2021-2022 Annual Groundwater Monitoring Report

Pertaining to the Mines Act Permit C-172 & Effluent Permit PE: 7008

Submitted to: Ministry of Energy and Mines & Ministry of Environment and Climate Change Strategy

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Table of Contents

List of Figures

List of Tables

List of Appendices:

1 Introduction

Quinsam Coal Corporation, as part of the requirements under Mines Act Permit C-172 (administered by the Ministry of Energy, Mines and Low Carbon Innovation) and Effluent Permit PE-7008 (administered by the Ministry of Environment and Climate Change Strategy), conducts a comprehensive groundwater monitoring program to characterize water quality associated with mining development. This edition covers a 12-month period and interprets the results from April 1, 2021, to March 31, 2022, to synchronize with the surface water monitoring report and relate to the effluent permit.

Prior to 2012, the groundwater monitoring program was executed by external consultants. In 2012, in an effort to reduce costs and improve the logistics of the program, Quinsam Coal internalized the groundwater monitoring program. Methodology of sampling followed the procedures developed in the Lorax Hydrogeological Assessment and the *British Columbia Field Sampling Manual for Continuous Monitoring and the Collection of Air, Air-Emissions, Water, Wastewater, Soil Sediment, and Biological Field Sampling 2013 Edition.* The groundwater program has been defined through work performed by Quinsam Coal and Lorax Environmental on the hydrogeology of the respective mining areas, which governs the sampling locations, methods and frequency with consideration of their relationship to mining.

As in previous reports, groundwater wells have been categorized as either 'in-situ' or 'ex-situ'; the definition for each is as follows:

- In-situ: groundwater wells located within the mine workings (disturbance footprint) and therefore represent water accumulated within the mining void. In the absence of groundwater well samples, underground sump samples are used for comparison.
- Ex-situ: groundwater wells located outside the mine workings (disturbance footprint) which reflect water quality flowing from the mine void towards the receiving environment. This also includes baseline and background (up-gradient of workings) groundwater wells.

The groundwater wells outside the mine footprint (ex-situ) are compared to the British Columbia Contaminated Site Regulation (CSR) (BC reg.37/96. O.C. 1480/96), including the amendments (343/2008 January 1, 2009) describing water quality standards for freshwater Aquatic Life (AW). The aquatic life standard assumes that a minimum 1:10 dilution is available for groundwater discharged to a freshwater system; together, they are referred to as CSR-AW.

The parameters of interest (POI) captured under the CSR-AW and applied to Quinsam include: arsenic (As), cobalt (Co), copper (Cu), fluoride (F), iron (Fe), sulphate (SO_4), sulphide (as H_2S) and zinc (Zn). Section 4.1 compares sampling results performed during this program to the CSR-AW standards (by development area).

Derived from numerous studies, POI source terms have been developed by Lorax Environmental for various areas, including: geochemical characterization of the 4-South mine pool, laboratory kinetic testing conducted on the 7-South coarse coal reject, 7-South formation water and 2-North, 3-North and 5-South mine water and formation water samples collected from underground mine dewatering. It is therefore important to consider water captured and stored within the mine workings (in-situ) to ascertain potential discharge (through existing water management structures) and seepage water quality. Accordingly, groundwater wells that are located within a mine void are sampled as part of the monitoring program with results being compared to source terms developed for each respective area.

2 Groundwater Monitoring Regime

Throughout the monitoring period, Quinsam Coal monitored 36 groundwater sites within the vicinity of the mine footprint. These sites consisted of 22 ex-situ wells, 10 in-situ wells and 4 in-situ underground sumps, as illustrated in Table 1 below.

Table 1: Groundwater Wells & Sumps Monitored in 2021-2022

Area	In-Situ Sumps	In-Situ Wells	Ex-Situ Wells	
2-North	3M2N	1M2N 5M#2 QU10-13 D	QU08-21G S QU10-10 S QU10-11 S	QU08-21G D QU10-10 D QU10-11 D
River Barrier Pillar		QU11-09 M	QU11-05 S QU11-09 S	QU11-05 D
2-North Coal Processing Plant			MW00-1 S MW00-6 S	MW00-1 D MW00-6 D
7-South	7SPS 1M7S 1M7SA5	QU14-10	QU08-13 A QU12-06 S QU11-36 D	QU08-13 B QU08-10
242 Mine pool		242MW		
4-South		QU11-01	QU10-09 S QU10-09 D	QU10-08 D
5-South		5SMW		
2/3 South		QU11-11 (INF), MW00-4 and MW00-2		

The groundwater areas and wells description are listed in the Table 46 in the Appendix I of Annual Water Quality Monitoring Report (AWQMR) for 2021-2022, Appendix IX of AWQMR for 2020-2021, Site Plan, Groundwater Monitoring Locations, presents a map of the groundwater sampling sites with respect to underground workings, groundwater and pumped mine water flow paths and disturbed areas. These wells are regularly evaluated and modified in order to best monitor groundwater and potential impacts from mining.

The monitoring wells have been selected as they relate to:

- hydrogeology of the area
- groundwater regime

- stratigraphy and geologic structure
- formation groundwater
- mine pool water
- past and present mining conditions
- underground PAG–CCR storage
- fine tailings storage

Appendix I, Tables 4, 31 and 39 display the groundwater analytical results this monitoring period. Completion logs for the well installations can be found in Appendix A of previous annual reports and a further discussion of these wells can be found in Mine Permit (C-172) Amendment: 7-South Development Volume 3: Appendix I through J and Volume 4: Appendix K. Lorax Environmental Services was retained by Quinsam Coal to perform a hydrogeological investigation in these areas. The wells are a combination of nested wells, single wells and boreholes. The nested wells include a deep well and a shallow well that are screened in zones of interest. The deeper wells are generally drilled into the lowest coal seam and the shallower wells represent other zones of interest which may include shallower coal seams, or areas of increased permeability (Lorax, 2011).

2.1 Hydrogeological and Stratigraphic Setting

Groundwater wells relating to mining voids or defined as ‘down gradient’ from mine development zones have been established to characterize water quality for each respective area. The water chemistry is compared to source terms for parameters of interest established through:

- Sulphur distribution in the proposed workings
- Solid phase and leaching characteristics of CCR and tailings from the 7-South areas and disposed in mined out workings
- Geochemical characterization of the hanging wall strata over the mine area
- Formation groundwater characteristics

The information pertaining to column leach testing and derivation of source terms can be found in the application for 7-South Development Mine Permit Amendment (C-172) Volume 3: Appendix J and Volume 4, Appendix K (Lorax[(1)], 2011).

Figure 1 below displays the stratigraphic column at the Quinsam mine.

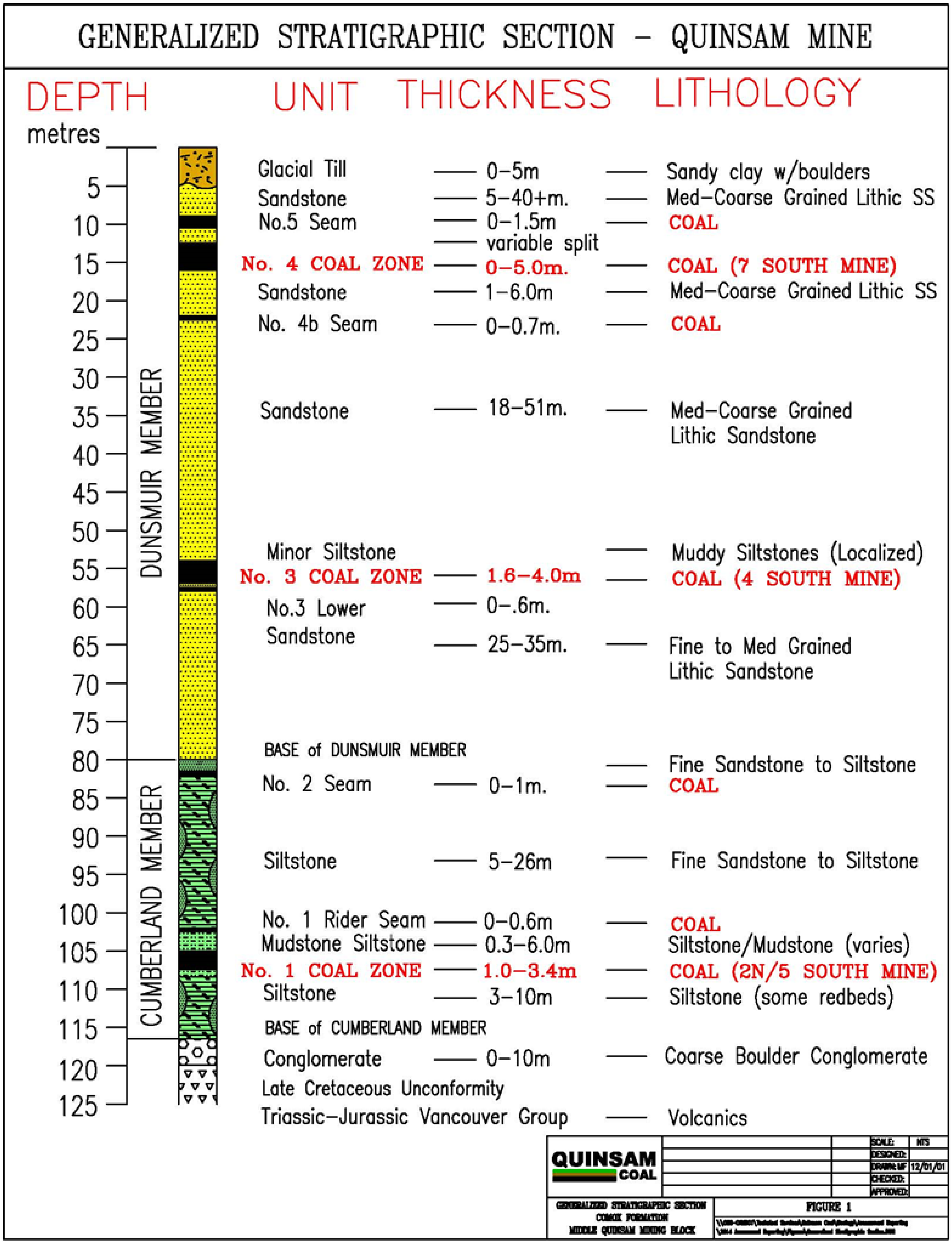


Figure 1: General Stratigraphic Column - Quinsam Mine

2.1.1 Underground PAG-CCR Storage in the River Barrier Pillar

Coarse coal reject (CCR) material produced from the processing of raw No. 1 seam coal is defined as potentially acid generating material (PAG) when the sulphur content exceeds 1.3 %. As development of the 5-South mine progressed, inherent sulphur levels found in the #1 coal zone progressively increased above 1.3% sulphur. The run of mine coal processed through the Coal Preparation Plant and the resultant waste materials (fine tailings and CCR) were therefore classified as PAG. To mitigate potential metal leaching/acid rock drainage, Quinsam Coal established a sub-aqueous PAG-CCR disposal facility within the mine workings known as 87 Panel River Barrier Pillar (RBP). This disposal method was used as a pilot project for future PAG-CCR storage of material from the then proposed 7-South mine. Accordingly, groundwater monitoring at this facility has been a crucial part of Quinsam's past and current groundwater monitoring program. Wells used to monitor the seepage of groundwater are QU11-05 (S and D) and QU11-09 S while in-situ waters are monitored using well QU11-09 M.

2.1.2 Down Gradient of Subaqueous Disposal of PAG Tailings in 2-North and 3-North

The 2-North mine has been a subaqueous disposal site of fine tailings from processing of the 7-South coal since 2012. 1Mains 2-North (1M2N) is an area within the 2-North Mine that was mined, depillared and subsequently used as a sub-aqueous storage facility for fine tailings from the processing of 7-South coal. Prior to the injection of tailings into this area, this part of the naturally flooded workings was dewatered. The fine tailings were then pumped into the mine voids, allowing for the tailings to settle out throughout 1Mains until it was necessary to relocate the tailings line in early 2015 to accommodate underground operations. The 7-South fine tailings were then pumped into another area of the 2-North Mine, called 5-Mains. At the end of 2018 (December) the tailings line was redirected back to 1M2N.

The wells installed in these areas initially supported a hydrogeological investigation performed by Lorax. The 2-North, 3-North and 5-South mine waters and formation waters have been defined as: mine water, No.1 coal seam groundwater, and Dunsmuir sandstone groundwater. In these areas, the mine water is classified as circum-neutral pH, elevated alkalinity and conductivity, with the elevated conductivity directly related to elevated sulphate concentrations. All mine pool water (2N, 3N, 2S, 3S, 4S, 5S and 7S) has a distinct sulphate geochemical signature that can be used to trace the flow paths of mine water (Lorax [(1)], 2011). The in-situ waters in the 2-North mine pool are monitored at well locations 1Mains 2-North (1M2N), 3Mains 2-North (3M2N), 5Mains #2 (5M#2), and QU10-13 D. This well measures the hydraulic head above the 2-North mine (1 Mains) and fine tailings disposal.

Ex-situ groundwater wells QU10-10 (S and D), and QU10-11 (D) have been installed down gradient of the 2-North subaqueous disposal areas and measure formation water quality and hydraulic head downstream of the 2-North mine workings. Quinsam originally drilled QU08-21G in the 2-North area as a geotechnical hole but was later converted into nested monitoring wells QU08-21G S and QU08-21G D. These wells were used to characterize water quality on the opposite side of the Forjan Fault in both the No. 1 coal zone (deep well) and the overlying Dunsmuir Sandstones in the No. 4 coal zone (shallow well). QU10-11 S monitors groundwater in the overlying Dunsmuir sandstones in a fracture zone.

Water quality in the formation groundwater of the Dunsmuir sandstone is defined as being circum-neutral pH with low alkalinity and conductivity levels. The No. 1 coal seam groundwater is defined as having circum-neutral pH, elevated conductivity and moderate alkalinity. Conductivity and chloride concentrations in the No. 1 seam at QU08-21G D and QU10-10D are significantly higher than those found within the 2-North mine pool due to elevated sodium and chloride, not sulphate.

2.1.3 2-North Coal Processing Plant and Coal Pad

The coal processing plant is located east of Middle Quinsam Lake and lies at an elevation approximately 40 metres above the lake surface. Two nested groundwater wells MW00-6 (S and D) and MW00-1 (S and D) have been installed at the peripheries of a surface collection ditch to intercept groundwater and surface runoff from the coal processing plant and coal stockpile pad. The depth of the shallow wells MW00-1 S and MW00-6 S are 8.1 and 8.7 metres respectively, while the deeper wells MW00-1 D and MW00-6 D measure 29.8 and 18.0 metres respectively. These wells monitor groundwater quality at different depths in the glacial till overburden layered overtop of the bedrock.

2.1.4 4-South Water Chemistry

The 4-South mine is developed in the #3 coal zone. The #3 coal zone lies within the Dunsmuir Member of the Comox Formation. The Dunsmuir Member consists of thick-bedded medium to coarse grained arkosic sandstones containing localized silty interbeds. Lorax classified the groundwater in this area into two groups; formation groundwater with lower overall dissolved ion concentrations and mine pool water with higher dissolved ion levels. The mine pool water is elevated in sulphate and iron; this signature is used to assess the mine pool seepage rates and groundwater flow path.

Lorax's assessment of the area found that formation groundwater wells had water quality with a geochemical signature that suggested mine pool influence in the down gradient wells of the flooded 4–South Mine. In Volume 3, Appendix I, Section 4 of the 4-South Mine Groundwater Evaluation, Lorax concludes that "*The component of seepage from the shallow westernmost portion of the 4-South mine inferred to flow to Long Lake represent about 10% (0.14 m^3/day) of the 1.4 m^3/day, estimated to represent the total seepage from 4-South. All seepage is ultimately directed to the Quinsam River"* (Lorax[(2)], 2011).

The monitoring wells established in this area were situated to intercept any groundwater transport that may occur from the 4-South mine pool. These wells include QU10-09 (S and D) and QU10-08 D (Lorax. 2011). QU10-08 is located up gradient of the 4-South mine and displays minimal influence from the 4-South mine pool.

The monitoring wells dedicated to monitoring in-situ water of the flooded workings are wells QU11-01 and QU78-161. QU11-01 is situated in the depillared area of the mine while QU78-161 is located in open mine workings east of a large fault. In past monitoring years, both of these wells were sampled due to their distance apart. It has been deemed that only one of these wells are necessary to determine mine-pool water chemistry as they have both exhibited similar characteristics when assessing historic data. Monitoring at QU78-161 has been ceased until further notice.

2.1.5 2-South – 3-South Area

The 2-South – 3-South area consists of naturally flooded mine workings, the 2-South subaqueous PAG-CCR storage pit, the 3-South subaqueous PAG-CCR storage pit and other surface disturbances. Wells established in this location are used to determine if parameters of interest are emanating from the mine workings or the PAG-CCR storage pits towards the receiving environment.

The 2-South open pit area was engineered to contain PAG-CCR material and included a sand-bentonite liner to minimize seepage and to retain water necessary for cover. Backfilling of PAG-CCR was completed in summer 2015 and water cover has been maintained since late 2015 (subaqueous disposal). It was projected that approximately $50m^3$ of water will seep from the facility daily with 10% of the water reporting to No Name Lake. The wells MW12-23 and MW12-24 were intended to intercept any water transporting from the 2-South PAG-CCR storage towards the lake. However, these two wells have been extremely difficult to monitor due to refill rates. As a result, only one sample set was collected from MW12-23 in 2019-20. The 3-South open pit development has been backfilled with PAG-CCR and was flooded to provide a full water cover; similar to the requirements of 2-South. Groundwater well MW00-2 was installed down gradient of this facility in shallow bedrock approximately 5 metres from the northeast corner to characterize seepage from 3-South. It is inferred that MW00-2 is hydraulically connected with the 3-South pit based on proximity and reported water quality (Golder Associates, 2006). This well is considered an ex-situ well.

Groundwater wells MW00-4 and QU11-11 (INF) are used to monitor the 2-South mine pool and depillared areas. MW00-4 is located on the north-eastern margin of the 2-South mine in the depillared workings near Long Lake. QU11-11 (INF) is located at the deepest portion of the 2-South mine pool. Mine water is pumped from the underground mine pool and discharged through the Passive Treatment System (PTS). This well is monitored weekly for sulphate, pH and conductivity and monthly for metals and nutrients in order to assess mine pool chemistry and to assess the performance of sulphate reduction through the PTS. Historically, MW00-3 and MW00-5 were also monitored in this location but are presently only used to monitor the water elevation in the mine pool. The underground workings in the 3-South pit area were developed and accessed by two portals located in the 2-South pit, with the 3-South Pit separated from the underground workings by intact bedrock. It is expected that the hydraulic connection between the flooded 3-South pit and the former 2-South underground workings are a result of bedrock fractures within the intact bedrock (Golder Associates. 2007).

2.1.6 7-South Down Gradient of Subaqueous Disposal of PAG-CCR in 7-South

The nested groundwater well QU08-13 (A & B) is situated topographically down gradient of the 7-South mine workings to intercept groundwater flow from the workings towards the Quinsam River. The well is located to monitor water quality and detect any seepage from the 7-South PAG-CCR underground disposal area in the 7-South mine at the stratigraphic level of the No. 4 coal zone (QU08-13 A) or as it rises through the stratigraphic column towards the Quinsam River (QU08-13 B). Source terms derived specifically for this development will be used as a comparison of water quality. Other groundwater wells within the 7-South area are used to monitor groundwater quality in relation to the seepage from the run of mine stockpile (QU08-10). At present, monitoring well QU14-10 is being used to measure water quality of the in-situ underground PAG-CCR subaqueous disposal area. When the storage of PAG-CCR commences in 7SA5, drillholes QU08-07 and / or QU09-01 will be developed into monitoring wells to measure in-situ underground water quality within the PAG-CCR storage facility.

2.1.7 Baseline/Background

Groundwater monitoring wells within areas without mine related impact or up gradient of the perceived flow path are established to identify baseline/background information on water quality for modeling purposes and when comparing/identifying sites encountering mining influence. Two primary areas of focus for collecting baseline groundwater quality in the near future are 7-South Area 5 and the 4-South / 6-South areas. Wells in 7-South Area 5 were monitored in the past (2013-2015) with additional monitoring performed in 2018. If mining operations continue some wells will be required to be drilled and completed as monitoring wells in 7S Area 5. These include QU11-21S and QU14-A. The shallow well QU11-21S will be designated to intercept the potential seepage from the northerly portions of 7SA5. On the south side of 7SA5 another well QU14-A will be required to intercept the potential for peripheral pathways between 7SA5 and the Iron river.

The C-172 permit has an important stipulation for this area, south of the northing 100280 m. This northing is significant in that it represents the southernmost influence of the 7SA5 pump test performed by Lorax, in support of the 7-South Area 5 mine permit amendment. Section A3, of the amended C-172 permit received for 7SA5, approves mining up to northing 100280 m with stipulations for further progression south of this point. The development of these wells will provide further information to support the structural and hydrogeological conditions of the mine beyond this point.

2.1.8 Mine Pools and Underground Sumps

A mine pool is a flooded mine void or previously mined out area which may or may not be backfilled with waste material. Mine pools often exhibit elevated concentrations of metals and sulphate associated with developed coal seams. Concentrations become increasingly elevated if mine pools have waste deposits present as constituents tend to dissolve and accumulate at depth. A chemical stratification occurs when there is limited mixing of the mine water and the heavily mineralized waters settle on the bottom of the water column while the lighter, less mineralized waters, concentrate in the upper portion.

In-situ mine pool monitoring locations include: 1M2N, 5M#2, 3M2N, and QU10-13 D in 2-North; 5SMW in 5-South; QU11-09 M in the RBP; QU14-10 in 7-South; QU11-01 in 4-South; MW00-4 and QU11-11 in 2-South; and 242MW for the 242 mine. In addition to mine pool monitoring sites that are not accessible to monitoring personnel, underground sumps are used to characterize in-situ locations including: 1 Mains 7-South (1M7S), (7SA5) and combined 1 Mains 7-South Area 5 (1M7SA5).

3 Methods and Procedures for Monitoring Groundwater

During groundwater sampling, water is directed through a flow cell connected to a water quality sonde to instantaneously measure parameters such as pH, conductivity, temperature, oxidation reduction potential and dissolved oxygen. These parameters are used to identify when intercepted groundwater entering the column is steady and representative of the targeted water based on the well design. Water samples are obtained for laboratory analysis when the appropriate volume of water has been purged, water levels have stabilized, and the physical parameters listed above stabilize. Ultimately, the objective is to collect a sample that represents the ‘active’ groundwater in an area as opposed to stagnant water within a well.

3.1 Sampling Techniques

Generally, four methods/systems (dependent on groundwater setting) are employed for monitoring groundwater. These methods include:

- Inertial lift
- Peristaltic pumping
- Portable bladder pump
- Dedicated bladder pump

The most suitable sampling device is selected based on:

- Parameters being monitored
- Maximum efficiency
- Purging rate compared to well yield
- Well diameter
- Depth of well
- Sample collection point
- Ease of use of the sampling device

3.1.1 Inertial Lift Sampling

This method of sampling uses HDPE tubing fitted with an inert foot valve placed down the well casing at the desired depth. Oscillation of this tubing forces water up to surface while the foot valve prevents backflow on the downswing. This constant oscillation is achieved using a mechanical actuator known as a hydrolift. The hydrolift is attached to the tubing end on surface and cycles up and down to provide the motion needed to lift water. Flow rate is directly proportional to the speed of oscillation, well design and water level. Inertial lift sampling is appropriate in wells in which a high purge rate is required as flow rates can range from 0.5 to over 4 L/min.

3.1.2 Peristaltic Sampling

This method employs a peristaltic pump connected to tubing that is placed within the well casing at a desired depth. Peristalsis is a cyclic compression and decompression on the tubing to create a negative pressure point in which the water is drawn up the tubing. This method is employed at very shallow wells that can potentially have poor recharge rates.

3.1.3 Bladder Pumps

Bladder pumps are submerged to an appropriate level and operate by filling and discharging a bladder system inside a housing unit. Compressed gas (N_2) is supplied at surface and is pumped down the tubing to provide the compression and release of water within the bladder housing. Flow rate is controlled via timing cycles of recharge and discharge, air pressure and depth of water. Bladder pumps are used in deeper wells in which inertial lift and peristaltic pumping capabilities and efficiencies are not possible.

3.2 Parameters Monitored

The total metals suite was removed from the analytical requests in 2014 to eliminate the potential artifacts (associated with higher total suspended sediment) in sampling results. Since then, analytical results have included dissolved metals, turbidity or Total Suspended Solids (TSS), dissolved anions (i.e. bromide (Br^-), chloride (Cl^-), fluoride (F^-), sulphide (S^{2-}), sulphide as (H_2S), sulphate (SO_4), total dissolved nitrogen (TDN), dissolved organic carbon (DOC), total-alkalinity (Alk) and acidity. Furthermore, field measurements for pH, temperature, conductivity, oxidation reduction potential and dissolved oxygen continue to be part of the monitoring program.

Results for hydrogen sulphide are calculated using a gravimetric conversion factor (sulphide result multiplied by 1.063) as the laboratory only provides results as sulphide. This calculation is necessary to compare results to the CSR-AW standards as the standard is measured as H_2S (0.02 mg/L). In the past, sulphide results that were expressed as <MDL were calculated using the MDL value which was often 0.02 mg/L. For all previous results and results included in this reporting year that were <MDL, a value of half the MDL was used for calculation. This may eliminate past issues of false positive bias when the gravimetric conversion factor is applied.

In 2013 the Ambient Water Quality Guideline for dissolved sulphate was updated from an acute guideline of 100 mg/L to a chronic guideline based on a 30-day average. The new guideline is relative to background water hardness concentrations. As a result, sulphate water quality guidelines for the protection of aquatic life were developed for different categories of water hardness as displayed in Table 2 below.

Table 2: Sulphate Water Quality Guideline (mg/L) - Based on Water Hardness (mg/L) Categories

Water Hardness* (mg/L)	Sulphate Guideline (mg/L)
Very Soft (0-30)	128
Soft to moderately soft (31-75)	218
Moderately soft/hard to hard (76-180)	309
Very hard (181-250)	429

*Water hardness categories adapted from the CCME.

** Toxicity tests on the early stage rainbow trout were only conducted up to a water hardness of 250 mg/L.

The BC Land Remediation Section develops the Contaminated Sites Regulations standards. As it is a regulation, standards do not change when a water quality guideline change. As a result, the CSR-AW for some updated parameters was not updated when the BC Water Quality Guideline was revised.

Currently, the CSR-AW standards are subject to revision, with the first step of the process being to review the policy (e.g. developing a CSR standard) and the second step applying the newly derived standard. These new guidelines derived from the Water Quality Guidelines are often a factor of the guideline (e.g. 10 times higher).

Starting March 2015, in an effort to reduce costs, all water samples were analyzed by Maxxam Analytics in favor of ALS Environmental (ALS). While both labs provided analyses of water with similar detection limits, not all analysis methods were the same. Results have been consistent for all parameters except Sulphide as H_2S at low ranges.

3.3 Quality Assurance/Quality Control

Quality Assurance / Quality Control (QA/QC) for the Quinsam groundwater sampling program is conducted in accordance with *"The British Columbia Field Sampling Manual, For Continuous Monitoring and Collection of Air, Air-Emissions, Water, Wastewater, Soil, Sediment, and Biological Samples, 2013 Edition"* (MOE, 2013).

Quality control measures that have been applied since last year's monitoring period includes an increased attention to cleanliness of sampling equipment and tubing installed in groundwater wells. Tubing assemblies installed within the wells are re-used as it is unfeasible to replace tubing assembly wells every sampling event. An in-depth review of the integrity of the assemblies will occur immediately to evaluate the need for replacement. For tubing assemblies not installed in the well (portable bladder pump and surface sampling tubing), increased cleaning and proper storage methods will be applied.

Relative Percent Difference (RPD) values were calculated for the analytical results from the sample and its respective replicate. In accordance with the British Columbia Field-Sampling Manual, the calculation was applied as stated below:

$$RPD = Absolute\frac{(Sample\ Concentration - Replicate\ Concentration)}{\left(\frac{Sample\ Concentration + Replicate\ Concentration}{2}\right)}\ x\ 100\%$$

RPD calculations were only practical for results where concentrations were found at or greater than five times the reported detection limit (RDL) as there is considerable uncertainty at low levels. In addition, mathematical calculations for RPD appear exaggerated with low values where absolute differences may be relatively low.

3.3.1 Results of Field Replicates

Refer to Appendix I, Tables 51 to 55 display the results of the RPD calculations. Refer to Section 5.3 of the AWQMR for a discussion of field replicates.

4 Results and Discussion

4.1 References for Water Quality Data

Geochemical source terms have been developed by Lorax as a conceptual model that represents the progression of mine pool geochemistry for all mine pool areas on the Quinsam Mine Site. This model is explained in detail in the 7-South Development Mine Permit Amendment Volume 3, Appendix I and Volume 4, Appendix K.

Geochemical source terms were developed for the anticipated mine plan in 2-North, 3-North and 5-South mine areas where 7-South tailings will be stored, as well as 2/3North, 4-South and 5-South flooded mine voids without PAG-CCR or fine tailings. Source terms provide an overview developed for each respective mine area compared to the measured water quality.

The source terms have been developed using a set of empirical data including the following:

- Water chemistry collected from underground mine dewatering and mine void,

- Kinetic saturated column leach tests performed on 7-South CCR and tailings,
- Sulphur distribution in the proposed workings.

Comparison of water quality data to source terms can be found in tables within each respective area in the discussion of results.

All water quality results for groundwater wells located between mine working(s) and the receiving environment have been compared to Contaminated Sites Regulations for Aquatic Life (CSR-AW). Numerical standards used for CSR-AW are described in Table 3 below. A groundwater map displaying the location of each well in relationship to the underground mine area can be found in Appendix IX of AWQMR, Site Plan Groundwater Monitoring. Appendix I, Tables 4, 32-39 display the analytical groundwater.

Table 3: CSR-AW Lowest Level for Dissolved Metals and Total Sulphide as H_2S

Parameter	CSR-AW (mg/L)	Parameter	CRS-AW (mg/L)
Dissolved Sulphate*	1280	Dissolved Lead*	0.04
Dissolved Chloride	1500	Dissolved Mercury	0.00025
Dissolved Fluoride*	2-3	Dissolved Molybdenum	10
Dissolved Silver	0.0005 - 0.015	Dissolved Nickel*	0.25
Dissolved Arsenic	0.05	Dissolved Antimony	0.09
Dissolved Barium	10	Dissolved Selenium	0.02
Dissolved Boron	12	Dissolved Thallium	0.003
Dissolved Beryllium	0.0015	Dissolved Titanium	1
Dissolved Cadmium*	0.0005	Dissolved Uranium	0.085
Dissolved Chromium*	0.01	Dissolved Zinc*	0.075
Dissolved Cobalt	0.04	Sulphide as H_2S*	0.02
Dissolved Copper*	0.02		
***Indicates the CSR-AW is a calculated parameter**			

Table 4 below displays a summary of exceedances noted during sampling program at the ex-situ wells compared to the CSR-AW.

Table 4: Parameters Above the CSR-AW Standards found in Ex-Situ Groundwater Wells

Parameter	Site > CSR-AW	CSR-AW	Range mg/L
As-D	QU08-13 (A and B), QU08-21G (S and D), QU10-08 (D), QU10-09 (S and D), QU10-10 S, QU11-05 S, QU11-36 D, QU11-05S and QU11-09 (S)	0.05	0.06 to 0.88
Se-D	QU11-05 D	0.01	0.0132 and 0.021
Sulphide as H2S	QU08-13 (A and B), QU08-21G (S and D), QU11-05 (S and D), QU11-09S, QU10-09 (S and D), QU10-08 D, QU10-10 (S), QU10-11 D	0.02	0.02 to 54.2
Cl-D	QU10-10D	1500	3200 and 3500
F-D	QU10-08D	2	2.30

4.2 Key Observations and Conclusions

4.2.1 North Mining Area

The North mining area represents the largest operation on the mine-site and has been the longest project at Quinsam Coal spanning nearly 30 years of mining. The North mining area is divided into 3 sections based on source terms: 2/3 North Mine Void, 2 North Mine Water with 7-South tailings, and North Mining Area Ex-Situ formation groundwater.

4.2.1.1 2/3 North Mine Void

Much of the mined out 2/3-North mine is allowed to naturally flood and mine pool water has been found to be circum-neutral pH, elevated alkalinity and conductivity with a unique sulphate geochemical characteristic. Water is found to be oxic to strongly reducing in various locations in the mine. Source terms as established by Lorax (2011) are displayed in Table 5.

The location 3Mains 2-North (3M2N) site has been included in this program since 2019. The 3M2N is the area of the mine where combined 5-South and 7-South mine water enters the 2-North mine and is diluted with water in flooded 2-North mine pool, 3-Mains. Table 5 compares the expected and worst-case scenarios for the flooded mine void in 2 / 3 North with the 7 sets of results from 2021/2022.

Sulphate, Cobalt and Nickle were above expected source terms values. Those that were averaging slightly higher than the expected case include sulphate. No parameters were above worst case. Further monitoring on a more frequent basis has been included in the monitoring program to accurately represent this location and ensure consistency and overall representation of this area. The 3M2N mine water was influenced by pumping periodically from 5-South mine pool mixed with 7-South water until January 2022 when the 5-South pump failed and has not been replaced. Monitoring in 2022 may reflect decreases in certain parameters as a result.

Table 5: Source Terms Comparison for 2/3 North Mine Void

2N Mine Void - 3M2N (N=7)				
Parameters	**Expected**	**Worst Case**	**Annual Average**	**Comparison to Source Terms**
Alkalinity (CaCO3)	450	-	383	Below Expected
Fluoride (F)	0.29	0.3	0.133	Below Expected
Sulphate (SO4)	278	1280	789	**Above Expected**
Dissolved Metals				
Aluminum (Al)	0.013	0.027	0.008	Below Expected
Arsenic (As)	0.036	0.040	0.0006	Below Expected
Boron (B)	1.1	1.2	0.8	Below Expected
Cadmium (Cd)	0.00002	0.00008	0.000012	Below Expected
Cobalt (Co)	0.001	0.004	0.0017	**Above Expected**
Copper (Cu)	0.001	0.004	0.00037	Below Expected
Iron (Fe)	0.49	2.45	0.12136	Below Expected
Manganese (Mn)	0.36	0.95	0.220	Below Expected
Nickel (Ni)	0.001	0.008	0.003	**Above Expected**
Selenium (Se)	0.0002	0.001	0.00011	Below Expected
Zinc (Zn)	0.006	0.007	0.006	**At Expected**

All units in mg/L

Note: If the Result < DL, then the DL value was used.

4.2.1.2 2-North Mine Water with 7-South Tailings

Both 1M2N and 5M#2 are compared to geochemical source terms and are expected to reflect those terms very closely. In February, 2019 the 5-Mains dewatering pump (5M#2 / 5M2N) located in 5-Mains 2-North faulted on restart. It was not replaced until March 25th, 2021, as a result only 1 sample was collected in 2019. The 1M2N was the only pump operating to dewater the 2-North 1 Mains area from February 23rd, 2019 until November 30th, 2020. November 30th, 2020 1M2N pump also faulted and was not operating until April 13th, 2021. 3M2N pumping system was operating to maintain the mine pool at a higher elevation than normal. This is depicted in the figure below.

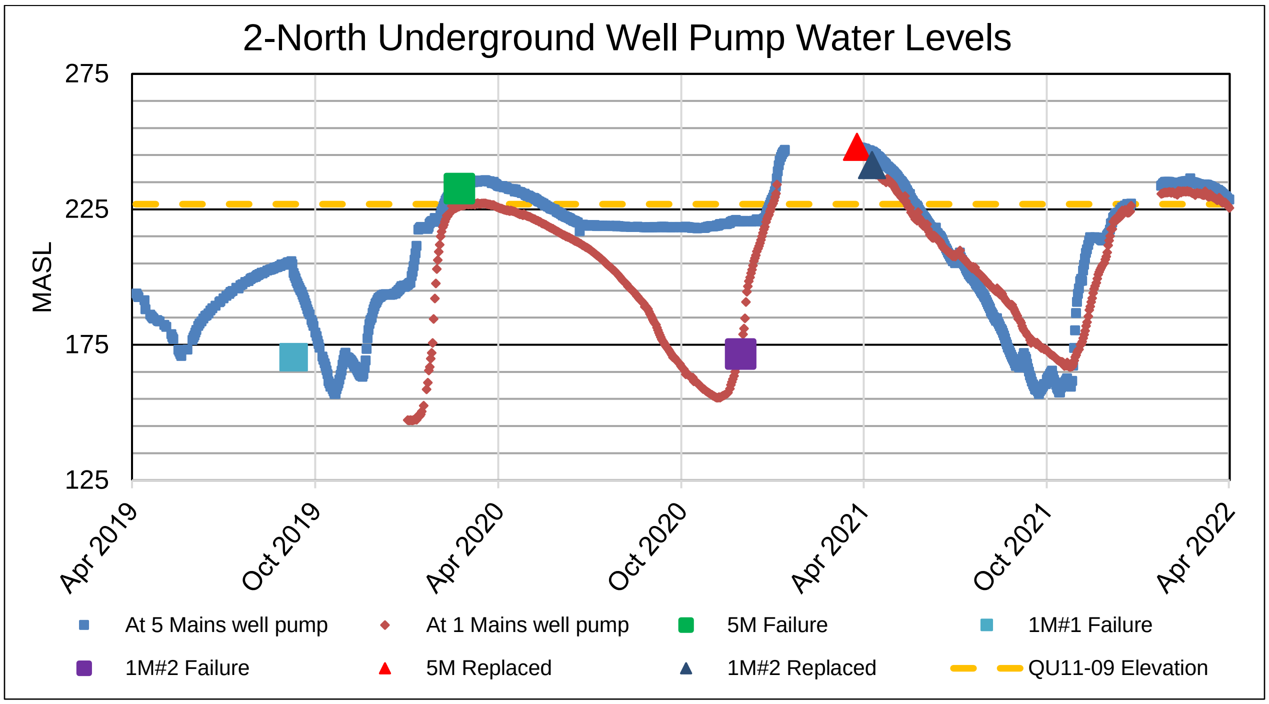


Figure 2: 2-North Underground Well Pump Water Levels (MASL)

The POI annual averages are displayed in Table 6 and 7, below. As shown, most of the parameters were below the expected values, with the exception of 1M2N average boron, and selenium were at expected and alkalinity and sulphate were above expected with manganese at worst case and iron and zinc above worst case. Certain anoxic, redox reactive metals were observed to be suspiciously low in past monitoring and field filtering/preservation was implemented to improve representation. Redox processes require one chemical species that donates electrons and another chemical species that accepts those electrons. As a chemical species donates electrons it is “oxidized,” and as the other species accepts electrons it is “reduced.”

If dissolved oxygen is present in the water, it is the preferred electron acceptor, and the water is "oxic." The atmosphere is the source of the dissolved oxygen in water, so the redox conditions in an aquifer near where recharge occurs usually are oxic. If no dissolved oxygen is present, the water is "anoxic", but there are other chemical species such as nitrate, manganese, iron, sulphate, and carbon dioxide, that can accept electrons in oxygen's place. Redox processes typically are enabled by bacteria, which use the energy produced by the processes.

Water quality at 5M#2 is normally lower in concentrations of most parameters compared to 1M2N due to this location being higher in elevation with less accumulated tailings stored here. The 2-North mine pool is moderately to strongly reducing (for parameters that lose electrons) indicated by the elevated concentrations of dissolved iron and sulphide in the mine pool. These are redox indicator species. These parameters are present in the 2-North, No. 1 Seam and Dunsmuir sandstone groundwater. Table 7 displays those POI in 5M2N compared to source terms with average concentrations of nickel tending at expected, alkalinity, sulphate and iron above expected and zinc above worst case.

Table 6: Source Terms Comparison for 2-North Mine Water with 7-South Tailings

2N with 7S Tailings - 1M2N (N=10)				
Parameters	**Expected**	**Worst Case**	**Annual Average**	**Comparison to Source Terms**
Alkalinity (CaCO3)	450	-	499	**Above Expected**
Fluoride (F)	1.1	1.2	0.0956	Below Expected
Sulphate (SO4)	278	1280	1145	**Above Expected**
Dissolved Metals				
Aluminum (Al)	0.013	0.027	0.00528	Below Expected
Arsenic (As)	0.036	0.125	0.006	Below Expected
Boron (B)	1.1	1.2	1.13	**At Expected**
Cadmium (Cd)	0.00002	0.00008	0.000017	Below Expected
Cobalt (Co)	0.001	0.023	0.00039	Below Expected
Copper (Cu)	0.001	0.004	0.00045	Below Expected
Iron (Fe)	0.49	2.902	10.183	**Above Worst Case**
Manganese (Mn)	0.36	0.95	0.943	**At Worst Case**
Nickel (Ni)	0.001	0.033	0.00234	**Above Expected**
Selenium (Se)	0.0002	0.007	0.0002	**At Expected**
Zinc (Zn)	0.006	0.019	0.0526	**Above Worst Case**

All units in mg/L

Note: If the Result < DL, then the DL value was used.

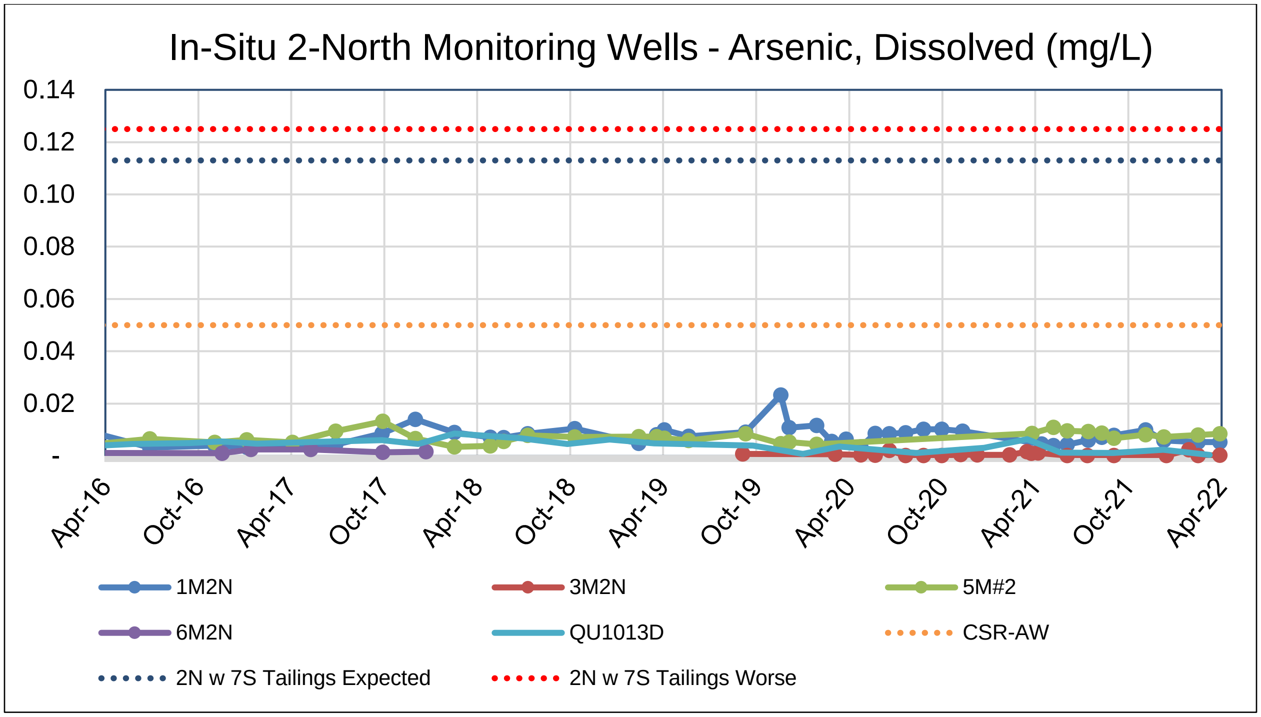
Table 7: Source Terms Comparison for 2-North Mine Water with 7-South Tailings

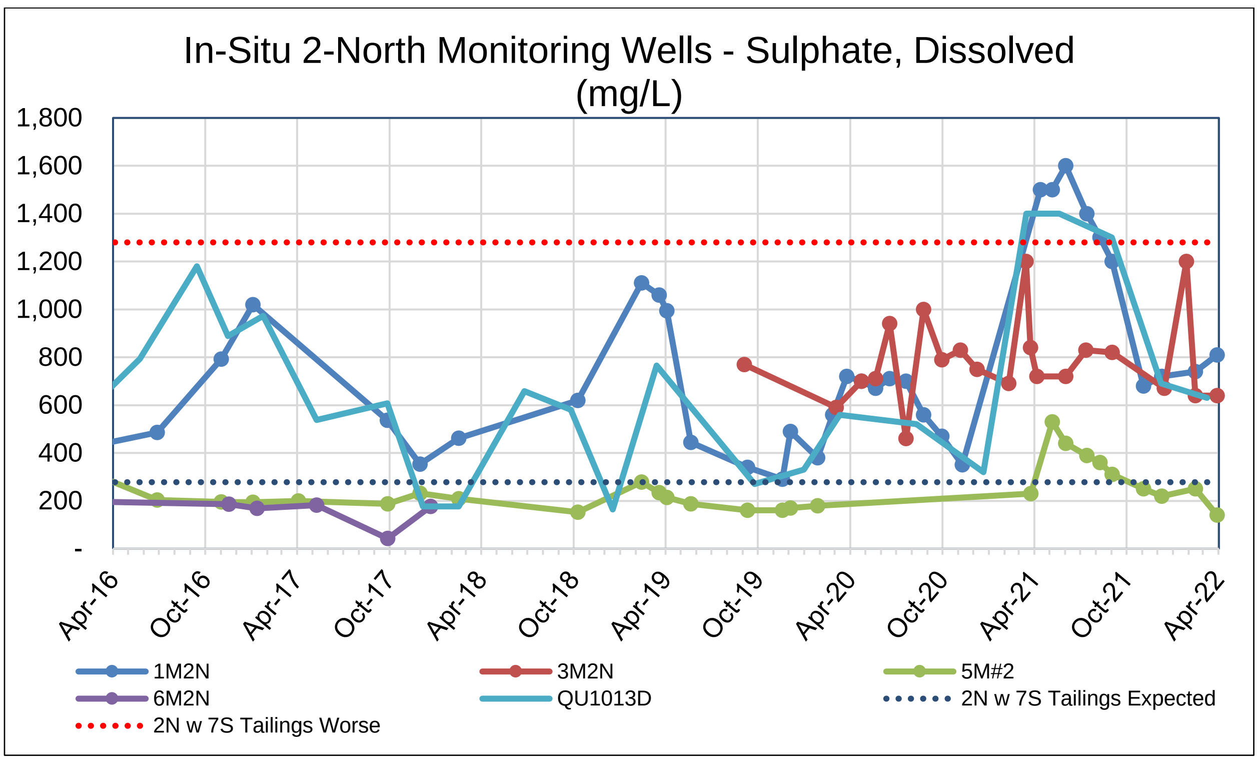
2N with 7S Tailings - 5M#2 (N=11)				
Parameters	**Expected**	**Worst Case**	**Annual Average**	**Comparison to Source Terms**
Alkalinity (CaCO3)	450	-	546	**Above Expected**
Fluoride (F)	1.1	1.2	0.0768	Below Expected
Sulphate (SO4)	278	1280	322	**Above Expected**
Dissolved Metals				
Aluminum (Al)	0.013	0.027	0.0033	Below Expected
Arsenic (As)	0.113	0.125	0.0084	Below Expected
Boron (B)	1.1	1.2	0.9963	Below Expected
Cadmium (Cd)	0.00002	0.00008	0.000011	Below Expected
Cobalt (Co)	0.001	0.023	0.00038	Below Expected
Copper (Cu)	0.001	0.004	0.0003	Below Expected
Iron (Fe)	0.49	2.902	0.58	**Above Expected**
Manganese (Mn)	0.36	0.95	0.22	Below Expected
Nickel (Ni)	0.001	0.033	0.001	**At Expected**
Selenium (Se)	0.0002	0.007	0.00011	Below Expected
Zinc (Zn)	0.006	0.019	0.043	**Above Worst Case**

All units in mg/L

Note: If the Result < DL, then the DL value was used.

Figure 3 below displays arsenic, sulphate and iron concentrations in the 2-North mine pool compared to those developed as the expected and worst-case scenario predictions derived by Lorax. The results indicate that 1M2N, QU1013D and 3M2N have remained between the expected and worst case for sulphate nearing the worst-case scenarios in winter with peak concentrations occurring when the mine pool was full after being dewatered during summer. 5M#2 has remained at or below the expected case since April 2016. This area is situated higher in the mine pool with more dilution and influence from groundwater. Concentrations are on an upward trend in spring of 2021 at 3M2N and QU10-13D as the mine pool was elevated. QU10-13D follows a similar trend as 1M2N as they are situated in the same area and are influenced by fluctuating water elevations controlled by pumping rates and groundwater infiltration.


In-Situ 2-North Monitoring Wells - Arsenic, Dissolved (mg/L)
0.14
0.12
0.10
0.08
0.06
0.04
0.02
-
Apr-16
Oct-16
Apr-17
Oct-17
Apr-18
Oct-18
Apr-19
Oct-19
Apr-20
Oct-20
Apr-21
Oct-21
Apr-22
1M2N
3M2N
5M#2
6M2N
QU1013D
CSR-AW
2N w 7S Tailings Expected
2N w 7S Tailings Worse


In-Situ 2-North Monitoring Wells - Sulphate, Dissolved (mg/L)
1,800
1,600
1,400
1,200
1,000
800
600
400
200
-
Apr-16
Oct-16
Apr-17
Oct-17
Apr-18
Oct-18
Apr-19
Oct-19
Apr-20
Oct-20
Apr-21
Oct-21
Apr-22
1M2N
3M2N
5M#2
6M2N
QU1013D
2N w 7S Tailings Expected
2N w 7S Tailings Worse

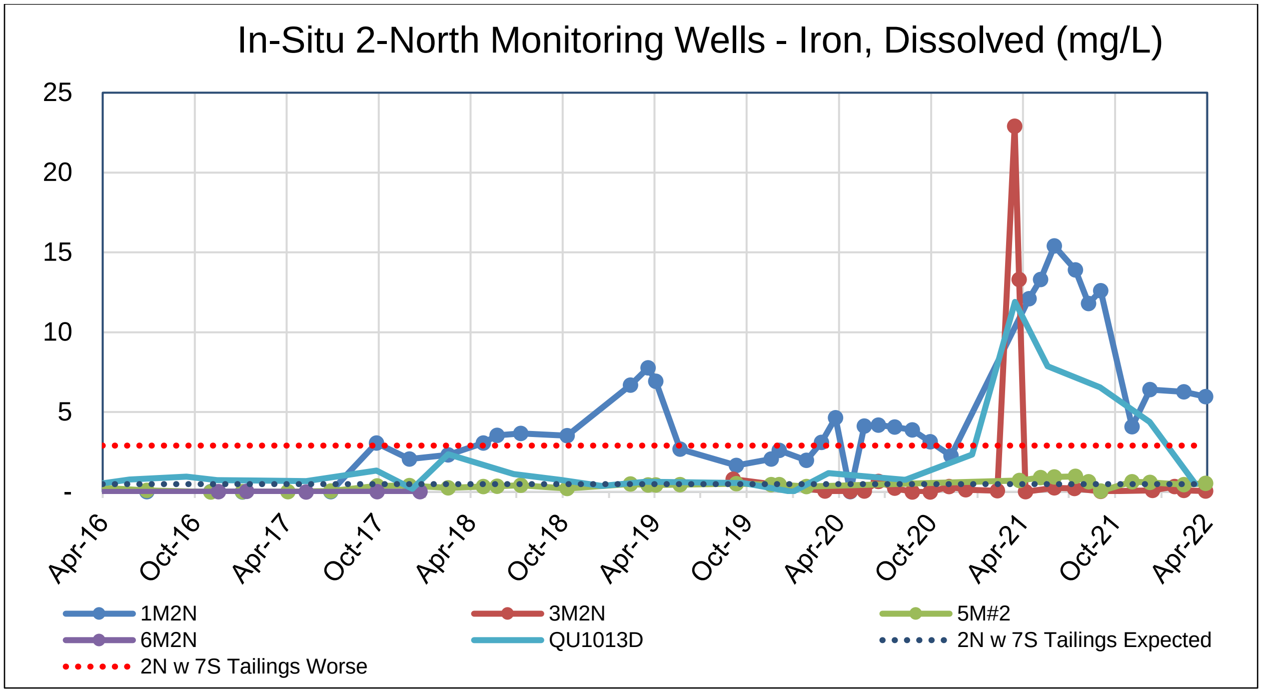


Figure 3: In-Situ 2N Monitoring Wells - Dissolved Arsenic, Sulphate and Iron

4.2.1.3 North Mining Area Ex-Situ Groundwater

The parameters of interest in the in-situ 2-North mining area were previously identified by Lorax in the 2-North/3-North and 5-South groundwater evaluation and include: fluoride, sulphate, aluminum, arsenic, boron, cadmium, cobalt, copper, iron, manganese, nickel, selenium, and zinc (Lorax 2011). These parameters may be found within ex-situ formation groundwater based on the geology the well is intercepting. Seepage from the 2-North area is expected to transport outside the mine void through the geological features surrounding and encompassing the 2-North mine. Migration and transportation rates are considerably slower in groundwater compared to surface waters; therefore, incremental increases are observed over many years.

Parameters that were observed to be naturally elevated in 2-North / 3-North include arsenic, sodium, chloride, sulphide as H_2S and iron. Those parameters that displayed exceedances against the CSR-AW were graphed along with sodium and dissolved iron. Parameters above the CSR-AW included arsenic, chloride, and sulphide (as H_2S). Arsenic and sulphide (as H_2S) were observed elevated in groundwater wells QU10-10 S, QU08-21G (S and D) with chloride elevated above the CSR-AW in QU10-10 D. Sodium and chloride is elevated in all deep groundwater wells in the No. 1 seam of 2-North area as formation groundwater is defined as sodium - chloride type waters.

QU08-21GD and QU10-10D are not strongly influenced by mine water. Elevated chloride in formation groundwater is an indication of older formation groundwater. Appendix I, Table 36 to 39, and Figure 4 below, represent the water quality results for these areas.

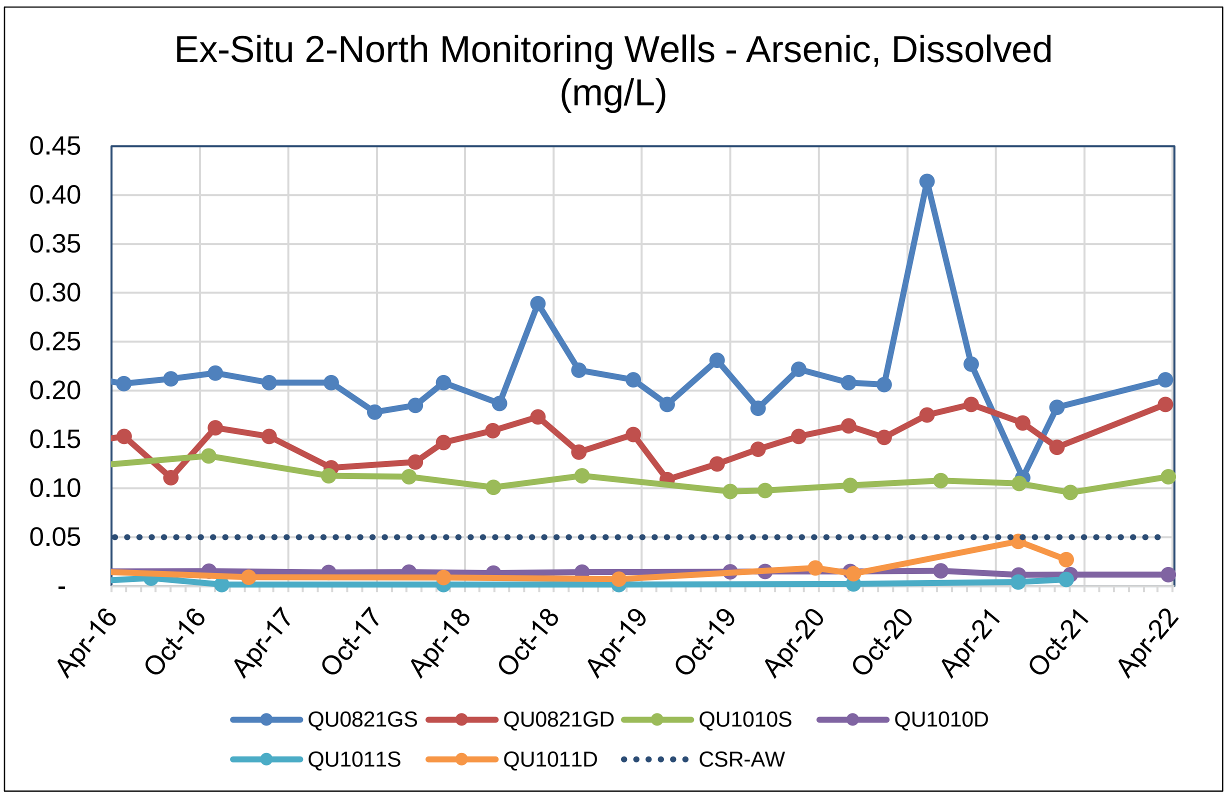
Notable observations for this area include:

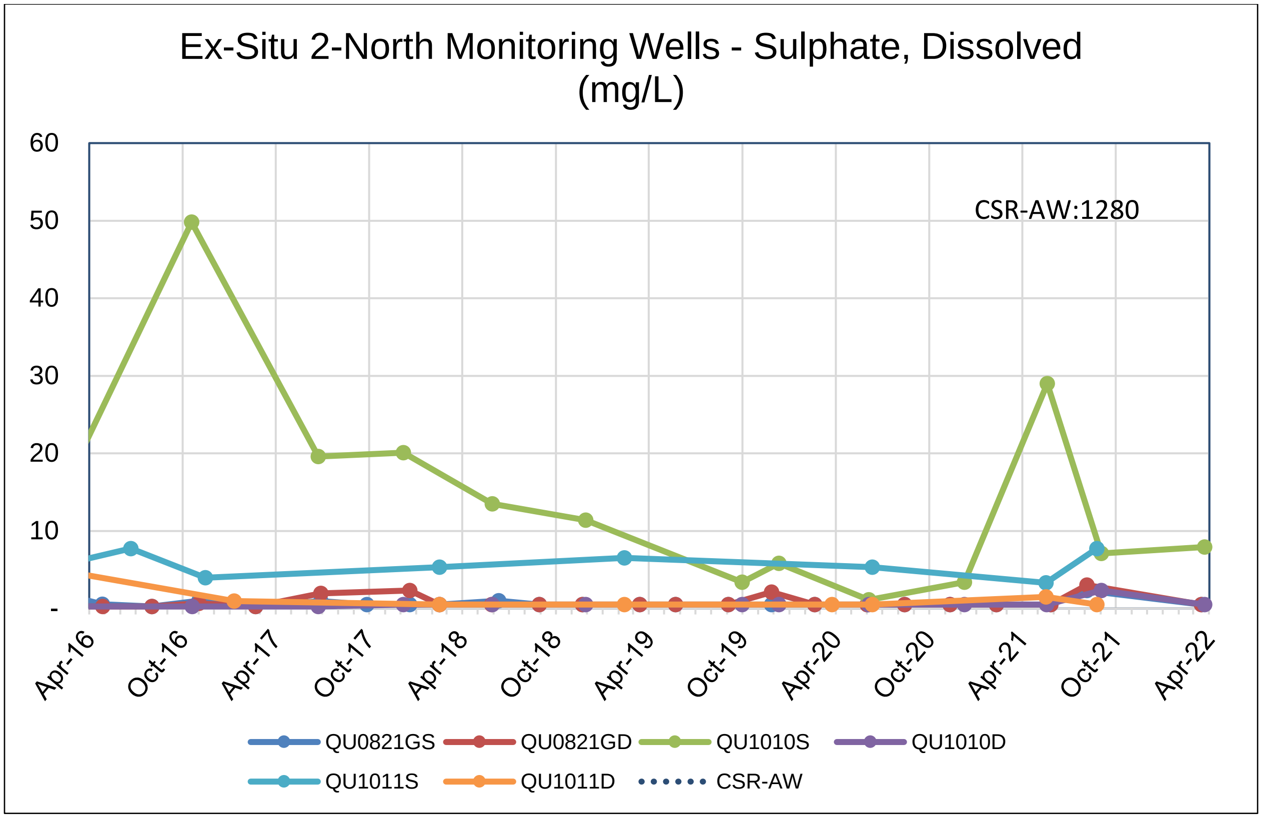
- Most parameters remained consistent with previous monitoring years with no major changes
- 2-North ex-situ deep formation groundwater wells intersecting the No. 1 seam have elevated chloride, sodium, conductivity and dissolved iron
- All POI were below the CSR-AW standards except dissolved arsenic, sulphide as H2S and chloride
- Dissolved arsenic concentrations exceeded the CSR-AW standard (0.05 mg/L) in all sampling events at Q08-21G (S and D) and QU10-10 S since monitoring began
- H_2S concentrations at QU08-21G (S and D) and QU10-10 S were above the CSR-AW standards (0.02 mg/L)
- Dissolved iron was found in highest concentration in the No. 1 coal seam (QU10-10 D) consistent with previous years
- Sodium concentrations found within the Ex-Situ wells have shown similar profiles to that of chloride evolving to sodium chloride type water as its ages in the formation flow path
- Sulphate is observed in low concentrations in all ex-situ groundwater in 2-North. QU10-10 S continues to trend down from the peak in Oct 2016

Throughout the 2-North, 3-North, and RBP areas, wells located in the ‘deep’ Cumberland Member of the stratigraphic column, particularly No.1 coal seam, have consistently reported low dissolved arsenic during all sampling events. Wells in ‘shallower’ Dunsmuir Member sandstones, particularly nested in the area of the #4 coal zone, reported arsenic values that were consistently elevated. The Dunsmuir sandstone member contains higher levels of arsenic and has been verified during drilling programs conducted by Quinsam Coal. These observations are consistent with the findings of Lorax (Lorax(2), 2011), who determined that elevated arsenic concentrations are found in formation waters of the Dunsmuir Formation including sandstone and the #3 and #4 coal zones. These results are in contrast of those found from formation waters of the #1 coal zone of the Cumberland Member. An exception to this observation is the monitoring well QU08-21G S and

D. QU08-21G is fault separated from the other 2 North and 5 South wells in the No. 1 coal seam (Lorax[(2)], 2011). This well is nested within the Cumberland Member on the Eastern side of the Forjan Fault, and while lower than those found in the Dunsmuir Member Sandstones and coal measures, all sampling events during this reporting period exceeded the CSR-AW standards. The groundwater in this location follows a different flow path than other No. 1 coal seam wells in 2-North (Lorax[(2)], 2011).

Concentrations of dissolved sulphate in the 2-North mine area outside of mine workings are low and frequently below detection levels (0.5 mg/L). A notably higher sulphate result was reported at the well QU 10-10S during October 2016 and more recently in April 2021 when the mine pool was at peak elevations. This could indicate 2-North mine pool influence on the shallower groundwater in these areas. There is little trending or concerns with sulphate for the remainder of the 2-North ex-situ wells.





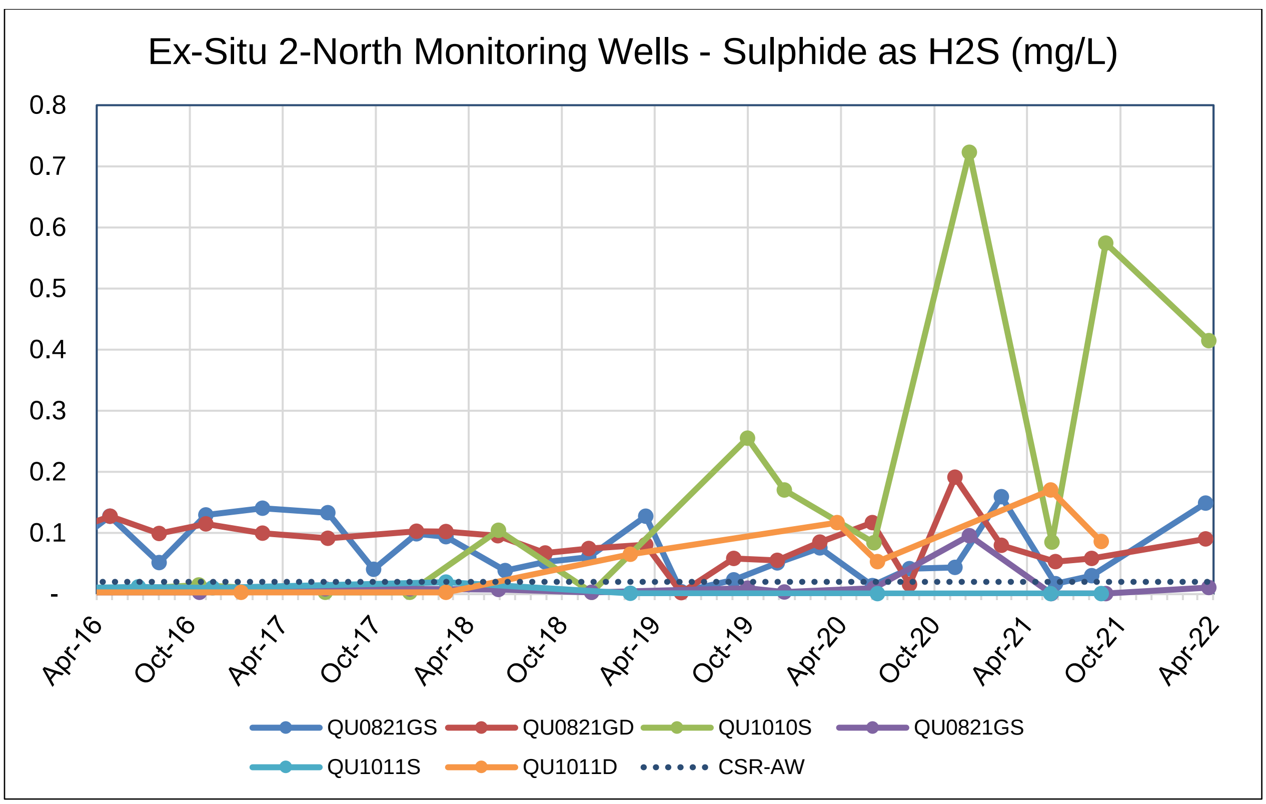


Figure 4: Ex-Situ 2N Monitoring Wells – Dissolved Arsenic, Sulphate and Sulphide as Hydrogen Sulphide (mg/L)

Sulphide has been found in elevated concentrations in many monitoring wells near the mine site. Sulphur is present in local geologic formations (particularly coal seams) and has been extensively documented by Quinsam Coal. As water interacts with sulphur bearing rock, leaching of the sulphur occurs and it can take many different forms dissolved into the water. Sulphide (as H_2S) occurs in groundwater with low dissolved oxygen and negative redox potentials. In the presence of oxygen, sulphur typically takes the form of sulphate. Figure 4 displays sulphide (as H_2S) concentrations found with ex-situ 2-North wells, sulphide displays a stable trend in all wells except in QU10-10S elevated in December 2020, September 2021 and March 2022. Field results displayed negative redox potential in the water. These wells intercept groundwater from the #1 and #4 coal seams, respectively and have been found to have low dissolved oxygen and negative redox potentials.

4.2.2 River Barrier Pillar Area

4.2.2.1 River Barrier Pillar with 5-South CCR

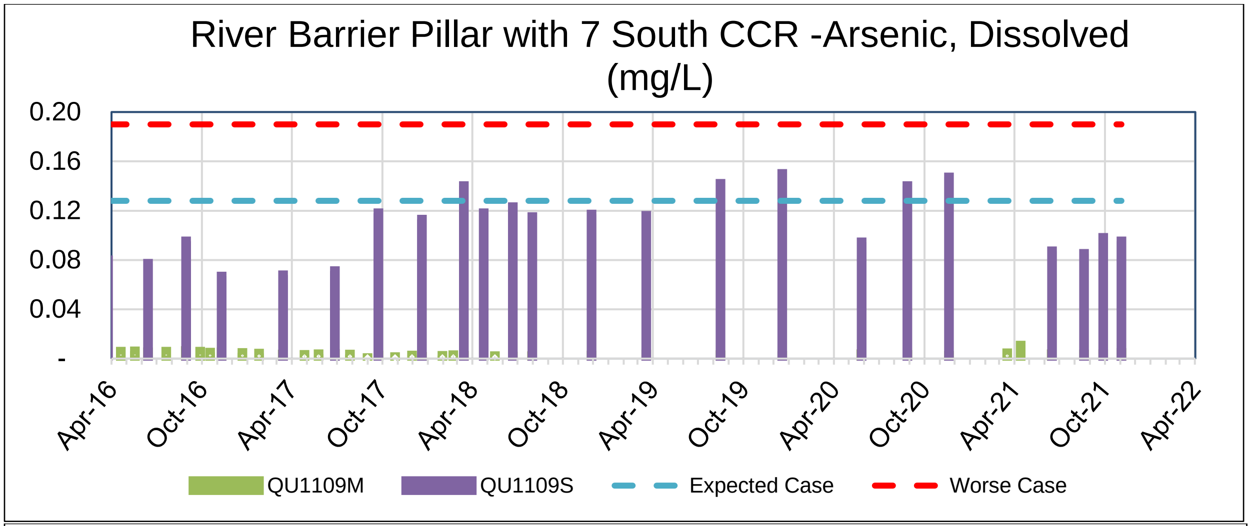
Groundwater well QU11-09 M represents water in the underground PAG-CCR disposal location at 87 Panel RBP. Disposing of PAG-CCR was completed in the RBP in September of 2012 with the PAG-CCR elevation at 153.5 m. The water level in QU11-09 M increased since 2012 from 145 m to 180 - 210 m dependent on groundwater influx and dewatering efforts in 2-North. In February 2021, an unauthorized discharge occurred at the well QU11-09 when the well became artesian, discovered on March 17, 2021. QU11-09 is a nested well that accesses three zones, shallow groundwater, water cover over course coal refuse (CCR) in 1 seam and water quality below the 1 seam. The water table in 2-North Mine (aquifer recharge zone) increased to ground elevation at QU11-09 which discharged mine water into the Quinsam river in 2021. The well pumps (1M2N and 5M2N) were both replaced by the beginning of April 2021. Groundwater elevations continue to be monitored to better understand the dynamics within the RBP with respect to mine pool closure options. This provided an opportunity to assess the seepage areas and impacts on the Quinsam river.

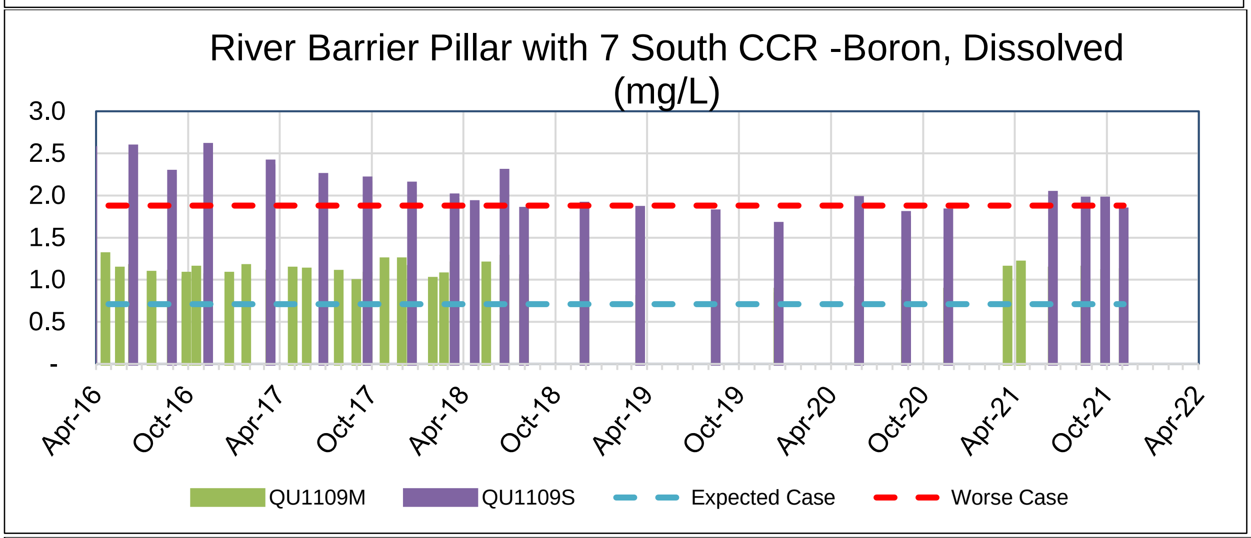
Source terms for the River Barrier Pillar (RBP) with PAG-CCR were originally developed using 7-South CCR quality data. As mining operations progressed, a storage area for the existing 5-South PAG-CCR was needed prior to mining 7-South. The RBP location was deemed suitable and excess 5-South PAG-CCR was backfilled in that location. In previous reports, the generated source terms (using 7-South PAG-CCR) were used for comparing and evaluating water quality results. As these source terms aren't necessarily applicable for water quality in this storage area, additional information including annual averages were used to help evaluate water quality.

Table 8 compares source terms derived from 7-South PAG-CCR compared to annual averages from 2021. The highlighted red numbers represent those parameters greater than the expected case. There were no parameters above the worst case. Figure 5 below represents concentrations of arsenic, boron and sodium in the flooded mine void and the shallow groundwater. The trend for elevated arsenic and sodium in shallow groundwater continues this year and is similar to the concentration observed at the seepage location referred to as S. This year there were 5 samples collected. The well was capped in November in order to mitigate the risk of discharging groundwater from the well.

Table 8: Source Terms Comparison for RBP with 7-South CCR and Averages

RPB (QU11-09 M) w/ 7S CCR	Expected	Worst Case	Annual Average
Parameter (mg/L)			N=5
Alkalinity (Total as CaCO3)	282		482
Dissolved Fluoride (F)	0.71	1	0.0954
Sulphate (SO4)	396	1990	1280
Dissolved Aluminum (Al)	0.02	0.05	0.006
Dissolved Arsenic (As)	0.128	0.19	0.005252
Dissolved Boron (B)	0.71	1.88	1.106
Dissolved Cadmium (Cd)	0.000017	0.000175	0.00002
Dissolved Cobalt (Co)	0.005	0.148	0.001154
Dissolved Copper (Cu)	0.0001	0.001	0.0004
Dissolved Iron (Fe)	0.805	33.5	24.94
Dissolved Manganese (Mn)	0.14	2.89	1.0792
Dissolved Nickel (Ni)	0.007	0.213	0.002
Dissolved Selenium (Se)	0.0002	0.0004	0.0002
Dissolved Zinc (Zn)	0.008	0.088	0.01





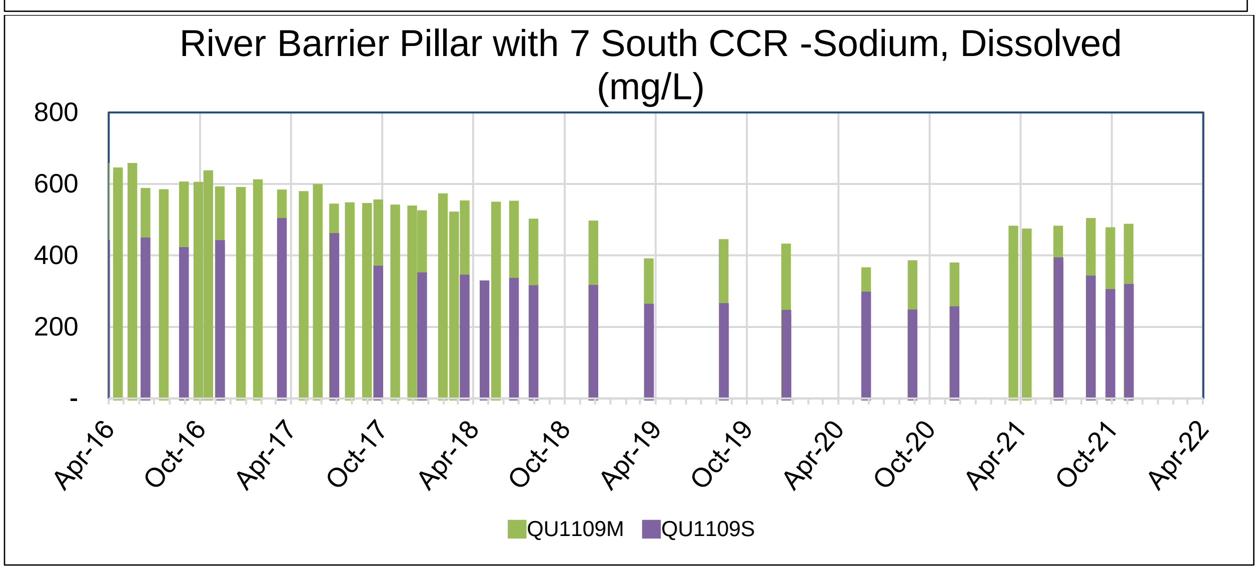


Figure 5: River Barrier Pillar with 7-South CCR- Dissolved Arsenic, Boron and Sodium

4.2.2.2 RBP Ex-Situ Groundwater

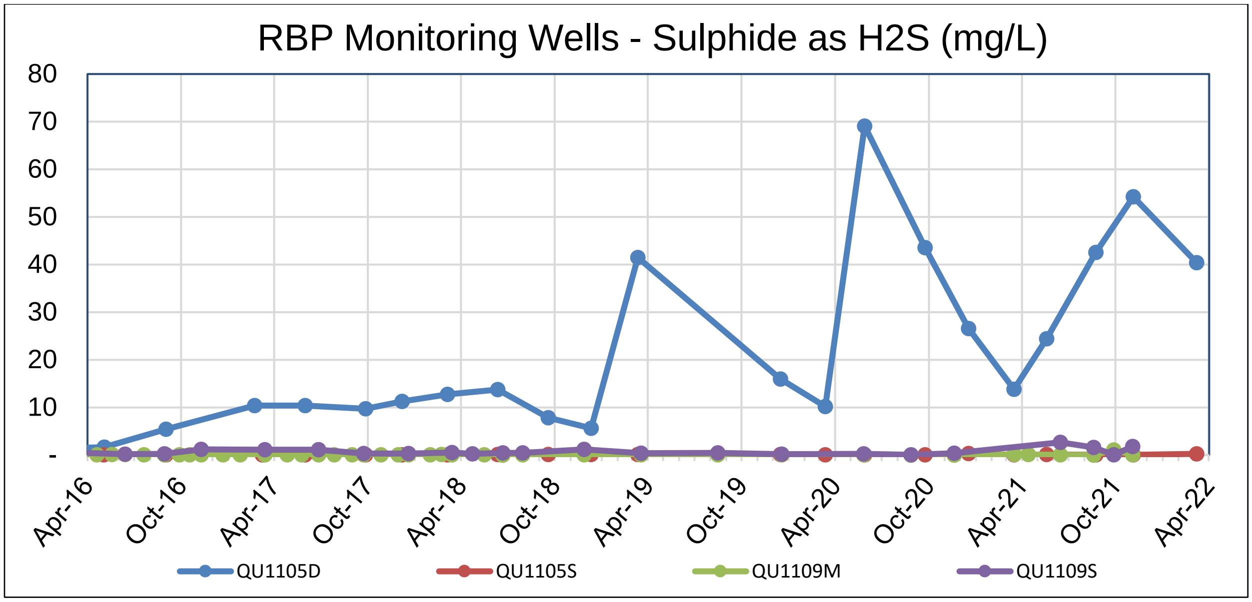
Concentrations of dissolved sulphate measured in the ex-situ wells of the River Barrier Pillar area are lower than CSR-AW but are displaying the mine signature for sulphate and are elevated enough to assist with analysis of the groundwater paths exiting from the in-situ mine waters (Figure 6). Storage of the PAG-CCR and subsequent flooding of the workings have contributed to these elevated sulphate concentrations in shallow groundwater. Sulphate was on a low stable trend until 2021 when a sharp increase was observed associated with the increased mine pool displayed in QU1105 (S and D). Increased sulphate and in deeper wells sulphide as H_2S indicate mine contact water influence. Fluctuating sulphide results have been observed in QU11-05 D since 2019. With peaks at 70 mg/L coinciding with lower dissolved sulphate. Sulphate follows the same trend as groundwater levels recorded at QU1109 M as it relates to 2-North mine pool elevation. The nested well QU1105 S/D is down dip/gradient from the RBP in the #1 coal seam. Both deep and shallow groundwater contain dissolved sulphate that has steadily increased with the deeper well having the highest concentration of sulphide levels. The depth of this well along with low dissolved oxygen indicates a favourable location to have high sulphide concentrations. This trend for high sulphide decreased considerably in 2020-21 from May 2020, 69.09 mg/L to 13.81 mg/L in March 2021 as displayed in Figure 6 displaying an inverse relationship with increased sulphate and increasing mine pool water levels.

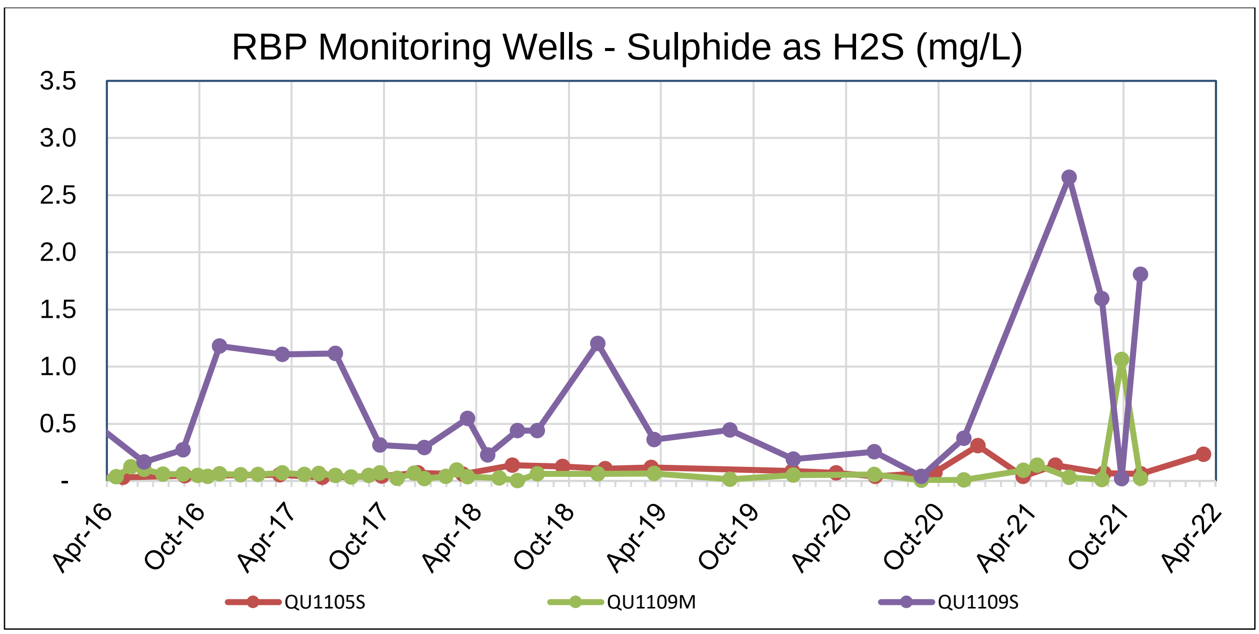
QU11-05 S, nested stratigraphically above, but down gradient/dip from the RBP, report sulphate concentrations that are elevated compared to other ex-situ 2-North wells. The increase in sulphate concentrations occur as autumn precipitation bring large quantities of water to the mine site and water levels underground rise. The fluctuations are completely proportionate to underground water levels in the RBP or 2-North mine pool and they provide some evidence that there is hydraulic conductivity or migration of groundwater across the stratigraphy.

QU11-09 S is a well nested in the stratigraphy directly above the RBP in-situ monitoring well, QU11-09 M. Prior to 2015, sulphate concentrations at this well have ranged from approximately 20-50 mg/L when water levels were low in the PAG-CCR storage area below. Since early 2015, sulphate concentrations have fluctuated in both shallow groundwater wells (QU11-09S and QU11-05 S), with decreasing concentrations observed in QU11-09 S since 2018 with a stable trend until Mach 2021 in QU11-05 S with increasing mine pool water levels.

As displayed in Figure 7, sulphate concentrations at all wells appeared to be directly correlated to groundwater elevations in the 2-North Mine Pool and the RBP. These increases indicate migrating in-situ waters rise vertically, likely via the natural hydraulic conductivity of the geology, as well as structural conduits (fault and joint planes) encountered during mining. Based on observations, these increases occur when groundwater elevation in the well below rise above 181-185 MASL, the elevation at which the lithology transitions into the sandstone that hosts QU11-09 S. Water migrating to this well is sourced from above the 5-South mine and direct infiltration from the 2-North mine. See Figure 7 for groundwater migration paths (Lorax, 2011).

Dissolved Selenium was elevated above the CSR-AW (0.02 mg/L) in the deep groundwater of QU11-05 D and found in lower concentrations in the shallow groundwater of QU11-05 S and QU11-09 S. Selenium has displayed highs and lows possibly related to fluctuating groundwater elevations since March 2019 with results in 2021-2022 ranging from 0.021 mg/L to 0.033 mg/L in the deep groundwater.


RBP Monitoring Wells - Sulphide as H2S (mg/L)
80
70
60
50
40
30
20
10
-
Apr-16
Oct-16
Apr-17
Oct-17
Apr-18
Oct-18
Apr-19
Oct-19
Apr-20
Oct-20
Apr-21
Oct-21
Apr-22
QU1105D
QU1105S
QU1109M
QU1109S


RBP Monitoring Wells - Sulphide as H2S (mg/L)
3.5
3.0
2.5
2.0
1.5
1.0
0.5
-
Apr-16
Oct-16
Apr-17
Oct-17
Apr-18
Oct-18
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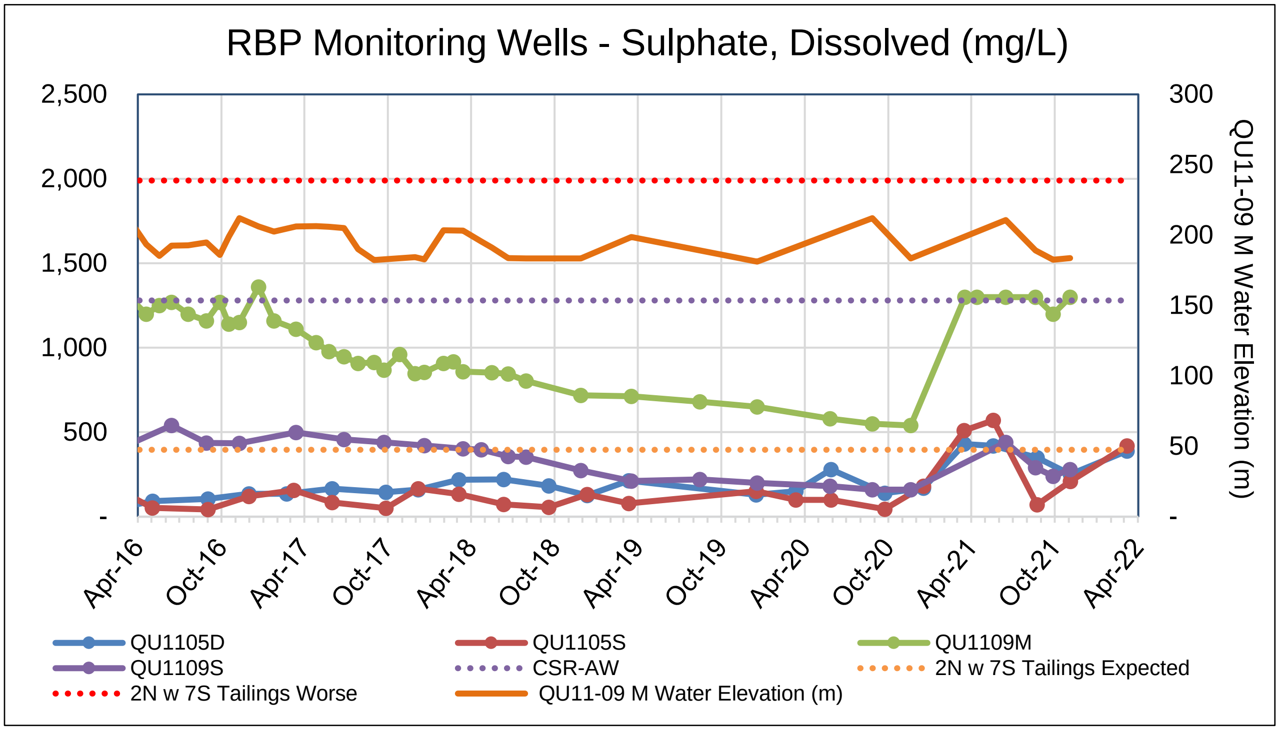
Apr-22
QU1105S
QU1109M
QU1109S



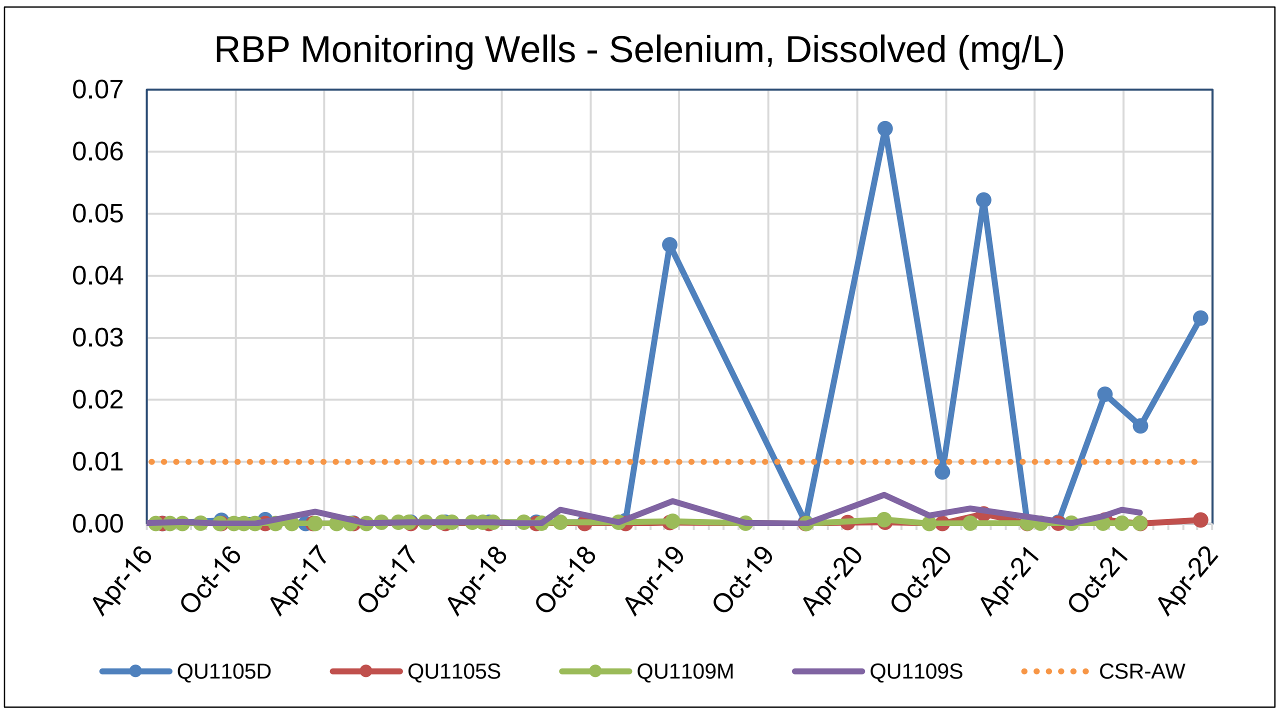


Figure 6: Ex-Situ River Barrier Pillar Monitoring - Sulphide as H_2S, Dissolved Sulphate vs Water Elevation and Selenium

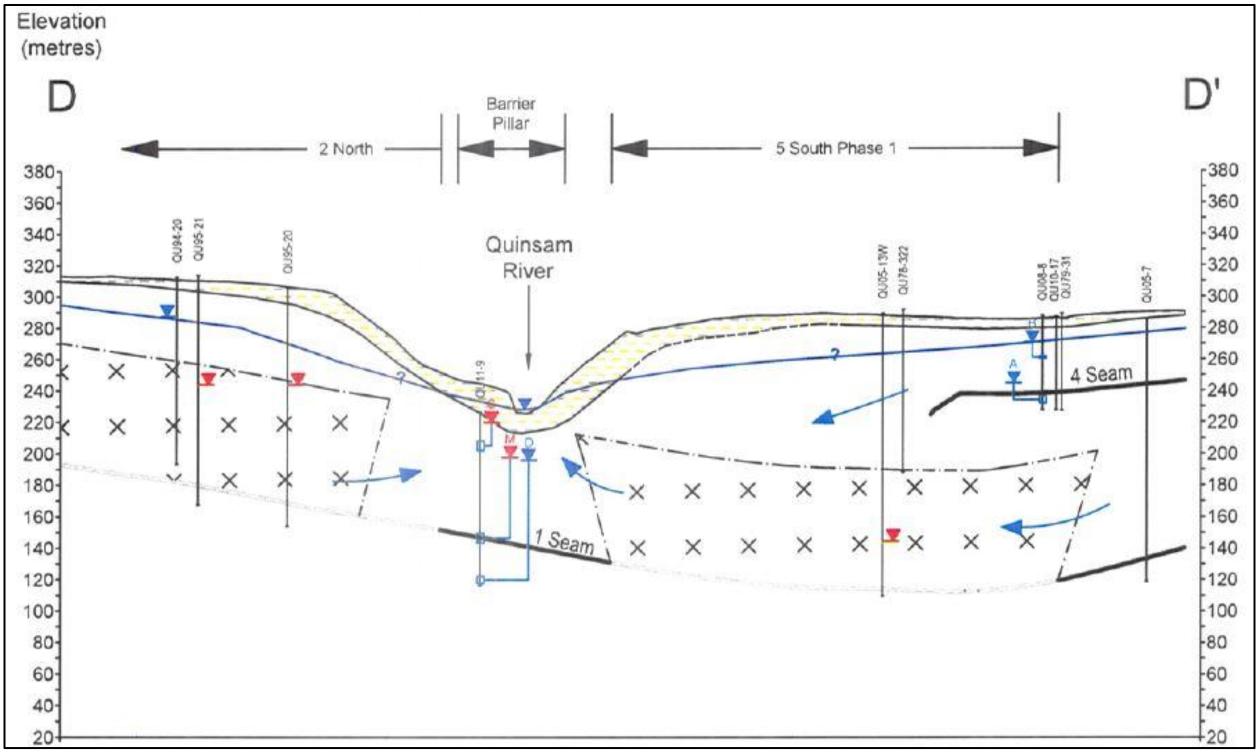


Figure 7: Groundwater Transport in RBP and Vicinity

Following the completion of the 8-Mains plugs (engineering control established to eliminate unnatural mixing of groundwater accumulated in the 5-South side of the mine, and the 2-North side of the mine) in February of 2018 and in February to March 2021, the water levels in 5-South and 2-North mine began to rise, increasing the hydraulic head pressure on the groundwater stored in 5-South, and RBP of 2-North. It is assumed that as the water level rose, the pressure on the groundwater flow path was increased, as shown by the increase in sulphate in the wells.

4.2.3 North Mining Area Plant Monitoring Wells

Two nested monitoring wells (MW00-6 and MW00-1) are in the peripheries of a catchment drainage ditch located below the coal processing plant (CPP) and the clean coal pad. Both wells contain a "shallow" and "deep" groundwater intercept nested at different depths of the overburden till layer.

Noted in the well installation completion log for MW00-1 (D&S), the ‘Shallow’ well was nested in a layer of the till that contained a larger percentage of cobbles and coarse gravels compared to the finer grained gravelly sands and clay materials are surrounding the ‘Deep’ well. This is important to note, as observations made in the shallow groundwater wells compared to the deep wells include more conductive water that is higher in alkalinity and exhibits elevated concentrations of dissolved sulphate. This leads to the assumption that the shallow wells are getting direct communication from the CPP and clean coal pad via the catchment drainage ditch while the deeper wells are isolated from that groundwater due to some other control, possibly based on grain size differences in the till. However, while the differences between the groundwater results from the shallow and deep wells are obvious, any difference between the host till of the shallow and deep well located at MW00-6 were not noted in the completion log and therefore cannot be easily explained by geologic control. MW00-1 D is nested significantly deeper in the till at 28 metres than MW00-6 D at 14 metres. Interestingly, MW00-6 is geographically closer (while only 15 metres) to the plant ditch and coal pad where iron and sulphate should be observed in higher concentrations.

Historically, MW00-1 S displayed slightly acidic conditions, with the pH falling just below 6.4 on most occasions, while MW00-6 S was generally neutral. The deeper wells are more alkaline with pH ranging from 8.3 - 9.5. MW00-1 S displayed the highest concentrations of dissolved sulphate, hardness, iron, manganese and other constituents. The deeper wells (MW00-1 D and MW00-6 D) have low concentrations of metals and sulphate with alkaline pH and low conductivity. Since January of 2013, regardless of the variation of precipitation throughout the year, the groundwater maintains its natural path through the coal pad and its surroundings, into the ditch, and through the till substrates.

Consistent with past years, dissolved arsenic (Figure 8), aluminum and zinc are found in greater concentrations in the deeper wells than the shallow wells but remain at moderate concentrations and below CSR-AW standards. In 2020 to present the deeper well MW001 D displayed a sharp decrease in arsenic. The well was resampled and confirmed the results. The main concern and objective of these wells is to intercept plant stockpile water to trace effects the coal pad may have on groundwater flowing toward Middle Quinsam Lake.

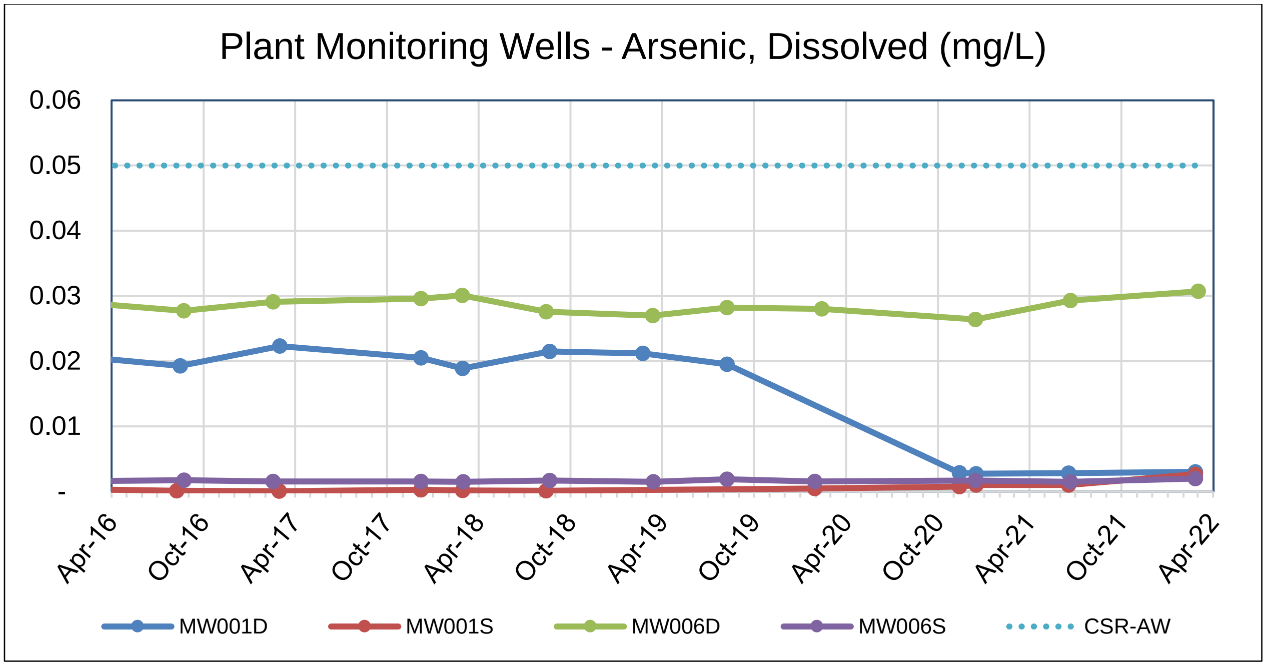


Figure 8: Plant Monitoring Wells - Dissolved Arsenic

Dissolved sulphate levels (Figure 9) in both shallow wells exhibit a decreasing trend with some apparent seasonal variation showing higher concentrations of sulphate throughout the drier season and lower concentrations through the rainy season. Dissolved sulphate concentrations at MW00-6 S have shown stable trends with little seasonal variation since 2015. Sulphate is the main parameter of interest as it indicates any changes or improvement on water management practices implemented and those effects on local groundwater from the coal pad and plant site collection ditch.

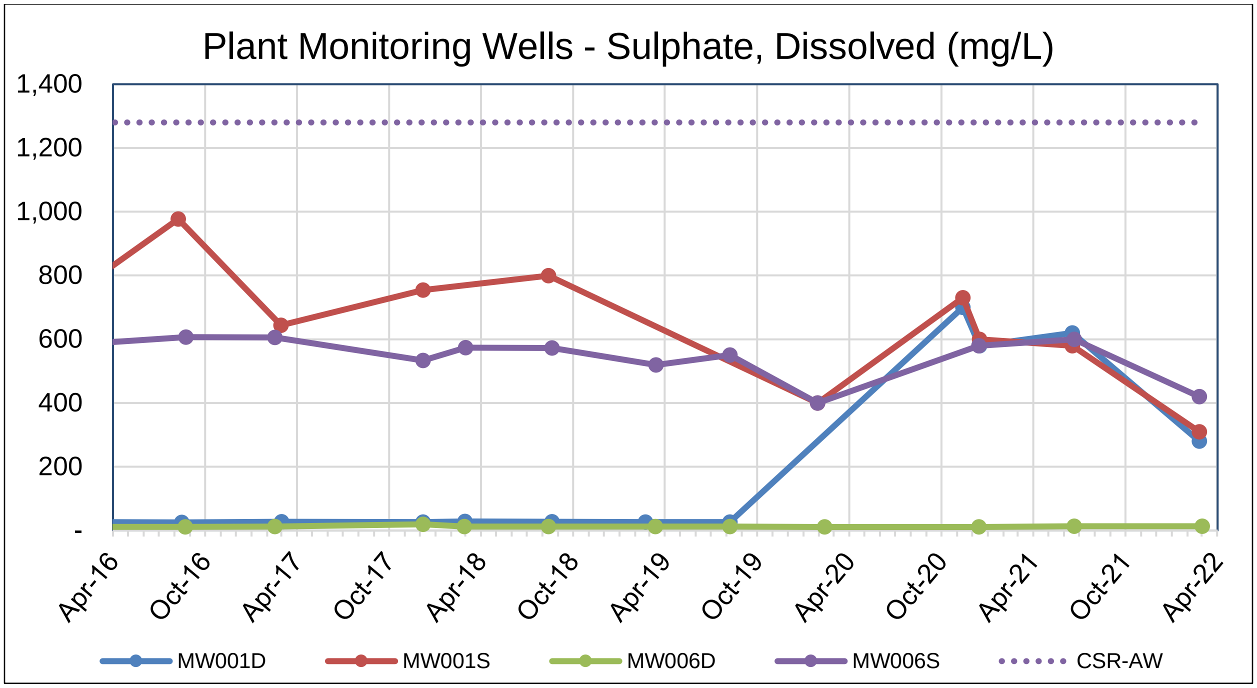


Figure 9: Plant Monitoring Wells - Dissolved Sulphate

The Quinsam Coal Environmental Department is currently assessing this area of groundwater monitoring, considering the possibility of eliminating one of these monitoring wells (due to similar parameter trends) and re-establishing a groundwater monitoring site closer to the southern drainage of the CPP and the clean coal pad. In 2019-20 the deeper well MW001 D was unable to be sampled and possibly the reason for the elevated sulphate result when the line was replaced. The well was thought to have collapsed and could not be monitored in 2019-2020. In 2020 to present results of sampling displayed a sharp increase in sulphate in the deeper well. Further sampling has confirmed the results. The deeper groundwater well (MW001D) is suspected to be influenced from the shallower groundwater as the well was compromised. The deep groundwater well MW006 D does not display the same sulphate concentrations and is within 20 m of MW001 D. Further monitoring has confirmed the results and the well will be removed from the monitoring program in 2022-2023.

4.2.4 7-South

4.2.4.1 7-South Mine with PAG-CCR

Area 2 of the 7-South mine is being used as a sub-aqueous PAG-CCR storage facility for waste material produced by the mechanical processing (crushing and floatation) of the 7-South raw coal product. Storage of this PAG-CCR commenced March 12, 2015 and has subsequently flooded due to natural groundwater infiltration. The in-situ flooded water in this area has been monitored using well QU14-10, with 5 sampling events taking place during this monitoring period. The 7-South mine void water will continue to be monitored following completion of mining and subsequent subaqueous disposal of PAG-CCR.

Lorax predicted Source Term concentrations, which are provided in Mine Permit (C-172) Amendment; 7-South Development Volume 3 Appendix J. Lorax outlined three scenarios in which results would vary, which are, in summary:

> Scenario 1: Water quality based on the CCR that is being stored, having been given enough time on surface (greater than 2 years) to become acidic, prior to being flooded.
>
> Scenario 2: Water quality based on the CCR being stored less than 2 years since being produced, which would not be acidic.
>
> Scenario 3: Expected long term water quality concentrations following the complete dissolution of stored oxidation products and the influenced mine water being completely discharged from the mine or re-stabilized as metal sulphides within the flooded workings.

Table 9 displays the Source Term expectations for Scenario 2 for 7-South mine containing saturated CCR. The average results for the sampling events of 2021-22 were derived using the detection limits for those results reported as less than detection limits. Average concentrations calculated are then compared to scenario 2 as they are most applicable. Although not a parameter of interest, the water in the flooded 7-South workings is very hard, higher than any other well on site. Hardness levels averaged 1986 mg/L, indicating a strong influence from calcium and magnesium carbonates, likely found interstitially in the sandstone that is a large constituent in the

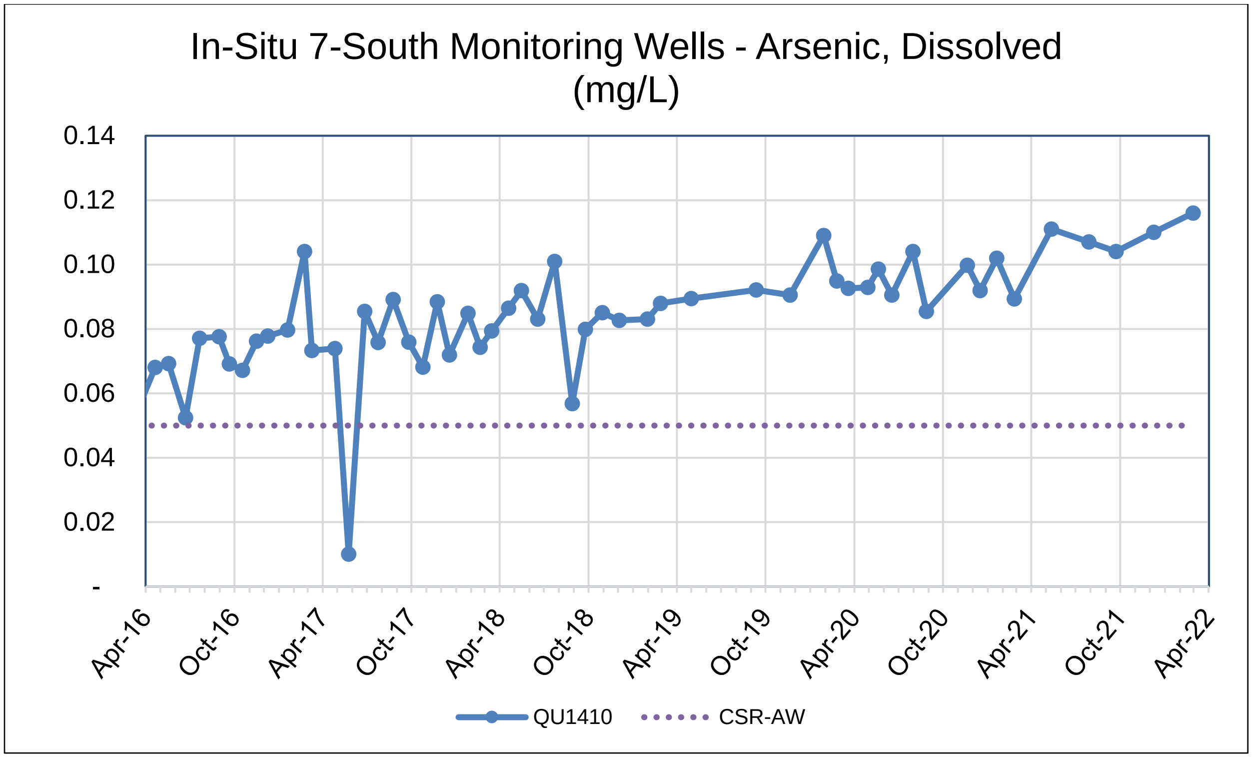
7-South coarse coal reject (Figure 11). Arsenic remains above the CSR-Aw (0.005 mg/L) but below the expected case of 0.19 mg/L in the water quality.

Table 9: Source Terms Comparison for 7-South with PAG-CCR

Parameters	Source Terms for 7 South Mine Containing Saturated CCR [1]	2021-2022 results (N=4) *Average >Expected
pH	6.48	7.85
Acidity (as $CaCO_3$)		25.9
Alkalinity (as $CaCO_3$)		310
Fluoride (F)	0.6	0.1425
Sulphate (SO_4)	1260	1820
Aluminum (Al)	0.009	0.0114
Arsenic (As)	0.19	0.1104
Boron (B)	0.98	1.036
Cadmium (Cd)	0.0002	0.000038
Cobalt (Co)	0.062	0.0008
Copper (Cu)	0.001	0.00076
Iron (Fe)	6.705	2.078
Manganese (Mn)	2.885	1.428
Nickle (Ni)	0.122	0.0038
Selenium (Se)	0.004	0.00038
Zinc (Zn)	0.088	0.019

All units are in mg/L except pH

***Note: If the Result < DL, then the DL value was used.**



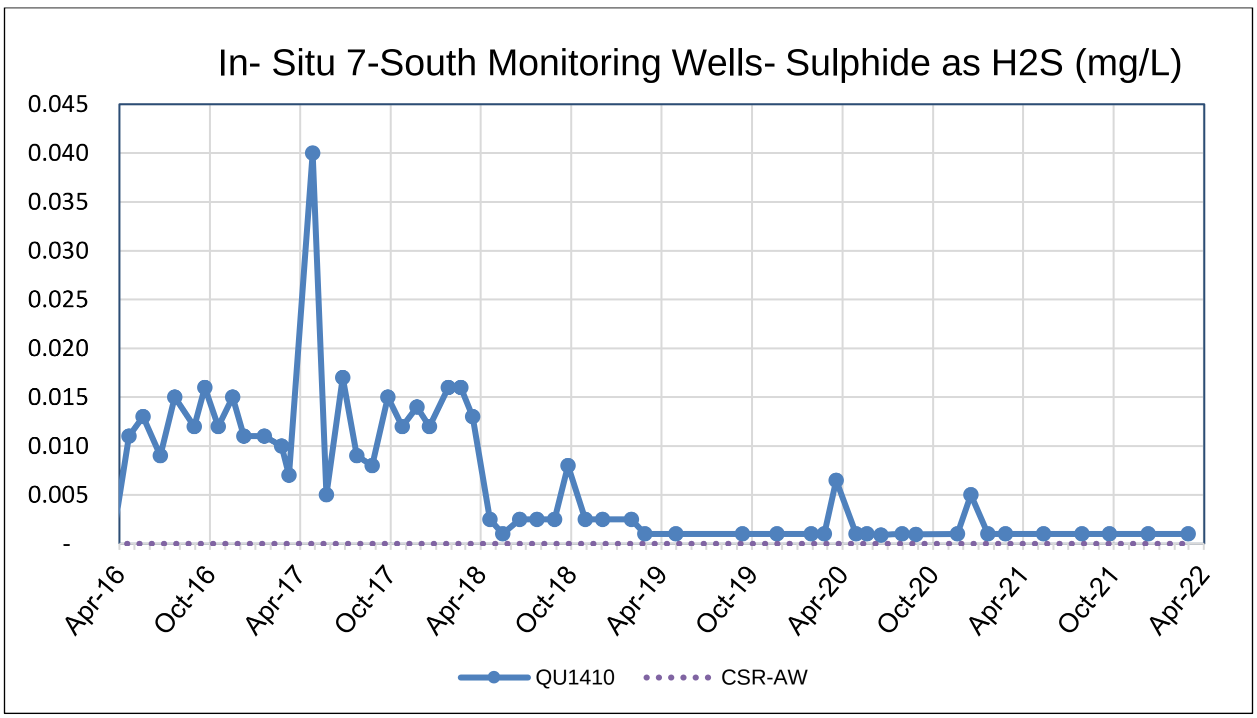


Figure 10: 7-South In-Situ Monitoring Wells - Dissolved Arsenic and Sulphide as H2S

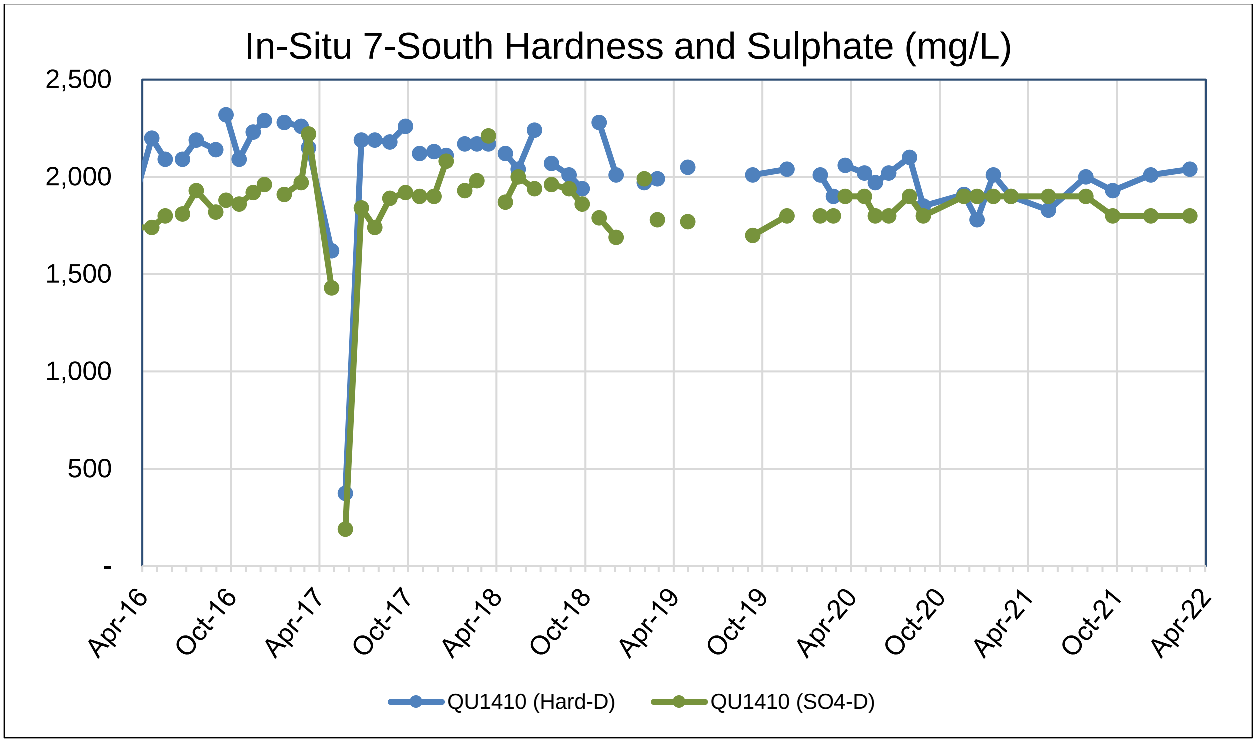


Figure 11: 7-South In-Situ – Dissolved Hardness and Sulphate

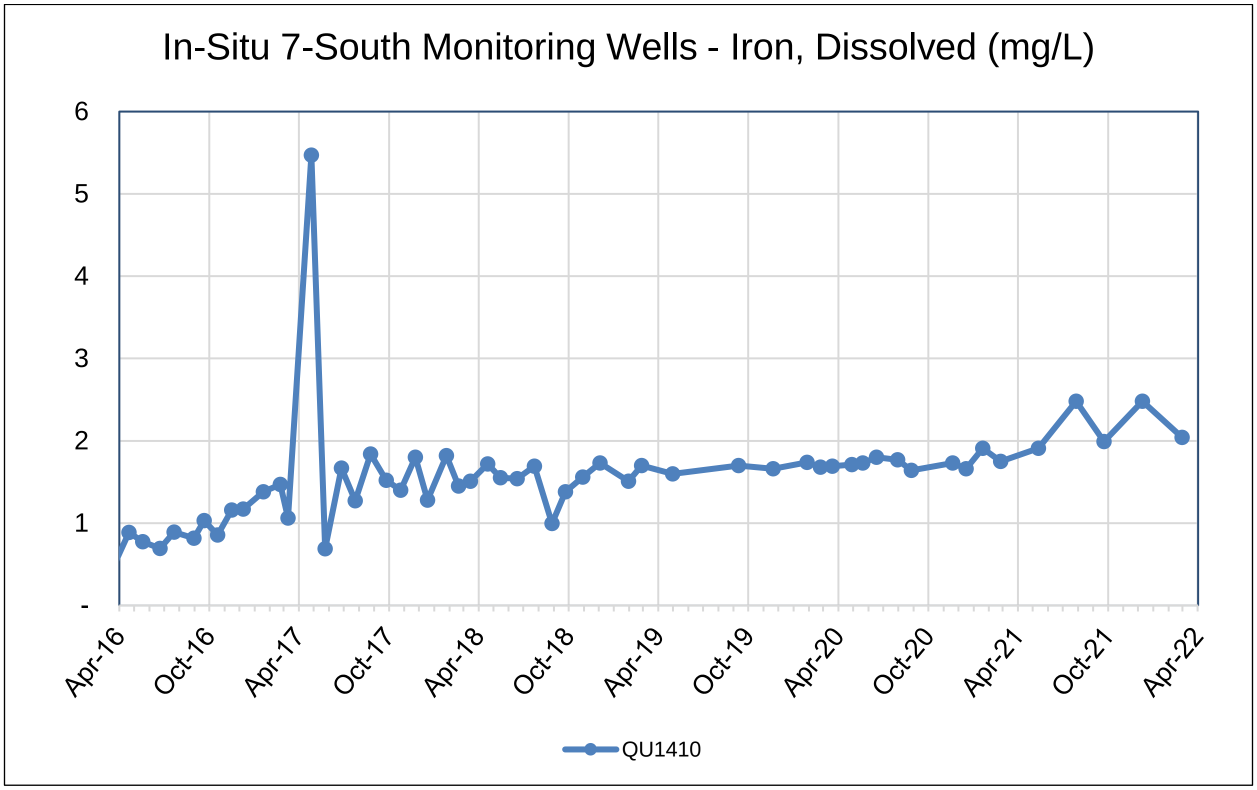
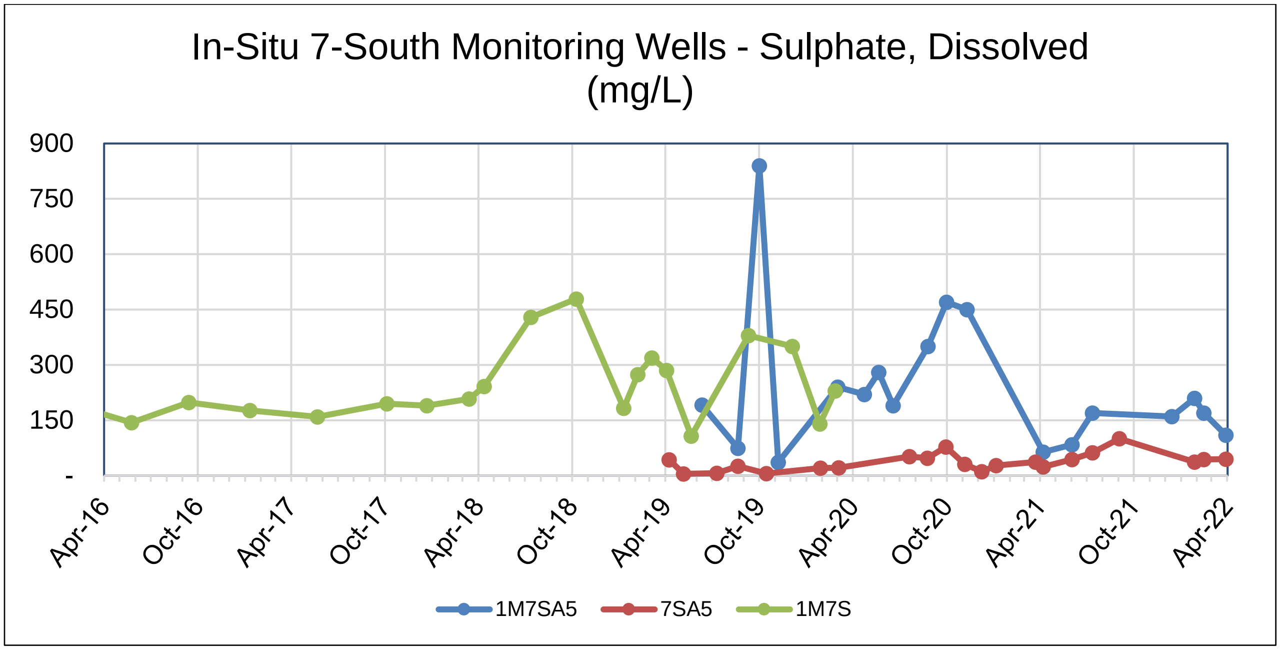


Figure 12: 7-South In-Situ Monitoring Wells - Dissolved Iron

4.2.4.2 7-South Underground Sump

Water chemistry in the 7-South mine pool has been monitored via sump sampling in 1 Mains (1M7S). In 2019 this sump also included 7-South Area 5 where the sump was renamed 1M7SA5 in order to differentiate and characterize the water chemistry. The 7-South Area 5 sump (7SA5) is sampled separately in order to characterize the water quality coming from that location. Samples from 1M7S / 1M7SA5 exhibit moderate levels of dissolved sulphate with 7SA5 having low levels (Figure 13). Dissolved arsenic, however, has shown fluctuations since monitoring has been established, with the higher concentrations observed throughout the winter, likely attributed to high groundwater infiltration through sandstone. These inconsistent arsenic values may also be attributed to variable amounts of water either pumped into or out of this sump for mining purposes.



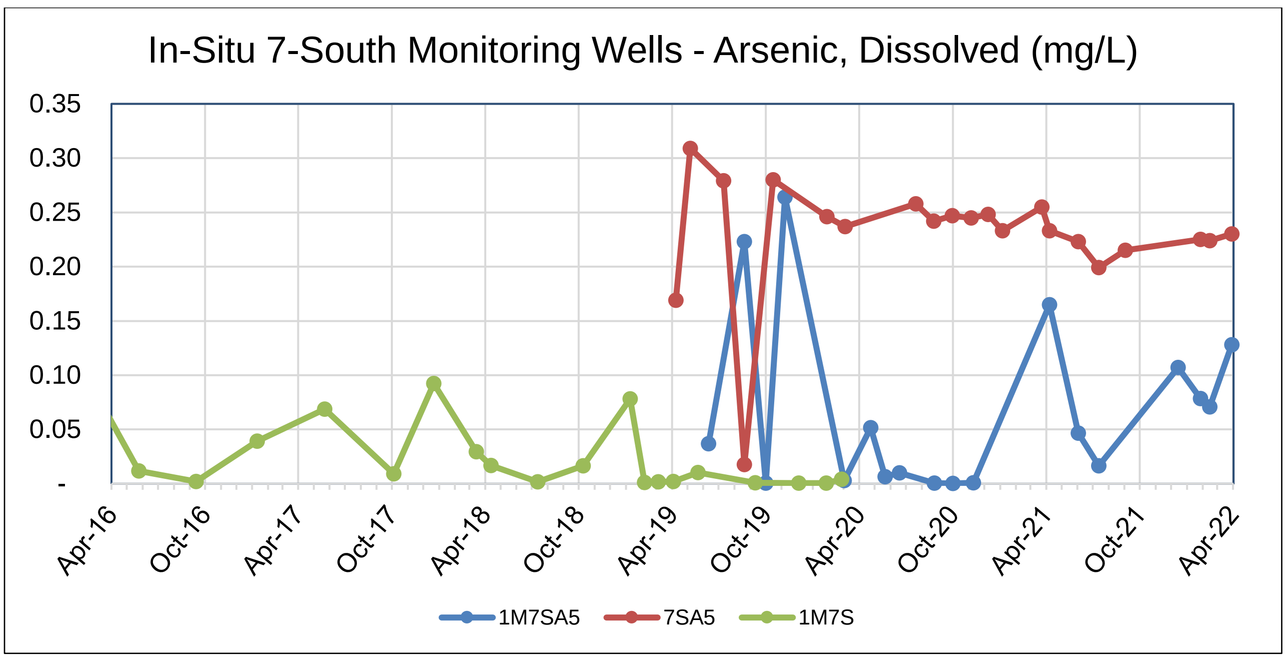


Figure 13: Dissolved Sulphate and Arsenic (mg/L)

4.2.4.3 7-South Ex-Situ

The primary focus of the 7-South ex-situ groundwater monitoring is to evaluate water flowing from Area 2 (permanent PAG CCR storage location) towards the Quinsam River; monitoring wells QU08-13 A and B satisfy this consideration. In addition to monitoring seepages from Area 2, monitoring well QU08-10 is situated to monitor groundwater transport from permitted mining reserves in 7-South (areas 4 & 5) towards the Iron river. This well is located adjacent to the Area 4 development on the North side of the Long Lake fault and is nested in the #4 coal zone.

The No. 4 coal zone at 7-South is hosted within the Dunsmuir Member sandstones of the Comox Formation, which is naturally elevated in arsenic and fluoride. On average, the highest concentration of arsenic in the current Quinsam Coal monitoring regime is found in the 7-South area. The northern limit of the 7-South underground mine workings is limited by the location of a normal fault called the Overlook Fault, which displaces the #4 coal zone vertically by 14 metres. The Overlook Fault defines the groundwater flow path between the 7-South mine, and the monitoring wells QU08-13 A and B. Well QU08-13 A monitor's groundwater traveling down-gradient from the 7-South workings within the #4 coal zone at 52 metres deep. QU08-13 B monitors groundwater higher up in the stratigraphic column at the glacial till overburden/sandstone contact at 26 metres deep, effectively monitoring groundwater that would be migrating up through the stratigraphy towards the Quinsam River. This groundwater is suspected to follow a different flow path at the down gradient northern extent of the 7-South mine than other groundwater in the area (Lorax, 2011). Lorax has described this well as significantly sodium enriched with circum-neutral pH. The groundwater is anoxic with mild to moderate reducing conditions.

Starting March 2015 PAG-CCR from the processing of 7-South raw coal was transported from the Quinsam Coal Preparation Plant to the 7-South Disposal Bin, which delivers PAG-CCR directly onto the underground belt structure for transport into Area 2. Since that date, material has been backfilled, and allowed to naturally flood. The in-situ flooded water in this area has been monitored using well QU14-10, while the ex-situ groundwater has been monitored using QU08-13 A & B. Data acquired prior to March 2015 has provided information about baseline conditions and will be used for comparison when analyzing future monitoring.

The most notable and relevant observation was the low, stable sulphate concentrations throughout the years with a distinctive increase in dissolved iron and sulphate in February 2018. This increase was concurrent with advance mining in the northern extent of 3-Mains. With expansion of mining boundaries in this area, it is believed that mobilization of materials and "shrinkage" of the effective barrier between the mine and monitoring well has contributed to the increase in these parameters. Further monitoring has displayed a decreasing trend in these parameters where they have not persisted at elevated levels. In both QU08-13 A & B arsenic and sulphide as hydrogen sulphide exceeded the CSW-AW. QU08-10 displayed an increase in sulphate and iron in recent monitoring, the sulphate result is suspicious, further monitoring will confirm the results. Most results are following a tend based on season and groundwater fluctuation.

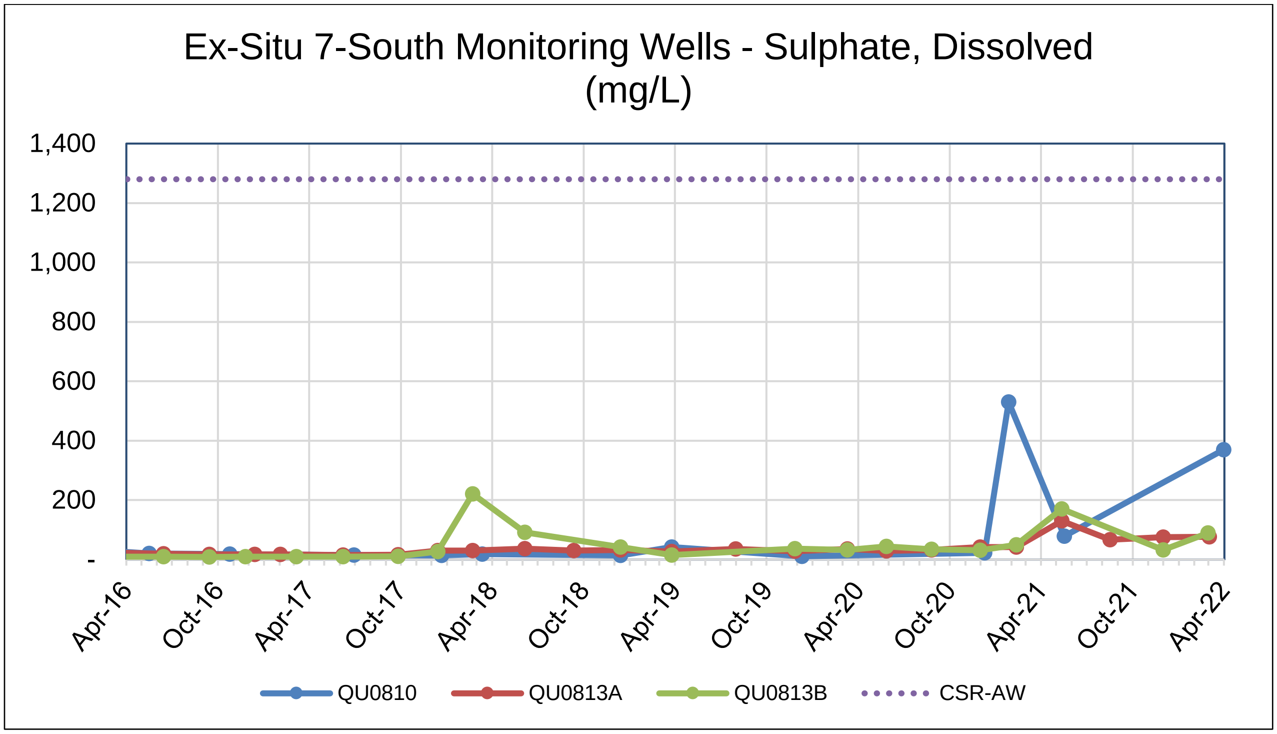


Figure 14: 7-South Ex-Situ Monitoring Wells - Dissolved Sulphate

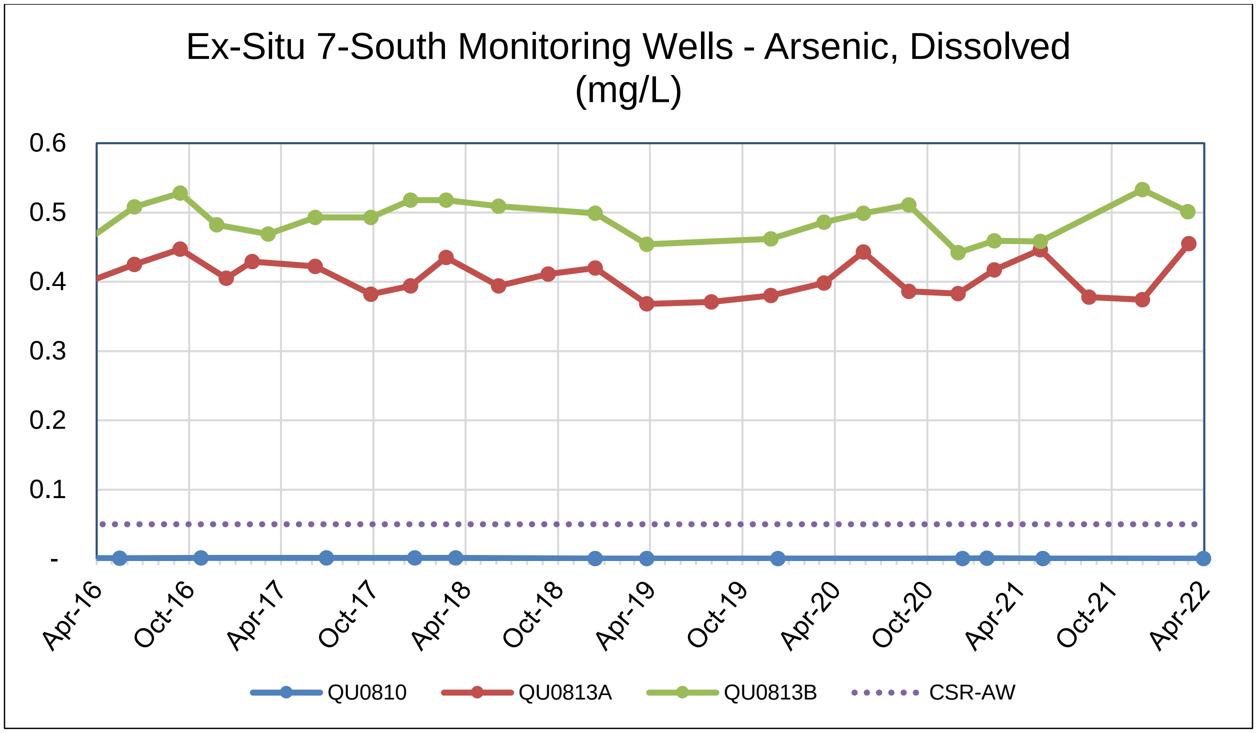


Figure 15: 7-South Ex-Situ Monitoring Wells - Dissolved Arsenic

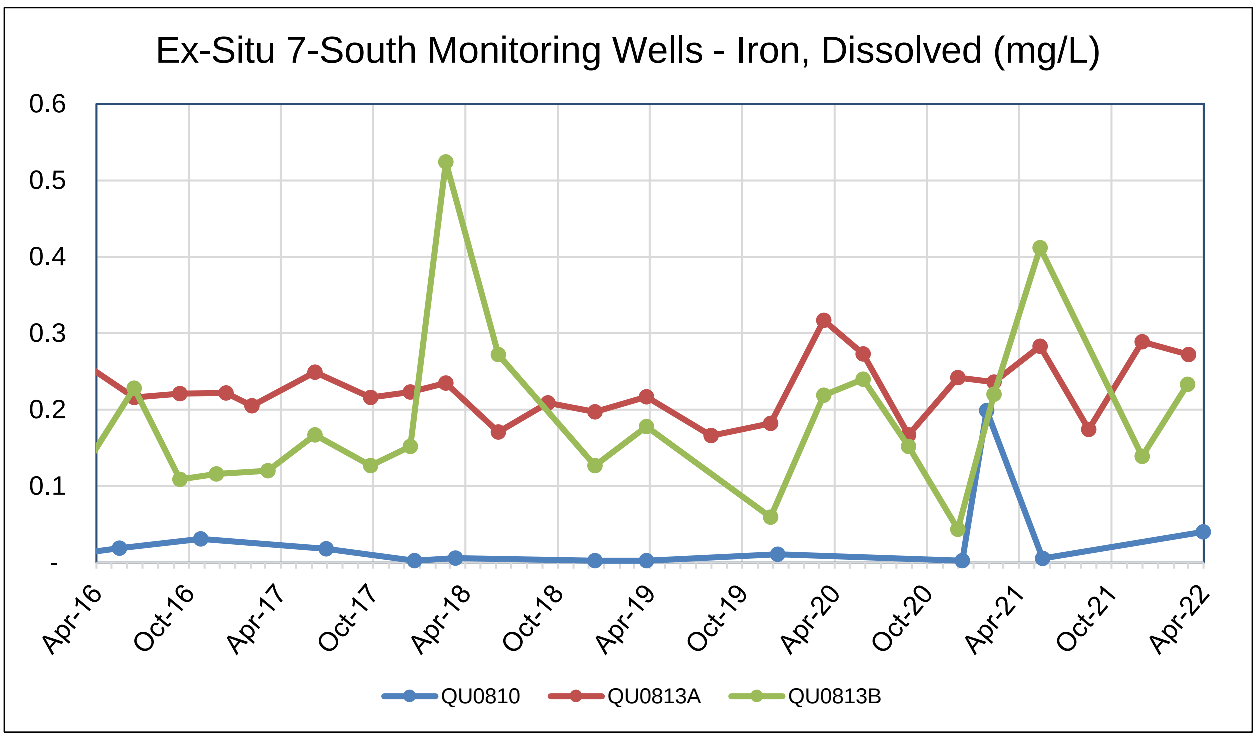


Figure 16: 7S Ex-Situ Monitoring Wells - Dissolved Iron

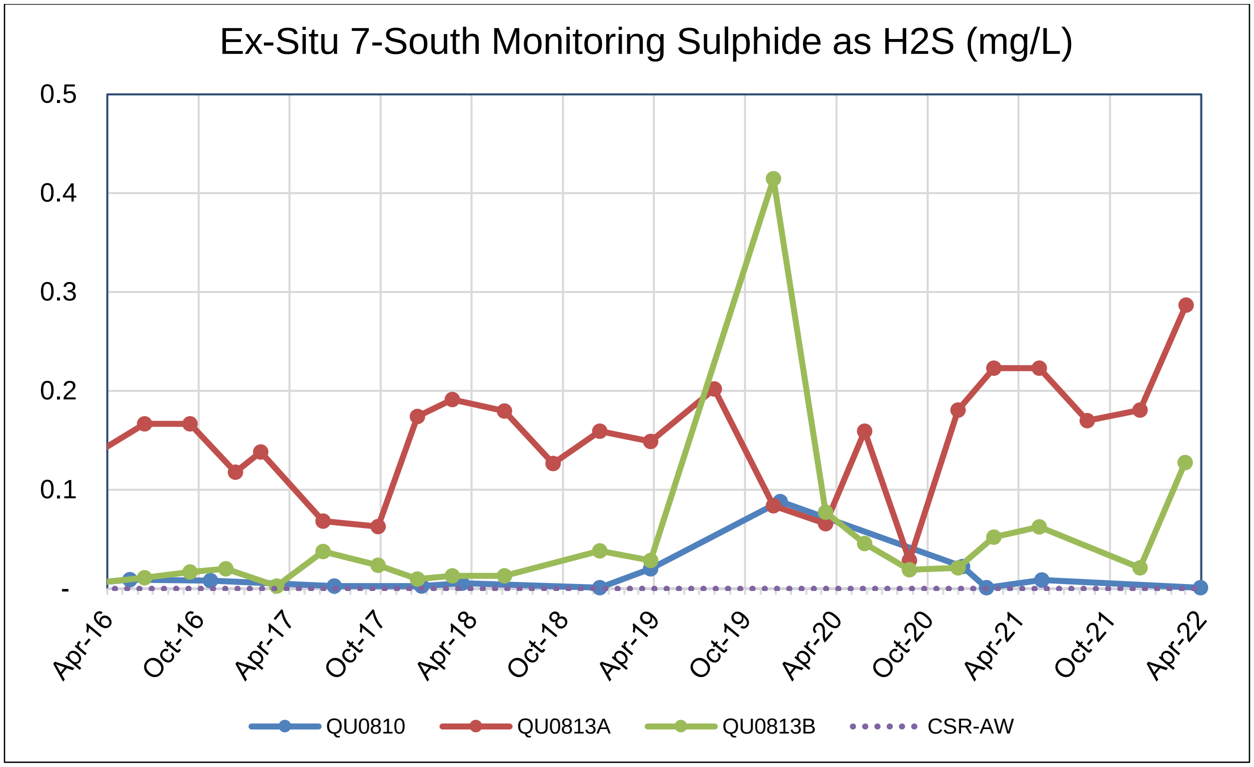


Figure 17: 7S Ex-Situ Monitoring Wells – Sulphide as Hydrogen Sulphide (H_2S)

4.2.5 2/3 South Monitoring Wells

4.2.5.1 2/3 South Mine Pool

Monitoring wells MW00-4 and QU11-11 were established for monitoring the 2-South mine pool water quality while QU11-11 is also used for reference for the treatment system influent. 2-South mine pool water enters Long Lake via the Long Lake Seep and discharges are closely related to water levels monitored at MW00-4. These wells exhibit moderate concentrations of sulphate ranging from 210 mg/L to 430 mg/L (MW00-4) and 400 mg/L to 760 mg/L (QU11-11) historically. It is noted that both wells are relatively stable for sulphate concentrations. Concentrations of dissolved metals are relatively low in these wells and exhibit neutral pH. Dissolved arsenic and iron concentrations display a periodic spike in well QU11-11 (INF) and are typically related to rising mine pool water elevations as flushing of the mine walls encourages a gradational increase in dissolved metals. The distinct increase of dissolved arsenic and iron in mid-2017 at QU11-11 is a direct result of changing to field filtering and preservation on site. A peak dissolved iron was observed at both QU11-11 and MW004 in was observed in summer at QU11-11 and MW004 resulting in 9.47 mg/L and 0.024 mg/L, respectively. Concentrations declined in further monitoring. There results don't seem to be correlated with low mine water levels as peaks are also observed in winter months.

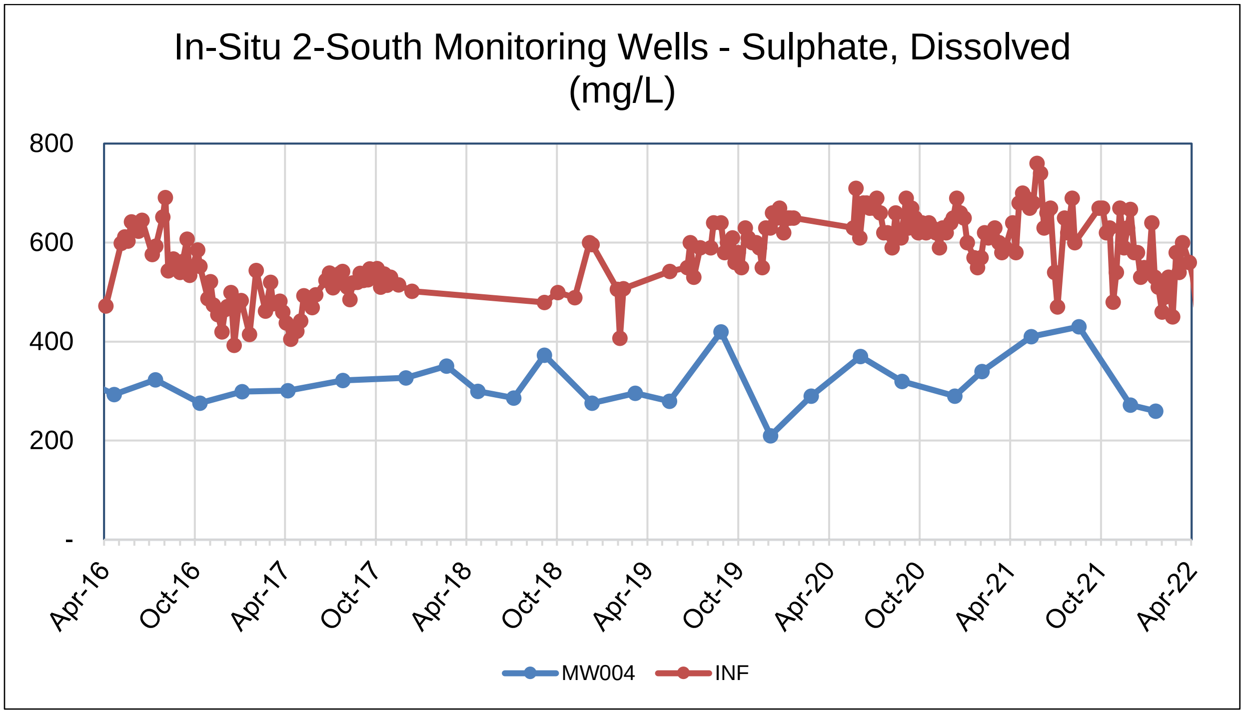


Figure 18: In-Situ 2S Monitoring Wells - Dissolved Sulphate

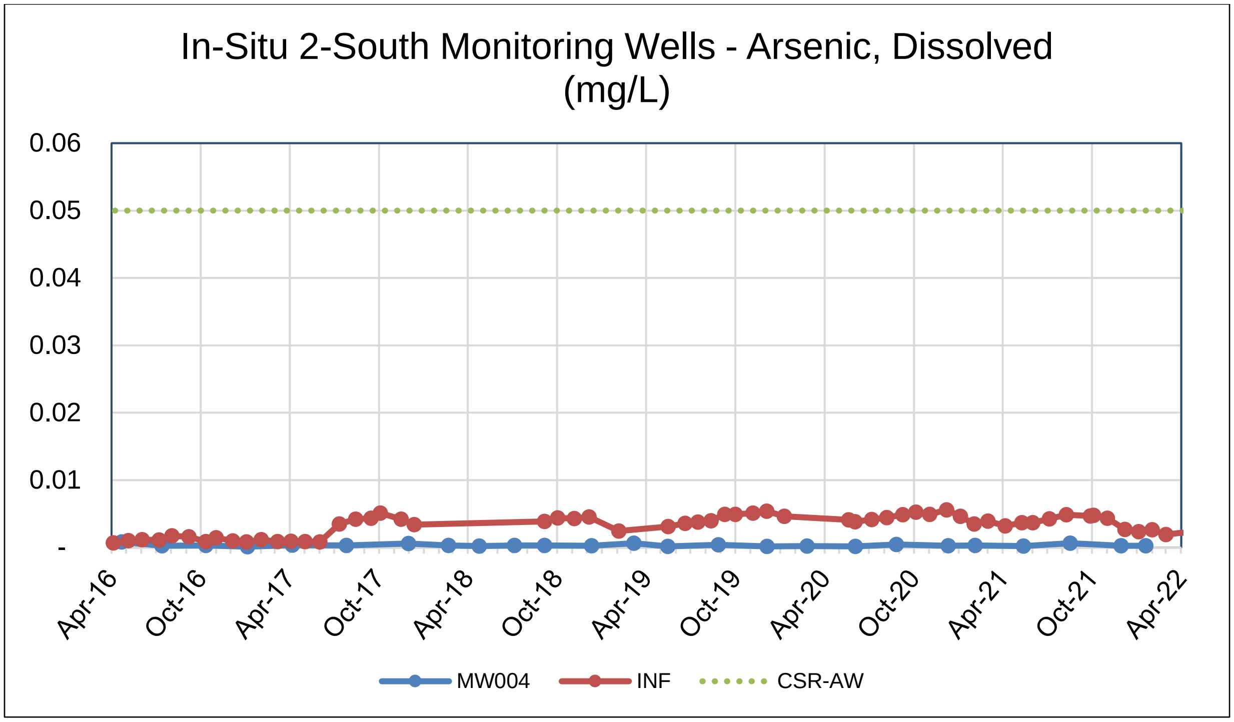


Figure 19: In-Situ 2-South Monitoring Wells - Dissolved Arsenic

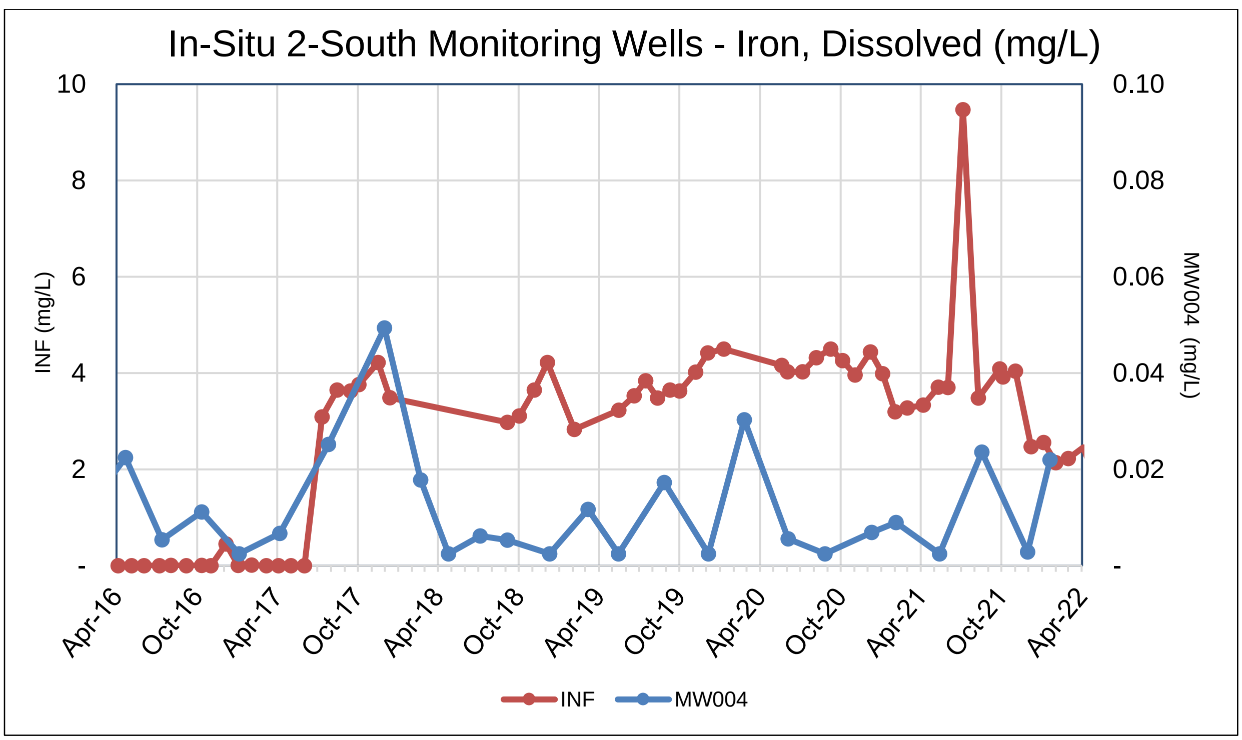


Figure 20: In-Situ 2-South Monitoring Wells - Dissolved Iron

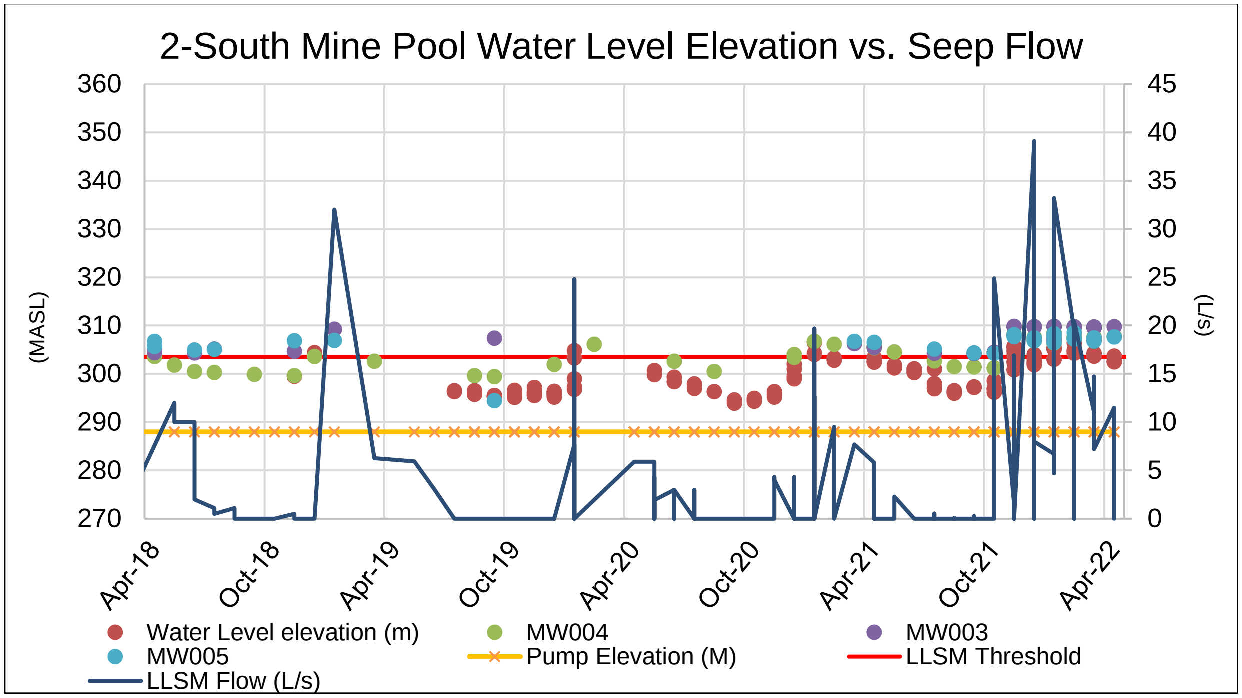


Figure 21: 2-South Mine Pool Water Elevations vs. Seep Flow

In February 2020 the underground dewatering pump at QU11-11 faulted on restart and was replaced in May 2020. The relationship between the mine pool elevation and flow at the Long lake seeps continues to be established. The threshold level for seep flow approximately 301.5 mASL for LLS and 303.5 mASL for LLSM measured at QU11-11.

4.2.5.2 2 & 3 South In-situ and Ex-Situ Wells

Monitoring wells in the 2 and 3-South areas exhibit elevated concentrations of sulphate and some metals based on their proximity to the 2-South and 3-South PAG-CCR storage facilities and past surface disturbances; both open pit and underground mining activities. These wells include MW00-2 (in-situ) located next to the 3-South flooded PAG-CCR Storage Facility as well as MW12-23 and MW12-24 (ex-situ) established as wells between the 2-South flooded PAG-CCR Storage Facility and No Name Lake. Dissolved iron, manganese and other dissolved materials are elevated at MW00-2 as it is situated about 5 metres from the 3-South PAG-CCR pond and intercepts the water that flows through the hydraulically conductive till.

While MW00-2 is located to monitor the drainage from the 3-South pit, MW12-23 and 24 are designed to intercept seepage from the reclaimed 1-South pit, the 1-South sump, and the 2-South pit. As evidence by the dissolved sulphate levels found in these wells, the shallower well MW12-24, intercepts a perched water table, potentially attributed to the reclaimed 1-South pit up gradient, but independent of 2-South groundwater, whereas the deeper well MW12-23, intercepts 2-South seepage groundwater at an elevation approximately 3 metres below the surface water elevation in No Name Lake. Lorax suggests that No Name Lake is a 'losing' lake (i.e., recharging the aquifer at its downstream end). According to initial drill logs during the installation of these monitoring wells, the siltstone bedrock appears very tight in this area with no water bearing features intercepted.

Monitoring wells MW12-23 and MW12-24 (particularly MW12-23) have slow recharging rates, making proper sampling very difficult and often, not feasible. Sampling at MW12-23 occurs over two days; day one involves purging the well and day two involves a low flow sampling technique to obtain water that has formed over a 24-hour period using a portable bladder. While quarterly sampling is required, MW12-23 is often found to be dry, (especially during the summer) and sampling is not possible. Most of the time the groundwater has been found to oxidize and remain stagnant rather than have any freshwater infiltration. These wells were not monitored due to the wells not representative of the actual groundwater.

Notable observations in for MW002 include:

- Dissolved arsenic, iron, manganese and sulphate concentrations in groundwater at MW-002 are displaying stable trends.
- Dissolved iron has a slightly upward trend.
- Conductivity was found to be very high in MW00-2 related to the 3-South PAG-CCR
- Sulphate is displaying an elevated but stable trend at the at or just above the CSR-AW of 1280 mg/L.

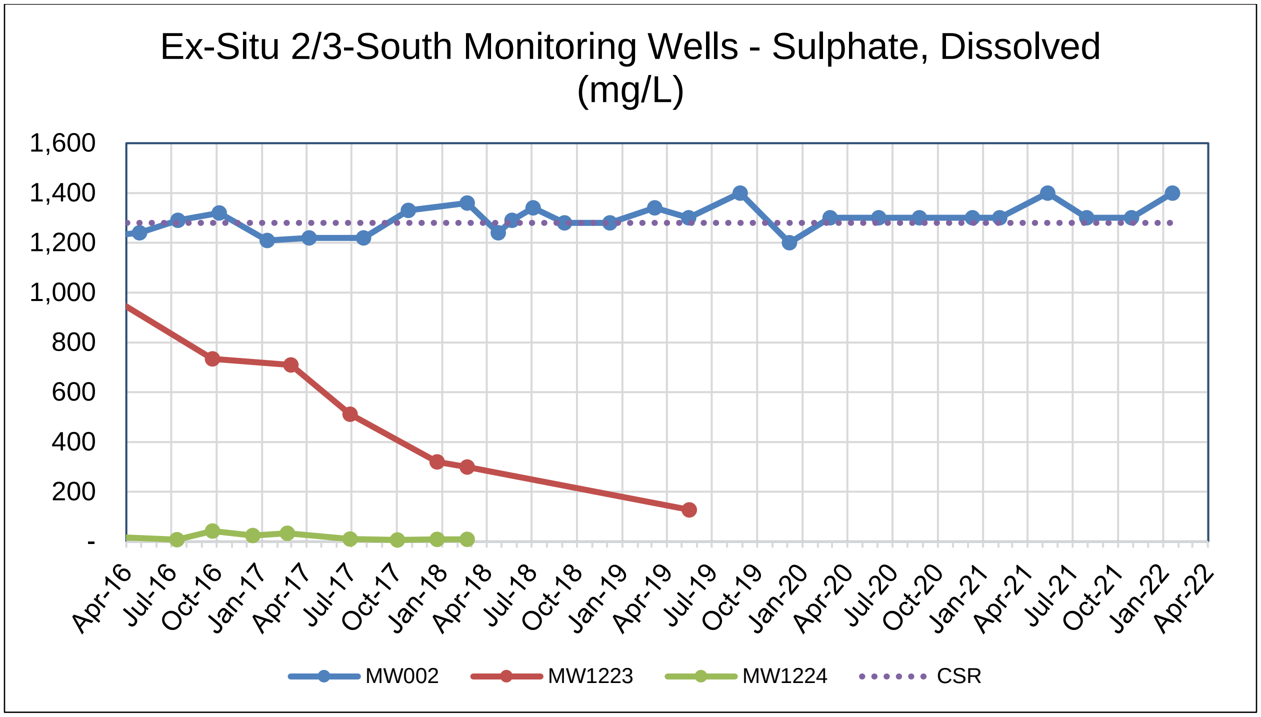


Figure 22: Ex-Situ/ In-Situ 2/3 South Monitoring Wells - Dissolved Sulphate

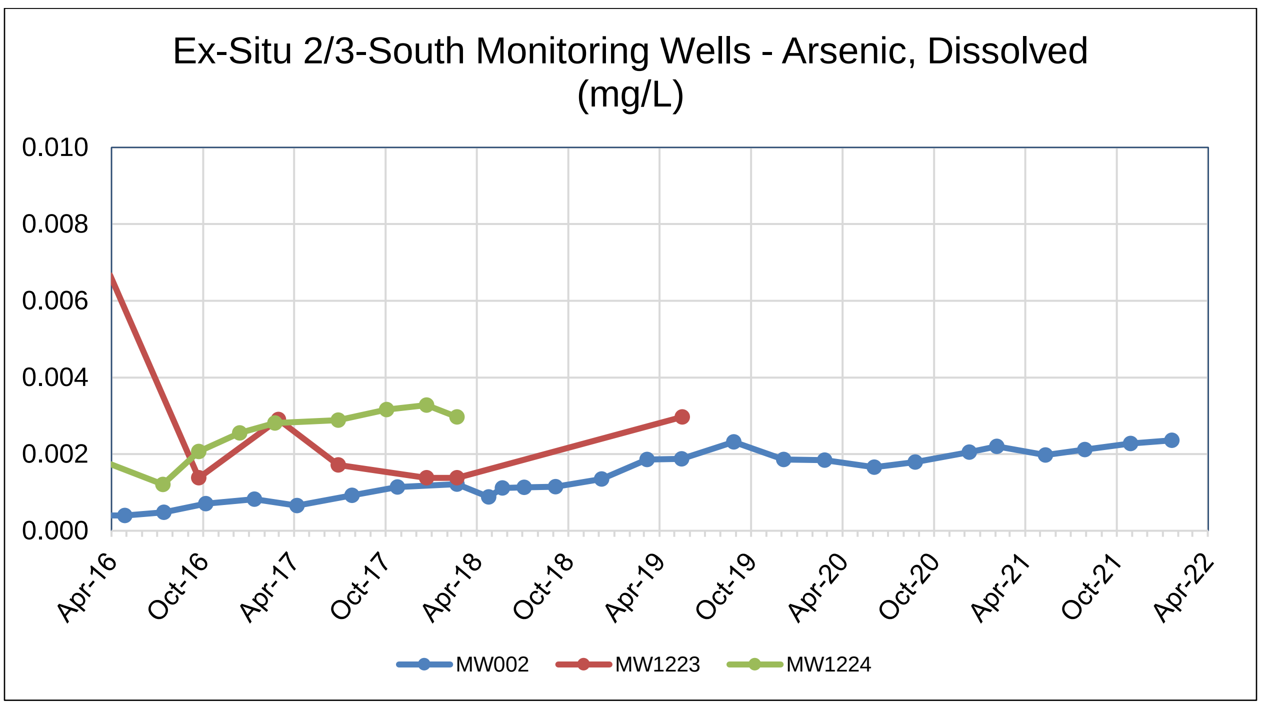


Figure 23: Ex-Situ/ In-Situ 2/3 South Monitoring Wells - Dissolved Arsenic

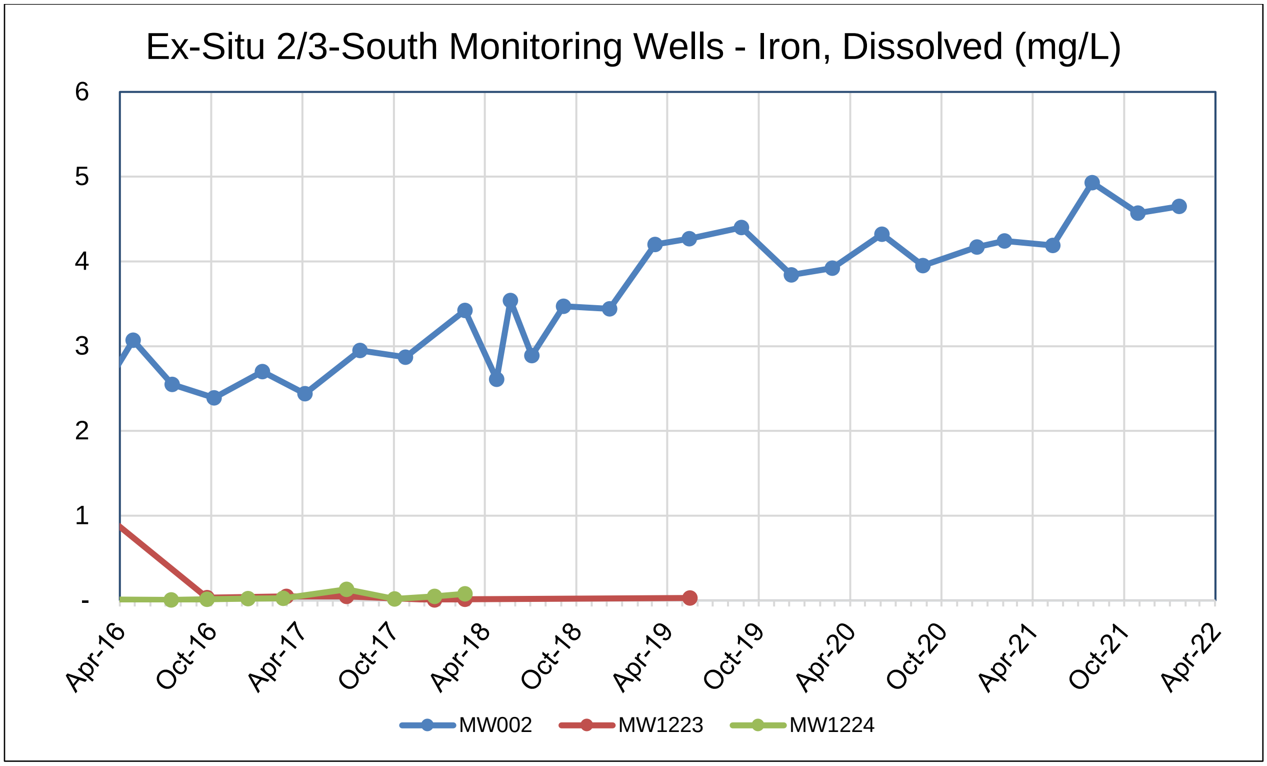


Figure 24: Ex-Situ/ In-Situ 2/3 South Monitoring Wells - Dissolved Iron

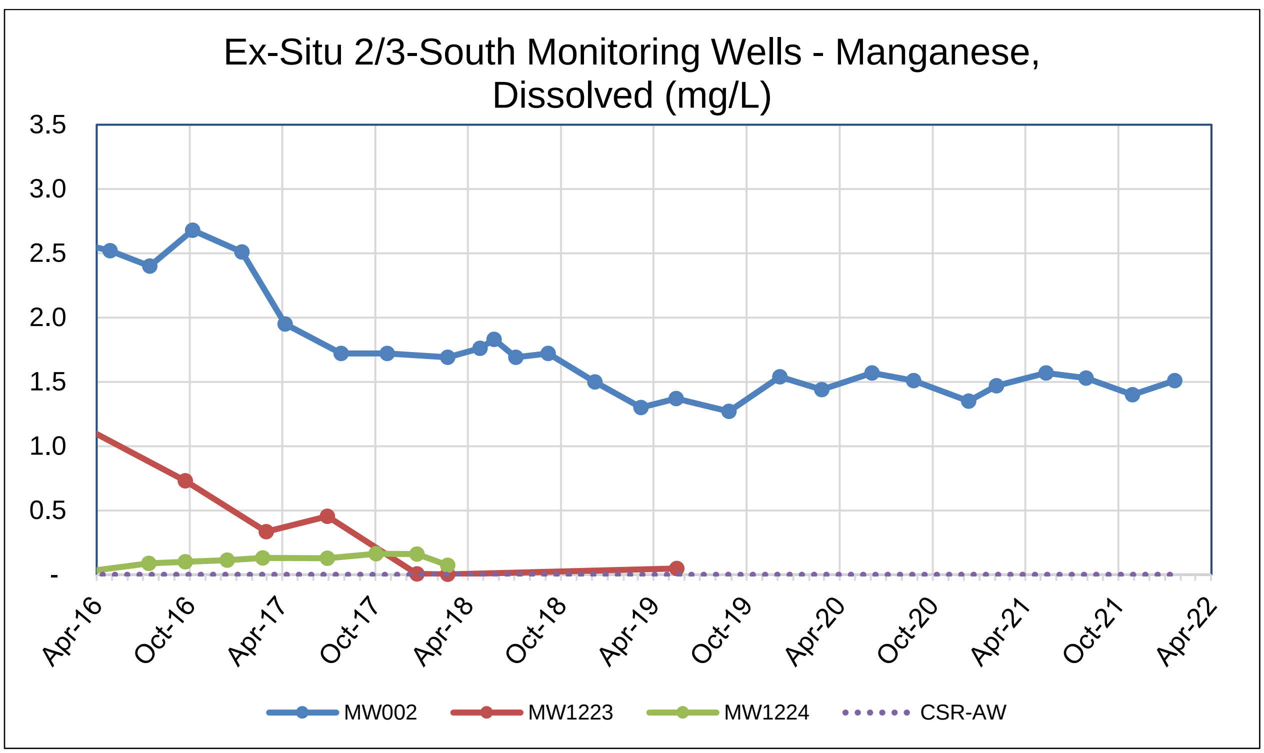


Figure 25: Ex-Situ/ In-Situ 2/3 South Monitoring Wells - Dissolved Manganese

4.2.6 4-South Mine Area

4.2.6.1 4-South Mine Pool

Predicted mature mine pool source terms were developed for the flooded 4-South mine and are quantified using maximum concentrations measured in QU78-161 and QU11-01. The 4-South mine pool chemistry indicates that the mine water has evolved into a mature state and can be used to estimate long term water chemistry. The mine water is expected to be anoxic and contain elevated sulphate, reduced iron and traces of dissolved sulphide, although eventually the mine waters are predicted to display higher pH, alkalinity and lower metal concentrations as iron and other metals are sequestered into sulphide minerals. The monitoring well 78-161 was eliminated from the monitoring program due to difficult access and chemical similarities to QU11-01. POI concentrations seen this monitoring period are lower compared to previous monitoring years and continue to demonstrate a decline in iron, manganese and sulphate.

Table 10 below displays the comparison between predicted to observed water quality during this monitoring period. Results from 1 sampling set were used for QU11-01 from the only sampling event completed in 2020-21. The only parameters that were above the predicted concentration levels were arsenic and boron.

Table 10: Source Terms Comparison of Flooded 4-South Mine Void Mature Mine Pool

Parameters	Predicted Max. Values	2021-22 QU11 -01 (N=2)	Results obtained
Alkalinity (as $CaCO_3$)	450	70	Below Predicted
Aluminum (Al)	0.024	0.011	Below Predicted
Arsenic (As)	0.0924	0.132	**Above Predicted**
Boron (B)	0.637	1.115	**Above Predicted**
Cadmium (Cd)	0.000085	0.000035	Below Predicted
Cobalt (Co)	0.063	0.0007	Below Predicted
Copper (Cu)	0.0564	0.0007	Below Predicted
Fluoride (F)	1	0.487	Below Predicted
Iron (Fe)	257	152	Below Predicted
Manganese (Mn)	5.97	2.38	Below Predicted
Selenium (Se)	0.0004	0.00035	Below Predicted
Sulphate (SO_4)	2060	478.5	Below Predicted
Zinc (Zn)	0.0712	0.0175	Below Predicted

All units in mg/L

According to Lorax, chemical stratification is apparent in this mine pool as the heavily mineralized water remains on the bottom of the water column and the less mineralized water remains in the upper portion due to limited mixing of the water column. Lorax described the groundwater in this area as having an age affected signature of fluoride and arsenic, directly related to the increased residence time in the groundwater system.

The mine void is "flooded" and water levels in the mine pool show little change as there are no dewatering efforts or active operations in this mine. The water level measuring device (*pressure transducer*) installed at QU11-01 failed in May 2018 and was reinstalled in September 2019 until April 2020 as noted in Figure 26. Currently there is no pressure transduce in this mine pool. Further investigation is warranted to re-establish and confirm the mine pool elevation.

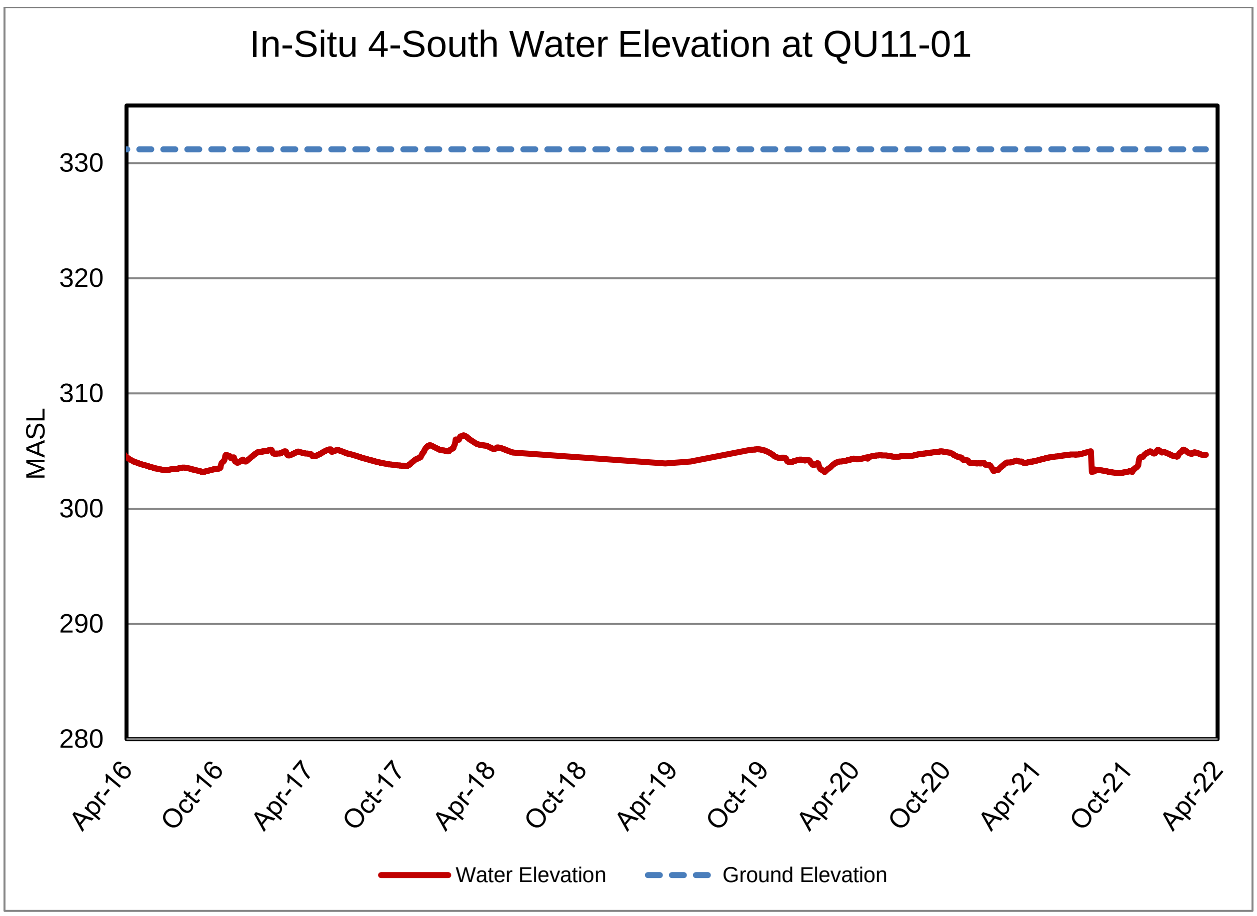


Figure 26: 4-South Mine Pool Water Elevation at QU11-01

POI are generally elevated with slight decrease observed with the redox reactive parameters between 2018 to present due to the maturity and flooded status of the mine. Dissolved selenium has fluctuating results since 2017 with results below detection limits of 0.0005 mg/L in 2021-2022. This detection limit is lower than the flooded mine pool source terms.

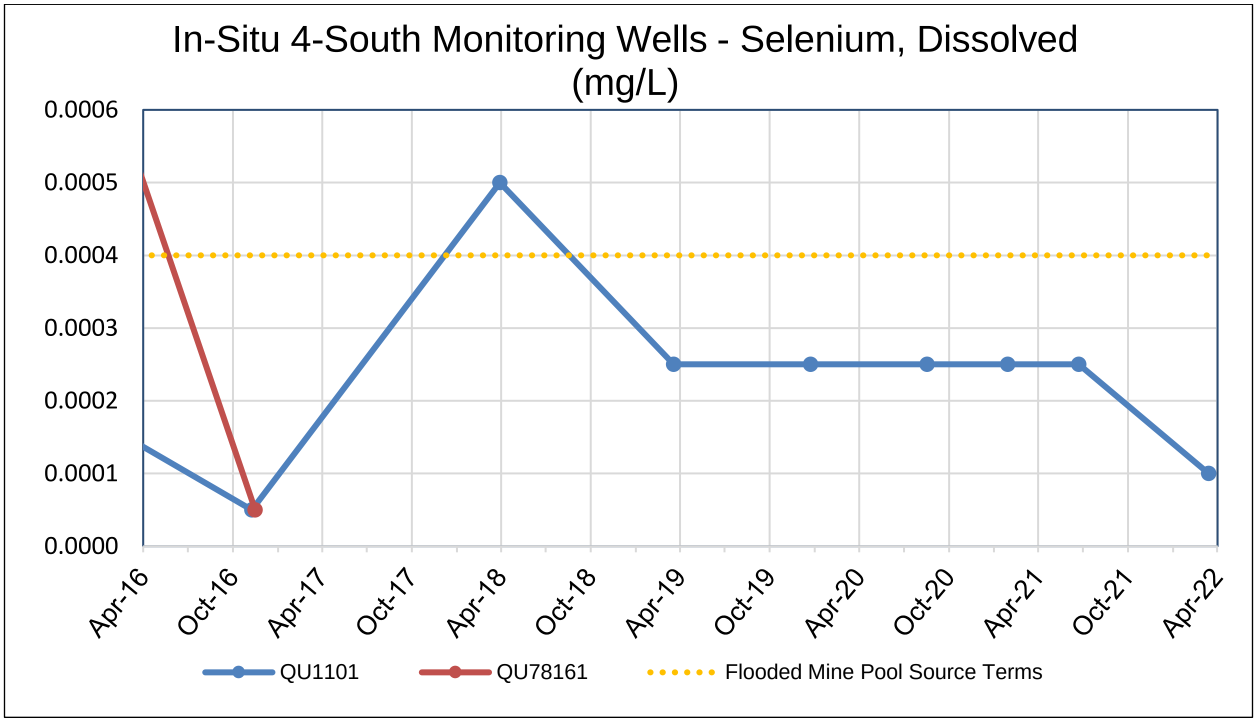


Figure 27: In-Situ 4-South Monitoring Wells - Dissolved Selenium

The mine pool has remained flooded at a steady elevation limiting exposure and oxidation of mine walls from fluctuating mine pools. Most redox reactive POI concentrations have trended downward and are stabilizing (iron, manganese and sulphate and arsenic). Arsenic displayed a steady increase with a spike observed in April 2018, and a steep decline stabilizing just above predicted mine pool source terms in 2021 and in March 2022 a slight increase was observed again (0.156mg/L) (Figures 28-31). Parameters seem to have high but stable trends with some seasonal peaks.

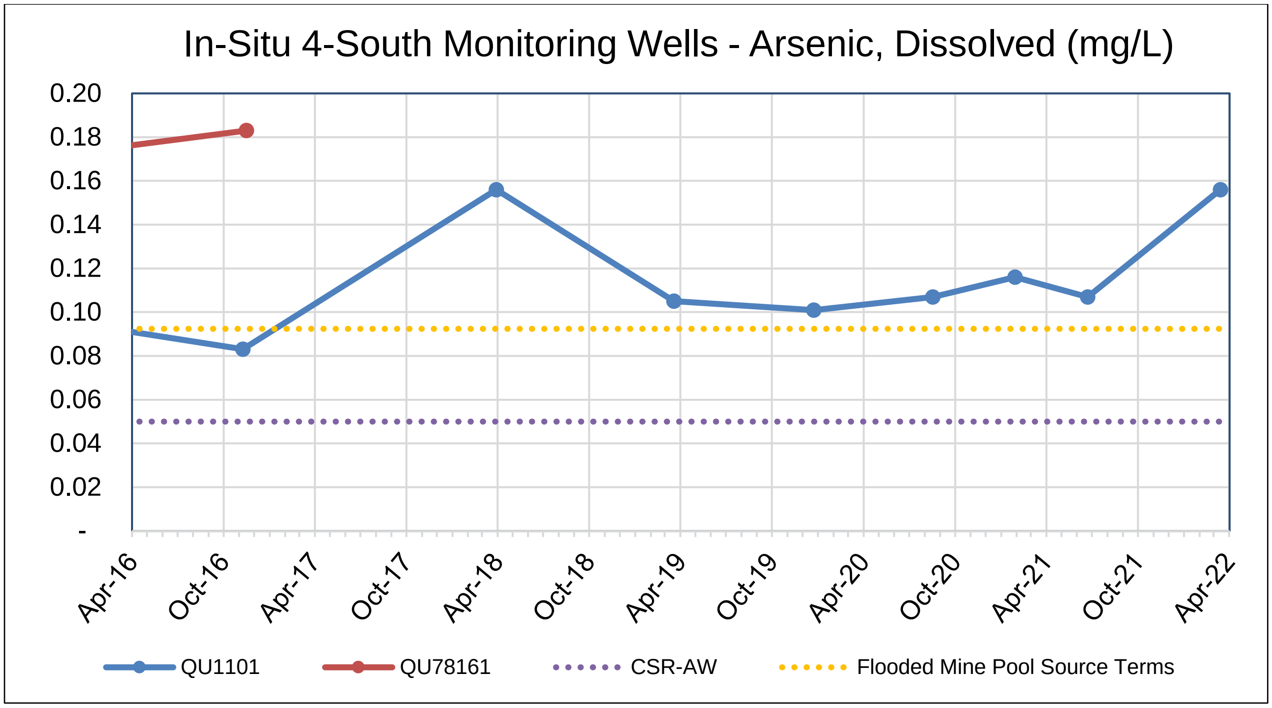


Figure 28: In-Situ 4-South Monitoring Wells - Dissolved Arsenic

The 4-South mine pool is dominated by iron reducing conditions with elevated concentrations of iron and sulphate. The chemical stratification is characterized by the high concentrations of iron and sulphate found at depth in the mine pool. The mine pool water quality has the highest concentration of dissolved iron on the mine site, having exhibited concentrations greater than 200 mg/L at QU11-01 this year concentrations were in the range of 150 mg/L to 153 mg/L.

Lorax observed that sulphate has an opposite trend to fluoride; sulphate is found in lowest concentrations in the formation water and highest in the mine pool. Sulphate concentrations are elevated and follow a similar profile to dissolved iron where concentrations have been generally decreasing since 2013 to below the predicted values of the flooded mine pool. Fluoride is developing an increasing tend in QU11-11 indicting the mine pool in being influenced by younger formation waters.

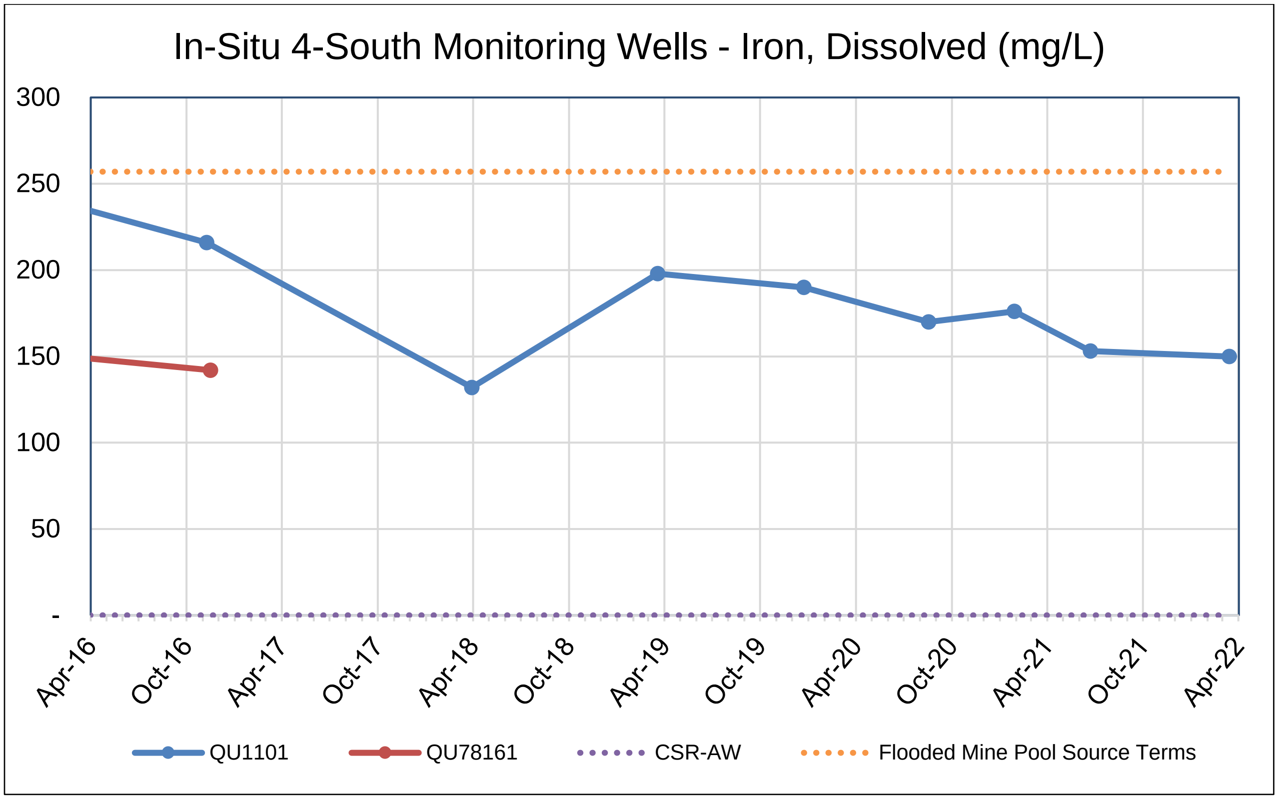


Figure 29: In-Situ 4-South Monitoring Wells - Dissolved Iron

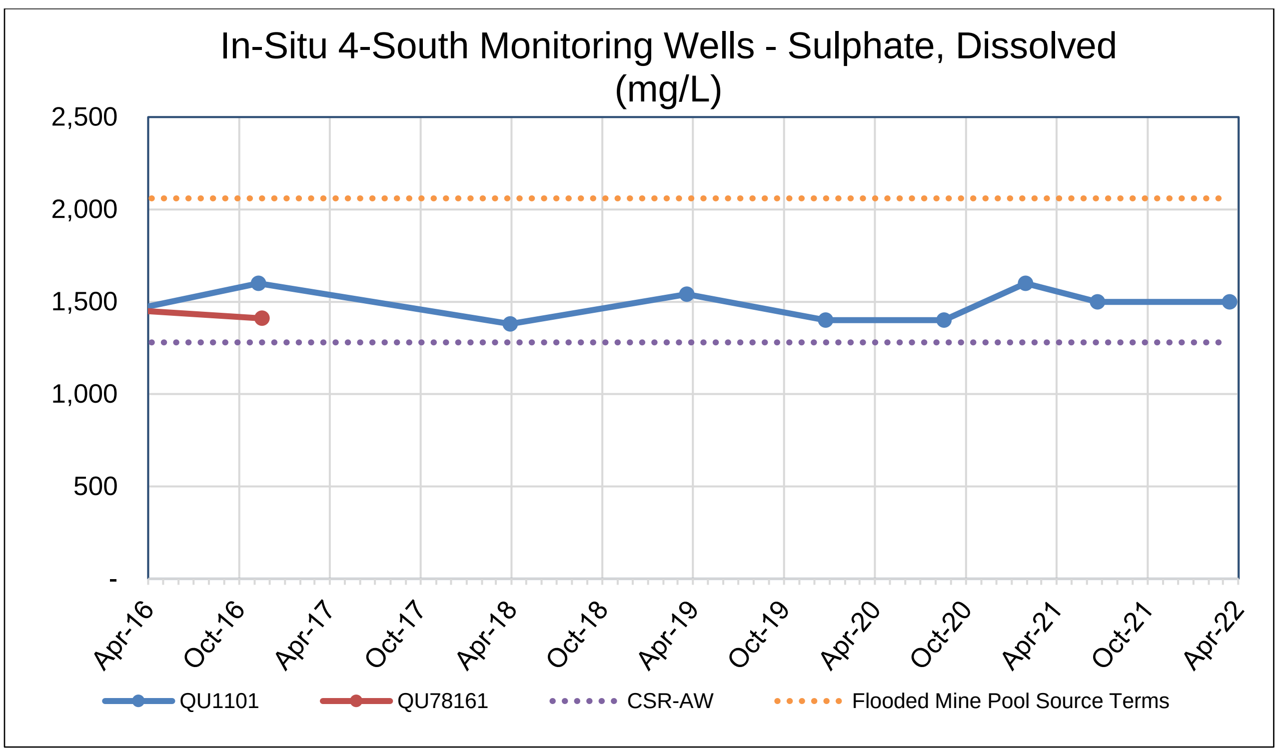


Figure 30: In-Situ 4-South Monitoring Wells - Dissolved Sulphate

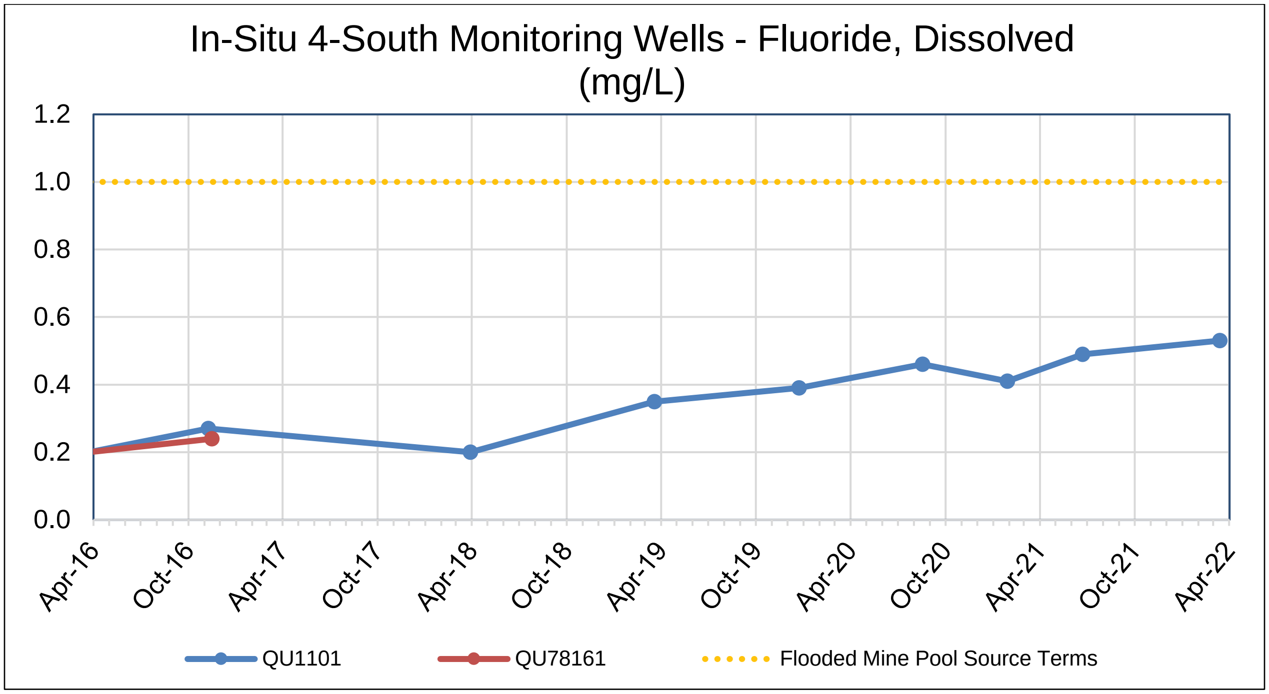


Figure 31: In-Situ 4-South Monitoring Wells - Dissolved Fluoride

4.2.6.2 4-South Ex-Situ Wells

Observations made of formation water down-gradient of the 4-South mine indicate mine and age-affected groundwater signatures suggesting a hydraulic connection between the 4-South mine pool and the down gradient monitoring wells. The hydraulic connection is most obvious at QU10-09 S, and less obvious at QU10-07 D and QU10-08 D. The strong mine signature in QU10-09 indicates that it is along the flow path of the juvenile mine waters discharging from the upper portion of the 4-South mine workings (Lorax, 2011).

Monitoring wells in this area are focused on four types of water quality:

- QU10-09 (S & D) ex-situ formation waters, outside of existing workings, assess vertical gradients and water quality adjacent to Long Lake
- QU10-07 D ex-situ formation waters; down gradient of existing workings next to the Long Lake Entrance wetland (LLE)

- QU10-08 D ex-situ up gradient of the existing workings; assess water quality immediately up gradient of existing workings

Generally, major ion concentrations are highest in the mine pool waters and lowest in the formation groundwater. POI concentrations in and outside the 4-South mine pool are relatively stable, showing some minor trending.

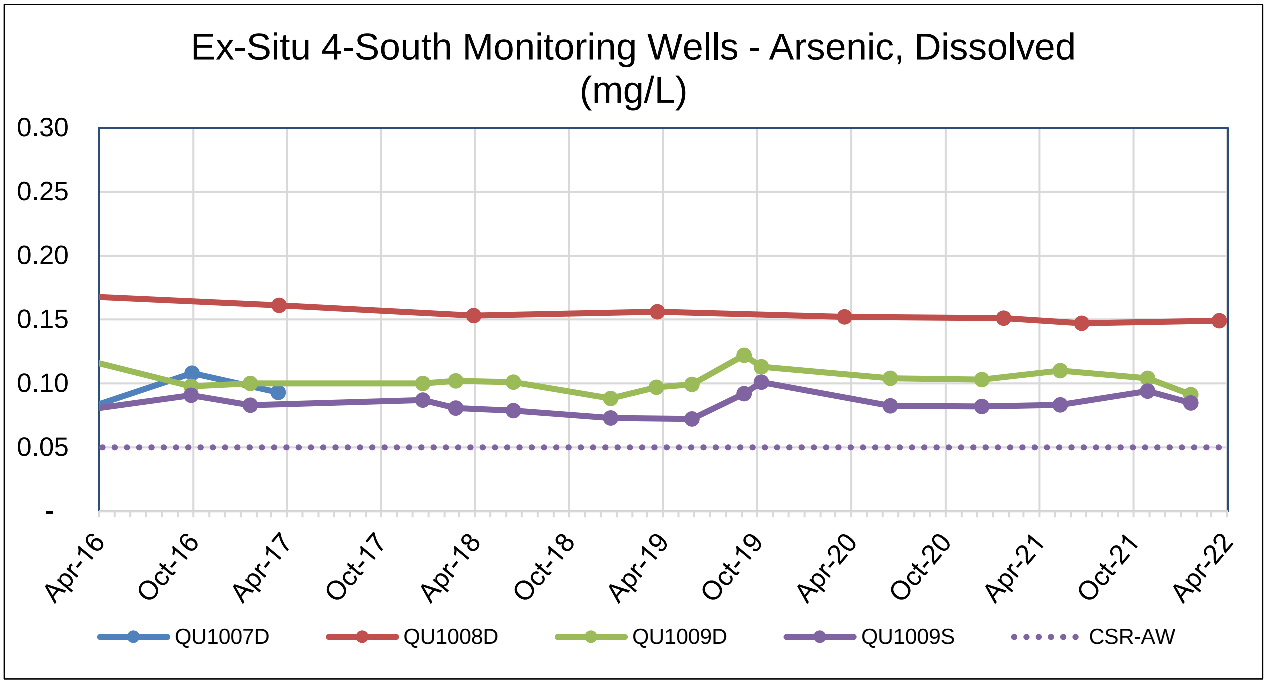


Figure 32: Ex-Situ 4-South Monitoring Wells - Dissolved Arsenic

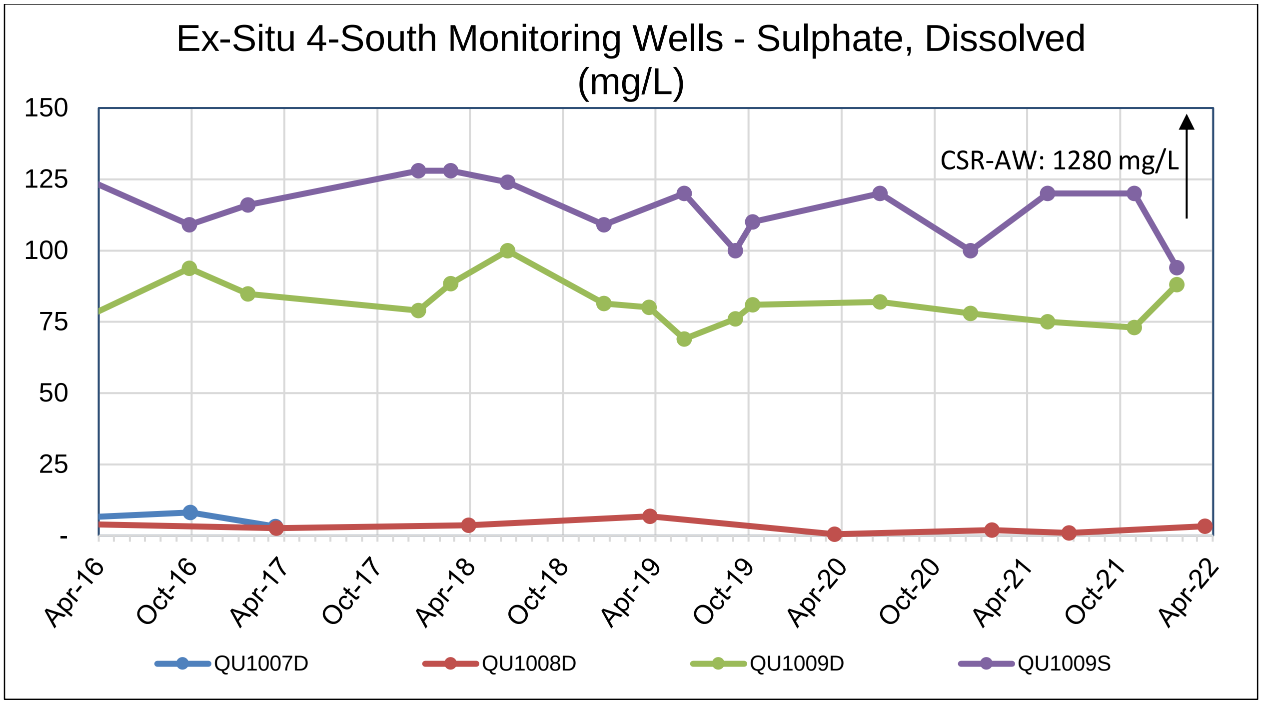


Figure 33: Ex-Situ 4S Monitoring Wells - Dissolved Sulphate

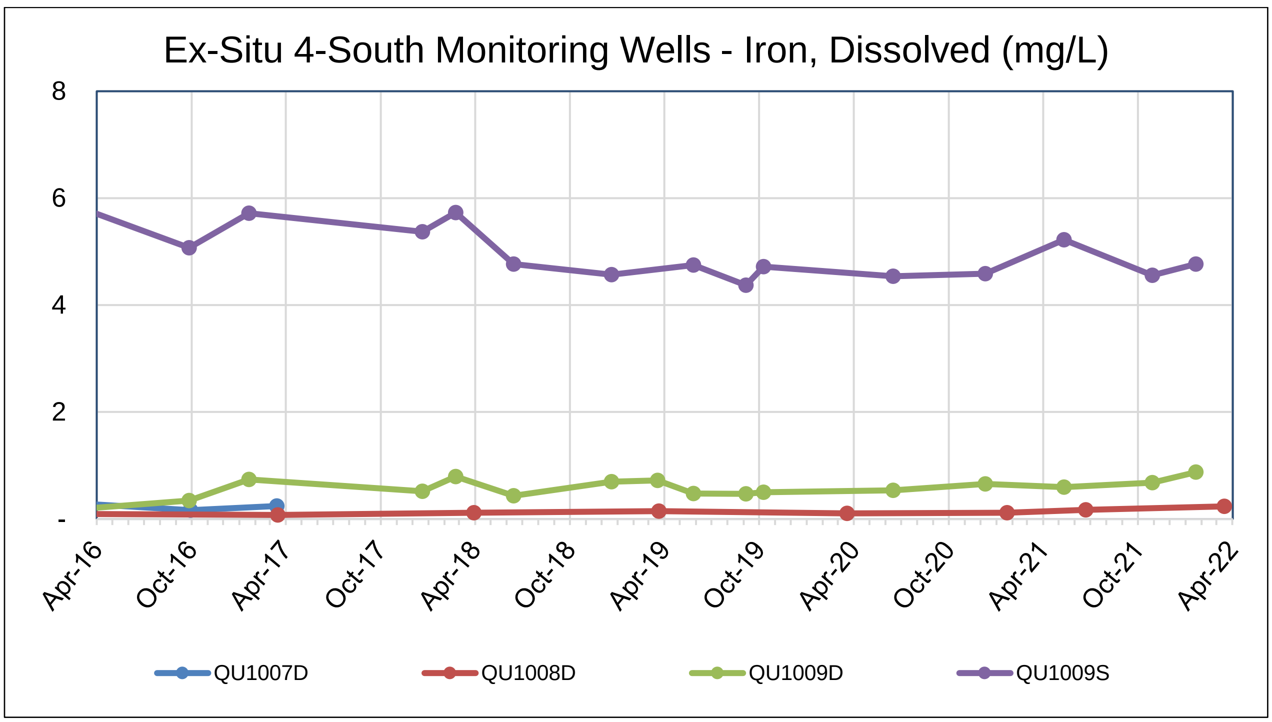


Figure 34: Ex-situ 4S Monitoring Wells - Iron dissolved

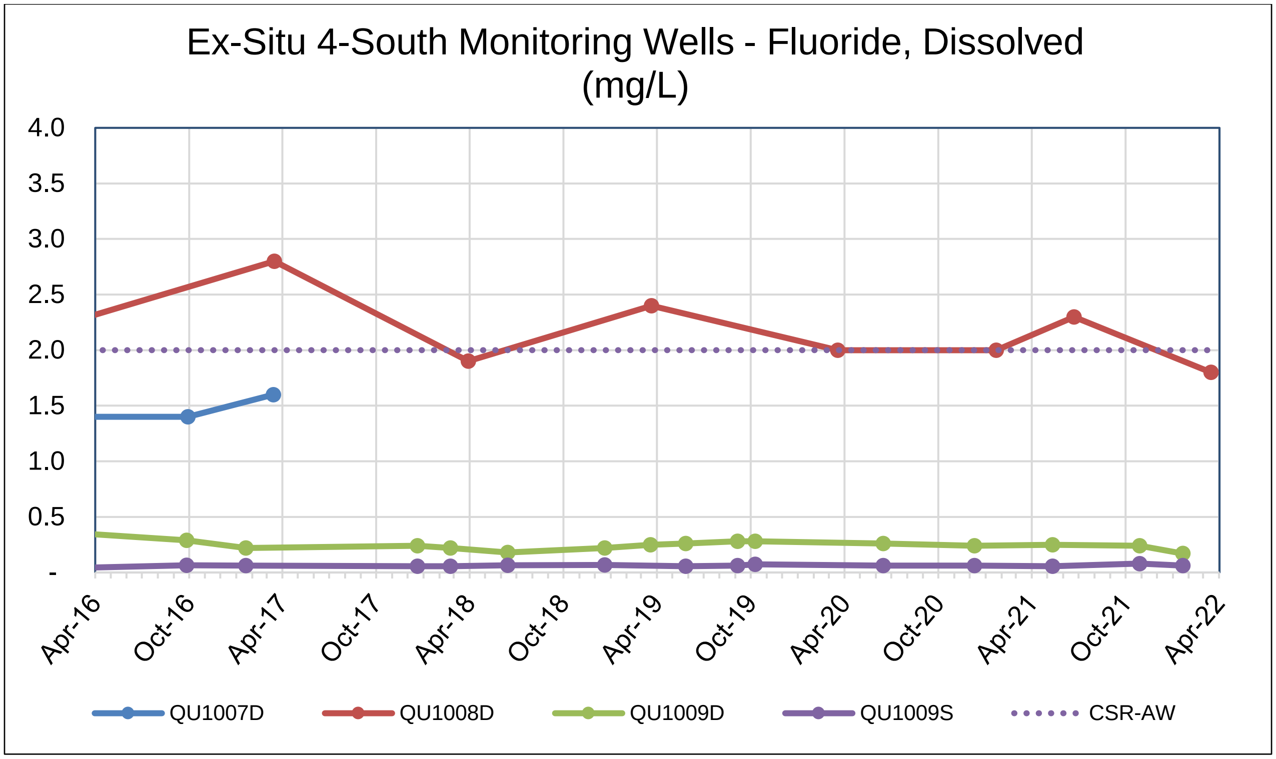


Figure 35: Ex-situ 4S Monitoring Wells – Fluoride dissolved

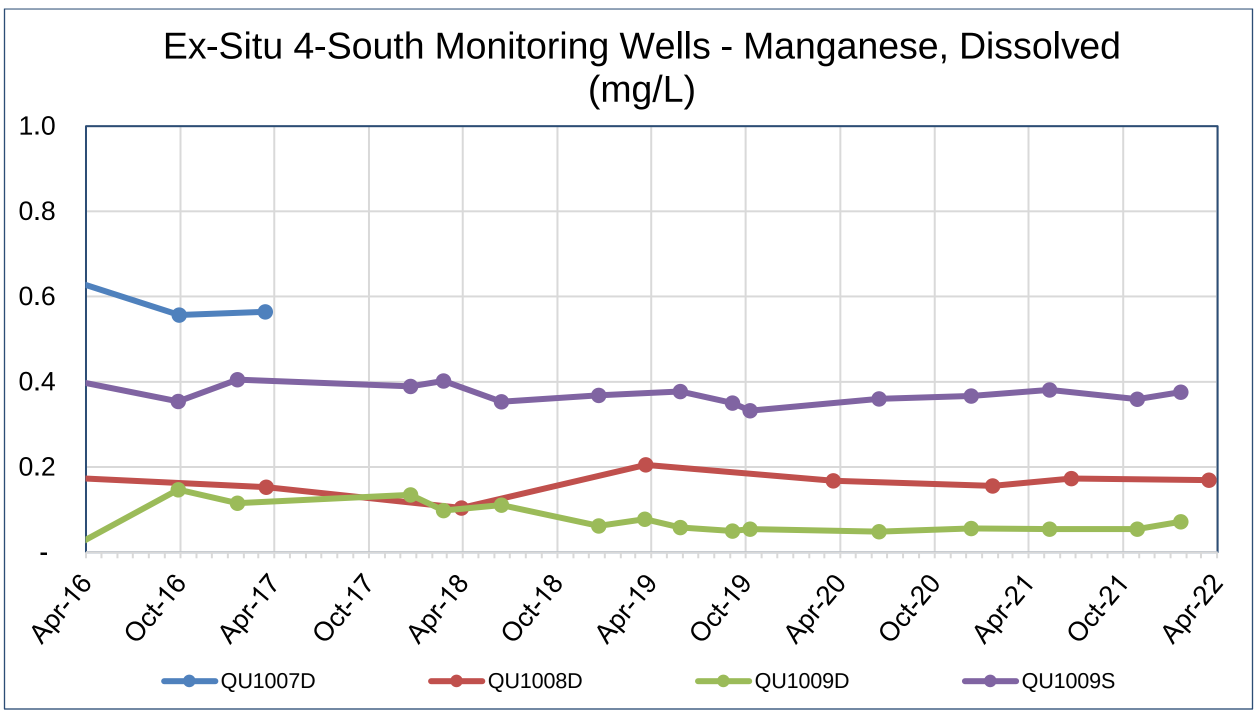


Figure 36: Ex-situ 4S Monitoring Wells –Manganese dissolved

Notable observations include:

- Dissolved arsenic concentrations were elevated above CSR-AW standards (0.05mg/L) at each well for all sampling events, reflecting historic results
- Dissolved sulphate levels were generally low (as observed in the past), highest in QU10-09 S & D and lowest at QU10-08 D
- Dissolved iron was below 1.0 mg/L in all wells except in QU10-09 S, where results were ranged from 4.56 mg/L to 5.22 mg/L
- Fluoride was above the CSR-AW standards in well QU10-08 D during one sampling event in June resulting in 2.3 mg/L. Fluoride is an indication of younger groundwater influencing the water in this well.
- Manganese is highest in wells QU10-09 S and QU10-08 D

4.2.7 242 Mine

The 242 Portal site was reclaimed in Spring, 2016 with backfilling of the portal, permanent slope creation, topsoil cover and subsequent revegetation. A new sampling site (242MW) was created in 2017 with the drilling and installation of an additional groundwater well.

The pH of the flooded waters of the 242 mine averaged 5.75 and low conductivity averaging 258. The water exhibits low concentrations of alkalinity, sulphate and metals, consistent with past monitoring events since 2014. Water quality is expected to contain low levels of sulphate and metals due to the limited impact from mining in this area that occurred prior to 1996. After mining was completed the mine flooded immediately, with no additional disturbances.

Dissolved arsenic has an inconsistent pattern related to seasonal highs and lows, although mostly elevated in fall and winter. Both arsenic and iron are trending upwards since monitoring began. Dissolved fluoride remains in low concentrations indicating limited influence of younger formation water.

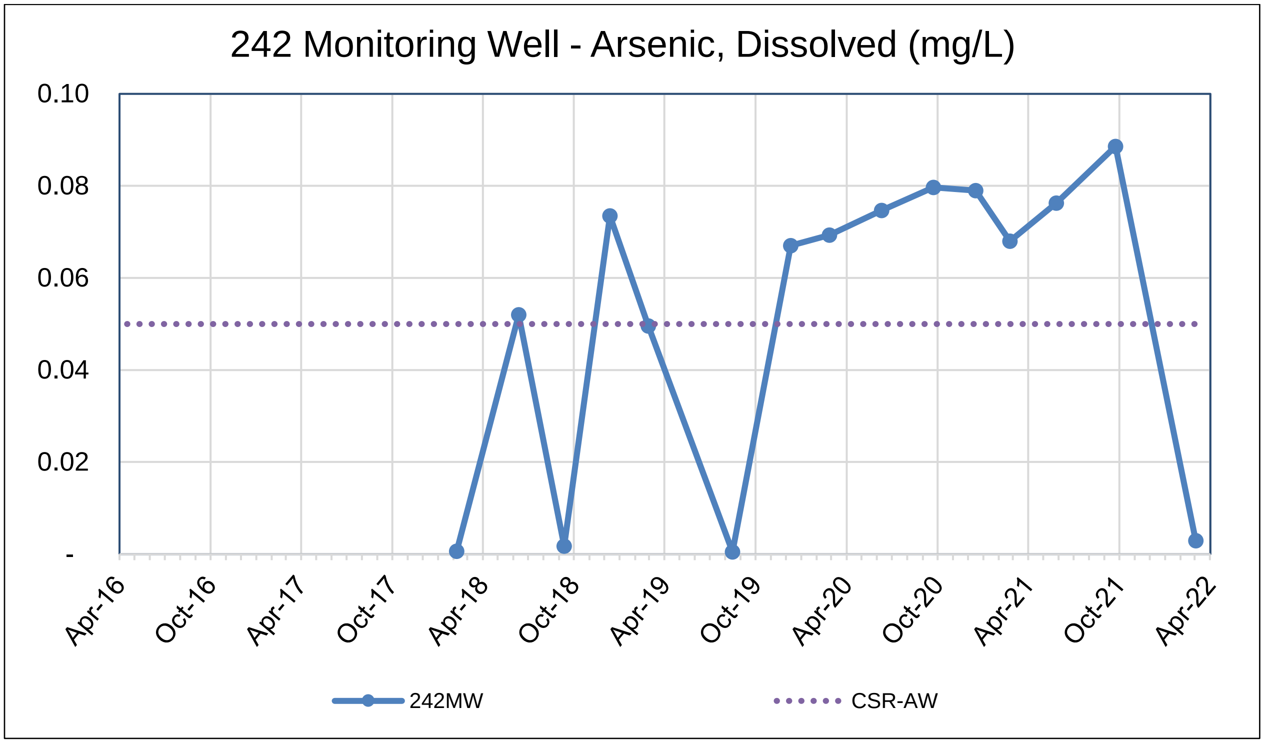


Figure 37: In-situ 242 Mine Pool – Arsenic, dissolved

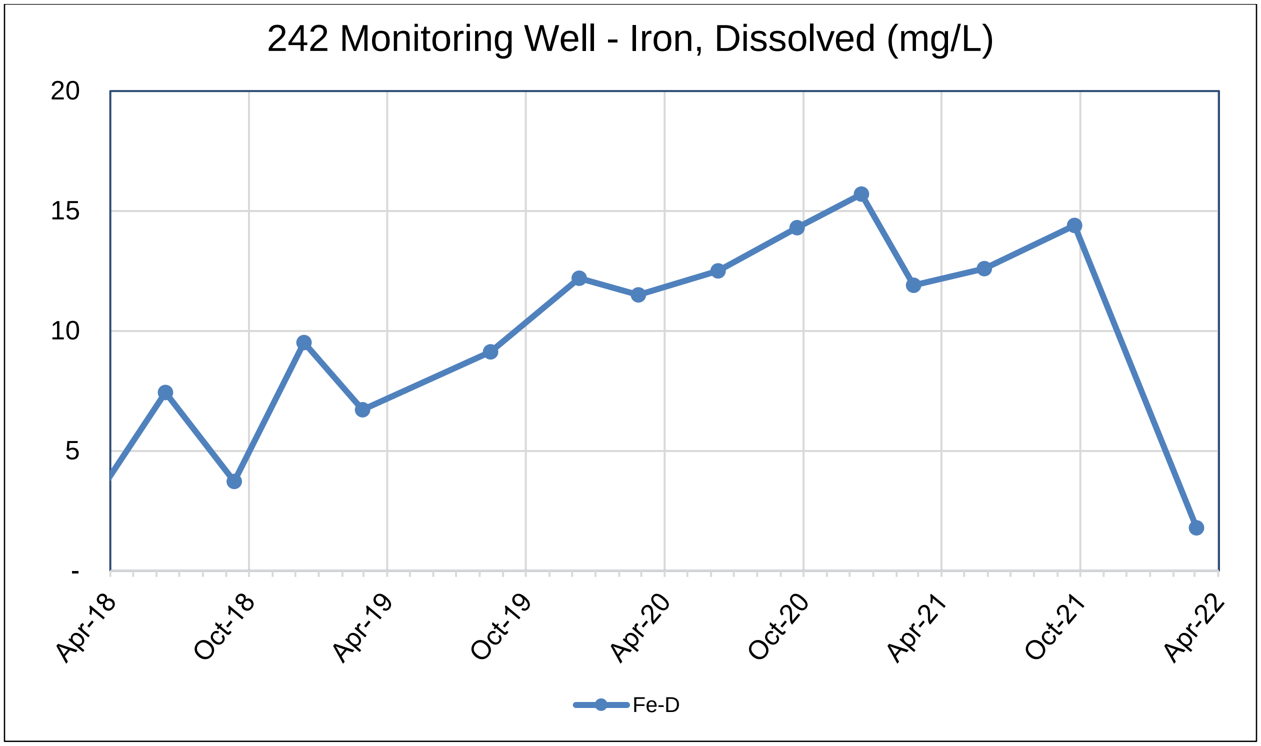


Figure 38: In-situ 242 Mine Pool – Iron, dissolved

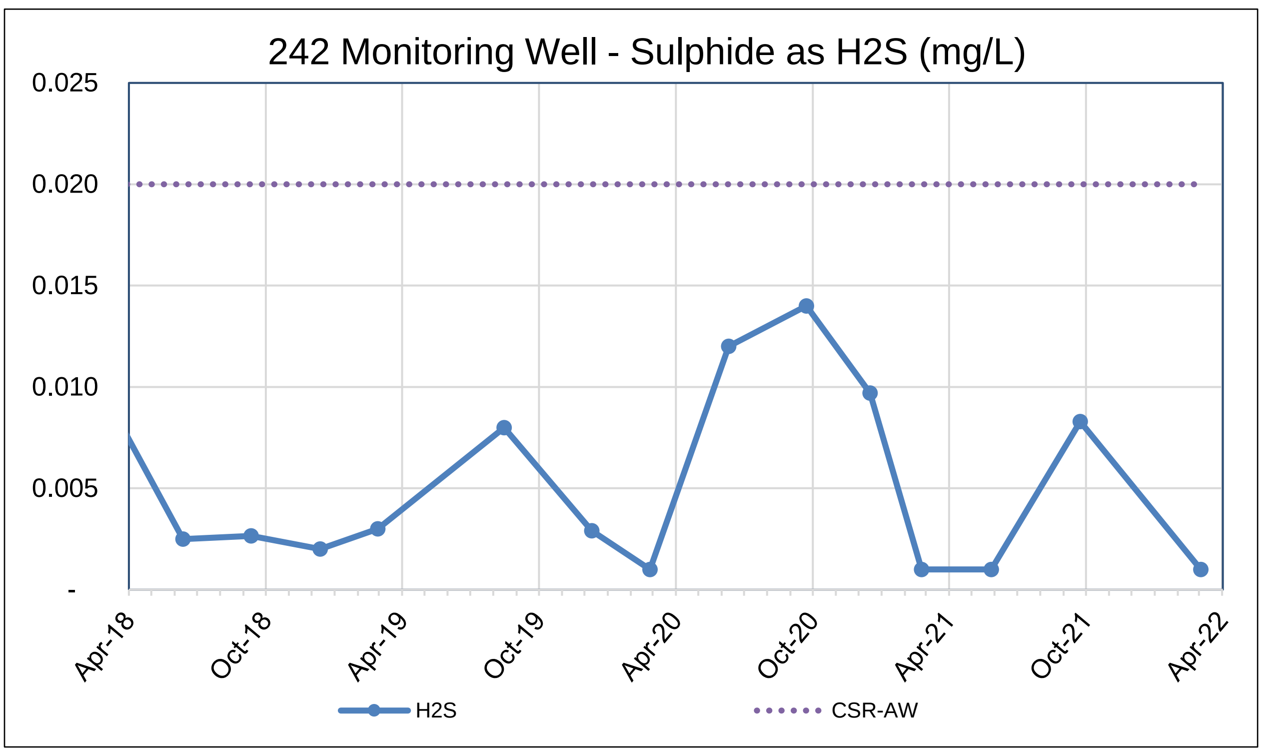


Figure 39: In-situ 242 Mine Pool – Sulphide as H_2S

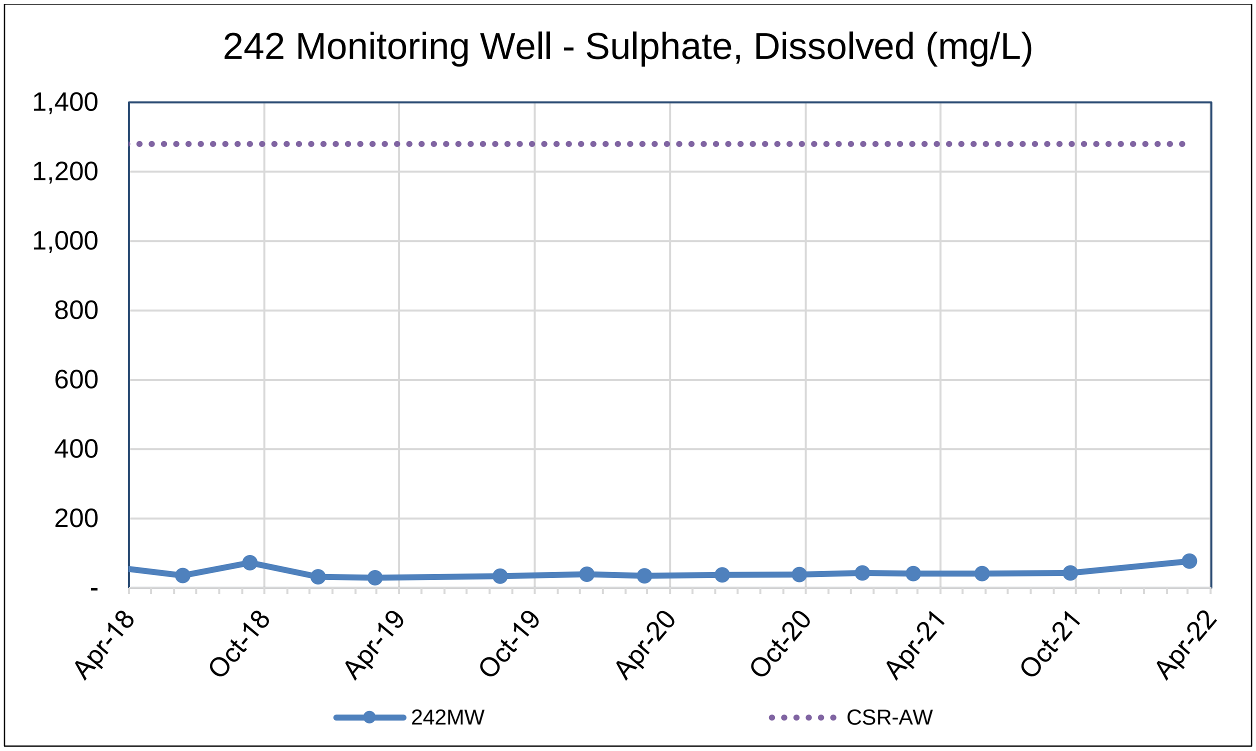


Figure 40: In-situ 242 Mine Pool – Sulphate, dissolved

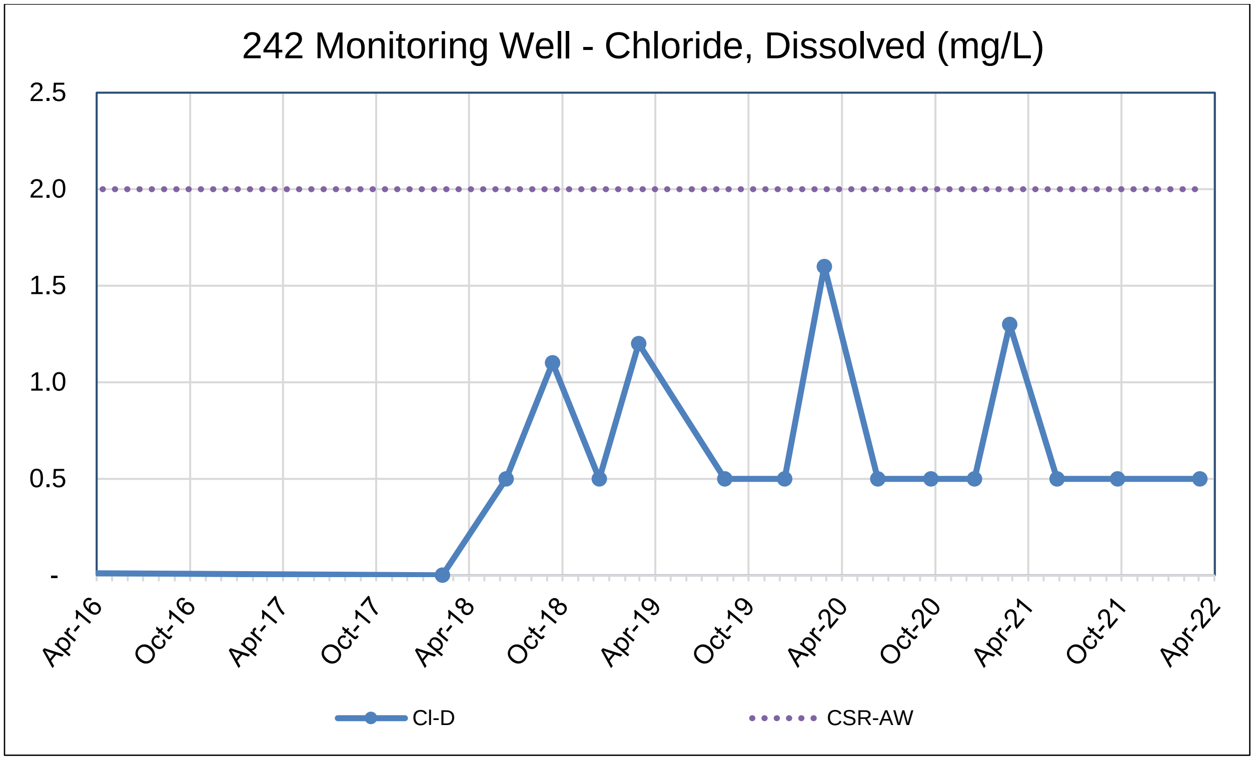


Figure 41: In-situ 242 Mine Pool –Chloride, dissolved

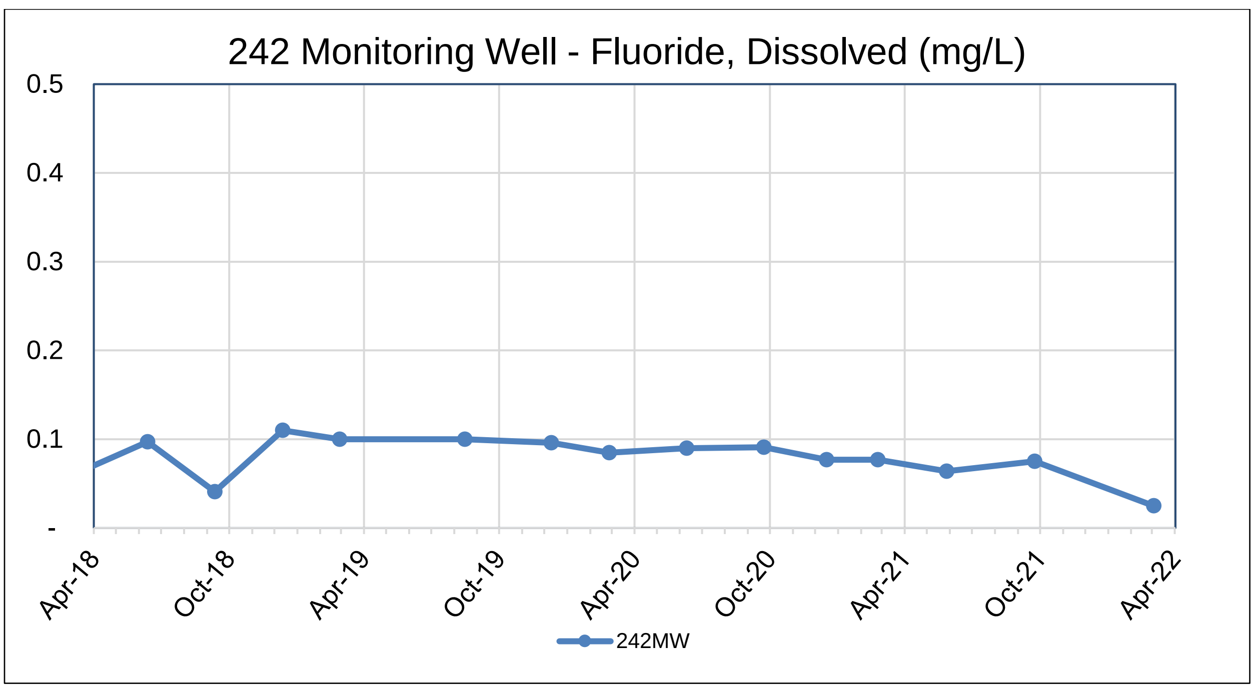


Figure 42: In-situ 242 Mine Pool –Fluoride, dissolved

4.2.8 7-South Area 5 Background

In July 2018 blasting through the Long Lake Fault Zone commenced in order to gain access to 7-South Area 5 No. 4 seam coal. Mining did not occur until late January to early February 2019. A full set of groundwater wells were monitored. Those include QU11-36 S/D, QU12-06 S, QU11-18 S/D and QU11-28. The groundwater in this area is characterized as being elevated in arsenic with some wells exhibiting elevated concentrations of sulfide as H_2S. Figures 43 and 45 display these results since monitoring began in 2013. Currently the groundwater in this area is non-mine impacted and all monitoring results contribute to baseline conditions. This year only QU11-36 D was monitored. Arsenic is elevated above the CSR-Aw (0.05 mg/L) in groundwater of QU11-36D. All other paraments remain in low concentrations.

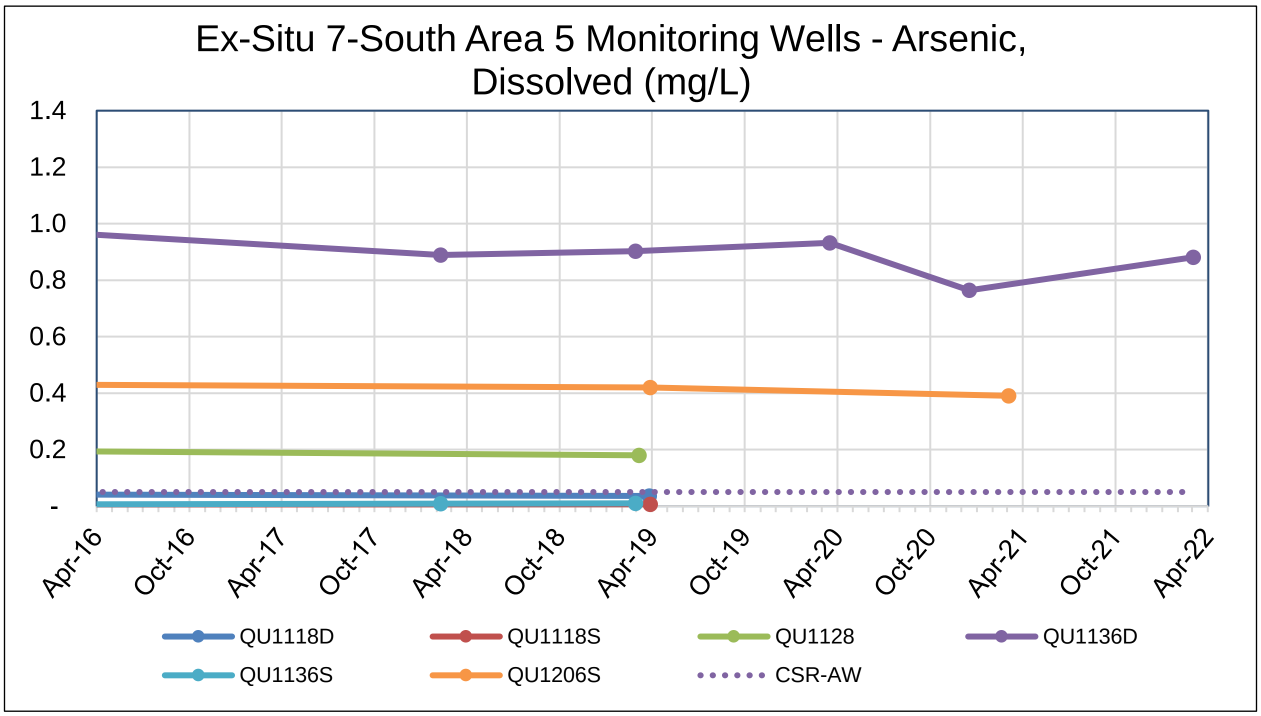


Figure 43: Dissolved Arsenic in 7SA5

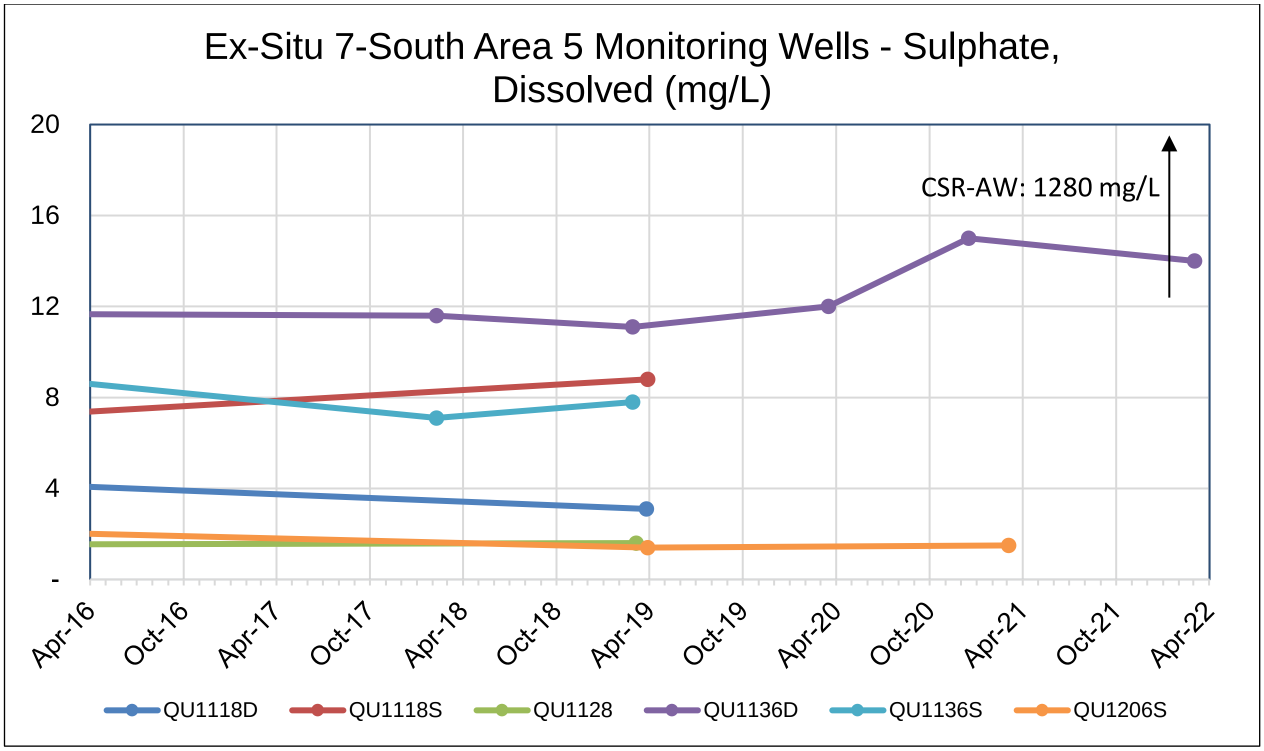


Figure 44: Dissolved Sulphate in 7SA5

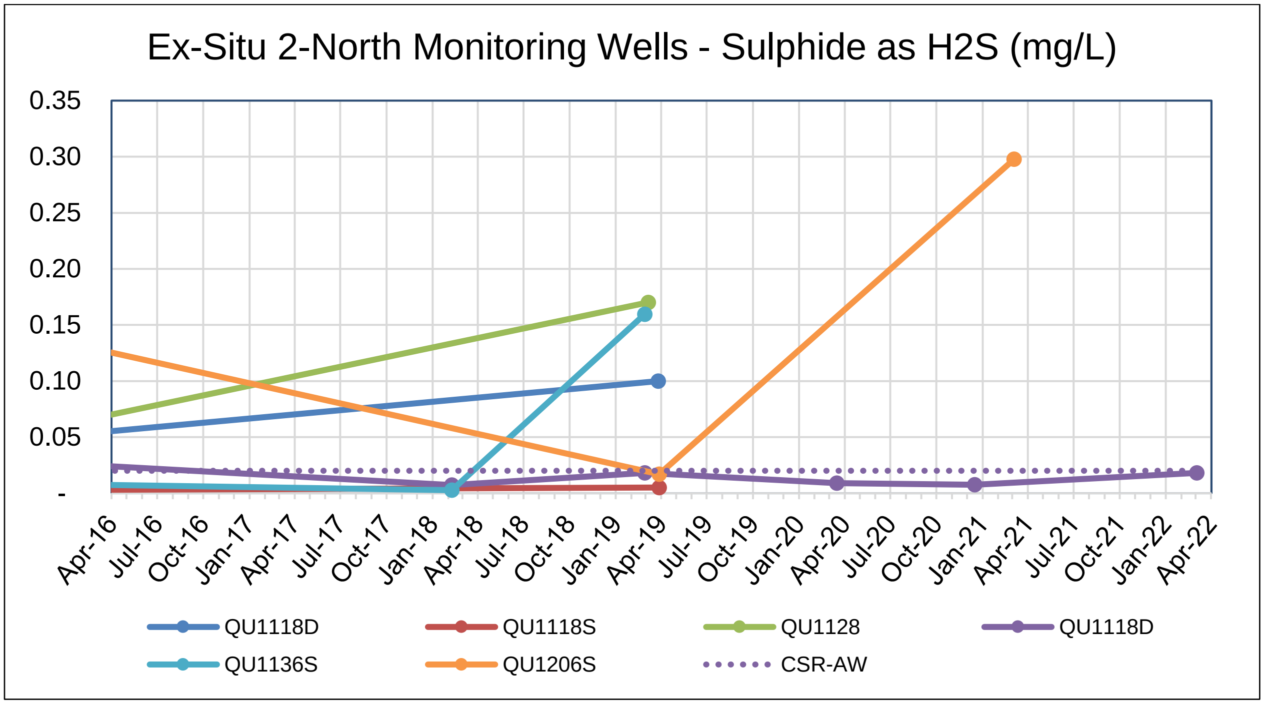


Figure 45: Sulphide as H_2S in 7SA5

5 Summary

The groundwater monitoring program at Quinsam Coal has been established to capture the interaction between mine related surface and underground disturbance areas (contact water) with the receiving environment. The comprehensive nature of this program allows Quinsam to generate water quality predictions, strategically manage surplus water generated as a result of mining activities and create management plans with a focus on mitigating potential receiving environment impacts.

During the mine operations phase, the groundwater program provides critical information to ensure that plans and targets are being achieved. For example, in-situ wells provide the necessary information to validate water quality predictions (source terms) within a mining area. The program also provides opportunity to monitor water quality associated with three key operational waste management practices:

1) Subaqueous PAG-CCR disposal
2) Fine Tailings underground storage in 2 North mine void(s)
3) Backfilled and flooded underground PAG-CCR

The information attained from monitoring these unique and innovative disposal methods will inform future waste management plans and opportunities for Quinsam Coal.

Overall, in-situ groundwater at Quinsam Coal is generally within the water quality prediction scenarios and ex-situ groundwater typically trends below the CSR-AW standards. The two exceptions to the aforementioned is groundwater influenced by host geological formations (e.g. Dunsmuir Member sandstones, Cumberland Member No.1 Coal seam and mudstones) with naturally elevated concentrations of parameters of interest and by weathering processes (i.e. mine wall oxidation and flushing) of disturbed materials within the mine footprint.

The long-term groundwater quality trend(s) demonstrate that deeper formation groundwater systems are not substantially influenced by contact water at most locations (i.e. 2-North/5-South and 7-South), as moderate concentrations of dissolved metals and low concentrations of sulphate are typical. In contrast, the underground mine voids, flooded open pit mining areas, and those areas used for subaqueous PAG-CCR and tailings stowage have, in some cases, elevated concentrations of certain parameters. Sulphate and sulphide as H_2S are the primary parameters of interest within these mining areas, due to the fact that sulphate and sulphide have a distinctive geochemical signature and the contact water flow path can be tracked.

The groundwater program will continue to evolve as mining advances into new areas, or retreats from existing areas, and information on existing mine developments is evaluated. Furthermore, the program will be adapted to encompass the progression of our waste management strategy and any well or area with specific trending.

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