APPENDIX VI

Annual Groundwater Monitoring Report

2023-2024 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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1 Introduction

Quinsam Coal Corporation conducts a comprehensive groundwater monitoring program to characterize water quality associated with mining operations and past development. This is regulated as part of the requirements under Mines Act Permit C-172, administered by the Ministry of Energy, Mines and Low Carbon Innovation (EMLI) and Waste Discharge Permit PE-7008 (administered by the Ministry of Environment and Climate Change Strategy (ENV).

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 Latest 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 (formation waters).

The groundwater wells outside the mine footprint (ex-situ) are compared to the British Columbia Contaminated Site Regulation (CSR) Aquatic life (CSR-AL) (Last amended March 1, 2023, by B.C. Reg. 133/2022), Schedule 3.2, describing water quality standards for freshwater Aquatic Life (AL). 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-AL. Recently all groundwater and mine water (in-situ and ex-situ) have been compared to the CSR-AL, as mine voids are dewatered to the receiving environment.

The parameters of interest (POI) captured under the CSR-AL and applied to Quinsam include the following: 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-AL standards (by development area). Refer to Appendix I, Tables 4, Results Above Freshwater Aquatic Life Dissolved Copper Guideline.

Derived from numerous studies, POI source terms have been developed by Lorax Environmental and Enterprise Geoscience Services Ltd. (Lorax 2011) 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. The Source terms and annual averages tables within the report compare the calendar year.

2 Groundwater Monitoring Regime

Throughout the monitoring period, Quinsam Coal monitored 37 sites within the vicinity of the mine footprint for water quality. These sites consisted of 21 ex-situ groundwater wells, 12 in-situ wells and 5 in-situ underground sumps, as illustrated in Table 1, below.

Table 1: Groundwater Wells & Sumps Monitored

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 2M7S, 3M7S	QU14-10	QU08-13 A QU11-36 D QU11-36 S	QU08-13 B QU08-10
242 Flooded Mine Void		242MW		
4-South		QU11-01	QU10-09 S QU10-09 D	QU10-08 D
5-South		QU05-16W		
2 / 3 South		QU11-11 (INF), MW00-4, MW00-5 and MW00-2		

The groundwater areas and well descriptions are listed in Appendix I, Table 32 of Annual Water Quality Monitoring Report (AWQMR). Appendix IX includes a Site Map of Groundwater Monitoring Locations, with respect to underground workings, groundwater and pumped mine water flow paths and disturbed areas. These wells are regularly evaluated and modified 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, 32 to 36 display the groundwater analytical results this monitoring period. Completion logs for the well installations can be found in Appendix A of previous Annual Reports. Further hydrogeological evaluations can be found in *Mine Permit (C-172) Amendment: 7-South Development Volume 3: Appendices: H - J and Volume 4: Appendices K – N, May 2011* prepared by Lorax Environmental and Enterprise Geoscience Services Ltd (Lorax 2011). Lorax 2011 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, that 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, 2011).

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

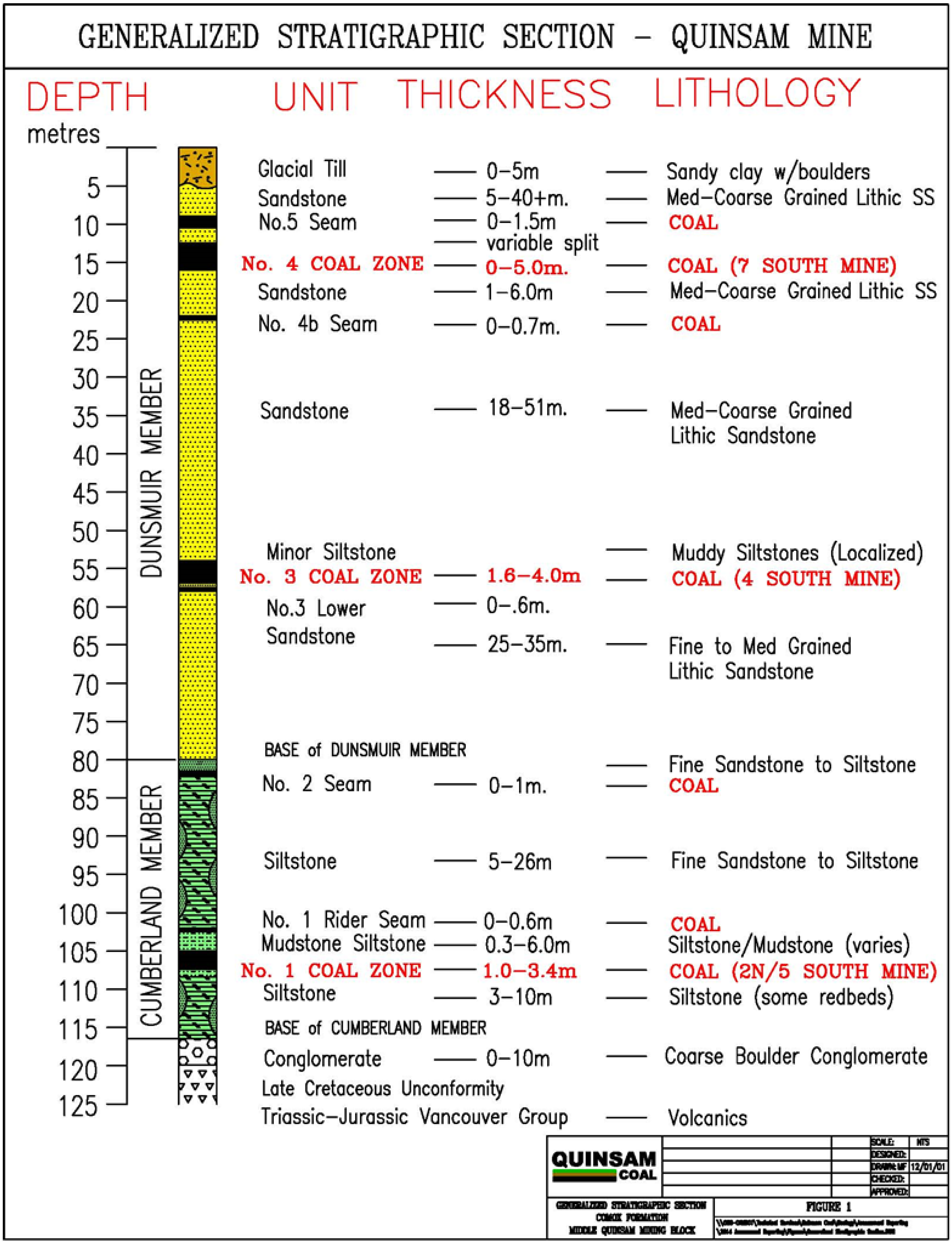


Figure 1: General Stratigraphic Column - Quinsam Mine

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.

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. 1-Mains 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 1-Mains 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 2011. 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. QU10-13D 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 D 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 the open mine workings east of a large fault. In past monitoring years, both wells were sampled due to their distance apart. It has been deemed that only one of these wells is necessary to determine mine-pool water chemistry as they have both exhibited similar characteristics when assessing historic data. Monitoring at QU78-161 has 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 meters 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. This year we continued to monitor MW00-5 (three samples) to observe water chemistry and 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. Wells in 7-South Area 5 were monitored in the past (2013-2015) with additional monitoring performed in 2018. 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 flooded mine void monitoring locations include: 1M2N, 5M#2, and QU10-13 D in 2-North; 5SMW in 5-South (not sampled in 2023-24) QU11-09 M in the RBP, QU14-10 in 7-South, QU11-01 in 4-South, MW00-4, MW00-3, MW00-5 and QU11-11 in 2-South; and 242MW for the 242 adit. Substitute locations for areas that are accessible include underground sumps. These are used to characterize in-situ locations including: 1 Mains 7-South (1M7S), (7SA5), combined 1 Mains 7-South Area 5 (1M7SA5), 3 Mains 7 South (3M7S), 2 Mains 7 South (2M7S), and 3 Mains 2-North (3M2N).

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-AL 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 changes. As a result, the CSR-AL for some updated parameters was not updated when the BC Water Quality Guideline was revised.

Currently, the CSR-AL 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 Bureau Veritas Laboratories (BVlabs) 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 lower 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 occurs 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 are 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 49 to 50 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.

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.

A comparison of water quality data to 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-AL). Numerical standards used for CSR-AL 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 5, 33-37 display the analytical results for groundwater.

Table 3: CSR-AL Lowest Level for Dissolved Metals and Total Sulphide as H2S

Parameter	CSR-AL (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-AL is a calculated, variable standard.**			

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

Table 4: Parameters Above the CSR-AL Standards found in Ex-Situ and In-Situ Groundwater

Parameter	Site > CSR-AL	CSR-AL (mg/L)	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, QU11-01, QU11-05 (S), QU11-09 (S), QU11-36 D, QU14-10, 7SA5, 1M7SA5, and 242MW	0.05	0.0653 to 0.957
Se-D	QU11-05 D	0.01	0.0251and 0.048
Sulphide as H_2S	1M2N, 242MW, 5M#2, INF, MW0-06 (D), QU05-16W, QU08-13 (A and B), QU08-21G (S and D), QU10-08 D, QU10-09 (S and D), QU10-10 S, QU10-13 (D), QU11-01, QU11-05 (S and D) and QU11-09 (M and S)	0.02	0.022 to 97
SO_4	MW002, MW005 and QU14-10	1280	1300 to 1900
Cl-D	QU10-10D	1500	3200 to 3300

4.1 Key Observations and Conclusions

4.1.1 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.

4.1.1.1 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, below.

The location 3M2N site has been included in this program since 2019. This area of the mine is where combined 5-South and 7-South mine water was previously pumped into the 2-North mine. The waters mix and become diluted with water 1M2N flooded voids. Table 5 compares the annual

Statistics (minimum, maximum, average and 90th percentiles) from 11 sets of results from January to December 2023.

Additional sampling 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. The parameters below reflect circumneutral conditions for pH (6.89 to 8.03), moderate concentrations of alkalinity (average 366 mg/L) and low levels of metals.

Table 5: Statistical Results for 3M2N - 2023

2-North Underground	**2023 Statistic Results - 3M2N (n=11)**			
	MIN	MAX	AVG	90TH PERCENTILE
pH-F	6.89	8.03	7.27	7.54
Acidity83	0.50	13.40	7.43	12.32
Alkalinity (as CaCO3)	240	400	366	400
Fluoride (F)	0.100	0.140	0.128	0.140
Sulphate (SO4)	720	1000	798	850
Aluminum (Al)	0.0015	0.0196	0.0043	0.0034
Arsenic (As)	0.0001	0.0005	0.0003	0.0004
Boron (B)	0.670	0.900	0.799	0.880
Cadmium (Cd)	0.00001	0.00003	0.00001	0.00001
Cobalt (Co)	0.0002	0.0026	0.0006	0.0007
Copper (Cu)	0.0001	0.0064	0.0012	0.0027
Iron (Fe)	0.005	0.35	0.11	0.24
Manganese (Mn)	0.006	0.195	0.142	0.188
Nickel (Ni)	0.0005	0.0104	0.0018	0.0014
Selenium (Se)	0.000050	0.000270	0.000102	0.000100
Zinc (Zn)	0.0025	0.0270	0.0063	0.0050

All units in mg/L

4.1.1.2 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. Sourcing new pumps during the pandemic was the reason for the pumps being replaced so late. 3M2N pumping system was operating to maintain the mine pool at a higher elevation than normal. The 1M2N pump faulted again this year on June 30, 2023, and remained down until November 23, 2023. This is depicted in Figure 2 below, with reference to the groundwater well QU11-09 surface elevation (227 Masl) as an indication of high-water levels underground. Since the pumps were replaced the well QU11-09 has been capped from fall to early spring, ensuring the mine water does not exit at the well head.

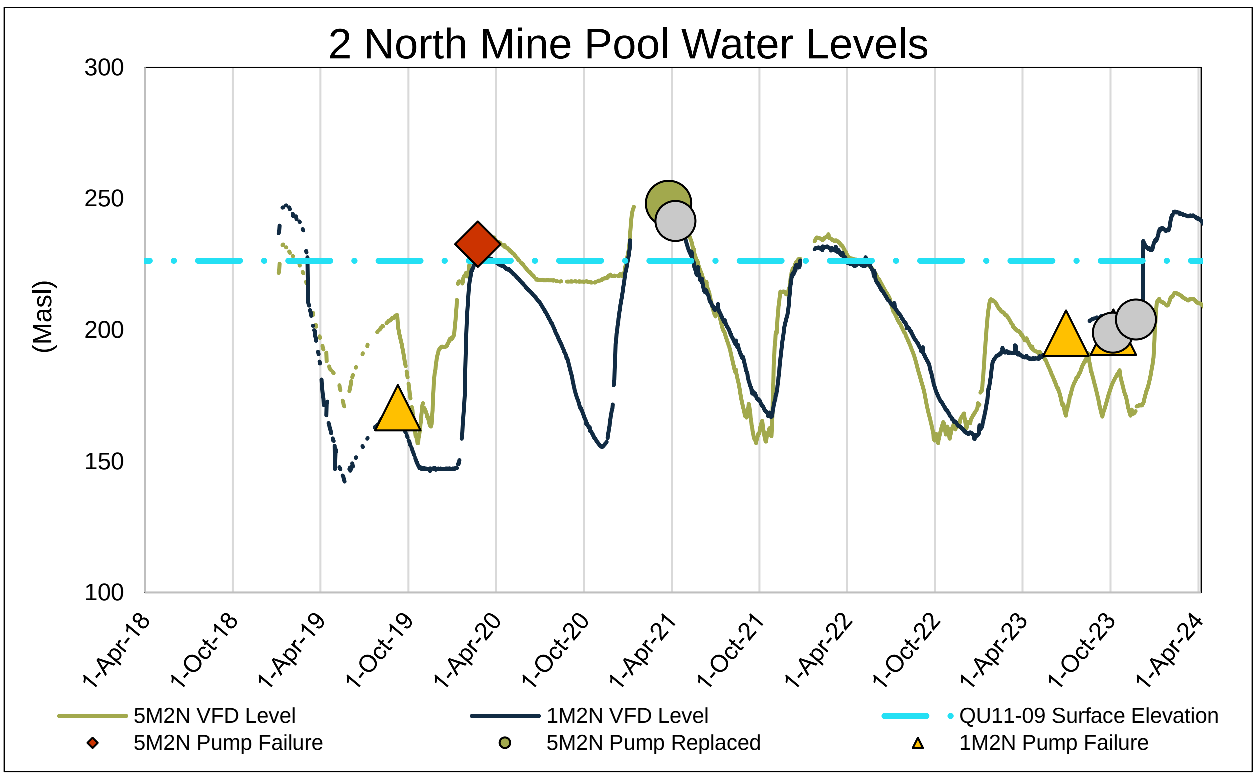


Figure 2: 2-North Underground Well Pump Water Levels (MASL)

The POI annual averages are displayed in Table 6 and Table 7 below for water collected from 1M2N and 5M#2, respectively. In Table 6: Source Terms Comparison for 2-North Mine Water with 7-South Tailings in 2023, for the samples collected from 1M2N in 2023. The 90th percentiles for iron and zinc at 1M2N were above worst case but remained below at 5M#2. All other parameters of interest were below worst case at 1M2N and 5M#2.

Table 6: Source Terms Comparison for 2-North Mine Water with 7-South Tailings in 2023

2-North Underground	2-North with 7S Tailings Source Terms		**2023 Statistic Results - 1M2N (n=8)**			
	Expected*	Worst-Case	MIN	MAX	AVG	90TH PERCENTILE
pH-F	8.10		7.07	7.86	7.53	7.83
Acidity83			0.50	15.90	7.86	15.69
Alkalinity (as CaCO3)	450		430	490	461	483
Fluoride (F)	1.1	1.20	0.120	0.200	0.153	0.193
Sulphate (SO4)	278	1280	210	470	360	428
Aluminum (Al)	0.013	0.027	0.0015	0.0015	0.0015	0.0015
Arsenic (As)	0.113	0.125	0.0035	0.0151	0.0094	0.0137
Boron (B)	1.1	1.2	0.844	1.010	0.948	1.003
Cadmium (Cd)	0.00002	0.00008	0.00001	0.00001	0.00001	0.00001
Cobalt (Co)	0.001	0.023	0.0001	0.0001	0.0001	0.0001
Copper (Cu)	0.001	0.004	0.0001	0.0001	0.0001	0.0001
Iron (Fe)	0.490	2.902	0.005	3.42	2.05	3.20
Manganese (Mn)	0.360	0.950	0.174	0.394	0.309	0.374
Nickel (Ni)	0.001	0.033	0.0005	0.0005	0.0005	0.0005
Selenium (Se)	0.0002	0.007	0.000050	0.000050	0.000050	0.000050
Zinc (Zn)	0.006	0.019	0.0025	0.0315	0.0111	0.0243

All units in mg/L
Highlighted indicates concentration is above expected or greater than worst case.
Note: If the Result < DL, then the DL value was used.

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 recharging 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 flooded mine void 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 the POI in 5M#2 compared to source terms with average concentrations of nickel trending at expected, alkalinity and iron above expected, and no parameters above worst case.

Table 7: Source Terms Comparison for 2-North Mine Water with 7-South Tailings in 2023

2-North Underground	2-North with 7S Tailings Source Terms		**2023 Statistic Results - 5M#2 (n=10)**			
	Expected*	Worst-Case	MIN	MAX	AVG	90TH PERCENTILE
pH-F	8.10		7.23	7.93	7.48	7.89
Acidity83			0.50	12.20	3.30	11.12
Alkalinity (as CaCO3)	450		540	580	558	580
Fluoride (F)	1.1	1.20	0.025	0.085	0.060	0.073
Sulphate (SO4)	278	1280	140	160	156	160
Aluminum (Al)	0.013	0.027	0.0015	0.0311	0.0047	0.0067
Arsenic (As)	0.113	0.125	0.0063	0.0086	0.0070	0.0085
Boron (B)	1.1	1.2	0.835	1.010	0.912	0.986
Cadmium (Cd)	0.00002	0.00008	0.00001	0.00001	0.00001	0.00001
Cobalt (Co)	0.001	0.023	0.0001	0.0001	0.0001	0.0001
Copper (Cu)	0.001	0.004	0.0001	0.0004	0.0001	0.0001
Iron (Fe)	0.490	2.902	0.620	0.84	0.68	0.75
Manganese (Mn)	0.360	0.950	0.138	0.169	0.153	0.165
Nickel (Ni)	0.001	0.033	0.0005	0.0005	0.0005	0.0005
Selenium (Se)	0.0002	0.007	0.000050	0.000050	0.000050	0.000050
Zinc (Zn)	0.006	0.019	0.0025	0.0025	0.0025	0.0025

Figure 3 and Figure 4 below, display arsenic, iron and sulphate concentrations in the 2-North flooded mine void compared expected and worst-case scenario predictions. The results indicate that 1M2N, QU10-13D and 3M2N have remained below the expected and worst-case scenarios for arsenic. Dissolved iron has been trending above the worst-case scenario in 1M2N since 2017 possibly related to the initiation of field filtering the samples on site. QU10-13D and 3M2N experienced a spike related to elevated mine water levels in 2021 when the pumps were being replaced. 5M#2 has remained below or within the expected case since 2016. Trends for dissolved sulphate were nearing worst-case scenarios in winter for 1M2N and QU10-13D 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 1M2N, 3M2N and QU10-13D when the dewatering pumps (1M2N and 5M#2) were being replaced and the mine water elevation was higher than previously experienced. A declining trend is observed from April 2021 onward with dewatering of the mine voids. 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.

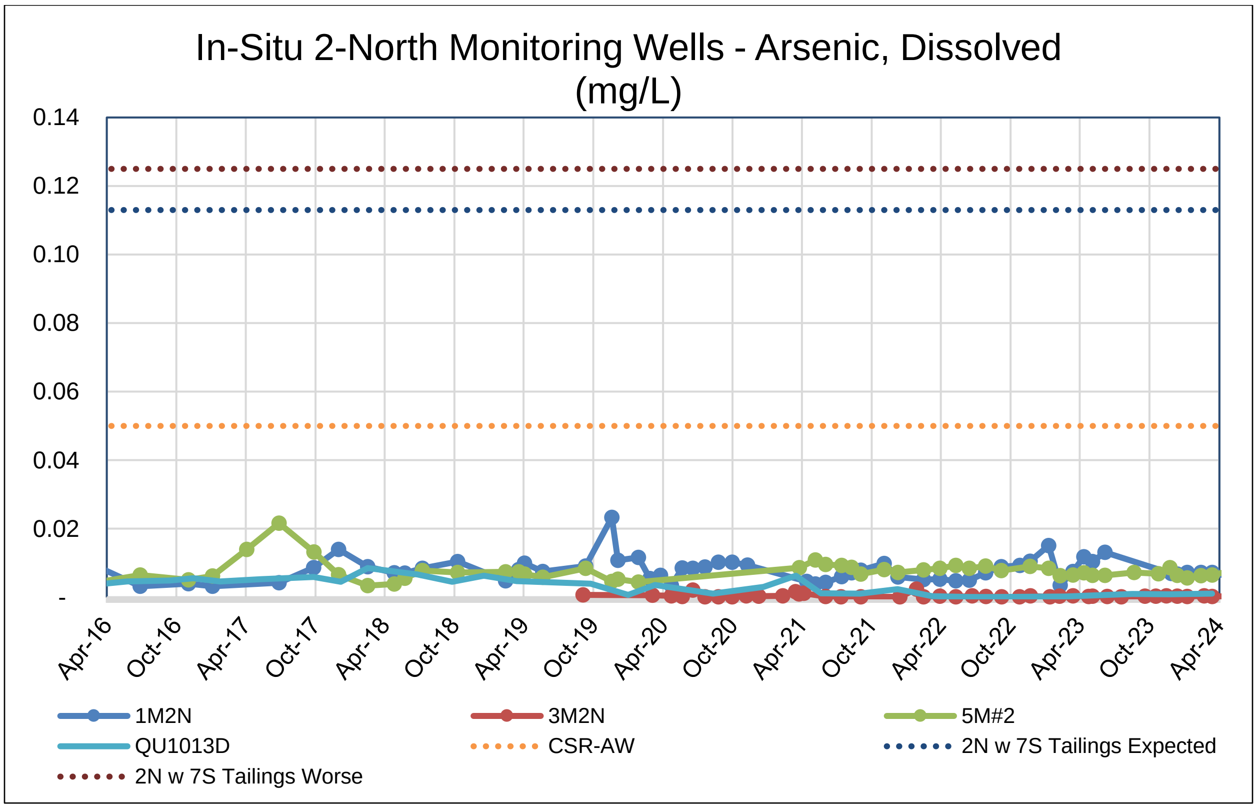
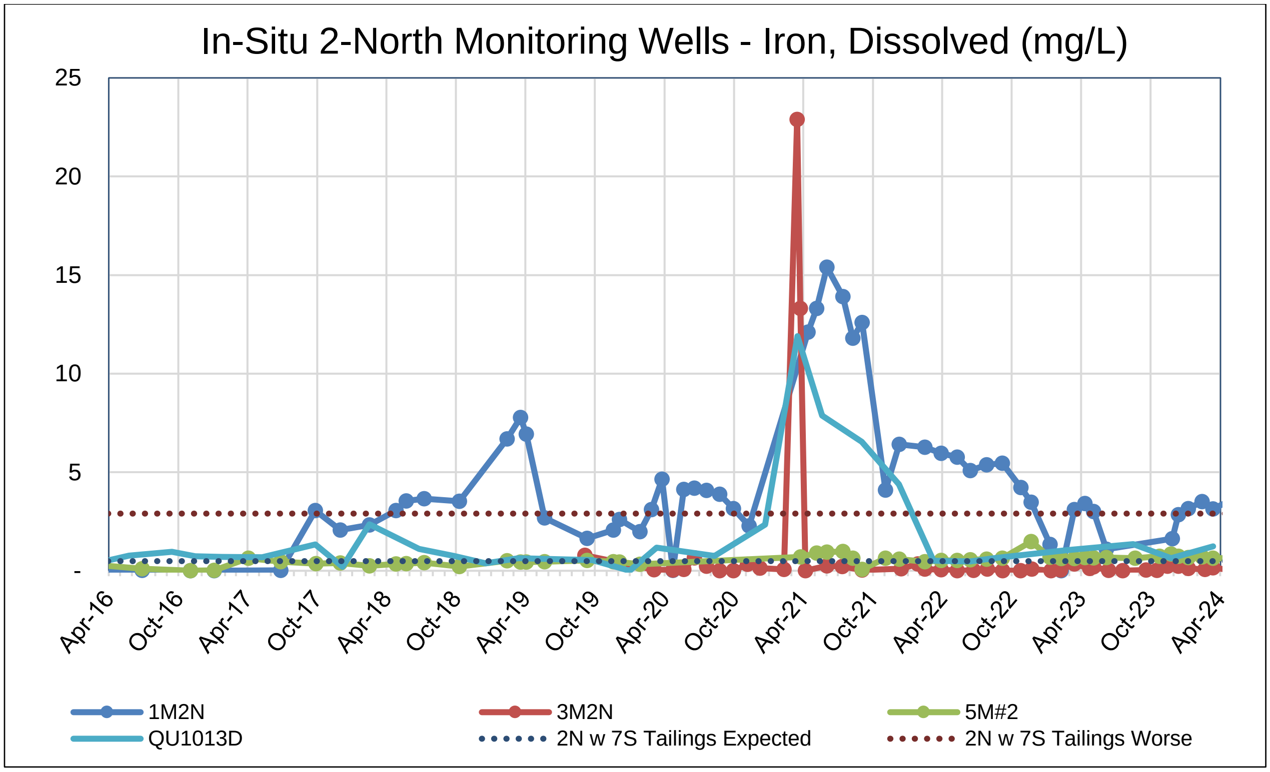


Figure 3: In-Situ 2N Monitoring Wells - Dissolved Arsenic



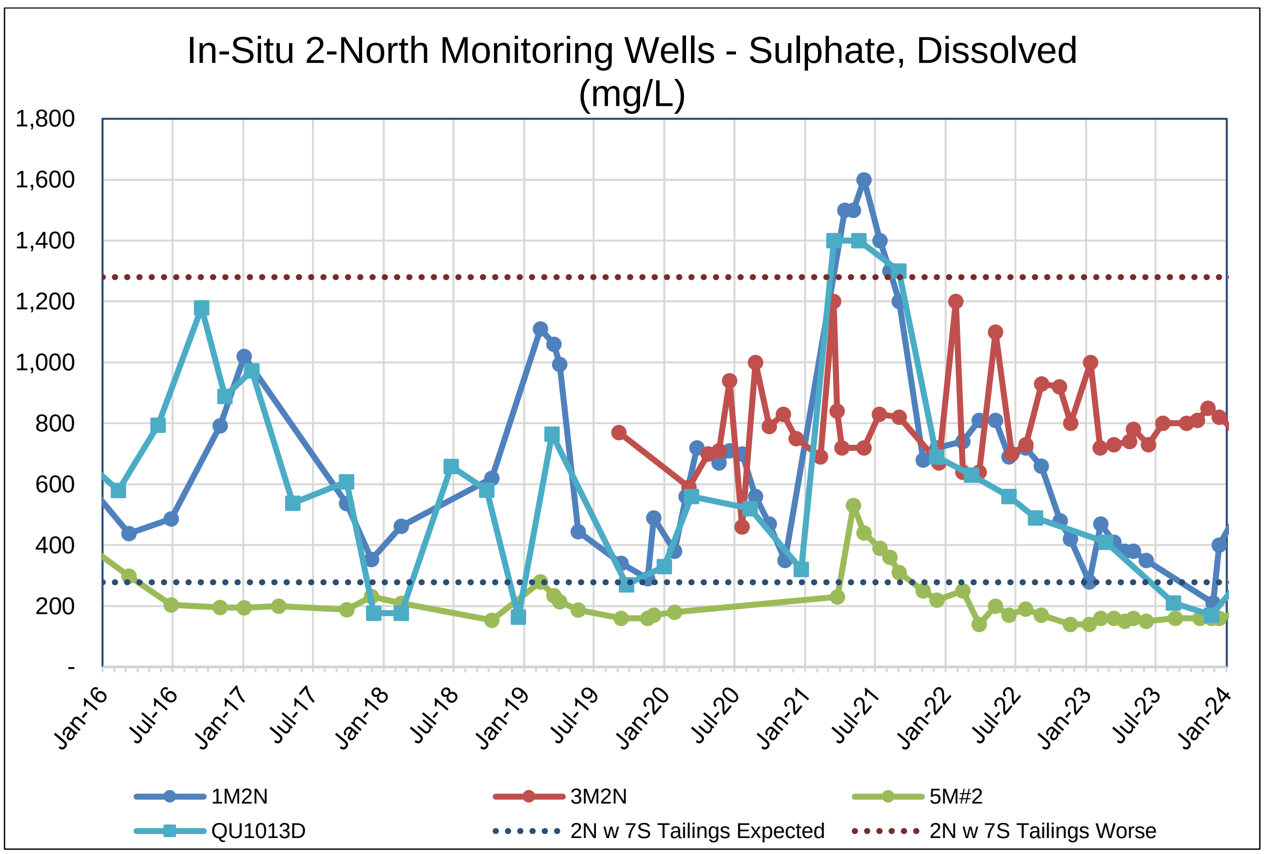


Figure 4: In-Situ 2N Monitoring Wells - Dissolved Iron and Sulphate

4.1.1.3 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-AL (arsenic, chloride, and sulphide (as H_2S)) are displayed below in Figure 6 with dissolved sulphate graphed for observation purposes. Appendix I, Tables 33 to 37, represent the water quality results for these areas.

Sodium and chloride are elevated in deep groundwater within the No. 1 seam of 2-North area. The formation groundwater of the No. 1 seam is defined as sodium - chloride type waters. Chloride is an age-related groundwater parameter indicating longer residence time of the formation waters.

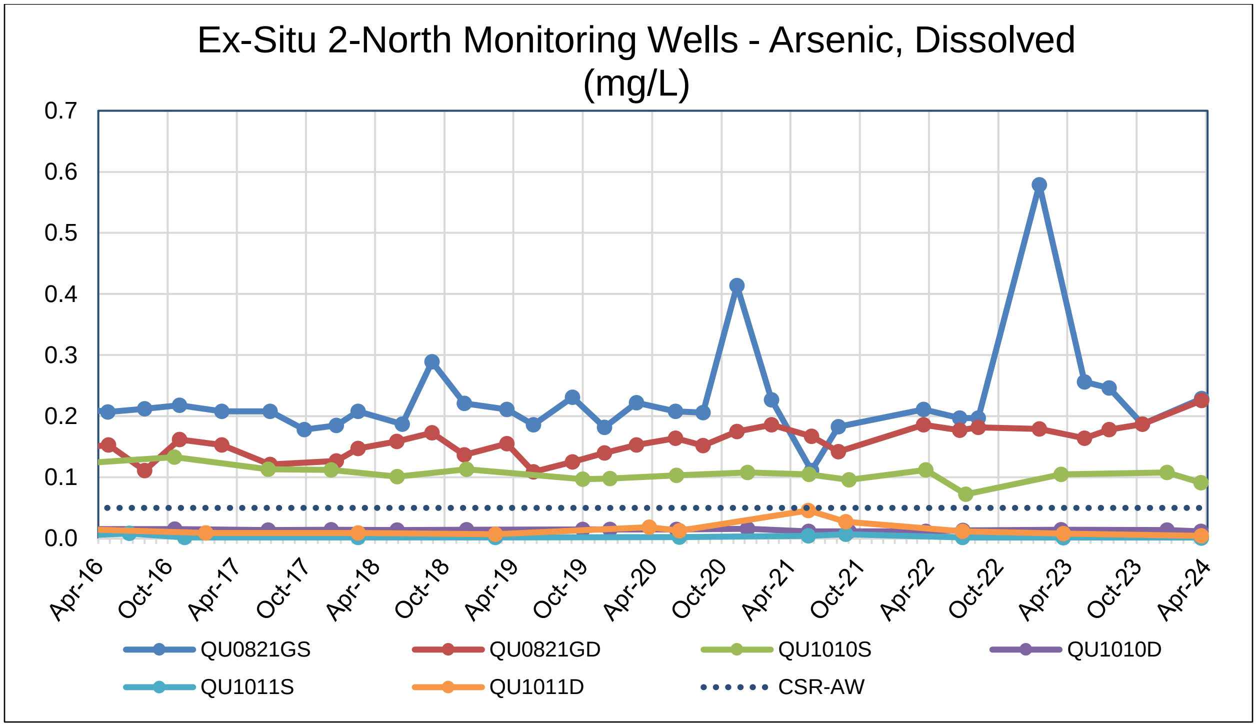
Notable observations for this area include:

- Ex-situ groundwater wells QU08-21GD and QU10-10D are not strongly influenced by mine water.
- 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-AL standards except dissolved arsenic, sulphide as H2S and chloride.
- Dissolved arsenic concentrations exceeded the CSR-AL standard (0.05 mg/L) in all sampling events at Q08-21G (S and D) and QU10-10 S since monitoring began. QU08-21GS peaked in January 2023.

- H_2S concentrations at QU08-21G (S and D), QU10-11 D and QU10-10 S were above the CSR-AL 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 (QU10-10D).
- Sulphate is observed in low concentrations in all ex-situ groundwater in 2 - 3 North. QU10-10 S continues to trend down from the peak in Oct 2016, with an increase in May of 2021 which declined further during following sample collections.

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 Lorax's findings where it was determined that elevated arsenic concentrations are found in the 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 in a fault separated from the other 2 North and 5 South wells in the #1 coal seam (Lorax, 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-AL standards. The groundwater in this location follows a different flow path than other No. 1 coal seam wells in 2-North (Lorax, 2011).

Concentrations of dissolved sulphate in the 2 - 3 North mine area (ex-situ wells) are low (>10 mg/L). A notably higher sulphate result was reported at the well QU 10-10S during October 2016 (49 mg/L) and more recently in May 2021 (29 mg/L) 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.



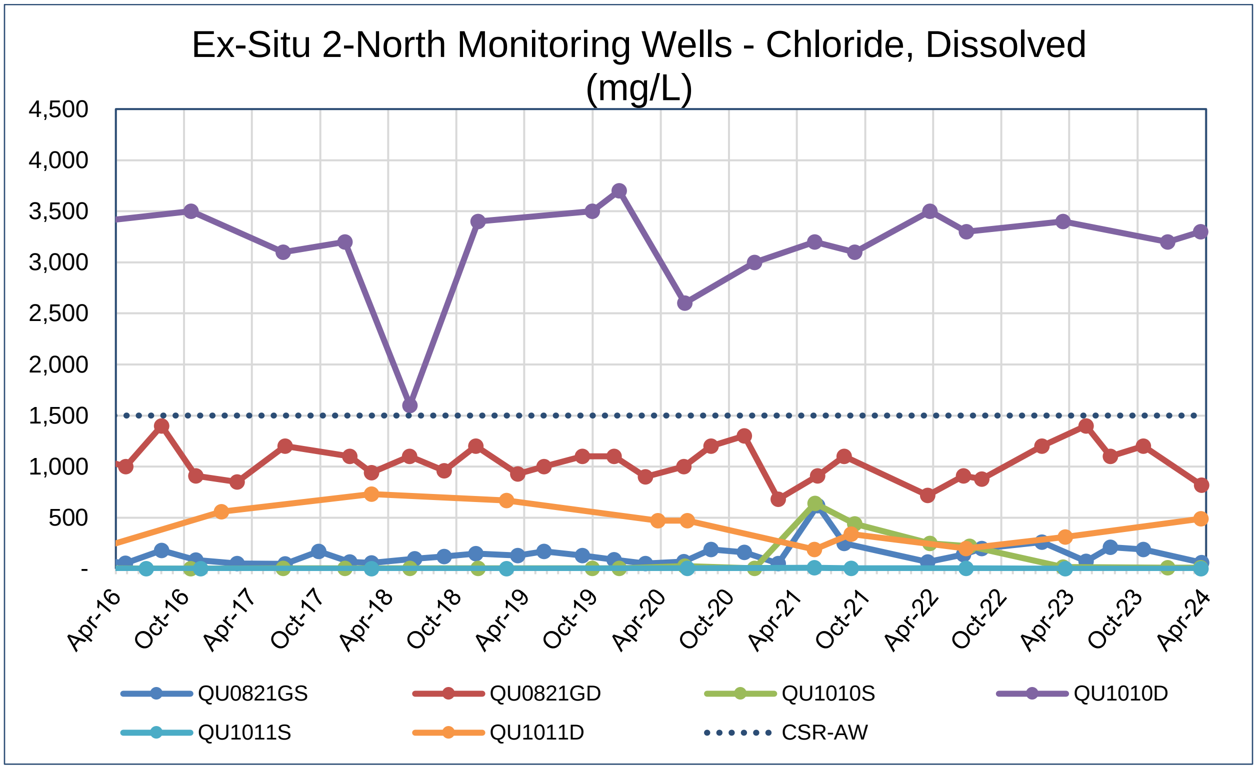
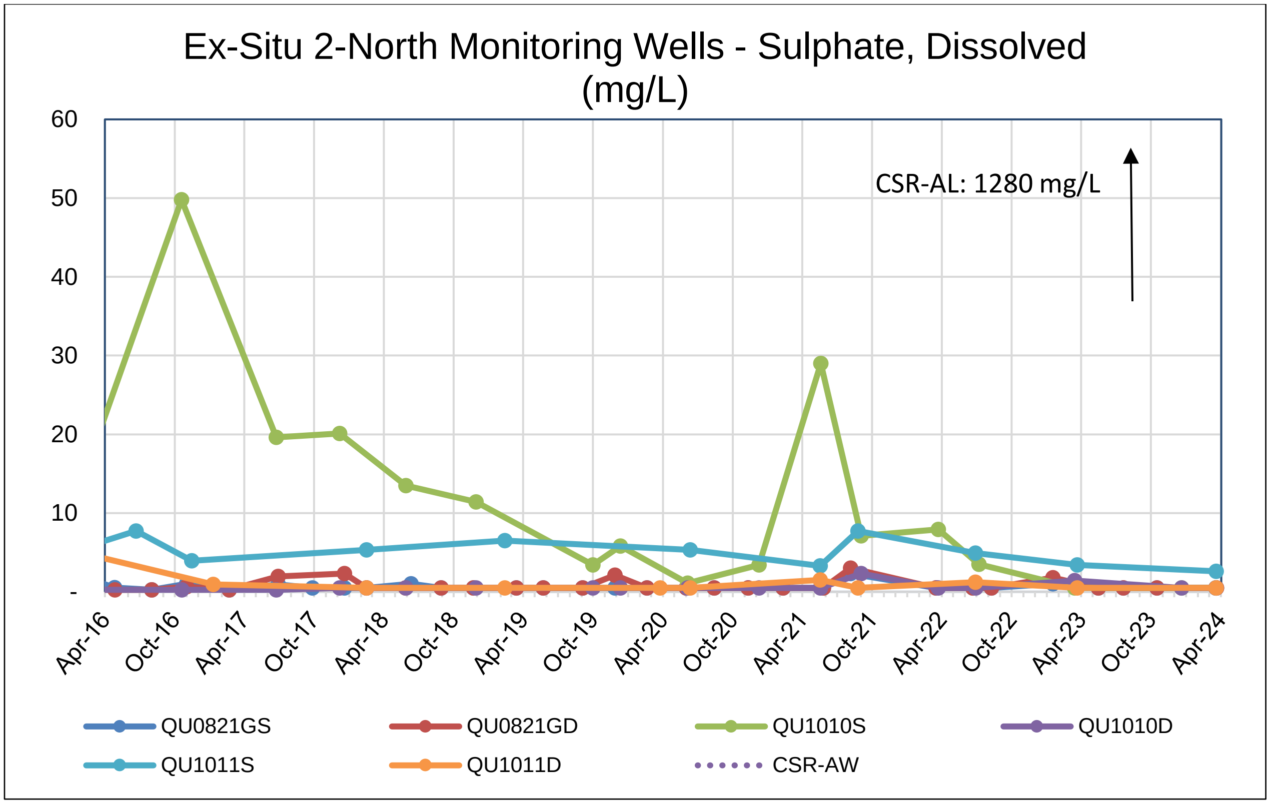


Figure 5: Ex-Situ 2N Monitoring Wells – Dissolved Arsenic and Chloride (mg/L)



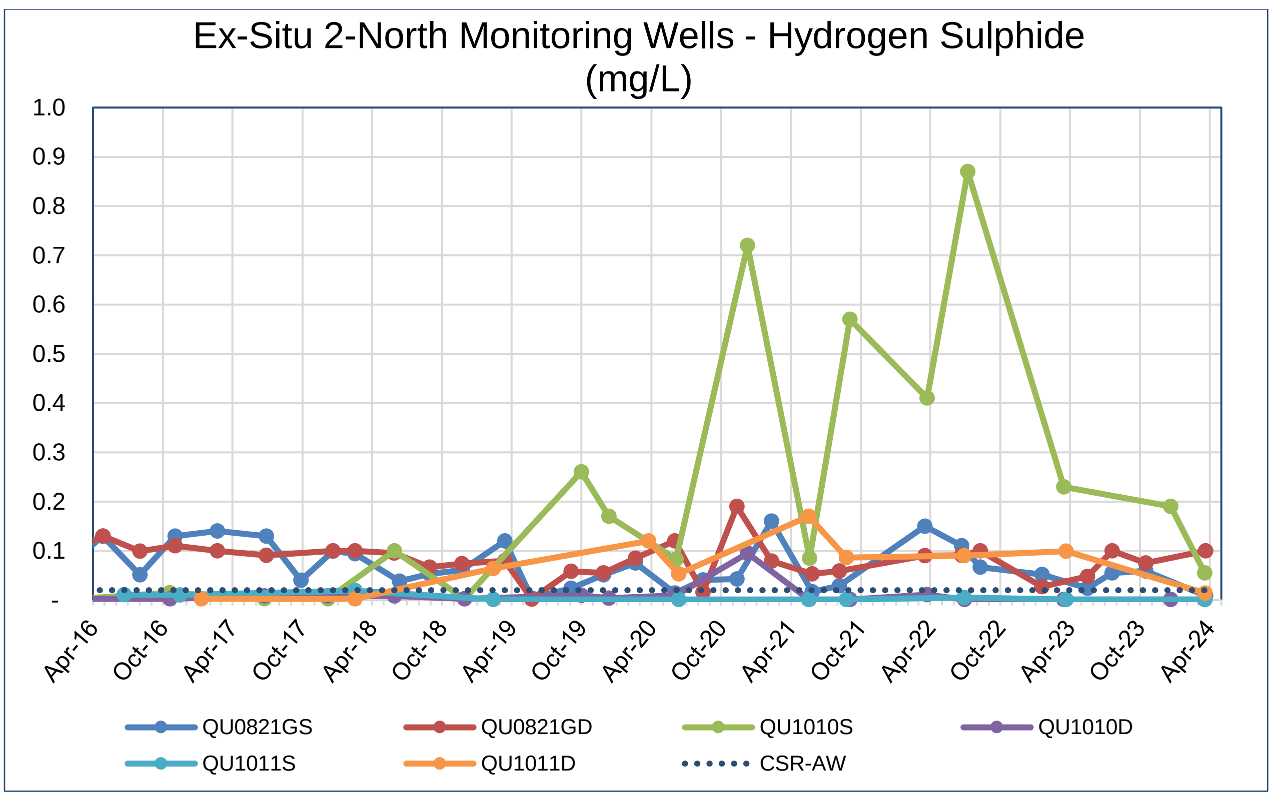


Figure 6: Ex-Situ 2N Monitoring Wells Dissolved Sulphate and Hydrogen Sulphide

Sulphide as Hydrogen Sulphide (H_2S) 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 sulphur occurs and takes different forms as it 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 dissolved sulphate (SO_4). Figure 6 displays sulphide (as H_2S) concentrations found with ex-situ 2-North wells, sulphide has been at or just above detection limits in all wells except in QU10-10 S with increases displayed since December 2020 coinciding with low dissolved sulphate and 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.

4.1.2 River Barrier Pillar Area

4.1.2.1 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 210 m dependent on groundwater influx and dewatering efforts in 2-North. In February 2021, an unauthorized discharge occurred at 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 (228 masl) at QU11-09, where mine water discharged 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 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 and 90th percentile was used to evaluate water quality.

Table 8 compares source terms derived from 7-South PAG-CCR compared to annual averages from 2023.

Figure 7, below represents concentrations of arsenic, boron and sodium in the flooded mine void and the shallow groundwater. Historically B-D has risen above worst case. Fe-D and SO_4-D were trending higher than expected values. All others were marginally above or below expected values.

Table 8: Source Terms Comparison for RBP with 7-South CCR and Averages 2023

QU11-09M	River Barrier Pillar (RBP) with CCR Source Terms		2023 Statistic Results (n=4)				
	Expected*	Worst-Case	COUNT	MIN	MAX	AVG	90TH PERCENTILE
pH-F	7.5		4	6.79	7.15	7.03	7.14
Alkalinity (as CaC(	282		4	460	500	488	500
Fluoride (F)	0.71	1	4	0.11	0.12	0.11	0.12
Sulphate (SO4)	396	1990	4	450	550	500	547
Aluminum (Al)	0.02	0.05	4	0.003	0.003	0.003	0.003
Arsenic (As)	0.128	0.19	4	0.0017	0.0048	0.0038	0.0048
Boron (B)	0.71	1.88	4	0.94	1.09	1.01	1.08
Cadmium (Cd)	0.000017	0.000175	4	0.00001	0.00001	0.00001	0.00001
Cobalt (Co)	0.005	0.148	4	0.0002	0.0002	0.0002	0.0002
Copper (Cu)	0.001	0.001	4	0.0002	0.0002	0.0002	0.0002
Iron (Fe)	0.805	33.5	4	4.80	6.62	5.42	6.21
Manganese (Mn)	0.14	2.89	4	0.185	0.32	0.23	0.29
Nickel (Ni)	0.007	0.213	4	0.0010	0.0010	0.0010	0.0010
Selenium (Se)	0.0002	0.004	4	0.0001	0.00010	0.00010	0.00010
Zinc (Zn)	0.008	0.088	4	0.0050	0.01	0.01	0.01

All units in mg/L

Highlighted indicates concentration is above expected or greater than worst case.

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

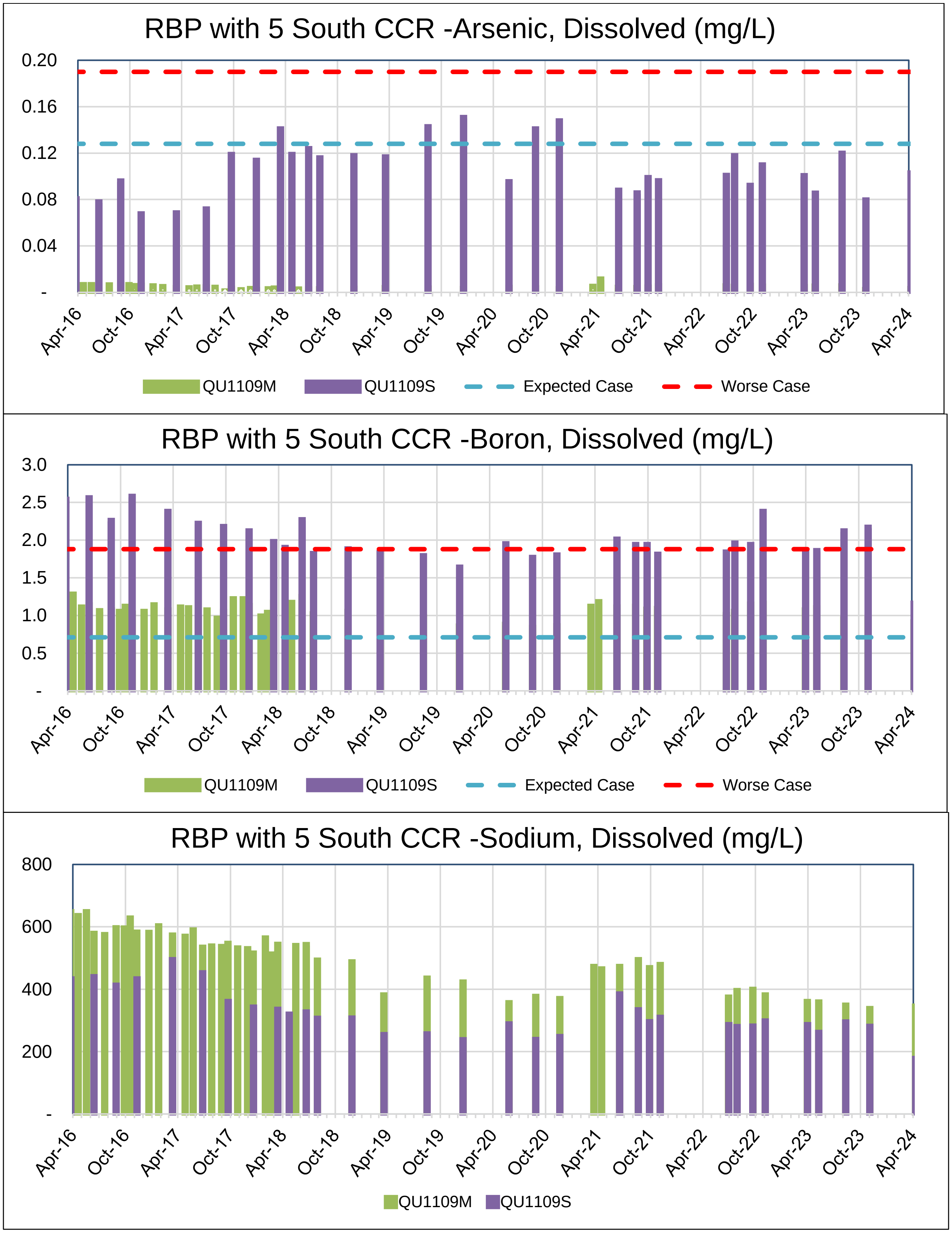


Figure 7: River Barrier Pillar with 7-South CCR- Dissolved Arsenic, Boron, and Sodium

4.1.2.2 RBP Ex-Situ Groundwater

Concentrations of dissolved sulphate measured in the ex-situ wells of the River Barrier Pillar area are lower than CSR-AL but are displaying the mine signature for sulphate and are elevated enough to assist with analysis of the groundwater pathways associated with mine waters (Figure 8). 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) and in QU1109M. Fluctuating sulphide results have been observed in QU11-05 D since 2019. With peaks at 80 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 elevations (Figure 8). 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. Hydrogen sulphide displays high concentrations with peaks ranging from 42 mg/L to 80 mg/L from 2019 to 2022, displayed in Figure 9.

QU11-05 S, nested stratigraphically above, but down gradient/dip from the RBP, illustrate sulphate concentrations that are elevated compared to other ex-situ 2-North wells. The increase in sulphate concentrations occur as 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 to 50 mg/L when water levels were low in the PAG-CCR storage area below and 2-North mine. 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 2017 coinciding with QU11-09 M. Stable trends were observed all wells until Mach 2021 with increasing mine pool water levels shown in Figure 6, below.

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 through 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 suspected to be influenced from the 5-South mine, with direct infiltration from the 2-North mine. See Figure 10 for groundwater migration paths (Lorax, 2011).

Dissolved Selenium was elevated above the CSR-AL (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 peaks ranging from 0.063 mg/L to 0.054 mg/L in the deep groundwater. In 2023 - 2024 results ranged from 0.012 mg/L to 0.048 mg/L in the deep groundwater of QU11-05 (Figure 9).

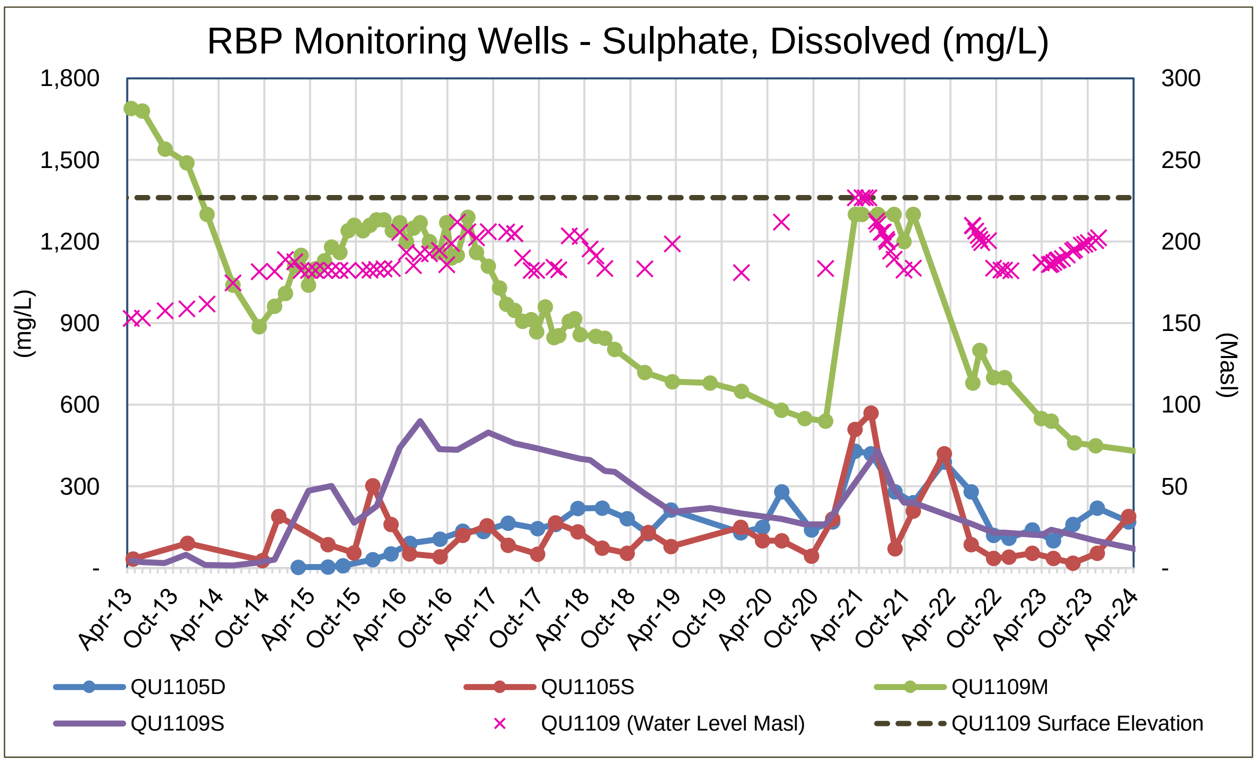
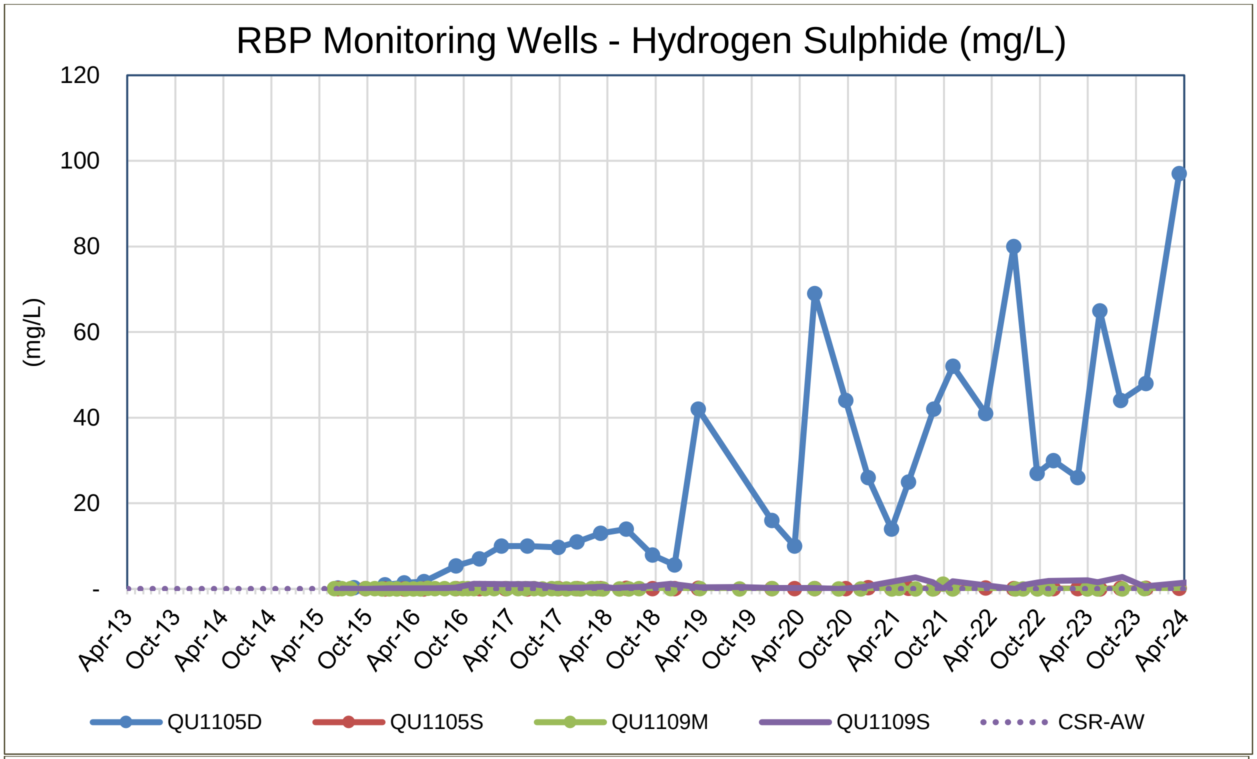


Figure 8: River Barrier Pillar –Water Elevation versus SO_4-D



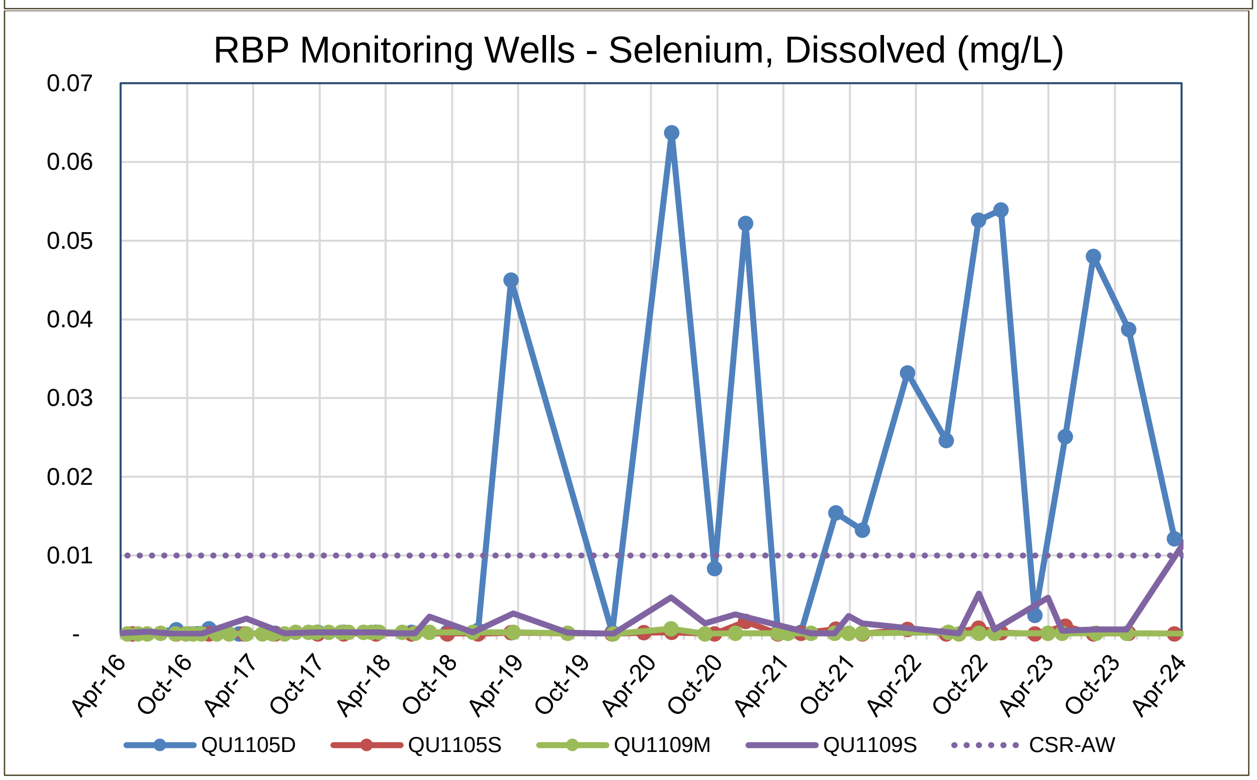


Figure 9: Ex-Situ River Barrier Pillar –H_2S and Se-D Compared to CSR-AL

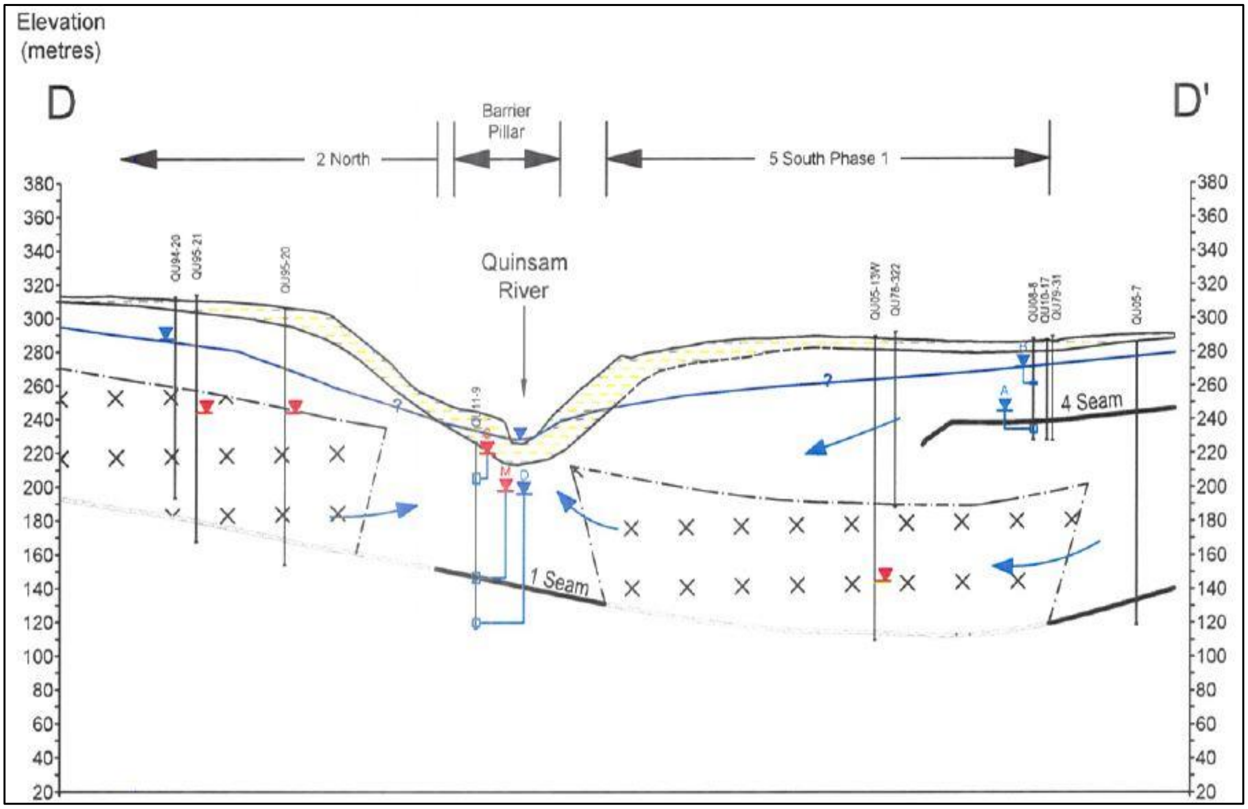


Figure 10: Groundwater Transport in 2-North, RBP and 5-South Phase 1

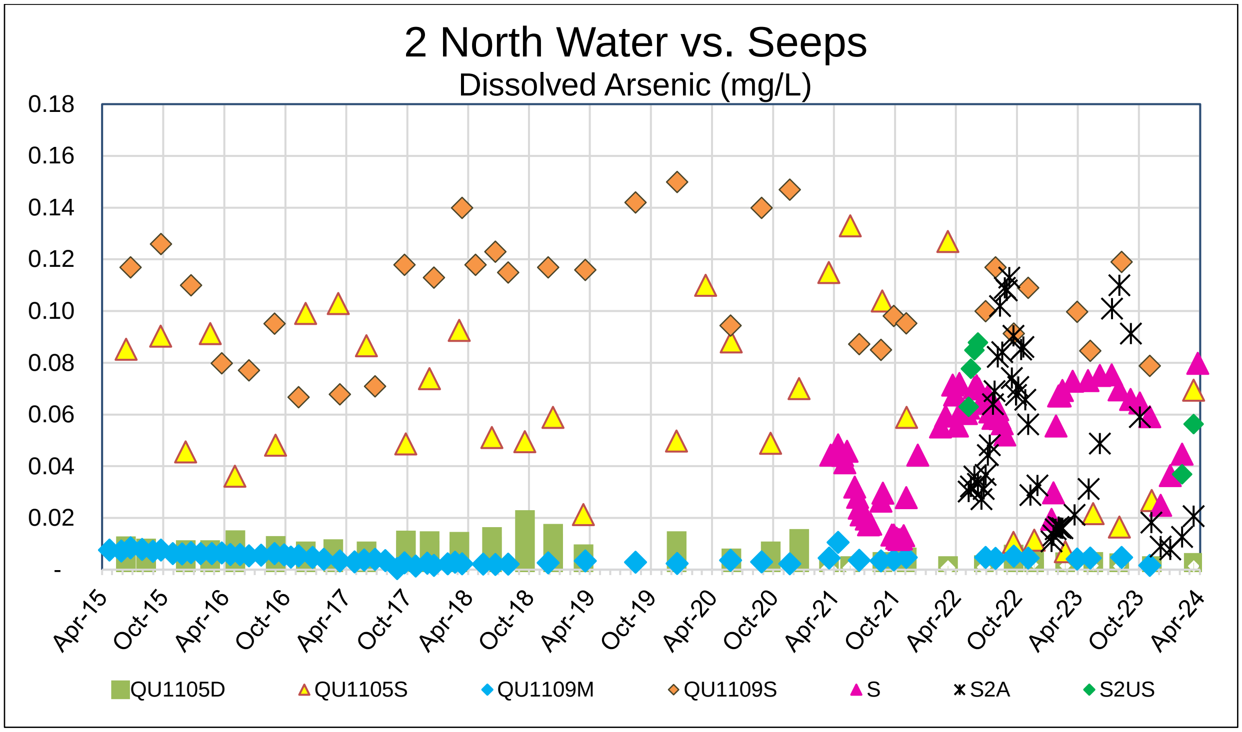
4.1.2.3 Seeps versus River Barrier Pillar and 2-North Mine

The trend for elevated arsenic in shallow groundwater of the RBP continues this year, observed at the seepage locations referred to as S, S2, S2A and S2US (
Figure 11). Dissolved sulphate displays a declining trend indicating that there is more influence from the formation groundwater that contains low dissolved sulphate. This year there were 29 samples collected from S, 16 collected at S2, 34 collected at S2A and 4 collected from S2US. The frequency of samples was dependent on the discharge from each location.

The seepage waters were elevated in arsenic above acute-WQG of 0.005 mg/L, on most sampling events and dissolved sulphate was above chronic-WQG of 128 mg/L, with concentrations on a decreasing trend. Seepage waters (S) compare closely to the shallow groundwater at QU11-09 S
(

Figure 11). QU11-09 was capped in November to mitigate the risk of discharging groundwater from the well. Further evaluation of the seepage water quality and source will be determined through the Water Quality Predictions Model and Water Balance that will be provided by Lorax Environmental in Fall 2024.

Figure 12, compares the water levels in 2-North Mine (QU10-13D) versus the 5-South Mine (5SMW) and RBP (QU11-09 S, QU-1105 S and D) with seep start and stop dates. Water levels in all areas follow a similar trend with seep (S) corresponding to the shallow groundwater of QU11-09 S, with flows subsiding when the shallow groundwater is depleted below 220 Masl. The other areas of seepage (S2, S2A and S2US) located near QU11-05 are irregular and seepage elevation is uncertain. Further details will be evaluated with Lorax's investigation into groundwater seepage and relationships to coal seam elevations.



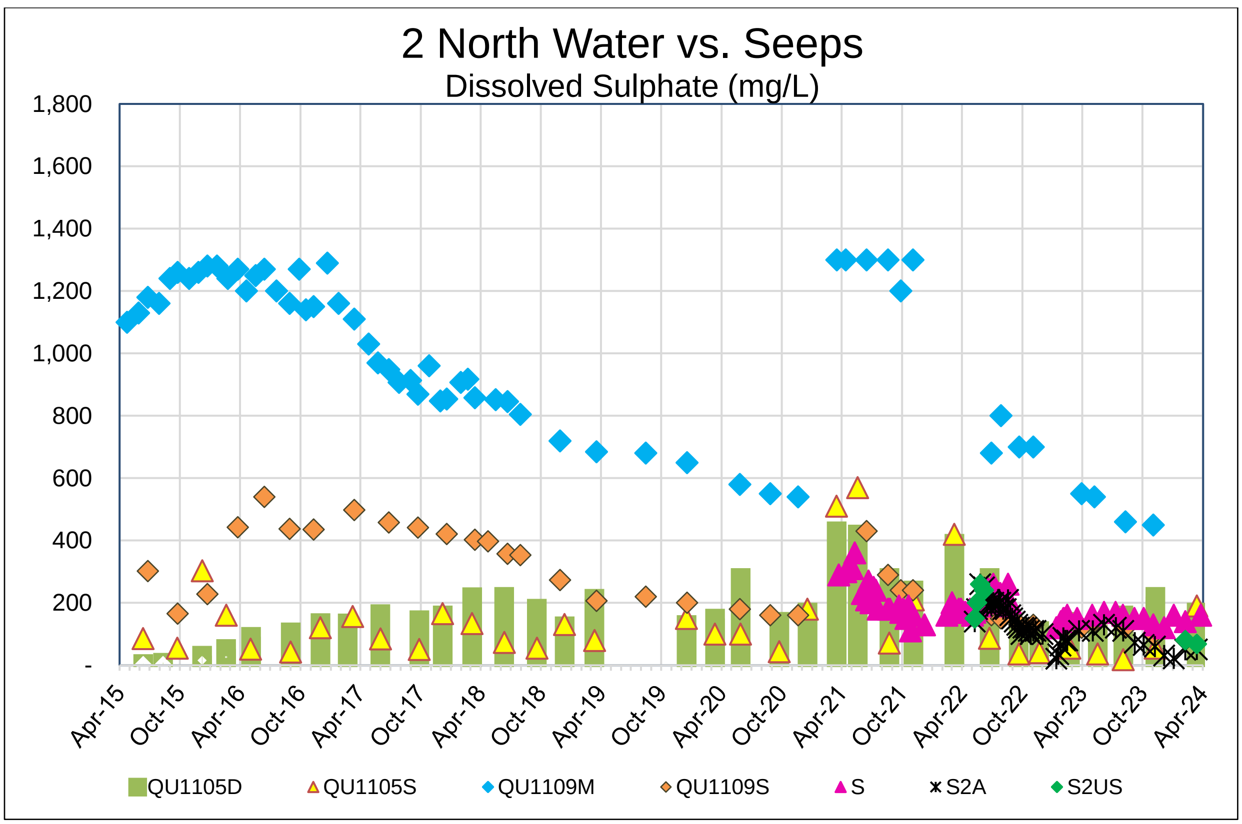
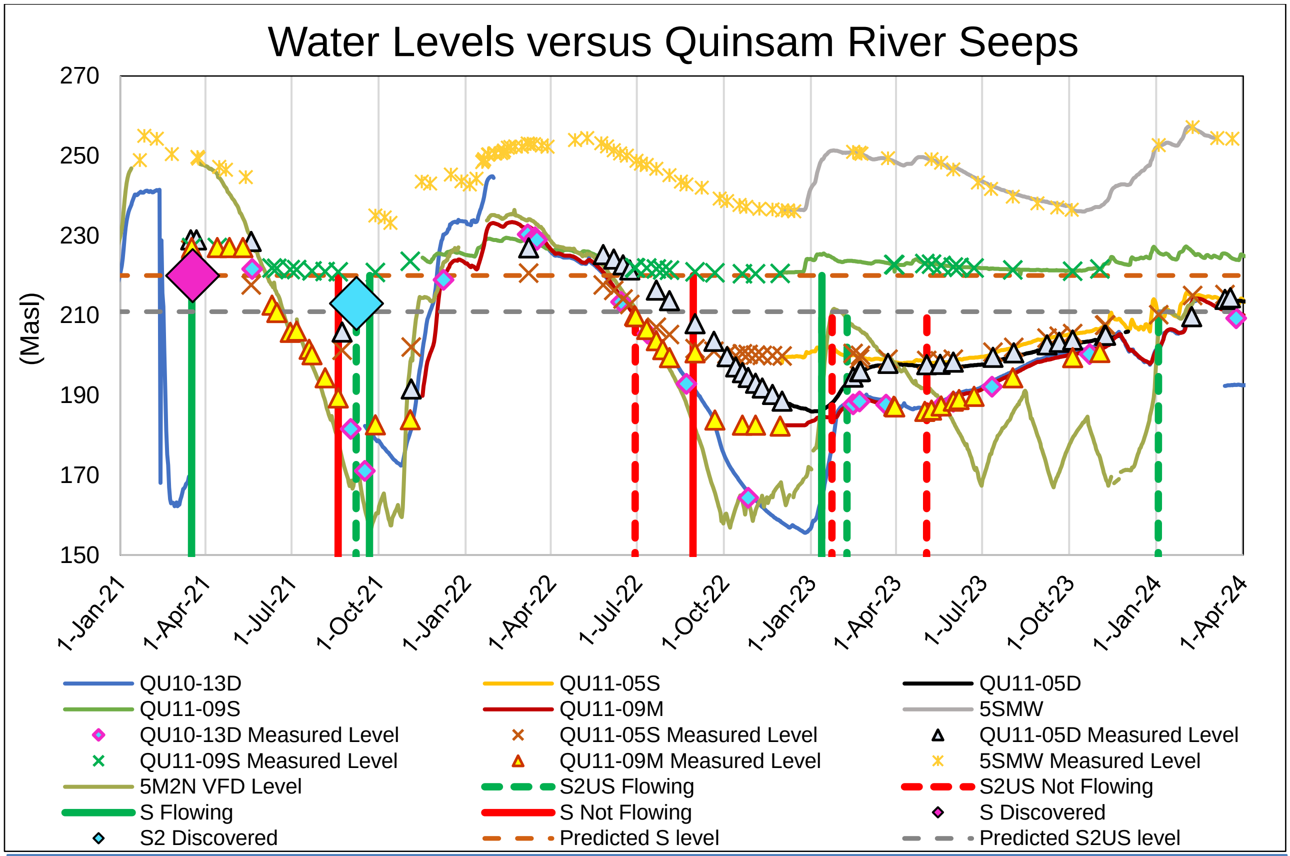


Figure 11: 2 North Water vs. Seeps Dissolved Arsenic and Dissolved Sulphate



Date	QU1013D	QU1105S	QU1105D	QU1109M	QU1109S	5SMW	1M2N	5M#2	S	S2US
17-Mar-21	163.10	226.45	228.95	226.90	226.90			248.12	Discovered	
19-Aug-21		201.28	205.87	189.33	220.91		192.27	178.42	No Flow	
07-Sep-21	181.59						181.05	160.37		Discovered
21-Sep-21	170.35			182.62	220.76	235.01	175.84	158.64	Flow	
29-Jun-22	209.30	212.74	221.46	209.76	221.54		210.47	211.49		No Flow
29-Aug-22	191.19	201.74	207.99	200.66	220.93	242.83	193.61	183.11	No Flow	
12-Jan-23	163.18	201.97	186.32	184.48	225.26	249.06	167.80	190.55	Flow	Flow
23-Jan-23	176.15	202.19	188.14	184.51	224.53	251.31	180.11	211.06		No Flow
08-Feb-23	186.84	199.81	193.16	187.35	223.66	250.78	190.32	208.93		Flow
03-May-23	186.00	198.25	197.39	249.32	223.06	248.99	188.98	191.37		No Flow
Brown bolded values are not exact dates, taken within the week.										

Figure 12: Water Levels versus Quinsam River Potential Mine Related Seeps

4.1.3 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 13), aluminum and zinc are found in greater concentrations in the deeper wells than the shallow wells but remain at moderate concentrations and below CSR-AL standards. In 2020 to present the deeper well MW001 D displayed a sharp decrease in arsenic with continued monitoring confirming these 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.

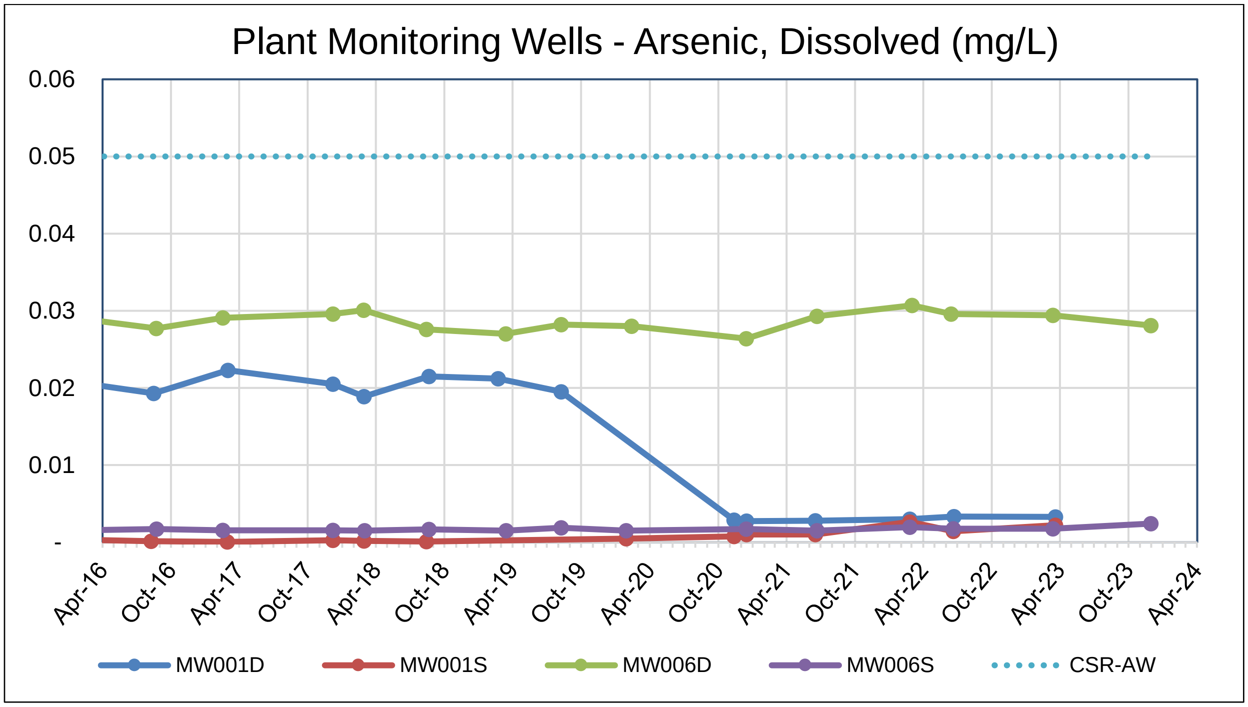
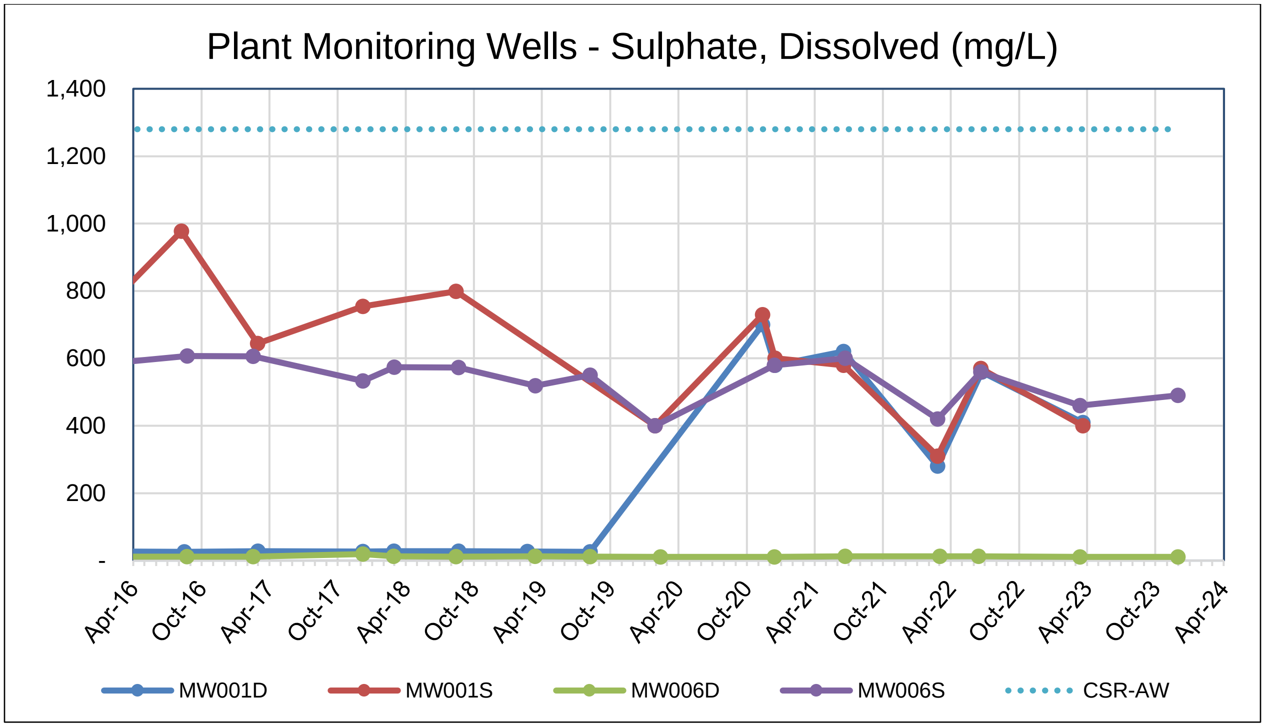


Figure 13: Plant Monitoring Wells - Dissolved Arsenic

Dissolved sulphate levels (Figure 14) in both shallow wells seasonal variation showing higher concentrations of sulphate throughout the drier season and lower concentrations through the rainy season. Dissolved sulphate concentrations at MW00-6 D have shown low stable trends with little seasonal variation since 2015. MW00-1 D displayed a spike in sulphate and dissolved iron and seems to be flowing the same trend as the shallow groundwater. 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.



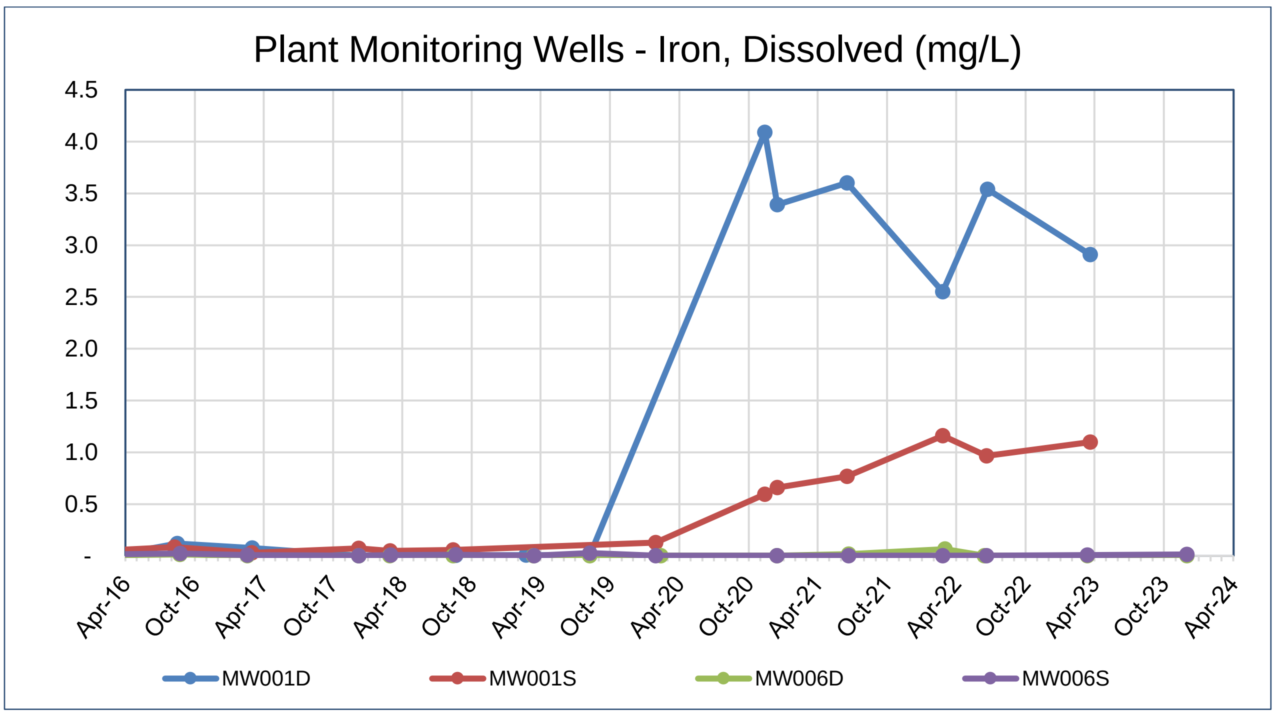


Figure 14: Plant Monitoring Wells - Dissolved Sulphate and Iron

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 MW00-1 D was unable to be sampled and possibly the reason for the elevated sulphate and iron results 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 (MW00-1D) is suspected to be influenced from the shallower groundwater as the well was compromised. The deep groundwater well MW00-6 D does not display the same sulphate concentrations and is within 20 m of MW00-1 D.

4.1.4 5-South

All water from the 7-South Mine surface and underground is pumped into the 5-South mine at QU05-13. The dewatering well (5SMW) historically dewatered 5-South Mine water into the 3-Mains Area of the 2-North Mine. In January 2022, the pump failed, and the mine was allowed to flood with assistance from 7-South mine water (Figure 15). Water levels are monitored through the 5SMW borehole where recently a continuous water level logging device has been established. The water levels follow a pattern of seasonal highs and lows and resemble the 2-North Mine trends.

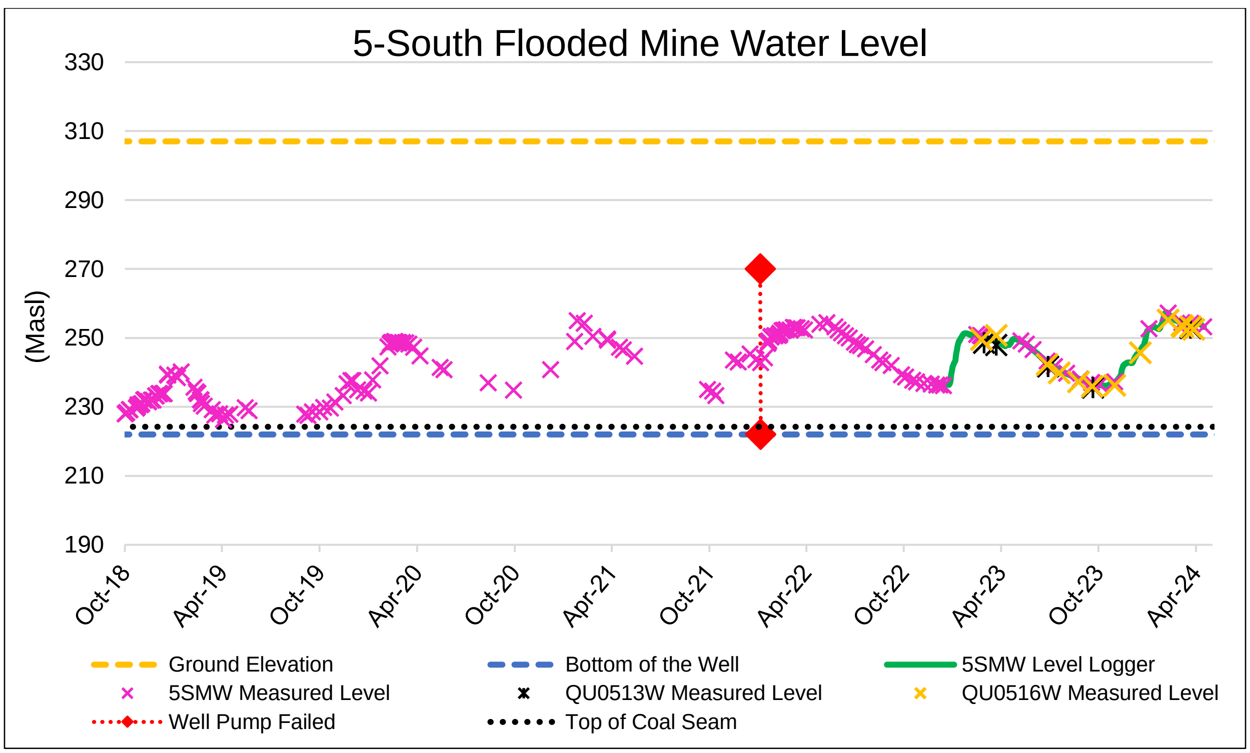


Figure 15: 5-South Flooded Mine Void Water Elevation (Masl)

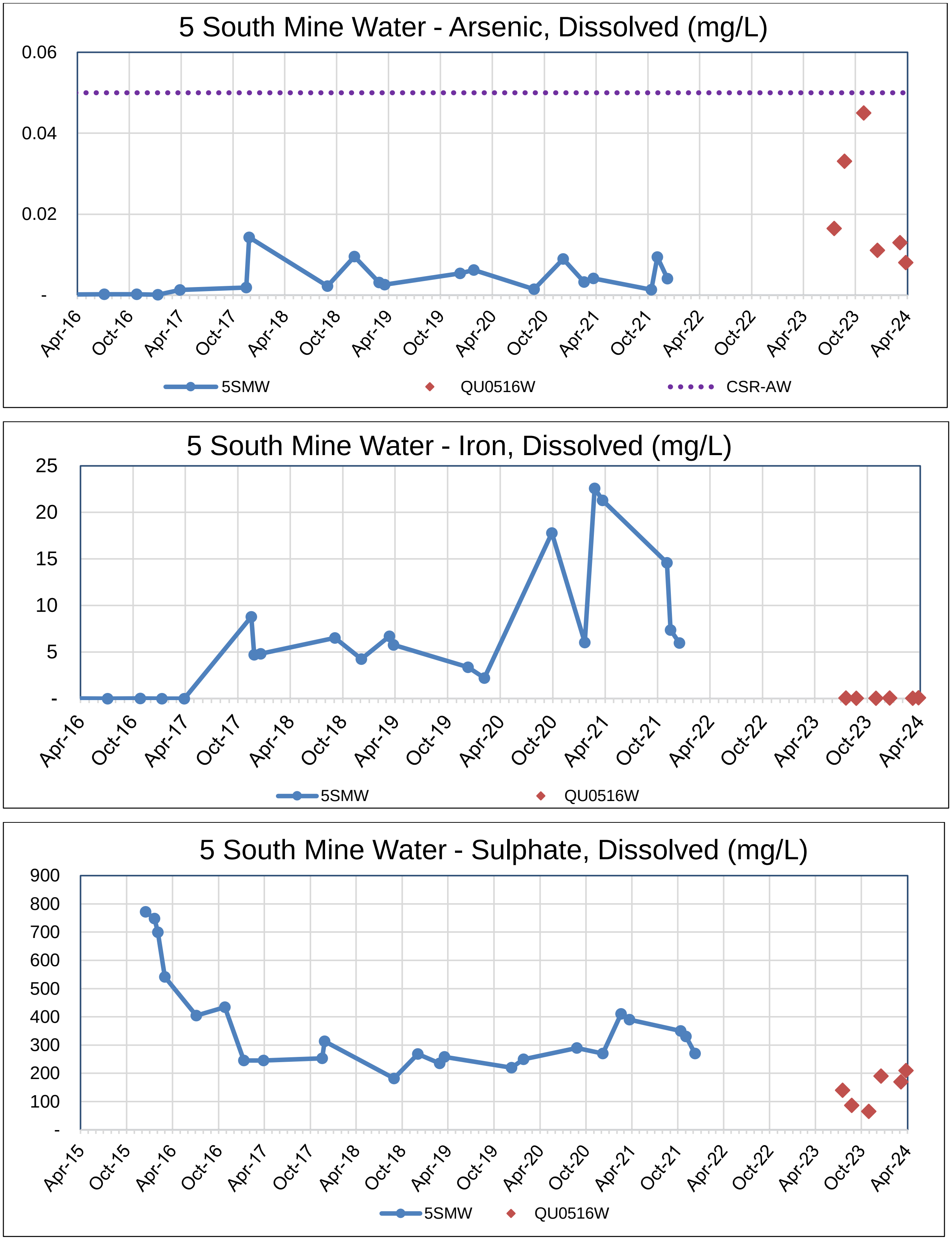


Figure 16: Dissolved Arsenic, Iron and Sulphate in 5-South Mine

Dissolved arsenic is found in low concentrations in the mine water with iron elevated in more recent years. Dissolved sulphate displays a stable trend and remaining well below the CSR-AL of 1200 mg/L (Figure 16). Since 2022 with the pump failure, the mine water has not been sampled at 5SMW, a new location for monitoring was established this year at QU05-16W. The borehole QU05-16W, is in a coal pillar and represents the water accumulated within the coal pillar. Results may not be representative of the flooded mine void but still add value to the data set. Results indicated that parameters fall within the same range as the historical samples collected from the well pump at 5SMW. Arsenic displayed an increasing trend nearing the CSR-AL (0.05 mg/L) during summer and fall with lower water levels and decreased into the winter months with increased water levels (average 0.021 mg/L).

4.1.5 7-South

4.1.5.1 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 4 sampling events taking place during this monitoring period. The 7-South mine void water will continue to be monitored following flooding and possible 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 where results would vary, summarized below:

> <u>Scenario 1</u>: 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.
> <u>Scenario 2</u>: Water quality based on the CCR being stored less than 2 years since being produced, which would not be acidic.

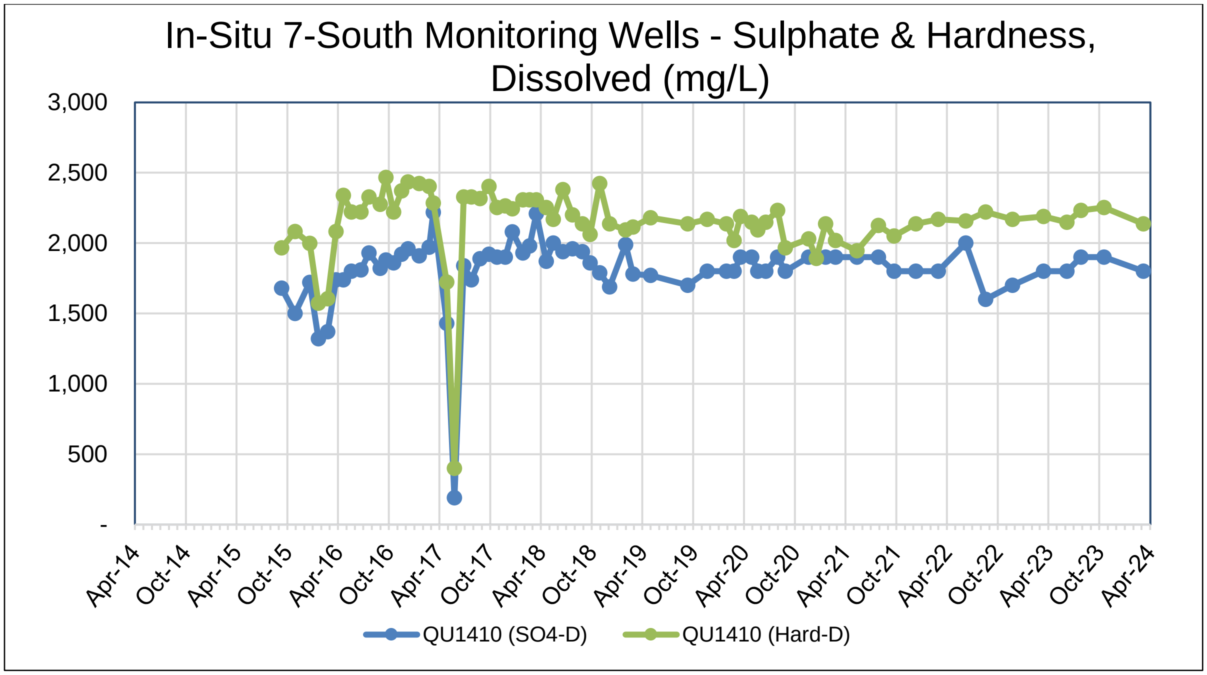
Scenario 3: Expected long term water quality concentrations following the complete dissolution of stored oxidation products and the influenced mine water being completely discharged from the mine or re-stabilized as metal sulphides within the flooded workings.

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 2023 were derived using half 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 has the highest hardness concentrations on site. Hardness concentrations averaged 2191 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 17). Dissolved sulphate (average 1850 mg/L) is found in high concentrations and has an inverse relationship compared to hydrogen sulfide (average 0.0009 mg/L) in the presence of oxygen. Dissolved arsenic remains above the CSR-AL (0.005 mg/L) but below the expected case of 0.19 mg/L in the water quality with average concentrations of 0.10 mg/L. Dissolved iron has remained below the expected value of 6.705 mg/L averaging 2.58 mg/L for 2023. Once completely flooded it is anticipated concentrations will decline over time. Refer to Figure 18.

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

QU14-10	7-South Containing Saturated CCR Scenario 2*	2023 Statistic Results				
		COUNT	MIN	MAX	AVERAGE	90TH PERCENTILE
pH-F	6.48	4	6.56	6.73	6.6725	6.724
Acidity83		4	25.2	68.9	40.25	60.11
Alk-T		4	320	330	322.5	327
F-D	0.6	4	0.025	0.17	0.13125	0.17
SO4-D	1260	4	1800	1900	1850	1900
Al-D	0.009	4	0.0075	0.0075	0.0075	0.0075
As-D	0.190	4	0.101	0.109	0.10575	0.1087
B-D	0.98	4	1.05	1.16	1.0925	1.145
Cd-D	0.0002	4	0.000025	0.000025	0.000025	0.000025
Co-D	0.062	4	0.0005	0.0005	0.0005	0.0005
Cu-D	0.001	4	0.0005	0.0005	0.0005	0.0005
Fe-D	6.705	4	2.4	2.73	2.575	2.691
Mn-D	2.885	4	1.45	1.56	1.51	1.548
Ni-D	0.122	4	0.0025	0.0025	0.0025	0.0025
Se-D	0.004	4	0.00025	0.00025	0.00025	0.00025
Zn-D	0.088	4	0.0125	0.0125	0.0125	0.0125

All units in mg/L
Highlighted indicates concentration is above expected or greater than worst case.
Note: If the Result < DL, then the DL value was used.



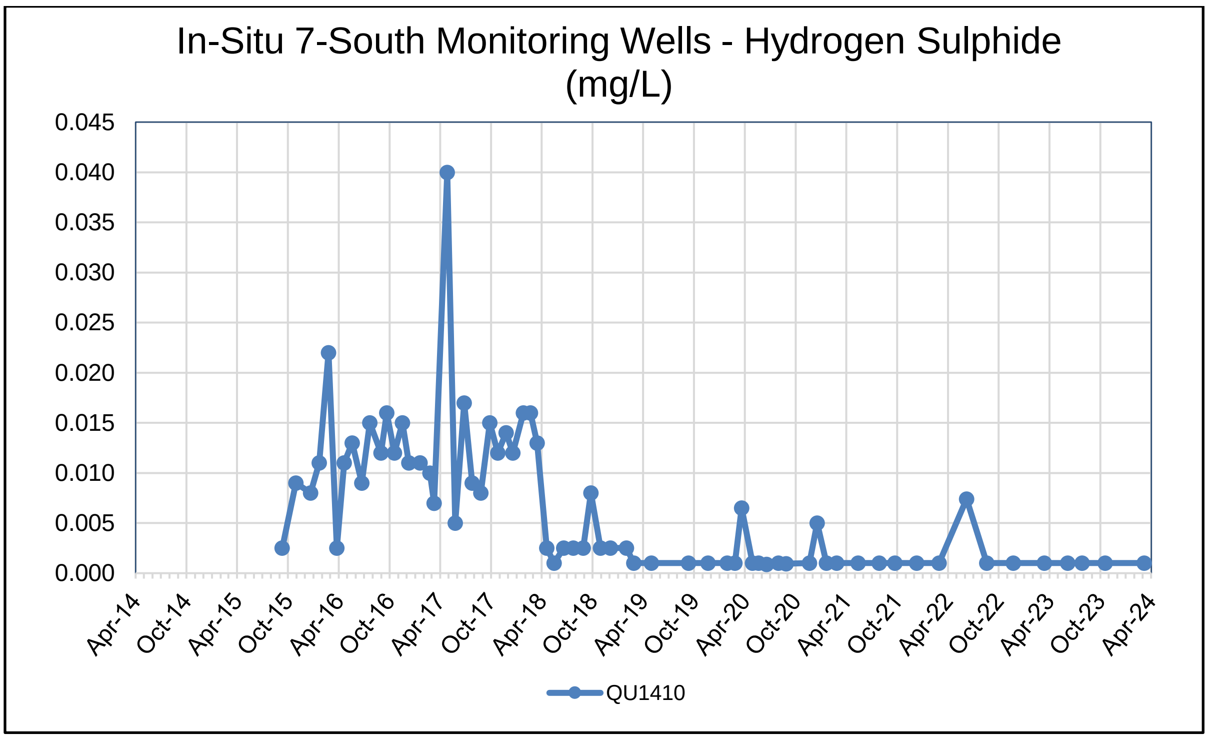
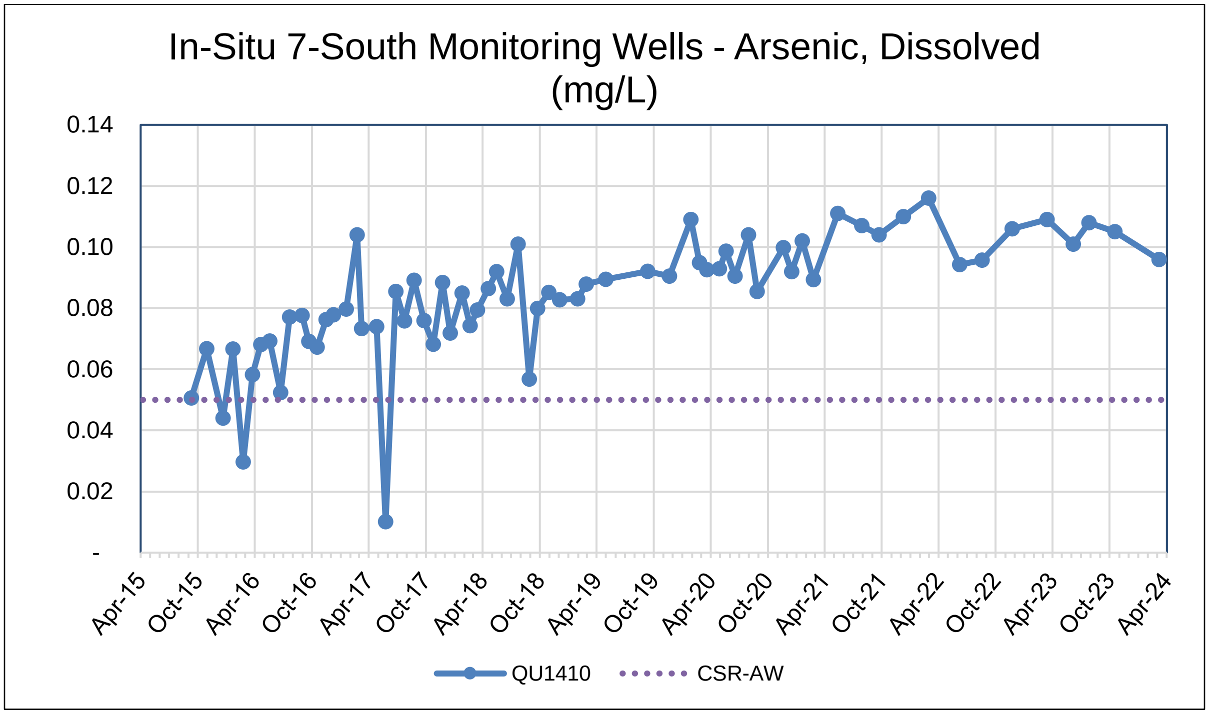


Figure 17: 7-South In-Situ – Dissolved Hardness, Sulphate and Hydrogen Sulphide as H_2S



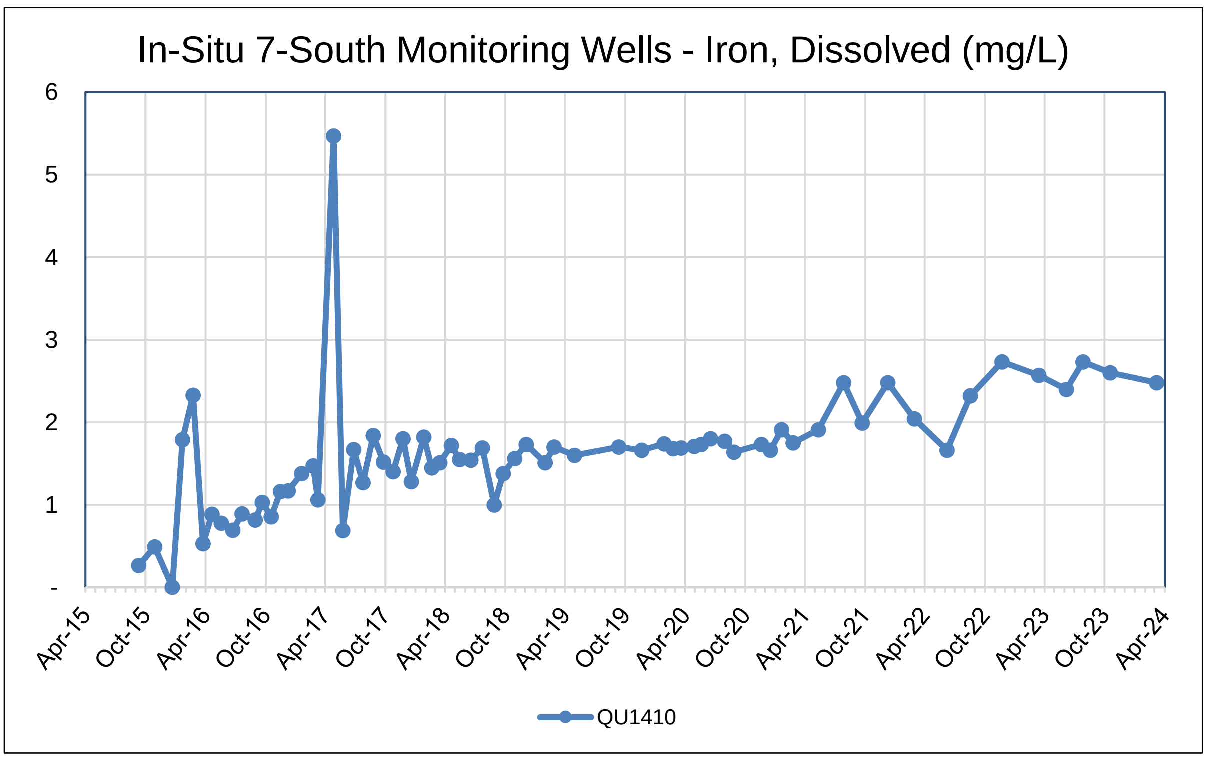


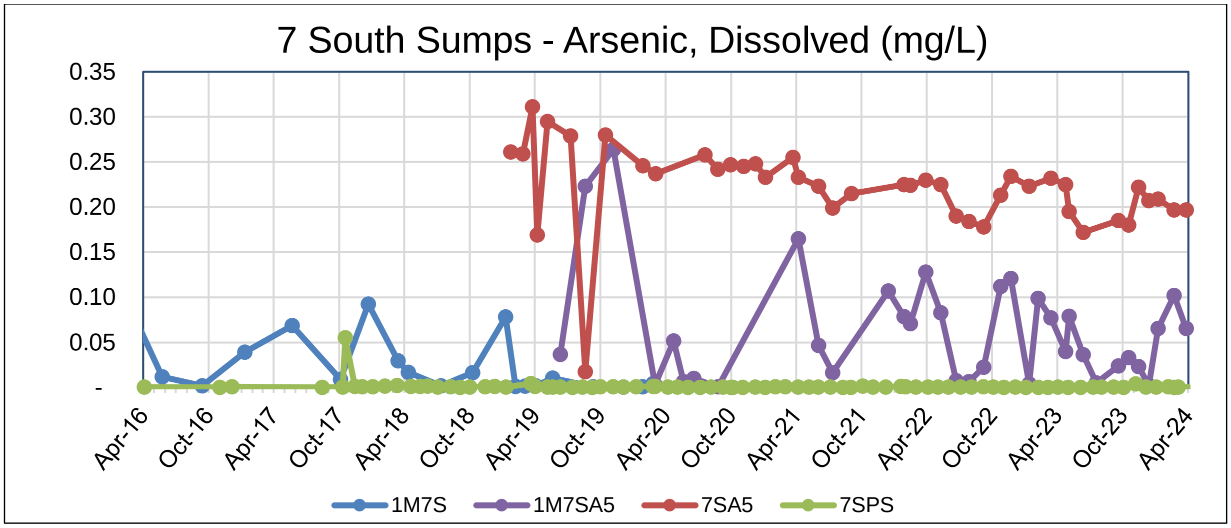
Figure 18: 7-South In-Situ Monitoring Well – Dissolved Arsenic and Iron

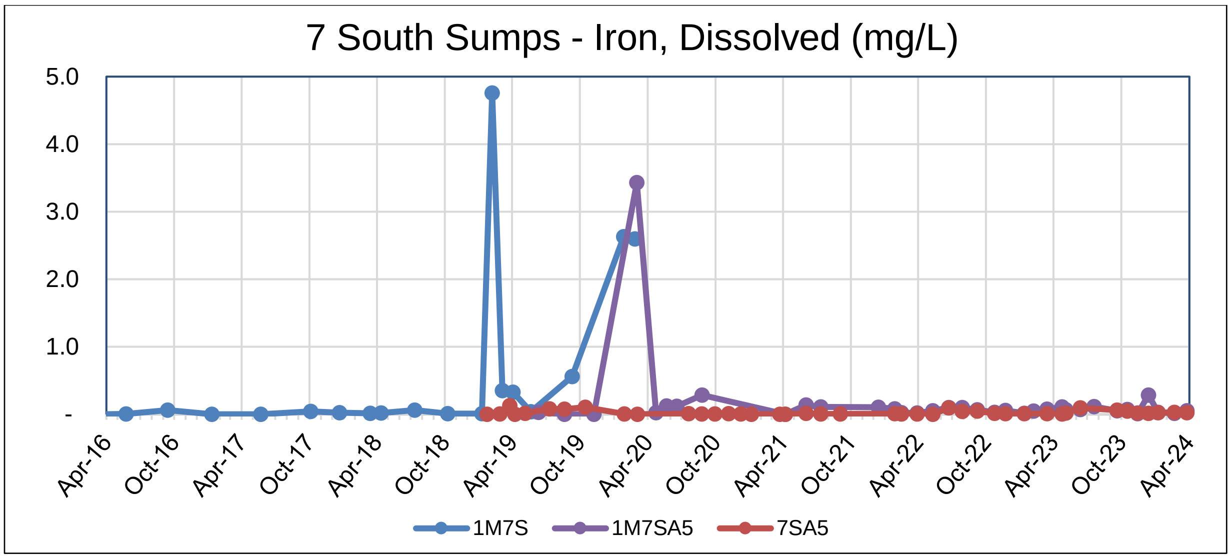
4.1.5.2 7-South Sumps

Water chemistry in the 7-South mine has been monitored through underground sump sampling in 1-Mains 7-South (1M7S) and 7-South Area 5 (7SA5). Since mining into Area 5 in 2019, the 1M7S sump has been combined water from 1M7S and 7SA5. The 1M7S was renamed 1M7SA5 to differentiate and characterize water chemistry. The 7SA5 is sampled separately to characterize the water quality from this location. The 7-South Portal Sump (7SPS) contains surface mine contact water.

Dissolved arsenic has shown fluctuations since monitoring has been established, with the higher concentrations observed throughout the wet seasons. This is 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 the underground sumps for mining purposes. The 7SPS contains low concentrations of arsenic in comparison. Dissolved iron in underground samples has displayed some pikes that seem to be suspicious and may be eliminated from the data set as outliers. Most results remain at consistently low concentrations. The 7SPS is contained in a sandstone bowl that becomes acidic and has elevated iron concentrations with peaks up to 105 mg/L in October 2017 since then iron has been on declining trend (Figure 19).

Samples from 1M7S / 1M7SA5 exhibit moderate levels of dissolved sulphate with 1M7S having low levels. 7SPS has moderately elevated sulphate, again with concentrations on a declining trend (Figure 20).





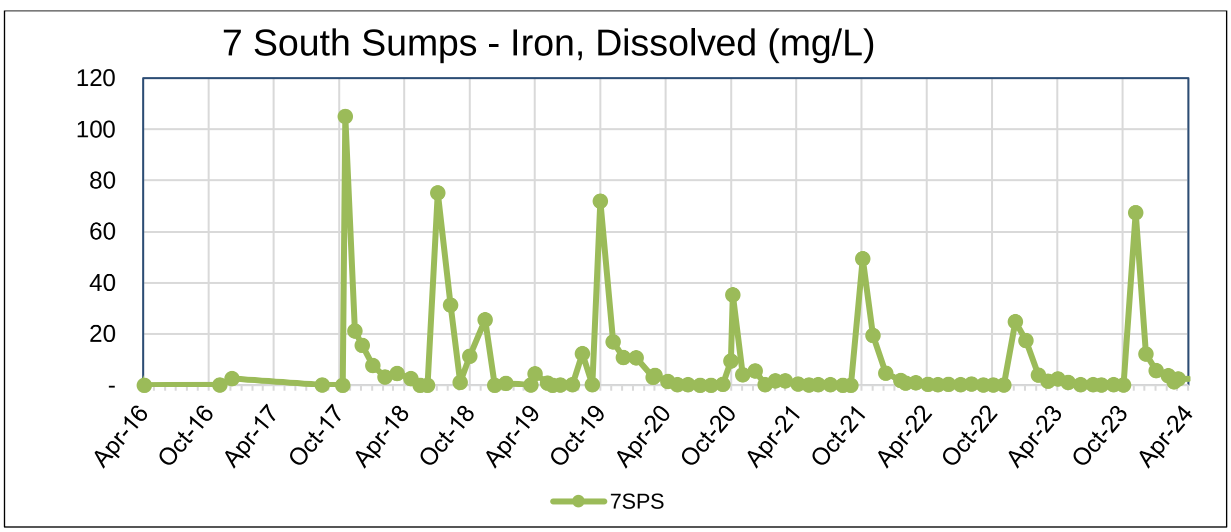


Figure 19: Dissolved Arsenic and Iron in 7-South Sumps

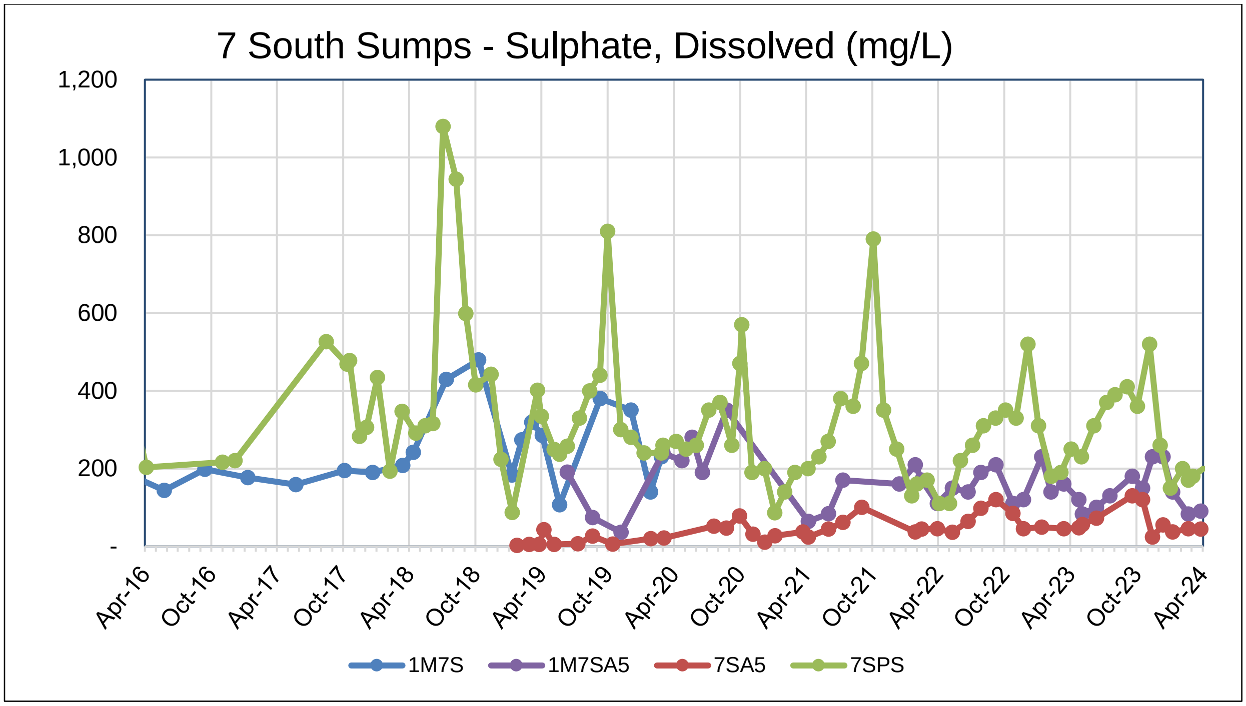


Figure 20: Dissolved Sulphate 7-South Sumps

4.1.5.3 7-South Ex-Situ

The primary focus of the 7-South ex-situ groundwater monitoring is to evaluate groundwater flow paths from Area 2 (permanent PAG CCR storage location) towards the Quinsam River; monitoring wells QU08-13 A and B satisfy this consideration. Monitoring well QU08-10, is situated to monitor groundwater transport from permitted mining reserves in 7-South Areas 4 and 5 (once flooded) 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. Water levels in this well are normally low with little groundwater infiltration resultant of underground dewatering efforts in Areas 4 and 5.

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. The 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-AL. QU08-10 displayed an increase in sulphate (Figure 21) and iron (Figure 23) in recent monitoring. The sulphate result for January 2021 appeared suspicious, however continued monitoring confirms that sulphate did have an increase in concentrations at QU08-10 with the highest result appearing March 6, 2023 (590 mg/L). Most results are following a trend based on season and groundwater fluctuation.

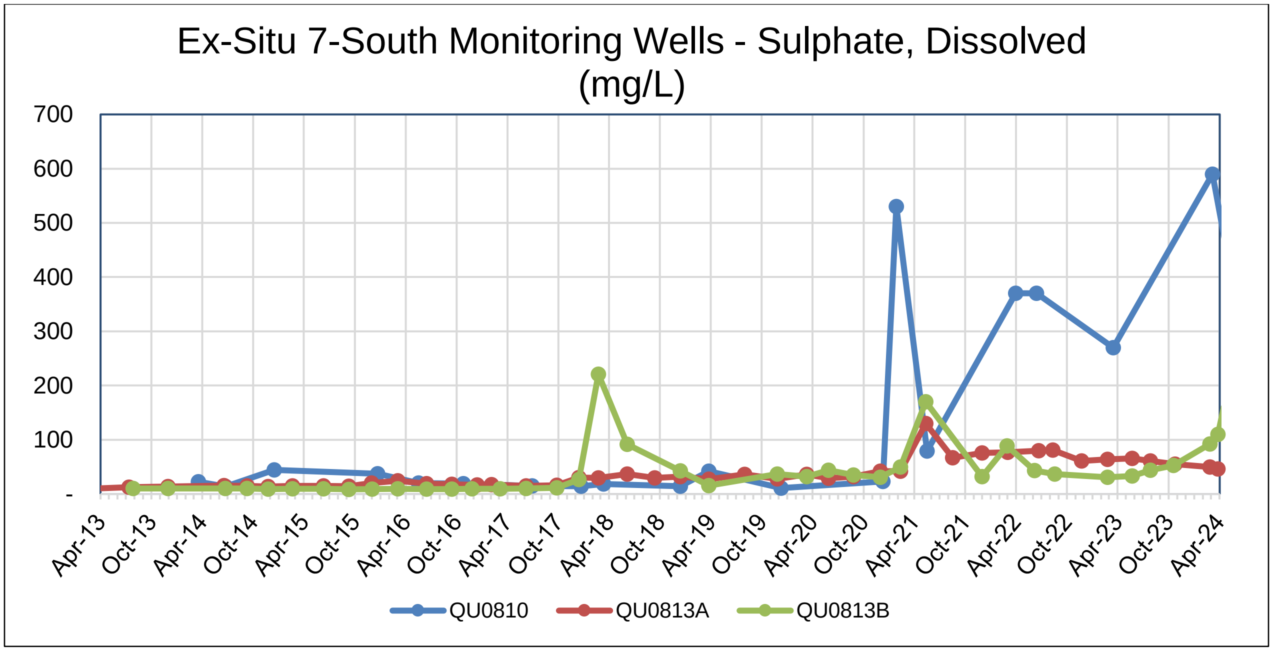


Figure 21: 7-South Ex-Situ Monitoring Wells - Dissolved Sulphate

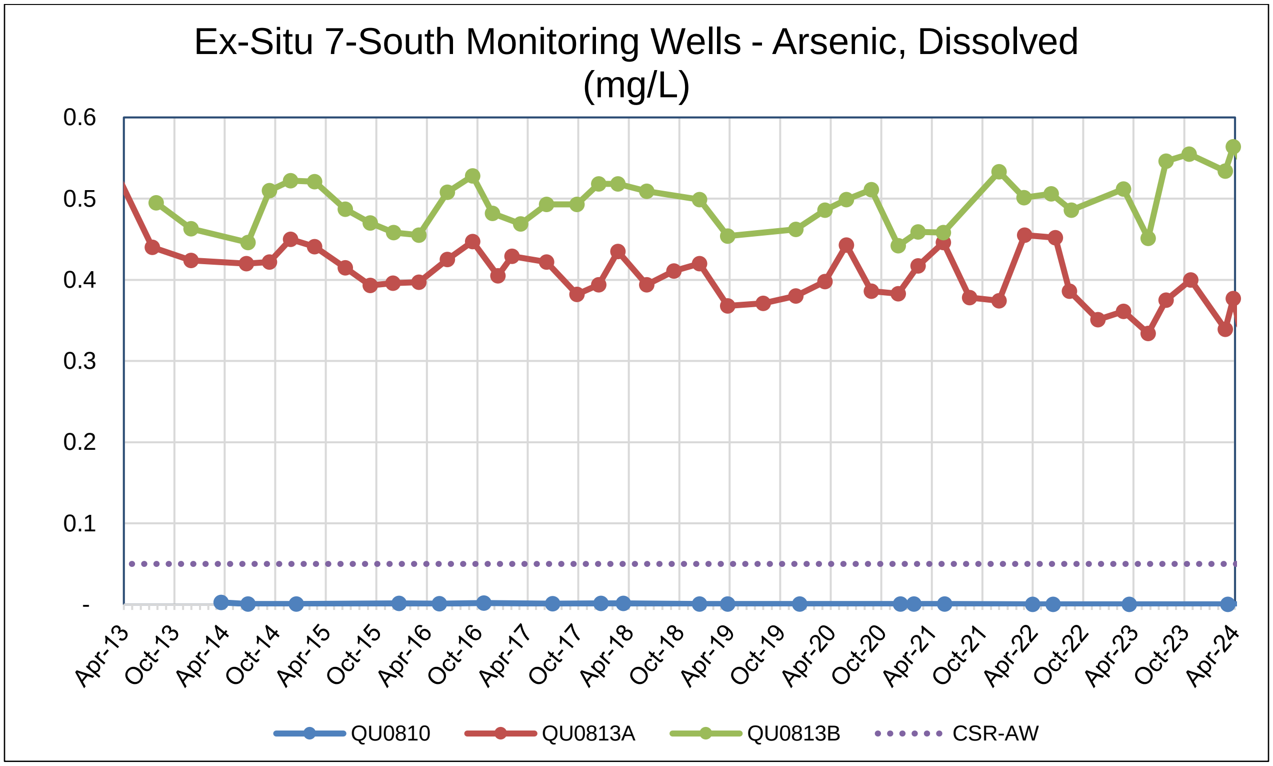


Figure 22: 7-South Ex-Situ Monitoring Wells - Dissolved Arsenic

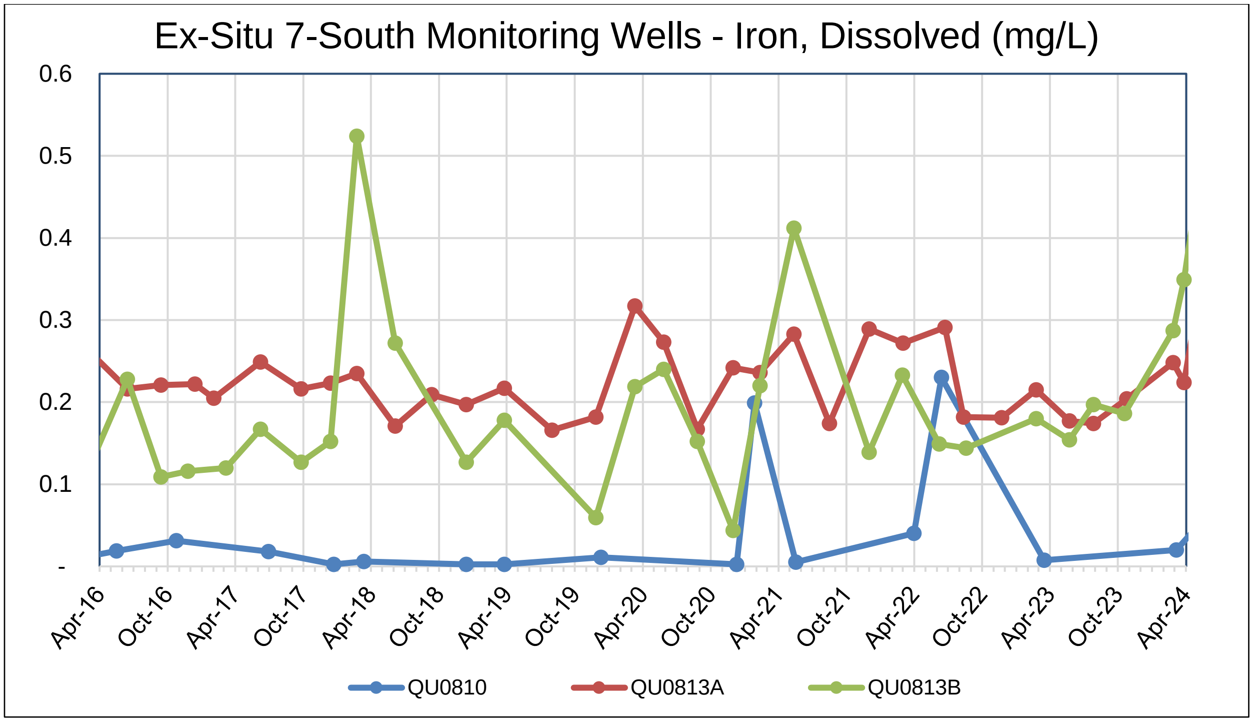


Figure 23: 7S Ex-Situ Monitoring Wells - Dissolved Iron

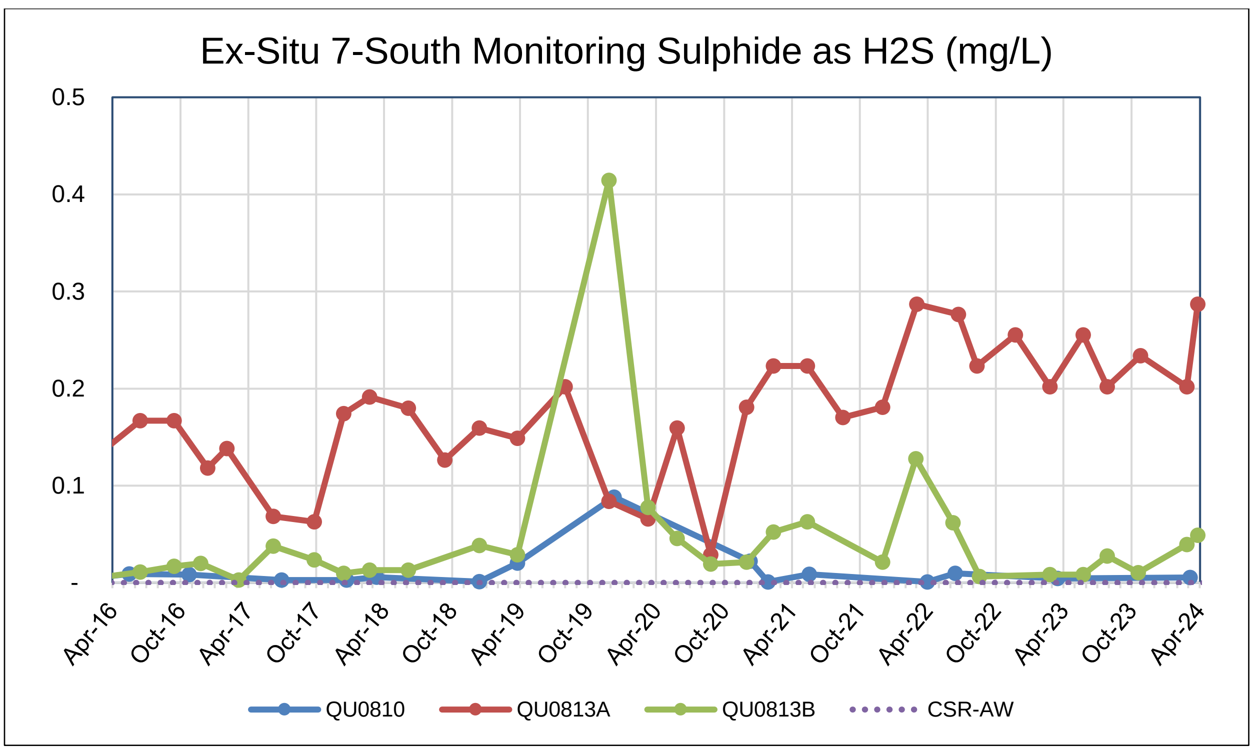


Figure 24: 7S Ex-Situ Monitoring Wells – Sulphide as Hydrogen Sulphide (H_2S)

4.1.6 2/3 South Monitoring Wells

4.1.6.1 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 Passive Treatment System (PTS) influent. 2-South flooded mine void mine 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 440 mg/L (MW00-4) and 380 mg/L to 760 mg/L (QU11-11) historically, displayed in (Figure 25), below. 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 low water reservoirs and flooding in the mine void where metals and sulphate accumulate. Concentrations decrease in fall and winter after an initial flushing of the mine walls. Distinct increases of dissolved arsenic and iron in mid-2017 at QU11-11 is a direct result of changing to field filtering and preservation on site. Dissolved iron peaks observed at both QU11-11 and MW00-4 typically correlate with low water elevations in the mine void (Figure 26). An increase in dissolved iron was observed on March 5, 2023 (0.119 mg/L) at MW00-4.

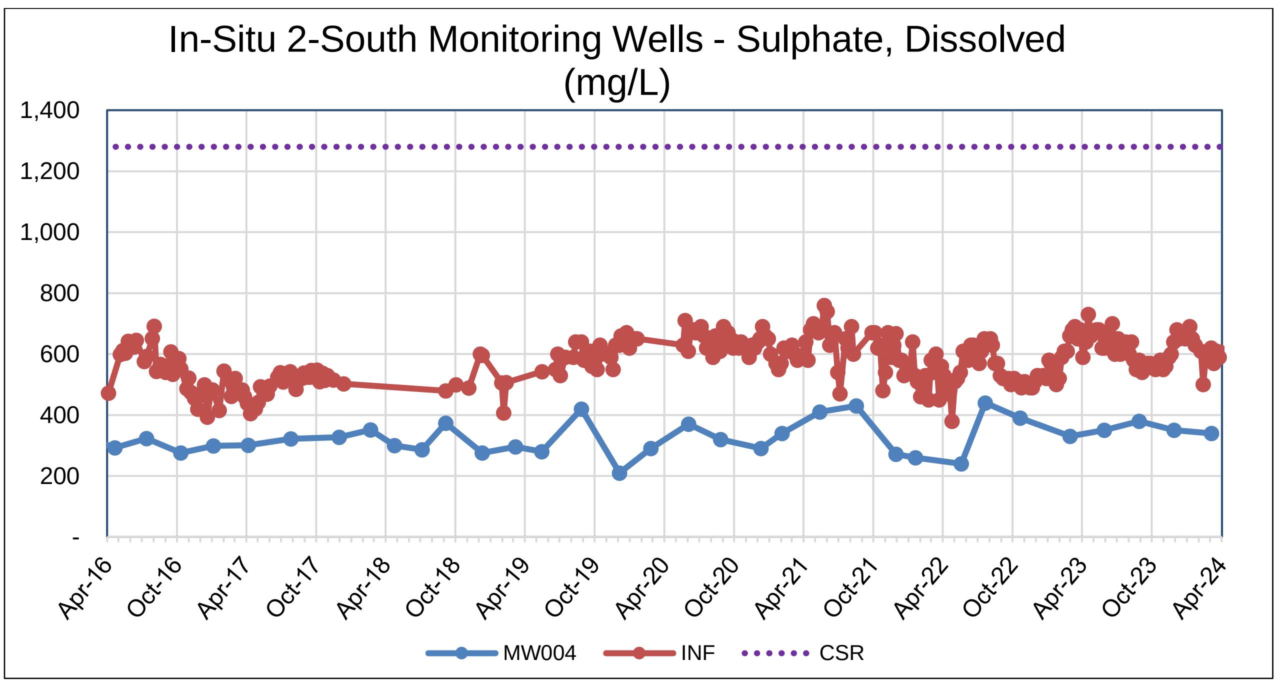
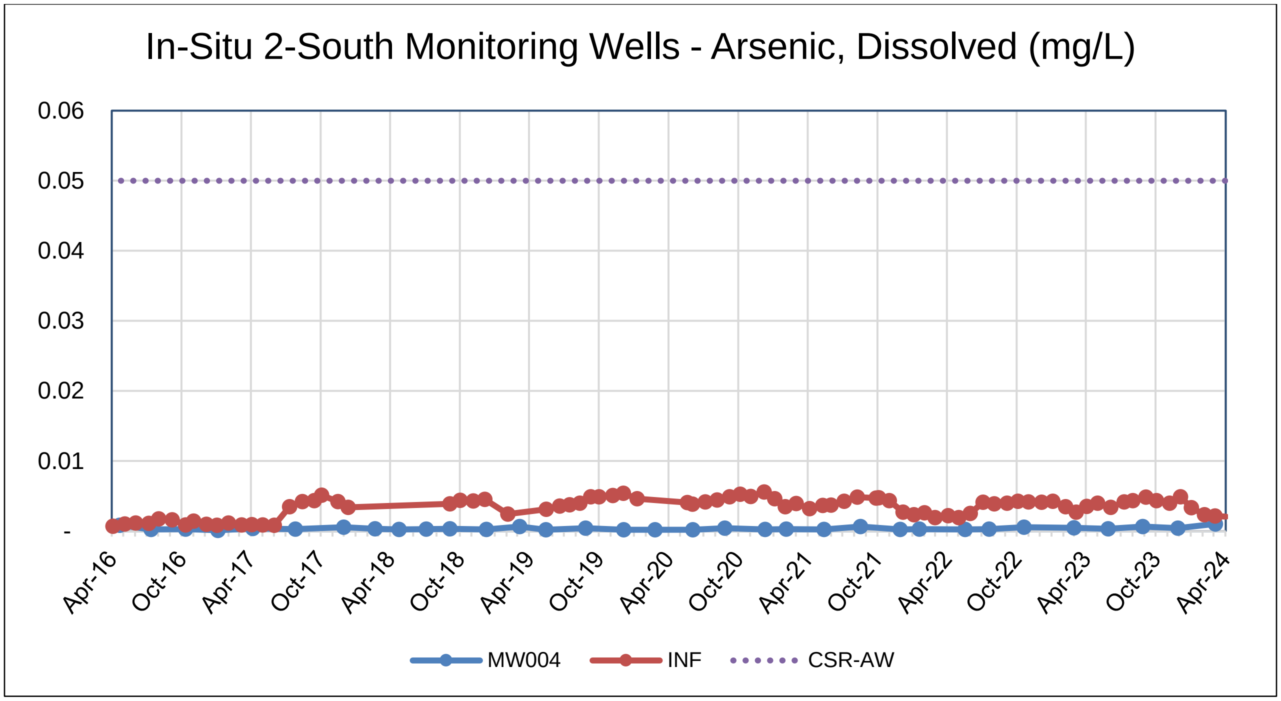


Figure 25: In-Situ 2-South Monitoring Wells - Dissolved Sulphate



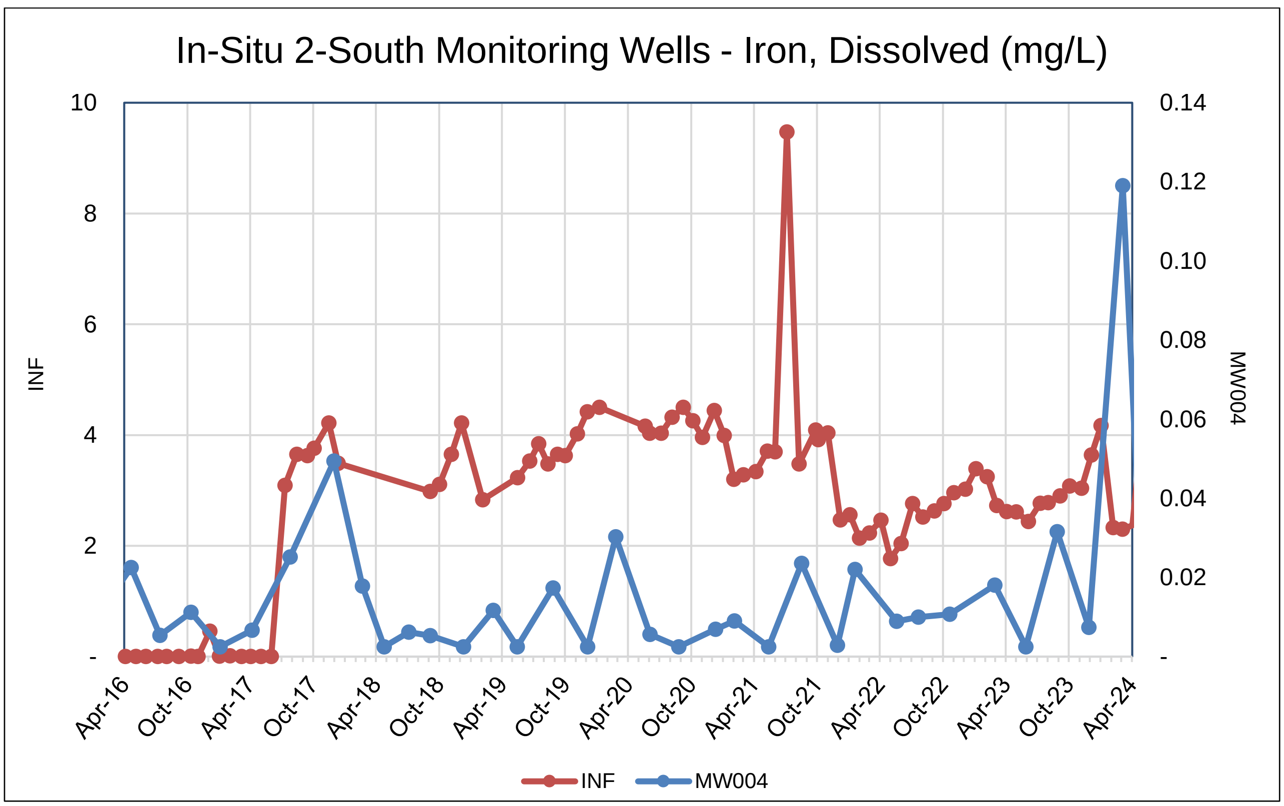


Figure 26: In-Situ 2-South Monitoring Wells - Dissolved Arsenic and Iron

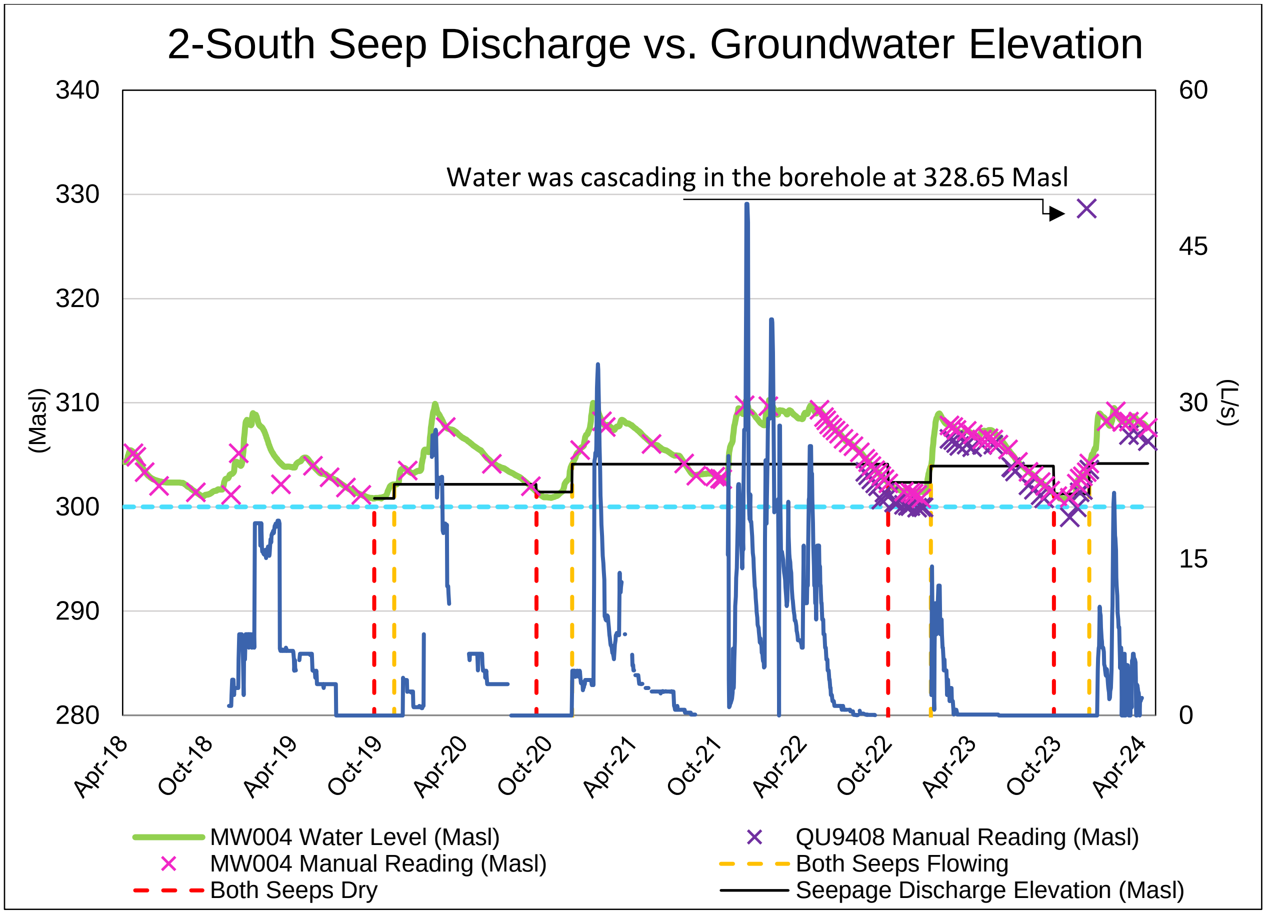


Figure 27: 2-South Seep Discharge versus Groundwater Elevation

The relationship between the underground flooded mine void water elevation, measured at MW00-4 and flow at the Long Lake seeps continues to be established, Figure 27 above. The threshold level for seep flow is approximately 301.5 Masl for LLS and 303.5 Masl for LLSM measured at MW00-4, the coal seam is situated at 300 Masl.

4.1.6.2 2 & 3 South In-situ and Ex-Situ Wells

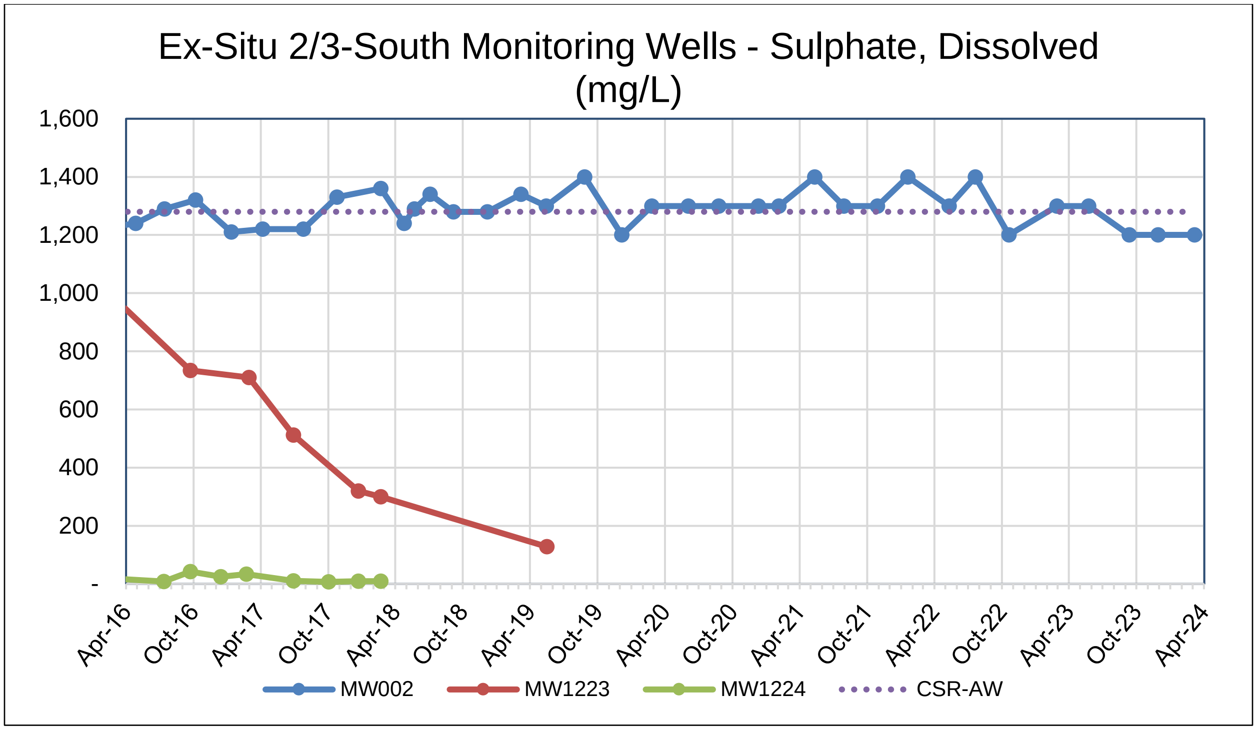
Monitoring wells in the 2 and 3 South areas exhibit elevated concentrations of sulphate and some metals based on their proximity to the 2-South and 3-South PAG-CCR storage facilities and past surface disturbance, both open pit and underground mining activities. These wells include MW00-2 (in-situ) located 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 display 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 has displayed an elevated but stable trend at or just above the CSR-AL of 1280 mg/L and declining in 2024.



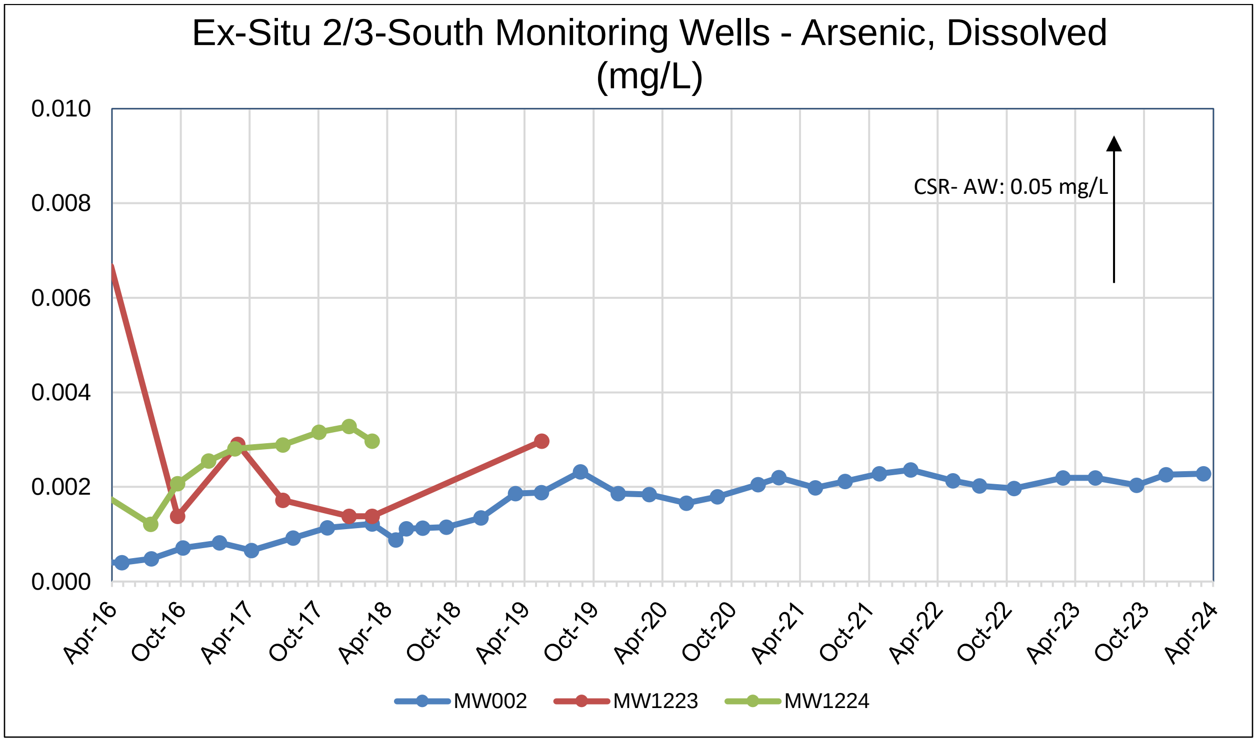
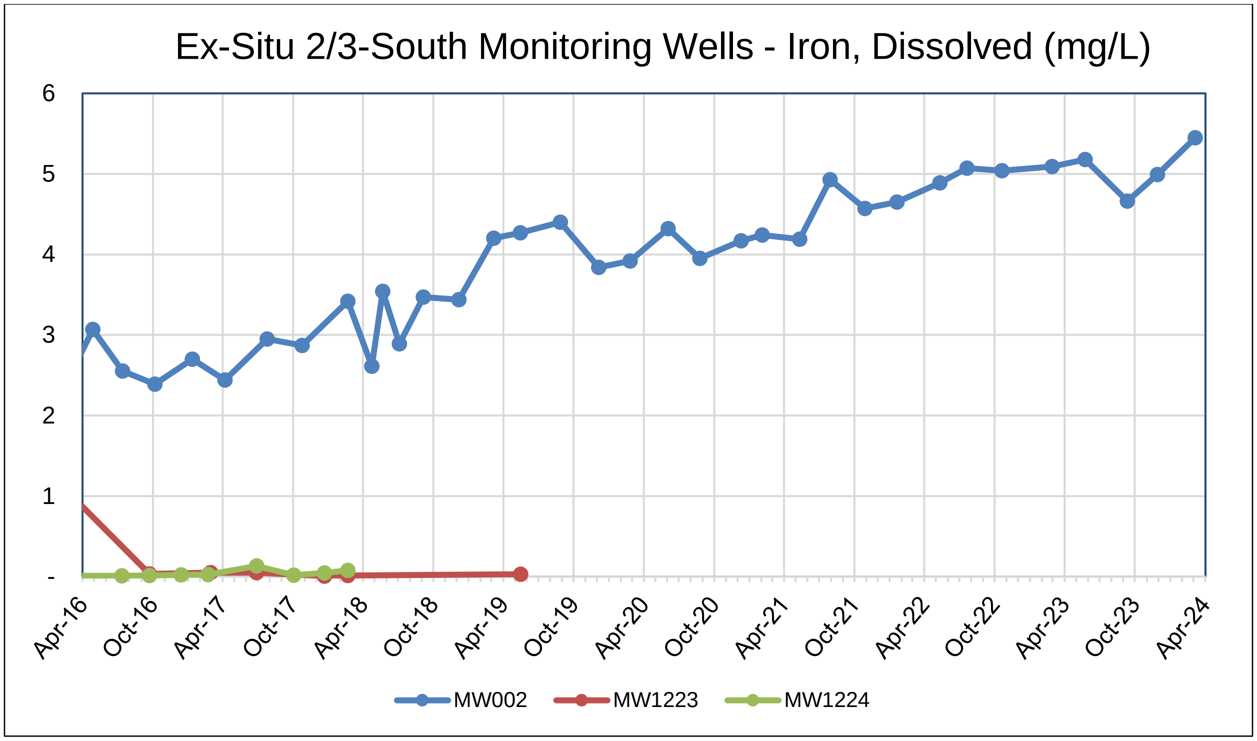


Figure 28: Ex-Situ/ In-Situ 2/3 South Monitoring Wells - Dissolved Sulphate and Arsenic



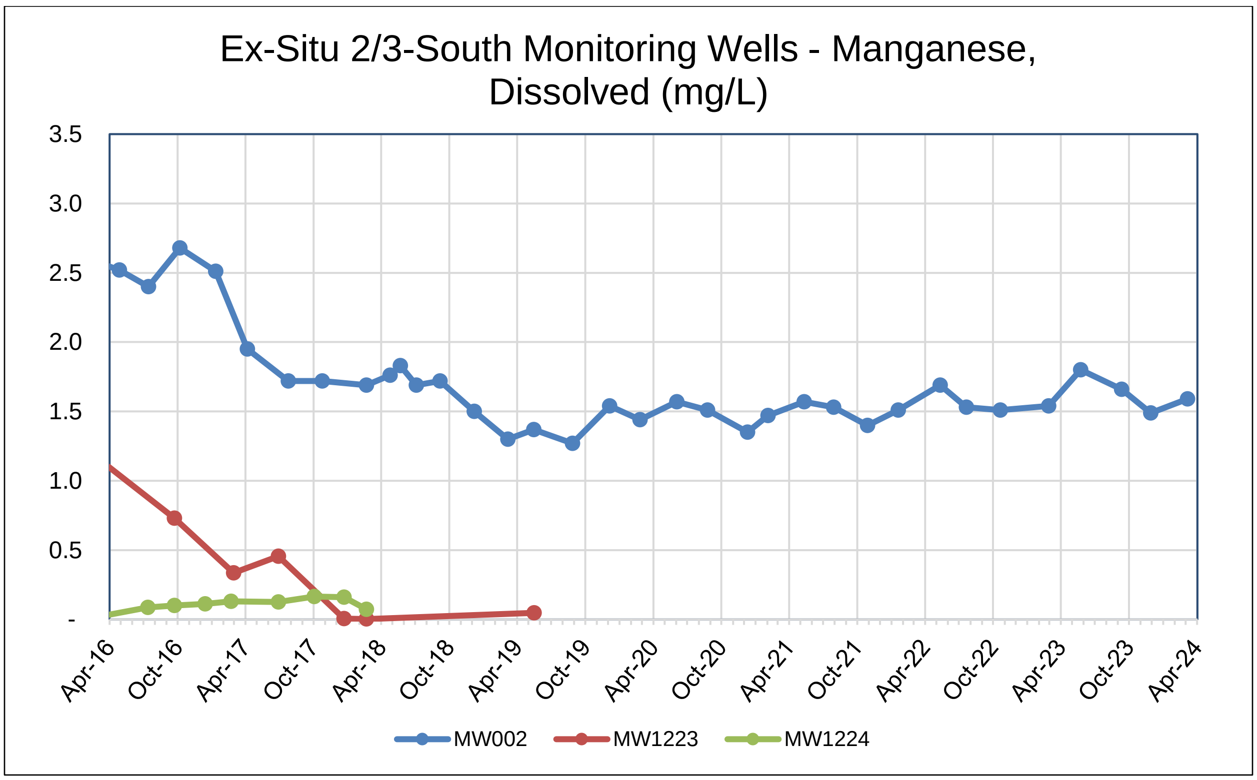


Figure 29: Ex-Situ/ In-Situ 2/3 South Monitoring Wells - Dissolved Iron and Manganese

4.1.7 4-South Mine Area

4.1.7.1 4-South Mine Pool

Predicted mature mine pool source terms were developed for the flooded 4-South mine and were 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 slightly lower compared to previous monitoring years and continue to demonstrate a decline in iron, manganese, and sulphate; expect for June 2023, where peaks were observed for all parameters, most likely attributed to lower mine void water levels.

Table 10 below displays the minimum, maximum, average, 90^{th} percentile, and comparison between predicted to observed water quality during this monitoring period. Results from 2 sampling sets were averaged for QU11-01 from sampling completed in 2023. The averaged parameters were not above the predicted concentration levels. The 90^{th} percentiles for pH, arsenic and boron were above the source terms.

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

QU11-01	Flood Mature Mine Pool Source Terms	2023 Statistic Results				
		COUNT	MIN	MAX	AVG	90TH PERCENTILE
pH-F	5.5 - 6.5	2	6.59	6.8	6.695	6.779
Acidity83	450	1	49.4	49.4	49.4	49.4
Alk-T		1	69	69	69	69
Al-D	0.024	2	0.003	0.0074	0.0052	0.00696
As-D	0.0924	2	0.12	0.248	0.184	0.2352
B-D	0.637	2	1.25	2.21	1.73	2.114
Cd-D	0.000085	2	0.00001	0.00001	0.00001	0.00001
Co-D	0.063	2	0.0002	0.0002	0.0002	0.0002
Cu-D	0.0564	2	0.0002	0.0002	0.0002	0.0002
F-D	1	2	0.42	0.49	0.455	0.483
Fe-D	257	2	133	253	193	241
Mn-D	5.97	2	1.81	3.92	2.87	3.71
Se-D	0.0004	2	0.0001	0.0001	0.0001	0.0001
SO4-D	2060	2	1200	1300	1250	1290
Zn-D	0.0712	2	0.005	0.005	0.005	0.005

All units in mg/L
Highlighted indicates concentration is above expected or greater than worst case.
Note: If the Result < DL, then the DL value was used.

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, 2011 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 September 2022 until September 2023 and a new logger was deployed in February 2024 as noted in Figure 30. Currently there is a pressure transducer in this mine pool to verify water elevation. Further investigation is warranted to re-establish and confirm the mine pool elevation as there are some anomalies in the recent data.

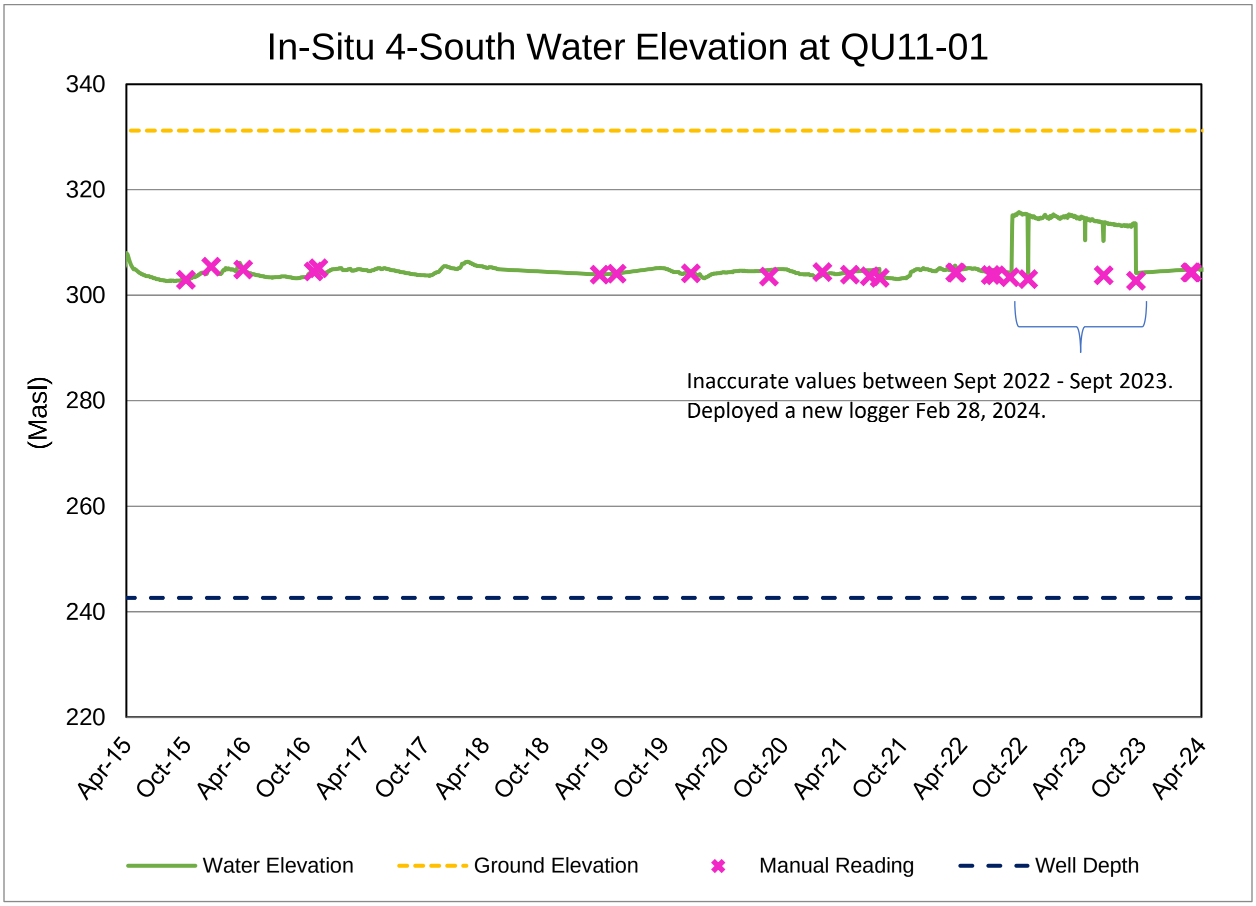


Figure 30: 4-South Mine Pool Water Elevation at QU11-01

The mine pool has remained flooded at a steady elevation limiting exposure and oxidation of mine walls from fluctuating water levels. Most redox reactive POI concentrations have trended downward and are stabilizing (iron, manganese, and sulphate). An increase in iron and manganese appeared in June 2023. Arsenic displayed a steady trend stabilizing just above predicted mine pool source terms in 2019 with a slight peak in March 2022 and further increase was observed again in June 2023 (0.248mg/L), (Figure 31 to Figure 34). Parameters seem to have high but stable trends with some seasonal peaks.

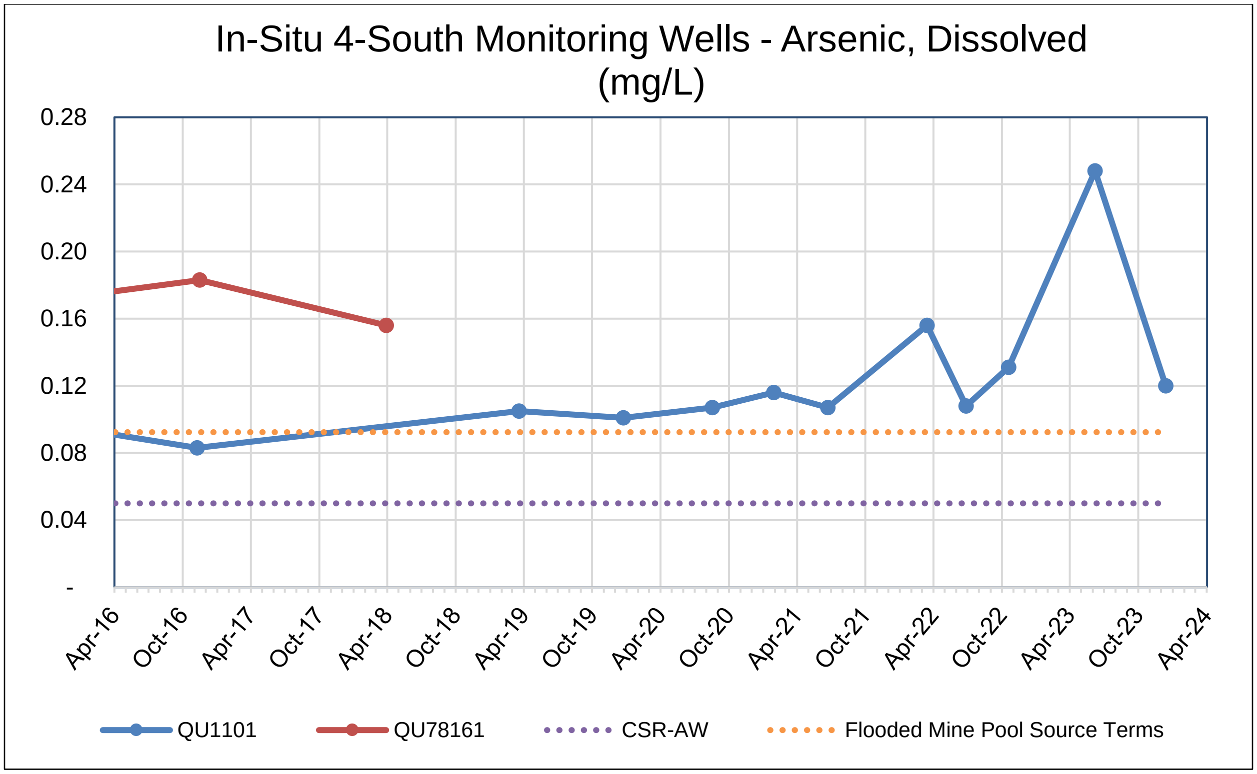


Figure 31: In-Situ 4-South Monitoring Wells - Dissolved Arsenic

The 4-South mine pool is dominated by iron reducing conditions with elevated concentrations of iron and sulphate. Chemical stratification is characterized by 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 133 mg/L to 257 mg/L.

Lorax observed that sulphate has an opposite trend to fluoride; sulphate is found in lowest concentrations in the formation water (QU10-08) and highest in the mine pools. Sulphate concentrations are elevated and follow a similar profile to dissolved iron where concentrations have been generally decreasing since 2016 to below the predicted values of the flooded mine pool (Figure 33). Fluoride displaying a stable trend in QU11-01 indicting the mine pool is not being influenced by younger formation waters as displayed in Figure 34.

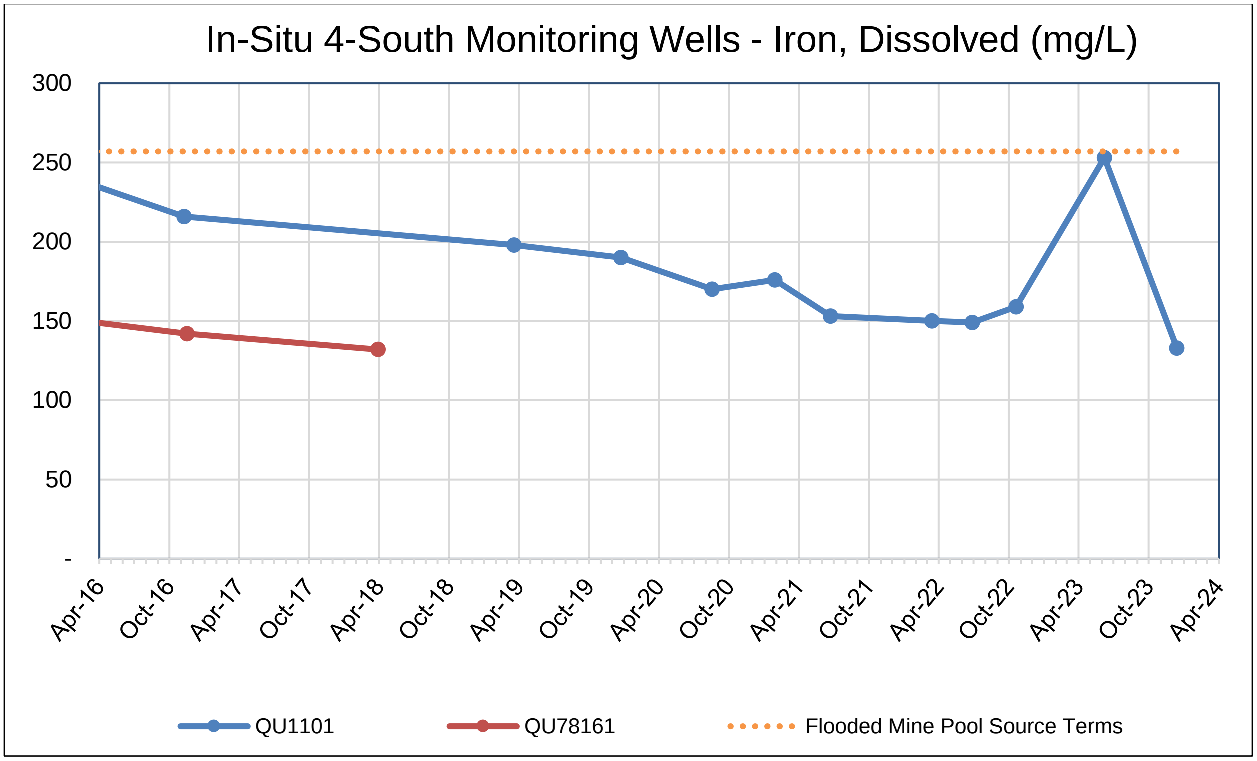
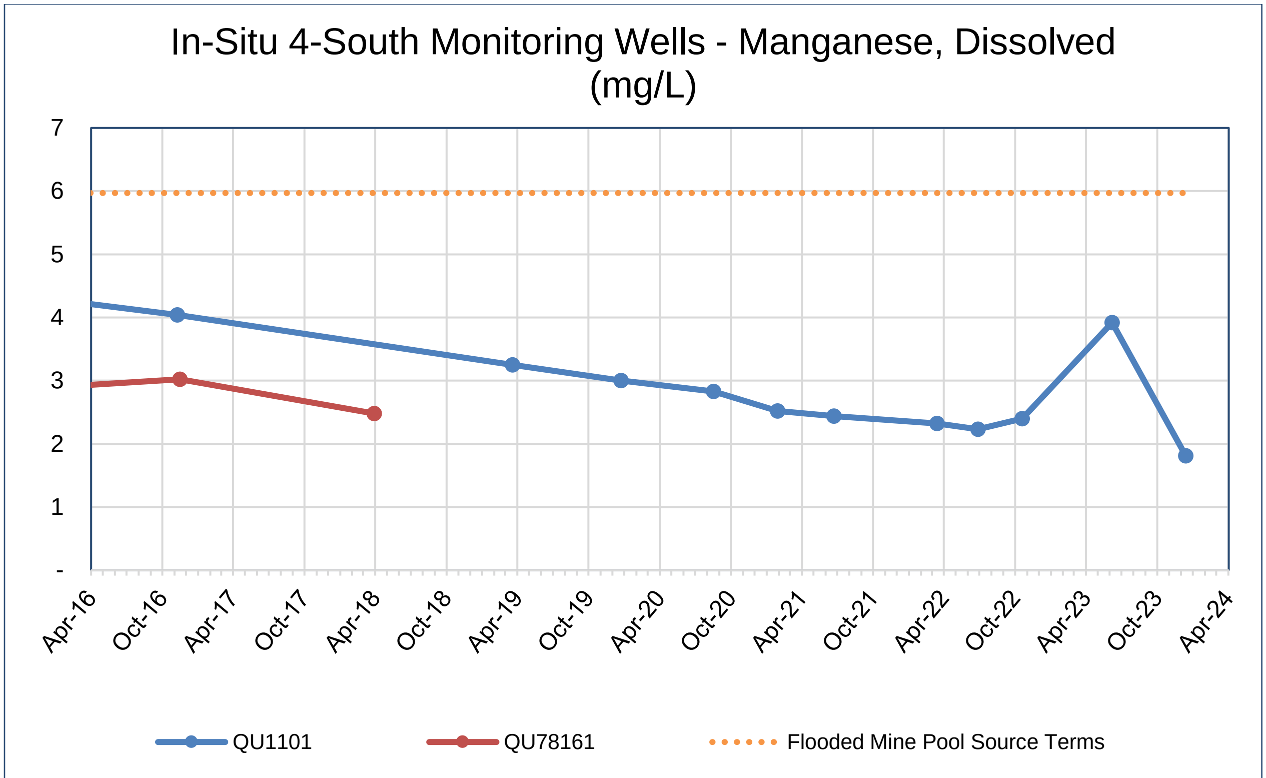


Figure 32: In-Situ 4-South Monitoring Wells - Dissolved Iron



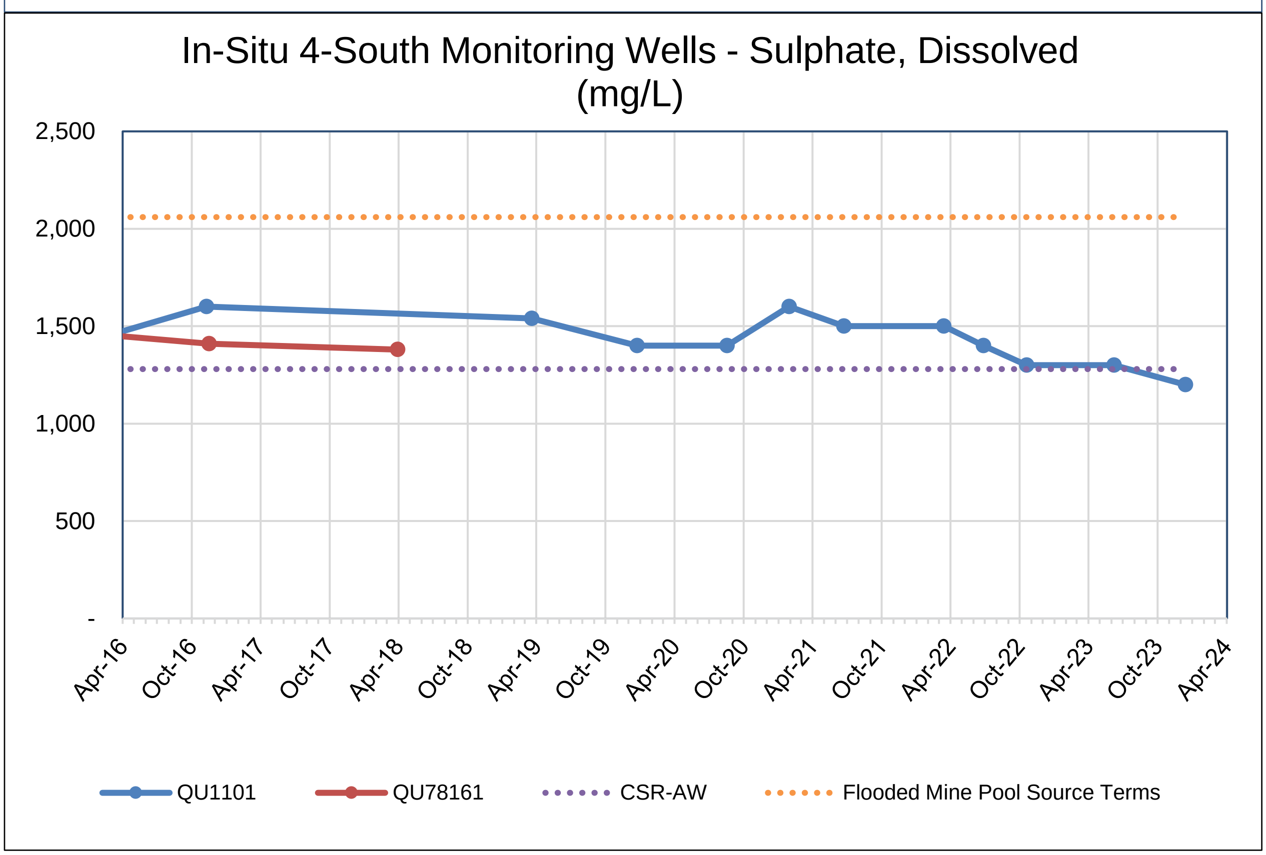


Figure 33: In-Situ 4-South Monitoring Wells - Dissolved Manganese and Sulphate

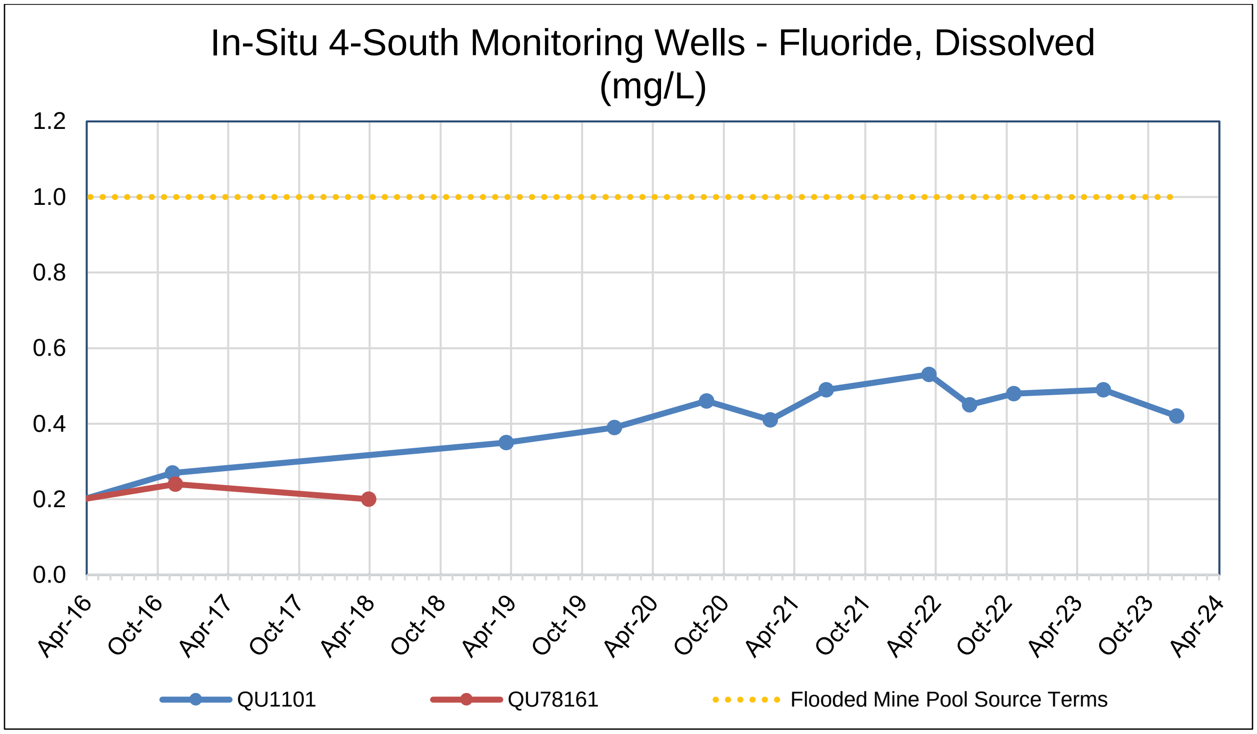


Figure 34: In-Situ 4-South Monitoring Wells - Dissolved Fluoride

4.1.7.2 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 QU10-08 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
- QU10-08 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 displayed in Figure 35 to Figure 37 below.

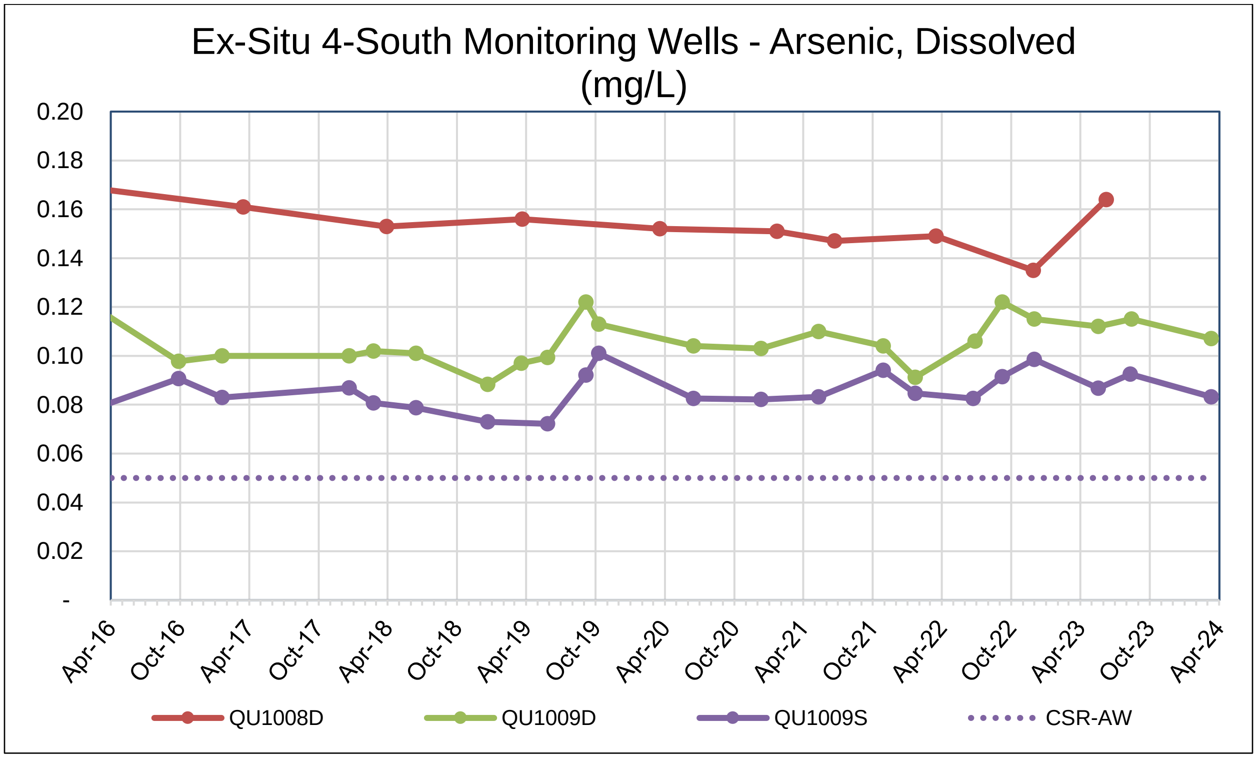
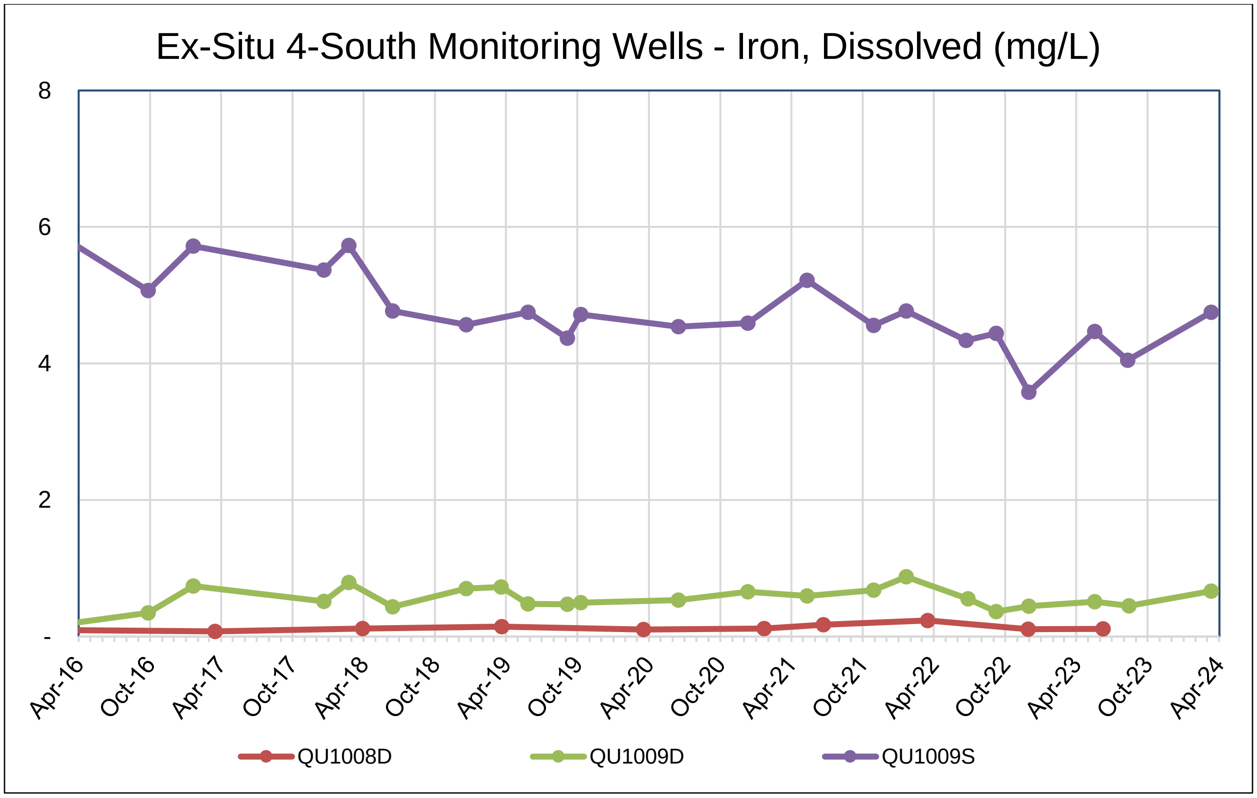


Figure 35: Ex-Situ 4-South Monitoring Wells - Dissolved Arsenic



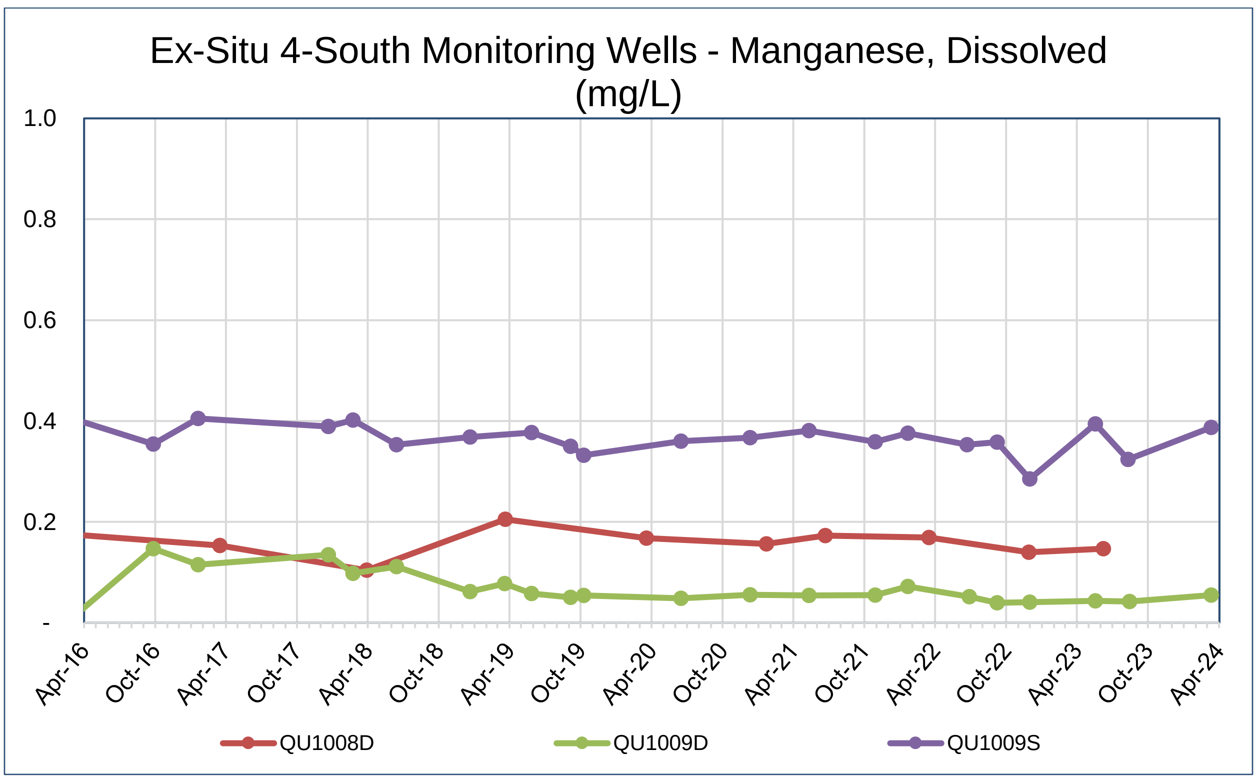
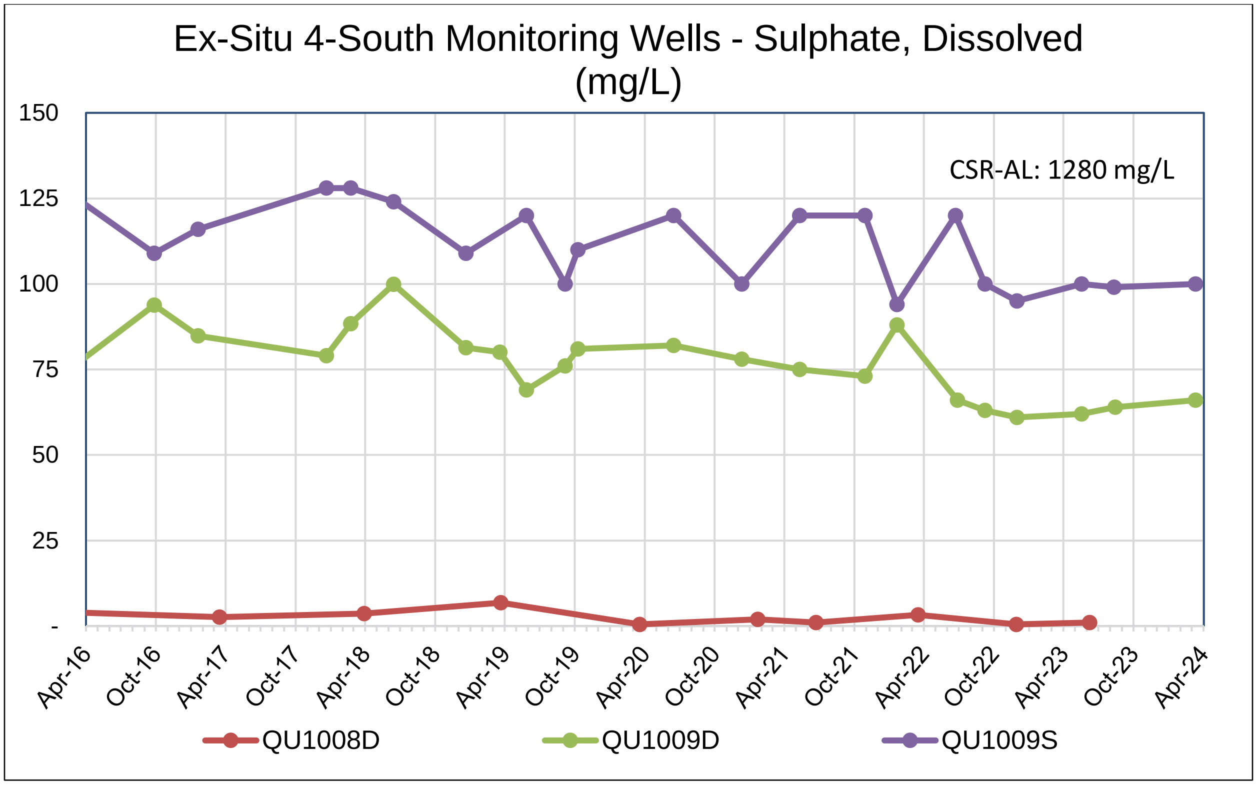


Figure 36: Ex-situ 4S Monitoring Wells – Dissolved Iron and Manganese



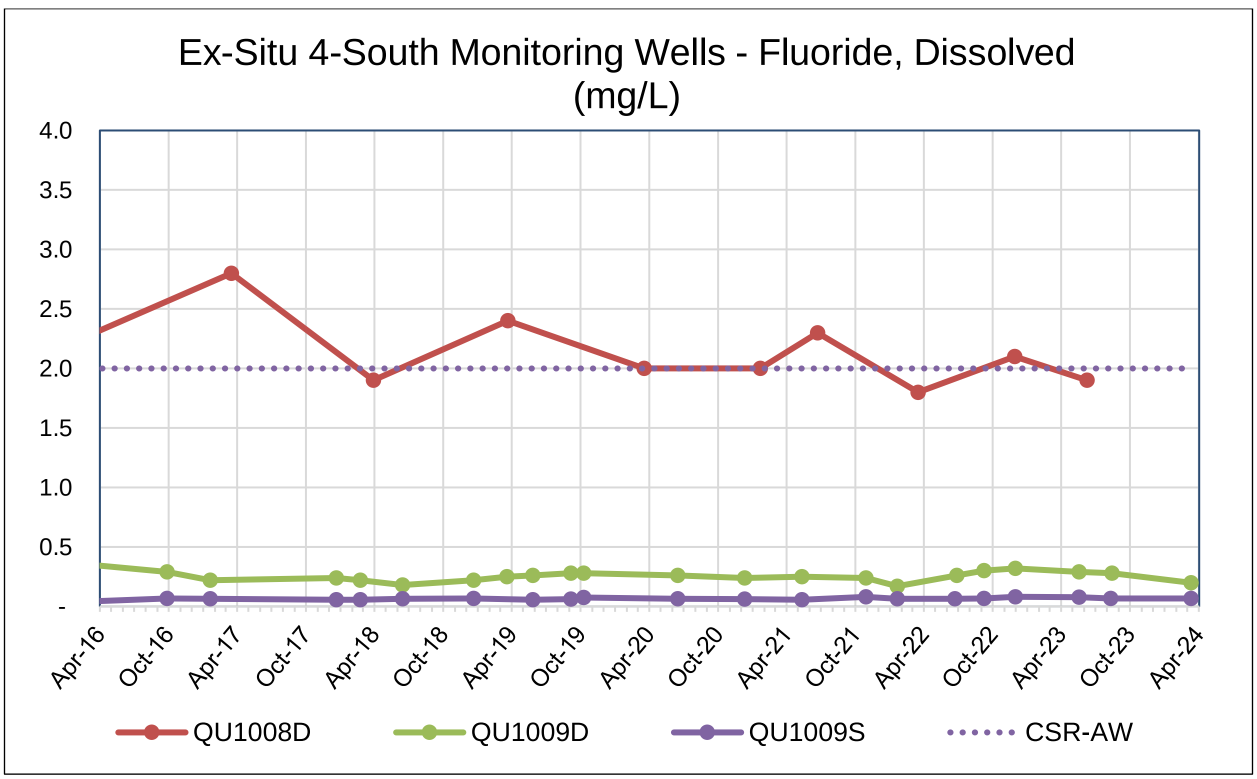


Figure 37: Ex-situ 4S Monitoring Wells – Dissolved Sulphate and Fluoride

Notable observations include:

- Dissolved arsenic concentrations were elevated above CSR-AL standards (0.05mg/L) at each well for all sampling events, reflecting historic results.
- Dissolved iron was below 1.0 mg/L in all wells except in QU10-09 S, where historical to present results ranged from 3.58 mg/L to 5.57 mg/L
- Manganese is highest in wells QU10-09 S and QU10-08 D
- Dissolved sulphate levels were generally low (as observed in the past), highest in QU10-09 S & D and lowest at QU10-08 D
- Fluoride reduced slightly below the CSR-AL standards in well QU10-08 D during 2023 sampling event. Fluoride is an indication of younger formation waters.

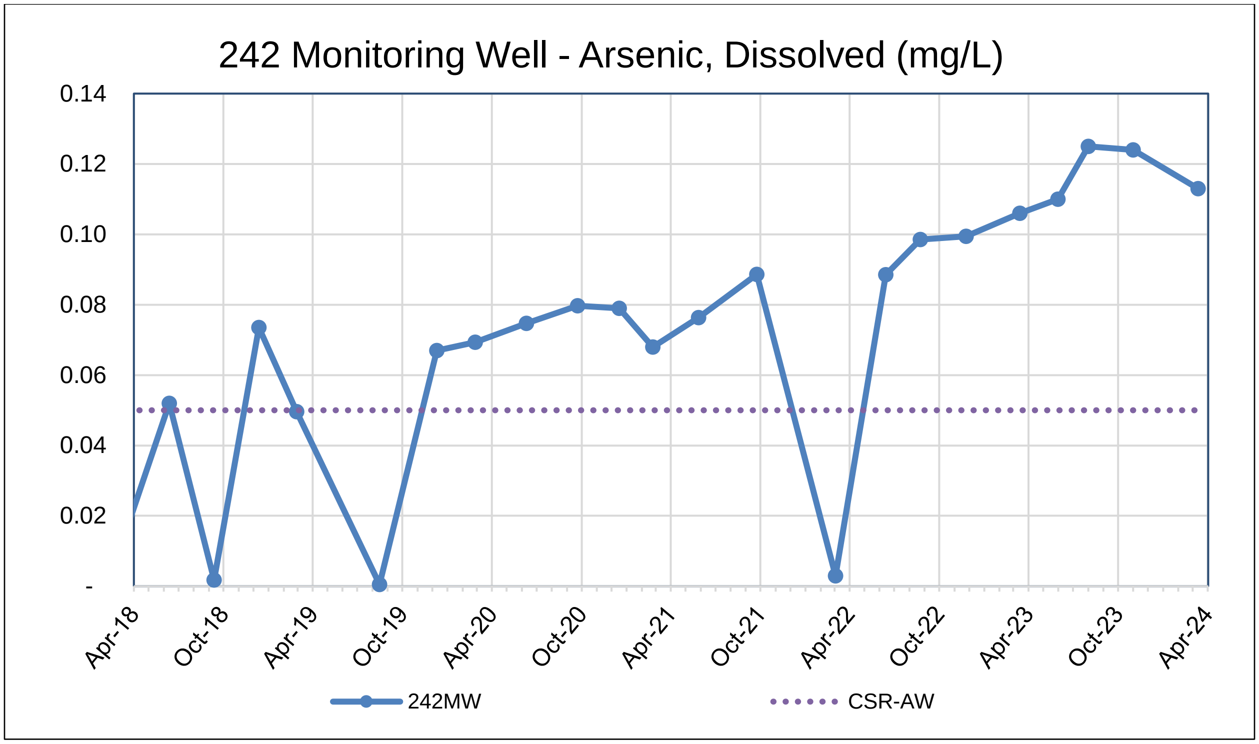
4.1.8 242 Mine

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 borehole drilled into the underground workings.

The pH of the flooded waters of the 242-mine averaged 6.35 with low conductivity averaging 265µs/cm. 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 (

Figure 38) displayed a low concentration in March 2022 and it is unclear what it is related too. Dissolved fluoride remains in low concentrations indicating limited influence of younger formation water.



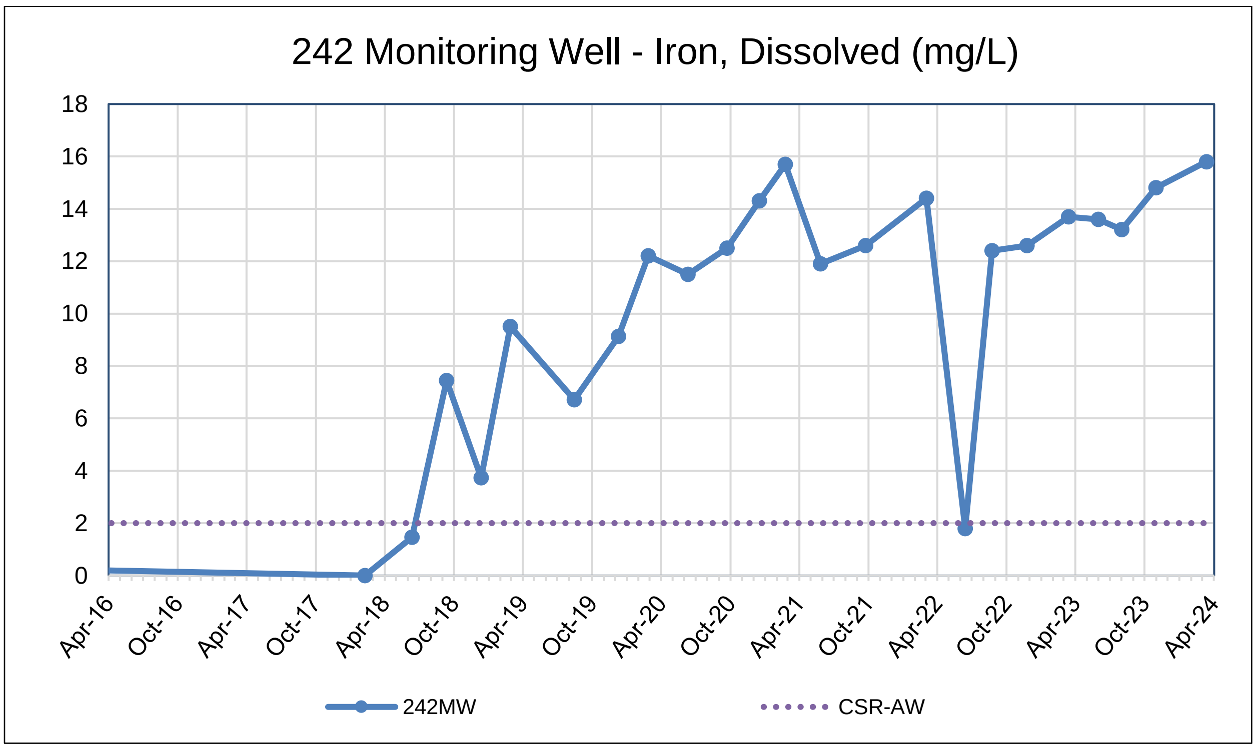
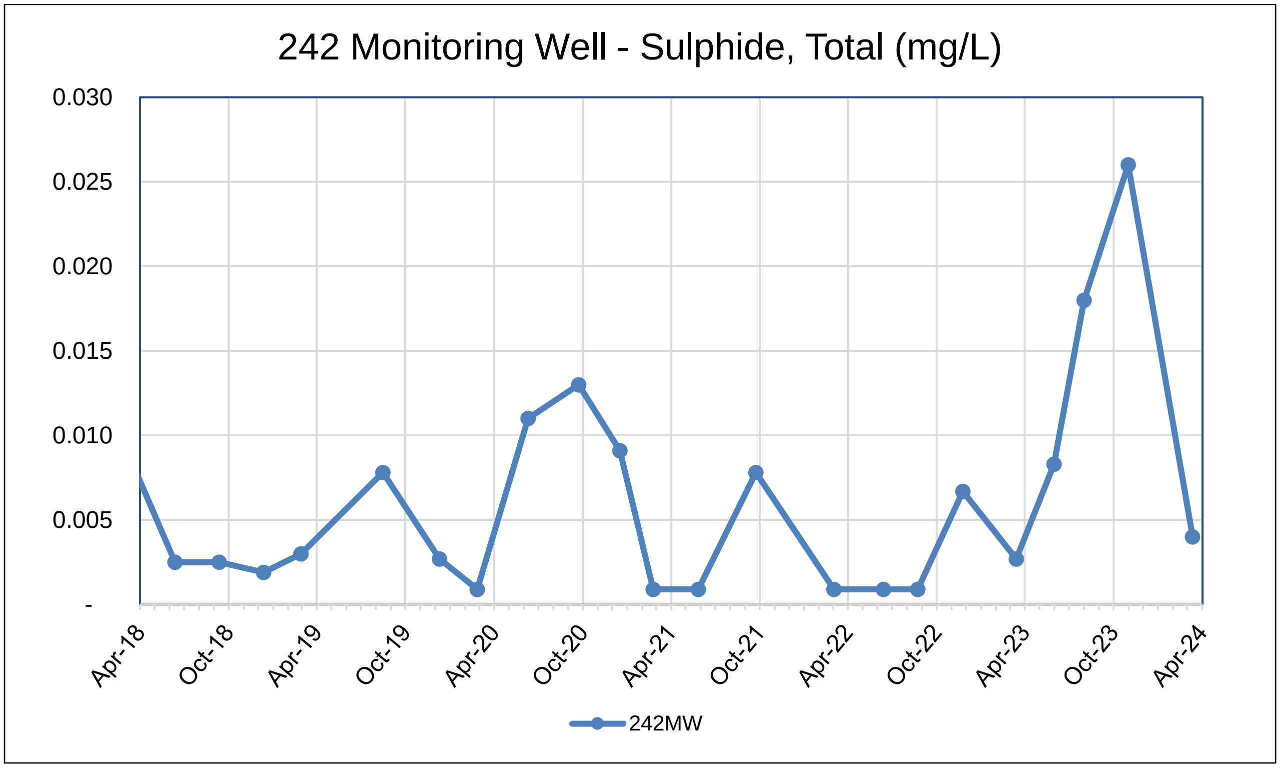


Figure 38: In-situ 242 Mine Pool –Dissolved Arsenic and Iron



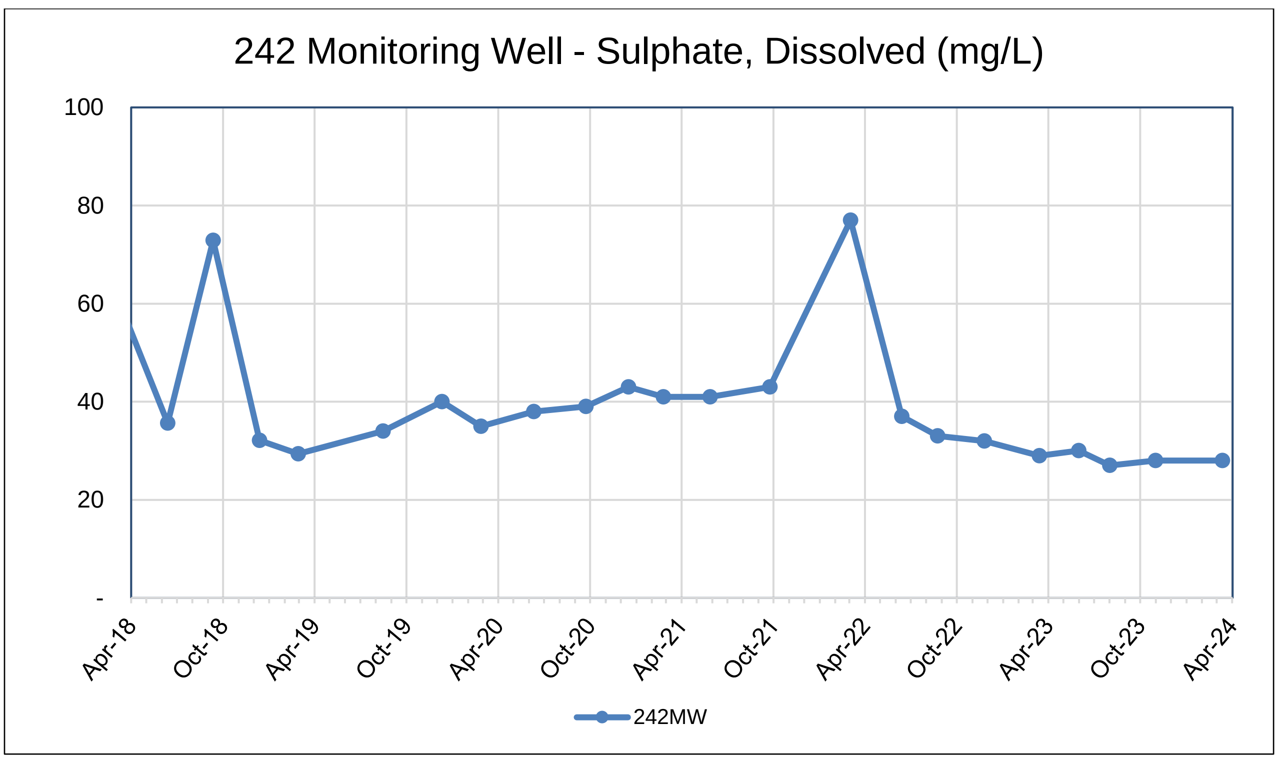
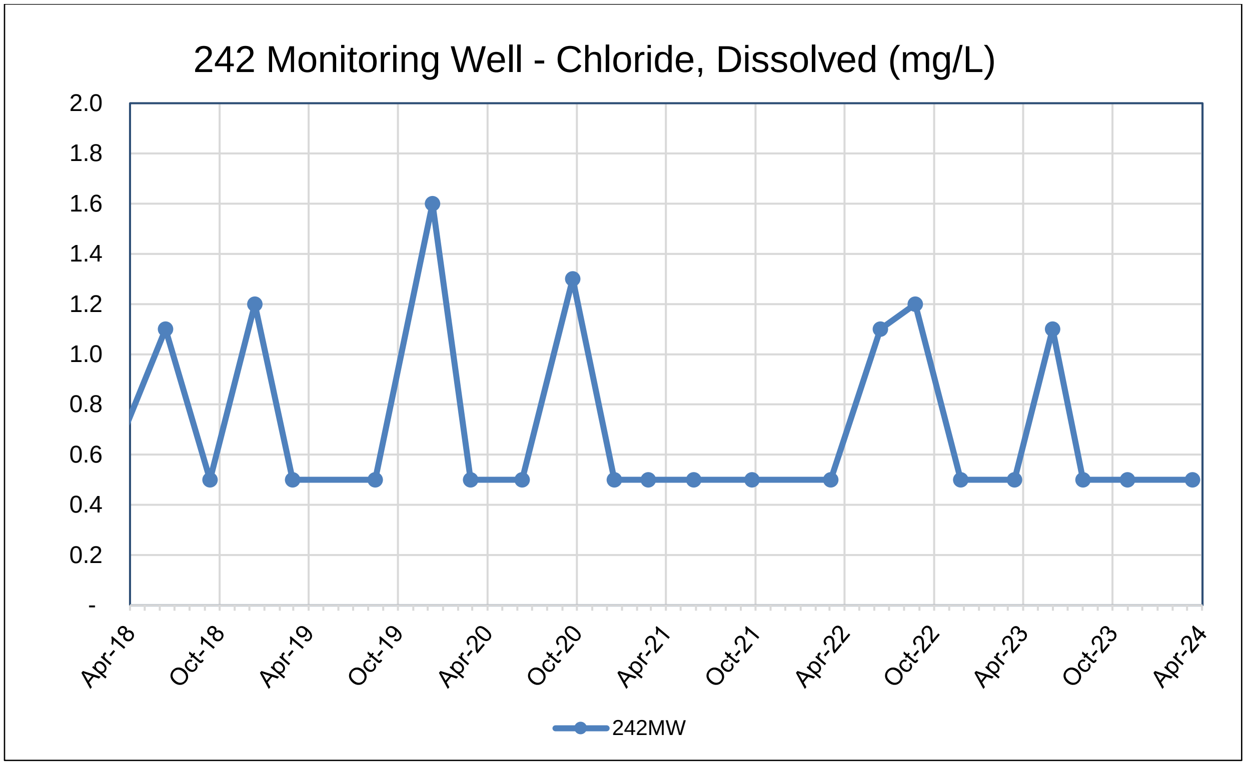


Figure 39: In-situ 242 Mine Pool – Sulphide as H_2S and Dissolved Sulphate



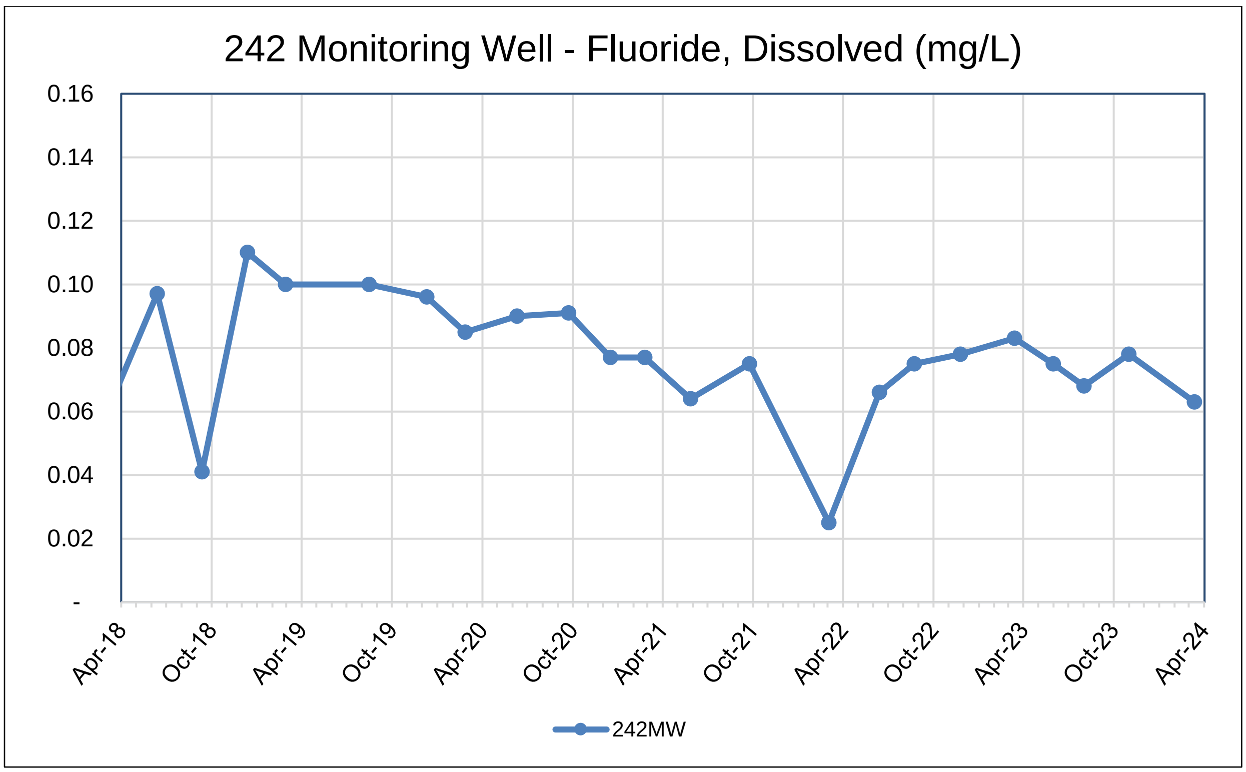


Figure 40: In-situ 242 Mine Pool –Dissolved Chloride and Fluoride

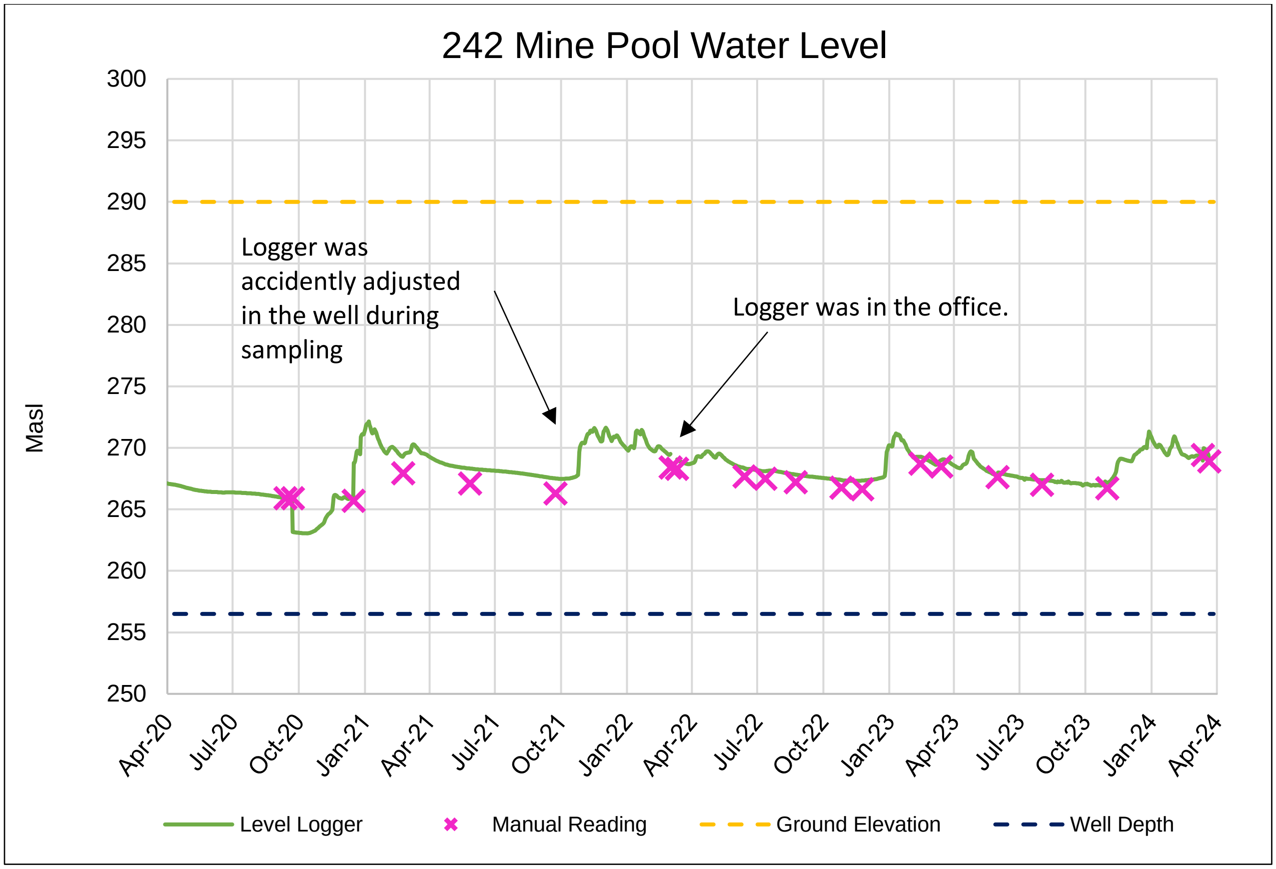
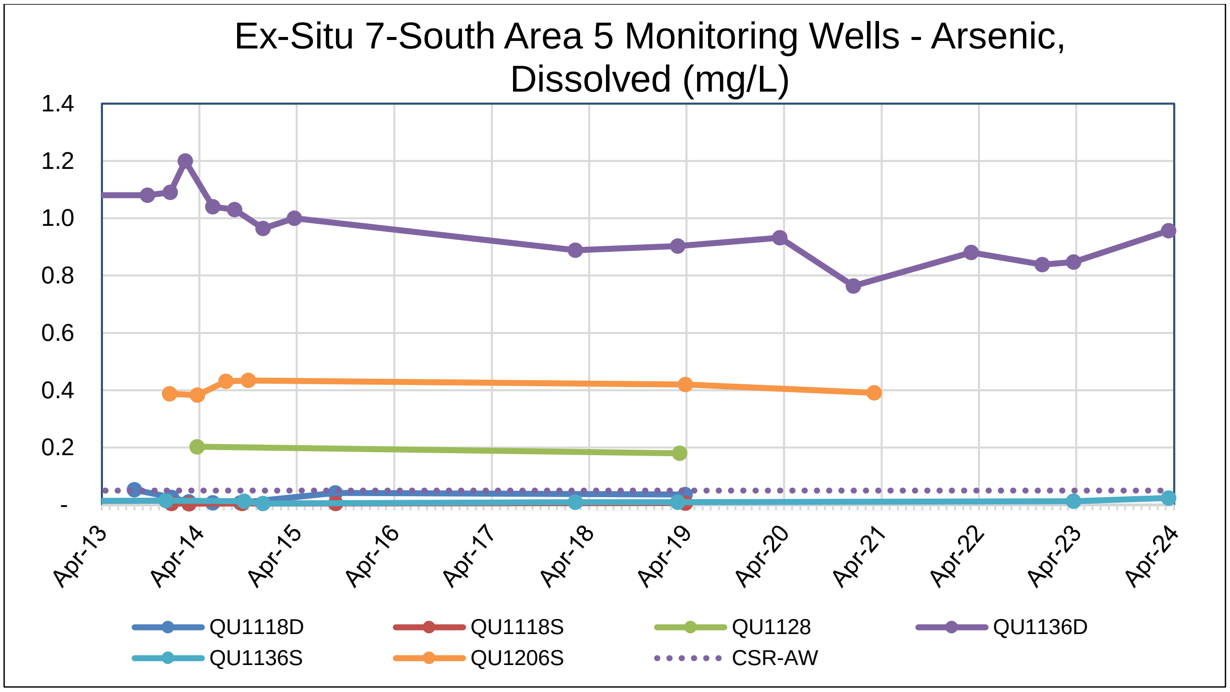


Figure 41: In-situ 242 Mine Pool – Water Elevation (Masl)

4.1.9 7-South Area 5 Background

In July 2018 blasting through the Long Lake Fault Zone commenced 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. 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-AL (0.05 mg/L) in the deep groundwater of QU11-36 D. All other paraments remain in low concentrations. Refer to Figure 42 through Figure 43.



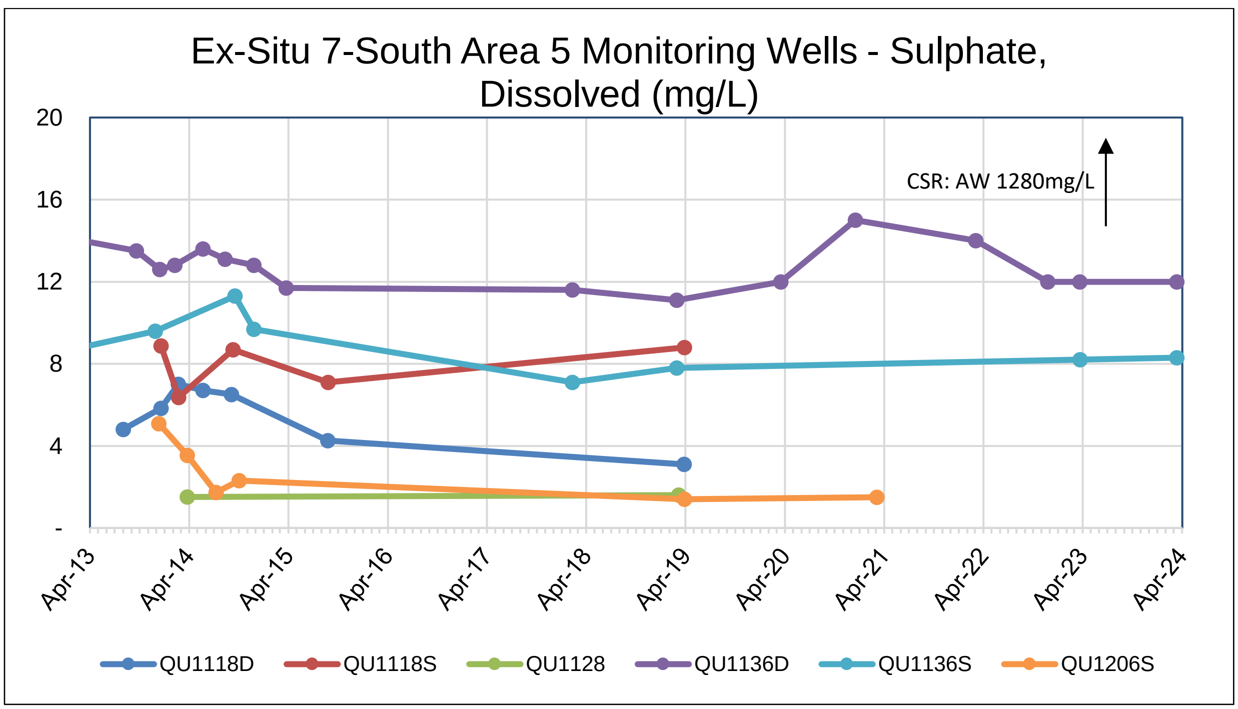


Figure 42: Ex-Situ 7SA5 - Dissolved Arsenic and Sulphate

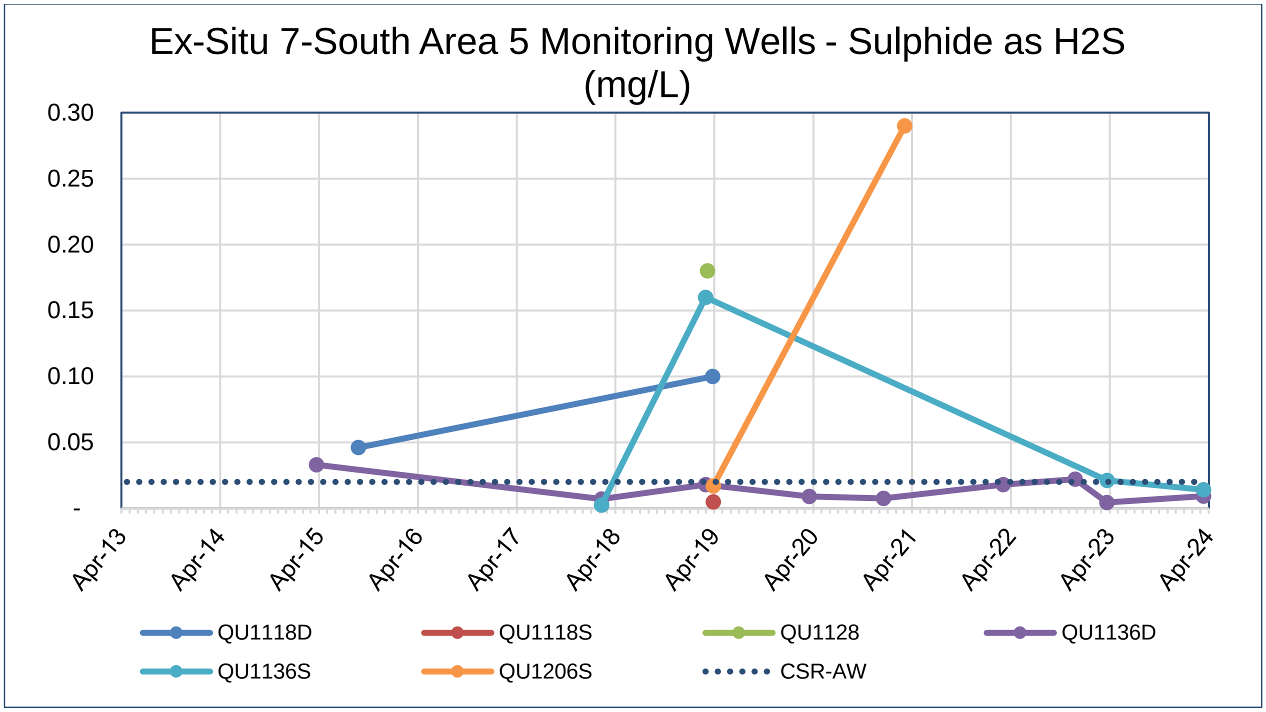


Figure 43: Ex - Situ 7SA5 - Sulphide as H_2S

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 flooded mine voids and 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-AL 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 storage 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 since sulphate and sulphide have a distinctive geochemical signature and the contact water flow paths can be tracked.

The groundwater program will continue to evolve as the mine moves towards closure with some mine areas being flooded and migration out of the mine voids occurs. The groundwater migration is traced with water quality compared to predicted source terms and seepage rates allowing for an evaluation of existing reclamation and closure plans. Furthermore, the program will be adapted to encompass the progression of our waste management strategies and areas will be closely monitored for upward trending of parameters of concern migrating out of the mine voids.

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