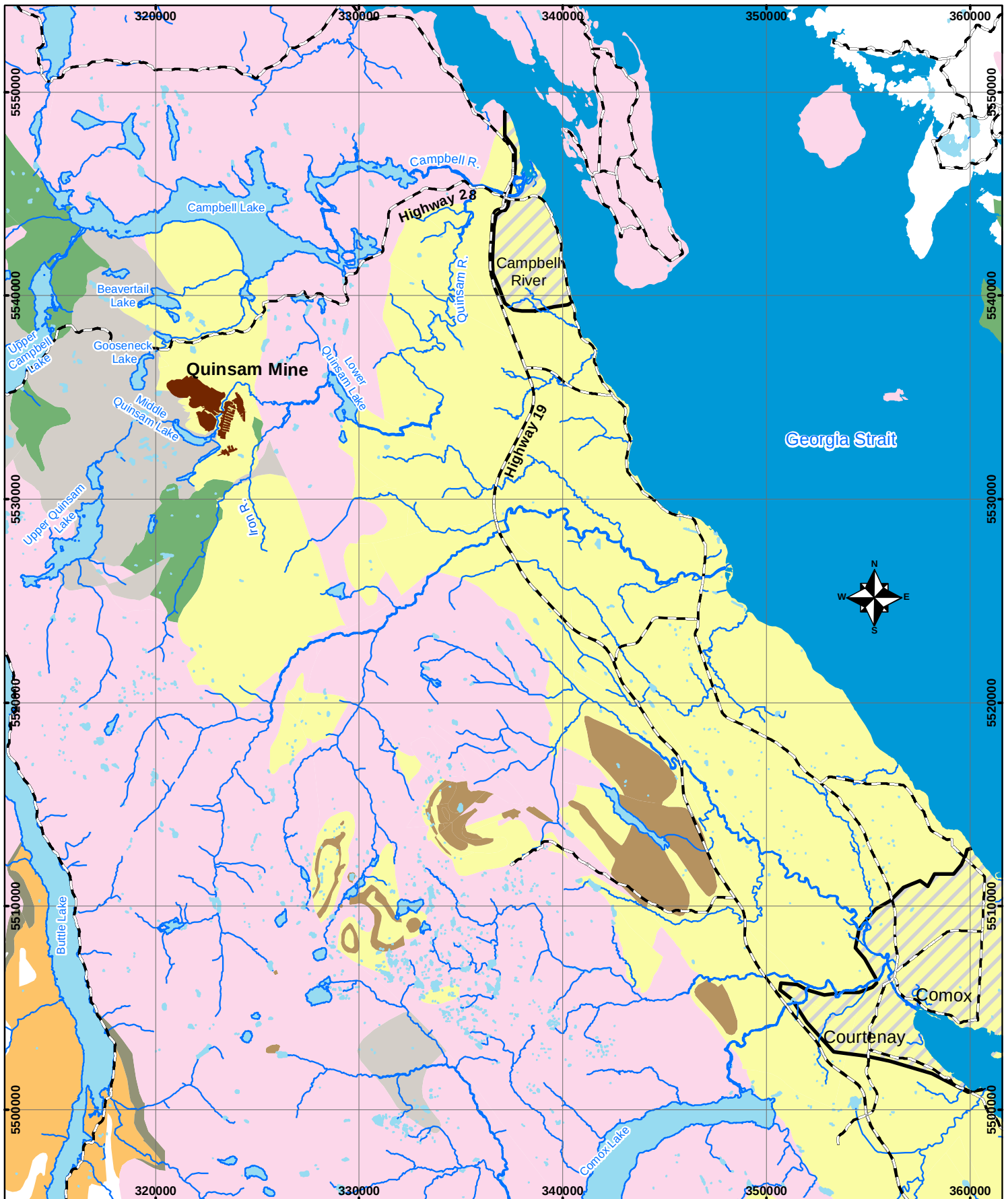
Structure contours for the top of the No.1 coal seam are shown in Figure 2-3. The seam generally dips from mine grid west to east with a maximum elevation of 300m along the western margin of the 3 North (No. 18 Panel), 300-310 m at the 2 North portal and 290 m at the updip end of the 5-South Phase 2 workings. The seam ultimately subcrops along the western margin of the 2 and 3 North areas and is mined to within 5-10 m of the till interface along the No. 18 panel of the 3 North mine. The No.1 seam reaches its lowest elevation (90-100 m) at the eastern end of 2 North (along the No. 1 mains) and 5 South Phase 1 (along No. 10 Mains). In these areas, the overlying bedrock thickness exceeds 150 m.

The Quinsam mine area has been transected by numerous high angle faults. The major faults in the 2 North / 3 North and 5 South areas include the Five South, Forjan, Two North, and Sledgehammer faults. In addition to these faults, these mining areas also contain numerous other faults trending mine grid north-south. While displacement has occurred along many of these faults (both major and minor), they are not necessarily water bearing. The exception is the Forjan fault downstream of the wetland which produced significant water during the drilling of a monitoring well. Other structural features in the 2 North and 3 North area include subsidence related sinkholes and fractures that have occurred in depillared areas where the coal seam has been mined close to the bedrock surface. In some cases, the fractures are visible as cracks on the ground surface. These subsidence features are discussed in detail in MCG (2011) and are shown on Figure 2-3. Of particular note are the sinkholes which occur along the western margin of the 3 North mine and the surface crack which intersects the wetland flanking the northeastern margin of the mine. These features have resulted in significant inflows to the mine. There are also several subsidence cracks above the 2 North mine, two of which have been observed upcasting air. Surface cracks have not been observed in the footprint of the depillared 5 South Phase 1 mine.

The topography in the 2 North/3 North and 5 South areas consists of rolling hills transected by creeks which often drain wetland areas. These drainages report to the Quinsam River or Middle Quinsam Lake and appear to follow the surface expression of major faults. The land drops sharply towards the Quinsam River from both the north and south with flatter areas occurring in select meanders. The land falls more gently (~14 %) towards Middle Quinsam Lake from the western margin of the 2 North Mine. The highest areas north of the Quinsam River include the hill adjacent to the main tailings facility (elevation >340 meters) and the hill centered over the eastern part of the No. 1 Mains (> 320 m). The 3 North area is flanked by a topographic high on its western margin (>330 meters elevation) while its eastern margin drains towards the wetland. South of the Quinsam River, the 5 South mine is highest over the Phase 2 area

(320-330 meters elevation). The Quinsam River itself falls from 275 meters at the outlet of Middle Quinsam Lake to 210 meters at the down dip end of the 5 South and 2 North mines.

The Middle Quinsam landscape has been shaped by glacial activity which has eroded 3-6 meters of rock in higher areas and more in the valleys. The area is blanketed by an extensive cover of till ranging in size from clay to boulders (Luscar, 1978). In the 2 North / 3 North and 5 South mine areas, the till is generally less than 10 meters thick on topographic highs and can exceed 30 meters thickness in buried valleys. One of these buried valleys exists between the 2 North and 3 North mines on the western margin. MCG (2011) has indicated that till exceeding 10 m thickness will blind off and heal larger subsidence fractures.



Stratigraphic Units

Bonanza Group	Mount Washington Plutonic Suite	Underground Mine Workings
Buttle Lake Group	Nanaimo Group	Highway
Buttle Lake Group	Sicker Group	Rivers
Mount Hall Gabbro	Vancouver Group	Municipality
Island Plutonic Suite		

Figure: 2-1

Title Regional Geology Map

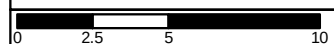
Client



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Notes

1. Municipal boundaries are approximate
2. Geology Basemap Source: B.C. Digital Geology Maps (1.0. 20050, Ministry of Energy, Mines, and Petroleum Resources)



Units Kilometers

Proj. UTM Zone 10

Datum NAD 1983

Date April, 2011

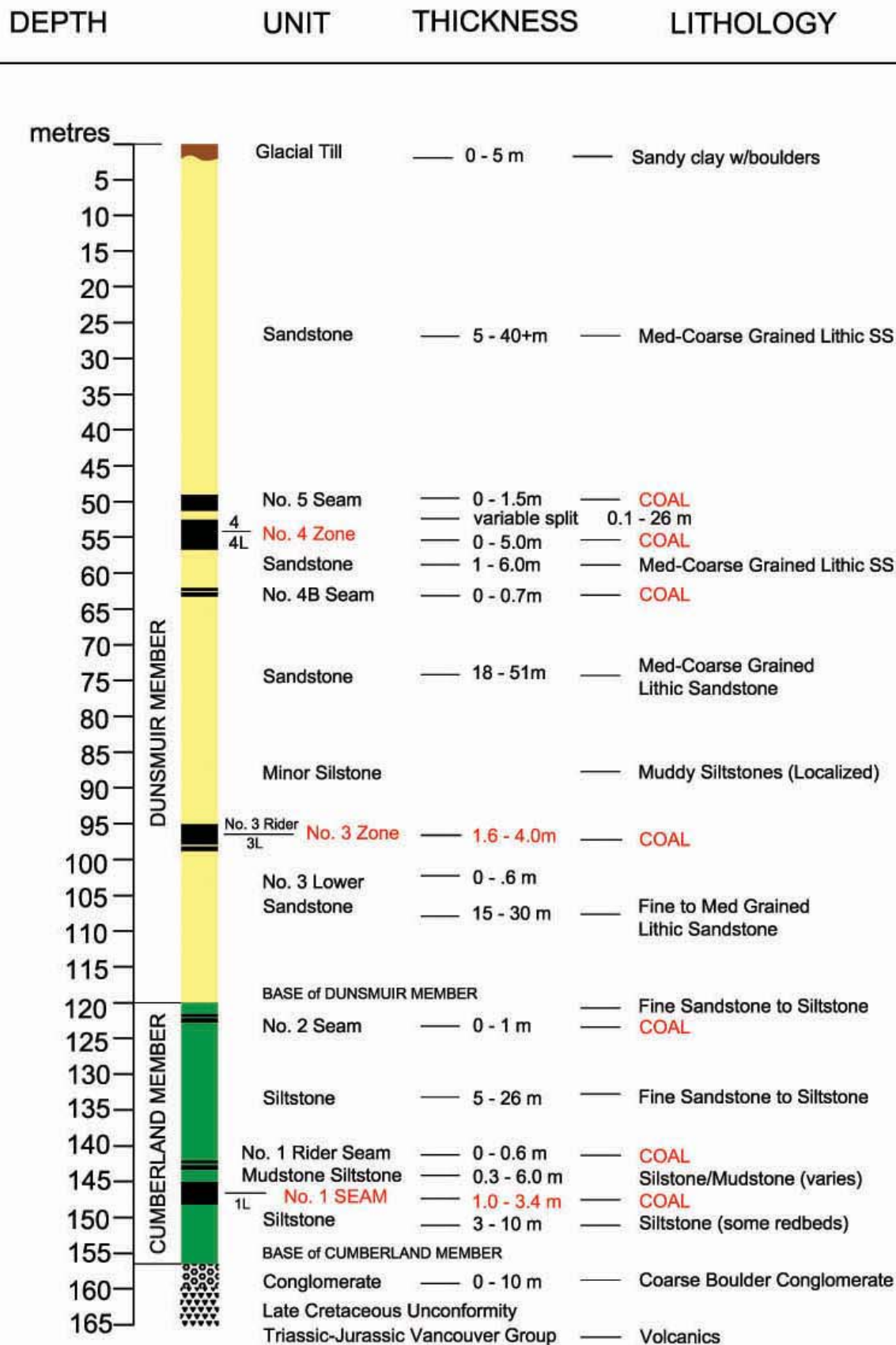
Project No. **J885-1**

Project



LORAX
ENVIRONMENTAL

GENERALIZED STRATIGRAPHIC SECTION - QUINSAM MINE



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DESIGNED BY

DWG. CHECK

DRAWN BY

SSS

Oct 26, 2009

SCALE: 1:1,000

PROJECT NO:

885-2

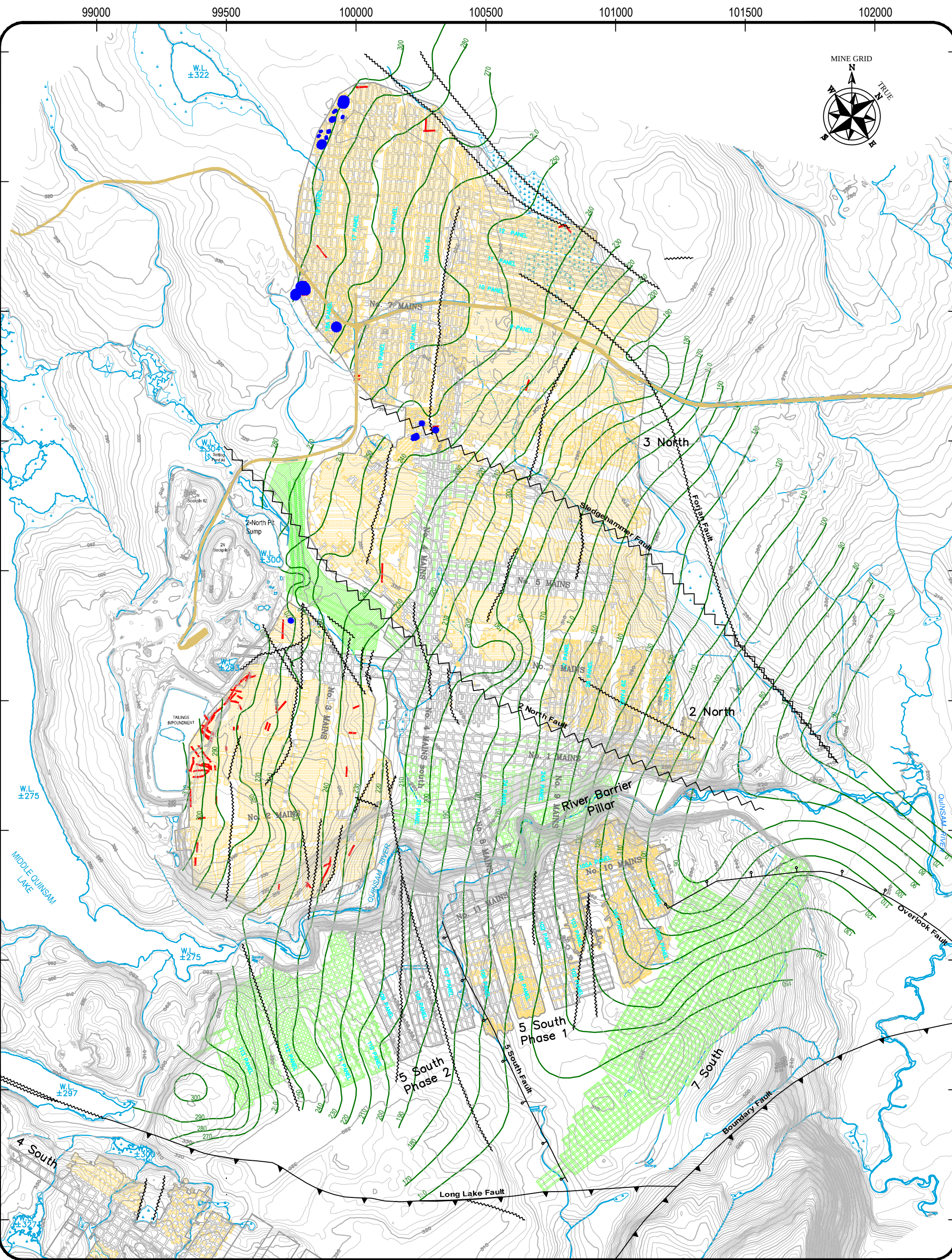
QUINSAM COAL CORPORATION

**Generalized Stratigraphic Section
Quinsam Mine**

FIGURE

2-2

REV.





LORAX
ENVIRONMENTAL

Meters
0 100 200

Projection: Mine Grid Coordinates

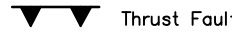
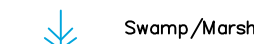
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Date
May 10, 2011

Figure Title
2 North/3 North
and
5 South
Mine Layout

Figure Number
2-3

 Mine Workings	 1 Seam Contour (m)	 Surface Water Body
 Proposed and Recent (2011) Workings	 Subsidence Cracks	 Significant Faults
 GOB	 Thrust Fault	 Road
	 High Angle Normal Fault	 Sinkholes
		 Swamp/Marsh

Legend

3. Scope of Work



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3. Scope of Work

Numerous tasks were carried out to collect the information necessary to address the MEM comments presented in Chapter 1. The scope of work for the study included the following:

- Drilling and packer testing of five boreholes in the 2 North / barrier pillar area with the completion of nested monitoring well installations;
- Drilling borehole in the 3 North area to access the mine pool;
- Conducting hydraulic response tests in monitoring wells to determine representative hydraulic conductivity values for the 2 North area bedrock units. Hydraulic conductivity test results from coal seams in other parts of the mine were also used to develop a representative database for use in estimating groundwater flow and mass flux from the 2 North / 3 North and 5 South mines;
- Water level monitoring of 2 North and 5 South monitoring wells;
- Sampling of 2 North and 5 South monitoring wells to determine groundwater quality;
- Literature review of previous consultants reports and data from QCC files on the 2 North / 3 North and 5 South areas;
- Static testing of Cumberland and Dunsmuir strata overlying No. 1 Seam;
- Ongoing leaching of 7 South coarse reject and tailings in saturated and unsaturated kinetic tests to evaluate metal release rates under both exposed and flooded conditions;
- Mineralogic examination of 7 South tailings;
- Development of representative “geochemical source terms” for future conditions where the 2 North / 3 North and 5 South mines are allowed to re-flood;
- Determine NP depletion rates of coarse reject, raw coal and tailings from 7 South mine;
- Development of a conceptual model for groundwater flow to identify the flow paths from the 2 North / 3 North and 5 South mines to the ultimate receiving waters;
- Provide an overview of groundwater quality in the 2 North / 3 North and 5 South mine areas;

- Estimation of groundwater seepage rates from the 2 North / 3 North, barrier pillar and 5 South mine under steady-state conditions;
- Estimation of mass flux from the underground workings for key chemical parameters associated with expected mine water chemistry. Estimation of groundwater seepage rates and groundwater mass fluxes were determined using a Monte Carlo simulation method that accounts for the ranges in hydrogeologic parameters in the area surrounding the 2 North / 3 North and 5 South mines;
- Assessment of time of travel to the receiving waters and predicted effects in water quality in the receiving waters; and,
- Preparation of this report to address the requirements of MEM as described previously in Chapter 1.

4. Hydrogeology



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4. Hydrogeology

4.1 Monitoring Network

In 2010-2011, numerous monitoring wells were drilled and installed across the Quinsam Mine site including the 2 North, RBP and 5 South areas. Installation details for these wells are included in Table 4-1. Half of the monitoring wells listed in Table 4-1 were installed as a part of the hydrogeological investigation undertaken by Lorax; they were designed for water quality sampling in addition to water level monitoring. Typically, the deep well installation targeted the No. 1 coal seam while the shallower installation targeted other zones of interest, including shallower coal seams, fracture zones or other areas of increased permeability. The logs for these monitoring wells are included in Appendix A-1. In the 2 North area, the monitoring wells were installed downgradient of the workings. QU10-10S/D was installed to characterize water quality and gradients downgradient of the mine but upgradient from the Forjan fault. QU10-11S screens the Forjan fault, while QU10-11D screens the No. 1 coal seam. QU08-21G was originally drilled by Quinsam as a geotechnical hole and was selected for monitoring well installation to characterize water quality on the opposite (mine grid east) side of the Forjan fault. QU11-09 was drilled in the footprint area of the RBP to provide information on vertical gradients between the Benson Conglomerate, No. 1 Coal seam and shallow fractured sandstone, in addition to characterizing water quality in the No. 1 seam prior to mining. QU11-05 was drilled downgradient of the RBP to determine potential water quality impacts from existing and proposed mining activities upstream (RBP and 2 North Mine). QU05-13W is an exploration hole that was drilled in 2005 but was reamed out and cased with 100 mm PVC pipe in 2011 to provide a sampling point for the 5 South mine pool.

The remaining wells listed in Table 4-1 were installed in boreholes drilled as a part of the mine subsidence study undertaken by Michael Cullen Geotechnical (MCG). These wells were installed primarily for water level monitoring in subsidence zones above depillared areas although one of the locations has been used to sample the 2 North mine pool (QU10-13D). The logs for the MCG wells are contained in the 2011 geotechnical report appended to the permit application document.

Both the Lorax and MCG drillholes were packer tested prior to PVC installation using either a single or double packer system. The results of the packer testing are summarized in Appendix A-2 and discussed further in Section 4.3.

**Table 4-1:
Summary of 2010-2011 Monitoring Wells.**

Well ID	Mine Area	Field Program ¹	Purpose	Screened Interval	Well Completion Date	Ground Surface Elev. ⁴	Total ⁵	Filter Pack Interval ⁶		Most Recent Water Level Date	DTW ^{2,5}	WLE ^{3, 7}
QU10-10S	2N	H	Measure water quality and gradients downstream of 2 North workings	No. 4 Seam	20-Oct-10	244.3	64.2	56.8	64.3	14-Mar-11	32.2	212.6
QU10-10D	2N	H		No. 1 Seam	20-Oct-10	244.3	172.7	163.7	174.3	14-Mar-11	38.0	206.8
QU10-11S	2N	H	Measure water quality and hydraulic head in Forjan Fault	Fractured Sandstone	26-Oct-10	249.1	42.3	38.1	43.4	14-Mar-11	0.4	249.0
QU10-11D	2N	H	Measure water quality and hydraulic head downstream of 2 North workings	No. 1 Seam	26-Oct-10	249.1	163.1	149.7	164.6	14-Mar-11	22.0	227.5
QU08-21GS	2N	H	Measure water quality and hydraulic gradients downstream of Forjan Fault	No. 4 Seam/SST	01-Nov-10	213.7	80.3	73.8	81.7	15-Mar-11	flowing	213.7
QU08-21GD	2N	H		No. 1 Seam	01-Nov-10	213.7	175.8	163.4	186.8	15-Mar-11	flowing	213.7
QU10-12S	2N	S	Measure water level in different zones above 2 North Mine (5 Mains)	Fracture zone	08-Dec-10	267.9	48.5	43.9	49.7	14-Mar-11	48.2	220.0
QU10-12D	2N	S		Caved Zone	08-Dec-10	267.9	131.4	124.1	132.3	14-Mar-11	59.5	208.7
QU10-13S	2N	S	Measure hydraulic head above 2 North mine (1 Mains)	No. 3 Seam	10-Dec-10	270.7	57.9	53.9	58.8	11-Apr-11	55.3	215.6
QU10-13D	2N	S	Measure water quality and hydraulic head in 2 North mine (1 Mains)	Caved Zone	10-Dec-10	270.7	143.0	139.3	147.2	11-Apr-11	112.4	158.6
QU10-14S	2N	S	Measure water level in different zones above 2 North Mine (5 Mains)	Dilated aquiclude zone	17-Dec-10	280.1	39.7	35.7	40.5	14-Mar-11	37.9	242.6
QU10-14D	2N	S		Caved Zone	17-Dec-10	280.1	102.5	95.1	103.9	14-Mar-11	71.9	208.5
QU11-03	2N	H	Measure water quality in 2 North mine (10 Panel)	Fracture Zone	In progress	288.4	105.5			15-Mar-11	40.3	248.6

**Table 4-1:
Summary of 2010-2011 Monitoring Wells (continued).**

Well ID	Mine Area	Field Program ¹	Purpose	Screened Interval	Well Completion Date	Ground Surface Elev. ⁴	Total ⁵	Filter Pack Interval ⁶		Most Recent Water Level Date	DTW ^{2,5}	WLE ^{3, 7}
QU05-13W	5S	H	Measure water quality in 5 South Mine (104 Panel)	No. 1 Seam (Pillar)	11-Jan-11	289.3	175.0	no filter pack		13-Apr-11	132.7	156.5
QU10-15S	5S	S	Measure water levels in different zones above 5 South Mine	No. 3 Seam	24-Jan-11	291.8	66.9	58.8	67.1	16-Mar-11	61.6	230.5
QU10-15M	5S	S		Transition Aquiclude Zone	24-Jan-11	291.8	85.8	77.7	86.0	16-Mar-11	85.2	207.0
QU10-15D	5S	S		Fracture Zone	24-Jan-11	291.8	107.2	99.1	109.7	16-Mar-11	106.7	185.5
QU10-16	5S	S		No. 4 Seam (Dilated Aquiclude Zone)	25-Jan-11	289.6	55.0	45.4	55.8	16-Mar-11	27.5	262.4
QU10-17S	5S	S		Above No. 4 Seam in Zone with tight fractures	17-Dec-10	287.2	43.0	38.7	43.6	16-Mar-11	7.1	280.6
QU10-17D	5S	S		Below No. 4 Seam in Fracture Zone	17-Dec-10	287.2	58.2	53.9	58.8	16-Mar-11	50.8	236.8
QU11-05S	RBP	H	Monitor water quality and vertical gradients downstream of the River Barrier Pillar and 2 North workings.	Fractured SST/No. 4B Seam	07-Mar-11	228.4	33.6	28.3	34.8	27-Apr-11	24.0	204.9
QU11-05D	RBP	H		No. 1 Seam	07-Mar-11	228.4	130.3	119.3	128.9	27-Apr-11	49.4	179.4
QU11-09S	RBP	H	Monitor water quality and gradients downstream of the River Barrier Pillar and 2 North workings.	SST	15-Mar-11	228.4	24.8	17.4	25.0	26-Apr-11	7.1	219.8
QU11-09M	RBP	H		No. 1 Seam	15-Mar-11	226.3	83.9	75.6	84.1	27-Apr-11	70.9	156.0
QU11-09D	RBP	H		Benson Conglomerate	15-Mar-11	226.3	109.7	103.6	110.0	27-Apr-11	70.2	156.7

NOTES :¹ H = Hydrogeology; S=subsidence

² DTW = Depth to water

³ WLE=Water Level Elevation

⁴ units = m mine grid

⁵ units = m bTOC

⁶ units = m bgs

⁷ units= mine grid

4.2 Groundwater Flow System

4.2.1 Introduction

A limited amount of shallow groundwater flow occurs within the till unit mantling portions of the mine site, as well as within fracture zones within the underlying bedrock, consisting primarily of sandstone, with coal, siltstone and mudstone interbeds. In addition, there are two mine-influenced groundwater flow regimes within bedrock, Case 1 being mined coal seams with intact pillars, and Case 2 being mined gob areas, where the coal pillars have been completely or partially removed. These two mine-influenced groundwater flow regimes are illustrated on Figures 4-1 and 4-2.

For Case 1, while the permeability of the mined coal seams is greatly enhanced, and the mined zones of the coal seams form mine pools following re-flooding, groundwater flow out of the mined coal seams is ultimately controlled by the permeability of the remaining intact portion of the coal seams downgradient of the mined areas. The hydraulic gradient adjacent to mined out areas with pillars left intact is not expected to be greatly altered by the mining process, unless the mined zone intersects a major water-bearing fracture or fractures, enhancing groundwater recharge to the mined seam. Groundwater flux out of the coal seam will be controlled by the hydraulic conductivity and cross-sectional area of the intact coal seam, along with the hydraulic gradient within the intact seam.

For Case 2, the de-pillaring of mined coal seams (gob areas) results in the collapse of the bedrock immediately overlying the coal seam into the mine voids, as well as the propagation of both horizontal and vertical fracturing upward within the overlying bedrock strata, significantly enhancing the permeability of the overlying bedrock mass. There are two mine-influenced groundwater flow regimes for Case 2, the first being for flow within the remaining intact coal seam downgradient of the gob areas (*i.e.* Case 1), and the second being flow associated with the stress-fractured bedrock overlying the gob mined areas. Hydraulic gradients within the stress-fractured bedrock overlying mine gob areas are generally expected to decrease following fracturing, as a result of enhanced horizontal and vertical permeabilities in the stress-fractured zones above the mined coal seams. However, gradients may increase at the downgradient end of the fractured zones as a result of enhanced groundwater recharge to the gob -impacted bedrock zones via gob -propagated sinkholes or other subsidence features. Lateral groundwater flow through the downgradient end of the stress-fractured bedrock, however, will ultimately be controlled by the hydraulic conductivity and hydraulic gradients within the intact sandstone and coal downgradient of the gob -impacted areas.

It should be noted, however, that final groundwater fluid level distributions within the 2 North / 3 North and 5 South mine areas will ultimately depend on several factors that are currently unknown, including the number, nature and distribution of gob-related sinkholes and other subsidence-related structural features that may develop within these mine footprints over time. QCC is planning to install a plug in the No. 8 mains post-mining to hydraulically isolate the 2 North and 5 South mines and thereby limit the influence of subsidence features currently mapped in 2 North on water levels in the 5 South Mine. Given these uncertainties, the current assessment of post-mining groundwater head distributions within these mine areas must be viewed as an approximation of ultimate post-mining conditions. For the purposes of estimating groundwater fluxes and mass loadings from the 2 North and 3 North mines, an expected case has been calculated and also a worst case to account for uncertainties, including potential discharge of mine pool waters from subsidence features. Discharge from subsidence cracks or sinkholes can occur where the subsidence feature extends from the workings to ground surface and the water level in the workings in the area of the subsidence feature recovers during flooding to ground surface. Based on pre-mine water levels and the locations of mapped subsidence features, these conditions could potentially exist in the southwestern limit of the 2 North mine in the vicinity of the Quinsam River.

Pre-mining water levels have been contoured for the 2 North, 3 North, 5 South and RBP areas in Figure 4-3. This contour plot represents a synthesis of data from several sources and is discussed by mine area below. Locations of hydrogeologic cross-sections A-A' and B-B' extending through the 2N/3N Mine area, and hydrogeologic cross-sections C-C' and D-D' extending through the 5 South mine area are shown on Figure 4-3. Hydrogeologic cross-sections A-A' through D-D' are shown on Figures 4-4 through 4-7, respectively. The groundwater flow regimes inferred for these mining areas under pre-mine, current and predicted post-closure conditions are discussed separately below.

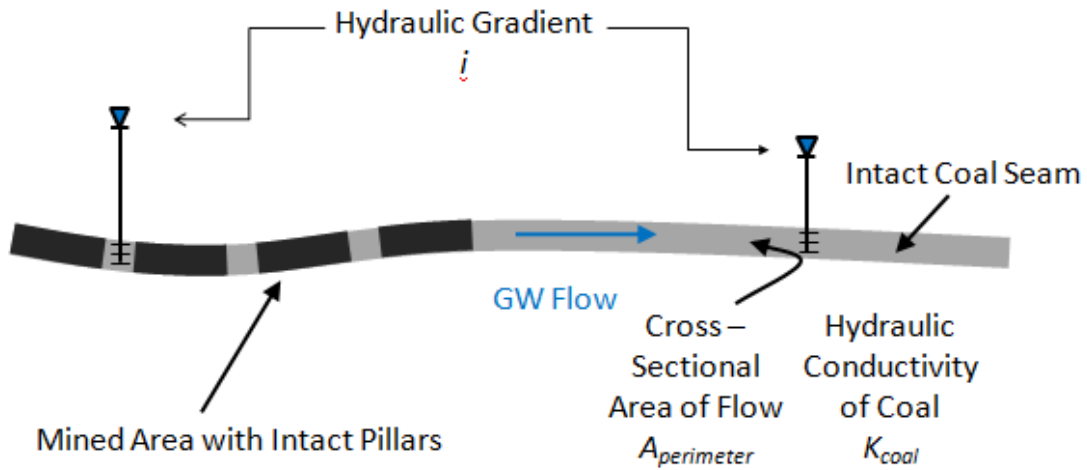


Figure 4-1: Case 1 – groundwater flow regime in mined areas with intact pillars.

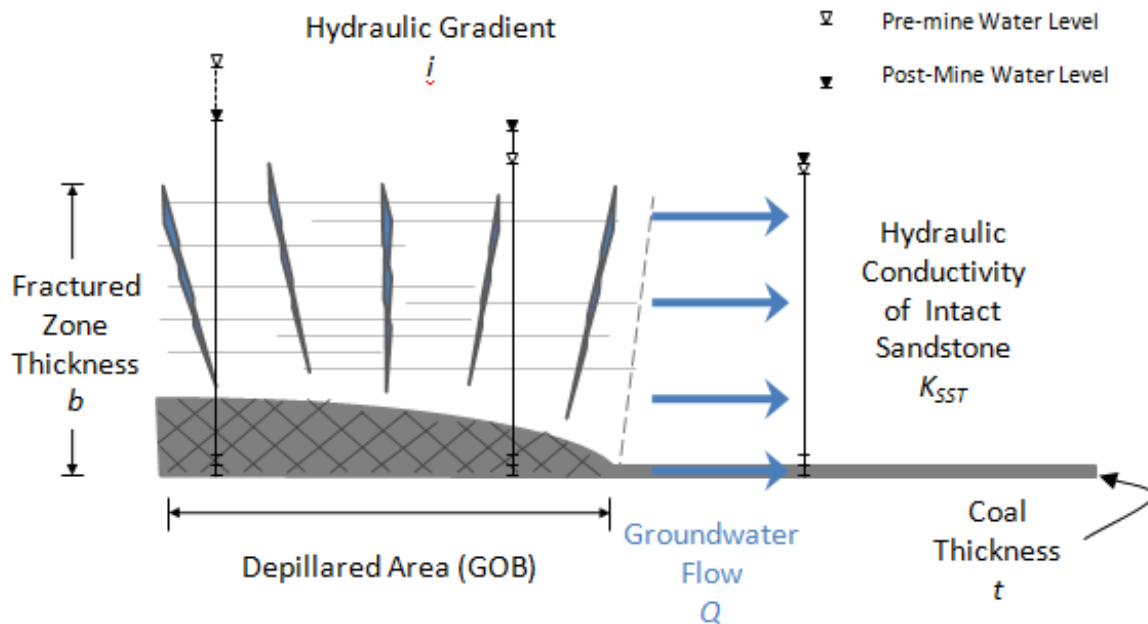
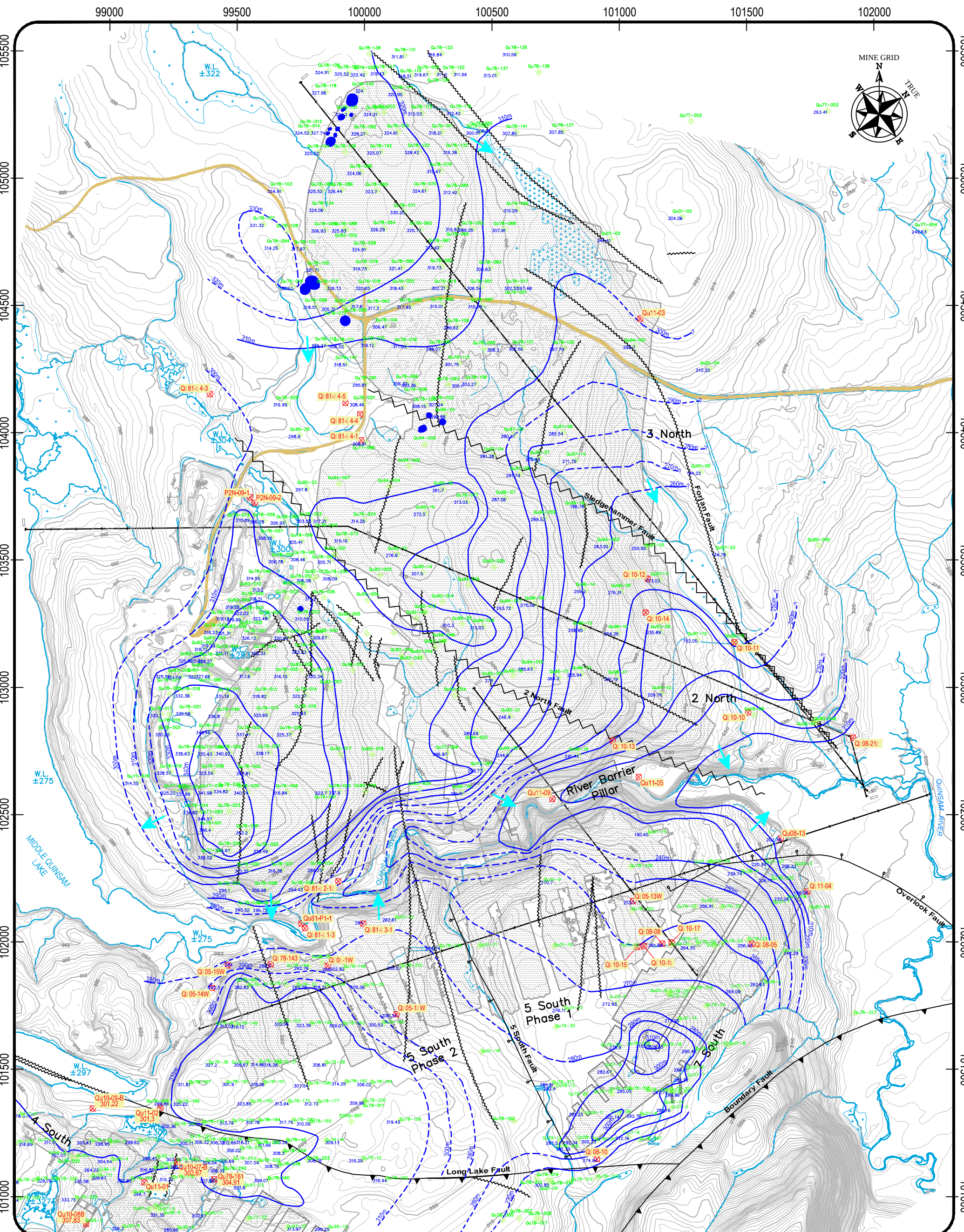


Figure 4-2: Case 2 – groundwater flow regime in depillared mine areas.



Meters
0 100 200

Projection: Mine Grid Coordinates

Project No.
J885-1

Client
Hillsborough Resources

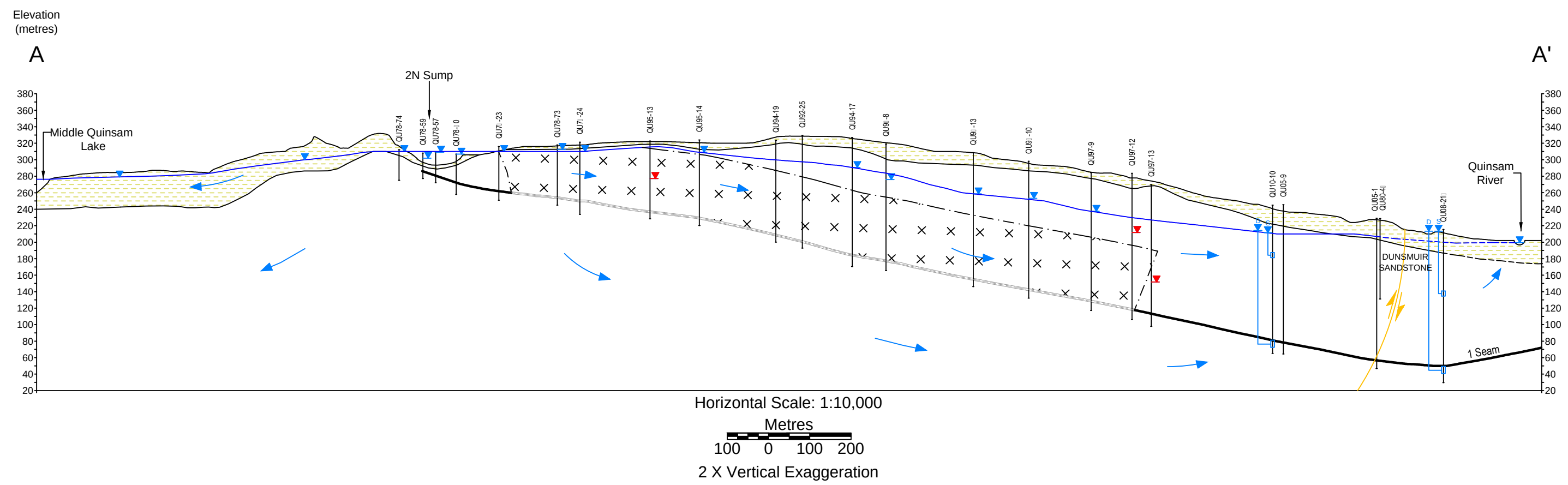
Date
May 10, 2011

Figure Title
2 North/3 North
and
5 South
Mine
Groundwater
Equipotentials
(Pre-Mine)

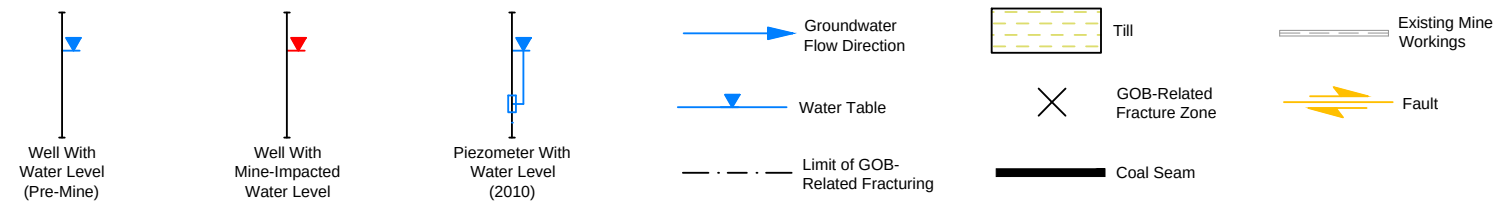
Figure Number
4-3

- | | | | | | |
|--|-----------------------------|--|--|--|---------------------------------|
| | Mine Workings Outline | | Definite Groundwater Equipotential (m) | | Road |
| | Surface Water Body | | Inferred Groundwater Equipotential (m) | | Groundwater Well |
| | Significant Faults | | Groundwater Flow Direction | | Boreholes with Fluid Levels (m) |
| | Hydrogeologic Cross Section | | Thrust Fault | | Sinkholes |
| | | | High Angle Normal Fault | | Swamp/Marsh |

Legend



LEGEND



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HORIZONTAL SCALE: 1:10,000

VERTICAL SCALE: 1:5,000

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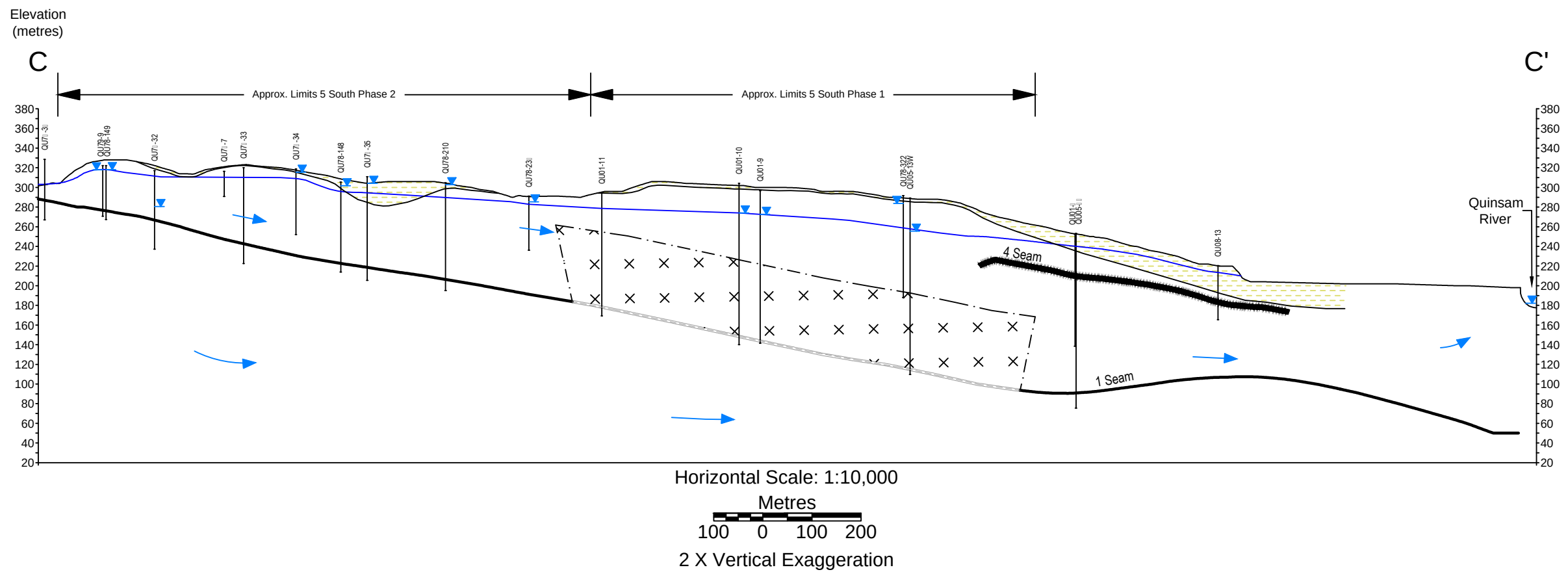
Figure 4-4: Cross Section A-A'

PROJECT: Quinsam Coal - Assessment of Underground Disposal of Coarse Coal Refuse

CREATED BY: VV

PROJECT NO. J885-1

DATE: May 24, 2011



LEGEND

Well With Water Level (Pre-Mine)	Piezometer With Water Level (2010)	Groundwater Flow Direction	Till	Existing Mine Workings
		Water Table	GOB-Related Fracture Zone	
		Limit of GOB-Related Fracturing	Coal Seam	

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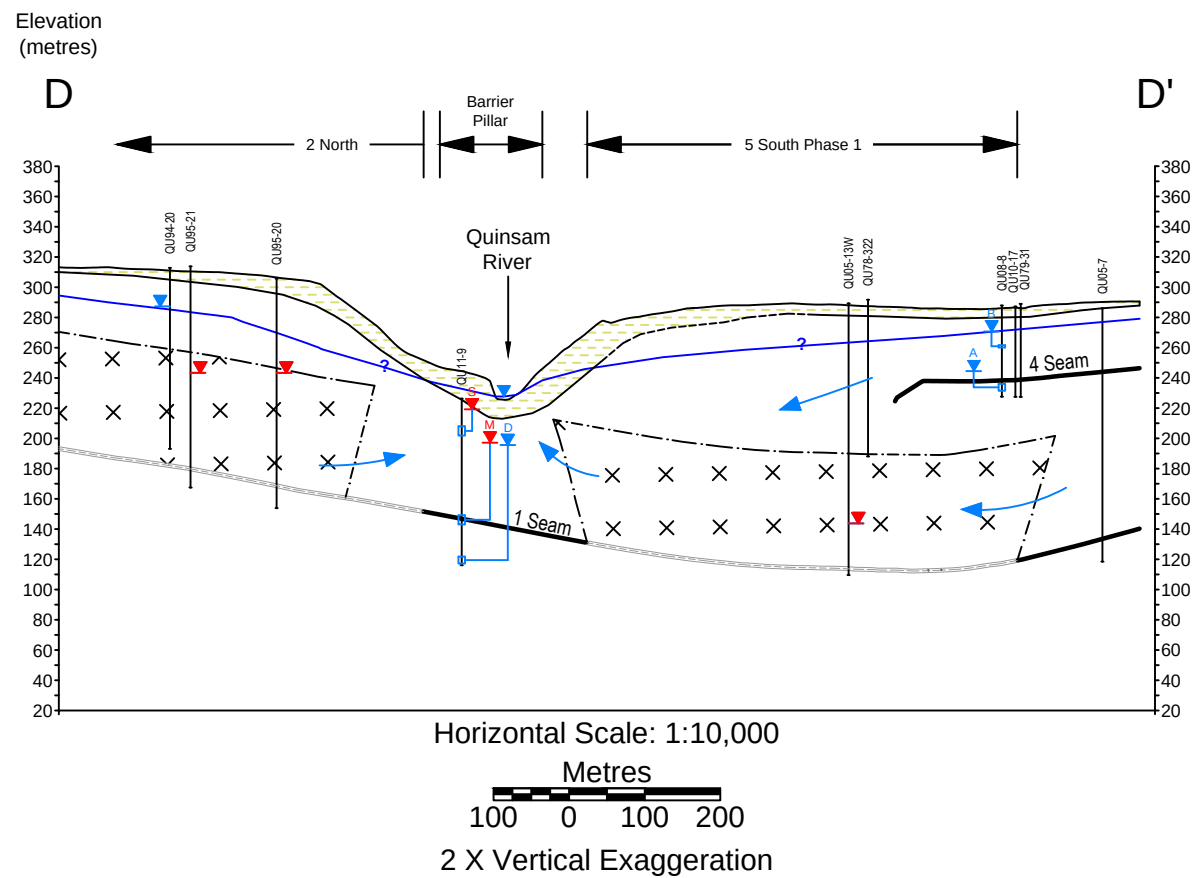
LORAX ENVIRONMENTAL

HORIZONTAL SCALE: 1:10,000

VERTICAL SCALE: 1:5,000

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Figure 4-6: Cross Section C-C'



LEGEND

Borehole With Water Level	Well with Mine-Impacted Water Level	Monitoring Well With Water Level	Water Table	GOB-Related Fracture Zone	
			Limit of GOB - Related Fracturing	Coal Seam	

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LORAX ENVIRONMENTAL

HORIZONTAL SCALE: 1:10,000

VERTICAL SCALE: 1:5,000

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Figure 4-7: Cross Section D-D'

4.2.2 2 North and 3 North Mines

Pre-Mine Period

Water levels determined from geophysical logs are available for over two hundred exploration holes drilled in the 2 North and 3 North Mine areas between 1976 and 2001. While this represents an extensive dataset, these water levels are typically recorded shortly after drilling and may not reflect the true static water level in the borehole. Experience in other areas of the mine has indicated that water levels in boreholes drilled in tight formations may take several weeks to recover. Where possible, the geophysical water levels have been compared to subsequent measurements taken by Brown, Erdman and Associates (BEA) in 1981 and by Morwijk Enterprises in 1989; however, this represents a very small portion of the total data set. In addition to the exploration boreholes, water levels were also available for several sets of nested piezometers completed in 1981 by BEA as part of their hydrogeological evaluation of the site (BEA, 1982). These piezometers nests are located immediately downstream of Middle Quinsam Lake along the Quinsam River (QU81-P1-1, Qu81-P1-3 and Qu81-P2-1c) and north of the 2 North Pit (Qu81-P4-1, Qu81-P4-3 through -P4-5). When contouring the data, emphasis was put on points where more than one measurement was available with contours roughly following the trend of topography.

Figure 4-3 indicates that overall, the No. 1 coal seam was entirely saturated in the footprint areas of the 2 North and 3 North mines under pre-mine conditions. The 300 m equipotential formed a saddle across these areas and straddles three groundwater mounds. The highest water levels (~340 m) were in the 2 North area, centred over the topographic high that is currently flanked by the tailings impoundment. From this mound, groundwater flowed radially towards Middle Quinsam Lake and the Quinsam River. In the 3 North area, a groundwater mound existed coincident with the topographic high immediately east of the No. 18 panel. Groundwater flows from this area were in a southeasterly direction with equipotentials inferred to deflect along a surface water draw that follows the Forjan fault trace ultimately reporting to the Quinsam River. There are several other surface drainages that punctuate the 2 North/3 North landscape which are also thought to follow fault traces. The wetland that occupies the Forjan fault trace is believed to lose water to the fault; water level in QU10-11S, which screens the fault, is near ground surface and is much higher (~20 m) than the water level in the nested well screening the No. 1 Coal seam (QU10-11D).

Mining Period

Groundwater levels have decreased substantially in the 2 North / 3 North mine areas as a result of mining of the No.1 coal seam and pumping to control water levels in the mine

workings. Recent water levels measured in 18 PVC piezometers installed within the 2 North and 3 North Mine areas are shown of Figure 4-8, and indicate groundwater levels have generally stabilized in the monitored zones, but with some portion of groundwater flow within the 2 North / 3 North footprint currently inundating the mine pool north of the Barrier Pillar site.

Post-Mine Period

Groundwater levels are expected to gradually rise over the long term as remaining mine pool voids are inundated, although are not expected to re-attain pre-mining levels within the 2 North / 3 North area, associated with maximum groundwater elevations of ~ 340m, as a result of the presence of sinkholes or other subsidence-related features due to mine-related subsidence within these areas, which are hydraulically connected to the mine workings. Where groundwater levels rise to the level of the sinkhole outlets, they will become groundwater discharge zones. The lowest- elevation subsidence outlet feature appears to be located east of the groundwater flow divide east of the 2 North Pit, with an approximate outlet elevation of 280 m. This is expected to be the first sinkhole to saturate and become a groundwater discharge zone, limiting further water table rise within the mine footprint areas upgradient of the subsidence feature.

4.2.3 5 South and RBP Areas

Pre-Mine Period

The 5 South Mine, which trends roughly east-west along a plateau immediately south of the Quinsam River, consists of two mine areas, Phase 1 and Phase 2. The down-dip, eastern 5 South Phase 1 area is now mined out, with the eastern portion of the up-dip, Phase 2 mine area being currently being mined. Water levels obtained from geophysical logs are available for over 60 exploration holes drilled in the 5 South Mine areas between 1976 and 2010, with approximately 50 boreholes drilled in the Phase 2 partially-mined area. While this is a significant dataset, as noted in Section 4.2.2.1 above, these water levels are typically recorded shortly after drilling and, as in the case of the 2 North and 3 North mine areas, may not reflect longer-term equilibrium conditions. Thus, where possible, the initial water levels have been compared to subsequent measurements taken by later investigators. In addition to the exploration boreholes, water levels were also available for several sets of nested piezometers completed in 1981 by BEA (Q81-P1-2c-1/2, Q81-P1-3c-1/2, Q81-P1-4c-1/2/3 and Q81-P1-5c-1/2/3) as part of their hydrogeological evaluation of the site. The water level hydrographs for piezometers installed in 5-South Phase 1 and Phase 2 areas are shown in Figures 4-9 and 4-10, respectively, and the relationships of all BEA nested piezometer screened zones with

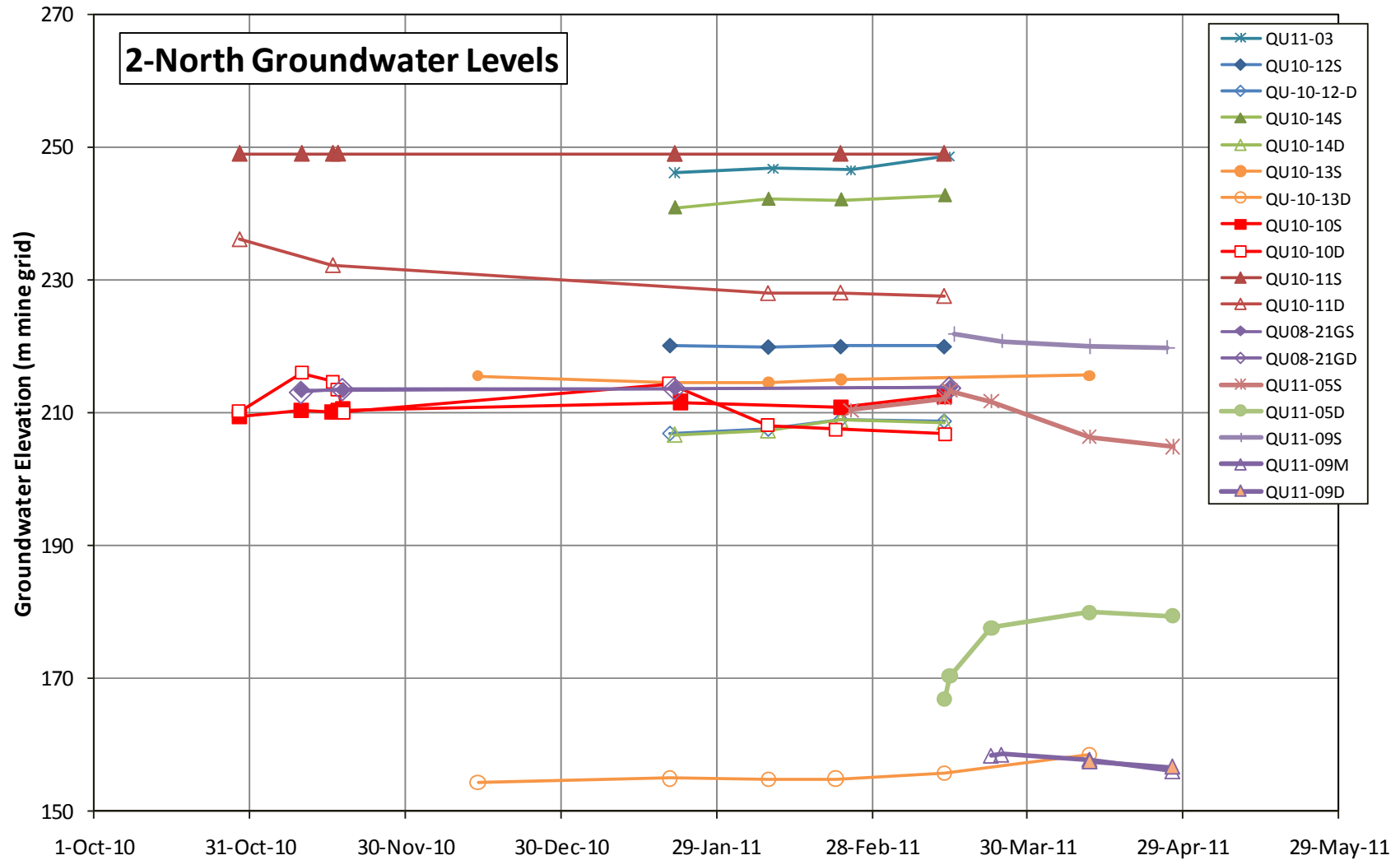


Figure 4-8: Water level hydrographs for 2 North/3North monitoring wells.

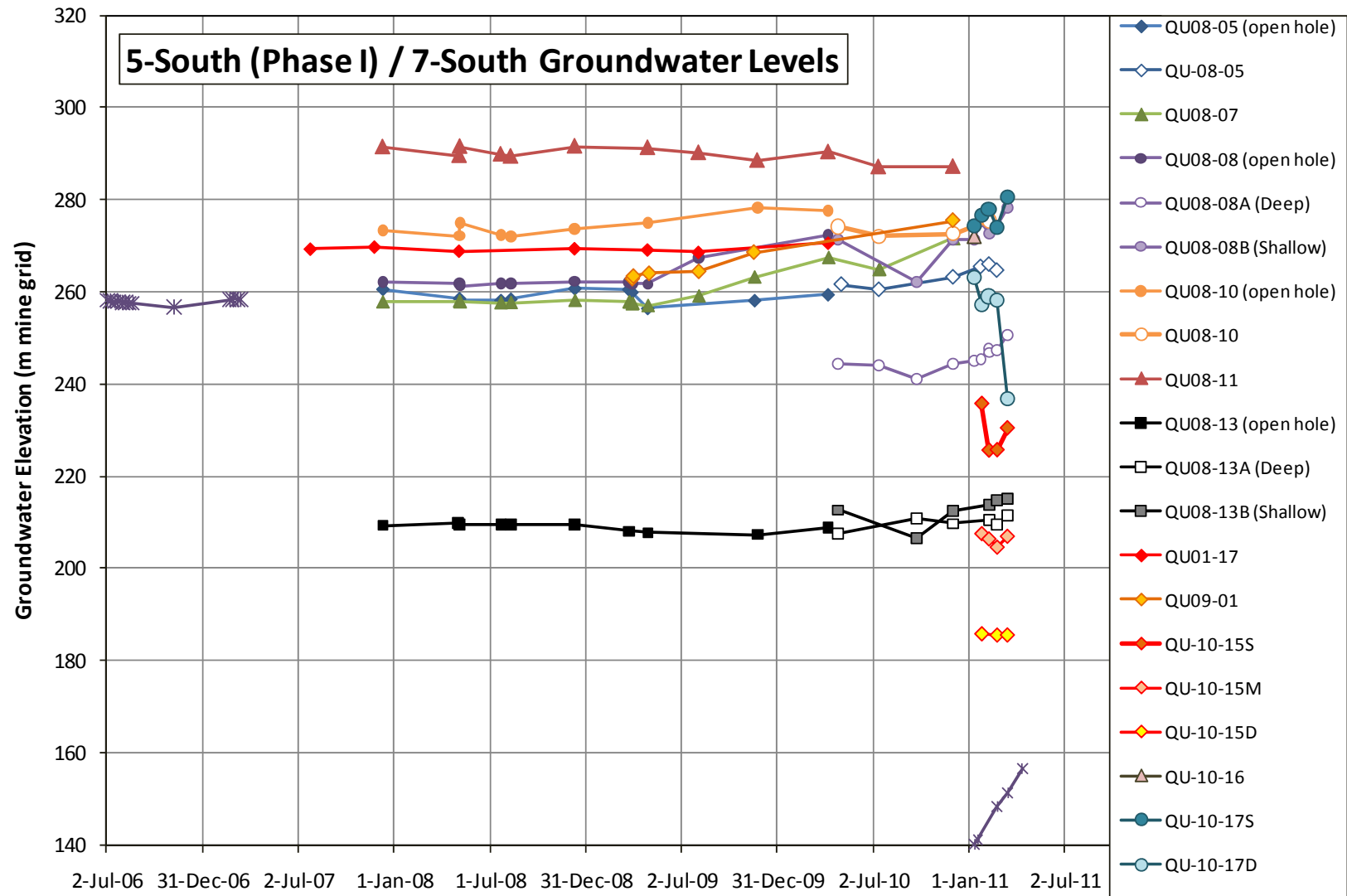


Figure 4-9: Water level hydrographs for 5 South (Phase 1) monitoring wells.

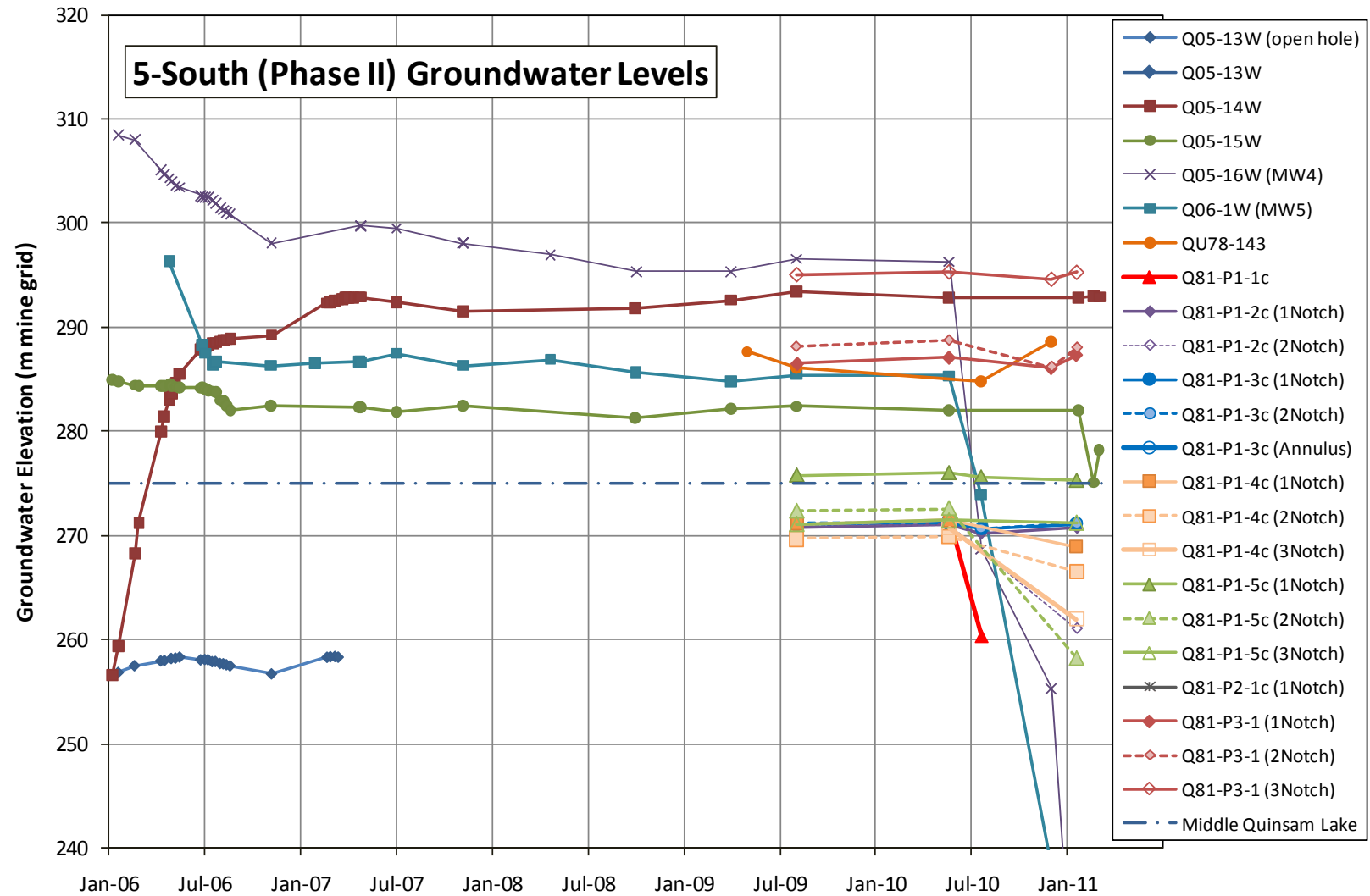


Figure 4-10: Water level hydrographs for 5 South (Phase 2) monitoring wells.

respect to the bedrock interface at the borehole location, as well as vertical hydraulic gradients at BEA nested piezometer locations are shown in Figure 4-11. Several nested piezometers were also completed in the Phase 1 mine area by Lorax in 2009 (QU08-08A/B and QU08-13A/B) and MCG in 2010 (QU10-15S/M/D and QU10-17S/D). In contouring the groundwater equipotentials, preference was given to points where multiple measurements were available, and to points where head contours roughly followed topography.

The groundwater equipotential distribution shown on Figure 4-3 indicates that the No. 1 coal seam was entirely saturated in the footprint area of the 5 South mine under pre-mine conditions. The highest groundwater levels (~310 m) are located in the westernmost, up-dip portion of the Phase 2 mine area, coincident with the topographic high for the 5 South Mine footprint. From this groundwater high, groundwater flows to the north directly to the Quinsam River, as well as northeast through the Phase 1 mine area, before ultimately reporting to the Quinsam River at further-downgradient locations.

The nested BEA piezometer installations Q81-P1-4c-1/2/3 and Q81-P1-5c-1/2/3 were screened in bedrock, and in both cases indicate significant upward hydraulic gradients of between 5% and 19% towards the Quinsam River, consistent with the locations of these piezometer installations in proximity to the Quinsam River, the regional groundwater discharge zone.

Groundwater level hydrographs for the 5 South Phase 1 mine area indicate generally stable water level conditions with the exception of QU10-17D, where the fluid level in the deep piezometer appears to be falling over time, which is consistent with the location of this piezometer installation adjacent to the eastern terminus of the Phase 1 mine gob area, with local groundwater flow toward the underlying mine void. The relatively stable water levels in the 5 South area is consistent with observations made during an inspection of the 5 South underground workings during 2009, with very little seepage into the mine workings observed during the site visit.

There is no historical water level data available for RBP area as QU11-09 was installed very recently (March 2011). Based on the water levels that have been measured in the river valley farther upstream (Q81-P1-4c and Q81-P1-5c), it is believed that pre-mine water levels in the RBP would have displayed an upward gradient.

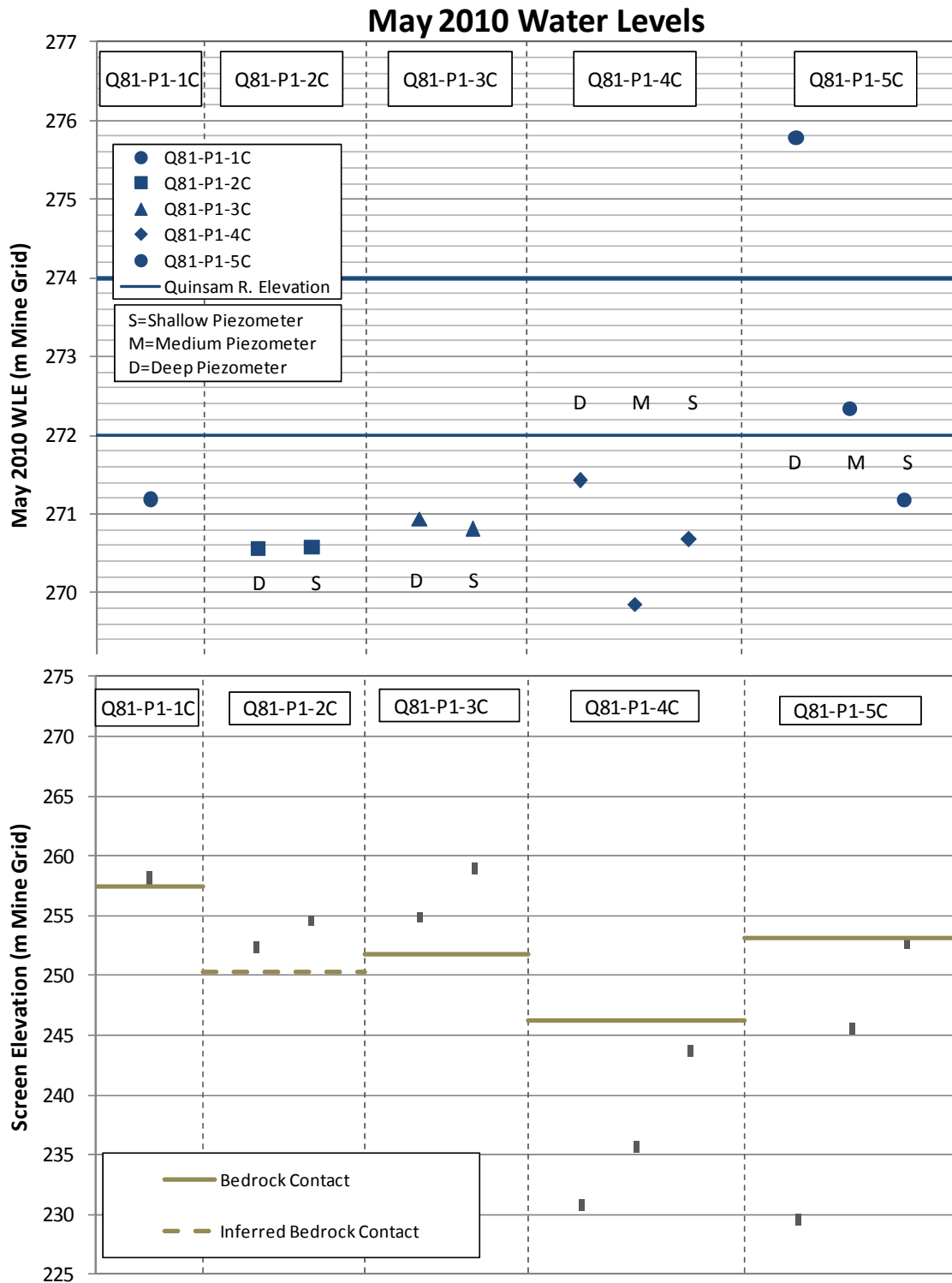


Figure 4-11: May 2010 water levels and screened intervals at Brown Erdman piezometers installed in the Quinsam River valley.

Mining Period

Deep groundwater levels in the 5 South Phase 1 mine were influenced by mining as evidenced by the recovering water level at QU05-13W (4-9). Shallower monitoring wells in this area (QU08-08, QU08-05) however, did not demonstrate declining water levels in response to mining. Groundwater levels in piezometers completed in the eastern portion of the 5 South Phase 2 mine area, however, appear to be dropping substantially, in response to the current mining-out of coal in this portion of the Phase 2 mine area, as observed in piezometers Q05-1W, Q05-15W, Q81-P1-1, Q81-P1-2, Q81-P1-4 and Q81-P1-5.

Current water levels from the wells installed in and downstream of the RBP are shown in Figure 4-8. The significant downward gradient measured at QU11-09 and QU11-05 in conjunction with similar water levels measured at QU11-09M/D (screened in the No. 1 seam and Benson conglomerate, respectively) as the 2 North mine pool (QU10-13D) would indicate that water levels in this area are significantly influenced by mining and dewatering in 2 North and in the RBP itself.

Post-Mine Period

With mining completed within the 5 South Phase 1 Mine area, groundwater levels appear to have essentially equilibrated, or are demonstrating a modest uptrend. In the post-mine period, groundwater levels in the 5 South Mine are expected to recover to levels approximating the pre-mining groundwater conditions, provided that subsidence features do not develop that may act as zones of groundwater discharge as has been identified for 2 North. Provided that water levels recover in 2 North and 5 South, it is expected that upward vertical gradients will return to the RBP and downstream areas and seepage gradients and flow towards the Quinsam River will be re-established.

4.3 Hydrogeologic Parameters

Calculations of groundwater fluxes and travel times from the 2 North, 3 North, 5 South and RBP areas post-mining are reliant on both the hydraulic characteristics and physical dimensions of the groundwater flow system. Section 4.3.1 discusses these parameters as they relate to the 2 North and 3 North mine areas, while Section 4.3.2 discusses these parameters as they relate to the 5 South and RBP areas.

4.3.1 2 North and 3 North Mine Areas

Hydraulic Conductivity of Coal, Sandstone and Till

Through this hydrogeological assessment and others, numerous hydraulic conductivity measurements in coal and other units have been performed at the Quinsam mine site. Appendix A-3 contains a compilation of all of the test results for coal seams, sandstone and till across the site. Data sources for these measurements include packer testing (open boreholes) and slug testing (completed wells) performed by Lorax in 2010 and 2011; recovery tests on open boreholes performed by Golder in 2009 and pump tests performed by BEA compiled in 1982. In total, the database contains 26 hydraulic conductivity measurements for coal, 10 measurements for sandstone and 3 measurements for till.

The database of coal permeability includes measurements from coal seams No. 1 through No. 5. Six of the measurements are from the No. 1 coal seam which is mined in the 2 North, 3 North, 5 South and RBP mines. Evaluations of the coal data have not revealed significant differences in hydraulic conductivity between the coal seams and as a result, the data from all coal seams have been included in this assessment (and in previous assessments or the 4 South and 7 South mines) to provide a more robust representation of hydraulic conductivity. The geometric mean hydraulic conductivity of coal at Quinsam is 1.0×10^{-7} m/s, with minimum and maximum measurements of 4×10^{-10} m/s and 1×10^{-4} m/s, respectively.

Appendix A-3 includes nine measurements of sandstone hydraulic conductivity measured by Lorax in the 2010 and 2011 field investigations as well as an additional value back-calculated from reflooding data that was available for the 4 South mine. In five of the hydraulic tests, the permeability of the sandstone was below the resolution of the packer testing method. For the purpose of this assessment, a hydraulic conductivity one half order of magnitude smaller than the reported method resolution has been assumed for these tests. The four remaining measurements range from a maximum of 8×10^{-5} m/s in fractured sandstone (4 South) to a minimum of 6.5×10^{-9} m/s (7 South). Since the high conductivity (8×10^{-5} m/s) from 4 South was measured in shallow, fractured sandstone; it is thought to be unrepresentative of the bulk sandstone properties in the 2 North – 5 South areas and thus has been excluded from subsequent data analysis. Based on these assumptions, the resultant geometric average of sandstone hydraulic conductivity is 6×10^{-9} m/s. This lower conductivity value for deeper sandstone is supported by observations in the underground workings. For example, no seepage was noted in the 8 Mains which crosses directly underneath the Quinsam River.

The till layer which blankets the mine site may act as a pathway for seepage from the 2 North-5 South mines in areas where the No. 1 seam subcrops. The flow path to the river may include a flow component through the till. A few measurements of till hydraulic conductivity have been performed across the site, including one measured at QU08-13B in 7 South and two measured at wells installed near the 2 North sump (Appendix A-2). All three hydraulic conductivity measurements are within the same order of magnitude; their geometric average is 4×10^{-6} m/s.

Cross-Sectional Area of Seepage

In general, there are three pathways whereby seepage can leave the 2 North and 3 North mine areas. There is downward vertical seepage through the mine floor, horizontal seepage through the mine perimeter as well as seepage through the Forjan Fault which is inferred from the field investigation to have a high transmissivity relative to the coal and sandstone strata. In this analysis, the Forjan Fault is treated as a distinct seepage pathway; the vertical and horizontal seepage components are estimated via Darcy's law which requires knowledge of the cross-sectional area of flow.

The vertical component of mine seepage is inferred to occur only in areas where the No. 1 coal seam is mined above the elevation of base drainage which is assumed to 275 m, *i.e.*, the elevation of the Quinsam River at the outlet of Middle Quinsam Lake. The areas where No. 1 seam has been mined above the 275 m coal contour are outlined in Figure 4-12. Area 1 in 3 North corresponds to $\sim 202,000 \text{ m}^2$ (or 20 ha) while Area 2 in 2 North corresponds to $\sim 331,000 \text{ m}^2$ (or 33 ha). Areas 1 and 2 represent the cross-sectional area for downward vertical seepage from the 3 North and 2 North mines.

Horizontal seepage is inferred to be the dominant seepage direction in areas where the No. 1 coal seam has been mined below base drainage (275 m). The cross-sectional area for this component of mine seepage is complicated by extensive depillaring; this has created a subsidence-related fracture zone above workings resulting in a larger and variable cross-sectional area of flow (see Figure 4-2). The subsidence study undertaken at the mine site has indicated that the height of the fracture zone is equivalent to 20 to 29 times the thickness of the mined workings (MCG, 2011). Accordingly, the height of the fractured zone may range between 60 to 87 m assuming a mined thickness of 3 m. It follows that the fractured zone may intersect the bedrock-till interface where the height of

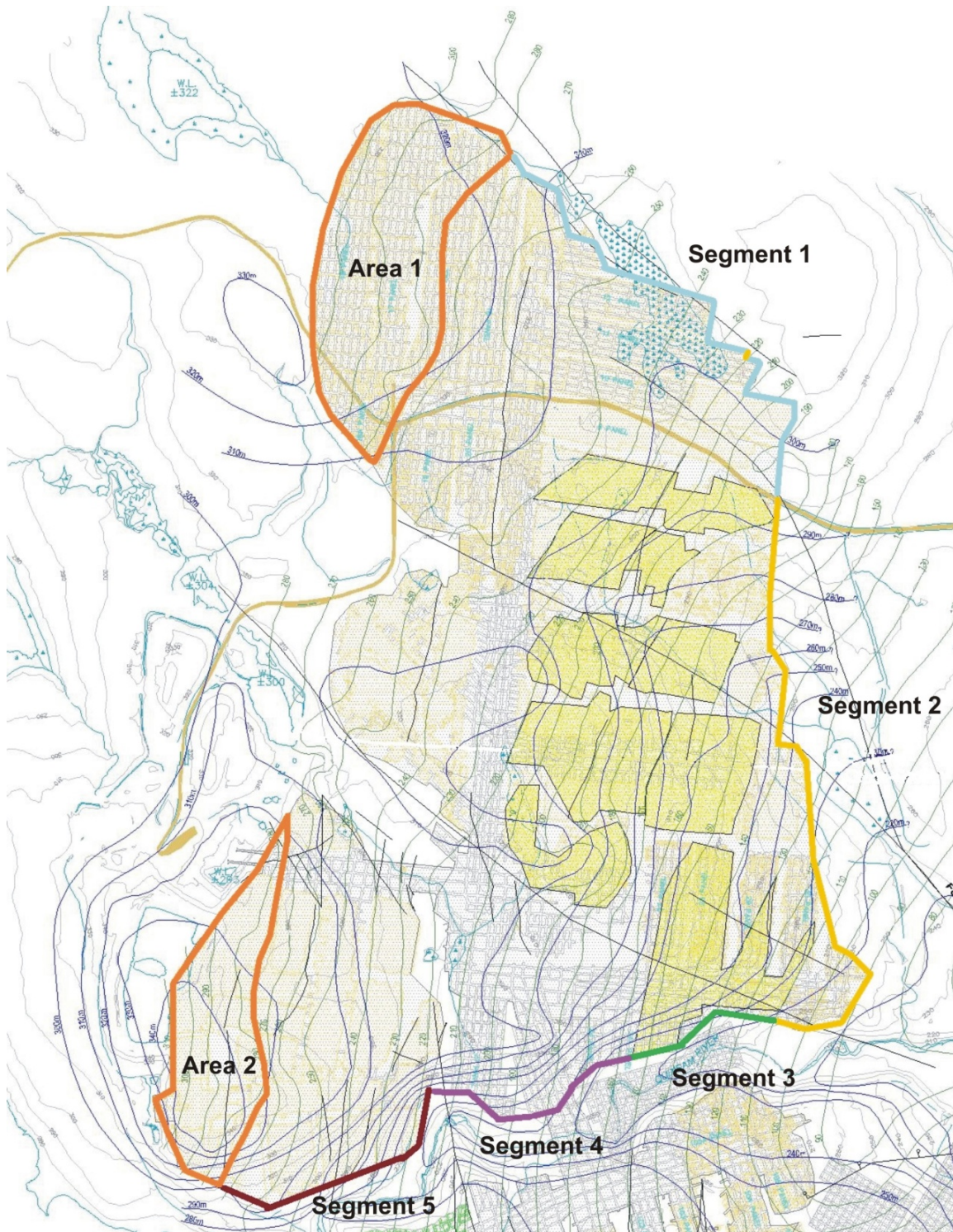


Figure 4-12: 2 North / 3 North mine perimeter segments and areas used for seepage calculations.

the bedrock above the workings is less than 87 m. Along the mine perimeter, the height of the bedrock above the No. 1 seam varies from 25 m to over 150 m, thus the height of the fracture zone might vary from 25 to 87 m. To simplify the analysis, the mine perimeter below base drainage was separated into five segments where a constant or average range of fracture zone thicknesses could be attributed (Figure 4-12). The cross-sectional area of horizontal flow from these areas is based on the lengths and heights for the segments summarized in Table 4-2 below.

Table 4-2:
Cross-sectional areas for calculation of horizontal seepage from the 2 North and 3 North Mines.

Perimeter Segment	Perimeter Length (m)	Height of Fracture Zone (m)	Thickness of Workings (m)
1	1,850	60-68	3
2	2,020	60-87	3
3	400	60-87	3
4	1,461	n/a	3
5	744	28	3

n/a Not applicable. Pillars are intact thus subsidence not expected.

Hydraulic Gradients

The inferred pre-mine horizontal hydraulic gradients vary widely across the 2 North and 3 North areas. Overall, the hydraulic gradients are steepest along the southern margin of the 2 North mine where the land falls sharply to the Quinsam River (Figure 4-3). Here, horizontal gradients can range from 20% to 40% towards the river. Along the eastern margin of the 2 North mines, the horizontal gradients are much shallower, typically between 5-10%. Along the western margin of the 2 North Mine, the pre-mine gradient towards Middle Quinsam Lake was on the order of 13%.

Vertical pre-mine hydraulic gradients are not well constrained across the 2 North and 3 North Mine areas. Along the eastern margin of the mine, the water levels at QU10-10 display shallow vertical gradients (<5%) that have oscillated between downward and upward. This is consistent with the assumption that seepage from the mine travels laterally in this area. Unfortunately, there is no information on vertical gradients on the eastern margin of the mines in Areas 1 and 2 (Figure 4-3) which are believed to drain vertically towards Middle Quinsam Lake and/or the Quinsam River. For these areas, it is believed that the vertical gradient measured at the downstream end of 7 South at QU08-13 (14% downward) would a reasonable estimate of vertical gradients in these areas.

For the purpose of calculating seepage fluxes from the mine areas, average *post-mine* gradients have been assigned to the perimeter segments and footprint areas originally outlined in Table 4-2 and shown in Figure 4-12. As discussed in Section 4.2.2, extensive depillaring of the 2 North and 3 North mine and the consequent development of a permeable fracture zone above the mine footprint is inferred to cause a ‘flattening’ of the head distribution within the footprint area of the mine and steepening of gradients along its perimeter due to the enhanced hydraulic conductivity of the caved and fractured areas in the workings relative to intact rock under pre-mine conditions (Figure 4-2). For the purpose of this analysis, it is assumed that horizontal gradients at the margin may increase on average by 3%. The post-mine gradients assigned to the various perimeter segments are summarized in Table 4-3.

Table 4-3:
Hydraulic gradients assumed for calculation of horizontal seepage from the 2 North and 3 North mine areas.

Conceptual Model Region	Pre-mine Hydraulic Gradient (%)	Post-mine Hydraulic Gradient (%)
Segment 1	5	8
Segment 2	8	11
Segment 3	25	28
Segment 4	33	36
Segment 5	20	23

Forjan Fault

The Forjan Fault (Figure 2-3) is another potential pathway for seepage from the 2 North and 3 North mines. What has been observed is that the fault can sustain relatively high airlift yields as was encountered when drilling QU10-11. These flows could not be accurately estimated as circulation from the drill rig caused water to erupt from a nearby exploration hole (QU05-10) which also intersected the fault. However, flows up to 30 gpm were measured at QU11-10, and therefore the combined flow from both holes would exceed this rate. A brief review of drilling information from exploration holes across the Quinsam mine site has indicated that 40 gpm (218 m³/d) is the maximum airlift yield encountered while drilling. Field observations indicate that Forjan fault can support a similar airlift yield. Water quality at QU10-11S, which screens the fault, indicates that shallower portions of the fault are fed by drainage from the wetland. It is assumed that deeper portions of the fault intersect the gob areas of the 2 North mine. For the purpose of this analysis, it is assumed that 60% of the 220 m³/d (*i.e.*, 130 m³/d) of this flow originates from the mine, based on the proportion of gob height to the total height of saturated bedrock above the No. 1 Coal seam in this area.

Effective Porosity

Effective porosity is the percentage of the rock/overburden comprised of interconnected pore space that contributes to groundwater flow. Effective porosity is required to estimate groundwater flow velocity and to determine the time for contaminants to travel from the workings to the Quinsam River. Effective porosity is difficult to measure in the field, thus a representative value for bedrock was based on a literature review of studies where values have been determined at the field scale (*i.e.*, flowpath lengths of hundreds of meters). Based on a review of all current literature, an effective porosity of 0.001 (0.1 %) is considered representative for the Dunsmuir Sandstone (L. Smith, per. comm.). An effective porosity of 30% is believed to be representative for the till, based on the experience of the author.

4.3.2 Hydrogeologic Parameters for the 5 South and River Barrier Pillar Areas

The hydraulic conductivity and porosity values previously discussed for the 2 North and 3 North mines are also valid for the 5 South and RBP mine areas. The following discussion is thus focussed only on hydraulic gradients and cross-sectional areas as applicable to these mine areas.

Cross-Sectional Area of Seepage

Similar to the 2 North and 3 North mines, seepage can discharge from the 5-South Mine through downward flow through the mine floor and horizontal flow through the mine perimeter. Observations from mining suggest that the 5 South Fault does not carry significant water therefore this feature is not considered in the analysis. Downward flow through the mine floor is limited to areas where the No. 1 seam is mined above base drainage (275 m), which in this case is limited to a very small area (~24,000 m²) at the up-dip (western) end near the proposed portal (Figure 4-13).

Horizontal seepage from the 5 South Mine occurs in areas where the No. 1 coal seam has been mined below base drainage (275 m). As was the case in 2 North, the cross-sectional area for this component of mine seepage is complicated by current and proposed mine depillaring which will create a fracture zone above the workings. For a mined thickness of 3 m, the height of this fracture zone may be anywhere between 60 and 87 m or less if the thickness of bedrock overburden is limited. Along the perimeter of the gob areas, the height of the bedrock above the No. 1 seam varies from 70 m (Phase 2) to over 150 m (Phase 1). The up-dip portion of the mine will not be depillared, thus the mined thickness of 3 m will apply as the cross-sectional area of lateral seepage under post-mine conditions. To account for the differences in cross-sectional area and gradients along the perimeter of the 5 South mine, the perimeter has been divided into four segments. The cross-sectional areas (given as length and height) for these segments are provided in Table 4-4.

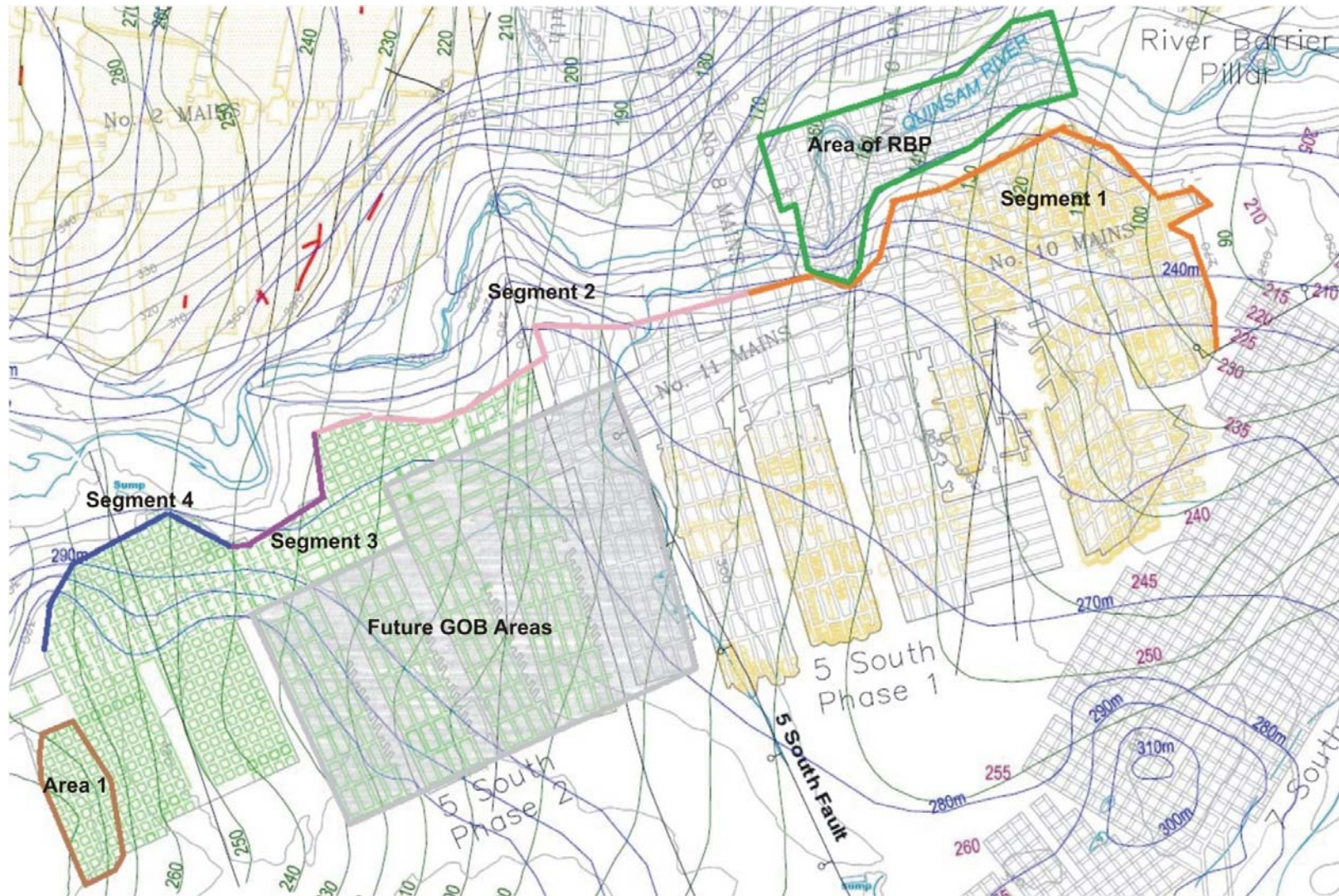


Figure 4-13: 5 South and RBP perimeter segments and areas used for seepage calculations.

Table 4-4:
Cross-sectional areas for calculation of horizontal seepage from the 5 South Mine.

Perimeter Segment	Perimeter Length (m)	Height of Fracture Zone (m)	Thickness Workings (m)
1	1200	60-87	3
2	1060	60-87	3
3	298	70	3
4	447	n/a	3

n/a Not applicable. Pillars are intact thus subsidence not expected.

The most likely pathway for seepage from the River Barrier Pillar based on pre-mine gradients (see discussion below) is upward through the roof. Thus, the cross-sectional area of groundwater seepage is the entire footprint of the RBP, or ~ 67,300 m².

Hydraulic Gradients in the 5 South and River Barrier Pillar Areas

Overall, horizontal gradients from the edge of the 5 South mine towards the Quinsam River are very steep along the perimeter segments flanking gob areas. Along segments 1 and 2, the pre-mine gradients are inferred to be on the order of 25%. Towards the up-dip end of the mine, the gradients are much shallower, on the order of 5% in segments 3 and 4. As previously describe, depillaring of the 5 South Mine will create a permeable fracture zone above the mine footprint causing heads to flatten within the footprint area; potentially creating steeper gradients along its perimeter. Analogous to the 2 North-3 North areas, it is assumed that horizontal gradients at the margin in areas of gob may increase on average by 3%. The post-mine gradients assigned to the various perimeter segments are summarized in Table 4-5.

Pre-mine vertical gradients have not been measured in the extreme up-dip portion of the mine which is expected to drain vertically through the floor. For this area, a downward vertical gradient of 14% has been assumed based on the gradients measured at QU08-13 in 7 South.

Table 4-5:
Hydraulic gradients assumed for calculation of horizontal seepage from the 5 South Mine.

Conceptual Model Region	Pre-mine Hydraulic Gradient (%)	Post-mine Hydraulic Gradient (%)
Segment 1	25	28
Segment 2	27	30
Segment 3	5	8
Segment 4	5	8

The water levels measured in the recently completed piezometers in the RBP (QU11-09) and downstream (QU11-05) have been clearly influenced by mining and do not reflect expected vertical gradients post closure. BEA (1982) installed nested piezometers at sites QU81-P1-1 through QU81-P1-5 in a meander of the Quinsam River immediately downstream of the outlet at Middle Quinsam Lake. 1982 water levels at one of these locations (QU81-P1-5) indicated upward vertical gradients in the bedrock on the order of 38%. More recent water levels at these nests (May 2010) also indicated an average upward gradients at QU81-P1-5 (19%) and QU81-P1-4 (~5%). Therefore, predicted post-mine gradients in the RBP are expected to be ~12% upwards, representing upward groundwater flow to the overlying Quinsam River.

4.4 Hydrogeological Analysis

As discussed in Section 4.3 and in previous Lorax reports on the 4 South and 7 South mine areas, the parameters required to estimate seepage from the 2 North, 3 North, 5 South and RBP mine areas are expected to vary widely. For instance, the hydraulic conductivity of the coal and sandstone can vary over orders of magnitude. To account for these ranges in hydrogeological properties, the Oracle Crystal Ball (OCB) software was used to estimate potential seepage rates from the mine areas. OCB software is a spreadsheet-based tool that is widely used throughout industry for predictive modelling, forecasting and simulation. Using Monte Carlo simulation, OCB produces a range or distribution of outcomes based on a large number of calculations selected at random based on user-defined distributions for the input parameters (*i.e.* K , i , A). As discussed in Section 4.3, geometric mean values will be used for K_{coal} and $K_{sandstone}$. Simple triangular distributions have been assumed for hydraulic gradients and cross-sectional thickness of flow. These distributions are shown in Appendix A-4, along with the output from OCB.

The following section discuss seepage rates from the mine areas calculated from the Crystal Ball simulations and compares these seepage rates to independent estimates based on watershed yield and infiltration rates.

4.4.1 Seepage Rates From the 2 North – 3 North Mine Areas

Calculations of Seepage Flux From Hydraulic Conductivity

As discussed previously, seepage from the 2 North and 3 North areas may occur via three mechanisms: (i) vertical flow through portions of the mine floor above base drainage (275 m), (ii) horizontal seepage through the perimeter of the mine below base drainage and (iii) flow through the Forjan fault. Thus, the total flow Q_{total} from the 2 North and 3 North mine areas can be summarized by the following equation:

$$Q_{total} = Q_{vertical} + Q_{horizontal} + Q_{fault}$$

The vertical and horizontal seepage fluxes can be calculated according to Darcy's law whereby Q is equal to the product of the hydraulic conductivity K , hydraulic gradient i (horizontal or vertical) and cross-sectional area A (or perimeter length l multiplied by thickness b , where $b_{fracture\ zone}$ represents the thickness of the fractured sandstone above the workings in gob areas). Seepage via the Forjan Fault has been estimated based on observations of maximum airlift yields from exploration drilling at the Quinsam Mine. Thus, the equation above can be expanded to the following.

$$Q = K_{sandstone} \cdot i_v \cdot A_{footprint} + K_{coal} \cdot i_h \cdot l_{perimeter} \cdot b_{coal} + K_{sandstone} \cdot i_h \cdot l_{perimeter} \cdot b_{fracture\ zone} + Q_{fault}$$

Recall from Section 4.2.1 that horizontal seepage from the margin of the mine will travel through the intact sandstone flanking the fracture zone as well as through the intact No.1 coal seam. Since horizontal gradients and fracture zone thickness vary along the perimeter of the 2 North and 3 North mines, the perimeter has been partitioned into five segments of similar hydraulic properties, as depicted in Figure 4-12 and discussed in Section 4.3.1. Median seepage rates calculated by Crystal Ball through each of these perimeter segments and through the mine floor are summarized in Table 4-6.

Assessment of Seepage Rates from Quinsam River Baseflow

As an independent check on the groundwater fluxes calculated by Crystal Ball, baseflow measurements in the Quinsam River have been analysed to determine an approximate gross-scale measure of groundwater yield per unit area of watershed. This areal yield can then be prorated for the 2 North and 3 North mine areas to determine an estimate of total groundwater fluxes from the proposed mine.

Table 4-6:
Calculated seepage rates from the 2 North and 3 North mines.

Mine Area	Seepage Component	Seepage Flux (m ³ /d)
Perimeter of Mine		
Segment 1	horizontal	8.3
Segment 2	horizontal	13.4
Segment 3	horizontal	6.8
Segment 4	horizontal	13.5
Segment 5	horizontal	6.7
Footprint of Mine		
Area A	vertical	36
Area B	vertical	
Forjan Fault	fracture flow	131
TOTAL (rounded)	all components	220

The hydrology of Quinsam River was discussed in detail in the 7 South Mine Groundwater Evaluation (Lorax, 2011b). Analysis of 15 years of data indicated that the Quinsam River gains very little ($0.03 \text{ m}^3/\text{s}$) during the low flow period in August between two Water Survey of Canada hydrometric stations located on the Quinsam River at Argonaut Bridge and at the outlet of Lower Quinsam Lake, which span the area of the Quinsam Mine. Based on the assumption that the gain in the river is due primarily to groundwater discharge, it has been calculated that the groundwater yield per unit area of watershed between these two stations ($\sim 133 \text{ km}^2$) is $\sim 2 \times 10^{-5} \text{ m}^3/\text{s}$ per m^2 . If this yield is applied to the area of the 2 North and 3 North mines ($\sim 360 \text{ ha}$), the resultant groundwater flux to the Quinsam River from these areas is calculated to be on the order of $72 \text{ m}^3/\text{d}$. This compares to the seepage rate of $\sim 220 \text{ m}^3/\text{d}$ calculated for the 2 North and 3 North mines using the hydrogeologic properties noted above in Section 4.3.1.

Although groundwater baseflow yields are dependent on soil cover and bedrock geology, which are variable across the Quinsam River watershed, and flows will also be affected by storage and evaporation effects in Lower Quinsam Lake, the $80 \text{ m}^3/\text{d}$ groundwater flux calculated for the 2 North and 3 North mines is believed to be a reasonable order-of-magnitude lower bound on groundwater fluxes from these areas.

Assessment of Seepage Rates from Precipitation and Infiltration

For assessment of contaminant loading rates from the 2 North and 3 North mines, calculations have been performed representing “most likely” or expected seepage fluxes and “upper bound” or worst case conditions. The seepage rate of $\sim 220 \text{ m}^3/\text{d}$ calculated with Crystal Ball using the hydrogeological parameters discussed in Section 4.3.1 is considered to be the most likely condition, but does not explicitly address the potential for discharge of mine pool waters from subsidence features.

To represent an upper bound estimate of seepage rates, we have assumed a percentage of total annual precipitation which could infiltrate and recharge the groundwater system over the 2 North and 3 North areas. Selection of an appropriate infiltration rate was based on field observations and experience of the authors. Review of drillhole data and site reconnaissance indicate the mine area has a thin cover of colluvium or till and exposures in road cuts indicate shallow groundwater seepage tends to flow over the bedrock surface at the soil/bedrock interface. This information, as well as experience from other sites, suggests that infiltration rates are low. For this assessment, to account for uncertainties in the analysis, including potential discharge from subsidence features, an upper bound estimate of 10% infiltration of mean annual precipitation has been used for the worst case condition.

Mean annual precipitation at the Quinsam Mine was previously determined by analysis of long-term records from weather stations and correlation with a shorter period of record from climate observations at the mine (Lorax, 2009). Based on this analysis, mean annual precipitation was determined to be 1,034 mm/yr. Total daily precipitation over footprint of the 2 North and 3 North mines equates to approximately 11,300 m³/d. Thus, the upper bound seepage rate based on 10% infiltration is 1,130 m³/d. The seepage rate calculated from Crystal Ball, 220 m³/d, represents an infiltration rate of 2% which is low and consistent with field observations.

4.4.2 Travel Time From 2 North – 3 North Mine Areas To Quinsam River

The fastest seepage pathway from the 2 North mine will occur along its southern margin where it is in close proximity to Quinsam River. As shown in Figure 4-14, the seepage may travel from the fractured area through intact sandstone to the river (Pathway A), or it might travel along the intact coal seam and then upward through intact sandstone to the river (Pathway B).

Recall that the travel time for groundwater is calculated according to the following equation:

$$t = d / v = d / (K \cdot i / n)$$

where d is the path length (m), v is the groundwater velocity (m/s), K is the hydraulic conductivity (m/s), i is the hydraulic gradient (m/m) and n is the effective porosity (dimensionless). While travel distance d is shorter in Pathway A than Pathway B, the mean hydraulic conductivity of intact sandstone is (6x10⁻⁹ m/s) is much smaller than the mean hydraulic conductivity of coal (1x10⁻⁷ m/s). Ultimately, in situations where the No.1 coal seam is shallower than the setback distance of the mine from the river, pathway B may be the quickest means through which seepage may report to the Quinsam River. This situation occurs along Segment 5 (Figure 4-12), where the No. 1 coal seam is shallow (in places less than 30 m below the river bed) and the margin of the mine is set back about 70 m from the river. Assuming that the seepage travels through the coal under the post-mine horizontal gradients assumed for Segment 5 (23%) and then travels upwards through the sandstone under the vertical gradients assumed in the river bed (12%), the shortest travel time to the river is 519 days or 1.4 years.

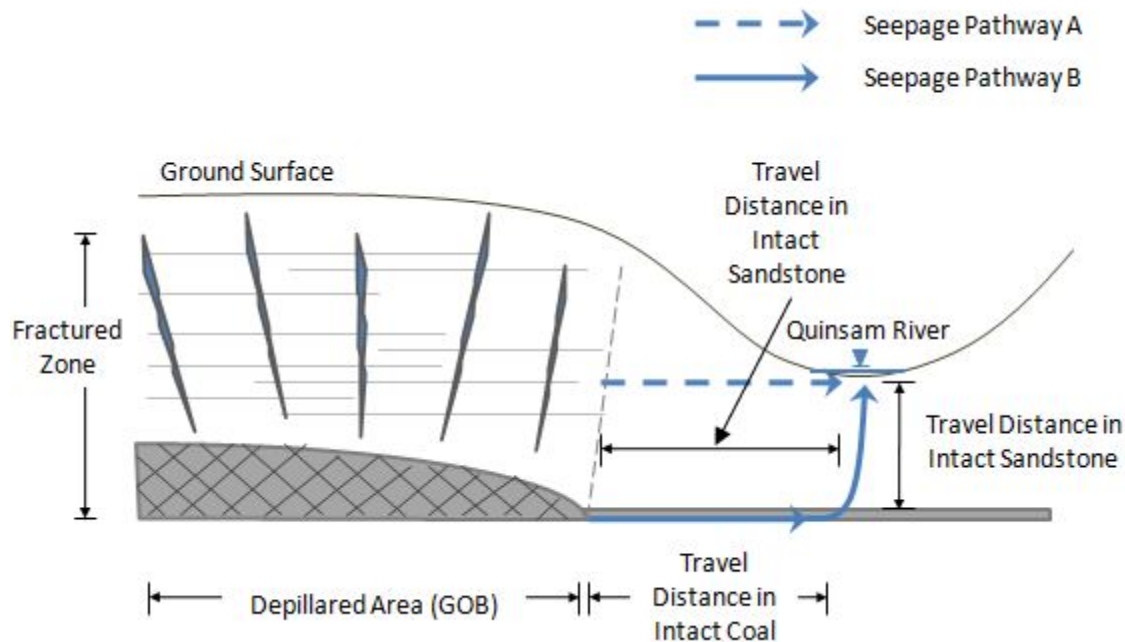


Figure 4-14: Seepage pathways from 2 North Mine (Segment 5) to Quinsam River.

4.4.3 Recharge Rate to a Fully Dewatered Mine (2 North and 3 North)

To estimate the reflooding rate and time for the 2 North and 3 North mines, we have assumed that current mine dewatering rates will be applicable in the future. Currently, mine water pumped from the 2 North and 3 North workings is directed to Sediment Pond 4 (SP4) which also receives runoff from the surrounding drainage. QCC monitors flows at the outlet of SP4 and has estimated average annual flow from the pond to be $\sim 2 \times 10^6 \text{ m}^3$ (from 2006 to 2010 data). If a runoff coefficient of 0.8 is applied to the surrounding drainage, then average annual component originating from mine dewatering is $1.5 \times 10^6 \text{ m}^3$, which translates to a daily dewatering rate of $4,100 \text{ m}^3/\text{d}$. Based on a 2 North and 3 North mine void volume of $5.5 \times 10^6 \text{ m}^3$, it is estimated that the mine will reflood in approximately 3.7 years.

4.4.4 Seepage Rates From the 5 South and River Barrier Pillar Mine Areas

Calculations of Seepage Flux From Hydraulic Conductivity

Seepage from the 5 South mine may occur via vertical flow through portions of the mine floor above base drainage (275 m) and by horizontal through the perimeter of the mine below base drainage. These components of mine seepage can be calculated using Darcy's law according to the following equation:

$$Q = K_{\text{sandstone}} \cdot i_v \cdot A_{\text{footprint}} + K_{\text{coal}} \cdot i_h \cdot l_{\text{perimeter}} \cdot b_{\text{coal}} + K_{\text{sandstone}} \cdot i_h \cdot l_{\text{perimeter}} \cdot b_{\text{fracture zone}}$$

where the groundwater flux Q is equal to the product of the hydraulic conductivity K , hydraulic gradient i (horizontal and vertical) and cross-sectional area A (or perimeter length l multiplied by thickness b).

Horizontal seepage from the margin of the mine will travel through the intact sandstone flanking the fracture zone as well as through the intact No.1 coal seam. In Section 4.3.2, the downstream perimeter of the 5 South mine was subdivided into 4 segments to account for differences in hydraulic gradients and cross-sectional areas perpendicular to flow (Figure 4-13). Median seepage rates calculated by Crystal Ball through each of these perimeter segments and through the mine floor are summarized in Table 4-7. The seepage rates from perimeter segments 1 and 2 are significantly larger due to both the longer perimeter lengths and steeper hydraulic gradients. The vertical seepage emanating from the extreme up-dip end of the mine is expected to be small ($1 \text{ m}^3/\text{d}$).

Table 4-7:
Calculated seepage rates from the 5 South Mine and RBP.

Mine Area	Seepage Component	Seepage Flux (m^3/d)
Perimeter of 5 South Mine		
Segment 1	Horizontal	21
Segment 2	Horizontal	19
Segment 3	Horizontal	1.4
Segment 4	Horizontal	0.9
Footprint of 5 South Mine	Vertical	2
Footprint of River Barrier Pillar	Vertical	4
TOTAL	all components	48

Upward vertical gradients are expected to return to the Quinsam River valley post-mining, thus seepage from the River Barrier Pillar is expected to travel upward from the mine footprint. This amount of seepage is expected to be small ($2 \text{ m}^3/\text{d}$) in relation to volumetric fluxes calculated for other areas of the mine.

Assessment of Seepage Rates from Quinsam River Baseflow

A groundwater yield per unit area of watershed of $\sim 2 \times 10^{-5} \text{ m}^3/\text{s}$ per m^2 has been calculated for the mine areas flanking the Quinsam River. This calculation has been discussed in detail in the 7 South Mine Groundwater Evaluation (Lorax, 2011b) and has been summarized in this report in Section 4.4.1.2. Prorating this groundwater yield for the combined areas of the 5 South mine and River Barrier Pillar provides an independent

check on the groundwater seepage fluxes calculated by Crystal Ball. The resultant groundwater flux is $\sim 16 \text{ m}^3/\text{d}$, or one third of the value predicted by Crystal Ball ($48 \text{ m}^3/\text{d}$). The groundwater yield rate based on Quinsam River baseflows is dependent on a number of factors which are variable across the mine site (soil cover, bedrock geology) and is also impacted by storage and evaporation effects for water bodies in the catchment. However, it is believed to be a reasonable lower bound estimate of groundwater fluxes from these mine areas.

Assessment of Seepage Rates from Precipitation and Infiltration

For assessment of contaminant loading rates from the 5 South mine and River Barrier Pillar, calculations have been performed representing “most likely” or expected seepage fluxes and “upper bound” or worst case conditions, as has been done for the 2 North and 3 North (and 7 South) areas. The combined seepage rate of $\sim 48 \text{ m}^3/\text{d}$ calculated with Crystal Ball is considered to be the most likely seepage condition.

Lorax (2009) modelled the mean annual precipitation for the mine site and estimated it to be 1,034 mm/yr (Lorax, 2009), which translates to a total daily precipitation over the 5 South and RBP areas of $2,400 \text{ m}^3/\text{d}$. Note that the seepage rate calculated using Crystal Ball (*i.e.* the ‘expected’ rate of $48 \text{ m}^3/\text{d}$) is equivalent to 2% of mean annual precipitation. This low infiltration rate is consistent with field observations and experience of the author at other sites. In other mine areas of the site, infiltration rates expressed as a percentage of mean annual precipitation have ranged between 2-4%.

In previous analyses, we have assumed that the worst case (*i.e.* highest flow) condition is best estimated by assuming 10% infiltration of mean annual precipitation, which, for the 5 South, is about four times higher than the ‘expected’ seepage rate. The upper bound estimate of seepage is thus $240 \text{ m}^3/\text{d}$. As was the case for the 2 North / 3 North mines, the upper bound seepage rate takes into account uncertainties such as the potential for development of subsidence features which propagate to surface and preferential flow through faults.

4.4.5 Travel Times from 5 South and River Barrier Pillar Area to Quinsam River

The travel time for seepage originating from the 5 South area can be treated in a similar fashion to the seepage originating from the 2 North area. For the 2 North area, it was found that the fastest seepage pathway occurs where the coal seam is shallow with seepage travelling from the workings through the intact coal and then deflecting upward to the river through intact sandstone (Figure 4-14, Pathway B). This same situation applies for the 5 South area. Along the western portion of 5 South segment 2 (Figure 4-13), the horizontal hydraulic gradients are steep (30%), the No. 1 coal seam is

shallow (~30 m below the river bed) and the mine is set back a minimal distance from the river (~60 m). Based on these parameters, the minimal travel time for seepage from 5 South to reach the Quinsam River is 553 days or 1.5 years.

The predominant seepage pathway from the River Barrier Pillar is directly upward from the mine footprint to the bed of the Quinsam River through intact sandstone. The shortest travel time will occur at the upstream portion of the RBP, where the coal seam is higher. At this location, the coal seam is about 75 meters below the river elevation. The calculated travel time is 1300 days or 3.6 years.

4.4.6 Recharge Rate to a Fully Dewatered Mine (5 South and RBP Areas)

QCC has produced a reflooded volume vs. water level elevation curve for the 5 South Phase 1 workings based on water levels measured at QU05-13W (Appendix A-5). Between the middle of 2010 and March 16th, 2011, the water level elevation in the mine rose from 115 m to 151 m, corresponding to a volume change of ~359,000 m³. Assuming this took about 260 days to occur, the resultant reflooding rate is 1,385 m³/d. If this early reflooding rate is applied to the projected total mine volume including Phase 2 (~1,200,000 m³); the anticipated reflooding time for the entire 5 South mine is approximately 2.4 years. Using the early reflooding rate will underestimate the reflooding time since recovery rates are expected to slow down as reflooding progresses.

The mine plans plug the 8 Mains (under river) workings which will isolate the 2 North and 5 South mine voids. The RBP will remain connected to the 2 North workings and as such is expected to reflood within the timeframe estimated for the reflooding of the 2 North mine, *i.e.*, 3.7 years.

4.5 Summary

The groundwater flow system in the vicinity of the 2 North/3 North, 5 South and River Barrier Pillar (RBP) mines is complex due to the presence of significant water-bearing faults, subsidence related fracturing in much of the mining area, including sinkholes and cracks extending to surface, as well the hydraulic linkage of the mines beneath the Quinsam River. A conceptual model for groundwater flow in the study area has been developed for predicting seepage rates and contaminant mass flux from the mine areas that explicitly recognizes the effects of subsidence induced fracturing and water-bearing faults that intersect the mine areas. The potential for seepage from existing or future subsidence features is addressed by considering an upper bound seepage rate based on infiltration of 10 % of mean annual precipitation. The conceptual model and hydrogeologic analysis was designed to predict seepage rates of mine-influenced waters

from underground mine voids with mine pools as well as underground areas proposed for disposal of tailings and coarse coal refuse (CCR).

The assessment of groundwater seepage in the mining areas was based on review of previous work, a geotechnical assessment of subsidence and a field program conducted during 2010/2011. The field investigation involved measurement of rock mass permeabilities from packer tests and slug tests, a water level monitoring program, and a baseline groundwater quality sampling program.

The 2 North/3 North mine, located north of the Quinsam River, is the largest underground mining area at the Quinsam Mine with extensive gob areas that have been depillared or partially depillared. Sinkholes and subsidence-related cracks have been identified, largely at the western up-dip area of the mine. A significant water-bearing fault, the Forjan Fault intersects the 2 North mine and is a conduit for seepage from the mine towards the Quinsam River. Under the post-closure conditions assumed for this hydrogeological assessment, tailings produced from the 7 South Mine will be disposed in a portion of the 2 North / 3 North mines and allowed to flood. The majority of the 2 North / 3 North mine is expected to remain flooded under post-closure conditions with the exception of western up-dip region of the mine where flooding levels are expected to be controlled by discharge from subsidence-induced cracks or other subsidence features. The expected seepage rate from the 2 North / 3 North mine is 220 m³/day which includes approximately 130 m³/day (60 %) via the Forjan Fault and the remainder through lesser fractures in the sedimentary strata. Reflooding of the mine, based on recharge from precipitation and snowmelt and assuming this mining area is hydraulically isolated from the 5 South and RBP mines, is expected to take on the order of 3.7 years. The shortest travel time for seepage from the 2 North Mine to the adjacent Quinsam River is expected to be less than 2 years.

The 5 South mine is located south of the Quinsam River and develops the same No. 1 Coal Seam as the 2 North / 3 North mines. A significant portion of the 5 South mine will be partially depillared and these areas will be associated with subsidence-related fracture zones overlying the workings. Following development, the mine will be allowed to flood with no plans for tailings or coarse coal refuse disposal in the workings. No significant water-bearing faults have been identified as intersecting the 5 South mine and seepage will be controlled by fracturing in the coal seam and sandstones. The expected seepage rate reporting to the Quinsam River from the 5 South mine is 48 m³/day. Reflooding of the 5 South mine, based on rates of water level recovery during late 2010/early 2011, and assuming the mine is hydraulically isolated from the 2 North / 3 North mines, is expected to take a minimum 2.4 years. The shortest groundwater seepage travel time from the 5 South Mine to the Quinsam River is expected to be in the order of 1.5 years.

The RBP Mine is a relatively small mine covering a plan area of some 7 ha. This mine also develops the No. 1 Coal Seam and is located some 75 m below the Quinsam River. The mining plan calls for leaving the pillars intact and disposing of CCR in the underground workings and then allowing the mine to flood. When the RBP mine has flooded, seepage from the mine is expected to be upward through the roof of the mine and then into the Quinsam River. The expected seepage rate is approximately 4 m³/day and the travel time to the Quinsam River is expected to be in the order of 4 years. The RBP will remain connected to the 2 North workings after placement of a plug in the No. 8 Mains and as such is expected to reflood within the timeframe estimated for the reflooding of the 2 North mine, *i.e.*, 3.7 years.

5. Water Quality



HILLSBOUROUGH
Resources Limited

5. Water Quality

A field sampling program was carried out to characterize water quality in the 2 North / 3 North and 5 South areas of the Quinsam Coal Mine. This chapter discusses the implementation of the field investigation, sample collection and water quality evaluation, including a comparison to the relevant British Columbia guidelines. The components of the investigation are described in Section 5.1 below. Section 5.2 discusses the water quality results and the conclusions are summarized in Section 5.3.

5.1 Water Monitoring Program Description

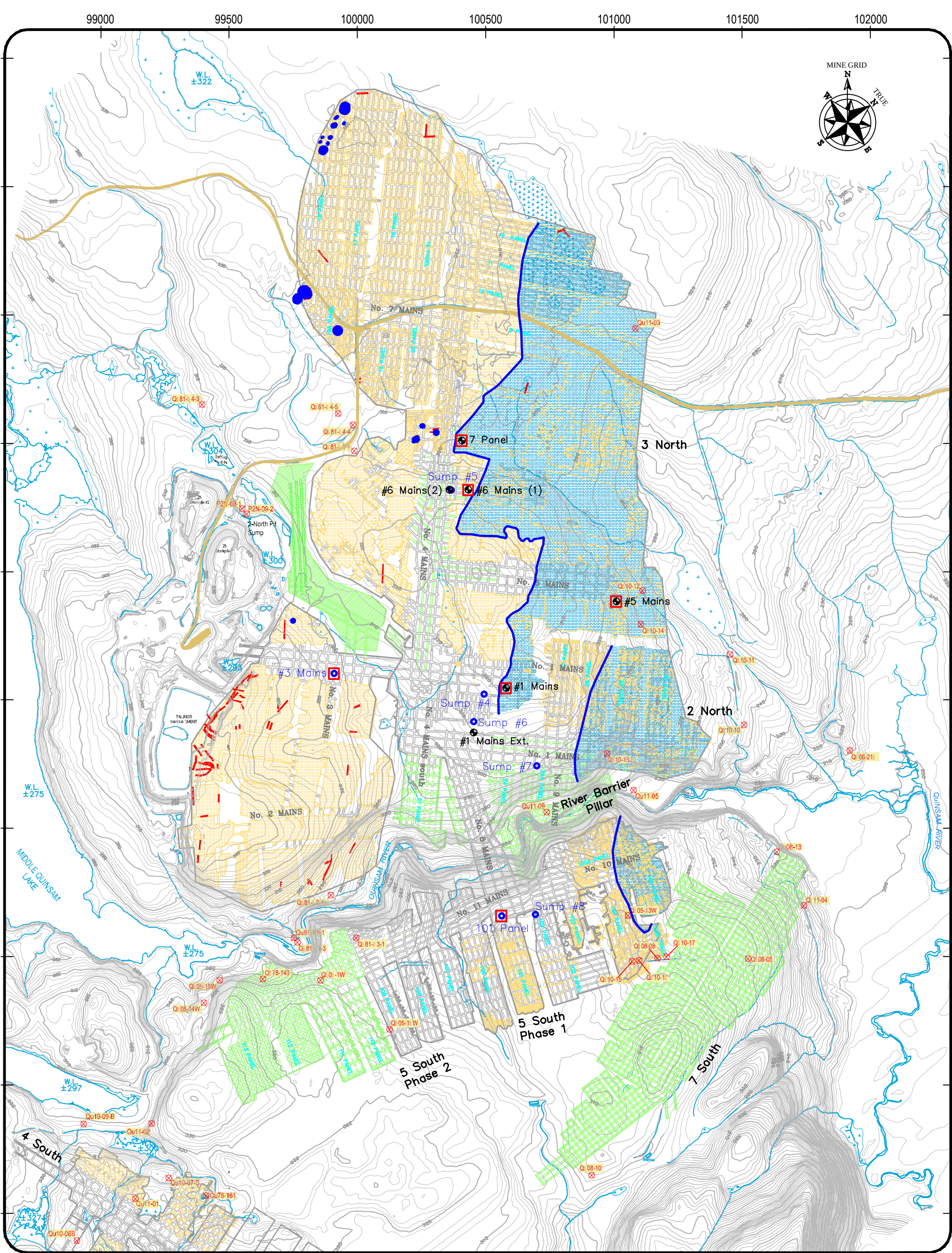
The field program is comprised of two components:

1. Sampling of underground mine pools either directly from underground or from surface through boreholes that intersect the mine workings and
2. The installation, development and sampling of monitoring wells to collect formation groundwater.

Water flows into the underground mine workings pools in the down-dip ends (lower portions) of the 2 North / 3 North and 5 South mines. Once all the coal has been extracted from an area of the existing mine, the area is allowed to flood up to an elevation that does not affect mining in other active mine areas. The approximate extent of the mine pools in June 2010 is presented on Figure 5-1. Currently, the elevation of the mine pool is controlled by pumping from several underground sumps and more recently by pumping from three boreholes that intersect the mine workings by three vertical turbine pumps. The locations of the underground sumps and vertical turbine pumps are also shown on Figure 5-1 and listed in Table 5-1. Monitoring has been conducted intermittently by QCC at these locations starting as early as 2006.

Additional mine pool samples have been collected by Lorax from monitoring wells that intersect the mine workings. Samples were collected in January 2011 from the 2 North mine pool through QU-10-13 and from the 5 South mine pool through QU-05-13W (Figure 5-1).

The 5 South monitoring well network was installed by Golder (QU-05-15, QU-05-16 and QU-06-01) and by BEA (QU-81-P3-1-1 and QU-81-P3-1-3). The location of the monitoring wells is illustrated in Figure 5-1 and a list of the monitoring wells and the screened zones are summarized in Table 5-1. Groundwater water quality monitoring at 5 South has been conducted by QCC and Golder since June 2006 with wells QU-05-15, QU-05-16 and QU-06-01. In 2010, Golder also sampled QU-81-P3-1-1 and QU-81-P3-1-2.





LORAX
ENVIRONMENTAL

Meters
0 100 200

Projection: Mine Grid Coordinates

Project No.
J885-1

Client
Hillsborough Resources

Date
May 10, 2011

Figure Title

Groundwater and Mine Water Sampling Locations

Figure Number

5-1

	Mine Workings		Mine Pool Extent June 2010		Groundwater Well
	Proposed and Recent (2011) Workings		Road		Sump / Pumping Stations
	GOB		Subsidence Cracks		Vertical Well Bore
	Surface Water Body		Water Sample Site		Sinkholes
					Swamp/Marsh

Legend

**Table 5-1::
Description of 5 South and 2 North Water Quality monitoring locations.**

Water Classification	Target Zone for Water Quality Monitoring	5 South		2 North	
		Well ID	Observations	Well ID	Observations
Mine water	Mine void	QU-05-13	Flooded mine pool	QU-10-13-D	Flooded mine pool
				QU-11-03	Flooded mine pool, fracture flow from upper strata
	Mine sumps	101 Panel	Surface grab samples	7 Panel	Surface grab samples
				1 Mains	Surface grab samples
				3 Mains	Surface grab samples
				5 Mains	Surface grab samples
				6 Mains	Surface grab samples
Formation Water	No. 1 Coal Seam	QU-05-16-MW4	Up-dip	QU-08-21G-D	Down-dip, slow
		QU-06-01-MW5	Up-dip, slow, surface water affected	QU-10-10-D	Down-dip, slow
				QU-10-11-D	Down-dip, slow
				QU-11-05-D	Down-dip
				QU-11-09-M	Down-dip
	Dunsmuir sandstone	QU-81-P3-1-1	Up-dip, till interface	QU-08-21G-S	Down-dip, fast
		QU-81-P3-1-2	Up-dip, till interface	QU-10-10-S	Down-dip, moderate
				QU-10-11-S	Down-dip, fast, fracture flow
				QU-11-05-S	Down-dip, fast, fracture flow
				QU-11-09-S	Down-dip, fast
	Quartz Diorite intrusion	QU-05-15-MW1	Slow, shallow		

A network of monitoring wells was installed by Lorax along the eastern and southern limits of the 2 North Mine (Figure 5-1). Installations were initiated in November 2010 and completed in April 2011. A summary of the target zone for the screened intervals of the monitoring wells are listed in Table 5-1. A detailed description of the well installation and development is presented in Section 4-1 and well completion logs are presented in Appendix A1. Sampling of the 2 North groundwater monitoring network was conducted by Lorax in December 2010 through April 2011.

Based on observations during well installation and sampling the water quality results from two locations are not included in the overall water quality discussion, although the analytical results of the samples are included in Appendix C3. During the drilling of QU-11-03 in January 2011, significant inflows were observed from fractures above the mine void. Significant effervescence was observed in the water sample collected shortly thereafter and it is suspected younger formation water from upper strata entered the well through fracture flow during sampling. Thus, the water chemistry of this well is a mixture

of shallow groundwater and mine water and is only representative of the water in the bore hole. The monitoring well QU-06-01-MW5 terminated in a road box below ground surface, on several occasions surface water was observed to pool at the well opening and the J-plug was noted to be loosely seated in the well opening, suggesting this well is surface water affected.

5.2 Water Quality Characterization

Water quality samples characterizing the 2 North and 5 South mine and formation waters were collected and tested in accordance with BCMOE (2009) guidelines. The water quality of 2 North and 5 South groundwater is summarized and presented as general characteristics (Section 5.2.1), major ion chemistry (Section 5.2.2), and parameters of concern (Section 5.2.3) for each of the water types identified in Table 5-1. Trends and anomalies in the major ion chemistry and concentrations of metal(oid)s with respect to the relevant British Columbia water quality guidelines are identified and described. The groundwater sampling methods and data quality control discussion are presented in Appendix C1 and C2 and the full water quality dataset is presented in Appendix C3. A summary of percentile values for a subset of parameters is included in Appendix C4.

The parameter concentration ranges are shown as box plots overlaid with scatter plots, an example of the plot is presented in Figure 5-2. The box plot depicts the concentration ranges in terms of data set percentiles; a shaded box is drawn between the 25th and 75th percentiles, the median (50th percentile) is shown as a long vertical line inside the box, outside the box vertical lines are drawn at the 10th and 90th percentiles and connected to the box with a single horizontal line (also referred to as “whiskers”). Individual sample data are plotted as discrete points overlaid on the box plot and show the scatter of data points for each parameter. As a consequence of assigning detection limit values to non-detect results, or due to a limited number of data points some data sets are asymmetrical with percentiles overlapping or missing on the box plots.

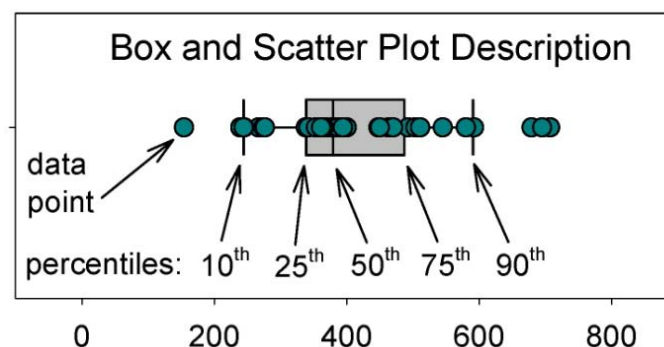


Figure 5-2: An example of a box plot overlaid with a scatter plot illustrating how the data points, median and percentiles are displayed in the graph.

5.2.1 General Water Quality Characteristics

The general groundwater characteristics are described in terms of conductivity, alkalinity, pH and reduction-oxidation (redox) tendency. Of these, the redox tendency is inferred by evaluating parameters associated with groundwater redox buffering reactions (ammonia, iron and sulphide). Parameter concentrations in terms of the median and 10th and 90th percentiles are indicated on figures in this Section and in Appendix C4. The water quality parameters of pH, conductivity and alkalinity are described in relative terms as low, moderate or elevated; redox tendency is described as mildly, moderately or strongly reducing.

The conductivity, pH and alkalinity ranges of 2 North groundwater are shown in Figure 5-3. The mine water was circum-neutral with elevated alkalinity and conductivity, with the elevated conductivity levels directly related to elevated sulphate concentrations. The mine water (with pH 10th and 90th percentiles of 7.70 and 8.35 respectively) was slightly more alkaline than the No. 1 Seam groundwater, while the Dunsmuir sandstone groundwater pH range spans both of the other water types.

The No.1 Seam groundwater in 2 North was circum-neutral with moderate alkalinity and an elevated conductivity ranging from 1770 $\mu\text{S}/\text{cm}$ (10th percentile) to 7720 $\mu\text{S}/\text{cm}$ (90th percentile). Unlike the mine waters, the conductivity values at QU-08-21G-D and QU-10-10-D are due to elevated sodium and chloride concentrations and are significantly greater than the 2 North mine water conductivity levels.

The 2 North Dunsmuir sandstone groundwater was circum-neutral and was marked by the lowest alkalinity and conductivity levels in the 2 North waters; conductivity ranges from 166 $\mu\text{S}/\text{cm}$ (10th percentile) to 1120 $\mu\text{S}/\text{cm}$ (90th percentile).

The 5 South mine water, similar to 2 North, was circum-neutral with elevated alkalinity and conductivity levels (Figure 5-4). The elevated conductivity ranging from 1330 $\mu\text{S}/\text{cm}$ (10th percentile) to 3610 $\mu\text{S}/\text{cm}$ (90th percentile) is directly related to the elevated sulphate present in the mine water.

The up-dip No.1 seam groundwater in 5 South was circum-neutral with moderate alkalinity and moderate conductivity ranging from 412 $\mu\text{S}/\text{cm}$ (10th percentile) to 671 $\mu\text{S}/\text{cm}$ (90th percentile), significantly lower than the down-dip groundwater conductivity values observed in 2 North. The pH of these waters was slightly more alkaline than the mine water.

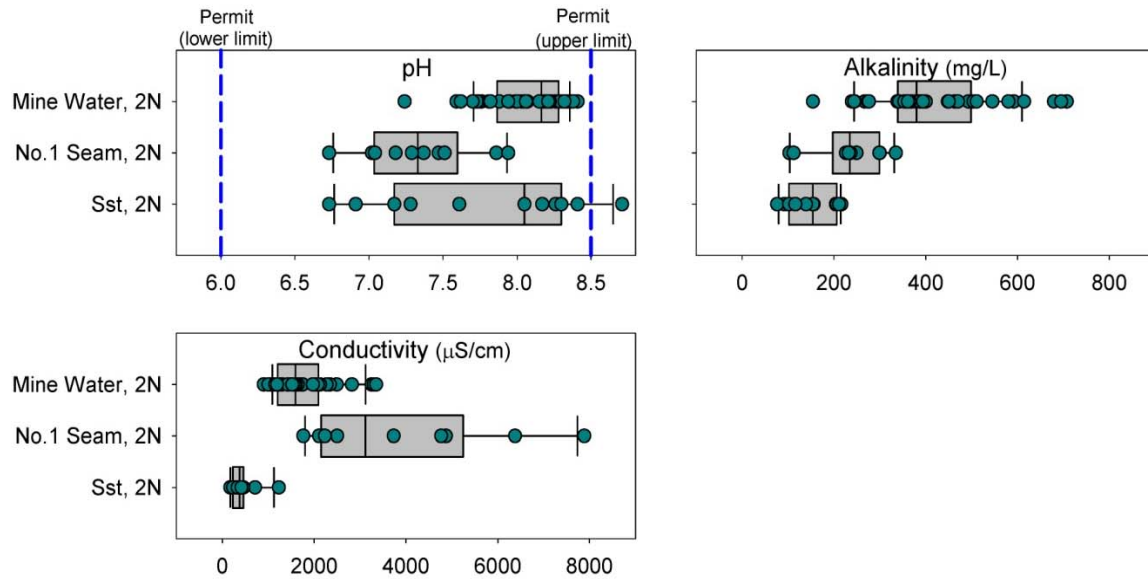


Figure 5-3: Alkalinity, pH and conductivity concentration ranges for the 2 North groundwaters.

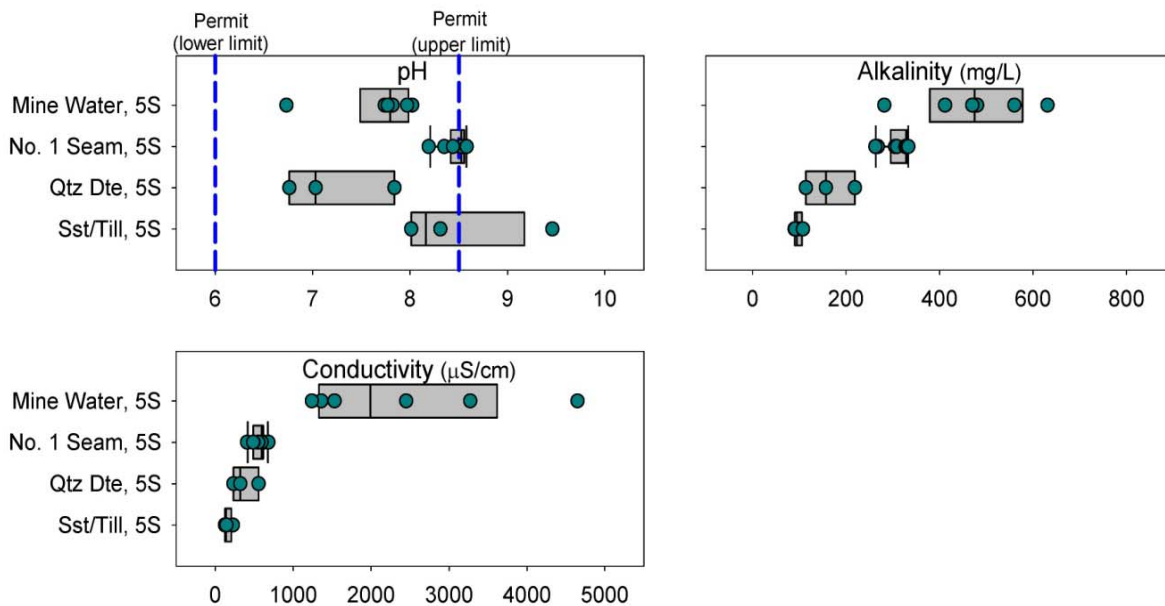


Figure 5-4: Alkalinity, pH and conductivity concentration ranges for the 5 South groundwaters.

The 5 South quartz diorite and sandstone/till interface groundwater was circum-neutral with low alkalinity and conductivity. A pH of 9.46 was observed in the groundwater of the sandstone/till interface at QU-81-P3-1-1 (14 July, 2010), and though this result is suspect there are insufficient data to statistically identify this result as an outlier.

The reduction-oxidation (redox) condition of groundwater is typically governed by redox buffering reactions of oxidizable or reducible chemical species present in the groundwater system, and can be evaluated by examining the presence of reduced species such as ammonia, ferrous iron and hydrogen sulphide (Drever, 1988). The progression of groundwater redox conditions leading to the formation of reduced species can be generally described as mildly reducing (ammonia), moderately reducing (dissolved iron) and strongly reducing (hydrogen sulphide). The presence of any of these species in the formation groundwater indicates the groundwater is anoxic.

The 2 North and 5 South mine water sumps are affected by both surface water and formation water inflows with fluctuating levels of dissolved iron and ammonia (Figure 5-7; Figure 5-8; Appendix C3) indicating that the sump mine water varied from oxic (oxidizing) to anoxic (moderately reducing) conditions. Whereas the dissolved iron, ammonia and sulphide levels in mine void water collected at QU-05-13 and QU-10-13-D (Figure 5-6; Appendix C3) indicate the flooded mine void water are moderately to strongly reducing in both the 2 North and 5 South mines.

All three redox indicator species are present in 2 North No.1 Seam and Dunsmuir Sandstone groundwater (Figure 5-7; Appendix C3) indicating moderately to strongly reducing conditions in these formation waters. The 5 South No. 1 Seam and sandstone/till interface groundwater was moderately reducing based on the observed dissolved iron levels (Figure 5-8) for the No. 1 coal seam groundwater and the ammonia and sulphide levels in the sandstone/till interface. Dissolved iron and ammonia detected in 5 South quartz diorite groundwater indicate these waters are moderately reducing.

5.2.2 Major Ion Chemistry

The major ion chemistry of the 2 North and 5 South waters is illustrated using trilinear Piper plots (Freeze, 1979) that present the relative proportion of the major ions as charge equivalents. For 2 North and 5 South the significant major ions include calcium, magnesium, sodium, bicarbonate, chloride and sulphate. Based on the piper plots the waters are classified into distinct types and the evolution and mixing of the different water types identified in Table 5-1 is discussed. The major ion chemistry of 2 North waters are presented in Figure 5-5 and the 5 South waters are presented in Figure 5-6.

The 2 North mine waters have a distinct sulphate signature (Figure 5-5) and are classified as sodium-sulphate type waters but have a variable calcium and bicarbonate influence. Specifically, underground sump samples have the strongest influence of younger calcium-bicarbonate water likely reflecting high seasonal inflows of surface and shallow groundwaters.

No. 1 Seam groundwater samples from the 2 North area are sodium-chloride type waters. It is notable that the samples with the highest total dissolved solids (QU-10-10-D, QU-08-21G-D) have a slightly higher proportion of calcium and sulphate. However the No. 1 Seam samples plot distinctly from the mine waters, indicating that these waters are not strongly mine influenced. The chloride signature of these relatively deep (below base drainage – Quinsam River) formation groundwaters indicates that these waters are older than sodium and calcium bicarbonate formation waters observed in other locations.

Samples from monitoring wells screened in the Dunsmuir sandstone are predominately sodium-bicarbonate type waters, however, major ion signatures are more variable in this data set compared to the mine waters and No. 1 Seam waters. QU-10-11-S displays a distinct calcium bicarbonate type which suggests this water is affected by fracture flows with significant influence of younger surface waters. The possible influence of sulphate-rich mine water is only observed at QU-11-05-S, which has a sodium bicarbonate-sulphate signature. Fracture flow is suspected at this location as indicated by the high hydraulic conductivity and very rapid recharge rates observed in QU-11-05-S. The sodium chloride-bicarbonate groundwater at QU-08-21G-S and sample collection observations indicate a possible connection between the shallow and deep nested wells at this location suggests there is some mixing of the deeper No. 1 Seam sodium chloride groundwater water with the shallower sandstone sodium bicarbonate groundwater.

The 5 South major ion piper plot indicates that each class of waters has a distinct major ion signature (Figure 5-6). Similar to the 2 North mine water, the 5 South mine water is a sodium-sulphate type water. The strong sulphate signature in these waters is the result of sulphide oxidation in exposed walls and roof of the underground mines.

The No. 1 Seam groundwater in the 5 South area is a sodium bicarbonate type water, which is different than the sodium chloride waters sampled in the 2 North area. The sodium bicarbonate signature and the lower conductivity of the 5 South samples suggest that these are younger waters than those obtained down dip of the 2 North mine from the same stratigraphic interval. Although the No. 1 Seam samples from the 5 South and 2 North areas were collected from the same stratigraphic interval, the 5 South samples are on the up-dip end of the 5 South mine near the base drainage elevation whereas the 2 North samples were obtained at lower elevations well below base drainage of the Quinsam River.

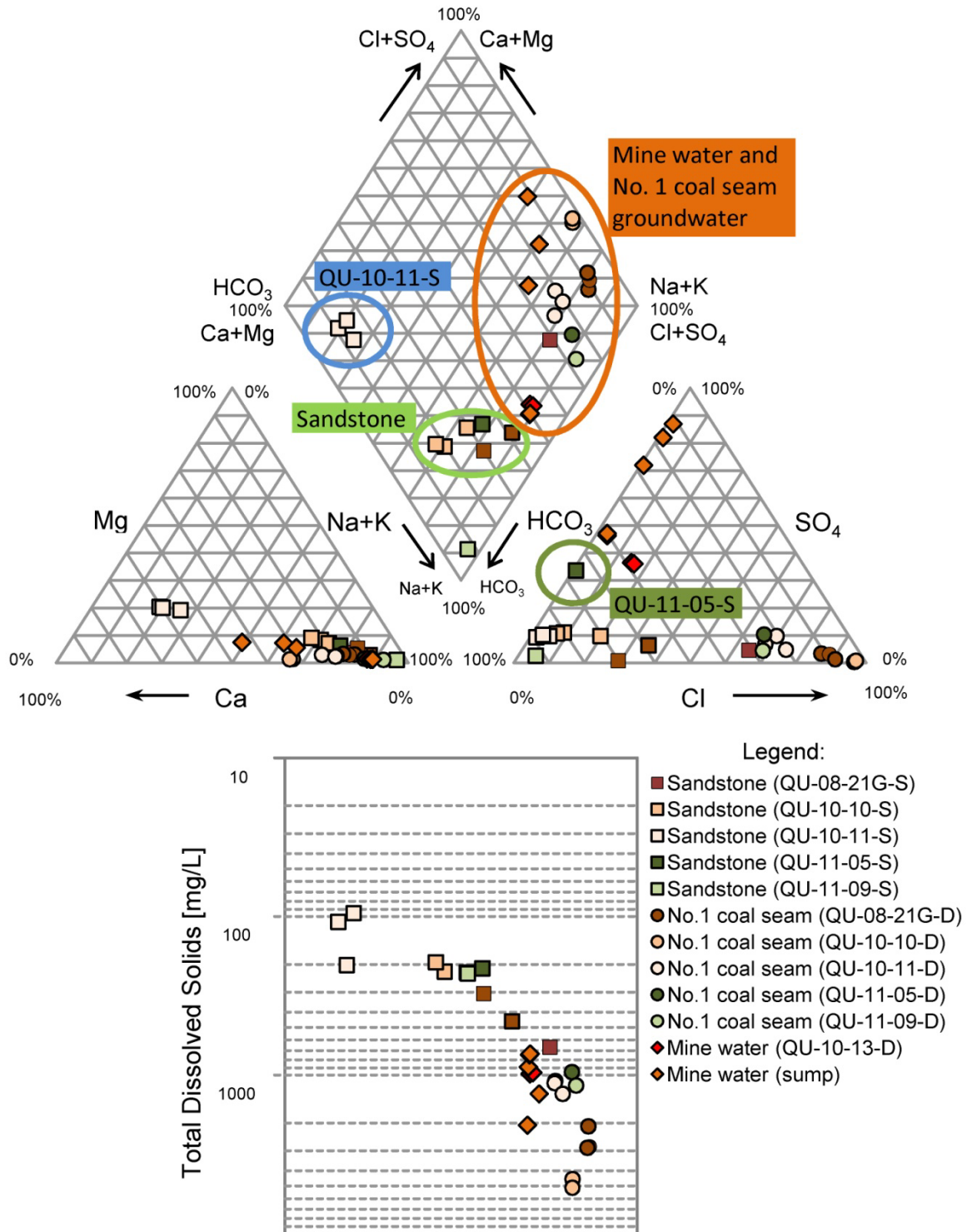


Figure 5-5: Piper plot of 2 North groundwaters showing three distinct water types; mine water, Dunsmuir sandstone and No. 1 coal seam. The ion contents are plotted as percentages of total equivalents per litre.

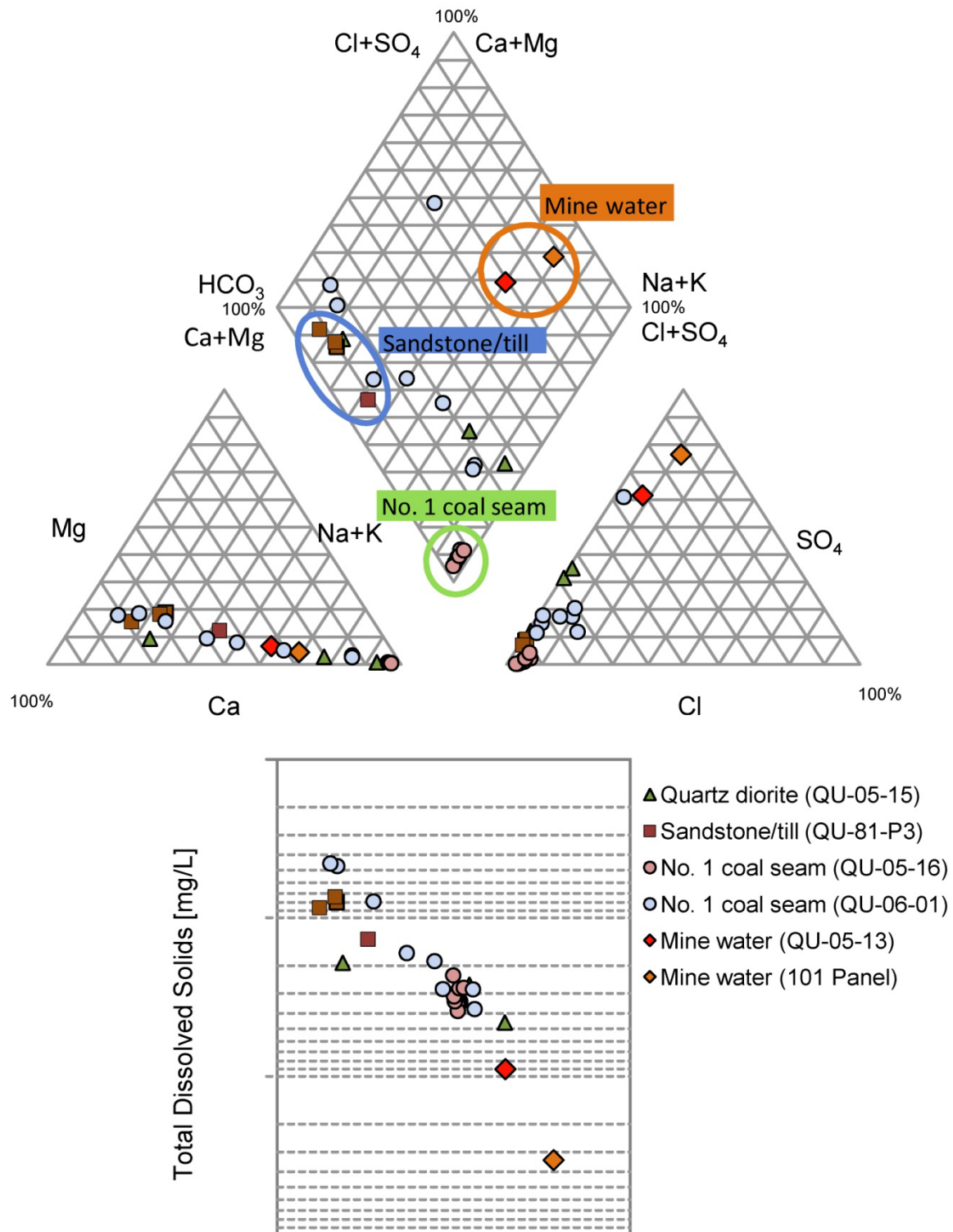


Figure 5-6: Piper plot of 5 South groundwaters showing four distinct water types; mine water, quartz diorite, sandstone/till and No. 1 coal seam. The ion contents are plotted as percentages of total equivalents per litre.

The No. 1 Seam monitoring well QU-06-01 is affected by surface inflows into the well due to the below grade well opening and by a slow recharge. The contamination of this well by inflowing surface waters is confirmed by the variable major ion chemistry ranging from calcium bicarbonate to sodium bicarbonate water and as such has been excluded from further discussion in Section 5.2.3 below.

The 5 South sandstone/till interface groundwater is low conductivity younger calcium bicarbonate type water. This is consistent with the shallow sampling interval well above base drainage near the contact of the Dunsmuir sandstone with the overlying till.

The quartz diorite groundwater is evolved from calcium to sodium bicarbonate-sulphate water with the first collected sample (QU-05-15; May 6, 2010) primarily calcium bicarbonate water. There is no evidence of mine influence in the formation groundwater.

5.2.3 Parameters of Concern

The following discussion pertains to parameters of concern and these have been previously identified as fluoride, sulphate, aluminum, arsenic, boron, cadmium, cobalt, copper, iron, manganese, nickel, selenium, and zinc. Although not a parameter of concern, chloride has been included in this section due to the elevated concentrations observed in the down dip wells of the No.1 coal seam in the 2 North mine area. The 10th to 90th percentile concentration ranges of the parameters of concern and chloride are shown in Figures 5-7 and 5-8 and in Appendix C4, and are compared to Quinsam Coal Corporation Effluent Permit PE-07008 limits and British Columbia Contaminated Sites Regulation Schedule 6 Aquatic Life guidelines (CSR-AW). The 10th to 90th percentile concentration ranges of all parameters of concern were below the CSR-AW guidelines and Effluent Permit limits; except chloride, fluoride, sulphate, dissolved arsenic, dissolved cobalt and dissolved iron. The exceedences are due to the unique chemistries of the mine water and formation water as described below. The concentration ranges of the parameters of concern are described in relative terms as low, moderate or elevated.

For non-detected results the detection limit value is used for graphing and for comparison to permit and/or guideline levels, however where the reported detection limit was significantly elevated above expected and measured concentrations the value is excluded from the graphs to avoid contributing a significant false positive bias to the plot. The excluded data is further described in Appendix C4.

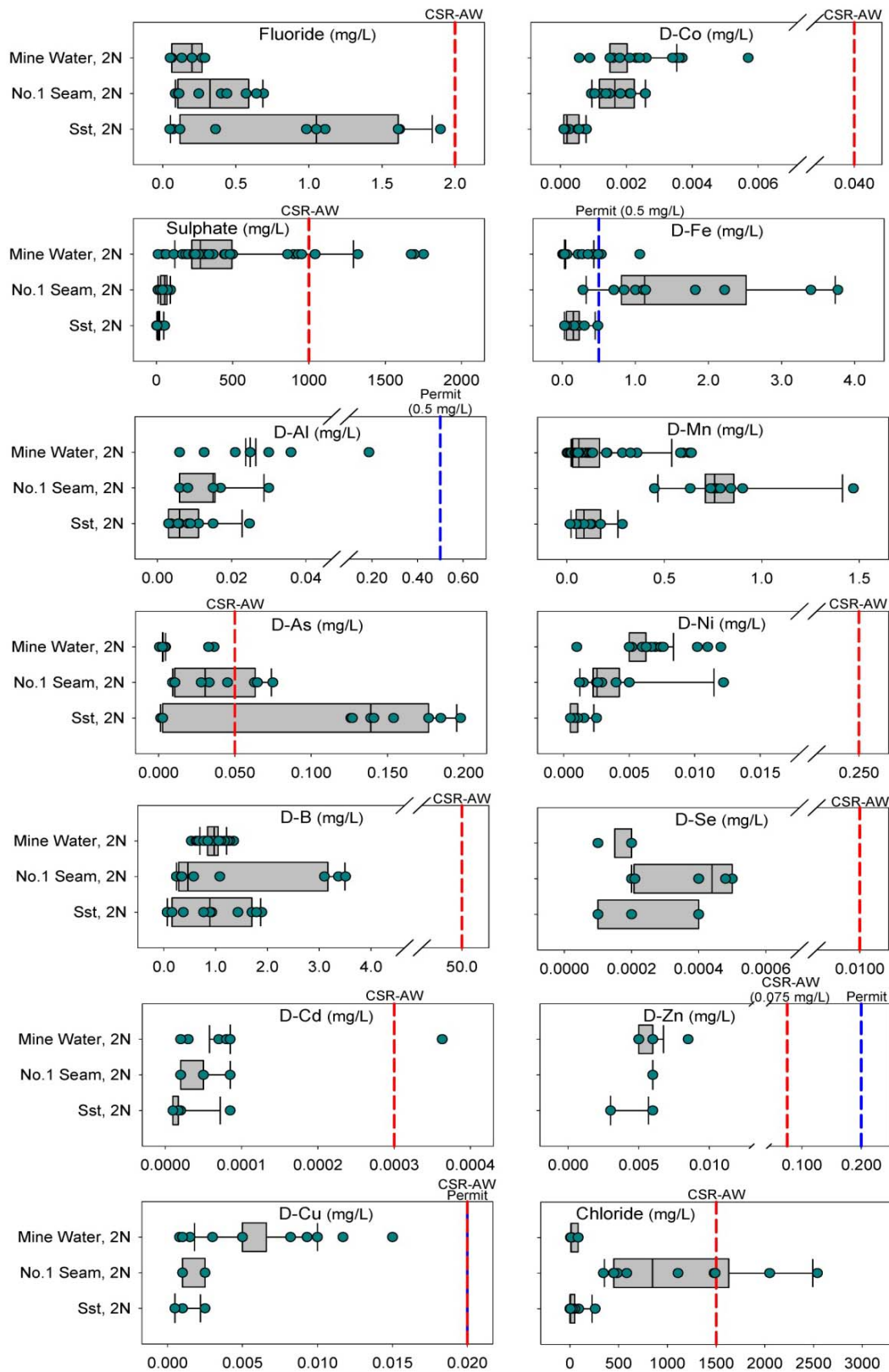


Figure 5-7: Concentration ranges for the 2 North parameters of concern in mine water, No. 1 coal seam and Dunsmuir sandstone (Sst).

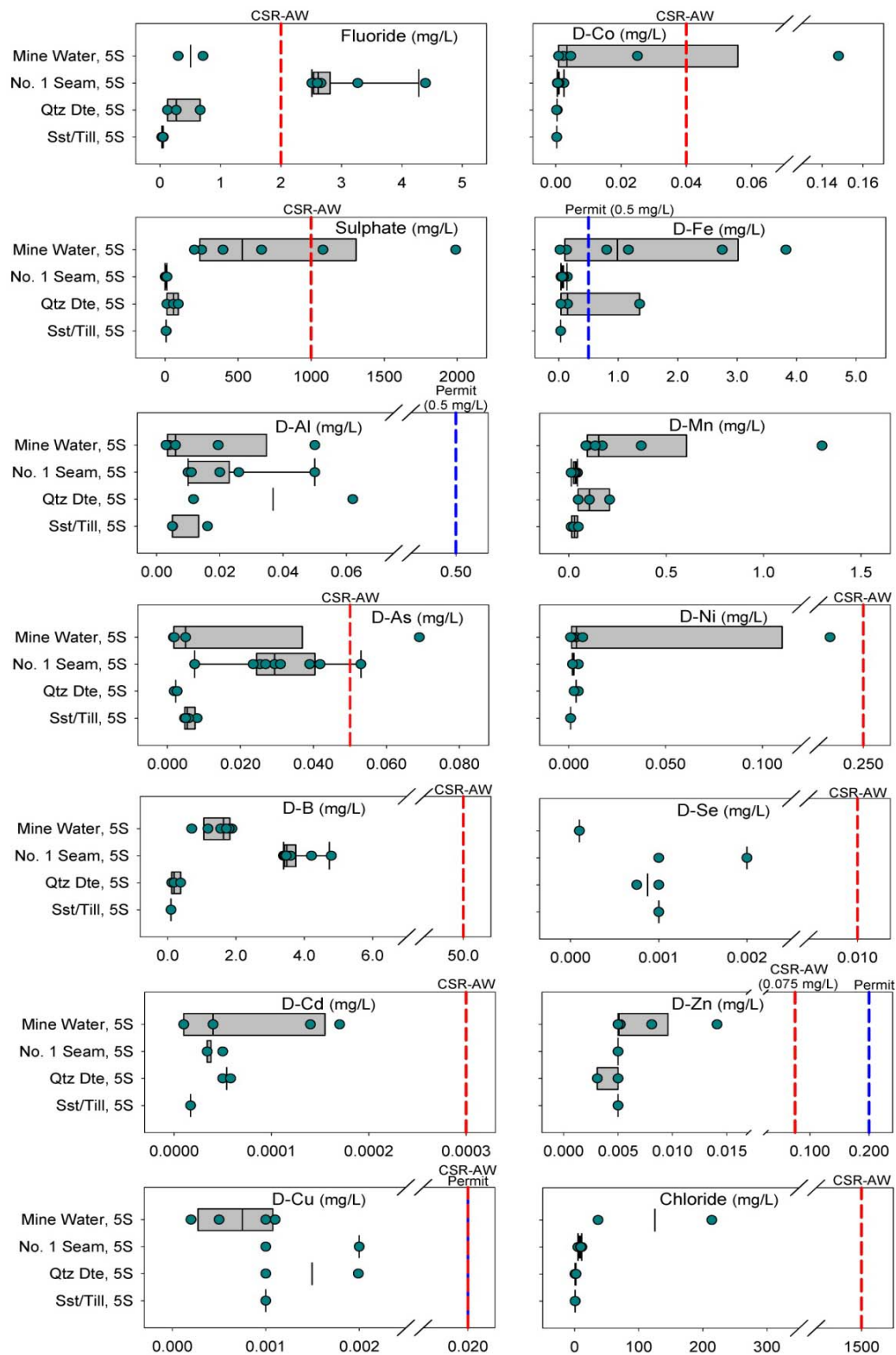


Figure 5-8: Concentration ranges for the 5 South parameters of concern in mine water, No. 1 coal seam, sandstone/till interface (Sst/Till) and quartz diorite (Qtz Dte).

Several parameters of concern (fluoride, dissolved arsenic and dissolved boron) were present at elevated concentrations in 2 North and 5 South groundwaters and are typical of the Nanaimo Group. Elevated fluoride and boron concentrations in groundwater have been previously observed in the Nanaimo Group sandstone and mudstone lithologies (Earle, 2006), and realgar, an arsenic bearing mineral, was reported in the Nanaimo Group Haslam formation by Massey (1989). Elevated levels of these parameters were observed in the shallower 7 South No. 4 coal seam and overlying Dunsmuir sandstone; realgar mineralization in the Dunsmuir sandstone was also noted and discussed in the recent 7 South groundwater study (Lorax, 2011).

As shown in Figure 5-7, fluoride was detected at elevated levels in the Dunsmuir sandstone groundwater with concentrations ranging from 0.049 mg/L (10th percentile) to 1.84 mg/L (90th percentile). The low concentrations observed at Dunsmuir sandstone groundwater well QU-10-11-S (0.048 mg/L and 0.071 mg/L) reflect the influence of younger waters (Section 5.2.2). Fluoride is at moderate levels in the 2 North No. 1 coal seam groundwater, and is at low concentrations in the mine water.

The 5 South fluoride levels shown in Figure 5-8 are distinct from 2 North with the elevated levels in No. 1 Seam exceeding the CSR-AW guideline (2 mg/L) and ranging from 2.51 mg/L (10th percentile) to 4.28 mg/L (90th percentile), while low concentrations were observed in mine water, sandstone/till interface and quartz diorite groundwater. The low fluoride levels in the younger 5 South sandstone/till groundwater compared to the elevated levels in the older 2 North Dunsmuir sandstone groundwater suggest the 5 South waters are relatively young.

Fluoride is a groundwater age related parameter (Brunt, 2004) with fluoride concentrations in groundwater generally increasing with formation contact time. However as described by Stumm (1981) fluoride mobilization is limited by solubility of fluorite (CaF₂). At the observed fluoride concentrations and in the presence of elevated calcium concentrations (exceeding approximately 100 mg/L) the groundwater becomes oversaturated with fluorite and the thermodynamic equilibrium shifts to fluorite precipitation leading to fluoride immobilization and lower groundwater concentrations. The immobilization of fluoride is observed in No. 1 coal seam groundwater by comparing the up-dip 5 South QU-05-15 groundwater with elevated fluoride (2.51 mg/L to 4.39 mg/L) and low dissolved calcium (3.53 mg/L to 4.77 mg/L) to the down-dip 2 North QU-10-10-D groundwater which has low fluoride (0.085 mg/L and 0.095 mg/L) and elevated dissolved calcium (382 mg/L and 480 mg/L). Due to the thermodynamic limitation imposed by fluorite precipitation, the 2 North No. 1 coal seam waters are still considered relatively old waters despite lower fluoride concentrations.

The dissolved arsenic concentration was elevated, and the CSR-AW guideline level (0.050 mg/L) was exceeded in the 2 North Dunsmuir sandstone groundwater with dissolved arsenic ranging from 0.0012 mg/L (10th percentile) to 0.195 mg/L (90th percentile), and in the No.1 coal seam with moderate levels of dissolved arsenic ranging from 0.0091 mg/L (10th percentile) to 0.0738 mg/L (90th percentile). The low concentrations observed in the QU-10-11-S Dunsmuir sandstone groundwater (0.00128 mg/L and 0.00144 mg/L) were likely due to the influence of surface water entering the well via fracture flow at this location as described previously (Section 5.2.2). The 2 North mine water was low in dissolved arsenic (Figure 5-7), however dissolved arsenic in the mine pool mine water at QU-10-13-D was detected at moderate levels (0.0327 mg/L and 0.0364 mg/L), suggesting the arsenic concentration in the stagnant mine pool increases with water residence time in the mine void.

In 5 South the moderate dissolved arsenic levels in No. 1 coal seam groundwater ranged from 0.0074 mg/L (10th percentile) to 0.053 mg/L (90th percentile), slightly exceeding the CSR-AW guideline and in a similar range as the 2 North No. 1 coal seam groundwater. Low levels of dissolved arsenic were observed in the quartz diorite and sandstone/till interface groundwaters (Figure 5-8). The 5 South mine water had moderate levels of dissolved arsenic with the QU-05-13 mine pool dissolved arsenic concentration (0.0690 mg/L) exceeding the CSR-AW guideline.

Dissolved boron in the No. 1 coal seam water was elevated in 2 North ranging from 0.24 mg/L (10th percentile) to 3.49 mg/L (90th percentile), and 5 South ranging from 3.39 mg/L (10th percentile) to 4.73 mg/L (90th percentile). The highest boron levels in 2 North were observed at QU-08-21G-D (3.10 mg/L to 3.51 mg/L). The 2 North mine water and Dunsmuir sandstone groundwater had moderate concentrations of dissolved boron. As shown in Figure 5-8, the 5 South mine water had moderate dissolved boron levels, while low concentrations were encountered in the quartz diorite and sandstone/till interface groundwaters.

The 2 North and 5 South mine water elevated sulphate concentrations exceed the CSR-AW guideline (1000 mg/L) with levels ranging from 119 mg/L (10th percentile) to 1280 mg/L (90th percentile) in 2 North and from 235 mg/L (10th percentile) to 1310 mg/L (90th percentile) in 5 South (Figure 5-7 and 5-8). Median mine water concentrations are 289 mg/L in 2 North, and 527 mg/L in 5 South. Sulphate levels were low in all formation waters of the 2 North and 5 South mine areas. Elevated sulphate has been previously observed in the flooded mine pools of other underground coal mines (Banks, 1997). As discussed in Section 5.2.2 sulphate is a signature of mine affected groundwater. Elevated sulphate levels in mine water originate with the oxidation of exposed sulphide minerals

and subsequent mobilization of oxidized sulphide minerals in the contact waters of the mine walls and floor.

The elevated dissolved iron concentrations in 2 North No.1 coal seam groundwater exceed the Effluent Permit limit (0.5 mg/L) and ranged from 0.319 mg/L (10th percentile) to 3.73 mg/L (90th percentile). The No. 1 Seam groundwater at QU-10-11-D had the highest concentrations (3.40 mg/L and 3.77 mg/L). Moderate dissolved iron levels in 2 North mine water ranged from 0.027 mg/L (10th percentile) to 0.427 (90th percentile) with a median value of 0.030 mg/L (detection limit concentration) with the highest concentrations observed in the 1 Mains (1.06 mg/L) and 3 Mains (0.535 mg/L) mine water sumps. Low to moderate dissolved iron levels were observed in the Dunsmuir sandstone groundwater.

The Effluent Permit limit (0.5 mg/L) for dissolved iron is exceeded in 5 South mine water with levels ranging from 0.094 mg/L (10th percentile) to 3.01 mg/L (90th percentile) and a median value of 0.988 mg/L; and in the quartz diorite groundwater with dissolved iron concentrations ranging from 0.035 mg/L (10th percentile) to 1.36 mg/L (90th percentile). The up-dip 5 South No. 1 Seam and the sandstone/till interface groundwater had low levels of dissolved iron in contrast to the elevated levels in down-dip 2 North No. 1 coal seam and the moderate levels in the 2 North Dunsmuir sandstone.

Elevated chloride levels in 2 North No. 1 coal seam exceed the CSR-AW guideline of 1500 mg/L with concentrations ranging from 349 mg/L (10th percentile) to 2490 (90th percentile). The highest concentrations were observed at QU-10-10-D (2050 mg/L and 2540 mg/L) and QU-08-21G-D (1110 mg/L to 1490 mg/L). Moderate levels of chloride were measured in the 2 North mine water and Dunsmuir sandstone groundwater (Figure 5-7). The 5 South mine water had moderate chloride levels, while low levels were observed in the 5 South No. 1 coal seam, quartz diorite and sandstone/till groundwaters (Figure 5-8). In general, groundwater tends to evolve to sodium chloride type water as it ages in the formation flow path (Freeze, 1979) indicating the down-dip 2 North No.1 coal seam groundwater is older groundwater.

As shown in Figure 5-7 dissolved manganese was elevated in 2 North No. 1 coal seam groundwater with values ranging from 0.465 mg/L (10th percentile) to 1.41 mg/L (90th percentile). Moderate dissolved manganese concentrations were observed the 2 North mine water ranging from 0.020 mg/L (10th percentile) to 0.537 mg/L (90th percentile) with a median of 0.062 mg/L. The Dunsmuir sandstone groundwater was also moderately elevated with dissolved manganese.

The 5 South dissolved manganese levels were moderate to elevated in the mine water and ranged from 0.093 (10th percentile) to 0.602 mg/L (90th percentile) with a median value

of 0.154 mg/L (Figure 5-8). The 5 South quartz diorite groundwater was moderately elevated with dissolved manganese, whereas low levels of dissolved manganese were encountered in the No. 1 coal seam and the sandstone/till interface groundwater.

Dissolved aluminum is at low levels in all 2 North and 5 South mine water and groundwaters (Figure 5-7 and 5-8). The 2 North mine water had a median dissolved aluminum concentration of 0.025 mg/L and a narrow range of 0.024 mg/L (10th percentile) to 0.027 mg/L (90th percentile) due to the many non-detect results at the 0.025 mg/L concentration. The 5 South mine water ranged from 0.003 mg/L (10th percentile) to 0.035 mg/L (90th percentile) with a median of 0.013 mg/L.

All remaining parameters of concern (cadmium, copper, cobalt, nickel, selenium and zinc) in the 2 North and 5 South mine water and formation groundwater were at low concentrations with the exception of the 5 South mine water where moderate concentrations of cadmium and zinc, and elevated levels of cobalt were observed (Figure 5-7 and 5-8). Dissolved cobalt in the 5 South mine water ranged from 0.0008 mg/L (10th percentile) to 0.0556 mg/L (90th percentile), exceeding the guideline level of 0.04 mg/L.

5.3 Summary

The 2 North and 5 South mine water and formation waters are categorized as mine water, No. 1 coal seam groundwater and Dunsmuir sandstone groundwater. In both areas, the mine water is classified as circum-neutral with a distinct sulphate geochemical signature that has been observed in other flooded underground coal mines (Banks, 1997) and can be used to trace the flow paths of mine water. The No. 1 coal seam groundwater is distinct between 5 South and 2 North, with the up-dip 5 South sodium bicarbonate type groundwater evolving to the down-dip 2 North sodium chloride type groundwater. The calcium bicarbonate type water in the up-dip 5 South sandstone/till interface is distinct from the sodium bicarbonate type water observed in the down-dip 2 North Dunsmuir sandstone. The quartz diorite intrusion groundwater in 5 South is sodium bicarbonate type and there is no evidence of influence from 5 South mine water. All parameters of concern are below the CSR-AW guidelines and Effluent Permit limits; except chloride, fluoride, sulphate, dissolved arsenic, dissolved cobalt and dissolved iron. Additional observations are summarized below:

- The wells at QU-06-01 and QU-11-03 do not yield representative samples due to suspected influences from younger waters; data from these wells was excluded from the 2 North and 5 South water quality evaluation.

- The 2 North No. 1 coal seam well at QU-08-21G-D is fault separated from the other 2 North and 5 South wells in the No. 1 Seam. Elevated boron, arsenic and fluoride levels suggest the waters at this location follow a different flow path than other No. 1 coal seam wells in 2 North.
- The 2 North Dunsmuir sandstone well at QU-10-11-S is calcium bicarbonate type water and the low fluoride levels indicate the fracture flow of surface waters is influencing the groundwater at this location.
- Arsenic was elevated in the Dunsmuir sandstone relative to levels observed in the No. 1 Seam, this is consistent with the realgar mineralization previously observed in the sandstone formation (Lorax, 2011b).
- The 2 North and 5 South sump mine water was variably oxic to anoxic, whereas the flooded mine void mine water was anoxic and moderately to strongly reducing. The anoxic formation waters are also moderately to strongly reducing.

6. Geochemical Characterization



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6. Geochemical Characterization

Although the geochemical characteristics of the 2 North / 3 North and 5 South mines are not the focus of 7 South mine permitting, an overview of the geochemical characteristics of these areas are provided in this section to evaluate the combined influence on water chemistry of the combined mine waters and tailings / coarse reject disposal. Potentially acid generating tailings are proposed to be disposed in the 2 North mine workings and PAG coarse reject will be placed in the barrier pillar workings between the 2 North and 5 South mines. A general understanding of the coal and overlying rock strata is required to formulate the rationale for the development of geochemical source terms of the water that will evolve within the 2 North / 3 North and 5 South mine workings. Section 6.1 provides an overview of the No. 1 Seam geochemical characteristics and Section 6.2 provides a summary of the 7 South tailings characteristics. Section 6.3 discusses the geochemical characteristics of the rock strata above the No. 1 Coal seam and finally Section 6.4 presents the geochemical source terms that are used to develop loading estimates from these areas.

6.1 No. 1 Coal Seam Characterization

In the 5 South Mine, the No. 1 Coal Zone varies from 2 to 2.5 m thick. It consists of an upper and middle ply of coal, separated by a thin coaly mudstone parting ranging from 3 to 10 cm in thickness. The middle ply of coal is underlain by a zone measuring 0.5 to 1 m of variable coal and mudstone interbeds. Where this lower zone is more coaly, it is termed the 1 Lower Coalbed and is mined in localized areas. The No. 1 Coal Zone is overlain by a silty mudstone interval called the Rider Parting. The Rider Parting ranges from 0.25m to greater than 0.7 m in thickness and consists of three recognizable intervals (the Upper Rider Parting, the Middle Rider Parting and the Lower Rider Parting). The No. 1 Rider Coal Seam, which overlies the Rider Parting, varies from 0.25 m to 0.50 m thick. The rider seam is overlain by < 1.0 m of mudstone which is in turn overlain by siltstones of the Cumberland Member.

In the 2 North and 3 North areas the general stratigraphy surrounding No. 1 Coal Zone remains the same as observed in the 5 South mine although thicknesses of the units change. In the 2 North / 3 North area No. 1 Coal Zone varies from 2 to 3.3m thick in the central portion of the mining block but decreases in thickness along the northern and eastern margins of the mine. The rider parting increases in thickness toward the northern limits of the mine where it has been observed to be up to 15 m thick. The No. 1 Rider Coal Seam remains in the 0.3 to 0.5 m thickness range. In the 2 North and 3 North areas,

the No. 1 Rider Seam is seldom mined, due to the increased thickness of the intervening Rider Parting.

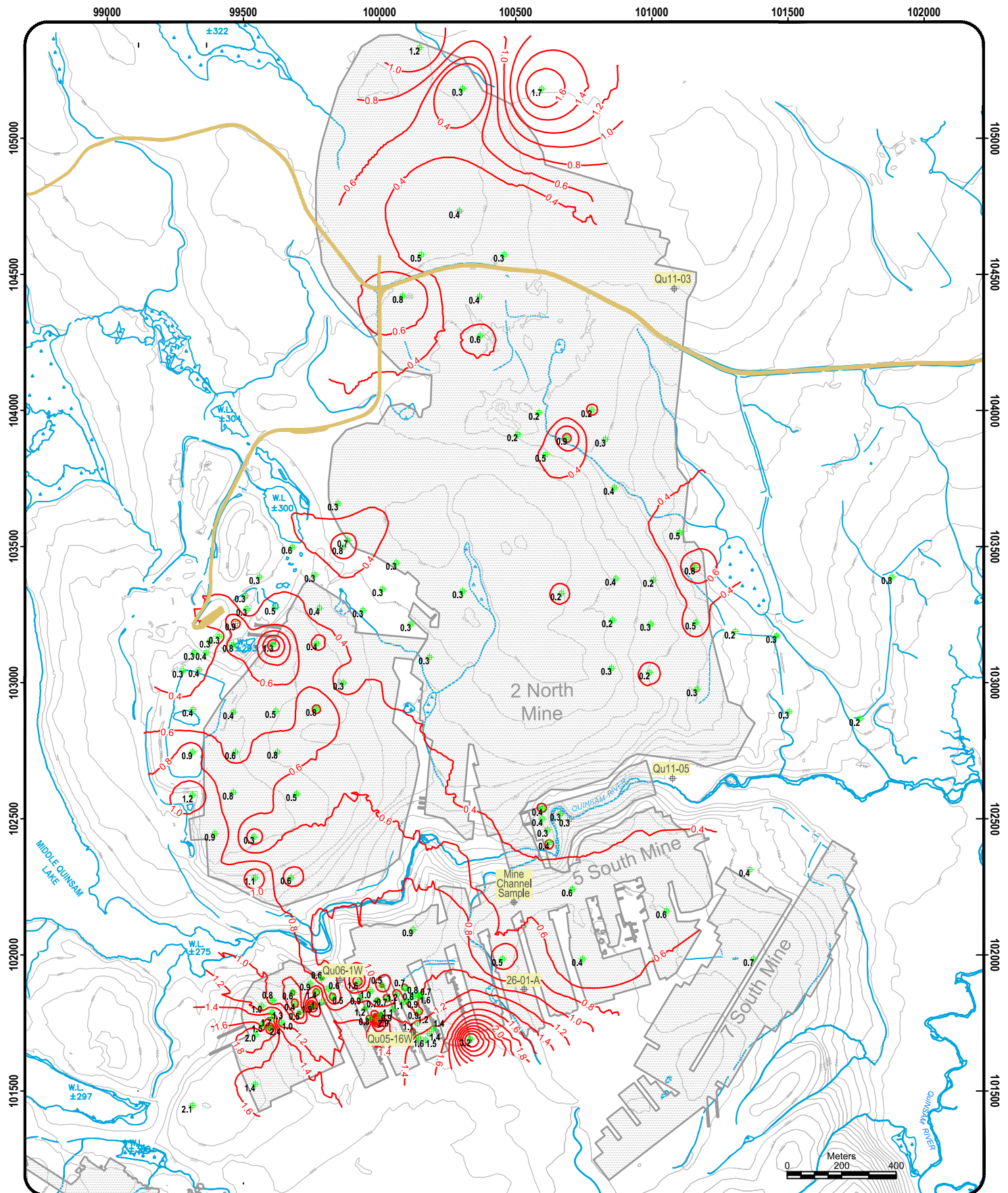
6.1.1 Sulphur Distribution

Total sulphur content increases upward in the stratigraphic section from the base of No. 1 Seam through to the roof of the Rider Seam. The highest sulphur content is observed in the roof strata immediately overlying the Rider Seam, Rider Seam, and Rider Parting. Lower sulphur content is recorded in the No. 1 Seam. The spatial distribution of total sulphur in No. 1 Seam, Rider Parting and the Rider Seam are presented in Figures 6-1, 6-2 and 6-3, respectively.

No. 1 Seam sulphur content is typically < 1.0 %S throughout the 2 North / 3 North and 5 South Phase I mine areas. Higher sulphur contents > 1.0 are identified in the southern portion of the 5 South Phase II with a maximum recorded value of 3.2 %S.

Sulphur contents in the Rider Parting intervals are variable and localized occurrences of up to 5.2 %S in 5 South Phase II. Where the Rider Parting increases in thickness, sulphur contents are lower. Although there are few samples of the Rider Parting in the 2 North / 3 North area, sulphur content would be on the order of 1 %S through this area assuming a correlation with the trends observed in No. 1 Seam sulphur content.

Sulphur content of the Rider Seam is considerably higher than observed in No. 1 Seam or the Rider Parting. Sulphur content is consistently > 2.0 %S throughout the mined areas with a maximum sulphur content of 8.3 %S recorded on the up dip end of the 2 North Mine near the tailings impoundment.



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Projection: Mine Grid Coordinates



Project No. J885-1

Client Hillsborough Resources

Date May 20, 2011

Figure Title

No. 1 Seam
Sulphur Content

Figure Number

6-1

Sulphur Contour
(0.2% interval)

Surface Water Body

Road



Mine Workings
Outline

Qu06-1W

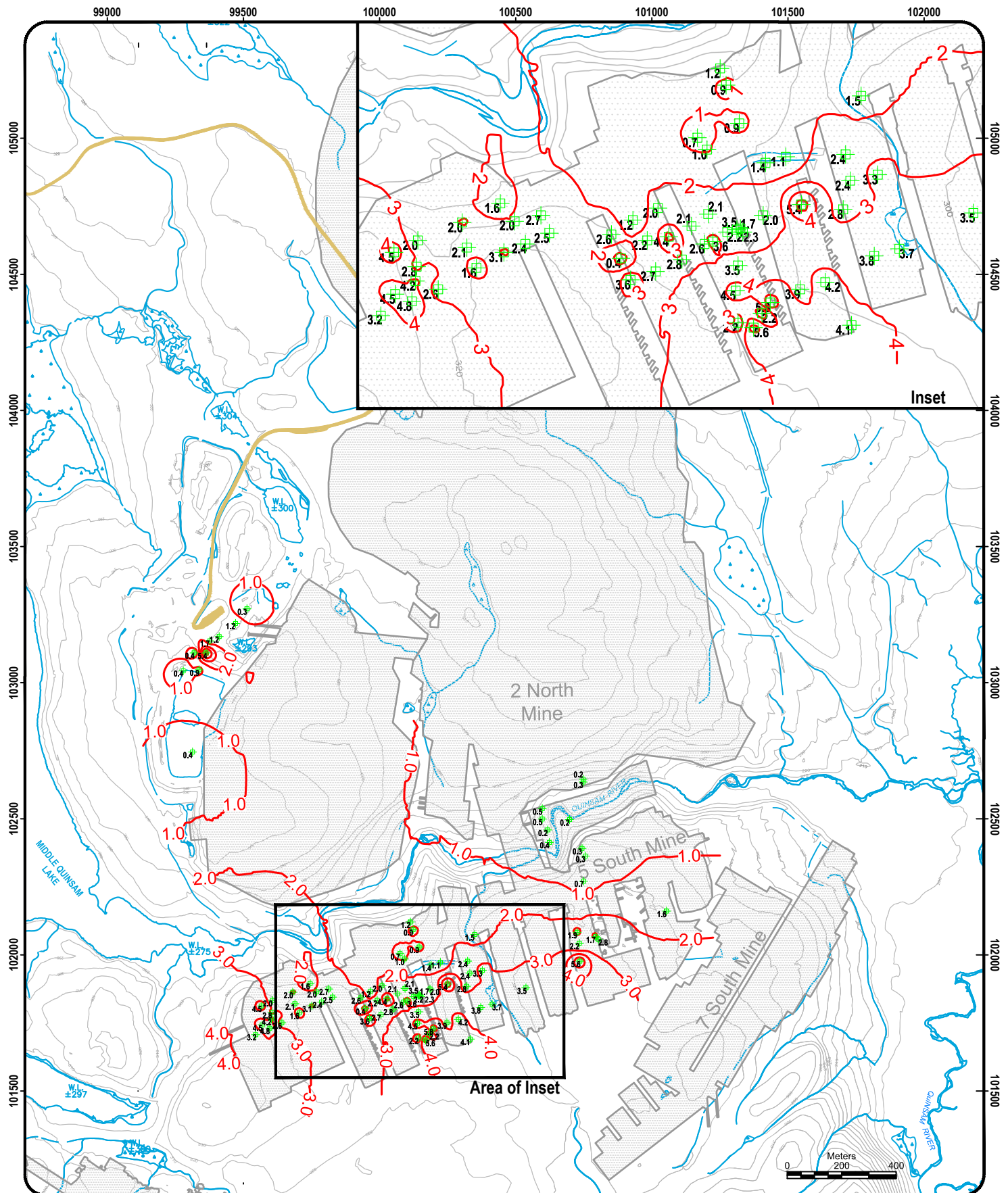


Geochemistry
Samples



Boreholes with
Sulphur Value

Legend



LORAX
ENVIRONMENTAL

Projection: Mine Grid Coordinates



Project No. J885-1

Client Hillsborough Resources

Date May 20, 2011

Figure Title

Rider Parting
Sulphur Content

Figure Number

6-2

— Sulphur Contour

— Surface Water Body

— Road



Mine Workings
Outline



Boreholes with
Sulphur Value

Legend

6.1.2 Static Test Sample Selection

Static test characterization of the No. 1 Seam presented in this section is based on samples collected from the 5 South Mine. The units encountered around No. 1 Seam are similar to those observed in the 2 North / 3 South area. However, due to the higher sulphur content of No. 1 Seam in the 5 South area the overall acid generating potential of No. 1 Seam in the 2 North / 3 South area is expected to be lower than documented in the 5 South samples discussed below. Samples were obtained from two cored drillholes (QU-05-16 and QU-06-01) and one channel sample from the coal face at the west end of the 10 Mains B Road, on the updip extent of the existing workings. The three sample locations are illustrated in Figure 6-1.

The core and underground channel samples were collected by Quinsam Mine staff following discussion with Lorax regarding the sample locations and sample collection methodology. The core was drilled in 2005 and 2006 and stored at an uncovered storage area in wooden core boxes. Core was sampled in May 2009 following 3 to 4 years of storage. Under these storage conditions the core was noticeably weathered and sulphides exposed on the surface of the core were oxidized (Figure 6-4). Core intervals were selected from No. 1 Seam, Rider Parting, Rider Seam and strata located above and below the coal interval. Sample intervals were selected to correspond with distinct lithologies and accounted for underground mining procedures that may result in a particular stratigraphic interval to be included or restricted from the mined section. The core was not split, rather, the entire core from a selected sample interval was removed from the core box, crushed and placed in sample bags or buckets and shipped to the laboratory.



Figure 6-4: Photograph of Upper Rider Seam in Core QU-05-16.

The underground mine channel sample was collected from an existing coal face on the updip side of 10 Mains B Road using a scoop tram (F.E.L.) to clean the coal face and excavate to the base of the No. 1 Coal Seam. Samples from distinct lithologic units were collected in proportions representing the lithologic units within the No. 1 Coal Zone. Samples were placed in sealed 20 litre buckets, palletized and transported to the analytical laboratory at Birtley Coal and Minerals in Calgary.

6.1.3 Acid Base Accounting

The results of the static test analyses and the geochemical characteristics of the strata that are exposed in the 2 North / 3 North and 5 South underground mine workings are discussed in this section. The No. 1 Seam stratigraphy and the acid-base accounting results from the three sampling locations are illustrated in Figure 6-5.

Lithology and Thickness	Lithology	Depth 107.2 m	Paste pH	TIC %	CaCO ₃ NP*	Modified NP*	Sobek NPSc*	C(T) %	S(T) %	S(SO ₄) %	S(S-2) %	Insol. S %	AP*	Modified NP/AP	Sobek Sc NP/AP
Siltstone 0.36 m		107.56 m	7.0	2.63	219.2	61.3	56.4	11.2	0.40	0.060	0.43	0.010	13.4	4.56	4.20
Mudst/Coal 0.62 m		108.18 m	6.1	0.750	62.5	26.2	37.8	16.5	1.1	0.33	0.89	0.010	27.8	0.94	1.36
			4.0	0.130	10.8	-4.8	-7.1	27.1	10	0.96	8.0	1.2	248.4	-0.02	-0.03
No. 1 Rider Seam 0.73 m		108.91 m	6.0	0.550	45.8	44.6	42.4	68.1	1.7	0.25	1.2	0.28	37.2	1.20	1.14
Rider Parting; Mudst/coaly 0.43 m		109.34 m	4.1	0.140	11.7	1.5	3.8	19.5	2.6	0.66	2.0	0.010	61.9	0.02	0.06
No. 1 Coal Seam 2.26 m		109.82 m	5.8	0.450	37.5	36.3	31.3	67.2	2.3	0.34	1.6	0.42	49.1	0.74	0.64
		110.24 m	7.1	0.650	54.2	52.6	51.7	74.1	1.1	0.080	0.74	0.24	23.1	2.27	2.24
			7.1	0.460	38.3	51.4	52.3	71.4	0.80	0.040	0.30	0.46	9.4	5.48	5.58
		110.92 m													
			7.4	0.330	27.5	25.7	30.0	66.9	0.50	0.020	0.090	0.39	2.8	9.14	10.67
		111.6 m													
		111.68 m	7.5	4.81	400.8	408.5	414.8	48.9	0.63	0.17	0.44	0.020	13.8	29.71	30.17
No. 1 Coal Seam 0.46 m		112.14 m	7.5	0.890	74.2	75.4	79.2	71.7	0.32	0.040	0.040	0.24	1.3	60.32	63.36
Mudstone 1.21 m			7.4	1.12	93.3	86.4	97.0	23.3	0.060	0.030	0.030	0.010	0.9	92.16	103.47
		113.35 m	7.3	0.0900	7.5	6.9	11.8	15.3	0.030	0.010	0.030	0.010	0.9	7.36	12.59
No. 1 Basal Dull Coal 0.4 m		113.75 m	7.4	1.30	108.3	104.2	110.7	40.2	0.10	0.040	0.070	0.010	2.2	47.63	50.61
Mdst/Siltst 0.14 m			7.2	1.25	104.2	41.7	48.2	10.9	0.030	0.040	0.060	0.010	1.9	22.24	25.71

* units = kg CaCO₃ / tonne

Figure 6-5a: Acid-Base Accounting Results from QU-05-16.

Lithology and Thickness	Lithology	Depth	Paste pH	TIC %	CaCO ₃ NP*	Modified NP*	Sobek NP Sc*	C(T) %	S(T) %	S(SO ₄) %	S(S-2) %	Insol. S %	AP*	Modified NP/AP	Sobek Sc NP/AP
Rider Roof Mudstone 0.27 m		75.44 m	4.7	0.30	25.0	6.5	15.5	5.5	3.7	0.50	2.9	0.29	91.6	0.07	0.17
		75.71 m													
Rider Roof Mudstone 0.27 m		75.98 m	3.0	<0.010	<0.8	-14.0	-9.2	15	8.4	1.0	6.6	0.77	205.3	-0.07	-0.04
No. 1 Rider Coal Seam 0.43 m		76.41 m	6.3	0.56	46.7	47.8	51.6	66	3.4	0.29	2.3	0.83	70.9	0.67	0.73
Rider Parting 0.24 m		76.65 m	4.5	0.030	2.5	2.0	9.5	11	0.73	0.12	0.60	0.010	18.8	0.11	0.51
No. 1 Main Coal Seam (upper) 0.26 m		76.91 m	7.5	0.24	20.0	28.8	30.1	73	0.51	0.030	0.090	0.39	2.8	10.24	10.70
No. 1 Main Coal Seam 1.55 m		78.46 m	7.3	0.58	48.3	49.2	52.5	66	0.27	0.040	0.090	0.14	2.8	17.49	18.67
1 Seam Floor 0.14 m		78.6 m	6.4	0.060	5.0	5.4	13.3	24	0.20	0.020	0.090	0.090	2.8	1.92	4.73

* units = kg CaCO₃ / tonne

Figure 6-5b: Acid-Base Accounting Results from QU-06-01.

Lithology and Thickness	Lithology	Depth	Paste pH	TIC %	CaCO ₃ NP*	Modified NP*	Sobek NP Sc*	C(T) %	S(T) %	S(SO ₄) %	S(S-2) %	Insol. S %	AP*	Modified NP/AP	Sobek Sc NP/AP
Rider Roof		0.19 m	5.5	0.23	19.2	15.1	20.8	24.6	6.2	0.36	5.5	0.30	173.1	0.09	0.12
1 Rider Seam 0.51 m		0.70 m	6.5	0.49	40.8	73.0	61.8	61.4	4.4	0.26	3.7	0.46	115.6	0.63	0.53
Rider Parting 0.79 m		1.49 m	5.9	0.080	6.7	10.9	18.1	8.7	1.3	0.10	1.27	<0.010	39.7	0.27	0.46
1 Main Seam (Upper) 1.40 m		2.89 m	7.5	0.64	53.3	56.9	61.7	66.8	0.55	0.03	0.09	0.43	2.8	20.23	21.94
1 Main Seam (Middle) 1.10 m (includes middle parting)		3.99 m	7.6	0.52	43.3	48.3	36.4	69.8	0.48	0.02	0.05	0.41	1.6	30.91	23.30

* units = kg CaCO₃ / tonne.

Figure 6-5c: Acid-Base Accounting Results from 10 Mains Channel.

Paste pH

Paste pH is a primary indicator of the availability of existing buffering capacity. On its own the paste pH is not a predictor of the acid generation potential of a given sample. Paste pH is governed by the carbonate mineral solubility and hence the neutralizing potential (NP) present. When the paste pH values are < 5.5 , the NP is limited or non-existent. Conversely, higher paste pH values indicate NP is available and capable of buffering at circum-neutral pH.

Acidic paste pH (< 5.5) was recorded for the immediate roof of the Rider Seam and Rider Parting from the partially oxidized core (Figure 6-5). Paste pH values < 7.0 were also observed from these intervals from the 10 Mains Channel Sample. Based on the exposed age of the core samples, these results indicate the Rider Seam roof and Rider Parting are capable of producing acidic conditions within 3 years of exposure. The Rider Seam also had paste pH < 7.0 suggesting that exposure times slightly longer than 4 years may also result in acid generation from this zone.

Neutral pH (7.0 to 8.0) was recorded from the No. 1 Coal sample intervals indicating that these intervals contribute alkalinity to waters coming into contact with the coal seam.

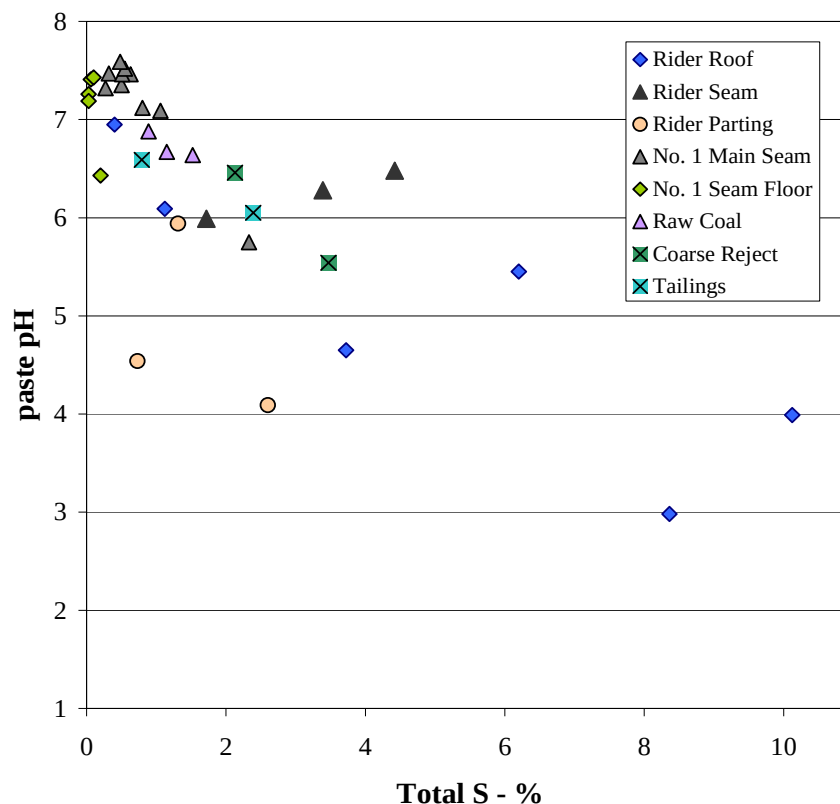


Figure 6-6: Paste pH vs Total Sulphur of 5 South Mine samples.

Sulphur Speciation

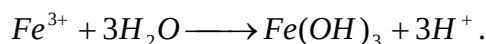
When considering the acid rock drainage (ARD) potential of a geological material it is important to not only consider the amount of sulphur, but also the forms of sulphur present. Sulphur may be present in rock materials as: a) sulphide or pyritic sulphur; b) sulphate sulphur; and c) organic or d) elemental sulphur. Since acidic drainage at mine sites is typically generated from the oxidation of sulphide minerals, total sulphur measurement is not always an accurate way to predict the acid generating potential of a sample. The estimation of total acid potential (AP), as determined by the total sulphur in a sample, assumes that all sulphur measured is in the form of pyrite and would oxidize completely, forming sulphate and iron hydroxide $[\text{Fe}(\text{OH})_3]$. However, when a significant portion of the total sulphur measured is present as non-acid generating forms of sulphur, sulphide sulphur provides a more accurate estimation of acid generating capacity.

ABA and petrographic studies indicate sulphur is predominately present in the form of the iron sulphide mineral pyrite. These studies also indicate that sulphur is also present as non-acid generating organic sulphur and sulphate sulphur. For the purposes of this report, the sulphide sulphur measurement is included in the calculation of AP listed below.

$$\text{AP} = 31.25 \times S_{\text{Sulphide}}$$

Neutralization Potential

The neutralization potential (NP) of weathering materials is dependent on the composition of minerals that dissolve when exposed to acidic conditions and buffer acidity. Carbonate minerals are fast dissolving and the minerals most typically responsible for acid neutralization. However, not all carbonate minerals neutralize acid as effectively as others. For example, Fe-bearing carbonate minerals, such as siderite and ankerite that contain Fe^{2+} , are much less effective at neutralizing acid than calcite. This is due to the liberation of aqueous Fe^{2+} that is oxidized to Fe^{3+} , which then precipitates as $\text{Fe}(\text{OH})_3$ producing acidity in the process:



Therefore, although Fe-bearing carbonate minerals contribute to the neutralizing potential of a sample, the net capacity of a sample to neutralize acid decreases as the amount of Fe-bearing carbonate increases (Jambor *et al.*, 2003). As a result, not only is it important to quantify the carbonate fraction in a sample, but also it is important to determine the types of carbonate minerals present.

Modified NP (NP), Siderite Corrected Sobek (ScNP) and carbonate NP (CaNP) values were determined for the Quinsam samples. Both the NP and ScNP measurements are determined by titration and provide information on the bulk neutralization potential of a sample, which is not mineral specific. Carbonate NP, is calculated from the inorganic carbon content and assumes that all the inorganic carbon is present as calcite. If the CaNP method yields values that are considerably greater than Modified NP, this is an indication that iron-bearing carbonate minerals (*i.e.* siderite and ankerite) are present and caution should be used when using the CaNP values to estimate the available neutralization potential.

Modified NP measurements range from $> 400 \text{ kgCaCO}_3/\text{t}$ in the middle parting of the Main No. 1 Coal Seam to negative values in the acidic samples from the Rider Seam roof. Comparison of the NP methods indicate that the two bulk NP measurements correspond relatively well (Figure 6-7). Although the CaNP values also correspond with the bulk NP measurements for the coal seam samples, CaNP values are considerably greater than the bulk NP for the majority of the non-coal samples from the parting, roof and floor strata (Figure 6-8). The correlation between all three NP methods for the coal samples suggests that calcite is the predominant carbonate mineral in the No. 1 coal seam and Rider Seam rather than dolomite or siderite. This is corroborated by low Mg content relative to Ca in the coal seams producing very high Ca/Mg ratio. However, the discrepancy between CaNP and the bulk NP measurements in the non-coal samples suggests iron carbonates are present in the strata above No. 1 Seam.

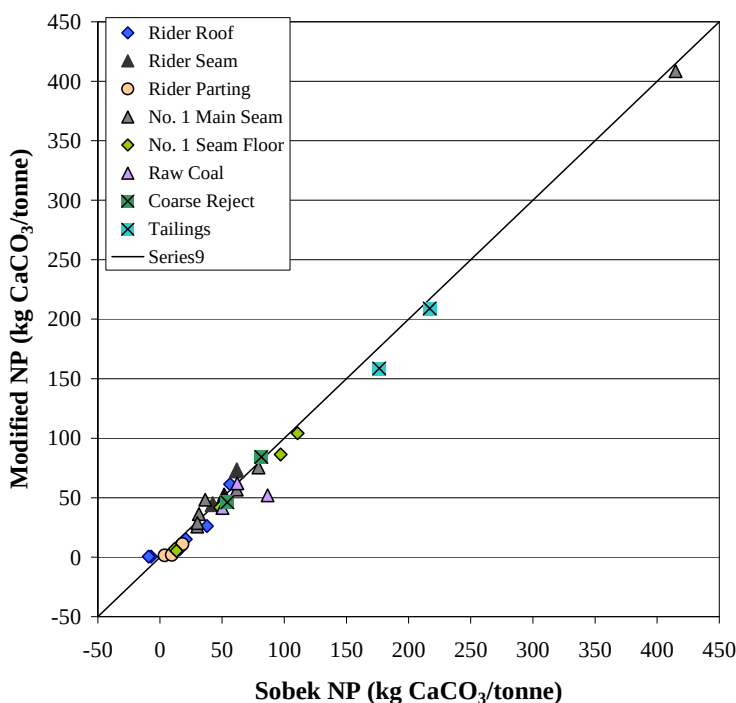


Figure 6-7: Modified NP vs. Siderite Corrected Sobek NP o 5 South Mine samples.

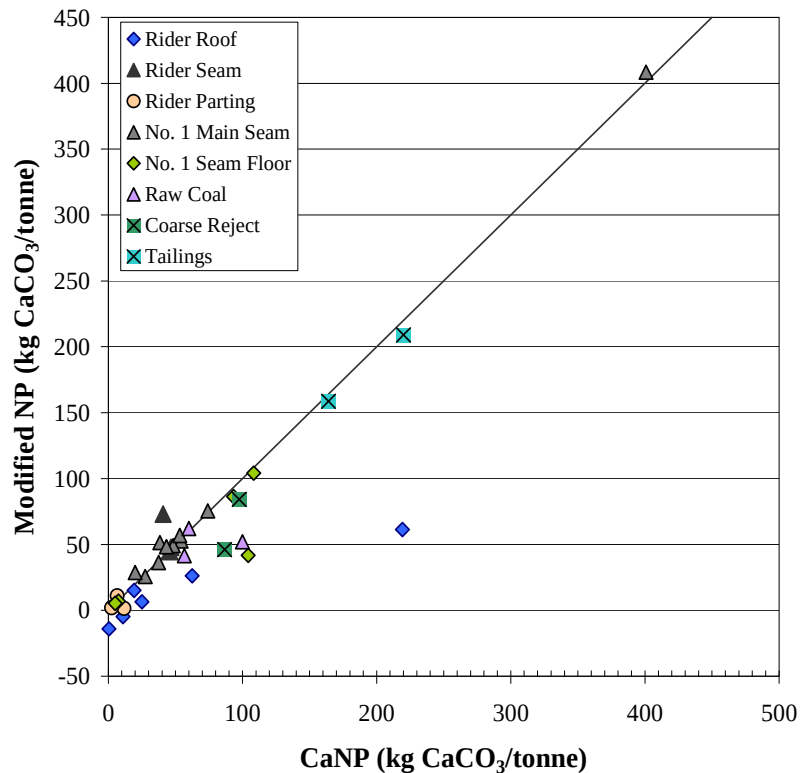


Figure 6-8: Modified NP vs. Carbonate NP of 5 South Mine samples.

Modified NP results have been selected as the most accurate measure of the available neutralization potential for the Quinsam samples. Those samples that have paste pH < 5.5 have corresponding Modified NP values approaching zero and had lower values than the other NP methods. Indeed all samples with paste pH < 5.0 had Modified NP values < 5 kgCaCO₃/t, which indicates the Modified NP is a reliable measurement of the available NP that is more accurate for the Quinsam strata than the other two methods utilized in this study. Subsequently, the results from the Modified NP will be used in this study to evaluate the acid generating potential.

Acid Generating Potential

The net potential ratio (NPR) compares the relative proportions of NP to AP, and it can be used over a wide range of AP and NP values. To that end the NPR is used in the following discussion for the purposes of delineating the potentially acid generating (PAG) from the non-PAG samples for the 5 South samples.

The NPR is compared to criteria specified in the BC Ministry of Energy Mines and Petroleum Resources regulatory guidelines (Price, 1997). These guidelines, as summarized in Table 3-1, indicate that in the absence of any other information a sample with a NPR of less than 1 can be considered as PAG. For a sample with a NPR between 1 and 2, there is a possibility of becoming acid generating, given that the NP is depleted

at faster rates than the rate of sulphide oxidation or that the buffering minerals are partially unavailable. NPR values between 2 and 4 indicate a low risk of acid drainage, while NPR values greater than 4 have no potential of ARD.

**Table 6-1:
British Columbia Acid-Base Accounting Screening Criteria (from Price, 1997).**

Potential for ARD	Criteria	Comments
Likely	$\text{NPR} < 1$	Likely ARD generating unless sulphide minerals are non-reactive
Possibly	$1 < \text{NPR} < 2$	Possibly ARD generating if NP is insufficiently reactive or is depleted at a faster rate than sulphides
Low	$2 < \text{NPR} < 4$	Not potentially ARD generating unless significant preferential exposure of sulphides along fracture planes, or extremely reactive sulphides in combination with insufficiently reactive NP
None	$\text{NPR} > 4$	

Designation of the 5 South samples as potentially acid-generating (PAG) or not potentially acid-generating (non-PAG) is undertaken by comparing the NPR measured in samples to the most appropriate criteria specified in BC MEM regulatory guidelines (Table 6-1). For this analysis, the Modified NP is used to estimate the neutralizing potential available from carbonate minerals and AP is calculated from the sulphide sulphur content. The acid generation potential is assessed using NPR values calculated according to the formula $\text{NPR} = \text{Modified NP} / \text{AP}$. Taking into account both the regulatory guidelines and the scrutiny that was undertaken to select the most appropriate and conservative measure of AP and NP, PAG samples are designated as those with an $\text{NPR} < 2.0$.

The NPR values < 2.0 for the 5 South samples indicate that PAG strata include the mudstone roof strata immediately adjacent to the Rider Seam, Rider Seam and Rider Parting (Figure 6-9). Non-PAG samples were collected from No.1 Seam and the footwall of the No. 1 Seam. Tailings samples and one Raw Coal sample obtained solely from the Main Seam were also non-PAG.

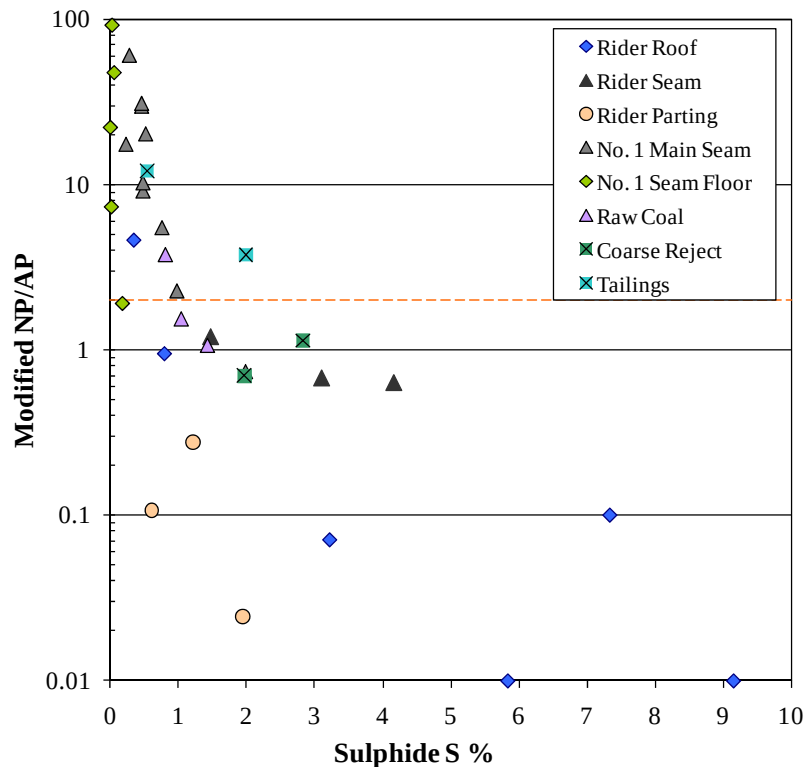


**Table 6-2:
Elemental Concentrations and Average Abundance in the Earth's Crust.**

Sample Designation	As ppm	Bi ppm	Ca %	Cd ppm	Cu ppm	Fe %	Hg ppb	Mg %	Mn ppm	Ni ppm	Se ppm	S %	Zn ppm
Avg. Crustal Abundance	1.8	0.0085	4.15	0.15	60	5.63	85	2.33	950	84	0.05	0.035	70
Hole Qu-05-16													
1 Rider Roof Rock	25	0.04	1.94	0.09	234.26	7.81	16	0.91	1318	64.6	0.6	0.52	83.3
1 Rider Roof Dilution	50.6	0.04	1.01	0.13	237.62	2.76	28	0.51	166	91.8	0.4	1.3	94.4
1 Rider Roof Dilution	235.8	0.04	0.72	0.24	147.56	9.59	410	0.17	229	94.7	1.6	8.72	64.7
No. 1 Rider Seam	55.6	0.05	1.85	0.06	26.61	1.24	111	0.09	74	9.5	0.2	1.47	25.2
Rider Parting	70.5	0.05	0.74	0.08	225.75	2.82	239	0.12	90	61.8	0.7	2.83	41.7
No. 1 Main Seam	72.9	0.07	1.83	0.07	26.87	1.58	159	0.07	87	16.7	0.5	2.04	16.9
No. 1 Main Seam	49.1	0.03	2.17	0.02	4.63	0.58	77	0.03	67	5.1	0.3	0.85	2.9
No. 1 Main Seam	53.3	0.04	2.01	0.02	8	0.29	54	0.03	72	7.1	0.1	0.38	4.8
No. 1 Main Seam	59.6	0.06	1.17	0.03	28.36	0.21	114	0.02	57	11.6	0.05	0.14	8.5
No. 1 Seam (Parting)	88	0.01	15.65	0.01	1.14	0.8	47	0.06	592	6.8	0.2	0.43	1.8
No. 1 Main Seam	87.9	0.02	2.95	0.51	6.05	0.25	28	0.05	138	14	0.05	0.08	35.7
No. 1 Seam (Floor Rock)	13.1	0.14	3.28	0.21	97.2	0.31	20	0.1	151	20.4	0.1	0.05	35.7
No. 1 Seam (Floor Rock)	28.1	0.11	0.33	0.04	142.74	0.14	15	0.04	19	28.1	0.05	0.05	32.9
No. 1 Basal Coal	61.6	0.06	3.83	0.16	46.6	0.37	25	0.14	187	19	0.05	0.12	34.2
No. 1 Basal Floor Dilution	65.9	0.06	1.44	0.14	243.59	3.86	37	0.22	557	83	0.3	0.11	103.5
Hole Qu-06-01													
Rider Roof Mudstone	10.9	0.11	0.76	0.2	181.25	6.65	245	0.83	441	96.8	0.9	3.58	155.4
Rider Roof Mudstone	9.7	0.1	0.25	0.15	127.24	8.84	894	0.46	396	54.1	1.1	7.91	59.6
1 Rider Seam	4.1	0.05	2.17	0.05	22.21	2.01	197	0.02	34	17	0.3	2.54	23.6
Rider Parting	1.5	0.06	0.32	0.04	258.96	1.59	219	0.24	67	39.3	0.3	0.73	56.1
1 Main Seam (upper)	0.4	0.06	1.25	0.03	12.32	0.36	23	0.02	30	8.2	0.1	0.12	15.6
1 Main Seam	1.1	0.05	2.13	0.17	17.02	0.38	23	0.02	43	14.5	0.1	0.15	27.3
1 Seam Floor Dilution	0.3	0.08	0.32	0.42	162.16	0.66	28	0.13	42	39	0.1	0.13	59.2
10 Mains Channel Sample													
Rider Roof Dilution	3.7	0.05	1.02	0.17	177.26	5.36	374	0.28	338	57.6	0.8	5.53	81.2
1 Rider Seam	7.7	0.04	3.32	0.07	23.25	2.95	462	0.04	55	32.6	0.4	3.77	15.4
Rider Parting	4.4	0.04	0.68	0.17	267.73	6.19	433	0.63	706	106.5	1.3	1.31	126.2
1 Main Seam (Upper)	2.3	0.06	2.33	0.05	27.62	0.44	32	0.05	56	12.9	0.4	0.13	19.7
1 Main Seam (Middle)	2.3	0.07	1.94	0.09	13.44	0.18	6	0.005	53	11.9	0.2	0.05	25.2
Raw Coal and Refuse													
Hole Qu-05-16													
Raw Coal Main Seam	59.4	0.04	2.56	0.05	15.23	0.56	75	0.04	106	9.5	0.3	0.67	24.4
Coarse Reject (Rider Seam t	73.6	0.04	3.96	0.09	169.89	3.04	257	0.13	205	49.3	0.6	3.17	44.7
Tailings (Rider parting to Bas	89.1	0.05	8.34	0.13	79.85	2.34	227	0.19	391	25.2	0.6	2.18	397.6
10 Mains Channel Sample													
Coarse Reject	4	0.04	2.04	0.14	222.25	5.55	386	0.5	555	78.7	1	2.1	86.5
Raw Coal	3.2	0.04	1.74	0.08	101.65	2.53	194	0.23	230	41.3	0.6	1.16	53.6
Raw Coal	3.6	0.04	2.3	0.16	235.5	5.2	379	0.55	563	87.2	1	1.13	102.6
Tailings	3.4	0.04	6.42	0.15	67.65	1.31	130	0.13	226	27.4	0.7	0.55	65.1

Shaded Cells indicate sample is enriched > 3x average crustal abundance

Despite elevated sulphur content in the Quinsam strata, metal concentrations are not enriched relative to the average concentration in the earths crust. Only copper appears to be elevated in the mudstones in the roof of the Rider Seam and the Rider Parting. Elements that are consistently enriched in the No.1 Seam strata include the metalloids arsenic, bismuth and selenium. Notably, another element, antimony, often associated with these metalloids was not enriched in the Quinsam samples.

6.1.5 Shake Flask Extractions

The water soluble constituents of samples from the two partially weathered drill cores were determined using a shake flask extraction (SFE) method. SFE measures geochemical parameters readily leached by water, and are used in conjunction with other static test results to evaluate the potential for acid rock drainage and metal leaching. Using weathered core samples rather than recently extracted core for SFE provides a better assessment of elemental constituents that may be released to infiltrating waters that come into contact with the strata exposed in the underground mine.

The results of the SFE are consistent with the ABA results, which indicate that the greatest metal leaching risk is posed by the PAG strata comprising the roof strata adjacent to the Rider Seam and the Rider Parting. Samples from both of these stratigraphic intervals released SFE leachate with $\text{pH} < 5$; high acidity ($> 2,000 \text{ mg CaCO}_3/\text{L}$); which correspond with elevated concentrations of aluminum and iron (Table 6-3). Under these acidic conditions numerous elements are elevated above BC Aquatic Life Water Quality Guidelines including As, Cd, Cr, Co, Cu, Mn, Ni, V and Zn.

Although ABA data indicate that the Rider Seam is also PAG, the Rider Seam samples contain sufficient NP (Modified NP $> 40 \text{ kgCaCO}_3/\text{t}$) to produce pH-neutral SFE leachate. Under these conditions metal concentrations were below aquatic life guidelines except for Cd and Se. This result implies that metal leaching proceeds slowly and these elements are relatively immobile at neutral pH.

SFE leachate from the No. 1 Main Seam and floor was pH-neutral with low elemental concentrations. Notably, selenium that was elevated in the solid-phase is not highly elevated in the SFE leachate at concentrations above aquatic life water quality guidelines. Under both acidic and pH neutral conditions $\text{Se} < 0.010 \text{ mg/L}$ was measured in SFE except for one acidic roof sample (0.014 mg/L).

**Table 6-3:
Shake Flask Extraction Result Summary.**

Designation	pH	Total Acidity to pH 8.3 mg CaCO ₃ /L	Alkalinity mg CaCO ₃ /L	SO ₄ mg/L	Al mg/L	As mg/L	Cd mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Mn mg/L	Ni mg/L	Se mg/L	V mg/L	Zn mg/L
Hole Qu-06-01	FWAL Guideline				0.100	0.0050	3.0E-05	0.0010	0.11	0.011	0.35	1.642	0.065	0.002	0.006	0.04
Rider Roof	3.96	175	#N/A	1980	9.7	0.0023	0.00726	0.0107	1.5	0.765	25	7.6	3.15	0.0142	<0.001	5.28
Rider Roof	2.63	3188	#N/A	4880	145	0.0204	0.0111	0.907	1.12	5.86	1020	11.2	3.16	0.0043	0.703	4.23
1 Rider Seam	7.28	7.9	33.8	1562	0.057	0.0002	<0.00003	<0.0005	0.00511	0.002	0.009	0.132	0.0189	0.0033	<0.001	0.0009
Rider Parting	4.84	30.7	0.2	650	0.745	0.00035	0.000804	0.0019	0.408	3.14	3.26	0.322	0.68	0.00679	<0.0002	0.909
1 Main Seam (U)	7.67	5.1	54.7	80	0.134	0.00013	0.000028	<0.0001	0.00199	0.00206	0.005	0.0131	0.00232	0.00164	<0.0002	0.0013
1 Main Seam (M)	7.81	4.2	63.3	8	0.0608	0.00667	0.000064	<0.0001	0.00048	0.00331	0.033	0.00922	0.00118	0.00122	0.0101	0.0021
1 Seam Floor	7.66	4.7	45.3	161	0.0178	0.00032	0.000031	<0.0001	0.000925	0.00173	0.003	0.00811	0.00125	0.00742	0.0017	0.0006
Hole Qu-05-16																
1 Rider Roof	3.13	5063	#N/A	6000	35.6	0.0904	0.0216	0.094	5.65	6.89	1640	28.2	10	0.0033	0.338	6.64
No. 1 Rider Seam	7.42	12	60.87	1611	0.004	0.0004	0.00009	<0.0005	0.0112	0.0014	0.021	0.707	0.0494	0.0031	<0.001	0.0023
Rider Parting	2.99	2350	#N/A	3816	50.5	0.0581	0.0097	0.111	6.59	13.1	753	11	10.5	0.0071	0.371	5.21
No. 1 Main Seam	7.35	6.0	26.6	1770	0.003	0.0004	0.00015	<0.0005	0.137	0.0028	0.009	2.61	0.314	0.0074	<0.001	0.0012
No. 1 Main Seam	7.71	4.3	43.4	374	0.0029	0.00066	0.000024	<0.0001	0.000593	0.00084	0.011	0.0812	0.00496	0.00209	<0.0002	0.0013
No. 1 Main Seam	7.85	3.4	57.0	99	0.0067	0.00113	0.00002	<0.0001	0.000288	0.00149	0.003	0.0348	0.00152	0.00071	<0.0002	0.0017
No. 1 Main Seam	7.94	2.6	61.0	2	0.0214	0.00819	<0.000005	<0.0001	0.00177	0.00377	0.005	0.0187	0.0061	0.0004	0.0009	0.0012
No. 1 Main Seam	7.91	2.5	60.0	<1	0.0331	0.00979	0.000029	<0.0001	0.00396	0.00119	0.002	0.0238	0.00391	0.00053	<0.0002	0.0034

Shaded Cells denote concentrations that exceed BC freshwater aquatic life water quality guidelines.

6.1.6 Leaching Characteristics

The objective of the 5 South kinetic test program is to obtain a direct measure of the sulphide oxidation for the No. 1 Coal seam. This is accomplished by presenting the leaching results of a No. 1 coal seam sample (Col4). Leaching characteristics of coarse reject samples (Col 5 and 6) and Rider Seam sample (Col 7) are also presented to provide a more extensive data set on materials derived from No. 1 Seam. Although several of the kinetic tests were conducted on coarse reject rather than raw coal, the coarse reject contains a portion of the same material that will be left exposed in the mine roof, floor and walls and as a result provides an indication of what metal(oid)s could be elevated in water coming into contact with No. 1 Seam coal and provide worst case conditions of the No. 1 Seam coal if left unsaturated and exposed to the air. The potential benefit and improvement of drainage chemistry if the No 1 coal material is flooded is illustrated by saturated column (HQB). The following sections present an overview of the leachate quality from the 5 South columns as well as estimates for the timing to NP depletion. The description of these columns is presented in Appendix C1.

Unsaturated Raw Coal (Col 4) and Coarse Reject (Col 5, 6 and 7)

pH and Anions

Leachate from the raw coal (Col 4) and coarse reject (Col 5 and Col 6) columns have neutral to slightly alkaline pH (7.4 to 8.0) and total alkalinity values between 45 - 95 mg CaCO₃/L (Figure 6-10). Leachate from the high sulphur Rider Parting coarse reject (Col 7) column shows a gradual decrease in pH from 7.5 to ~4, becoming acidic by week 35. Concentrations of alkalinity (as CaCO₃) in leachate from Col 7 decrease to < 5 mg/L by week 37.

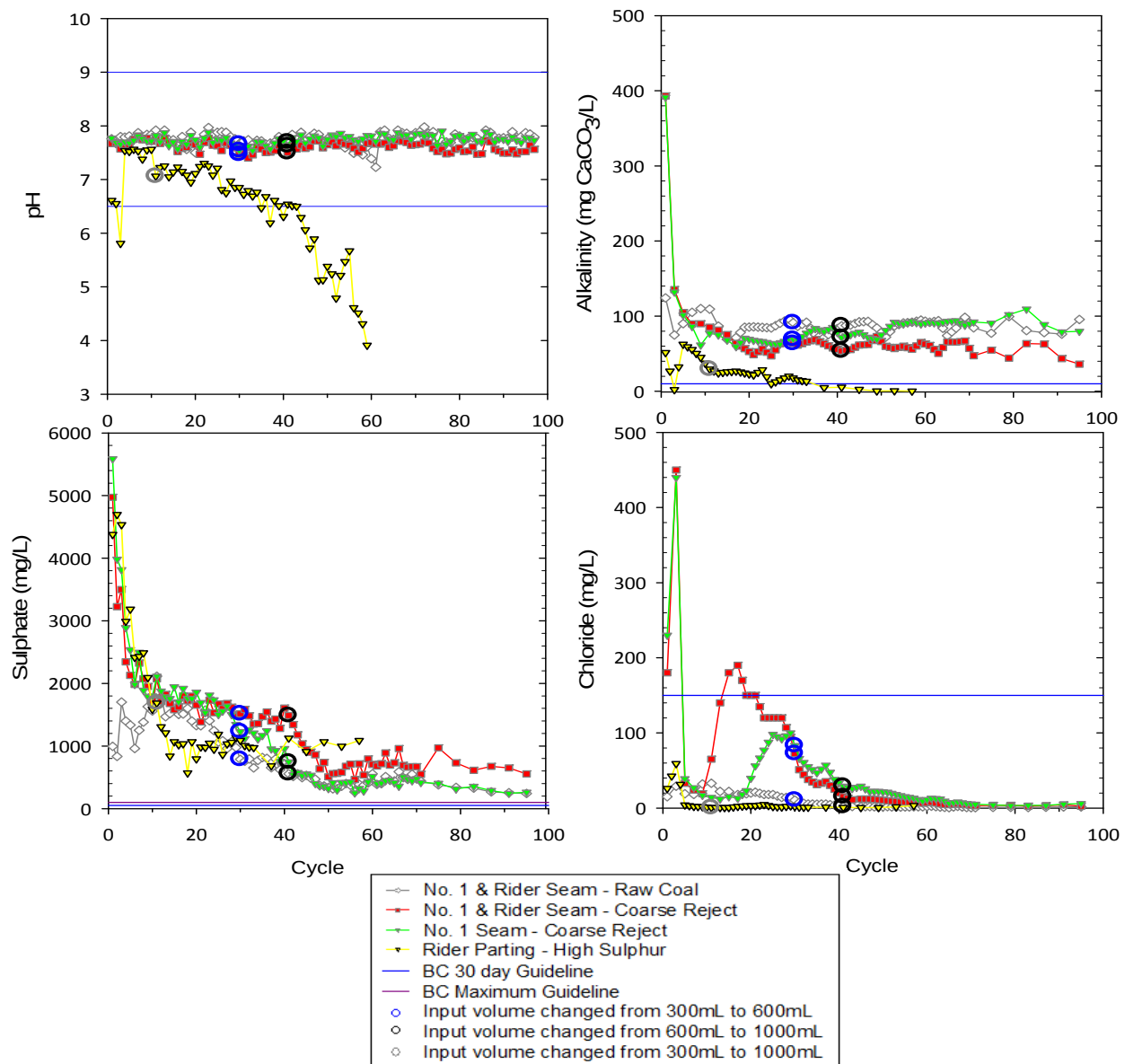


Figure 6-10: pH, sulphate, alkalinity and chloride in drainage from unsaturated raw coal and coarse reject from the No. 1 Coal Zone.

Dissolved sulphate concentrations in leachate from Col 5, Col 6 and Col 7 are initially very high (~5000 mg/L), but decrease rapidly (< 2000 mg/L) over the first 10 weeks following the initial flush of surface oxidation products (Figure 6-10). Dissolved sulphate concentrations in leachate from the raw coal column (Col 4) are initially lower than the coarse reject (~1000 mg/L), but increase (~2000 mg/L) over the first 10 weeks. Concentrations of sulphate in leachate from the raw coal and coarse reject continue to decrease over the remainder of test period, but remain above the maximum BC WQG (100 mg/L).

The high sulphate concentrations in leachate from the 5 South columns indicate that pyrite minerals in the No.1 Coal Seam and Partings oxidize at an accelerated rate. However, with the exception of Col 7, the leachate was maintained at a pH of > 7.5 with total alkalinity $> 70 \text{ mg CaCO}_3 / \text{L}$, indicating that when present, the carbonate minerals are capable of buffering pH in an acceptable pH-neutral range despite the accelerated sulphide oxidation kinetics displayed by the reactive pyrite. As indicated, the high sulphur coarse reject sample from the Rider Parting (Col 7) shows an immediate decrease in pH and alkalinity, becoming acidic by cycle 35 of the test.

In general, unsaturated columns Col 5 and Col 6 have similar geochemical leachate signatures. The raw coal sample also has a similar geochemical leachate signature to Col 5 and 6, however, pH and alkalinity values for the raw coal are slightly higher while sulphate, chloride and dissolved metal concentrations tend to be lower.

Dissolved Metals

Dissolved metal concentrations in leachate from the raw coal and unsaturated coarse reject samples from the No. 1 Coal Zone are presented in Figures 6-11 and 6-12 with the 30-day and maximum BC WQG. Hardness dependent guidelines were calculated based on an average hardness for Middle Quinsam Lake of $45 \text{ mg CaCO}_3 / \text{L}$. Dissolved metals (Sb, As, B, Cd, Co, Cu, Mn, Ni, Se, Tl and Zn) in leachate from the raw coal and coarse reject columns are initially high, consistent with the initial flush of dissolved sulphate.

The majority of the dissolved metal concentrations in leachate from the raw coal (Col 4) and lower sulphur-bearing coarse reject samples (Col 5 and Col 6) decrease during the first few cycles to levels below their respective BC WQG. However, concentrations of dissolved Cd, Co, Cu, Ni and Se remain elevated in leachate from columns 4, 5 and 6, exceeding the maximum and/or 30-day criteria for most of the test period. By the end of the 95 test cycles, all metals in leachate from Col 4 are below the guidelines and all metals in leachate from Col 6, except for dissolved Se, are below the guidelines.

Concentrations of dissolved Cd and Co in leachate from Col 5 remain above the maximum and 30-day criteria, respectively, for the duration of the test. Concentrations of dissolved Mn and Ni in leachate from Col 5 increase to levels above the BC WQG around cycle 75, consistent with an observed increase in sulphate concentration and slight increases in dissolved Cd, Co, Mn and Zn.

Dissolved metal concentrations are elevated in leachate from the high sulphur-bearing Rider Parting coarse reject sample (Col 7). In particular, concentrations of dissolved Al, Cd, Cr, Co, Cu, Fe, Mn, Ni, Tl and Zn exceed the maximum BC WQG throughout the test period (60 weeks). The elevated metals in leachate from Col 7 are consistent with the

low pH conditions of the test and continue to increase during the last few cycles of the test period.

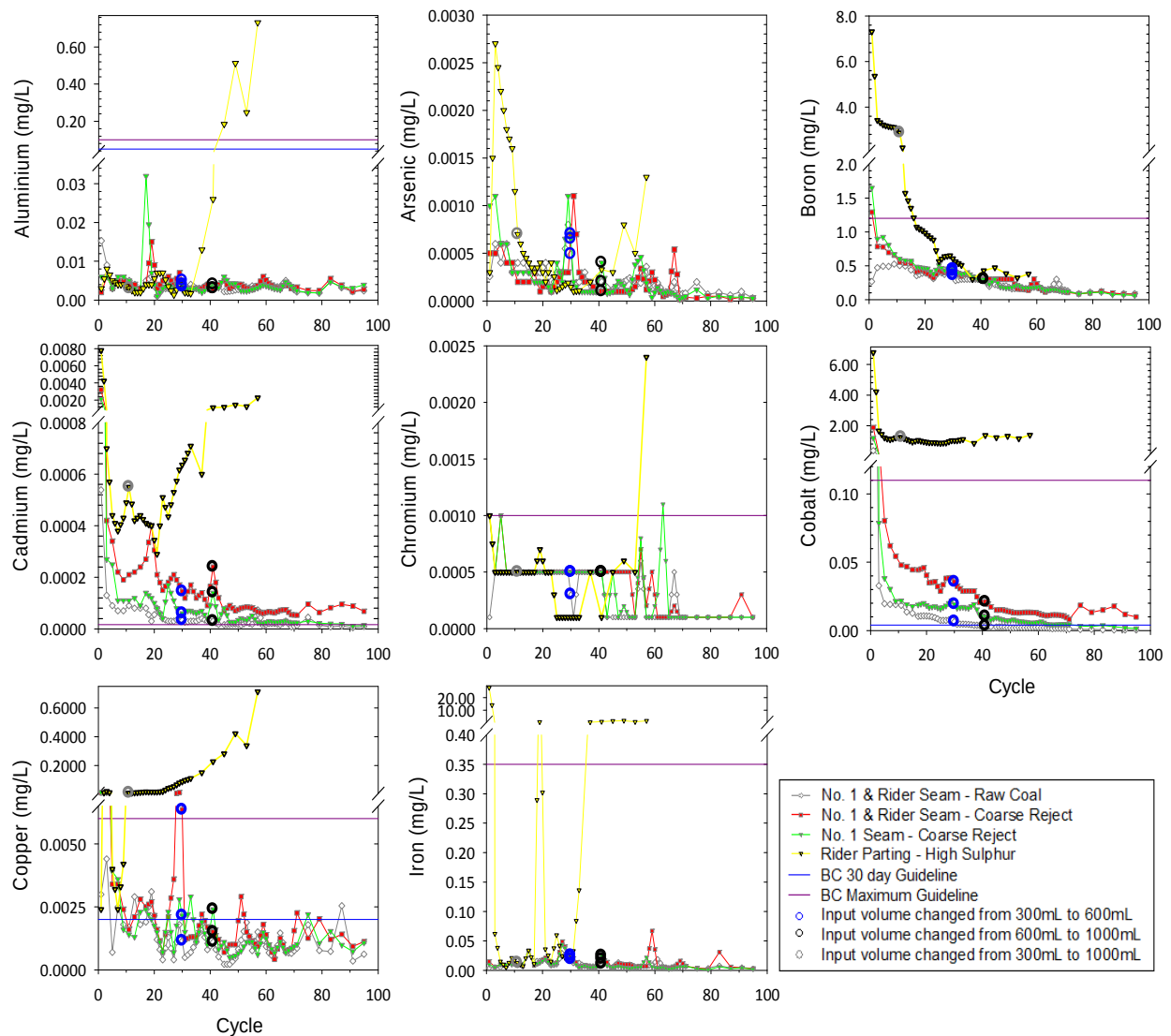


Figure 6-11: Dissolved Al, As, B, Cd, Cr, Co, Cu and Fe concentrations in leachate from unsaturated raw coal and coarse reject from the No. 1 Coal Seam.

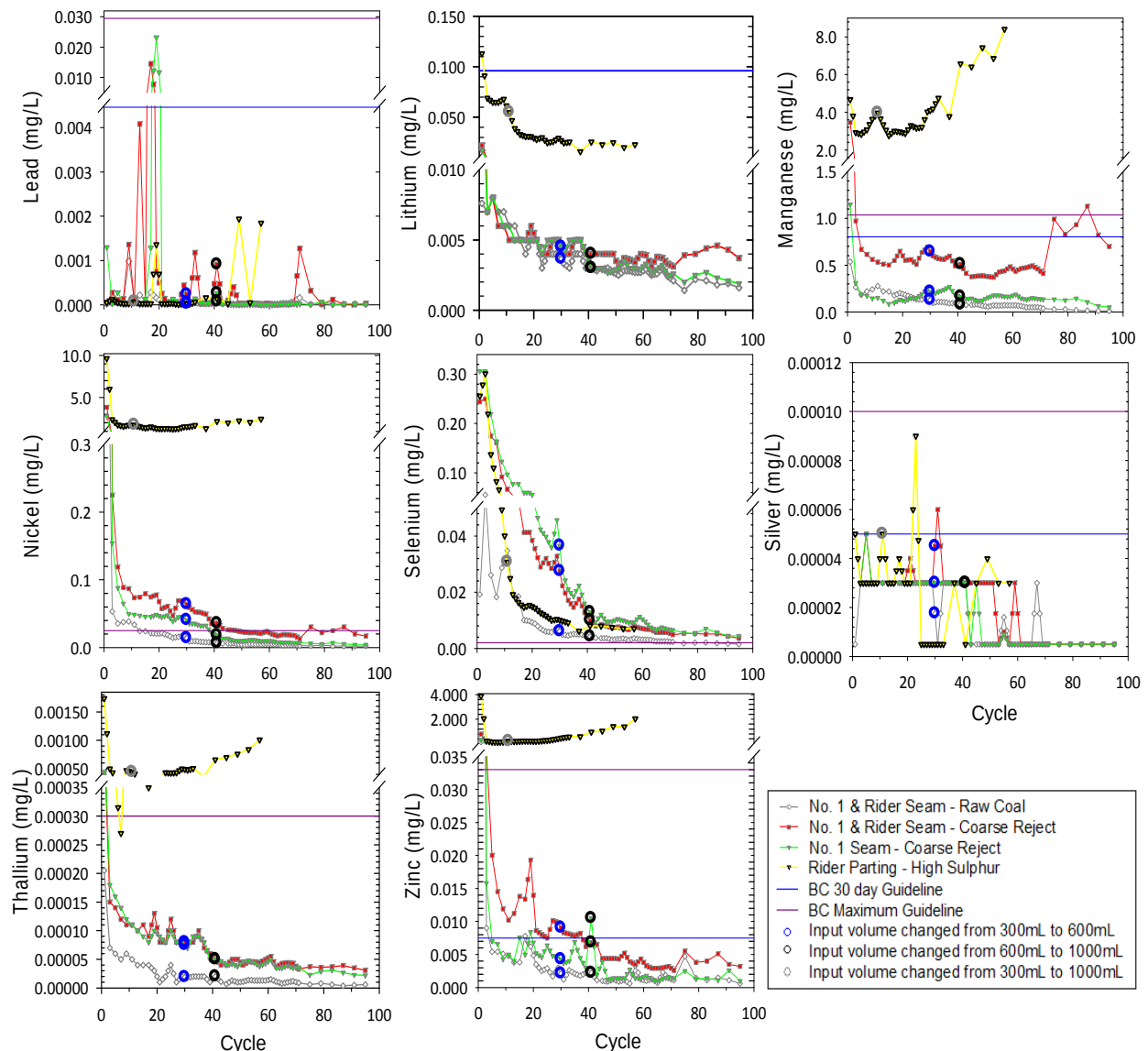


Figure 6-12: Dissolved Pb, Li, Mn, Ni, Se, Ag, Tl and Zn in drainage from unsaturated raw coal and coarse reject from the No. 1 Coal Seam.

Saturated Coarse Reject (HQB)

pH and Anions

Leachate from saturated coarse reject of the No. 1 Coal Zone was initially slightly acidic (< 6.5) but increases rapidly to slightly alkaline conditions (6.8 – 7.5) for the duration of the test (Figure 6-13). Concentrations of alkalinity and sulphate are initially high (>450 mg CaCO₃/L and > 2500 mg/L, respectively) but decrease rapidly to stabilize at ~ 50 mg/L sulphate and ~150 mg CaCO₃/L total alkalinity by approximately cycle 20. Sulphate concentrations tend to hover just below the 30-day guideline (50 mg/L),

periodically exceeding the criteria. Chloride is also initially high (> 60 mg/L) and decreases rapidly; however, periodic increases in concentration are observed during the test period. The initial depressed pH and elevated concentrations of anions in solution is a response to the dissolution of surface oxidation products during saturation of the test sample.

Reducing conditions in the column appears to have initially been present as evidenced by dissolved sulphide concentrations of up to $28 \mu\text{g/L}$ during the first 10 cycles of kinetic testwork (Figure 6-14) and iron (Figure 6-15). Concentrations of dissolved sulphide are three to four orders of magnitude lower than sulphate concentrations, but its presence indicates that the system is anoxic and that it was initially strongly reducing. The fuel driving the oxygen consuming reactions and lowering of the redox potential is typically organic matter, which in this case could be milling reagents used to wash the coal or possibly the coal itself.

Dissolved Metals

Dissolved metal concentrations in leachate from the saturated coarse reject sample are presented with BC WQG in Figure 6-15. Concentrations of dissolved Cd, Co, Cu, Li, Mn, Ni, Se, Tl and Zn are initially high and many are above maximum provincial guidelines, consistent with the initial flush of sulphate and low pH conditions (Figure 6-13). Following this initial influx, metal concentrations in leachate from the saturated coarse reject decrease by one to two orders of magnitude, stabilizing in less than 5 cycles at concentrations below the maximum and 30-day guidelines.

The reduction of the metal concentrations in the saturated column leachate compared to those concentrations measured in the leachate from unsaturated columns that contained similar materials from the No. 1 coal seam indicate that saturating the No. 1 coal seam and coal washing by-products derived from the seam is an effective way of reducing metal leaching from this material.

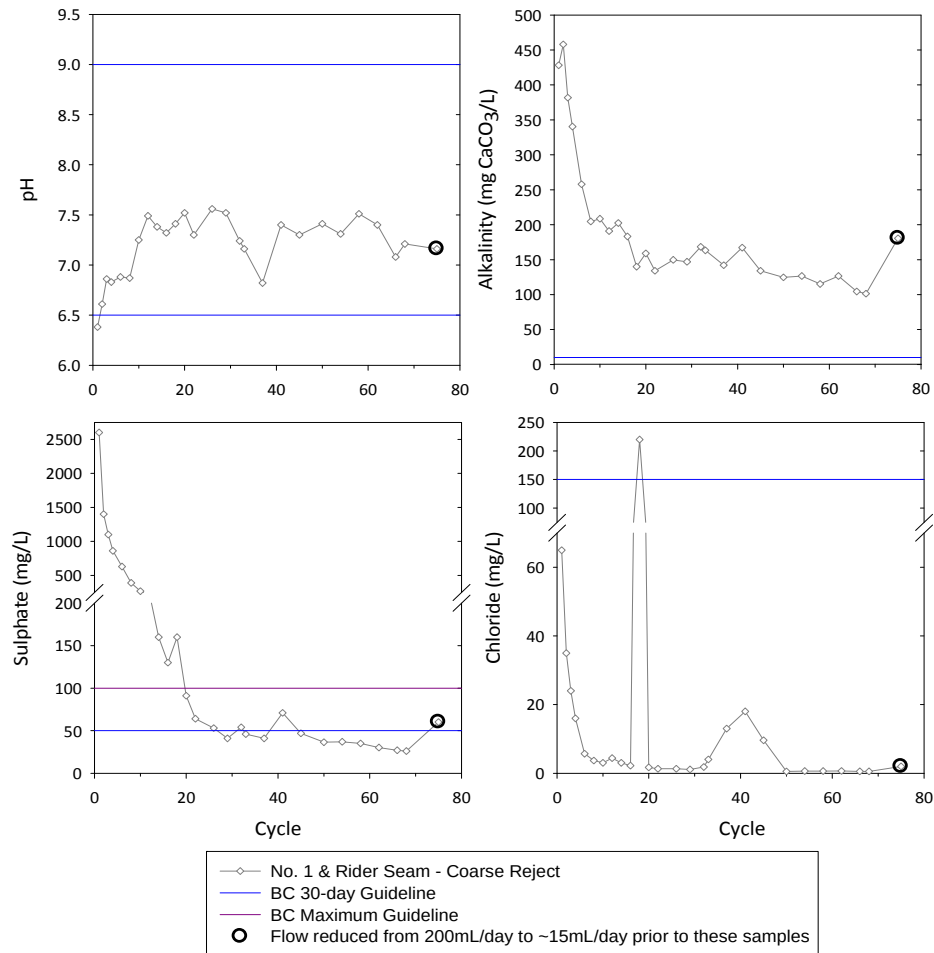


Figure 6-13: pH, sulphate, alkalinity and chloride in No. 1 Coal Zone saturated coarse reject (HQB) leachate.

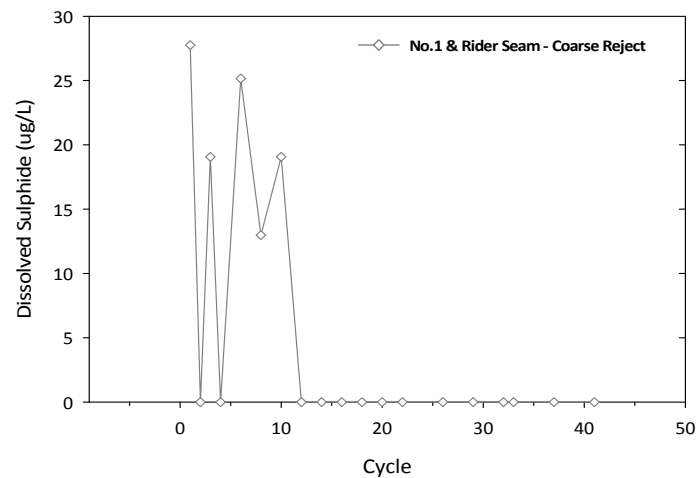


Figure 6-14: Sulphide in No. 1 Coal Zone saturated coarse reject (HQB) leachate.

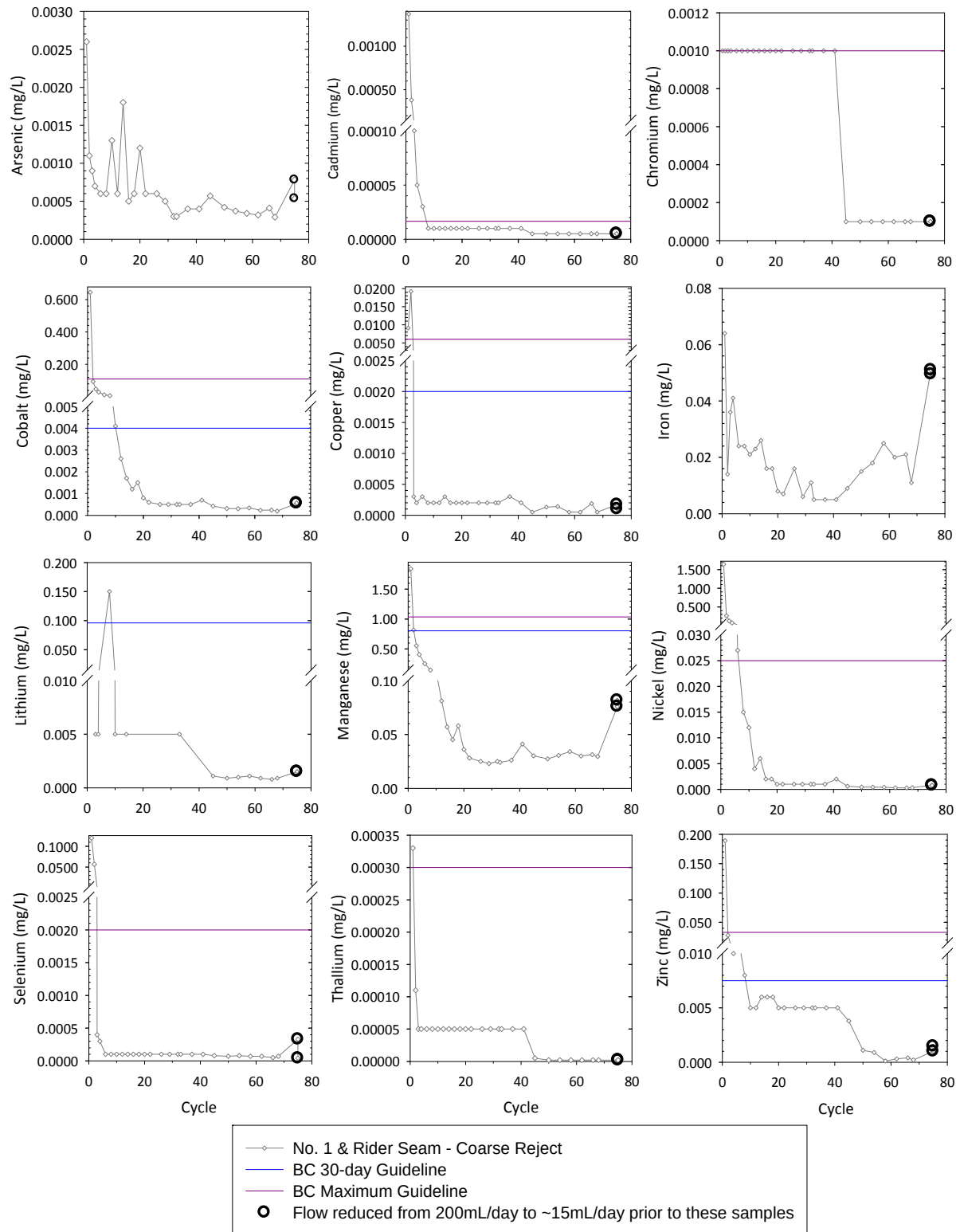


Figure 6-15: Dissolved metal concentrations in No. 1 Coal Zone saturated coarse reject (HQB) leachate.

6.1.7 Time to NP Depletion for No. 1 Raw Coal and Coarse Reject

During mining, materials from the No. 1 Coal Zone, both raw coal and coarse reject, may be stockpiled prior to processing or post processing. The concern related to placing the raw coal and/or the coarse reject material into stockpiles is the depletion of available NP and formation of acidic conditions prior to moving the material to either the processing facility, in the case of the raw coal, or saturated storage facility, in the case of the coarse reject. Unsaturated column data for Col 4, 5, 6 and 7 was used to evaluate the time to NP depletion of the No. 1 Coal Zone raw coal and coarse reject. The complete leachate dataset for each kinetic test are presented in Appendix C3.

The rate of sulphide mineral oxidation and associated acid production are determined from the unsaturated column tests by the sulphate measurements in weekly leachates. Similarly, the relative rate of NP consumption is calculated from the rate of sulphate production and release rates of major cations such as Ca and Mg that are derived from the congruent dissolution of neutralizing carbonate minerals. Thus, when considered together, the weekly leachate concentrations of Ca, Mg, and SO₄ can be used to calculate the carbonate molar ratio (CMR), as expressed in the following form:

Equation 1:

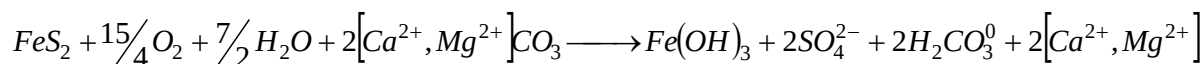
$$\text{CMR} = \frac{[\text{Ca}^{2+}] + [\text{Mg}^{2+}]}{[\text{SO}_4^{2-}]}$$

The CMR indicates the actual rate of carbonate dissolution (NP depletion) and sulphide oxidation occurring in the laboratory test reactor, assuming that the base cations are derived only from the NP source and the sulphate is derived from the oxidation of pyrite. A direct comparison can be made between the CMR and NP/AP ratio, since both parameters represent normalized ratios. The premise of the comparison is that if the NP/AP ratio of a sample exceeds the CMR value, the sample is non-acid generating because the laboratory-measured rates (CMR) are sufficiently low to ensure that NP will remain in the sample once the sulphide has completely oxidized.

In theory, CMR values could range from 1.0 to 2.0 due to the pH sensitive nature of carbonate speciation in aqueous solutions. In the most simplistic scenario, two carbonate consumption reactions can describe the sulphide oxidation-neutralization process:

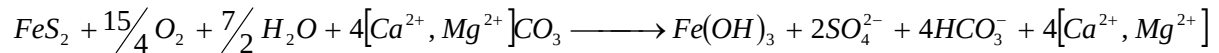
Equation 2:

at pH < 6.3:



Equation 3:

at $6.3 < pH < 10.3$:



Neutralization of acidity up to pH levels of 6.3 produce one mole of Ca for each mole of SO_4 released, producing a CMR = 1.0. At pH levels above 6.3, $H_2CO_3^0$ is not the dominant form of inorganic carbon in an aqueous solution and the bicarbonate ion (HCO_3^-) is by far the most abundant. Thus, at near-neutral pH levels, calcium carbonate is less efficient at neutralizing acidity and twice as much carbonate is required to produce a balanced solution. Under these conditions, 4 moles of Ca (+ Mg) are released relative to 2 moles of SO_4 producing a CMR = 2.0. The relationships derived from these chemical equations assume that pyrite oxidation is the sole source of sulphur and iron in the product that take the form of sulphate and iron hydroxide, respectively. Thus, the oxidation of other sulphide minerals, dissolution of soluble sulphate minerals, or the formation of other secondary products may alter the relationship.

Direct measure of the CMR in the column solutions provides an indication of the actual rate of carbonate dissolution (NP consumption) relative to sulphide oxidation, and thus can be used in estimating the time to onset of acid generation under laboratory conditions. Furthermore, when these laboratory conditions are met, the CMR can be compared directly to the critical NPR value obtained via acid base accounting to delineate potentially acid generating material from non acid generating material, since both parameters represent normalized ratios.

The rate of sulphide oxidation is estimated from sulphate analyses of column leachate. Table 6-4 provides the average sulphate production rates for the 5 South coal and coarse reject unsaturated columns, based on leachate results from cycles when the weekly input volumes were increased to 1000 mL (*i.e.*, cycles 41 to 95) to ensure all sulphate is released to the leachate and is not retained in sulphate products such as gypsum. Note that because Col 7 went acidic after cycle 45 (Figure 6-10), only cycles 11 to 45 are used to calculate averages and predict timing to NP depletion.

Based on the leachate results produced under the conditions of the unsaturated column tests, sulphate production rates for the 5 South coal is 80 mg/kg/wk when initial total sulphur concentrations are 1.52 %S. Col 6, which has an initial total sulphur value of 1.15 %S also has a sulphate production rate of ~80 mg/kg/wk. Col 5, which has a slightly higher initial total sulphur concentration of 2.13 %S has a higher sulphate production rate of 148 mg/kg/wk and Col 7, which has a considerably higher initial sulphur value of 4.0 %S has the highest sulphate production rate of 213 mg/kg/wk.

Table 6-4:
Calculation of NP Depletion Time for Low, Moderate and High Sulphur Coarse Reject Samples from the 5 South Mine.

	Units	Col #4 <i>test cycles 41-95</i>	Col #5 <i>test cycles 41-95</i>	Col #6 <i>test cycles 41-95</i>	Col #7 <i>test cycles 11-45</i>
Total Sulphur ¹	%S	1.52	2.13	1.15	4.01
Sulphate Production Rate ²	mg/kg/wk	80.1	148.7	80.8	213
CMR ³	mol/mol	1.2	1.1	1.2	1
NP Depletion Rate ⁴	kg CaCO ₃ /t/wk	0.096	0.17	0.097	0.22
NP (modified) ¹	kg CaCO ₃ /t	41.5	46.1	52.1	31.4
NP Depleted ⁵	kg CaCO ₃ /t	9.1	16.2	9.2	20.9
NP Remaining ⁶	kg CaCO ₃ /t	32.4	30.0	42.9	10.5
Time to Deplete NP	weeks	432	271	537	NA
Time to Deplete NP	years	8.3	5.2	10.3	NA
Available NP ⁷	kg CaCO ₃ /t	31.0	35.6	41.6	20.9
Time to Deplete NP	weeks	322.9	209.4	428.9	95.0
Time to Deplete NP	years	6.2	4.0	8.2	1.8

Notes: 1. Derived from ABA analysis of solids;
2. Calculated from average of indicated test cycles of kinetic tests (when 1000 mL water was added to the columns each cycle);
3. Carbon molar ratio ((Ca+Mg+Sr)/SO₄), calculated from average of indicated test cycles of kinetic test;
4. Calculated as sulphate production rate in mmol/kg * CMR (average of test cycles) / 1000 to convert to kg CaCO₃/t; and
5. Calculated as NP Depletion Rate * total number of indicated test cycles;
6. Calculated as Initial NP - NP Depleted after indicated test cycles;
7. Initial NP – NP remaining in Col 7 after 45 cycles (*i.e.*, when column became acidic (pH < 6)).
NA = not applicable

The rate of NP depletion is assessed using the CMR. Table 6-4 lists the average CMR values using the same cycles used to calculate sulphate production. The coal (Col 4) and coarse reject sample of Col 6, which have similar initial total sulphur values and sulphate production rates have similar NP depletion rates of 0.096 and 0.097 kg CaCO₃/t/wk, respectively. Col 5, which contains higher total sulphur values and sulphate production values compared to Col 4 and Col 6 has a higher NP depletion rate (0.17 kg CaCO₃/t/wk) and Col 7, which has the highest total sulphur and sulphate production rate has the highest NP depletion rate (0.22 kg CaCO₃/t/wk).

The carbonate mineral assemblage is the most reactive form of NP identified in the 5 South coarse reject and acidic conditions may develop once the carbonate minerals have been depleted. It is believed that the modified NP method conducted by SGS-CEMI provides the most accurate measure of NP contained in the coarse reject carbonate mineral assemblage. Estimates for the time to onset of acidic conditions from the coarse reject, assume that acidic drainage will be generated when all NP, as determined by the modified NP method, is depleted.

A number of assumptions are inherent in the estimation, including:

- all sulphide-S initially present is available for oxidation and production of acid;
- all sulphate produced in the column leachate is from sulphide oxidation;
- all sulphate produced from sulphide oxidation is released to the leachate and is not retained in the column as secondary minerals such as gypsum; and
- average sulphate production rates and NP depletion rates observed in the selected test cycles will continue indefinitely until all NP is depleted.

Calculation of the time to onset of acidic drainage is conducted by adjusting the sulphate loading rate to NP units of kg CaCO_3/t and normalizing them to the relative cation release rate provided by the CMR. Table 6-4 provides the calculations used to determine the amount of time required to deplete the NP present in the 5 South coal and coarse reject samples. Mine waste drainage will not acidify as long as the rate of acid neutralization equals or exceeds the rate of acid production. However, this is to a large degree dependent upon the relative surface areas of sulphide and carbonate minerals available for reaction (Lapakko *et al*, 1998). Precipitates may gradually accumulate over time on the surfaces of both sulphide minerals and acid neutralizing minerals, which can inhibit the reactivity of the minerals on which they form. If coatings form on the acid neutralizing minerals and sulphide oxidation continues, the coated portion of the NP will become unavailable and drainage from the waste will become acidic. The occlusion of carbonate minerals appears to have occurred in Col 7 when acidic conditions developed following the completion of 45 cycles. Following cycle 45, only 67% of the initial measured modified NP (31.4 mg CaCO_3/t) was consumed, indicating that 10.5 mg CaCO_3/t of the initial NP measured in the Col 7 sub-sample may not be available for neutralization of acid in the 5 South coarse reject from the Rider Parting. To provide a more conservative time estimate for NP depletion of Col 4, Col 5 and Col 6, “available NP” values were calculated by subtracting the unavailable NP in Col 7 (after 45 cycles before it produced acidic drainage) from the initial NP values measured in Col 4, Col 5 and Col 6. Under the conditions of the column tests, the available NP (45.6 CaCO_3/t) in the lowest sulphur bearing coarse reject (Col 6) is estimated to be depleted in approximately 8 years, while the available NP (35.6 mg CaCO_3/t) in the higher sulphur bearing coarse reject (Col 5) is estimated to be depleted in 4 years. Under these same conditions, the available NP (31.0 mg CaCO_3/t) in the raw coal (Col 4) will be depleted in approximately 6 years.

Extrapolation of NP Depletion Times Based on Initial NP Values

The high sulphate concentrations in the unsaturated raw coal and coarse reject samples indicate that the pyrite contained in the No.1 coal and partings oxidizes at an accelerated rate. However the > 7.5 pH demonstrates that the carbonate minerals are initially capable of buffering pH in an acceptable range despite the accelerated sulphide oxidation kinetics of the reactive pyrite. When the carbonate minerals are depleted, acidic conditions are anticipated to prevail, as is observed for the unsaturated coarse reject sample (Col 7). It is anticipated that similar trends would be observed if or when PAG coarse reject or raw coal is exposed to the atmosphere for a sufficient period of time to allow acidic conditions to develop.

The time for NP depletion is evaluated for a range of initial NP values that could be present in the No. 1 Seam coal zone and for a range of NP depletion rates which are defined by the range of sulphide oxidation rates measured in the kinetic tests (Table 6-4). By extrapolating the NP depletion rates measured in the kinetic tests to the range of possible NP values for coarse reject, a range of time estimates for the onset of acidic conditions is presented in Figure 6-16. The results of the calculations indicate that PAG raw coal or low sulphur bearing coarse reject containing an initial NP of 50 kg CaCO_3/t would produce acidic drainage within eight years. Higher sulphide oxidation and NP depletion rates were observed from the higher sulphur bearing coarse reject (Col 5 and Col 7) and the results indicate that higher sulphur containing PAG coarse reject with the same initial NP of 50 kg CaCO_3/t would become acidic within approximately four years.

As would be expected, materials with higher initial NP values have longer depletion times. PAG coarse reject containing approximately 2.0 wt. %S and an initial NP of 100 kg CaCO_3/t is predicted to remain pH-neutral for 10 years while PAG coarse reject containing 4.0 wt. %S is predicted to remain pH-neutral for eight years. Raw coal and lower sulphur bearing coarse reject with this amount of NP would be expected to remain pH neutral for 18 years prior to the onset of acidic conditions.

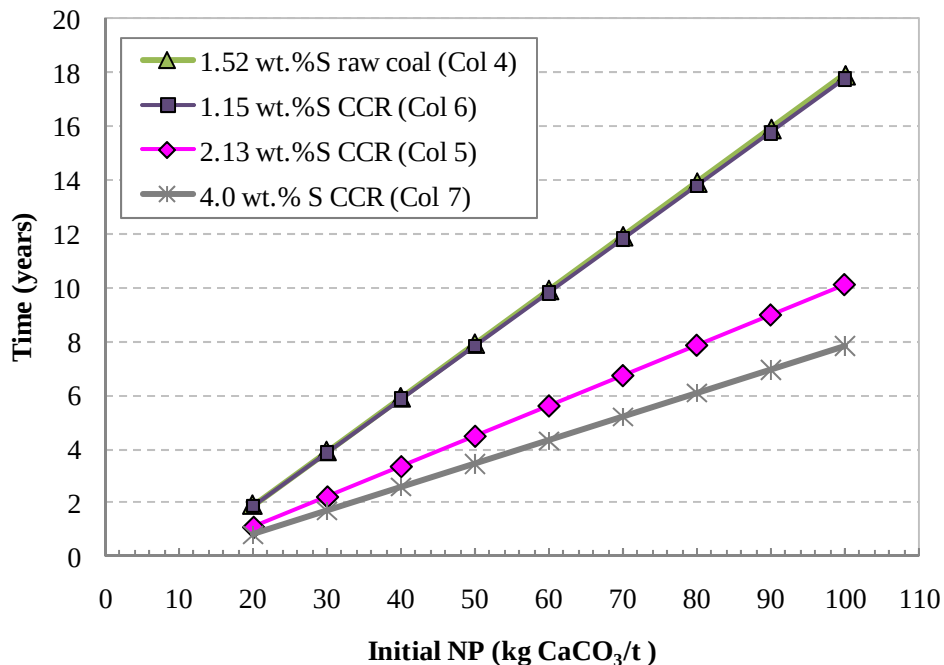


Figure 6-16: NP Depletion Time Estimates for a Range of Initial NP and Sulphur Values for the 5 South coal and coarse reject.

6.2 7 South Tailings

Potentially acid generating (PAG) tailings from the No. 4 Coal zone in the 7 South mine are proposed to be placed in the 2 North mine voids and flooded. A full description of the 7 South tailings characterization was provided in the 7 South Groundwater Assessment (Lorax, 2011b). The following sections summarize relevant portions of the characterization presented in Lorax (2011b) including brief overview of the mineralogy of the No. 4 Coal Zone, and the static test characterization of the tailings that are expected from the 7 South mine. The rate of neutralization potential (NP) depletion is assessed from the 7 South tailings and the saturated leaching characteristics are also presented.

6.2.1 Mineralogy

The mineralogy discussion below incorporates the results of the mineralogy reported for the 7 South column samples discussed in Section 6.1 and a recently completed study on the 7 South tailings sample HQD that is presented in Appendix C3.

Calcite is the primary neutralizing phase in the No. 4 Coal zone with measurable quantities of dolomite. The No. 4 Coal Zone only contains minor to trace amounts of siderite.

The No. 4 Coal zone contains sulphur primarily as pyrite. Pyrite is present as discrete textured porous grains, equant anhedral grains and framboidal forms. The pyrite fragments may be mantled by a thin rind of Fe-sulphate, which contains minor and varied concentrations of Mg and As. Pyrite phases themselves rarely contain detectable As. The copper-arsenic sulphide mineral tennantite ((Cu,Fe)₁₂As₄S₁₃) was observed in sample HQD. Although realgar (AsS) has been identified in Dunsmuir Sandstone strata in the 7 South area, this mineral has not been identified in No. 1 Seam or in coarse reject and tailings samples derived from No. 1 Seam.

In addition to sulphide minerals, petrographic observations identified minor amounts of sulphur hosted by barite (BaSO₄) and Fe-sulphate. Additionally, organic sulphur is present in coal. In general, coal fragments that contain pyrite have higher organic sulphur contents than coal fragments that lack pyrite.

6.2.2 Acid Generating Potential

The ABA analyses indicate that the sulphide content of the 7 South tailings will be similar or greater than the sulphur content of the raw coal product (*i.e.* 0.8 to 6.0 %S). The analyses also confirm the presence of non-acid generating organic S, which is present in tailings at quantities up to 0.45 %S. Neutralization potential values are typically < 85 kg CaCO₃/t for the 7 South coal strata, with higher NP values indicated for the No. 4 Upper Coal Seam. Washing of the raw coal appears to concentrate carbonates in the fine fraction of the coal washing by-products, thus, tailings are expected to have a higher neutralization potential than the coarse reject or the raw coal that it was derived from. Based on these observations, 7 South tailings are likely to have NP in the range of 70 to 140 kg CaCO₃/t. The trend of increased NP in the tailings is also observed in operational monitoring of tailings derived from No. 1 Seam.

The high sulphate concentrations released in unsaturated column leachate from raw coal, coarse reject and tailings samples indicate that the pyrite contained in the No.4 coal and partings oxidizes at an accelerated rate. However the > 7.5 pH demonstrates that the carbonate minerals are initially capable of buffering pH in an acceptable range despite the accelerated sulphide oxidation kinetics of the reactive pyrite. When the carbonate minerals are depleted, acidic conditions are anticipated to prevail, as is observed for the unsaturated coarse reject sample (Col 3). It is anticipated that similar trends would be observed if tailings are exposed to the atmosphere for a sufficient period of time to allow acidic conditions to develop. NP depletion calculations using the available humidity cell data indicate that PAG tailings with the expected range of NP would remain pH-neutral for 8 to 17.5 years.

6.2.3 Leaching Characteristics (HQD)

Saturated column HQD was initiated to evaluate the metal release potential of 7 South tailings under flooded conditions. The results of the column test are presented here and subsequently used to develop geochemical source terms for the loading model (Section 6.4).

pH and Anions

Leachate from saturated tailings from the No. 4 Coal Zone remains pH neutral, increasing from 7.0 to >7.5 (Figure 6-17), consistent with high total alkalinity concentrations of up to 300 mg CaCO₃/L. Concentrations of dissolved sulphate are initially high (800 mg/L) and well above the 30-day and maximum BC WQG, reflecting the dissolution of surface oxidation products. However, concentrations of sulphate rapidly decrease to stabilize at < 15 mg/L by the 4th cycle. Dissolved organic carbon in leachate from the saturated tailings follows a similar pattern to sulphate, with initially high concentrations of 23.6 mg/L that decrease to < 2 mg/L by the 5th cycle. The rapidly decreasing sulphate concentrations indicate that anoxic conditions were established in the saturated tailings column that inhibits sulphide oxidation by cycle 6. Nitrogen species and chloride concentrations in leachate from the saturated tailings decrease to below detection levels by cycle 5 (Figure 6-17). However, fluoride concentrations increase to 1.3 mg/L over the 9 cycles, exceeding the maximum BC WQG.

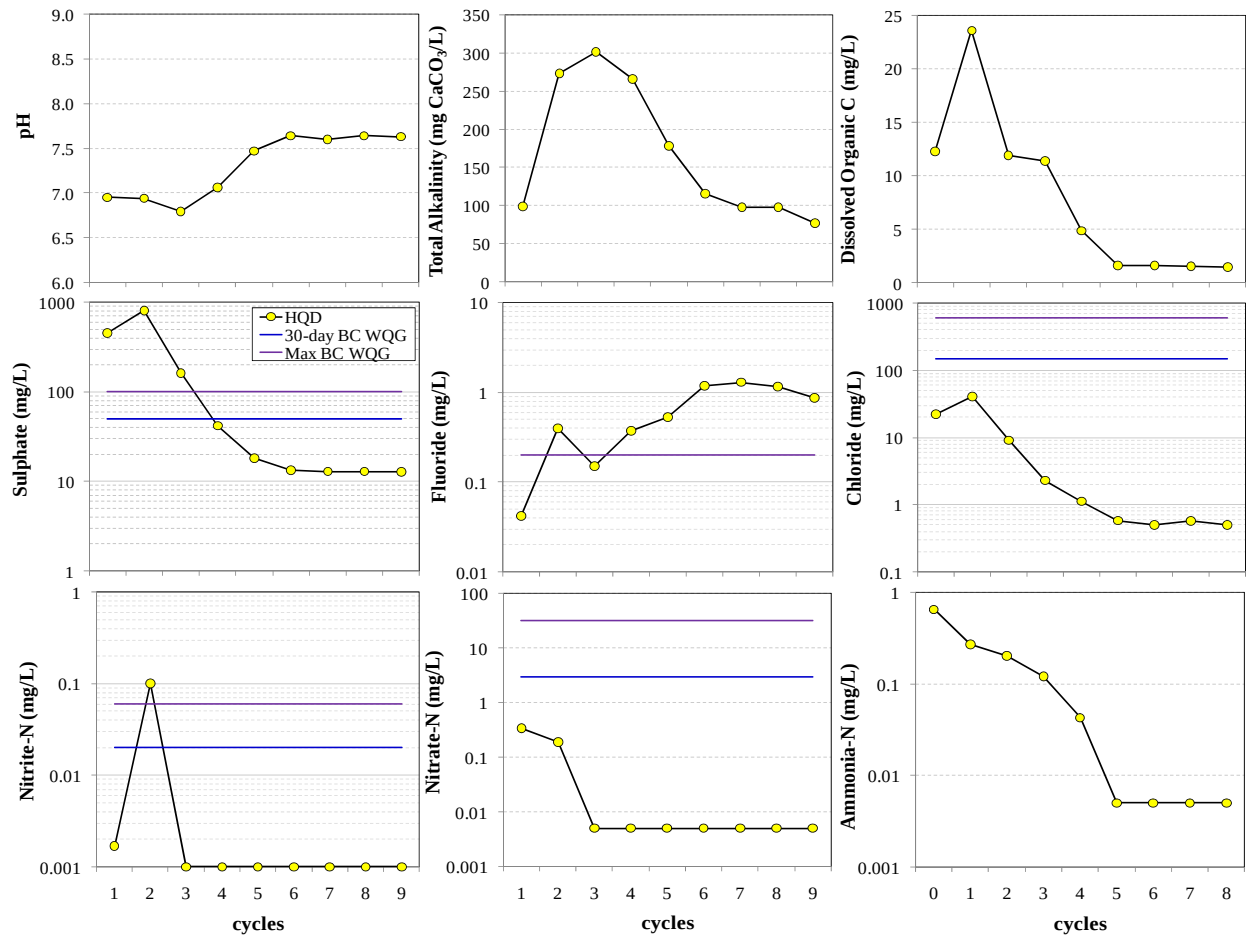


Figure 6-17: pH and anions in drainage from saturated tailings of the No. 4 Coal Zone.

Dissolved Metals

Dissolved metal concentrations in leachate from the saturated coarse reject sample are presented with BC WQG in Figure 6-18. Concentrations of dissolved As, B, Cd, Co, Cu, Fe, Mn, Ni, Sb, Se, Ni, Tl and Zn initially exceed the 30-day and/or maximum BC WQG. However, with the exception of dissolved As, all metals in leachate from the saturated tailings decrease to concentrations below their respective guidelines within the first 6 weeks of testing.

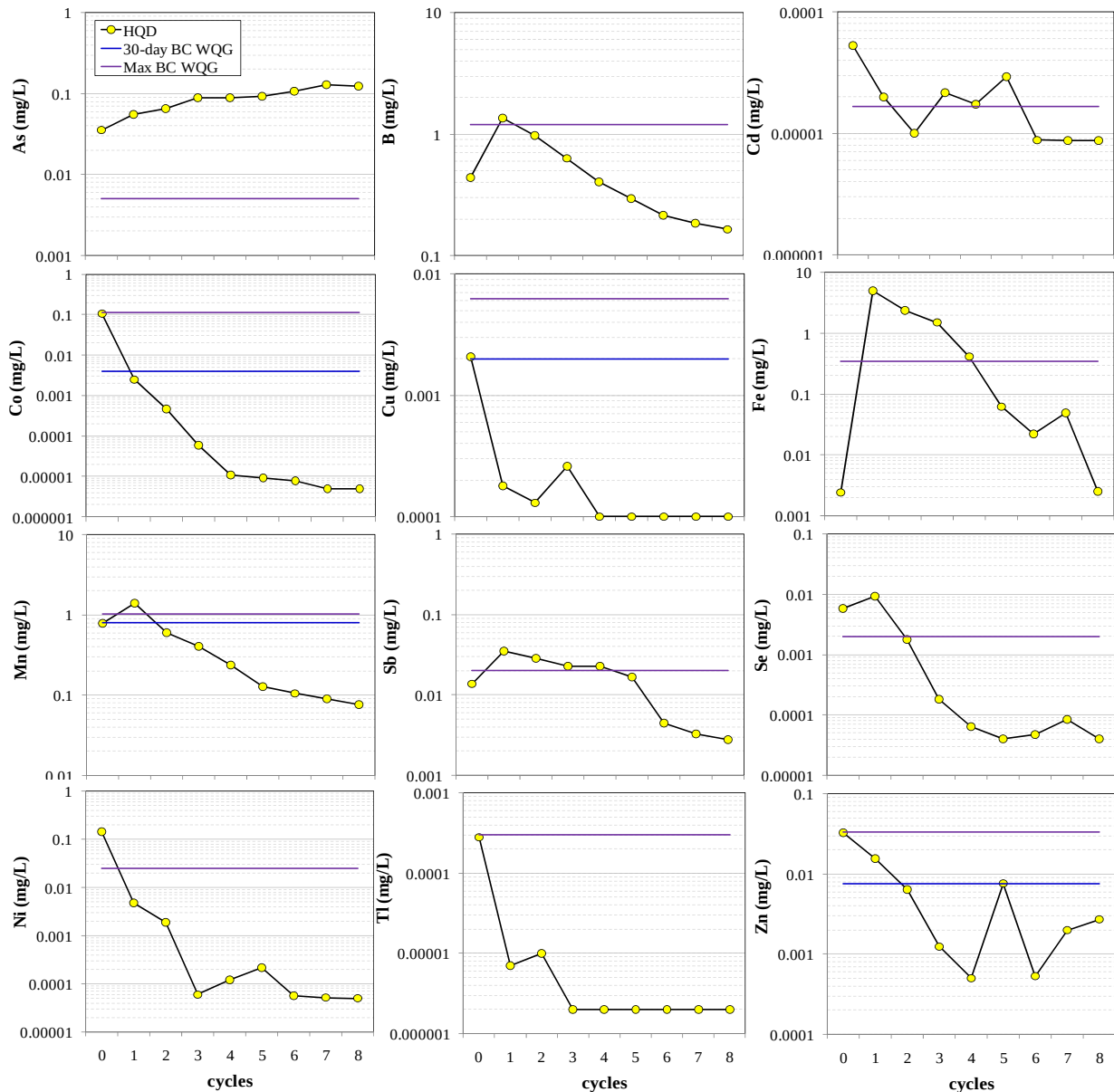


Figure 6-18: Dissolved metal concentrations in drainage from saturated tailings of the No. 4 Coal Zone.

6.3 Geochemistry of 5 South Hanging Wall Stratigraphy

The geochemical characteristics of the strata in the hanging wall of the 2 North / 3 North and 5 South mines are of interest due to the potential increased exposure of these strata from the influence of mine dewatering and mine subsidence. This assessment provides an evaluation of the hanging wall of the No. 1 Coal Zone based on samples selected from boreholes QU11-03 and QU11-05. QU11-03 is located on the margin of the 3 North Mine and QU11-05 is located adjacent to the RBP, which is between the 2 North and 5 South Mines. The locations of sampled boreholes are illustrated in Figure 6-1.

6.3.1 Sample Selection

A total of 27 samples were selected from the hanging wall strata of the No. 1 Coal Zone in the 3 North Mine area from borehole QU11-03 and 55 samples were obtained from QU11-05. The sample intervals are illustrated with the borehole stratigraphy in Tables 6-5 and 6-6, respectively. Samples selected for analysis are from the coal seams and partings within the No.3, No.2 and No.1 coal zones as well as the Dunsmuir sandstones above No. 2 Seam and Cumberland member siltstones between the coal zones. All samples were characterized using ABA and aqua-regia metal determination to evaluate the ARD/ML potential of the strata. Note that recorded observation of visible pyrite and/or carbonate content of a sample interval during core logging are provided in the tables for reference.

Table 6-5:
Stratigraphic Section for Borehole QU11-03 Showing Sample Locations.

Stratigraphic Unit			Static Test Sample		
From (m)	To (m)	Core Description	Sample ID	From (m)	To (m)
71.52	73.64	Silty SANDSTONE (dirty, f-gr)	110301	71.52	73
			110302	73	74.18
73.64	74.18	SANDSTONE (f-gr, carbonate filled fractures)			
74.18	75.44	Silty SANDSTONE (dirty, f-gr, calcite filled fractures)	110303	74.18	75.44
75.44	77.11	SANDSTONE (f-gr, calcite filled fractures)	110304	75.44	77.11
*****Formation Change*****					
77.11	81.58	SANDSTONE (blue-grey, c-gr, poorly sorted, in f-gr matrix of lithic clasts and shale frags)	110305	77.11	79.58
			110306	79.58	81.58
*****Formation Change*****					
81.58	81.75	CONGLOMERATE (siltstone matrix with rounded and elongate pebbles)			
81.75	86.48	SILTSTONE (massive, interstitial calcite, 81.75-82.45 m disseminated blebs/masses of f-gr py (1-3%), 84.50-84.70 m calcite veins)	110307	81.58	83.1
			110308	83.1	84.6
			110309	84.6	86.1
			110310	86.1	86.48
86.48	86.54	COAL (No. 2 Rider Seam) (dirty, 1-2 mm vf-gr sandy parting)	No. 2 Coal Zone		
86.54	86.66	Coaly SANDSTONE (f-gr, increasingly dense 0.5-1 mm coal seams towards			
86.66	87.57	COAL (No. 2 Rider Seam) (dirty, no py, tr calcite near bottom)			
87.57	87.67	Coaly SILTSTONE Parting (dirty coal)			
87.67	87.96	COAL (No. 2 Rider Seam) (clean, some is bright/shiny)			
87.96	88.43	SILTSTONE			
88.43	89.52	Coaly SILTSTONE			
89.52	89.71	Silty COAL (coal is bright and clean)	110313	88.43	90.08
89.71	90.08	COAL (No. 2 Seam) (bright/clean, tr platy py along cleats in bottom 10 cm)			

No. 2 Coal Zone

Table 6-5 (continued):

Stratigraphic Unit			Static Test Sample		
From (m)	To (m)	Core Description	Sample ID	From (m)	To (m)
90.08	91.56	Silty SILTSTONE	110314	90.08	91.56
91.56	91.8	SILTSTONE	110315	91.56	91.8
91.8	93.74	Sandy SILTSTONE (minor coal seams, calcite lined cleats and tr py)	110316	91.8	93.74
93.74	94.14	Silty SANDSTONE	110317	93.74	95
94.14	96.51	SANDSTONE (f-m gr dirty, minor plant trash, silts and trace coal)			
96.51	96.85	CONGLOMERATE (cemented by silts and sands, highly variable tightly packed clasts)	110319	96.51	97.74
96.85	97.6	SANDSTONE (vf-gr)			
97.6	97.74	CONGLOMERATE (cemented by silts and sands, highly variable tightly packed clasts)			
97.74	99.67	SANDSTONE (m-gr, at 98.71 m a 0.5 cm bright coal seam)	110320	97.74	99.67
99.67	103.1	Sandy SILTSTONE	110321	99.67	101.5
			110322	101.5	103.1
103.1	109.6	SILTSTONE	110323	103.1	105.1
			110324	105.1	106.76
			110325	106.76	108.2
			110326	108.2	109.64
109.64	110.6	Coaly SILTSTONE (hairline coal seams every cm (~10%))	110327	109.64	110.64
110.64		No 1 Coal Rider Seam	no sample		

**Table 6-6:
Stratigraphic Section for Borehole QU11-05 Showing Sample Locations.**

Stratigraphic Unit			Static Test Sample		
From (m)	To (m)	Core Description	Sample ID	From (m)	To (m)
46.12	56.74	SANDSTONE (f-m gr, poorly to unsorted, intensely bioturbation (51.5 - 53.5 m), 1-3 cm pyrite bands and blebs of f-gr pyrite at 55.0-56.74 m)	110501b	46.12	48.62
			110502b	48.62	51.51
			110503b	51.51	53.75
			110504b	53.75	55.01
			110505	55.01	56.74
*****Formation Change*****					
56.74	58.45	Coaly SILTSTONE (abundant coal wisps associated with f-gr py, 1cm blebs of f-gr py (~5%))	110506	56.74	58.45
58.45	63.05	SILTSTONE (abundant pyrite blebs)	110507	58.45	60.65
			110508	60.65	63.05
63.05	63.25	Fissile COAL and SILTSTONE (tightly banded with pyritic siltstone at bottom)	110509	63.05	63.25
63.25	64.14	COAL (No. 3 Rider Seam) (dirty dull fissile, minor calcite and py)	110501	63.25	64.14
64.14	64.49	Coaly SILTSTONE Parting (thin band of py at bottom)	110502	64.14	64.49
64.49	65.17	COAL (No. 3 Seam) (dull, abundant cleats and minor py, calcite band mid seam)	110503	64.49	65.17
65.17	65.58	Coaly SILTSTONE	No. 3 Coal Seam	65.17	66.09
65.58	66.09	SILTSTONE			
66.09	67.33	Coaly SILTSTONE			
67.33	67.47	Silty SANDSTONE			
67.47	67.51	Coaly SILTSTONE			
67.51	68.33	COAL (No. 3 Lower Seam) (bright, clean coal with platy calcite along cleats)	110504	67.51	68.33
68.33	68.44	Coaly SILTSTONE	110512a	68.33	68.44
68.44	69.5	SILTSTONE	110513	68.44	70.62
69.5	70.08	SANDSTONE (dirty, poorly sorted, f-gr)			
70.08	70.62	Sandy SILTSTONE			
70.62	72.62	SANDSTONE (dirty, f-m gr with trace coal, tr calcite)	110514	70.62	72.62

Table 6-6 (continued):

Stratigraphic Unit			Static Test Sample		
From (m)	To (m)	Core Description	Sample ID	From (m)	To (m)
72.62	73.74	Silty SANDSTONE (dirty, f-m gr, minor pinch and swell calcite vein)	110515	72.62	73.74
73.74	74.03	COAL (dirty dull fissile with siltstone parting)	110516	73.74	74.03
74.03	74.14	Coaly SANDSTONE (minor fissile coal laminations)			
74.14	95.28	SANDSTONE (f-c gr, massive, generally well sorted, minor localized intensely bioturbated areas)	110517	74.03	76.41
			110518	76.41	77.8
			110519	77.8	80.65
			110520	80.65	85.61
			110521	85.61	87.02
			110522	87.02	91.52
			110523	91.52	95.28
95.28	95.42	COAL (No. 2 Rider Seam) (dirty with tr calcite along cleats and tr py with siltstones)	110524	95.28	95.42
95.42	96.3	Coaly SILTSTONE (py is abundant around the minor coal seams)	No. 2 Coal Zone	110525	95.42
96.3	96.92	SANDSTONE (f-gr with dense interstitial silts and py)	No. 2 Coal Zone	110526	96.3
*****Formation Change***** (Start of the Cumberland Formation)					
96.92	97.1	CONGLOMERATE (sandst blebs surrounded by f-gr py masses in siltst matrix, minor coal)	No. 2 Coal Zone	110527	96.92
97.1	98.1	Coaly SILTSTONE	No. 2 Coal Zone	110528	97.1
98.1	98.45	COAL (No. 2 Seam) (bright and dull banding with minor calcite and specks of py)		110529	98.1
98.45	99.39	Coaly SILTSTONE		110530	98.45
99.39	99.94	SANDSTONE (vf-gr, abundant disseminated calcite filled bioturbation)		110531	98.87
					99.94

Table 6-6 (continued):

Stratigraphic Unit			Static Test Sample		
From (m)	To (m)	Core Description	Sample ID	From (m)	To (m)
99.94	115.35	SILTSTONE (generally massive with some bioturbation)	110532	99.94	101.5
			110533	101.5	102.9
			110534	102.9	104.9
			110535	104.9	108.7
			110536	108.7	111.2
			110537	111.2	115.4
115.35	116.43	Coaly SILTSTONE	110538	115.4	116.4
116.43	116.87	SILTSTONE (minor wisps and seams of coal)	110539	116.4	116.9
116.87	116.99	COAL (No. 1 Rider Seam) (dirty)	110540	116.9	117.6
116.99	117.08	SILTSTONE Parting			
117.08	117.61	COAL (No. 1 Rider Seam) (dirty, hairline silt and calcite bands <1 mm, minor py)			
117.61	117.86	Coaly SILTSTONE			
117.86	121.51	SILTSTONE (rare thin coal seams, often associated with abundant calcite)	110542	117.9	119.7
			110543	119.7	121.5
121.51	121.67	Coaly SILTSTONE Middle Rider Parting	110544	121.5	122.5
121.67	122.46	SILTSTONE Lower Rider Parting			
122.46	124.2	COAL (No. 1 Upper Seam) (abundant calcite veinlets, minor diss py <1 mm bands)			
124.2	124.25	SILTSTONE Middle Parting			
124.25	125.21	COAL (No. 1 Middle Seam) (dull, with low amounts of py, tr calcite)	110547	124.3	125.2
125.21	125.27	SILTSTONE	110548	125.2	125.3
125.27	125.35	COAL (No. 1 Lower Seam) (dull)	110549	125.3	126.1
125.35	125.49	Coaly SILTSTONE			
125.49	125.56	COAL (No. 1 Lower Seam) (bright fissile with silty laminations)			
125.56	125.81	Coaly SILTSTONE			
125.81	126.05	COAL (No. 1 Lower Seam) (bright and dull banding with minor calcite)	110550	126.1	127.8
126.05	127.75	SILTSTONE			
127.75	127.86	COAL (banded dull wth trace calcite)	no sample		

No. 1 Coal Zone

6.3.2 Acid Base Accounting

Acid-base-accounting results for hanging wall samples from holes QU11-03 and QU11-05 are presented in Tables 6-7 and 6-8, respectively. Paste pH values are generally slightly alkaline (median of 7.9). Only two samples from within the No. 2 Coal Zone of hole QU11-05 have paste pH values of < 6.0 .

Total and sulphide sulphur values tend to be highest (1.2 - 14.0 % Total S) in coal-bearing strata and strata directly overlying the coal zones (red type in Tables 6-7 and 6-8). Samples containing > 1 % total sulphur generally have NPR values of < 2.0 and are classified as PAG (red highlighted cells in Tables 6-7 and 6-8). Concentrations of total and sulphide sulphur are notably higher in samples from the No.3 and No. 2 coal zones of hole 11-05 where concentrations of up to 14.0 %S have been measured. However, sulphur concentrations are < 0.5 % for many samples from within the No.1 coal zone of hole 11-05. Sandstone and siltstone units between the coal zones generally have low total and sulphide sulphur values (< 0.1 %S), higher NP values (> 100 kg CaCO_3/t) and NPR values of > 2.0 indicating that these strata are non-PAG.

Higher carbonate NP values relative to modified NP values, such as is observed with the hanging wall samples, is a strong indication that Fe-bearing carbonates (*i.e.*, siderite), which do not neutralize acid as efficiently as calcite, are present in the samples. The method applied for the modified NP values are corrected for siderite content; thereby providing a more accurate value for the carbonate phases available for neutralization. Therefore, for the purpose of assessing the acid generating potential of the samples, modified NP is conservatively used to estimate available NP and AP is calculated from sulphide sulphur. Samples with NPR values of < 2.0 are classified as PAG and samples with NPR values of > 2.0 as non-PAG. Overall, samples from within and directly above the coal zones of holes 11-03 and 11-05 from the 5 South mine that contain total sulphur values of $> 1\%$ S have NPR values > 2.0 and are classified as PAG (Table 6-7 and 6-8).

6.3.3 Solid Phase Metal Content

The solid phase metal contents for the strata overlying No. 1 Seam from holes QU11-03 and QU11-05 are presented in Tables 6-9 and 6-10, respectively. Metal content is compared relative to average metal concentrations of the earth's crust as an indicator of significant solid-phase enrichment is assigned to be values greater than or equal to three times the average abundance in the earth's crust (shaded values).

Solid phase As, Bi, Cu and Se are enriched in the hanging wall strata of holes QU11-03 and QU11-05. Arsenic, Bi and Se are consistently enriched in the majority of the samples while Cu is enriched in samples from the Cumberland member siltstones and strata

within the No. 2 and No. 1 coal zones. Solid phase Mo is also elevated in samples associated with the No. 3 and No. 2 coal zones.

Table 6-7:
Acid-Base Accounting Results for 5 South Hanging Wall Hole QU11-03.

Lith Code	Sample ID	Paste pH	Total S %	Sulphate S %	Sulphide S %	AP kg CaCO ₃ /t	Total C %	CO ₂ %	CaNP kg CaCO ₃ /t	ModNP kg CaCO ₃ /t	NPR ModNP/AP
silty SS	110301	7.8	2.82	0.08	2.20	68.8	1.38	4.18	95.0	85.1	1.2
SS	110302	8.8	0.93	0.04	0.89	27.8	2.56	9.09	206.6	173.6	6.2
silty SS	110303	8.2	1.19	0.04	0.98	30.6	0.98	2.41	54.8	32.0	1.0
SS	110304	8.3	3.68	0.07	2.88	90.0	3.16	10.7	244.1	217.5	2.4
*****Formation Change*****											
SS	110305	8.3	1.63	0.06	1.44	45.0	2.02	6.93	157.5	145.0	3.2
	110306	7.6	1.60	0.06	1.41	44.1	1.41	4.80	109.1	93.4	2.1
*****Formation Change*****											
SST	110307	8.2	5.47	0.03	4.67	145.9	2.49	2.15	48.9	44.9	0.3
	110308	8.3	2.86	0.03	2.55	79.7	4.31	5.50	125.0	83.0	1.0
	110309	8.4	2.28	0.02	2.50	78.1	3.84	4.11	93.4	39.6	0.5
	110310	8.2	5.04	0.02	4.83	150.9	4.34	1.08	24.5	9.1	0.06
No.2 Rider	110311	8.7	3.09	0.02	2.64	82.5	45.6	1.91	43.4	46.1	0.6
SST	110312	8.3	0.11	<0.01	0.08	2.5	5.05	0.34	7.7	7.6	3.0
silty Coal	110313	7.4	5.00	0.05	3.97	124.1	17.2	3.40	77.3	28.5	0.2
sandy SST	110314	8.5	0.07	<0.01	0.07	2.2	2.29	6.93	157.5	11.9	5.4
SST	110315	8.4	0.05	<0.01	0.03	0.9	2.21	1.76	40.0	8.8	9.4
sandy SST	110316	8.3	0.29	<0.01	0.28	8.8	3.31	6.20	140.9	33.8	3.9
SS	110317	8.6	0.04	<0.01	0.03	0.9	3.59	12.1	274.1	167.1	178.2
	110318	8.7	0.09	<0.01	0.08	2.5	6.13	21.2	481.6	360.9	144.4
	110319	8.5	0.10	<0.01	0.07	2.2	2.88	9.50	215.9	123.3	56.4
	110320	8.9	<0.02	<0.01	<0.01	0.3	3.53	12.4	280.9	160.8	514.6
sandy SST	110321	8.5	0.03	<0.01	0.02	0.6	3.49	10.01	227.5	42.9	68.6
	110322	8.4	0.12	<0.01	0.11	3.4	3.33	8.36	190.0	64.0	18.6
SST	110323	8.3	0.02	<0.01	0.01	0.3	3.58	7.77	176.6	44.9	143.7
	110324	8.5	0.09	<0.01	0.08	2.5	3.95	9.61	218.4	69.6	27.8
	110325	8.4	0.03	<0.01	0.02	0.6	3.75	8.43	191.6	37.9	60.6
	110326	8.5	0.03	<0.01	0.02	0.6	6.59	14.2	321.6	33.8	54.1
coaly SST	110327	8.4	0.11	<0.01	0.08	2.5	20.5	3.21	73.0	32.8	13.1

Notes: AP = acid potential, calculated from Sulphide S * 31.25; CaNP calculated from CO₂ originating from carbonate minerals; and Modified NP corrected for siderite content; SS = sandstone and SST = siltstone.

Table 6-8:
Acid-Base Accounting Results for 5 South Hanging Wall Hole QU11-05.

Lith Code	Sample ID	Paste pH	Total S %	Sulphate S %	Sulphide S %	AP kg CaCO ₃ /t	Total C %	CO ₂ %	CaNP kg CaCO ₃ /t	ModNP kg CaCO ₃ /t	NPR ModNP/AP
SS	110501B	8.8	0.25	0.06	0.30	9.4	2.04	7.81	177.5	133.6	14.3
	110502B	8.6	0.93	0.06	0.95	29.7	2.01	6.64	150.9	120.2	4.0
	110503B	8.8	0.73	0.04	0.83	25.9	1.76	6.86	155.9	125.1	4.8
	110504B	8.6	4.46	0.07	4.41	137.8	2.39	9.17	208.4	169.5	1.2
	110505	8.0	7.29	0.12	7.07	220.9	2.00	6.67	151.6	117.2	0.5
*****Formation Change*****											
coaly SST	110506	6.6	7.63	0.11	7.27	227.2	14.2	2.30	52.3	12.9	0.06
SST	110507	8.0	3.02	0.06	3.07	95.9	4.87	4.18	95.0	48.8	0.5
	110508	7.5	4.75	0.06	4.73	147.8	5.84	3.36	76.4	40.1	0.3
coaly SST	110509	7.0	14.02	0.11	13.50	421.9	25.6	2.43	55.2	35.5	0.08
No.3 Rider	110501	7.5	1.71	0.04	1.17	36.6	59.9	3.00	68.2	62.2	1.7
coaly SST	110502	6.6	8.00	0.07	7.82	244.4	25.2	0.82	18.6	15.0	0.06
No.3 Seam	110503	7.4	3.22	0.03	2.24	70.0	70.4	1.93	43.9	42.0	0.6
coaly SST	110510	7.2	8.86	0.07	8.63	269.7	11.5	3.12	70.9	30.5	0.11
silty SS	110511	7.1	9.97	0.12	9.68	302.5	14.0	3.92	89.1	47.8	0.2
coaly SST	110512	7.0	6.76	0.04	7.00	218.8	30.8	1.51	34.3	23.1	0.11
No.3 Lower	110504	7.3	3.42	0.03	2.51	78.4	68.3	1.99	45.2	37.8	0.5
coaly SST	110512A	7.1	8.32	0.06	6.05	189.1	37.4	0.91	20.7	8.7	0.05
SST	110513	6.0	6.85	0.06	6.37	199.1	5.76	3.85	87.5	16.6	0.08
SS	110514	8.5	0.62	0.05	0.71	22.2	3.40	10.3	234.1	159.9	7.2
silty SS	110515	6.7	6.04	0.08	6.07	189.7	6.25	5.98	135.9	24.1	0.13
Coal	110516	6.9	6.84	0.04	5.92	185.0	46.9	2.14	48.6	24.8	0.13
SS	110517	7.5	0.54	0.01	0.64	20.0	1.86	5.28	120.0	50.2	2.5
	110518	7.8	0.37	0.01	0.41	12.8	1.49	5.32	120.9	56.9	4.4
	110519	7.8	0.29	0.04	0.32	10.0	2.45	9.24	210.0	146.0	14.6
	110520	7.7	0.19	<0.01	0.24	7.5	1.40	4.99	113.4	47.2	6.3
	110521	7.8	0.09	0.03	0.13	4.1	2.46	8.40	190.9	134.7	33.2
	110522	7.9	0.23	0.04	0.29	9.1	2.77	10.2	232.5	148.6	16.4
	110523	7.8	1.17	0.03	1.29	40.3	2.30	8.07	183.4	77.1	1.9
No.2 Rider	110524	6.8	7.07	0.07	6.01	187.8	58.3	2.97	67.5	63.7	0.3
coaly SST	110525	6.1	7.31	0.10	7.59	237.2	8.31	2.85	64.8	17.6	0.07
SS	110526	8.1	0.66	0.05	0.75	23.4	1.68	5.61	127.5	113.1	4.8
*****Formation Change*****											
CG	110527	5.7	11.33	0.18	11.20	350.0	13.1	2.33	53.0	15.8	0.05
coaly SST	110528	5.8	9.74	0.04	9.63	300.9	21.5	1.31	29.8	13.2	0.04
No.2 Seam	110529	7.3	2.50	0.29	1.99	62.2	67.0	4.36	99.1	95.0	1.5
coaly SST	110530	7.5	1.23	0.01	1.41	44.1	10.2	3.85	87.5	16.3	0.4
SS	110531	7.7	0.05	<0.01	0.06	1.9	7.00	6.78	154.1	37.0	19.7
SST	110532	8.0	<0.02	<0.01	0.05	1.6	2.99	9.64	219.1	46.5	29.8
	110533	7.8	<0.02	<0.01	0.04	1.3	3.57	9.06	205.9	27.8	22.2
	110534	7.7	0.08	<0.01	0.12	3.8	3.91	5.02	114.1	18.2	4.9
	110535	7.8	<0.02	<0.01	0.02	0.6	2.37	6.86	155.9	27.1	43.4
	110536	8.2	0.03	0.02	0.07	2.2	3.66	9.20	209.1	59.5	27.2
	110537	8.4	<0.02	0.03	0.05	1.6	3.62	11.2	253.4	110.4	70.7
	110538	7.7	2.85	0.05	3.22	100.6	6.22	5.87	133.4	48.8	0.5
SST	110539	6.9	5.68	0.09	5.69	177.8	6.32	1.45	33.0	26.6	0.1
No.1 Rider	110540	7.5	2.56	0.04	2.65	82.8	44.6	1.97	44.8	39.2	0.5
coaly SST	110541	8.1	1.83	0.01	1.81	56.6	20.2	1.03	23.4	19.7	0.3
SST	110542	8.4	<0.02	0.01	0.07	2.2	5.08	8.91	202.5	55.2	25.2
	110543	8.2	0.38	0.02	0.46	14.4	7.09	9.09	206.6	36.8	2.6
coaly SST	110544	7.5	1.17	0.01	1.35	42.2	3.34	2.71	61.6	6.4	0.2
No.1 Upper	110545	7.8	0.16	0.02	0.08	2.5	67.7	3.55	80.7	75.1	30.0
SST	110546	7.9	0.04	<0.01	0.08	2.5	9.36	4.22	95.9	6.8	2.7
No.1 Middle	110547	7.9	0.13	0.02	0.07	2.2	66.9	3.01	68.4	65.3	29.9
SST	110548	7.6	0.02	<0.01	0.06	1.9	7.51	3.58	81.4	5.6	3.0
No.1 Lower	110549	8.3	0.07	<0.01	0.10	3.1	20.7	1.60	36.4	25.5	8.2
SST	110550	7.7	<0.02	<0.01	0.05	1.6	2.00	3.92	89.1	2.8	1.8

Notes: AP = acid potential, calculated from Sulphide S * 31.25; CaNP calculated from CO₂ originating from carbonate minerals; and Modified NP corrected for siderite content; SS = sandstone; SST = siltstone and CG = conglomerate.

Table 6-9:
Solid Phase Metal Concentrations for 5 South Hanging Wall Hole QU11-03.

Lith Code	Sample ID	Al %	As ppm	B ppm	Bi ppm	Cd ppm	Co ppm	Cu ppm	Fe %	Mn ppm	Mo ppm	Ni ppm	Se ppm	Zn ppm
silty SS	110301	1.77	19.3	<20	0.05	0.08	20.9	53.5	4.91	603	0.26	33.9	0.5	59.1
SS	110302	2.10	19.1	<20	0.05	0.07	22.4	54.6	4.75	1079	0.09	35	0.4	61.7
silty SS	110303	2.89	43.2	<20	0.05	0.11	35.9	91.8	7.13	642	0.08	58.3	0.3	102
SS	110304	2.17	41.3	<20	0.03	0.05	29.9	62.8	6.19	1061	0.25	46.2	0.4	66.4
*****Formation Change*****														
SS	110305	0.98	29.7	<20	0.03	0.03	10.6	23.9	2.96	631	0.17	18.9	0.4	29.1
	110306	0.89	43.0	<20	0.04	0.04	11.6	23.3	2.95	524	0.4	20.1	0.3	37.1
*****Formation Change*****														
SST	110307	3.52	54.4	30	0.04	0.06	47.7	180	10.45	554	0.19	82.3	0.6	115
	110308	3.84	51.4	32	0.03	0.07	43.3	165	11.47	1193	0.23	82.4	0.8	98.4
	110309	3.46	45.0	25	0.04	0.07	50.2	228	9.93	749	0.22	83.1	0.8	114
	110310	3.16	53.9	26	0.05	0.08	47.8	238	9.79	506	0.22	97.7	1	113
No.2 Seam	110311	0.86	49.1	73	0.05	0.05	16.3	85.9	3.00	269	0.46	34.5	0.7	39.4
SST	110312	3.15	1.50	<20	0.04	0.02	28.8	299	3.72	253	<0.01	63.5	0.6	86.7
silty Coal	110313	2.32	9.30	21	0.04	0.12	62.1	217	9.29	1007	0.72	91.8	0.6	114
sandy SST	110314	3.02	0.70	<20	0.03	0.16	64.0	275	12.71	2172	0.06	92.8	0.5	126
SST	110315	3.39	0.70	<20	0.02	0.18	66.4	285	12.16	1555	0.13	104	0.6	133
sandy SST	110316	3.20	4.50	<20	0.02	0.17	65.5	236	11.16	1322	0.31	102	0.4	122
SS	110317	2.42	0.80	<20	<0.02	0.08	36.0	135	8.44	1275	0.01	64.8	0.3	96.4
	110318	1.70	3.20	<20	<0.02	0.08	37.5	74.8	7.39	1700	0.13	49.3	0.3	46.8
	110319	2.46	1.50	<20	<0.02	0.23	46.6	149	8.36	1416	0.12	73.0	0.2	102
	110320	2.52	0.40	<20	<0.02	0.04	39.6	159	8.71	1414	<0.01	68.6	0.4	85.9
sandy SST	110321	3.06	0.70	<20	<0.02	0.18	57.1	214	14.33	1906	<0.01	86.7	0.3	115
	110322	3.02	1.20	<20	<0.02	0.13	50.6	220	11.44	1340	0.04	83.1	0.5	109
SST	110323	3.07	0.70	<20	<0.02	0.17	57.2	259	11.42	1803	0.04	94.0	0.3	114
	110324	2.79	2.70	<20	<0.02	0.11	50.4	227	11.23	1802	0.05	91.2	0.3	104
	110325	2.72	1.00	<20	0.03	0.22	55.2	257	11.72	2166	0.02	88.8	0.7	122
	110326	2.10	1.00	<20	0.03	0.26	59.4	225	16.81	2555	0.12	71.0	0.7	151
coaly SST	110327	1.93	1.50	<20	0.04	0.04	25.5	216	4.18	544	0.13	65.0	0.4	75.3
Average Crust		8.23	1.8	10.0	0.0085	0.15	25.0	60.0	5.60	950	1.2	84.0	0.05	70.0

Notes: Shaded values are elevated with respect to >3x's the average continental crustal abundance (Price, 1997).

Table 6-10:
Solid Phase Metal Concentrations for 5 South Hanging Wall Hole QU11-05.

Lith Code	Sample ID	Al %	As ppm	B ppm	Bi ppm	Cd ppm	Co ppm	Cu ppm	Fe %	Mn ppm	Mo ppm	Ni ppm	Se ppm	Zn ppm
SS	110501B	2.15	24.8	<20	0.15	0.08	16.8	18.5	10.95	1787	0.53	22	0.4	76.3
	110502B	1.85	24.5	<20	0.12	0.07	20.7	36.1	5.60	1223	0.26	30.2	0.4	71.6
	110503B	1.25	13.8	<20	0.08	0.05	15.0	20.3	3.87	1005	0.27	22.4	0.2	47.0
	110504B	1.38	44.5	<20	0.11	0.08	16.9	25.1	7.00	1046	0.51	22.6	0.4	60.0
	110505	0.91	107	<20	0.15	0.14	20.1	23.9	8.13	1104	1.6	25.9	0.7	74.2
*****Formation Change*****														
coaly SST	110506	1.33	125	<20	0.03	0.08	32.6	154	9.48	321	0.61	61.4	0.7	84.2
SST	110507	2.01	46.2	21	0.05	0.11	38.4	175	7.90	559	0.32	69.3	0.9	110
	110508	1.58	74.6	<20	0.07	0.14	37.9	162	7.84	590	0.61	70.1	1.1	119
coaly SST	110509	0.67	192	26	0.05	0.24	24.7	107	12.55	525	8.28	52.2	1.7	65.8
No.3 Rider	110501	0.17	39.5	158	0.04	0.03	2.20	18.8	0.89	80.0	0.32	4.2	0.4	7.60
coaly SST	110502	0.34	126	40	0.04	0.08	31.9	138	5.98	124	1.53	53.5	0.9	49.5
No.3 Seam	110503	0.07	57.0	200	0.03	0.06	6.40	23.6	1.53	41.0	0.38	6	0.6	14.1
coaly SST	110510	0.87	58.8	<20	0.04	0.14	41.0	173	8.89	405	2.14	72.6	1.6	104
silty SS	110511	0.52	15.5	<20	0.05	0.18	43.3	146	9.86	558	4.59	65.0	1.7	86.3
coaly SST	110512	0.25	20.1	<20	0.05	0.15	17.3	76.1	4.65	325	3.83	28.7	0.7	46.2
No.3 Lower	110504	0.08	21.2	174	0.03	0.07	8.6	25.4	1.82	54	1.07	9	0.5	12.7
coaly SST	110512A	0.26	73.5	49	0.03	0.12	28.0	113	5.91	152	1.96	36.6	0.9	40.4
SST	110513	0.39	81.9	<20	0.07	0.14	40.9	155	8.13	424	1.47	66.9	0.8	96.1
SS	110514	0.28	33.9	<20	0.06	0.06	25.8	44.8	2.97	803	0.42	32.4	0.2	61.3
silty SS	110515	0.36	114	<20	0.07	0.19	38.9	113	9.53	483	1.82	58.1	1	95.3
Coal	110516	0.25	201	88	0.04	0.13	15.6	95.6	5.53	153	5.53	33.1	0.9	33.3
SS	110517	0.25	30.0	<20	0.18	0.14	18.9	37.9	3.44	433	0.4	23.0	0.2	67.3
	110518	0.28	20.1	<20	0.06	0.05	13.6	31.7	2.84	507	0.24	19.0	0.2	45.8
	110519	0.24	23.4	<20	0.06	0.06	11.4	26.3	2.82	717	0.31	17.4	0.1	37.6
	110520	0.28	20.4	<20	0.06	0.07	13.5	34.4	3.21	327	0.31	20.7	0.1	40.4
	110521	0.24	17.3	<20	0.05	0.07	11.6	33.8	2.88	786	0.26	18.2	0.3	41.8
	110522	0.30	27.2	<20	0.07	0.07	18.8	48.3	3.64	789	0.17	26.2	0.2	55.2
	110523	0.34	44.0	<20	0.06	0.09	23.6	62.1	4.71	634	0.31	36.9	0.3	73.2

Table 6-10 (continued):

Lith Code	Sample ID	Al %	As ppm	B ppm	Bi ppm	Cd ppm	Co ppm	Cu ppm	Fe %	Mn ppm	Mo ppm	Ni ppm	Se ppm	Zn ppm
No.2 Rider	110524	0.10	101	97	0.03	0.07	8.2	29.9	4.80	171	2.14	13.6	0.6	12.8
coaly SST	110525	0.97	62.4	<20	0.05	0.11	41.4	149.5	9.68	523	2.13	70.6	1.2	101.4
SS	110526	2.05	27.0	<20	0.14	0.08	20.7	33.2	5.79	1272	0.29	29.0	0.3	73.7
*****Formation Change*****														
CG	110527	0.68	35.1	<20	0.04	0.14	32.7	94.3	11.39	617	4.35	49.7	1	78.7
coaly SST	110528	0.79	14.9	<20	0.05	0.16	33.6	141	9.02	445	4.57	55.2	1.2	76.7
No.2 Seam	110529	0.10	9.00	97	<0.02	0.07	9.10	17.4	1.55	157	0.56	26.7	0.4	16.5
coaly SST	110530	1.36	5.80	<20	0.04	0.15	56.6	234	5.75	839	0.53	90.2	0.6	95.6
SS	110531	1.53	1.40	<20	0.03	0.16	50.3	241	8.19	1157	0.13	78.7	0.3	102
SST	110532	1.73	0.40	<20	0.07	0.19	61.3	233	12.04	2130	0.09	84.6	0.2	89.6
	110533	1.86	0.60	<20	0.05	0.05	50.6	239	11.82	2209	0.17	79.9	0.5	92.4
	110534	1.99	0.50	<20	0.05	0.38	56.6	276	7.93	1770	0.13	86.4	0.4	104.3
	110535	2.20	0.20	<20	0.03	0.06	60.5	259	10.50	2060	0.07	85.9	0.3	101.3
	110536	2.05	1.10	<20	0.02	0.19	56.3	227	11.06	1545	0.22	78.5	0.5	95.7
	110537	1.96	0.40	<20	0.02	0.08	45.2	216	9.92	1660	0.09	73.1	0.3	84.9
coaly SST	110538	1.71	5.00	<20	0.06	0.19	56.2	221	9.19	1062	0.53	83.9	0.6	98.2
SST	110539	1.77	13.4	<20	0.1	0.16	42.9	179	7.44	558	1.35	67.8	0.7	105
No.1 Rider	110540	0.51	5.70	31	0.05	0.09	19.9	112	2.62	135	1.76	39.9	0.4	38.2
coaly SST	110541	1.27	8.70	<20	0.03	0.52	83.6	238	3.31	212	0.44	101.6	0.8	172
SST	110542	1.68	1.40	<20	0.03	0.08	42.1	222	9.49	1719	0.08	71.2	0.5	91.0
	110543	1.62	5.70	<20	0.03	0.1	53.0	240	11.13	1891	0.14	83.8	0.8	86.1
coaly SST	110544	2.03	13.3	<20	0.03	0.21	73.4	283	6.61	1251	0.2	109	1	146
No.1 Upper	110545	0.26	6.30	41	0.04	0.05	13.7	26.7	0.42	99.0	0.38	16.7	0.3	25.7
SST	110546	1.32	3.30	<20	0.04	0.03	29.9	269	6.48	883	0.06	45.2	0.4	61.2
No.1 Middle	110547	0.17	7.80	30	0.04	0.09	19.2	32.1	0.45	175	0.4	19.0	0.3	24.7
SST	110548	1.59	3.50	<20	0.03	0.07	31.6	269	6.25	1262	0.06	64.0	0.4	76.2
No.1 Lower	110549	0.92	4.60	<20	0.05	0.47	15.1	192	1.50	417	0.21	39.6	0.4	159
SST	110550	1.69	1.30	<20	0.04	0.01	41.9	298	7.42	1003	0.08	78.7	0.4	89.6
Average Crust		8.23	1.8	10.0	0.0085	0.15	25.0	60.0	5.60	950	1.2	84.0	0.05	70.0

Notes: Shaded values are elevated with respect to >3x's the average continental crustal abundance (Price, 1997).

6.4 Geochemical Source Terms

A conceptual model to understand the evolution of mine pool geochemistry is illustrated in Figure 6-19, which is similar to that described by McDonough *et al.* 2005. The bulk water chemistry of the mine pool (C_1) is dependent on the chemistry of the recharging water (C_R), the relative rates of groundwater recharging the mine void (R_1), the production and release of coal weathering products in the unsaturated mine void (P_2), the dissolution and release of coal weathering products in the flooded mine void (P_1) and the loss of these dissolved constituents in the mine discharge ($C_1 \times D_1$). A more detailed description of the conceptual model and references to a series of papers in the primary literature that have reported similar evolution in mine pool waters at abandoned coal mines is provided in Lorax (2011a).

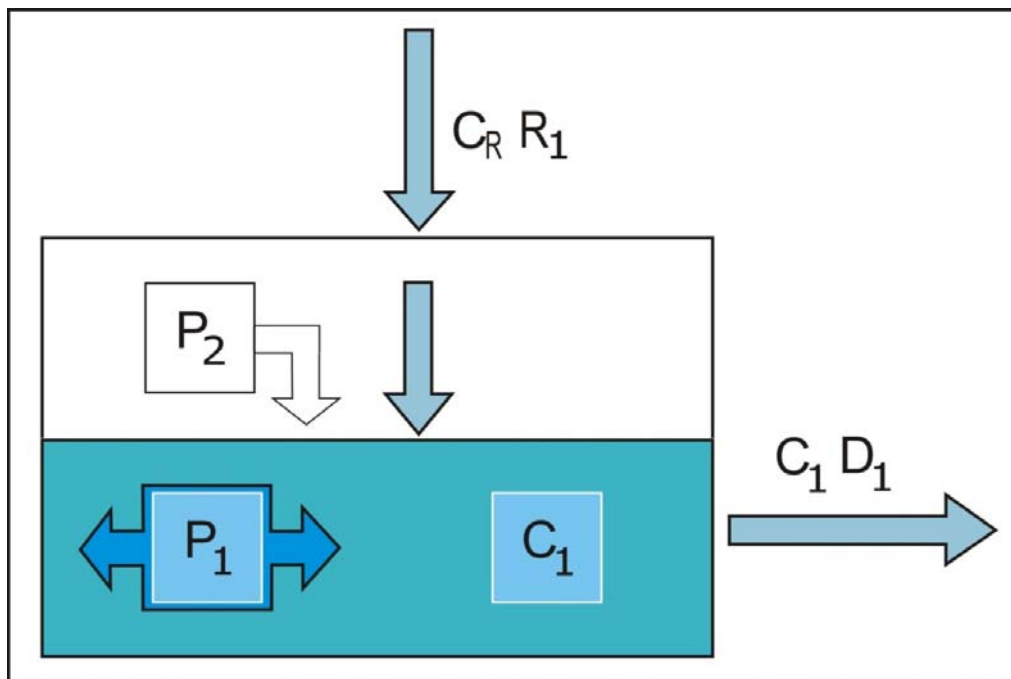


Figure 6-19: Conceptual Hydro-Geochemical Model Schematic for flooded underground mines - R_1 is the recharge rate to the mine void, D_1 is the discharge rate from the mine void, C_1 represents the constituent concentrations of the mine pool, C_R is the constituent concentrations of the recharge water, P_1 is the constituent production terms within the mine pool including flooded tailings and coarse reject, and P_2 is the constituent production terms from unsaturated portions of the mine.

Geochemical source terms have been developed for the expected mine configurations in the 2 North , 3 North and 5 South mine areas. The source terms have been developed using a set of empirical data including the following:

- water samples collected from underground mine dewatering and mine voids and
- laboratory kinetic test results from saturated columns on 7 South coarse reject and tailings.

6.4.1 Mine Pool Source Terms in Areas with no Tailings or Coarse Reject Storage

Flooded mine pools currently exist in both the 2 North / 3 North and 5 South mines. Currently, the mine pool chemistries are similar. However, the water chemistry of the 2 North / 3 North mine pool may evolve in a slightly different manner than the 5 South mine pool even though the mines are in the same coal seam. The primary reason for the difference in the mine pool source terms is the difference of the rate of water inflow (R_1) to the mines and the higher sulphur content in the 5 South Phase 2 area. Descriptions of how the recharging waters affect the mine pool water chemistry for both areas are discussed in turn below with a tabulated list of the expected and worst case mine pool water chemistry.

5 South

At the 5 South mine, water inflow will occur along mine subsidence features and pre-existing faults. However, unlike 3 North, subsidence features at 5 South are not expected to intersect significant surface water features, thus inflow rates are expected to be moderate and seasonal with higher inflow rates occurring during winter months. As the mine pool forms, the PAG strata in the roof of the mine void (Rider Parting and Rider Seam) will be rinsed and soluble oxidation products that have formed on this will be rinsed and locally producing water chemistry similar to acidic waters leached from unsaturated column Col7 that contains Rider Parting (Section 6.1). However, as this water flows down the walls and along the roadways to the mine pool it comes into contact with the non-PAG coal on the floor of the mine that neutralizes the water and attenuates aqueous metal concentrations. Similarly, water currently entering the mine that has limited contact with the Rider Seam and parting will be influenced by infiltration through the non-PAG gob (Cumberland siltstone) that will provide additional alkaline input to the mine water. As the mine pool fills, it will submerge previously exposed walls including the PAG gob, which will effectively stop the acid generating sulphide oxidation reaction.

Flooding of the mine will release stored acidity on the exposed PAG Rider Seam and Rider Parting if sufficient time has passed prior to flooding for these units to have acidic pH, which is expected. However, unlike the 4 South mine where the mine pool formed in the PAG No. 3 Seam, the 5 South mine pool will be in contact with available carbonates in the No. 1 Seam and non-PAG Cumberland siltstones in the gob that will dissolve and release alkalinity and maintain pH in the circum-neutral range. Portions of No.1 Seam are in the up-dip end of the 5 South mine, thus, the predicted a greater range of concentrations between the expected and worst case are presented for the 5 South mine than the 2 North mine that is discussed in the next section.

There are currently two direct measures of water quality from the 5 South mine that document the expected mine pool water chemistry. Panel 101 has been exposed since it was mined in 2007, which is sufficient time for acidic conditions to develop in the Rider Seam (Section 6.1). Water samples from the 101 panel in the 5 South mine since 2009 illustrate interim water chemistry of water influenced by PAG Rider Seam and Rider Parting and subsequently neutralized along the flow path to the mine pool. However, the best measure of mine pool water was obtained from borehole QU05-13, which sampled the 5 South mine pool as it was flooding. This sample accounts for waters seeping to the mine pool, mine wall rinsing and dilute water inflows. The QU05-13 water is moderately reducing as indicated by ferrous Fe concentrations > 0.5 mg/L, but did not contain detectable sulphide. It is expected that as the mine pool continues to mature the waters will become more strongly reducing that would result in the reductive dissolution of hydrous ferric oxides and sulphates on the oxidized walls. This has the potential to increased Fe and sulphide concentrations in the mine pool, which in turn will also increase the total alkalinity of the mine pool.

The worst case and expected mine pool water quality predictions for the 5 South mine pool are presented in Figure 6-20. The expected 5 South mine pool source terms for a fully flooded mine are set equal to those concentrations observed in the QU05-13 sample. The worst case 5 South mine pool source terms are set equal to the maximum observed concentrations from the 101 panel and QU05-13. Worst case iron concentrations have been increased by a factor of 5 to account for the possibility of further evolution of the redox potential in a mature mine pool. Manganese concentrations have not been increased due to the limitation of maximum Mn concentrations by rhodochrosite (MnCO_3) in an alkaline mine pool.

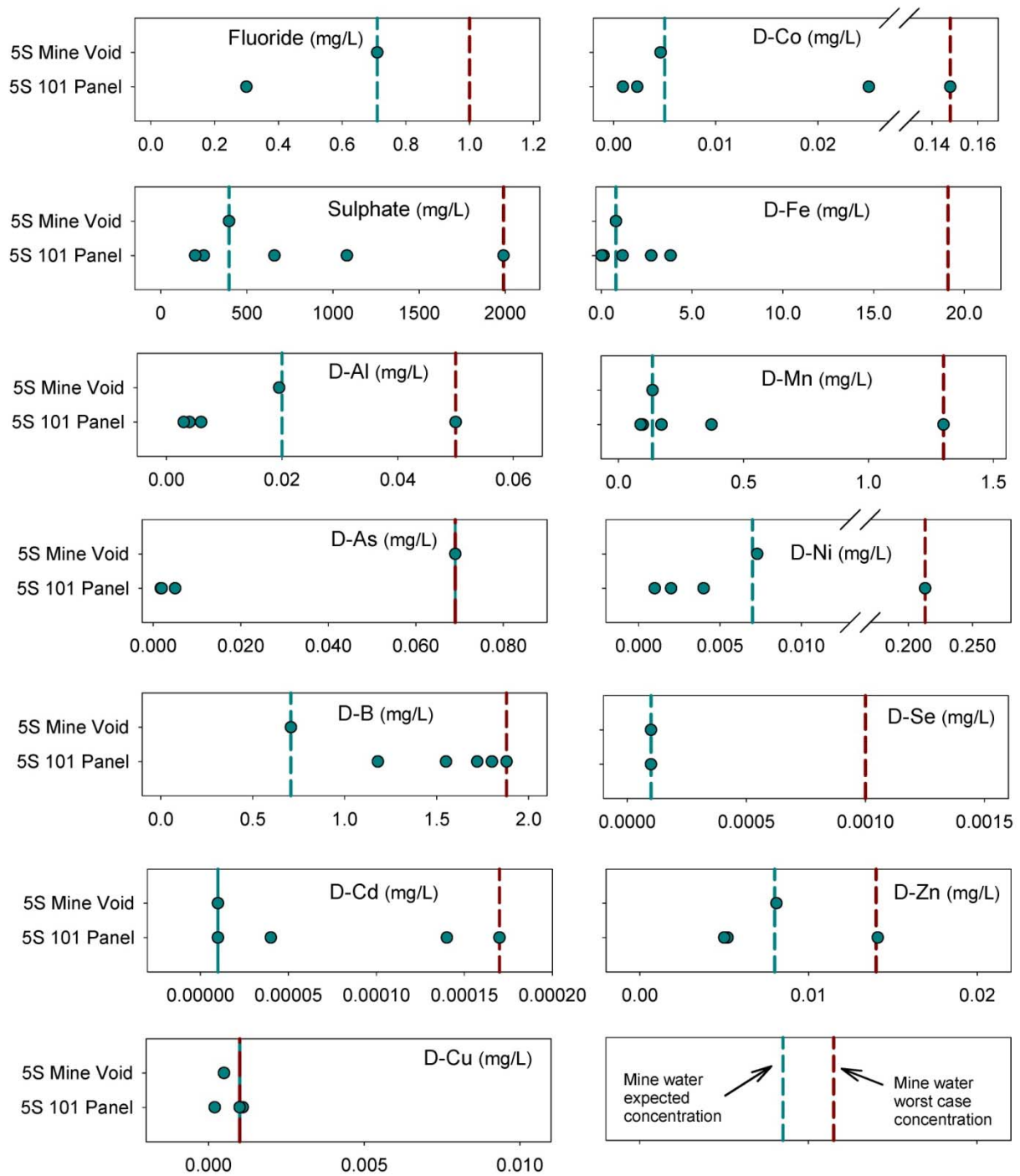


Figure 6-20: 5 South Mine Water Sample Results and Expected and Worst Case Mine Pool Water Quality Predictions.

**Table 6-11:
Expected and Worst Case Concentrations of Mine Pool Source Terms.**

		5S Mine Void		2N Mine Void		RBP w 7S CCR		2N w 7S Tailings	
		Expected	Worst Case	Expected	Worst Case	Expected	Worst Case	Expected	Worst Case
pH		7.4		8.1		7.5		8.1	
Alkalinity (CaCO ₃)	mg/L	282		450		282		450	
Fluoride (F)	mg/L	0.71	1.00	0.29	0.3	0.71	1.00	1.1	1.2
Sulfate (SO ₄)	mg/L	396	1990	278	1280	396	1990	278	1280
Dissolved Metals									
Aluminum (Al)	mg/L	0.020	0.050	0.013	0.027	0.020	0.050	0.013	0.027
Arsenic (As)	mg/L	0.069	0.069	0.036	0.040	0.128	0.190	0.113	0.125
Boron (B)	mg/L	0.707	1.88	1.10	1.20	0.71	1.88	1.1	1.2
Cadmium (Cd)	mg/L	0.00001	0.00017	0.00002	0.00008	0.000017	0.000175	0.00002	0.00008
Cobalt (Co)	mg/L	0.005	0.148	0.001	0.0035	0.005	0.148	0.001	0.023
Copper (Cu)	mg/L	0.001	0.001	0.001	0.004	0.001	0.001	0.001	0.004
Iron (Fe)	mg/L	0.805	19.1	0.490	2.45	0.805	33.5	0.490	2.902
Manganese (Mn)	mg/L	0.136	1.3	0.360	0.95	0.14	2.89	0.360	0.950
Nickel (Ni)	mg/L	0.007	0.213	0.001	0.008	0.007	0.213	0.001	0.033
Selenium (Se)	mg/L	0.0001	0.001	0.0002	0.001	0.0002	0.004	0.0002	0.007
Zinc (Zn)	mg/L	0.008	0.014	0.006	0.007	0.008	0.088	0.006	0.019

2 North / 3 North

At the 3 North mine, surface sink holes and cracks associated with mine subsidence has allowed for significant inflows to the 2 North / 3 North underground mine from surface drainage features (Figure 5-1). This occurrence is corroborated by Lorax's observations in 2009 of channelized flows on the mine floor near the 6 Mains underground sump. The inflowing waters provide a source of dilute pH-neutral water that enters the mine at restricted points and flows in channels along the mine floor until the water reaches a mine pool or sump where it is pumped to the surface water management system and ultimately released to Middle Quinsam Lake through Sediment Pond SP4. Where inflowing waters come into contact with large proportions of PAG Rider Seam, these waters will become acidic. Kinetic testing indicates that the high sulphur portions of the Rider Parting in

5 South are expected to become acidic within one year of exposure (Section 6.1). It is likely that a similar time frame would also be required for the high sulphur Rider Seam in the 2 North / 3 North mines to become acidic, thus, the existing mine pool is likely receiving metal loading contributions from the acidic Rider Seam. The mine dewatering network maintained a mine pool as of June 2010 at an elevation of 240 m in the 3 North mine, 180 m in the northern portion of the 2 North mine and 140 m in the southern portion of the 2 North mine (Figure 5-1). This has resulted in a mine pool flooding approximately 30% of the 2 North / 3 North mine workings. The existing mine pool waters are comprised of both acidic waters that come into contact with PAG rider seam, and inflowing waters that are limited to discreet channels on the mine floor. Sampling of the pumped mine pool waters indicate that the dilute inflow waters provide a sufficient dilution ratio to maintain neutral pH (Section 5.2).

Following completion of mining, dewatering will stop and the mine workings are expected to flood to at least the 280 m elevation (Section 4.4.3). The rate of inflow through surface subsidence cracks is expected to remain similar to existing inflow rates, which will continue to provide a source of dilute pH-neutral water to the mine pool. Although, the up-dip (west) end of the mine is expected to remain unflooded, the proportion of unflooded workings will be less than currently observed, thus, the contribution of acidic waters from exposed PAG Rider Seam will also decrease. When the 2 North mine pool floods, submergence of the PAG Rider Seam between the 140 m and 280 m elevation will occur and the dissolution of soluble oxidation products will be released to the mine pool. This occurrence is expected to be of relatively short duration and the resulting concentrations are expected to be captured by the range of concentrations in the existing monitoring data set.

Observations from other underground coal mines have shown that mine pool water chemistry is known to evolve over time as mine pools stratify due to the presence of higher rates of inflow / outflow in the upper portions of the mine and the tendency of stagnant mine pools to become strongly reducing. It should be noted that the documented occurrence in the Appalachian Basin of mature mine pools that are circum-neutral, strongly reducing and contain elevated iron and aluminum concentrations have evolved from juvenile mine waters that are strongly acidic (Perry, 2001). This is not the case in the 2 North / 3 North mines.

The worst case and expected mine pool water quality predictions for the 2 North / 3 North mine pools are presented in Figure 6-21. Predicted mine pool concentrations for the 2 North / 3 North mine pool are lower than predicted for the 4 South mine pool.

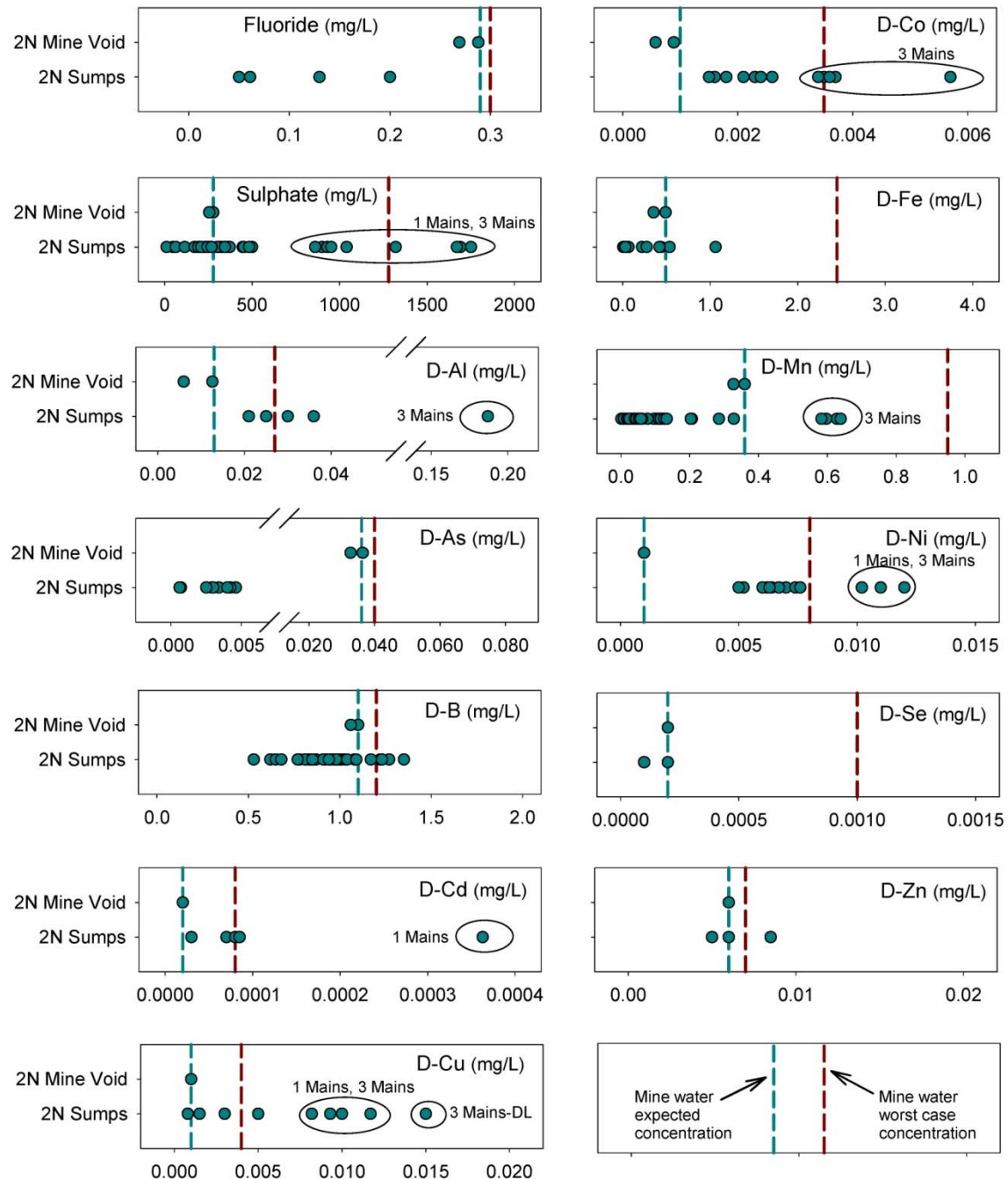


Figure 6-21: 2 North / 3 North Mine Water Sample Results and Expected and Worst Case Mine Pool Water Quality Predictions.

These lower concentrations are expected due to the predominance of the low-sulphur non-PAG coal exposed in the 2 North / 3 North mine void rather than PAG coal from No. 3 Seam. Although there will be existing sulphide oxidation products available to reductively dissolve into the mine pool at 2 North, the total inventory of these hydrous ferric oxides and sulphates will be much lower in strata that has not become acidic prior to flooding. Thus, the release of sulphate, iron and other metal(oid)s will be much lower

than observed in 4 South. This is supported by direct measures of water quality from monitoring well QU10-13, which sampled the mine pool in the southern portion of 2 North as it was flooding. The two samples from this location account for waters seeping to the mine pool, mine wall rinsing and dilute water inflows. The QU10-13 water is strongly reducing as indicated by the presence of sulphide. Despite the strongly reducing conditions iron concentrations are maintained at < 0.50 mg/L, which suggests that there is not a large source of reducible iron within the flooded mine void, unlike the strongly reducing 4 South mine void water that contained dissolved ferrous iron concentrations > 250 mg/L.

With the exception of the Rider Seam, the zone of most intense fracturing in the overlying gob will be in non-PAG Cumberland siltstone that contains carbonates that will contribute alkalinity to the mine pool as it floods. Thus, the 2 North / 3 North mine pool is expected to maintain pH neutral conditions and have higher alkalinity than the 4 South mine pool or the 5 South mine pool. The higher alkalinity in the flooded mine pool will tend to have an ameliorating effect on most metal concentrations. In particular, maximum Mn concentrations are expected to be thermodynamically limited by the precipitation of rhodochrosite (MnCO_3). PHREEQC thermodynamic modeling indicates that the February sample from QU10-13 is saturated with respect to rhodochrosite and the April sample that has lower manganese and alkalinity concentrations is slightly undersaturated. Thus, a worst case concentration of Mn is set based on

The expected 2 North / 3 North mine pool source terms for a fully flooded mine are set equal to the maximum concentration observed in the existing mine void samples from monitoring well QU10-13D. The worst case 2 North / 3 North mine pool source terms are set to the 90th percentile of the complete 2 North / 3 North mine pool data set. In instances when the expected concentration from QU10-13D exceeds the 90th percentile, the worst case is set equal to the QU10-13D concentration. Although iron concentrations are expected to increase in a strongly reducing mine pool above those concentrations that are currently observed, they are not expected to increase to levels observed in the 4 South mine due to the lower sulphur content (pyrite) of the No. 1 Seam in the 2 North / 3 North mines and the predominately NAG Cumberland Member siltstones that will form part of the gob. Thus, worst case iron concentrations are set equal to be 5 times the expected concentration measured in QU10-13D, which exceeds any measured iron concentration.

6.4.2 2 North Mine Pool Source Terms with 7 South Tailings

The deposition of tailings in the 2 North mine has the potential to alter the water quality of the mine pool in areas adjacent to the tailings deposition area. The resulting water chemistry will be the combined effect of mine waters interacting with tailings. In order

to predict the resulting chemistry, empirical results from the 2 North mine pool sampling and the HQD saturated column test on 7 South tailings have been utilized.

The expected water chemistry is assigned as the greater of the expected 2 North mine water prediction or the average of the stabilized metal release (Cycles 5-8) from the 7 South tailings saturated column (HQD). Fresh tailings from the mill are expected to have excess NP available in the form of calcite when they are deposited in the mine void. Thus, mine waters comingling with the tailings are expected to maintain neutral pH, although concentrations of F and As are expected to be higher than areas of the 2 North mine where tailings are not being stored (Table 6-11).

The worst case water chemistry is assigned as the greater of the predicted worst case 2 North mine water (Section 6.4.1) or the 90th percentile from the entire leaching record from the 7 south tailings saturated column HQD (Section 6.2.3). Under a worst case condition, concentrations of F, As, Co, Fe, Ni, Se and Zn may be higher in areas where the 7 South tailings are stored.

6.4.3 River Barrier Pillar Mine Pool Source Terms with 7 South Coarse Reject

The storage of coarse reject in the River Barrier Pillar has the potential to alter the water quality of the mine pool water discharging from the storage areas. The resulting water chemistry will be the combined effect of mine waters interacting with coarse reject. In order to predict the resulting chemistry, empirical results from the 5 South mine pool sampling and the HQA and HQC saturated column tests on 7 South coarse reject have been utilized (Lorax, 2011b). The predicted concentrations assume that coarse reject is placed in the mine and flooded before the onset of acidic conditions.

The expected water chemistry is assigned as the greater of the expected 5 South mine water quality or the average from the stabilized leaching rates from the 7 South coarse reject saturated columns (HQA and HQC). Mine waters coming into contact with the coarse reject are expected to maintain neutral pH although concentrations of As, Cd, and Se are expected to be higher than in areas of the 5 South mine where tailings are not being stored (Table 6-11).

The worst case water chemistry is assigned as the greater of the predicted worst case 5 South mine water (Section 6.4.1) or the 90th percentile from the entire leaching record from the 7 South coarse reject columns HQA and HQC. Under a worst case condition, concentrations of As, Fe, Mn, Se and Zn may be higher in areas where the 7 South coarse reject is stored.

7. Estimation of Groundwater Loadings to Receiving Waters



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7. Estimation of Groundwater Loadings to Receiving Waters

Groundwater loading estimates for the parameters of concern (POCs) from the 2 North/3 North, 5 South and RBP mines (post-mining) to the Quinsam River have been calculated using the groundwater seepage fluxes described in Chapter 4 and water quality source terms described in Chapter 6. The general procedures used to estimate loadings via groundwater seepage from the mine areas and to predict changes in existing (baseline) water quality in the Quinsam River are similar to those employed previously for the 7 South Mine. The loading model incorporates seepage from the 2 North/ 3 North mine from areas where mine pool waters will evolve and where tailings will be placed and allowed to flood, seepage from mine pool waters in the 5 South Mine and upwards vertical seepage from the RBP Mine where coarse reject will be disposed.

Two loading scenarios were determined for each of the mine areas. Scenario 1 is based solely on seepage of mine pool waters from the mine voids; no underground disposal of tailings or coarse reject are considered. Scenario 2 incorporates the expected case where there is subaqueous disposal of tailings in a portion of the 2 North/3 North mines and coarse reject is disposed in the RBP mine. For each scenario, a median or expected condition and worst case condition has been predicted. The expected condition is based on the expected or median groundwater fluxes and the expected source water quality for each condition (*i.e.* mine pool, mine pool with tailings and mine pool with coarse reject). The worst case condition assumes higher seepage rates (based on infiltration of 10 % of mean annual precipitation over the footprint of each mine) and higher or upper bound source term concentrations as described in Chapter 6.

Assuming subaqueous disposal of tailings occurs as planned in the 2 North/3 North Mine and coarse reject is disposed of in the RBP Mine, Scenario 2 represents the most realistic assessment with the median values representing the expected condition and the upper bound estimate representing a worst case condition.

7.1 Loading Model Description

Groundwater mass fluxes can be determined by multiplying groundwater volumetric fluxes (Q in m^3/d) by the predicted concentrations (C in mg/L) of the POCs for the various conditions (*i.e.* mine pool, mine pool with tailings and mine pool with coarse reject), and accounting for consistency in units:

$$\text{Mass flux (kg/d)} = Q \cdot C_{\text{POC}} / 1000$$

The methods and assumptions used to calculate groundwater fluxes out of the 2 North/3 North, 5 South and RBP mine areas have been described in detail in Section 4.3 and 4.4 and the expected seepage rates for these areas are described in Tables 4-5 And 4-6, respectively. The upper bound seepage rates are approximately three to four times higher than the expected seepage rates and are based on an assumption that seepage from each mine area is equivalent to a recharge rate of 10 % of mean annual precipitation over the entire mine footprint area. The source concentrations of the contaminants of concern predicted for the mine pool waters, mine pool waters in contact with tailings and mine pool waters in contact with coarse reject have been discussed in detail in Section 6.4.

7.2 Groundwater Mass Loadings From Mine Areas

Groundwater mass loadings for the contaminants of concern are summarized for each of the mine areas in the following.

7.2.1 2 North/3 North

The predicted groundwater mass loadings to the Quinsam River expressed in kg/day for the cases with and without subaqueous tailings storage are presented in Table 7-1. Loading values for Scenario 2 (*i.e.* with tailings disposal) assumes the expected groundwater fluxes and source term concentrations represent the best estimate of predicted conditions and these values have been shaded grey in Table 7-1. The worst case load under Scenario 2 assumes that rock permeabilities are somewhat greater than determined from the field program or faults are capable of transmitting higher groundwater flows than estimated. The worst case estimate also accounts for higher rates of discharge through subsidence features that break through to surface along the Quinsam River Valley at the updip end of the 2 North Mine and that future water quality of mine pool waters is poorer than typically observed from the mine pool sampling program and saturated column testing.

Comparison of predicted loadings from Scenario 1 and 2 provides insight on the effect of subaqueous tailings disposal. The results indicate no predicted increases in loadings for Al, B, Cd, Cu, Mn, and SO₄, while tailings disposal is anticipated to increase loadings of As, Co, F, Fe, Ni, Se and Zn.

**Table 7-1:
 2 North/ 3 North Mass Fluxes for Scenarios 1 and 2.**

Contaminant of Concern (Dissolved)	Unit	Scenario 1 No Tailings Stored in Mine Void		Scenario 2 7S Tailings Stored in Mine Void	
		Expected Load	Worst Case Load	Expected Load	Worst Case Load
Aluminum (Al)	kg/d	0.0027	0.028	0.0027	0.028
Arsenic (As)	kg/d	0.0079	0.041	0.019	0.10
Boron (B)	kg/d	0.24	1.2	0.24	1.2
Cadmium (Cd)	kg/d	4.3E-06	8.2E-05	4.3E-06	8.2E-05
Cobalt (Co)	kg/d	1.9E-04	0.0036	1.9E-04	0.018
Copper (Cu)	kg/d	2.2E-04	0.0036	2.2E-04	0.0036
Fluoride (F)	kg/d	0.062	0.31	0.19	0.96
Iron (Fe)	kg/d	0.11	2.5	0.11	2.8
Manganese (Mn)	kg/d	0.078	0.97	0.078	0.97
Nickel (Ni)	kg/d	2.2E-04	0.0086	2.2E-04	0.026
Selenium (Se)	kg/d	4.3E-05	0.0010	4.3E-05	0.0050
Sulphate (SO ₄)	kg/d	60	1,310	60	1,310
Zinc (Zn)	kg/d	0.0013	0.0072	0.0013	0.016

7.2.2 5 South and River Barrier Pillar Mine

The predicted groundwater mass loadings to the Quinsam River expressed in kg/day for the 5 South and RBP mines are shown in Table 7-2. Loadings have been determined based solely on seepage of mine pool waters (Scenario 1) and for the expected condition with disposal of 7 South coarse reject in the RBP mine (Scenario 2). Loading values for Scenario 2 (*i.e.* with coarse reject disposal) and assuming the expected groundwater fluxes and source term concentrations represent the best estimate of predicted conditions and these values have been shaded grey in Table 7-2. The worst case load under Scenario 2 assumes that rock permeabilities are somewhat greater than determined from the field program, and that future water quality of mine pool waters is poorer than typically observed from the mine pool sampling program and the saturated column testing.

**Table 7-2:
5 South and RBP Mass Fluxes for Scenarios 1 and 2.**

Contaminant of Concern (Dissolved)	Unit	Scenario 1 No CCR Stored in Mine Void		Scenario 2 7S CCR Stored in RBP	
		Expected Load	Worst Case Load	Expected Load	Worst Case Load
Aluminum (Al)	kg/d	9.3E-04	0.012	9.3E-04	0.012
Arsenic (As)	kg/d	0.0033	0.016	0.0035	0.019
Boron (B)	kg/d	0.034	0.45	0.034	0.45
Cadmium (Cd)	kg/d	4.8E-07	4.1E-05	5.0E-07	4.1E-05
Cobalt (Co)	kg/d	2.2E-04	0.035	2.2E-04	0.035
Copper (Cu)	kg/d	2.4E-05	2.6E-04	2.4E-05	2.6E-04
Fluoride (F)	kg/d	0.034	0.24	0.034	0.24
Iron (Fe)	kg/d	0.038	4.6	0.038	4.9
Manganese (Mn)	kg/d	0.0065	0.31	0.0065	0.34
Nickel (Ni)	kg/d	3.5E-04	0.051	3.5E-04	0.051
Selenium (Se)	kg/d	4.8E-06	2.4E-04	5.0E-06	3.0E-04
Sulphate (SO ₄)	kg/d	19	476	19	476
Zinc (Zn)	kg/d	3.9E-04	0.0034	3.9E-04	0.0049

Comparison of predicted loadings from Scenario 1 and 2 indicates small predicted increases in potential loadings of As, Cd, Fe, Mn, Se and Zn with no changes for Al, B, Co, Cu, F, Ni and SO₄. This is consistent with the relatively small contribution of mass loadings from the RBP mine due to the small mine area and associated small groundwater flux relative to the groundwater flux predicted for the 2 North / 3 North and 5 South mines.

7.3 Predicted Effects in Quinsam River

The predicted concentrations in the Quinsam River receiving waters were estimated based on the contaminant loadings tabulated above and on the monthly average water quality in the Quinsam River which was described in detail in the 7 South Mine Groundwater Evaluation (Lorax, 2011b). The groundwater mass loadings represent a constant input (*i.e.* no seasonal variations) and are added to the existing baseline water quality in the Quinsam River assuming no attenuation of concentrations in the groundwater system and full mixing with the surface water. Predicted concentration changes in the Quinsam River due to mass loadings from the 2 North/3 North mines, and the 5 South and RBP mines are described below.

The modeled monthly contaminant concentrations in the Quinsam River after inputs from the 2 North/3 North, 5 South and RBP mines for both Scenarios 1 and 2 are depicted graphically in Figures 7-1 through 7-4 and are tabulated in Appendix D. Note that to provide resolution of the predicted concentrations and to illustrate the water quality guidelines, results for Mn, As, Co, Se, B and Ni are presented on a logarithmic concentration scale. The baseline water quality of the Quinsam River is shown in green, while the concentration increase due to groundwater loading from the 2 North/3 North mine is shown in purple and the increase due to loading from the 5 South / RBP areas is shown in orange. The 7Q10 bar represents modeled concentrations for the 7-day, one in ten year low flow period determined from 17 years of records at WSC stations on the Quinsam River (spanning 1993 to present). As was the case for the loading estimates described above in Tables 7-1 and 7-2, the most realistic case based on the assumptions of the loading model (*i.e.* Scenario 2 with coarse reject disposal in RBP and median groundwater fluxes) has been highlighted grey in Figures 7-1 through 7-4.

Assessment of the potential impact to receiving waters in the Quinsam River was determined by comparing the predicted water quality (*i.e.* baseline plus groundwater mass loading) to the most recent version of the provincial Approved and Working Water Quality Criteria for protection of freshwater aquatic life (MOE, last updated January, 2010). For most chemical parameters, guidelines are provided for both acute and chronic (30 day mean concentration) exposure.

Under the expected case, all water quality parameters remain below both chronic and acute water quality guidelines. Under the worst case conditions assumed for Scenario 2, the SO₄ concentration could potentially exceed the guidelines for chronic exposure in March and April and under the 7Q10 low flow event. It is noted that the chronic exposure is typically based on a longer term (*e.g.* 30 day) exposure, while the 7Q10 low flow is a shorter-term (*i.e.* 7 day) event. Iron, arsenic and cadmium concentrations could also exceed acute guidelines under the 7Q10 low flow event under worst case conditions assumed for Scenario 2. Cadmium may also exceed the acute guideline under worst case conditions assumed for Scenario 1.

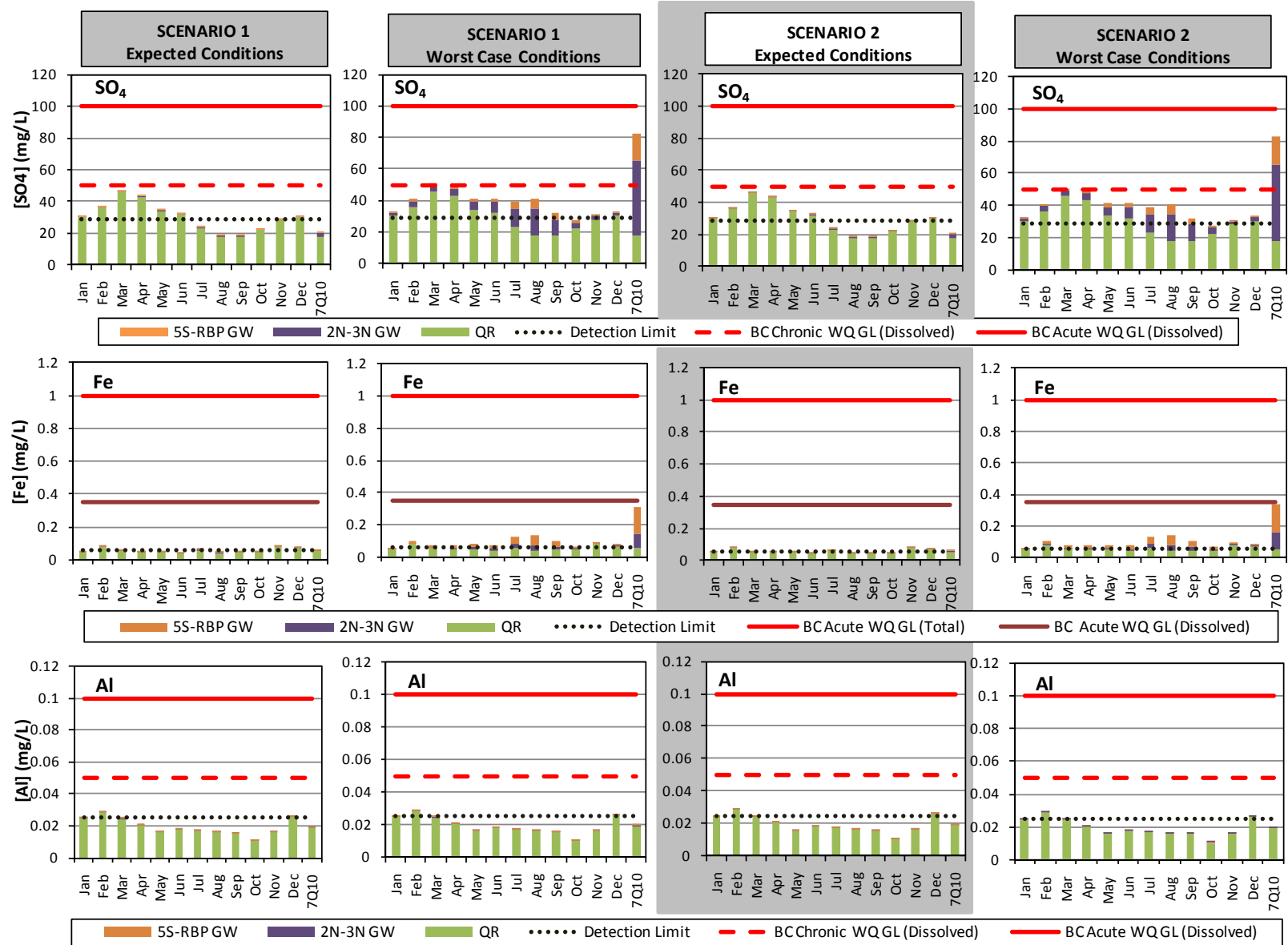


Figure 7-1: Predicted Concentrations of Sulphate, Iron and Aluminum in Quinsam River from 2 North / 3 North and 5 South / RBP Loading.

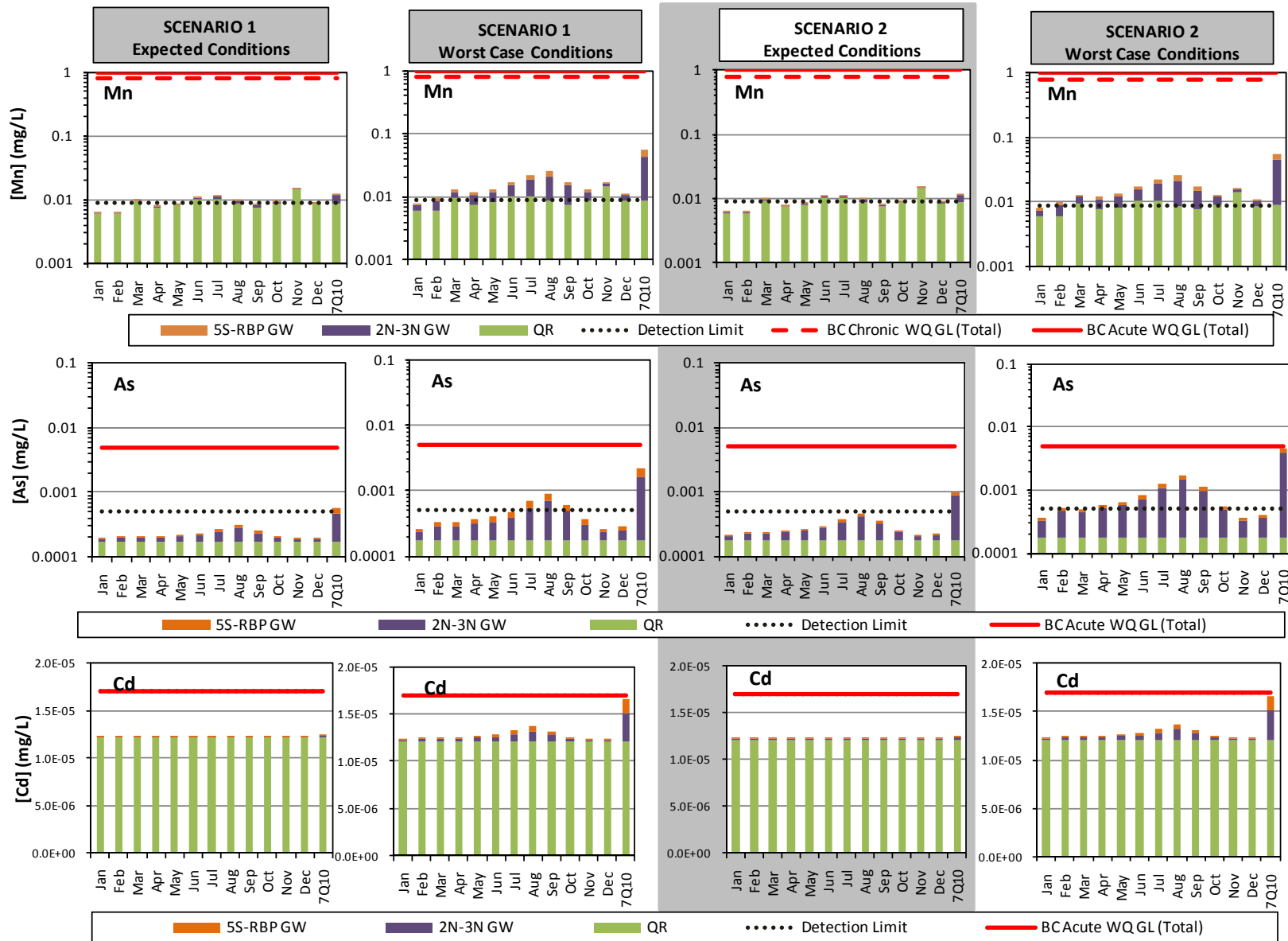


Figure 7-2: Predicted Concentrations of Manganese, Arsenic, and Cadmium in Quinsam River from 2 North / 3 North and 5 South / RBP Loading.

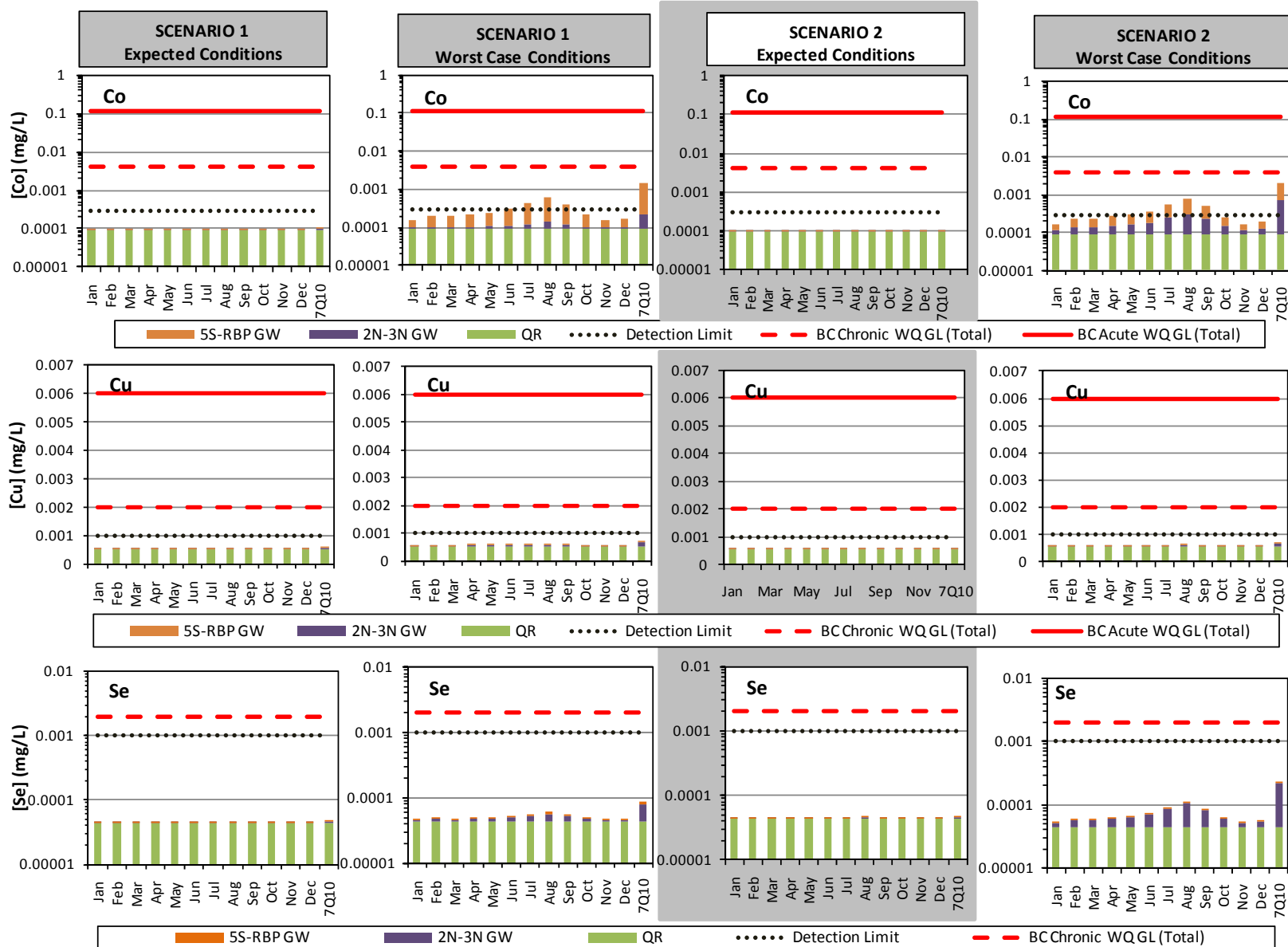


Figure 7-3: Predicted Concentrations of Cobalt, Copper, and Selenium in Quinsam River from 2 North / 3 North and 5 South / RBP Loading.

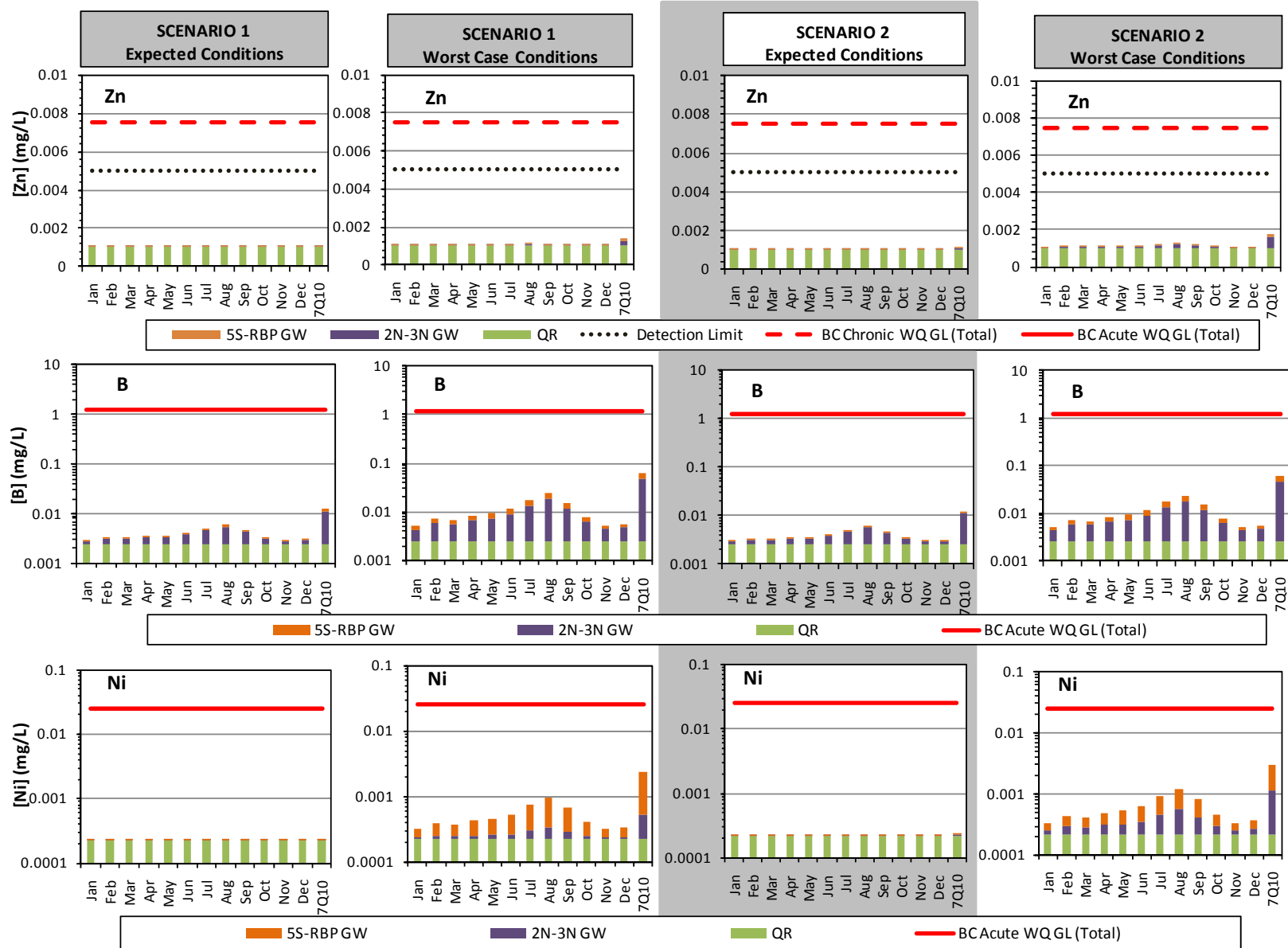


Figure 7-4: Predicted Concentrations of Zinc, Boron and Nickel in Quinsam River from 2 North / 3 North and 5 South / RBP Loading.

8. Summary and Conclusions



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8. Summary and Conclusions

A groundwater assessment has been conducted for the existing 2 North, 3 North, 5 South mines and the River Barrier Pillar (RBP). These mines extract coal from the No. 1 Coal Zone which lies in the Cumberland Member of the Comox Formation. The focus of the study was to evaluate the physical and chemical characteristics of the groundwater system in the mine area and to make a predictive assessment of groundwater mass loadings under closure conditions on the water quality in the Quinsam River. Specifically, the study evaluated flow rates into and out of the mine void, the potential for mine subsidence to influence seepage rates from the mine workings, the geochemical characteristics of the No. 1 Coal Zone and the strata that overlies the coal, how the drainage chemistry is expected to evolve over time from PAG coarse reject that will be stored in River Barrier Pillar mine void and PAG tailings that will be stored in the 2 North mine void, the groundwater quality in the mine areas, and the expected influence the mine water will have on the receiving environment.

Background

The 2 North and 3 North mines were mined through the end of 2009 and have been largely depillared. In 2007, mining in 2 North advanced under the Quinsam River via the 8 Mains into the 5 South Phase 1 area. Currently; mining continues in the 5 South Phase 2 and the RBP directly under the Quinsam River.

Depillaring of the coal pillars in portions of the 2 North / 3 North and 5 South mines produces fractured zones (gob) in the strata above the mine. In depillared areas where the coal seam has been mined close to the bedrock surface area, mine subsidence related features have propagated to surface producing sinkholes and fractures that are visible at ground surface (MCG, 2011). Of particular note are the sinkholes which occur along the western margin of the 3 North mine and the surface crack which intersects the wetland flanking the northeastern margin of the mine that have resulted in significant inflows to the mine. There are also several subsidence cracks above the 2 North mine.

Hydrogeology

A conceptual model for groundwater flow in the study area has been developed that explicitly recognizes the effects of subsidence induced fracturing and water-bearing faults that intersect the mine areas. The model predicts that the 2 North / 3 North mine is expected to remain flooded under post-closure conditions with the exception of the

western up-dip region of the mine where flooding levels are expected to be controlled by discharge from subsidence-induced cracks or other subsidence features.

A key component of the post-mine conceptual groundwater model is estimating the expected and upper bounds of groundwater flux rates out of the mine void. In order to assess groundwater fluxes from the mining areas a review of previous work, a geotechnical assessment of subsidence and a field program were undertaken during 2010/2011. The field investigation involved measurement of rock mass permeabilities from packer tests and slug tests, a water level monitoring program, and a baseline groundwater quality sampling program.

Calculations of the expected groundwater fluxes from the 2 North, 3 North, 5 South and RBP areas post-mining are reliant on both the hydraulic characteristics and physical dimensions of the groundwater flow system, which vary around the perimeter of the mines. In mine areas where the coal seam has not been depillared, groundwater flux out of the coal seam will be controlled by the hydraulic conductivity, cross-sectional area of the intact coal seam, and the hydraulic gradient within the intact seam. In mine areas where the coal seam has not been depillared groundwater flux out of the mine is through the coal seam as was the case above, as well as flux through stress-fractured zones in the gob above the depillared mine. Lateral groundwater flow through the downgradient end of the gob, however, will ultimately be controlled by the hydraulic conductivity and hydraulic gradients within the intact sandstone and coal downgradient of the gob -impacted areas.

The expected seepage flux from the 2 North / 3 North mine areas using the Darcy flow conditions is approximately 220 m³/d. The potential for seepage from existing or future subsidence features is addressed by considering an upper bound seepage rate based on an infiltration rate of 10% of mean annual precipitation (MAP) or 1,130 m³/d. The expected seepage rate reporting to the Quinsam River from the 5 South mine is 48 m³/day of which 4 m³/day originates from the River Barrier Pillar mine. The upper bound seepage rate from these areas is 239 m³/day.

Formation Water and Mine Water Chemistry

A field sampling program was carried out to characterize water quality in the 2 North / 3 North and 5 South areas of the Quinsam Coal Mine. The 2 North and 5 South mine water samples are categorized by the location of origin as mine water, No. 1 Seam groundwater or Dunsmuir sandstone groundwater.

Waters derived from the underground mine pools (mine water) are circum-neutral with a distinct sulphate signature. Mine water samples had variable redox characteristics

ranging from oxic to strongly reducing, which is largely due to the influence of fresh water inflow rates and the location where the sample was taken (i.e. surface of the mine pool or deep mine pool).

All formation waters sampled were anoxic and moderately to strongly reducing. Dunmuir sandstone formation waters contain elevated arsenic relative to levels observed in the No. 1 Seam, this is consistent with the realgar mineralization previously observed in the sandstone formation (Lorax, 2011b). None of the formation waters sampled displayed had a distinct mine water signature suggesting that there is not currently a large component of flow out of the mine void.

The No. 1 Seam formation water has variable major ion chemistry. Up-dip areas have a sodium bicarbonate type groundwater distinct from the down-dip sodium chloride type groundwater. Similarly, the calcium bicarbonate type water in the up-dip 5 South sandstone/till interface is distinct from the sodium bicarbonate type water observed in the down-dip 2 North Dunsmuir sandstone. These distinct groundwater chemistries from similar stratigraphic horizons indicate that major ion chemistry within the Comox Formation is associated with the depth of groundwater. In particular, groundwaters obtained with increasing depth below the base drainage feature of the Quinsam River have a higher conductivity and stronger chloride signature.

Distinct water chemistry was observed at two locations that is in part believed to be influenced by fault induced groundwater flow paths. Fault fracturing down-dip of the 2 North mine at well QU-10-11-S is inferred from the distinct calcium bicarbonate type water and the low fluoride levels. Elevated boron, arsenic and fluoride levels at QU-08-21G-D suggest that the influence of the Forjan Fault results in waters at this location following a different flow path than nearby wells in 2 North.

Geochemical Characteristics of Coal and Overlying Strata

Sulphur content, which is an indicator of acid generating potential, is typically low (< 1.0 %S) in No. 1 Seam throughout the 2 North / 3 North and 5 South Phase I mine areas. Higher sulphur contents > 1.0 are identified in the southern portion of the 5 South Phase 2 with a maximum recorded value of 3.2 %S. Sulphur content of the Rider Seam is considerably higher than observed in No. 1 Seam or the Rider Parting. Sulphur content is consistently > 2.0 %S throughout the mined areas.

Although the low sulphur in No. 1 Seam results in non acid generating coal from this zone, portions of the overlying Rider Parting and all of the Rider Seam are potentially acid generating. Conversely, the Cumberland member siltstones in the 10 m to 15 m stratigraphic interval above the Rider Seam are predominately non-acid generating.

The metal(oid)s As, Bi and Se are consistently elevated in both the coal and the Cumberland siltstone and Dunsmuir sandstone that overly No. 1 Seam. Copper was also elevated in the Cumberland siltstones.

Geochemical source terms have been developed for the expected mine configurations in the 2 North , 3 North and 5 South mine areas using a set of empirical data including: water samples collected from underground mine dewatering, laboratory kinetic tests.

Predictions of Water Quality in the Quinsam River

Geochemical loading models with the associated predicted changes to concentrations in the Quinsam River were prepared. An expected case that accounts for subaqueous disposal of tailings in a portion of the 2 North/3 North mines and coarse reject is disposed in the RBP mine was modeled. An expected condition and worst case condition has been predicted. The expected condition is based on the expected groundwater fluxes and the expected source water chemistry and the worst case condition assumes higher seepage rates and higher or upper bound source term concentrations.

The modeled monthly contaminant concentrations in the Quinsam River including seepage from the 2 North/3 North and 5 South/RBP mine areas for the expected case remain below both chronic and acute water quality guidelines. Under the worst case conditions assumed for Scenario 2 (tailings disposal in 2 North/3 North and CCR disposal in the RBP), the SO₄ concentration could potentially exceed the guidelines for chronic exposure under average March and April flow conditions and under the 7Q10 low flow event. It is noted that the chronic exposure is typically based on a longer term (*e.g.* 30 day) exposure, while the 7Q10 low flow is a shorter-term (*i.e.* 7 day) event. Iron, arsenic and cadmium concentrations could also exceed acute guidelines under the 7Q10 low flow event under worst case conditions assumed for Scenario 2. Cadmium may also exceed the acute guideline under worst case conditions assumed for Scenario 1.

9. Report Limitations



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9. Report Limitations

This report was prepared for the exclusive use of Hillsborough Resources Ltd. and Quinsam Coal for the purpose described in Section 1 of this report. Ministry of Energy and Mines and other government agencies involved with reviewing Hillsborough's applications may also rely upon this report; any other use or reliance on this report by any third party is at that party's sole risk. The authors accept no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

Respectfully submitted,

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Appendix A: Hydrogeological Data

Appendix A1 – Borehole Logs

Appendix A2 – Results of Packer Testing

Appendix A3 – Summary of Hydraulic Testing Results

Appendix 4 – Seepage Model Assumptions and output

*Appendix 5 – Volume – Elevation Curve for 5 South
Mine*



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Appendix A1 – Borehole Logs



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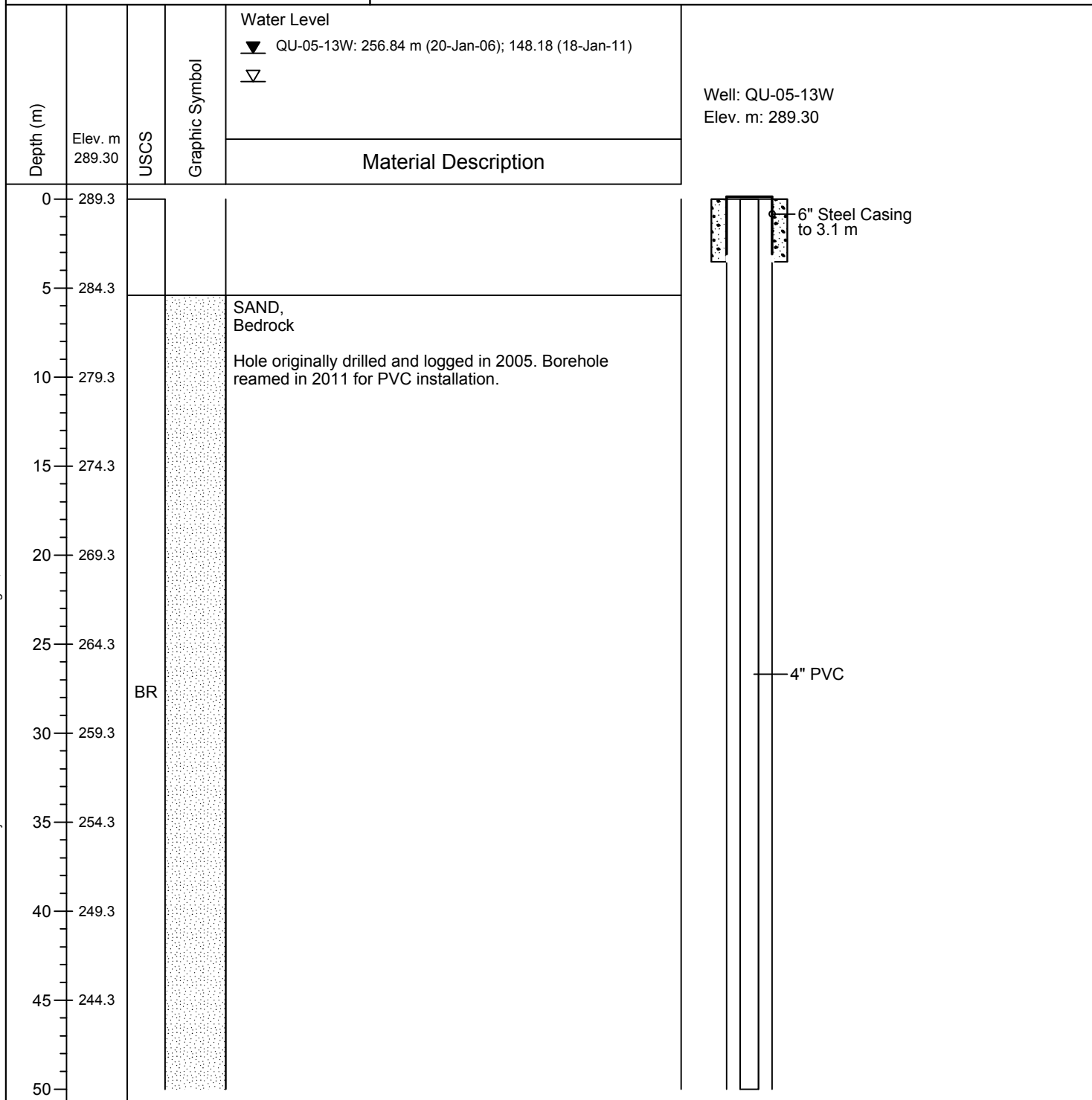
Enterprise Geoscience Services Ltd.



LORAX
ENVIRONMENTAL

Borehole Log of QU-05-13W (5 South)

Date Started	: Jan 10, 2011 (Originally Drilled)	Drilled By	: Drillwell Enterprises
Date Completed	: Jan 11, 2011 (Redrilled)	Northing Coord.	: 102160
Hole Diameter	: 152 mm	Easting Coord.	: 101053
Drilling Method	: Air rotary	Survey By	:
Sampling Method	: n/a	Logged By	:



Quinsam Coal
Assessment of Underground Disposal
of Coarse Coal Refuse

Campbell River, B.C.



Enterprise Geoscience Services Ltd.



LORAX
ENVIRONMENTAL

Borehole Log of QU-05-13W (5 South)

Date Started	: Jan 10, 2011 (Originally Drilled)	Drilled By	: Drillwell Enterprises
Date Completed	: Jan 11, 2011 (Redrilled)	Northing Coord.	: 102160
Hole Diameter	: 152 mm	Easting Coord.	: 101053
Drilling Method	: Air rotary	Survey By	:
Sampling Method	: n/a	Logged By	:

Depth (m)	Elev. m 289.30	USCS	Graphic Symbol	Water Level ▼ QU-05-13W: 256.84 m (20-Jan-06); 148.18 (18-Jan-11) ▽	Well: QU-05-13W Elev. m: 289.30
				Material Description	
50	239.3	BR			
55	234.3				
60	229.3				
65	224.3				
70	219.3				
75	214.3				
80	209.3				
85	204.3				
90	199.3				
95	194.3				
100					
				Quinsam Coal Assessment of Underground Disposal of Coarse Coal Refuse	
				Campbell River, B.C.	



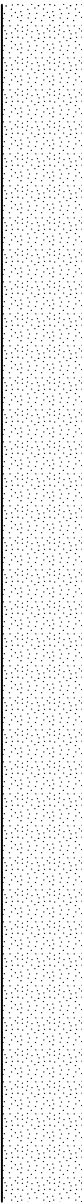
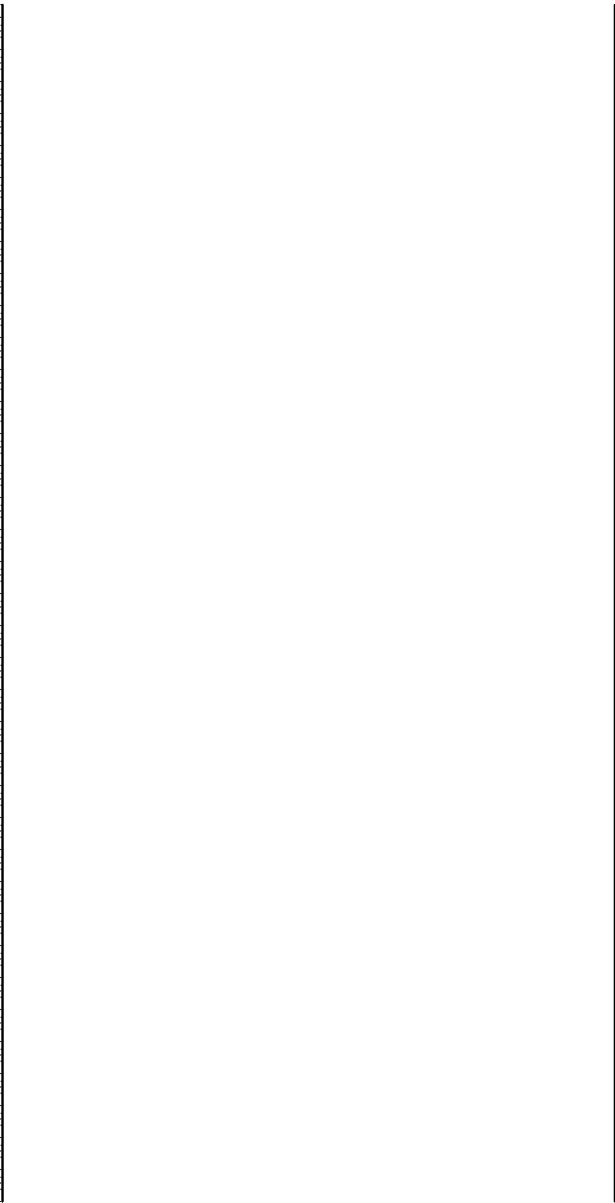
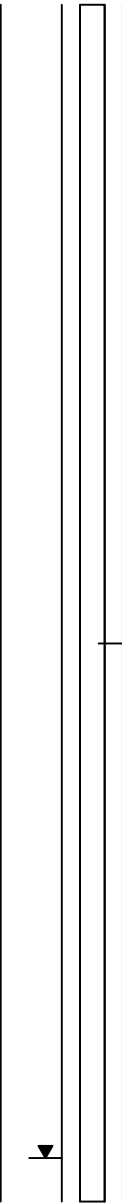
Enterprise Geoscience Services Ltd.



LORAX
ENVIRONMENTAL

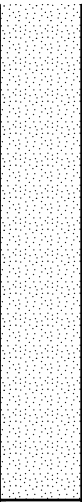
Borehole Log of QU-05-13W (5 South)

Date Started	: Jan 10, 2011 (Originally Drilled)	Drilled By	: Drillwell Enterprises
Date Completed	: Jan 11, 2011 (Redrilled)	Northing Coord.	: 102160
Hole Diameter	: 152 mm	Easting Coord.	: 101053
Drilling Method	: Air rotary	Survey By	:
Sampling Method	: n/a	Logged By	:

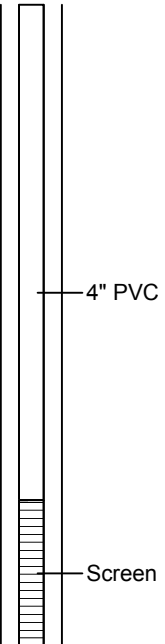
Depth (m)	Elev. m 289.30	USCS	Graphic Symbol	Water Level ▼ QU-05-13W: 256.84 m (20-Jan-06); 148.18 (18-Jan-11) ▽	Well: QU-05-13W Elev. m: 289.30
				Material Description	
100	189.3	BR			 4" PVC
105	184.3				
110	179.3				
115	174.3				
120	169.3				
125	164.3				
130	159.3				
135	154.3				
140	149.3				
145	144.3				
150					
				Quinsam Coal Assessment of Underground Disposal of Coarse Coal Refuse	
				Campbell River, B.C.	

Borehole Log of QU-05-13W (5 South)

Date Started	: Jan 10, 2011 (Originally Drilled)	Drilled By	: Drillwell Enterprises
Date Completed	: Jan 11, 2011 (Redrilled)	Northing Coord.	: 102160
Hole Diameter	: 152 mm	Easting Coord.	: 101053
Drilling Method	: Air rotary	Survey By	:
Sampling Method	: n/a	Logged By	:

Depth (m)	Elev. m	USCS	Graphic Symbol	Water Level	Material Description	
				▼ QU-05-13W: 256.84 m (20-Jan-06); 148.18 (18-Jan-11) ▽		
150	139.3	BR				
155	134.3					
160	129.3					
165	124.3					
170	119.3	CO			SEAM	
175	114.3					
				yellowish brown, EOH @ 176.8 m		
180	109.3					
185	104.3					
190	99.3					
195	94.3					
200						

Well: QU-05-13W
 Elev. m: 289.30



4" PVC

Screen

Notes from 2011 Reaming:
 1) Drift not encountered. (in pillar)
 2) Hole started making water at 147 m.
 3) Hole started drilling faster at 166.5 m .

	Quinsam Coal Assessment of Underground Disposal of Coarse Coal Refuse	
	Campbell River, B.C.	

Borehole Log of QU-08-21G

Date Started	: May 20, 2008	Drilled by	: Drillwell Enterprises
Date Completed	: May 21, 2008	Northing Coord.	: 102802
Hole Diameter	: 140 mm	Easting Coord.	: 101917
Drilling Method	: Air Rotary with wireline coring	Survey By	: McElhanney
Sampling Method	: Core	Logged By	: C.G. Cathyl-Bickford

Depth (m)	Elev. m	USCS	Graphic Symbol	Water Levels	Material Description	
				▼ QU-08-21G-S 213.14 m (10-Nov-10) ▽ QU-08-21G-D 212.86 m (10-Nov-10)		
	213.66					Well1: QU-08-21G-S Well2: QU-08-21G-D Elev. m: 213.66
0	213				NOT CORED	Pea gravel
5	208					Bentonite chips
10	203					
15	198					Pea gravel
20	193					PVC 2"/Schedule 40
25	188	SS			SANDSTONE - light grey to dark brown, medium to coarse grained, non-calcareous	Bentonite chips
		SL			COAL SEAM 6- dull to bright, with siltstone/mudstone lenses	PVC 1.25"/Schedule 40
30	183				SILTSTONE & MUDSTONE interbeds - medium brown to black, carbonaceous	Pea gravel
35	178				SANDSTONE - 26.7-34m: light to medium grey, medium to coarse grained, with conglomerate lenses.	Bentonite chips
		SS			34-52m: light to dark grey, fine to coarse grained. Top of Dunsmuir 'E' Sandstone at 34m	Pea gravel
40	173					Bentonite chips
45	168					Pea gravel
50						Bentonite chips
						Pea gravel

Quinsam Coal
Assessment of Underground Disposal
of Coarse Coal Refuse

Campbell River, B.C.

Borehole Log of QU-08-21G

Date Started	: May 20, 2008	Drilled by	: Drillwell Enterprises
Date Completed	: May 21, 2008	Northing Coord.	: 102802
Hole Diameter	: 140 mm	Easting Coord.	: 101917
Drilling Method	: Air Rotary with wireline coring	Survey By	: McElhanney
Sampling Method	: Core	Logged By	: C.G. Cathyl-Bickford

Depth (m)	Elev. m	USCS	Graphic Symbol	Water Levels	Material Description	
				▼ QU-08-21G-S 213.14 m (10-Nov-10) ▽ QU-08-21G-D 212.86 m (10-Nov-10)		
	213.66					Well1: QU-08-21G-S Well2: QU-08-21G-D Elev. m: 213.66
50	163	SS				Pea gravel
					COAL SEAM 5 - 52-53.3m: bright to dull, minor sandstone lensing 53.3-55.1m: bright ot dull, with pyrite and mudstone lenses.	Bentonite chips
55	158				SANDSTONE - light grey to brown, fine to coarse grained	Pea gravel
						Bentonite chips
60	153					PVC 1.25"/Schedule 40
						Pea gravel
65	148	SS				Bentonite chips
						Pea gravel
70	143					PVC 2"/Schedule 40
						Bentonite chips
75	138	SL			COAL SEAM 4R - dull to bright. Top of Dunsmuir member middle division	QU-08-21G-S Screen
					SILTSTONE - dark grey, with mudstone lenses	Filter sand
80	133				COAL SEAM 4/4L - 76.9-8m: dull to bright, with mudstone beds 79-80.4m: dull to bright, with sandstone and mudstone beds.	
					SANDSTONE - 80.4-92.1m: light grey to black, fine to coarse grained Top of Dunsmuir 'C' sandstone at 81.7m Minor siltstone/mudstone interbeds at 86m, 92m depths	Bentonite pellets
85	128	SS				Pea gravel
						Bentonite pellets
90	123				COAL SEAM 4B- bright to dull with sandstone interbeds	
					SANDSTONE - light grey to black, fine to coarse grained, carbonaceous	Pea gravel
95	118	SS				Bentonite pellets
100						
				Quinsam Coal Assessment of Underground Disposal of Coarse Coal Refuse		
				Campbell River, B.C.		

Borehole Log of QU-08-21G

Date Started	: May 20, 2008	Drilled by	: Drillwell Enterprises
Date Completed	: May 21, 2008	Northing Coord.	: 102802
Hole Diameter	: 140 mm	Easting Coord.	: 101917
Drilling Method	: Air Rotary with wireline coring	Survey By	: McElhanney
Sampling Method	: Core	Logged By	: C.G. Cathyl-Bickford

Depth (m)	Elev. m 213.66	USCS	Graphic Symbol	Water Levels	Material Description	Well1: QU-08-21G-S Well2: QU-08-21G-D Elev. m: 213.66
				▼ QU-08-21G-S 213.14 m (10-Nov-10) ▽ QU-08-21G-D 212.86 m (10-Nov-10)		
100	113	SS			SANDSTONE - light grey to black, fine to coarse grained, carbonaceous	
105	108					
110	103					
115	98					
120	93					
125	88	SL			COAL SEAM 3R - bright, with carbonaceous mudstone interbeds/at top of sequence.	
		SL			SILTSTONE & MUDSTONE - dark brown to grey, interbedded	
130	83	SL			COAL SEAM 3 - bright to dull, with mudstone lenses at top and bottom of sequence.	
					SILTSTONE - medium to dark brown, with mudstone interbeds	
135	78	SS			COAL SEAM 3L - dull to bright, interlaminated with mudstone at top of sequence.	
					SILTSTONE - 130-133m: dark brown, with dark brown mudstone beds	
140	73				-minor coal lenses at 131m and between 132.7 and 133m	
					SANDSTONE - 133-154.6m: light to dark grey, fine to coarse grained, top of Dunsmuir 'A' sandstone at 133m.	
145	68				147-149m: dark brown mudstone lenses	
150						

	Pea Gravel
	Bentonite Pellets
	Pea Gravel
	Bentonite Pellets
	Pea Gravel
	Bentonite Pellets
	Pea Gravel
	Bentonite Pellets
	Pea Gravel
"Schedule 40 symbol: diagonal solid lines"/>	PVC 2"/"Schedule 40
	Bentonite Pellets
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	Pea Gravel
	Bentonite Pellets
	Pea Gravel

Quinsam Coal	
Assessment of Underground Disposal of Coarse Coal Refuse	
Campbell River, B.C.	

Borehole Log of QU-08-21G

Date Started	: May 20, 2008	Drilled by	: Drillwell Enterprises
Date Completed	: May 21, 2008	Northing Coord.	: 102802
Hole Diameter	: 140 mm	Easting Coord.	: 101917
Drilling Method	: Air Rotary with wireline coring	Survey By	: McElhanney
Sampling Method	: Core	Logged By	: C.G. Cathyl-Bickford

Depth (m)	Elev. m 213.66	USCS	Graphic Symbol	Water Levels	Material Description	Well1: QU-08-21G-S Well2: QU-08-21G-D Elev. m: 213.66
				▼ QU-08-21G-S 213.14 m (10-Nov-10) ▽ QU-08-21G-D 212.86 m (10-Nov-10)		
150	63	SS				Pea Gravel Bentonite Pellets PVC 2"/Schedule 40 Pea Gravel Bentonite Pellets QU-08-21G-D Screen Filter Sand
155	58		MS		MUDSTONE - grey brown, with siltstone lenses, medium brown, carbonaceous	
		SL		COAL SEAM 2 - bright to dull, dirty at base (155.0-156.1m)		
160	53	SS		SILTSTONE - 156-157.3m: dark grey, with dark brown mudstopbe interbeds		
165	48			SANDSTONE, IRONSTONE and SILTSTONE interbeds - dark grey to brown. Possible fault at 157.3m		
170	43					
		MS		COAL SEAM 1 - 171.6-172.7m: dull to bright, dirty, with mudstone lensese at top and bottom of sequence (Quinsam No. 1 coal bed)		
175	38	SL		MUDSTONE - 172.7-173.6m: medium brown with siltstone lense at top of sequence		
180	33	SL		-floor of upper bench/top of main parting at 172.9m		
				-interlaminated coal and mudstone between 173.4m and 173.6m		
185	28			-base of main parting at 173.5m		
				IRONSTONE, SILTSTONE and MUDSTONE - dark grey to brown		
				SANDY SILT, COALY ROCK (Coal Seam 1L).		
190	23			SILTSTONE, IRONSTONE, SANDSTONE and MUDSTONE interbeds -		
				176.9-177.8m: bright coal bands		
				176.9-184m: dark grey to dark brown conglomerate with sandstone bed at base, dark green, coarse grained		
195	18			EOH @ 185.8m		
200						
				Quinsam Coal Assessment of Underground Disposal of Coarse Coal Refuse		
				Campbell River, B.C.		

Borehole Log of QU-10-10

Date Started : Oct 6, 2010
 Date Completed : Oct 7, 2010
 Hole Diameter : 150 mm
 Drilling Method : Air Rotary
 Sampling Method : Grab sample

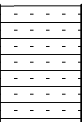
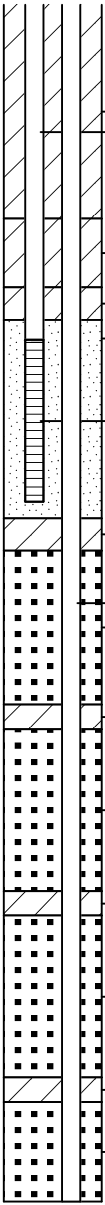
Drilled by : Drillwell Enterprises
 Northing Coord. : 102903
 Easting Coord. : 101506
 Survey By : McElhanney
 Logged By : O. Quinn

Depth (m)	Elev. m	USCS	Graphic Symbol	Water Levels	Material Description	
				▼ QU-10-10-S: 210.55M (11/19, 2010) ▽ QU-10-10-D: 210.44M (11/18/2010)		
	244.26					Well1: QU-10-10-S Well2: QU-10-10-D Elev. m: 244.26
0	244				Silty, sandy TILL - with boulders, red-brown	Pea gravel
5	239					6" Steel Casing to 18m
10	234				TILL - grey, with boulders	Bentonite chips
15	229					Pea gravel
20	224	SS			SANDSTONE - 17.7-24.4m: light grey, fine-medium grained, slightly weathered, slightly carbonaceous to 21.3m	PVC 1.25" Schedule 40
25	219	SS			24.4-29.3m: medium grey, fined grained, fresh	PVC 2" Schedule 40
30	214	SL			SILTSTONE - dark grey, fresh	Bentonite chips
35	209	SS			SANDSTONE - 31.1-34.8m: dark grey, fine grained, fresh 34.8-38.1m: light grey, fine-medium grained, moderately weathered flow 0.25 US GPM at 36.6m	▽
40	204	SS			COAL SEAM 5 - shiny, with light grey/brown, coarse-grained sandstone SANDSTONE - 38.4-42.7m: medium grey, fine-med grained, fresh 42.7-57.9m: grey, medium-coarse grained, fresh Flow 7.5 US GPM at 42.7m	Bentonite grout
45						
				Quinsam Coal Assessment of Underground Disposal of Coarse Coal Refuse		
				Campbell River, B.C.		

Borehole Log of QU-10-10

Date Started : Oct 6, 2010
Date Completed : Oct 7, 2010
Hole Diameter : 150 mm
Drilling Method : Air Rotary
Sampling Method : Grab sample

Drilled by : Drillwell Enterprises
Northing Coord. : 102903
Easting Coord. : 101506
Survey By : McElhanney
Logged By : O. Quinn

Depth (m)	Elev. m	USCS	Graphic Symbol	Water Levels	Material Description	
				▼ QU-10-10-S: 210.55M (11/19, 2010) ▽ QU-10-10-D: 210.44M (11/18/2010)		
	244.26					Well1: QU-10-10-S Well2: QU-10-10-D Elev. m: 244.26
45	199	SS			Flow 10 US GPM at 48.8m	 Bentonite grout PVC 1.25" Schedule 40 Bentonite chips Bentonite pellets Filter sand QU-10-10-S Screen Bentonite pellets PVC 2" Schedule 40 Pea gravel Bentonite pellets Pea gravel Bentonite pellets Pea gravel Bentonite pellets Pea gravel
50	194					
55	189					
60	184	SS			COAL (No. 4 Seam). Flow 10 US GPM at 57.91m SANDSTONE - 58.2-63.1m: grey, fine-medium grained, fresh 63.1-80.8m: light grey, medium-coarse grained, fresh	
65	179				Flow 10 US GPM at 67.1m	
70	174					
75	169	MS				
80	164					
85	159					
90		SS			MUDSTONE - dark brown, weathered COAL (No. 4 B) - shiny, interbedded with dark grey MUDSTONE MUDSTONE - dark grey, fresh SANDSTONE - 84.73-105.77m: light grey, coarse grained, fresh	
				Quinsam Coal Assessment of Underground Disposal of Coarse Coal Refuse		
				Campbell River, B.C.		

Borehole Log of QU-10-10

Date Started : Oct 6, 2010
Date Completed : Oct 7, 2010
Hole Diameter : 150 mm
Drilling Method : Air Rotary
Sampling Method : Grab sample

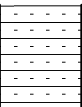
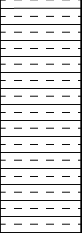
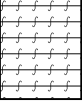
Drilled by : Drillwell Enterprises
Northing Coord. : 102903
Easting Coord. : 101506
Survey By : McElhanney
Logged By : O. Quinn

Depth (m)	Elev. m 244.26	USCS	Graphic Symbol	Water Levels	Material Description	Well1: QU-10-10-S Well2: QU-10-10-D Elev. m: 244.26	
				▼ QU-10-10-S: 210.55m (11/19, 2010) ▽ QU-10-10-D: 210.44m (11/18/2010)			
90	154	SS		SANDSTONE (cont'd)			Pea Gravel
95	149						Bentonite pellets
							Pea Gravel
100	144						Bentonite pellets
105	139			COAL - shiny, interbedded with dark brown MUDSTONE			Pea Gravel
				SILTSTONE - dark brown, fresh			Bentonite pellets
110	134	SL					PVC 2" Schedule 40
				COAL SEAM 3R - dull to shiny with light brown, weathered mudstone			Pea Gravel
115	129	SL		SILTSTONE - dark brown, fresh			Bentonite pellets
				COAL SEAM 3 - shiny			Pea Gravel
120	124	MS		MUDSTONE - dark brown, fresh			Bentonite pellets
				SANDSTONE - 118.3-118.9m: light grey, coarse grained with dull COAL SEAM 3L.			Pea Gravel
125	119	MS		118.9-120.1m: light grey, fine-medium grained, fresh			Bentonite pellets
				MUDSTONE - dark brown, fresh			Pea Gravel
130	114	SS		SANDSTONE - 121.9-132.9m: light grey, medium grained, fresh, with interbedded dark brown, fresh, carbonaceous MUDSTONE			Bentonite pellets
				Flow 10 US GPM at 128.0m			Pea Gravel
135				132.9-141.1m: light to medium grey, fine-coarse grained, fresh			Bentonite pellets
				Quinsam Coal Assessment of Underground Disposal of Coarse Coal Refuse			
				Campbell River, B.C.			

Borehole Log of QU-10-10

Date Started : Oct 6, 2010
Date Completed : Oct 7, 2010
Hole Diameter : 150 mm
Drilling Method : Air Rotary
Sampling Method : Grab sample

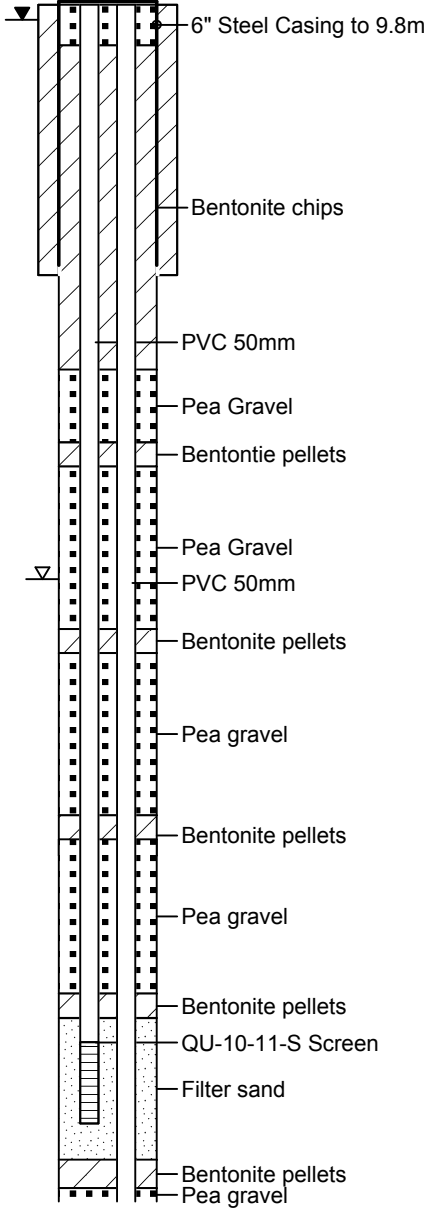
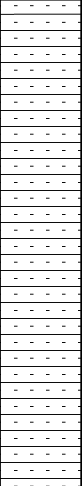
Drilled by : Drillwell Enterprises
Northing Coord. : 102903
Easting Coord. : 101506
Survey By : McElhanney
Logged By : O. Quinn

Depth (m)	Elev. m 244.26	USCS	Graphic Symbol	Water Levels	Material Description	
				▼ QU-10-10-S: 210.55m (11/19, 2010) ▽ QU-10-10-D: 210.44m (11/18/2010)		
						Well1: QU-10-10-S Well2: QU-10-10-D Elev. m: 244.26
135	109	SS				Bentonite pellets
						Pea Gravel
140	104	MS		Flow 12 US GPM at 140.2m		Bentonite pellets
				MUDSTONE - dark brown, fresh		
145	99	MS		COAL SEAM 2 - shiny, with dark brown, fresh		Pea Gravel
				MUDSTONE		
				MUDSTONE -		PVC 2" Schedule 40
				144.3-148.7m: medium brown, fresh		Bentonite pellets
				148.7-149.0m: COAL lens		
				148.7-150.3m: dark brown		Pea Gravel
150	94			150.3-156.7m: dark brown, with grey-green, fine-medium grained SILTSTONE, fresh		
155	89			156.7-160.9m: dark brown, fresh		Bentonite pellets
				Flow 12 US GPM at 158.5m		Pea Gravel
160	84			COAL SEAM 2L/1R - shiny, with light brown, fresh		Bentonite pellets
		MS		MUDSTONE -		
165	79			162.5-165.4m: light brown, fresh		
				Flow 12 US GPM at 164.6m		QU-10-10-D Screen
		MS		COAL SEAM 1- shiny		Sand Pack
				MUDSTONE - grey-brown, fresh		
170	74	MS		COAL SEAM 1 - shiny, with medium-brown, fresh,		
				MUDSTONE		
		MS		MUDSTONE - dark brown-grey, fresh		
				COAL - shiny, with medium-brown, fresh, MUDSTONE		
				MUDSTONE - dark brown-grey, fresh		
175	69	SL		COAL SEAM 1L - shiny with medium-brown, fresh		Bentonite pellets
				MUDSTONE		
				SILTSTONE -		Pea Gravel.
				173.1-177.7m: green-grey, fresh		
180				EOH @ 179.83m (Flow 12 US GPM)		
				Quinsam Coal Assessment of Underground Disposal of Coarse Coal Refuse		
				Campbell River, B.C.		

Borehole Log of QU-10-11

Date Started : Oct 8, 2010
Date Completed : Oct 13, 2010
Hole Diameter : 150 mm
Drilling Method : Air Rotary
Sampling Method : Grab sample

Drilled by : Drillwell Enterprises
Northing Coord. : 103177
Easting Coord. : 101451
Survey By : McElhanney
Logged By : O. Quinn

Depth (m)	Elev. m	USCS	Graphic Symbol	Water Levels	Material Description	
				▼ QU-10-11-S 248.939 m (21/01/2011) ▽ QU-10-11-D 227.892 m (08/02/2011)		
	249.5					Well1: QU-10-11-S Well2: QU-10-11-D Elev. m: 249.5
0	249	f42			sandy SILT TILL - with boulders 0-3.7m red brown	 6" Steel Casing to 9.8m Bentonite chips PVC 50mm Pea Gravel Bentonite pellets Pea Gravel PVC 50mm Bentonite pellets Pea gravel Bentonite pellets Pea gravel Bentonite pellets QU-10-11-S Screen Filter sand Bentonite pellets Pea gravel
5	244				3.7-9.1m grey-brown	
10	239				SANDSTONE - 9.1-17.4m light grey, coarse-grained, highly weathered	
15	234	ss			17.4-18.9m greenish grey, medium grained	
20	229				18.9-25.9m light grey, medium grained	
25	224				25.9-34.4m light grey, medium grained, moderately weathered	
30	219				Hole dry at 33.5m	
35	214				34.1-45.7m light-medium grey, medium to coarse grained, fresh	
40	209				flow at fracture (40.8m) 30 US GPM	
45						
				Quinsam Coal Assessment of Underground Disposal of Coarse Coal Refuse		
				Campbell River, B.C.		

Borehole Log of QU-10-11

Date Started : Oct 8, 2010
Date Completed : Oct 13, 2010
Hole Diameter : 150 mm
Drilling Method : Air Rotary
Sampling Method : Grab sample

Drilled by : Drillwell Enterprises
Northing Coord. : 103177
Easting Coord. : 101451
Survey By : McElhanney
Logged By : O. Quinn

Depth (m)	Elev. m	USCS	Graphic Symbol	Water Levels	Material Description	
				▼ QU-10-11-S 248.939 m (21/01/2011) ▽ QU-10-11-D 227.892 m (08/02/2011)		
	249.5					Well1: QU-10-11-S Well2: QU-10-11-D Elev. m: 249.5
45	204	SS			45.7-47.5m dark grey, fine-medium grained, fresh, carbonaceous	
					COAL SEAM - dirty	
50	199				SANDSTONE - 47.8-71.3m grey to grey-brown, medium-coarse to medium grained, fresh flow 30 US GPM at 48.8m	Pea gravel
55	194				flow 30 US GPM at 54.9m	Bentontie pellets
60	189	SS				Pea gravel
65	184				flow 20 US GPM at 67.1m (water was flowing out of adjacent exploration hole, QU-05-10 during this measurement)	Bentontie pellets
70	179					Pea Gravel
		MS			COAL SEAM 4B- with SILTSTONE/MUDSTONE	Benotnite pellets
					MUDSTONE - dark brown, fresh	
75	174				COAL (No. 4 B Seam) - with SILTSTONE/MUDSTONE	Pea gravel
					SANDSTONE - 72.85-86.26m grey brown to grey, medium to coarse grained, fresh	Benotnite pellets
80	169				flow 15 US GPM at 79.25m	Pea Gravel
85	164	SS				Bentonite pellets
					86.26-91.44m dark brown, fine grained, fresh	Pea gravel
90						
				Quinsam Coal Assessment of Underground Disposal of Coarse Coal Refuse		
				Campbell River, B.C.		

Borehole Log of QU-10-11

Date Started : Oct 8, 2010
Date Completed : Oct 13, 2010
Hole Diameter : 150 mm
Drilling Method : Air Rotary
Sampling Method : Grab sample

Drilled by : Drillwell Enterprises
Northing Coord. : 103177
Easting Coord. : 101451
Survey By : McElhanney
Logged By : O. Quinn

Depth (m)	Elev. m	USCS	Graphic Symbol	Water Levels	Material Description	
				▼ QU-10-11-S 248.939 m (21/01/2011) ▽ QU-10-11-D 227.892 m (08/02/2011)		
	249.5					Well1: QU-10-11-S Well2: QU-10-11-D Elev. m: 249.5
90	159	SS			SANDSTONE (cont'd) - 91.44-94.49m dark grey, medium grained, fresh. flow 12 US GPM at 91.44m. (QU-10-05 flowing during measurement).	Pea gravel
95	154	SS			COAL SEAM 3R - shiny, with dark brown, fresh MUDSTONE	Bentonite pellets
					SANDSTONE - medium grey	Pea gravel
100	149	MS			MUDSTONE - 96.93-102.11m dark brown, fresh flow 30 US GPM at 97.54m (QU-10-05 flowing during measurement).	Bentonite pellets
					COAL SEAM 3L - shiny, with dark brown, fresh MUDSTONE	Pea gravel
105	144	MS			MUDSTONE - 103.02-106.07m dark brown, fresh flow 18 US GPM at 103.63m (QU-10-05 flowing during measurement).	Bentonite pellets
		SS			SANDSTONE - light grey, fine-medium grained with dark brown mudstone	PVC 2"/Schedule 40
110	139	MS			MUDSTONE - 108.21-109.73m dark brown, fresh, with minor COAL seams flow 30 US GPM at 109.73m (QU-10-05 flowing during measurement).	Pea gravel
115	134				SANDSTONE - 109.73-115.21m grey, fine to medium grey, with dark brown MUDSTONE lenses	Bentonite pellets
120	129	SS			115.21-130.45m grey, fine to medium grained, fresh flow 12 US GPM at 115.82m (QU-10-05 flowing during measurement).	Pea gravel
125	124				COAL stringers at 118.87m and 121.62-121.92m flow 7 US GPM at 121.92m (QU-10-05 flowing during measurement).	Bentonite pellets
					flow 9 US GPM at 128.02m (QU-10-05 flowing during measurement).	Pea gravel
130	119	SL			SILTSTONE - 130.45-132.89m dark brown, fresh flow 6 US GPM at 132.59m (QU-10-05 flowing during measurement).	Bentonite pellets
135		MS			MUDSTONE - dark brown	Pea gravel

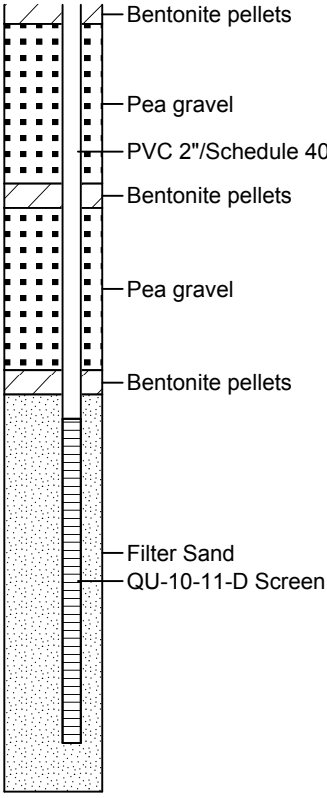
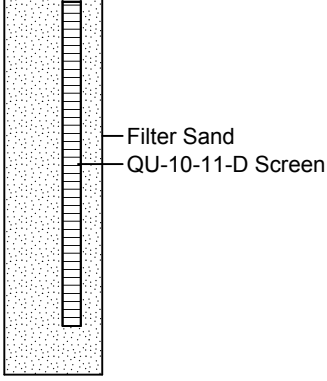
Quinsam Coal
Assessment of Underground Disposal
of Coarse Coal Refuse

Campbell River, B.C.

Borehole Log of QU-10-11

Date Started : Oct 8, 2010
Date Completed : Oct 13, 2010
Hole Diameter : 150 mm
Drilling Method : Air Rotary
Sampling Method : Grab sample

Drilled by : Drillwell Enterprises
Northing Coord. : 103177
Easting Coord. : 101451
Survey By : McElhanney
Logged By : O. Quinn

Depth (m)	Elev. m	USCS	Graphic Symbol	Water Levels	Material Description	
				▼ QU-10-11-S 248.939 m (21/01/2011) ▽ QU-10-11-D 227.892 m (08/02/2011)		
	249.5					Well1: QU-10-11-S Well2: QU-10-11-D Elev. m: 249.5
135	114	MS			coal beds at 134.11, 136.25 and 138.07m	
140	109	MS			COAL SEAM 2 - shiny, with MUDSTONE	
					MUDSTONE - flow 4 US GPM at 140.21m (QU-10-05 flowing during measurement).	
		MS			COAL SEAM 2- shiny, with MUDSTONE	
145	104				MUDSTONE - fresh	
					COAL SEAM 2L/1U	
		MS			MUDSTONE - medium grey-brown, with shiny COAL stringers	
150	99				flow 16 US GPM at 146.3m (QU-10-05 flowing during measurement).	
					COAL SEAM 1 - shiny with MUDSTONE	
					flow 4 US GPM at 152.4m (QU-10-05 flowing during measurement).	
155	94	MS			MUDSTONE - light brown to green/grey	
					COAL SEAM 1L - shiny with MUDSTONE	
160	89	SS			SANDSTONE - greenish grey, fine-medium grained, fresh	
					flow 11 GPM at 158.5m (QU-10-05 flowing during measurement).	
		SH			SHALE - red-brown, fresh	
165	84				EOH @ 164.59m, flow 11 GPM	
170	79					
175	74					
180						
				Quinsam Coal Assessment of Underground Disposal of Coarse Coal Refuse Campbell River, B.C.		



Enterprise Geoscience Services Ltd.



LORAX
ENVIRONMENTAL

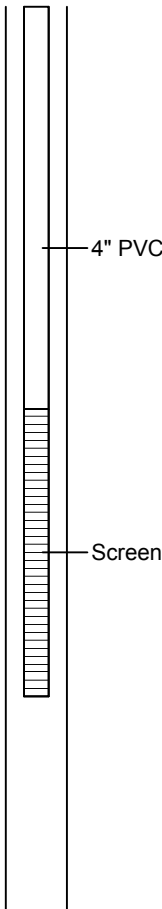
Borehole Log of QU-11-03 (2 North)

Date Started	: Jan 12, 2011	Drilled By	: Drillwell Enterprises
Date Completed	:	Northing Coord.	: n/a
Hole Diameter	: 150 mm / 140 mm core	Easting Coord.	: n/a
Drilling Method	: Air rotary with wireline coring	Survey By	:
Sampling Method	: Grab sample / Core	Logged By	: N. Bazowski

Depth (m)	Elev. m 304	USCS	Graphic Symbol	Water Levels ▼ QU-11-03: 42.21 m bTOC (18-Jan-2011) ▽	Material Description	Well: QU-11-03 Elev. m: xxx	Remarks
65	239						
					From 0 - 69.34 m not logged SANDSTONE, zone of silty sandstone, from: 71.52 - 73.64 m and 74.18 - 75.44 m Conglomerate at base from: 81.58 - 81.75 m		+ Completion details to follow.
70	234						
		SP					
75	229						
80	224						
		SS			SILTSTONE		
85	219						
		SM			SILTSTONE, Coaly siltstone and coal, Coal layers from: 86.48-86.54 m 86.66-87.57 m 87.67-87.98 m 89.71-90.08 m		
90							
				Quinsam Coal Assessment of Underground Disposal of Coarse Coal Refuse			
				Campbell River, B.C.			

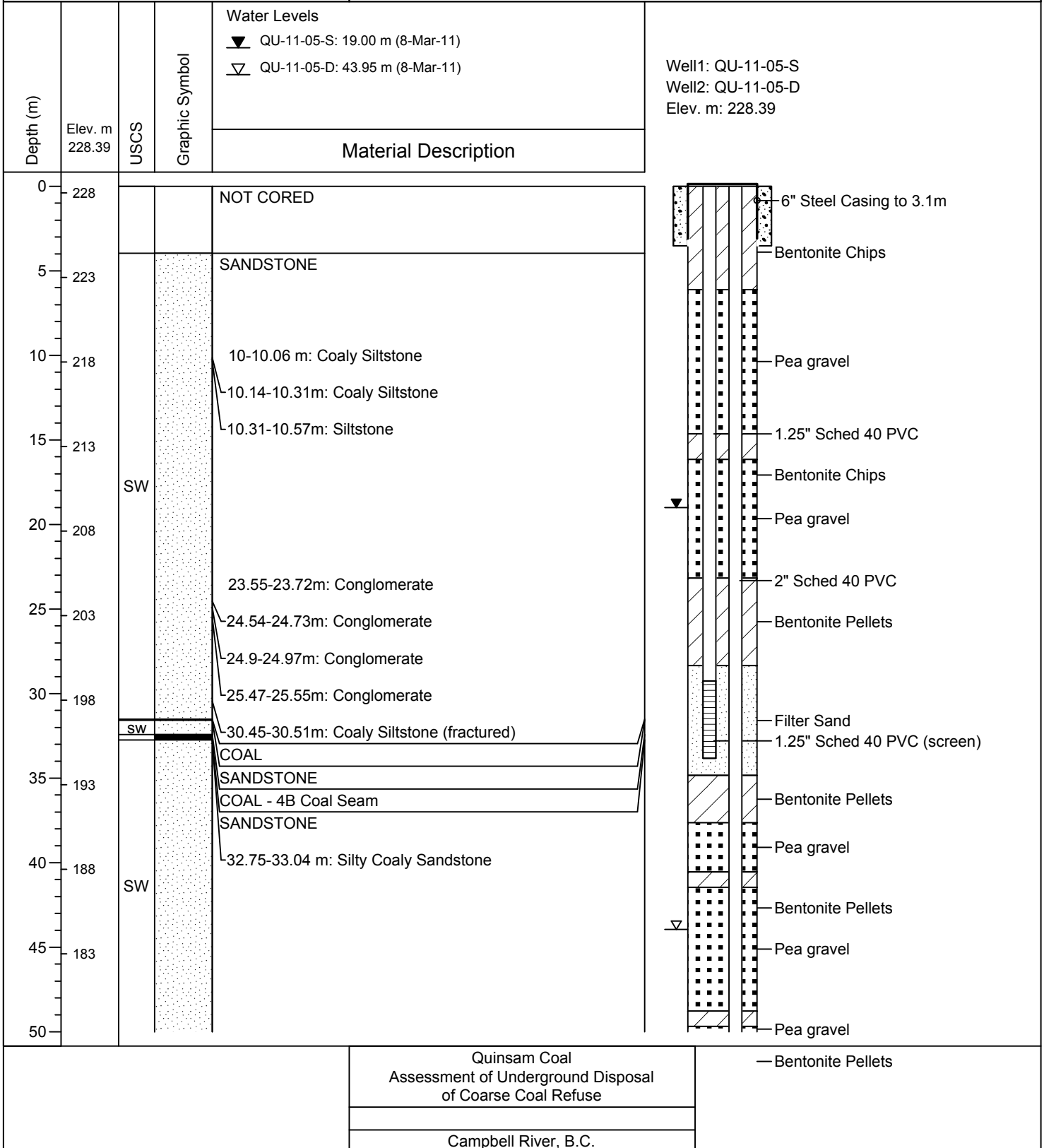
Borehole Log of QU-11-03 (2 North)

Date Started	: Jan 12, 2011	Drilled By	: Drillwell Enterprises
Date Completed	:	Northing Coord.	: n/a
Hole Diameter	: 150 mm / 140 mm core	Easting Coord.	: n/a
Drilling Method	: Air rotary with wireline coring	Survey By	:
Sampling Method	: Grab sample / Core	Logged By	: N. Bazowski

Depth (m)	Elev. m 304	USCS	Graphic Symbol	Water Levels ▼ QU-11-03: 42.21 m bTOC (18-Jan-2011) ▽	Material Description	Well: QU-11-03 Elev. m: xxx	Remarks
90	214	SM			SILTSTONE, Sandstone and Conglomerate		
95	209						
100	204	SS					
105	199						
110	194	CO					

Borehole Log of QU-11-05

Date Started	: Feb 15, 2011	Drilled By	: Drillwell Enterprise
Date Completed	: Feb 18, 2011	Northing Coord.	: 102648.3
Hole Diameter	: 140 mm	Easting Coord.	: 101075.9
Drilling Method	: Air rotary with wireline coring	Survey By	: QCC
Sampling Method	: Core	Logged By	: N. Bazowski





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Borehole Log of QU-11-05

Date Started : Feb 15, 2011

Date Completed : Feb 18, 2011

Hole Diameter : 140 mm

Drilling Method : Air rotary with wireline coring

Sampling Method : Core

Drilled By : Drillwell Enterprise

Northing Coord. : 102648.3

Easting Coord. : 101075.9

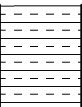
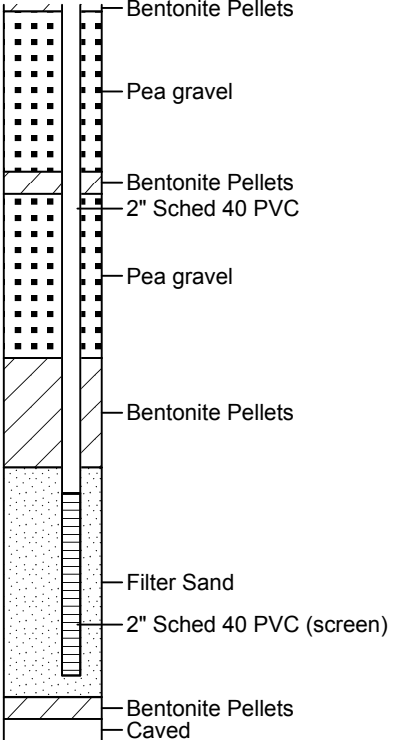
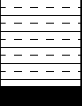
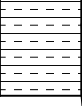
Survey By : QCC

Logged By : N. Bazowski

Depth (m)	Elev. m	USCS	Graphic Symbol	Water Levels	Material Description	
				▼ QU-11-05-S: 19.00 m (8-Mar-11) ▽ QU-11-05-D: 43.95 m (8-Mar-11)		
	228.39					Well1: QU-11-05-S Well2: QU-11-05-D Elev. m: 228.39
50	178	SW				Pea gravel
55	173					Bentonite Pellets
60	168	MS			SILTSTONE	Pea gravel
65	163	CO			COAL - 3 Rider Coal Seam	Bentonite Pellets
		CO			COALY SILTSTONE	
		MS			COAL - 3 Coal Seam	
		CO			SILTSTONE	
70	158	MS			COAL - 3 Lower Coal Seam	Pea gravel
					SILTSTONE	
75	153				COAL - Coal Seam	2" Sched 40 PVC
					SANDSTONE	Bentonite Pellets
80	148	SW				Pea gravel
85	143					Bentonite Pellets
						Pea gravel
90	138					Bentonite Pellets
						Pea gravel
95	133	MS			COAL - 2R Coal Seam	
		MS			SILTSTONE	
100		MS			COAL - 2 Coal Seam	Bentonite Pellets
				Quinsam Coal Assessment of Underground Disposal of Coarse Coal Refuse		
				Campbell River, B.C.		

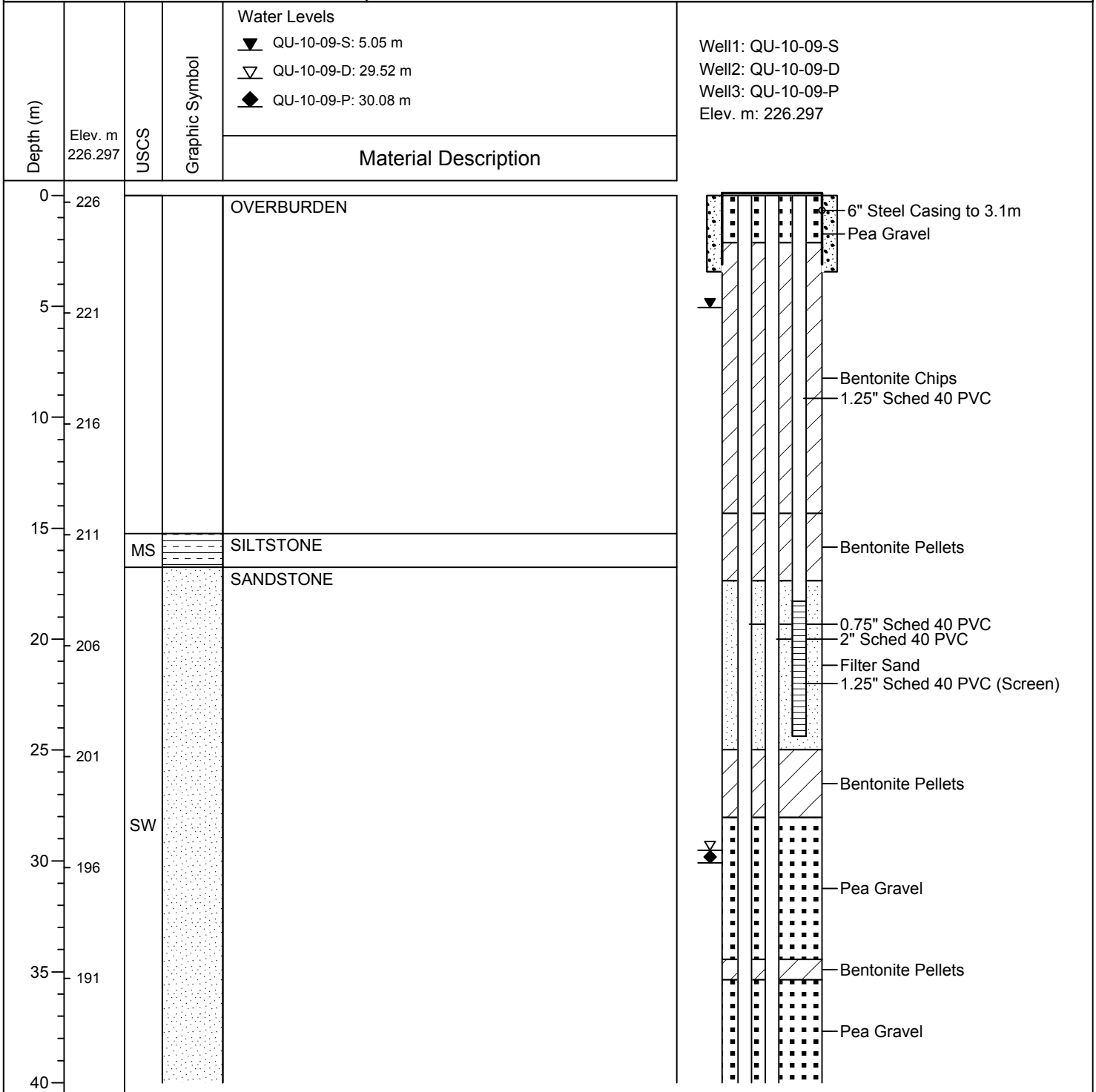
Borehole Log of QU-11-05

Date Started	: Feb 15, 2011	Drilled By	: Drillwell Enterprise
Date Completed	: Feb 18, 2011	Northing Coord.	: 102648.3
Hole Diameter	: 140 mm	Easting Coord.	: 101075.9
Drilling Method	: Air rotary with wireline coring	Survey By	: QCC
Sampling Method	: Core	Logged By	: N. Bazowski

Depth (m)	Elev. m	USCS	Graphic Symbol	Water Levels	Material Description	
				▼ QU-11-05-S: 19.00 m (8-Mar-11) ▽ QU-11-05-D: 43.95 m (8-Mar-11)		
	228.39					Well1: QU-11-05-S Well2: QU-11-05-D Elev. m: 228.39
100	128	MS				
105	123					
110	118					
115	113					
		CO			COAL- 1 Rider Coal Seam	
120	108	MS			~116.99-117.08m: Siltstone SILTSTONE	
		CO			COAL- 1 Seam Upper Coal	
125	103	CO			SILTSTONE	
		CO			COAL- 1Seam Middle Coal	
		MS			~125.21-127.27m: Siltstone	
					COAL - 1 Seam Lower Coal	
130	98				~125.35-125.49m: Coaly Siltstone	
					~125.56-125.81m: Coaly Siltstone	
					SILTSTONE	
135	93				~127.75-127.86m: Coal	
					EOH @ 130.76 M	
140	88					Quinsam Coal Assessment of Underground Disposal of Coarse Coal Refuse Campbell River, B.C.
145	83					
150						

Borehole Log of QU-11-09

Date Started	:		Drilled By	:	Drillwell Enterprise
Date Completed	:	March 8, 2011	Northing Coord.	:	102561.8
Hole Diameter	:	152 mm / 140 mm	Easting Coord.	:	100736
Drilling Method	:	Air rotary with wireline coring	Survey By	:	QCC
Sampling Method	:	Grab sample and core	Logged By	:	N. Bazowski



Quinsam Coal
Assessment of Underground Disposal
of Coarse Coal Refuse

Campbell River, B.C.



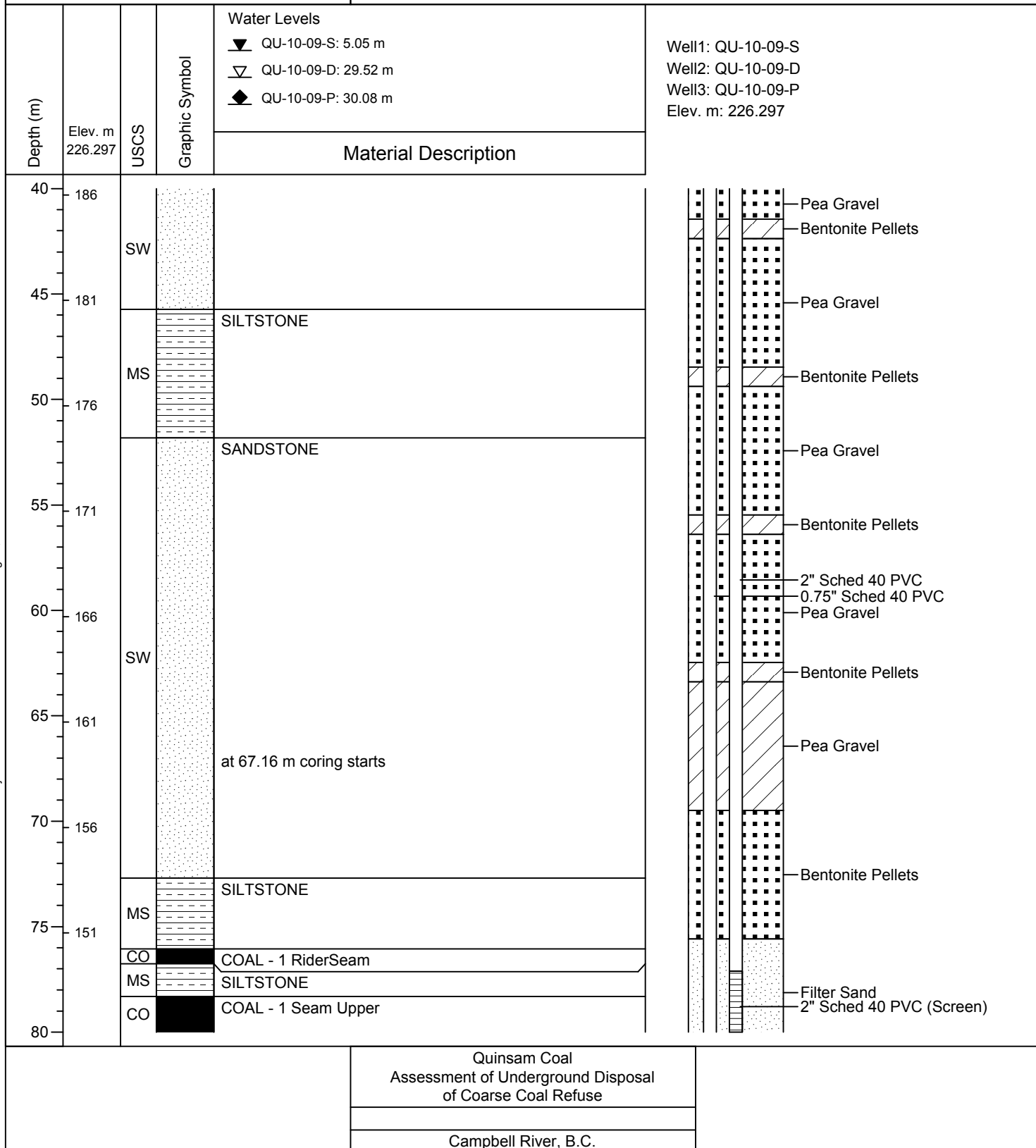
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Borehole Log of QU-11-09

Date Started	:		Drilled By	:	Drillwell Enterprise
Date Completed	:	March 8, 2011	Northing Coord.	:	102561.8
Hole Diameter	:	152 mm / 140 mm	Easting Coord.	:	100736
Drilling Method	:	Air rotary with wireline coring	Survey By	:	QCC
Sampling Method	:	Grab sample and core	Logged By	:	N. Bazowski



Quinsam Coal
Assessment of Underground Disposal
of Coarse Coal Refuse

Campbell River, B.C.



Enterprise Geoscience Services Ltd.



LORAX
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Borehole Log of QU-11-09

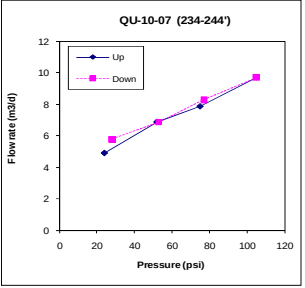
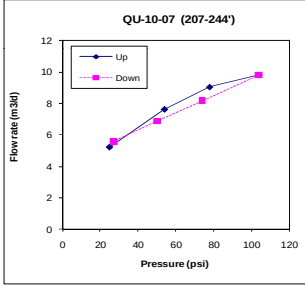
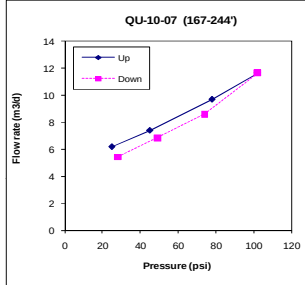
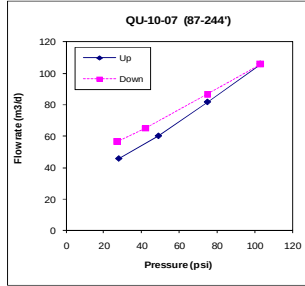
Date Started	:		Drilled By	:	Drillwell Enterprise
Date Completed	:	March 8, 2011	Northing Coord.	:	102561.8
Hole Diameter	:	152 mm / 140 mm	Easting Coord.	:	100736
Drilling Method	:	Air rotary with wireline coring	Survey By	:	QCC
Sampling Method	:	Grab sample and core	Logged By	:	N. Bazowski

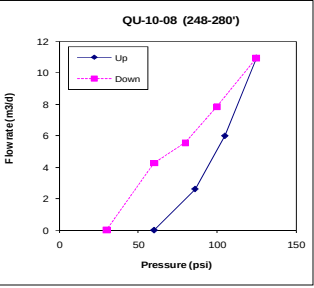
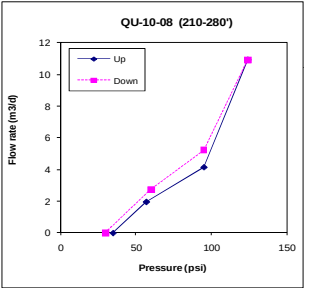
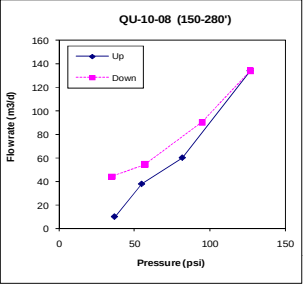
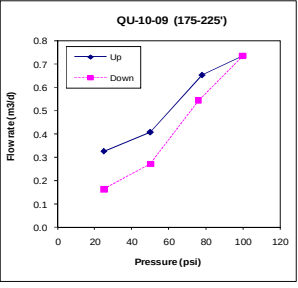
Depth (m)	Elev. m 226.297	USCS	Graphic Symbol	Water Levels	Material Description	
				▼ QU-10-09-S: 5.05 m ▽ QU-10-09-D: 29.52 m ◆ QU-10-09-P: 30.08 m		
80	146	CO				Well1: QU-10-09-S Well2: QU-10-09-D Well3: QU-10-09-P Elev. m: 226.297
		MS			SILTSTONE	
					COAL- 1 Seam Lower	
					SILTSTONE	
85	141					
		MS				
90	136					
95	131					
		GC			CONGLOMERATE	
					96.2-96.64 m: Very Coarse Grained Sandstone	
					97.08-967.45 m: Very Coarse Grained Sandstone	
100	126	MS			SILTSTONE	
		SW			SANDSTONE	
105	121				COGLOMERATE	
		GC				
110	116				EOH @ 110.19	
115	111					
120						

Appendix A2 – Results of Packer Testing



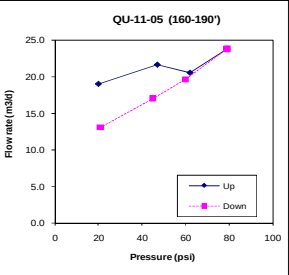
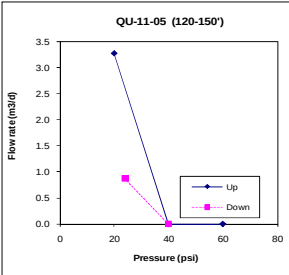
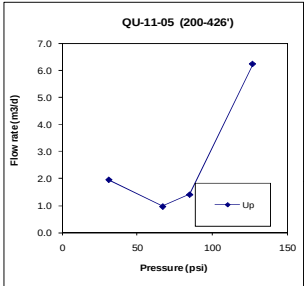
HILLSBOUROUGH
Resources Limited

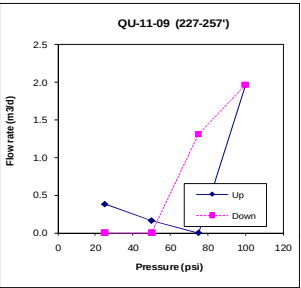
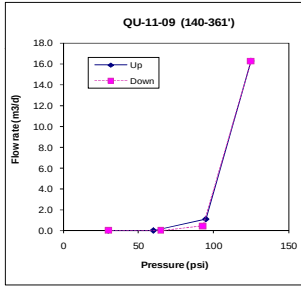
Well ID	Test Interval (ft)	Test Interval (ft)	Lithology Interval (ft)	Lithology Interval (ft)	Lithology Tested	Other Features	Average T (entire test) (m2/s)	Best Engineering Judgement T (m2/s)	Comments on Test	Graphs
QU-10-07	234	244	234	244	Fine grained SANDSTONE and siltstone	OO: Heavily Fractured throughout	9.8E-07	9.8E-07	Good agreement between up and down curves. Laminar flow.	
QU-10-07	207	244	207	213	Fine-med grained SANDSTONE		1.0E-06	1.0E-06	Good agreement between up and down curves. Concave down flow rate in 'up' curve may indicate non-linear flow after 80 psi, but is not indicated by 'down curve'. Gap in 'up' and 'down' curves may suggest some blockage of fractures during test, otherwise laminar flow.	
			213	222.5	No. 3 Coal	Rapid penetration. Flow 0.5 GPM in coal seam				
			222.5	234	SANDSTONE and siltstone	Heavily fractured 222-230.5				
			234	244	Fine grained SANDSTONE and siltstone	Heavily fractured 234-238, 242.5-244				
QU-10-07	167	244	167	213	Fine-med grained SANDSTONE	Moderately weathered 180-190 ft	1.1E-06	1.1E-06	Good agreement between upward and downward curves. Gap in 'up' and 'down' curves may suggest some blockage of fractures during test. Essentially same results 207-244' (no new permeable areas)	
			213	222.5	No. 3 Coal	Rapid penetration. Flow 0.5 GPM in coal seam				
			222.5	234	SANDSTONE and siltstone	Heavily fractured 222-230.5				
			234	244	Fine grained SANDSTONE and siltstone	Heavily fractured 234-238, 242.5-244				
QU-10-07	87	244	87	213	Fine-med grained SANDSTONE	Moderately weathered 180-190 ft	1.0E-05	1.2E-05	Reasonable agreement between upward and downward curves. Higher 'down' curve may indicate washing out of gouge material, increasing permeability. Much higher permeability than tests further downhole. Incomplete step tests performed on intermediate intervals indicates flow is from area between 87-102'. This zone did not originally produce water during drilling. Conclude it is a nearly vertical fracture that was mostly dry. Some pressure increases during test (while not manipulating flow) indicate test was hitting boundaries of fracture.	
			213	222.5	No. 3 Coal	Rapid penetration. Flow 0.5 GPM in coal seam				
			222.5	234	SANDSTONE and siltstone	Heavily fractured 222-230.5				
			234	244	Fine grained SANDSTONE and siltstone	Heavily fractured 234-238, 242.5-244				
QU-10-08	267	280	267	280	SANDSTONE (fine grained 267-271', med-coarse grained 271-280)	Fractured minor coal seams 267-271, minor fractures 272-281			Flows not measurable; test abandoned.	

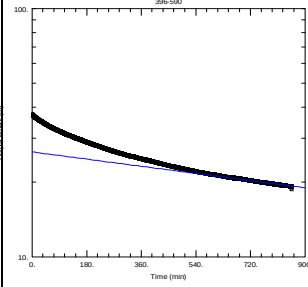
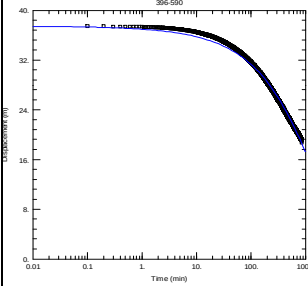
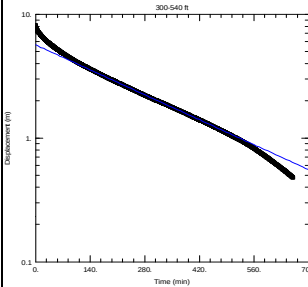
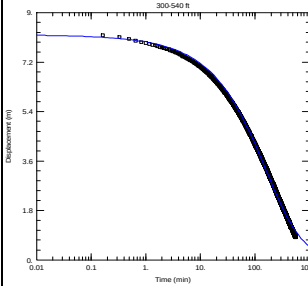
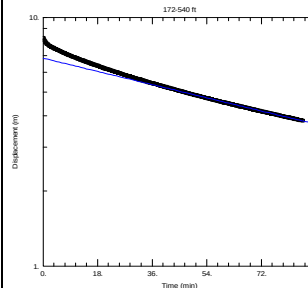
Well ID	Test Interval (ft)	Test Interval (ft)	Lithology Interval (ft)	Lithology Interval (ft)	Lithology Tested	Other Features	Average T (entire test) (m2/s)	Best Engineering Judgement T (m2/s)	Comments on Test	Graphs
QU-10-08	248	280	248.6	250.5	No. 3 Coal	Heavily fractured	4.6E-07	Unreliable test	More permeable on 'down' curve, suggesting some washout of fractures. Higher flows at higher P may suggest temporary dilation of fissures in rock mass. Some bypass leakage at T values are lower for 210-280' test.	
			250.5	259.5	Coal with mudstone lenses	Heavily fractured				
			259.5	266	Coal, minor pyrite	Heavily fractured				
			267	280	SANDSTONE (fine grained 267-271', med-coarse grained 271-280)	Fractured minor coal seams 267-271, minor fractures 272-281				
QU-10-08	210	280	210	248.5	SANDSTONE, coarse grained	Moderately fractured 234.5-241.5	2.9E-07	2.9E-07	As in the previous test, dilation and some washout of fractures. Lower T values in this test indicate some bypass leakage in previous test (248-280'). T values do not include high pressure value in average.	
			248.6	250.5	No. 3 Coal	Heavily fractured				
			250.5	259.5	Coal with mudstone lenses	Heavily fractured				
			259.5	266	Coal, minor pyrite	Heavily fractured				
			267	280	SANDSTONE (fine grained 267-271', med-coarse grained 271-280)	Fractured minor coal seams 267-271, minor fractures 272-281				
QU-10-08	150	280	150	248.5	SANDSTONE, coarse grained	Moderately fractured 234.5-241.5	4.7E-06	5.5E-06	As in the previous test, dilation and some washout of fractures. Incomplete step tests performed on intermediate intervals indicates flow is from area between 160-170'. This zone did not originally produce water during drilling. Conclude it is a nearly vertical fracture that was mostly dry. T values do not include high pressure value in average.	
			248.6	250.5	No. 3 Coal	Heavily fractured				
			250.5	259.5	Coal with mudstone lenses	Heavily fractured				
			259.5	266	Coal, minor pyrite	Heavily fractured				
			267	280	SANDSTONE (fine grained 267-271', med-coarse grained 271-280')	Fractured minor coal seams 267-271, minor fractures 272-281				
QU-10-09	175	225	175	225	CUMBERLAND: Siltstone and/or mudstone, with coal stringers 165-184.5, 199.5-202	Fractured throughout interval	7.7E-08	5.0E-08	Overall low permeability with decrease in permeability on 'down' curve (infilling of fractures). Slight decrease in permeability at higher pressure due to possible turbulent flow.	

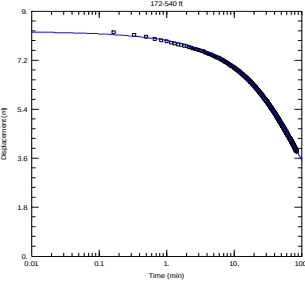
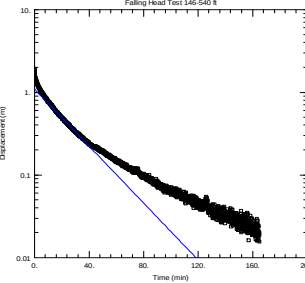
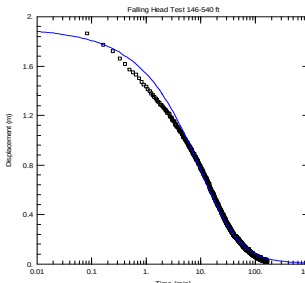
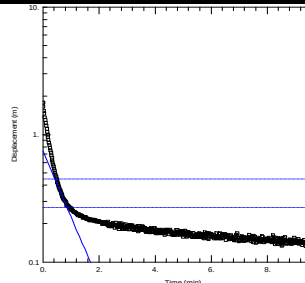
Well ID	Test Interval (ft)	Test Interval (ft)	Lithology Interval (ft)	Lithology Interval (ft)	Lithology Tested	Other Features	Average T (entire test) (m2/s)	Best Engineering Judgement T (m2/s)	Comments on Test	Graphs
QU-10-09	140	225	140	161.5	SANDSTONE, med-coarse grained	fractured	3.2E-05	3.0E-05	Overall high permeability which decreases at higher pressures (turbulent flow). Lower permeability on 'down' curve indicates infilling of fractures.	
			162	165	No. 2 Coal	Fractured. Flow increased from 12 to 16 USGPM across coal seam.				
			165	225	CUMBERLAND: Siltstone and/or mudstone, with coal stringers 165-184.5, 199.5-202	Fractured throughout interval. Flow increased to 28 USGPM by 188 ft.				
QU-10-09	100	225	100	125	SANDSTONE, med-coarse grained, with coal stringer (No. 3 Seam) at 105.75 ft.	Fractured 105-109 ft, 117.5-124 ft. Flow 9 US GPM at 124 ft.	3.4E-05	3.1E-05	Overall high permeability which decreases at higher pressures (turbulent flow). Lower permeability on 'down' curve indicates infilling of fractures. Only slightly higher T values (10% increase) over previously tested interval (140-225)	
			125	129	Mudstone	Multiple fractures.				
			129	161.5	SANDSTONE, med-coarse grained	fractured				
			162	165	No. 2 Coal	Fractured. Flow increased from 12 to 16 USGPM across coal seam.				
			165	225	CUMBERLAND: Siltstone and/or mudstone, with coal stringers 165-184.5, 199.5-202	Fractured throughout interval. Flow increased to 28 USGPM by 188 ft.				
QU-10-09	58	225	58	97	SANDSTONE, fine-med grained		4.4E-05	4.1E-05	Overall high permeability which decreases at higher pressures (turbulent flow). Lower permeability on 'down' curve indicates infilling of fractures. Over 25% increase in flow over prior tested interval (100-225 ft)	
			97	125	SANDSTONE, med-coarse grained, with coal stringer (No. 3 Seam) at 105.75 ft.	Fractured 105-109 ft, 117.5-124 ft. Flow 9 US GPM at 124 ft.				
			125	129	Mudstone	Multiple fractures.				
			129	161.5	SANDSTONE, med-coarse grained	fractured				
			162	165	No. 2 Coal	Fractured. Flow increased from 12 to 16 USGPM across coal seam.				
			165	225	CUMBERLAND: Siltstone and/or mudstone, with coal stringers 165-184.5, 199.5-202	Fractured throughout interval. Flow increased to 28 USGPM by 188 ft.				
QU-10-10	345	590	345	390	Unnamed coal seam plus No. 3 Coal seams (Rider to Lower) separated by mudstone or siltstone		8.5E-08	6.6E-08	Overall low permeability which decreased on 'down' curve, indicating infilling of fractures	
			390	472	SANDSTONE with mudstone layers (394-400, 463-472 ft)	Airlift yield increased 2 GPM (from 10-12 gpm) over 420 to 460 ft interval.				
			472	473.5	No. 2 Coal Seam					
			473.5	528	Mudstone					
			528	568	No. 1 Coal seams (Rider through lower) ranging from 0.5-5.5 ft thick (5 seams total); interlayered with mudstone.					
			568	590	Siltstone					
QU-10-10	220	590	220	265	SANDSTONE, med-coarse grained		1.0E-07	8.2E-08	Results similar to test from interval 345-590 ft. High flows encountered during 200-590 ft are thus taken up in 200-220 ft interval.	
			265	268	Mudstone					
			268	272	No. 4 B coal					
			272	278	Mudstone					
			278	347	SANDSTONE, coarse grained					
			347	390	Unnamed coal seam plus No. 3 Coal seams (Rider to Lower) separated by mudstone or siltstone					
			390	472	SANDSTONE with mudstone layers (394-400, 463-472 ft)	Airlift yield increased 2 GPM (from 10-12 gpm) over 420 to 460 ft interval.				
			472	473.5	No. 2 Coal Seam					
			473.5	528	Mudstone					
			528	568	No. 1 Coal seams (Rider through lower) ranging from 0.5-5.5 ft thick (5 seams total); interlayered with mudstone.					
			568	590	Siltstone					

Well ID	Test Interval (ft)	Test Interval (ft)	Lithology Interval (ft)	Lithology Interval (ft)	Lithology Tested	Other Features	Average T (entire test) (m2/s)	Best Engineering Judgement T (m2/s)	Comments on Test	Graphs
QU-10-10	200	590	200	265	SANDSTONE, med-coarse grained		2.6E-06	3.8E-06	Permeability increases as test progresses, with 'down' curve indication washout of gouge material.	
			265	268	Mudstone					
			268	272	No. 4 B coal					
			272	278	Mudstone					
			278	347	SANDSTONE, coarse grained					
			347	390	Unnamed coal seam plus No. 3 Coal seams (Rider to Lower) separated by mudstone or siltstone					
			390	472	SANDSTONE with mudstone layers (394-400, 463-472 ft)	Airlift yield increased 2 GPM (from 10-12 gpm) over 420 to 460 ft interval.				
			472	473.5	No. 2 Coal Seam					
			473.5	528	Mudstone					
			528	568	No. 2 Coal seams (Rider through lower) ranging from 0.5-5.5 ft thick (5 seams total); interlayered with mudstone.					
QU-10-11	220	250	568	590	Siltstone		9.9E-08	7.3E-08	Permeability decreases as test progresses, indicating void filling and/or swelling of the formation.	
			220	234	SANDSTONE, grey to grey-brown, medium-coarse to medium grained, fresh	Flow 20 US GPM at 220 ft (water was blowing out of adjacent exploration hole, QU-05-10 during this measurement)				
			234	235	COAL (No. 4B Seam), with SILTSTONE/MUDSTONE					
			235	238	MUDSTONE, dark brown, fresh					
			238	239	COAL (No. 4 B Seam), with SILTSTONE/MUDSTONE					
QU-10-11	251	281	251	281	SANDSTONE, grey brown to grey, medium to coarse grained, fresh				No measurable flow through 115 PSI.	
			251	281	SANDSTONE, grey brown to grey, medium to coarse grained, fresh					
QU-10-11	170	200	157	234	SANDSTONE, grey to grey-brown, medium-coarse to medium grained, fresh				No measurable flow through 90 PSI.	
QU-08-21G	452	EOH	452	507	Dunsmuir Group				No measurable flow through 120 PSI.	
			507	EOH	CUMBERLAND: Siltstone and/or mudstone, including No 2 and No.1 Coal Seams	Faults at 515 and 548'				
QU-11-05	386	416	386	402	SILTSTONE, coaly				No measureable flow through 150 psi	
			402	413.5	COAL (No. 1)	Fractured at 30 and 45 degree dip				
QU-11-05	345	375	413	416	SILTSTONE				No measureable flow through 125 psi	
			345	375	SILTSTONE					
QU-11-05	306	336	306	312.6	SANDSTONE				No measureable flows through 120 psi	
			312.6	313.1	COAL (No. 2R)					
			313.1	316	SILTSTONE, coaly					
			316	318	SANDSTONE					
			318	318.6	CONGLOMERATE					
			318.6	321.9	SILTSTONE, coaly					
			321.9	323	COAL (No. 2)					
			323	326	SILTSTONE, coaly					
			326	327.9	SANDSTONE, vey fine grained	Bottom Contact is partially intact breccia zone (35 degree healed fault zone)				
			327.9	336	SILTSTONE	Small fault 334.5 ft (rock flour and fragments within a void, at 0 degrees dip)				
QU-11-05	275	305	275	305	SANDSTONE, fine-med grained	Fracture ~228 ft, 70 degrees dip, thin layer of clay within			No measureable flows through 120 psi	
QU-11-05	242	272	242	272	SANDSTONE, fine-coarse grained	Fracture at 252 ft			No measureable flows through 125 psi	
QU-11-05	200	230	200	207.5	SILTSTONE				No measureable flows through 100 psi	
			207.5	210.4	COAL (No. 3R)	Two fractures at ~209 ft (35 degrees dip)				
			210.4330709	211.5813648	SILTSTONE, coaly					
			211.5813648	213.812336	COAL (No. 3)					
			213.8	221.5	SILTSTONE, coaly					
			221.4895013	224.17979	COAL (No. 3L)					
			224.18	230	SILTSTONE and SANDSTONE					

Well ID	Test Interval (ft)	Test Interval (ft)	Lithology Interval (ft)	Lithology Interval (ft)	Lithology Tested	Other Features	Average T (entire test) (m2/s)	Best Engineering Judgement T (m2/s)	Comments on Test	Graphs
QU-11-05	160	190	160	186	SANDSTONE, fine-med grained	Quartz cemented fracture at 179 ft (80 degrees dip)	3.1E-06	2.8E-06		
			186	190	SILTSTONE, coaly					
QU-11-05	120	150	120	150	SANDSTONE, medium grained				Inconclusive test. Permeability appears below limit of instrumentation.	
QU-11-05	200	416	200	207.5	SILTSTONE		2.8E-07	2.2E-07	Ramp-up tests performed only because final step failed to stabilize in a reasonable amount of time (<15 min). Best T value based on first 3 steps where some stabilization was achieved.	
			207.5	210.4	COAL (No. 3R)	Two fractures at ~209 ft (35 degrees dip)				
			210.4330709	211.5813648	SILTSTONE, coaly					
			211.5813648	213.812336	COAL (No. 3)					
			213.8	221.5	SILTSTONE, coaly					
			221.4895013	224.17979	COAL (No. 3L)					
			224.18	230	SILTSTONE and SANDSTONE					
			230	312.6	SANDSTONE					
			312.6	313.1	COAL (No. 2R)					
			313.1	316	SILTSTONE, coaly					
			316	318	SANDSTONE					
			318	318.6	CONGLOMERATE					
			318.6	321.9	SILTSTONE, coaly					
			321.9	323	COAL (No. 2)					
			323	326	SILTSTONE, coaly					
			326	327.9	SANDSTONE, vey fine grained	Bottom Contact is partially intact breccia zone (35 degree healed fault zone)				
			327.9	383.4	SILTSTONE	Small fault 334.5 ft (rock flour and fragments within a void, at 0 degrees dip)				
			383.4	386	COAL (No. 1R)					
			386	402	SILTSTONE, coaly					
			402	413.5	COAL (No. 1)					
			413	416	SILTSTONE					
QU-11-09	312	342	312	317	SILTSTONE and SANDSTONE				No measureable flows through 120 psi	
			317	318.5	CONGLOMERATE, matrix supported					
			318.5	319.7	SANDSTONE					
			319.7	324	CONGLOMERATE, matrix supported	Bottom Contact is sharp at 45 degrees, along a fracture				
			324	338	SILTSTONE	Fractured at 330.5 ft, 50 degree dip with slickensides				
			338	340.7	SANDSTONE					
QU-11-09	256	286	340.7	342	CONGLOMERATE, clast supported (BENSON)				No measureable flows through 118 psi	
			256	256.9	SILTSTONE, coaly					
			256.9	273.6	COAL (No. 1U, M, L), with coal SILTSTONE and MUDSTONE					
QU-11-09	256	286	273.6	286	SILTSTONE and SANDSTONE	Fracture at ~278 ft, 50 degrees dip, rough with trace green clasy or rock flour				

Well ID	Test Interval (ft)	Test Interval (ft)	Lithology Interval (ft)	Lithology Interval (ft)	Lithology Tested	Other Features	Average T (entire test) (m2/s)	Best Engineering Judgement T (m2/s)	Comments on Test	Graphs
QU-11-09	243	273	243	249.5	SILTSTONE				No measureable flows through 115 psi	
			249.5	251.8	COAL (No. 1R)					
			251.8	256.9	SILTSTONE, coaly					
			256.9	273	COAL (No. 1U, M, L), with SILTSTONE and MUDSTONE partings					
QU-11-09	227	257	227	238.5	SANDSTONE				Inconclusive test. Permeability appears below limit of instrumentation.	
			238.5	249.5	SILTSTONE					
			249.5	251.8	COAL (No. 1R)					
			251.8	256.9	SILTSTONE, coaly					
QU-11-09	180	210	180	195	SANDSTONE, very fine to fine grained				No measureable flows through 80 psi	
			195	210	SANDSTONE, dark green black, with trace quartz, very hard					
QU-11-09	145	175	145	150	SANDSTONE, very fine grained				No measureable flows through 75 psi	
			150	170	SILTSTONE					
			170	175	SANDSTONE					
QU-11-09	110	140	110	140	SANDSTONE, fine to very fine grained				No measureable flows through 60 psi	
QU-11-09	80	110	80	110	SANDSTONE, very fine to medium grained				No measureable flows through 45 psi	
QU-11-09	140	361	140	150	SANDSTONE, very fine grained		2.3E-07	2.9E-08	Dialation of fractures at high pressures, otherwise low permeability. Best T estimates based on lower pressure steps (<100 psi)	
			150	170	SILTSTONE					
			170	195	SANDSTONE, very fine to fine grained					
			195	210	SANDSTONE, dark green black, with trace quartz, very hard					
			210	238.5	SANDSTONE					
			238.5	249.5	SILTSTONE					
			249.5	251.8	COAL (No. 1R)					
			251.8	256.9	SILTSTONE, coaly					
			256.9	273.6	COAL (No. 1U, M, L), with coal SILTSTONE and MUDSTONE					
			273.6	286	SILTSTONE and SANDSTONE	Fracture at ~278 ft, 50 degrees dip, rough with trace green clay or rock flour				
			286	312	SILTSTONE, coaly					
			312	317	SILTSTONE and SANDSTONE					
			317	318.5	CONGLOMERATE, matrix supported					
			318.5	319.7	SANDSTONE					
			319.7	324	CONGLOMERATE, matrix supported	Bottom Contact is sharp at 45 degrees, along a fracture				
			324	338	SILTSTONE	Fractured at 330.5 ft, 50 degree dip with slickensides				
			338	340.7	SANDSTONE					
			340.7	361	CONGLOMERATE, clast supported (BENSON)					

Well ID	Test Interval (ft)	Test Interval (ft)	Lithology Interval (ft)	Lithology Interval (ft)	Lithology Tested	Other Features	Aquifer Type	Aquifer Thickness (m)	Analytical Solution	K (m/s)	T (m2/s)	Comments on Test	Graphs
QU-10-10	396	590	396	472	SANDSTONE with mudstone layers (394-400, 463-472 ft)	Airlift yield increased 2 GPM (from 10-12 gpm) over 420 to 460 ft interval.	Confined	59	Hvorslev	1.6E-09		Test recovered ~50%. Results based on projections of earlier-time data.	
			472	473.5	No. 2 Coal Seam								
			473.5	528	Mudstone					Cooper et al	6.1E-08	Test recovered ~50%. Results based on projections of earlier-time data.	
			528	568	No. 1 Coal seams (Rider through lower) ranging from 0.5-5.5 ft thick (5 seams total); interlayered with mudstone.								
			568	590	Siltstone								
QU-10-11	300	540	300	310	SANDSTONE, grey brown to grey, medium to coarse grained except fine grained at 283-300 ft, fresh	Flow 15 US GPM at 260 ft Flow 12 US GPM at 300 ft	Confined	73.2	Hvorslev	1.2E-08		Test recovered 95%. Late time data show an increased recovery rate. Possible influence of rainfall.	
			310	313	COAL (No. 3R Seam), shiny, with dark brown, fresh								
			313	318	SST, medium grey								
			318	335	MUDSTONE, dark brown, fresh	Flow 30 US GPM at 320 ft							
			335	338	COAL (No. 3L Seam), shiny, with dark brown, fresh								
			338	348	MUDSTONE, dark brown, fresh	Flow 18 US GPM at 340 ft							
			348	355	SST, light grey, fine-medium grained with dark brown mudstone								
			355	360	MUDSTONE, dark brown, fresh, with minor COAL seams	Flow 30 US GPM at 360 ft							
			360	428	SST, grey, fine to medium grey, with dark brown MUDSTONE lenses (360-378 ft) and COAL stringers 390 ft and 399 ft	Flow 12 US GPM at 380 ft Flow 7 US GPM at 400 ft Flow 9 US GPM at 420 ft			Cooper et al	6.4E-07			
			428	436	SILTSTONE, dark brown, fresh	Flow 6 US GPM at 435 ft							
			436	457	MUDSTONE, dark brown, with coal beds at 440, 447 and 453 ft								
			457	463	COAL (No.2), shiny, with MUDSTONE (460-462 ft)	Flow 4 US GPM at 460 ft							
			462	478	MUDSTONE, fresh								
			478	479	COAL (No. 2L/1U)	Flow 16 US GPM at 480 ft							
			479	495	MUDSTONE, medium grey-brown, with shiny COAL stringers								
			495	519	COAL (No. 1 & 1L) shiny, with MUDSTONE (508-518 ft)	Flow 4 US GPM at 500 ft							
			519	537	SST, greenish grey, fine-medium grained, fresh	Flow 11 GPM at 520 ft							
			537	540	SHALE, red-brown, fresh	Flow 11 GPM at 540 ft							
QU-10-11	172	540	172	234	SST, grey to grey-brown, medium-coarse to medium grained, fresh	Flow 30 US GPM at 180 ft, 20 US GPM at 220 ft (water was blowing out of adjacent exploration hole, QU-05-10 during this measurement)	Confined	112.2	Hvorslev	1.6E-08		Test recovered ~50%. Results based on projections of earlier-time data.	
			234	239	COAL (No. 4B Seam), with MUDSTONE (235-238 ft)								
			239	310	SANDSTONE, grey brown to grey, medium to coarse grained except fine grained at 283-300 ft, fresh	Flow 15 US GPM at 260 ft Flow 12 US GPM at 300 ft							
			310	313	COAL (No. 3R Seam), shiny, with dark brown, fresh								
			313	318	SST, medium grey								
			318	335	MUDSTONE, dark brown, fresh	Flow 30 US GPM at 320 ft							
			335	338	COAL (No. 3L Seam), shiny, with dark brown, fresh								
			338	348	MUDSTONE, dark brown, fresh	Flow 18 US GPM at 340 ft							
			348	355	SST, light grey, fine-medium grained with dark brown mudstone								
			355	360	MUDSTONE, dark brown, fresh, with minor COAL seams	Flow 30 US GPM at 360 ft							

Well ID	Test Interval (ft)	Test Interval (ft)	Lithology Interval (ft)	Lithology Interval (ft)	Lithology Tested	Other Features	Aquifer Type	Aquifer Thickness (m)	Analytical Solution	K (m/s)	T (m2/s)	Comments on Test	Graphs
			360	428	SST, grey, fine to medium grey, with dark brown MUDSTONE lenses (360-378 ft) and COAL stringers 390 ft and 399 ft	Flow 12 US GPM at 380 ft Flow 7 US GPM at 400 ft Flow 9 US GPM at 420 ft			Cooper et al		8.9E-07		
			428	436	SILTSTONE, dark brown, fresh	Flow 6 US GPM at 435 ft							
			436	457	MUDSTONE, dark brown, with coal beds at 440, 447 and 453 ft								
			457	463	COAL (No.2), shiny, with MUDSTONE (460-462 ft)	Flow 4 US GPM at 460 ft							
			462	478	MUDSTONE, fresh								
			478	479	COAL (No. 2L/1U)	Flow 16 US GPM at 480 ft							
			479	495	MUDSTONE, medium grey-brown, with shiny COAL stringers								
			495	519	COAL (No. 1 & 1L) shiny, with MUDSTONE (508-518 ft)	Flow 4 US GPM at 500 ft							
			519	537	SST, greenish grey, fine-medium grained, fresh	Flow 11 GPM at 520 ft							
			537	540	SHALE, red-brown, fresh	Flow 11 GPM at 540 ft							
QU-10-11	146	590	146	156	SANDSTONE, fresh, fracture at 134 ft	Flow at fracture (134 ft) 30 US GPM	Confined	120	Hvorslev	8.4E-08		Almost complete recovery.	
			156	157	COAL (No. 4L Seam), dirty	Flow 30 US GPM at 160 ft							
			157	234	SST, grey to grey-brown, medium-coarse to medium grained, fresh	Flow 30 US GPM at 180 ft, 20 US GPM at 220 ft (water was blowing out of adjacent exploration hole, QU-05-10 during this measurement)							
			234	239	COAL (No. 4B Seam), with MUDSTONE (235-238 ft)								
			239	310	SANDSTONE, grey brown to grey, medium to coarse grained except fine grained at 283-300 ft, fresh	Flow 15 US GPM at 260 ft Flow 12 US GPM at 300 ft							
			310	313	COAL (No. 3R Seam), shiny, with dark brown, fresh MUDSTONE								
			313	318	SST, medium grey								
			318	335	MUDSTONE, dark brown, fresh	Flow 30 US GPM at 320 ft							
			335	338	COAL (No. 3L Seam), shiny, with dark brown, fresh MUDSTONE								
			338	348	MUDSTONE, dark brown, fresh	Flow 18 US GPM at 340 ft							
			348	355	SST, light grey, fine-medium grained with dark brown mudstone								
			355	360	MUDSTONE, dark brown, fresh, with minor COAL seams	Flow 30 US GPM at 360 ft							
			360	428	SST, grey, fine to medium grey, with dark brown MUDSTONE lenses (360-378 ft) and COAL stringers 390 ft and 399 ft	Flow 12 US GPM at 380 ft Flow 7 US GPM at 400 ft Flow 9 US GPM at 420 ft			Cooper et al	7.6E-06			
			428	436	SILTSTONE, dark brown, fresh	Flow 6 US GPM at 435 ft							
			436	457	MUDSTONE, dark brown, with coal beds at 440, 447 and 453 ft								
			457	463	COAL (No.2), shiny, with MUDSTONE (460-462 ft)	Flow 4 US GPM at 460 ft							
			462	478	MUDSTONE, fresh								
			478	479	COAL (No. 2L/1U)	Flow 16 US GPM at 480 ft							
			479	495	MUDSTONE, medium grey-brown, with shiny COAL stringers								
			495	519	COAL (No. 1 & 1L) shiny, with MUDSTONE (508-518 ft)	Flow 4 US GPM at 500 ft							
			519	537	SST, greenish grey, fine-medium grained, fresh	Flow 11 GPM at 520 ft							
			537	540	SHALE, red-brown, fresh	Flow 11 GPM at 540 ft							
QU-08-21G	404	610	307		Top of Dunsmuir B sandstone		Confined	63	Hvorslev	7.0E-06		Test is not ideal. Double straight-line response. Possible influence of fractures.	
			361	374	Soft, kaolinized sandstone								
			409	413	No. 3R coal								
			416	418	No. 3 coal								
			425	427	No. 3L coal								
			507		Comox FM, Cumberland member (faulted section)								
			511	512	No. 2 Coal								
			516		Fault								
			548		Fault								
			549	552	Fault								
			563	567	No. 1 Coal				Cooper et al		n/a	Did not converge	
			569	570	No. 1 Coal								
			578	580	No. 1L Coal (horizon only)								
			604		Top of Benson Member								
			613		EOH								

Appendix A3 – Summary of Hydraulic Testing Results



HILLSBOUROUGH
Resources Limited

Hydraulic Conductivity of Sandstone and Till

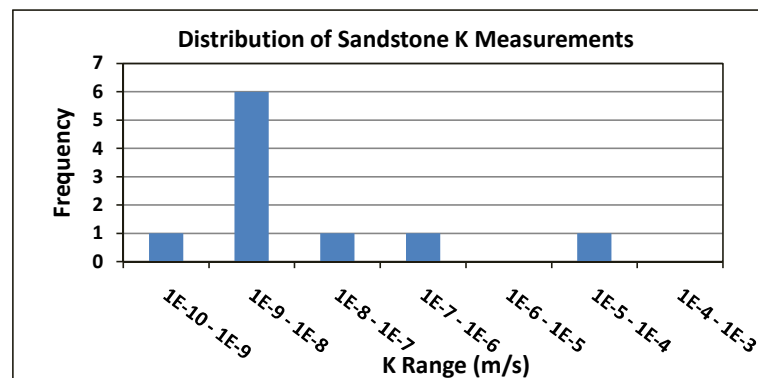
Borehole ID	Mine Area	Lithology	Interval Top (ft)	Interval Bottom (ft)	Measured K (m/s)	Assumed K (m/s)	Test Type	Analytical Method	Source
QU08-05	7 South	Sandstone	62	102	6.5E-09	6.5E-09	Slug Test	Hvorslev	Lorax May 2010 Field Investigation
QU10-07S	4 South	Sandstone	109	135	8.2E-09	8.2E-09	Slug Test	Cooper Green	Lorax Fall 2010 Field Investigation
QU10-09S	4 South	Fractured Sandstone	41	49	7.9E-05	7.9E-05	Slug Test	Hvorslev	Lorax Fall 2010 Field Investigation
QU10-07	4 South	Sandstone	234	244	9.8E-07	9.8E-07	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
QU10-08	4 South	Sandstone	267	280	<7.5E-09	1.5E-09	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
QU11-05	River Barrier Pillar	Sandstone	242	272	<3E-09	6.0E-10	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
QU11-05	River Barrier Pillar	Sandstone	120	150	<6E-09	1.2E-09	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
QU11-09	River Barrier Pillar	Sandstone	80	110	<8E-09	1.6E-09	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
QU11-09	River Barrier Pillar	Sandstone	110	140	<6E-09	1.2E-09	Packer - Lugeon	Thiem	Lorax Fall 2010 Field Investigation
n/a	4-South	Sandstone	40	50	-	5.0E-08	Large scale deH20	n/a	Lorax 2011 4 South Report
P2N-09-01	2 North	Till+Sand	40	50	6.5E-06	6.5E-06	Slug Test	n/a	EGSL 2009 Field Investigation
P2N-09-02	2 North	Till	70	80	2.2E-06	2.2E-06	Slug Test	n/a	EGSL 2009 Field Investigation
QU08-13B	7 South	Till-Sandstone	77	87	5.2E-06	5.2E-06	Slug Test	Hvorslev	Lorax May 2010 Field Investigation

Notes:

n/a: Not available

Value not believed to be representative of sandstone in 7 South

Unit	Geometric Average K (m/s)	Log (Geometric Average K) (m/s)
Sandstone	5.6E-09	-8.3
Till	4.2E-06	-5.4

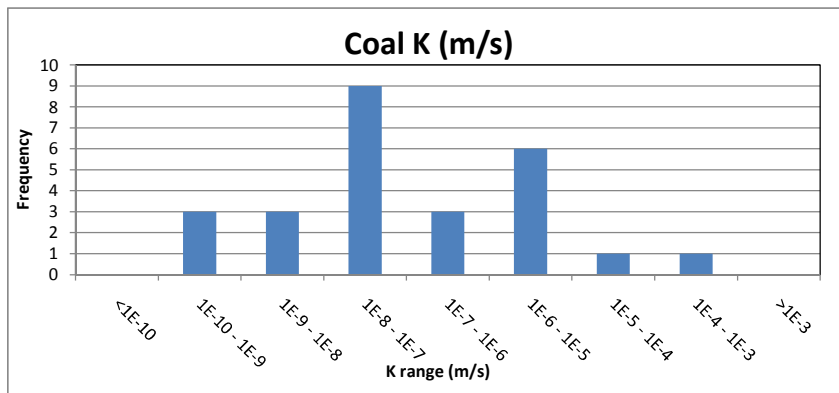


Hydraulic Conductivity of Coal

Borehole ID	Mine Area	Test Type	Lithology ¹	Interval Top (ft)	Interval Bottom (ft)	Interval Thickness (m)	T (m ² /s)	K (m/s)	Analytical Method	Source
QU08-08B	7 South	Slug Test	No. 5 + SST	26	28	0.5	2.6E-05	5.5E-05	Hvorslev	Lorax May 2010 Field Investigation
QU07-05	7 South	Bail down recovery test	No. 4+No. 5			6.1	8.0E-07	1.0E-07	Theis	Golder, 2009
QU07-07	7 South	Bail down recovery test	No. 4+No. 5			13.3	4.0E-05	3.0E-06	Theis	Golder, 2009
QU08-05	7 South	Bail down recovery test	No. 4+No. 5			5.7	1.0E-07	2.0E-08	Theis	Golder, 2009
QU08-08A	7 South	Slug Test	No. 4 + MST/SLST	52	56	1.4	4.0E-10	2.9E-10	Hvorslev	Lorax May 2010 Field Investigation
QU08-10	7 South	Slug Test	No. 4 + SST+ MST	20	27	2.3	1.1E-08	5.0E-09	Hvorslev	Lorax May 2010 Field Investigation
QU08-13A	7 South	Slug Test	No. 4 + SST+ MST	23	26	0.9	9.8E-05	1.1E-04	Hvorslev	Lorax May 2010 Field Investigation
QU10-11	2 North	Packer-Lugeon	SST + No. 4B	220	250	9.1	7.3E-08	8.0E-09	Thiem	Lorax May 2010 Field Investigation
QU10-10S	2 North	Slug Test	No. 4/SST	187	209	6.9	7.5E-06	1.1E-06	Bouwer-Rice	Lorax Fall 2010 Field Investigation
QU08-21G-S	2 North	Slug Test	No. 4/SST	242	265	7.0	1.5E-06	2.1E-07	Bouwer-Rice	Lorax Fall 2010 Field Investigation
QU07-08	7 South	Bail down recovery test	No. 4			4.8	5.0E-07	1.0E-07	Theis	Golder, 2009
QU08-07	7 South	Bail down recovery test	No. 4			3.7	2.0E-07	5.0E-08	Theis	Golder, 2009
QU09-01	7 South	Bail down recovery test	No. 4			4.4	1.0E-07	3.0E-08	Theis	Golder, 2009
QU10-07	4 South	Packer-Lugeon	No. 3 + SST	207	244	11.3	1.0E-06	2.4E-09	Thiem	Lorax Fall 2010 Field Investigation
QU10-07D	4 South	Slug Test	No. 3/MDST	205	225	6.2	6.5E-08	1.0E-08	Cooper-Green	Lorax Fall 2010 Field Investigation
QU10-08	4 South	Packer-Lugeon	SST + No. 3 + SST	210	280	21.3	2.9E-07	1.4E-08	Thiem	Lorax Fall 2010 Field Investigation
QU10-08D	4 South	Slug Test	No. 3	245	268	7.2	1.1E-06	1.6E-07	Cooper et al	Lorax Fall 2010 Field Investigation
QU10-09D	4 South	Slug Test	No. 3/SST	102	125	7.0	2.4E-05	3.4E-06	Bouwer-Rice	Lorax Fall 2010 Field Investigation
QU10-09	4 South	Packer-Lugeon	SST + No. 3 + MDST	100	140	12.2	1.0E-06	8.2E-08	Thiem	Lorax Fall 2010 Field Investigation
QU10-09	4 South	Packer-Lugeon	SST + No. 2 + SLST	140	225	25.9	3.0E-05	2.8E-06	Thiem	Lorax Fall 2010 Field Investigation
QU10-10D	2 North	Slug Test	No. 1/MDST	537	566	8.7	1.7E-07	2.0E-08	Hvorslev	Lorax Fall 2010 Field Investigation
QU10-11D	2 North	Slug Test	No. 1/MDST	491	534	13.1	1.3E-04	9.7E-06	Cooper-Green	Lorax Fall 2010 Field Investigation
QU08-21G-D	2 North	Slug Test	No. 1	536	580	13.4	2.1E-05	1.6E-06	Cooper-Green	Lorax Fall 2010 Field Investigation
QU11-05M	RBP	Slug Test	No. 1	392	423	9.6	9.6E-09	1.0E-09	Hvorslev	Lorax Fall 2010 Field Investigation
QU11-09D	RBP	Slug Test	No. 1	248	276	8.5	8.5E-09	1.0E-09	Hvorslev	Lorax Fall 2010 Field Investigation
P1-4-2 (P1-1C)	5 South	Pump Test	Shale+No.1					1.7E-07	Theis	Brown Erdman, 1982

1. SST= Sandstone, MDST=Mudstone, SLST=Siltstone, No. # = Coal Seam

Values are calculated from original method output



	T (m ² /s)	K (m/s)
Min	4.0E-10	2.9E-10
Max	1.3E-04	1.1E-04
Geo. Mean	7.1E-07	1.0E-07

All Coal Seams	
Bin	Frequency
<1E-10	0
1E-10 - 1E-9	3
1E-9 - 1E-8	3
1E-8 - 1E-7	9
1E-7 - 1E-6	3
1E-6 - 1E-5	6
1E-5 - 1E-4	1
1E-4 - 1E-3	1
>1E-3	0
Count	26

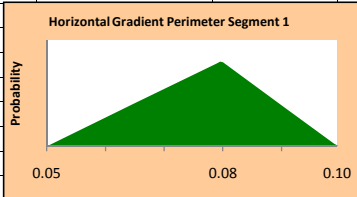
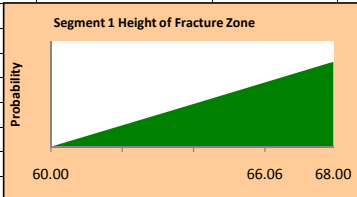
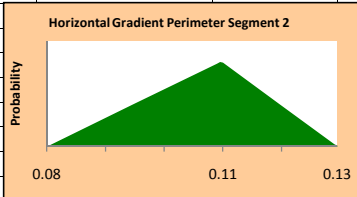
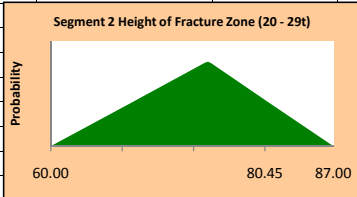
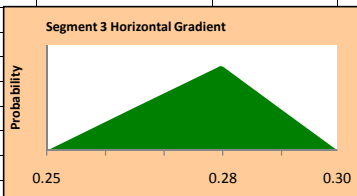
Appendix A4 – Seepage Model Assumptions and Output



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2 NORTH / 3 NORTH MASS FLUX CALCULATIONS					
INPUT PARAMETERS					
Hydraulic Conductivity of Coal (K)		Units	Value	Comments	
geomean		(m/s)	1.0E-07	geometric mean of all coal seams	
Hydraulic Conductivity of SST (K)		Units	Value	Comments	
geomean		(m/s)	5.6E-09	geometric mean of all measured SST values (excluding outlier)	
Hydraulic Conductivity of Till (K)		Units	Value	Comments	
Till		m/s	4.2E-06	geometric mean of 3 tests in till	
Effective Porosity (Bedrock)		Units	Value	Comments	
log(minimum)		(-)	-5		
log(maximum)		(-)	-1		
log(average)		(-)	-3	median based on literature values	
Mean Annual Precipitation		Units	Value	Comments	
MAP		mm/yr	1034	modeled mine MAP from Lorax (2009)	
Effective Porosity (Till)		(-)	0.3		
Problem Dimensions		Units	Value	Comments	
Footprint area of 2N-3N Mine above Base Drainage					
Total Footprint area of 2N-3N Mine		m²	3,613,948		
Avg. Thickness of Mined Workings 2N-3N		m	3		
Footprint area of 2N-3N Mine above base drainage		m²	532,958	area above 275m 1 Seam contour	
Vertical Gradient in footprint		m²	0.14	gradient estimated in 7 South	
Perimeter Segment 1 - Gob Area with Variable Fractured Zone Height					
Length of workings (Segment 1)		m	1853		
Thickness of Fracture Zone		m	68		
Gradient		(-)	0.08	based on pre-mine water-levels (5%)	
Perimeter Segment 2 - Gob Area with Constant Fractured Zone Height					
Length of workings (Segment 2)		m	2021	tailings to be injected in this segment	
Thickness of fracture zone		m	75		
Gradient		(-)	0.11	based on pre-mine water-levels (8%)	
Perimeter Segment 3 - Gob Area with Constant Fractured Zone Height					
Length of workings (Segment 3)		m	400	tailings to be injected in this segment	
Thickness of fracture zone		m	75		
Gradient		(-)	0.28	based on pre-mine water-levels (25%)	
Perimeter Segment 4 - Mine Area with Intact Pillars					
Length of workings (Segment 4)		m	1461		
Gradient		(-)	0.36	based on pre-mine water-levels (33%)	
Perimeter Segment 5 - Gob Area with Variable Fractured Zone Height					
Length of workings (Segment 5)		m	744		
Thickness of fracture zone		m	28		
Gradient		(-)	0.23	based on pre-mine water-levels (20%)	
Fault Zone Flux					
Estimated Yield from Forjan Fault		gpm	40	max airlift yield measured from a borehole at Quinsam	
Estimated Yield from Forjan Fault		m³/d	218	includes wetland and mine water components	
Q - throught Forjan fault (mine component)		m3/d	131	based on thickness of GOB	
Flow Pathway B					
Distance travelled in Coal (horizontal)		m	70	Path from Segment 5 to the Quinsam River	
Distance travelled in Sandstone (Vertical)		m	25		
Horizontal gradient		(-)	0.23	Assumed gradient from Segment 5	
Vertical Gradient		(-)	0.12	Average gradient measured at QU81-P1-5 and -4	
Contaminant of Concern		Units	Scenario 1 No waste in mine void		Scenario 2 7S Tailings in mine void
			Expected	Worse Case	Expected
Aluminum (Al) Dissolved		mg/L	0.013	0.027	0.013
Arsenic (As) Dissolved		mg/L	0.036	0.040	0.113
Boron (B) Dissolved		mg/L	1.1	1.2	1.1
Cadmium (Cd) Dissolved		mg/L	0.000020	0.000080	0.000020
Cobalt (Co) Dissolved		mg/L	0.001	0.004	0.001
Copper (Cu) Dissolved		mg/L	0.001	0.004	0.001
Fluoride (F) Dissolved		mg/L	0.29	0.30	1.13
Iron (Fe) Dissolved		mg/L	0.490	2.45	0.490
Manganese (Mn) Dissolved		mg/L	0.36	0.95	0.360
Nickel (Ni) Dissolved		mg/L	0.001	0.008	0.001
Selenium (Se) Dissolved		mg/L	0.0002	0.001	0.0002
Sulphate (SO4) Dissolved		mg/L	278	1280	278
Zinc (Zn) Dissolved		mg/L	0.006	0.007	0.006

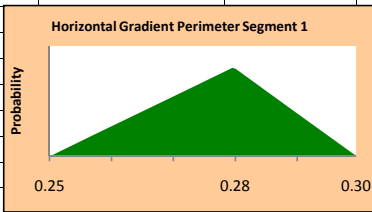
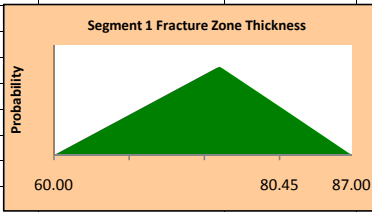
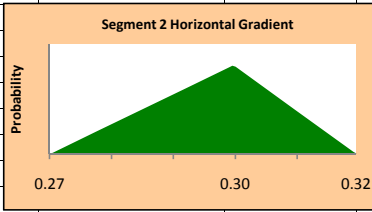
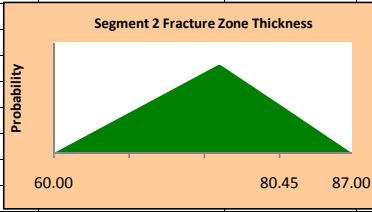
MODEL OUTPUT					
Volumetric Flux - Based on SST and Coal K-values (Geo. Avg.)					
Parameter	Unit	Excel Output	OCB Output Median		
Q - through Segment 1	m3/d	9	8.27		
Q - through Segment 2	m3/d	14	13.23		
Q - through Segment 3	m3/d	7	6.83		
Q - through Segment 4	m3/d	14	13.56		
Q - through Segment 5	m3/d	7	6.63		
Q - through footprint of mine (Area A+B)	m3/d	36	36		
Q - through Forjan fault (mine component)	m3/d	131	131		
Q - total	m3/d	217	216		
Ratio of Q(2,3,fault) to Qtotal	m3/d	0.70			
Volumetric Flux - Based on Infiltration = 10% MAP					
Parameter	Unit	Excel Output			
10% of MAP over entire 2N-3N area	m3/d	1024			
Travel Time Calculations					
	Unit	Most Likely Value	Median		
Flow Path B - Segment 5 to Quinsam R	days	466	455		
	years	1.3	1.2		
Mass Fluxes - Scenario 1 No Waste Stored in 2N-3N workings					
		Mass Flux (Based on K & Expected Conc)		Mass Flux (Based on MAP & Worst Case Conc)	
Contaminant of Concern	Unit	Excel Output	OCB Output Median	Excel Output	OCB Output Median
Aluminum (Al) Dissolved	kg/d	0.0027	0.0027	0.028	0.028
Arsenic (As) Dissolved	kg/d	0.0079	0.0079	0.041	0.041
Boron (B) Dissolved	kg/d	0.24	0.24	1.2	1.2
Cadmium (Cd) Dissolved	kg/d	4.3E-06	4.3E-06	8.2E-05	8.2E-05
Cobalt (Co) Dissolved	kg/d	1.9E-04	1.9E-04	0.0036	0.0036
Copper (Cu) Dissolved	kg/d	2.2E-04	2.2E-04	0.0036	0.0036
Fluoride (F) Dissolved	kg/d	0.062	0.062	0.31	0.31
Iron (Fe) Dissolved	kg/d	0.11	0.11	2.5	2.5
Manganese (Mn) Dissolved	kg/d	0.078	0.078	0.97	0.97
Nickel (Ni) Dissolved	kg/d	2.2E-04	2.2E-04	0.0086	0.0086
Selenium (Se) Dissolved	kg/d	4.3E-05	4.3E-05	0.0010	0.0010
Sulphate (SO4) Dissolved	kg/d	60	60	1,310	1,310
Zinc (Zn) Dissolved	kg/d	0.0013	0.0013	0.0072	0.0072
Mass Fluxes - Scenario 2 7S Tailings Stored in 2N-3N					
		Mass Flux (Based on K & Expected Conc)		Mass Flux (Based on MAP & Worst Case Conc)	
Contaminant of Concern	Unit	Excel Output	OCB Output Median	Excel Output	OCB Output Median
Aluminum (Al) Dissolved	kg/d	0.0027	0.0027	0.028	0.028
Arsenic (As) Dissolved	kg/d	0.020	0.019	0.10	0.10
Boron (B) Dissolved	kg/d	0.24	0.24	1.2	1.2
Cadmium (Cd) Dissolved	kg/d	4.3E-06	4.3E-06	8.2E-05	8.2E-05
Cobalt (Co) Dissolved	kg/d	1.9E-04	1.9E-04	0.018	0.018
Copper (Cu) Dissolved	kg/d	2.2E-04	2.2E-04	0.0036	0.0036
Fluoride (F) Dissolved	kg/d	0.19	0.19	0.95	0.96
Iron (Fe) Dissolved	kg/d	0.11	0.11	2.8	2.8
Manganese (Mn) Dissolved	kg/d	0.078	0.078	0.97	0.97
Nickel (Ni) Dissolved	kg/d	2.2E-04	2.2E-04	0.026	0.026
Selenium (Se) Dissolved	kg/d	4.3E-05	4.3E-05	0.0050	0.0050
Sulphate (SO4) Dissolved	kg/d	60	60	1,310	1,310
Zinc (Zn) Dissolved	kg/d	0.0013	0.0013	0.016	0.016

Crystal Ball Report - Assumptions Used for 2 North and 3 North Mines									
No Simulation Data									
Assumptions									
Assumption: Horizontal Gradient Perimeter Segment 1									
Triangular distribution with parameters:									
Minimum						0.05			
Likeliest						0.08			
Maximum						0.10			
									
Assumption: Segment 1 Height of Fracture Zone									
Triangular distribution with parameters:									
Minimum						60.00			
Likeliest						68.00			
Maximum						68.00			
									
Assumption: Horizontal Gradient Perimeter Segment 2									
Triangular distribution with parameters:									
Minimum						0.08			
Likeliest						0.11			
Maximum						0.13			
									
Assumption: Segment 2 Height of Fracture Zone (20 - 29t)									
Triangular distribution with parameters:									
Minimum						60.00			
Likeliest						75.00			
Maximum						87.00			
									
Assumption: Segment 3 Horizontal Gradient									
Triangular distribution with parameters:									
Minimum						0.25			
Likeliest						0.28			
Maximum						0.30			
									

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5 SOUTH - RBP MASS FLUX CALCULATIONS					
INPUT PARAMETERS					
Hydraulic Conductivity of Coal (K)	Units	Value	Comments		
geomean	(m/s)	1.0E-07	geometric mean of all coal seams		
Hydraulic Conductivity of SST (K)	Units	Value	Comments		
geomean	(m/s)	5.6E-09	geometric mean of all measured SST values (excluding outlier)		
Hydraulic Conductivity of SST (K)	Units	Value	Comments		
Till	m/s	4.2E-06	geometric mean of 3 tests in till		
Effective Porosity (Bedrock)	Units	Value	Comments		
log(minimum)	(-)	-5			
log(maximum)	(-)	-1			
log(average)	(-)	-3	median based on literature values		
Mean Annual Precipitation	Units	Value	Comments		
MAP	mm/yr	1034	modeled mine MAP from Lorax (2009)		
Effective Porosity (Till)	(-)	0.3			
Problem Dimensions	Units	Value	Comments		
Footprint area of 5S					
Total Footprint area of 5S	m ²	776723			15.53446
Footprint area of 5S Mine above base drainage	m ²	23892	area above 275 contour		
Gradient in footprint	m ²	0.14	downward gradient assumed from QU08-13		
Footprint area of RBP					
Total Footprint area of RBP	m ²	67,317			
Vertical Gradient	(-)	0.12	upward gradient from QU81-P1-4 and -P1-5		
Perimeter Segment 1 - Gob Area with Constant Fractured Zone Height					
Length of workings (Segment 1)	m	1198			
Thickness of fracture zone	m	75			
Thickness of Coal	m	3			
Gradient	(-)	0.28	based on pre-mine water-levels (25%)		
Perimeter Segment 2 - Gob Area with Variable Fractured Zone Height					
Length of workings (Segment 2)	m	1060			
Thickness of fracture zone	m	75			
Thickness of Coal	m	3			
Gradient	(-)	0.3	based on pre-mine water-levels (27%)		
Perimeter Segment 3 - Gob Area with Constant Fractured Zone Height					
Length of workings (Segment 3)	m	298			
Thickness of fracture zone	m	70			
Thickness of Coal	m	3			
Gradient	(-)	0.08	based on pre-mine water-levels (5%)		
Perimeter Segment 4 - Mine Area with Intact Pillars					
Length of workings (Segment 4)	m	447			
Thickness of Workings	m	3			
Gradient	(-)	0.08	based on pre-mine water-levels (5%)		
Flow Path - 5 South Mine					
Distance travelled in Intact Coal	m	56	Path from QU-11-10 east to Quinsam River		
Distance travelled in Sandstone	m	30			
Horizontal Gradient	(-)	0.36			
Vertical Gradient	(-)	0.12			
Flow Path - River Barrier Pillar					
Distance travelled in Sandstone	m	75	Path from northern end of workings to Quinsam River		
Gradient	(-)	0.12			
Contaminant of Concern	Units	Scenario 1		Scenario 2	
		Expected	Worse Case	Expected	Worse Case
Aluminum (Al) Dissolved	mg/L	0.020	0.050	0.020	0.050
Arsenic (As) Dissolved	mg/L	0.069	0.069	0.128	0.19
Boron (B) Dissolved	mg/L	0.707	1.88	0.707	1.88
Cadmium (Cd) Dissolved	mg/L	0.00010	0.000170	0.000017	0.000175
Cobalt (Co) Dissolved	mg/L	0.005	0.148	0.005	0.148
Copper (Cu) Dissolved	mg/L	0.001	0.001	0.001	0.001
Fluoride (F) Dissolved	mg/L	0.71	1.00	0.71	1.00
Iron (Fe) Dissolved	mg/L	0.805	19.10	0.805	33.5
Manganese (Mn) Dissolved	mg/L	0.136	1.3	0.136	2.885
Nickel (Ni) Dissolved	mg/L	0.007	0.213	0.007	0.213
Selenium (Se) Dissolved	mg/L	0.0001	0.001	0.0002	0.0040
Sulphate (SO4) Dissolved	mg/L	396	1990	396	1990
Zinc (Zn) Dissolved	mg/L	0.008	0.014	0.008	0.088

MODEL OUTPUT					
Volumetric Flux - Based on SST and Coal K-values (Geo. Avg.)					
Parameter	Unit	Excel Output	OCB Output Median		
Q - through Segment 1	m3/d	21	20.55		
Q - through Segment 2	m3/d	20	19.43		
Q - through Segment 3	m3/d	1	1.37		
Q - through Segment 4	m3/d	1	0.89		
Q - through footprint of 5S (above 275m)	m3/d	2	2		
Q - RBP	m3/d	4	4		
Q - total	m3/d	45	48		
Volumetric Flux - Based on Infiltration = 10% MAP					
Parameter	Unit	Excel Output			
10% of MAP over entire 5S and RBP area	m3/d	239		0.019	
Ratio of RBP Area to 5 S area	m3/d	0.09			
Travel Time Calculations					
Parameter	Unit	Most Likely Value	Median		
Flow Path - 5 South Mine	days	535	553		
	years	1.5	1.5		
Flow Path - River Barrier Pillar	days	1,292	1,335		
	years	3.5	4		
Mass Fluxes - Scenario 1 No Waste Stored 5-South or RBP					
		Mass Flux (Based on K & Expected Conc)		Mass Flux (Based on MAP & Worst Case Conc)	
Contaminant of Concern	Unit	Excel Output	OCB Output Median	Excel Output	OCB Output Median
Aluminum (Al) Dissolved	kg/d	9.3E-04	9.3E-04	0.012	0.012
Arsenic (As) Dissolved	kg/d	0.0033	0.0033	0.016	0.016
Boron (B) Dissolved	kg/d	0.034	0.034	0.45	0.45
Cadmium (Cd) Dissolved	kg/d	4.8E-07	4.8E-07	4.1E-05	4.1E-05
Cobalt (Co) Dissolved	kg/d	2.2E-04	2.2E-04	0.035	0.035
Copper (Cu) Dissolved	kg/d	2.4E-05	2.4E-05	2.6E-04	2.6E-04
Fluoride (F) Dissolved	kg/d	0.034	0.034	0.24	0.24
Iron (Fe) Dissolved	kg/d	0.038	0.038	4.6	4.6
Manganese (Mn) Dissolved	kg/d	0.0065	0.0065	0.31	0.31
Nickel (Ni) Dissolved	kg/d	3.5E-04	3.5E-04	0.051	0.051
Selenium (Se) Dissolved	kg/d	4.8E-06	4.8E-06	2.4E-04	2.4E-04
Sulphate (SO4) Dissolved	kg/d	19	19	476	476
Zinc (Zn) Dissolved	kg/d	3.9E-04	3.9E-04	0.0034	0.0034
Mass Fluxes - Scenario 2 7S Tailings Stored in RBP					
		Mass Flux (Based on K & Expected Conc)		Mass Flux (Based on MAP & Worst Case Conc)	
Contaminant of Concern	Unit	Excel Output	OCB Output Median	Excel Output	OCB Output Median
Aluminum (Al) Dissolved	kg/d	9.3E-04	9.3E-04	0.012	0.012
Arsenic (As) Dissolved	kg/d	0.0035	0.0035	0.019	0.019
Boron (B) Dissolved	kg/d	0.034	0.034	0.45	0.45
Cadmium (Cd) Dissolved	kg/d	5.0E-07	5.0E-07	4.1E-05	4.1E-05
Cobalt (Co) Dissolved	kg/d	2.2E-04	2.2E-04	0.035	0.035
Copper (Cu) Dissolved	kg/d	2.4E-05	2.4E-05	2.6E-04	2.6E-04
Fluoride (F) Dissolved	kg/d	0.034	0.034	0.24	0.24
Iron (Fe) Dissolved	kg/d	0.038	0.038	4.9	4.9
Manganese (Mn) Dissolved	kg/d	0.0065	0.0065	0.34	0.34
Nickel (Ni) Dissolved	kg/d	3.5E-04	3.5E-04	0.051	0.051
Selenium (Se) Dissolved	kg/d	5.0E-06	5.0E-06	3.0E-04	3.0E-04
Sulphate (SO4) Dissolved	kg/d	19	19	476	476
Zinc (Zn) Dissolved	kg/d	3.9E-04	3.9E-04	0.0049	0.0049

Crystal Ball Report - Assumptions for 5 South and RBP					
No Simulation Data					
Assumptions					
Assumption: Horizontal Gradient Perimeter Segment 1					
Triangular distribution with parameters:					
Minimum			0.25	Horizontal Gradient Perimeter Segment 1 	
Likeliest			0.28		
Maximum			0.30		
Assumption: Segment 1 Fracture Zone Thickness					
Triangular distribution with parameters:					
Minimum			60.00	Segment 1 Fracture Zone Thickness 	
Likeliest			75.00		
Maximum			87.00		
Assumption: Segment 2 Horizontal Gradient					
Triangular distribution with parameters:					
Minimum			0.27	Segment 2 Horizontal Gradient 	
Likeliest			0.30		
Maximum			0.32		
Assumption: Segment 2 Fracture Zone Thickness					
Triangular distribution with parameters:					
Minimum			60.00	Segment 2 Fracture Zone Thickness 	
Likeliest			75.00		
Maximum			87.00		

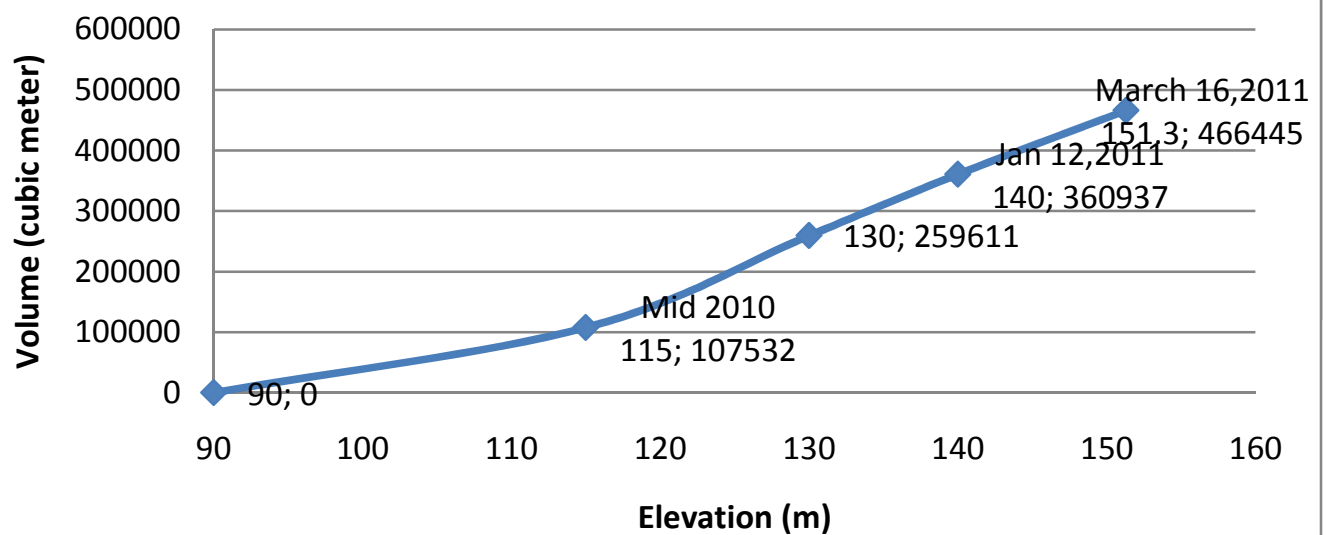
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***Appendix A5 – Volume – Elevation Curve for 5
South Mine***



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5 South Flooded Workings Estimated Volume vs. Elevation Curve



Appendix B: Groundwater Quality

Appendix B1 – Water Quality Sampling

Appendix B2 – Groundwater Quality Data Evaluation

*Appendix B3 – Groundwater Quality Data and
Guidelines*

*Appendix B4– Groundwater Quality Percentiles 2 North
and 5 South Parameters of Concern*



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Appendix B1 – Water Quality Sampling



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Appendix B1: Water Quality Sampling

Groundwater and mine sump water sampling has been conducted in the 2 North and 5 South areas since 2006 as shown in Figure B-1. The routine groundwater monitoring samples in 5 South were collected by Golder Associates of Victoria, BC (Golder) or by Quinsam. Mine sump water samples were collected by Quinsam. Groundwater samples in 2 North (and a few in 5 South) were collected by Lorax.

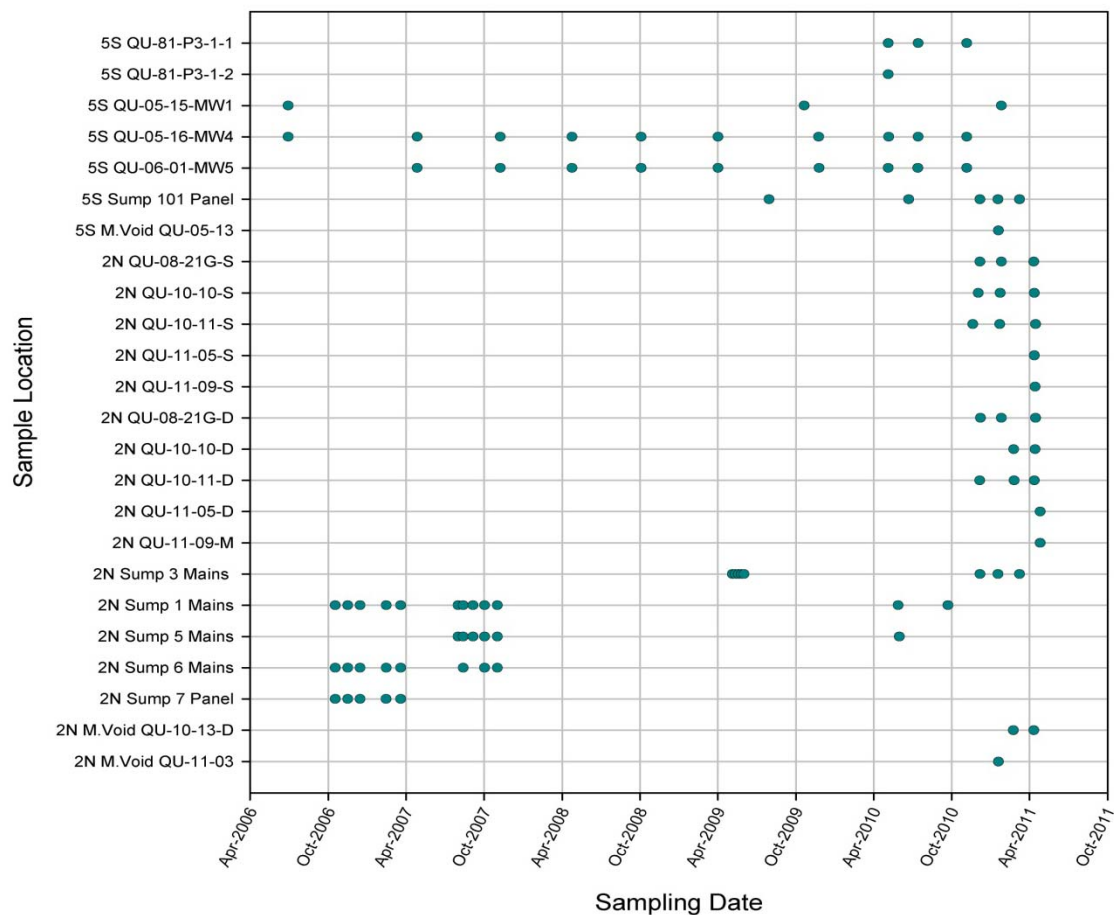


Figure B-1: Timing of groundwater sample collection in the 5 South (5S) and 2 North (2N) mine areas.

Several methods were employed to collect water quality samples. The mine sump water was collected by dip sampling, whereas a variety of pumps were used to collect water from groundwater and flooded mine void monitoring wells. One pumping method consisted of Watera tubing terminating in a one-way foot valve and actuated by a

Hydrolift. Alternately, the Wattera tubing and Hydrolift was used in combination with a peristaltic pump; this involved threading ¼ inch tubing coupled to the peristaltic pump into the larger diameter Wattera tubing. The peristaltic pump smooths the strongly pulsed flow of the Hydrolift, and aids with the pumping of wells at the limits of Hydrolift head pressure range. A peristaltic pump connected to Wattera tubing was used in April 2011 for sampling shallow wells. Deep wells were sampled using a Grundfos 2” submersible pump attached to the submerged end of Wattera tubing. Wells with very low water levels or slow recharge were sampled with permanently installed micropurge low flow pumps (QU-10-10-D, QU-10-11-D, QU-10-13-D, QU-11-05-D and QU-11-09-M).

At QU-05-13 and QU-11-03 Lorax retained BC Aquifer of Duncan, BC to conduct sampling using a Goulds 4” Submersible Pump under the direct supervision of Lorax personnel. The pump was lowered to the screen level of the well, and mine pool water was pumped up to the surface through 5/8” Wattera tubing. The pump motor is electrically powered and controlled from the surface, and is attached to an impeller stack that draws in surrounding water and pushes it up through the tubing outlet.

All wells were purged prior to sampling. A minimum of one to three well volumes was removed prior to sampling depending on well recharge rates and well volume (*i.e.*, if the well had a low recharge rate and/or a large well volume then purging was limited to one well volume). During sampling an in-line flow cell with a multi-parameter probe (*e.g.*, YSI model 600XL or similar device) was used to monitor general water quality parameters (*i.e.*, pH, conductivity, temperature and oxidation reduction potential) at regular intervals until stabilized prior to sub-sampling the groundwater. Separate subsamples were then collected for general chemistry/anions, nutrients, sulphide, total metals, dissolved metals, total organic carbon (TOC), dissolved organic carbon (DOC) and iron species. A 0.45 micron filter was used to collect dissolved metals and DOC samples, except for the samples collected by Lorax in January and April 2011 when a 0.2 micron filter was used (to enhance the removal of colloidal particles by filtration). All subsamples (save general chemistry/anions) were preserved in the field and submitted to ALS Environmental or Maxxam Analytics (both in Burnaby, BC) for analysis.

Appendix B2 – Water Quality Data Evaluation



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Appendix B2: Water Quality Data Evaluation

An extensive quality assurance program was implemented for the groundwater quality monitoring program. Samples were collected, preserved, stored, transported and tested in accordance with the requirements in the British Columbia Lab Manual (BC, 2009). Laboratory quality control included the preparation and analysis of blanks, sample duplicates and reference samples. Field quality control included the monitoring of indicator parameters during sampling and the preparation of field blanks and field replicates. The quality assurance program indicates good overall sample data quality, although dissolved organic carbon, total nitrogen and total metals should be evaluated considering the observations outlined in the following paragraphs. QU-06-01 well water quality does not represent the groundwater quality in this location, and data for this well has been excluded from the 5 South groundwater characterization.

Laboratory quality control data indicate good precision, accuracy and contamination control in the laboratory test procedures. The field blank data indicates good contamination control with the exception of October 29, 2010 field blank total nitrogen (0.385 mg/L) and dissolved organic carbon (4.19 mg/L). The field replicates indicate good precision and sample homogeneity with the high RPD's generally due to results at or near the detection limit. A single replicate had an elevated RPD (63.6%) for dissolved iron (QU-05-16, November 8, 2007).

The water quality consistency was evaluated for wells and mine sumps with multiple samples by deriving the relative standard deviation (RSD) of water quality parameters at locations with three or more samples, or the relative percent difference (RPD) of water quality parameters at locations with only two samples. Two or more samples were collected at all wells and mine sumps except at QU-11-05-S and -D, QU-11-09-S and -D, QU-11-03, QU-05-13, QU-81-P3-1-2. The water quality is generally consistent at each location, with most of the elevated RSD's and RPD's a consequence of non-detects at varying detection limits with each data set. Exceptions are noted on the following paragraphs.

The most consistent groundwater water quality was observed at boreholes QU-10-10-S and -D, QU-10-11-S, QU-10-13-D, QU-81-P3-1-1, QU-05-16. The wells at QU-08-21G had initially elevated levels of total suspended solids that declined significantly in the April 2011 round of sampling; this is reflected in the elevated RSD's of total metals (ranging to 139%) which are linked to suspended particulate concentration in the sub-sample. The RPD for dissolved iron was elevated (134%) for QU-10-11-S. Total metal

RSD's were elevated for QU-10-11-D due the influence of suspended solids in the first sample (December 5, 2010). The quartz diorite groundwater RSD's at QU-05-15 were elevated for anions and dissolved metals.

The monitoring well at QU-06-01 had elevated RSD's for alkalinity and anions (ranging to 123%) and dissolved metals (ranging to 170%). This well was noted to open below grade, and pooling of surface water has been observed at the well opening. As discussed in section 5.2.2 this sample is suspected to be surface influenced and water quality data is excluded from the overall water quality characterization in sections 5.2.2 and 5.2.3.

Mine water sumps collect surface contact waters that flow through the mine workings, and the water quality is expected to fluctuate due to changes in water flow path and flow volume with time. The RSD's reflect the degree to which the mine sump water quality fluctuates with the largest fluctuations observed at 3 Mains sump.

Field Quality Control Data

Sample ID	Units	Field Blanks				QU-05-16			QU-05-16			QU-10-11-S			QU-11-05-S			QU-10-11-D			QU11-09-M		
Date		29/10/2010	19/01/2011	22/02/2011	11/04/2011	08/11/2007		RPD ¹	14/07/2010		RPD ¹	19/11/2010		RPD ¹	12/04/2011		RPD ¹	24/02/2011		RPD ¹	26/04/2011		RPD ¹
Field																							
Field	mg/L											117			132	123	7.1%	285			306		
Field	uS/cm					614	614	0.0%	490			180	180	0.0%	331	332	0.3%	2105	2116	0.5%	2231	2227	0.2%
Field Eh	mV					-70	-70		54.8			168.2	167.4	0.5%	-222.4	-222.4	0.0%	-127.0	-124.6	1.9%	-151.4	-151.2	0.1%
Field pH	pH					8.52	8.52	0.0%	8.58			6.91	6.91	0.0%	8.3	8.3	0.0%	7.04	7.04	0.0%	7.94	7.91	0.4%
Field Tempera	C					8.9	8.9	0.0%	10.44			7.27	7.27	0.0%	7.96	7.96	0.0%	7.35	7.55	2.7%	7.73	7.93	2.6%
Field	%											6.9	7.4	7.1%	2	2.1	4.9%	0.2	0.3	66.7%	3.8	4.0	5.8%
Physical																							
Conductivity	uS/cm	2	2		2							197	193	2.1%	334	335	0.3%	2020	2010	0.5%	2080	2080	0.0%
Hardness (as	mg/L	0.5	0.5		0.5	11.8	11.6	1.7%	11.7		100.0%	84.2	84.0	0.2%	37.9	38.1	0.5%	218	215	1.4%	81.1	78.7	3.0%
pH	pH	5.69	6.28		6.40							7.73	7.77	0.5%	8.25	8.23	0.2%	7.97	7.98	0.1%	7.87	7.90	0.4%
Total	mg/L		3		3							3	3	0.0%	5.9	3.9	40.8%	45.8	47.1	2.8%	213	209	1.9%
Total	mg/L		10		10							108	102	5.7%	212	209	1.4%	1120	1150	2.6%	1160	1170	0.9%
Turbidity	NTU		0.1		0.1							2.42	2.42	0.0%	5.22	5.02	3.9%	32.9	34.9	5.9%	206	208	1.0%
Anions and																							
Acidity (as	mg/L		3.0		2.8										1.6	1.7	6.1%	6.2	6.7	7.8%	8.9	8.2	8.2%
Alkalinity,	mg/L	2	2		2	331	335	1.2%	332	329	0.9%	92.0	92.4	0.4%	116	128	9.8%	300	299	0.3%	335	336	0.3%
Ammonia as	mg/L	0.005	0.005	0.005	0.005							0.0073	0.0079	7.9%	0.123	0.125	1.6%	0.180	0.179	0.6%	0.143	0.154	7.4%
Bromide (Br)	mg/L	0.05	0.05		0.05	0.05	0.05	0.0%	0.05	0.05	0.0%	0.05	0.05	0.0%	0.05	0.05	0.0%	1	1	0.0%	1	1	0.0%
Chloride (Cl)	mg/L	0.5	0.5		0.5	8.20	8.22	0.2%	8.92	8.96	0.4%	1.30	1.30	0.0%	1.04	1.04	0.0%	447	446	0.2%	451	452	0.2%
Fluoride (F)	mg/L	0.02	0.02		0.03	2.53	2.53	0.0%	3.27	3.28	0.3%	0.071	0.071	0.0%	0.361	0.349	3.4%	0.106	0.104	1.9%	0.438	0.460	4.9%
Nitrate (as N)	mg/L	0.005	0.005		0.005	0.005	0.005	0.0%	0.005	0.005	0.0%	0.0549	0.0568	3.4%	0.005	0.005	0.0%	0.1	0.1	0.0%	0.1	0.1	0.0%
Nitrite (as N)	mg/L	0.001	0.001		0.001	0.001	0.001	0.0%	0.001	0.001	0.0%	0.0038	0.0042	10.0%	0.001	0.001	0.0%	0.02	0.02	0.0%	0.02	0.02	0.0%
Total	mg/L	0.385	0.05	0.05	0.05										0.240	0.230	4.3%	0.130	0.080	47.6%	0.750	0.740	1.3%
Ortho	mg/L	0.001										0.001	0.001	0.0%							0.0078	0.0074	5.3%
Total	mg/L		0.002		0.002							0.0033	0.002	49.1%	0.0084	0.0069	19.6%	0.0020	0.002	0.0%	0.0157	0.0163	3.8%
Total	mg/L	0.002	0.002	0.002	0.002							0.0065	0.0062	4.7%	0.0169	0.0169	0.0%	0.0803	0.0836	4.0%	0.274	0.278	1.4%
Sulfate (SO4)	mg/L	0.5	0.5		0.5	4.81	4.82	0.2%	6.14	6.19	0.8%	9.72	9.72	0.0%	53.8	53.9	0.2%	60	60	0.0%	40	41	2.5%
Sulphide as S	mg/L	0.02	0.002		0.002							0.02	0.02	0.0%	0.002	0.002	0.0%	0.002	0.002	0.0%	0.002	0.002	0.0%
Organic /																							
Dissolved	mg/L	4.19	0.5		0.5							4.05	4.78	16.5%	1.44	1.55	7.4%	4.75	4.55	4.3%	13.7	16.7	19.7%
Total Organic	mg/L	0.5	0.5	0.5	0.5							3.87	4.57	16.6%	1.58	1.53	3.2%	4.72	4.67	1.1%	20.1	20.6	2.5%
Total Metals																							
Aluminum	mg/L	0.003	0.003		0.003							0.0994	0.0938	5.8%	0.325	0.296	9.3%	0.931	1.09	15.7%	12.2	11.8	3.3%
Antimony	mg/L	0.0001	0.0001		0.0001							0.00012	0.00012	0.0%	0.0001	0.0001	0.0%	0.0002	0.0002	0.0%	0.00027	0.00028	3.6%
Arsenic	mg/L	0.0001	0.0001		0.0001							0.00137	0.00120	13.2%	0.111	0.113	1.8%	0.0112	0.0105	6.5%	0.0336	0.0322	4.3%
Barium	mg/L	0.00005	0.00005		0.00005							0.117	0.117	0.0%	0.163	0.167	2.4%	0.216	0.220	1.8%	0.117	0.115	1.7%
Beryllium	mg/L	0.0005	0.0005		0.0005							0.0005	0.0005	0.0%	0.0005	0.0005	0.0%	0.001	0.001	0.0%	0.001	0.001	0.0%
Bismuth	mg/L	0.0005	0.0005		0.0005							0.0005	0.0005	0.0%	0.0005	0.0005	0.0%	0.001	0.001	0.0%	0.001	0.001	0.0%
Boron	mg/L	0.01	0.01		0.01							0.077	0.080	3.8%	0.372	0.389	4.5%	0.358	0.328	8.7%	1.14	1.09	4.5%
Cadmium	mg/L	0.000017	0.00001		0.00001							0.000017	0.000017	0.0%	0.00001	0.00001	0.0%	0.00002	0.00002	0.0%	0.000503	0.000462	8.5%
Calcium	mg/L	0.05	0.02		0.05							24.4	23.9	2.1%	10.6	10.8	1.9%	78.8	75.5	4.3%	30.5	30.1	1.3%
Chromium	mg/L	0.0005	0.0001		0.0001							0.0005	0.0005	0.0%	0.00022	0.00028	24.0%	0.00054	0.00064	16.9%	0.0337	0.0318	5.8%
Cobalt	mg/L	0.0001	0.0001		0.0001							0.00082	0.00078	5.0%	0.00012	0.00011	8.7%	0.00198	0.00184	7.3%	0.00934	0.00932	0.2%
Copper	mg/L	0.0005	0.0005		0.0005							0.00096	0.00092	4.3%	0.00073	0.0005	37.4%	0.001	0.001	0.0%	0.0199	0.0193	3.1%
Iron (Fe)Total	mg/L	0.03	0.01		0.03							0.128	0.131	2.3%	0.428	0.427	0.2%	4.24	4.05	4.6%	9.07	9.08	0.1%
Lead	mg/L	0.00005	0.00005		0.000099							0.000071	0.00005	34.7%	0.								

Field Quality Control Data

Sample ID	Units	Field Blanks				QU-05-16			QU-05-16			QU-10-11-S			QU-11-05-S			QU-10-11-D			QU11-09-M		
Date		29/10/2010	19/01/2011	22/02/2011	11/04/2011	08/11/2007		RPD ¹	14/07/2010		RPD ¹	19/11/2010		RPD ¹	12/04/2011		RPD ¹	24/02/2011		RPD ¹	26/04/2011		RPD ¹
Dissolved																							
Aluminum	mg/L	0.003	0.003		0.003	0.05	0.05	0.0%	0.01	0.01	0.0%	0.003	0.003	0.0%	0.0089	0.0115	25.5%	0.006	0.006	0.0%	0.0082	0.0087	5.9%
Antimony	mg/L	0.0001	0.0001		0.0001	0.0025	0.0025	0.0%	0.001	0.001	0.0%	0.00014	0.00014	0.0%	0.0001	0.0001	0.0%	0.0002	0.0002	0.0%	0.0002	0.0002	0.0%
Arsenic	mg/L	0.0001	0.0001		0.0001	0.0418	0.0423	1.2%	0.0269	0.0265	1.5%	0.00128	0.00127	0.8%	0.126	0.127	0.8%	0.0105	0.0101	3.9%	0.0279	0.0281	0.7%
Barium	mg/L	0.00005	0.00005		0.00005	0.02	0.02	0.0%	0.026	0.026	0.0%	0.122	0.121	0.8%	0.165	0.167	1.2%	0.200	0.202	1.0%	0.0753	0.0745	1.1%
Beryllium	mg/L	0.0005	0.0005		0.0005	0.005	0.005	0.0%	0.002	0.002	0.0%	0.0005	0.0005	0.0%	0.0005	0.0005	0.0%	0.001	0.001	0.0%	0.001	0.001	0.0%
Bismuth	mg/L	0.0005	0.0005		0.0005	0.2	0.2	0.0%	0.2	0.2	0.0%	0.0005	0.0005	0.0%	0.0005	0.0005	0.0%	0.001	0.001	0.0%	0.001	0.001	0.0%
Boron	mg/L	0.01	0.01		0.01	3.4	3.4	0.0%	4.21	4.23	0.5%	0.081	0.085	4.8%	0.375	0.378	0.8%	0.337	0.314	7.1%	1.08	1.06	1.9%
Cadmium	mg/L	0.000017	0.00001		0.00001	0.00025	0.00025	0.0%	0.000034	0.000034	0.0%	0.000017	0.000017	0.0%	0.00001	0.00001	0.0%	0.00002	0.00002	0.0%	0.00002	0.00002	0.0%
Calcium	mg/L	0.05	0.02		0.05	3.96	3.89	1.8%	3.98	3.97	0.3%	25.2	25.1	0.4%	10.9	11.0	0.9%	77.3	76.3	1.3%	27.8	26.9	3.3%
Chromium	mg/L	0.0005	0.0001		0.0001	0.0025	0.0025	0.0%	0.002	0.002	0.0%	0.0005	0.0005	0.0%	0.0001	0.0001	0.0%	0.0002	0.0002	0.0%	0.00137	0.00123	10.8%
Cobalt	mg/L	0.0001	0.0001		0.0001	0.0025	0.0025	0.0%	0.0006	0.0006	0.0%	0.00079	0.00080	1.3%	0.0001	0.0001	0.0%	0.00182	0.00165	9.8%	0.00258	0.00251	2.8%
Copper	mg/L	0.0005	0.0005		0.0005	0.005	0.005	0.0%	0.002	0.002	0.0%	0.0005	0.0005	0.0%	0.0005	0.0005	0.0%	0.001	0.001	0.0%	0.001	0.001	0.0%
Iron	mg/L	0.03	0.01		0.03	0.143	0.074	63.6%	0.041	0.038	7.6%	0.03	0.03	0.0%	0.303	0.310	2.3%	3.77	3.69	2.1%	1.14	1.11	2.7%
Lead	mg/L	0.00005	0.00005		0.00005	0.005	0.005	0.0%	0.001	0.001	0.0%	0.00005	0.00005	0.0%	0.000075	0.00005	40.0%	0.0001	0.0001	0.0%	0.0001	0.0001	0.0%
Lithium	mg/L	0.005	0.005		0.005	0.05	0.05	0.0%	0.01	0.01	0.0%	0.0181	0.0188	3.8%	0.0358	0.0350	2.3%	0.011	0.011	0.0%	0.01	0.01	0.0%
Magnesium	mg/L	0.1	0.005		0.1	0.46	0.45	2.2%	0.43	0.43	0.0%	5.17	5.17	0.0%	2.57	2.58	0.4%	5.97	5.88	1.5%	2.82	2.78	1.4%
Manganese	mg/L	0.00005	0.00005		0.00005	0.044	0.043	2.3%	0.0248	0.0239	3.7%	0.119	0.118	0.8%	0.0481	0.0476	1.0%	0.788	0.722	8.7%	1.47	1.46	0.7%
Mercury	mg/L		0.00001		0.00001	0.0002	0.0002	0.0%	0.00001	0.00001	0.0%				0.00001	0.00001	0.0%	0.00001	0.00001	0.0%	0.00001	0.00001	0.0%
Molybdenum	mg/L	0.00005	0.00005		0.00005	0.0055	0.0055	0.0%	0.0044	0.0043	2.3%	0.000198	0.000200	1.0%	0.00177	0.00175	1.1%	0.00167	0.00167	0.0%	0.00902	0.00908	0.7%
Nickel	mg/L	0.0005	0.0005		0.0005	0.025	0.025	0.0%	0.002	0.002	0.0%	0.00154	0.00154	0.0%	0.0005	0.0005	0.0%	0.0015	0.0011	30.8%	0.0122	0.0120	1.7%
Phosphorus	mg/L	0.3	0.3		0.3	0.3	0.3	0.0%	0.3	0.3	0.0%	0.3	0.3	0.0%	0.3	0.3	0.0%	0.3	0.3	0.0%	0.3	0.3	0.0%
Potassium	mg/L	2	0.05		2	2	2	0.0%	2	2	0.0%	2	2	0.0%	2.8	2.7	3.6%	3.2	3.1	3.2%	2.8	2.7	3.6%
Selenium	mg/L	0.0004	0.0001		0.0001	0.005	0.005	0.0%	0.002	0.002	0.0%	0.0004	0.0004	0.0%	0.0001	0.0001	0.0%	0.0002	0.0002	0.0%	0.00048	0.00045	6.5%
Silicon	mg/L	0.05	0.05		0.05	3.34	3.30	1.2%	3.37	3.36	0.3%	3.19	3.19	0.0%	3.11	3.14	1.0%	5.00	5.00	0.0%	4.90	4.80	2.1%
Silver	mg/L	0.00001	0.00001		0.00001	0.00025	0.00025	0.0%	0.00004	0.00004	0.0%	0.00001	0.00001	0.0%	0.00001	0.00001	0.0%	0.00002	0.00002	0.0%	0.00002	0.00002	0.0%
Sodium	mg/L	2	0.05		2	156	152	2.6%	163	162	0.6%	7.9	7.9	0.0%	58.1	58.0	0.2%	357	353	1.1%	447	435	2.7%
Strontium	mg/L	0.0001	0.0001		0.0001	0.0638	0.0626	1.9%	0.0683	0.0678	0.7%	0.246	0.243	1.2%	0.210	0.212	0.9%	0.679	0.681	0.3%	0.267	0.268	0.4%
Thallium	mg/L	0.0001	0.0001		0.0001	0.001	0.001	0.0%	0.0004	0.0004	0.0%	0.0001	0.0001	0.0%	0.0001	0.0001	0.0%	0.0002	0.0002	0.0%	0.0002	0.0002	0.0%
Tin	mg/L	0.0001	0.0001		0.0001	0.03	0.03	0.0%	0.001	0.001	0.0%	0.0001	0.0001	0.0%	0.0001	0.0001	0.0%	0.0002	0.0002	0.0%	0.0002	0.0002	0.0%
Titanium	mg/L	0.01	0.01		0.01	0.05	0.05	0.0%	0.01	0.01	0.0%	0.01	0.01	0.0%	0.01	0.01	0.0%	0.011	0.010	9.5%	0.01	0.01	0.0%
Uranium	mg/L	0.00001	0.00001		0.00001	0.001	0.001	0.0%	0.0004	0.0004	0.0%	0.000199	0.000200	0.5%	0.000106	0.000107	0.9%	0.00166	0.00159	4.3%	0.00398	0.00399	0.3%
Vanadium	mg/L	0.001	0.001		0.001	0.03	0.03	0.0%	0.002	0.002	0.0%	0.001	0.001	0.0%	0.001	0.001	0.0%	0.002	0.002	0.0%	0.002	0.002	0.0%
Zinc	mg/L	0.003	0.003		0.003	0.005	0.005	0.0%	0.005	0.005	0.0%	0.003	0.003	0.0%	0.003	0.003	0.0%	0.006	0.006	0.0%	0.006	0.006	0.0%

Results in *blue italics* are

below the detection limit

¹ RPD = Relative Percent

Difference

Well Evaluation Data

Sample ID	Units	QU-81-P3-1-1								QU-05-15								QU-05-16														
Target Zone		5 South Sandstone/till interface								5 South Quartz Diorite								5 South No. 1 Coal Seam														
Date Sampled		05-May-2010	14-Jul-2010	05-Nov-2010	n	Max	Min	Mean	% RSD	29-Jun-2006	20-Oct-2009	25-Jan-2011	n	Max	Min	Mean	% RSD	29-Jun-2006	27-Apr-2007	08/11/2007	24/04/2008	03/10/2008	01/04/2009	23/11/2009	06/05/2010	14/07/2010	05/11/2010	n	Max	Min	Mean	% RSD
Field Physical Tests																																
Field Alkalinity, Total (as CaCO3)	mg/L	99	89.9		2	99.0	89.9	94.5	6.8%	114		207	2	207.0	114.0	160.5	41.0%	305	309		268	263			330			5	330	263	295.0	9.7%
Field Conductivity	uS/cm	226	132	122	3	226.0	122.0	160.0	35.9%	233	320	555	3	555.0	233.0	369.3	45.1%	593	613	614	621	681	593	553	407	490	486	10	681	407	565.1	14.4%
Field Eh	mV	9.3	44.8	128.5	3	128.5	9.3				35.1	23.3	2	35.1	23.3			-	-40	-70	-82	12	-43	-131.6	-149.6	54.8	-123.1	9	54.8	-149.6		
Field pH	pH	8.01	9.46	8.31	3	9.5	8.0	8.6	8.9%	6.76	7.84	7.03	3	7.8	6.8	7.2	7.8%	8.53	8.35	8.52	8.55	8.57	8.53	8.19	8.44	8.58	8.44	10	8.58	8.19	8.470	1.4%
Field Temperature	C	9.79	9.34	7.57	3	9.8	7.6	8.9	13.2%	9.3	8.66	5.96	3	9.3	6.0	8.0	22.2%	8.9	10.4	8.9	9.3	9.8	8.55	8.18	8.61	10.44	10.95	10	10.95	8.18	9.403	10.0%
Field Dissolved Oxygen (% Saturation)	%				0							56.5	1															0				
Physical Tests																																
Conductivity	uS/cm				0							594	1															0				
Hardness (as CaCO3)	mg/L	66.1	80.0	77.1	3	80.0	66.1	74.4	9.9%	108	58.0	24.3	3	108.0	24.3	63.4	66.4%	14.6	11.6	11.8	12.1	10.6	10.9	10.6	10.5	11.7	10.6	10	14.6	10.5	11.50	10.8%
pH	pH				0							8.43	1															0				
Total Suspended Solids	mg/L				0							2600	1															0				
Total Dissolved Solids	mg/L				0							458	1															0				
Turbidity	NTU				0							1660	1															0				
Anions and Nutrients																																
Acidity (as CaCO3) (pH 8.3)	mg/L				0							1	1															0				
Alkalinity, Total (as CaCO3)	mg/L			91.4	1						157	219	2	219.0	157.0	188.0	23.3%			331			333	327		332	333	5	333	327	331.2	0.8%
Ammonia as N	mg/L				0							0.0609	1															0				
Bromide (Br)	mg/L	0.05	0.05	0.05	3	0.05	0.05	0.050	0.0%	0.05	0.05	0.05	3	0.05	0.05	0.050	0.0%	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	10	0.05	0.05	0.050	0.0%
Chloride (Cl)	mg/L	0.84	0.59	0.60	3	0.84	0.59	0.677	20.9%	0.55	0.59	2.11	3	2.11	0.55	1.08	82.1%	11.1	8.21	8.20	7.49	7.43	7.09	6.03	5.11	8.92	9.66	10	11.10	5.11	7.924	21.8%
Fluoride (F)	mg/L	0.053	0.028	0.03	3	0.053	0.028	0.0370	37.5%	0.122	0.267	0.664	3	0.664	0.122	0.3510	79.9%	2.55	2.54	2.53	2.63	2.64	2.66	2.51	2.6	3.27	4.39	10	4.39	2.51	2.832	20.9%
Nitrate (as N)	mg/L	0.0653	0.005	0.005	3	0.065	0.005	0.0251	138.7%	0.005		0.0111	2	0.011	0.005	0.0081	53.6%	0.005	0.005	0.005	0.005	0.005	0.005		0.005	0.005	0.005	9	0.005	0.005	0.005	0.0%
Nitrite (as N)	mg/L	0.001	0.001	0.001	3	0.001	0.001	0.0010	0.0%	0.001		0.0016	2	0.002	0.001	0.0013	32.6%	0.001	0.001	0.001	0.001	0.001	0.001		0.001	0.001	0.001	9	0.001	0.001	0.0010	0.0%
Nitrate + Nitrite (as N)	mg/L				0								0															0				
Total Nitrogen	mg/L				0							0.5	1															0				
Total Dissolved Phosphate As P	mg/L				0							0.237	1															0				
Total Phosphate as P	mg/L				0							0.598	1															0				
Sulfate (SO4)	mg/L	6.53	6.80	7.38	3	7.4	6.5	6.9	6.3%	12.5	57.4	89.9	3	89.9	12.5	53.3	73.0%	5.75	5.75	4.81	2.88	2.21	1.02	0.50	0.5	6.14	12.5	10	12.5	0.50	4.206	87.2%
Sulphide as S	mg/L											0.002	1															0				
Organic / Inorganic Carbon																																
Dissolved Organic Carbon	mg/L				0							5.79	1															0				
Total Organic Carbon	mg/L				0							8.94	1															0				
Total Metals																																
Aluminum (Al)Total	mg/L				0							19.1	1															0				
Antimony (Sb)Total	mg/L				0							0.00041	1															0				
Arsenic (As)Total	mg/L				0							0.0101	1															0				
Barium (Ba)Total	mg/L				0							0.443	1															0				
Beryllium (Be)Total	mg/L				0							0.00172	1															0				
Bismuth (Bi)Total	mg/L				0							0.00079	1															0				
Boron (B)Total	mg/L				0							0.379	1															0				
Cadmium (Cd)Total	mg/L				0							0.00136	1															0				
Calcium (Ca)Total	mg/L				0							28.2	1															0				
Chromium (Cr)Total	mg/L				0							0.00704	1															0				
Cobalt (Co)Total	mg/L				0							0.00965	1															0				
Copper (Cu)Total	mg/L				0							0.0404	1															0				
Iron (Fe)Total	mg/L				0							20.9	1															0				
Lead (Pb)Total	mg/L				0							0.0199	1															0				
Lithium (Li)Total	mg/L				0							0.0097	1															0				
Magnesium (Mg)Total	mg/L				0							5.86	1															0				
Manganese (																																

Well Evaluation Data

Sample ID	Units	QU-81-P3-1-1								QU-05-15								QU-05-16														
Target Zone		5 South Sandstone/till interface								5 South Quartz Diorite								5 South No. 1 Coal Seam														
Date Sampled		05-May-2010	14-Jul-2010	05-Nov-2010	n	Max	Min	Mean	% RSD	29-Jun-2006	20-Oct-2009	25-Jan-2011	n	Max	Min	Mean	% RSD	29-Jun-2006	27-Apr-2007	08/11/2007	24/04/2008	03/10/2008	01/04/2009	23/11/2009	06/05/2010	14/07/2010	05/11/2010	n	Max	Min	Mean	% RSD
Dissolved Metals																																
Aluminum (Al)Dissolved	mg/L	0.0161	0.005	0.0051	3	0.016	0.005	0.0087	73.1%	0.2	0.062	0.012	3	0.2	0.012	0.0912	106.9%	0.2	0.026	0.05	0.02	0.01	0.01	0.01	0.01	0.01	0.011	10	0.2	0.01	0.036	165.6%
Antimony (Sb)Dissolved	mg/L	0.0009	0.0005	0.0005	3	0.0009	0.0005	0.00063	36.5%	0.2	0.0005	0.00026	3	0.2	0.00026	0.06692	172.2%	0.2	0.001	0.0025	0.001	0.001	0.001	0.0005	0.001	0.001	0.001	10	0.2	0.0005	0.02100	299.5%
Arsenic (As)Dissolved	mg/L	0.00817	0.00471	0.00585	3	0.00817	0.00471	0.006243	28.2%	0.2	0.0019	0.0027	3	0.2	0.0019	0.06820	167.4%	0.2	0.0530	0.0418	0.0294	0.031	0.0254	0.0235	0.0390	0.0269	0.0075	10	0.2	0.0075	0.04775	114.9%
Barium (Ba)Dissolved	mg/L	0.036	0.02	0.02	3	0.036	0.020	0.0253	36.5%	0.160	0.065	0.023	3	0.160	0.023	0.0827	84.7%	0.022	0.022	0.02	0.023	0.024	0.036	0.025	0.042	0.026	0.027	10	0.042	0.020	0.0267	26.0%
Beryllium (Be)Dissolved	mg/L	0.001	0.001	0.001	3	0.001	0.001	0.0010	0.0%	0.005	0.005	0.0005	3	0.005	0.0005	0.00350	74.2%	0.005	0.005	0.005	0.005	0.002	0.002	0.005	0.002	0.002	10	0.005	0.002	0.0035	45.2%	
Bismuth (Bi)Dissolved	mg/L	0.2	0.2	0.2	3	0.2	0.2	0.20	0.0%	0.2	0.2	0.0005	3	0.2	0.0005	0.1335	86.3%	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	10	0.2	0.2	0.20	0.0%	
Boron (B)Dissolved	mg/L	0.1	0.1	0.1	3	0.1	0.1	0.100	0.0%	0.12	0.19	0.38	3	0.38	0.12	0.230	58.7%	3.42	3.39	3.4	3.43	3.5	3.51	3.60	3.47	4.21	4.79	10	4.79	3.39	3.672	12.6%
Cadmium (Cd)Dissolved	mg/L	0.000017	0.000017	0.000017	3	0.000017	0.000017	0.000017	0.0%	0.01	0.00005	0.000058	3	0.01	0.00005	0.003369	170.4%	0.01	0.0001	0.00025	0.0001	0.000034	0.000034	0.00005	0.000034	0.000034	0.000034	10	0.01	0.000034	0.001067	294.2%
Calcium (Ca)Dissolved	mg/L	20.8	24.1	23.6	3	24.1	20.8	22.83	7.8%	38.0	20.5	8.79	3	38.0	8.79	22.43	65.5%	4.77	3.85	3.96	4.07	3.56	3.69	3.59	3.54	3.98	3.71	10	4.77	3.54	3.872	9.5%
Chromium (Cr)Dissolved	mg/L	0.001	0.001	0.001	3	0.001	0.001	0.0010	0.0%	0.01	0.0005	0.0001	3	0.01	0.0001	0.00353	158.6%	0.01	0.001	0.0025	0.001	0.002	0.002	0.0005	0.002	0.002	10	0.01	0.0005	0.0025	108.3%	
Cobalt (Co)Dissolved	mg/L	0.0003	0.0003	0.0003	3	0.0003	0.0003	0.00030	0.0%	0.01	0.0005	0.00025	3	0.01	0.0003	0.00358	155.1%	0.01	0.001	0.0025	0.001	0.0006	0.0006	0.0005	0.0006	0.0006	0.0006	10	0.01	0.0005	0.0018	163.4%
Copper (Cu)Dissolved	mg/L	0.001	0.001	0.001	3	0.001	0.001	0.0010	0.0%	0.01	0.001	0.00199	3	0.01	0.001	0.0043	114.0%	0.01	0.002	0.005	0.002	0.002	0.002	0.001	0.002	0.002	0.002	10	0.01	0.001	0.0030	88.9%
Iron (Fe)Dissolved	mg/L	0.03	0.03	0.031	3	0.031	0.030	0.0303	1.9%	1.36	0.147	0.035	3	1.36	0.035	0.5140	143.0%	0.035	0.057	0.143	0.082	0.063	0.074	0.081	0.062	0.041	0.055	10	0.143	0.035	0.0693	43.5%
Lead (Pb)Dissolved	mg/L	0.0005	0.0005	0.0005	3	0.001	0.001	0.0005	0.0%	0.05	0.001	0.000101	3	0.05	0.0001	0.01703	167.6%	0.05	0.002	0.005	0.002	0.001	0.001	0.001	0.001	0.001	0.001	10	0.05	0.001	0.0065	235.9%
Lithium (Li)Dissolved	mg/L	0.005	0.0066	0.005	3	0.0066	0.0050	0.00553	16.7%	0.01	0.05	0.005	3	0.05	0.005	0.0217	113.8%	0.01	0.05	0.05	0.05	0.01	0.01	0.05	0.01	0.01	0.01	10	0.05	0.01	0.026	79.4%
Magnesium (Mg)Dissolved	mg/L	3.45	4.82	4.42	3	4.82	3.45	4.230	16.7%	3.22	1.66	0.56	3	3.22	0.56	1.813	73.7%	0.66	0.48	0.46	0.46	0.41	0.40	0.40	0.41	0.43	0.33	10	0.66	0.33	0.444	19.6%
Manganese (Mn)Dissolved	mg/L	0.0123	0.0345	0.0241	3	0.035	0.012	0.0236	47.0%	0.209	0.106	0.048	3	0.209	0.048	0.1211	67.2%	0.0448	0.040	0.044	0.035	0.0346	0.0316	0.033	0.0239	0.0248	0.012	10	0.045	0.012	0.0324	31.0%
Mercury (Hg)Dissolved	mg/L	0.00001	0.00001	0.00001	3	0.00001	0.00001	0.000010	0.0%		0.0002	0.00001	2	0.0002	0.00001	0.000105	128.0%		0.0002	0.0002	0.0002	0.00002	0.00002	0.0002	0.00001	0.00001	0.00001	9	0.0002	0.00001	0.000097	101.5%
Molybdenum (Mo)Dissolved	mg/L	0.0019	0.0011	0.0012	3	0.0019	0.0011	0.00140	31.1%	0.03	0.0021	0.0058	3	0.03	0.0021	0.01262	120.2%	0.03	0.0059	0.0055	0.0042	0.0036	0.0035	0.0025	0.002	0.0044	0.0063	10	0.03	0.002	0.0068	121.9%
Nickel (Ni)Dissolved	mg/L	0.001	0.001	0.001	3	0.001	0.001	0.0010	0.0%	0.05	0.005	0.0028	3	0.05	0.0028	0.01927	138.3%	0.05	0.01	0.025	0.01	0.002	0.002	0.005	0.002	0.002	0.002	10	0.05	0.002	0.0110	140.8%
Phosphorus (P)Dissolved	mg/L	0.3	0.3	0.3	3	0.3	0.3	0.30	0.0%	0.3	0.3	0.3	3	0.3	0.3	0.30	0.0%	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	10	0.3	0.3	0.30	0.0%
Potassium (K)Dissolved	mg/L	2	2	2	3	2.0	2.0	2.0	0.0%	2	2	2	3	2	2	2.0	0.0%	2	2	2	2	2	2	2	2	2	2	10	2	2	2.0	0.0%
Selenium (Se)Dissolved	mg/L	0.001	0.001	0.001	3	0.001	0.001	0.0010	0.0%	0.2	0.001	0.00075	3	0.2	0.00075	0.06725	171.0%	0.2	0.002	0.005	0.002	0.002	0.002	0.001	0.002	0.002	0.002	10	0.2	0.001	0.0220	284.3%
Silicon (Si)Dissolved	mg/L	4.28	5	5.08	3	5.1	4.3	4.79	9.2%	6.30	4.93	3.38	3	6.30	3.38	4.870	30.0%	3.23	3.23	3.34	3.18	3.17	3.14	3.22	3.01	3.37	3.36	10	3.4	3.0	3.23	3.4%
Silver (Ag)Dissolved	mg/L	0.00002	0.00002	0.00002	3	0.0000	0.00002	0.00002	0.0%	0.02	0.00005	0.00001	3	0.02	0.00001	0.006687	172.4%	0.01	0.0001	0.00025	0.0001	0.00004	0.00004	0.00005	0.00004	0.00004	0.00004	10	0.01	0.00004	0.00107	293.3%
Sodium (Na)Dissolved	mg/L	21.3	10.4	9.2	3	21	9	13.6	48.9%	13.5	87.7	144.0	3	144	13.5	81.73	80.1%	160	157	156	156	148	154	157	152	163	163	10	163	148	156.6	3.0%
Strontium (Sr)Dissolved	mg/L	0.0938	0.18	0.146	3	0.180	0.094	0.1399	31.0%	0.230	0.189	0.081	3	0.23	0.081	0.1665	46.4%	0.0608	0.0626	0.0638	0.0666	0.0615	0.0619	0.0597	0.0601	0.0683	0.0608	10	0.0683	0.0597	0.06261	4.5%
Thallium (Tl)Dissolved	mg/L	0.0002	0.0002	0.0002	3	0.000	0.0002	0.0002	0.0%	0.2	0.0002	0.0001	3	0.20	0.0001	0.0668	172.8%	0.2	0.0004	0.001	0.0004	0.0004	0.0004	0.0002	0.0004	0.0004	0.0004	10	0.2	0.0002	0.02040	309.3%
Tin (Sn)Dissolved	mg/L	0.0005	0.0005	0.0005	3	0.001	0.001	0.001	0.0%	0.03	0.03	0.00023	3	0.03	0.00023	0.02008	85.6%	0.03	0.03	0.03	0.03	0.001	0.001	0.03	0.001	0.001	0.001	10	0.03	0.001	0.0155	98.6%
Titanium (Ti)Dissolved	mg/L	0.01	0.01	0.01	3	0.01	0.01	0.010	0.0%	0.01	0.05	0.01	3	0.05	0.01	0.023	99.0%	0.01	0.05	0.05	0.05	0.01	0.01	0.05	0.01	0.01	0.01	10	0.05	0.01	0.026	79.4%
Uranium (U)Dissolved	mg/L	0.00041	0.0002	0.0002	3	0.0004	0.0002	0.00027	44.9%		0.00169	0.00395	2	0.00395	0.00169	0.002820	56.7%		0.0004	0.001	0.0004	0.0004	0.0004	0.0002	0.0004	0.0004	0.0004	9	0.001	0.0002	0.00044	49.2%
Vanadium (V)Dissolved	mg/L	0.0014	0.001	0.001	3	0.001	0.001	0.0011	20.4%	0.03	0.03	0.0046	3	0.03	0.005	0.0215	68.1%	0.03	0.03	0.03	0.03	0.002	0.002	0.03	0.002	0.002	0.002	10	0.03	0.002	0.0160	92.2%
Zinc (Zn)Dissolved	mg/L	0.005	0.005	0.005	3	0.005	0.005	0.0050	0.0%	0.005	0.005	0.0031	3	0.005	0.003	0.0044	25.1%	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.01	10	0.005	0.005	0.0050	0.0%

Results in *blue italics* are below the detection limit indicated.

¹ RSD = Percent Relative Standard Deviation
= 100 * | s / mean |

² RPD = Relative Percent Difference
= 100 * | (result 1 - result 2) / average (result 1, result 2) |

Well Evaluation Data

Sample ID	Units	QU-06-01													101 Panel										QU-08-21G-S									
Target Zone		5 South No. 1 Coal Seam													5 South Mine Sump										2 North Sandstone									
Date Sampled		27/04/2007	08/11/2007	24/04/2008	03/10/2008	01/04/2009	24/11/2009	05/05/2010	13/07/2010	05/11/2010	n	Max	Min	Mean	% RSD	30/07/2009	22/06/2010	06/12/2010	17/01/2011	08/03/2011	n	Max	Min	Mean	% RSD	06/12/2010	25/01/2011	11/04/2011	n	Max	Min	Mean	% RSD	
Field Physical Tests																																		
Field Alkalinity, Total (as CaCO3)	mg/L	181		122				51			3	181	51	118.0	55.2%						0					210	255	198	3	255.0	198.0	221.0	13.6%	
Field Conductivity	uS/cm	663	498	294	331	496	83	80	139	208	9	663	80	310.2	66.4%						0					918	714	458	2	714.0	458.0	586.0	30.9%	
Field Eh	mV	-61	-38	-9	85	11	238.4	78.5	61.3	-108.9	9	238.4	-108.9							0					146.0	-126.5	-103.9	3	146.0	-126.5				
Field pH	pH	7.5	7.05	7.79	7.22	7.22	6.8	7.87	7.31	7.65	9	7.87	6.80	7.379	4.8%						0					8.41	7.28	8.05	3	8.4	7.3	7.9	7.3%	
Field Temperature	C	10.5	9.5		12.8	6.14	7.79	8.54	09.5	8.59	9	12.80	6.14	9.142	20.1%						0					7.35	7.68	8.49	3	8.5	7.4	7.8	7.5%	
Field Dissolved Oxygen (% Saturation)	%										0										0					6.3	2.3	2.3	2	6.3	2.3	4.3	65.8%	
Physical Tests																																		
Conductivity	uS/cm										0					4650	3270	2450	1530	1360	5	4650.0	1360.0	2652.0	51.1%	1230	0723	527	3	1230.0	527.0	826.7	43.9%	
Hardness (as CaCO3)	mg/L	40	64.2	76.2	123	92.3	35.3	56.4	68.3	64.5	9	123.0	35.3	68.91	38.7%	894		208	126	85.8	4	894.0	85.8	328.45	115.8%	105	048	47.3	3	105.0	47.3	66.6	49.9%	
pH	pH										0					7.74	7.82	8.02	7.77	7.97	5	8.0	7.7	7.9	1.6%	8.08	8.07	8.18	3	8.2	8.1	8.1	0.8%	
Total Suspended Solids	mg/L										0					38.7					1					521	2430	8.8	3	2430.0	8.8	986.6	129.3%	
Total Dissolved Solids	mg/L										0					3700					1					666	457	305	3	666.0	305.0	476.0	38.1%	
Turbidity	NTU										0										0					264	2380	3.82	3	2380.0	3.8	882.6	147.7%	
Anions and Nutrients																																		
Acidity (as CaCO3) (pH 8.3)	mg/L										0					12.9		2.2	11.3	11.5	4	12.9	2.2	9.5	51.7%		2.8	2.9	2	2.9	2.8	2.9	2.5%	
Alkalinity, Total (as CaCO3)	mg/L		310		67.9	189	29.6		81.8	135	6	310	29.6	135.6	75.2%	412	631	560	480	470	5	631	412	510.6	16.7%	204	216	206	3	216.0	204.0	208.7	3.1%	
Ammonia as N	mg/L										0					0.799	0.553	0.40	0.30	0.24	5	0.799	0.240	0.4584	48.9%	0.127	0.146	0.171	3	0.171	0.127	0.1480	14.9%	
Bromide (Br)	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	9	0.05	0.05	0.050	0.0%	10					1					0.5	0.5	0.05	3	0.50	0.05	0.350	74.2%	
Chloride (Cl)	mg/L	14.3	34.5	5.93	2.89	14.2	0.5	0.49	1.51	9.34	9	34.50	0.49	9.296	117.4%	214					1					260	090	49.3	3	260.0	49.3	133.2	83.8%	
Fluoride (F)	mg/L	0.383	0.382	0.089	0.07	0.206	0.02	0.022	0.054	0.092	9	0.38	0.02	0.146	98.7%	0.3					1					1.61	1.62	1.61	3	1.62	1.61	1.613	0.4%	
Nitrate (as N)	mg/L	0.005	0.005	0.013	0.0415	0.005		0.0286	0.0892	0.005	8	0.089	0.005	0.024	123.2%						0					0.05	0.05	0.005	3	0.050	0.005	0.0350	74.2%	
Nitrite (as N)	mg/L	0.001	0.001	0.001	0.0012	0.001		0.001	0.001	0.001	8	0.001	0.001	0.0010	6.9%						0					0.01	0.01	0.001	3	0.010	0.001	0.0070	74.2%	
Nitrate + Nitrite (as N)	mg/L										0					0.89	0.10	0.02	0.02	0.02	5	0.89	0.02	0.210	181.8%				0					
Total Nitrogen	mg/L										0										0					0.5	0.250	2	0.500	0.250	0.3750	47.1%		
Total Dissolved Phosphate As P	mg/L										0					0.0020	0.0020				2	0.002	0.002	0.0020	0.0%	0.0241	0.0325	0.0612	3	0.061	0.024	0.0393	49.5%	
Total Phosphate as P	mg/L										0					0.020	0.0065				2	0.020	0.007	0.0133	72.0%	0.077	0.263	0.0830	3	0.263	0.077	0.1410	75.0%	
Sulfate (SO4)	mg/L	34.2	39.2	22	89.6	43.3	4.25	8.86	8.63	8.99	9	89.6	4.3	28.78	94.3%	1990	1080	660	250	200	5	1990	200	836.0	88.1%	25.0	22.2	1.92	3	25.0	1.9	16.4	76.9%	
Sulphide as S	mg/L										0										0					0.025	0.002	0.002	3	0.025	0.002	0.0097	137.4%	
Organic / Inorganic Carbon																																		
Dissolved Organic Carbon	mg/L										0										0					3.09	5.24	1.41	3	5.2	1.4	3.2	59.1%	
Total Organic Carbon	mg/L										0										0					7.71	7.61	1.40	3	7.7	1.4	5.6	64.9%	
Total Metals																																		
Aluminum (Al)Total	mg/L										0					0.20	0.20	0.039	0.044	0.029	5	0.2	0.029	0.1024	87.2%	20.0	46.3	0.201	3	46.3	0.2	22.2	104.3%	
Antimony (Sb)Total	mg/L										0					0.20	0.20	0.0005	0.0005	0.0005	5	0.2	0.0005	0.0803	136.1%	0.0005	0.0002	0.0001	3	0.0005	0.0001	0.00027	78.1%	
Arsenic (As)Total	mg/L										0					0.20	0.20	0.0033	0.0094	0.0108	5	0.2	0.0033	0.0847	124.3%	0.184	0.205	0.195	3	0.205	0.184	0.1947	5.4%	
Barium (Ba)Total	mg/L										0					0.018	0.019	0.019	0.028	0.026	5	0.028	0.018	0.0220	21.1%	0.358	0.428	0.249	3	0.4280	0.2490	0.34500	26.1%	
Beryllium (Be)Total	mg/L										0					0.0050	0.0050	0.0001	0.0001	0.0001	5	0.005	0.0001	0.0021	130.3%	0.0032	0.0067	0.0005	3	0.0067	0.0005	0.00347	89.7%	
Bismuth (Bi)Total	mg/L										0					0.20	0.20	0.001	0.001	0.001	5	0.2	0.001	0.08	135.2%	0.0025	0.0014	0.0005	3	0.0025	0.0005	0.00147	68.3%	
Boron (B)Total	mg/L										0					1.21	1.54	1.67	2.18	1.85	5	2.18	1.21	1.690	21.3%	1.64	1.99	1.88	3	1.99	1.64	1.837	9.7%	
Cadmium (Cd)Total	mg/L										0					0.010	0.010	0.00001	0.00001	0.00001	5	0.01	0.00001	0.004006	136.6%	<								

Well Evaluation Data

Sample ID	Units	QU-06-01														101 Panel										QU-08-21G-S									
Target Zone		5 South No. 1 Coal Seam														5 South Mine Sump										2 North Sandstone									
Date Sampled		27/04/2007	08/11/2007	24/04/2008	03/10/2008	01/04/2009	24/11/2009	05/05/2010	13/07/2010	05/11/2010	n	Max	Min	Mean	% RSD	30/07/2009	22/06/2010	06/12/2010	17/01/2011	08/03/2011	n	Max	Min	Mean	% RSD	06/12/2010	25/01/2011	11/04/2011	n	Max	Min	Mean	% RSD		
Dissolved Metals																																			
Aluminum (Al)Dissolved	mg/L	0.060	0.093	0.143	0.005	0.008	0.024	0.0065	0.005	0.0448	9	0.143	0.005	0.0433	111.5%	0.050	0.20	0.004	0.003	0.006	5	0.2	0.003	0.0526	161.1%	0.015	0.006	0.0083	3	0.015	0.006	0.0098	47.9%		
Antimony (Sb)Dissolved	mg/L	0.001	0.0025	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.001	9	0.003	0.0005	0.00078	85.7%	0.005					1					0.0005	0.0002	0.0001	3	0.001	0.000	0.0003	78.1%		
Arsenic (As)Dissolved	mg/L	0.0853	0.037	0.0037	0.00205	0.0141	0.001	0.0005	0.00072	0.00544	9	0.085	0.0005	0.01665	169.9%	0.0050	0.20	0.0017	0.0019	0.0050	5	0.2	0.0017	0.0427	205.8%	0.177	0.185	0.198	3	0.198	0.1770	0.1867	5.7%		
Barium (Ba)Dissolved	mg/L	0.023	0.042	0.041	0.059	0.052	0.02	0.02	0.024	0.031	9	0.059	0.020	0.0347	41.8%	0.020	0.025	0.017	0.023	0.027	5	0.027	0.017	0.0224	17.7%	0.246	0.068	0.241	3	0.246	0.068	0.1850	54.8%		
Beryllium (Be)Dissolved	mg/L	0.005	0.005	0.005	0.001	0.001	0.005	0.001	0.001	0.001	9	0.005	0.001	0.0028	75.9%	0.010	0.0050	0.0001	0.0001	0.0001	5	0.01	0.0001	0.00306	144.5%	0.0025	0.001	0.0005	3	0.003	0.001	0.0013	78.1%		
Bismuth (Bi)Dissolved	mg/L	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	9	0.2	0.2	0.20	0.0%						0					0.0025	0.001	0.0005	3	0.0025	0.0005	0.00133	78.1%		
Boron (B)Dissolved	mg/L	1.17	1.91	0.53	0.31	1.34	0.1	0.1	0.54	0.55	9	1.91	0.10	0.728	84.7%	1.18	1.55	1.88	1.80	1.72	5	1.88	1.18	1.626	17.1%	1.70	1.89	1.79	3	1.89	1.70	1.793	5.3%		
Cadmium (Cd)Dissolved	mg/L	0.0001	0.00025	0.00005	0.000041	0.000017	0.00005	0.000017	0.000017	0.00002	9	0.00025	0.000017	0.0000624	120.6%	0.00017	0.010	0.00014	0.00004	0.00001	5	0.01	0.00001	0.002072	213.9%	0.000085	0.00002	0.00001	3	0.000085	0.00001	0.000038	106.2%		
Calcium (Ca)Dissolved	mg/L	12.7	21.4	25.7	38.9	31.7	11.0	18.0	23.0	21.5	9	38.9	11.0	22.66	38.7%	307	130	69.9	42.4	27.9	5	307	27.9	115.4	98.7%	33.7	14.7	13.0	3	33.7	13	20.467	56.1%		
Chromium (Cr)Dissolved	mg/L	0.004	0.0025	0.00052	0.0011	0.002	0.0005	0.001	0.001	0.001	9	0.004	0.0005	0.00151	75.2%	0.010	0.010	0.001	0.001	0.001	5	0.01	0.001	0.0046	107.2%	0.0025	0.0002	0.0001	3	0.0025	0.0001	0.0009	145.5%		
Cobalt (Co)Dissolved	mg/L	0.0032	0.0025	0.0005	0.00036	0.00079	0.0005	0.0003	0.0003	0.00074	9	0.0032	0.00030	0.00102	104.4%	0.148	0.025	0.0023	0.0009	0.0009	5	0.1480	0.0009	0.03542	180.0%	0.00072	0.00020	0.00027	3	0.00072	0.0002	0.00040	71.1%		
Copper (Cu)Dissolved	mg/L	0.002	0.005	0.0013	0.0023	0.001	0.0027	0.0012	0.001	0.001	9	0.005	0.001	0.0019	67.3%	0.010	0.010	0.0002	0.0011	0.0010	5	0.01	0.0002	0.00446	113.7%	0.0025	0.001	0.0005	3	0.0025	0.0005	0.0013	78.1%		
Iron (Fe)Dissolved	mg/L	0.078	0.072	0.195	0.03	0.156	0.052	0.03	0.03	0.266	9	0.266	0.030	0.1010	84.3%	0.130	3.82	2.75	0.019	1.17	5	3.820	0.019	1.5778	105.5%	0.152	0.141	0.201	3	0.201	0.141	0.1647	19.4%		
Lead (Pb)Dissolved	mg/L	0.002	0.005	0.001	0.0005	0.0005	0.001	0.0005	0.0005	0.0005	9	0.005	0.0005	0.00128	115.9%	0.0050	0.050	0.0002	0.0002	0.0002	5	0.05	0.0002	0.01112	196.3%	0.00025	0.0001	0.00005	3	0.00025	0.00005	0.0001	78.1%		
Lithium (Li)Dissolved	mg/L	0.05	0.05	0.05	0.0055	0.005	0.05	0.005	0.005	0.005	9	0.05	0.005	0.0251	94.4%	0.050	0.010	0.006	0.008	0.009	5	0.05	0.006	0.0166	112.8%	0.090	0.060	0.0729	3	0.09	0.06	0.074	20.3%		
Magnesium (Mg)Dissolved	mg/L	2.01	2.63	2.9	6.31	3.18	1.91	2.75	2.62	2.59	9	6.31	1.91	2.989	43.7%	30.9	14.7	8.02	4.88	3.92	5	30.9	3.92	12.484	89.1%	5.09	2.66	3.61	3	5.09	2.66	3.787	32.3%		
Manganese (Mn)Dissolved	mg/L	0.095	0.223	0.015	0.0416	0.196	0.027	0.00101	0.182	0.243	9	0.243	0.00101	0.1137	85.5%	1.30	0.372	0.172	0.097	0.088	5	1.300	0.088	0.4058	126.4%	0.285	0.173	0.128	3	0.285	0.128	0.1953	41.4%		
Mercury (Hg)Dissolved	mg/L	0.0002	0.0002	0.0002	0.00002	0.00002	0.0002	0.00001	0.00001	0.00001	9	0.0002	0.00001	0.000097	101.5%	0.000020		0.00002	0.00002	0.00005	4	0.00005	0.00002	0.000028	54.5%		0.0000	0.00001	2	0.00001	0.00001	0.000010	0.0%		
Molybdenum (Mo)Dissolved	mg/L	0.0051	0.005	0.001	0.0011	0.002	0.001	0.001	0.001	0.0026	9	0.0051	0.0010	0.00220	77.8%	0.010	0.030	0.002	0.002	0.003	5	0.0300	0.0020	0.00940	127.6%	0.00072	0.00068	0.000364	3	0.0007	0.0004	0.00059	33.2%		
Nickel (Ni)Dissolved	mg/L	0.01	0.025	0.005	0.0025	0.003	0.005	0.001	0.001	0.001	9	0.025	0.001	0.0062	123.1%	0.213	0.050	0.004	0.002	0.001	5	0.213	0.001	0.0540	169.0%	0.0025	0.001	0.0005	3	0.003	0.001	0.0013	78.1%		
Phosphorus (P)Dissolved	mg/L	0.63	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	9	0.6	0.3	0.34	32.7%		0.30		0.005	0.005	3	0.30	0.005	0.103	164.8%	0.3	0.3	0.3	3	0.3	0.3	0.30	0.0%		
Potassium (K)Dissolved	mg/L	2.1	2.5	2.3	4.2	2.7	2	2	2	2	9	4.2	2.0	2.42	29.5%	9.9	8.6	6.25	5.47	4.84	5	9.90	4.84	7.012	30.7%	4.8	4.0	3.8	3	4.8	3.8	4.2	12.6%		
Selenium (Se)Dissolved	mg/L	0.002	0.005	0.001	0.001	0.001	0.001	0.001	0.001	0.001	9	0.005	0.001	0.0016	85.7%	0.010	0.20	0.0001	0.0001	0.0001	5	0.2	0.0001	0.0421	210.2%	0.0004	0.0002	0.0001	3	0.000	0.0001	0.0002	65.5%		
Silicon (Si)Dissolved	mg/L	3.41	3.26	1.6	1.23	1.96	0.435	0.429	0.982	1.34	9	3.41	0.43	1.627	66.9%						0					3.64	3.64	3.19	3	3.6	3.2	3.49	7.4%		
Silver (Ag)Dissolved	mg/L	0.0001	0.00025	0.00005	0.00002	0.00002	0.00005	0.00002	0.00002	0.00002	9	0.00025	0.00002	0.000061	123.9%	0.00020	0.010	0.00002	0.00002	0.00002	5	0.01	0.00002	0.002052	216.6%	0.00005	0.00002	0.00001	3	0.0001	0.00001	0.00003	78.1%		
Sodium (Na)Dissolved	mg/L	100	165	33	16.9	74.6	2	2	19.9	38.1	9	165	2.0	50.17	107.7%	908	722	486	367	276	5	908	276	551.8	47.1%	210	152	103	3	210	103	155.0	34.6%		
Strontium (Sr)Dissolved	mg/L	0.0995	0.154	0.119	0.14	0.159	0.0285	0.0431	0.0787	0.0832	9	0.159	0.0285	0.1006	46.4%						0					0.557	0.268	0.351	3	0.557	0.268	0.3920	38.0%		
Thallium (Tl)Dissolved	mg/L	0.0004	0.001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	9	0.001	0.0002	0.00031	85.7%	0.0020	0.20	0.00005	0.00005	0.00005	5	0.2	0.0001	0.04043	220.6%	0.0005	0.0002	0.0001	3	0.001	0.0001	0.0003	78.1%		
Tin (Sn)Dissolved	mg/L	0.03	0.03	0.03	0.0005	0.0005	0.03	0.0005	0.0005	0.0005	9	0.03	0.0005	0.01361	114.2%	0.0050	0.030	0.005	0.005	0.005	5	0.03	0.005	0.0100	111.8%	0.0005	0.0002	0.0001	3	0.0005	0.0001	0.00027	78.1%		
Titanium (Ti)Dissolved	mg/L	0.05	0.05	0.05	0.01	0.01	0.05	0.01	0.01	0.01	9	0.05	0.01	0.028	75.9%	0.017					1					0.01	0.01	0.01	3	0.01	0.01	0.010	0.0%		
Uranium (U)Dissolved	mg/L	0.00070	0.001	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	9	0.001	0.0002	0.00034	86.0%	0.0020		0.0001	0.0001	0.0001	4	0.002	0.0001	0.00058	165.2%	0.00192	0.00163	0.000328	3	0.0019	0.0003	0.00129	65.6%		
Vanadium (V)Dissolved	mg/L	0.03	0.03	0.03	0.001	0.001	0.03	0.001	0.001	0.001	9	0.03	0.001	0.0139	110.0%	0.010	0.030	0.005	0.005	0.005	5	0.030	0.005	0.0110	98.5%	0.005	0.002	0.001	3	0.005	0.001	0.0027	78.1%		
Zinc (Zn)Dissolved</																																			

Results in *blue italics* are below the detection limit indicated.

¹ RSD = Percent Relative Standard Deviation
= 100 * | s / mean |

² RPD = Relative Percent Difference
= 100 * | (result 1 - result 2) / average (result 1, result 2) |

Well Evaluation Data

Sample ID	Units	QU-10-10-S								QU-10-11-S								QU-08-21G-D							
Target Zone		2 North Sandstone								2 North Sandstone								2 North No. 1 Coal Seam							
Date Sampled		02/12/2010	22/01/2011	12/04/2011	n	Max	Min	Mean	% RSD	19/11/2010	21/01/2011	15/04/2011	n	Max	Min	Mean	% RSD	07/12/2010	25/01/2010	15/04/2011	n	Max	Min	Mean	% RSD
Field Physical Tests																									
Field Alkalinity, Total (as CaCO3)	mg/L	183	156	129	3	183.0	129.0	156.0	17.3%	117	84	105	3	117.0	84.0	102.0	16.4%	255	243	228	3	255.0	228.0	242.0	5.6%
Field Conductivity	uS/cm	376	407	302	3	407.0	302.0	361.7	14.9%	180	172	229	3	229.0	172.0	193.7	15.9%	3527	3732	4766	3	4766.0	3527.0	4008.3	16.6%
Field Eh	mV	-206.5	-109.5	-110.6	3	-109.5	-206.5			168.2	50.5	-74	3	168.2	-74.0			179.9	-136.0	-47.7	3	179.9	-136.0		
Field pH	pH	8.17	7.61	8.26	3	8.3	7.6	8.0	4.4%	6.91	6.73	7.17	3	7.2	6.7	6.9	3.2%	7.37	7.47	7.02	3	7.5	7.0	7.3	3.2%
Field Temperature	C	7.50	6.27	7.44	3	7.5	6.3	7.1	9.8%	7.27	7.00	7.3	3	7.3	7.0	7.2	2.3%	7.78	7.55	7.48	3	7.8	7.5	7.6	2.1%
Field Dissolved Oxygen (% Saturation)	%	0.9	1.3	1.4	3	1.4	0.9	1.2	21.2%	6.9	29.7	10.8	3	29.7	6.9	15.8	77.2%	1.4	7.9	2	3	7.9	1.4	3.8	95.8%
Physical Tests																									
Conductivity	uS/cm	358	440	323	3	440.0	323.0	373.7	16.1%	197	180	221	3	221.0	180.0	199.3	10.3%	4870	3840	4970	3	4970.0	3840.0	4560.0	13.7%
Hardness (as CaCO3)	mg/L	57.4	55.6	54.3	3	57.4	54.3	55.8	2.8%	84.2	79.8	87.6	3	87.6	79.8	83.9	4.7%	435	324	476	3	476.0	324.0	411.7	19.1%
pH	pH	8.23	8.18	7.95	3	8.2	8.0	8.1	1.8%	7.73	7.35	7.96	3	8.0	7.4	7.7	4.0%	7.71	7.51	7.86	3	7.9	7.5	7.7	2.3%
Total Suspended Solids	mg/L	13.5	48.0	44.9	3	48.0	13.5	35.5	53.8%	3	5.0	6.3	3	6.3	3.0	4.8	34.9%	122	264	34.3	3	264.0	34.3	140.1	82.7%
Total Dissolved Solids	mg/L	222	225	194	3	225.0	194.0	213.7	8.0%	108	202	95	3	202.0	95.0	135.0	43.2%	2820	2100	2870	3	2870.0	2100.0	2596.7	16.6%
Turbidity	NTU		27.5	23.1	2	27.5	23.1	25.3	12.3%	2.42	5.06	10.7	3	10.7	2.4	6.1	69.8%	55.2	114.0	13.1	3	114.0	13.1	60.8	83.4%
Anions and Nutrients																									
Acidity (as CaCO3) (pH 8.3)	mg/L		1.4	4.3	2	4.3	1.4	2.9	72.0%		7.4	2.8	2	7.4	2.8	5.1	63.8%		16.3	10.5	2	16.3	10.5	13.4	30.6%
Alkalinity, Total (as CaCO3)	mg/L	156	154	139	3	156.0	139.0	149.7	6.2%	92.0	76.4	102	3	102.0	76.4	90.1	14.3%	233	249	226	3	249.0	226.0	236.0	5.0%
Ammonia as N	mg/L	0.192	0.160	0.185	3	0.192	0.160	0.1790	9.4%	0.0073	0.005	0.0306	3	0.031	0.005	0.0143	99.0%	0.310	0.278	0.450	3	0.450	0.278	0.3460	26.4%
Bromide (Br)	mg/L	0.05	0.05	0.05	3	0.05	0.05	0.050	0.0%	0.05	0.05	0.05	3	0.05	0.05	0.050	0.0%	1.0	1.0	1.7	3	1.7	1.0	1.23	32.8%
Chloride (Cl)	mg/L	11.7	25.9	6.40	3	25.9	6.40	14.67	68.7%	1.30	2.98	2.22	3	2.98	1.30	2.167	38.8%	1480	1110	1490	3	1490	1110	1360.0	15.9%
Fluoride (F)	mg/L	1.11	1.05	0.983	3	1.110	0.983	1.0477	6.1%	0.071	0.048	0.117	3	0.117	0.048	0.0787	44.7%	0.57	0.69	0.641	3	0.690	0.570	0.6337	9.5%
Nitrate (as N)	mg/L	0.005	0.005	0.005	3	0.005	0.005	0.0050	0.0%	0.0549	0.0463	0.005	3	0.055	0.005	0.0354	75.4%	0.1	0.1	0.1	3	0.1	0.1	0.10	0.0%
Nitrite (as N)	mg/L	0.001	0.001	0.001	3	0.001	0.001	0.0010	0.0%	0.0038	0.0013	0.001	3	0.004	0.001	0.0020	75.6%	0.02	0.02	0.02	3	0.02	0.02	0.020	0.0%
Nitrate + Nitrite (as N)	mg/L				0								0								0				
Total Nitrogen	mg/L	0.190	0.140	0.290	3	0.290	0.140	0.2067	37.0%		0.05	0.130	2	0.130	0.050	0.0900	62.9%		0.26	0.66	2	0.66	0.26	0.460	61.5%
Total Dissolved Phosphate As P	mg/L	0.0158	0.0223	0.0223	2	0.022	0.016	0.0191	24.1%	0.0033	0.002	0.0062	3	0.006	0.002	0.0038	56.1%	0.0060	0.0020	0.0101	3	0.010	0.002	0.0060	67.1%
Total Phosphate as P	mg/L	0.0205	0.0370	0.0371	3	0.037	0.021	0.0315	30.3%	0.0065	0.0042	0.0234	3	0.023	0.004	0.0114	92.2%	0.0340	0.0787	0.0296	3	0.079	0.030	0.0474	57.3%
Sulfate (SO4)	mg/L	20.2	17.4	13.6	3	20.2	13.6	17.1	19.4%	9.72	7.56	9.73	3	9.73	7.56	9.003	13.9%	69	59	28	3	69	28	52.0	41.1%
Sulphide as S	mg/L	0.02	0.0048	0.002	3	0.020	0.002	0.0089	108.4%	0.02	0.0022	0.0023	3	0.020	0.002	0.0082	125.5%	0.02	0.002	0.002	3	0.020	0.002	0.0080	129.9%
Organic / Inorganic Carbon																									
Dissolved Organic Carbon	mg/L	1.68	1.58	0.53	3	1.7	0.5	1.3	50.4%	4.05	1.33	1.10	3	4.1	1.1	2.2	76.0%	5.63	9.24	3.28	3	9.2	3.3	6.1	49.6%
Total Organic Carbon	mg/L	1.84	1.87	0.96	3	1.9	1.0	1.6	33.2%	3.87	1.38	1.17	3	3.9	1.2	2.1	70.2%	5.93	12.00	3.61	3	12.0	3.6	7.2	60.3%
Total Metals																									
Aluminum (Al)Total	mg/L	0.382	1.57	1.25	3	1.6	0.4	1.1	57.6%	0.0994	0.215	0.222	3	0.2	0.1	0.2	38.5%	5.32	7.32	0.639	3	7.3	0.6	4.4	77.5%
Antimony (Sb)Total	mg/L	0.00026	0.00013	0.0001	3	0.0003	0.0001	0.00016	52.1%	0.00012	0.00012	0.0001	3	0.0001	0.0001	0.00011	10.2%	0.001	0.0005	0.0005	3	0.001	0.0005	0.00067	43.3%
Arsenic (As)Total	mg/L	0.139	0.128	0.131	3	0.139	0.128	0.1327	4.3%	0.00137	0.00154	0.00285	3	0.003	0.001	0.0019	42.2%	0.0703	0.0686	0.0723	3	0.072	0.069	0.0704	2.6%
Barium (Ba)Total	mg/L	0.249	0.195	0.230	3	0.2490	0.1950	0.22467	12.2%	0.117	0.113	0.150	3	0.1500	0.1130	0.12667	16.0%	1.31	1.13	2.06	3	2.0600	1.1300	1.50000	32.9%
Beryllium (Be)Total	mg/L	0.0005	0.0005	0.0005	3	0.0005	0.0005	0.00050	0.0%	0.0005	0.0005	0.0005	3	0.0005	0.0005	0.00050	0.0%	0.005	0.0025	0.0025	3	0.0050	0.0025	0.00333	43.3%
Bismuth (Bi)Total	mg/L	0.0005	0.0005	0.0005	3	0.0005	0.0005	0.00050	0.0%	0.0005	0.0005	0.0005	3	0.0005	0.0005	0.00050	0.0%	0.005	0.0025	0.0025	3	0.0050	0.0025	0.00333	43.3%
Boron (B)Total	mg/L	0.933	0.879	0.742	3	0.93	0.74	0.851	11.6%	0.077	0.063	0.164	3	0.16	0.06	0.101	54.0%	3.39	3.42	3.06	3	3.42	3.06	3.290	6.1%
Cadmium (Cd)Total	mg/L	0.000017	0.000013	0.00001	3	0.000017	0.000010	0.0000133	26.3%	0.000017	0.00001	0.00001	3	0.000017	0.000010	0.0000123	32.8%	0.00017	0.00005	0.00005	3	0.000170	0.000050	0.0000900	77.0%
Calcium (Ca)Total	mg/L	16.0	16.3	15.7	3	16.3	15.7	16.00	1.9%	24.4	22.7	26.2	3	26.2	22.7	24.43	7.2%	148	108	164	3	164.0	108.0	140.00	20.6%
Chromium (Cr)Total	mg/L	0.0005	0.00067	0.00065	3	0.0007	0.0005	0.00061	15.3%	0.0005	0.00034	0.00033	3	0.0005	0.0003	0.00039	24.5%	0.0108	0.0012	0.0005	3	0.0108	0.0005	0.00416	138.6%
Cobalt (Co)Total	mg/L	0.00023	0.00048	0.00035	3	0.00048	0.00023	0.000353	35.4%	0.00082	0.00061	0.00063	3	0.00082	0.00061	0.000687	16.9%	0.0028	0.0023	0.00125	3	0.00280	0.00125	0.002123	37.4%
Copper (Cu)Total	mg/L	0.00072	0.00158	0.00198	3	0.0020	0.0007	0.00143	45.1%	0.00096	0.00082	0.00066	3	0.0010	0.0007	0.00081	18.5%	0.005	0.0025	0.0025	3	0.0050	0.0025	0.00333	43.3%

Well Evaluation Data

Sample ID	Units	QU-10-10-S								QU-10-11-S								QU-08-21G-D							
Target Zone		2 North Sandstone								2 North Sandstone								2 North No. 1 Coal Seam							
Date Sampled		02/12/2010	22/01/2011	12/04/2011	n	Max	Min	Mean	% RSD	19/11/2010	21/01/2011	15/04/2011	n	Max	Min	Mean	% RSD	07/12/2010	25/01/2010	15/04/2011	n	Max	Min	Mean	% RSD
Dissolved Metals																									
Aluminum (Al)Dissolved	mg/L	0.0111	0.0037	0.003	3	0.011	0.003	0.0059	75.6%	0.003	0.0056	0.003	3	0.006	0.003	0.0039	38.8%	0.03	0.015	0.015	3	0.030	0.015	0.0200	43.3%
Antimony (Sb)Dissolved	mg/L	0.00016	0.0001	0.0001	3	0.00016	0.00010	0.000120	28.9%	0.00014	0.00012	0.0001	3	0.0001	0.0001	0.00012	16.7%	0.001	0.0005	0.0005	3	0.0010	0.0005	0.00067	43.3%
Arsenic (As)Dissolved	mg/L	0.154	0.139	0.141	3	0.154	0.1390	0.1447	5.6%	0.00128	0.00144	0.00262	3	0.003	0.0013	0.0018	41.1%	0.0628	0.0647	0.0749	3	0.075	0.0628	0.0675	9.6%
Barium (Ba)Dissolved	mg/L	0.236	0.190	0.222	3	0.236	0.190	0.2160	10.9%	0.122	0.117	0.146	3	0.146	0.117	0.1283	12.1%	1.25	1.09	2.07	3	2.070	1.090	1.4700	35.8%
Beryllium (Be)Dissolved	mg/L	0.0005	0.0005	0.0005	3	0.001	0.001	0.0005	0.0%	0.0005	0.0005	0.0005	3	0.001	0.001	0.0005	0.0%	0.005	0.0025	0.0025	3	0.005	0.003	0.0033	43.3%
Bismuth (Bi)Dissolved	mg/L	0.0005	0.0005	0.0005	3	0.0005	0.0005	0.00050	0.0%	0.0005	0.0005	0.0005	3	0.0005	0.0005	0.00050	0.0%	0.005	0.0025	0.0025	3	0.0050	0.0025	0.00333	43.3%
Boron (B)Dissolved	mg/L	0.927	0.888	0.767	3	0.93	0.77	0.861	9.7%	0.081	0.064	0.158	3	0.16	0.06	0.101	49.6%	3.37	3.51	3.10	3	3.51	3.10	3.327	6.3%
Cadmium (Cd)Dissolved	mg/L	0.000017	0.00001	0.00001	3	0.00	0.000010	0.000012	32.8%	0.000017	0.00001	0.00001	3	0.000017	0.000010	0.0000123	32.8%	0.00017	0.00005	0.00005	3	0.00017	0.00005	0.000090	77.0%
Calcium (Ca)Dissolved	mg/L	16.4	16.2	15.6	3	16.40	15.60	16.067	2.6%	25.2	23.9	26.0	3	26.00	23.90	25.033	4.2%	148	107	160	3	160.00	107.00	138.333	20.1%
Chromium (Cr)Dissolved	mg/L	0.0005	0.0001	0.0001	3	0.0005	0.0001	0.00023	99.0%	0.0005	0.0001	0.0001	3	0.001	0.000	0.0002	99.0%	0.005	0.0005	0.0005	3	0.005	0.001	0.0020	129.9%
Cobalt (Co)Dissolved	mg/L	0.00011	0.00015	0.0001	3	0.0002	0.0001	0.00012	22.0%	0.00079	0.00053	0.00056	3	0.0008	0.0005	0.00063	22.7%	0.0021	0.0015	0.00123	3	0.0021	0.0012	0.00161	27.8%
Copper (Cu)Dissolved	mg/L	0.0005	0.0005	0.0005	3	0.001	0.001	0.0005	0.0%	0.0005	0.0005	0.0005	3	0.0005	0.0005	0.00050	0.0%	0.005	0.0025	0.0025	3	0.0050	0.0025	0.00333	43.3%
Iron (Fe)Dissolved	mg/L	0.146	0.232	0.164	3	0.232	0.146	0.1807	25.1%	0.03	0.057	0.487	3	0.487	0.030	0.1913	134.0%	0.707	0.845	1.00	3	1.000	0.707	0.8507	17.2%
Lead (Pb)Dissolved	mg/L	0.00005	0.00005	0.00005	3	0.00005	0.00005	0.000050	0.0%	0.00005	0.00005	0.00005	3	0.00005	0.00005	0.000050	0.0%	0.0005	0.00025	0.00025	3	0.00050	0.00025	0.000333	43.3%
Lithium (Li)Dissolved	mg/L	0.0476	0.0433	0.0462	3	0.05	0.04	0.046	4.8%	0.0181	0.0148	0.0222	3	0.02	0.01	0.018	20.2%	0.191	0.132	0.185	3	0.19	0.13	0.169	19.2%
Magnesium (Mg)Dissolved	mg/L	4.01	3.68	3.74	3	4.01	3.68	3.810	4.6%	5.17	4.88	5.50	3	5.50	4.88	5.183	6.0%	16.1	14.0	18.4	3	18.40	14.00	16.167	13.6%
Manganese (Mn)Dissolved	mg/L	0.0424	0.0878	0.0642	3	0.088	0.042	0.0648	35.0%	0.119	0.0877	0.173	3	0.173	0.088	0.1266	34.1%	0.842	0.902	0.768	3	0.902	0.768	0.8373	8.0%
Mercury (Hg)Dissolved	mg/L		0.00001	0.00001	2	0.00001	0.00001	0.000010	0.0%		0.00001	0.00001	2	0.00001	0.00001	0.000010	0.0%		0.0000	0.00001	2	0.00001	0.00001	0.000010	0.0%
Molybdenum (Mo)Dissolved	mg/L	0.00255	0.00224	0.00175	3	0.0026	0.0018	0.00218	18.5%	0.000198	0.000158	0.000241	3	0.0002	0.0002	0.00020	20.9%	0.00223	0.00174	0.00119	3	0.0022	0.0012	0.00172	30.2%
Nickel (Ni)Dissolved	mg/L	0.0005	0.0005	0.0005	3	0.001	0.001	0.0005	0.0%	0.00154	0.00107	0.00080	3	0.002	0.001	0.0011	32.9%	0.005	0.0025	0.0025	3	0.005	0.003	0.0033	43.3%
Phosphorus (P)Dissolved	mg/L	0.3	0.3	0.3	3	0.3	0.3	0.30	0.0%	0.3	0.3	0.3	3	0.3	0.3	0.30	0.0%	0.3	0.3	0.3	3	0.3	0.3	0.30	0.0%
Potassium (K)Dissolved	mg/L	3.0	3.1	2.9	3	3.1	2.9	3.0	3.3%	2	2	2	3	2.0	2.0	2.0	0.0%	9.8	8.8	10.5	3	10.5	8.8	9.7	8.8%
Selenium (Se)Dissolved	mg/L	0.0004	0.0001	0.0001	3	0.0004	0.0001	0.00020	86.6%	0.0004	0.0001	0.0001	3	0.0004	0.0001	0.0002	86.6%	0.0004	0.0005	0.0005	3	0.0005	0.0004	0.0005	12.4%
Silicon (Si)Dissolved	mg/L	4.01	4.04	4.07	3	4.1	4.0	4.04	0.7%	3.19	2.85	2.94	3	3.2	2.9	2.99	5.9%	5.05	4.97	4.66	3	5.1	4.7	4.89	4.2%
Silver (Ag)Dissolved	mg/L	0.00001	0.00001	0.00001	3	0.00001	0.00001	0.000010	0.0%	0.00001	0.00001	0.00001	3	0.00001	0.00001	0.000010	0.0%	0.0001	0.00005	0.00005	3	0.00010	0.00005	0.000067	43.3%
Sodium (Na)Dissolved	mg/L	62.7	70.1	51.2	3	70	51	61.3	15.5%	7.9	8.0	12.2	3	12	8	9.4	26.2%	895	733	861	3	895	733	829.7	10.3%
Strontium (Sr)Dissolved	mg/L	0.264	0.246	0.247	3	0.264	0.246	0.2523	4.0%	0.246	0.226	0.286	3	0.286	0.226	0.2527	12.1%	2.19	1.98	2.91	3	2.910	1.980	2.3600	20.7%
Thallium (Tl)Dissolved	mg/L	0.0001	0.0001	0.0001	3	0.0001	0.0001	0.00010	0.0%	0.0001	0.0001	0.0001	3	0.0001	0.0001	0.00010	0.0%	0.001	0.0005	0.0005	3	0.0010	0.0005	0.00067	43.3%
Tin (Sn)Dissolved	mg/L	0.0001	0.0001	0.0001	3	0.0001	0.0001	0.00010	0.0%	0.0001	0.0001	0.0001	3	0.0001	0.0001	0.00010	0.0%	0.001	0.0005	0.0005	3	0.0010	0.0005	0.00067	43.3%
Titanium (Ti)Dissolved	mg/L	0.01	0.01	0.01	3	0.01	0.01	0.010	0.0%	0.01	0.01	0.01	3	0.01	0.01	0.010	0.0%	0.011	0.013	0.01	3	0.013	0.010	0.011	13.5%
Uranium (U)Dissolved	mg/L	0.000233	0.000325	0.000131	3	0.0003	0.0001	0.00023	42.3%	0.000199	0.000129	0.000100	3	0.0002	0.0001	0.00014	35.7%	0.00671	0.00720	0.00355	3	0.0072	0.0036	0.00582	34.0%
Vanadium (V)Dissolved	mg/L	0.001	0.001	0.001	3	0.001	0.001	0.0010	0.0%	0.001	0.001	0.001	3	0.001	0.001	0.0010	0.0%	0.01	0.005	0.005	3	0.010	0.005	0.0067	43.3%
Zinc (Zn)Dissolved	mg/L	0.003	0.003	0.003	3	0.003	0.003	0.0030	0.0%	0.003	0.003	0.003	3	0.003	0.003	0.0030	0.0%	0.03	0.015	0.015	3	0.030	0.015	0.0200	43.3%

Results in *blue italics* are below the detection limit indicated.

¹ RSD = Percent Relative Standard Deviation
= 100 * | s / mean |

² RPD = Relative Percent Difference
= 100 * | (result 1 - result 2) / average (result 1, result 2) |

Well Evaluation Data

Sample ID	Units	QU-10-10-D				QU-10-11-D								QU-10-13-D				3 Mains													
Target Zone		2 North No. 1 Coal Seam				2 North No. 1 Coal Seam								2 North Flooded Mine Void				2 North Mine Sump													
Date Sampled		23/02/2011	14/04/2011	Mean	RPD	05/12/2010	24/02/2011	12/04/2011	n	Max	Min	Mean	% RSD	22/02/2011	11/04/2011	Mean	RPD	05/05/2009	11/05/2009	19/05/2009	26/05/2009	01/06/2009	06/12/2010	17/01/2011	08/03/2011	n	Max	Min	Mean	% RSD	
Field Physical Tests																															
Field Alkalinity, Total (as CaCO3)	mg/L	117	114	115.5	2.6%	246	285	273	3	285.0	246.0	268.0	7.5%	468	429	448.5	8.7%										0				
Field Conductivity	uS/cm	6374	7886	7130	21.2%	2166	2105	2498	3	2498.0	2105.0	2256.3	9.4%	1595	1564	1579.5	2.0%										0				
Field Eh	mV	-96.2	-87			-	-127.0	-137	2	-127.0	-137.0			-110.6	-61.4											0					
Field pH	pH	6.73	7.18	6.955	6.5%	7.29	7.04	7.86	3	7.9	7.0	7.4	5.7%	7.24	7.62	7.43	5.1%									0					
Field Temperature	C	5.95	5.99	5.97	0.7%		7.35	7.35	2	7.4	7.4	7.4	0.0%	7.00	7.72	7.36	9.8%									0					
Field Dissolved Oxygen (% Saturation)	%	1.1	9.9	5.38435115	160.3%		0.2	10.4	2	10.4	0.2	5.3	137.3%	2.7	7.2	4.94	91.7%									0					
Physical Tests																															
Conductivity	uS/cm	6220	7590	6905	19.8%	1960	2020	2390	3	2390.0	1960.0	2123.3	11.0%	1590	1540	1565	3.2%	3340	3250	2340	3300	3350	2490	2340	2270	8	3350.0	2270.0	2835.0	18.1%	
Hardness (as CaCO3)	mg/L	994	1240	1117	22.0%	256	218	243	3	256.0	218.0	239.0	8.1%	106	93.3	99.65	12.7%					1020	387	467	499	4	1020.0	387.0	593.25	48.6%	
pH	pH	7.72	7.52	7.62	2.6%	8.07	7.97	7.85	3	8.1	7.9	8.0	1.4%	8.10	8.00	8.05	1.2%	7.59	7.72	8.04	7.76	7.75	8.03	7.73	7.95	8	8.0	7.6	7.8	2.1%	
Total Suspended Solids	mg/L	41.8	24.3	33.05	53.0%	1170	45.8	30.5	3	1170.0	30.5	415.4	157.3%	4.4	3	3.7	37.8%					4.1				1					
Total Dissolved Solids	mg/L	4520	5130	4825	12.6%	1090	1120	1310	3	1310.0	1090.0	1173.3	10.2%	982	964	973	1.8%					2320				1					
Turbidity	NTU	48.7	23.6	36.15	69.4%		32.9	22.6	2	32.9	22.6	27.8	26.2%	2.34	2.43	2.385	3.8%									0					
Anions and Nutrients																															
Acidity (as CaCO3) (pH 8.3)	mg/L	6.5	12.0	9.25	59.5%		6.2	10.3	2	10.3	6.2	8.25	35.1%	4.4	7.9	6.15	56.9%					18.5	5.6	10.9	11.1	4	18.5	5.6	11.5	46.0%	
Alkalinity, Total (as CaCO3)	mg/L	103	112	107.5	8.4%	236	300	299	3	300	236	278.3	13.2%	448	450	449	0.4%		267	275	274	276	390	380	340	7	390	267	314.6	17.2%	
Ammonia as N	mg/L	0.435	0.582	0.5085	28.9%	0.158	0.180	0.226	3	0.226	0.158	0.1880	18.5%	0.207	0.191	0.199	8.0%		0.0050	0.020	0.0050	0.0087	0.14	0.15	0.090	7	0.150	0.005	0.0598	109.4%	
Bromide (Br)	mg/L	1.3	2.7	2.00	70.0%	1	1	1	3	1	1	1.0	0.0%	0.5	1.3	0.90	88.9%					8.3				1					
Chloride (Cl)	mg/L	2050	2540	2295	21.4%	488	447	584	3	584	447	506.3	13.9%	85.3	84.3	84.80	1.2%					24.8				1					
Fluoride (F)	mg/L	0.095	0.085	0.0900	11.1%	0.4	0.106	0.111	3	0.400	0.106	0.2057	81.8%	0.269	0.288	0.2785	6.8%					0.2				1					
Nitrate (as N)	mg/L	0.1	0.25	0.175	85.7%	0.1	0.1	0.1	3	0.1	0.1	0.10	0.0%	0.05	0.05	0.050	0.0%									0					
Nitrite (as N)	mg/L	0.02	0.05	0.035	85.7%	0.02	0.02	0.02	3	0.02	0.02	0.020	0.0%	0.01	0.01	0.010	0.0%									0					
Nitrate + Nitrite (as N)	mg/L								0										0.10	0.0054	0.050	0.05	0.04	0.04	0.02	7	0.1	0.0	0.0	68.2%	
Total Nitrogen	mg/L	0.200	0.740	0.47	114.9%	0.490	0.130	0.350	3	0.49	0.13	0.323	56.1%	0.060	0.230	0.145	117.2%									0					
Total Dissolved Phosphate As P	mg/L	0.002	0.002	0.002	0.0%		0.0020	0.002	2	0.002	0.002	0.0020	0.0%	0.002	0.0034	0.0027	51.9%		0.0020	0.0025	0.0020	0.0034	0.0020			4	0.0	0.0	0.0	11.8%	
Total Phosphate as P	mg/L	0.0378	0.0267	0.03225	34.4%	0.209	0.0803	0.0760	3	0.209	0.076	0.1218	62.1%	0.0133	0.0146	0.01395	9.3%		0.0020	0.0026	0.0020	0.0023				4	0.0	0.0	0.0	12.9%	
Sulfate (SO4)	mg/L	10	25	17.5	85.7%	93	60	50	3	93	50	67.7	33.3%	278	255	266.5	8.6%		1750	1040	1690	1670	900	860	930	7	1750.0	860.0	1262.86	33.0%	
Sulphide as S	mg/L	0.002	0.002	0.0020	0.0%	0.024	0.002	0.002	3	0.024	0.002	0.0093	136.1%	0.0022	0.0054	0.0038	84.2%									0					
Organic / Inorganic Carbon																															
Dissolved Organic Carbon	mg/L	1.30	2.60	1.95	66.7%	11.8	4.75	3.95	3	11.8	4.0	6.8	63.2%	1.46	1.48	1.47	1.4%									0					
Total Organic Carbon	mg/L	1.25	2.47	1.86	65.6%	17.7	4.72	3.96	3	17.7	4.0	8.8	87.8%	1.79	1.49	1.64	18.3%									0					
Total Metals																															
Aluminum (Al)Total	mg/L	1.85	1.03	1.44	56.9%	29.0	0.931	1.09	3	29.0	0.9	10.3	156.3%	0.0976	0.0641	0.08085	41.4%		0.20	0.20	0.20	0.20	0.025	0.184	0.252	8	0.252	0.025	0.1859	36.8%	
Antimony (Sb)Total	mg/L	0.0005	0.0005	0.0005	0.0%	0.0005	0.0002	0.0002	3	0.0005	0.0002	0.00030	57.7%	0.0002	0.0002	0.0002	0.0%		0.20	0.20	0.20	0.20	0.0025	0.0005	0.0005	8	0.2	0.0005	0.1005	105.8%	
Arsenic (As)Total	mg/L	0.0542	0.0326	0.0434	49.8%	0.0199	0.0112	0.00908	3	0.020	0.009	0.0134	42.8%	0.0382	0.0344	0.0363	10.5%		0.20	0.20	0.20	0.20	0.0025	0.0028	0.0013	8	0.2	0.0013	0.1010	104.8%	
Barium (Ba)Total	mg/L	0.884	0.972	0.928	9.5%	0.393	0.216	0.238	3	0.3930	0.2160	0.28233	34.2%	0.0680	0.0600	0.064	12.5%		0.010	0.026	0.018	0.010	0.020	0.023	0.020	0.016	8	0.026	0.01	0.0179	32.0%
Beryllium (Be)Total	mg/L	0.0025	0.0025	0.0025	0.0%	0.0025	0.001	0.001	3	0.0025	0.0010	0.00150	57.7%	0.001	0.001	0.001	0.0%		0.0050	0.0050	0.0050	0.0050	0.0050	0.0001	0.0001	8	0.005	0.0001	0.0032	80.2%	
Bismuth (Bi)Total	mg/L	0.0025	0.0025	0.0025	0.0%	0.0025	0.001	0.001	3	0.0025	0.0010	0.00150	57.7%	0.001	0.001	0.001	0.0%		0.20	0.20	0.20	0.20	0.001	0.001	0.001	7	0.2	0.001	0.115	92.7%	
Boron (B)Total	mg/L	0.316	0.271	0.2935	15.3%	0.254	0.358	0.351	3	0.36	0.25	0.321	18.1%	1.11	1.11	1.11	0.0%		0.98	1.00	0.83	0.97	1.00	1.07	1.28	8	1.28	0.83	1.019	12.4%	
Cadmium (Cd)Total	mg/L	0.00005	0.00005	0.00005	0.0%	0.000159																									

Well Evaluation Data

Sample ID	Units	QU-10-10-D				QU-10-11-D								QU-10-13-D				3 Mains														
Target Zone		2 North No. 1 Coal Seam				2 North No. 1 Coal Seam								2 North Flooded Mine Void				2 North Mine Sump														
Date Sampled		23/02/2011	14/04/2011	Mean	RPD	05/12/2010	24/02/2011	12/04/2011	n	Max	Min	Mean	% RSD	22/02/2011	11/04/2011	Mean	RPD	05/05/2009	11/05/2009	19/05/2009	26/05/2009	01/06/2009	06/12/2010	17/01/2011	08/03/2011	n	Max	Min	Mean	% RSD		
Dissolved Metals																																
Aluminum (Al)Dissolved	mg/L	0.017	0.015	0.016	12.5%	0.015	0.006	0.006	3	0.015	0.006	0.0090	57.7%	0.0126	0.006	0.0093	71.0%	0.025	0.025	0.20	0.20	0.025	0.187	0.030	0.021	8	0.2	0.021	0.0891	99.1%		
Antimony (Sb)Dissolved	mg/L	0.0005	0.0005	0.0005	0.0%	0.0005	0.0002	0.0002	3	0.0005	0.0002	0.00030	57.7%	0.0002	0.0002	0.0002	0.0%					0.0025				1						
Arsenic (As)Dissolved	mg/L	0.0452	0.0331	0.03915	30.9%	0.0105	0.0105	0.00912	3	0.011	0.0091	0.0100	7.9%	0.0364	0.0327	0.03455	10.7%	0.0025	0.0025	0.20	0.20	0.0025	0.0025	0.0007	0.0006	8	0.2	0.0006	0.0514	178.4%		
Barium (Ba)Dissolved	mg/L	0.849	1.06	0.9545	22.1%	0.183	0.200	0.235	3	0.235	0.183	0.2060	12.9%	0.0630	0.0586	0.0608	7.2%	0.020	0.030	0.020	0.010	0.020	0.025	0.019	0.016	8	0.03	0.01	0.020	29.4%		
Beryllium (Be)Dissolved	mg/L	0.0025	0.0025	0.0025	0.0%	0.0025	0.001	0.001	3	0.003	0.001	0.0015	57.7%	0.001	0.001	0.001	0.0%	0.0050	0.0050	0.0050	0.0050	0.0001	0.0001	0.0001	8	0.005	0.0001	0.00316	80.2%			
Bismuth (Bi)Dissolved	mg/L	0.0025	0.0025	0.0025	0.0%	0.0025	0.001	0.001	3	0.0025	0.0010	0.00150	57.7%	0.001	0.001	0.001	0.0%									0						
Boron (B)Dissolved	mg/L	0.289	0.282	0.2855	2.5%	0.243	0.337	0.347	3	0.35	0.24	0.309	18.6%	1.10	1.06	1.08	3.7%	0.98	0.99	0.83	0.95	1.00	1.22	1.03	0.95	8	1.22	0.83	0.994	11.0%		
Cadmium (Cd)Dissolved	mg/L	0.00005	0.00005	0.00005	0.0%	0.000085	0.00002	0.00002	3	0.00009	0.00002	0.000042	90.1%	0.00002	0.00002	0.00002	0.0%	0.000085	0.000085	0.010	0.010	0.000085	0.00007	0.00008	0.00003	8	0.01	0.00003	0.002554	179.9%		
Calcium (Ca)Dissolved	mg/L	382	480	431	22.7%	91.2	77.3	87.1	3	91.20	77.30	85.200	8.4%	37.7	33.3	35.5	12.4%	362	347	288	350	350	129	153	163	8	362	129	267.8	38.0%		
Chromium (Cr)Dissolved	mg/L	0.0005	0.0005	0.0005	0.0%	0.0025	0.0002	0.0002	3	0.003	0.000	0.0010	137.4%	0.0002	0.0002	0.0002	0.0%	0.0050	0.0050	0.010	0.010	0.0050	0.001	0.001	0.001	8	0.01	0.001	0.0048	78.6%		
Cobalt (Co)Dissolved	mg/L	0.00213	0.00257	0.00235	18.7%	0.00094	0.00182	0.00138	3	0.0018	0.0009	0.00138	31.9%	0.00089	0.00057	0.00073	43.8%	0.0015	0.0015	0.010	0.010	0.0016	0.0037	0.0057	0.0026	8	0.01	0.0015	0.00458	79.5%		
Copper (Cu)Dissolved	mg/L	0.0025	0.0025	0.0025	0.0%	0.0025	0.001	0.001	3	0.0025	0.0010	0.00150	57.7%	0.001	0.001	0.001	0.0%	0.015	0.0093	0.010	0.010	0.0050	0.0030	0.0015	0.0008	8	0.015	0.0008	0.00683	73.4%		
Iron (Fe)Dissolved	mg/L	1.82	2.22	2.02	19.8%	1.11	3.77	3.40	3	3.770	1.110	2.7600	52.2%	0.490	0.352	0.421	32.8%	0.030	0.030	0.030	0.049	0.030	0.436	0.005	0.014	8	0.436	0.005	0.0780	186.2%		
Lead (Pb)Dissolved	mg/L	0.00028	0.00025	0.000265	11.3%	0.00025	0.0001	0.0001	3	0.00025	0.00010	0.000150	57.7%	0.00012	0.0001	0.00011	18.2%	0.0025	0.0025	0.050	0.050	0.0025	0.0002	0.0002	0.0002	8	0.05	0.0002	0.013513	166.9%		
Lithium (Li)Dissolved	mg/L	0.025	0.025	0.025	0.0%	0.025	0.011	0.01	3	0.03	0.01	0.015	54.7%	0.01	0.01	0.01	0.0%	0.026	0.025	0.017	0.027	0.025	0.012	0.013	0.013	8	0.03	0.012	0.0198	33.4%		
Magnesium (Mg)Dissolved	mg/L	9.71	11.0	10.355	12.5%	6.89	5.97	6.17	3	6.89	5.97	6.343	7.6%	2.97	2.49	2.73	17.6%	35.3	36.1	37.5	34.3	36.3	15.8	20.6	22.3	8	37.5	15.8	29.78	29.2%		
Manganese (Mn)Dissolved	mg/L	0.633	0.747	0.69	16.5%	0.449	0.788	0.737	3	0.788	0.449	0.6580	27.8%	0.360	0.327	0.3435	9.6%	0.628	0.597	0.0300	0.639	0.583	0.122	0.206	0.132	8	0.639	0.030	0.3671	72.5%		
Mercury (Hg)Dissolved	mg/L	0.00001	0.00001	0.00001	0.0%		0.00001	0.00001	2	0.00001	0.00001	0.000010	0.0%	0.00001	0.00001	0.00001	0.0%	0.000020	0.000020			0.000020	0.00002	0.00002	0.00005	6	0.00005	0.00002	0.000025	49.0%		
Molybdenum (Mo)Dissolved	mg/L	0.00157	0.00180	0.001685	13.6%	0.00224	0.00167	0.00140	3	0.0022	0.0014	0.00177	24.2%	0.00219	0.00212	0.002155	3.2%	0.0050	0.0050	0.030	0.030	0.0050	0.002	0.001	0.001	8	0.03	0.001	0.00988	127.0%		
Nickel (Ni)Dissolved	mg/L	0.0029	0.0040	0.00345	31.9%	0.0025	0.0015	0.0012	3	0.003	0.001	0.0017	39.3%	0.001	0.001	0.001	0.0%	0.0050	0.0120	0.050	0.050	0.0062	0.006	0.011	0.007	8	0.05	0.005	0.0184	106.8%		
Phosphorus (P)Dissolved	mg/L	0.3	0.6	0.45	66.7%	0.3	0.3	0.3	3	0.3	0.3	0.30	0.0%	0.3	0.3	0.3	0.0%			0.30	0.30		0.005	0.005	0.005	5	0.3	0.005	0.1230	131.4%		
Potassium (K)Dissolved	mg/L	6.2	7.2	6.7	14.9%	2.7	3.2	3.2	3	3.2	2.7	3.0	9.5%	2.8	2.7	2.75	3.6%	3.5	3.7	3.5	3.6	4.2	4.44	4.30	3.69	8	4.44	3.50	3.866	9.9%		
Selenium (Se)Dissolved	mg/L	0.0005	0.0005	0.0005	0.0%	0.0004	0.0002	0.0002	3	0.0004	0.0002	0.0003	43.3%	0.0002	0.0002	0.0002	0.0%	0.0050	0.0050	0.20	0.20	0.0050	0.0002	0.0001	0.0002	8	0.2	0.0001	0.0519	176.0%		
Silicon (Si)Dissolved	mg/L	3.89	3.92	3.905	0.8%	4.19	5.00	4.90	3	5.0	4.2	4.70	9.4%	3.15	3.19	3.17	1.3%									0						
Silver (Ag)Dissolved	mg/L	0.00005	0.00005	0.00005	0.0%	0.00005	0.00002	0.00002	3	0.00005	0.00002	0.000030	57.7%	0.00002	0.00002	0.00002	0.0%	0.00010	0.00010	0.010	0.010	0.00010	0.00002	0.00002	0.00002	8	0.01	0.00002	0.002545	180.8%		
Sodium (Na)Dissolved	mg/L	903	1090	996.5	18.8%	333	357	394	3	394	333	361.3	8.5%	340	333	336.5	2.1%	422	462	259	476	449	440	462	308	8	476	259	409.8	19.7%		
Strontium (Sr)Dissolved	mg/L	3.53	4.22	3.875	17.8%	0.813	0.679	0.766	3	0.813	0.679	0.7527	9.0%	0.347	0.306	0.3265	12.6%									0						
Thallium (Tl)Dissolved	mg/L	0.0005	0.0005	0.0005	0.0%	0.0005	0.0002	0.0002	3	0.0005	0.0002	0.00030	57.7%	0.0002	0.0002	0.0002	0.0%	0.0010	0.0010	0.20	0.20	0.0010	0.00005	0.00005	0.00005	8	0.2	0.00005	0.05039	183.2%		
Tin (Sn)Dissolved	mg/L	0.0005	0.0005	0.0005	0.0%	0.0005	0.0002	0.0002	3	0.0005	0.0002	0.00030	57.7%	0.0002	0.0002	0.0002	0.0%	0.0025	0.0025	0.030	0.030	0.0025	0.005	0.005	0.005	8	0.03	0.0025	0.01031	118.4%		
Titanium (Ti)Dissolved	mg/L	0.025	0.02	0.0225	22.2%	0.01	0.011	0.01	3	0.011	0.010	0.010	5.6%	0.01	0.01	0.01	0.0%					0.01				1						
Uranium (U)Dissolved	mg/L	0.000524	0.000816	0.00067	43.6%	0.00178	0.00166	0.00161	3	0.0018	0.0016	0.00168	5.2%	0.000169	0.000136	0.0001525	21.6%	0.0010	0.0010			0.0010	0.0001	0.0001	0.0001	6	0.001	0.0001	0.00055	89.6%		
Vanadium (V)Dissolved	mg/L	0.005	0.005	0.005	0.0%	0.005	0.002	0.002	3	0.005	0.002	0.0030	57.7%	0.002	0.002	0.002	0.0%	0.0050	0.0050	0.030	0.030	0.0050	0.005	0.005	0.005	8	0.03	0.005	0.0113	102.9%		
Zinc (Zn)Dissolved	mg/L	0.015	0.015	0.015	0.0%	0.015	0.006	0.006	3	0.015	0.006	0.0090	57.7%	0.006	0.006	0.006	0.0%	0.0050	0.0050	0.0050	0.0050	0.0050	0.005	0.006	0.006	8	0.006	0.005	0.0053	8.8%		

Results in *blue italics* are below the detection limit indicated.

¹ RSD = Percent Relative Standard Deviation
= 100 * |s / mean|

² RPD = Relative Percent Difference
= 100 * |(result 1 - result 2) / average (result 1, result 2)|

Well Evaluation Data

Sample ID	Units	1 Mains																5 Mains											
Target Zone		2 North Mine Sump																2 North Mine Sump											
Date Sampled		17/10/2006	15/11/2006	14/12/2006	13/02/2007	19/03/2007	01/08/2007	13/08/2007	05/09/2007	02/10/2007	01/11/2007	28/05/2010	22/09/2010	n	Max	Min	Mean	% RSD	01/08/2007	13/08/2007	05/09/2007	02/10/2007	01/11/2007	31/05/2010	n	Max	Min	Mean	% RSD
Field Physical Tests																													
Field Alkalinity, Total (as CaCO3)	mg/L													0											0				
Field Conductivity	uS/cm													0											0				
Field Eh	mV													0											0				
Field pH	pH													0											0				
Field Temperature	C													0											0				
Field Dissolved Oxygen (% Saturation)	%													0											0				
Physical Tests																													
Conductivity	uS/cm	1730	1710	901	1300	1440	1590	1610	1710	1750	1740	2130	2820	12	2820.0	901.0	1702.6	27.0%	1590	2020	2080	1970	1640	1570	6	2080.0	1570.0	1811.7	13.0%
Hardness (as CaCO3)	mg/L					257						462		2	462.0	257.0	359.50	40.3%						83.9	1				
pH	pH	7.88	8.19	7.70	7.88	8.26	8.28	8.31	8.23	7.99	7.81	8.21	8.00	12	8.3	7.7	8.1	2.6%	8.28	8.41	8.37	8.18	8.36	8.20	6	8.4	8.2	8.3	1.1%
Total Suspended Solids	mg/L					8.7						8.0		2	8.7	8.0	8.4	5.9%						3	1				
Total Dissolved Solids	mg/L											1650		1										965	1				
Turbidity	NTU													0											0				
Anions and Nutrients																													
Acidity (as CaCO3) (pH 8.3)	mg/L					1						2.8		2	2.8	1.0	1.9	67.0%						1	1				
Alkalinity, Total (as CaCO3)	mg/L	463	493	154	241	239	511	545	504	470	369	245	244	12	545	154	373.2	37.4%	511	679	707	695	592	580	6	707	511	627.3	12.5%
Ammonia as N	mg/L	0.0533	0.0147	0.0050	0.0050	0.0110						0.0156	0.005	7	0.053	0.005	0.0157	110.0%						0.189	1				
Bromide (Br)	mg/L					0.05						0.5		2	0.50	0.05	0.275	115.7%						0.5	1				
Chloride (Cl)	mg/L					4.49						11.6		2	11.60	4.49	8.045	62.5%						25.2	1				
Fluoride (F)	mg/L					0.130						0.2		2	0.20	0.13	0.165	30.0%						0.2	1				
Nitrate (as N)	mg/L													0											0				
Nitrite (as N)	mg/L													0											0				
Nitrate + Nitrite (as N)	mg/L	0.0050	0.0050	0.0437	0.0338	0.0353						0.05		6	0.05	0.01	0.029	67.2%						0.050	1				
Total Nitrogen	mg/L													0											0				
Total Dissolved Phosphate As P	mg/L	0.020	0.0020	0.0020	0.0020	0.0020						0.002	0.01	7	0.020	0.002	0.006	122.0%						0.0020	1				
Total Phosphate as P	mg/L	0.097	0.0616	0.0060	0.0020	0.016						0.002	0.01	7	0.097	0.002	0.028	132.9%						0.0042	1				
Sulfate (SO4)	mg/L	446	360	309	453	499	231	339	322	371	482	952	1320	12	1320	231	507.0	61.9%	233	47	11.1	64.0	115	239	6	239	11	118.2	82.3%
Sulphide as S	mg/L													0											0				
Organic / Inorganic Carbon																													
Dissolved Organic Carbon	mg/L													0											0				
Total Organic Carbon	mg/L													0											0				
Total Metals																													
Aluminum (Al)Total	mg/L	5.02		0.53	0.20	0.20	0.289	0.031	0.034	0.025	0.052	0.067	0.025	11	5.02	0.025	0.5885	251.2%	0.240	0.028	0.083	0.025	0.048	0.025	6	0.240	0.025	0.0748	112.2%
Antimony (Sb)Total	mg/L	0.20		0.20	0.20	0.20	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	11	0.2	0.0025	0.0743	134.1%	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	6	0.0025	0.0025	0.00250	0.0%
Arsenic (As)Total	mg/L	0.20		0.20	0.20	0.20	0.0025	0.0026	0.0031	0.0033	0.0035	0.0025	0.0025	11	0.2	0.0025	0.0745	133.4%	0.0025	0.0124	0.0047	0.0039	0.0025	0.0025	6	0.0124	0.0025	0.00475	81.2%
Barium (Ba)Total	mg/L	0.045		0.016	0.019	0.019	0.024	0.020	0.030	0.024	0.020	0.021	0.02	11	0.045	0.016	0.0235	34.2%	0.024	0.060	0.071	0.044	0.020	0.040	6	0.071	0.020	0.0432	46.0%
Beryllium (Be)Total	mg/L	0.0050		0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	11	0.005	0.005	0.0050	0.0%	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	6	0.005	0.005	0.0050	0.0%
Bismuth (Bi)Total	mg/L	0.20		0.20	0.20	0.20								4	0.2	0.2	0.20	0.0%							0				
Boron (B)Total	mg/L	1.07		0.54	0.61	0.66	0.92	1.05	1.06	1.01	0.96	0.93	1.06	11	1.07	0.54	0.897	22.0%	0.93	1.34	1.24	1.23	1.17	1.06	6	1.34	0.93	1.162	12.6%
Cadmium (Cd)Total	mg/L	0.010		0.010	0.010	0.010	0.000085	0.000085	0.000085	0.000085	0.000085	0.000085	0.000085	11	0.01	0.000085	0.003690	135.5%	0.000085	0.000085	0.000085	0.000085	0.000085	0.000085	6	0.000085	0.000085	0.0000850	0.0%
Calcium (Ca)Total	mg/L	92.7		56.8	74.8	87.8	40.0	31.9	55.0	59.9	96.0	146	240	11	240	31.9	89.17	66.4%	40.1	26.1	30.6	24.6	18.2	28.1	6	40.1	18.2	27.95	26.0%
Chromium (Cr)Total	mg/L	0.010		0.010	0.010	0.010	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	11	0.01	0.005	0.0068	37.0%	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	6	0.005	0.005	0.0050	0.0%
Cobalt (Co)Total	mg/L	0.010		0.010	0.010	0.010	0.0017	0.0015	0.0017	0.0026	0.0022	0.0039	0.0015	11	0.01	0.0015	0.00501	80.1%	0.0017	0.0015	0.0015	0.0015	0.0015	0.0015	6	0.0017	0.0015	0.00153	5.3%
Copper (Cu)Total	mg/L	0.029		0.011	0.010	0.010	0.0050	0.0152	0.0050	0.0050	0.0291	0.0050	0.0050	11	0.029	0.005	0.0118	78.2%	0.0050	0.0106	0.0050	0.0050	0.0050	0.0050	6	0.011	0.005	0.0059	38.5%
Iron (Fe)Total	mg/L	6.71		1.55	0.852	1.16	0.692	0.855	1.20	1.43	1.46	2.44	0.233	11	6.71	0.233	1.689	104.1%	0.695	1.16	0.290	0.354	0.235	0.327	6	1.16	0.235	0.5102	70.1%
Lead (Pb)Total	mg/L	0.050		0.050	0.050	0.050	0.0025	0.0037	0.0025	0.0025	0.0057	0.0025																	

Well Evaluation Data

Sample ID	Units	1 Mains																	5 Mains												
Target Zone		2 North Mine Sump																	2 North Mine Sump												
Date Sampled		17/10/2006	15/11/2006	14/12/2006	13/02/2007	19/03/2007	01/08/2007	13/08/2007	05/09/2007	02/10/2007	01/11/2007	28/05/2010	22/09/2010	n	Max	Min	Mean	% RSD	01/08/2007	13/08/2007	05/09/2007	02/10/2007	01/11/2007	31/05/2010	n	Max	Min	Mean	% RSD		
Dissolved Metals																															
Aluminum (Al)Dissolved	mg/L	0.025	0.025	0.20	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	12	0.2	0.025	0.0396	127.6%	0.025	0.025	0.036	0.025	0.025	0.025	6	0.036	0.025	0.0268	16.7%		
Antimony (Sb)Dissolved	mg/L					0.0025						0.0025		2	0.0025	0.0025	0.00250	0.0%							0						
Arsenic (As)Dissolved	mg/L	0.0025	0.0025	0.20	0.0025	0.0025	0.0025	0.0025	0.0029	0.0025	0.0025	0.0025	0.0025	12	0.2	0.0025	0.0190	300.1%	0.0025	0.0046	0.0046	0.0034	0.0025	0.0025	6	0.005	0.0025	0.00335	30.7%		
Barium (Ba)Dissolved	mg/L	0.024	0.024	0.015	0.020	0.020	0.023	0.020	0.030	0.020	0.030	0.020	0.020	12	0.03	0.015	0.0222	19.7%	0.023	0.058	0.072	0.049	0.030	0.041	6	0.072	0.023	0.0455	39.8%		
Beryllium (Be)Dissolved	mg/L	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	12	0.005	0.005	0.0050	0.0%	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	6	0.005	0.005	0.0050	0.0%		
Bismuth (Bi)Dissolved	mg/L													0											0						
Boron (B)Dissolved	mg/L	1.01	1.03	0.53	0.62	0.65	0.98	1.09	1.08	0.99	0.97	0.92	1.04	12	1.09	0.53	0.909	21.3%	0.97	1.35	1.27	1.23	1.17	1.09	6	1.35	0.97	1.180	11.5%		
Cadmium (Cd)Dissolved	mg/L	0.000363	0.000085	0.010	0.000085	0.000085	0.000085	0.000085	0.000085	0.000085	0.000085	0.000085	0.000085	12	0.01	0.000085	0.000934	305.6%	0.000085	0.000085	0.000085	0.000085	0.000085	0.000085	6	0.000085	0.000085	0.0000850	0.0%		
Calcium (Ca)Dissolved	mg/L	86.8	65.3	51.8	76.1	86.4	42.0	33.2	57.0	59.7	94.5	151	251	12	251	33.2	87.900	68.1%	42.1	26.3	31.4	24.9	18.5	29.9	6	42.1	18.5	28.85	27.4%		
Chromium (Cr)Dissolved	mg/L	0.0050	0.0050	0.010	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	12	0.01	0.005	0.0054	26.6%	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	6	0.005	0.005	0.0050	0.0%		
Cobalt (Co)Dissolved	mg/L	0.0035	0.0036	0.010	0.0015	0.0023	0.0015	0.0015	0.0018	0.0024	0.0021	0.0034	0.0015	12	0.01	0.0015	0.00293	81.0%	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	6	0.0015	0.0015	0.00150	0.0%		
Copper (Cu)Dissolved	mg/L	0.0050	0.0050	0.010	0.0050	0.0050	0.0050	0.0117	0.0050	0.0050	0.0050	0.0050	0.0050	12	0.0117	0.005	0.00598	38.6%	0.0050	0.0082	0.0050	0.0050	0.0050	0.0050	6	0.0082	0.005	0.00553	23.6%		
Iron (Fe)Dissolved	mg/L	0.030	0.030	0.535	0.419	0.219	0.030	0.030	1.06	0.042	0.030	0.030	0.030	12	1.06	0.03	0.2071	154.6%	0.030	0.030	0.273	0.030	0.030	0.031	6	0.273	0.030	0.0707	140.3%		
Lead (Pb)Dissolved	mg/L	0.0025	0.0025	0.050	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	12	0.05	0.0025	0.006458	212.3%	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	6	0.0025	0.0025	0.00250	0.0%		
Lithium (Li)Dissolved	mg/L	0.025	0.025	0.010	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	12	0.025	0.01	0.024	18.2%	0.025	0.025	0.025	0.025	0.025	0.025	6	0.025	0.025	0.0250	0.0%		
Magnesium (Mg)Dissolved	mg/L	9.00	6.34	6.36	8.57	9.97	3.94	3.12	5.01	5.56	9.26	20.7	30.8	12	30.8	3.12	9.886	81.0%	3.92	1.89	2.05	1.86	1.31	2.21	6	3.92	1.31	2.207	40.5%		
Manganese (Mn)Dissolved	mg/L	0.203	0.102	0.0958	0.112	0.110	0.0015	0.0775	0.116	0.126	0.133	0.285	0.328	12	0.328	0.0015	0.1408	64.0%	0.0085	0.0334	0.0389	0.0352	0.0275	0.0562	6	0.056	0.0085	0.0333	46.7%		
Mercury (Hg)Dissolved	mg/L	0.000020	0.000020		0.000020	0.000020	0.000020	0.000020	0.000020	0.000020	0.000020	0.000010	0.000010	11	0.00002	0.00001	0.000018	22.2%	0.000020	0.000020	0.000020	0.000020	0.000020	0.000010	6	0.00002	0.00001	0.000018	22.3%		
Molybdenum (Mo)Dissolved	mg/L	0.0050	0.0050	0.030	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	12	0.03	0.005	0.00708	101.9%	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	6	0.005	0.005	0.0050	0.0%		
Nickel (Ni)Dissolved	mg/L	0.0064	0.0067	0.050	0.0050	0.0052	0.0050	0.0102	0.0050	0.0050	0.0050	0.0063	0.0050	12	0.05	0.005	0.0096	134.0%	0.0050	0.0074	0.0050	0.0050	0.0050	0.0050	6	0.0074	0.005	0.0054	18.1%		
Phosphorus (P)Dissolved	mg/L			0.30										1											0						
Potassium (K)Dissolved	mg/L	4.4	3.0	2.0	2.0	2.1	2.9	2.3	3.5	3.0	3.7	2.6	3.5	12	4.4	2.0	2.92	26.0%	2.9	2.2	2.7	2.0	2.0	2.2	6	2.9	2.0	2.33	16.2%		
Selenium (Se)Dissolved	mg/L	0.0050	0.0050	0.20	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	12	0.2	0.005	0.0213	264.9%	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	6	0.005	0.005	0.0050	0.0%		
Silicon (Si)Dissolved	mg/L													0											0						
Silver (Ag)Dissolved	mg/L	0.00010	0.00010	0.010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	12	0.01	0.0001	0.000925	309.0%	0.00010	0.00010	0.00010	0.00010	0.00010	0.00010	6	0.0001	0.0001	0.00010	0.0%		
Sodium (Na)Dissolved	mg/L	337	357	173	210	222	331	367	357	344	320	331	434	12	434	173	315.3	23.8%	330	586	460	442	390	367	6	586	330	429.2	21.1%		
Strontium (Sr)Dissolved	mg/L													0											0						
Thallium (Tl)Dissolved	mg/L	0.0010	0.0010	0.20	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	12	0.2	0.001	0.01758	326.7%	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	6	0.001	0.001	0.0010	0.0%		
Tin (Sn)Dissolved	mg/L	0.0025	0.0025	0.030	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	12	0.03	0.0025	0.00479	165.7%	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025	6	0.0025	0.0025	0.00250	0.0%		
Titanium (Ti)Dissolved	mg/L					0.01								2	0.01	0.01	0.010	0.0%						0.01	1						
Uranium (U)Dissolved	mg/L	0.0010	0.0010		0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	11	0.001	0.001	0.00100	0.0%	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	6	0.001	0.001	0.0010	0.0%		
Vanadium (V)Dissolved	mg/L	0.040	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.0050	0.0050	0.0050	0.0050	12	0.04	0.005	0.0225	58.8%	0.030	0.030	0.030	0.0050	0.0050	0.0050	6	0.03	0.005	0.0175	78.2%		
Zinc (Zn)Dissolved	mg/L	0.025	0.025	0.0085	0.025	0.025	0.025	0.026	0.025	0.025	0.025	0.0050	0.0050	12	0.026	0.005	0.0204	42.3%	0.025	0.025	0.025	0.025	0.025	0.0050	6	0.025	0.005	0.0217	37.7%		

Results in *blue italics* are below the detection limit indicated.

¹ RSD = Percent Relative Standard Deviation
= 100 * | s / mean |

² RPD = Relative Percent Difference
= 100 * | (result 1 - result 2) / average (result 1, result 2) |



Well Evaluation Data

Sample ID	Units	6 Mains													7 Panel										
Target Zone		2 North Mine Sump													2 North Mine Sump										
Date Sampled		17/10/2006	15/11/2006	14/12/2006	13/02/2007	19/03/2007	13/08/2007	02/10/2007	01/11/2007	n	Max	Min	Mean	% RSD	17/10/2006	15/11/2006	14/12/2006	13/02/2007	19/03/2007	n	Max	Min	Mean	% RSD	
Field Physical Tests																									
Field Alkalinity, Total (as CaCO3)	mg/L									0										0					
Field Conductivity	uS/cm									0										0					
Field Eh	mV									0										0					
Field pH	pH									0										0					
Field Temperature	C									0										0					
Field Dissolved Oxygen (% Saturation)	%									0										0					
Physical Tests																									
Conductivity	uS/cm	1050	1180	1240	1150	1210	1130	1070	1260	8	1260	1050	1161.3	6.5%	1000	1170	1420	1150	1190	5	1420	1000	1186.0	12.7%	
Hardness (as CaCO3)	mg/L					68.1				1									68.4	1					
pH	pH	8.07	8.35	8.34	8.29	8.22	8.38	7.94	8.18	8	8.4	7.9	8.2	1.9%	8.06	8.32	8.21	8.15	8.21	5	8.3	8.1	8.2	1.2%	
Total Suspended Solids	mg/L					3				1									3	1					
Total Dissolved Solids	mg/L									0										0					
Turbidity	NTU									0										0					
Anions and Nutrients																									
Acidity (as CaCO3) (pH 8.3)	mg/L					1.1				1									1.4	1					
Alkalinity, Total (as CaCO3)	mg/L	390	400	338	357	360	378	358	387	8	400	338	371.0	5.7%	342	365	394	353	361	5	394	342	363.0	5.4%	
Ammonia as N	mg/L	0.0127	0.0320	0.114	0.0848	0.0650				5	0.114	0.013	0.0617	65.6%	0.107	0.127	0.167	0.181	0.169	5	0.2	0.1	0.2	21.0%	
Bromide (Br)	mg/L					1.3				1									1.3	1					
Chloride (Cl)	mg/L					14.0				1									12.4	1					
Fluoride (F)	mg/L					0.061				1									0.050	1					
Nitrate (as N)	mg/L									0										0					
Nitrite (as N)	mg/L									0										0					
Nitrate + Nitrite (as N)	mg/L	0.0129	0.121	0.0384	0.0744	0.0987				5	0.12	0.01	0.069	63.5%	0.100	0.0951	0.0175	0.0073	0.0288	5	0.10	0.01	0.050	89.1%	
Total Nitrogen	mg/L									0										0					
Total Dissolved Phosphate As P	mg/L	0.0020	0.0020	0.0027	0.0020	0.0038				5	0.004	0.002	0.003	31.5%	0.020	0.0020	0.0024	0.0020	0.0024	5	0.020	0.002	0.006	138.2%	
Total Phosphate as P	mg/L	0.0111	0.0058	0.042	0.0032	0.0081				5	0.042	0.003	0.014	113.2%	0.194	0.0042	0.0044	0.0035	0.0040	5	0.194	0.004	0.042	202.2%	
Sulfate (SO4)	mg/L	170	202	299	262	260	197	191	248	8	299	170	228.6	19.6%	209	244	345	269	268	5	345	209	267.0	18.7%	
Sulphide as S	mg/L									0										0					
Organic / Inorganic Carbon																									
Dissolved Organic Carbon	mg/L									0										0					
Total Organic Carbon	mg/L									0										0					
Total Metals																									
Aluminum (Al)Total	mg/L	0.20		1.61	0.20	0.20	0.050	0.025	0.047	7	1.61	0.025	0.3331	170.7%	0.20		0.20	0.20	0.20	4	0.2	0.2	0.20	0.0%	
Antimony (Sb)Total	mg/L	0.20		0.20	0.20	0.20	0.0025	0.0025	0.0025	7	0.2	0.0025	0.1154	91.5%	0.20		0.20	0.20	0.20	4	0.2	0.2	0.20	0.0%	
Arsenic (As)Total	mg/L	0.20		0.20	0.20	0.20	0.0043	0.0033	0.0045	7	0.2	0.0033	0.1160	90.3%	0.20		0.20	0.20	0.20	4	0.2	0.2	0.20	0.0%	
Barium (Ba)Total	mg/L	0.032		0.042	0.032	0.033	0.024	0.028	0.020	7	0.042	0.02	0.0301	23.5%	0.042		0.044	0.031	0.033	4	0.044	0.031	0.0375	17.2%	
Beryllium (Be)Total	mg/L	0.0050		0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	7	0.005	0.005	0.0050	0.0%	0.0050		0.0050	0.0050	0.0050	4	0.005	0.005	0.0050	0.0%	
Bismuth (Bi)Total	mg/L	0.20		0.20	0.20	0.20				4	0.2	0.2	0.20	0.0%	0.20		0.20	0.20	0.20	4	0.2	0.2	0.20	0.0%	
Boron (B)Total	mg/L	0.86		0.82	0.82	0.87	0.93	0.82	0.98	7	0.98	0.82	0.871	7.1%	0.71		0.95	0.80	0.83	4	0.95	0.71	0.823	12.1%	
Cadmium (Cd)Total	mg/L	0.010		0.010	0.010	0.010	0.000085	0.000085	0.000085	7	0.01	0.000085	0.005751	92.2%	0.010		0.010	0.010	0.010	4	0.01	0.01	0.010	0.0%	
Calcium (Ca)Total	mg/L	22.5		34.2	21.7	24.6	22.4	23.1	27.7	7	34.2	21.7	25.17	17.7%	30.9		33.9	21.6	24.1	4	33.9	21.6	27.63	20.8%	
Chromium (Cr)Total	mg/L	0.010		0.010	0.010	0.010	0.0050	0.0050	0.0050	7	0.01	0.005	0.0079	34.0%	0.010		0.010	0.010	0.010	4	0.01	0.01	0.010	0.0%	
Cobalt (Co)Total	mg/L	0.010		0.010	0.010	0.010	0.0015	0.0015	0.0015	7	0.01	0.0015	0.00636	71.5%	0.010		0.010	0.010	0.010	4	0.01	0.01	0.010	0.0%	
Copper (Cu)Total	mg/L	0.010		0.014	0.010	0.010	0.0103	0.0050	0.0050	7	0.014	0.005	0.0092	34.8%	0.010		0.010	0.010	0.010	4	0.0	0.0	0.010	0.0%	
Iron (Fe)Total	mg/L	0.208		1.94	0.118	0.050	0.084	0.053	0.101	7	1.94	0.05	0.3649	190.9%	0.081		0.089	0.059	0.075	4	0.089	0.059	0.0760	16.7%	
Lead (Pb)Total	mg/L	0.050		0.050	0.050	0.050	0.0025	0.0025	0.0025	7	0.05	0.0025	0.0296	85.7%	0.050		0.050	0.050	0.050	4	0.050	0.050	0.0500	0.0%	
Lithium (Li)Total	mg/L	0.010		0.010	0.010	0.010	0.025	0.025	0.025	7	0.025	0.010	0.0164	48.8%	0.010		0.010	0.010	0.010	4	0.01	0.01	0.010	0.0%	
Magnesium (Mg)Total	mg/L	1.87		3.40	1.86	2.02	1.76	2.01	2.13	7	3.40	1.76	2.150	26.3%	2.98		3.01	1.91	2.03	4	3.01	1.91	2.483	23.9%	
Manganese (Mn)Total	mg/L	0.0280		0.0561	0.0256	0.0229	0.0416	0.0288	0.0271	7	0.0561	0.023	0.0329	36.0%	0.0407		0.0634	0.0519	0.0559	4	0.063	0.041	0.0530	17.9%	
Mercury (Hg)Total	mg/L						0.000020	0.000020	0.000020	3	0.00002	0.00002	0.000020	0.0%						0					
Molybdenum (Mo)Total	mg/L	0.030		0.030	0.030	0.030	0.0050	0.0050	0.0050	7	0.03	0.005	0.0193	69.3%	0.030		0.030	0.030	0.030	4	0.03	0.03	0.030	0.0%	
Nickel (Ni)Total	mg/L	0.050		0.050	0.050	0.050	0.0080	0.0050	0.0050	7	0.05	0.005	0.0311	75.6%	0.050		0.050	0.050	0.050	4	0.05	0.05	0.050	0.0%	
Phosphorus (P)Total	mg/L	0.30		0.30	0.30	0.30				4	0.3	0.3	0.30	0.0%	0.30		0.30	0.30	0.30	4	0.3	0.3	0.30	0.0%	
Potassium (K)Total	mg/L	2.0		2.4	2.0	2.0	2.0	2.0	2.0	7	2.4	2.0	2.06	7.3%	2.0		2.1	2.0	2.0	4	2.1	2.0	2.03	2.5%	
Selenium (Se)Total	mg/L	0.20		0.20	0.20	0.20	0.0050	0.0050	0.0050	7	0.2	0.005	0.1164	89.5%	0.20		0.20	0.20	0.20	4	0.2	0.2	0.20	0.0%	
Silicon (Si)Total	mg/L	2.67		5.10	2.09	2.27				4	5.1	2.1	3.03	46.1%	2										

Well Evaluation Data

Sample ID	Units	6 Mains													7 Panel										
Target Zone		2 North Mine Sump													2 North Mine Sump										
Date Sampled		17/10/2006	15/11/2006	14/12/2006	13/02/2007	19/03/2007	13/08/2007	02/10/2007	01/11/2007	n	Max	Min	Mean	% RSD	17/10/2006	15/11/2006	14/12/2006	13/02/2007	19/03/2007	n	Max	Min	Mean	% RSD	
Dissolved Metals																									
Aluminum (Al)Dissolved	mg/L	0.025	0.025	0.20	0.025	0.025	0.025	0.025	0.025	8	0.2	0.025	0.0469	132.0%	0.025	0.025	0.20	0.025	0.025	5	0.2	0.025	0.0600	130.4%	
Antimony (Sb)Dissolved	mg/L					0.0025				1									0.0025	1					
Arsenic (As)Dissolved	mg/L	0.0029	0.0042	0.20	0.0025	0.0025	0.0040	0.0030	0.0040	8	0.2	0.0025	0.0279	249.4%	0.0025	0.0025	0.20	0.0025	0.0025	5	0.2	0.0025	0.0420	210.3%	
Barium (Ba)Dissolved	mg/L	0.032	0.034	0.032	0.030	0.032	0.024	0.028	0.020	8	0.034	0.020	0.0290	16.5%	0.041	0.039	0.043	0.030	0.033	5	0.043	0.030	0.0372	14.8%	
Beryllium (Be)Dissolved	mg/L	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	8	0.005	0.005	0.0050	0.0%	0.0050	0.0050	0.0050	0.0050	0.0050	5	0.005	0.005	0.0050	0.0%	
Bismuth (Bi)Dissolved	mg/L									0										0					
Boron (B)Dissolved	mg/L	0.86	0.92	0.87	0.78	0.84	0.91	0.83	0.98	8	0.98	0.78	0.874	7.1%	0.68	0.81	0.94	0.77	0.85	5	0.94	0.68	0.810	11.9%	
Cadmium (Cd)Dissolved	mg/L	0.000085	0.000085	0.010	0.000085	0.000085	0.000085	0.000085	0.000085	8	0.01	0.000085	0.001324	264.7%	0.000085	0.000085	0.010	0.000085	0.000085	5	0.01	0.000085	0.002068	214.4%	
Calcium (Ca)Dissolved	mg/L	22.3	25.4	34.3	20.9	24.0	22.1	23.1	27.7	8	34.3	20.9	24.98	17.3%	30.6	30.0	33.6	21.0	24.0	5	33.6	21.0	27.84	18.6%	
Chromium (Cr)Dissolved	mg/L	0.0050	0.0050	0.010	0.0050	0.0050	0.0050	0.0050	0.0050	8	0.01	0.005	0.0056	31.4%	0.0050	0.0050	0.010	0.0050	0.0050	5	0.01	0.005	0.0060	37.3%	
Cobalt (Co)Dissolved	mg/L	0.0015	0.0015	0.010	0.0015	0.0015	0.0015	0.0015	0.0015	8	0.01	0.0015	0.00256	117.3%	0.0015	0.0015	0.010	0.0015	0.0015	5	0.01	0.0015	0.00320	118.8%	
Copper (Cu)Dissolved	mg/L	0.0050	0.0050	0.010	0.0050	0.0050	0.0093	0.0050	0.0050	8	0.01	0.005	0.00616	35.1%	0.0050	0.0050	0.010	0.0050	0.0050	5	0.01	0.005	0.0060	37.3%	
Iron (Fe)Dissolved	mg/L	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.030	8	0.03	0.03	0.030	0.0%	0.064	0.030	0.030	0.030	0.030	5	0.064	0.03	0.0368	41.3%	
Lead (Pb)Dissolved	mg/L	0.0025	0.0025	0.050	0.0025	0.0025	0.0025	0.0025	0.0025	8	0.05	0.0025	0.00844	199.0%	0.0025	0.0025	0.050	0.0025	0.0025	5	0.05	0.0025	0.01200	177.0%	
Lithium (Li)Dissolved	mg/L	0.025	0.025	0.010	0.025	0.025	0.025	0.025	0.025	8	0.025	0.010	0.0231	22.9%	0.025	0.025	0.010	0.025	0.025	5	0.025	0.010	0.0220	30.5%	
Magnesium (Mg)Dissolved	mg/L	1.84	2.01	3.09	1.78	1.96	1.73	2.02	2.15	8	3.09	1.73	2.073	20.9%	2.97	2.65	3.00	1.85	2.04	5	3.00	1.85	2.502	21.2%	
Manganese (Mn)Dissolved	mg/L	0.0253	0.0178	0.0302	0.0235	0.0222	0.0302	0.0260	0.0249	8	0.030	0.018	0.0250	16.4%	0.0408	0.0450	0.0620	0.0528	0.0579	5	0.062	0.041	0.0517	17.0%	
Mercury (Hg)Dissolved	mg/L	0.000020	0.000020		0.000020	0.000020	0.000020	0.000020	0.000020	7	0.00002	0.00002	0.000020	0.0%	0.000020	0.000020		0.000020	0.000020	4	0.00002	0.00002	0.000020	0.0%	
Molybdenum (Mo)Dissolved	mg/L	0.0050	0.0050	0.030	0.0050	0.0050	0.0050	0.0050	0.0050	8	0.03	0.005	0.0081	108.8%	0.0050	0.0050	0.030	0.0050	0.0050	5	0.03	0.005	0.010	111.8%	
Nickel (Ni)Dissolved	mg/L	0.0050	0.0050	0.050	0.0050	0.0050	0.0076	0.0050	0.0050	8	0.05	0.005	0.0110	144.3%	0.0050	0.0050	0.050	0.0050	0.0050	5	0.05	0.005	0.0140	143.7%	
Phosphorus (P)Dissolved	mg/L			0.30						1							0.30			1					
Potassium (K)Dissolved	mg/L	2.0	2.0	2.4	2.0	2.0	2.0	2.0	2.0	8	2.4	2.0	2.05	6.9%	2.0	2.0	2.1	2.0	2.0	5	2.1	2.0	2.0	2.2%	
Selenium (Se)Dissolved	mg/L	0.0050	0.0050	0.20	0.0050	0.0050	0.0050	0.0050	0.0050	8	0.2	0.005	0.0294	234.7%	0.0050	0.0050	0.20	0.0050	0.0050	5	0.2	0.005	0.0440	198.2%	
Silicon (Si)Dissolved	mg/L									0										0					
Silver (Ag)Dissolved	mg/L	0.00010	0.00010	0.010	0.00010	0.00010	0.00010	0.00010	0.00010	8	0.01	0.0001	0.00134	261.7%	0.00010	0.00010	0.010	0.00010	0.00010	5	0.01	0.0001	0.002080	212.9%	
Sodium (Na)Dissolved	mg/L	227	266	300	246	258	232	232	287	8	300	227	256.0	10.5%	207	255	324	242	258	5	324	207	257.2	16.5%	
Strontium (Sr)Dissolved	mg/L									0										0					
Thallium (Tl)Dissolved	mg/L	0.0010	0.0010	0.20	0.0010	0.0010	0.0010	0.0010	0.0010	8	0.2	0.001	0.0259	271.9%	0.0010	0.0010	0.20	0.0010	0.0010	5	0.2	0.001	0.04080	218.1%	
Tin (Sn)Dissolved	mg/L	0.0025	0.0025	0.030	0.0025	0.0025	0.0025	0.0025	0.0025	8	0.03	0.0025	0.00594	163.8%	0.0025	0.0025	0.030	0.0025	0.0025	5	0.03	0.0025	0.0080	153.7%	
Titanium (Ti)Dissolved	mg/L					0.01				1									0.01	1					
Uranium (U)Dissolved	mg/L	0.0010	0.0010		0.0010	0.0010	0.0010	0.0010	0.0010	7	0.001	0.001	0.0010	0.0%	0.0010	0.0010		0.0010	0.0010	4	0.001	0.001	0.0010	0.0%	
Vanadium (V)Dissolved	mg/L	0.030	0.030	0.030	0.030	0.030	0.030	0.0050	0.0050	8	0.03	0.005	0.0238	48.7%	0.030	0.030	0.030	0.030	0.030	5	0.03	0.03	0.030	0.0%	
Zinc (Zn)Dissolved	mg/L	0.025	0.025	0.0050	0.025	0.025	0.025	0.025	0.025	8	0.025	0.005	0.0225	31.4%	0.025	0.025	0.0050	0.025	0.025	5	0.025	0.005	0.0210	42.6%	

Results in *blue italics* are below the detection limit indicated.

¹ RSD = Percent Relative Standard Deviation
= 100 * | s / mean |

² RPD = Relative Percent Difference
= 100 * | (result 1 - result 2) / average (result 1, result 2) |

Appendix B3 – Groundwater Quality Data and Guidelines



HILLSBOUROUGH
Resources Limited

Hillsborough Resources

Area		5 South				5 South	5 South			5 South										5 South									
Target Zone		Sandstone/till				Mine void	Quartz diorite			No. 1 coal seam										No. 1 coal seam									
Sample ID	Units	Q81-P3-1-1		Q81-P3-1-2	QU-05-13	QU-05-15-MW1			QU-05-16-MW4										QU-06-01-MW5										
Date Sampled		05-May-2010	14-Jul-2010	05-Nov-2010	05-May-2010	18-Jan-2011	29-Jun-2006	20-Oct-2009	25-Jan-2011	29-Jun-2006	27-Apr-2007	08-Nov-2007	24-Apr-2008	03-Oct-2008	01-Apr-2009	23-Nov-2009	06-May-2010	14-Jul-2010	05-Nov-2010	27-Apr-2007	08-Nov-2007	24-Apr-2008	03-Oct-2008	01-Apr-2009	24-Nov-2009	05-May-2010	13-Jul-2010	05-Nov-2010	
Dissolved Metals																													
Aluminum (Al)Dissolved	mg/L	0.0161	<0.0050	0.0051	<0.0050	0.0195	<0.20	0.062	0.012	<0.20	0.026	<0.050	0.02	<0.010	<0.010	<0.010	<0.010	<0.010	0.011	0.060	0.093	0.143	<0.0050	0.008	0.024	0.0065	<0.0050	0.0448	
Antimony (Sb)Dissolved	mg/L	0.00090	<0.00050	<0.00050	<0.00050	0.00024	<0.20	<0.00050	0.00026	<0.20	<0.0010	<0.0025	<0.0010	<0.0010	<0.0010	<0.00050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0025	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	
Arsenic (As)Dissolved	mg/L	0.00817	0.00471	0.00585	0.00501	0.0690	<0.20	0.0019	0.0027	<0.20	0.0530	0.0418	0.0294	0.031	0.0254	0.0235	0.0390	0.0269	0.0075	0.0853	0.037	0.0037	0.00205	0.0141	<0.0010	<0.00050	0.00072	0.00544	
Barium (Ba)Dissolved	mg/L	0.036	<0.020	<0.020	<0.020	0.0856	0.160	0.065	0.023	0.022	0.022	<0.020	0.023	0.024	0.036	0.025	0.042	0.026	0.027	0.023	0.042	0.041	0.059	0.052	<0.020	<0.020	0.024	0.031	
Beryllium (Be)Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.00050	<0.0050	<0.0050	<0.00050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0020	<0.0020	<0.0050	<0.0020	<0.0020	<0.0020	<0.0050	<0.0050	<0.0050	<0.0010	<0.0010	<0.0050	<0.0010	<0.0010	<0.0010	
Bismuth (Bi)Dissolved	mg/L	<0.20	<0.20	<0.20	<0.20	<0.00050	<0.20	<0.20	<0.00050	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	
Boron (B)Dissolved	mg/L	<0.10	<0.10	<0.10	<0.10	0.707	0.12	0.19	0.38	3.42	3.39	3.4	3.43	3.5	3.51	3.60	3.47	4.21	4.79	1.17	1.91	0.53	0.31	1.34	<0.10	<0.10	0.54	0.55	
Cadmium (Cd)Dissolved	mg/L	<0.000017	<0.000017	<0.000017	<0.000017	<0.000010	<0.010	<0.000050	0.000058	<0.010	<0.00010	<0.00025	<0.00010	<0.000034	<0.000034	<0.000050	<0.000034	<0.000034	<0.000034	<0.00010	<0.00025	<0.000050	0.000041	<0.000017	<0.000050	<0.000017	<0.000017	0.00002	
Calcium (Ca)Dissolved	mg/L	20.8	24.1	23.6	30.7	89.3	38.0	20.5	8.79	4.77	3.85	3.96	4.07	3.56	3.69	3.59	3.54	3.98	3.71	12.7	21.4	25.7	38.9	31.7	11.0	18.0	23.0	21.5	
Chromium (Cr)Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.00010	<0.010	<0.00050	<0.00010	<0.010	<0.0010	<0.0025	<0.0010	<0.0020	<0.0020	<0.00050	<0.0020	<0.0020	<0.0020	<0.0040	<0.0025	0.00052	0.0011	<0.0020	<0.00050	<0.0010	<0.0010	<0.0010	
Cobalt (Co)Dissolved	mg/L	<0.00030	<0.00030	<0.00030	<0.00030	0.00459	<0.010	<0.00050	0.00025	<0.010	<0.0010	<0.0025	<0.0010	<0.00060	<0.00060	<0.00050	<0.00060	<0.00060	<0.00060	0.0032	<0.0025	<0.00050	0.00036	0.00079	<0.00050	<0.00030	<0.00030	0.00074	
Copper (Cu)Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.00050	<0.010	<0.0010	0.00199	<0.010	<0.0020	<0.0050	<0.0020	<0.0020	<0.0020	<0.0010	<0.0020	<0.0020	<0.0020	<0.0020	<0.0050	0.0013	0.0023	<0.0010	0.0027	0.0012	<0.0010	<0.0010	
Iron (Fe)Dissolved	mg/L	<0.030	<0.030	0.031	<0.030	0.805	1.36	0.147	0.035	0.035	0.057	0.143	0.082	0.063	0.074	0.081	0.062	0.041	0.055	0.078	0.072	0.195	<0.030	0.156	0.052	<0.030	<0.030	0.266	
Lead (Pb)Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	0.000956	<0.050	<0.0010	0.000101	<0.050	<0.0020	<0.0050	<0.0020	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0020	<0.0050	<0.0010	<0.00050	<0.00050	<0.0010	<0.00050	<0.00050	<0.00050	
Lithium (Li)Dissolved	mg/L	<0.0050	0.0066	<0.0050	<0.0050	0.0304	<0.010	<0.050	<0.0050	<0.010	<0.050	<0.050	<0.050	<0.010	<0.010	<0.050	<0.010	<0.010	<0.010	<0.050	<0.050	<0.050	0.0055	<0.0050	<0.050	<0.0050	<0.0050	<0.0050	
Magnesium (Mg)Dissolved	mg/L	3.45	4.82	4.42	4.25	10.8	3.22	1.66	0.56	0.66	0.48	0.46	0.46	0.41	0.40	0.40	0.41	0.43	0.33	2.01	2.63	2.9	6.31	3.18	1.91	2.75	2.62	2.59	
Manganese (Mn)Dissolved	mg/L	0.0123	0.0345	0.0241	0.0486	0.136	0.209	0.106	0.048	0.0448	0.040	0.044	0.035	0.0346	0.0316	0.033	0.0239	0.0248	0.012	0.095	0.223	0.015	0.0416	0.196	0.027	0.00101	0.182	0.243	
Mercury (Hg)Dissolved	mg/L	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010		<0.00020	<0.000010		<0.00020	<0.00020	<0.00020	<0.000020	<0.000020	<0.00020	<0.000010	<0.000010	<0.000010	<0.00020	<0.00020	<0.00020	<0.000020	<0.000020	<0.000020	<0.000010	<0.000010	<0.000010	
Molybdenum (Mo)Dissolved	mg/L	0.0019	0.0011	0.0012	0.0020	0.00341	<0.030	0.0021	0.0058	<0.030	0.0059	0.0055	0.0042	0.0036	0.0035	0.0025	<0.0020	0.0044	0.0063	0.0051	<0.0050	<0.0010	0.0011	0.002	<0.0010	<0.0010	<0.0010	0.0026	
Nickel (Ni)Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	0.00729	<0.050	<0.0050	0.0028	<0.050	<0.010	<0.025	<0.010	<0.0020	<0.0020	<0.0050	<0.0020	<0.0020	<0.0020	<0.010	<0.025	<0.0050	0.0025	0.003	<0.0050	<0.0010	<0.0010	0.0029	
Phosphorus (P)Dissolved	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	0.63	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	
Potassium (K)Dissolved	mg/L	<2.0	<2.0	<2.0	<2.0	4.40	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.1	2.5	2.3	4.2	2.7	<2.0	<2.0	<2.0	<2.0	
Selenium (Se)Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.00010	<0.20	<0.0010	0.00075	<0.20	<0.0020	<0.0050	<0.0020	<0.0020	<0.0020	<0.0010	<0.0020	<0.0020	<0.0020	<0.0020	<0.0050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	
Silicon (Si)Dissolved	mg/L	4.28	5.00	5.08	4.77	2.99	6.30	4.93	3.38	3.23	3.23	3.34	3.18	3.17	3.14	3.22	3.01	3.37	3.36	3.41	3.26	1.6	1.23	1.96	0.435	0.429	0.982	1.34	
Silver (Ag)Dissolved	mg/L	<0.000020	<0.000020	<0.000020	<0.000020	<0.000010	<0.020	<0.000050	<0.000010	<0.010	<0.00010	<0.00025	<0.00010	<0.000040	<0.000040	<0.000050	<0.000040	<0.000040	<0.000040	<0.00010	<0.00025	<0.000050	<0.000020	<0.000020	<0.000050	<0.000020	<0.000020	<0.000020	
Sodium (Na)Dissolved	mg/L	21.3	10.4	9.2	7.0	181	181	13.5	87.7	144.0	160	157	156	148	154	157	152	163	163	100	165	33	16.9	74.6	<2.0	<2.0	19.9	38.1	
Strontium (Sr)Dissolved	mg/L	0.0938	0.180	0.146	0.133	1.24	0.230	0.189	0.081	0.0608	0.0626	0.0638	0.0666	0.0615	0.0619	0.0597	0.0601	0.0683	0.0608	0.0995	0.154	0.119	0.14	0.159	0.0285	0.0431	0.0787	0.0832	
Thallium (Tl)Dissolved	mg/L	<0.00020	<0.00020	<0.00020	<0.00020	<0.00010	<0.20	<0.00020	<0.00010	<0.20	<0.00040	<0.0010	<0.00040	<0.00040	<0.00040	<0.00020	<0.00040	<0.00040	<0.00040	<0.00040	<0.0010	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	
Tin (Sn)Dissolved	mg/L	<0.00050	<0.00050	<0.00050	<0.00050	<0.00010	<0.030	<0.030	0.00023	<0.030	<0.030	<0.030	<0.030	<0.010	<0.0010	<0.030	<0.0010	<0.0010	<										

Hillsborough Resources

Area		2 North			2 North			2 North			Barrier Pillar	Barrier Pillar	2 North			2 North		2 North			2 North		2 North	Barrier Pillar	Barrier Pillar
Target Zone		Sandstone			Sandstone			Sandstone			Sandstone	Sandstone	No. 1 coal seam			No. 1 coal seam		No. 1 coal seam			Mine void		Mine void	No. 1 coal seam	No. 1 coal seam
Sample ID	Units	QU-08-21G-S			QU-10-10-S			QU-10-11-S			QU-11-05-S	QU-11-09-S	QU-08-21G-D			QU-10-10-D		QU-10-11-D			QU-10-13-D		QU-11-03	QU-11-05-D	QU11-09-M
Date Sampled		06-Dec-2010	25-Jan-2011	11-Apr-2011	02-Dec-2010	22-Jan-2011	12-Apr-2011	19-Nov-2010	21-Jan-2011	15-Apr-2011	12-Apr-2011	14-Apr-2011	07-Dec-2010	25-Jan-2010	15-Apr-2011	23-Feb-2011	14-Apr-2011	05-Dec-2010	24-Feb-2011	12-Apr-2011	22-Feb-2011	11-Apr-2011	18-Jan-2011	26-Apr-2011	26-Apr-2011
Disolved Metals																									
Aluminum (Al)Dissolved	mg/L	<0.015	<0.0060	0.0083	0.0111	0.0037	<0.0030	<0.0030	0.0056	<0.0030	0.0089	0.0248	<0.030	<0.015	<0.015	0.017	<0.015	<0.015	<0.0060	<0.0060	0.0126	<0.0060	0.0034	<0.0060	0.0082
Antimony (Sb)Dissolved	mg/L	<0.00050	<0.00020	<0.00010	0.00016	<0.00010	<0.00010	0.00014	0.00012	<0.00010	<0.00010	0.00012	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00020	<0.00020	<0.00020	<0.00020	0.00063	<0.00020	<0.00020
Arsenic (As)Dissolved	mg/L	0.177	0.185	0.198	0.154	0.139	0.141	0.0013	0.0014	0.0026	0.126	0.127	0.0628	0.0647	0.0749	0.0452	0.0331	0.01050	0.0105	0.0091	0.03640	0.033	0.0044	0.011	0.0279
Barium (Ba)Dissolved	mg/L	0.246	0.068	0.241	0.24	0.19	0.22	0.122	0.117	0.146	0.165	0.04	1.250	1.090	2.070	0.849	1.060	0.183	0.2000	0.2350	0.0630	0.059	0.0216	0.0836	0.0753
Beryllium (Be)Dissolved	mg/L	<0.0025	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0050	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0010	<0.0010	<0.0010	<0.0010	<0.00050	<0.0010	<0.0010
Bismuth (Bi)Dissolved	mg/L	<0.0025	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0050	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0010	<0.0010	<0.0010	<0.0010	<0.00050	<0.0010	<0.0010
Boron (B)Dissolved	mg/L	1.70	1.89	1.79	0.93	0.89	0.77	0.081	0.064	0.158	0.375	1.430	3.370	3.510	3.100	0.289	0.282	0.243	0.34	0.35	1.10	1.060	2.180	0.58	1.08
Cadmium (Cd)Dissolved	mg/L	<0.000085	<0.000020	<0.000010	<0.000017	<0.000010	<0.000010	<0.000017	<0.000010	<0.000010	<0.000010	<0.000010	<0.000017	<0.000050	<0.000050	<0.000050	<0.000050	<0.000085	<0.000020	<0.000020	<0.000020	<0.000020	<0.000010	<0.000020	<0.000020
Calcium (Ca)Dissolved	mg/L	33.7	14.7	13.0	016	016	016	25.2	23.9	26.0	011	003	148.0	107.0	160.0	382.0	480.0	91.2	77.3	87.1	37.7	33.3	21.6	39.30	27.8
Chromium (Cr)Dissolved	mg/L	<0.0025	<0.00020	<0.00010	<0.00050	<0.00010	<0.00010	<0.00050	<0.00010	<0.00010	<0.00010	<0.00010	<0.0050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0025	<0.00020	<0.00020	<0.00020	<0.00020	<0.00010	<0.00020	0.00137
Cobalt (Co)Dissolved	mg/L	0.00072	<0.00020	0.00027	0.0001	0.0002	<0.00010	0.00079	0.00053	0.00056	<0.00010	<0.00010	0.00210	0.00149	0.00123	0.00213	0.00257	0.00094	0.00182	0.00138	0.00089	0.00057	<0.00010	0.00104	0.00258
Copper (Cu)Dissolved	mg/L	<0.0025	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0050	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0010	<0.0010	<0.0010	<0.0010	0.0048	<0.0010	<0.0010
Iron (Fe)Dissolved	mg/L	0.152	0.141	0.201	0.146	0.232	0.16	<0.030	0.057	0.487	0.30	<0.030	0.707	0.845	1.000	1.82	2.22	1.11	3.770	3.400	0.49	0.352	<0.010	0.283	1.14
Lead (Pb)Dissolved	mg/L	<0.00025	<0.00010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	0.00008	<0.000050	<0.00050	<0.00025	<0.00025	0.00028	<0.00025	<0.00025	<0.00025	<0.00010	<0.00010	0.000120	<0.00010	0.00078	<0.00010
Lithium (Li)Dissolved	mg/L	0.090	0.060	0.0729	0.048	0.043	0.046	0.0181	0.0148	0.0222	0.0358	0.0205	0.1910	0.1320	0.1850	<0.025	<0.025	<0.025	0.011	<0.010	<0.010	<0.010	<0.0050	<0.010	<0.010
Magnesium (Mg)Dissolved	mg/L	5.09	2.66	3.61	04.0	03.7	03.7	5.17	4.88	5.50	2.57	00.6	16.10	14.00	18.40	9.71	11.00	6.89	5.97	6.17	2.970	2.49	0.97	3.10	2.82
Manganese (Mn)Dissolved	mg/L	0.285	0.173	0.128	0.042	0.088	0.064	0.1190	0.0877	0.1730	0.048	0.017	0.842	0.9020	0.768	0.633	0.747	0.449	0.788	0.737	0.3600	0.3270	0.010	0.7370	1.47
Mercury (Hg)Dissolved	mg/L		<0.000010	<0.000010		<0.000010	<0.000010		<0.000010	<0.000010	<0.000010	<0.000010		<0.000010	<0.000010	<0.000010	<0.000010		<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Molybdenum (Mo)Dissolved	mg/L	0.00072	0.00068	0.000364	0.00255	0.00224	0.00175	0.00020	0.00016	0.00024	0.00177	0.00048	0.002230	0.001740	0.001190	0.00157	0.00180	0.00224	0.00167	0.00140	0.0022	0.00212	0.01030	0.006460	0.00902
Nickel (Ni)Dissolved	mg/L	<0.0025	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050	0.00154	0.00107	<0.00050	<0.00050	<0.00050	<0.0050	<0.0025	<0.0025	0.0029	0.0040	<0.0025	0.0015	0.0012	<0.0010	<0.0010	<0.00050	0.0026	0.0122
Phosphorus (P)Dissolved	mg/L	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.60	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)Dissolved	mg/L	4.8	4.0	3.8	3.0	3.1	02.9	<2.0	<2.0	<2.0	2.8	<2.0	9.8	8.8	10.5	6.2	7.2	2.7	3.2	3.2	2.80	2.7	1.3	3.4	2.8
Selenium (Se)Dissolved	mg/L	<0.00040	<0.00020	<0.00010	<0.00040	<0.00010	<0.00010	<0.00040	<0.00010	<0.00010	<0.00010	<0.00010	<0.00040	<0.00050	<0.00050	<0.00050	<0.00050	<0.00040	<0.00020	<0.00020	<0.00020	<0.00020	0.00028	0.00021	0.00048
Silicon (Si)Dissolved	mg/L	3.64	3.64	3.19	4.01	4.04	4.07	3.19	2.85	2.94	3.11	4.46	5.05	4.97	4.66	3.89	3.92	4.19	5.00	4.90	3.15	3.19	2.28	4.22	4.90
Silver (Ag)Dissolved	mg/L	<0.000050	<0.000020	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.00010	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000020	<0.000020	<0.000020	<0.000020	<0.000010	<0.000020	<0.000020
Sodium (Na)Dissolved	mg/L	210	152	103	063	070	051	07.9	08.0	12.2	058	0103	895.0	733.0	861.0	903	1090	333	357	394	340	333.0	323	332	447
Strontium (Sr)Dissolved	mg/L	0.557	0.268	0.351	0.26	0.25	0.25	0.246	0.226	0.286	0.21	0.05	2.190	1.980	2.910	3.530	4.220	0.813	0.679	0.766	0.347	0.306	0.203	0.2920	0.267
Thallium (Tl)Dissolved	mg/L	<0.00050	<0.00020	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00020	<0.00020	<0.00020	<0.00020	<0.00010	<0.00020	<0.00020
Tin (Sn)Dissolved	mg/L	<0.00050	<0.00020	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00020	<0.00020	<0.00020	<0.00020	<0.00010	<0.00020	<0.00020
Titanium (Ti)Dissolved	mg/L	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.011	0.013	<0.010	0.025	<0.020	<0.010	0.011	0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)Dissolved	mg/L	0.00192	0.00163	0.000328	0.00023	0.00033	0.00013	0.000199	0.000129	0.000100	0.000106	0.000110	0.006710	0.007200	0.003550	0.00052	0.00082	0.00178	0.001660	0.001610	0.000169	0.000136	0.00014	0.002160	0.00398
Vanadium (V)Dissolved	mg/L	<0.0050	<0.0020	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.010	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0020	<0.0020	<0.0020	<0.0020	0.0062	<0.0020	<0.0020
Zinc (Zn)Dissolved	mg/L	<0.015	<0.0060	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.030	<0.030	<0.015	<0.015	<0.015	<0.015	<0.015	<0.0060	<0.0060	<0.0060	0.0036	<0.0060	<0.0060

Results preceded by "<" are below the reported detection limits.

Results in blue exceed the CSR-AW guideline; yellow highlighted results exceed the Effluent Permit.

Results in gray shade were excluded from percentile calculations as described in Appendix C4.

^aBC Permit PE-07008: British Columbia Ministry of Environment Effluent Dischage Permit PE-07008 for Quinsam Coal Corporation, South Coal Mining Operation, amended September 10, 2010.

^bCSR-AW: British Columbia Environmental Management Act Contaminated Site regulation, Schedule 6, Aquatic Life (AW), October 4, 2010.

^cBC WQG-AL: British Columbia Ministry of Environment Water Quality Guidelines, Freshwater Aquatic Life, as at February 13, 2011.

^dBC WQG-AL is intended for surface waters, they are included for reference only.

^eBC WQG-AL total metal guidelines are compared to dissolved metals as they more accurately represent groundwater quality naturally emerging at a surface water interface. All metal guidelines are for total metals except Al, Ca and Fe.

^fReceiving water quality is modelled on Middle Quinsam Lake water quality. Hardness = 45 mg/L, pH = 7.5, Temperature = 10 C (assumed), Cl = 2 (assumed).

^gWorking guideline.

^hTemperature and/or pH dependant guideline.

ⁱHardness dependant guideline.

^kChloride dependant guideline.

Table B3: Groundwater Quality Data and Guidelines
2 North / 3 North and 5 South Groundwater Evaluation - Quinsam Mine

Area		5 South					2 North								2 North											
Target Zone		Mine sump					Mine sump								Mine sump											
Sample ID	Units	101 Panel					3 Mains								1 Mains											
Date Sampled		30-Jul-2009	22-Jun-2010	06-Dec-2010	17-Jan-2011	08-Mar-2011	05-May-2009	11-May-2009	19-May-2009	26-May-2009	01-Jun-2009	06-Dec-2010	17-Jan-2011	08-Mar-2011	17-Oct-2006	15-Nov-2006	14-Dec-2006	13-Feb-2007	19-Mar-2007	01-Aug-2007	13-Aug-2007	05-Sep-2007	02-Oct-2007	01-Nov-2007	28-May-2010	22-Sep-2010
Field Physical Tests																										
Field Alkalinity, Total (as CaCO3)	mg/L																									
Field Conductivity	uS/cm																									
Field Eh	mV																									
Field pH	pH																									
Field Temperature	C																									
Field Dissolved Oxygen (% Saturation)	%																									
Field Iron Species Tests																										
Field Dissolved Iron, Ferrous	mg/L																									
Field Dissolved Iron, Total	mg/L																									
Field Dissolved Iron, Ferric (calculated)	mg/L																									
Physical Tests																										
Colour, True	CU																									
Conductivity	uS/cm	4650	3270	2450	1530	1360	3340	3250	2340	3300	3350	2490	2340	2270	1730	1710	901	1300	1440	1590	1610	1710	1750	1740	2130	2820
Hardness (as CaCO3)	mg/L	894		208	126	85.8					1020	387	467	499					257						462	
pH	pH	7.74	7.82	8.02	7.77	7.97	7.59	7.72	8.04	7.76	7.75	8.03	7.73	7.95	7.88	8.19	7.70	7.88	8.26	8.28	8.31	8.23	7.99	7.81	8.21	8.00
Total Suspended Solids	mg/L	38.7									4.1								8.7						8	
Total Dissolved Solids	mg/L	3700									2320														1650	
TDS, Conductivity to TDS factor		0.7264									0.6164								0.6164						0.6164	
TDS, Calculated from conductivity	mg/L	3378									2065								888						1313	
Turbidity	NTU																									
Anions and Nutrients																										
Acidity (pH 4.5)	mg/L																									
Acidity (as CaCO3) (pH 8.3)	mg/L	12.9		2.2	11.3	11.5					18.5	5.6	10.9	11.1					<1.0						2.8	
Alkalinity, Total (as CaCO3)	mg/L	412	631	560	480	470		267	275	274	276	390	380	340	463	493	154	241	239	511	545	504	470	369	245	244
Ammonia as N	mg/L	0.799	0.553	0.40	0.30	0.24		<0.0050	<0.020	<0.0050	0.0087	0.14	0.15	0.090	0.0533	0.0147	<0.0050	<0.0050	0.0110						0.0156	<0.0050
Bromide (Br)	mg/L	<10									<8.3								<0.050						<0.50	
Chloride (Cl)	mg/L	214									24.8								4.49						11.6	
Fluoride (F)	mg/L	<0.3									<0.20								0.13						<0.20	
Nitrate (as N)	mg/L																									
Nitrite (as N)	mg/L																									
Nitrate + Nitrite (as N)	mg/L	0.89	<0.10	<0.02	<0.02	<0.02		<0.10	0.0054	<0.050	<0.050	0.04	0.04	0.02	<0.0050	<0.0050	0.0437	0.0338	0.0353						<0.050	
Total Kjeldahl Nitrogen	mg/L	0.98									0.38														0.114	
Total Nitrogen	mg/L																									
Ortho Phosphate as P	mg/L																									
Total Dissolved Phosphate As P	mg/L	<0.0020	<0.0020					<0.0020	0.0025	<0.0020	<0.0020				<0.020	<0.0020	<0.0020	<0.0020	<0.0020						<0.0020	<0.010
Total Phosphate as P	mg/L	<0.020	0.0065					<0.0020	0.0026	<0.0020	0.0023				0.097	0.0616	0.0060	<0.0020	0.016						<0.0020	<0.010
Sulfate (SO4)	mg/L	1990	1080	660	250	200		1750	1040	1690	1670	900	860	930	446	360	309	453	499	231	339	322	371	482	952	1320
Sulphide as S	mg/L																									
Total Sulphur (S)																										
Organic / Inorganic Carbon																										
Dissolved Organic Carbon	mg/L																									
Total Organic Carbon	mg/L																									
Total Metals																										
Aluminum (Al)Total	mg/L	<0.20	<0.20	0.039	0.044	0.029	<0.20	<0.20	<0.20	<0.20	<0.025	0.184	0.252	0.226	5.02		0.53	<0.20	<0.20	0.289	0.031	0.034	<0.025	0.052	0.067	<0.025
Antimony (Sb)Total	mg/L	<0.20	<0.20	<0.0005	<0.0005	<0.0005	<0.20	<0.20	<0.20	<0.20	<0.0025	<0.0005	<0.0005	<0.0005	<0.20		<0.20	<0.20	<0.20	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Arsenic (As)Total	mg/L	<0.20	<0.20	0.0033	0.0094	0.0108	<0.20	<0.20	<0.20	<0.20	<0.0025	0.0028	0.0013	0.0015	<0.20		<0.20	<0.20	<0.20	<0.0025	0.0026	0.0031	0.0033	0.0035	<0.0025	<0.0025
Barium (Ba)Total	mg/L	0.018	0.019	0.019	0.028	0.026	0.010	0.026	0.018	<0.010	<0.020	0.023	0.020	0.016	0.045		0.016	0.019	0.019	0.024	<0.020	0.030	0.024	<0.020	0.021	<0.020
Beryllium (Be)Total	mg/L	<0.0050	<0.0050	<0.0001	<0.0001	<0.0001	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0001	<0.0001	<0.0001	<0.0050		<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bismuth (Bi)Total	mg/L	<0.20	<0.20	<0.001	<0.001	<0.001	<0.20	<0.20	<0.20	<0.20	<0.001	<0.001	<0.001	<0.001	<0.20		<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B)Total	mg/L	1.21	1.54	1.67	2.18	1.85	0.98	1.00	0.83	0.97	1.00	1.07	1.28	1.02	1.07		0.54	0.61	0.66	0.92	1.05	1.06	1.01	0.96	0.93	1.06
Cadmium (Cd)Total	mg/L	<0.010	<0.010	<0.00001	<0.00001	0.00001	<0.010	<0.010	<0.010	<0.010	<0.000085	0.00003	<0.00001	<0.00005	<0.010		<0.010	<0.010	<0.010	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085
Calcium (Ca)Total	mg/L	309	128	64.6	39.1	29.3	361	349	282	352	352	126	143	170	92.7		56.8	74.8	87.8	40.0	31.9	55.0	59.9	96.0	146	240
Chromium (Cr)Total	mg/L	<0.010	<0.010	<0.001	<0.001	<0.001	<0.010	<0.010	<0.010	<0.010	<0.0050	<0.001	<0.001	<0.001	<0.010		<0.010	<0.010	<0.010	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Cobalt (Co)Total	mg/L	0.143	0.024	0.0025	0.0010	0.0007	<0.010	<0.010	<0.010	<0.010	0.0015	0.0040	0.0065	0.0026	<0.010		<0.010	<0.010	<0.010	0.0017	<0.0015	0.0017	0.0026	0.0022	0.0039	<0.0015
Copper (Cu)Total	mg/L	<0.010	<0.010	0.0008	0.0007	0.0024	<0.010	<0.010	<0.010	<0.010	<0.0050	0.0040	0.0045	0.0025	0.029		0.011	<0.010	<0.010	<0.0050	0.0152	<0.0050	<0.0050	0.0291	<0.0050	<0.0050
Iron (Fe)Total	mg/L	8.07	7.65	6.44	3.87	3.20	0.565	0.466	0.111	0.550	0.519	0.707	0.798	0.867	6.71		1.55	0.852	1.16	0.692	0.855	1.20	1.43	1.46		

Area		5 South					2 North								2 North											
Target Zone		Mine sump					Mine sump								Mine sump											
Sample ID	Units	101 Panel					3 Mains								1 Mains											
Date Sampled		30-Jul-2009	22-Jun-2010	06-Dec-2010	17-Jan-2011	08-Mar-2011	05-May-2009	11-May-2009	19-May-2009	26-May-2009	01-Jun-2009	06-Dec-2010	17-Jan-2011	08-Mar-2011	17-Oct-2006	15-Nov-2006	14-Dec-2006	13-Feb-2007	19-Mar-2007	01-Aug-2007	13-Aug-2007	05-Sep-2007	02-Oct-2007	01-Nov-2007	28-May-2010	22-Sep-2010
Dissolved Metals																										
Aluminum (Al)Dissolved	mg/L	<0.050	<0.20	0.004	<0.003	0.006	<0.025	<0.025	<0.20	<0.20	<0.025	0.187	0.030	0.021	<0.025	<0.025	<0.20	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Antimony (Sb)Dissolved	mg/L	<0.0050									<0.0025								<0.0025						<0.0025	
Arsenic (As)Dissolved	mg/L	<0.0050	<0.20	0.0017	0.0019	0.0050	<0.0025	<0.0025	<0.20	<0.20	<0.0025	0.0025	0.0007	0.0006	<0.0025	<0.0025	<0.20	<0.0025	<0.0025	<0.0025	<0.0025	0.0029	<0.0025	<0.0025	<0.0025	<0.0025
Barium (Ba)Dissolved	mg/L	<0.020	0.025	0.017	0.023	0.027	<0.020	0.030	0.020	<0.010	<0.020	0.025	0.019	0.016	0.024	0.024	0.015	<0.020	<0.020	0.023	<0.020	0.030	0.020	<0.030	<0.020	<0.020
Beryllium (Be)Dissolved	mg/L	<0.010	<0.0050	<0.0001	<0.0001	<0.0001	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0001	<0.0001	<0.0001	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Bismuth (Bi)Dissolved	mg/L																									
Boron (B)Dissolved	mg/L	1.18	1.55	1.88	1.80	1.72	0.98	0.99	0.83	0.95	1.00	1.22	1.03	0.95	1.01	1.03	0.53	0.62	0.65	0.98	1.09	1.08	0.99	0.97	0.92	1.04
Cadmium (Cd)Dissolved	mg/L	<0.00017	<0.010	0.00014	0.00004	<0.00001	<0.000085	<0.000085	<0.010	<0.010	<0.000085	0.00007	0.00008	0.00003	0.000363	<0.000085	<0.010	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085
Calcium (Ca)Dissolved	mg/L	307	130	69.9	42.4	27.9	362	347	288	350	350	129	153	163	86.8	65.3	51.8	76.1	86.4	42.0	33.2	57.0	59.7	94.5	151	251
Chromium (Cr)Dissolved	mg/L	<0.010	<0.010	<0.001	<0.001	<0.001	<0.0050	<0.0050	<0.010	<0.010	<0.0050	<0.001	<0.001	<0.001	<0.0050	<0.0050	<0.010	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Cobalt (Co)Dissolved	mg/L	0.148	0.025	0.0023	0.0009	0.0009	<0.0015	<0.0015	<0.010	<0.010	0.0016	0.0037	0.0057	0.0026	0.0035	0.0036	<0.010	0.0015	0.0023	0.0024	<0.0015	0.0018	0.0024	0.0021	0.0034	<0.0015
Copper (Cu)Dissolved	mg/L	<0.010	<0.010	0.0002	0.0011	0.0010	<0.015	0.0093	<0.010	<0.010	<0.0050	0.0030	0.0015	0.0008	<0.0050	<0.0050	<0.010	<0.0050	<0.0050	<0.0050	0.0117	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Iron (Fe)Dissolved	mg/L	0.130	3.82	2.75	0.019	1.17	<0.030	<0.030	<0.030	0.049	<0.030	0.436	<0.005	0.014	<0.030	<0.030	0.535	0.419	0.219	<0.030	<0.030	1.06	0.042	<0.030	<0.030	<0.030
Lead (Pb)Dissolved	mg/L	<0.0050	<0.050	<0.0002	<0.0002	<0.0002	<0.0025	<0.0025	<0.050	<0.050	<0.0025	<0.0002	<0.0002	<0.0002	<0.0025	<0.0025	<0.050	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Lithium (Li)Dissolved	mg/L	<0.050	<0.010	0.006	0.008	0.009	0.026	<0.025	0.017	0.027	<0.025	0.012	0.013	0.013	<0.025	<0.025	0.010	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025
Magnesium (Mg)Dissolved	mg/L	30.9	14.7	8.02	4.88	3.92	35.3	36.1	37.5	34.3	36.3	15.8	20.6	22.3	9.00	6.34	6.36	8.57	9.97	3.94	3.12	5.01	5.56	9.26	20.7	30.8
Manganese (Mn)Dissolved	mg/L	1.30	0.372	0.172	0.097	0.088	0.628	0.597	0.0300	0.639	0.583	0.122	0.206	0.132	0.203	0.102	0.0958	0.112	0.110	<0.0015	0.0775	0.116	0.126	0.133	0.285	0.328
Mercury (Hg)Dissolved	mg/L	<0.000020		<0.00002	<0.00002	<0.00005	<0.000020	<0.000020			<0.000020	<0.00002	<0.00002	<0.00005	<0.000020	<0.000020		<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000010	<0.000010
Molybdenum (Mo)Dissolved	mg/L	<0.010	<0.030	0.002	0.002	0.003	<0.0050	<0.0050	<0.030	<0.030	<0.0050	0.002	0.001	0.001	<0.0050	<0.0050	<0.030	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Nickel (Ni)Dissolved	mg/L	0.213	<0.050	0.004	0.002	0.001	<0.0050	0.0120	<0.050	<0.050	0.0062	0.006	0.011	0.007	0.0064	0.0067	<0.050	<0.0050	0.0052	<0.0050	0.0102	<0.0050	<0.0050	<0.0050	0.0063	<0.0050
Phosphorus (P)Dissolved	mg/L		<0.30		<0.005	<0.005			<0.30	<0.30		<0.005	<0.005	<0.005			<0.30									
Potassium (K)Dissolved	mg/L	9.9	8.6	6.25	5.47	4.84	3.5	3.7	3.5	3.6	4.2	4.44	4.30	3.69	4.4	3.0	<2.0	<2.0	2.1	2.9	2.3	3.5	3.0	3.7	2.6	3.5
Selenium (Se)Dissolved	mg/L	<0.010	<0.20	<0.0001	<0.0001	<0.0001	<0.0050	<0.0050	<0.20	<0.20	<0.0050	0.0002	<0.0001	0.0002	<0.0050	<0.0050	<0.20	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Silicon (Si)Dissolved	mg/L																									
Silver (Ag)Dissolved	mg/L	<0.00020	<0.010	<0.00002	<0.00002	<0.00002	<0.00010	<0.00010	<0.010	<0.010	<0.00010	<0.00002	<0.00002	<0.00002	<0.00010	<0.00010	<0.010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Sodium (Na)Dissolved	mg/L	908	722	486	367	276	422	462	259	476	449	440	462	308	337	357	173	210	222	331	367	357	344	320	331	434
Strontium (Sr)Dissolved	mg/L																									
Thallium (Tl)Dissolved	mg/L	<0.0020	<0.20	<0.00005	<0.00005	<0.00005	<0.0010	<0.0010	<0.20	<0.20	<0.0010	<0.00005	<0.00005	<0.00005	<0.0010	<0.0010	<0.20	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Tin (Sn)Dissolved	mg/L	<0.0050	<0.030	<0.005	<0.005	<0.005	<0.0025	<0.0025	<0.030	<0.030	<0.0025	<0.005	<0.005	<0.005	<0.0025	<0.0025	<0.030	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
Titanium (Ti)Dissolved	mg/L	0.017									<0.010								<0.010						<0.010	
Uranium (U)Dissolved	mg/L	<0.0020		<0.0001	<0.0001	<0.0001	<0.0010	<0.0010			<0.0010	0.0001	<0.0001	0.0001	<0.0010	<0.0010		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Vanadium (V)Dissolved	mg/L	<0.010	<0.030	<0.005	<0.005	<0.005	<0.0050	<0.0050	<0.030	<0.030	<0.0050	<0.005	<0.005	<0.005	<0.040	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030
Zinc (Zn)Dissolved	mg/L	0.0141	0.0052	<0.005	<0.005	<0.005	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	0.006	0.006	<0.025	<0.025	0.0085	<0.025	<0.025	<0.025	0.026	<0.025	<0.025	<0.025	<0.0050	<0.0050

Results preceded by "<" are below the reported detection limits.

Results in blue exceed the CSR-AW guideline; yellow highlighted results exceed the Effluent Permit.

Results in gray shade were excluded from percentile calculations as described in Appendix C4.

^a BC Permit PE-07008: British Columbia Ministry of Environment Effluent Discharge Permit PE-07008 for Quinsam Coal Corporation, South Coal Mining Operation, amended September 10, 2010.

^b CSR-AW: British Columbia Environmental Management Act Contaminated Site regulation, Schedule 6, Aquatic Life (AW), October 4, 2010.

^c BC WQG-AL: British Columbia Ministry of Environment Water Quality Guidelines, Freshwater Aquatic Life, as at February 13, 2011.

^d BC WQG-AL is intended for surface waters, they are included for reference only.

^e BC WQG-AL total metal guidelines are compared to dissolved metals as they more accurately represent groundwater quality naturally emerging at a surface water interface. All metal guidelines are for total metals except Al, Ca and Fe.

^f Receiving water quality is modelled on Middle Quinsam Lake water quality. Hardness = 45 mg/L, pH = 7.5, Temperature = 10 C (assumed), Cl = 2 (assumed).

^g Working guideline.

^h Temperature and/or pH dependant guideline.

ⁱ Hardness dependant guideline.

^k Chloride dependant guideline.

Area		2 North						2 North								2 North					Guideline and Permit Limits			
Target Zone		Mine sump						Mine sump								Mine sump					Effluent Permit PE-07008 ^a	BC CSR-AW ^{b, f}	BC WQG-AL ^{c, d, e, f}	BC WQG-AL ^{c, d, e, f}
Sample ID	Units	5 Mains						6 Mains								7 Panel						CSR-AW	30 day	Max
Date Sampled		01-Aug-2007	13-Aug-2007	05-Sep-2007	02-Oct-2007	01-Nov-2007	31-May-2010	17-Oct-2006	15-Nov-2006	14-Dec-2006	13-Feb-2007	19-Mar-2007	13-Aug-2007	02-Oct-2007	01-Nov-2007	17-Oct-2006	15-Nov-2006	14-Dec-2006	13-Feb-2007	19-Mar-2007		(freshwater) ²		
Field Physical Tests																								
Field Alkalinity, Total (as CaCO3)	mg/L																							
Field Conductivity	uS/cm																							
Field Eh	mV																							
Field pH	pH																							
Field Temperature	C																							
Field Dissolved Oxygen (% Saturation)	%																							
Field Iron Species Tests																								
Field Dissolved Iron, Ferrous	mg/L																							
Field Dissolved Iron, Total	mg/L																							
Field Dissolved Iron, Ferric (calculated)	mg/L																							
Physical Tests																								
Colour, True	CU																							
Conductivity	uS/cm	1590	2020	2080	1970	1640	1570	1050	1180	1240	1150	1210	1130	1070	1260	1000	1170	1420	1150	1190				
Hardness (as CaCO3)	mg/L						83.9					68.1								68.4				
pH	pH	8.28	8.41	8.37	8.18	8.36	8.20	8.07	8.35	8.34	8.29	8.22	8.38	7.94	8.18	8.06	8.32	8.21	8.15	8.21	6.0 - 8.5		6.5-9	NP
Total Suspended Solids	mg/L						<3.0					<3.0								<3.0	25		5	25
Total Dissolved Solids	mg/L						965																	
TDS, Conductivity to TDS factor												0.6164								0.6164				
TDS, Calculated from conductivity	mg/L											746								734				
Turbidity	NTU																					2		8
Anions and Nutrients																								
Acidity (pH 4.5)	mg/L																							
Acidity (as CaCO3) (pH 8.3)	mg/L						<1.0					1.1								1.4				
Alkalinity, Total (as CaCO3)	mg/L	511	679	707	695	592	580	390	400	338	357	360	378	358	387	342	365	394	353	361			NP	10 ^g
Ammonia as N	mg/L						0.189	0.0127	0.0320	0.114	0.0848	0.0650				0.107	0.127	0.167	0.181	0.169	1.0	11.3 ^h	1.85 ^k	12.7 ^k
Bromide (Br)	mg/L						<0.50					<1.3								<1.3				
Chloride (Cl)	mg/L						25.2					14								12.4		1500	150	600
Fluoride (F)	mg/L						<0.20					0.061								0.05		2 ⁱ	NP	0.2 ^j
Nitrate (as N)	mg/L																					400	3	32.8
Nitrite (as N)	mg/L																					0.2 ^k	0.02 ^k	0.06 ^k
Nitrate + Nitrite (as N)	mg/L						<0.050	0.0129	0.121	0.0384	0.0744	0.0987				0.100	0.0951	0.0175	0.0073	0.0288				
Total Kjeldahl Nitrogen	mg/L						0.15																	
Total Nitrogen	mg/L																							
Ortho Phosphate as P	mg/L																							
Total Dissolved Phosphate As P	mg/L						<0.0020	<0.0020	<0.0020	0.0027	<0.0020	0.0038				<0.020	<0.0020	0.0024	<0.0020	0.0024	0.03			
Total Phosphate as P	mg/L						0.0042	0.0111	0.0058	0.042	0.0032	0.0081				0.194	0.0042	0.0044	0.0035	0.0040				
Sulfate (SO4)	mg/L	233	47	11.1	64.0	115	239	170	202	299	262	260	197	191	248	209	244	345	269	268		1000	50	100
Sulphide as S	mg/L																					0.02		0.002 ^g
Total Sulphur (S)																								
Organic / Inorganic Carbon																								
Dissolved Organic Carbon	mg/L																							
Total Organic Carbon	mg/L																							
Total Metals																								
Aluminum (Al)Total	mg/L	0.240	0.028	0.083	<0.025	0.048	<0.025	<0.20		1.61	<0.20	<0.20	0.050	<0.025	0.047	<0.20		<0.20	<0.20	<0.20				
Antimony (Sb)Total	mg/L	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.20		<0.20	<0.20	<0.20	<0.0025	<0.0025	<0.0025	<0.20		<0.20	<0.20	<0.20				
Arsenic (As)Total	mg/L	<0.0025	0.0124	0.0047	0.0039	<0.0025	<0.0025	<0.20		<0.20	<0.20	<0.20	0.0043	0.0033	0.0045	<0.20		<0.20	<0.20	<0.20				
Barium (Ba)Total	mg/L	0.024	0.060	0.071	0.044	<0.020	0.040	0.032		0.042	0.032	0.033	0.024	0.028	<0.020	0.042		0.044	0.031	0.033				
Beryllium (Be)Total	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050		<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050		<0.0050	<0.0050	<0.0050				
Bismuth (Bi)Total	mg/L						<0.20	<0.20		<0.20	<0.20	<0.20				<0.20		<0.20	<0.20	<0.20				
Boron (B)Total	mg/L	0.93	1.34	1.24	1.23	1.17	1.06	0.86		0.82	0.82	0.87	0.93	0.82	0.98	0.71		0.95	0.80	0.83				
Cadmium (Cd)Total	mg/L	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.010		<0.010	<0.010	<0.010	<0.000085	<0.000085	<0.000085	<0.010		<0.010	<0.010	<0.010				
Calcium (Ca)Total	mg/L	40.1	26.1	30.6	24.6	18.2	28.1	22.5		34.2	21.7	24.6	22.4	23.1	27.7	30.9		33.9	21.6	24.1				
Chromium (Cr)Total	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010		<0.010	<0.010	<0.010	<0.0050	<0.0050	<0.0050	<0.010		<0.010	<0.010	<0.010				
Cobalt (Co)Total	mg/L	0.0017	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.010		<0.010	<0.010	<0.010	<0.0015	<0.0										

Area		2 North						2 North						2 North						Guideline and Permit Limits				
Target Zone		Mine sump						Mine sump						Mine sump						Effluent Permit PE-07008 ^a	BC CSR-AW ^{b, f}	BC WQG-AL ^{c, d, e, f}	BC WQG-AL ^{c, d, e, f}	
Sample ID	Units	5 Mains						6 Mains						7 Panel							CSR-AW	30 day	Max	
Date Sampled		01-Aug-2007	13-Aug-2007	05-Sep-2007	02-Oct-2007	01-Nov-2007	31-May-2010	17-Oct-2006	15-Nov-2006	14-Dec-2006	13-Feb-2007	19-Mar-2007	13-Aug-2007	02-Oct-2007	01-Nov-2007	17-Oct-2006	15-Nov-2006	14-Dec-2006	13-Feb-2007	19-Mar-2007		(freshwater) ²		
Dissolved Metals																								
Aluminum (Al)Dissolved	mg/L	<0.025	<0.025	0.036	<0.025	<0.025	<0.025	<0.025	<0.025	<0.20	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.20	<0.025	<0.025	0.5		0.05 ^h	0.1 ^h
Antimony (Sb)Dissolved	mg/L												<0.0025						<0.0025			0.2	NP	0.02 ^g
Arsenic (As)Dissolved	mg/L	<0.0025	0.0046	0.0046	0.0034	<0.0025	<0.0025	0.0029	0.0042	<0.20	<0.0025	<0.0025	0.0040	0.0030	0.0040	<0.0025	<0.0025	<0.20	<0.0025	<0.0025		0.05	NP	0.005
Barium (Ba)Dissolved	mg/L	0.023	0.058	0.072	0.049	<0.030	0.041	0.032	0.034	0.032	0.030	0.032	0.024	0.028	<0.020	0.041	0.039	0.043	0.030	0.033		10	1 ^g	5 ^g
Beryllium (Be)Dissolved	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050		0.053	0.0053 ^g	NP
Bismuth (Bi)Dissolved	mg/L																							
Boron (B)Dissolved	mg/L	0.97	1.35	1.27	1.23	1.17	1.09	0.86	0.92	0.87	0.78	0.84	0.91	0.83	0.98	0.68	0.81	0.94	0.77	0.85		50	NP	1.2
Cadmium (Cd)Dissolved	mg/L	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.010	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.010	<0.000085	<0.000085		0.0003	NP	0.000017 [†]
Calcium (Ca)Dissolved	mg/L	42.1	26.3	31.4	24.9	18.5	29.9	22.3	25.4	34.3	20.9	24.0	22.1	23.1	27.7	30.6	30.0	33.6	21.0	24.0			NP	4
Chromium (Cr)Dissolved	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050	<0.0050		0.01	NP	0.001 ^g
Cobalt (Co)Dissolved	mg/L	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.010	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.010	<0.0015	<0.0015		0.04	0.004	0.11
Copper (Cu)Dissolved	mg/L	<0.0050	0.0082	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050	<0.0050	0.0093	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050	<0.0050	0.02	0.02 [†]	0.002 [†]	0.006 [†]
Iron (Fe)Dissolved	mg/L	<0.030	<0.030	0.273	<0.030	<0.030	0.031	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	0.064	<0.030	<0.030	<0.030	<0.030	0.5		NP	0.35
Lead (Pb)Dissolved	mg/L	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.050	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.050	<0.0025	<0.0025	0.05	0.04 [†]	0.004 [†]	0.030 [†]
Lithium (Li)Dissolved	mg/L	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.010	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.010	<0.025	<0.025			0.096	0.87
Magnesium (Mg)Dissolved	mg/L	3.92	1.89	2.05	1.86	1.31	2.21	1.84	2.01	3.09	1.78	1.96	1.73	2.02	2.15	2.97	2.65	3.00	1.85	2.04				
Manganese (Mn)Dissolved	mg/L	0.0085	0.0334	0.0389	0.0352	0.0275	0.0562	0.0253	0.0178	0.0302	0.0235	0.0222	0.0302	0.0260	0.0249	0.0408	0.0450	0.0620	0.0528	0.0579			0.8 [†]	1.0 [†]
Mercury (Hg)Dissolved	mg/L	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000010	<0.000020	<0.000020		<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020		<0.000020	<0.000020		0.001	0.00002	NP
Molybdenum (Mo)Dissolved	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.030	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.030	<0.0050	<0.0050		10	1	2
Nickel (Ni)Dissolved	mg/L	<0.0050	0.0074	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.050	<0.0050	<0.0050	<0.0050	<0.0076	<0.0050	<0.0050	<0.0050	<0.050	<0.0050	<0.0050		0.25 [†]	NP	0.025 ^{g, †}
Phosphorus (P)Dissolved	mg/L									<0.30								<0.30			0.03			
Potassium (K)Dissolved	mg/L	2.9	2.2	2.7	2.0	<2.0	2.2	<2.0	<2.0	2.4	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0	2.1	<2.0	<2.0			NP	373 ^g
Selenium (Se)Dissolved	mg/L	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.20	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.20	<0.0050	<0.0050		0.01	0.002	NP
Silicon (Si)Dissolved	mg/L																							
Silver (Ag)Dissolved	mg/L	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.010	<0.00010	<0.00010		0.0005 [†]	0.00005 [†]	0.0001 [†]
Sodium (Na)Dissolved	mg/L	330	586	460	442	390	367	227	266	300	246	258	232	232	287	207	255	324	242	258				
Strontium (Sr)Dissolved	mg/L																							
Thallium (Tl)Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.20	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.20	<0.0010	<0.0010		0.003	0.0008 ^g	0.0003 ^g
Tin (Sn)Dissolved	mg/L	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.030	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.030	<0.0025	<0.0025				
Titanium (Ti)Dissolved	mg/L						<0.010						<0.010							<0.010		1	NP	2 ^g
Uranium (U)Dissolved	mg/L	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010		<0.0010	<0.0010		3	NP	0.3 ^g
Vanadium (V)Dissolved	mg/L	<0.030	<0.030	<0.030	<0.0050	<0.0050	<0.0050	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	<0.0050	<0.0050	<0.030	<0.030	<0.030	<0.030	<0.030			NP	0.006 ^g
Zinc (Zn)Dissolved	mg/L	<0.025	<0.025	<0.025	<0.025	<0.025	<0.0050	<0.025	<0.025	<0.0050	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.0050	<0.025	<0.025	0.2	0.075 [†]	0.0075 [†]	0.033 [†]

Results preceded by "<" are below the reported detection limits.

Results in **blue** exceed the CSR-AW guideline; yellow highlighted results exceed the Effluent Permit.

Results in gray shade were excluded from percentile calculations as described in Appendix C4.

^a BC Permit PE-07008: British Columbia Ministry of Environment Effluent Dischage Permit PE-07008 for Quinsam Coal Corporation, South Coal Mining Operation, amended September 10, 2010.

^b CSR-AW: British Columbia Environmental Management Act Contaminated Site regulation, Schedule 6, Aquatic Life (AW), October 4, 2010.

^c BC WQG-AL: British Columbia Ministry of Environment Water Quality Guidelines, Freshwater Aquatic Life, as at February 13, 2011.

^d BC WQG-AL is intended for surface waters, they are included for reference only.

^e BC WQG-AL total metal guidelines are compared to dissolved metals as they more accurately represent groundwater quality naturally emerging at a surface water interface. All metal guidelines are for total metals except Al, Ca and Fe.

[†] Receiving water quality is modelled on Middle Quinsam Lake water quality. Hardness = 45 mg/L, pH = 7.5, Temperature = 10 C (assumed), Cl = 2 (assumed).

^g Working guideline.

^h Temperature and/or pH dependant guideline.

ⁱ Hardness dependant guideline.

^k Chloride dependant guideline.

***Appendix B4 – Groundwater Quality
Percentiles 2 North and 5 South Parameters
of Concern***



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Appendix B4:

Water Quality Percentile Calculations

Statistical analysis of the data sets for each sample grouping (described in Section 5.1) was conducted to derive the 10th, 50th and 90th percentiles for selected parameters using the Standard method for percentile derivation. The percentile distributions are displayed graphically in Sections 5.2.2 and 5.2.3. The Standard method uses the following formulas to derive the percentiles for a data set:

$$V = f * x_{(k+1)} + (1-f) * x_k$$

and

$$f = (N+1)*p/100 - k$$

where

V is the percentile value (*i.e.*, concentration at a percentile),

p is the percentile,

N is the number of data points,

k be the largest integer less than or equal to $(N+1)*p/100$,

x_k is a data point of k order in the data set.

For non-detected results the detection limit value is used for statistical calculations, however where the reported detection limit is significantly elevated the result is excluded from the data set to avoid contributing a significant false bias to the data set. The excluded values are highlighted in grey shading in Table B3. In the 1 Mains (August 13, 2007) sample Zn was reported at 0.026 mg/L with a detection limit of 0.025 mg/L, this was suspected to be a spurious result due to the proximity to the detection limit and was therefore excluded from the statistical calculations.

Table B4: Groundwater Quality Percentiles 2 North and 5 South Parameters of Concern
2 North/ 3 North and 5 South Groundwater Evaluation - Quinsam Mine

B4-1

		2 North								
		mine water			No.1 Seam			Sandstone		
parameter	units	10 th Percentile	median	90 th Percentile	10 th Percentile	median	90 th Percentile	10 th Percentile	median	90 th Percentile
pH	mg/L	7.70	8.18	8.35	6.75	7.33	7.92	6.76	8.05	8.64
alkalinity	mg/L	243	379	590	102	234.5	330	78.2	154	213
conductivity	mg/L	1070	1595	3150	1790	3115	7720	166	376	1120
chloride	mg/L	6	14	81	349	847	2490	2	6.55	223
fluoride	mg/L	0.059	0.2	0.261	0.080	0.323	0.678	0.049	1.05	1.84
sulphate	mg/L	119	289	1280	9.90	54.5	90.3	2.2	13.6	46.3
D-Al	mg/L	0.024	0.025	0.027	0.006	0.015	0.0029	0.003	0.006	0.023
D-As	mg/L	0.0023	0.0025	0.0043	0.0091	0.0305	0.0738	0.0012	0.139	0.195
D-B	mg/L	0.69	0.97	1.20	0.24	0.462	3.49	0.06	0.888	1.87
D-Cd	mg/L	0.00006	0.000085	0.00008	0.00002	0.00005	0.00008	0.00001	0.00001	0.00007
D-Cu	mg/L	0.0018	0.0015	0.0100	0.0010	0.001655	0.0025	0.0005	0.0002	0.0022
D-Co	mg/L	0.0015	0.005	0.0035	0.0009	0.0025	0.0026	0.0001	0.0005	0.0008
D-Fe	mg/L	0.027	0.03	0.427	0.319	1.125	3.73	0.030	0.152	0.445
D-Mn	mg/L	0.020	0.062	0.537	0.465	0.7575	1.41	0.020	0.0878	0.261
D-Ni	mg/L	0.0050	0.005	0.0084	0.0012	0.00255	0.0115	0.0005	0.0005	0.0023
D-Se	mg/L	0.0002	0.005	0.0002	0.0002	0.00044	0.0005	0.0001	0.0001	0.0004
D-Zn	mg/L	0.005	0.025	0.007	0.006	0.015	0.006	0.003	0.003	0.006

Table B4: Groundwater Quality Percentiles 2 North and 5 South Parameters of Concern
2 North/ 3 North and 5 South Groundwater Evaluation - Quinsam Mine

B4-2

		5 South											
parameter	units	mine water			No.1 Seam			Quartz Diorite			Sandstone/Till		
		10 th Percentile	median	90 th Percentile	10 th Percentile	median	90 th Percentile	10 th Percentile	median	90 th Percentile	10 th Percentile	median	90 th Percentile
pH	mg/L	7.48	7.795	7.98	8.21	8.525	8.58	6.76	7.03	7.84	8.01	8.16	9.17
alkalinity	mg/L	378	475	577	262	328.5	333	114	157	218	90	95.2	105
conductivity	mg/L	1330	1990	3610	412	593	671	233	320	555	122	137.5	199
chloride	mg/L	125	125.25	125	5.1	7.845	10.6	0.55	0.59	2.11	0.6	0.62	0.6
fluoride	mg/L	0.503	0.505	0.503	2.51	2.615	4.28	0.122	0.267	0.664	0.03	0.0375	0.049
sulphate	mg/L	235	527	1310	2.8	3.845	10.8	12.5	57.4	89.9	6.8	6.675	6.8
D-Al	mg/L	0.003	0.013	0.035	0.010	0.0105	0.050	0.037	0.062	0.037	0.005	0.00505	0.013
D-As	mg/L	0.0017	0.005	0.0340	0.0074	0.0302	0.0530	0.0025	0.00269	0.0025	0.0047	0.00543	0.0075
D-B	mg/L	1.05	1.635	1.82	3.39	3.485	4.73	0.12	0.19	0.38	0.10	0.1	0.10
D-Cd	mg/L	0.000010	0.00009	0.00015	0.000034	4.2E-05	0.000038	0.00005	5.8E-05	0.00005	0.000017	1.7E-05	0.000017
D-Cu	mg/L	0.0003	0.00345	0.0011	0.0020	0.0006	0.0020	0.0015	0.0005	0.0015	0.0010	0.0003	0.0010
D-Co	mg/L	0.0008	0.00105	0.0556	0.0004	0.002	0.0024	0.0003	0.00199	0.0003	0.0003	0.001	0.0003
D-Fe	mg/L	0.094	0.988	3.01	0.030	0.0625	0.133	0.035	0.147	1.36	0.030	0.03	0.030
D-Mn	mg/L	0.093	0.154	0.602	0.01	0.0338	0.042	0.048	0.106	0.209	0.013	0.0293	0.044
D-Ni	mg/L	0.001	0.00565	0.110	0.002	0.0035	0.003	0.004	0.005	0.004	0.001	0.001	0.001
D-Se	mg/L	0.0001	0.0001	0.0001	0.0020	0.002	0.0020	0.0009	0.001	0.0009	0.0010	0.001	0.0010
D-Zn	mg/L	0.005	0.0051	0.010	0.005	0.005	0.005	0.003	0.005	0.005	0.005	0.005	0.005

Appendix C: Geochemical Evaluation

Appendix C1 – Column Sample Characterization

Appendix C2 – Laboratory Methods

Appendix C3 – Mineralogy

Appendix C4 – kinetic Test Data



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Appendix C1 – Column Sample Characterization



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Appendix C1:

Column Sample Characterization

C1.1 Sample Description

Samples for kinetic testing of the No. 1 Coal Seam were obtained in the 5 South mine from channel samples in the coal face. Samples for Col4, Col5 and Col6 were sampled from the west end of the 10 Mains B Road, on the updip extent of the existing workings (Figure 6-1). The rider parting sample 26-01-A in Col7 was obtained from the 106 Panel, A Road, 6 x-cut. Samples from distinct stratigraphic intervals were collected in proportions representing the lithologic units within the No. 1 Coal Zone (Table C1-1) and were combined into 2 separate composite samples to evaluate the geochemical characteristics of raw coal and coal processing byproducts:

- *Rider Seam*: from 0.19 m of mudstone in the roof of the Rider Seam to the base of the No.1 Main Seam (including the Middle Parting), samples A to E; and
- *Rider Parting*: from the Rider Parting at the base of the Rider Seam to the base of the No.1 Main Seam, samples C to E.

Samples were placed in sealed 20 L buckets, palletized and transported to Birtley Coal and Minerals for processing. Coal processing byproducts were simulated by separating the raw coal samples by particle size and density. The raw composite samples were screened to obtain four size fractions, including 1) + 1/4", 2) 1/4" x 28 Mesh, 3) 28 Mesh x 100 Mesh and 4) 100 Mesh x 0. A float sink analysis was conducted on the 3 coarse size fractions at a 1.60 specific gravity. The float fraction represents the clean coal product and the sink fraction represents the coarse reject.

Kinetic testing includes saturated and unsaturated columns (Table C1-1 and C1-2). Unsaturated column testing is being conducted on the following 4 samples:

- Col 4: raw coal composite sample 91945 (samples A – E);
- Col 5: coarse reject (+100 Mesh 1.60 Sink), composite sample 91945 (samples A – E);
- Col 6: coarse reject (+100 Mesh 1.60 Sink), composite sample 91946 (samples C – E); and
- Col 7: high sulphur coarse reject (+100 Mesh 1.60 Sink), sample 26-01-A Rider 1.04 m.

Saturated column testing is being conducted on a split sample of coarse reject used for Col 5:

- HQB: coarse reject (+100 Mesh 1.60 Sink) from composite sample 91945 (samples A – E).

Table C1-1:
Composite Sample Intervals Selected from 10 Mains B Channel for 5 South Kinetic Tests.

Lithology	Sample			Seam Designation	Col 4	Col 5 /HQB	Col 6	Col 7
	ID	From (m)	To (m)					
Rider Roof Mudstone	"A"	0	0.19	Rider Roof Dilution				
No. 1 Rider Coal Seam	"B"	0.19	0.7	1 Rider Seam				
Rider Parting	"C"	0.7	1.49	Rider Parting				*
No. 1 Main Coal Seam	"D"	1.49	2.89	1 Main Seam (Upper)				
	"E"	2.89	3.99	1 Main Seam (Middle) includes Middle Parting				
1 Seam Floor Dilution								

Notes: * Col 7 consists of sample 26-01-A-Rider 1.04 m from a channel sample in the 5 South mine workings. The sample is exclusively from the Rider Parting interval.

Table C1-2:
Summary of Samples Selected for 5 South Kinetic Tests.

Test	Sample	Material	Process	Stratigraphic Interval
<i>Unsaturated Columns</i>				
Col 4	91945	raw coal		Rider Seam roof to base of No.1 Seam
Col 5	91945	coarse reject	+100 Mesh 1.60 sink	Rider Seam roof to base of No.1 Seam
Col 6	91946	coarse reject	+100 Mesh 1.60 sink	Rider Parting to base of No.1 Seam
Col 7	26-01-A Rider 1.04m	High S coarse reject	+100 Mesh 1.60 sink	Rider Parting
<i>Saturated Column</i>				
HQB*	split from #5	coarse reject	+100 Mesh 1.60 sink	Rider Seam roof to base of No.1 Seam

The composite test samples selected for kinetic testwork were sent to SGS Laboratories in Burnaby, BC for solids analyses, including acid-base accounting (ABA), solid-phase elemental determination by aqua-regia digestion and mineralogical determination, including Rietveld refined XRD and petrographic investigation and SEM.

Kinetic testing was undertaken to evaluate the drainage chemistry and geochemical loading rates from raw coal and coarse reject. Unsaturated trickle leach columns were constructed to simulate drainage chemistry from exposed raw coal and subaerial

stockpiled coarse reject. A saturated column experiment was constructed to simulate drainage chemistry from submerged coarse reject. A summary of the kinetic test set-up and operating procedures is provided in Table C1-3.

Table C1-3:
Summary of 5 South Kinetic Test Set-Up and Procedures.

Test	Column Dimensions		Column Packing		Current Flushing Rate / Weekly Input (mL) ¹	Temp (°C)	Start-Up Date	Operation Procedure	Sample Prep before flushing
	Inner Diam. (cm)	Length (cm)	Ht. of Sample (cm)	Dry Wt. of Sample (kg)					
Unsaturated Columns									
Col 4	14	38	32	5	1000	20-22	24-Jun-09	Trickle Leach	none
Col 5	14	38	24	5	1000	20-22	24-Jun-09		none
Col 6	14	38	24	5	1000	20-22	24-Jun-09		none
Col 7	14.5	41	21	5	1000	20-22	10-Mar-10		none
Saturated Column									
HQB ²	15	20	19.5	4.83	1400	20-22		Saturated, vertical flow upwards	none

Notes: 1. Flushing rates/weekly inputs were increased from 300 mL to 1000 mL to increase the dilutionary capacity of the rinse water and avoid precipitation of gypsum, which would removal Ca and sulphate from solution and potentially underestimate the sulphate mass released via sulphide oxidation.
2. Additional details of the saturated column set-up and procedures for HQB at Lorax are provided in Lorax 2011b.

The unsaturated column leaching method was changed at cycle 30 by increasing the volume of water added to the column each cycle from 300 ml to 1000 mL after cycle 10. resulted in more dilute leachate solutions that are not saturated with respect to gypsum and allowed for the estimation of sulphide oxidation rates and NP depletion rates.

6.1.2.2 Evaluation of the 5 South Kinetic Test Solid Phase

A summary of the solid phase evaluation for the kinetic test samples, including ABA results and aqua regia solid phase determination, are provided below.

Acid Generating Potential

Acid-base-accounting results for the 5 South kinetic test samples are presented in Table C1-4. The paste pH of the raw coal and coarse reject samples are neutral to slightly acidic (6.5 to 7.3). Total sulphur values for the raw coal and coarse reject samples for the kinetic tests are high, ranging from 1.15 %S in the Main Seam and Rider Parting (Col 6) up to 4.0 %S in the high sulphur Rider Parting sample (Col 7). Sulphur from the 5 South area is predominately present as sulphide (pyrite), as indicated by quantitative phase analysis, and is used to calculate acid potential (AP) for ARD predictions.

Table C1-4:
Acid base Accounting Results for 5 South Kinetic Tests.

Parameter	Unit	Col 4 Roof to base of Main Seam raw coal	Col 5 / HQB Roof to base of Main Seam CCR	Col 6 Rider Parting & Main Seam CCR	Col 7 Rider Parting high S CCR
Paste pH		6.6	6.5	6.7	7.3
Total S	%	1.52	2.13	1.15	4.01
Sulphate S	%	0.1	0.16	0.11	0.02
Sulphide S	%	1.24	2.12	1.08	3.99
Organic S	%	0.18	0.005	0.005	-
AP	kg CaCO ₃ /t	38.8	66.3	33.8	124.7
Total C	%	45.9	12.4	11.1	14.9
TIC	%	0.68	1.04	1.2	0.71
Organic C	%	45.2	11.4	9.9	14.2
CaNP	kg CaCO ₃ /t	56.7	86.7	100	59.2
Modified NP	kg CaCO ₃ /t	41.5	46.1	52.1	31.4
NPR (Modified NP/AP)		1.1	0.7	1.5	0.3

Notes: AP = calculated from pyritic (sulphide) sulphur * 31.25;
CaNP calculated from total inorganic carbon (TIC); and
Modified NP is corrected for siderite content

Neutralization potential (NP) in the 5 South kinetic test samples are low to moderate (< 100 kg CaCO₃/L). The highest NP values are indicated for Col 6, which contains the lowest total and sulphide sulphur values. Due to the presence of siderite in the 5 South coarse reject samples, modified NP, which is corrected for siderite content, is conservatively applied to ARD predictions for the 5 South samples. Fe-bearing carbonates, such as siderite, do not neutralize acidity as efficiently as calcite; and as a result, CaNP values tend to overestimate the amount of available NP.

NPR values of < 2.0 were consistently observed for the 5 South kinetic test samples, indicating that the raw coal and coarse reject from the No. 1 Coal Zone are PAG and that subaerial storage of these waste products or extended exposure in underground mine workings will eventually produce acidic drainage if not flooded to limit the rate of sulphide oxidation.

NPR values of < 2.0 are consistent with previous geochemical evaluations of exploration core samples in the 5 South area. However, sulphur content varies throughout the Phase II area for the No.1 Main Seam, Rider Parting and Rider Seam; therefore, portions of the coarse reject may be non-PAG (Section 6.1.1). The samples selected for kinetic testing provide a conservative estimate of drainage quality for the raw coal and coarse reject produced during mining of the 5 South Phase II area.

Solid-Phase Elemental Analyses

Solid phase Bi and Se are consistently enriched in the 5 South kinetic test samples with respect to average metal concentrations of the earth's crust (Table C1-5). Copper and Hg are also enriched in the raw coal (Col 4) and the coarse reject samples from the Rider Parting and Main Seam (Col 6 and Col 7); and As is enriched in the Rider Parting (Col 7). In general, metal concentrations are highest in the high sulphur coarse reject from the Rider Parting (Col 7).

Table C1-5:
Elemental Concentrations and Average Abundance in the Earth's Crust¹

Element	Unit	Col 4 Rider roof to base of Main Seam raw coal	Col 5/HQB Rider roof to base of Main Seam CCR	Col 6 Rider Parting and Main Seam CCR	Col 7 Rider Parting high S CCR	T2 Rider roof to base of Main Seam tailings	Av. Crust ²
Ag	ppb	83	41	90	83	43	75
Al	%	1.71	0.77	1.78	0.69	0.42	8.23
As	ppm	4	3.2	3.6	48	3.4	1.8
Ba	ppm	26.7	22.1	25.6	40.1	43.7	425
Bi	ppm	0.04	0.04	0.04	0.03	0.04	0.17
Ca	%	2.04	1.74	2.3	1.24	6.42	4.15
Cd	ppm	0.14	0.08	0.16	0.25	0.15	0.15
Co	ppm	44.8	25.8	48.9	69.9	18.3	25
Cr	ppm	61.9	32.3	71.8	44.8	18.6	102
Cu	ppm	222.25	101.65	235.5	264.41	67.65	60
Fe	%	5.55	2.53	5.2	4.33	1.31	5.63
Hg	ppb	386	194	379	499	130	80
K	%	0.02	<0.005	0.02	0.03	<0.005	2.085
La	ppm	9.7	5.8	11.4	9.3	4.2	39
Mg	%	0.5	0.23	0.55	0.23	0.13	2.33
Mn	ppm	555	230	563	211	226	950
Mo	ppm	0.2	0.26	0.09	0.32	0.43	1.5
Na	%	0.06	0.03	0.062	0.044	0.023	2.355
Ni	ppm	78.7	41.3	87.2	116.8	27.4	84
P	%	0.023	0.022	0.022	0.017	0.043	1050
Pb	ppm	2.15	1.53	2.21	1.71	3.66	12.5
S	%	2.1	1.16	1.13	3.54	0.55	0.035
Sb	ppm	<0.01	0.03	<0.01	0.04	0.21	0.2
Sc	ppm	19.2	9.5	21.2	19.1	5.6	22
Se	ppm	1	0.6	1	1.7	0.7	0.05
Sr	ppm	79.2	82.7	71.9	34	110.9	375
Th	ppm	0.8	0.4	0.9	0.7	0.4	9.6
Ti	%	0.006	0.011	0.006	0.012	0.01	0.565
Tl	ppm	<0.01	<0.01	<0.01	0.14	<0.01	0.001
U	ppm	0.2	0.2	0.1	0.2	0.2	2.7
V	ppm	150	70	153	173	71	120
Zn	ppm	86.5	53.6	102.6	172.1	65.1	70

Notes: 1. Shaded values exceed the average continental crust concentration by three times; and
2. Average continental crustal abundances according to Price (1997). Bold values are from CCR (1985).

Shake Flask Extractions

The water soluble constituents of individual samples used in composite samples 91945 and 91946 for 5 South kinetic test samples were determined using a shake flask extraction (SFE) method (Table C1-6). SFE measures geochemical parameters readily leached by water, and are used in conjunction with other static test results to evaluate the potential for ARD/ML. Weathered core samples were used rather than recently extracted core and provides a better assessment of elemental constituents that may be released to infiltrating waters that come into contact with the strata exposed in the underground mine.

The results of the SFE are consistent with the ABA results, which indicate that the greatest metal leaching risk is posed by the PAG strata comprising the roof strata adjacent to the Rider Seam and the Rider Parting (Samples “A” and “B”). Samples from both of these stratigraphic intervals released SFE leachate with pH < 4 (high acidity) which correspond with elevated concentrations of Al and Fe (Table C1-6). Under these acidic conditions numerous elements are elevated above British Columbia water quality guidelines (BC WQG) for the protection of freshwater aquatic life, including As, Cd, Cr, Co, Cu, Mn, Ni, Se, Ag, V and Zn.

Although ABA data indicate that the Rider Seam is also PAG, the Rider Seam sample (Sample “C”) contains sufficient NP to produce pH-neutral SFE leachate. Under these conditions, all metal concentrations, except Cd and Se, were below their respective guidelines. This result implies that metal leaching proceeds slowly and these elements are relatively immobile at neutral pH. SFE leachate from the No. 1 Main Seam was also pH-neutral with generally low elemental concentrations.

Table C1-6:
Shake Flask Extraction Results for Samples A – E (Hole QU-06-01) Used in
Composite Samples 91945 (Col 4 and Col 5/HQB) and 91946 (Col 6) for 5 South
Kinetic Tests.

Parameter	Unit	"A" Rider Roof Mudstone	"B" Rider Roof Mudstone	"C" 1 Rider Seam	"D" Rider Parting	"E" 1 Main Seam (upper)	BC WQG Max
pH		4.0	2.6	7.3	4.8	7.7	
Redox	mV	436	419	187	313	259	
Conductivity	uS/cm	2322	4760	1880	1035	215	
T-Acidity (pH 8.3)	mg CaCO ₃ /L	175	3188	7.9	30.7	5.1	
Alkalinity	mg CaCO ₃ /L	#N/A	#N/A	33.8	0.2	54.7	
Sulphate	mg/L	1980	4880	1562	650	80	
Hardness	mg CaCO ₃	1580	1570	1460	465	108	
Al	mg/L	9.7	145	0.057	0.75	0.13	0.1
Sb	mg/L	0.0001	<0.0004	<0.0001	0.00003	0.00008	0.02
As	mg/L	0.0023	0.020	0.0002	0.00035	0.00013	0.005
Ba	mg/L	0.013	0.0025	0.025	0.046	0.033	5
Be	mg/L	0.0021	0.0074	<0.00005	0.00045	<0.00001	
Bi	mg/L	<0.00003	<0.0001	<0.00003	<0.000005	<0.000005	
B	mg/L	0.56	<1	0.37	1.31	0.27	1.2
Cd	mg/L	0.0073	0.0111	<0.00003	0.0008	0.00003	0.00003
Ca	mg/L	532	433	573	165	41.9	
Cr	mg/L	0.0107	0.907	<0.0005	0.0019	<0.0001	0.001
Co	mg/L	1.5	1.12	0.0051	0.408	0.002	0.11
Cu	mg/L	0.77	5.86	0.002	3.14	0.0021	0.011
Fe	mg/L	25	1020	0.009	3.26	0.005	0.35
Pb	mg/L	0.0003	0.0006	0.00011	0.00014	0.000089	0.003
Li	mg/L	0.058	0.26	0.006	0.04	0.001	0.87
Mg	mg/L	61.4	119	6.05	12.5	0.82	
Mn	mg/L	7.6	11.2	0.13	0.32	0.013	1.642
Hg	ug/L	<0.05	<0.2	0.09	0.01	<0.01	
Mo	mg/L	<0.0003	0.005	0.0004	<0.00005	0.00087	2
Ni	mg/L	3.15	3.16	0.019	0.68	0.0023	0.065
P	mg/L	<0.01	0.67	<0.01	0.005	0.006	
K	mg/L	1.91	<0.2	1.03	6.77	0.46	
Se	mg/L	0.014	0.0043	0.0033	0.0068	0.0016	0.002
Si	mg/L	6.85	18.8	<0.5	5.97	0.30	
Ag	mg/L	0.00011	0.0002	<0.00003	<0.000005	<0.000005	0.0001
Na	mg/L	46.9	0.5	10.3	49.1	4.2	
Sr	mg/L	1.93	0.84	0.87	1.47	0.13	
S	mg/L	600	1460	475	207	26	
Tl	mg/L	0.00012	0.0001	0.00002	0.00017	0.000002	0.0003
Sn	mg/L	<0.00005	<0.0002	<0.00005	<0.00001	<0.00001	
Ti	mg/L	<0.003	<0.01	<0.003	<0.0005	<0.0005	
U	mg/L	0.0015	0.0074	0.00005	0.000021	0.000009	0.3
V	mg/L	<0.001	0.70	<0.001	<0.0002	<0.0002	0.02*
Zn	mg/L	5.28	4.23	0.0009	0.91	0.0013	0.041
Zr	mg/L	<0.0005	<0.002	<0.0005	<0.0001	<0.0001	

Notes: Shaded values exceed the maximum British Columbia water quality guidelines (BC WQG) for protection of freshwater aquatic life;

* 30-day guideline

Appendix C2 – Laboratory Methods



HILLSBOUROUGH
Resources Limited



Canadian Environmental & Metallurgical Inc.

Test Procedures for Quinsam Coal Corp.

July 27, 2009

1.0 Sample Receiving

Samples were received, weighed and logged in.

2.0 Sample Preparation

Where necessary, samples were crushed in a jaw crusher to approximately 80% -1/4 inch. Each sample was mixed by passing through a 1/2 inch splitter box and recombining. A 200 g split was then made and pulverized in a ring pulverizer to 80% -200 mesh. Splits of the pulverized samples were then submitted for analysis.

3.0 Analysis

3.1 Paste pH

Paste pH was conducted according to the procedure by Sobek A., et. al. 1978 “Field and Laboratory Methods Applicable to Overburdens and Minesoils” (Report EPA-600/2-78-054).

3.2 Acid Base Accounting

Acid base accounting was conducting according to Method 3: Modification of Conventional EPA Neutralization Potential Determination by Addition of Hydrogen Peroxide. The procedure is outlined in MEND Project 1.16.1c, 1991.

Samples were also subjected to the modified ABA procedure outlined in outlined in MEND Project 1.16.1b, 1991.

3.3 Total Sulphur and Carbon

Total sulphur and carbon were determined by Assayers Canada Ltd. (for rush analysis) or Acme Analytical using a Leco furnace.

3.4 Sulphate-Sulphur

Acid-soluble sulphate was determined by Assayers Canada. In this procedure, the sample is digested with 20% hydrochloric acid and the sulphur content measured by ICP.

3.5 Sulphide-Sulphur

Sulphide-sulphur was determined by Assayers Canada Ltd. The procedure is based on a modified sulphide-sulphur method by Sobek, A. A., *et al.* 1978. “Field and Laboratory

Methods Applicable to Overburdens And Minesoils” Report EPA-600/2-78-054. In this procedure, acid-soluble sulphate is first removed by treatment with 20% hydrochloric acid. The sulphide-sulphur in the residue is oxidized to sulphate in a 1:7 nitric acid to water solution, and the sulphur content is then measured by ICP.

3.6 Insoluble Sulphur

Insoluble sulphur is calculated as the difference between total sulphur and the sum of sulphate-sulphur and sulphide-sulphur (Total S – Sulphate S + Sulphide S). Insoluble sulphur is acid insoluble sulphur which is attributed to refractory sulphate compounds such as barite and alunite and to organic sulphur found in coal.

3.7 Inorganic Carbon

Total inorganic carbon was determined by Assayers Canada Ltd. In this procedure, a known weight of sample is placed into a glass test tube and acidified with 25% hydrochloric acid. The sample is boiled to evolve CO₂ which is measured by coulometric titration with a UIC Carbon Dioxide Analyzer.

3.8 Total Metals

Total metals were conducted at Acme on the pulverized sample by digesting 0.500 g in aqua regia at 95°C for one hour. The extract is then diluted to 10.0 mL and analysed for metals by ICP-MS.

3.9 X-Ray Diffraction

Samples for were sent to Dr. Mati Raudsepp at the University of British Columbia for quantitative Rieveld X-ray diffraction.

3.10 Shake Flask Extraction

Shake flask extractions were conducted using a 3:1 liquid to solid ratio as described by W. A. Price “Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia”; British Columbia Ministry of Employment and Investment, Energy and Minerals Division.

The leachate was filtered through 0.45µm membrane filter paper and submitted for analysis. The pH was measured using the pH meter; conductivity was measured using the conductivity meter; acidity was determined by titration with base to an end point of either pH 4.5 (free acidity) and/or pH 8.3 (total acidity); alkalinity was determined by titration with an acid to an end point of pH 4.5; sulphate was measured by the turbidimetric method. Subsamples of the leachate were sent to Maxxam Analytics Inc. for metals analysis by ICP-

MS, chloride and fluoride analysis by ion selective electrode, nitrate analysis by colourimetry, and total dissolved solids by gravimetry.

3.11 Size Fraction Analysis

Samples for kinetic testing were screened using a Ro-Tap Sieve Shaker and Tyler ASTM Certified Test Sieves. Up to 7 screens were selected with opening sizes of 0.053mm, 0.150mm, 0.425mm, 1.70mm, 6.60mm, and 9.5mm, respectively.

3.12 Tailings Humidity Cell

Tailings Humidity Cell is made from acrylic tubing with an inside diameter of eight inches and a height of four inches. The cell has a fixed base plate with a leachate drainage hole fitted with a tubing nipple. A perforated PVC support plate is placed inside the cell, one inch above the base plate and covered with a Shark Skin® filter paper and one layer of 200 mesh nylon. Inflow of humid and dry air is through an air line placed on the cell through the top cover. The cell conforms and is operated according to procedure outlined in Acid Rock Drainage Prediction Manual. March 1991. The leachate was analysed as per the parameters described in Section 3.9

3.13 Column Tests

Columns were setup using 14.6 ID acrylic tubing with a drain hole fitted in the bottom. A perforated support plate rests on the column bottom separated by 0.6 cm spacers. To prevent loss of fines one layer of 200 mesh nylon is placed on the support plate. 4.5 to 5 kg of material is placed in the column. The columns are operated on continuous humid air and sampled weekly for analysis. Prior to the sampling day a minimum amount of water is trickled onto the surface in order to obtain sufficient leachate for analysis. The leachate was analysed as per the parameters described in Section 3.10.

Appendix C3 – Mineralogy



HILLSBOUROUGH
Resources Limited

7 May, 2011

Mr. Bruce Mattson
Lorax Environmental
2289 Burrard St.
Vancouver, BC
V6J 3H9

Re: 7South Samples

Dear Bruce:

I have examined the polished sections prepared from the samples that you submitted, and the petrographic report is attached.

The polished thin sections were prepared in the polishing lab of the Dept of Earth Sciences, UNB. The polished samples were carbon-coated (to ensure surface conductivity), and examined with a JEOL-6400 Scanning Electron Microscope (SEM). The examination was conducted using backscattered electron imaging (which gives compositional contrast), and the mineral phases present in each sample were identified by Energy-Dispersive X-ray Spectrometry (EDS) using an EDAX Genesis x-ray microanalyser. The electron images were collected with Digital Micrograph (Gatan Inc.). The images are backscattered electron images unless otherwise specified.

If you have any questions, please do not hesitate to contact me.

Best Regards,

Douglas C. Hall, Ph.D.
Senior X-ray Microanalyst

/dch

Petrographic Report on 7South samples

Prepared by:

**Douglas C. Hall, Ph.D.
Senior X-ray Microanalyst
Microscopy and Microanalysis Facility
University of New Brunswick
Fredericton, New Brunswick
E3B 5A3**

Comp1:

This sample predominantly consists of irregular lithic fragments comprising coarse, anhedral quartz grains in a very fine-grained kaolinite-rich matrix. Quartz (0.2-1.0 mm) is anhedral, and is equant to slightly elongate. Quartz grains have a dusty appearance in transmitted light, and exhibit weak undulatory extinction. As the quartz grains are coarse relative to the size of the lithic fragments (0.3-3.0 mm), many fragments consist of a single quartz grain with a thin rind of the fine-grained kaolinite-rich matrix. Larger lithic fragments consist of quartz grains set in a kaolinite-rich interstitial matrix. Coarse-grained K-feldspar is a very rare component of these lithic fragments.

The very fine-grained matrix is dominated by kaolinite (<5 μm) but locally, the matrix consists of a mix of kaolinite and illite. Fine-grained quartz and TiO_2 are also locally abundant in the matrix. A Ca-poor Mg-Fe carbonate (20-30 μm) is a rare matrix component, and represents a magnesite-siderite solid solution. Compositional heterogeneity of this carbonate (Mg versus Fe) is indicated by varied backscattered electron intensity. Compositions range from 30-47 wt.% FeO.

Fine- to medium-grained pyrite is of varied abundance in the matrix, ranging from trace amounts to locally exceeding 50 %. Pyrite (5-30 μm) is texturally varied. Relatively coarse-grained quartz (20-30 μm) is typically anhedral, and equant to slightly elongate. Many of these grains consist of an As-free core, mantled by a very thin rind (1-2 μm) of As-bearing pyrite (0.7-1.0 % As). More commonly, pyrite is equant (10-20 μm) and may exhibit a concentric structure. These grains may consist of a non-porous core of circular cross-section, with a very porous rim, or such a grain may also have a non-porous outer mantle, yielding a atoll-like structure. Much more rarely, pyrite exhibits a framboidal texture.

In one lithic fragment, grains of iron sulphide (FeS_2) occur as elongate blades (up to 10x50 μm). Based on their morphology, these grains may be marcasite.

Figure Captions:

Comp10001: Low magnification overview. The sample predominantly consists of consists of quartz (medium grey), kaolinite (dark grey), and pyrite (white).

Comp10002: Low magnification overview. The sample predominantly consists of consists of quartz (medium grey), kaolinite (dark grey), and pyrite (white).

Comp10003: Fine-grained pyrite (top right) and quartz and TiO_2 (bottom left). At top left and bottom-right is fine-grained kaolinite with minor illite and pyrite.

Comp10004: Fine-grained kaolinite mantling coarse quartz (bottom) with polygranular pyrite (top). The thin, brighter rind on the pyrite is As-bearing (As<1 wt.%).

Comp10005: K-feldspar (light grey) adjacent to coarse quartz (medium grey). The matrix consists of fine-grained kaolinite (dark grey) and minor pyrite (white).

Comp10006: Pyrite (white) set in a fine-grained matrix interstitial to quartz. The matrix consists of fine-grained kaolinite and minor illite.

Comp10007: Higher magnification image of concentric pyrite structures in Comp10006. The rare, fine equant grains are TiO_2 (medium grey).

Comp10008: Higher magnification image of elongate marcasite (?) in Comp10006.

Comp10009: Concentric pyrite structure set in a fine-grained kaolinite matrix. The light grey grains near the centre are TiO_2 . The light grey grain at bottom-right is Mg-Fe carbonate.

Comp10010: Concentric pyrite structure from Comp10009.

Comp10012: Fe-Mg carbonate patch, within which brightness is proportional to FeO content. An equant pyrite grain (white) at top-left contains 3.7% As, but other grains in this image are As-poor.

Comp10013: Pyrite in fine-grained kaolinite matrix. The thin, brighter rim contains 1.1% As.

Comp10014: Framboidal pyrite in kaolinite.

Comp2:

This sample is similar to Comp1, but carbonate is significantly more abundant in Comp2, and pyrite is significantly less abundant.

This sample predominantly consists of irregular lithic fragments (0.3-3.5 mm) comprising coarse quartz grains in a very fine-grained kaolinite-rich matrix. Quartz (0.2-0.8 mm) is anhedral and ranges from equant to slightly elongate. Quartz grains have a dusty appearance in transmitted light, and exhibit weak undulatory extinction. Many lithic fragments consist of a single quartz grain with a thin rind of the fine-grained kaolinite-rich matrix. Larger lithic fragments consist of quartz grains set in a kaolinite-rich interstitial matrix. Coarse-grained K-feldspar is more abundant than in Comp1, but is of minor abundance.

The matrix typically consists of very fine-grained kaolinite (<5 μm). Locally, the matrix also contains euhedral to subhedral calcite (10-100 μm), dolomite (10-30 μm), subhedral to anhedral K-feldspar (10-30 μm), or rarely magnesite-siderite (<10 μm ; 45 wt.% FeO).

Dolomite is typically Fe-bearing (approximately 15 wt.% FeO), and is more abundant than calcite.

Pyrite is less abundant than in Comp1. Pyrite (5-30 μm) is texturally varied, and ranges from euhedral cubes (5-10 μm), coarser subhedral to anhedral grains (10-30 μm), and rarely as concentric structures. Pyrite typically occurs as rare, discrete grains dispersed in the kaolinite matrix, but locally also as rare clusters of grains that may comprise up to 30% of the matrix.

Figure Captions:

Comp20001: Low magnification overview. The sample consists of anhedral quartz (medium grey) , fine-grained pyrite (white), and a fine-grained interstitial matrix of kaolinite (dark grey) and Fe-dolomite (light grey).

Comp20003: Low magnification overview, illustrating coarse, anhedral quartz with a fine-grained interstitial matrix of kaolinite. Also present are K-feldspar and Fe-dolomite (light grey), and pyrite (white).

Comp20004: Lithic fragment consisting of anhedral quartz with a thin mantle of Fe-dolomite and K-feldspar (light grey), and fine-grained kaolinite (dark grey).

Comp20005: Texturally-varied fine-grained pyrite in a fine-grained kaolinite matrix. Some pyrite grains have detectible arsenic contents (As=0.75 wt.%).

Comp20007: Coarse-grained calcite and fine-grained dolomite (light grey) together with fine-grained kaolinite (dark grey). The minor fine-grained phase (bright grey) is Fe-Mg carbonate.

Comp20008: Calcite and lesser dolomite (light grey) interstitial to quartz. The quartz is mantled by fine-grained kaolinite (dark grey).

Comp20009: Concentric pyrite structure.

Comp20010: Fine-grained kaolinite matrix (dark grey) with pyrite (white) and fine-grained Fe-Mg carbonate (light grey).

7South Tailings Comp:

This sample predominantly consists of coarse grains of quartz and less abundant K-feldspar in a fine-grained kaolinite matrix. Quartz grains are subhedral to anhedral (100-800 μm) and may rarely contain abundant inclusions of equant pyrite (5-20 μm). K-feldspar (300-500 μm) is anhedral to subhedral and slightly elongate, and may contain

fine-grained Fe-bearing dolomite inclusions (10-20 μm). Quartz and K-feldspar occur both as discrete grains and together in lithic fragments.

The fine-grained matrix is highly varied. It is typically dominated by fine-grained kaolinite (<5 μm), but may contain significant and highly varied amounts of fine-grained anhedral quartz (5-20 μm), framboidal pyrite (5-10 μm), anhedral calcite (5-20 μm), subhedral to euhedral pyrite (5-20 μm), subhedral Fe-dolomite (5-20 μm ; 15 wt.% FeO), or anhedral Mg-Fe carbonate (10-30 μm ; 40-45 wt.% FeO). Locally, any one of these minerals may be modally dominant. Lithic fragments consisting solely of the matrix, without coarse-grained quartz or K-feldspar, are relatively abundant.

Pyrite also occurs as discrete grains (<100 μm), or as monomineralic multi-granular fragments. Coarse grained calcite also occurs as discrete fragments, typically as elongate blade-like grains (100-300 μm), but also as slightly elongate anhedral grains. Dolomite rarely occurs as discrete blade-like grains (100-200 μm), which may exhibit compositional heterogeneity (4-14 wt.% FeO).

Framboidal pyrite is most abundant in association with coal fragments. The coal fragments are typically elongate, and are commonly mineralogically banded by alternating continuous or discontinuous layers of coal and kaolinite. Framboidal pyrite may be very abundant in some coal fragments, but they are not generally spatially related to the mineralogical layering.

Rare, very elongate blade-like grains of FeS_2 (10x120 μm) may represent marcasite.

Tennantite (10-20 μm) occurs as very rare subhedral, equant grains in the kaolinite matrix. The tennantite contains approximately 7 wt.% Zn.

Figure Captions:

7STC0001: Low magnification overview.

7STC0002: Low magnification overview.

7STC0003: Lithic fragment consisting of pyrite (white), Fe-dolomite (medium grey), and dolomite (dark grey).

7STC0004: Framboidal pyrite (white) in coal fragment (black), together with fine-grained kaolinite (dark grey).

7STC0005: Lithic fragment consisting of quartz (medium grey) with interstitial fine-grained kaolinite (dark grey), and minor pyrite (white). Light grey patches (lower left) consist of calcite.

7STC0006: Anhedral quartz with rind of fine-grained kaolinite (dark grey), framboidal pyrite (white), and fine-grained quartz (medium grey).

7STC0007: Fragment consisting of fine-grained kaolinite (dark grey) and coal (black).

7STC0008: Intergrowth of fine-grained pyrite (white) and quartz (medium grey).

7STC0009: Elongate calcite blades (light grey). A banded lithic fragment of kaolinite and coal is at left.

7STC0010: Elongate dolomite blade. Lighter shades of grey represent relative Fe-enrichment.

7STC0011: Coarse calcite (light grey) with kaolinite (dark grey) and fine-grained pyrite (white).

7STC0012: Coarse-grained pyrite fragment.

7STC0013: Coal fragment (white) with kaolinite (dark grey) and pyrite (white). Framboidal pyrite occurs in the lithic fragment at left.

7STC0014: Framboidal pyrite (white), together with fine-grained kaolinite (dark grey).

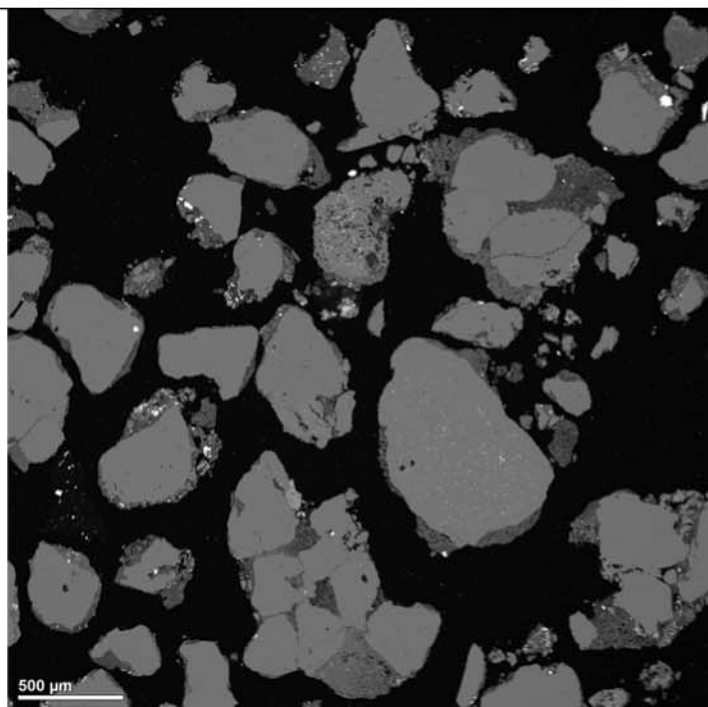
7STC0015: Lithic fragment of K-feldspar and quartz, with interstitial kaolinite (dark grey). The K-feldspar at right is partially replaced by fine-grained Fe-Mg carbonate (light grey), which also occurs in a vein at the top of the fragment.

7STC0016: Fine-grained As-sulphide (white) set in fine-grained kaolinite (dark grey).

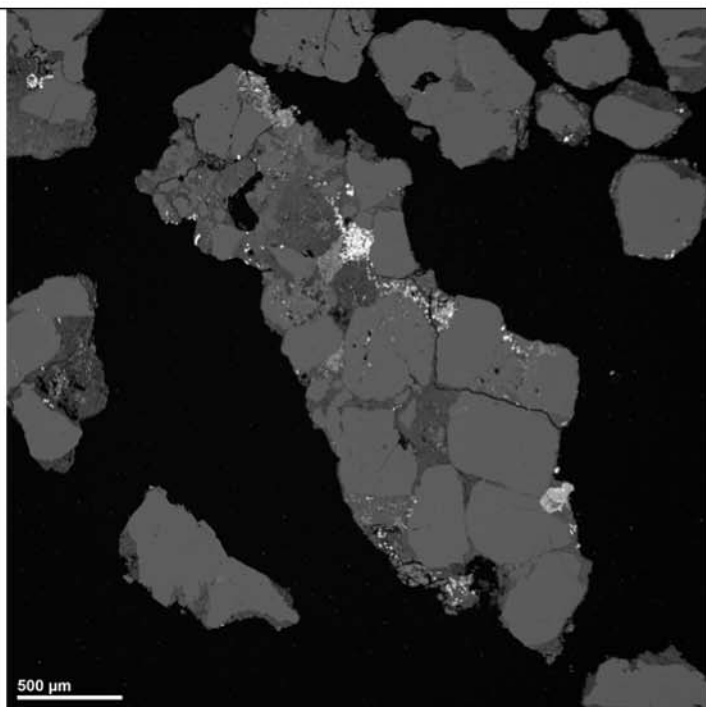
7STC0017: Fine-grained As-sulphide (white) with fine-grained kaolinite (dark grey), calcite (medium grey), and minor blades of chlorite (light grey).

7STC0018: Equant pyrite grains set in a very fine-grained matrix of euhedral pyrite.

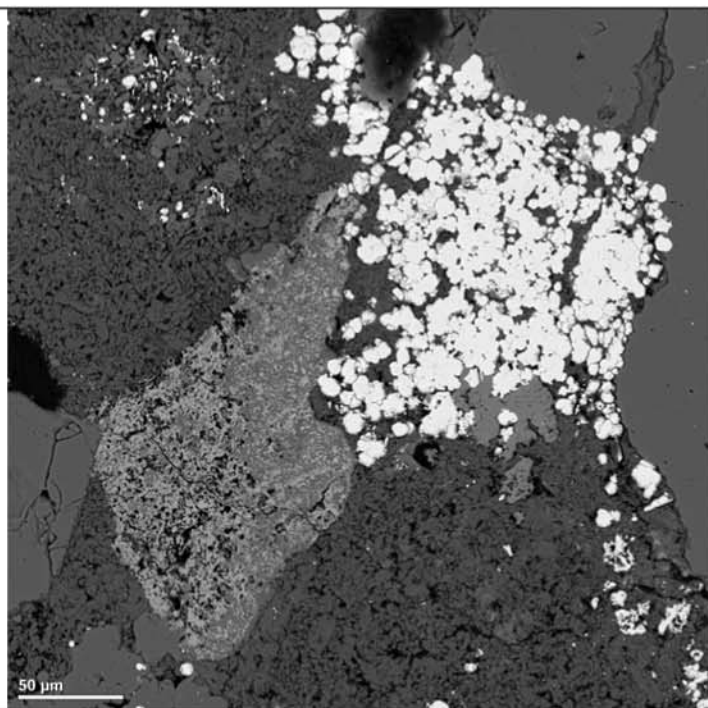
7STC0019: Carbonate-rich matrix consisting of pyrite (white), Mg-Fe carbonate (light grey), Fe-dolomite (medium grey), and kaolinite (dark grey).



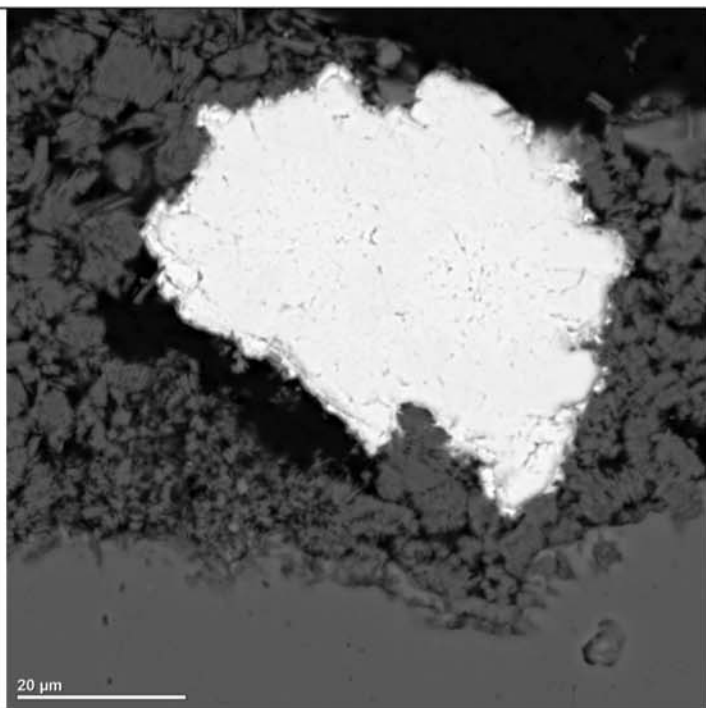
Comp10001



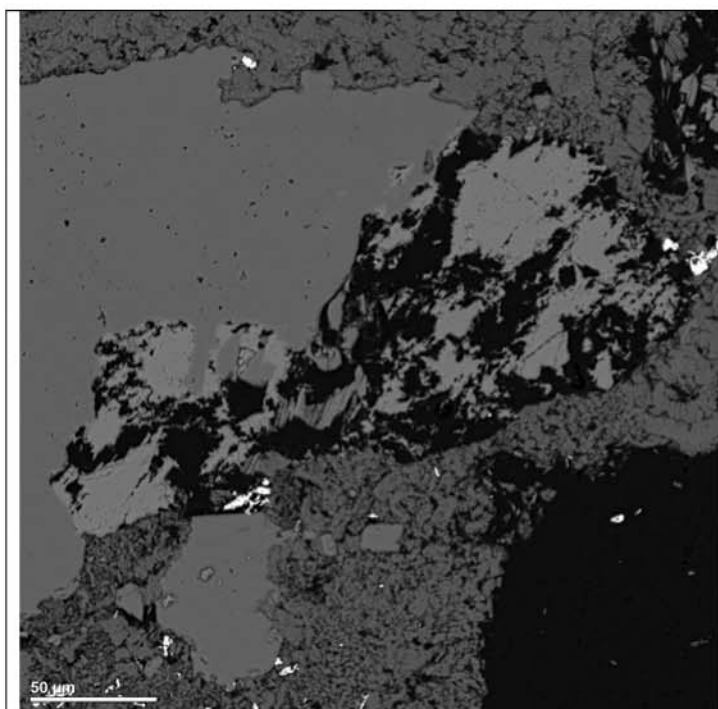
Comp10002



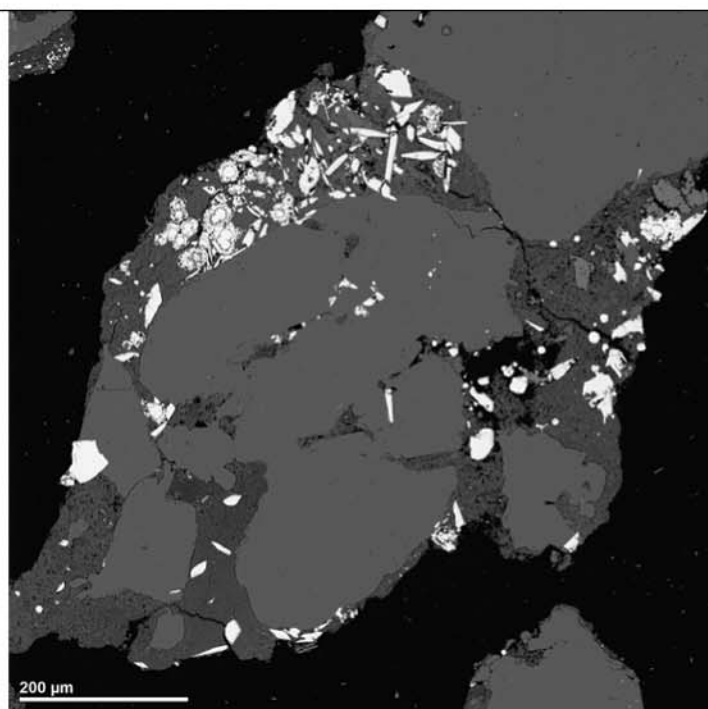
Comp10003



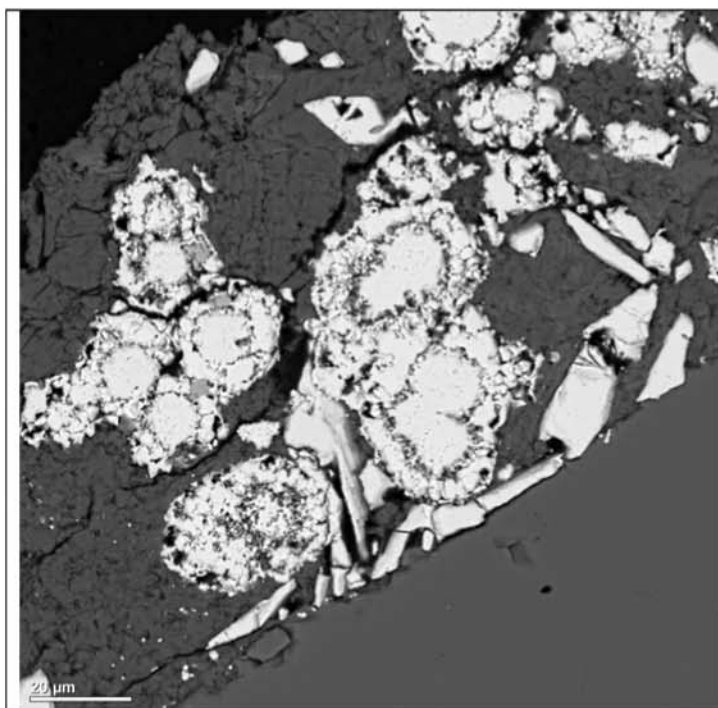
Comp10004



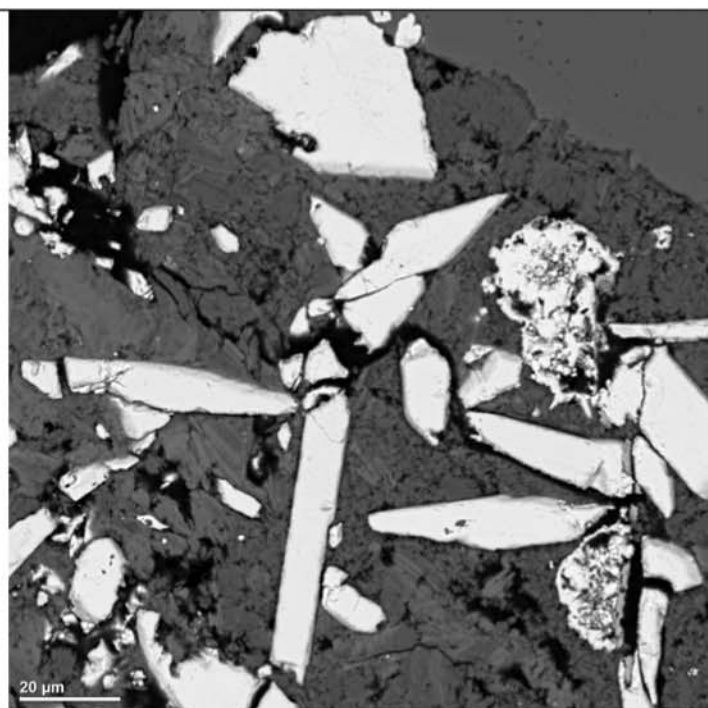
Comp10005



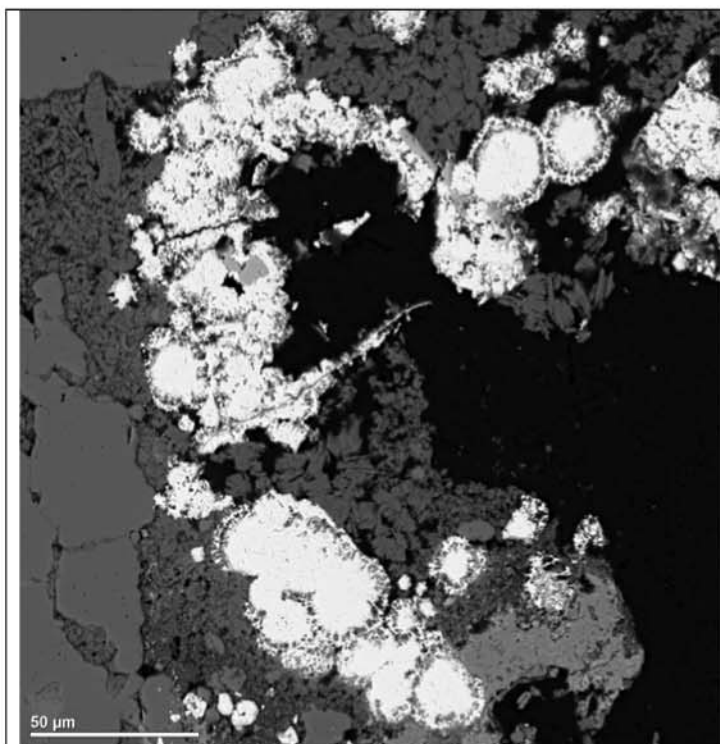
Comp10006



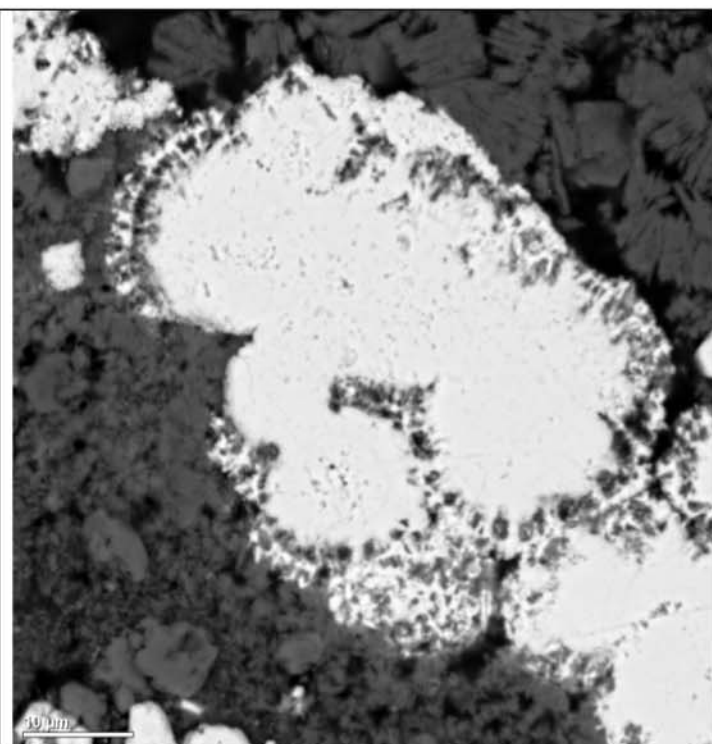
Comp10007



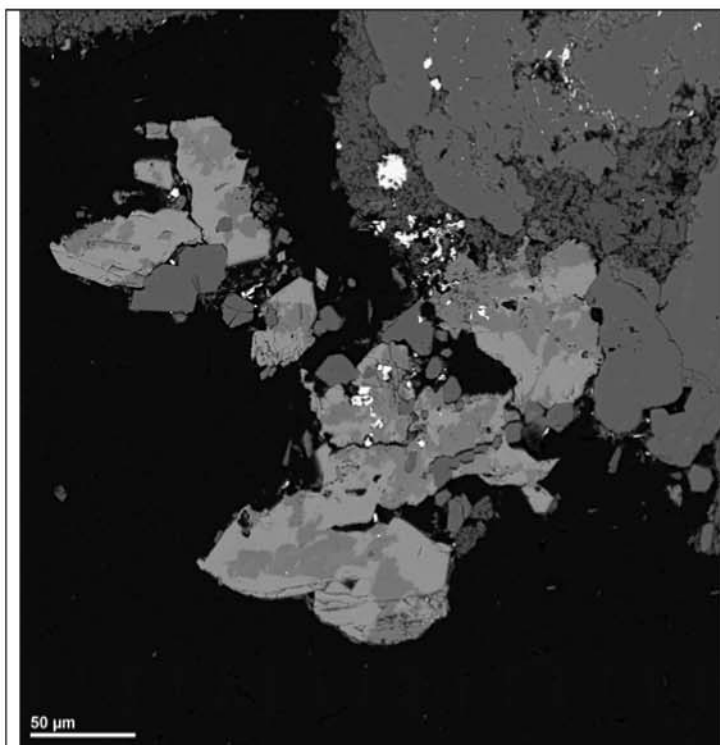
Comp10008



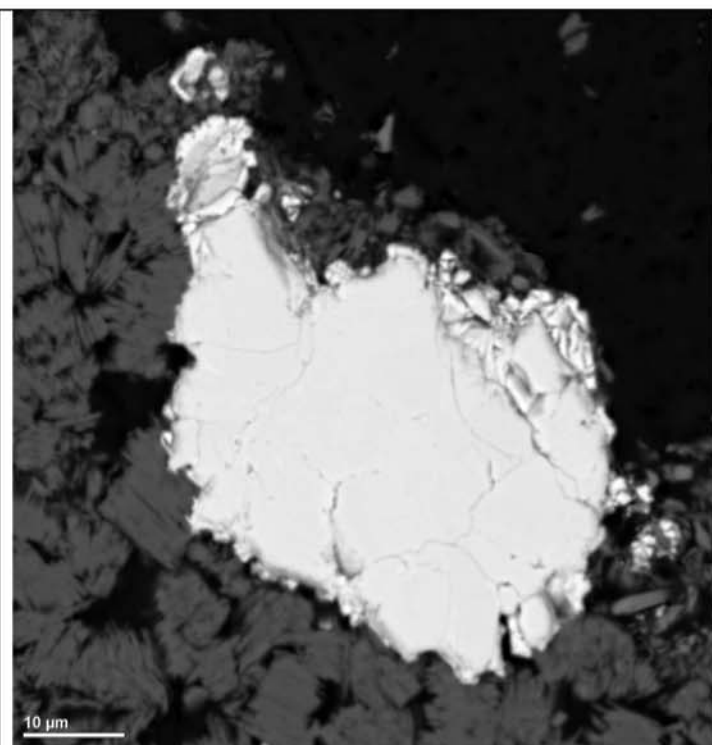
Comp10009



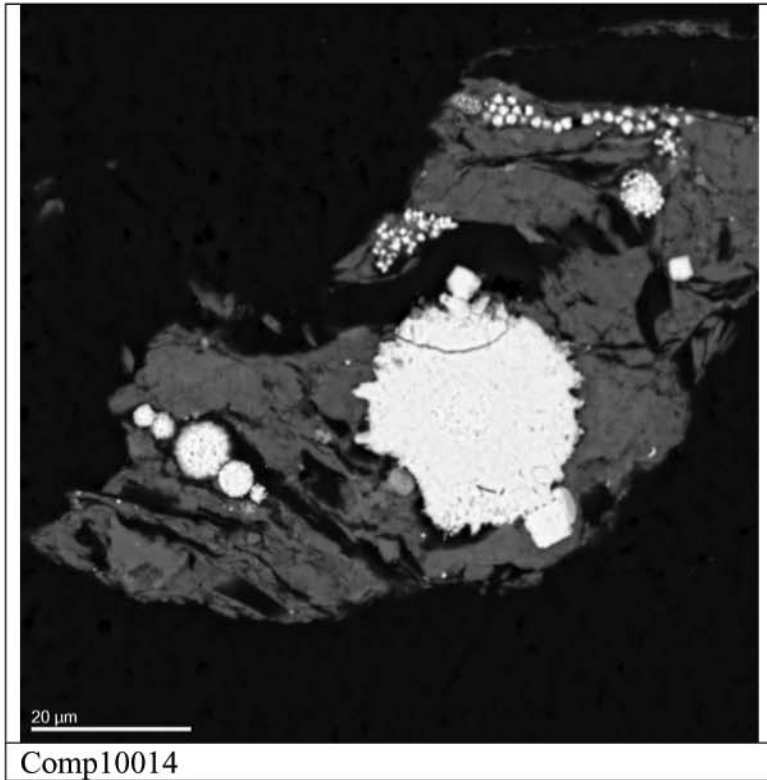
Comp10010



Comp10012



Comp10013



Appendix C4 – kinetic Test Data



HILLSBOUROUGH
Resources Limited

Results of Leachate Analysis

Unsaturated Column Col 4 (Raw Col)

Results of Leachate Analysis

Date	Cycle No.	Volume mL		pH	Cond. umhos/cm	Acidity (pH 4.5)	Acidity (pH 8.3)	Alkalinity	Sulphate	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li
		Input	Output			mg CaCO ₃ /L	mg CaCO ₃ /L	mg CaCO ₃ /L	mg/L	mg/L	mg CaCO ₃ /L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
16-Jun-10	52	1000	985	7.68	822				319																	
23-Jun-10	53	1000	990	7.75	873	#N/A	5.7	86.9	358	1.2	533	0.0026	0.00004	0.0002	0.0302	<0.00001	<0.000005	0.168	0.000025	205	<0.0001	0.0022	0.00188	0.006	2.4E-05	0.0028
30-Jun-10	54	1000	975	7.59	888				399																	
07-Jul-10	55	1000	995	7.66	874	#N/A	6.3	90.8	373	1.4	557	0.0036	0.00004	0.0002	0.0282	<0.00001	<0.000005	0.162	0.000018	214	0.0006	0.002	0.00076	0.007	1.1E-05	0.0028
14-Jul-10	56	1000	980	7.49	868				266																	
21-Jul-10	57	1000	990	7.61	882	#N/A	9.3	91.8	388	1.6	541	0.0033	0.00004	0.0004	0.0271	<0.00001	<0.000005	0.162	0.000074	208	0.0001	0.0021	0.0015	0.007	7E-06	0.0027
28-Jul-10	58	1000	995	7.46	823				372																	
04-Aug-10	59	1000	990	7.61	841	#N/A	9.0	94.7	410	1.6	516	0.0045	0.00004	0.0001	0.0286	<0.00001	<0.000005	0.188	0.000012	198	0.0001	0.0024	0.00116	0.009	6E-06	0.0027
11-Aug-10	60	1000	990	7.39	840				556																	
18-Aug-10	61	1000	990	7.23	803	#N/A	11.8	91.8	385	2.4	522	0.0037	0.00003	0.0002	0.0288	<0.00001	<0.000005	0.177	0.000021	201	<0.0001	0.002	0.00068	0.019	7E-06	0.0029
25-Aug-10	62	1000	1000	7.89	781				397																	
01-Sep-10	63	1000	990	7.92	837	#N/A	7.9	93.9	512	1.2	507	0.0034	0.00003	9E-05	0.0285	<0.00001	<0.000005	0.14	0.000021	196	<0.0001	0.0019	0.00047	0.006	1.2E-05	0.0025
08-Sep-10	64	1000	995	7.77	817				454																	
15-Sep-10	65	1000	995	7.75	702	#N/A	5.3	74.0	442	<0.5	449	0.0034	0.00003	0.0001	0.0264	<0.00001	<0.000005	0.157	0.000016	173	<0.0001	0.0013	0.00146	0.004	0.00003	0.0026
22-Sep-10	66	1000	995	7.92	626				589																	
29-Sep-10	67	1000	995	7.87	595	#N/A	4.7	84.0	496	2.3	528	0.005	<0.0001	0.0002	0.0279	<0.00005	<0.00003	<0.3	<0.00003	204	<0.0005	0.0016	0.0007	0.007	<0.00003	<0.003
06-Oct-10	68	1000	995	7.86	788				468																	
13-Oct-10	69	1000	995	7.82	785	#N/A	6.2	98.5	550	0.6	508	0.0033	0.00003	7E-05	0.0283	<0.00001	<0.000005	0.15	0.000008	197	0.0001	0.0014	0.00065	0.011	0.00007	0.0024
20-Oct-10	70	1000	995	7.87	732				478																	
27-Oct-10	71	1000	990	7.89	736	#N/A	3.8	84.4	439	<0.5	460	0.0021	0.00002	8E-05	0.0262	<0.00001	<0.000005	0.128	0.000013	178	<0.0001	0.0011	0.00086	0.007	0.00016	0.0021
03-Nov-10	72	1000	995	7.98	761																					
10-Nov-10	73	1000	995	7.86	824																					
17-Nov-10	74	1000	990	7.89	743																					
24-Nov-10	75	1000	1005	7.65	687	#N/A	5.4	77.3	380	0.9	353	0.002	0.00003	0.0002	0.0223	<0.00001	<0.000005	0.087	0.000045	136	<0.0001	0.0008	0.00179	0.003	0.00001	0.0014
01-Dec-10	76	1000	990	7.71	761																					
08-Dec-10	77	1000	1000	7.70	676																					
15-Dec-10	78	1000	1000	7.69	727																					
22-Dec-10	79	1000	985	7.85	738	#N/A	8.1	99.3	340	0.8	422	0.0018	<0.00002	7E-05	0.0307	<0.00001	<0.000005	0.11	0.000015	163	<0.0001	0.0009	0.00077	0.004	1.9E-05	0.0022
29-Dec-10	80	1000	995	7.81	752																					
05-Jan-11	81	1000	985	7.72	625																					
12-Jan-11	82	1000	985	7.77	635																					
19-Jan-11	83	1000	1005	7.78	660	#N/A	5.6	80.8	328	0.7	408	0.0048	<0.00002	9E-05	0.0296	<0.00001	<0.000005	0.12	0.000008	158	<0.0001	0.0006	0.00073	0.008	6E-06	0.0021
26-Jan-11	84	1000	995	7.77	635																					
02-Feb-11	85	1000	955	7.71	599																					
09-Feb-11	86	1000	1010	7.92	682																					
16-Feb-11	87	1000	1010	7.88	654	#N/A	4.0	78.0	268	1	399	0.0032	<0.00002	6E-05	0.0287	<0.00001	<0.000005	0.085	0.000011	155	<0.0001	0.0004	0.00254	0.004	1.3E-05	0.0018
23-Feb-11	88	1000	920	7.79	768																					
02-Mar-11	89	1000	970	7.77	639																					
09-Mar-11	90	1000	990	7.78	707																					
16-Mar-11	91	1000	980	7.77	689	#N/A	5.0	76.1	254	1.5	358	0.0022	0.00002	0.0001	0.0289	<0.00001	<0.000005	0.088	0.000005	139	<0.0001	0.0004	0.00035	0.005	1.7E-05	0.0019
23-Mar-11	92	1000	990	7.89	694																					
30-Mar-11	93	1000	985	7.79	691																					
06-Apr-11	94	1000	985	7.80	679																					
13-Apr-11	95	1000	990	7.87	663	#N/A	4.7	95.5	241	1.4	360	0.0024	<0.00002	3E-05	0.0261	<0.00001	<0.000005	0.087	0.000009	140	<0.0001	0.0004	0.00062	0.003	1.5E-05	0.0016
20-Apr-11	96	1000	985	7.85	702																					
27-Apr-11	97	1000	990	7.79	651																					
04-May-11	98	1000	995																							

Notes: Values in red are below the detection limit.
For calculation purposes, values below detection were set at half the value of the analytical limit.

Unsaturated Column Col 4 (Raw Col)

Results of Leachate Analysis

Date	Cycle No.	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major Anions	Major Cations	Diff	Diff (%)
		mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
24-Jun-09	1	13.4	0.538	<0.01	0.00167	0.636	0.005	7.3	0.0192	1.39	<0.000005	201	1.64	314	0.00021	0.00002	<0.0005	0.000076	<0.0002	0.137	<0.0001	23.62	20.46	-3.16	-7.2%
01-Jul-09	2																								
08-Jul-09	3	26.8	0.264	<0.05	0.0012	0.0533	0.015	8.48	0.0551	1.52	<0.00003	229	3.05	521	0.00007	<0.00005	<0.003	0.00006	<0.001	0.009	<0.0005	37.77	32.84	-4.94	-7.0%
15-Jul-09	4																								
22-Jul-09	5	20.3	0.184	<0.05	0.0015	0.0354	<0.01	6.78	0.0261	1.37	<0.00003	136	2.61	390	0.00006	<0.00005	<0.003	0.00004	<0.001	0.0054	<0.0005	30.12	25.07	-5.05	-9.2%
29-Jul-09	6																								
05-Aug-09	7	20.9	0.219	<0.05	0.0014	0.0375	<0.01	6.55	0.0183	1.55	<0.00003	104	2.57	410	0.00005	<0.00005	<0.003	0.00006	<0.001	0.0054	<0.0005	28.67	26.07	-2.60	-4.8%
12-Aug-09	8																								
19-Aug-09	9	25.5	0.242	<0.05	0.0015	0.0386	<0.01	7.11	0.0287	1.78	<0.00003	212	3.21	593	0.00006	<0.00005	<0.003	0.0001	<0.001	0.0051	<0.0005	37.06	36.20	-0.86	-1.2%
26-Aug-09	10																								
02-Sep-09	11	32.4	0.277	<0.05	0.0015	0.0339	0.012	7.51	0.0348	1.36	<0.00003	229	3.43	664	0.00005	0.00018	<0.003	0.00009	<0.001	0.0048	<0.0005	47.18	39.76	-7.42	-8.5%
09-Sep-09	12																								
16-Sep-09	13	29.2	0.219	<0.05	0.0015	0.0242	<0.01	6.32	0.0195	1.23	<0.00003	129	3.19	507	0.00004	0.00023	<0.003	0.00004	<0.001	0.0038	<0.0005	32.94	32.13	-0.81	-1.3%
23-Sep-09	14																								
30-Sep-09	15	28.4	0.218	<0.05	0.0013	0.0242	<0.01	5.98	0.0185	1.19	<0.00003	94.7	3.29	529	0.00004	<0.00005	<0.003	0.00004	<0.001	0.0038	<0.0005	36.63	31.36	-5.27	-7.7%
07-Oct-09	16																								
14-Oct-09	17	20.9	0.179	<0.05	0.001	0.0212	<0.01	4.91	0.0101	1.09	<0.00003	59	2.69	437	0.00004	<0.00005	<0.003	0.00005	<0.001	0.0078	<0.0005	33.46	27.37	-6.09	-10.0%
21-Oct-09	18																								
28-Oct-09	19	20	0.201	<0.05	0.0011	0.0205	<0.01	5.04	0.0097	1.09	<0.00003	54.4	2.8	466	0.00003	<0.00005	<0.003	0.00009	<0.001	0.0062	<0.0005	31.36	29.09	-2.27	-3.8%
04-Nov-09	20																								
11-Nov-09	21	19.1	0.183	<0.05	0.001	0.0211	<0.01	4.37	0.0088	1.13	<0.00003	46.5	2.46	413	0.00001	<0.00005	0.003	0.00002	<0.001	0.0035	<0.0005	29.87	26.71	-3.16	-5.6%
18-Nov-09	22																								
25-Nov-09	23	18.8	0.163	<0.05	0.0008	0.0184	<0.01	3.88	0.007	0.97	<0.00003	38.2	2.33	401	0.00002	<0.00005	<0.003	0.00005	<0.001	0.0025	<0.0005	31.44	25.81	-5.63	-9.8%
02-Dec-09	24																								
09-Dec-09	25	15.4	0.135	<0.05	0.001	0.0146	<0.01	3.93	0.006	1.06	<0.00003	28.4	2.16	343	0.00004	<0.00005	<0.003	0.00005	<0.001	0.0029	<0.0005	24.32	23.26	-1.05	-2.2%
16-Dec-09	26																								
23-Dec-09	27	14.3	0.132	<0.05	0.0007	0.0158	<0.01	3.41	0.0058	1.12	<0.00003	26.8	1.89	332	0.00001	<0.00005	<0.003	0.00003	<0.001	0.0017	<0.0005	22.18	20.34	-1.84	-4.3%
30-Dec-09	28																								
06-Jan-10	29	16.3	0.158	<0.05	0.0006	0.0184	<0.01	3.77	0.0072	1.26	<0.00003	26.9	2.05	383	0.00002	0.00012	<0.003	0.00016	<0.001	0.003	<0.0005	22.63	22.97	0.34	0.7%
13-Jan-10	30																								
20-Jan-10	31	10.2	0.0977	<0.01	0.00071	0.009	<0.002	2.91	0.0049	0.96	<0.000005	16.3	1.41	252	1.8E-05	0.00002	<0.0005	0.000022	<0.0002	0.0012	<0.0001	17.70	15.84	-1.86	-5.5%
27-Jan-10	32																								
03-Feb-10	33	10.5	0.108	<0.05	0.0007	0.0095	<0.01	2.88	0.0046	1.04	<0.00003	13.4	1.33	223	0.00002	0.00007	<0.003	0.00003	<0.001	0.0026	<0.0005	15.55	15.99	0.44	1.4%
10-Feb-10	34																								
17-Feb-10	35	11.6	0.105	<0.05	0.0007	0.0086	<0.01	2.77	0.0051	0.9	<0.00003	13.3	1.51	240	0.00002	<0.00005	<0.003	0.00004	<0.001	0.0021	<0.0005	18.62	16.97	-1.64	-4.6%
24-Feb-10	36																								
03-Mar-10	37	11.2	0.0925	<0.05	0.0007	0.0078	<0.01	2.61	0.005	0.82	<0.00003	12.1	1.42	224	0.00002	<0.00005	<0.003	0.00002	<0.001	0.0018	<0.0005	15.18	17.18	2.00	6.2%
10-Mar-10	38																								
17-Mar-10	39	10.4	0.0948	<0.05	0.0006	0.0076	<0.01	2.3	0.0046	0.97	<0.00003	9.6	1.34	249	0.00001	<0.00005	<0.003	0.00002	<0.001	0.0022	<0.0005	14.66	15.70	1.05	3.4%
24-Mar-10	40																								
31-Mar-10	41	7.41	0.0774	<0.05	0.0007	0.0064	<0.01	1.73	0.0042	0.79	<0.00003	6.44	0.95	172	0.00002	<0.00005	<0.003	0.00002	<0.001	0.0022	<0.0005	13.41	11.51	-1.89	-7.6%
07-Apr-10	42																								
14-Apr-10	43	6.45	0.0737	<0.01	0.00056	0.0059	0.004	1.63	0.00375	0.91	<0.000005	4.61	0.95	168	1.1E-05	0.00006	<0.0005	0.000019	<0.0002	0.0011	<0.0001	13.38	11.20	-2.18	-8.9%
21-Apr-10	44																								
28-Apr-10	45	6.32	0.0761	<0.01	0.00054	0.0058	<0.002	1.56	0.0036	0.88	<0.000005	3.98	0.95	171	7E-06	<0.00001	<0.0005	0.000016	<0.0002	0.001	<0.0001	12.96	11.26	-1.70	-7.0%
05-May-10	46																								
12-May-10	47	6.38	0.0823	0.02	0.00051	0.0061	<0.002	1.67	0.00362	1.08	<0.000005	3.78	0.92	186	1.3E-05	0.00001	<0.0005	0.000017	<0.0002	0.0009	<0.0001	11.68	12.01	0.33	1.4%
19-May-10	48																								
26-May-10	49	5.41	0.0663	<0.01	0.00052	0.0046	<0.002	1.4	0.00311	0.9	<0.000005	3.06	0.844	162	0.00001	<0.00001	<0.0005	0.000017	<0.0002	0.0012	<0.0001	9.27	10.84	1.58	7.9%
02-Jun-10	50																								
09-Jun-10	51	4.7	0.0566	<0.01	0.00048	0.004	<0.002	1.29	0.00325	0.67	<0.000005	2.79	0.782	154	1.1E-05	0.00002	<0.0005	0.000012	<0.0002	0.0009	<0.0001	8.07	9.37	1.30	7.5%

Unsaturated Column Col 4 (Raw Col)

Results of Leachate Analysis

Date	Cycle No.	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major Anions	Major Cations	Diff	Diff (%)	
		mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L					
16-Jun-10	52																									
23-Jun-10	53	5.18	0.0712	<0.01	0.00061	0.0052	0.002	1.33	0.00349	0.96	<0.000005	3.23	0.854	166	1.4E-05	0.00002	<0.0005	0.00002	<0.0002	0.0011	<0.0001		9.23	10.83	1.60	8.0%
30-Jun-10	54																									
07-Jul-10	55	5.24	0.0664	<0.01	0.00051	0.0046	0.002	1.27	0.00302	0.89	0.000016	3.05	0.749	163	1.3E-05	0.00029	<0.0005	0.000018	<0.0002	0.0006	<0.0001		9.63	11.28	1.65	7.9%
14-Jul-10	56																									
21-Jul-10	57	5.14	0.072	<0.01	0.00042	0.0049	0.003	1.3	0.00354	0.91	<0.000005	3.09	0.78	181	1.3E-05	<0.00001	<0.0005	0.000033	<0.0002	0.0033	<0.0001		9.96	10.97	1.01	4.8%
28-Jul-10	58																									
04-Aug-10	59	4.89	0.0712	<0.01	0.00041	0.0056	<0.002	1.28	0.00321	0.91	<0.000005	2.8	0.694	171	1.3E-05	0.00002	<0.0005	0.000016	<0.0002	0.0012	<0.0001		10.48	10.44	-0.04	-0.2%
11-Aug-10	60																									
18-Aug-10	61	4.93	0.0711	0.01	0.00035	0.005	<0.002	1.26	0.00313	0.92	<0.000005	2.63	0.727	169	1.5E-05	<0.00001	<0.0005	0.000015	<0.0002	0.001	<0.0001		9.92	10.58	0.66	3.2%
25-Aug-10	62																									
01-Sep-10	63	4.37	0.0642	<0.01	0.00036	0.0048	<0.002	1.01	0.00303	0.75	<0.000005	2.09	0.656	152	1.1E-05	0.00029	<0.0005	0.000012	<0.0002	0.0013	<0.0001		12.58	10.31	-2.27	-9.9%
08-Sep-10	64																									
15-Sep-10	65	3.8	0.0498	0.01	0.00037	0.0033	<0.002	0.9	0.00247	0.68	<0.000005	1.8	0.625	135	8E-06	0.00003	<0.0005	0.000017	<0.0002	0.0007	<0.0001		10.69	9.10	-1.58	-8.0%
22-Sep-10	66																									
29-Sep-10	67	4.7	0.0494	<0.05	0.0003	0.0038	<0.01	1	0.0025	0.84	<0.00003	2	0.591	148	<0.00001	<0.00005	<0.003	0.00002	<0.001	0.0023	<0.0005		12.08	10.69	-1.39	-6.1%
06-Oct-10	68																									
13-Oct-10	69	4.29	0.0516	<0.01	0.00031	0.004	<0.002	0.98	0.00246	0.81	<0.000005	1.86	0.592	157	1.2E-05	0.00002	<0.0005	0.000022	<0.0002	0.0014	<0.0001		13.44	10.34	-3.10	-13.0%
20-Oct-10	70																									
27-Oct-10	71	3.83	0.038	<0.01	0.00029	0.0029	<0.002	0.85	0.00231	0.75	<0.000005	1.49	0.565	142	9E-06	<0.00001	<0.0005	0.000013	<0.0002	0.0011	<0.0001		10.83	9.33	-1.50	-7.4%
03-Nov-10	72																									
10-Nov-10	73																									
17-Nov-10	74																									
24-Nov-10	75	3.45	0.0271	0.02	0.00029	0.0025	0.002	0.63	0.00181	0.48	<0.000005	1.13	0.433	111	6E-06	0.00001	<0.0005	0.000016	<0.0002	0.0047	<0.0001		9.49	7.17	-2.32	-13.9%
01-Dec-10	76																									
08-Dec-10	77																									
15-Dec-10	78																									
22-Dec-10	79	3.5	0.0293	<0.01	0.00016	0.0033	<0.002	0.76	0.00201	0.71	<0.000005	1.16	0.509	129	8E-06	0.00002	<0.0005	0.00001	<0.0002	0.0014	<0.0001	Z27186	B0C5480		9.09	8.53
29-Dec-10	80																									
05-Jan-11	81																									
12-Jan-11	82																									
19-Jan-11	83	3.27	0.0205	<0.01	0.00029	0.0025	<0.002	0.73	0.00205	0.57	<0.000005	1.18	0.481	130	6E-06	0.00004	<0.0005	0.000019	<0.0002	0.0011	<0.0001	Z55853	B105797		8.47	8.27
26-Jan-11	84																									
02-Feb-11	85																									
09-Feb-11	86																									
16-Feb-11	87	2.96	0.0145	<0.01	0.00023	0.0022	0.003	0.6	0.00188	0.55	<0.000005	1	0.423	117	4E-06	0.00002	<0.0005	0.00002	<0.0002	0.0015	<0.0001	Z98850	B113549		7.17	8.07
23-Feb-11	88																									
02-Mar-11	89																									
09-Mar-11	90																									
16-Mar-11	91	2.71	0.0123	<0.01	0.00025	0.0019	<0.002	0.55	0.00173	0.55	<0.000005	0.85	0.427	108	5E-06	0.00003	<0.0005	0.00001	<0.0002	0.0011	<0.0001	AE1298	B121655			
23-Mar-11	92																									
30-Mar-11	93																									
06-Apr-11	94																									
13-Apr-11	95	2.71	0.0114	<0.02	0.00025	0.0023	0.003	0.54	0.00155	0.65	<0.000005	0.81	0.389	99	6E-06	0.00003	<0.0005	0.000015	<0.0002	0.0006	<0.0001	AI6211	B130184			
20-Apr-11	96																									
27-Apr-11	97																									
04-May-11	98																									

Notes: Values in red are below the detection limit.
For calculation purposes, values below detection were set at half the value of the analytical limit.

Unsaturated Column Col 5 (Coarse Reject)																											
Results of Leachate Analysis																											
Date	Cycle No.	Volume mL		pH	Cond. umhos/cm	Acidity (pH 4.5)	Acidity (pH 8.3)	Alkalinity	Sulphate	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	
		Input	Output			mg CaCO ₃ /L	mg CaCO ₃ /L	mg CaCO ₃ /L	mg/L	mg/L	mg CaCO ₃ /L	mg/L	mg/L	mg CaCO ₃ /L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
24-Jun-09	1	750	325	7.67	7577	#N/A	27.7	393.0	4972	180	1720	0.002	0.0005	0.0005	0.0613	<0.0001	<0.00005	1.29	0.00321	550	<0.001	1.88	0.0113	0.015	<0.00005	0.022	
01-Jul-09	2	300	280	7.68	5582				3226																		
08-Jul-09	3	300	285	7.57	5091	#N/A	12.3	135.4	3499	450	1680	0.006	0.0002	0.0005	0.0229	<0.00005	<0.00003	0.781	0.00042	556	<0.0005	0.139	0.012	0.006	0.00027	0.007	
15-Jul-09	4	300	285	7.65	4213				2344																		
22-Jul-09	5	300	315	7.65	3788	#N/A	10.7	104.7	2128	33	1480	0.003	<0.0002	0.0006	0.0205	<0.0001	<0.00005	0.777	0.00034	490	<0.001	0.0804	0.0034	<0.01	0.00011	0.008	
29-Jul-09	6	300	295	7.75	3367				1983																		
05-Aug-09	7	300	280	7.81	3456	#N/A	8.3	89.6	2324	24	1590	0.005	0.0003	0.0004	0.0202	<0.00005	<0.00003	0.696	0.00022	537	<0.0005	0.062	0.0034	0.008	0.00013	0.006	
12-Aug-09	8	300	295	7.74	3214				2075																		
19-Aug-09	9	300	295	7.77	3014	#N/A	9.2	89.8	1951	19	1620	0.005	0.0001	0.0004	0.02	<0.00005	<0.00003	0.654	0.00019	555	<0.0005	0.0544	0.0024	0.014	0.00136	0.006	
26-Aug-09	10	300	300	7.71	2789				1720																		
02-Sep-09	11	300	300	7.78	2931	#N/A	12.0	85.3	2075	65	1720	0.004	0.0001	0.0002	0.0202	<0.00005	<0.00003	0.553	0.00021	593	<0.0005	0.0479	0.0016	0.008	0.00006	0.005	
09-Sep-09	12	300	300	7.67	2736				1710																		
16-Sep-09	13	300	310	7.77	2835	#N/A	8.8	81.3	1825	140	1650	0.004	0.0002	0.0002	0.0206	<0.00005	<0.00003	0.537	0.00022	576	<0.0005	0.0468	0.0021	0.007	0.00408	0.005	
23-Sep-09	14	300	300	7.69	2667				1678																		
30-Sep-09	15	300	295	7.69	2830	#N/A	8.1	75.5	1580	180	1730	0.003	0.0002	0.0002	0.0229	<0.00005	<0.00003	0.532	0.00024	610	<0.0005	0.0445	0.0028	0.033	0.00005	0.005	
07-Oct-09	16	300	305	7.52	2847				1624																		
14-Oct-09	17	300	295	7.58	2806	#N/A	7.2	63.7	1799	190	1740	0.004	0.0002	0.0003	0.0211	<0.00005	<0.00003	0.407	0.00027	623	<0.0005	0.0443	0.0025	0.008	0.0145	0.005	
21-Oct-09	18	300	305	7.60	2694				1722																		
28-Oct-09	19	300	305	7.68	2680	#N/A	7.0	56.7	1796	150	1690	0.015	0.0002	0.0001	0.0235	<0.00005	<0.00003	0.435	0.0004	613	<0.0005	0.0459	0.0027	0.014	0.00075	0.006	
04-Nov-09	20	300	315	7.65	2835				1653																		
11-Nov-09	21	300	295	7.47	2583	#N/A	12.2	48.7	1385	150	1620	0.003	<0.0001	0.0002	0.0195	<0.00005	<0.00003	0.378	0.00021	591	<0.0005	0.035	0.0016	0.021	0.00025	0.005	
18-Nov-09	22	300	305	7.69	2693				1531																		
25-Nov-09	23	300	295	7.77	2614	#N/A	6.6	56.4	1732	120	1660	0.005	<0.0001	<0.0001	0.0198	<0.00005	<0.00003	0.322	0.00015	608	<0.0005	0.0357	0.0007	0.011	0.00003	0.004	
02-Dec-09	24	300	300	7.64	2582				1530																		
09-Dec-09	25	300	305	7.63	2483	#N/A	6.6	47.1	1670	120	1630	0.006	<0.0001	0.0002	0.0247	<0.00005	<0.00003	0.431	0.00018	606	<0.0005	0.0288	0.0021	0.013	0.00004	0.004	
16-Dec-09	26	300	295	7.54	2639				1598																		
23-Dec-09	27	300	295	7.68	2228	#N/A	6.7	63.2	1680	120	1630	0.004	0.0001	0.0003	0.0216	<0.00005	<0.00003	0.398	0.00021	603	<0.0005	0.0382	0.0036	0.049	<0.00003	0.005	
30-Dec-09	28	300	285	7.64	2494				1620																		
06-Jan-10	29	300	300	7.59	2451	#N/A	9.5	65.8	1503	94	1760	0.007	0.0002	0.0003	0.0213	<0.00005	<0.00003	0.436	0.00017	653	<0.0005	0.0386	0.0115	0.031	0.00044	0.005	
13-Jan-10	30	600	585	7.47	2418				1514																		
20-Jan-10	31	600	590	7.52	2276	#N/A	11.8	61.4	1584	51	1560	0.003	0.0002	0.0011	0.0219	<0.00005	<0.00003	0.398	0.00012	582	<0.0005	0.0325	0.0012	0.02	<0.00003	0.004	
27-Jan-10	32	600	550	7.40	2010				1483																		
03-Feb-10	33	600	580	7.46	1791	#N/A	8.5	65.4	1352	38	1450	0.003	<0.0001	0.0003	0.0225	<0.00005	<0.00003	0.345	0.00017	542	<0.0005	0.0288	0.0013	0.006	0.00118	0.004	
10-Feb-10	34	600	570	7.61	2124				1358																		
17-Feb-10	35	600	550	7.57	2061	#N/A	8.6	68.7	1471	31	1540	0.003	<0.0001	0.0002	0.0245	<0.00005	<0.00003	0.39	0.00012	577	<0.0005	0.029	0.0013	0.009	0.00003	0.005	
24-Feb-10	36	600	600	7.50	2292				1544																		
03-Mar-10	37	600	500	7.51	2128	#N/A	8.5	63.3	1396	35	1710	0.003	<0.0001	0.0002	0.0229	<0.00005	<0.00003	0.332	0.00014	641	<0.0005	0.0289	0.0022	0.006	<0.00003	0.005	
10-Mar-10	38	600	595	7.54	2067				1431																		
17-Mar-10	39	600	580	7.63	2018	#N/A	6.6	57.7	1281	25	1320	0.004	<0.0001	0.0001	0.0204	<0.00005	<0.00003	<0.3	0.00009	498	<0.0005	0.0206	0.0017	0.006	0.00004	0.004	
24-Mar-10	40	600	585	7.63	2057				1605																		
31-Mar-10	41	1000	965	7.50	1966	#N/A	7.6	53.6	1487	15	1400	0.003	<0.0001	0.0001	0.0206	<0.00005	<0.00003	<0.3	0.00024	529	<0.0005	0.021	0.0015	0.019	0.00091	0.004	
07-Apr-10																											

Unsaturated Column Col 5 (Coarse Reject)																											
Results of Leachate Analysis																											
Date	Cycle No.	Volume mL		pH	Cond. umhos/cm	Acidity (pH 4.5)	Acidity (pH 8.3)	Alkalinity	Sulphate	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	
		Input	Output			mg CaCO ₃ /L	mg CaCO ₃ /L	mg CaCO ₃ /L	mg/L	mg/L	mg CaCO ₃ /L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	
16-Jun-10	52	1000	965	7.63	1179				564																		
23-Jun-10	53	1000	965	7.70	1212	#N/A	5.5	56.9	580	8.5	796	0.0031	0.00004	0.00015	0.0205	<0.00001	<0.00000E	0.157	8.5E-05	304	<0.0001	0.0129	0.0015	0.006	2.7E-05	0.0037	
30-Jun-10	54	1000	955	7.66	1228				677																		
07-Jul-10	55	1000	965	7.64	1316	#N/A	6.1	60.0	710	7.8	879	0.0027	0.00006	0.00034	0.0206	<0.00001	<0.00000E	0.154	8.1E-05	336	0.0007	0.0132	0.00115	0.007	3.4E-05	0.0036	
14-Jul-10	56	1000	955	7.58	1152				466																		
21-Jul-10	57	1000	970	7.51	1160	#N/A	8.0	55.8	715	7.6	888	0.0037	0.00003	0.00012	0.0195	<0.00001	<0.00000E	0.138	6.7E-05	340	0.0002	0.0132	0.00093	0.007	<0.00000E	0.0034	
28-Jul-10	58	1000	960	7.58	1226				536																		
04-Aug-10	59	1000	965	7.67	1206	#N/A	8.9	65.0	794	6.3	808	0.006	0.0002	0.0003	0.0229	<0.00005	<0.00003	<0.3	0.00006	306	<0.0005	0.0131	0.0018	0.067	<0.00003	0.004	
11-Aug-10	60	1000	965	7.69	1127				705																		
18-Aug-10	61	1000	960	7.66	1096	#N/A	10.9	60.9	680	7.6	819	0.0043	0.00004	0.00014	0.0211	<0.00001	<0.00000E	0.162	6.7E-05	312	<0.0001	0.0116	0.00098	0.004	1.2E-05	0.0039	
25-Aug-10	62	1000	965	7.66	1081				718																		
01-Sep-10	63	1000	980	7.68	1156	#N/A	8.4	50.5	890	5.3	800	0.0033	0.00004	0.00005	0.0199	<0.00001	<0.00000E	0.112	6.2E-05	305	<0.0001	0.0108	0.00042	0.006	5E-06	0.0031	
08-Sep-10	64	1000	990	7.60	1120				694																		
15-Sep-10	65	1000	980	7.63	950	#N/A	5.7	65.8	732	4.4	748	0.0029	0.00003	0.00008	0.0211	<0.00001	<0.00000E	0.152	7.2E-05	284	<0.0001	0.0114	0.00125	0.003	1.4E-05	0.0038	
22-Sep-10	66	1000	970	7.73	892				960																		
29-Sep-10	67	1000	970	7.71	821	#N/A	5.0	65.4	688	5.5	801	0.0045	0.00004	0.00054	0.0219	<0.00001	<0.00000E	0.141	7.4E-05	304	0.0002	0.0113	0.00074	0.006	9E-06	0.0037	
06-Oct-10	68	1000	970	7.69	1083				660																		
13-Oct-10	69	1000	965	7.64	1065	#N/A	6.1	67.0	670	4.1	760	0.003	0.00003	<0.00002	0.0207	<0.00001	<0.00000E	0.127	5.5E-05	290	<0.0001	0.0106	0.00085	0.016	3.4E-05	0.0033	
20-Oct-10	70	1000	970	7.65	1046				670																		
27-Oct-10	71	1000	985	7.66	957	#N/A	3.8	47.2	546	3	661	0.0033	0.00003	0.00004	0.0197	<0.00001	<0.00000E	0.105	5.3E-05	251	<0.0001	0.00818	0.00226	0.007	0.00127	0.0031	
03-Nov-10	72	1000	1010	7.70	1100																						
10-Nov-10	73	1000	895	7.68	1688																						
17-Nov-10	74	1000	975	7.58	1013																						
24-Nov-10	75	1000	960	7.52	1309	#N/A	7.4	54.7	930	3.5	858	0.0025	0.00004	0.00003	0.0201	<0.00001	<0.00000E	0.085	9.6E-05	325	<0.0001	0.0184	0.00126	0.004	0.00032	0.0039	
01-Dec-10	76	1000	970	7.56	1166																						
08-Dec-10	77	1000	985	7.48	1176																						
15-Dec-10	78	1000	960	7.49	1188																						
22-Dec-10	79	1000	985	7.56	1153	#N/A	7.6	43.9	730	3.5	805	0.0024	<0.00002	0.00005	0.0233	<0.00001	<0.00000E	0.098	6.4E-05	305	<0.0001	0.0134	0.00202	0.002	1.1E-05	0.004	
29-Dec-10	80	1000	965	7.59	1245																						
05-Jan-11	81	1000	935	7.52	983																						
12-Jan-11	82	1000	990	7.53	958																						
19-Jan-11	83	1000	960	7.61	1067	#N/A	6.9	63.4	613	2.4	749	0.0055	0.00002	0.00005	0.0231	<0.00001	<0.00000E	0.119	8.2E-05	283	<0.0001	0.015	0.00121	0.031	0.00011	0.0044	
26-Jan-11	84	1000	985	7.47	1126																						
02-Feb-11	85	1000	980	7.48	970																						
09-Feb-11	86	1000	930	7.73	1266																						
16-Feb-11	87	1000	910	7.70	1195	#N/A	5.2	62.9	674	3.2	761	0.0038	<0.00002	0.00002	0.023	<0.00001	<0.00000E	0.094	9.5E-05	287	<0.0001	0.0178	0.00141	0.006	1.1E-05	0.0046	
23-Feb-11	88	1000	1000	7.56	1120																						
02-Mar-11	89	1000	980	7.53	1085																						
09-Mar-11	90	1000	965	7.49	1198																						
16-Mar-11	91	1000	990	7.49	1101	#N/A	5.4	43.4	650	4.1	675	0.0022	<0.00002	0.00004	0.0211	<0.00001	<0.00000E	0.086	8.8E-05	255	0.0003	0.0118	0.00093	0.004	0.00001	0.0043	
23-Mar-11	92	1000	995	7.55	1146																						
30-Mar-11	93	1000	970	7.48	1117																						
06-Apr-11	94	1000	980	7.52	1075																						
13-Apr-11	95	1000	995	7.52	1072	#N/A	4.2	36.0	554	2.4	648	0.0028	<0.00002	0.00003	0.0174	<0.00001	<0.00000E	0.075	6.8E-05	246	<0.0001	0.00992	0.00112	0.003	2.8E-05	0.0037	
20-Apr-11	96	1000	950	7.64	1198																						
27-Apr-11	97	1000	960	7.56	1156																						
04-May-11	98	1000	990																								

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Unsaturated Column Col 5 (Coarse Reject)

Results of Leachate Analysis

Date	Cycle No.	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major Anions	Major Cations	Diff	Diff (%)
		mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
24-Jun-09	1	83.7	3.46	<0.1	0.0033	3.84	0.029	16.5	0.244	4.2	<0.00005	1470	6.59	1740	0.00043	<0.0001	<0.005	0.00062	<0.002	0.78	<0.001	116.51	99.14	-17.37	-8.1%
01-Jul-09	2																								
08-Jul-09	3	70	0.971	0.17	0.0023	0.225	0.022	14.6	0.25	2.85	<0.00003	895	5.81	1500	0.00015	<0.00005	<0.003	0.00017	<0.001	0.0356	<0.0005	88.28	72.97	-15.31	-9.5%
15-Jul-09	4																								
22-Jul-09	5	62.2	0.669	<0.1	0.0021	0.119	<0.02	12.9	0.174	2.07	<0.00005	513	5.26	804	0.00014	<0.0001	<0.005	0.0001	<0.002	0.02	<0.001	47.36	52.36	5.00	5.0%
29-Jul-09	6																								
05-Aug-09	7	59.3	0.614	<0.05	0.0023	0.0887	0.013	12.7	0.161	2.28	<0.00003	372	5.33	775	0.00012	<0.00005	<0.003	0.00007	<0.001	0.0145	<0.0005	50.89	48.32	-2.56	-2.6%
12-Aug-09	8																								
19-Aug-09	9	57.6	0.56	<0.05	0.0018	0.0869	<0.01	12.3	0.0914	2.12	0.00003	238	5.38	717	0.00011	0.00043	<0.003	0.00007	<0.001	0.0119	<0.0005	42.98	43.25	0.27	0.3%
26-Aug-09	10																								
02-Sep-09	11	57.3	0.532	<0.05	0.0015	0.0734	<0.01	12.4	0.0665	1.61	<0.00003	166	5.48	667	0.00011	<0.00005	<0.003	0.00006	<0.001	0.0102	<0.0005	46.77	41.99	-4.78	-5.4%
09-Sep-09	12																								
16-Sep-09	13	51.5	0.511	<0.05	0.0015	0.0743	<0.01	11	0.054	1.78	<0.00003	112	5.4	559	0.0001	0.00026	<0.003	0.00005	<0.001	0.0112	<0.0005	43.59	38.28	-5.31	-6.5%
23-Sep-09	14																								
30-Sep-09	15	51.1	0.502	<0.05	0.0015	0.0794	<0.01	11.4	0.0532	1.96	<0.00003	91.5	5.84	581	0.00011	<0.00005	<0.003	0.00005	<0.001	0.0138	<0.0005	39.50	39.07	-0.43	-0.5%
07-Oct-09	16																								
14-Oct-09	17	44	0.55	<0.05	0.0012	0.0746	<0.01	10.3	0.0413	1.6	<0.00003	70.1	5.23	540	0.00009	<0.00005	<0.003	0.00004	<0.001	0.0134	<0.0005	44.11	38.16	-5.94	-7.2%
21-Oct-09	18																								
28-Oct-09	19	37.7	0.648	<0.05	0.001	0.0778	<0.01	10	0.0413	1.56	<0.00003	56.5	5.4	540	0.00013	<0.00005	<0.003	0.00004	<0.001	0.0193	<0.0005	42.78	36.56	-6.22	-7.8%
04-Nov-09	20																								
11-Nov-09	21	35.8	0.552	<0.05	0.0012	0.0575	<0.01	8.96	0.0355	1.41	0.00004	47.2	4.55	498	0.00008	0.00006	<0.003	0.00004	<0.001	0.0086	<0.0005	34.05	34.85	0.79	1.1%
18-Nov-09	22																								
25-Nov-09	23	34.2	0.559	<0.05	0.001	0.0609	<0.01	8.34	0.029	1.36	<0.00003	35.4	4.39	505	0.00008	0.00009	<0.003	0.00004	<0.001	0.008	<0.0005	40.59	35.03	-5.56	-7.4%
02-Dec-09	24																								
09-Dec-09	25	29	0.509	<0.05	0.0012	0.047	<0.01	8.68	0.032	1.67	<0.00003	25.9	4.23	492	0.00012	<0.00005	<0.003	0.00005	<0.001	0.0075	<0.0005	39.11	34.09	-5.02	-6.9%
16-Dec-09	26																								
23-Dec-09	27	30.3	0.636	<0.05	0.0008	0.0692	<0.01	7.92	0.0285	1.66	<0.00003	26	4.15	537	0.00008	<0.00005	<0.003	0.00004	<0.001	0.0101	<0.0005	39.64	34.04	-5.61	-7.6%
30-Dec-09	28																								
06-Jan-10	29	30.5	0.69	<0.05	0.0008	0.0685	<0.01	8.32	0.0328	1.9	<0.00003	25.7	4.15	590	0.00008	0.00018	0.003	0.00007	0.001	0.0098	<0.0005	35.28	36.55	1.27	1.8%
13-Jan-10	30																								
20-Jan-10	31	26.3	0.599	<0.05	0.0008	0.059	<0.01	6.8	0.0223	1.56	0.00006	20	3.41	513	0.00008	<0.00005	0.003	0.00004	<0.001	0.0083	<0.0005	35.67	32.35	-3.31	-4.9%
27-Jan-10	32																								
03-Feb-10	33	23.1	0.569	<0.05	0.0006	0.0527	<0.01	6.49	0.0171	1.41	<0.00003	11	3.11	462	0.00008	0.00008	<0.003	0.00005	<0.001	0.0081	<0.0005	30.55	29.69	-0.86	-1.4%
10-Feb-10	34																								
17-Feb-10	35	24.5	0.56	<0.05	0.0006	0.0517	<0.01	6.61	0.0146	1.45	<0.00003	9.56	3.28	459	0.0001	<0.00005	<0.003	0.00003	<0.001	0.0078	<0.0005	32.89	31.49	-1.40	-2.2%
24-Feb-10	36																								
03-Mar-10	37	27.2	0.597	<0.05	0.0006	0.0493	<0.01	6.8	0.0175	1.28	<0.00003	9.62	3.32	495	0.00007	<0.00005	<0.003	0.00006	<0.001	0.0082	<0.0005	31.34	34.92	3.58	5.4%
10-Mar-10	38																								
17-Mar-10	39	19.3	0.495	<0.05	0.0006	0.0352	<0.01	5.1	0.0127	1.28	<0.00003	6.7	2.69	465	0.00006	<0.00005	<0.003	0.00004	<0.001	0.0062	<0.0005	28.54	26.94	-1.60	-2.9%
24-Mar-10	40																								
31-Mar-10	41	19.1	0.511	<0.05	0.0007	0.0358	<0.01	4.97	0.01	1.03	<0.00003	5.77	2.65	469	0.00005	<0.00005	<0.003	0.00003	<0.001	0.0068	<0.0005	32.47	28.43	-4.05	-6.6%
07-Apr-10	42																								
14-Apr-10	43	12.7	0.414	<0.05	0.0005	0.0283	<0.01	3.7	0.0079	1.16	<0.00003	3.2	2.05	363	0.00004	<0.00005	<0.003	0.00002	<0.001	0.0065	<0.0005	25.98	22.70	-3.28	-6.7%
21-Apr-10	44																								
28-Apr-10	45	11.3	0.376	<0.05	0.0005	0.0261	<0.01	3.3	0.0085	1.05	<0.00003	3.3	1.76	324	0.00004	<0.00005	<0.003	0.00002	<0.001	0.0044	<0.0005	21.24	20.47	-0.76	-1.8%
05-May-10	46																								
12-May-10	47	11.6	0.383	<0.05	<0.0003	0.0257	<0.01	3.5	0.008	1.35	<0.00003	3.3	1.71	311	0.00005	<0.00005	<0.003	0.00002	<0.001	0.0044	<0.0005	19.48	21.45	1.97	4.8%
19-May-10	48																								
26-May-10	49	10.3	0.386	<0.05	0.0004	0.0239	<0.01	2.9	0.0073	1.28	<0.00003	2.8	1.6	274	0.00005	<0.00005	<0.003	0.00002	<0.001	0.0044	<0.0005	17.14	19.61	2.47	6.7%
02-Jun-10	50																								
09-Jun-10	51	9.5	0.377	<0.05	<0.0003	0.0225	<0.01	2.7	0.0076	0.963	<0.00003	2.8	1.44	272	0.00004	<0.00005	<0.003	<0.00001	<0.001	0.0043	<0.0005	13.09	15.69	2.60	9.0%

Unsaturated Column Col 5 (Coarse Reject)

Results of Leachate Analysis

Date	Cycle No.	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major Anions	Major Cations	Diff	Diff (%)
		mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
16-Jun-10	52																								
23-Jun-10	53	8.8	0.371	<0.01	0.00036	0.0218	<0.002	2.47	0.00713	1.14	<0.00000E	2.65	1.43	271	4.6E-05	<0.00001	<0.0005	2.3E-05	<0.0002	0.0052	<0.0001	13.46	16.12	2.66	9.0%
30-Jun-10	54																								
07-Jul-10	55	10	0.427	0.01	0.00046	0.0219	0.003	2.53	0.00662	1.07	0.00001	2.98	1.31	289	4.6E-05	0.00026	<0.0005	1.6E-05	<0.0002	0.0039	<0.0001	16.21	17.83	1.62	4.8%
14-Jul-10	56																								
21-Jul-10	57	9.84	0.438	<0.01	0.00035	0.0207	0.003	2.43	0.00796	1.07	<0.00000E	2.86	1.29	308	4.4E-05	<0.00001	<0.0005	1.2E-05	<0.0002	0.0035	<0.0001	16.23	18.01	1.78	5.2%
28-Jul-10	58																								
04-Aug-10	59	10.5	0.482	<0.05	0.0003	0.0237	<0.01	2.4	0.0072	1.18	<0.00003	3.1	1.2	282	0.00005	<0.00005	<0.003	0.00003	<0.001	0.0043	<0.0005	18.02	16.38	-1.64	-4.8%
11-Aug-10	60																								
18-Aug-10	61	9.84	0.435	<0.01	0.00035	0.0196	<0.002	2.31	0.00684	1.04	<0.00000E	2.67	1.25	266	5.5E-05	0.00005	<0.0005	1.2E-05	<0.0002	0.0033	<0.0001	15.60	16.60	1.00	3.1%
25-Aug-10	62																								
01-Sep-10	63	9.39	0.463	<0.01	0.00033	0.0173	<0.002	1.98	0.0067	0.885	<0.00000E	2.22	1.21	265	3.7E-05	0.00028	<0.0005	6E-06	<0.0002	0.0029	<0.0001	19.70	16.22	-3.48	-9.7%
08-Sep-10	64																								
15-Sep-10	65	9.2	0.475	<0.01	0.00027	0.0191	<0.002	1.9	0.00573	0.947	<0.00000E	2	1.19	263	4.3E-05	0.00002	<0.0005	6.6E-05	<0.0002	0.0029	<0.0001	16.69	15.15	-1.54	-4.8%
22-Sep-10	66																								
29-Sep-10	67	10.4	0.493	<0.01	0.00029	0.0188	<0.002	1.98	0.00574	1.14	<0.00000E	2.35	1.15	276	4.4E-05	0.00002	<0.0005	0.00028	0.0002	0.003	<0.0001	15.80	16.26	0.47	1.5%
06-Oct-10	68																								
13-Oct-10	69	8.36	0.461	<0.01	0.00028	0.0177	0.004	1.67	0.00569	1.11	<0.00000E	1.86	1.07	234	4.3E-05	0.00002	<0.0005	0.0002	<0.0002	0.0032	<0.0001	15.41	15.36	-0.05	-0.2%
20-Oct-10	70																								
27-Oct-10	71	7.97	0.411	<0.01	0.00028	0.0131	<0.002	1.61	0.00488	0.901	<0.00000E	1.72	0.98	229	3.3E-05	<0.00001	<0.0005	1.4E-05	<0.0002	0.0026	<0.0001	12.40	13.36	0.96	3.7%
03-Nov-10	72																								
10-Nov-10	73																								
17-Nov-10	74																								
24-Nov-10	75	11.1	0.992	<0.01	0.00017	0.0303	0.002	1.51	0.00535	1.2	<0.00000E	1.88	1.21	296	3.7E-05	0.00002	<0.0005	0.0001	<0.0002	0.0055	<0.0001			20.57	17.34
01-Dec-10	76																								
08-Dec-10	77																								
15-Dec-10	78																								
22-Dec-10	79	10.4	0.829	<0.01	0.00013	0.022	0.003	1.6	0.00527	1.02	<0.00000E	1.66	1.12	270	3.6E-05	0.00001	<0.0005	4.2E-05	<0.0002	0.0038	<0.0001	Z27187	B0C5480	16.19	16.27
29-Dec-10	80																								
05-Jan-11	81																								
12-Jan-11	82																								
19-Jan-11	83	10.1	0.932	<0.01	0.0002	0.0249	0.003	1.51	0.00506	1.01	<0.00000E	1.79	1.05	255	3.7E-05	0.00002	<0.0005	2.2E-05	<0.0002	0.004	<0.0001	Z55854	B105797	14.11	15.16
26-Jan-11	84																								
02-Feb-11	85																								
09-Feb-11	86																								
16-Feb-11	87	10.7	1.13	<0.01	0.00015	0.0303	0.006	1.41	0.00519	0.926	<0.00000E	1.76	1.11	271	3.9E-05	0.00002	<0.0005	9E-06	<0.0002	0.0051	<0.0001	Z98851	B113549	15.39	15.41
23-Feb-11	88																								
02-Mar-11	89																								
09-Mar-11	90																								
16-Mar-11	91	9.35	0.822	<0.01	0.00015	0.0199	0.003	1.24	0.00425	1.04	<0.00000E	1.5	0.969	235	3.5E-05	0.00002	<0.0005	6E-06	<0.0002	0.0035	<0.0001	AE1299	B121655		
23-Mar-11	92																								
30-Mar-11	93																								
06-Apr-11	94																								
13-Apr-11	95	8.04	0.698	<0.02	0.00015	0.0169	0.004	1.05	0.00361	1.07	<0.00000E	1.19	0.85	204	3.1E-05	0.00002	<0.0005	6E-06	<0.0002	0.0032	<0.0001	AI6212	B130184		
20-Apr-11	96												</												

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Unsaturated Column Col 6 (Coarse Reject)

Results of Leachate Analysis

Date	Cycle No.	Volume mL		pH	Cond. umhos/cm	Acidity	Acidity	Alkalinity	Sulphate	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li		
		Input	Output			(pH 4.5)	(pH 8.3)																					
						mg CaCO ₃ /L	mg CaCO ₃ /L	mg CaCO ₃ /L	mg/L	mg/L	mg CaCO ₃ /L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
24-Jun-09	1	750	285	7.77	8012	#N/A	26.8	391.5	5589	230	1640	0.006	0.0006	0.001	0.0805	<0.0001	<0.00005	1.65	0.00212	559	<0.001	1.19	0.0142	<0.01	0.0013	0.017		
01-Jul-09	2	300	270	7.69	5961				3985																			
08-Jul-09	3	300	280	7.66	5680	#N/A	10.7	132.0	3816	440	1520	0.006	0.0002	0.0011	0.0258	<0.00005	<0.00003	0.895	0.00027	525	<0.0005	0.0787	0.0141	0.005	0.00003	0.007		
15-Jul-09	4	300	225	7.70	4732				2891																			
22-Jul-09	5	300	315	7.68	3982	#N/A	10.2	101.3	2538	39	1430	0.003	<0.0002	0.0006	0.0242	<0.0001	<0.00005	0.923	0.00025	496	<0.001	0.0383	0.0039	<0.01	0.00028	0.008		
29-Jul-09	6	300	295	7.73	3505				1983																			
05-Aug-09	7	300	285	7.81	3390	#N/A	9.0	86.2	2497	27	1590	0.006	0.0003	0.0006	0.0236	<0.00005	<0.00003	0.804	0.00011	557	<0.0005	0.0305	0.0036	0.01	0.00006	0.007		
12-Aug-09	8	300	305	7.76	3138				1891																			
19-Aug-09	9	300	295	7.72	2992	#N/A	7.4	61.4	1789	17	1570	0.006	0.0001	0.0003	0.0232	<0.00005	<0.00003	0.671	0.00011	557	<0.0005	0.0215	0.0016	0.01	0.00004	0.006		
26-Aug-09	10	300	290	7.72	2822				1800																			
02-Sep-09	11	300	300	7.82	2876	#N/A	10.7	77.3	2115	14	1640	0.005	0.0001	0.0003	0.0225	<0.00005	<0.00003	0.6	0.00011	587	<0.0005	0.0219	0.0014	0.009	0.00008	0.006		
09-Sep-09	12	300	295	7.70	2640				1875																			
16-Sep-09	13	300	300	7.87	2669	#N/A	7.3	74.9	1785	12	1550	0.003	0.0001	0.0003	0.0236	<0.00005	<0.00003	0.577	0.00012	557	<0.0005	0.0191	0.0013	0.009	<0.00003	0.005		
23-Sep-09	14	300	310	7.63	2469				1758																			
30-Sep-09	15	300	285	7.70	2581	#N/A	7.4	68.2	1946	15	1640	0.002	<0.0001	0.0003	0.0241	<0.00005	<0.00003	0.571	0.00009	593	<0.0005	0.0177	0.0023	0.033	0.00013	0.005		
07-Oct-09	16	300	275	7.57	2579				1703																			
14-Oct-09	17	300	270	7.71	2513	#N/A	6.3	59.4	1921	13	1560	0.032	0.0001	0.0002	0.0218	<0.00005	<0.00003	0.482	0.00014	567	<0.0005	0.0188	0.0024	0.01	0.00129	0.005		
21-Oct-09	18	300	275	7.66	2449				1762																			
28-Oct-09	19	300	300	7.82	2496	#N/A	7.3	70.4	1756	23	1570	0.007	0.0002	0.0002	0.0244	<0.00005	<0.00003	0.471	0.00012	580	<0.0005	0.02	0.002	0.013	0.0232	0.005		
04-Nov-09	20	300	295	7.74	2644				1857																			
11-Nov-09	21	300	280	7.60	2470	#N/A	12.8	67.7	1694	56	1450	<0.001	<0.0001	0.0002	0.0215	<0.00005	<0.00003	0.456	0.00008	535	<0.0005	0.0169	0.0015	0.019	0.00004	0.005		
18-Nov-09	22	300	285	7.77	2603				1531																			
25-Nov-09	23	300	295	7.88	2542	#N/A	6.6	66.2	1814	77	1670	0.003	<0.0001	<0.0001	0.0229	<0.00005	<0.00003	0.376	0.00004	620	<0.0005	0.0176	0.0007	0.01	<0.00003	0.004		
02-Dec-09	24	300	290	7.69	2538				1735																			
09-Dec-09	25	300	265	7.75	2472	#N/A	7.1	63.4	1503	98	1620	0.004	<0.0001	0.0004	0.0276	<0.00005	<0.00003	0.503	0.00017	607	<0.0005	0.0158	0.0023	0.012	0.00013	0.005		
16-Dec-09	26	300	285	7.73	2533				1557																			
23-Dec-09	27	300	285	7.78	2157	#N/A	5.9	62.7	1639	92	1540	0.003	0.0001	0.0002	0.0246	<0.00005	<0.00003	0.426	0.00011	576	<0.0005	0.0181	0.0007	0.044	<0.00003	0.005		
30-Dec-09	28	300	290	7.68	2401				1503																			
06-Jan-10	29	300	295	7.62	2379	#N/A	9.5	70.0	1345	100	1680	0.005	0.0002	0.0011	0.0247	<0.00005	<0.00003	0.487	0.00005	629	<0.0005	0.0219	0.0028	0.033	0.00006	0.005		
13-Jan-10	30	600	585	7.54	2177				1231																			
20-Jan-10	31	600	570	7.63	2053	#N/A	10.6	68.3	1118	66	1380	0.003	0.0002	0.0002	0.0255	<0.00005	<0.00003	0.412	0.00007	519	<0.0005	0.0164	0.0015	0.015	<0.00003	0.004		
27-Jan-10	32	600	525	7.62	1801				1260																			
03-Feb-10	33	600	555	7.54	1597	#N/A	8.6	77.2	1206	55	1270	0.003	<0.0001	<0.0001	0.0268	<0.00005	<0.00003	0.375	0.00007	479	<0.0005	0.0171	0.0029	<0.005	0.00014	0.005		
10-Feb-10	34	600	525	7.71	1952				1110																			
17-Feb-10	35	600	575	7.70	1726	#N/A	7.6	83.5	1167	47	1200	0.003	<0.0001	0.0001	0.0279	<0.00005	<0.00003	0.389	0.00006	452	<0.0005	0.0163	0.0011	0.008	0.00005	0.005		
24-Feb-10	36	600	485	7.63	1905				1243																			
03-Mar-10	37	600	595	7.57	1694	#N/A	7.9	79.5	952	57	1300	0.002	<0.0001	<0.0001	0.0284	<0.00005	<0.00003	0.337	0.00007	491	<0.0005	0.0192	0.0019	<0.005	<0.00003	0.005		
10-Mar-10	38	600	535	7.68	1614				927																			
17-Mar-10	39	600	535	7.76	1484	#N/A	6.1	84.8	757	38	925	0.003	<0.0001	0.0001	0.0294	<0.00005	<0.00003	<0.3	0.00004	349	<0.0005	0.0115	0.001	0.006	0.00005	0.004		
24-Mar-10	40	600	585	7.71	1523				959																			
31-Mar-10	41	1000	985	7.63	1195	#N/A	6.9	71.7	744	29	760	0.004	0.0001	0.0004	0.0267	<0.00005	<0.00003	<0.3	0.00014	287	<0.0005	0.0103	0.0024	0.025	0.00026	0.003		
07-Apr-10	42	1000																										

Results of Leachate Analysis

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Unsaturated Column Col 6 (Coarse Reject)

Results of Leachate Analysis

Date	Cycle No.	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major Anions	Major Cations	Diff	Diff (%)
		mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
24-Jun-09	1	60.7	1.15	<0.1	0.0048	2.77	0.027	18.7	0.306	5.2	<0.00005	1670	6.82	1840	0.00045	<0.00001	<0.005	0.00052	<0.002	0.321	<0.001	130.75	106.31	-24.44	-10.3%
01-Jul-09	2																								
08-Jul-09	3	51	0.309	0.26	0.0032	0.154	0.012	15.5	0.306	2.73	<0.00003	1090	5.75	1560	0.00018	<0.00005	<0.003	0.00012	0.001	0.0158	<0.0005	94.53	78.33	-16.20	-9.4%
15-Jul-09	4																								
22-Jul-09	5	48	0.188	<0.1	0.0028	0.0881	<0.02	14.4	0.219	2.07	<0.00005	589	5.46	815	0.00016	<0.00001	<0.005	0.00005	<0.002	0.007	<0.001	56.00	54.81	-1.19	-1.1%
29-Jul-09	6																								
05-Aug-09	7	47.2	0.174	<0.05	0.003	0.0652	<0.01	14.6	0.164	2.03	<0.00003	368	5.59	790	0.00014	<0.00005	<0.003	0.00006	<0.001	0.0066	<0.0005	54.51	48.19	-6.32	-6.2%
12-Aug-09	8																								
19-Aug-09	9	42.6	0.147	<0.05	0.0029	0.0496	<0.01	13.9	0.123	1.82	<0.00003	240	5.43	707	0.00012	<0.00005	<0.003	0.00004	<0.001	0.0043	<0.0005	38.98	42.22	3.24	4.0%
26-Aug-09	10																								
02-Sep-09	11	42.5	0.154	<0.05	0.0025	0.0486	0.01	13.7	0.0967	1.52	<0.00003	180	5.26	690	0.00011	0.00018	<0.003	0.00004	<0.001	0.005	<0.0005	46.00	41.09	-4.91	-5.6%
09-Sep-09	12																								
16-Sep-09	13	37.5	0.121	<0.05	0.0024	0.0473	<0.01	12	0.0775	1.58	<0.00003	123	5.06	589	0.0001	0.00018	<0.003	0.00003	<0.001	0.004	<0.0005	39.02	36.66	-2.36	-3.1%
23-Sep-09	14																								
30-Sep-09	15	38.5	0.0865	<0.05	0.002	0.0458	<0.01	12.6	0.0774	1.69	<0.00003	102	5.15	641	0.00009	<0.00005	<0.003	0.00003	<0.001	0.0076	<0.0005	42.33	37.64	-4.69	-5.9%
07-Oct-09	16																								
14-Oct-09	17	33.7	0.1	<0.05	0.0018	0.0454	<0.01	11	0.0597	1.43	<0.00003	73.6	4.6	553	0.00008	<0.00005	<0.003	0.00004	<0.001	0.005	<0.0005	41.58	34.66	-6.92	-9.1%
21-Oct-09	18																								
28-Oct-09	19	29.2	0.131	<0.05	0.0019	0.0484	<0.01	11.2	0.0595	1.37	<0.00003	57.6	4.84	544	0.0001	<0.00005	<0.003	0.00004	<0.001	0.0084	<0.0005	38.64	34.25	-4.38	-6.0%
04-Nov-09	20																								
11-Nov-09	21	28.8	0.118	<0.05	0.0016	0.0449	<0.01	9.82	0.0506	1.33	<0.00003	52.8	4.18	493	0.00009	<0.00005	<0.003	0.00002	<0.001	0.0052	<0.0005	38.22	31.72	-6.51	-9.3%
18-Nov-09	22																								
25-Nov-09	23	30.6	0.148	<0.05	0.0015	0.0477	<0.01	10.3	0.0424	1.17	<0.00003	45.7	4.34	505	0.00008	<0.00005	<0.003	0.00004	<0.001	0.0046	<0.0005	41.28	35.81	-5.47	-7.1%
02-Dec-09	24																								
09-Dec-09	25	25.3	0.149	<0.05	0.0016	0.0387	<0.01	10.5	0.0398	1.35	<0.00003	33.2	4.1	497	0.0001	<0.00005	<0.003	0.00011	<0.001	0.0064	<0.0005	35.34	34.18	-1.16	-1.7%
16-Dec-09	26																								
23-Dec-09	27	25	0.193	<0.05	0.0014	0.0451	<0.01	9.41	0.036	1.37	<0.00003	30.4	3.82	530	0.00008	<0.00005	<0.003	0.00003	<0.001	0.0048	<0.0005	37.99	32.46	-5.53	-7.9%
30-Dec-09	28																								
06-Jan-10	29	25.5	0.246	<0.05	0.0013	0.0457	<0.01	10.1	0.0457	1.83	<0.00003	30.7	3.88	577	0.00008	0.00017	0.004	0.00024	<0.001	0.0048	<0.0005	32.24	35.18	2.94	4.4%
13-Jan-10	30																								
20-Jan-10	31	19.4	0.187	<0.05	0.0012	0.0356	<0.01	8.02	0.0274	1.34	<0.00003	19	2.85	447	0.00007	<0.00005	<0.003	0.00003	<0.001	0.0037	<0.0005	26.52	28.60	2.08	3.8%
27-Jan-10	32																								
03-Feb-10	33	17.6	0.217	<0.05	0.001	0.0354	<0.01	8.18	0.0211	1.28	<0.00003	19.2	2.72	371	0.00009	<0.00005	<0.003	0.00002	<0.001	0.004	<0.0005	28.22	26.47	-1.75	-3.2%
10-Feb-10	34																								
17-Feb-10	35	16.8	0.238	<0.05	0.001	0.0324	<0.01	7.7	0.0186	1.33	<0.00003	14.1	2.59	354	0.00009	0.00011	<0.003	0.00003	<0.001	0.0069	<0.0005	27.31	24.82	-2.49	-4.8%
24-Feb-10	36																								
03-Mar-10	37	17.9	0.27	<0.05	0.0009	0.0325	<0.01	8	0.0224	1.2	<0.00003	12.4	2.51	339	0.00008	<0.00005	<0.003	0.00002	<0.001	0.0045	<0.0005	23.03	26.79	3.76	7.5%
10-Mar-10	38																								
17-Mar-10	39	12.8	0.185	<0.05	0.0009	0.022	<0.01	5.9	0.016	1.24	<0.00003	8	1.97	285	0.00005	<0.00005	<0.003	0.00003	<0.001	0.003	<0.0005	18.54	19.02	0.48	1.3%
24-Mar-10	40																								
31-Mar-10	41	11	0.164	<0.05	0.0009	0.0183	<0.01	5.11	0.0129	0.919	<0.00003	6.58	1.56	236	0.00005	0.00008	<0.003	0.00018	<0.001	0.0105	<0.0005	17.75	15.69	-2.06	-6.2%
07-Apr-10	42																								
14-Apr-10	43	8.53	0.139	0.01	0.0008	0.0132	0.002	4.72	0.00943	0.996	<0.000005	3.93	1.34	182	4.7E-05	0.00006	<0.0005	1.3E-05	0.0003	0.0019	<0.0001	14.20	12.46	-1.74	-6.5%
21-Apr-10	44																								
28-Apr-10	45	9	0.145	<0.05	0.0008	0.0135	<0.01	4.3	0.012	1.07	<0.00003	3.3	1.28	173	0.00004	<0.00005	<0.003	0.00003	<0.001	0.0039	<0.0005	13.91	12.51	-1.40	-5.3%
05-May-10	46																								
12-May-10	47	6.9	0.122	0.02	0.00061	0.0102	<0.002	4.01	0.00953	1.09	<0.000005	2.57	1.03	153	4.2E-05	<0.00001	<0.0005	2.8E-05	<0.0002	0.0012	<0.0001	10.41	10.24	-0.17	-0.8%
19-May-10	48																								
26-May-10	49	7.1	0.125	<0.01	0.00052	0.00991	<0.002	3.52	0.00962	1.02	<0.000005	2.02	1.12	161	3.8E-05	0.00001	<0.0005	1.7E-05	0.0002	0.0014	<0.0001	9.41	11.12	1.71	8.3%
02-Jun-10	50																								
09-Jun-10	51	7.73	0.155	<0.01	0.00051	0.0104	<0.002	3.87	0.0105	0.774	<0.000005	2.2	1.18	167	4.6E-05	0.00001	<0.0005	1.4E-05	0.0003	0.0014	<0.0001	10.79	10.00	-0.80	-3.8%

Unsaturated Column Col 6 (Coarse Reject)

Results of Leachate Analysis

Date	Cycle No.	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major Anions	Major Cations	Diff	Diff (%)
		mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
16-Jun-10	52																								
23-Jun-10	53	8.39	0.178	0.01	0.00058	0.0113	<0.002	3.86	0.00993	1.14	<0.00000E	2.11	1.23	173	4.8E-05	<0.00001	<0.0005	4.5E-05	0.0003	0.0014	<0.0001	11.01	11.74	0.73	3.2%
30-Jun-10	54																								
07-Jul-10	55	8.86	0.178	0.01	0.00063	0.0111	0.003	3.75	0.00925	1.05	9E-06	1.96	1.06	170	4.4E-05	0.00032	<0.0005	1.6E-05	<0.0002	0.0027	<0.0001	11.05	12.12	1.07	4.6%
14-Jul-10	56																								
21-Jul-10	57	7.56	0.166	0.02	0.00052	0.00943	0.003	3.28	0.00944	1.01	<0.00000E	1.69	0.997	167	3.8E-05	<0.00001	<0.0005	1.2E-05	<0.0002	0.0014	<0.0001	8.91	10.19	1.28	6.7%
28-Jul-10	58																								
04-Aug-10	59	7.72	0.165	<0.01	0.00046	0.00978	<0.002	3.55	0.0113	1.39	<0.00000E	1.64	0.925	168	4.3E-05	0.00001	<0.0005	1.1E-05	<0.0002	0.0014	<0.0001	10.90	13.60	2.70	11.0%
11-Aug-10	60																								
18-Aug-10	61	8.37	0.188	<0.01	0.00049	0.00977	<0.002	3.49	0.00951	0.979	<0.00000E	1.75	1.09	172	0.00005	<0.00001	<0.0005	1.5E-05	0.0003	0.0018	<0.0001	10.51	11.12	0.60	2.8%
25-Aug-10	62																								
01-Sep-10	63	6.45	0.146	<0.01	0.00043	0.00792	<0.002	2.65	0.00752	0.777	<0.00000E	1.49	0.854	133	3.5E-05	0.00025	<0.0005	1.2E-05	0.0003	0.0012	<0.0001	11.44	9.16	-2.28	-11.1%
08-Sep-10	64																								
15-Sep-10	65	6.1	0.131	<0.01	0.00038	0.00747	<0.002	2.6	0.00659	0.804	<0.00000E	1.2	0.764	132	3.5E-05	0.00001	<0.0005	2.3E-05	0.0003	0.001	<0.0001	10.62	8.77	-1.85	-9.6%
22-Sep-10	66																								
29-Sep-10	67	7.09	0.15	<0.01	0.00039	0.00744	<0.002	2.61	0.00749	1.01	<0.00000E	1.39	0.851	151	3.9E-05	0.00001	<0.0005	1.6E-05	0.0003	0.0013	<0.0001	12.68	10.61	-2.08	-8.9%
06-Oct-10	68																								
13-Oct-10	69	5.73	0.141	<0.01	0.00035	0.00687	<0.002	2.24	0.00692	0.798	<0.00000E	1.08	0.743	133	3.5E-05	0.00002	<0.0005	1.4E-05	<0.0002	0.0016	<0.0001	11.17	8.62	-2.55	-12.9%
20-Oct-10	70																								
27-Oct-10	71	5.98	0.136	<0.01	0.00031	0.00713	<0.002	2.19	0.00657	0.828	<0.00000E	1.07	0.743	129	3.6E-05	<0.00001	<0.0005	2.4E-05	<0.0002	0.0014	<0.0001	10.65	8.68	-1.97	-10.2%
03-Nov-10	72																								
10-Nov-10	73																								
17-Nov-10	74																								
24-Nov-10	75	6.04	0.136	0.01	0.00029	0.00614	<0.002	1.83	0.00555	0.605	<0.00000E	0.99	0.652	120	2.3E-05	<0.00001	<0.0005	1.4E-05	<0.0002	0.0025	<0.0001			9.89	7.87
01-Dec-10	76																								
08-Dec-10	77																								
15-Dec-10	78																								
22-Dec-10	79	5.36	0.127	<0.01	0.00017	0.00544	<0.002	1.88	0.00529	0.785	<0.00000E	0.91	0.618	109	2.9E-05	0.00002	<0.0005	1.1E-05	<0.0002	0.0013	<0.0001	Z27188	B0C5480	8.65	7.61
29-Dec-10	80																								
05-Jan-11	81																								
12-Jan-11	82																								
19-Jan-11	83	6.49	0.144	<0.01	0.00028	0.00718	<0.002	2	0.007	0.723	<0.00000E	0.97	0.742	139	3.1E-05	0.00001	<0.0005	0.00093	<0.0002	0.0014	<0.0001	Z55855	B105797	9.68	9.76
26-Jan-11	84																								
02-Feb-11	85																								
09-Feb-11	86																								
16-Feb-11	87	5.13	0.106	<0.01	0.0002	0.00562	0.003	1.53	0.00569	0.53	<0.00000E	0.83	0.603	116	2.7E-05	0.00002	<0.0005	1.3E-05	<0.0002	0.0011	<0.0001	Z98852	B113549	7.89	7.62
23-Feb-11	88																								
02-Mar-11	89																								
09-Mar-11	90																								
16-Mar-11	91	4.1	0.066	<0.01	0.00019	0.00417	<0.002	1.29	0.0045	0.634	<0.00000E	0.72	0.472	94	2.3E-05	0.00002	<0.0005	8E-06	<0.0002	0.0026	<0.0001	AE1300	B121655		
23-Mar-11	92																								
30-Mar-11	93																								
06-Apr-11	94																								
13-Apr-11	95	4.43	0.0518	<0.01	0.00015	0.004	0.003	1.21	0.00447	0.671	<0.00000E	0.71	0.484	98	2.2E-05	0.00003	<0.0005	7E-06	<0.0002	0.001	<0.0001	AI6213	B130184		
20-Apr-11	96																								
27-Apr-11	97																								
04-May-11	98																								

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Unsaturated Column Col 7 (Coarse Reject)

Results of Leachate Analysis

Date	Cycle No.	Volume mL		pH	Cond. umhos/cm	Acidity (pH 4.5)	Acidity (pH 8.3)	Alkalinity	Sulphate	Chloride	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li
		Input	Output			mg CaCO ₃ /L	mg CaCO ₃ /L	mg CaCO ₃ /L	mg/L	mg/L	mg CaCO ₃ /L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
17-Mar-10	1	900	370	6.61	6418	#N/A	100.2	51.4	4378	26	1520	0.003	<0.0002	0.0003	0.0339	0.0002	<0.00005	7.31	0.00781	492	<0.001	6.78	0.0024	28.1	<0.00005	0.113
24-Mar-10	2	300	290	6.55	6968				4698																	
31-Mar-10	3	300	295	5.81	5619	#N/A	16.8	2.0	4535	59	1510	0.008	<0.0001	0.0027	0.0235	<0.00005	<0.00003	3.42	0.0007	483	<0.0005	1.67	0.0227	0.062	0.00013	0.069
07-Apr-10	4	300	270	7.54	5057				2991																	
14-Apr-10	5	300	280	7.52	4449	#N/A	11.1	62.5	3185	3.9	1530	0.005	<0.0001	0.0022	0.0203	<0.00005	<0.00003	3.22	0.00044	487	<0.0005	1.21	0.004	0.015	0.00005	0.065
21-Apr-10	6	300	305	7.56	3866				2414																	
28-Apr-10	7	300	300	7.53	3496	#N/A	5.4	55.4	2431	2	1690	0.004	<0.0001	0.0018	0.0214	<0.00005	<0.00003	3.15	0.00038	520	<0.0005	1.1	0.0024	0.005	<0.00003	0.065
05-May-10	8	300	295	7.38	3174				2488																	
12-May-10	9	300	290	7.55	3038	#N/A	8.2	45.0	2092	1.6	2010	0.004	<0.0001	0.0016	0.0251	<0.00005	<0.00003	3.11	0.00043	614	<0.0005	1.21	0.0042	0.021	<0.00003	0.068
19-May-10	10	300	260	7.56	2981				1584																	
26-May-10	11	1000	995	7.06	2594	#N/A	17.1	29.5	1685	<0.5	1870	0.003	<0.0001	0.0007	0.0228	<0.00005	<0.00003	2.87	0.00055	578	<0.0005	1.25	0.0102	0.013	0.00007	0.055
02-Jun-10	12	1000	995	7.22	2454				1305																	
09-Jun-10	13	1000	1010	7.25	2054	#N/A	7.7	24.2	1210	<0.5	1350	0.002	<0.0001	0.0005	0.0295	<0.00005	<0.00003	1.57	0.00042	417	<0.0005	1.1	0.0123	0.007	<0.00003	0.039
16-Jun-10	14	1000	1005	7.05	1865				838																	
23-Jun-10	15	1000	1005	7.14	1827	#N/A	7.2	25.7	1066	<0.5	1190	0.002	<0.0001	0.0004	0.034	<0.00005	<0.00003	1.35	0.00044	385	<0.0005	0.945	0.0143	0.034	<0.00003	0.033
30-Jun-10	16	1000	995	7.23	1704				1017																	
07-Jul-10	17	1000	985	7.15	1769	#N/A	6.5	26.8	1034	2	1160	0.004	<0.0001	0.0003	0.0314	<0.00005	<0.00003	1.07	0.00041	368	<0.0005	1.05	0.0187	0.011	<0.00003	0.031
14-Jul-10	18	1000	980	7.08	1557				567																	
21-Jul-10	19	1000	990	6.95	1593	#N/A	10.0	24.2	1067	3	1120	0.004	<0.0001	0.0004	0.0269	<0.00005	<0.00003	1.02	0.0004	357	0.0007	0.956	0.0176	0.568	0.00136	0.031
28-Jul-10	20	1000	995	7.11	1550				794																	
04-Aug-10	21	1000	990	7.24	1496	#N/A	8.6	21.5	984	3.1	1170	0.007	<0.0001	0.0002	0.0287	<0.00005	<0.00003	0.948	0.00029	383	<0.0005	0.908	0.0172	0.036	<0.00003	0.028
11-Aug-10	22	1000	985	7.30	1596				977																	
18-Aug-10	23	1000	990	7.25	1424	#N/A	12.0	28.4	1044	4.6	1090	0.007	<0.0001	0.0004	0.0257	<0.00005	<0.00003	0.881	0.00051	340	<0.0005	0.897	0.0205	0.015	<0.00003	0.03
25-Aug-10	24	1000	985	7.08	1318				946																	
01-Sep-10	25	1000	1005	7.21	1437	#N/A	10.0	9.8	1186	1.8	1020	0.0035	<0.00002	0.00011	0.0269	0.00006	5E-06	0.564	0.00044	322	0.0001	0.855	0.0421	0.06	3.3E-05	0.0249
08-Sep-10	26	1000	985	6.81	1341				861																	
15-Sep-10	27	1000	985	6.75	1197	#N/A	7.7	15.0	1032	1.2	908	0.0013	<0.00002	0.00015	0.0225	0.00006	<0.000005	0.635	0.00053	271	<0.0001	0.887	0.0549	0.024	9E-06	0.0261
22-Sep-10	28	1000	975	6.97	1081				1057																	
29-Sep-10	29	1000	970	6.85	1008	#N/A	6.6	20.2	1134	2.8	1070	0.004	<0.00002	0.00019	0.0223	0.00011	<0.000005	0.649	0.00062	311	<0.0001	1.03	0.0795	0.018	3.4E-05	0.0294
06-Oct-10	30	1000	900	6.85	1352				1087																	
13-Oct-10	31	1000	980	6.72	1311	#N/A	7.3	15.0	1005	1	926	0.002	<0.00002	0.0001	0.022	0.00016	<0.000005	0.561	0.00066	265	0.0001	1.03	0.0974	0.033	1.8E-05	0.0247
20-Oct-10	32	1000	995	6.79	1327				981																	
27-Oct-10	33	1000	990	6.69	1400	#N/A	7.1	13.1	973	0.9	1040	0.0017	<0.00002	0.00011	0.0207	0.00016	<0.000005	0.509	0.00071	295	0.0001	1.11	0.111	0.136	6.1E-05	0.0256
03-Nov-10	34	1000	990	6.76	1121																					
10-Nov-10	35	1000	995	6.47	1432																					
17-Nov-10	36	1000	990	6.68	1353																					
24-Nov-10	37	1000	995	6.19	1148	#N/A	8.5	4.8	682	1	660	0.013	<0.0001	0.0002	0.0182	0.00018	<0.00003	<0.3	0.0006	168	<0.0005	0.851	0.151	0.483	0.00016	0.016
01-Dec-10	38	1000	985	6.61	1512																					
08-Dec-10	39	1000	1025	6.51	1292																					
15-Dec-10	40	1000	985	6.31	1392																					
22-Dec-10	41	1000	985	6.54	1497	#N/A	13.2	5.4	1126	0.6	1160	0.026	<0.00002	0.00033	0.0201	0.00029	<0.000005	0.426	0.00113	302	<0.0001	1.37	0.228	0.808	0.00013	0.0256
29-Dec-10	42	1000	995	6.51	1518																					
05-Jan-11	43	1000	970	6.50	1277																					
12-Jan-11	44	1000	960	6.29	1363																					
19-Jan-11	45	1000	965	6.06	1388	#N/A	12.8	2.5	910	<0.5	940	0.185	<0.0001	0.0003	0.0194	0.00045	<0.00003	0.473	0.00118	231	<0.0005	1.22	0.283	1.32	0.00003	0.023
26-Jan-11	46	1000	910	5.72	1289																					
02-Feb-11	47	1000	915	5.89	1212																					
09-Feb-11	48	1000	945	5.12	1630																					
16-Feb-11	49	1000	945	5.13	1713	#N/A	15.8	0.2	1067	<0.5	992	0.513	<0.0001	0.0008	0.0147	0.00071	<0.00003	0.384	0.00145	239	0.0006	1.32	0.422	1.68	0.00194	0.025
23-Feb-11	50	1000	1000	5.38	1702																					
02-Mar-11	51	1000	960	5.24	1459																					
09-Mar-11	52	1000	985	4.79	1659																					
16-Mar-11	53	1000	965	5.21	1496	#N/A	13.1	0.5	994	1.4	883	0.248	<0.0001	0.0005	0.0207	0.00074	<0.00003	0.322	0.00125	205	<0.0005	1.16	0.339	0.701	0.00005	0.02
23-Mar-11	54	1000	965	5.47	1490																					
30-Mar-11	55	1000	990	5.67	1365																					
06-Apr-11	56	1000	895	4.61	1847																					
13-Apr-11	57	1000	975	4.51	1749	#N/A	24.2	<0.1	1088	3.3	1030	0.732	<0.0001	0.0013	0.0144	0.00123	<0.00003	0.38	0.00227	235	0.0024	1.39	0.713	1.47	0.00185	0.023
20-Apr-11	58	1000	980	4.31	1953																					

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Unsaturated Column Col 7 (Coarse Reject)

Results of Leachate Analysis

Date	Cycle No.	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr	Major Anions	Major Cations	Diff	Diff (%)
		mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L				
17-Mar-10	1	71.1	4.68	<0.1	0.0007	9.64	<0.02	21	0.256	6.75	<0.00005	1280	5.8	1620	0.00174	0.0001	0.007	0.00008	<0.002	3.89	<0.001	92.97	87.57	-5.40	-3.0%
24-Mar-10	2																								
31-Mar-10	3	73	2.93	0.08	0.0005	2.38	0.011	20	0.301	1.96	<0.00003	1140	4.69	1480	0.0005	0.00006	<0.003	0.00002	<0.001	0.233	<0.0005	96.18	80.55	-15.64	-8.8%
07-Apr-10	4																								
14-Apr-10	5	76.2	2.84	<0.05	0.0004	1.76	<0.01	18.6	0.137	2.01	<0.00003	640	4.56	1020	0.00036	<0.00005	<0.003	0.00001	<0.001	0.153	<0.0005	67.71	59.19	-8.53	-6.7%
21-Apr-10	6																								
28-Apr-10	7	95.1	3.08	<0.05	0.0004	1.6	<0.01	19.1	0.0823	1.95	0.00003	357	4.87	858	0.00027	<0.00005	<0.003	0.00002	<0.001	0.128	<0.0005	51.81	50.10	-1.71	-1.7%
05-May-10	8																								
12-May-10	9	115	3.64	<0.05	<0.0003	1.74	<0.01	22.6	0.0494	2.33	<0.00003	217	5.54	796	0.00047	<0.00005	<0.003	0.00002	<0.001	0.152	<0.0005	44.53	50.48	5.95	6.3%
19-May-10	10																								
26-May-10	11	103	3.97	<0.05	<0.0003	1.74	<0.01	19.2	0.0308	2.56	0.00005	68.6	5.19	634	0.00044	<0.00005	<0.003	0.00001	<0.001	0.211	<0.0005	35.69	41.16	5.47	7.1%
02-Jun-10	12																								
09-Jun-10	13	75.5	3.35	<0.05	<0.0003	1.56	<0.01	15.7	0.0192	1.61	<0.00003	17.7	3.9	573	0.00038	0.00024	<0.003	<0.00001	<0.001	0.198	<0.0005	25.69	28.50	2.81	5.2%
16-Jun-10	14																								
23-Jun-10	15	55.2	2.77	<0.05	<0.0003	1.38	<0.01	11.7	0.0164	2.46	<0.00003	8	2.74	452	0.00037	0.00037	<0.003	0.00001	<0.001	0.207	<0.0005	22.72	24.65	1.93	4.1%
30-Jun-10	16																								
07-Jul-10	17	59.5	3.01	<0.05	0.0004	1.52	<0.01	10.8	0.0147	2.4	0.00004	6.2	2.32	448	0.00035	0.00062	<0.003	0.00001	<0.001	0.232	<0.0005	22.13	24.06	1.93	4.2%
14-Jul-10	18																								
21-Jul-10	19	55	2.97	<0.05	<0.0003	1.35	0.012	8.9	0.0154	2.38	<0.00003	4.5	2.08	445	0.00038	0.00031	<0.003	<0.00001	<0.001	0.224	<0.0005	22.80	23.01	0.21	0.5%
28-Jul-10	20																								
04-Aug-10	21	52.9	2.88	<0.05	<0.0003	1.31	<0.01	8.2	0.0144	2.66	<0.00003	3.6	1.65	391	0.00036	0.00034	<0.003	<0.00001	<0.001	0.207	<0.0005	21.02	24.06	3.04	6.7%
11-Aug-10	22																								
18-Aug-10	23	58.5	3.3	<0.05	<0.0003	1.35	<0.01	7.6	0.0127	2.51	0.00009	3.2	1.74	407	0.00043	0.00036	<0.003	<0.00001	<0.001	0.252	<0.0005	22.45	22.60	0.16	0.3%
25-Aug-10	24																								
01-Sep-10	25	52.9	3.17	<0.01	0.00014	1.27	<0.002	6.12	0.0116	2.1	<0.000005	2.44	1.61	375	0.00042	0.00077	<0.0005	3E-06	<0.0002	0.274	<0.0001	24.96	21.07	-3.88	-8.4%
08-Sep-10	26																								
15-Sep-10	27	56	3.22	<0.01	0.00008	1.33	<0.002	5.6	0.0101	2.61	<0.000005	2.2	1.27	345	0.00043	0.00083	<0.0005	1.1E-05	<0.0002	0.344	<0.0001	21.83	18.78	-3.05	-7.5%
22-Sep-10	28																								
29-Sep-10	29	71.3	4.02	<0.01	0.00011	1.53	0.003	5.57	0.0104	3.08	<0.000005	2.43	1.39	389	0.0005	0.00087	<0.0005	0.00086	<0.0002	0.432	<0.0001	24.11	22.09	-2.01	-4.4%
06-Oct-10	30																								
13-Oct-10	31	64.2	4.18	<0.01	0.00014	1.57	0.005	4.9	0.00976	2.66	<0.000005	2.04	1.22	354	0.00048	0.00108	<0.0005	2.5E-05	<0.0002	0.512	<0.0001	21.27	19.16	-2.10	-5.2%
20-Oct-10	32																								
27-Oct-10	33	74.5	4.75	<0.01	0.0001	1.7	0.005	4.65	0.00914	3.06	<0.000005	1.86	1.22	377	0.0005	0.00137	<0.0005	2.3E-05	<0.0002	0.561	<0.0001			20.56	21.52
03-Nov-10	34																								
10-Nov-10	35																								
17-Nov-10	36																								
24-Nov-10	37	58.1	3.78	<0.05	<0.0003	1.32	<0.01	2.6	0.0062	2.06	<0.00003	1.1	0.747	249	0.00037	0.00337	<0.003	0.00002	<0.001	0.6	<0.0005			14.33	13.56
01-Dec-10	38																								
08-Dec-10	39																								
15-Dec-10	40																								
22-Dec-10	41	97.5	6.58	<0.01	0.00007	2.18	0.006	3.89	0.00803	3.35	<0.000005	1.59	1.07	415	0.00066	0.00322	<0.0005	0.00023	<0.0002	0.96	<0.0001	Z27189	B0C5480	23.58	23.85
29-Dec-10	42																								
05-Jan-11	43																								
12-Jan-11	44																								
19-Jan-11	45	88	6.41	<0.05	<0.0003	2.01	<0.01	2.9	0.008	3.69	<0.00003	1.3	0.834	329	0.0007	0.00339	<0.003	0.00011	<0.001	1.04	<0.0005	Z55856	B105797	19.01	19.51
26-Jan-11	46																								
02-Feb-11	47																								
09-Feb-11	48																								
16-Feb-11	49	96.2	7.44	<0.05	<0.0003	2.25	0.208	2.6	0.0075	4.14	0.00004	1.3	0.828	346	0.00076	0.00595	<0.003	0.00012	<0.001	1.42	<0.0005	Z98853	B113549	22.23	20.63
23-Feb-11	50																								
02-Mar-11	51																								
09-Mar-11	52																								
16-Mar-11	53	90.3	6.87	<0.05	<0.0003	2.06	<0.01	2	0.007	3.86	<0.00003	0.9	0.703	334	0.00084	0.0146	<0.003	0.00008	<0.001	1.38	<0.0005	AE1301	B121655		
23-Mar-11	54																								
30-Mar-11	55																								
06-Apr-11	56																								
13-Apr-11	57	107	8.42	<0.05	<0.0003	2.47	0.013	1.9	0.007	6.18	<0.00003	1.1	0.738	367	0.00101	0.0183	<0.003	0.00019	<0.001	2.04	<0.0005	AI6214	B130184		
20-Apr-11	58																								

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Saturated Column HQD (7 South Tailings)*Results of Leachate Analysis*

Parameter	Units	HQD									BC Guideline	
		03-Feb-11 0	09-Feb-11 cycle 1	16-Feb-11 cycle 2	23-Feb-11 cycle 3	02-Mar-11 cycle 4	16-Mar-11 cycle 5	30-Mar-11 cycle 6	12-Apr-11 cycle 7	26-Apr-11 cycle 8	30-day	Max
Physical												
pH	pH	7.0	6.9	6.8	7.1	7.5	7.6	7.6	7.6	7.6	6.5-8.5	NP
Conductivity	uS/cm	1128	1418	976	721	494	339	286	258	201		
Alkalinity	mg/L	99	273	302	266	178	116	98	98	77		
Anions & Nutrients												
Bromide (Br)	mg/L	16.2	65.4	62.2	36.7	26.9	19.2	12.7	10.2	7.86	150	600
Chloride (Cl)	mg/L	22.1	41	9.10	2.29	1.12	0.58	<0.5	0.57	<0.5		
Fluoride (F)	mg/L	0.042	<0.4	0.150	0.371	0.533	1.18	1.30	1.16	0.874		
Ammonia as N	mg/L	0.651	0.270	0.202	0.121	0.0428	<0.005	<0.005	<0.005	<0.005	3	31.3
Nitrate (as N)	mg/L	0.337	0.19	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005		
Nitrite (as N)	mg/L	0.0017	0.10	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001		
Dissolved Phosphate-P	mg/L	0.0055	0.0044	<0.002	<0.002	<0.002	<0.002	0.0028	0.0042	0.0049	NP	Lakes
Sulfate (SO4)	mg/L	454	805	162	41.7	18.2	13.3	12.9	12.9	12.7	50	100
Sulphide as S	mg/L	0.0203	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.0051	<0.005		
DOC	mg/L	12.3	23.6	11.9	11.4	4.86	1.60	1.60	1.51	1.45		
Dissolved Metals												
Al	mg/L	0.00554	0.00402	<0.003	0.00213	0.00178	0.00333	0.00531	0.00551	0.00703	0.05	0.1
Ag	mg/L	0.0000148	0.0000083	<5E-06	<5E-06	<5E-06	<0.000005	<5E-06	<5E-06	<5E-06	0.00005	0.0001
As	mg/L	0.0354	0.0553	0.0655	0.0883	0.0891	0.0923	0.107	0.129	0.124	NP	0.005
B	mg/L	0.438	1.36	0.974	0.630	0.405	0.295	0.215	0.185	0.164	NP	1.2
Ba	mg/L	0.146	0.0514	0.105	0.263	0.324	0.266	0.228	0.212	0.199	1	5
Be	mg/L	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.0053	NP
Bi	mg/L	0.0000063	0.0000150	0.0000140	0.0000138	<5E-06	<0.000005	<5E-06	<5E-06	<5E-06		
Ca	mg/L	195	344	154	110	67.5	51.2	41.4	36.9	32.6		
Cd	mg/L	0.000053	0.00002	0.00001	0.000022	0.000017	0.000029	0.0000088	0.0000087	0.0000087	NP	0.000017
Co	mg/L	0.105	0.00247	0.000461	0.0000594	0.0000108	0.0000093	0.0000078	<5E-06	<5E-06	0.004	0.11
Cr	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	NP	0.001
Cu	mg/L	0.0021	0.00018	0.00013	0.00026	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002	0.00623
Fe	mg/L	0.0024	4.99	2.38	1.50	0.413	0.0620	0.0221	0.0489	0.0025	NP	0.35
Hg	mg/L	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002		
K	mg/L	6.23	8.11	5.10	3.74	2.34	1.43	1.11	0.886	0.730		
Li	mg/L	0.0332	0.0656	0.0517	0.0379	0.0244	0.0169	0.0140	0.0124	0.0115	0.096	0.87
Mg	mg/L	25.4	49.5	20.3	11.5	6.30	3.81	3.05	2.74	2.38	NP	NP
Mn	mg/L	0.79	1.40	0.602	0.404	0.237	0.128	0.105	0.0902	0.0766	0.803	1.04
Mo	mg/L	0.0136	0.0283	0.0282	0.0506	0.0898	0.0805	0.0483	0.0361	0.0281	1	2
Na	mg/L	6.92	10.0	3.16	1.12	0.481	0.284	0.224	0.186	0.156		
Ni	mg/L	0.144	0.00482	0.00188	0.000060	0.000120	0.000218	0.000057	0.000052	<0.00005	NP	0.025
P	mg/L	ND	ND	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3		
Pb	mg/L	0.0000476	0.0000798	0.0000070	0.0000141	<5E-06	0.0000105	<5E-06	0.0000115	0.0000230	0.0045	0.0295
Sb	mg/L	0.014	0.035	0.029	0.023	0.023	0.017	0.0044	0.0033	0.0028	NP	0.02
Se	mg/L	0.0058	0.0094	0.0018	0.00018	0.000064	<0.00004	0.000047	0.000084	<0.00004	NP	0.002
Si	mg/L	1.53	6.74	6.61	5.02	3.94	2.97	2.59	2.36	2.05		
Sn	mg/L	<0.00001	0.000024	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001		
Sr	mg/L	1.05	1.78	0.921	0.630	0.434	0.275	0.230	0.206	0.183		
Ti	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	NP	2
Tl	mg/L	0.000280	0.0000070	0.00001	<2E-06	<2E-06	<0.000002	<2E-06	<2E-06	<2E-06	NP	0.0003
U	mg/L	0.00048	0.00015	0.000083	0.000041	0.000030	0.000025	0.000028	0.000028	0.000025	NP	0.3
V	mg/L	0.00030	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.02	0.006*
Zn	mg/L	0.033	0.016	0.0064	0.0012	<0.0005	0.0076	0.00053	0.0020	0.0027	0.0075	0.033
Zr	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		

Notes:

British Columbia Water Quality Guidelines (BC WQG) for the protection of freshwater aquatic life (BC MOE, 2006)

Shaded values exceed the maximum guideline, bold italics exceed the 30-day guideline

All guidelines are for total metals except Al and Fe, which are dissolved guidelines

Hardness dependent guidelines (Ag, Cd, Cu, Pb, Mn, Ni, Zn) based on average concentrations of Middle Quinsam Lake of 45 mg CaCQL

***Appendix D:
Predicted Concentrations
in Quinsam River***



HILLSBOUROUGH
Resources Limited

Scenario 1 (No Mine Waste Storage): Expected concentrations in Quinsam River from 2N, 3N, 5S and RBP groundwater seepage

COC	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Aluminum (Al) Dissolved	mg/L	2.5E-02	2.9E-02	2.4E-02	2.0E-02	1.6E-02	1.8E-02	1.7E-02	1.6E-02	1.6E-02	1.0E-02	1.6E-02	2.6E-02	1.9E-02
Arsenic (As) Total	mg/L	1.9E-04	2.1E-04	2.1E-04	2.1E-04	2.2E-04	2.3E-04	2.8E-04	3.2E-04	2.6E-04	2.1E-04	1.9E-04	2.0E-04	5.8E-04
Boron (B) Total	mg/L	2.9E-03	3.3E-03	3.2E-03	3.4E-03	3.6E-03	3.9E-03	4.9E-03	6.0E-03	4.6E-03	3.4E-03	2.9E-03	3.0E-03	1.2E-02
Cadmium (Cd) Total	mg/L	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05
Cobalt (Co) Total	mg/L	9.2E-05	9.3E-05	9.2E-05	9.3E-05	9.3E-05	9.4E-05	9.5E-05	9.7E-05	9.5E-05	9.3E-05	9.2E-05	9.2E-05	1.1E-04
Copper (Cu) Total	mg/L	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.6E-04
Fluoride (F) Total	mg/L													
Iron (Fe) Total	mg/L	4.8E-02	7.9E-02	5.4E-02	4.9E-02	5.2E-02	4.1E-02	6.1E-02	4.5E-02	4.7E-02	4.5E-02	8.2E-02	6.9E-02	6.1E-02
Manganese (Mn) Total	mg/L	6.1E-03	6.2E-03	9.7E-03	7.8E-03	8.4E-03	1.1E-02	1.1E-02	9.8E-03	8.1E-03	9.1E-03	1.5E-02	8.8E-03	1.2E-02
Nickel (Ni) Total	mg/L	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.3E-04	2.3E-04	2.3E-04	2.2E-04	2.2E-04	2.2E-04	2.4E-04
Selenium (Se) Total	mg/L	4.4E-05	4.4E-05	4.4E-05	4.4E-05	4.4E-05	4.4E-05	4.5E-05	4.5E-05	4.5E-05	4.4E-05	4.4E-05	4.4E-05	4.6E-05
Sulphate (SO4) Dissolved	mg/L	3.0E+01	3.6E+01	4.6E+01	4.3E+01	3.4E+01	3.2E+01	2.4E+01	1.9E+01	1.9E+01	2.2E+01	2.8E+01	3.0E+01	2.1E+01
Zinc (Zn) Total	mg/L	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.1E-03

Scenario 1 (No Mine Waste Storage): Worst case concentrations in Quinsam River from 2N, 3N, 5S and RBP groundwater seepage

COC	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Aluminum (Al) Dissolved	mg/L	2.5E-02	2.9E-02	2.5E-02	2.0E-02	1.6E-02	1.8E-02	1.7E-02	1.7E-02	1.6E-02	1.0E-02	1.6E-02	2.6E-02	2.0E-02
Arsenic (As) Total	mg/L	2.6E-04	3.4E-04	3.3E-04	3.7E-04	4.1E-04	4.8E-04	6.9E-04	9.1E-04	6.2E-04	3.6E-04	2.6E-04	2.8E-04	2.3E-03
Boron (B) Total	mg/L	5.1E-03	7.2E-03	6.9E-03	8.2E-03	9.2E-03	1.1E-02	1.7E-02	2.4E-02	1.5E-02	7.9E-03	5.1E-03	5.6E-03	6.3E-02
Cadmium (Cd) Total	mg/L	1.2E-05	1.2E-05	1.2E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.4E-05	1.3E-05	1.3E-05	1.2E-05	1.2E-05	1.7E-05
Cobalt (Co) Total	mg/L	1.5E-04	2.0E-04	1.9E-04	2.2E-04	2.5E-04	3.0E-04	4.4E-04	5.9E-04	3.9E-04	2.2E-04	1.5E-04	1.6E-04	1.5E-03
Copper (Cu) Total	mg/L	5.5E-04	5.6E-04	5.6E-04	5.6E-04	5.6E-04	5.7E-04	5.8E-04	6.0E-04	5.8E-04	5.6E-04	5.5E-04	5.5E-04	6.9E-04
Fluoride (F) Total	mg/L													
Iron (Fe) Total	mg/L	5.9E-02	9.9E-02	7.3E-02	7.3E-02	7.9E-02	7.7E-02	1.2E-01	1.3E-01	1.0E-01	6.8E-02	9.3E-02	8.2E-02	3.1E-01
Manganese (Mn) Total	mg/L	8.0E-03	9.6E-03	1.3E-02	1.2E-02	1.3E-02	1.7E-02	2.2E-02	2.5E-02	1.7E-02	1.3E-02	1.6E-02	1.1E-02	5.5E-02
Nickel (Ni) Total	mg/L	3.1E-04	3.9E-04	3.8E-04	4.2E-04	4.6E-04	5.3E-04	7.5E-04	9.9E-04	6.8E-04	4.1E-04	3.1E-04	3.3E-04	2.4E-03
Selenium (Se) Total	mg/L	4.6E-05	4.8E-05	4.7E-05	4.8E-05	4.9E-05	5.1E-05	5.5E-05	6.0E-05	5.4E-05	4.8E-05	4.6E-05	4.7E-05	9.0E-05
Sulphate (SO4) Dissolved	mg/L	3.3E+01	4.1E+01	5.1E+01	4.9E+01	4.1E+01	4.1E+01	3.9E+01	4.1E+01	3.2E+01	2.8E+01	3.1E+01	3.3E+01	8.3E+01
Zinc (Zn) Total	mg/L	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.0E-03	1.0E-03	1.0E-03	1.4E-03

Scenario 2 (Tailings in 2N/3N, CCR in RBP): Expected concentrations in Quinsam River from 2N, 3N, 5S and RBP groundwater seepage

COC	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Aluminum (Al) Dissolved	mg/L	2.5E-02	2.9E-02	2.4E-02	2.0E-02	1.6E-02	1.8E-02	1.7E-02	1.6E-02	1.6E-02	1.0E-02	1.6E-02	2.6E-02	1.9E-02
Arsenic (As) Total	mg/L	2.1E-04	2.4E-04	2.4E-04	2.5E-04	2.7E-04	3.0E-04	3.8E-04	4.7E-04	3.5E-04	2.5E-04	2.1E-04	2.2E-04	1.0E-03
Boron (B) Total	mg/L	2.9E-03	3.3E-03	3.2E-03	3.4E-03	3.6E-03	3.9E-03	4.9E-03	6.0E-03	4.6E-03	3.4E-03	2.9E-03	3.0E-03	1.2E-02
Cadmium (Cd) Total	mg/L	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05	1.2E-05
Cobalt (Co) Total	mg/L	9.2E-05	9.3E-05	9.2E-05	9.3E-05	9.3E-05	9.4E-05	9.5E-05	9.7E-05	9.5E-05	9.3E-05	9.2E-05	9.2E-05	1.1E-04
Copper (Cu) Total	mg/L	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.5E-04	5.6E-04
Fluoride (F) Total	mg/L													
Iron (Fe) Total	mg/L	4.8E-02	7.9E-02	5.4E-02	4.9E-02	5.2E-02	4.1E-02	6.1E-02	4.5E-02	4.7E-02	4.5E-02	8.2E-02	6.9E-02	6.1E-02
Manganese (Mn) Total	mg/L	6.1E-03	6.2E-03	9.7E-03	7.8E-03	8.4E-03	1.1E-02	1.1E-02	9.8E-03	8.1E-03	9.1E-03	1.5E-02	8.8E-03	1.2E-02
Nickel (Ni) Total	mg/L	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.2E-04	2.3E-04	2.3E-04	2.3E-04	2.2E-04	2.2E-04	2.2E-04	2.4E-04
Selenium (Se) Total	mg/L	4.4E-05	4.4E-05	4.4E-05	4.4E-05	4.4E-05	4.4E-05	4.5E-05	4.5E-05	4.5E-05	4.4E-05	4.4E-05	4.4E-05	4.6E-05
Sulphate (SO4) Dissolved	mg/L	3.0E+01	3.6E+01	4.6E+01	4.3E+01	3.4E+01	3.2E+01	2.4E+01	1.9E+01	1.9E+01	2.2E+01	2.8E+01	3.0E+01	2.1E+01
Zinc (Zn) Total	mg/L	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.0E-03	1.1E-03

Scenario 2 (Tailings in 2N/3N, CCR in RBP): Worst case concentrations in Quinsam River from 2N, 3N, 5S and RBP groundwater seepage

COC	Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	7Q10
Aluminum (Al) Dissolved	mg/L	2.5E-02	2.9E-02	2.5E-02	2.0E-02	1.6E-02	1.8E-02	1.7E-02	1.7E-02	1.6E-02	1.0E-02	1.6E-02	2.6E-02	2.0E-02
Arsenic (As) Total	mg/L	3.6E-04	5.2E-04	4.9E-04	5.9E-04	6.6E-04	8.1E-04	1.3E-03	1.7E-03	1.1E-03	5.6E-04	3.6E-04	4.0E-04	4.5E-03
Boron (B) Total	mg/L	5.1E-03	7.2E-03	6.9E-03	8.2E-03	9.2E-03	1.1E-02	1.7E-02	2.4E-02	1.5E-02	7.9E-03	5.1E-03	5.6E-03	6.3E-02
Cadmium (Cd) Total	mg/L	1.2E-05	1.2E-05	1.2E-05	1.3E-05	1.3E-05	1.3E-05	1.3E-05	1.4E-05	1.3E-05	1.3E-05	1.2E-05	1.2E-05	1.7E-05
Cobalt (Co) Total	mg/L	1.7E-04	2.4E-04	2.3E-04	2.7E-04	3.0E-04	3.7E-04	5.6E-04	7.7E-04	5.0E-04	2.6E-04	1.7E-04	1.9E-04	2.0E-03
Copper (Cu) Total	mg/L	5.5E-04	5.6E-04	5.6E-04	5.6E-04	5.6E-04	5.7E-04	5.8E-04	6.0E-04	5.8E-04	5.6E-04	5.5E-04	5.5E-04	6.9E-04
Fluoride (F) Total	mg/L													
Iron (Fe) Total	mg/L	6.0E-02	1.0E-01	7.4E-02	7.5E-02	8.2E-02	8.1E-02	1.3E-01	1.4E-01	1.1E-01	7.0E-02	9.4E-02	8.3E-02	3.3E-01
Manganese (Mn) Total	mg/L	8.0E-03	9.7E-03	1.3E-02	1.2E-02	1.3E-02	1.7E-02	2.2E-02	2.6E-02	1.8E-02	1.3E-02	1.6E-02	1.1E-02	5.6E-02
Nickel (Ni) Total	mg/L	3.4E-04	4.4E-04	4.2E-04	4.8E-04	5.3E-04	6.3E-04	9.1E-04	1.2E-03	8.2E-04	4.7E-04	3.4E-04	3.7E-04	3.0E-03
Selenium (Se) Total	mg/L	5.2E-05	5.9E-05	5.8E-05	6.2E-05	6.5E-05	7.2E-05	9.1E-05	1.1E-04	8.5E-05	6.1E-05	5.2E-05	5.4E-05	2.4E-04
Sulphate (SO4) Dissolved	mg/L	3.3E+01	4.1E+01	5.1E+01	4.9E+01	4.1E+01	4.1E+01	3.9E+01	4.1E+01	3.2E+01	2.8E+01	3.1E+01	3.3E+01	8.3E+01
Zinc (Zn) Total	mg/L	1.0E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.1E-03	1.2E-03	1.3E-03	1.2E-03	1.1E-03	1.0E-03	1.0E-03	1.8E-03