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RGC Project No: 118016

Faro Project Management Team
Assessment and Abandoned Mines
Government of Yukon
Energy, Mines and Resources
Yukon Territory

Attention: Deborah Pitt, ASLA
Senior Project Manager

**RE: DRAFT REV-0 - 2009 Performance Review of ETA SIS, Faro Mine, Yukon Territory**

Deborah,

This letter report summarizes the results of a performance review of the seepage interception system (SIS) installed immediately downgradient of the Emergency Tailings Area (ETA) at the Faro Mine, Yukon Territory.

# 1 Background & Study Objectives

The Faro Creek valley, historically used for emergency tailings discharge (now referred to as ETA area), collects seepage from a significant portion of the Faro WRDs, including several low-grade stockpiles and waste rock dumps (including the Faro Main Dump). Detailed flow monitoring and sampling along Faro Creek (below the ETA area) completed in 2005 and 2006 indicated that the total zinc load in seepage from the ETA area (surface flow and subsurface seepage discharging downstream of the access road combined) ranged from about 35 to 80 t/yr zinc (Robertson GeoConsultants Inc., 2007)[1]. Seepage from the ETA area also carried significant loads of sulphate (700-1050 t/yr

[1] Robertson GeoConsultants Inc. (1997). Results of Faro Creek Seepage Surveys (Summer/Fall 2006). Technical memorandum submitted to Deloitte & Touche, April 16, 2007.

$SO_4$), total iron (90-165 t/yr Fe) and other contaminants. These surveys also indicated that a significant proportion of this seepage infiltrated into the natural soils and/or the tailings before it reached the Intermediate Impoundment.

Based on the results of these surveys, a seepage interception system (SIS) was designed and constructed in the fall of 2006 (D. Haggar, pers. comm.). The SIS is designed to capture most of the seepage from the ETA area (except potentially very high flows) during the ice-free periods of spring/summer/fall. The SIS captures surface runoff from the ETA area (FCS-2) in a drop-box from where it is pumped to the Intermediate Pond in a pipeline. In addition, all subsurface seepage from the ETA area (FCS-3) is captured in a lined cutoff ditch and directed to a manhole from where it is also pumped (in the same pipeline) to the Intermediate Pond. Operation of the ETA SIS started in the open water season of 2007.

The objective of this performance review is to determine the efficiency of the ETA SIS, i.e. the percentage of seepage flow and contaminant load intercepted by the SIS.

# 2 Methods

## 2.1 Site Inspection

The principal investigator (Dr. Christoph Wels) visited the site on September 9th 2009 to inspect the ETA SIS. During this site visit the author also met with Mr. Roy Morrell and Ms. Jay Cherian (both from Denison Environmental Services, DES) to discuss past and current operation of the ETA SIS.

## 2.2 Seepage Flow Monitoring

### *2.2.1 Manual Flow Surveys*

Detailed flow surveys were completed by Laberge Environmental Services (LES) on three separate dates (August 16, September 10 and October 1) during the 2009 open water season. Discharge was measured using the volumetric method (time to fill a bucket of measured volume), weir measurements, Parshall Flume and/or rotating cup (Price mini) velocity meter (see Appendix A). These manual flow surveys included the following stations (see Figure 1 and Photos 1 & 2):

- Seepage from the Faro waste rock dumps (WRDs) upstream of the ETA area at station X23 (also referred to as “FCS-1”)

- Surface runoff from the ETA area as intercepted in the drop box below the road culvert (“FCS-2”)
- Subsurface seepage collected in the manhole from the east side of the ETA SIS (“FCS-3a”)
- Subsurface seepage collected in the manhole from the west side of the ETA SIS (“FCS3-b”)
- Faro Creek seepage that is bypassing the ETA SIS and reporting to the mouth of Faro Creek Canyon (“FCS-4” )
- Total seepage collected in the ETA SIS and discharged into the Intermediate Impoundment (at end of pipeline, “EOP”)

In addition, discharge measurements were taken of uncollected seepage day-lighting under the access road culvert (below FCS-2) and seepage day-lighting immediately downhill from the ETA SIS manhole (when present).

### *2.2.2 Continuous Flow Measurements*

Monitoring stations FCS-1 (X23) and FCS-4 are equipped with 90 degree weirs. Those weirs had been equipped in previous years with pressure transducers for earlier seepage monitoring (RGC, 2007). An initial site inspection by LES in June 2009 indicated that the weir at FCS-4 was completely filled with sediments. Although the pool behind this weir was cleaned out no pressure transducer was installed for continuous flow monitoring. The weir at X23 was still equipped with a PT2X pressure transducer and this pressure data was downloaded on several occasions throughout the summer of 2009.

QA/QC procedures for flow measurements included a comparison of theoretical and volumetric flows at the weirs. In addition, the maximum error due to the observed change in the offset (between two visits) was calculated. Table 1 summarizes the results of this QA/QC analysis.

The PT2X transducer for the X23 weir showed some drift in the off-set introducing uncertainty in the calculation of the flow rate from the original pressure data. The last column in Table 2 shows the maximum error in the calculated discharge. This value was obtained by using the old off-set to calculate the discharge. Prior to July, the drift in the off-set was acceptable and the maximum error due to uncertainty in the offset typically ranged from 5-30%. After July 18, however, the pressure transducer showed significant variations in off-set (and computed flows). Problems with the pressure transducer were also noted by LES staff during data downloading on August 16 and September 10 (see

Appendix A). Therefore continuous flow data computed from the pressure transducer after mid-July are considered unreliable.

The original scope of work had also proposed continuous flow measurements for seepage flow intercepted in the ETA SIS (at the manhole) and discharged into the Intermediate Impoundment (at end-of-pipe). However, the cost of the required monitoring equipment (flow meters) was beyond the approved budget for this study and this component of the study was therefore not carried out.

## 2.3 Water Quality Monitoring

At the time of the flow surveys seepage water was also collected for water quality analysis to estimate the contaminant loads intercepted and by-passing the SIS, respectively. The original scope of work had included three sampling rounds to cover spring, summer and fall conditions. However, due to delays in authorization of this study, the spring survey could not be completed.

### *2.3.1 L.E.S. Surveys*

During the August and October flow surveys, seepage waters in the ETA area were collected by L.E.S. (at the same time of the flow survey). Sample sites were prescribed as follows.

1. Toe of the Faro Main Waste Rock Dump (FCS-1 or X-23)
2. Surface runoff reporting to the drop box below the access road (FCS_2)
3. Seepage collected from the east side in the manhole (FCS-3a)
4. Seepage collected from the west side in the manhole (FCS-3b)
5. Faro Creek seepage at the mouth of Faro Creek Canyon (FCS-4)
6. The seepage collected and discharged into the Intermediate Impoundment (EOP)

In the first round of sampling (August 16), the two seepage inflows FCS-3a and FCS-3b were combined into a single sample, while in the October 1 sampling event, separate samples were collected from FCS-3a and FCS-3b. Blind Duplicates and field blanks were also prepared and submitted to the laboratory.

Every station was sampled in accordance with L.E.S. standard operating procedure, including pH, EC, and temperature field measurements with freshly standardized instruments. All dissolved metal samples were promptly field filtered.

All samples were shipped by L.E.S. to Maxxam Analytics Inc. for analysis. The suite of parameters analyzed in the laboratory included the following;

- Lab pH
- Major ions (SO4, Cl, F, Br)
- Alkalinity/Acidity
- Low Level Total and Dissolved metals by ICPOES

The laboratory reports for those samples are provided in Appendix B.

### *2.3.2 RGC Survey*

On September 9 2009, RGC staff sampled seepage waters in the ETA area for a geochemical and isotopic mixing study (RGC, 2010). Note that the corresponding flow survey was taken on the following day (September 10) by L.E.S. staff. However this delay in flow measurements likely did not introduce significant error in the load balance calculations as seepage flows were fairly constant throughout the 2 days.

During this RGC survey detailed measurements of field parameters (pH, EC, dissolved oxygen (DO) and oxidation-reduction potential (ORP)) were taken at all seepage monitoring stations discussed above. However, only a select number of water samples were submitted for geochemical and isotopic analysis:

1. Toe of the Faro Main Waste Rock Dump (FCS-1 or X-23)
2. Subsurface seepage from the ETA day-lighting below the access road (FCS_3)
3. Faro Creek seepage in the remnant channel below the canyon (FCS-4)

For more details on the sampling methods and QA/QC for the RGC water quality survey the reader is referred to RGC (2010)[2]. Note that only the geochemical analyses of the RGC survey are presented and discussed in this letter report. For a discussion of the isotopic analyses the reader is referred to RGC (2010).

[2] Robertson GeoConsultants Inc. (2010). Geochemical And Isotopic Constraints on the Sources of Acid Rock Drainage (ARD) Products to Groundwater, Anvil Range Mining Complex, YT, RGC Report 1180015/1 in preparation.

# 3 Results

## 3.1 Data Review & Site Inspection

### *3.1.1 ETA SIS Design*

Neither design specifications nor as-built drawings of the ETA seepage interception system were available for review. However, based on earlier discussions with Mr. Dana Haggar and visual observations by the author during construction of the ETA SIS back in October 2006 and during the September 2009 site inspection the following design is inferred (see Figure 1 and Photo Log):

- Surface runoff from the ETA area is collected in a metal drop box immediately downstream of the access road culvert (Photo 3); seepage collecting in this collection box can be discharged to the Intermediate Impoundment in two ways:
    - By gravity in a 10” HDPE pipeline (“gravity line”) which loops around the Faro Creek canyon, then runs parallel to the clean water discharge line and discharges into the wet beach of the Intermediate Impoundment; flow from the collection box into this gravity line can be regulated by a gate valve at the collection box (see blue throttle in Photo 3)
    - By gravity in a 6” HDPE pipeline which discharges into the manhole of the ETA SIS (see Photos 1 and 2); this discharge line usually takes peak flows during the spring freshet but all seepage from FCS-2 during low to moderate flow;
- Subsurface seepage from the ETA area is collected in two sumps which are located in the central and western portion of the Faro Creek Canyon (Photo 1); these collection sumps were constructed by excavating a sump partially into the surficial soils and shallow, weathered bedrock and filling them with coarse drain rock (specifications unknown); the downstream side of these collection sumps was sealed by placing a liner (specifications unknown); seepage collecting in these two rock-filled sumps is flowing by gravity through separate 3” PVC pipes into the ETA SIS manhole; the centrally located sump discharges into the slightly higher and longer (eastern) drain pipe while the western sump discharges in the slightly lower and shorter (western) drain pipe (Photo 2);
- All seepage collecting in the manhole is pumped uphill into the 10” gravity line using either a 15 HP or a 30 HP sump pumps (Photo 4); the larger high capacity

sump pump is used during the high flows of spring freshet whereas the smaller pump is used for moderate to low flows (i.e. during summer and fall);

- The seepage pumped into the 10” HDPE discharge line flows by gravity into the Intermediate Impoundment (Photo 5); at the discharge point (“EOP”) the seepage water discharges freely into the tailings and eventually collects in the Intermediate Pond

### *3.1.2 Field Observations*

The following field observations were made by the author during the site inspection on September 9 2009:

- A settlement pond had been constructed by DES from clean rock fill upstream of the access road culvert to allow settling out of suspended matter and to improve discharge of surface runoff from the ETA area through the culvert into the collection box (Photo 6);
- at the time of the site inspection all surface runoff from the ETA area was captured in the drop box (i.e. no seepage by-pass was observed in the channel downstream of FCS-2); the high water level in the drop box (to the invert of the 6” polyline) suggested that all seepage water collecting in the weir box was flowing into the manhole via the 6” HDPE line; the 10” gravity line was either shut off (or potentially clogged);
- subsurface seepage was observed day-lighting both in the central portion (Photo 7) and in the western portion (Photo 8) of the Faro Creek Canyon (just below the toe of the road embankment; however, this seepage then infiltrates back into the two collections sumps before discharging via the 3” drain pipes into the ETA SIS manhole (Photo 2);
- surface runoff from the ETA collecting in the drop box (at FCS-2) and subsurface seepage day-lighting at the toe of the access road (at FCS-3) had an orange-brown colour but were relatively clear (low turbidity); although the discharge pipes and the manhole showed some iron staining, excessive precipitation of iron-oxi-hydroxides in the manhole or on the sump pumps was not observed;
- at the time of the site inspection, the smaller 15 HP sump pump was used to pump seepage collecting in the manhole into the 10” gravity line to the Intermediate Impoundment with the larger sump pump (30 HP Flyght) on stand-by (Photo 4);

- the pumps are controlled by a subpanel located immediately to the west of the manhole; at the time of the site visit power to the subpanel was provided by a temporary power line, however, construction of a permanent (overhead) power line has recently been completed (J. Brodie, pers. comm.); none of the discharge lines were equipped with flow meters at the time of the site inspection;
- some seepage was observed day-lighting to the east of the manhole (Photo 9) and immediately downstream of the manhole; these smaller seeps which by-pass the ETA SIS eventually merge and flow down the Faro Creek Canyon (Photo 10);
- the weir at the mouth of the Faro Creek Canyon (FCS-4) was almost completely filled with sediments (Photo 11) but seepage was still flowing over the V-notch; the total flow at FCS-4 was about 1 L/s (Photo 12);
- seepage from Faro Creek Canyon (at FCS-4) flows in the diversion channel and discharges into the Intermediate Impoundment (Photo 13); seepage flow at this location (FCS-5) was visually estimated to be about 0.3 L/s suggesting a seepage loss of approximately 0.7 L/s along the diversion channel; the remaining seepage flow infiltrates into the tailings before reaching the Intermediate Pond;

#### *3.1.3 Past & Current Operation of ETA SIS*

The ETA SIS was constructed in October 2006 and was first operated in the calendar year of 2007. However, no information was available on the ETA SIS performance for 2007.

In 2008, the ETA SIS was operated from May 12 to October 22, 2008 (Jay Cherian, pers. comm.). The reported total volume collected and discharged to the Intermediate Impoundment in 2008 was 104,698 m3 which represents an average flow of 7.38 L/s over this 164 day period.

In 2009, operation of the ETA SIS was started up on May 4$^{th}$ and shut down on October 14$^{th}$. During the first 3-4 weeks of operation, the larger 30 HP pump was used to handle the higher flows. For the remainder of 2009 the smaller 15 HP pump was used (Roy Morrell, pers. comm.). DES recorded pumping times of the ETA sump pumps in order to estimate total volumes collected in the ETA SIS and discharged to the Intermediate Impoundment in 2009 (J. Cherian, pers. Comm.). However, these discharge estimates had not been completed at the time of preparation of this report.

## 3.2 Seepage Flow Monitoring

### *3.2.1 Manual Flow Surveys*

Table 1 summarizes the results of the three detailed manual flow surveys conducted by LES between August and October 2009. The three flow surveys yielded very similar results suggesting near steady-state flow conditions during this observation period.

Waste rock seepage reporting to X23 (upstream of the ETA area) averaged about 1.0 L/s.

Total seepage intercepted in the ETA SIS averaged 7.9 L/s. Surface flow from the ETA area collected at FCS-2 averaged 4.3 L/s (or 54% of total). Subsurface seepage collected from the central sump (FCS-3a) averaged 2.7 L/s (or 35%) with subsurface seepage collected from the western sump (FCS-3b) averaging 0.8 L/s (or 11%).

The combined flows of FCS-2, FCS-3a and FCS-3b collected in the ETA manhole were very close to the discharge at the end-of-pipe (EOP) of the gravity line suggesting that there was no significant contribution from the 10” gravity line at FCS-2. This observation is consistent with the high water level in the drop box (at FCS-2) which was at the invert level of the 6” line to the manhole as opposed to the invert level of the 10” line at the base of the drop box. It is not known whether the 10” line was shut off or whether the line was blocked by sediments (Roy Morrell, pers. comm.).

### *3.2.2 Continuous Flow Monitoring (X23)*

Figure 2 shows the observed (instantaneous) seepage flows recorded at the V notch weir at monitoring station FCS-1 for the monitoring period March 1 2009 to August 16, 2009. Manual spot measurements of weir flow at X23 taken by DES personnel between March and December 2009 are also shown for comparison. As mentioned earlier, due to problems with the pressure transducer flow data after about mid-July are not reliable.

The continuous flow measurements at X23 indicate that spring freshet occurred between late April and mid-May with peak flows in the order of 15-20 L/s. Secondary peaks of seepage flow at X23 were observed in June, presumably due to rainfall events. Thereafter seepage flows receded and remained at base flow levels (1-2 L/s) except for some isolated rainfall events in late July and brief periods of snowmelt runoff (up to 2.5 L/s) in November and December.

Using linear interpolation of the manual spot flow measurements and reliable automated weir data the total discharge at X23 (FCS-1) for the calendar year 2009 is estimated to be about 46,000 m3 (or 1.9 L/s).

Earlier flow monitoring in the ETA has shown that the surface runoff from the ETA area (at FCS-2) shows a very similar flow pattern (albeit higher flows) than at X23 (FCS-1). It is thus concluded that the period of active operation of the ETA SIS (from May 4 to October 14) missed the early portion of snowmelt runoff (about 7 days) and some smaller runoff peaks during the intermittent thaws observed in November and December (aside from the regular winter baseflow).

Note also that the detailed manual flow surveys (completed between August and October 2009) were completed during periods of typical summer baseflow. The absence of detailed manual flow surveys during spring runoff and/or early summer rainfall events precluded a detailed performance assessment of the ETA SIS for high flow conditions.

### 3.3 Water Quality Monitoring

Table 2 shows the seepage water quality results for the three rounds of sampling. The results of the QA/QC analyses (duplicate samples and blank samples) are also shown in table 2. Detailed field readings taken by RGC during the September survey are summarized in table 3.

The duplicate samples taken on the August and October surveys generally show very good RPD values for all major ions and dissolved metals (< 10%) suggesting good reproducibility.

Seepage collected in the ETA SIS is moderately acidic (lab pH ~ 3.5 to 4.0) and shows highly elevated concentrations of selected trace metals (in particular Fe, Mn and Zn). Note that most metals (including all major trace metals) are predominantly present in the dissolved form. Concentrations of calcium, magnesium and sulphate are also significantly elevated.

Table 4 summarizes the observed concentrations of sulphate, dissolved zinc and dissolved iron for the three individual seepage components of the ETA SIS (FCS-2, FCS-3a and FCS-3b), the total (combined) seepage discharged into the Intermediate Impoundment (“EOP”) and the seepage by-passing the ETA SIS (at FCS-4).

The three surveys showed consistent differences in the chemical composition of the various seepage components:

- Surface runoff from the ETA area (FCS-2) showed the highest sulphate and zinc concentrations but the lowest iron concentrations likely due to iron precipitation;

- Subsurface seepage collected in the eastern collection sump (FCS-3a) showed 3 to 20 times higher iron concentrations than the other seeps suggesting seepage from the ETA tailings
- Subsurface seepage collected in the western collection sump (FCS-3b) showed 2-3 times lower contaminant concentrations than the eastern collection sump suggesting significant dilution by non-impacted groundwater from the ridge to the west of Faro Creek Canyon
- Seepage by-passing the ETA SIS and sampled at the mouth of the Faro Creek Canyon (at FCS-4) also showed 2-4 times lower contaminant concentrations than seepage intercepted in the ETA SIS; suggesting significant contributions of unimpacted, or less impacted, groundwater

# 4 Discussion

## 4.1 Comparison with Historic ETA Monitoring

Table 5 compares recent ETA seepage monitoring data to earlier monitoring completed in 2005 and 2006. The following conclusions can be drawn from this comparison:

- Although seepage flows at FCS-1 (X23) were similar to earlier spot measurements (~1 L/s) water quality has significantly deteriorated (e.g. a three-fold increase in zinc);
- Surface seepage flow at FCS-2 almost doubled (likely due to improved capture of surface seepage through the culvert) and seepage water quality also deteriorated significantly (e.g. a two-fold increase in zinc);
- Subsurface seepage day-lighting at the seepage face immediately downstream of the ETA (FCS-3) showed very similar flows to previous surveys (~2.7 L/s) but showed some, albeit smaller, increase in contaminant concentrations (e.g. Zn, Fe);
- Seepage flow at the mouth of Faro Creek canyon (FCS-4) decreased from ~6-7 L/s observed in 2005/06 (prior to seepage interception) to ~1 L/s in 2009 due to operation of the ETA SIS; major ion chemistry (pH, EC, SO4) did not change significantly but metal concentrations (in particular zinc and iron) were lower in 2009 due to preferential interception of “high-strength” seepage (FCS2 and FCS-3a).

## 4.2 Observed Efficiency of Seepage Recovery (August to October)

### *4.2.1 Efficiency of Seepage Interception*

Table 7 compares the total volume of seepage intercepted in the ETA (at EOP) versus the amount of seepage by-passing the ETA SIS for the three dates of detailed flow surveys. Under the low flow conditions monitored, the ETA SIS captured on average 7.9 L/s representing 88% of the inferred total flow. The seepage by-passing the ETA-SIS averaged 1.1 L/s representing 12% of the inferred seepage.

The above statistics assume that all seepage from the ETA area daylights in the Faro Creek canyon and reports to FCS-4. Visual observations by the authors during the September site visit suggest that most seepage by-pass occurs to the east and immediately below the ETA SIS and runs along the Faro Creek canyon (primarily on bedrock) directly to FCS-4 with little opportunity to re-infiltrate. These visual observations are consistent with spot flow measurements taken by LES on August 16, 2009 which measured a seepage flow of ~1.1 L/s immediately below the manhole (using a Parshall flume) compared to 0.96 L/s at the mouth of the Frao Creek canyon (at FCS-4).

In the author’s opinion, additional by-pass of seepage from the ETA area via groundwater flow is likely very small for two reasons. First, any groundwater flow by-passing the ETA SIS at the bedrock-overburden interface or in shallow bedrock would likely discharge into the steep Faro Creek canyon which drops in elevation by several tens of meters. Second, recent inclined drilling at the mouth of the Faro Creek canyon did not intersect any structures in the deeper, competent bedrock. Furthermore, groundwater quality in the deeper bedrock well (SRK09-ETA-2) indicates no impact from ETA seepage (c. tables 2a/b).

The groundwater quality observed in the recently installed monitoring well SRK-09-ETA-02, also located at the mouth of Faro Creek canyon but screened at the overburden-bedrock contact, is significantly less impacted than ETA seepage (c. tables 2a/b) and is inferred to be a mixture of unimpacted groundwater and seepage losses from surface seepage in Faro Creek canyon which has infiltrated through the tailings profile.

### *4.2.2 Efficiency of Contaminant Load Interception*

Table 7 summarizes the estimated loads of sulphate, zinc and iron intercepted in the ETA SIS (and by-passing at FCS-4) for the three dates of detailed monitoring. The total contaminant loads intercepted in the ETA SIS shoed relatively little variation for these three surveys. The average sulphate load intercepted in the ETA SIS and discharged to the Intermediate Impoundment during this low flow period was 1,874 t/yr. The average zinc and iron loads intercepted in the ETA SIS on those days were 163 t/yr and 229 t/yr, respectively.

Note that the combined contaminant loads for the three seepage components collected in the ETA manhole (FCS-2, FCS-3a and FCS-3b) agreed fairly well with the contaminant load observed at the end-of-pipe (EOP) of the gravity line discharging into the Intermediate Impoundment.

The contaminant load by-passing the ETA SIS (at FCS-4) averaged about 169 t SO4 per year, 5 t Zn per year and 13 t Fe per year. Note that the collection efficiency of the ETA SIS is higher when expressed in terms of contaminant load compared to in seepage flow. For example, the average collection efficiency of the ETA SIS for zinc and SO4 was 94 and 97%, respectively, compared to only 88% for seepage flow (Table 7).

## 4.3 Estimated Efficiency of Seepage Recovery (Jan – Dec 2009)

This section provides estimates of seepage collection in the ETA SIS for the entire calendar year 2009. These estimates are preliminary in nature and should be checked against reported seepage flows (by DES) once they become available.

### *4.3.1 Annual Seepage Interception*

According to site personnel the ETA SIS intercepted "most" of the high flows during spring runoff and subsequent rain storm events (Roy Morrel, pers. comm.). However, no monitoring data were available to quantify the degree of seepage by-pass during these high flow periods.

Table 8a show our preliminary estimates of total seepage from the ETA area for the entire calendar year 2009 and table 9a provides our initial estimates of seepage intercepted by the ETA SIS. For the purpose of these preliminary estimates, subsurface flow (from FCS-3a and FCS-3b) was assumed to be constant and surface flow from the ETA area (at FCS-2) was estimated by prorating observed flows at X23.

Using these assumptions, the total seepage flow from the ETA area during the calendar year 2009 was estimated to be about 258,300 $m^3$ or 8.2 L/s. The estimated total seepage flow over the period of active operation (from May 4$^{th}$ to October 14$^{th}$) was approximately 131,500 m3 or about 9.3 L/s.

Assuming 80% capture of the high flows during spring runoff and 90% capture during the remainder of the operational period, the total volume of seepage collected by the ETA SIS in 2009 is estimated to be about 119,600 $m^3$, representing approximately 8.0 L/s over this 173-day period. The seepage flow by-passing the ETA SIS is estimated to be about 1.3 L/s (or about 88 %) for the period of active operation (May 4$^{th}$ to October 14$^{th}$ 2009).

Clearly, the main limitation of the current setup of the ETA SIS is the fact that operation is seasonal with no seepage interception at all during the cold winter months (typically between mid-October and early May). Based on observed flows in 2009 and earlier year-round monitoring of seepage flow in the ETA and Faro Creek canyon, the seepage not collected during the winter months is estimated to be approximately 126,800 $m^3$ representing approximately 7.6 L/s over this 192-day period.

It is concluded that the current ETA SIS has a relatively high efficiency of seepage collection during the open-water season (capturing about 88 % of total seepage) but that significant seepage flow is by-passing the ETA SIS during the prolonged winter shut-down period. As a result the over-all efficiency of seepage interception considering the entire calendar year is estimated to be only about 46 %.

#### *4.3.2 Annual Contaminant Load Interception*

Table 8 shows the estimated total loads of sulphate, zinc and iron generated in the ETA area for the entire calendar year 2009. For purposes of these preliminary estimates we assumed that contaminant concentrations observed in October 2009 are representative of the entire low-flow period (Aug 16 to Apr 28). For the periods of higher flow (Apr 28 to Aug 16) contaminant concentrations in surface seepage (at FCS-2) were assumed to be 20% lower than those baseflow concentrations (due to dilution). Using these assumptions the annual contaminant load in seepage from the ETA area for the calendar year 2009 was estimated to be 1,929 tonnes sulphate, 131 tonnes zinc and 281 tonnes iron (Table 8).

Table 9 summarizes the estimated efficiency of contaminant load recovery in the ETA SIS for the entire calendar year 2009. The total contaminant load recovered during the active period of ETA SIS operation is estimated to be 921 tonnes SO4, 70 tonnes Zn and 120 tonnes Fe, representing between 43% and 53% of the estimated total annual load of iron and zinc, respectively. In other words, an estimated 57% of the annual iron load (or 161 tonnes) and 47% of the annual zinc load (or 61 tonnes) are still by-passing the ETA SIS, primarily due to shut-down of the ETA SIS for about half the year.

# 5 Conclusions & Recommendations

## 5.1 Conclusions

A performance review was completed for the ETA SIS of the Anvil Range Mining Complex which included a site inspection and three detailed surveys of seepage rates and seepage water quality. The 2009 monitoring data was used to estimate the efficiency of the ETA SIS in collecting seepage and contaminant loads. The following conclusions can be drawn from this 2009 performance review:

- The total seepage flow discharging from the ETA area in 2009 was estimated to be about 258,300 $m^3$ representing an annual average flow of 8.2 L/s; although seepage recovery is relatively high during active operation (about 80-90%) the annual seepage recovery is estimated to be slightly less than 50% due to the prolonged shutdown of the ETA SIS during the winter season;
- The water quality of surface and subsurface seepage entering the ETA SIS has significantly deteriorated since ETA monitoring began in 2005 with zinc concentrations now reaching 500-700 mg/L and iron concentrations exceeding 2,000 mg/L; the total contaminant load associated with the ETA seepage in 2009 has been estimated to be about 2,064 tonnes sulphate, 143 tonnes zinc and 281 tonnes iron;
- In 2009 the ETA SIS was operated from May 4 to Oct 14; the contaminant load intercepted during this 173-day period has been estimated to be 921 tonnes SO4, 70 tonnes Zn and 120 tonnes Fe, representing between 43% and 53% of the estimated total annual load of iron and zinc, respectively;
- The contaminant load by-passing the ETA SIS in 2009 has been estimated to be 1,009 tonnes sulphate, 61 tonnes Zn and 161 tonnes Fe representing approximately half of the total contaminant load in ETA seepage; the primary reason for this significant seepage by-pass is shut-down of the ETA SIS during the winter period.

In the author's opinion, the estimated contaminant load by-passing the interim ETA SIS is still significant and has the potential to significantly affect groundwater quality in the Rose Creek aquifer. It is therefore recommended that the collection efficiency of the current ETA SIS be improved (see below for more details).

## 5.2 Recommendations

Based on this 2009 performance review, the following recommendations are provided by the author for further consideration:

- The collection efficiency of the ETA SIS should be improved by implementing the following changes/upgrades to the current design:
    - Construction of a secondary containment (sump or concrete box) immediately downstream of the ETA manhole to collect any seepage by-passing the ETA SIS; this additional seepage (~1 to 3 L/s) could be pumped into the ETA manhole using a smaller sump pump;
    - Operation of the ETA SIS year-round to collect the substantial seepage flows observed during late fall, winter and early spring runoff; this will require heat-tracing of all pipe lines and possibly heating of the FCS-2 drop box, ETA manhole and secondary sump;
- Consideration should be given to pumping the ETA seepage directly into the water treatment plant at the mill site (or into the Faro Pit for temporary storage) to avoid discharge of this highly contaminated seepage into the Intermediate Impoundment and ultimately the Intermediate Pond;
- The condition of the 10” gravity line and upstream gate valve (at the drop box) should be checked for blockage; a screen should be placed at the intakes of the 10” HDPE line and the 6” line to the ETA manhole to avoid clogging of these lines due to debris and/or sediments;
- Flow monitoring of the ETA SIS should be improved as follows:
    - Monthly manual discharge measurements of seepage collected in the ETA SIS (at FCS2, FCS3a, FCS3b and EOP) and seepage by-passing the ETA SIS (at FCS-4);
    - Continuous monitoring of total volume of seepage collected in the ETA SIS using a flow meter with totalizer on the main discharge line (currently the 10” gravity line);
    - Monthly sampling of combined ETA seepage (from EOP) and of seepage by-passing the ETA SIS (at FCS-4) for full water quality analysis (incl. major ions and dissolved metals).

# 6 Closure

We trust that the information provided in this letter report meets your requirements.

Please contact the undersigned if you have any questions regarding the content of this report or require further information.

Best Regards,

ROBERTSON GEOCONSULTANTS INC.

**Prepared by:**

Dr. Christoph Wels, M.Sc., P.Geo.

Principal and Senior Hydrogeologist

# TABLES

**Table 1**. Comparison of Weir and Volumetric Flow Readings.

| Date/Time | Measured Height (H) (m) | Calculated Offset (m) | $Q_{calc.}$ (from H) (L/sec) | $Q_{volumetric}$ (measured using bucket) (L/sec) | delta Q $((Q_c-Q_v)/Q_c)$ (%) | Q w/ old offset ($Qc_{t-1}$) (L/sec) | Maximum Error in Q due to Drift in Offset Error($Q_c$ - $Q_{ct-1}$) (%) |
|---|---|---|---|---|---|---|---|
| Monitoring Station FCS_1 (at toe of Faro WRD - X23) | | | | | | | |
| 04/05/2009 | 0.167 | 0.244 | 15.53299 | - | - | 16.026 | -3% |
| 07/05/2009 | 0.162 | 0.2336 | 14.4 | - | - | 12.2 | 15% |
| 02/06/2009 | 0.105 | 0.2213 | 4.87 | - | - | 3.56 | 27% |
| 7/18/09 | 0.058 | 0.0001 | 1.30 | 1.3 | -0.4% | offset > H | - |
| 7/25/09 | 0.058 | 0.0001 | 1.10 | 1.1 | -0.5% | offset > H | - |
| 8/5/09 17:15 | 0.057 | 0.179 | 1.06 | 1.1 | 0.0% | 0.04 | 96% |
| 08/08/09 | 0.058 | 0.0001 | 1.10 | 1.1 | -0.5% | offset > H | - |
| 8/16/09 13:15 | 0.053 | 0.0958 | 0.88 | 0.8 | 8.1% | offset > H | - |
| 9/10/09 12:30 | 0.056 | 0.0768 | 1.01 | 1.1 | -8.9% | 0.36 | 64% |
| 9/10/09 12:45 | 0.056 | 0.3981 | 1.01 | 1.1 | -8.9% | 119.17 | -11699% |
| 9/30/09 18:23 | 0.056 | 0.4134 | 1.01 | 1.1 | -10.7% | 1.85 | -83% |
| 10/22/09 | 0.051 | -0.0041 | 0.80 | 0.8 | 0.1% | offset > H | - |
| 10/31/09 | 0.055 | -0.0068 | 0.97 | 1.0 | -0.3% | 1.16 | -20% |
| 11/05/09 | 0.062 | -0.0036 | 1.30 | 1.3 | 0.3% | 1.69 | -30% |
| 11/12/09 | 0.066 | -0.0136 | 1.53 | 1.5 | 1.7% | 1.74 | -14% |
| 11/19/09 | 0.079 | 0.0172 | 2.39 | 2.4 | -0.4% | 3.55 | -49% |
| 11/26/09 | 0.062 | 0.0068 | 1.30 | 1.3 | 0.3% | 0.58 | 56% |
| 12/03/09 | 0.055 | -0.0087 | 0.97 | 1.0 | -0.3% | 0.69 | 28% |
| 12/10/09 | 0.063 | 0.0186 | 1.36 | 1.4 | -3.1% | 1.88 | -38% |
| 12/17/09 | 0.045 | 0.0451 | 0.59 | 0.6 | -0.8% | 0.15 | 74% |

**Table 2.** Summary of Manual Flow Surveys

| | WRD seepage | Seepage collected in ETA SIS | | | | Total ETA SIS Discharge | Seepage Bypassing ETA SIS |
|---|---|---|---|---|---|---|---|
| | FCS-1 | FCS-2 | FCS-3a | FCS-3b | SUM | EOP | FCS-4 |
| Date | L/s | L/s | L/s | L/s | L/s | L/s | L/s |
| 16-Aug-09 | 0.9 | 3.7 | 2.9 | 0.8 | 7.3 | 7.5 | 1.0 |
| 10-Sep-09 | 1.0 | 4.5 | 2.8 | 0.8 | 8.1 | 7.4 | 1.1 |
| 1-Oct-09 | 1.1 | 4.6 | 2.5 | 0.9 | 8.1 | 8.8 | 1.2 |
| **Average** | **1.0** | **4.3** | **2.7** | **0.8** | **7.8** | **7.9** | **1.1** |

**Table 3a.** Results of Water Quality Surveys – Major Ion Chemistry

| SAMPLE ID | DESCRIPTION/LOCATION | DATE | FIELD | | LABORATORY | | MAJOR IONS | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | EC µS/cm | pH | EC µS/cm | pH | TDS mg/L | Alkalinity mg/L CaCO3 | Acidity mg/L pH 8.3 | Hardness mg/L CaCO3 | Ca mg/L | Mg mg/L | Na mg/L | K mg/L | HCO3 mg/L | SO4 mg/L | Cl mg/L |
| **August 2009** | | | | | | | | | | | | | | | | | |
| FCS-1 at X23 | Faro Creek seepage (FCS) from Main WRD | 16-Aug-09 | 8130 | 6.4 | 8510 | 5.2 | 12,000 | 1.1 | 1910 | 5880 | 504 | 1120 | 65.2 | 16.8 | 1.3 | 8300 | 12 |
| FCS-2 | End of culvert under mine access road | 16-Aug-09 | 7120 | 6.4 | 7210 | 4.4 | 9500 | 0.5 | 1390 | 5100 | 463 | 959 | 56.1 | 15.5 | 0.5 | 6700 | 8.9 |
| FCS-3A | Inflow to manhole | 16-Aug-09 | 8210 | 6.6 | 8200 | 4.3 | 15,000 | 0.5 | 3480 | 3760 | 494 | 614 | 83.5 | 12.3 | 0.5 | 7700 | 12 |
| FCS-4 | ETA SIS bypass at mouth of canyon | 16-Aug-09 | 5980 | 6.8 | 5930 | 5.6 | 7800 | 2.6 | 1040 | 4030 | 492 | 679 | 69.0 | 11.9 | 3.2 | 5200 | 15 |
| EOP | End of pipe | 16-Aug-09 | 8050 | 6.2 | 8060 | 4.3 | 12,000 | 0.5 | 2380 | 4610 | 467 | 837 | 65.9 | 14.1 | 0.5 | 7400 | 9.5 |
| **September 2009** | | | | | | | | | | | | | | | | | |
| FCS-1 at X23 | Faro Creek seepage (FCS) from Main WRD | 9-Sep-09 | 7915 | 6.0 | 8520 | 5.6 | 11,000 | 8.0 | 2200 | 6240 | 521 | 1200 | 67 | 19 | 10 | 8300 | 12 |
| FCS-3 | SIS seepage | 9-Sep-09 | 8555 | 5.4 | 9290 | 4.0 | 15,000 | 0.5 | 5310 | 3850 | 492 | 728 | 69 | 13 | 1 | 9400 | 5 |
| FCS-4 | ETA SIS bypass at mouth of canyon | 9-Sep-09 | 5609 | 6.7 | 6000 | 5.3 | 6600 | 2.6 | 925 | 4230 | 433 | 671 | 63 | 11 | 3 | 5200 | 15 |
| P09-ETA-1 | Groundwater in bedrock near mouth of Faro Creek canyon | 4-Aug-09 | 670 | 7.7 | 447 | 8.0 | *313* | 210 | - | 222 | 70 | 11 | 17 | 0 | 260 | 25 | 1 |
| P09-ETA-2 | Groundwater in overburden near mouth of Faro Creek canyon | 4-Aug-09 | 4000 | 6.4 | 5150 | 6.6 | *3605* | 160 | - | 3550 | 551 | 529 | 50 | 8 | 190 | 4500 | 14 |
| **October 2009** | | | | | | | | | | | | | | | | | |
| FCS-1 at X23 | Faro Creek seepage (FCS) from Main WRD | 1-Oct-09 | - | - | 8510 | 4.5 | 8000 | 0.5 | 2240 | 6240 | 547 | 1180 | 65 | 19 | 0.5 | 7500 | 11 |
| FCS-2 | End of culvert under mine access road | 1-Oct-09 | 7340 | 6.1 | 7670 | 4.0 | 7300 | 0.5 | 1860 | 5780 | 498 | 1100 | 60 | 19 | 0.5 | 7800 | 9.5 |
| FCS-3A | Inflow to manhole | 1-Oct-09 | 8840 | 5.9 | 9090 | 3.5 | 8800 | 0.5 | 5020 | 4270 | 498 | 734 | 69 | 12 | 0.5 | 8900 | 5.7 |
| FCS-3B | Inflow to manhole | 1-Oct-09 | 5890 | 6.3 | 5620 | 4.2 | 5400 | 0.5 | 1740 | 2940 | 576 | 364 | 103 | 15.2 | 0.5 | 4300 | 24 |
| FCS-4 | ETA SIS bypass at mouth of canyon | 1-Oct-09 | 5870 | 6.4 | 5970 | 4.1 | 5700 | 0.5 | 1100 | 4110 | 514 | 686 | 65.3 | 12.5 | 0.5 | 4400 | 13 |
| EOP | End of pipe | 1-Oct-09 | - | - | 8020 | 4.0 | 7600 | 0.5 | 2740 | 5030 | 524 | 904 | 67 | 16 | 0.5 | 7200 | 10 |
| **QA/QC** | | | | | | | | | | | | | | | | | |
| **August 2009** | | | | | | | | | | | | | | | | | |
| FCS-1 at X23 (BD) | Faro Creek seepage (FCS) from Main WRD | 16-Aug-09 | - | - | 8510 | 5.0 | 14,000 | 0.5 | 1880 | 5690 | 493 | 1080 | 63 | 16.5 | 0.5 | 7800 | 11 |
| **RPD, %** | | | - | - | 0 | 3.9 | 15.4 | - | 1.6 | 3.3 | 2.2 | 3.6 | 3.4 | 1.8 | - | 6.2 | 8.7 |
| **Maximum Allowable Spread** | | | - | - | - | - | - | >0.5 | - | - | - | - | - | - | >0.5 | - | - |
| Field Blank Sample | | 16-Aug-09 | - | - | 1 | 5.1 | 10 | 0.5 | 0.5 | 0.5 | 0.05 | 0.05 | 0.6 | 0.05 | 0.5 | 0.5 | 0.5 |
| **October 2009** | | | | | | | | | | | | | | | | | |
| FCS-2 | End of culvert under mine access road | 1-Oct-09 | - | - | - | 4.0 | 7200 | 0.5 | 1860 | 5650 | 491 | 1080 | 59 | 18 | 0.5 | 6700 | 9.7 |
| **Relative Percent Difference, %** | | | - | - | - | 0.0 | 1.4 | - | 0.0 | 2.3 | 1.4 | 1.8 | 1.7 | 5.4 | - | 15.2 | 2.1 |
| **Maximum Allowable Spread** | | | - | - | - | - | - | <0.5 | - | - | - | - | - | - | <0.5 | - | - |
| Field Blank Sample | | 1-Oct-09 | - | - | 3 | 4.9 | 14 | 0.5 | 1.6 | 0.5 | 0.05 | 0.05 | 0.05 | 0.05 | 0.5 | 0.5 | 0.5 |

0.01 **Concentration less than indicated detection limit**
\- **Data not available**
*210* **Italicized TDS values calculated from EC**

**Table 3b.** Results of Water Quality Surveys – Dissolved and Total Metals

| SAMPLE ID | DESCRIPTION/LOCATION | DATE | METALS DISSOLVED | | | | | | | | | | METALS TOTAL | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Al_f µg/L | As_f µg/L | Cd_f µg/L | Co_f µg/L | Cu_f µg/L | Fe_f µg/L | Mn_f µg/L | Ni_f µg/L | Pb_f µg/L | Zn_f µg/L | Al_T µg/L | As_T µg/L | Cd_T µg/L | Co_f µg/L | Cu_f µg/L | Fe_f µg/L | Mn_f µg/L | Ni_f µg/L | Pb_f µg/L | Zn_f µg/L |
| **August 2009** | | | | | | | | | | | | | | | | | | | | | | |
| FCS-1 at X23 | Faro Creek seepage (FCS) from Main WRD | 16-Aug-09 | 10 | 1 | 321 | 1840 | 36 | 355,000 | 122,000 | 1980 | 0.3 | 1,040,000 | 20 | 36 | 357 | 1760 | 82 | 355,000 | 123,000 | 1870 | 5.9 | 1,030,000 |
| FCS-2 | End of culvert under mine access road | 16-Aug-09 | 593 | 11.1 | 211 | 1860 | 246 | 86,500 | 113,000 | 1610 | 34.3 | 685,000 | 1860 | 25.8 | 213 | 1770 | 262 | 88,000 | 114,000 | 1530 | 114 | 665,000 |
| FCS-3A | Inflow to manhole | 16-Aug-09 | 452 | 1.1 | 7.2 | 831 | 13 | 1,730,000 | 75,100 | 811 | 0.1 | 466,000 | 1600 | 7.6 | 7.8 | 831 | 23 | 1,760,000 | 78,100 | 812 | 10.1 | 471,000 |
| FCS-4 | ETA SIS bypass at mouth of canyon | 16-Aug-09 | 4 | 0.9 | 12.1 | 298 | 9 | 354,000 | 54,300 | 414 | 1.4 | 148,000 | 2540 | 32.3 | 14.4 | 304 | 73 | 431,000 | 55,900 | 437 | 1220 | 160,000 |
| EOP | End of pipe | 16-Aug-09 | 381 | 1.9 | 140 | 1640 | 113 | 885,000 | 106,000 | 1400 | 0.4 | 662,000 | 2160 | 26.1 | 156 | 1700 | 158 | 935,000 | 114,000 | 1420 | 81.5 | 692,000 |
| **September 2009** | | | | | | | | | | | | | | | | | | | | | | |
| FCS-1 at X23 | Faro Creek seepage (FCS) from Main WRD | 9-Sep-09 | 30 | 1.0 | 271 | 1750 | 36.0 | 341,000 | 121,000 | 1910 | 2 | 969,000 | - | - | - | - | - | - | - | - | - | - |
| FCS-3 | SIS seepage | 9-Sep-09 | 2470 | 19.5 | 10.2 | 921 | 12.1 | 2,160,000 | 79,000 | 930 | 4.4 | 536,000 | - | - | - | - | - | - | - | - | - | - |
| FCS-4 | ETA SIS bypass at mouth of canyon | 9-Sep-09 | 9 | 1.6 | 11.5 | 298.0 | 9.1 | 377,000 | 54,700 | 405 | 0.4 | 144,000 | - | - | - | - | - | - | - | - | - | - |
| P09-ETA-1 | Groundwater in bedrock near mouth of Faro Cr | 4-Aug-09 | 2 | 0.1 | 0.01 | 0.1 | 0.1 | 11 | 16 | 0 | 0.1 | 1 | - | - | - | - | - | - | - | - | - | - |
| P09-ETA-2 | Groundwater in overburden near mouth of Faro | 4-Aug-09 | 16 | 53.9 | 0.1 | 181 | 0.5 | 254,000 | 39,500 | 184 | 1.2 | 70,600 | - | - | - | - | - | - | - | - | - | - |
| **October 2009** | | | | | | | | | | | | | | | | | | | | | | |
| FCS-1 at X23 | Faro Creek seepage (FCS) from Main WRD | 1-Oct-09 | 20 | 2 | 273 | 1670 | 38 | 362,000 | 123,000 | 1760 | 0.6 | 915,000 | 20 | 2 | 265 | 1770 | 66 | 349,000 | 128,000 | 1940 | 8.0 | 983,000 |
| FCS-2 | End of culvert under mine access road | 1-Oct-09 | 174 | 25 | 234 | 2020 | 120 | 139,000 | 134,000 | 1660 | 62.2 | 738,000 | 2640 | 56 | 214 | 2070 | 185 | 133,000 | 133,000 | 1750 | 753 | 761,000 |
| FCS-3A | Inflow to manhole | 1-Oct-09 | 3290 | 21 | 14.1 | 901 | 23 | 2,460,000 | 86,900 | 892 | 4.9 | 533,000 | 3070 | 27 | 11.4 | 964 | 24 | 2,160,000 | 90,600 | 1020 | 32.0 | 584,000 |
| FCS-3B | Inflow to manhole | 1-Oct-09 | 774 | 12.2 | 6.2 | 388 | 24 | 856,000 | 49,400 | 333 | 0.6 | 225,000 | 3260 | 16.1 | 5.8 | 407 | 44 | 802,000 | 50,000 | 353 | 19.7 | 233,000 |
| FCS-4 | ETA SIS bypass at mouth of canyon | 1-Oct-09 | 17 | 0.8 | 12.7 | 289 | 12 | 430,000 | 53,600 | 369 | 0.5 | 141,000 | 2870 | 25.3 | 12.9 | 303 | 100 | 446,000 | 55,200 | 395 | 313 | 156,000 |
| EOP | End of pipe | 1-Oct-09 | 433 | 10 | 138 | 1450 | 55 | 897,000 | 108,000 | 1260 | 3.8 | 609,000 | 2300 | 37 | 123 | 1560 | 89 | 871,000 | 116,000 | 1390 | 268 | 671,000 |
| **QA/QC** | | | | | | | | | | | | | | | | | | | | | | |
| **August 2009** | | | | | | | | | | | | | | | | | | | | | | |
| FCS-1 at X23 | Faro Creek seepage (FCS) from Main WRD | 16-Aug-09 | 10 | 1 | 317 | 1790 | 33 | 358,000 | 118,000 | 1910 | 0.3 | 990,000 | 20 | 9 | 349 | 1720 | 81 | 344,000 | 122,000 | 1890 | 4.8 | 1,020,000 |
| **RPD, %** | | | - | - | 1.3 | 2.8 | 8.7 | 0.8 | 3.3 | 3.6 | 0.0 | 4.9 | - | 120.0 | 2.3 | 2.3 | 1.2 | 3.1 | 0.8 | 1.1 | 20.6 | 1.0 |
| **Maximum Allowable Difference** | | | <10 | <1 | - | - | - | - | - | - | <0.3 | - | <20 | - | - | - | - | - | - | - | - | - |
| Field Blank Sample | | 16-Aug-09 | 1.0 | 0.02 | 0.005 | 0.005 | 0.11 | 3 | 0.08 | 0.02 | 0.076 | 1.7 | 1.2 | 0.02 | 0.005 | 0.010 | 0.05 | 9 | 0.54 | 0.02 | 0.042 | 3.9 |
| **October 2009** | | | | | | | | | | | | | | | | | | | | | | |
| FCS-2 | End of culvert under mine access road | 1-Oct-09 | 159 | 24 | 236 | 1970 | 113 | 136,000 | 130,000 | 1610 | 58.3 | 724,000 | 2720 | 60 | 223 | 2140 | 199 | 134,000 | 136,000 | 1800 | 771 | 783,000 |
| **RPD, %** | | | 9.0 | 4.1 | 0.9 | 2.5 | 6.0 | 2.2 | 3.0 | 3.1 | 6.5 | 1.9 | 3.0 | 6.9 | 4.1 | 3.3 | 7.3 | 0.7 | 2.2 | 2.8 | 2.4 | 2.8 |
| **Maximum Allowable Difference** | | | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Field Blank Sample | | 1-Oct-09 | 0.9 | 0.02 | 0.005 | 0.017 | 0.18 | 9 | 1.17 | 0.51 | 0.061 | 7 | 0.6 | 0.02 | 0.005 | 0.008 | 0.15 | 5 | 0.80 | 0.03 | 0.067 | 5.0 |

0.01 **Concentration less than indicated detection limit**
- **Data not available**
*210* **Italicized TDS values calculated from EC**

**Table 4.** Summary of Field Parameters, September 9, 2009

| ID | pH | Temp ($^oC$) | Cond (µs/cm$^o$) | Cond (µs/cm) | Salinity | DO (%) | DO (mg/L) | ORP |
|---|---|---|---|---|---|---|---|---|
| X23 | 6.01 | 6.18 | 7915 | 5068 | 4.37 | 79.5 | 9.5 | 6.8 |
| ETA (FCS-3) | 5.44 | 3.48 | 8555 | 5038 | 4.71 | 96.7 | 12.06 | 31 |
| Seep nearby | 5.95 | 6.13 | 5876 | 3764 | 3.18 | 67.1 | 7.94 | -30.4 |
| Large pipe (east side) | 5.57 | 3.9 | 8367 | 4990 | 4.62 | 117 | 15.2 | 24.2 |
| Short pipe (west side) | 5.95 | 5.5 | 5834 | 3721 | 3.14 | 94.5 | 11.2 | -18.4 |
| Combined flow (long and short and FCS-2) | 5.82 | 5.99 | 7455 | 4704 | 4.08 | 109.9 | 13.5 | -13.4 |
| SIS bypass | 5.78 | 4.39 | 6160 | 3725 | 3.33 | 39.1 | 4.7 | 21.1 |
| ETA culvert (FCS-2) | 5.62 | 7.65 | 7161 | 4788 | 3.94 | 88.4 | 10.35 | 72.5 |
| FCS-4 | 6.65 | 6.64 | 5609 | 3642 | 3.03 | 119.6 | 14.2 | -5.9 |
| Downstream of weir | 6.12 | 6.68 | 5597 | 3638 | 3.02 | 112.4 | 12.9 | -18.4 |

**Table 5.** Summary of Observed ETA SIS Seepage Water Quality

**A. Sulphate Concentrations**

| | Seepage collected in ETA SIS | | | Total ETA SIS Discharge | Seepage By-passing ETA SIS |
|---|---|---|---|---|---|
| | FCS-2 | FCS-3a | FCS-3b | EOP | FCS-4 |
| Date | mg/L | mg/L | mg/L | mg/L | mg/L |
| 16-Aug-09 | 6,700 | 7,700 | | 7,400 | 5,200 |
| 10-Sep-09 | n/a | 9,400 | n/a | n/a | 5,200 |
| 1-Oct-09 | 7,800 | 8,900 | 4,300 | 7,200 | 4,400 |
| **Average** | **7,250** | **8,667** | **4,300** | **7,300** | **4,933** |

**B. Zinc Concentrations**

| | Seepage collected in ETA SIS | | | Total ETA SIS Discharge | Seepage By-passing ETA SIS |
|---|---|---|---|---|---|
| | FCS-2 | FCS-3a | FCS-3b | EOP | FCS-4 |
| Date | mg/L | mg/L | mg/L | mg/L | mg/L |
| 16-Aug-09 | 685 | 466 | | 662 | 148 |
| 10-Sep-09 | n/a | 536 | n/a | n/a | 144 |
| 1-Oct-09 | 738 | 533 | 225 | 609 | 141 |
| **Average** | **712** | **512** | **225** | **636** | **144** |

**C. Iron Concentrations**

| | Seepage collected in ETA SIS | | | Total ETA SIS Discharge | Seepage By-passing ETA SIS |
|---|---|---|---|---|---|
| | FCS-2 | FCS-3a | FCS-3b | EOP | FCS-4 |
| Date | mg/L | mg/L | mg/L | mg/L | mg/L |
| 16-Aug-09 | 87 | 1,730 | | 885 | 354 |
| 10-Sep-09 | n/a | 2,160 | n/a | n/a | 377 |
| 1-Oct-09 | 139 | 2,460 | 856 | 897 | 430 |
| **Average** | **113** | **2117** | **856** | **891** | **387** |

**Table 6.** Comparison with Historic ETA Monitoring

| Station ID | Date | Flow L/s | field pH - | lab pH - | lab EC uS/cm | SO4 mg/L | Zn-T mg/L | Fe-T mg/L |
|---|---|---|---|---|---|---|---|---|
| FCS-1 at toe of WRD | Average (Oct '05-May '06) | **0.9** | **6.04** | **6.14** | **6,468** | **5,673** | **489** | **126.0** |
| | Average (Jun'06 - Oct '06) | **0.7** | **6.44** | **6.78** | **6,290** | **5,260** | **353** | **96.2** |
| | 16-Aug-09 | 0.9 | 6.42 | 5.20 | 8,510 | 8,300 | 1,030 | 355 |
| | 9-Sep-09 | 1.0 | 6.00 | 5.60 | 8,520 | 8,300 | 969 | 341 |
| | 1-Oct-09 | 1.1 | 6.33 | 4.50 | 8,510 | 7,500 | 915 | 362 |
| | **Average (Aug '09 - Oct '09)** | **1.0** | **6.3** | **5.1** | **8,513** | **8,033** | **971** | **353** |
| FCS-2 at culvert below road | Average (Oct '05-May '06) | **n/a** | **6.47** | **6.65** | **5,493** | **4,590** | **356** | **84** |
| | Average (Jun '06 - Oct '06) | **2.1** | **6.55** | **7.04** | **5,820** | **4,813** | **351** | **40** |
| | 16-Aug-09 | 3.7 | 6.40 | 4.40 | 7,210 | 6,700 | 655 | 88 |
| | 9-Sep-09 | 4.5 | | n/a | n/a | n/a | n/a | n/a |
| | 1-Oct-09 | 4.6 | 6.10 | 4.00 | 7,670 | 7,800 | 761 | 133 |
| | **Average (Aug '09 - Oct '09)** | **4.3** | **6.3** | **4.2** | **7,440** | **7,250** | **708** | **111** |
| FCS-3 seepage face below road | Average (Oct '05-May '06) | **2.9** | **6.07** | **5.19** | **7,745** | **6,958** | **358** | **1,565** |
| | Average (Jun '06 - Oct '06) | **2.6** | **5.85** | **4.55** | **7,495** | **6,865** | **388** | **1,485** |
| | 16-Aug-09 | 2.9 | 6.6 | 4.3 | 8,200 | 7,700 | 471 | 1,760 |
| | 9-Sep-09 | 2.8 | 5.4 | 4.0 | 9,290 | 9,400 | 536 | 2,160 |
| | 1-Oct-09 | 2.5 | 5.9 | 3.5 | 9,090 | 8,900 | 584 | 2,160 |
| | **Average (Aug '09 - Oct '09)** | **2.7** | **6.0** | **3.9** | **8,860** | **8,667** | **530** | **2,027** |
| FCS-4 mouth of Canyon | Average (Oct '05-May '06) | **6.9** | **6.08** | **5.31** | **5,925** | **5,067** | **263** | **799** |
| | Average (Jun '06 - Oct '06) | **6.1** | **6.09** | **5.24** | **6,268** | **5,545** | **265** | **666** |
| | 16-Aug-09 | 1.0 | 6.80 | 5.60 | 5,930 | 5,200 | 160 | 431 |
| | 9-Sep-09 | 1.1 | 6.7 | 5.30 | 6,000 | 5,200 | 144 | 354 |
| | 1-Oct-09 | 1.2 | 6.40 | 4.10 | 5,970 | 4,400 | 156 | 430 |
| | **Average (Aug '09 - Oct '09)** | **1.1** | **6.6** | **5.0** | **5,967** | **4,933** | **153** | **405** |

**Table 7.** Observed Seepage & Contaminant Load for ETA SIS, August – October 2009.

**A. ETA SIS Performance - Flows**

| | Seepage collected in ETA SIS | | | | Total ETA SIS Discharge | Seepage Bypassing ETA SIS | |
|---|---|---|---|---|---|---|---|
| | FCS-2 | FCS-3a | FCS-3b | SUM | EOP | FCS-4 | FCS-4 |
| Date | L/s | L/s | L/s | L/s | L/s | L/s | % |
| 16-Aug-09 | 3.7 | 2.9 | 0.8 | 7.3 | 7.5 | 1.0 | 11% |
| 10-Sep-09 | 4.5 | 2.8 | 0.8 | 8.1 | 7.4 | 1.1 | 13% |
| 1-Oct-09 | 4.6 | 2.5 | 0.9 | 8.1 | 8.8 | 1.2 | 12% |
| **Average** | **4.3** | **2.7** | **0.8** | **7.8** | **7.9** | **1.1** | **12%** |

**B. ETA SIS Performance - Sulphate Load**

| | Contaminant load collected in ETA SIS | | | | Total ETA SIS Load | Contaminant Load Bypassing ETA SIS | |
|---|---|---|---|---|---|---|---|
| | FCS-2 | FCS-3a | FCS-3b | SUM | EOP | FCS-4 | FCS-4 |
| Date | t/yr | t/yr | t/yr | t/yr | t/yr | t/yr | % |
| 16-Aug-09 | 782 | 692 | 185 | 1,658 | 1,750 | 157 | 8% |
| 10-Sep-09 | n/a | 824 | n/a | n/a | n/a | 182 | n/a |
| 1-Oct-09 | 1,132 | 713 | 127 | 1,972 | 1,998 | 167 | 8% |
| **Average** | **957** | **743** | **156** | **1,815** | **1,874** | **169** | **8%** |

**C. ETA SIS Performance - Zinc Load**

| | Contaminant load collected in ETA SIS | | | | Total ETA SIS Load | Contaminant Load Bypassing ETA SIS | |
|---|---|---|---|---|---|---|---|
| | FCS-2 | FCS-3a | FCS-3b | SUM | EOP | FCS-4 | FCS-4 |
| Date | t/yr | t/yr | t/yr | t/yr | t/yr | t/yr | % |
| 16-Aug-09 | 80 | 42 | 11 | 133 | 157 | 4 | 3% |
| 10-Sep-09 | n/a | 47 | n/a | n/a | n/a | 5 | n/a |
| 1-Oct-09 | 107 | 43 | 7 | 156 | 169 | 5 | 3% |
| **Average** | **93** | **44** | **9** | **145** | **163** | **5** | **3%** |

**D. ETA SIS Performance - Iron Load**

| | Contaminant load collected in ETA SIS | | | | Total ETA SIS Load | Contaminant Load Bypassing ETA SIS | |
|---|---|---|---|---|---|---|---|
| | FCS-2 | FCS-3a | FCS-3b | SUM | EOP | FCS-4 | FCS-4 |
| Date | t/yr | t/yr | t/yr | t/yr | t/yr | t/yr | % |
| 16-Aug-09 | 10 | 155 | 41 | 207 | 209 | 11 | 5% |
| 10-Sep-09 | n/a | 189 | n/a | n/a | n/a | 13 | n/a |
| 1-Oct-09 | 20 | 197 | 25 | 243 | 249 | 16 | 6% |
| **Average** | **15** | **181** | **33** | **225** | **229** | **13** | **6%** |

**Table 8.** Estimated Seepage & Contaminant Load for ETA SIS, Jan – Dec 2009

**A. ETA Seepage Flows**

| | ETA Seepage components | | | | Total |
|---|---|---|---|---|---|
| | FCS-2 | FCS-3a | FCS-3b | Other | Seepage |
| Period | L/s | L/s | L/s | L/s | L/s |
| Jan 1 - Apr 27 | 0 | 2.7 | 0.8 | 1.1 | 4.6 |
| Apr 28 - May 20 | 9.6 | 2.7 | 0.8 | 3 | 16.1 |
| May 21- Aug 15 | 4.8 | 2.7 | 0.8 | 2 | 10.3 |
| Aug 16 - Oct 13 | 3.9 | 2.7 | 0.8 | 1.1 | 8.5 |
| Oct 14 - Dec 31 | 3.7 | 2.7 | 0.8 | 1.5 | 8.7 |
| **TOTAL** | **3.2** | **2.7** | **0.8** | **1.5** | **8.2** |

**B. ETA Sulphate Loads**

| | ETA Seepage components | | | | Total |
|---|---|---|---|---|---|
| | FCS-2 | FCS-3a | FCS-3b | Other | SO4 Load |
| Period | t SO4 | t SO4 | t SO4 | t SO4 | t SO4 |
| Jan 1 - Apr 27 | 0 | 251 | 74 | 56 | 381 |
| Apr 28 - May 20 | 114 | 47 | 14 | 23 | 198 |
| May 21- Aug 16 | 228 | 189 | 56 | 61 | 534 |
| Aug 16 - Oct 14 | 154 | 127 | 38 | 28 | 347 |
| Oct 14 - Dec 31 | 199 | 170 | 50 | 51 | 470 |
| **TOTAL** | **695** | **783** | **232** | **218** | **1929** |

**C. ETA Zinc Loads**

| | ETA Seepage components | | | | Total |
|---|---|---|---|---|---|
| | FCS-2 | FCS-3a | FCS-3b | Other | Zn Load |
| Period | t Zn | t Zn | t Zn | t Zn | t Zn |
| Jan 1 - Apr 27 | 0 | 15 | 4 | 2 | 20 |
| Apr 28 - May 20 | 11 | 3 | 1 | 1 | 15 |
| May 21- Aug 16 | 22 | 11 | 3 | 2 | 38 |
| Aug 16 - Oct 14 | 15 | 7 | 2 | 1 | 25 |
| Oct 14 - Dec 31 | 19 | 10 | 3 | 1 | 33 |
| **TOTAL** | **66** | **45** | **13** | **6** | **131** |

**D. ETA Iron Loads**

| | ETA Seepage components | | | | Total |
|---|---|---|---|---|---|
| | FCS-2 | FCS-3a | FCS-3b | Other | Fe Load |
| Period | t Fe | t Fe | t Fe | t Fe | t Fe |
| Jan 1 - Apr 27 | 0 | 67 | 7 | 5 | 79 |
| Apr 28 - May 20 | 8 | 13 | 1 | 2 | 24 |
| May 21- Aug 16 | 3 | 51 | 5 | 5 | 64 |
| Aug 16 - Oct 14 | 4 | 34 | 3 | 2 | 43 |
| Oct 14 - Dec 31 | 16 | 45 | 5 | 4 | 71 |
| **TOTAL** | **31** | **209** | **22** | **19** | **281** |

**Table 9.** Estimated Collection Efficiency for ETA SIS, Jan – Dec 2009

**A. ETA Seepage Flows**

| Date | Duration | 2009 ETA SIS Collection Efficiency | | 2009 ETA SIS By-pass | |
|---|---|---|---|---|---|
| | Days | L/s | % | L/s | % |
| Jan 1 - Apr 27 | 117 | 0 | 0% | 4.6 | 100% |
| Apr 28 - May 20 | 22 | 11.2 | 69% | 4.9 | 31% |
| May 21- Aug 15 | 88 | 7.8 | 76% | 2.5 | 24% |
| Aug 16 - Oct 13 | 59 | 7.4 | 87% | 1.1 | 13% |
| Oct 14 - Dec 31 | 79 | 0 | 0% | 8.7 | 100% |
| **TOTAL** | **n/a** | **3.8** | **46%** | **4.4** | **54%** |

**B. ETA Sulphate Loads**

| Date | Duration | Estimated 2009 ETA SIS Collection Efficiency | | Estimated 2009 ETA SIS By-pass | |
|---|---|---|---|---|---|
| | Days | t SO4 | % | t SO4 | % |
| Jan 1 - Apr 27 | 117 | 0 | 0% | 381 | 100% |
| Apr 28 - May 20 | 22 | 152 | 77% | 46 | 23% |
| May 21- Aug 15 | 88 | 450 | 84% | 84 | 16% |
| Aug 16 - Oct 13 | 59 | 319 | 92% | 28 | 8% |
| Oct 14 - Dec 31 | 79 | 0 | 0% | 470 | 100% |
| **TOTAL** | **n/a** | **921** | **48%** | **1,009** | **52%** |

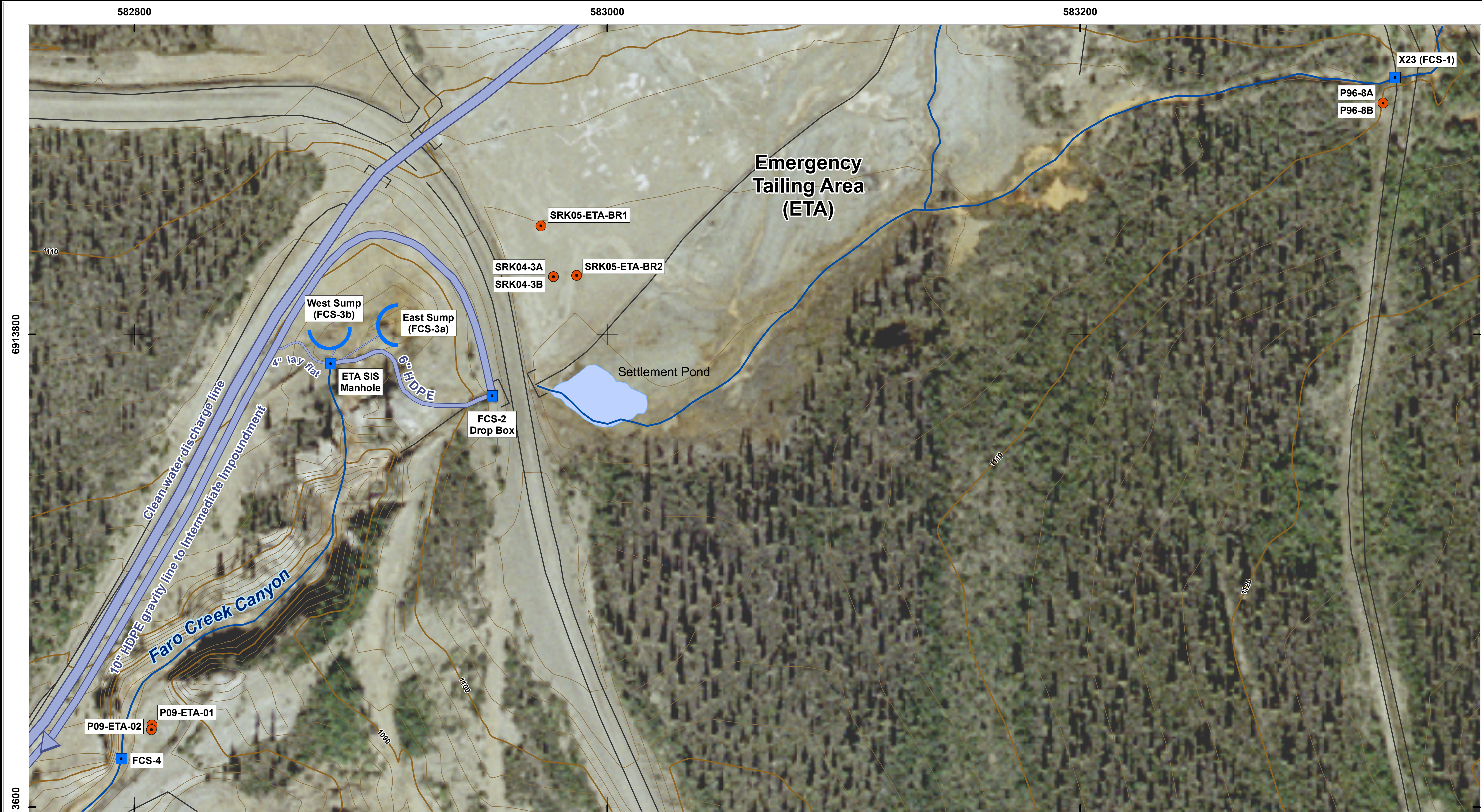
**C. ETA Zinc Loads**

| Date | Duration | Estimated 2009 ETA SIS Collection Efficiency | | Estimated 2009 ETA SIS By-pass | |
|---|---|---|---|---|---|
| | Days | t Zn | % | t Zn | % |
| Jan 1 - Apr 27 | 117 | 0 | 0% | 20 | 100% |
| Apr 28 - May 20 | 22 | 12 | 81% | 3 | 19% |
| May 21- Aug 15 | 88 | 34 | 90% | 4 | 10% |
| Aug 16 - Oct 13 | 59 | 24 | 97% | 1 | 3% |
| Oct 14 - Dec 31 | 79 | 0 | 0% | 33 | 100% |
| **TOTAL** | **n/a** | **70** | **53%** | **61** | **47%** |

**D. ETA Iron Loads**

| Date | Duration | Estimated 2009 ETA SIS Collection Efficiency | | Estimated 2009 ETA SIS By-pass | |
|---|---|---|---|---|---|
| | Days | t Fe | % | t Fe | % |
| Jan 1 - Apr 27 | 117 | 0 | 0% | 79 | 100% |
| Apr 28 - May 20 | 22 | 20 | 85% | 4 | 15% |
| May 21- Aug 15 | 88 | 58 | 91% | 6 | 9% |
| Aug 16 - Oct 13 | 59 | 41 | 94% | 2 | 6% |
| Oct 14 - Dec 31 | 79 | 0 | 0% | 71 | 100% |
| **TOTAL** | **n/a** | **120** | **43%** | **161** | **57%** |

# FIGURES




## LEGEND

- Monitoring Well
- ETA Seepage Monitoring Station
- Pipeline

PROJECTION: UTM
ZONE: 8
DATUM: NAD 27
UNITS: Meters

CONTOUR INTERVAL: 2m

N S W E

# Layout of ETA SIS

Faro Mine Site

SCALE

0 20 40 80 120 160 Meters

Deloitte & Touche

ROBERTSON GEOCONSULTANTS INC.
Consulting Geotechnical and Environmental Engineers

CLIENT: Deloitte & Touche Inc.
PROJECT: ETA SIS Performance Review
REPORT: RGC 118016
LOCATION: Anvil Range Mining Complex,YT, Canada

FIGURE: 1

DATE: 022210
DRAWN BY: OM
FILE: Faro_ETA_SIS.mxd

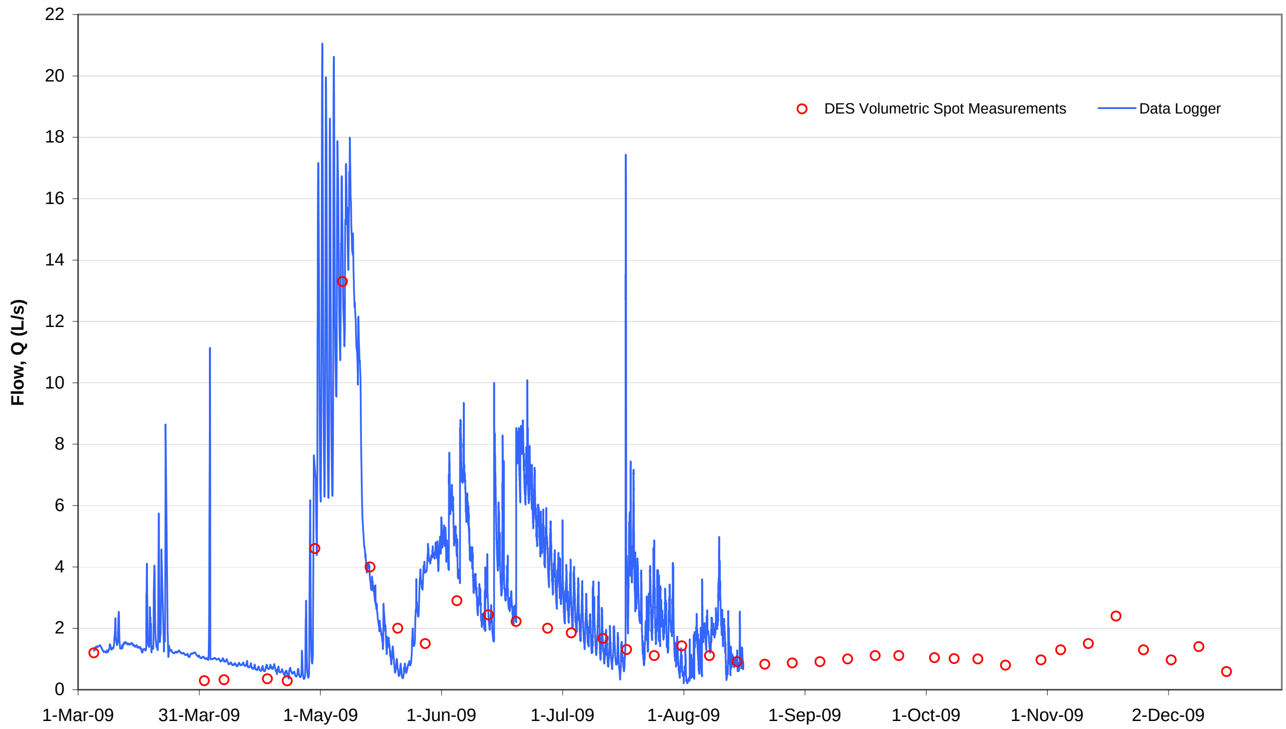



**Figure 2.** Hydrograph for X23 weir (FCS-1), 2009

# PHOTO LOG

**Photo 1.** Overview of ETA SIS Area

**Photo 2.** ETA SIS manhole

**Photo 3.** Collection box below access road (FCS-2)

**Photo 4.** 15 and 30 HP sump pumps in man hole

**Photo 5.** Discharge of ETA SIS seepage into wet beach of Intermediate Impoundment (EOP)

**Photo 6.** Settlement pond for ETA seepage upstream of road culvert

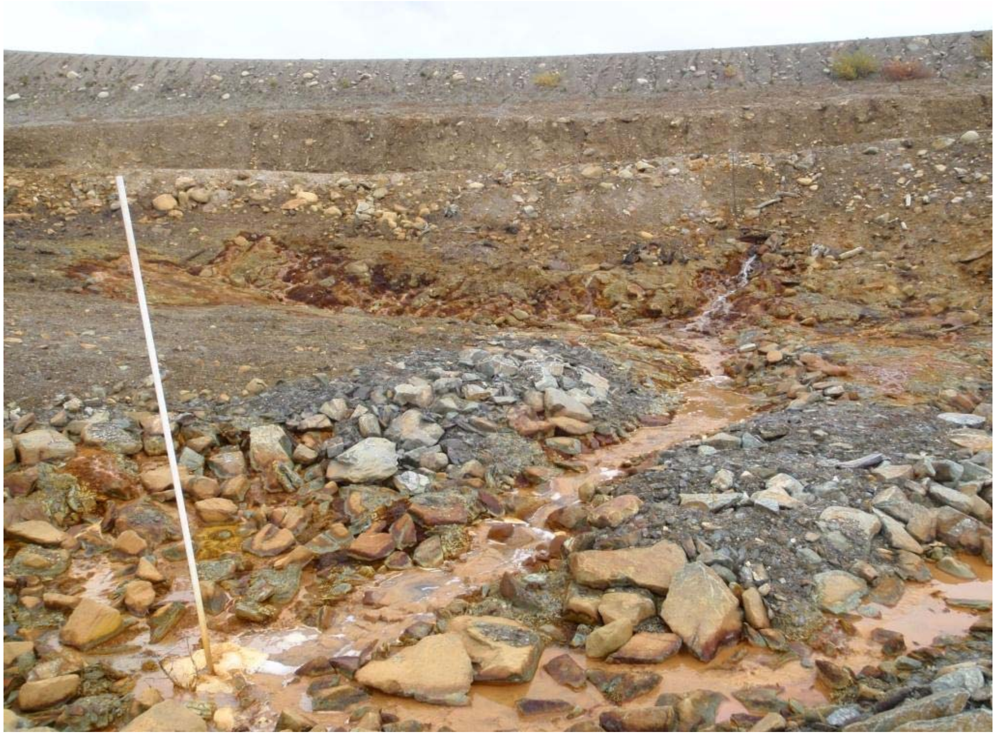


**Photo 7.** Subsurface seepage day-lighting in the central portion of Faro Creek Canyon (FCS-3a)

**Photo 8.** Subsurface seepage day-lighting in the western portion of Faro Creek Canyon (FCS-3b)

**Photo 9.** Small seep by-passing the ETA SIS to the east of the manhole

**Photo 10.** Seepage flow in the lower Faro Creek Canyon (by-passing ETA SIS)

**Photo 11.** Seepage at the mouth of Faro Creek Canyon (FCS-4)

**Photo 12.** Flow over 90 V-notch weir (FCS-4) on Sep 9 2009 (ca 9 AM)

**Photo 13.** Residual seepage discharging into the Intermediate Impoundment (at FCS-5)

End of Photo Log

# APPENDIX A

# Performance Evaluation of the Emergency Tailings Area (ETA) Seepage Interception System (SIS) 2009

**Submitted to:**

Yukon


**Deborah Pitt ASLA**
A/ Senior Project Manager
Faro Project Management Team
Assessment and Abandoned Mines
Government of Yukon
Energy, Mines and Resources


**Submitted By:**


Laberge
ENVIRONMENTAL SERVICES


October 22, 2009

## Background

The following is a summary of results of two snapshot surveys of the Emergency Tailings Area (ETA) performed as a component of Christoph Wels of Robertson GeoConsultants Inc. (RGC) proposal **Performance Assessment of the ETA Seepage Interception System** dated May 8, 2009. Monitoring of water quality and discharge along the flow pathway in the remnant Faro Creek channel was required in order to quantify the degree of losses / efficiency of the seepage interception system installed in late 2007. The role of Laberge Environmental Services (LES) was to collect water quality and discharge data at specified points along the system and report the results to Christoph Wels and to Leslie Gomm for interpretation.

Replicate methods of discharge measurement were required for QA/QC. Field filtering for dissolved metals was required. At all stations field readings of pH and EC were taken and water samples were submitted for water quality analysis. Data from all measurement points including X-23 (the only automated recorder in the system) is included.

## Methods

LES conducted two rounds of sampling. In early September the Principal Investigator, Christoph Wels, conducted a site visit.

### Discharge Monitoring

The following points were prescribed for discharge measurements. Discharge was measured using volumetric (time to fill a bucket of measured volume), weir measurements (for $90^0$ V-notch Q L/sec = 1362.9*H^2.5), Parshall Flume and rotating cup (Price mini) velocity meter.

1. Surficial seepage flow (FCS_2) as intercepted in the drop box below the road culvert
2. Flow from X-23 (FCS_1)
3. Faro Creek seepage that is bypassing the SIS and reporting to FCS_4 at the mouth of Faro Creek Canyon
4. Seepage daylighting under the access road culvert
5. Seepage daylighting immediately downhill from the manhole
6. Discharge from the end of the pipeline "EOP", representing the actual discharge into the Intermediate Impoundment and acting as a check on the Total Seepage mentioned above.

### Water Quality Monitoring

Sample sites were prescribed as follows. In the first round of sampling, the two seepage inflows FCS3a and FCS3b were combined into a single sample, while in the October 1 sampling event, separate samples were collected from FCS3A and FCS3B. Blind Duplicates and filed blanks were prepared.

1. Toe of the Faro Main Waste Rock Dump (FCS_1 or X-23)
2. Surface runoff reporting to the drop box below the access road (FCS_2)
3. Seepage collected in the manhole (FCS_3a)
4. Faro Creek seepage in the remnant channel below the canyon (FCS_4)
5. The seepage collected and as discharged into the Intermediate Impoundment (EOP)

Every station was sampled in accordance with standard operating procedure, including pH, EC, and temperature field measurements with freshly standardized instruments. All dissolved metal samples were be promptly field filtered.
The suite of parameters included the following;

- Lab pH
- Major ions (SO4, Cl, F, Br)
- Alkalinity/Acidity
- Low Level Total and Dissolved metals by ICPOES

LES handled all shipping and receiving; all samples were analyzed and reported by Maxxam Analytics Inc. Digital copies have been sent under separate cover, and hard copies are attached to this report.

**Results**

Following is a series of pictures and a summary table of instantaneous discharge measurements and other in-situ measurements and observations. The ETA-SIS was inspected 4 times and sampled twice.

17-Jun-09 FCS 4 was inspected. H= 0.057. Silted in. At FCS-2 there are two pipes; one loops around to join 12” tailings line upstream of manhole flow and the other 12” HDPE flows directly to the manhole. Noted numerous leaks – mainly in channel downstream of FCS-2 and just downstream of manhole. Situation hopeless for pipe flow monitoring. Improvements planned.

16-Aug-09; Sampling conducted. Flow had dried up downstream of FCS-2. A sump had been built upstream of the access road at FCS-2, seemed effective at confining flow to a single channel through the culvert. No seepage under the culvert as in the past. EOP was 7.5 – 7.7 L/sec while FCS-4 was 0.96 L/sec. The ETA-SIS was 87% efficient.

10-Sep-09; Discussed ETA-SIS with Christoph Wels on site. Conducted discharge measurements, no water quality. Inspected and downloaded X-23 (noted discrepancies with datalogger – not performing well).

30-Sep and 01-Oct-09; Full sampling and discharge measurements. EOP was 8.8 L/sec while FCS-4 was 1.2 L/sec. The ETA-SIS was 86 % efficient.


Flows into the ETA-SIS manhole


X-23


Looking upstream at FCS-2


Collection box at FCS-2; 12" HDPE with gate valve.


FCS-2; 12" HDPE, loops to tailings line


Channel downstream of FCS-2 17-Jun-09


Channel downstream of FCS-2 30-Sep-09

Collection sump upstream of mine access road; confines flow from X-23 and reports to FCS-2.

FCS-2

12" HDPE from FCS-2 to manhole.

Manhole 16-Aug-09

collection sump just upstream of manhole.


Looking downstream from manhole


Seepage below manhole 16-Aug-09


FCS-4 90 degree V-notch weir 16-Aug-09


Looking downstream from FCS-4 16-Aug-09


EOP – End of Pipe from seepage collection system


EOP looking downstream

**Summary of In Situ Measurements at ETA Seepage Collection System**

| WQ | Station | Date/Time | pH | Temp. C | Cond. *u*S/cm | Q L/sec | Comment |
|---|---|---|---|---|---|---|---|
| X | X-23 | 16-Aug-09 13:30 | 6.42 | 10.4 | 8130 | 0.88 | H = 0.053. Site of BD (Blind Duplicate). PT2X sensor acting up – offset changes between downloads. |
| | X-23 | 16-Aug-09 13:40 | | | | 0.81 | Volumetric (QA/QC) |
| | X-23 | 10-Sep-09 13:00 | | | | 1.01 | H = 0.056 |
| | X-23 | 10-Sep-09 13:00 | | | | 1.10 | Volumetric (QA/QC) |
| X | X-23 | 30-Sep-09 19:00 | 6.33 | 3.61 | 8340 | 1.01 | H = 0.056 |
| | X-23 | 30-Sep-09 19:30 | | | | 1.12 | Volumetric (QA/QC) |
| X | FCS-2 | 16-Aug-09 12:00 | 6.43 | 11.1 | 7120 | 3.7 | Volumetric at upstream end of culvert, old 90 weir |
| | FCS-2 | 10-Sep-09 15:30 | | | | 4.51 | Volumetric at upstream end of culvert, old 90 weir |
| X | FCS-2 | 01-Oct-09 10:30 | 6.05 | 2.6 | 7340 | 4.60 | Volumetric at upstream end of culvert, old 90 weir. Site of BD Blind Duplicate |
| | Seep immediately D/S Manhole | 16-Aug-09 | 6.5 | 5.1 | 6520 | 1.1 | Parshall Flume installed in flow immediately downstream of the manhole |
| | Flow into Manhole from West FCS3B | 16-Aug-09 | | | | 0.76 | 12” HDPE. Volumetric 22.8 L |
| | Flow into Manhole from West FCS3B | 10-Sep-09 | | | | 0.79 | 12” HDPE Volumetric 22.8 L |
| X | Flow into Manhole from West FCS3B | 01-Oct-09 10:15 | 6.34 | 4.3 | 5890 | 0.94 | 12” HDPE Volumetric 22.8 L |
| | Flow into Manhole from East FCS3A | 16-Aug-09 | | | | 2.85 | 12”HDPE Volumetric 22.8 L |
| | Flow into Manhole from East FCS3A | 10-Sep-09 | | | | 2.78 | 12”HDPE Volumetric 22.8 L |
| X | Flow into Manhole from East FCS3A | 01-Oct-09 10:00 | 5.94 | 3.2 | 8840 | 2.54 | 12”HDPE Volumetric 22.8 L |
| | Flow from FCS-2 into Manhole | 16-Aug-09 | | | | 3.56 | 90 degree 12” steel elbow Volumetric 22.8 L |
| | Flow from FCS-2 into Manhole | 10-Sep-09 | | | | 1.12 | 90 degree 12” steel elbow Volumetric 22.8 L |
| | Flow from FCS-2 into Manhole | 01-Oct-09 10:15 | | | | 3.0 | 90 degree 12” steel elbow Volumetric 22.8 L |
| X | FCS 3A (combined FCS3A and FCS3B) | 16-Aug-09 | 6.61 | 7.0 | 8210 | 3.61 (.76+2.85) | Combined water from the two inflows into the manhole |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | FCS-4 | 17-Jun-09 | | | | 1.01 | H = 0.057, after mucking out head pond (was silted in) |
| X | FCS-4 | 16-Aug-09 13:00 | 6.78 | 11.7 | 5980 | 0.96 | Volumetric; H is invalid due to silted-in head pond |
| | FCS-4 | 10-Sep-09 16:00 | | | | 1.11 | Volumetric. H is invalid due to silted-in head pond |
| X | FCS-4 | 01-Oct-09 11:00 | 6.44 | 2.6 | 5870 | 1.20 | Volumetric; H is invalid due to silted-in head pond |
| X | EOP | 16-Aug-09 | 6.19 | 8.8 | 8050 | 7.5 | Volumetric |
| | EOP | 16-Aug-09 | | | | 7.7 | Price mini meter (QA/QC) |
| | EOP | 10-Sep-09 14:00 | | | | 7.4 | Volumetric |
| X | EOP | 30-Sep-09 16:00 | 6.84 | 3.6 | 7890 | 8.8 | Volumetric |

Digital copies of water quality results for the two rounds of sampling have been sent separately. A file containing data from X-23 has also been sent separately. Hard copies of water quality results are attached to this report; Maxxam Analytics Certificates of Analysis A944208 (COC 08303695) and A956080 (COC 08304780). Note that field pH values are consistently higher than lab pH although the pH instruments used were freshly calibrated on the day of use. Also note that the Blind Duplicates (BD) for the two sampling events were as follows: 16-Aug-09 BD = X-23, 01-Oct-09 BD = FCS-2.

Respectfully Submitted

Ken Nordin AScT CCEP
Laberge Environmental Services
August 7, 2009