Analysis of 2012 Site-wide Field Data Report Faro Mine Remediation Project

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Introduction

Purpose

This technical memorandum presents an analysis of the data collected during the waste rock dump (WRD), Cross Valley Dam (CVD), and seep sampling field investigations performed during the summer of 2012 at the Faro Mine Complex (FMC). The activities associated with the collection of these data are described in more detail the following reports:

- *Waste Rock Dump Monitoring Data Report, Faro Mine Remediation Project* (CH2M HILL, 2013a)
- *Cross Valley Dam Interception System Investigation Data Report, Faro Mine Remediation Project* (CH2M HILL, 2013b)
- *2012 Seepage, Surface Water, and Water Treatment Plant Influent Field Sampling Report, Faro Mine Remediation Project* (CH2M HILL, 2013c)

The purpose of this technical memorandum is to provide analysis and interpretation of these data, compare the recent 2012 field results with historical data from the FMC, and provide modifications to the conceptual site model, as necessary, to provide a basis of design for the remedial elements associated with the Faro Mine Remediation Project (FMRP).

This technical memorandum is organized by the type of analysis and field investigation conducted, regardless of location. All geochemical solids analyses from each sub-area of the FMC are discussed together, followed by data collected from groundwater monitoring wells, the seep sampling program, and a discussion of hydrogeologic studies.

Background

The FMC consists of three open pits, associated WRDs, the Faro Mill, and the Rose Creek Tailings Area (RCTA) (see Figure 1). Ore was milled in the Faro Mill, and the tailings from the milling process were disposed in the RCTA. Approximately 55 million tonnes (MT) of tailings were deposited in the Rose Creek Tailings Facility (RCTF) over an approximate 1 km wide by 4 km long stretch of the former Rose Creek alluvial valley. About 300 MT (about 154 million cubic metres) of waste rock are located in areas adjacent to the three open pits across the FMC in the Faro, Grum, and Vangorda areas (see Figure 1). The management of mine waste at Faro did not involve rigorous segregation; therefore, all of the Faro WRD material has the potential to result in poor quality drainage (SRK

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Consulting [SRK], 2010). Although more rigorous segregation practices were followed when the Grum and Vangorda pits were mined (SRK, 2006), both Grum and Vagnorda WRDs have areas of high sulphide content that are potentially acid generating. However, relative to the other two pits, the Vangorda pit generated waste rock with a higher percentage of sulphide-bearing minerals (SRK, 2006).

Each of these three ore bodies occur in topographic low-lying areas and either had creeks running across the planned open pit (Faro and Vangorda) or was a low wetland area with a creek flowing away from the ore body (Grum). In general, these creeks flow from north to south in the FMC; background conditions prevail north of the FMC, and affected water flows to the south. Previous borehole data and other data indicate that the FMC WRDs are underlain by thin colluvium and low-permeability bedrock (Robertson GeoConsultants Inc. [RGC], 1996). The conceptual site model (CSM) for the FMC assumes that precipitation infiltrating into the WRDs migrates vertically downward to the underlying native colluvium (CH2M HILL, 2012). Affected groundwater flows beneath the WRDs either flowing along the pre-mining surface or within the shallow colluvial aquifer following the pre-mining drainage patterns. The affected groundwater either migrates to the surrounding receiving water bodies or, typically, daylights as a seep at the toe of the WRDs. Drainage monitoring at the WRDs indicates that most of the seep water is currently non-acidic to only mildly acidic, with some exceptions, but it often contains elevated concentrations of cadmium and zinc (CH2M HILL, 2013a).

On the Faro WRD area, water flows into Rose Creek, which contributes to Anvil Creek before ultimately flowing into the Pelly River. On the Vangorda/Grum portion of the site, water flows to Vangorda Creek before flowing into the Pelly River near the town of Faro. Faro Creek, flowing from the north, is diverted around Faro Pit via the Faro Creek Diversion (FCD). Leakage from the FCD flows through the North Faro WRD and seeps into Faro Pit along the north wall of the pit. The other main contributors affecting Faro Pit are seepage from the Northeast WRD, pumping from Zone II Pit (X26), and the S-wells. Faro Pit currently has a geochemistry indicating buffered acid rock drainage (i.e., pH is nearly neutral) and, in general, zinc concentrations have been gradually increasing since 2004 (Dennison Environmental Services [DES], 2012).

The FCD flows into North Fork Rose Creek (NFRC) northeast of the Faro Northeast WRD. Although the FCD and NFRC are unaffected above this confluence, there is an increasing trend of sulphate and dissolved metals concentrations in water emanating from the Northeast WRD in an easterly direction toward NFRC and below the FCD confluence (Robertson GeoConsultants Inc. [RGC], 2012). Groundwater in the Zone II Outwash area is affected by Zone II WRD seepage. Although groundwater quality conditions appear to be relatively stable in the Zone II Outwash area, there is uncertainty associated with the timing of future contaminant breakthrough, and future contaminant concentrations could increase.

South of the Faro WRDs, pre-mining topography focuses seepage at two main locations: the S-wells area and the historical Faro Creek drainage south of the Main Faro WRDs (X23). At the S-wells area, a seepage interception system (SIS) collects a significant percentage of the seepage in the area and pumps it to Faro Pit before the seepage can migrate to the NFRC. S-well seepage collected in the common sump (monitored since 2009) and pumped to Faro Pit has had variable but persistently elevated concentrations of zinc and sulphate.

The X23 monitoring location represents WRD seepage flow captured by the pre-mining Faro Creek channel. Contaminant concentrations have steadily increased at X23 over the past 14 years, with periods of apparent stability and occasional ephemeral decreases in concentration. Sulphate increases have been fairly consistent and steady; zinc has shown some indication of breakthrough in the past 4 years (DES, 2012).

Seepage from the Emergency Tailings Area (ETA) converges with X23 flow immediately above Faro Canyon. Currently, these two flows are captured in the ETA manhole sump, which was installed in 2006, limiting the flow entering Faro Canyon. The ETA sump intercepts about 80 to 85 percent of the flow when it is operating (RGC, 2010), which is a significant portion of the contaminant load. However, the interception system is currently only operated seasonally, and the ETA flow discharges to Faro Canyon when the system is shut down.

Under pre-mining conditions, Faro Creek flowed into Rose Creek. However, Rose Creek was diverted to the south via the Rose Creek Diversion (RCD) and approximately 4 kilometres (km) of the former creek bed was backfilled with tailings. The NFRC flows into Rose Creek immediately above the RCTA. Groundwater in the Rose Creek

Alluvial Aquifer (RCAA) contains low levels of mine related constituents upgradient from the RCTA, but becomes much more significantly affected below the RCTA. The two main sources of contaminants affecting the RCAA are vertical migration of tailings pore water within the RCTA, and runoff/groundwater flow from the Faro WRDs (discharges from X23 and the ETA). The tailings pore water is highly affected, but the tailings material is so fine-grained that the rate of pore water displacement is extremely slow. Seepage from the Faro WRDs has a significant impact on the RCAA, as evidenced by the trend over the past 10 to 12 years of gradually increasing sulphate concentrations followed by an increase in zinc concentrations in the northern portion of the RCAA (RGC, 2012). The more recent increase in zinc concentrations near the Intermediate (ID) Pond is a concern because it indicates the migration of contaminants toward the CVD (RGC, 2012).

The Vangorda/Grum Area became active later in the history of the FMC was better managed with respect to placement of WRDs relative to pre-mining topography. Moreover, the waste rock from the Grum Pit does not have as much acid-generating potential as does the Vangorda or Faro pits. Grum Pit lake was also subjected to a long-term algal treatment pilot study that reduced contaminant concentrations, although not low enough to meet compliance standards; the pilot study was terminated. Thus, contaminant levels are expected to increase because the algal treatment has been terminated.

The easternmost flank of the Grum WRD was constructed over the former Grum Creek channel. The former Grum Creek drainage channels infiltrating water to two adjacent perennial seep locations that are geochemically similar. Contaminant concentrations at these seeps are relatively stable and only moderately elevated (SRK, 2010).

During construction of the Grum WRD, the sulphidic waste rock with the highest potential for generating acid and leaching metals was strategically placed in the Grum Sulphide Cell; the cell was capped with a low-permeability cover in 2010 to minimize impacts downgradient. Seepage below the Grum Sulphide Cell collects in a small sump (V15) before flowing to Moose Pond. Contaminant concentrations at V15 appear to be stabilizing because of the cap, although the record of evidence is limited and monitoring is ongoing.

Vangorda Creek, which was unaffected, was diverted around Vangorda Pit prior to mining. Vangorda Pit Lake contains highly elevated levels of contaminants. The Vangorda WRD was constructed over an existing ridge. The Vangorda WRD is surrounded to the south, west, and north by a drainage ditch that collects seepage from the toe of the WRD. There are several transverse drains that direct the seepage to the collection ditch that leads to Little Creek Pond, where seepage is collected. Samples collected from these transverse drains are highly acidic, with elevated iron, zinc, and sulphate concentrations. In some of the transverse drains to the west and the south of the WRD, the contaminant concentrations appear to be fairly stable. However, in a few of the drains on the northwestern side of the WRD closest to the Little Creek Pond, the contaminant concentrations are increasing. Although the transverse drains and drainage ditch collect the majority of the seepage at the toe of Vangorda WRD, RGC (2012) reports that immediately downgradient from the drainage ditch, groundwater quality is deteriorating based on major ion breakthrough. Zinc concentrations remain low but have increased near the northwestern corner of the WRD.

Geochemical Solids Analysis

Geochemical samples of waste rock and soil were collected during groundwater monitoring well installations associated with the Faro, Grum, and Vangorda WRD investigations and as part of the CVD seepage interception system (SIS) investigation. Samples were submitted for soil pH, total metals, total inorganic carbon (TIC), total sulphur, neutralization potential, and metal leaching analyses, including the 96-hour leach and synthetic precipitation leaching procedure protocols. Samples were also submitted for sequential extraction analysis using a modified Tessier Method; however, those analyses are still being processed by the contract laboratory and, the data will be presented elsewhere.

Cross Valley Dam Field Investigations

Field investigations related to the CVD in 2012 included advancing boreholes, collecting soil and rock fragment samples for laboratory analysis and lithological description, installing groundwater monitoring wells at each new borehole, performing a survey of the new well locations, performing aquifer tests, and performing potentiomanometer surveys.

Ten monitoring wells (CH12-204-MW001 through CH12-204-MW006) and one piezometer (CH12-204-PZ01) were installed downgradient from the CVD, adjacent to Rose Creek (see Figure 2). Four monitoring wells (CH12-204-MW001, CH12-204-MW004, CH12-204-MW005, and CH12-204-MW006) included well pairs that are designated as “A” or “B.” The “A” wells are shallow wells and the “B” wells are deep wells. Monitoring wells CH12-204-MW001 through CH12-204-MW004 were constructed with a larger diameter for aquifer pumping tests. All new wells were developed by airlifting and over-pumping, with the exception of CH12-204-MW005 and CH12-204-MW006, which were developed using bailers and trash pumps. After well development, groundwater samples were collected from each of the new wells for chemical analysis.

Total Metals

Samples collected during the CVD investigation were collected from the Rose Creek Alluvial Aquifer (RCAA) material downgradient from the RCTA. The RCAA material is composed of fluvial deposits associated with the former Rose Creek channel prior to mining operations and the subsequent deposition of tailings in the area. Given that the area is, in general, a mineralized terrain and that Rose Creek received runoff from the Faro Mine Area, the total metal content of the RCAA sediments is expected to exceed the global median soil concentration.

Accordingly, 2 CVD samples had a Global Abundance Index of 3 for antimony, arsenic, and mercury; 16 samples exceeded the average crustal abundance concentrations for several trace metals by an order of magnitude (see Table 7 in the Cross Valley Dam Interception System Investigation Data Report [CH2M HILL, 2013b]). However, the total metal concentrations were generally considered to be within RCAA background levels. It is expected that these samples would exceed average crustal abundances given the mineralized nature of the deposit.

Acid Base Accounting Parameters

Soil and bedrock samples from the RCAA were near-neutral, with the exception of one sample from CH12-204-MW002B (see Table 1) collected 26 meters (m) below ground surface (bgs). This sample had a soil pH of 3.4. The neutralization potential (NP) was not determined for this sample, but the total inorganic carbon content was below the detection limit.

In general, samples collected during the CVD investigations had very low total sulphur content (less than 1 percent), with at least a portion of the total sulphur attributable to acid-soluble sulphates or barium sulphates, indicating that the samples were low in acid-generating sulphide minerals (see Table 1). One exception is the sample from CH12-204-MW002B at 26 m bgs, which had 13.5 percent total sulphur and very little acid-soluble or barium sulphate in the sample, indicating the sample contained a significant amount of sulphide-sulphur. The presence of sulphide-sulphur coupled to the low soil pH and lack of NP, suggests that this single sample contains appreciable reactive metal sulphide (i.e., iron sulphide) and is acid-generating (see acid-base accounting [ABA] analysis below). However, this sample appears to be the exception and not the rule for the RCAA material.

The leachate from the 96-hour deionized (DI) water leach tests conducted on the RCAA material was generally neutral to alkaline (median pH 7.5), with one acidic sample (pH 1.72) collected from CH12-204-MW002B at 26 m bgs (see Table 9 in the Cross Valley Dam Interception System Investigation Data Report [CH2M HILL, 2013b]). Alkalinity of the leachate ranged from 25 to 168 mg/L calcium carbonate ($CaCO_3$) equivalents and acidity was generally low (less than 3 mg/L $CaCO_3$ equivalents), with the exception of the acidic sample collected from CH12-204-MW002B, where the acidity was 13,600 mg/L $CaCO_3$ equivalents. The sulphate concentrations of the leachates were generally low (median 104 mg/L), with the exception of the CH12-204-MW002B sample collected at 26 m bgs, which had a sulphate concentration of 18,400 mg/L. Metal concentrations in the leachates were generally low, with the exception of the acidic sample from CH12-204-MW002B; the concentrations of aluminum, iron, and zinc were 343 mg/L, 7,840 mg/L, and 0.215 mg/L, respectively. Although the results at CH12-204-MW002B indicated the potential for the alluvium to generate acidic leachate and cause metals mobilization, results from the ABA analysis (see below) suggest the RCAA material is generally non-acid generating.

Analysis of the leachate from bedrock samples collected near the CVD indicated neutral to alkaline water (pH ranging from 7.8 to 8.4), with measurable alkalinity and low acidity. Alkalinity ranged from 78 to 147 mg/L $CaCO_3$ equivalents. Acidity was below detection, with the exception of a measured acidity of 6.4 mg/L $CaCO_3$ equivalents in the sample collected from CH12-204-MW002B at about 30 m bgs. Sulphate concentrations were generally low (48 mg/L to 111 mg/L) and concentrations of trace metals were less than the detection limit. Results from 96-hour leachate extraction tests for bedrock samples near the CVD suggest the bedrock material is relatively inert and does not exhibit the potential to generate acid (see ABA analysis below).

Acid-base accounting analyses were conducted on select samples from the RCAA collected during the CVD investigation using the total sulphur, acid-soluble sulphate, total barium, zinc, and lead values, and calculated neutralization potential (see Table 1). Before total sulphur can be used in ABA analysis, the concentration must be corrected for non-acid generating sulphate species (i.e., acid soluble and barium sulphates) as well as non-acid generating metal sulphide species such as zinc and lead (i.e., the mineral sulphides, sphalerite and galena, respectively). This correction does not preclude all of the sulphate minerals and organic sulphur species that could contribute to the AP; however, these contributions are considered to be minor at the FMC. Thus, the correction essentially results in the determination of iron sulphide-sulphur (S_{Fe}), which is the main acid-generating phase at the FMC (SRK, 2006).

Equation 1: $S_{Fe}(\%) = \text{Total S}(\%) - 32.07 \times (\text{Zn}(\%)/65.4 + \text{Pb}(\%)/207 + \text{Ba}(\%)/137) - S_{SO4}(\%)$

The sulphide-sulphur (S_{Fe}) can then be used to calculate the acid potential (AP) of the sample:

Equation 2: $\text{AP (kg CaCO}_3\text{/tonne)} = S_{Fe}(\%) \times 31.25$

The AP values for the CVD samples were less than 10 kg $CaCO_3$ equivalents per tonne, with the exception of two samples: (1) a sample taken from CH12-204-MW001B collected at 34.5 m bgs (34.4 kg $CaCO_3$ equivalents per tonne) and (2) a sample from CH12-204-MW002B collected at 26 m bgs (407 kg $CaCO_3$ equivalents per tonne).

Neutralization potential (NP) was determined by using the calcium carbonate equivalence (CCE) method. However, it was determined that the CCE method used for laboratory titration of NP was too aggressive for the samples submitted for analysis, resulting in NP values that were too high compared to historical values determined at the FMC (e.g., SRK, 2006). Moreover, previous studies (SRK, 2009) determined that the bulk of neutralizing material at the FMC is carbonate, with only minor iron and manganese-bearing carbonate phases present. Thus, for ABA calculations, TIC is used to estimate the NP rather than the NP values determined by the CCE method (see Table 1). The NP determined using the TIC values range from non-detect (assumed 50 percent detection limit for ABA calculations) to approximately 150 kg $CaCO_3$ equivalents per tonne, with an average of approximately 37 kg $CaCO_3$ equivalents per tonne. These values are well within the NP values previously reported for the site (e.g., SRK, 2006).

The neutralizing potential ratio (NPR) is the ratio of NP to AP. An NPR greater than 2 indicates that the material is non-potentially acid generating (non-PAG). Likewise, an NPR value of less than 1 generally indicates that the material is potentially acid generating (PAG). NPR values between 1 and 2 fall into a category of uncertainty and often require other factors to determine if the sample might become acid generating. The majority of the CVD samples had low AP values and elevated NP values and, therefore, have an NPR significantly greater than 2 (see Table 1). There are nine samples with TIC below detection limits and have very low assigned NP values; however, eight of these samples also have low AP values (less than 5 kg $CaCO_3$ per tonne). Therefore, although the NPR for these samples is less than 1, the likelihood that they would contribute significantly to acid generation is very low. The only sample with significant acid-generating potential (NPR = 0. 001) is the sample from CH12-204-MW002B with the high AP and low NP.

Waste Rock Dump Investigations

Fifty soil samples were collected from the waste rock dumps during borehole drilling in the Faro WRD (see Figure 3) and Grum/Vangorda WRD (see Figure 4) areas, including 34 waste rock samples, 10 alluvium samples, and 6 bedrock samples. These samples were analyzed for total metals and ABA analysis parameters. Boreholes CH12-014-MW003, CH12-014-MW005, and CH12-014-MW007 were drilled through the Faro WRDs and into the underlying alluvium or bedrock. Twenty-nine samples were collected from these boreholes and are assumed to be representative of the range of compositions within the Faro WRDs (21 waste rock samples, 6 alluvium samples, and 2 bedrock samples) around the Faro Pit area. Boreholes CH12-014-MW011 and CH12-014-MW012 were installed in the Grum WRD near the Grum Sulphide Cell. Fourteen samples were collected from these boreholes and are assumed to be representative of the uniform composition within the Grum WRD (8 waste rock samples, 3 alluvium samples, and 3 bedrock samples). Borehole CH12-014-MW013, which was installed in the sulphide cell of the Vangorda WRD sulphide cell of the Vangorda WRD, was drilled through the WRD and into the underlying alluvium and bedrock. Eight samples were collected from this borehole (6 waste rock samples, 1 alluvium sample, and 1 bedrock sample).

Total Metals

In general, the WRDs were placed on native ground, which consists of an organic-rich topsoil overlying alluvium, which is underlain by weathered bedrock and then competent bedrock. Boring logs from the WRD investigations indicate the presence of woody organic debris, peat, and other organic material at the top of the alluvial–WRD contact. According to the CSM, precipitation that infiltrates the WRD migrates vertically to this contact zone before flowing within the underlying alluvium along the pre-mining topography. Thus, it is anticipated that secondary deposition of metals may occur and enrich the total metal concentrations in the very bottom of the WRD material as well as the soil/alluvium along the contact zone. In the Faro WRD borehole CH12-014-MW005, the highest iron and zinc concentrations are in the organic-rich alluvium immediately below the WRD–alluvial contact (see Figure 5a MW05-Figure); the highest iron and zinc and iron concentrations are at the bottom of the WRD, immediately above the WRD–alluvial contact in borehole CH12-014-MW007 (see Figure 5b MW07-Figure). Similarly, the bedrock samples collected below the Grum WRD (from boreholes CH12-014-MW011 and CH12-014-MW012), which according to the boring logs show signs of weathering and secondary iron oxide deposition, tend to have higher iron and zinc concentrations than the overlying WRD material. This suggests the transport and deposition of metals from the WRD material (see Figures 5c and 5d MW11 and MW12-Figures). In the Vangorda WRD, the highest total iron and zinc concentrations detected in CH12-014-MW013 are associated with the WRD material (see Figure 5e MW13-figure), which is expected because the well was installed through the sulphide cell. However, the total zinc and iron concentrations in the underlying alluvium are similar to the highest levels detected in alluvium underlying the WRD at the FMC (e.g., CH12-014-MW005), suggesting transport and secondary precipitation. The only WRD monitoring well that does not suggest a trend of metal migration and accumulation is the CH12-014-MW003 (see Figure 5f MW03-figure); however, that well is installed on the upgradient edge of the Faro Main WRD and near one of the haul roads. Therefore, metal concentrations are generally lower in this area than at other WRD monitoring wells.

Acid Base Accounting Parameters

In general, the WRD and underlying alluvium and bedrock samples had soil pH that was near-neutral to slightly alkaline (see Figures 5a through 5f). Exceptions were in CH12-014-MW007 and CH12-014-MW013. In CH12-014-MW007, acidic soil pH was mainly focused at the WRD–alluvium contact with the lower WRD and upper alluvium having slightly acidic paste pH. In CH12-014-MW013, all of the WRD samples had acidic soil pH, which is expected because the well was installed in the sulphide cell of the Vangorda WRD; the underlying alluvial and bedrock material was near-neutral (soil pH greater than 6).

In general, the Faro WRD samples had relatively low total sulphur content (only a few percent total sulphur). Higher concentrations were detected in select portions of the cores (e.g., sample CH12-014-MW005_SOK), highlighting the heterogeneity of the WRDs. The total sulphur content of all the WRD samples from the Grum WRD and underlying native material were all less than or equal to 0.6 percent. In contrast, the total sulphur content of the Vangorda WRD samples were all high (7 to 27 percent), with the exception of one sample from the underlying bedrock (0.6 percent total sulphur); even the alluvium sample collected from below the WRD had elevated total sulphur (10.5 percent). Contributions from barium and acid-soluble sulphates were generally low to non-detect for most samples.

Faro WRD 96-hour DI Leach

The leachate from the 96-hour DI water leach tests conducted on the Faro WRD material generally indicate near-neutral water (median 7.14) with discrete acidic zones (pH between 4.5 and 5.5) that coincide with sulfide oxidation in CH12-014-MW005 (see Table 9 in the Waste Rock Dump Monitoring Report [CH2M HILL, 2013x]) from borehole logs). With the exception of the acidic samples collected from CH12-014-MW005, the Faro WRD leachates generally exhibit low acidity (median 6.1) and measureable alkalinity. Observed sulphate concentrations were highly variable, ranging from 170 to 3,540 mg/L (median 1,000 mg/L). Concentrations of aluminum were generally low (median 0.122 mg/L), with a maximum concentration detected in CH12-014-MW005 (2.77 mg/L). Similarly, leachate from CH12-014-MW005 also contained the greatest concentrations of trace metals, including iron concentrations as high as 105 mg/L and zinc concentrations up to 224 mg/L. Observed concentrations of trace metals in the other two monitoring boreholes were generally low (less than the detection limit).

Leachate extraction tests performed on the alluvial material underlying boreholes CH12-014-MW003 and CH12-014-MW005 indicated slightly alkaline water in borehole CH12-014-MW003 and slightly acidic water in borehole CH12-014-MW005. Measurable, leachable alkalinity is present in the alluvial material underlying the Faro WRDs. Similar to the Faro WRDs, concentrations of leachable sulphate were highly variable, with a median concentration of 204 mg/L. Concentrations of trace metals aluminum, copper, iron, and zinc were below the detection limit in the alluvium, except for one sample collected from CH12-014-MW005 that had a zinc concentration of 19.6 mg/L.

Samples were also collected from the bedrock underlying the alluvium at CH12-014-MW003 and underlying the WRD at CH12-014-MW007. Leachate extraction tests from bedrock near the Faro Pit indicated near-neutral to slightly alkaline water with measurable alkalinity and low acidity. Sulphate concentrations in the Faro bedrock were low (approximately 60 mg/L). Concentrations of trace metals aluminum, copper, iron, and zinc were below detection.

Grum WRD 96-hour DI Leach

Boreholes CH12-014-MW011 and CH12-014-MW012 were drilled through the Grum WRD in areas immediately adjacent to the Grum Sulphide Cell and into the underlying alluvium and bedrock. Thirteen samples were collected from these boreholes (7 waste rock samples, 3 alluvium samples, and 3 bedrock samples) and are considered representative of the range of compositions in the Grum WRD. Leachate extraction tests on the Grum WRD indicate near-neutral to slightly alkaline water with measurable alkalinity and low acidity. Sulphate concentrations were generally low (median 212 mg/L). Concentrations of trace metals aluminum, copper, iron, and zinc were below detection.

Leachate extraction tests on the alluvium that underlies the Grum WRD exhibited similar characteristics as the WRD samples, near-neutral to alkaline water with concentrations of trace metals aluminum, copper, iron, and zinc below the detection limit.

Bedrock samples collected from the Grum boreholes indicated more alkaline pH waters, with leachate pH ranging from 8.08 to 8.24 (3 samples), low sulphate, and concentrations of aluminum, copper, iron, and zinc below the detection limit.

Vangorda WRD 96-hour DI Leach

Borehole CH12-014-MW013 was drilled through the sulphide cell of the Vangorda WRD and into the underlying alluvium and bedrock. Eight samples were collected from this location (6 waste rock samples, 1 alluvium sample, and 1 bedrock sample) and are representative of the sulphide cell of the Vangorda WRD. Leachate extraction tests on the sulphide cell indicate slightly acidic waters, with pH ranging from 4.54 to 6.92 and variable alkalinity ranging from non-detect to 142 mg/L as $CaCO_3$. Concentrations of sulphate are generally greater in the sulphide cell of the Vangorda WRD (median 2,380 mg/L) than at the Faro or Grum WRDs. Concentrations of aluminum were below detection; however, concentrations of iron (median 84.6 mg/L) and zinc (median 200 mg/L) were also greater than concentrations at either the Faro or Grum WRDs.

Leachate extraction tests on the alluvium that underlies the sulphide cell of the Vangorda WRD indicated near-neutral water (pH 6.98) with low acidity and measurable alkalinity. The concentration of sulphate was relatively low (at 531 mg/L), and concentrations of aluminum and iron were below the detection limit.

In contrast, the sample collected from bedrock underlying the Vangorda alluvium indicated an alkaline leachate water (pH 8.36) with no detectable acidity and an alkalinity of 52.5 mg/L. The measured concentration of sulphate in the leachate extraction test was low (140 mg/L), and concentrations of trace metals aluminum, iron, and zinc were below the detection limit.

ABA Analysis

Equations 1 and 2 were used to calculate the acid potential (AP) of the samples (see Table 2). The calculated AP values for the Faro WRD samples ranged from non-detect to 246 kg $CaCO_3$ per tonne, which is similar to historical calculated AP values for the Faro WRD samples (e.g., SRK, 2006). The calculated AP values for the Grum WRD samples ranged from non-detect to only 17 kg $CaCO_3$ per tonne and are generally consistent with the low sulphide content of these samples. The samples from the sulphide cell of the Vangorda WRD have a very high calculated AP ranging from 187 to 789 kg $CaCO_3$ per tonne. In contrast, the bedrock samples collected below the Vangorda WRD had much lower values (16 kg $CaCO_3$ per tonne).

The FMC WRD NP, as estimated based on TIC, is shown on Figures 5a through 5f and provided in Table 2. The NP determined using the TIC values range from non-detect in the lower WRD material and underlying alluvium of CH12-014-MW007 to approximately 340 kg $CaCO_3$ equivalents per tonne in the bedrock underlying CH12-014-MW003. In general, the NP values measured for the FMC WRD material are within the NP values previously reported for the site (e.g., SRK, 2006).

The majority of the Faro WRD samples had an NPR value of less than 2 (most were less than 1), indicating the WRD material is, in general, PAG. However, the underlying alluvium and bedrock material was non-PAG, with NPR values greater than 2 (see Table 2). All of the samples collected from the Grum WRD were non-PAG, and all of the Vangorda WRD samples were PAG; the one exception being the bedrock sample underlying the sulphide cell of the Vangorda WRD, which was calculated as non-PAG.

WRD Temperature and Gas monitoring trends

Thermistor access ports were installed within each borehole (see Figures 3 and 4) to facilitate the measurement of waste rock temperature profiles, which were used to refine the understanding of geochemical processes in the WRDs, and to further develop the WRD geochemical model. In addition to thermistor access ports, up to five soil-gas monitoring ports were installed at each monitoring well at various depths (generally 5-m and 10-m intervals) to measure oxygen and carbon dioxide concentrations within the WRDs. Details of the installation of the thermistor and soil-gas monitoring access ports are provided in the Waste Rock Dump Monitoring Data Report (CH2M HILL, 2013a).

Data from thermistor profile readings and soil-gas monitoring occurred during two separate data collection efforts, one in late September/early October 2012, and one in late February/early March 2013. Temperature profile data were collected from the thermistor string concurrent with the two soil gas monitoring events.

Faro WRD

Monitoring wells CH12-014-MW003, CH12-014-MW005, and CH12-014-MW007) indicate near-surface temporal variations to about 7 m bgs, which is consistent with previous observations that the temperature of the upper 5.6 m is affected by seasonal fluctuations of surface temperatures (SRK, 2006) (see Figures 6 and 7 in the Waste Rock Dump Monitoring Data Report [CH2M HILL 2013a]). At depth, the temperature increased to a maximum of about 8 degrees Centigrade (°C) in the bottom of boreholes CH12-014-MW003 and CH12-014-MW005 (20.0 m and 38.6 m bgs, respectively) and about 20°C in the bottom of borehole CH12-014-MW007 (39.9 m bgs). Temperatures remained relatively constant throughout the depth profile at two locations in the Faro WRD, CH12-014-MW003 and CH12-014-MW005, which have variable lithologies and partially weathered rock fragments, but only minor proportions of sulphide minerals. In contrast, the increase in temperature with depth at CH12-014-MW007 coincides with a greater relative proportion of sulphide minerals in this borehole than encountered in the other Faro WRD monitoring locations. Concentrations of oxygen (O_2) gas in the Faro WRDs increased with depth to about 20 m bgs. At depths greater than 20 m, concentrations of O_2 gas decreased with depth. The oxygen profiles at depths to about 20 m bgs indicate the advective flow of air through the upper 20 m of the Faro WRDs. The advective flow through the Faro WRDs was also identified by SRK (2009).

Grum WRD

Monitoring wells CH12-014-MW011 and CH12-014-MW012 indicated near surface temporal variations to about 7 m bgs (see Figures 8 and 9 in the Waste Rock Dump Monitoring Data Report [CH2M HILL, 2013a]). However, CH12-014-MW011 was the only location with temperature measurements for both monitoring events. The change in gas concentrations at both wells and temperature at CH2-014-MW011 is consistent with the observations presented in SRK, 2006. During the September 2012 monitoring event, temperatures tended to decrease with depth atCH12-014-MW011 and CH12-014-MW012, where fresh phyllite was the dominant lithologic unit and only trace amounts of sulphide minerals were encountered. In February 2013, the temperature in CH12-014-MW011 remained relatively constant throughout the depth profile. In the study by SRK (2010), borehole temperatures were affected by season to a depth of 5.6 m bgs, with a maximum temperature of 12°C at about 20 m bgs. Concentrations of O_2 gas in the Grum WRDs generally decreased with depth, from nearly saturated with respect to atmospheric oxygen (20.7 percent volume) at the surface to 12.1 percent volume in CH12-014-MW011 at 22.9 m bgs and 6.1 percent volume in CH12-014-MW012 at 17.4 m bgs. Decreased concentrations of O_2 gas with depth were also reported by SRK (2006). The decreased concentrations of O_2 gas and relatively low temperatures at depth indicate a low oxidation rate of oxygen infiltration, which in turn suggests a low oxidation rate in the Grum WRD; however, the low temperature profile could also result from a general lack of enough sulphide to generate heat during oxidation.

Vangorda WRD

Temperature monitoring in the sulphide cell of the Vangorda WRD (CH12-014-MW013) only occurred during the September 2012 monitoring event. Temperature results from that monitoring event indicate increasing temperatures at depth, reaching a maximum of 17°C at 19.8 m bgs. Similar to observations at Faro WRD CH12-014-MW007, the increase in temperature with depth at CH12-014-MW013 coincides with a greater relative proportion of sulphide minerals in this borehole than encountered at the other monitoring locations. Concentrations of O_2 gas in the sulphide cell of the Vangorda WRD decreased from 19.9 percent volume at 9.8 m bgs to 0.4 percent volume at 24.7 m bgs. Similar to observations by SRK (2006), concentrations of O_2 gas were almost completely depleted at 24. 7 m bgs (and increased in concentrations of carbon dioxide [CO_2] gas), and borehole temperatures were elevated, generally indicating the oxidation of sulphide minerals.

Summary

The oxygen profiles for all monitoring locations generally indicated that the primary mechanism for oxygen entry into the Faro and Vangorda WRDs is by thermal convection. Results from the Grum WRD, however, suggest that oxygen may be limited by diffusion where there is a smaller temperature gradient (SRK, 2010). The oxidation of sulphide minerals consumes O_2 gas, and the neutralization of acid generates CO_2 gas. Depletion of O_2 and enrichment of CO_2 is used to identify sulphide oxidation within the WRD. A regression analysis was performed using O_2 and CO_2 values from all locations (see Figure 10 in the Waste Rock Dump Monitoring Data Report [CH2M HILL,2013a), but excludes pairs of data where CO_2 readings were at the upper method detection limit. A strong negative correlation between these values was apparent and expected if sulphidic material is being oxidized in the WRD. Depleted oxygen concentrations indicate that the rate oxygen is being consumed is greater than the rate it is being replenished. This would be expected if oxygen transfer processes is limited to diffusion. This suggests that the air permeability in these depleted areas of the pile is low, limiting transfer by advection (SRK, 2009).

Groundwater Geochemistry

WRD Monitoring Wells

According to the CSM, precipitation that infiltrates through the FMC WRDs collects in the underlying shallow alluvial aquifer and migrates along pre-mining topography following pre-existing drainage patterns (CH2M HILL, 2012). Therefore, in designated locations for the WRD monitoring well installations, pre-existing drainage areas were targeted with known downstream sampling locations (see Figures 3 and 4). For example, the monitoring location, X23, is located immediately downstream from the Main Faro WRD, within the former Faro Creek drainage. To evaluate how groundwater geochemistry changes as it migrates through the WRD and into the alluvial aquifer before daylighting at X23, monitoring well CH2-014-MW003 was installed within the former Faro Creek channel upgradient from the Main Faro WRD. Comparison of CH2-014-MW003 with X23 water chemistry allows an evaluation of the input from the Main Faro WRD as well as potential geochemical changes within the alluvial aquifer within the former Faro Creek channel. Similarly, CH2-014-MW007 was installed in a former drainage identified upgradient from the S-wells SIS area. Faro WRD monitoring well CH2-014-MW005 was not installed in the underlying alluvial aquifer and is, therefore, dry; it is only used for gas and temperature monitoring. At the Grum WRD, two monitoring wells were installed within the pre-mining drainage areas. CH2-014-MW011 was installed near the former Grum Creek drainage between the head of the former Grum Creek, which was near the current Grum Pit, and seeps SRK-GD01 and SRK-GD02. CH2-014-MW012 was installed downgradient from the Grum Sulphide Cell, upgradient from numerous seeps and monitoring location V15. Pre-mining topography indicates that the Vangorda WRD was constructed on a topographic ridge, with drainage to the west, south, and east, but without any distinct pre-mining drainage pattern. Therefore, CH2-014-MW013 was installed in the sulphide cell of the Vangorda WRD, mainly for gas and temperature monitoring, but is also available for monitoring GW trends on the western edge of the Vangorda WRD. Results from the groundwater sampling of the WRD monitoring wells are show in Table 10 in the Waste Rock Dump Monitoring Report (CH2M HILL, 2013a).

CH2-014-MW003 (compared to X23)

Groundwater quality data collected in September 2012 from CH2-014-MW003 was compared to seep water-quality data collected from seeps near the collection point at X23 (SRK-FD09, SRK-FD10, SRK-FD12, and SRK-FD31). Groundwater quality in CH2-014-MW003 indicated neutral water (pH 7.49) with measurable alkalinity and sulphate concentrations (2,120 mg/L). Concentrations of dissolved iron and zinc in groundwater were relatively low (0.364 mg/L and 1.23 mg/L, respectively). Seep water quality near X23 indicates slightly acidic water (pH from 5.67 to 6.92) and measurable alkalinity. The composition of the X23 area seep water is characterized by high sulphate (4,110 to 8,000 mg/L), high iron (22.9 to 342 mg/L), and high zinc (152 to 1080 mg/L) concentrations. Observed differences in the chemical composition of groundwater collected from CH12-014-MW003 and seep water near X23 can be attributed to the interaction of groundwater with weathered sulphide deposits in the Main Faro WRD as it migrates toward the seepage collection points and X23.

CH2-014-MW007 (compared to S-wells)

Groundwater-quality data collected in September and October 2012 from CH2-014-MW007 was compared to seep water-quality data collected from seeps near the S-wells (SRK-FD52, SRK-FD54, SRK-FD55, and SRK-FD56). Groundwater collected from CH2-014-MW007 and seep water collected from the S-wells area indicated slightly acidic water, with pH ranging from about 5.7 to 6.9. However, groundwater samples had more available alkalinity (392 to 490 mg/L) than the seep water (21 to 200 mg/L). Concentrations of sulphate and dissolved zinc were widely variable in groundwater and seep water. However, sulphate and dissolved zinc concentrations generally were less in groundwater samples (6,110 to 7,630 mg/L and 317 to 441 mg/L, respectively) than in the seep water samples (5,800 to 10,920 mg/L and 38.2 to 672 mg/L respectively). In contrast, concentrations of dissolved iron were greater in groundwater collected from CH2-014-MW007 (1.93 to 7.05 mg/L) than in the seep water collected near the S-wells (less than 0.15 mg/L). The lower iron and alkalinity in the seep water samples could indicate iron oxide precipitation (and subsequent consumption of alkalinity) along the flow path between CH2-014-MW007 and the seep area.

CH2-014-MW011

Groundwater-quality data collected in October 2012 from CH2-014-MW011 was compared to seep water-quality data collected from seeps near the Grum WRD (SRK-GD01 and SRK-GD02). Observed groundwater quality in CH2-014-MW011 indicates generally neutral water (pH 7.49) with measurable alkalinity and sulphate concentrations of 1,450 mg/L. Concentrations of dissolved iron and zinc in the CH2-014-MW011 were low (0.46 mg/L and 0.389 mg/L, respectively). Seep water quality in the main Grum WRD was near-neutral to slightly acidic; the more recent samples were slightly acidic (pH 6.86, September 2012 at SRK-GD02). Alkalinity and concentrations of sulphate in the seep samples were comparable to those for CH2-014-MW011. Concentrations of dissolved iron were also low in the seep water quality results (0.03 mg/L). However, concentrations of zinc were greater in the seep water (2.1 to 6.69 mg/L) than in the groundwater collected from CH2-014-MW011.

CH2-014-MW012

Groundwater quality data collected in August 2012 from CH2-014-MW012 was compared to seep water quality data collected from seeps near the Grum Sulphide Cell (SRK-GD05 and SRK-GD06). Observed groundwater quality in CH2-014-MW012 indicated alkaline waters (pH 8.04) and sulphate concentrations of 586 mg/L. Groundwater concentrations of dissolved iron were generally high (10.2 mg/L), and dissolved zinc concentrations were generally low (0.036 mg/L). Seep water quality from SRK-GD05 and SRK-GD06 indicated neutral to alkaline waters (pH 7.32 to 8.08). Although similar pH and alkalinity values were measured in groundwater and seep water, concentrations of sulphate in the seep water were between 1,040 and 1,980 mg/L, which was much greater than sulphate concentrations in groundwater. Concentrations of dissolved iron were generally less than the detection limit, and dissolved zinc concentrations ranged from 1.83 to 2.58. The evolution of moderate sulphate, high iron, and low zinc concentrations in groundwater to high sulphate, low iron, and high zinc concentrations in seep water suggests the possible effect of changing redox conditions as groundwater migrates through the WRD.

CH2-014-MW013

Groundwater quality data collected in September and October 2012 from CH2-014-MW013 was compared to seep water-quality data collected from seeps near the Vangorda WRD (SRK-VD04 and SRK-VD05). Groundwater quality in CH2-014-MW013 was neutral, with pH values about 7.4 and alkalinity about 1,070 mg/L. Concentrations of sulphate and zinc were generally high (2,530 to 2,590 mg/L and 1.2 to 1.3 mg/L respectively). Iron concentrations ranged from 0.065 to 0.203 mg/L in groundwater. In contrast, seep water quality in the main Vangorda WRD indicated low pH (ranging from 2.71 to 5.93) and low alkalinity water. Sulphate concentrations in SRK-VD04 and SRK-VD05 (23,000 to 82,300 mg/L, respectively) were an order of magnitude greater than concentrations in the groundwater samples collected from CH2-014-MW013. Concentrations of iron and zinc in the seep water collected from the main Vangorda WRD were also order(s) of magnitude greater than the groundwater composition. The interaction of groundwater with sulphide minerals as it migrates through the main Vangorda WRD causes the release of acid as the sulphide waste rock is oxidized and mobilizes trace elements iron and zinc.

RCTA Monitoring Wells

Figure 2 shows the location of historical groundwater monitoring wells in the RCTA that were sampled in 2012. Figures 1a through 6g present the vertical profile of key constituent concentrations (iron, sulphate, and zinc) and pH in groundwater samples collected from monitoring wells in the RCTA.

Vertical trends in groundwater samples collected from P03-01 (see Figure 6a) show concentrations of iron decrease in the upper 20 m and then increase at depths greater than 20 m. Concentrations of sulphate also decreased in the upper 20 m and stabilize at depths greater than 20 m bgs. The pH in P03-01 was somewhat variable in the upper 20 m, with a general increase in pH with increasing depth. The pH increased with increased depth below 20 m bgs. Concentrations of zinc decreased with increasing depth, with stable values between 5 and 20 m bgs. Results from the vertical profile suggest a tailings material transition zone near 20 m bgs.

Monitoring wells P03-02 and P03-03 showed similar characteristics in the vertical profile for iron, sulphate, pH, and zinc (see Figures 6a and 6b). In these wells, concentrations of iron and sulphate decreased with increasing depth. The pH generally increased with increasing depth in P03-02 and P03-03, with some variability at approximately 20 m bgs in well P03-03 (see Figure 6c). From 5 to 10 m bgs, zinc concentrations generally decreased with increasing depth; concentrations then increased with increasing depth between 10 to 20 m bgs, and decreased with increasing depth below 20 m bgs. These results suggest a transition zone from 10 to 20 m bgs where pH and redox conditions favor the mobilization of zinc into solution. Over time, P03-02 appears to be trending to lower iron and zinc concentrations and higher pH in the deepest portion of the aquifer. In contrast, P0-03 exhibits a trend of higher iron and sulphate concentrations over time throughout the well profile. This trend corresponds to a general decrease in pH over time in the upper portion of the aquifer (near the tailings interface), while pH appears to be increasing in the deepest portions of the aquifer.

Vertical trends in groundwater samples collected from P03-04 (see Figure 6d) show concentrations of iron decreased with increasing depth. Concentrations of sulphate decreased with increasing depth to about 25 m bgs, where concentrations stabilized or increased slightly. Concentrations of zinc decreased with increasing depth to 25 m bgs, and then increased at depths greater than 25 m. There was no significant change in iron, zinc, or sulphate trends over time. Observed pH values increased with increasing depth to about 25 m bgs, and then decreased at depths greater than 25 m. However, at any given depth within the aquifer at this location, the pH tended to increase over time. Results from the vertical profile suggest a tailings material transition zone near 25 m bgs where conditions favor the mobilization of zinc.

Vertical trends in groundwater samples collected from P03-05 (see Figure 6e) identify decreased iron and sulphate concentration as depth increases and a slight increase in iron concentrations over time; sulphate trends were stable over time. Observed pH values increased with increasing depth, but appear to be generally decreasing over time. Concentrations of zinc decreased with increasing depth to 10 m bgs and then increased at depths greater than 10 m bgs, with an order of magnitude of two increase at 10 m bgs between September 2009 and October 2011; this well was not sampled in 2012. Similar to the other P03 wells, the results from the vertical profile of P03-05 indicated a potential transition zone near 10 m where conditions favor the mobilization of zinc.

Trends in the vertical profile of groundwater samples collected from P03-06 (see Figure 6f) generally show concentrations of iron stable up to depths of 3 m bgs and increase with increasing depth below 3 m bgs. Concentrations of sulphate decrease with increasing depth for the upper 3 m and increase with increasing depth below 3 m bgs. Iron and sulphate trends appear stable over time. The pH values in P03-06 were variable with depth and sampling date. However, there was a general decrease in pH with increasing depth at depths greater than 3 m bgs. Over time, it appears that the pH may be decreasing above 3 m bgs and increasing below 3 m bgs. Concentrations of zinc decreased with increasing depth in the upper 3 m and increased at depths below 3 m bgs. However, zinc concentrations over time are too sporadic to establish a definitive trend. Results from the vertical profile suggest a possible transition in the composition of the tailings material near 3 m bgs.

Trends in the vertical profile of groundwater samples collected from P03-08 (see Figure 6g) generally show concentrations of iron and sulphate increased with increasing depth to about 10 m, and decreased with increasing depth at depths greater than 10 m. The pH and concentrations of zinc were highly variable throughout the entire vertical profile, suggesting local reactivity between groundwater and the subsurface tailings composition. The fluctuations over time were too great to establish long-term trends in the vertical profile at this location.

It is anticipated that over time the RCAA underlying the RCTA will be more affected by acidic, contaminated pore water migration originating from the tailings material. However, given the slow migration of pore water through the tailings and the limited time frame of historical sampling of the RCAA groundwater underlying the tailings, there is not enough data to clearly establish trends over time. Long-term monitoring and a robust data set are required to capture the long-term trends and distinguish them from seasonal and natural variations at a given sampling location. Continued groundwater sampling is recommended for these monitoring wells until a clear temporal trend is established.

Seep Analysis

A Mann-Kendall analysis was used to identify statistically significant trends in water quality parameters in samples collected from the Faro, Grum, and Vangorda seeps over the entire period of record. Details of the field investigation and sample collection of seep water quality from these areas are outlined in the 2012 Sampling Plan (CH2M HILL, 2012). The seep sampling locations are shown on Figures 7 through 11. The Mann-Kendall analysis was performed using the Microsoft Excel platform to compute a nonparametric correlation coefficient, tau, and its test of significance. The analysis requires a minimum of 10 measured (detectable) readings, assumes no distribution, does not require a regular sampling interval, and is capable calculating results based on incomplete datasets (Gilbert, 1987). The Mann-Kendall test was performed as follows:

1. Significance levels are chosen.
2. The data are listed in temporal order.
3. Each data point is compared to the points that follow in time.
4. The number of times the data increase is compared to the number of times the data decrease.
5. The greater the number of increases or decreases, the more evidence there is for an upward or downward trend.

Only trends above a 95 percent significance level were considered. If the value was below the detection limit it did not count as 1 of the 10, assuming there were 10 detectable concentrations in the dataset. If there were less than 10 detectable concentrations, on-half of the MDL was used as the assumed value for non-detects. The analysis was used to evaluate trends in pH, acidity, alkalinity, sulphate, and zinc (see Table 3). Overall, there is a general site-wide trend of decreasing pH and alkalinity, and increasing acidity and concentrations of sulphate and zinc as discussed in the following sections.

Faro Mine Area

Three seeps (A25, SRK-FD24, and SRK-FD40) out forty-one seeps that were sampled along the walls of the Faro Pit met the criteria for running the Mann-Kendall trend analysis test (see Figure 7). Water-quality data from seep A25, located along the northern wall of the Faro Pit, showed a statistically significant decrease in sulphate concentrations. In contrast, seep SRK-FD24 indicated decreased pH and alkalinity values, and increased acidity and concentrations of sulphate and zinc. Although the minimum criteria of 10 data points were met for SRK-FD40, no statistically significant trends in water quality were calculated.

Of the three seeps identified within the Northwest Faro Dumps (see Figure 8), water-quality analysis of seepage chemistry from seeps SRK-FD18 and SRK-FD19 had greater than 10 data points necessary for applying the Mann-Kendall statistical test for significance. Water quality in SRK-FD18 has shown statistically significant decreases in pH. Water quality in SRK-FD19 has shown statistically significant increases in acidity and concentrations of sulphate and zinc. While SRK-FD17 is a seep that is recommended to continue sampling, not enough data have been collected at this site to run the Mann-Kendall analysis.

Eleven seeps were included in the sampling and analysis program from the waste rock dumps to the northeast of the Faro Pit that drain toward the pit (see Figure 8), three of which had at least 10 water-quality analyses associated with them (SRK-FD21, SRK-FD23, and SRK-FD26). Seeps SRK-FD23 and SRK-FD26 had statistically significant trends of decreasing pH and increasing acidity and concentrations of sulphate and zinc. Seeps SRK-FD05 and SRK-FD06 are located at the toe of the Northeast waste Rock Dumps and drain toward the North Fork of Rose Creek. Although the minimum criteria of 10 data points were achieved for each seep location, no statistically significant trends in water quality were calculated and, thus, it appears the water chemistries are presently stable.

SRK-FD31 is located along the southwestern toe of the Northwest Rock Dump (see Figure 8), near X23, and was the only seep (out of three) sampled in the vicinity of Old Faro Creek and Mill Creek that had at least 10 water-quality samples to test for statistical significance. SRK-FD31 showed significant decreases in pH and alkalinity, and significant increases in acidity and concentrations of sulphate and zinc. Only one seep (SRK-FD38) was sampled in the Low Grade Stockpile area. However, SRK-FD38 did not meet the minimum requirement of 10 water-quality analysis and the Mann-Kendall test could not be run. Only one seep (SRK-FD37) was sampled in the Medium Grade Stockpile area. Results from the statistical test for significance indicated significant increases of acidity and concentrations of sulphate and zinc at SRK-FD37.

SRK-FD30 is located along the interface between the Main Rock Dump and the Intermediate Rock Dump (see Figure 8), and was the only seep (out of three) sampled in this area that had at least 10 water-quality samples to test for statistical significance. Significant decreases in pH and alkalinity, and significant increases in acidity were calculated for SRK-FD30. Seep SRK-FD13 is the only seep (of 5 sampled seeps) in the Intermediate Dump area that had at least 10 water-quality analyses associated with it. SRK-FD13 is situated along the northern toe of the Intermediate Dump and to the south of the Ramp Zone Dump, and exhibits significant decreases in pH and significant increases in concentrations of sulphate and zinc. SRK-FD14 is located at the eastern toe of the Ramp Zone Dump. Although the minimum criteria of 10 data points were achieved for SRK-FD13, no statistically significant trends in water quality were calculated. Historically, only one seep in the area near the S-wells (SRK-FD55) has been regularly sampled. However, SRK-FD55 did not meet the minimum requirement of 10 water-quality analysis and the Mann-Kendall test could not be run.

One of six sampled seeps in the Mill Area, SRK-FD01 (see Figure 8), met the minimum requirement of 10 data points to run the Mann-Kendall statistical test. Observed water quality at SRK-FD01 has shown statistically significant increases in acidity and concentrations of sulphate and zinc, and significant decreases in concentrations of lead. Three seeps were sampled in the ETA area. However, none of the sampled seeps met the minimum requirement of 10 water-quality analysis and the Mann-Kendall test could not be run.

Grum Area

Five seeps (SRK-GD01, SRK-GD05, SRK-GD06, SRK-GD07, and SRK-GD13) out of twenty-four sampled in the vicinity of the Grum WRD had at least 10 water-quality data points associated with each seep (see Figure 9). SRK-GD01 is located at the southeastern toe of the Grum WRD and east of the Grum Sulphide Cell and showed no statistically significant trends. Seeps SRK-GD05 and SRK-GD06 are located along the southern toe of the Grum WRD and south of the Grum Sulfide Cell and showed significant increases in sulphate concentrations, as calculated by the Mann-Kendall analysis. SRK-GD07 is located along the northern toe of the Grum WRD and showed no statistically significant trends. SRK-GD13 is located along the western-most toe of the Grum WRD (see Figure 9)and showed statistically significant trends of increased acidity, alkalinity, and concentrations of sulphate and zinc. An concomitant increase in acidity and alkalinity is possible when the acidity is due to an increase in ferrous iron.

Three seeps (SRK-GP02, SRK-GP04, and SRK-GP09) out of twenty –four sampled along the walls of the Grum Pit (see Figure 10) had at least 10 water-quality data points associated with each seep. SRK-GP02 is located along the southeastern wall of the Grum Pit and showed no significant increases or decreases in values over time. Located on the northern wall of the Grum Pit, SRK-GP04 showed statistically significant increases in concentrations of zinc. SRK-GP09 is located along the northwestern wall of the Grum Pit and indicated significant decreases in pH, as calculated by Mann-Kendall analysis.

Vangorda Area

Five seeps (SRK-VD03, SRK-VD04, SRK-VD05, SRK-VD09, and SRK-VD10) out of twelve sampled in the Vangorda WRD area met the minimum of 10 data points to run the Mann-Kendall statistical test for significance. SRK-VD03 is located along the southwestern toe of the Vangorda WRD (see Figure 9)and showed significant increases in concentrations of sulphate. Seeps SRK-VD04, SRK-VD05, and SRK-VD06 are located along the northwestern toe of the Vangorda WRD (see Figure 9) and showed significant decreases in pH (SRK-VD04 and SRK-VD05) and concentrations of lead (SRK-VD10). Significant increases in acidity and sulphate were calculated in SRK-VD04 and SRK-VD05. SRK-VD09 is located along the northern edge of the Vangorda WRD (see Figure 9), which showed significant increases in acidity as calculated in the Mann-Kendall statistical analysis.

Twenty seeps were sampled in the Vangorda Pit area (see Figure 11). However, none of the sampled seeps met the minimum requirement of 10 water-quality analysis and the Mann-Kendall test could not be run.

Hydrogeologic Field Testing

Three hydrogeologic testing programs were conducted during the 2013 field season. These programs consisted of an aquifer testing program at the Faro, Grum, and Vangorda WRDs, an aquifer testing program at the CVD, and a surface water/groundwater interaction study along Rose Creek, downstream of the CVD. Each of these field programs are described in the following sections. After completion of these field programs, pressure transducers were installed in selected monitoring wells to obtain transient groundwater elevation information at key locations across the site.

WRD Aquifer Testing Program

Short-term aquifer tests were conducted within the monitoring wells installed at each of the Faro, Grum, and Vangorda WRDs. These aquifer tests were conducted to obtain site-specific hydraulic conductivity estimates for the water-bearing units beneath each WRD complex. Estimation of the hydraulic conductivity values for the aquifers in these areas is important to both provide input to the numerical groundwater flow models being developed for the sites and to allow for, in conjunction with associated transient groundwater elevation data sets, estimation of the rate of seasonal recharge that occurs through the WRDs at each of the sites.

Faro WRD

Single well aquifer tests were performed in recently constructed monitoring wells CH12-014-MW003 and CH12-014-MW007 to estimate the hydraulic conductivity of the underlying alluvium and bedrock (CH2M HILL, 2013a). The locations of these wells are shown on Figure 2. Results of these aquifer tests suggested that the hydraulic conductivity of the alluvium is approximately 1.0×10^{-5} to 1.3×10^{-5} metres per second (m/s), the hydraulic conductivity of the weathered bedrock is approximately 1.2×10^{-6} m/s, and the hydraulic conductivity of the more competent bedrock is approximately 1.2×10^{-8} m/s (CH2M HILL, 2013a). Additional details of the aquifer testing are provided in the Waste Rock Dump Monitoring Data Report (CH2M HILL, 2013a).

After the aquifer testing, pressure transducers were deployed in these wells for long-term water level monitoring. The transducers, which were downloaded in late February and early March 2013, revealed very stable water level trends (see Figure 12). This behaviour was expected because of the frozen conditions through the late fall/early winter period. More significant groundwater elevation fluctuations are likely to occur after the spring freshet as snowmelt recharges the WRDs.

Grum/Vangorda WRD

Single well aquifer tests were performed at recently installed monitoring wells CH12-014-MW011, CH12-014-MW012, and CH12-014-MW013 to estimate the hydraulic conductivity of the underlying alluvium and bedrock (CH2M HILL, 2013a). All three wells are screened in alluvium, with CH12-014-MW011 screened in weathered bedrock as well. Results of these aquifer tests suggested that the hydraulic conductivity of the alluvium ranges from 5.8×10^{-5} to 3.9×10^{-8} m/s; the hydraulic conductivity of the weathered bedrock was approximately 1.2×10^{-6} m/s at CH12-014-MW011 (CH2M HILL, 2013a).

After the aquifer testing, pressure transducers were deployed in these wells for long-term water level monitoring. The transducers, which were downloaded in late February and early March 2013, revealed that water levels had dropped at CH12-014-MW011 by about 1.3 m, but water levels were very stable at CH12-014-MW013 (see Figure 12, same as for Faro). As previously discussed, relatively stable groundwater levels are expected during the winter months, with more dynamic fluctuations expected following freshet conditions.

CVD Aquifer Testing Program

In September and October 2012, aquifer tests were performed at new and existing wells at the base of the CVD to estimate the hydraulic conductivity of the underlying alluvial and bedrock aquifers. Three sets of aquifer stress tests were performed for the different areas of investigation:

- Eight-hour constant rate aquifer test using wells CH12-204-MW001B, CH12-204-MW002B, and CH12-204-MW004B along the proposed CVD SIS alignment (see Figure 13).

- Four-hour constant-rate aquifer tests using Rose Creek wells CH12-204-MW005B and CH12-204-MW006B
- Four-day aquifer test using pumping wells CH12-204-MW001A, CH12-204-MW004A, RGC-PW1, and RGC-PW2 along the proposed CVD SIS alignment.

Interpretation of the drawdown and recovery data from the aquifer tests were performed using the RCAA groundwater flow model, as presented in Appendix B of the Fiscal Year 2012 Water Modelling Analysis Report (CH2M HILL, 2013d). The aquifer tests were simulated using the RCAA model, and the assumed hydraulic parameters of the aquifer system were adjusted until model predicted drawdown and recovery values provided reasonable agreement with those at each location. Hydraulic conductivity values at observation and pumping wells are summarized in Table 4. Values in the alluvium (Model Layers 1 through 3) ranged from $3.5\text{x}10^{-3}$ to $5.8\text{x}10^{-2}$ centimetres per second (cm/sec) and were generally two to three orders of magnitude lower in Model Layers 4 and 5 (i.e., bedrock layers). These results are comparable to those from RCG (2006).

A specific yield value of 0.01 resulted from the calibration effort. Calibrated specific storage values includes $1\text{x}10^{-3}$ per metre (m^{-1}) in Model Layer 1, $2\text{x}10^{-4}$ m^{-1} in Model Layers 2 and 3, and $2\text{x}10^{-5}$ m^{-1} in Model Layers 4, 5 and 6. RGC (2006) reported a specific yield of 0.1, with comparable specific storage values using earlier versions of the MODFLOW code. The aquifer test data were used in conjunction with average long-term, site-wide water level data for RCAA calibration.

Appendix B of the Fiscal Year 2012 Water Modelling Analysis Report (CH2M HILL, 2013d) provides a complete discussion of the simulated and observed water level drawdown and recovery data during the aquifer testing program, and how it was used in the model calibration process. Many of the time-drawdown curves developed from the aquifer testing data are presented and discussed in that report, and are compared with simulated water level trends. However, data from a small subset of background wells (see Figure 2) were discussed in the report, but not presented in graphical format. Data from these background wells are presented below for completeness. Wells P01-04A, P01-04B, X25-96A, and X25-96B are located at the base of the ID (on the west or Polishing Pond side). These wells are screened as follows:

- X25-96A: 7.44 to 8.97 m bgs
- X25-96B: 17.7 to 19.17 m bgs
- P01-04A: 31.7 to 33.2 m bgs
- P01-04B: 51.0 to 52.5 m bgs

Water levels measured in these wells indicated a slight increase in water level during the duration of the CVD shallow aquifer test (see Figure 14). This may be due to the discharge water entering the Polishing Pond. The highest heads here were at well P01-04A.

Wells X16A and X16B are located near Rose Creek, and water levels here generally follow the trend of Rose Creek (see Figure 15). During the alluvial aquifer testing at the CVD, water levels dropped steadily in these wells for a total drawdown of about 0.02 m over the 4-day test. The sharp drops in groundwater levels during 10/3/12 and 10/4/12 are likely due to the very cold temperatures (approximately -8°C) experienced during the early mornings of these days (see Figure 19). The groundwater elevation at X16B was consistently about 0.1 m higher than that at X16A, indicating upward vertical hydraulic gradients.

Wells X17A and X17B are located in the floodplain downgradient from the CVD (see Figure 16). The decline in groundwater elevations here during the CVD alluvial aquifer test was about 0.05 m, about 0.03 m more than that at X16A and X16B. This magnitude of drawdown agrees with the prediction by the calibrated RCAA groundwater flow model at X17A and X17B (approximately 0.04 m).

Wells X18A and X18B are located along the north side of the valley, approximately 150 m from the nearest CVD pumping well, CH12-204-MW001A. The groundwater elevation at this location declined about 0.35 m during the CVD alluvial aquifer test, about 0.33 m more than at the X16 well cluster (see Figure 17). The groundwater level decline during the CVD aquifer test and subsequent recovery appear to have a somewhat linear trend over time. This magnitude of drawdown is about 30 percent less than that simulated by the calibrated RCAA model, and the onset of the drawdown occurs at a much slower rate. This drawdown behaviour in the model likely reflects the conservative approach taken in model development, where hydraulic conductivity values assigned to areas of significant uncertainty were biased high. This approach resulted in a higher estimated rate of groundwater pumping to achieve hydraulic containment of a given area of affected groundwater.

Groundwater – Surface Water Interaction Study

The purpose of this study was to investigate the nature of the interaction between Rose Creek and the underlying alluvial aquifer. If mine-affected groundwater moves downgradient from the CVD area, the primary mechanism for this groundwater to affect surface water quality is through the discharge of groundwater to Rose Creek. The objective of this study is to identify areas along Rose Creek downstream from the CVD where there is a high probability for groundwater to discharge into the creek. Once these areas are identified, groundwater monitoring activities can be focused on these areas to provide early warning for the potential discharge of contaminated groundwater to the surface water system.

As described in the Cross Valley Dam Interception System Investigation Data Report (CH2M HILL, 2013b), steel piezometers were installed along Rose Creek and in ditches west of the CVD to measure the hydraulic head differences and direction of water flow between the surface water and groundwater in the shallow streams in the area. The head difference between the shallow groundwater measured in the piezometers and surface water stage was collected by measuring the depth-to-water inside and outside the piezometers. The vertical hydraulic gradient (VHG) was then computed by dividing the head difference between the groundwater level and the stream stage by the distance between the measurements (the distance from the bottom of the streambed to the midpoint of the screen). The results of this study indicated that gaining stream conditions are dominant along the lower portions of Rose Creek; these results are presented in detail in the Cross Valley Dam Interception System Investigation Data Report (CH2M HILL, 2013b) (see Figure 18).

After the aquifer tests, several pressure transducers were available for temporary installation in select piezometers. Transducers were installed in CH12-204-SP02, CH12-204-SP03, CH12-204-SP04A, and CH12-204-SP04B for several days (see Figure 17). Figures 18 through 22 present the transducer data compared with manually measured water levels in the piezometers and in the Rose Creek stage gauges. At CH12-204-SP02, a transducer was installed in Rose Creek from 9/24/12 through 10/9/12 and in the piezometer from 10/4/12 through 10/9/12 (see Figure 18). Groundwater elevations were constantly higher in the piezometer than in Rose Creek (indicating gaining stream conditions), with the exception of during development and testing of well CH12-201-MW006B, which resulted in depressed groundwater levels near well CH12-204-SP02 (see Figure 19). Also of note are the rapid decreases in stream stage during the hard freezes of 10/3/12 and 10/4/12, and the overall general decline in Rose Creek stage by about 3 cm during the CVD multiday aquifer test (9/29/12 to 10/3/12).

At CH12-204-SP03, a transducer was installed in Rose Creek from 9/25/12 through 10/9/12 and in the piezometer from 10/4/12 through 10/9/12 (see Figure 18). Groundwater elevations were constantly higher in the piezometer than in Rose Creek (indicating gaining stream conditions), with the exception of during development and testing of well CH12-204-MW005B, which resulted in depressed groundwater levels near piezometer CH12-204-SP03 (see Figure 20). As was the case near CH12-204-SP02, rapid decreases in stream stage during the hard freezes of 10/3/12 and 10/4/12 were recorded as was an overall general decline in Rose Creek stage by about 3 cm during the CVD multiday aquifer test (9/29/12 to 10/3/12).

At CH12-204-SP04A and CH12-204-SP04B, transducers were installed only in the piezometers from 10/4/12 through 10/9/12 (see Figure 18). Water levels in the piezometers were constantly higher than the stage measured in Rose Creek during this period (indicating gaining stream conditions) (see Figure 21).

These semicontinuous transducer data confirm the general conclusions of the groundwater/surface-water study indicating gaining stream conditions in this reach of Rose Creek during fall 2012. The measured response in CH12-204-SP02 and CH12-204-SP03 to aquifer testing at nearby wells CH12-201-MW005B and CH12-201-MW006B, respectively, may be useful in future analysis if more precise information on aquifer properties in this area is needed.

Conclusions

The geochemical data collected in 2012 was planned to augment the existing historical data set for the FMC by filling in data gaps in that historical data set and establishing long-term trends to calibrate the geochemical modellings being developed for the site. The models were based on established empirical data (i.e., seep chemistry) and predictive laboratory data (i.e., ABA analysis) and were designed to predict geochemical changes at the FMC over time. Some of the key findings concluded from the analysis and comparison of the 2012 data historical data include the following:

- Results from the WRDs seep sampling program indicates that most of the seep water is currently non-acidic to only mildly acidic, with some exceptions, but that it often contains elevated concentrations of cadmium and zinc. However, when compared with the historical seep data, overall, there is a general site-wide trend of decreasing pH and alkalinity and increasing acidity and concentrations of sulphate and zinc.
- Results from the WRD solids analysis are similar to historical geochemical data. Specifically, the Faro and Vangorda WRDs are PAG and will likely become acidic in the future. Although the Grum Sulphide Cell is known to be acid generating, all of the Grum WRD samples collected outside of the cell during the 2012 field work were non-PAG. However, this does not mean that the Grum WRD won't generate net acidic water in the future, but the amount and degree of acidification is likely to be much lower than either the Vangorda or Faro WRDs.
- Temperature and gas monitoring of the WRDs suggest that the influx of oxygen is diffusion limited, especially in the Grum WRD. This raises concerns regarding the temporary reactivity of the WRDs during regrading for cap placement during closure, but also is encouraging that the reactivity of high-sulphide areas can be limited with a proper cap system. Some insight into this potential can be observed downgradient from the Grum Sulphide Cell, where seep water chemistry has improved since the cap was installed.
- Acid-base accounting of the samples collected during the 2012 CVD investigations indicate that, in general, the amount of acid potential in the RCAA material below the CVD is low (i.e., low total sulphur). The RCAA sediments do not contain significant sulphide minerals (though some sulphides were quantified in the ABA analysis) and are not expected to generate acid on their own. However, the RCAA sediments, in general, possess neutralization potential, which can slow the migration of acidic porewater downgradient from the RCTF.
- With the exception of CH2-014-MW005, which was not drilled to bedrock and not located along a pre-mining drainage path, all of the 2012 WRD monitoring wells were installed in the shallow alluvial and weathered bedrock aquifer underlying the WRDs. The fact that these wells produced groundwater and maintained relatively constant groundwater levels supports the hypothesis presented in the CSM that the main flow path of groundwater is underneath the WRD along the pre-mining drainage patterns
- Geochemical changes are noted between the WRD monitoring wells and the downstream corresponding seepage locations; however, long-term monitoring will be required to establish significant trends in the data set.
- Similarly temporal changes are noted in the RCTF porewater and the underlying RCAA groundwater, but continuous monitoring has not been carried out long enough to establish long-term trends.
- Aquifer testing at various locations across the site provided estimates of aquifer properties for various aquifer sediments. The range of hydraulic conductivity values obtained for alluvial materials beneath the WRDs was between 1x10-5 m/s and 5.8x10-5 m/s; the weathered bedrock estimate was approximately 1.2x10-6 m/s. The hydraulic conductivity of the alluvial aquifer in the CVD area was estimated to be between 5.8x10-2 and 3.5x10-3 m/s.
- The surface water–groundwater interaction study conducted along Rose Creek downstream from the CVD showed consistent upward gradients between the Rose Creek and the underlying aquifer, indicating that groundwater is discharging into the stream channel at most locations tested downstream from the dam.

In summary, the 2012 data are a key addition to the historical data already compiled for the FMC and help establish long-term trends at the site. However, in many sampling locations, data trends are not of sufficient length to establish trends over time. It is essential to continue monitoring and data collection at key locations across the site to establish long-term trends that can be used to calibrate geochemical modelling for even longer term prediction.

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Tables

TABLE 1

Acid Base Accounting

Faro Mine Remediation Project

	Soil pH		Acid Potential												Neutralization Potential			
	Paste pH (pH units)	pH (1:2 soil:water) (pH units)	Sulfur - Total (mg/kg)	Sulfur - Total (%)	Zinc - Total (mg/kg)	Zinc - Total (%)	Lead - Total (mg/kg)	Lead - Total (%)	Total Barium, Aqua Regia (mg/kg)	Total Barium, Aqua Regia (%)	Total Barium, Lithium Metaborate (ppm)	Total Barium, Lithium Metaborate (%)	Sulphate, Acid Soluble (percent)	Acid Potential[a] (as $CaCO_3$) (kg $CaCO_3$/tonne)	Total Inorganic Carbon (percent)	Inorganic Carbon (as $CaCO_3$) (percent)	Inorganic Carbon (as CaCO3 Equivalent) [Neutralization Potential][a] (kg $CaCO_3$/tonne)	NPR = NP:AP
CH12-204-MW001B_SOA	7.76	8.58	500 U	0.025	121	0.0121	46.4	0.00464	126	0.0126				0.48	0.63	5.25	52.50	109
CH12-204-MW001B_SOB	7.55	8.09	1100	0.11	162	0.0162	96.9	0.00969	190	0.019	937	0.0937	0.02	1.83	0.49	4.08	40.80	22
CH12-204-MW001B_SOC	7.61	8.55	2500	0.25	68.5	0.00685	14.7	0.00147	103	0.0103				7.63	0.76	6.31	63.10	8.3
CH12-204-MW001B_SOD	7.61	8.43	1400	0.14	47.9	0.00479	10.5	0.00105	56.6	0.00566				4.26	0.69	5.76	57.60	14
CH12-204-MW001B_SOE	7.64	8.47	2800	0.28	47.4	0.00474	9.58	0.000958	47.5	0.00475				8.64	0.66	5.54	55.40	6.4
CH12-204-MW001B_SOF	7.64	8.26	2800	0.28	36.9	0.00369	6.33	0.000633	57.8	0.00578				8.65	0.28	2.35	23.50	2.7
CH12-204-MW001B_SOG	7.73	8.46	3100	0.31	40	0.004	7.49	0.000749	43.8	0.00438				9.59	0.25	2.09	20.90	2.2
CH12-204-MW901B_SOG (duplicate)	7.65	8.51	3100	0.31	60.4	0.00604	6.49	0.000649	46.2	0.00462				9.56	0.24	1.97	19.70	2.1
CH12-204-MW001B_SOH	7.78	8.74	11100	1.11	73.1	0.00731	5.57	0.000557	20.2	0.00202	865	0.0865	0.01 U	33.79	1.24	10.40	104.00	3.1
CH12-204-MW002B_SOA	7.14	7.99	1000	0.1	65.2	0.00652	15.8	0.00158	119	0.0119				2.93	< 0.1	< 0.7	0.35	0.1
CH12-204-MW002B_SOB	6.93	7.72	700	0.07	120	0.012	30.6	0.00306	294	0.0294	535	0.0535	0.01 U	1.44	< 0.1	< 0.7	0.35	0.2
CH12-204-MW002B_SOC	6.88	7.85	2600	0.26	192	0.0192	95.2	0.00952	237	0.0237	1085	0.1085	0.04	6.36	0.39	3.24	32.40	5.1
CH12-204-MW002B_SOD	7.04	8.3	2100	0.21	81.4	0.00814	30.2 J	0.00302	108	0.0108				6.34	0.64	5.36	53.60	8.4
CH12-204-MW902B_SOD (duplicate)	6.78	8.28	1500	0.15	59.7	0.00597	15.7 J	0.00157	73.4	0.00734				4.53	0.83	6.93	69.30	15
CH12-204-MW002B_SOE	7.16	8.42	3100	0.31	60.7	0.00607	12	0.0012	59.3	0.00593				9.55	0.40	3.34	33.40	3.5
CH12-204-MW002B_SOF	3.36	3.41	135000	13.5	45.9	0.00459	8.93	0.000893	17.7	0.00177	140.5	0.01405	0.48	406.79	< 0.1	< 0.7	0.35	0.001
CH12-204-MW002B_SOG	7.09	8.8	9200	0.92	52.7	0.00527	37.9	0.00379	29.8	0.00298				28.63	1.23	10.30	103.00	3.6
CH12-204-MW003B_SOA	6.59	7.01	1700	0.17	137	0.0137	75.3	0.00753	613	0.0613				4.62	< 0.1	< 0.7	0.35	0.1
CH12-204-MW003B_SOB	6.65	7.63	900	0.09	94.8	0.00948	27.8	0.00278	85.6	0.00856				2.59	< 0.1	< 0.7	0.35	0.1
CH12-204-MW003B_SOC	7.1	8.09	1500	0.15	143	0.0143	20.9	0.00209	329	0.0329	1280	0.128	0.03	3.28	0.57	4.71	47.10	14
CH12-204-MW003B_SOD	6.99	8.47	500 U	0.025	58.7	0.00587	8.32	0.000832	55.9	0.00559				0.65	0.17	1.40	14.00	22
CH12-204-MW003B_SOE	6.98	8.38	500 U	0.025	78.1	0.00781	13.6	0.00136	139	0.0139				0.55	0.19	1.61	16.10	29
CH12-204-MW003B_SOF	7.01	8.34	500 U	0.025	110	0.011	27.7	0.00277	135	0.0135				0.50	0.29	2.39	23.90	48
CH12-204-MW003B_SOG	7.29	8.69	2300	0.23	57.1	0.00571	8.76	0.000876	116	0.0116				7.01	0.52	4.36	43.60	6.2
CH12-204-MW003B_SOH	7.34	8.44	1100	0.11	67.3	0.00673	9.38	0.000938	131	0.0131				3.23	0.12	0.96	9.60	3.0
CH12-204-MW003B_SOJ	7.5		1100	0.11	40.2	0.00402	6.86	0.000686	14.3	0.00143				3.36				
CH12-204-MW003B_SOL			5300	0.53										16.56				
CH12-204-MW004B_SOA	7.95	8.42	500	0.05	95.7	0.00957	31	0.0031	156	0.0156				1.29	0.34	2.83	28.30	22
CH12-204-MW004B_SOB	7.01	7.56	500 U	0.025	121	0.0121	20.5	0.00205	188	0.0188	775	0.0775	0.02	-0.60	0.16	1.37	13.70	
CH12-204-MW004B_SOC	7.42	7.68	500 U	0.025	53.6	0.00536	9.1	0.00091	64.1	0.00641				0.65	0.12	0.99	9.90	15
CH12-204-MW004B_SOD	7.76	8.5	500 U	0.025	61.9	0.00619	12.9	0.00129	93.9	0.00939				0.61	0.65	5.42	54.20	89
CH12-204-MW004B_SOE	6.98	8.64	500 U	0.025	97.1	0.00971	32.5	0.00325	82.4	0.00824				0.56	0.88	7.35	73.50	132

TABLE 1

Acid Base Accounting

Faro Mine Remediation Project

	Soil pH		Acid Potential											Neutralization Potential			
	Paste pH (pH units)	**pH (1:2 soil:water) (pH units)**	**Sulfur - Total (mg/kg)**	**Sulfur - Total (%)**	**Zinc - Total (mg/kg)**	**Zinc - Total (%)**	**Lead - Total (mg/kg)**	**Lead - Total (%)**	**Total Barium, Aqua Regia (mg/kg)**	**Total Barium, Aqua Regia (%)**	**Total Barium, Lithium Metaborate (ppm)**	**Total Barium, Lithium Metaborate (%)**	**Sulphate, Acid Soluble (percent)**	**Acid Potential[a] (as CaCO$_3$) (kg CaCO$_3$/tonne)**	**Total Inorganic Carbon (percent)**	**Inorganic Carbon (as CaCO$_3$) (percent)**	**Inorganic Carbon (as CaCO3 Equivalent) [Neutralization Potential][a] (kg CaCO$_3$/tonne)**	**NPR = NP:AP**
CH12-204-MW004B_SOF	6.97	8.78	1600	0.16	55.9	0.00559	8.31	0.000831	79.7	0.00797				4.85	0.74	6.19	61.90	13
CH12-204-MW904B_SOF (duplicate)	7.04		2300	0.23	63	0.0063	9.24	0.000924	87.7	0.00877				7.02	0.75	6.26	62.60	8.9
CH12-204-MW004B_SOG	7.13	8.69	1600	0.16	71.7	0.00717	9.95	0.000995	113	0.0113				4.80	1.18	9.86	98.60	21
CH12-204-MW004B_SOH	7.14	8.67	1700	0.17	70	0.007	14.4	0.00144	158	0.0158				5.08	0.76	6.33	63.30	12
CH12-204-MW004B_SOI	7.23	8.8	1300	0.13	79	0.0079	10.4	0.00104	171	0.0171				3.81	0.57	4.77	47.70	13
CH12-204-MW004B_SOJ	7.22	9.04	1500	0.15	45.7	0.00457	5.9	0.00059	45.3	0.00453				4.58	1.79	14.90	149.00	33
CH12-204-MW005B_SOA	6.34	5.92	700	0.07	93.1	0.00931	14.1	0.00141	79.4	0.00794				1.98	< 0.1	< 0.7	0.35	**0.2**
CH12-204-MW005B_SOB	6.83	7.56	600	0.06	195	0.0195	16.4	0.00164	95.2	0.00952	823	0.0823	0.01	0.65	< 0.1	< 0.7	0.35	**0.5**
CH12-204-MW005B_SOC	7.02	7.73	500 U	0.025	91.7	0.00917	14.4	0.00144	58.8	0.00588				0.59	< 0.1	< 0.7	0.35	**0.6**
CH12-204-MW005B_SOD	7.2	8.22	1000	0.1	156	0.0156	22.9	0.00229	326	0.0326	1170	0.117	0.04 J	0.77	0.34	2.83	28.30	37
CH12-204-MW905B_SOD (duplicate)	7.25	8.21	1200	0.12	129	0.0129	20.5	0.00205	287	0.0287	877	0.0877	0.01 J	2.59	0.34	2.82	28.20	11
CH12-204-MW006B_SOA	6.94	8.34	600	0.06	141	0.0141	72.7	0.00727	165	0.0165				1.50	0.29	2.40	24.00	16
CH12-204-MW006B_SOB	7.01	7.71	600	0.06	91	0.0091	26.9	0.00269	130	0.013				1.63	< 0.1	< 0.7	0.35	**0.2**
CH12-204-MW006B_SOC	7.14	8.51	700	0.07	100	0.01	24.6	0.00246	98.5	0.00985				1.95	< 0.1	0.75	7.50	3.8
CH12-204-MW006B_SOD	7.02	8.62	500 U	0.025	97.8	0.00978	21.6	0.00216	653	0.0653				0.14	0.21	1.78	17.80	123

[a] Concentrations less than the detection limit were considered as having half the value of the detection limit for calculations

Notes:

Samples shown highlighted in black are potentially acid generating (PAG) as the NPR < 2

CaCO$_3$ = calcium carbonate

J = analyte was present but the reported value may not be accurate or precise

kg CaCO$_3$/tonne = kilgram of calcium carbonate per tonne

mg/kg = milligram per kilogram

NP:AP = the ratio of Neutralization Potential to Acid Potential

NPR = neutralizing potential ratio

ppm = part per million

U = analyte was analyzed for and detected but data was flagged during validation

TABLE 2

Acid Base Accounting (ABA)

Faro Mine Remediation Project

	Soil pH		**Acid Potential**												**Neutralization Potential**			
	Paste pH (pH units)	**pH (1:2 soil:water) (pH units)**	**Sulfur - Total (mg/kg)**	**Sulfur - Total (%)**	**Zinc - Total (mg/kg)**	**Zinc - Total (%)**	**Lead - Total (mg/kg)**	**Lead - Total (%)**	**Total Barium, Aqua Regia (mg/kg)**	**Total Barium, Aqua Regia (%)**	**Total Barium, Lithium Metaborate (ppm)**	**Total Barium, Lithium Metaborate (%)**	**Sulfate, Acid Soluble (percent)**	**Acid Potential[a] (as $CaCO_3$) (kg $CaCO_3$/tonne)**	**Total Inorganic Carbon (percent)**	**Inorganic Carbon (as $CaCO_3$) (percent)**	**Inorganic Carbon (as $CaCO_3$ Equivalent) [Neutralization Potential][a] (kg $CaCO_3$/tonne)**	**NPR = NP:AP**
CH12-014-MW003_SOA	6.09	6.48	27,100	2.71	9,700	0.97	9,580	0.958	169	0.0169	5920	0.592	0.42	47.74	0.19 U	1.57	15.70	**0.3**
CH12-014-MW003_SOB	6.72	7.92	35,600	3.56	2,830	0.283	1,560	0.156	81.8	0.00818	1460	0.146	0.04	103.84	0.8 U	6.65	66.50	**0.6**
CH12-014-MW003_SOC	6.85	8	6,500	0.65	685	0.0685	245	0.0245	261	0.0261	1190	0.119	0.01 U	18.12	0.48 U	3.98	39.80	2.2
CH12-014-MW003_SOD	6.88	8.35	5,600	0.56	661	0.0661	531	0.0531	284	0.0284	1230	0.123	0.01 U	15.18	0.55 U	4.59	45.90	3.0
CH12-014-MW003_SOE	6.99	8.45	1,800	0.18	2,760	0.276	1,590	0.159	140	0.014	874	0.0874	0.01 U	-0.17	0.37 U	3.09	30.90	-
CH12-014-MW003_SOF	7.64	8.14	3700 J	0.025	262	0.0262	149	0.0149	202	0.0202	687	0.0687	0.01 U	-0.35	0.13 U	1.05 J	10.50	-
CH12-014-MW903_SOF		8.17	8800 J	0.025	326	0.0326	187	0.0187	191	0.0191	1125	0.1125	0.01	-0.94	0.26 U	2.16 J	21.60	-
CH12-014-MW003_SOG	7.45	8.12	5,400	0.54	236	0.0236	65	0.00653	200	0.02	1025	0.1025	0.01 U	15.58	0.49 U	4.07	40.70	2.6
CH12-014-MW003_SOH	7.66	8.45	4,000	0.4	655	0.0655	507	0.0507	127	0.0127	670	0.067	0.01 U	10.61	0.75 U	6.23	62.30	5.9
CH12-014-MW003_SOI	7.55	8.88	2,100	0.21	253	0.0253	70	0.00696	42	0.0042	351	0.0351	0.03	4.95	4.08	34	340.00	68.7
CH12-014-MW005_SOA	7.28	8.6	5,100	0.51	321	0.0321	152	0.0152	129	0.0129	748	0.0748	0.01 U	14.67	0.64	5.37	53.70	3.7
CH12-014-MW005_SOB	7.23	8.13	4,100	0.41	165	0.0165	241	0.0241	92.8	0.00928	787	0.0787	0.01 U	11.71	0.78	6.53	65.30	5.6
CH12-014-MW005_SOC	6.85	6.83	57,800	5.78	2,660	0.266	5,630	0.563	156	0.0156	8330	0.833	0.39	155.56	0.5	4.18	41.80	**0.3**
CH12-014-MW005_SOD	7.42	8.08	11,100	1.11	404	0.0404	102	0.0102	392	0.0392	1190	0.119	0.01	32.84	1.22	10.1	101.00	3.1
CH12-014-MW005_SOE	7.11	7.78	15,000	1.5	149	0.0149	65	0.00651	108	0.0108	1590	0.159	0.01 U	45.30	0.73	6.08	60.80	**1.3**
CH12-014-MW005_SOF	7.39	7.71	23,800	2.38	243 J	0.0243	96.1 J	0.00961	124	0.0124	1030	0.103	0.01 U	73.05	0.75	6.21	62.10	**0.9**
CH12-014-MW905_SOF	7.56	7.73	32,000	3.2	98 J	0.0098	247 J	0.0247	99	0.0099	804	0.0804	0.01 U	98.99	0.75	6.29	62.90	**0.6**
CH12-014-MW005_SOG	6.86	6	19,000	1.9	2,910	0.291	488	0.0488	110	0.011	1730	0.173	0.01	53.10	0.77	6.43	64.30	**1.2**
CH12-014-MW005_SOH	7.23	6.89	16,700	1.67	3,330	0.333	1,410	0.141	195	0.0195	1420	0.142	0.18	39.74	0.41	3.41	34.10	**0.9**
CH12-014-MW005_SOI	7.58	8.28	3,400	0.34	90	0.00897	14	0.00137	449	0.0449	2160	0.216	0.01 U	8.75	0.86	7.19	71.90	8.2
CH12-014-MW005_SOJ	6.31	6.07	9,100	0.91	1,330	0.133	781	0.0781	260	0.026	1295	0.1295	0.19	19.14	0.3	2.51	25.10	**1.3**
CH12-014-MW005_SOK	7.03	6.86	88,000	8.8	12,200	1.22	6,430	0.643	17.5	0.00175	2200	0.22	0.19	245.65	0.26	2.19	21.90	**0.1**
CH12-014-MW007_SOA	7.2	8.44	2,900	0.29	297	0.0297	1,050	0.105	138	0.0138	776	0.0776	0.01 U	7.38	0.47	3.95	39.50	5.4
CH12-014-MW007_SOB	6.51	5.25	15,000	1.5	1,320	0.132	763	0.0763	185	0.0185	1125	0.1125	0.02	43.04	0.24	2.02	20.20	**0.5**
CH12-014-MW007_SOC	7.28	5	15,900	1.59	1,330	0.133	846	0.0846	196	0.0196	1380	0.138	0.08	43.73	0.16	1.36	13.60	**0.3**
CH12-014-MW007_SOD	7.1	7.48	8,800	0.88	580 J	0.0058	309	0.0309	220	0.022	857	0.0857	0.01 U	26.48	0.34	2.81	28.10	**1.1**
CH12-014-MW007_SOE	7.08	7.52	15,900	1.59	892	0.0892	589	0.0589	228	0.0228	1585	0.1585	0.03	45.94	0.27	2.25	22.50	**0.5**
CH12-014-MW007_SOF	7.23	7.79	5,300	0.53	322	0.0322	220	0.022	189	0.0189	1155	0.1155	0.01 U	14.96	0.23	1.94	19.40	**1.3**
CH12-014-MW907_SOF	6.25	7.96	7,100	0.71	351	0.0351	251	0.0251	263	0.0263	1770	0.177	0.02	19.61	0.26	2.19	21.90	**1.1**
CH12-014-MW007_SOG	6.25	8.08	16,700	1.67	1,070	0.107	590	0.059	222	0.0222	3060	0.306	0.06	46.15	0.33	2.72	27.20	**0.6**
CH12-014-MW007_SOH	6.38	7.72	12,200	1.22	2,430	0.243	1,210	0.121	304	0.0304	2570	0.257	0.05	30.38	0.37	3.07	30.70	**1.0**
CH12-014-MW007_SOI	5.7	4.71	43,100	4.31	7,220	0.722	3,850	0.385	173	0.0173	4300	0.43	0.15	113.93	<0.1	<0.7	0.35	**0.003**
CH12-014-MW007_SOJ	5.58	6.19	3,900	0.39	2,240	0.224	309	0.0309	181	0.0181	1095	0.1095	0.01 U	7.65	<0.1	<0.7	0.35	**0.05**
CH12-014-MW007_SOK	6.28	6.17	2,100	0.21	2,330	0.233	325	0.0325	255	0.0255	891	0.0891	0.01 U	2.03	<0.1	<0.7	0.35	**0.2**
CH12-014-MW007_SOL	6.37	6.95	2,000	0.2	194	0.0194	35	0.00346	70.3	0.00703				5.73	<0.1	<0.7	0.35	**0.1**
CH12-014-MW011_SOA	6.23	8.51	65	0.00645	94	0.00938	21	0.00206	133	0.0133	1145	0.1145	0.01 U	-0.94	1.64	13.70	137.00	
CH12-014-MW011_SOB	6.21	8.67	2,700	0.27	87	0.00873	13	0.00134	129	0.0129	1655	0.1655	0.01 U	6.93	1.12	9.35	93.50	13.5
CH12-014-MW011_SOC	6.14	8.34	6,000	0.6	89	0.00892	21	0.0021	147	0.0147	1465	0.1465	0.01 U	17.38	1.56	13.00	130.00	7.5
CH12-014-MW011_SOD	6.17	8.45	4,400	0.44	93	0.00929	9.67 U	0.000484	92.9	0.00929	1460	0.146	0.01 U	12.38	2.07	17.30	173.00	14.0
CH12-014-MW911_SOD	6.36	8.26	3,600	0.36	66	0.00656	9.59 U	0.00048	118	0.0118			0.01 U	10.90	2.10	17.50	175.00	16.0
CH12-014-MW011_SOE	6.22	8.19	3,100	0.31	131	0.0131	53	0.00534	216	0.0216	767	0.0767	0.01	8.59	2.16	18.00	180.00	21.0
CH12-014-MW011_SOF	6.37	7.95	2,000	0.2	461	0.0461	467	0.0467	116	0.0116	2330	0.233	0.01 U	3.46	0.19	1.55	15.50	4.5
CH12-014-MW012_SOA	6.25	8.3	1,900	0.19	72	0.00716	10.4 U	0.00052	180	0.018	892	0.0892	0.01 U	5.02	1.37	11.40	114.00	22.7
CH12-014-MW012_SOB	6.49	8.23	3,100	0.31	72	0.00722	11.2 U	0.00056	179	0.0179	1220	0.122	0.01 U	8.53	0.60	5.03	50.30	5.9

TABLE 2

Acid Base Accounting (ABA)

Faro Mine Remediation Project

	Soil pH		Acid Potential												Neutralization Potential			
	Paste pH (pH units)	**pH (1:2 soil:water) (pH units)**	**Sulfur - Total (mg/kg)**	**Sulfur - Total (%)**	**Zinc - Total (mg/kg)**	**Zinc - Total (%)**	**Lead - Total (mg/kg)**	**Lead - Total (%)**	**Total Barium, Aqua Regia (mg/kg)**	**Total Barium, Aqua Regia (%)**	**Total Barium, Lithium Metaborate (ppm)**	**Total Barium, Lithium Metaborate (%)**	**Sulfate, Acid Soluble (percent)**	**Acid Potential[a] (as $CaCO_3$) (kg $CaCO_3$/tonne)**	**Total Inorganic Carbon (percent)**	**Inorganic Carbon (as $CaCO_3$) (percent)**	**Inorganic Carbon (as $CaCO_3$ Equivalent) [Neutralization Potential][a] (kg $CaCO_3$/tonne)**	**NPR = NP:AP**
CH12-014-MW012_SOC	6.65	8.87	1,700	0.17	84	0.00839	15	0.00147	230	0.023	989	0.0989	0.01 U	4.30	0.94	7.83	78.30	18.2
CH12-014-MW012_SOD	6.64	8.14	1,500	0.15	76	0.00762	17	0.00165	216	0.0216	947	0.0947	0.01 U	3.72	0.62	5.13	51.30	13.8
CH12-014-MW012_SOE	6.67	8.16	1,200	0.12	90	0.00903	58	0.00577	131	0.0131	1030	0.103	0.01 U	2.68	0.34	2.87	28.70	10.7
CH12-014-MW012_SOF	6.77	8.49	1,100	0.11	103	0.0103	25	0.00247	169	0.0169	650	0.065	0.02	2.17	2.53	21.10	211.00	97.3
CH12-014-MW912_SOF	6.4	8.32	1,700	0.17	103	0.0103	30	0.00296	163	0.0163	413	0.0413	0.01 U	4.68	2.42	20.10	201.00	42.9
CH12-014-MW013_SOA	5.33	5.72	78,900	7.89	12,800	1.28	8,330	0.833	63.1	0.00631	10000 J	0.5	0.67	198.33	0.20	1.69	16.90	**0.1**
CH12-014-MW013_SOB	5.59	5.62	214,000	21.4	33,000	3.3	14,200	1.42	4.61 U	0.0002305	10000 J	0.5	0.55	590.46	0.83	6.95	69.50	**0.1**
CH12-014-MW013_SOC	5	4.5	252,000	25.2	8,290	0.829	5,000	0.5	2.85 U	0.0002425	10000 J	0.5	0.75	745.29	0.50	4.17	41.70	**0.1**
CH12-014-MW013_SOD	4.07	3.74	74,200	7.42	11,200	1.12	7,890	0.789	49.1	0.00491	10000 J	0.5	0.64	187.24	0.16	1.34	13.40	**0.1**
CH12-014-MW013_SOE	3.65	3.57	271,000	27.1	15,600	1.56	2,510	0.251	2.42 U	0.000121	10000 J	0.5	0.92	789.35	0.26	2.20	22.00	**0.03**
CH12-014-MW013_SOF	5.03	5.38	109,000	10.9	15,600	1.56	7,450	0.745	30.6	0.00306	10000 J	0.5	0.35	298.52	0.67	5.58	55.80	**0.2**
CH12-014-MW013_SOG	5.98	7.19	105,000	10.5	11,100	1.11	10,700	1.07	51	0.0051	10000 J	0.5	0.25	294.47	0.23	1.91	19.10	**0.1**
CH12-014-MW013_SOH	6.13	8.33	6,200	0.62	1,460	0.146	735	0.0735	201	0.0201	1155	0.1155	0.01 U	15.78	1.31	10.90	109.00	6.9

[a] Concentrations less than the detection limit were considered as having half the value of the detection limit for calculations

Notes:

Samples shown highlighted in black are potentially acid generating (PAG) as the NPR < 2

$CaCO_3$ = calcium carbonate

J = analyte was present but the reported value may not be accurate or precise

kg $CaCO_3$/tonne = kilgram of calcium carbonate per tonne

mg/kg = milligram per kilogram

NP:AP = the ratio of Neutralization Potential to Acid Potential

NPR = neutralizing potential ratio

ppm = part per million

U = analyte was analyzed for and detected but data was flagged during validation

TABLE 3

Mann-Kendall Analysis of Geochemical Trends in the FMC Seep Data

Faro Mine Remediation Project

Sites	pH	Acidity	Alkalinity	Sulphate	Zinc
Northwest Faro Dumps					
SRK-FD17	ND	ND	ND	ND	ND
SRK-FD18	**97% (sig -)**	76% (+)	92% (+)	88% (+)	93% (+)
SRK-FD19	59% (-)	**100% (sig +)**	51% (+)	**99% (sig +)**	**100% (sig +)**
Northeast Faro Dump Towards Faro Pit					
SRK-FD21	82% (+)	87% (-)	98% (sig +)	78% (-)	78% (-)
SRK-FD23	**98.0% (sig -)**	**98% (sig +)**	ND	**96% (sig +)**	94% (+)
SRK-FD26	65% (+)	72% (+)	89% (+)	**100% (sig +)**	**99% (sig +)**
CH-FD-56	ND	ND	ND	ND	ND
CH-FD-59	ND	ND	ND	ND	ND
CH-FD-60	ND	ND	ND	ND	ND
CH-FD-61	ND	ND	ND	ND	ND
CH-FD-62	ND	ND	ND	ND	ND
CH-FD-63	ND	ND	ND	ND	ND
SRK-FD22	ND	ND	ND	ND	ND
SRK-FD51	ND	ND	ND	ND	ND
Northeast Faro Dumps Draining to NFRC					
SRK-FD05	54% (+)	53% (+)	88% (-)	77% (+)	85% (+)
SRK-FD06	60% (+)	68% (+)	68% (+)	86% (+)	92% (+)
Faro Pit					
A25	70% (+)	53% (-)	95% (-)	**96% (sig -)**	ND
A30	ND	ND	ND	ND	ND
CH-FP-22	ND	ND	ND	ND	ND
CH-FP-23	ND	ND	ND	ND	ND
CH-FP-24	ND	ND	ND	ND	ND
CH-FP-25	ND	ND	ND	ND	ND
CH-FP-26	ND	ND	ND	ND	ND
CH-FP-27	ND	ND	ND	ND	ND
CH-FP-28	ND	ND	ND	ND	ND
CH-FP-29	ND	ND	ND	ND	ND
CH--FP-30	ND	ND	ND	ND	ND
CH-FP-31	ND	ND	ND	ND	ND
CH-FP-32	ND	ND	ND	ND	ND
SRK-FD16	ND	ND	ND	ND	ND
FP01	ND	ND	ND	ND	ND
FP02	ND	ND	ND	ND	ND
FP03	ND	ND	ND	ND	ND
FP04	ND	ND	ND	ND	ND
FP05	ND	ND	ND	ND	ND
FP06	ND	ND	ND	ND	ND
FP07	ND	ND	ND	ND	ND
FP08	ND	ND	ND	ND	ND
FP09	ND	ND	ND	ND	ND
FP10	ND	ND	ND	ND	ND
FP11	ND	ND	ND	ND	ND
FP12	ND	ND	ND	ND	ND

TABLE 3

Mann-Kendall Analysis of Geochemical Trends in the FMC Seep Data

Faro Mine Remediation Project

Sites	pH	Acidity	Alkalinity	Sulphate	Zinc
FP13	ND	ND	ND	ND	ND
FP14	ND	ND	ND	ND	ND
FP15	ND	ND	ND	ND	ND
FP16	ND	ND	ND	ND	ND
FP17	ND	ND	ND	ND	ND
FP18	ND	ND	ND	ND	ND
FP19	ND	ND	ND	ND	ND
FP20	ND	ND	ND	ND	ND
FP21	ND	ND	ND	ND	ND
SRK-FD24	**98% (sig -)**	**100% (sig +)**	**99% (sig -)**	**99% (sig +)**	**98% (sig +)**
SRK-FD40	90% (-)	87% (+)	ND	94% (+)	90% (+)
Old Faro Creek and Mill Creek					
SRK-FD09	ND	ND	ND	ND	ND
SRK-FD31	**100% (sig -)**	**100% (sig +)**	**100% (sig -)**	**100% (sig +)**	**100% (sig +)**
CH-FD-64	ND	ND	ND	ND	ND
South Interface between Main and Intermediate Dump					
SRK-FD30	**99% (sig -)**	**99% (sig +)**	59% (-)	**98% (sig -)**	92% (+)
SRK-FD36	ND	ND	ND	ND	ND
SRK-FD53	ND	ND	ND	ND	ND
Low Grade Stockpile					
SRK-FD38	ND	ND	ND	ND	ND
Intermediate Dump					
SRK-FD08	ND	ND	ND	ND	ND
SRK-FD13	**99% (sig -)**	90% (+)	ND	**98% (sig +)**	**98% (sig +)**
SRK-FD44	ND	ND	ND	ND	ND
SRK-FD48	ND	ND	ND	ND	ND
SRK-FD50	ND	ND	ND	ND	ND
Ramp Zone Dump					
SRK-FD14	84% (-)	57% (-)	66% (+)	71% (-)	66% (-)
Swells					
SRK-FD55	ND	ND	ND	ND	ND
Medium Grade Stockpiles					
SRK-FD37	88% (-)	**98% (sig +)**	ND	**100% (sig +)**	**100% (sig +)**
Mill Building Area					
SRK-FD01	91% (-)	**100% (sig +)**	68% (-)	**100% (sig +)**	**100% (sig +)**
CH-FD-65	ND	ND	ND	ND	ND
CH-MILL-01	ND	ND	ND	ND	ND
CH-MILL-02	ND	ND	ND	ND	ND
CH-MILL-03	ND	ND	ND	ND	ND
SRK-FD34	ND	ND	ND	ND	ND
ETA					
CH-ETA-01	ND	ND	ND	ND	ND
CH-ETA-02	ND	ND	ND	ND	ND
CH-ETA-03	ND	ND	ND	ND	ND
Grum Waste Rock Dump					
SRK-GD01	96% (+)	86% (-)	53% (-)	86% (+)	68% (-)

TABLE 3

Mann-Kendall Analysis of Geochemical Trends in the FMC Seep Data

Faro Mine Remediation Project

Sites	pH	Acidity	Alkalinity	Sulphate	Zinc
SRK-GD02	ND	ND	ND	ND	ND
SRK-GD04	ND	ND	ND	ND	ND
SRK-GD05	59% (+)	63% (+)	65% (+)	**100% (sig +)**	65% (+)
SRK-GD06	55% (+)	54% (+)	76% (-)	**100% (sig +)**	69% (+)
SRK-GD07	50% (-)	50% (-)	67% (+)	81% (-)	76% (-)
SRK-GD08	ND	ND	ND	ND	ND
SRK-GD09	ND	ND	ND	ND	ND
SRK-GD10	ND	ND	ND	ND	ND
SRK-GD11	ND	ND	ND	ND	ND
SRK-GD12	ND	ND	ND	ND	ND
SRK-GD13	69% (+)	**99% (sig +)**	**96% (sig +)**	**100% (sig +)**	**100% (sig +)**
SRK-GD16	ND	ND	ND	ND	ND
SRK-GD17	ND	ND	ND	ND	ND
SRK-GD18	ND	ND	ND	ND	ND
SRK-GD19	ND	ND	ND	ND	ND
SRK-GD20	ND	ND	ND	ND	ND
SRK-GD21	ND	ND	ND	ND	ND
SRK-GD22	ND	ND	ND	ND	ND
SRK-GD23	ND	ND	ND	ND	ND
SRK-GD24	ND	ND	ND	ND	ND
V15	ND	ND	ND	ND	ND
WTA02	ND	ND	ND	ND	ND
Grum Pit					
GP01	ND	ND	ND	ND	ND
GP02	83% (+)	ND	56% (-)	92% (-)	ND
GP03	ND	ND	ND	ND	ND
GP04	78% (-)	78% (+)	68% (+)	68% (+)	**96% (sig +)**
GP05	ND	ND	ND	ND	ND
GP06	ND	ND	ND	ND	ND
GP07	ND	ND	ND	ND	ND
GP08	ND	ND	ND	ND	ND
GP09	**96% (sig -)**	ND	92% (+)	92% (+)	ND
GP10	ND	ND	ND	ND	ND
GP11	ND	ND	ND	ND	ND
GP12	ND	ND	ND	ND	ND
GP14	ND	ND	ND	ND	ND
CH-GP-19	ND	ND	ND	ND	ND
CH-GP-20	ND	ND	ND	ND	ND
CH-GP-21	ND	ND	ND	ND	ND

TABLE 3

Mann-Kendall Analysis of Geochemical Trends in the FMC Seep Data

Faro Mine Remediation Project

Sites	pH	Acidity	Alkalinity	Sulphate	Zinc
CH-GP-22	ND	ND	ND	ND	ND
CH-GP-23	ND	ND	ND	ND	ND
CH-GP-24	ND	ND	ND	ND	ND
GP13	ND	ND	ND	ND	ND
GP15	ND	ND	ND	ND	ND
GP16	ND	ND	ND	ND	ND
GP17	ND	ND	ND	ND	ND
GP18	ND	ND	ND	ND	ND
Vangorda Dump					
SRK-VD01	ND	ND	ND	ND	ND
SRK-VD02	ND	ND	ND	ND	ND
SRK-VD03	75% (-)	72% (+)	94% (-)	**99% (sig +)**	85% (+)
SRK-VD04	**98% (sig -)**	**100% (sig +)**	ND	**97% (sig +)**	89% (+)
SRK-VD05	**99% (sig -)**	**98% (sig +)**	ND	90% (+)	87% (+)
SRK-VD06	ND	ND	ND	ND	ND
SRK-VD07	ND	ND	ND	ND	ND
SRK-VD08	ND	ND	ND	ND	ND
SRK-VD09	90% (-)	**100% (sig +)**	ND	84% (+)	79% (+)
SRK-VD10	87% (-)	91% (+)	ND	89% (+)	89% (+)
SRK-VD12	ND	ND	ND	ND	ND
CH12-015-SE016	ND	ND	ND	ND	ND
Vangorda Pit					
VP01	ND	ND	ND	ND	ND
VP02	ND	ND	ND	ND	ND
VP03	ND	ND	ND	ND	ND
VP04	ND	ND	ND	ND	ND
VP05	ND	ND	ND	ND	ND
VP06	ND	ND	ND	ND	ND
VP07	ND	ND	ND	ND	ND
VP08	ND	ND	ND	ND	ND
VP09	ND	ND	ND	ND	ND
VP10	ND	ND	ND	ND	ND
VP11	ND	ND	ND	ND	ND
VP12	ND	ND	ND	ND	ND
VP13	ND	ND	ND	ND	ND
VP14	ND	ND	ND	ND	ND
VP15	ND	ND	ND	ND	ND
VP16	ND	ND	ND	ND	ND
CH12-15-VP20	ND	ND	ND	ND	ND
CH12-015-SE031	ND	ND	ND	ND	ND
CH12-015-SE032	ND	ND	ND	ND	ND
CH12-015-SE033	ND	ND	ND	ND	ND

Notes:

ND: less than 10 measurable data points

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TABLE 4

Hand-Measured Groundwater Elevations

Faro Mine Remediation Project

Well: X25-96A
Datum (m): 1032.070

Date	Depth to Water (m)	Groundwater Elevation (m amsl)
9/23/2012 12:23	4.504	1027.566
9/26/2012 9:09	4.488	1027.582
9/27/2012 10:31	4.478	1027.592
9/28/2012 9:28	4.466	1027.604
9/29/2012 9:54	4.443	1027.627
9/29/2012 19:53	4.423	1027.647
9/30/2012 8:38	4.409	1027.661
9/30/2012 19:16	4.391	1027.679
9/30/2012 23:14	4.382	1027.688
10/1/2012 2:23	4.382	1027.688
10/1/2012 8:30	4.370	1027.700
10/1/2012 15:07	4.360	1027.710
10/1/2012 19:30	4.352	1027.718
10/2/2012 0:05	4.340	1027.730
10/2/2012 5:09	4.332	1027.738
10/2/2012 12:56	4.314	1027.756
10/2/2012 17:53	4.306	1027.764
10/2/2012 23:30	4.284	1027.786
10/3/2012 8:34	4.269	1027.801
10/3/2012 14:39	4.252	1027.818
10/3/2012 17:58	4.247	1027.823
10/4/2012 9:20	4.239	1027.831
10/4/2012 14:16	4.235	1027.835
10/5/2012 10:02	4.205	1027.865
10/6/2012 14:04	4.178	1027.892
10/7/2012 8:47	4.154	1027.916

Well: X25-96B
Datum (m): 1032.040

Date	Depth to Water (m)	Groundwater Elevation (m amsl)
9/23/2012 12:23	4.361	1027.679
9/26/2012 9:10	4.345	1027.695
9/27/2012 10:36	4.337	1027.703
9/28/2012 9:29	4.320	1027.720
9/29/2012 9:56	4.303	1027.737
9/29/2012 19:54	4.288	1027.752
9/30/2012 8:39	4.270	1027.770
9/30/2012 19:15	4.252	1027.788
9/30/2012 23:15	4.245	1027.795
10/1/2012 2:23	4.243	1027.797
10/1/2012 8:30	4.237	1027.803
10/1/2012 15:07	4.221	1027.819
10/1/2012 19:30	4.217	1027.823
10/2/2012 0:05	4.206	1027.834
10/2/2012 5:09	4.198	1027.842
10/2/2012 12:56	4.177	1027.863
10/2/2012 17:53	4.169	1027.871
10/2/2012 23:30	4.152	1027.888
10/3/2012 8:34	4.130	1027.910
10/3/2012 14:40	4.116	1027.924
10/3/2012 17:58	4.109	1027.931
10/4/2012 9:20	4.095	1027.945
10/4/2012 14:16	4.090	1027.950
10/5/2012 10:02	4.072	1027.968
10/6/2012 14:04	4.045	1027.995
10/7/2012 8:47	4.018	1028.022

Well: P01-04A
Datum (m): 1031.800

Date	Depth to Water (m)	Groundwater Elevation (m amsl)
9/23/2012 12:45	2.626	1029.174
9/26/2012 9:12	2.616	1029.184
9/27/2012 10:38	2.610	1029.190
9/28/2012 9:31	2.605	1029.195
9/29/2012 9:58	2.589	1029.211
9/29/2012 19:56	2.568	1029.232
9/30/2012 8:41	2.564	1029.236
9/30/2012 19:14	2.554	1029.246
9/30/2012 23:16	2.553	1029.247
10/1/2012 2:25	2.548	1029.252
10/1/2012 8:32	2.539	1029.261
10/1/2012 15:10	2.533	1029.267
10/1/2012 19:37	2.533	1029.267
10/2/2012 0:08	2.528	1029.272
10/2/2012 5:12	2.521	1029.279
10/2/2012 12:59	2.505	1029.295
10/2/2012 17:54	2.494	1029.306
10/2/2012 23:32	2.486	1029.314
10/3/2012 8:36	2.470	1029.330
10/3/2012 14:42	2.457	1029.343
10/3/2012 18:00	2.444	1029.356
10/4/2012 9:22	2.424	1029.376
10/4/2012 14:18	2.419	1029.381
10/5/2012 10:04	2.404	1029.396
10/6/2012 14:06	2.380	1029.420
10/7/2012 8:49	2.355	1029.445

Well: P01-04B
Datum (m): 1031.770

Date	Depth to Water (m)	Groundwater Elevation (m amsl)
9/23/2012 12:45	3.271	1028.499
9/26/2012 9:13	3.258	1028.512
9/27/2012 10:39	3.250	1028.520
9/28/2012 9:32	3.242	1028.528
9/29/2012 9:59	3.226	1028.544
9/29/2012 19:55	3.215	1028.555
9/30/2012 8:42	3.198	1028.572
9/30/2012 19:15	3.189	1028.581
9/30/2012 23:16	3.185	1028.585
10/1/2012 2:25	3.182	1028.588
10/1/2012 8:32	3.175	1028.595
10/1/2012 15:10	3.169	1028.601
10/1/2012 19:33	3.173	1028.597
10/2/2012 0:08	3.157	1028.613
10/2/2012 5:12	3.154	1028.616
10/2/2012 12:59	3.135	1028.635
10/2/2012 17:54	3.125	1028.645
10/2/2012 23:32	3.112	1028.658
10/3/2012 8:36	3.101	1028.669
10/3/2012 14:42	3.094	1028.676
10/3/2012 18:00	3.074	1028.696
10/4/2012 9:22	3.053	1028.717
10/4/2012 14:18	3.052	1028.718
10/5/2012 10:04	3.046	1028.724
10/6/2012 14:06	3.016	1028.754
10/7/2012 8:49	2.983	1028.787

Well: P01-01A
Datum (m): 1015.860

Date	Depth to Water (m)	Groundwater Elevation (m amsl)
9/23/2012 13:10	3.596	1012.264
9/26/2012 8:40	3.603	1012.257
9/27/2012 12:49	3.613	1012.247
9/29/2012 12:17	3.626	1012.234
9/29/2012 19:38	3.618	1012.242
9/30/2012 8:25	3.632	1012.228
9/30/2012 17:27	3.633	1012.227
9/30/2012 23:47	3.633	1012.227
10/1/2012 3:11	3.633	1012.227
10/1/2012 10:26	3.638	1012.222
10/1/2012 15:20	3.637	1012.223
10/1/2012 19:42	3.640	1012.220
10/2/2012 0:20	3.642	1012.218
10/2/2012 5:27	3.643	1012.217
10/2/2012 13:43	3.645	1012.215
10/2/2012 17:34	3.645	1012.215
10/2/2012 23:39	3.647	1012.213
10/3/2012 8:50	3.652	1012.208
10/3/2012 14:58	3.652	1012.208
10/3/2012 18:25	3.652	1012.208
10/4/2012 9:34	3.654	1012.206
10/4/2012 15:56	3.655	1012.205
10/5/2012 12:10	3.645	1012.215
10/6/2012 13:37	3.652	1012.208

Well: P01-01A
Datum (m): 1015.820

Date	Depth to Water (m)	Groundwater Elevation (m amsl)
9/23/2012 13:10	3.659	1012.161
9/26/2012 8:41	3.677	1012.143
9/27/2012 12:50	3.684	1012.136
9/29/2012 12:18	3.703	1012.117
9/29/2012 19:39	3.701	1012.119
9/30/2012 8:26	3.706	1012.114
9/30/2012 17:28	3.712	1012.108
9/30/2012 23:47	3.710	1012.110
10/1/2012 3:11	3.711	1012.109
10/1/2012 10:26	3.714	1012.106
10/1/2012 15:20	3.719	1012.101
10/1/2012 19:42	3.721	1012.099
10/2/2012 0:20	3.723	1012.097
10/2/2012 5:28	3.725	1012.095
10/2/2012 13:43	3.729	1012.091
10/2/2012 17:34	3.729	1012.091
10/2/2012 23:39	3.726	1012.094
10/3/2012 8:50	3.734	1012.086
10/3/2012 14:59	3.735	1012.085
10/3/2012 18:25	3.735	1012.085
10/4/2012 9:34	3.737	1012.083
10/4/2012 15:57	3.750	1012.070
10/5/2012 12:10	3.737	1012.083
10/6/2012 13:37	3.736	1012.084

Well: X16A
Datum (m): 1015.307

Date	Depth to Water (m)	Groundwater Elevation (m amsl)
9/21/2012 8:50	3.565	1011.742
9/23/2012 12:15	3.561	1011.746
9/26/2012 8:50	3.565	1011.742
9/27/2012 10:27	3.561	1011.746
9/28/2012 9:21	3.570	1011.737
9/29/2012 10:05	3.576	1011.731
9/29/2012 17:45	3.577	1011.730
9/30/2012 8:33	3.587	1011.720
9/30/2012 19:06	3.591	1011.716
10/1/2012 8:24	3.592	1011.715
10/1/2012 15:01	3.595	1011.712
10/1/2012 19:25	3.597	1011.710
10/2/2012 12:49	3.605	1011.702
10/2/2012 12:45	3.602	1011.705
10/3/2012 8:26	3.616	1011.691
10/3/2012 14:47	3.606	1011.701
10/3/2012 18:06	3.602	1011.705
10/4/2012 9:12	3.620	1011.687
10/6/2012 13:54	3.609	1011.698
10/7/2012 8:40	3.611	1011.696
10/8/2012 11:01	3.614	1011.693

Well: X16B
Datum (m): 1015.513

Date	Depth to Water (m)	Groundwater Elevation (m amsl)
9/21/2012 8:49	3.634	1011.879
9/23/2012 12:15	3.625	1011.888
9/26/2012 8:49	3.634	1011.879
9/27/2012 10:26	3.643	1011.870
9/28/2012 9:20	3.649	1011.864
9/29/2012 10:06	3.652	1011.861
9/29/2012 17:46	3.652	1011.861
9/30/2012 8:32	3.662	1011.851
9/30/2012 19:05	3.664	1011.849
10/1/2012 8:23	3.665	1011.848
10/1/2012 15:01	3.667	1011.846
10/1/2012 19:25	3.670	1011.843
10/2/2012 12:48	3.675	1011.838
10/2/2012 17:45	3.671	1011.842
10/3/2012 8:26	3.687	1011.826
10/3/2012 14:46	3.684	1011.829
10/3/2012 17:00	3.680	1011.833
10/4/2012 9:12	3.690	1011.823
10/4/2012 17:17	3.705	1011.808
10/6/2012 13:54	3.686	1011.827
10/7/2012 8:40	3.688	1011.825
10/8/2012 11:00	3.691	1011.822

Well: X17A
Datum (m): 1014.814

Date	Depth to Water (m)	Groundwater Elevation (m amsl)
9/23/2012 15:30	2.196	1012.6183
9/27/2012 13:56	2.202	1012.6123
9/29/2012 14:44	2.213	1012.6013
10/1/2012 10:55	2.23	1012.5843
10/8/2012 10:50	2.248	1012.5663

Well: X17B
Datum (m): 1014.413

Date	Depth to Water (m)	Groundwater Elevation (m amsl)
9/23/2012 15:30	1.837	1012.576
9/27/2012 13:57	1.846	1012.567
9/29/2012 14:44	1.854	1012.559
10/1/2012 10:57	1.887	1012.526
10/8/2012 10:51	1.888	1012.525

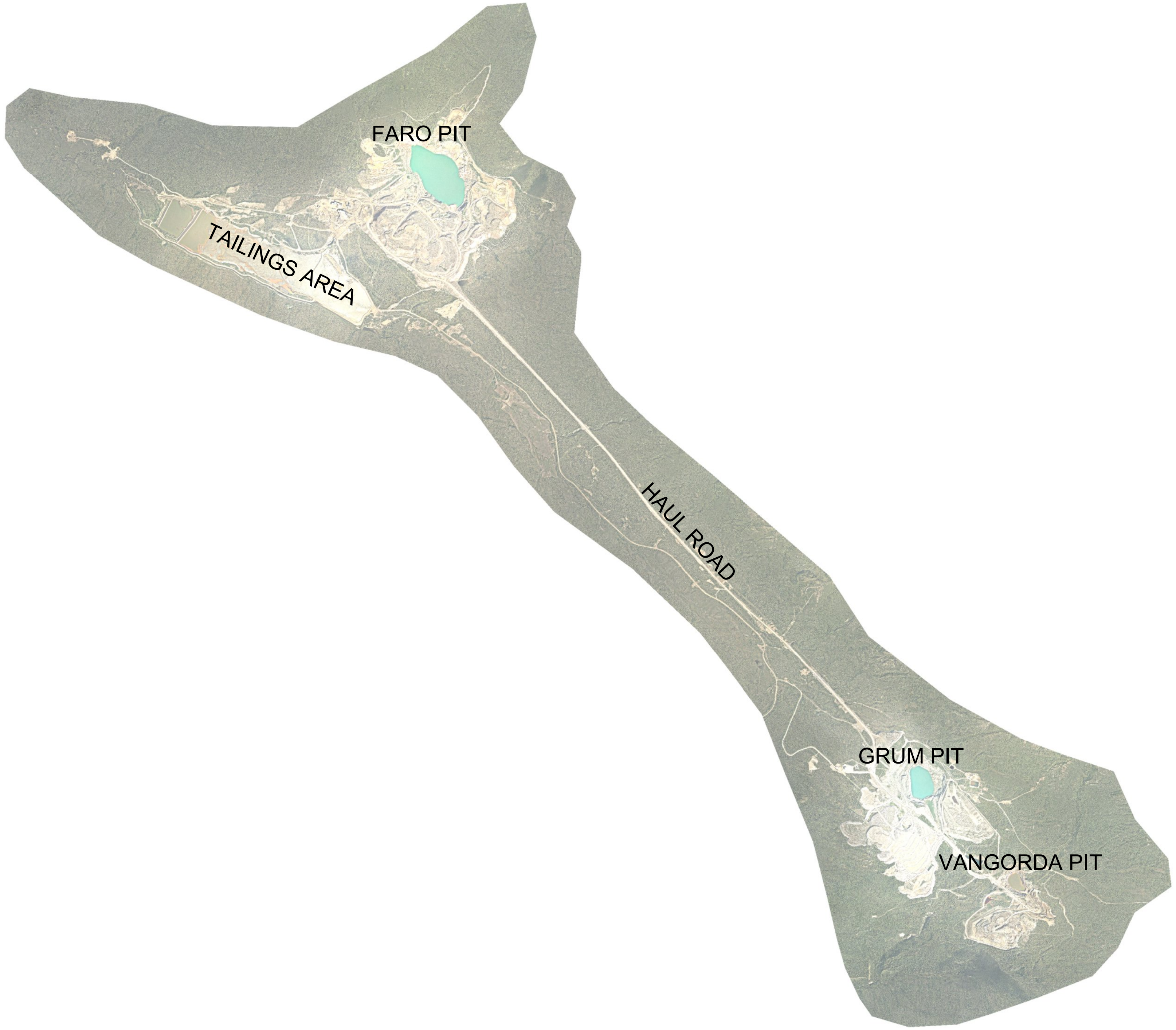
Well: X18A
Datum (m): 1019.590

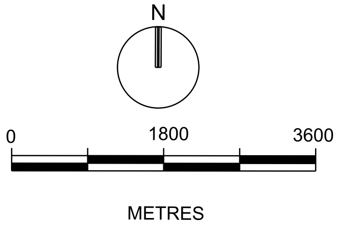
Date	Depth to Water (m)	Groundwater Elevation (m amsl)
9/23/2012 13:00	4.273	1015.317
9/26/2012 8:57	4.306	1015.284
9/27/2012 12:43	4.302	1015.288
9/29/2012 12:13	4.329	1015.261
9/29/2012 17:35	4.329	1015.261
9/30/2012 8:22	4.374	1015.216
9/30/2012 17:33	4.406	1015.184
9/30/2012 23:43	4.434	1015.156
10/1/2012 3:07	4.446	1015.144
10/1/2012 10:23	4.472	1015.118
10/1/2012 15:17	4.491	1015.099
10/1/2012 19:40	4.506	1015.084
10/2/2012 0:18	4.523	1015.067
10/2/2012 5:23	4.546	1015.044
10/2/2012 13:37	4.565	1015.025
10/2/2012 17:18	4.579	1015.011
10/3/2012 8:42	4.625	1014.965
10/3/2012 14:55	4.638	1014.952
10/3/2012 18:30	4.640	1014.95
10/4/2012 9:30	4.636	1014.954
10/4/2012 16:05	4.641	1014.949
10/6/2012 13:46	4.540	1015.05
10/8/2012 12:30	4.478	1015.112

Well: X18B
Datum (m): 1019.650

Date	Depth to Water (m)	Groundwater Elevation (m amsl)
9/23/2012 13:00	4.053	1015.597
9/26/2012 8:35	4.076	1015.574
9/27/2012 12:43	4.079	1015.571
9/29/2012 12:14	4.092	1015.558
9/29/2012 19:34	4.099	1015.551
9/30/2012 8:21	4.142	1015.508
9/30/2012 17:33	4.179	1015.471
9/30/2012 23:43	4.201	1015.449
10/1/2012 3:07	4.215	1015.435
10/1/2012 10:23	4.244	1015.406
10/1/2012 15:17	4.266	1015.384
10/1/2012 19:40	4.282	1015.368
10/2/2012 0:18	4.300	1015.35
10/2/2012 5:24	4.318	1015.332
10/2/2012 13:37	4.350	1015.3
10/2/2012 17:18	4.365	1015.285
10/3/2012 8:42	4.416	1015.234
10/3/2012 14:54	4.432	1015.218
10/3/2012 18:29	4.441	1015.209
10/4/2012 9:30	4.446	1015.204
10/4/2012 16:06	4.447	1015.203
10/6/2012 13:46	4.349	1015.301
10/8/2012 12:30	4.278	1015.372

Figures





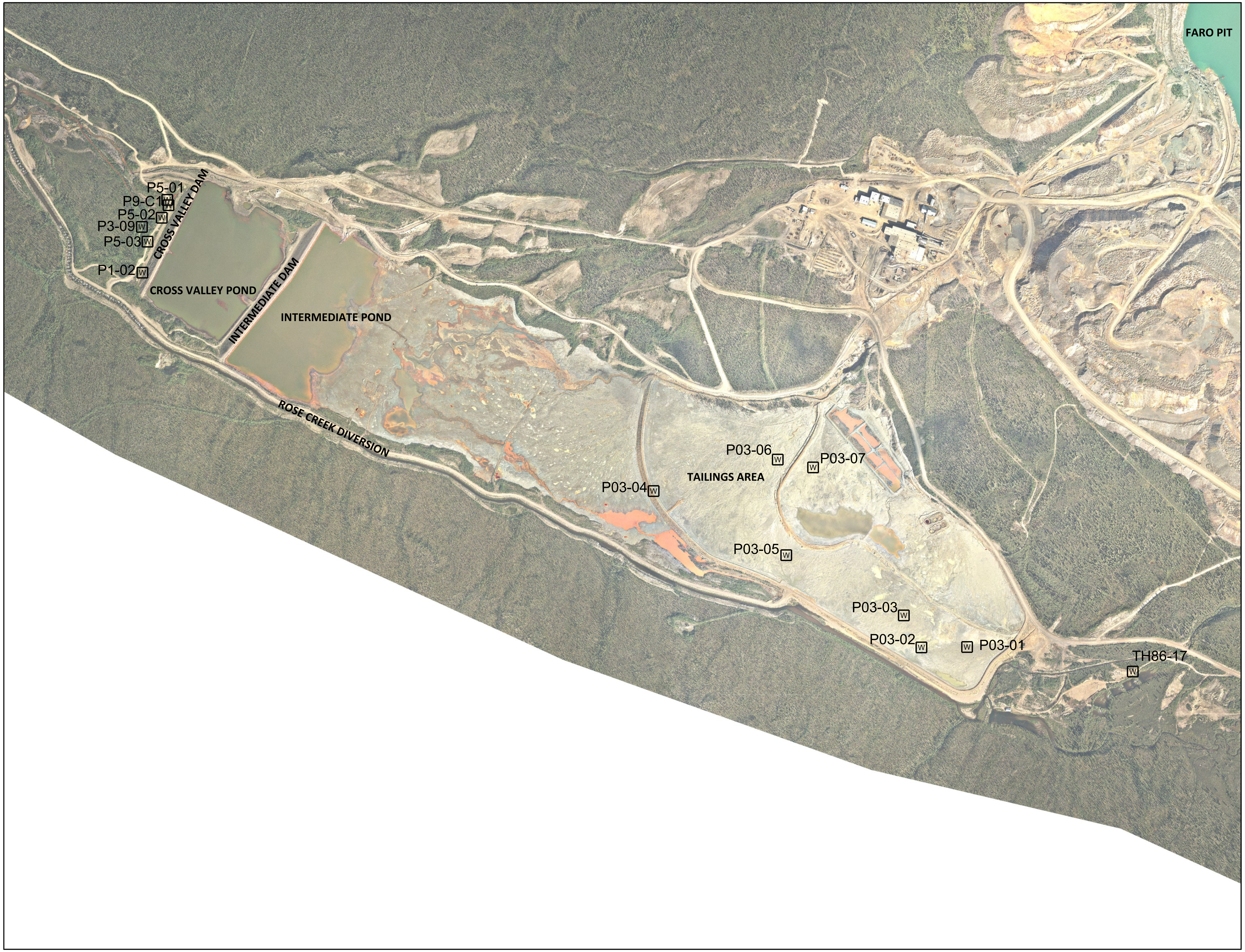
Notes:

1. Aerial Photo Shown Dated August 2012.

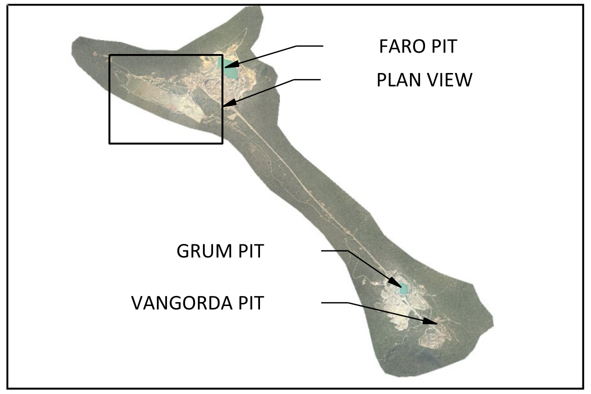
FIGURE 1

Site Wide Overview

Faro Mine Remediation Project



VICINITY MAP



LEGEND

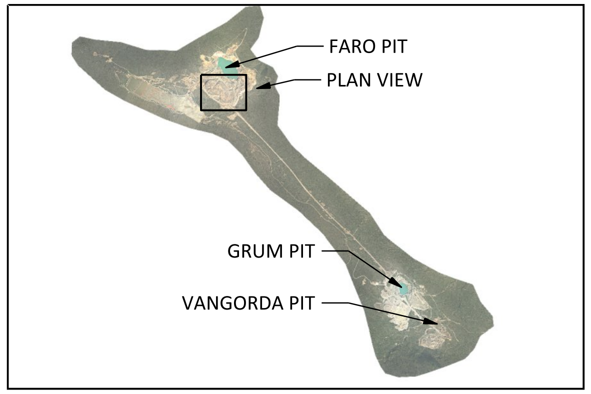
W MONITORING WELL

Notes:
1. AERIAL PHOTO SHOWN DATED AUGUST 2012.

FIGURE 2
Monitoring Well Locations
Rose Creek Tailings Area

CH2MHILL.

VICINITY MAP



LEGEND

W	MONITORING WELL (SEE NOTE 3)

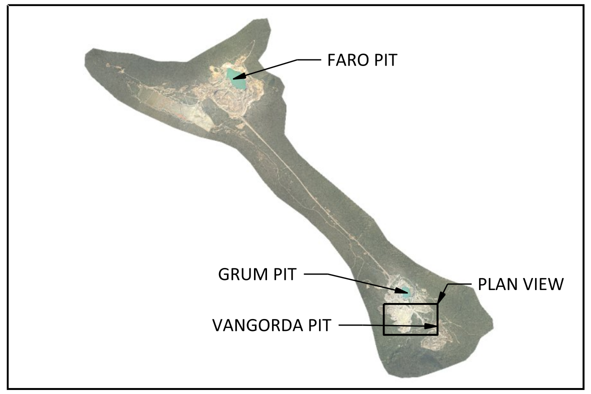
Notes:

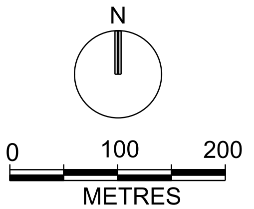
1. TOPOGRAPHY PREPARED FROM LIDAR DATED 10-03-11. HORIZONTAL DATUM: NAD83 CSRS EPOCH 2002. VERTICAL DATUM:CGVD28 (HTV2.0) 5 METRE INTERVAL CONTOURS ARE SHOWN.
2. AERIAL PHOTO SHOWN DATED AUGUST 2012.
3. ALL SAMPLES LOCATIONS SHOWN BASED ON FIELD SURVEY BY CHALLENGER GEOMATICS ON OCT. 2012. EXCEPT CH12-14-MW005 SHOWN BASED ON HAND HELD GPS COORDINATES.

FIGURE 3
Waste Rock Dump
Monitoring Locations - Faro Mine Area

CH2MHILL.

VICINITY MAP





LEGEND

W MONITORING WELL (SEE NOTE 3)

Notes:

1. TOPOGRAPHY PREPARED FROM LIDAR DATED 10-03-11. HORIZONTAL DATUM: NAD83 CSRS EPOCH 2002. VERTICAL DATUM:CGVD28 (HTV2.0) 5 METRE INTERVAL CONTOURS ARE SHOWN.
2. AERIAL PHOTO SHOWN DATED AUGUST 2012.
3. ALL SAMPLES LOCATIONS SHOWN BASED ON FIELD SURVEY BY CHALLENGER GEOMATICS ON OCT. 2012. EXCEPT CH12-14-MW005 SHOWN BASED ON HAND HELD GPS COORDINATES.

FIGURE 4
Waste Rock Dump
Monitoring Locations - Vangora/Grum Area

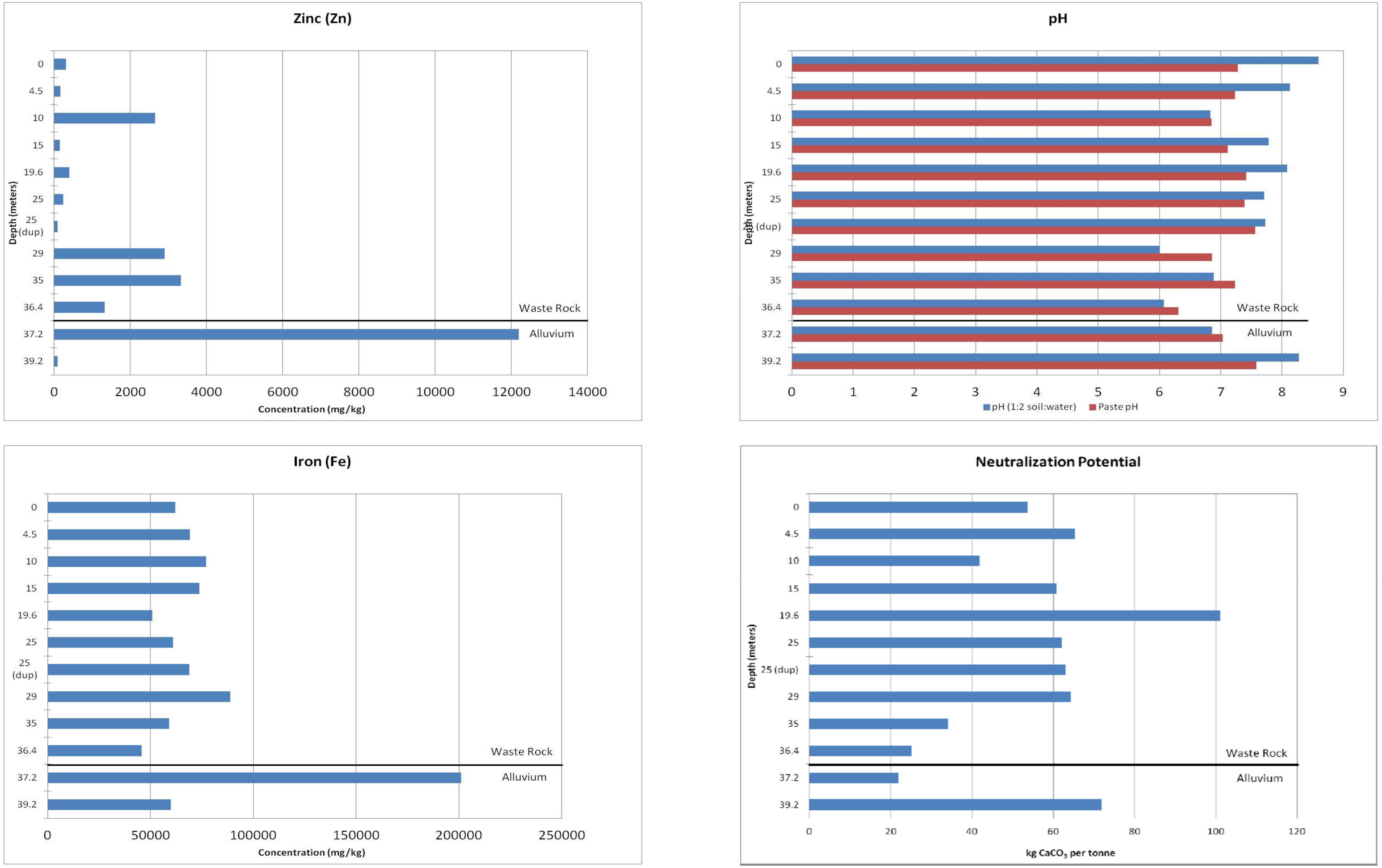


FIGURE 5a

Waste Rock Dump Geochemical Composition, CH12-014-MW005

Faro Mine Remediation Project

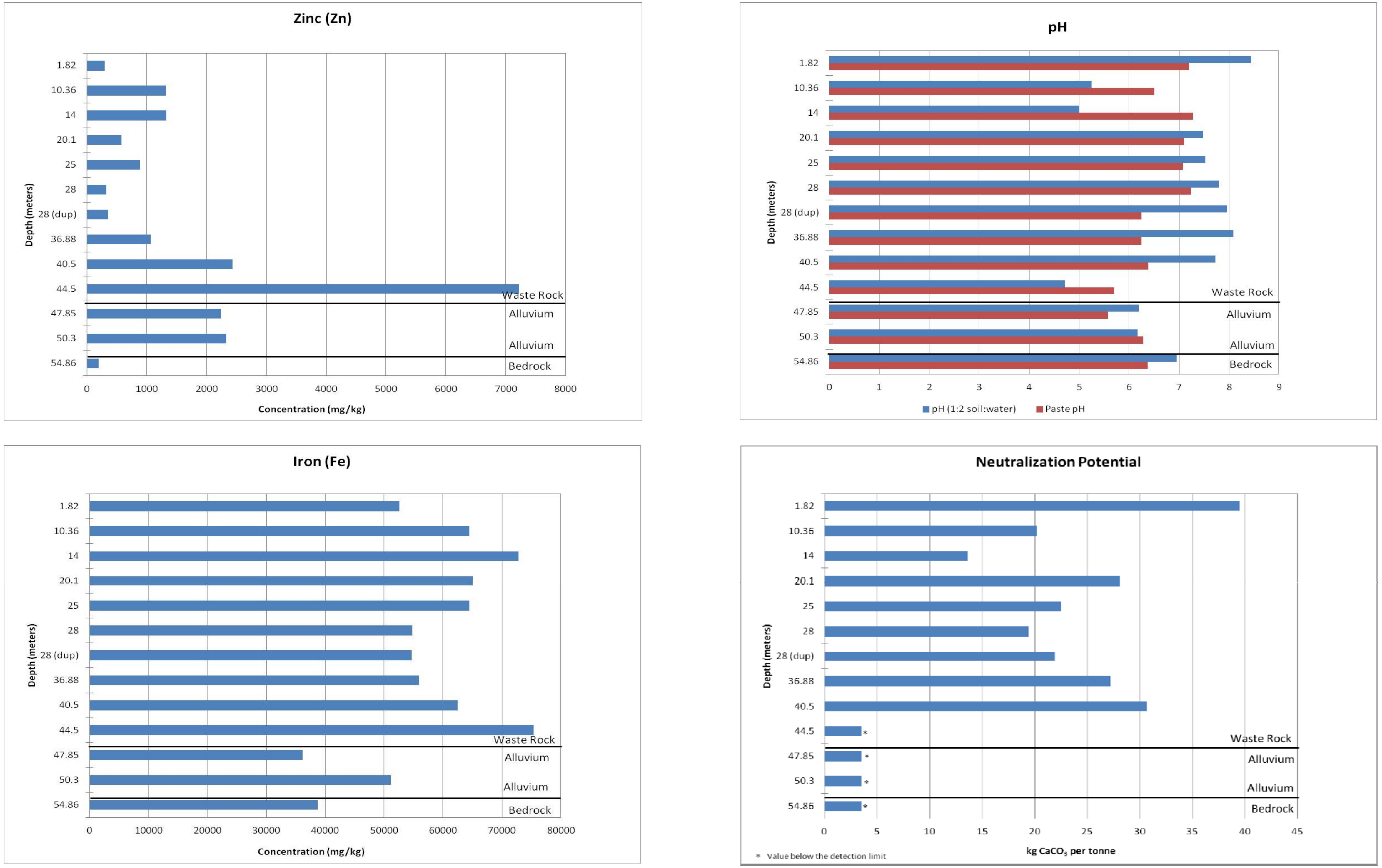


FIGURE 5b

Waste Rock Dump Geochemical Composition, CH12-014-MW007

Faro Mine Remediation Project

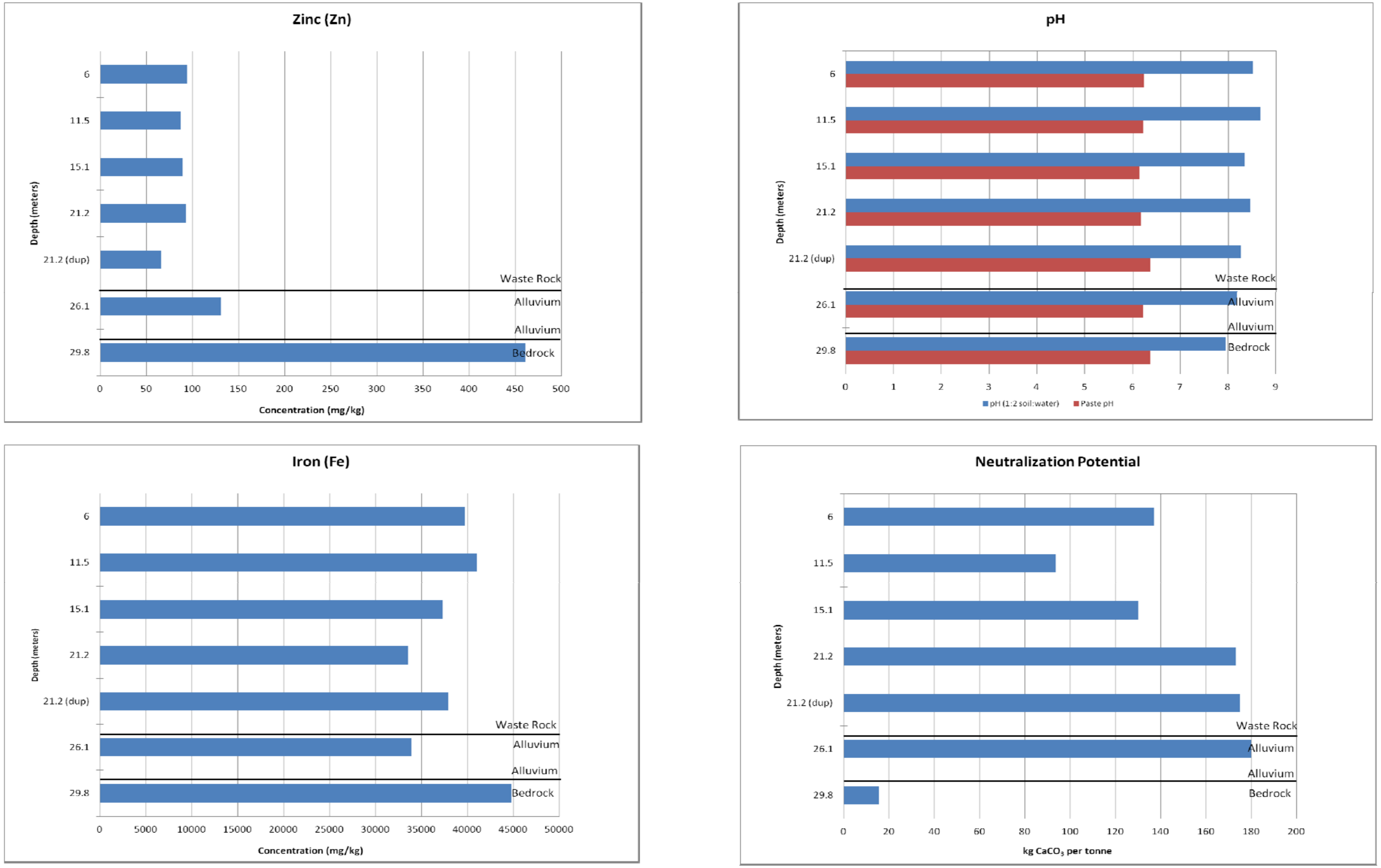


FIGURE 5c
Waste Rock Dump Geochemical Composition, CH12-014-MW011
Faro Mine Remediation Project

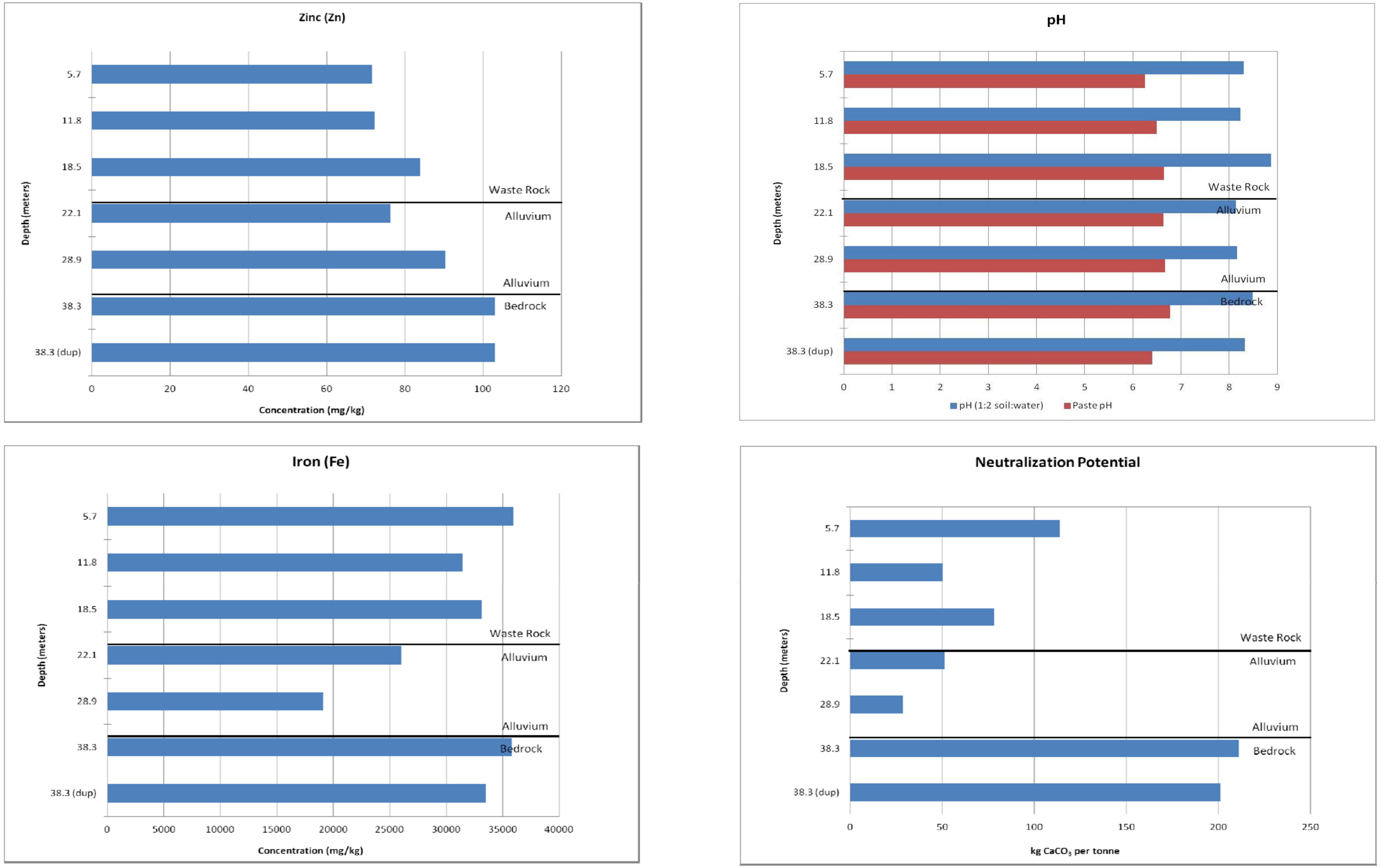


FIGURE 5d
Waste Rock Dump Geochemical Composition, CH12-014-MW012
Faro Mine Remediation Project

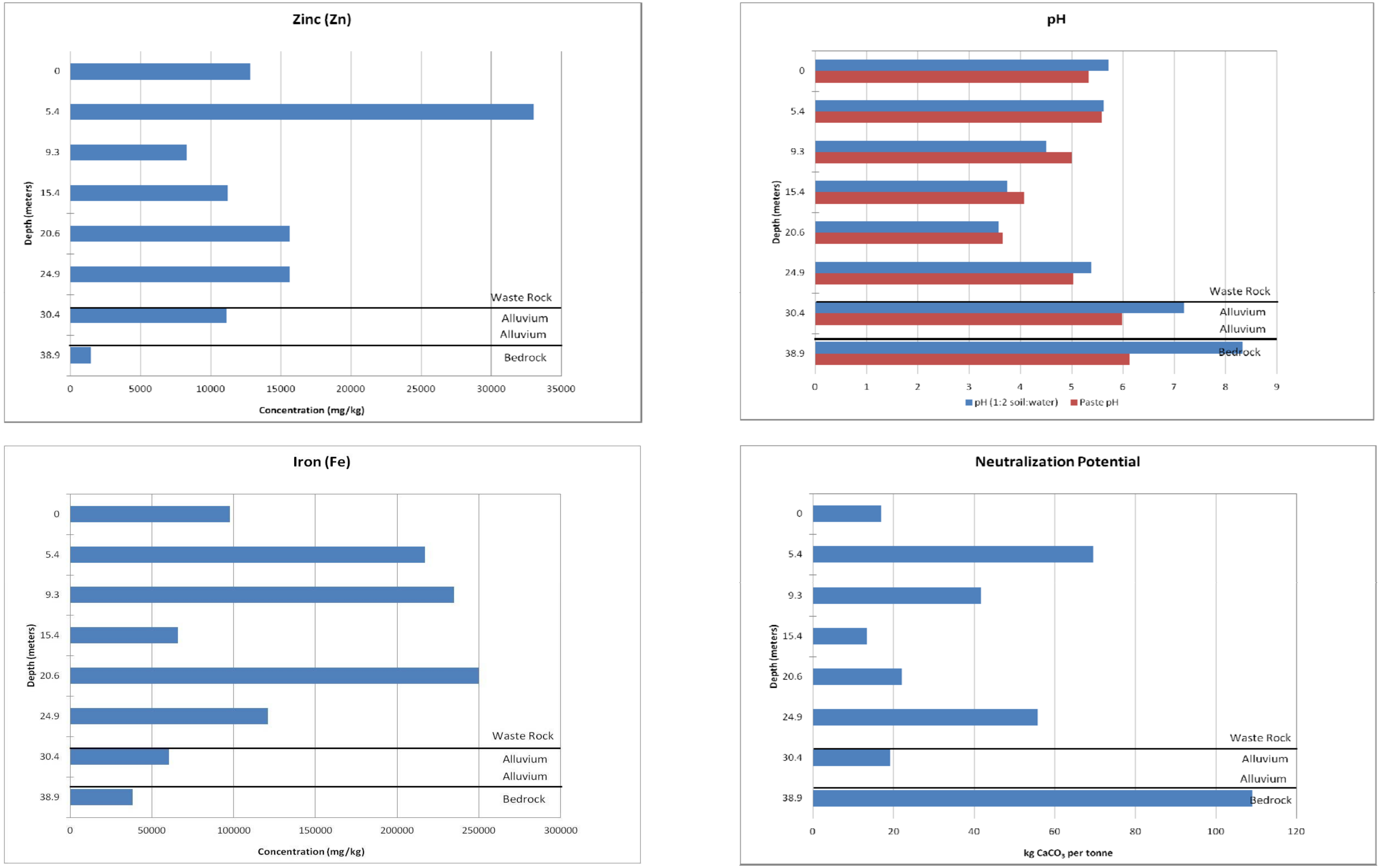


FIGURE 5e

Waste Rock Dump Geochemical Composition, CH12-014-MW013

Faro Mine Remediation Project

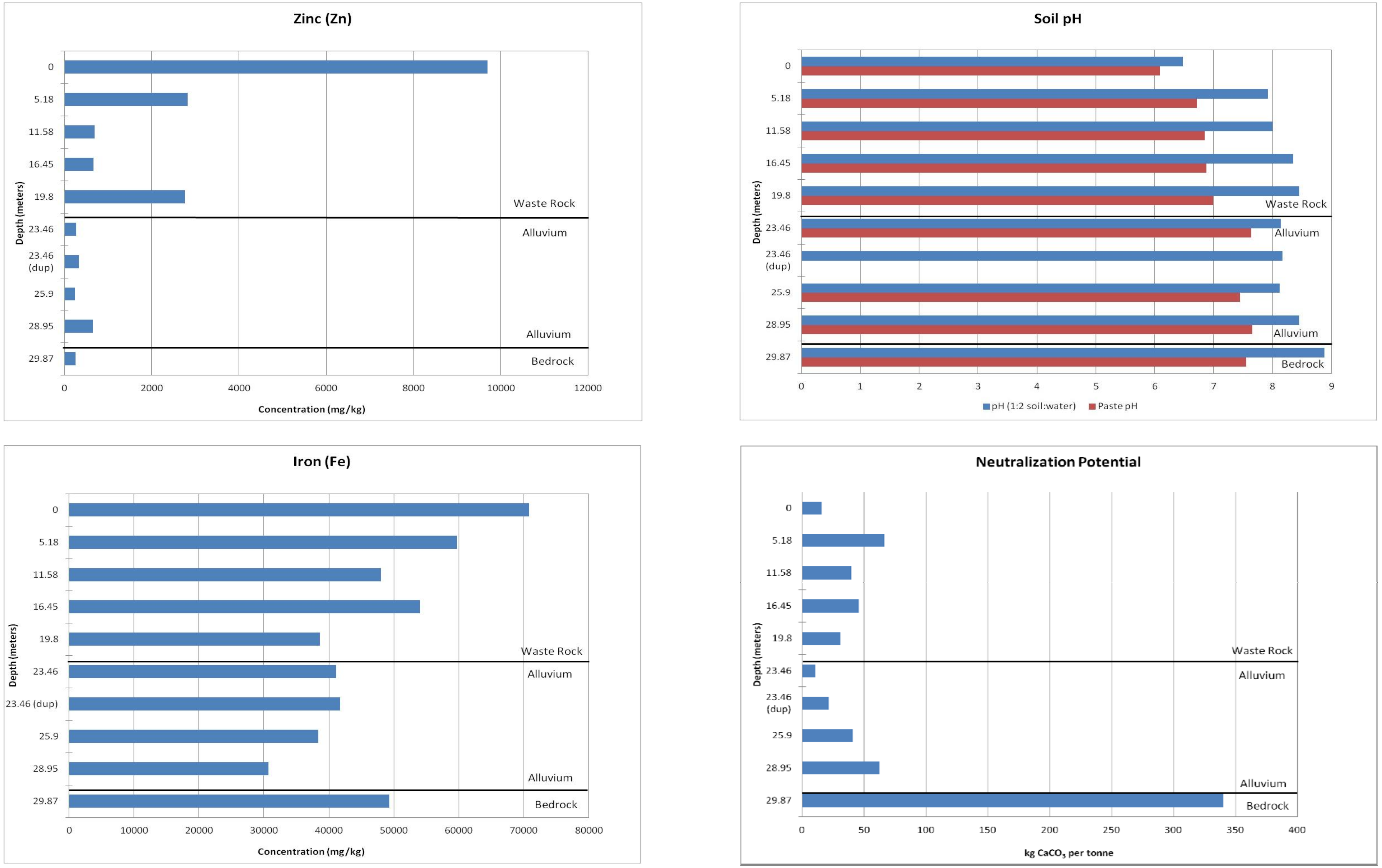


FIGURE 5f

Waste Rock Dump Geochemical Composition, CH12-014-MW003

Faro Mine Remediation Project

CH2MHILL.

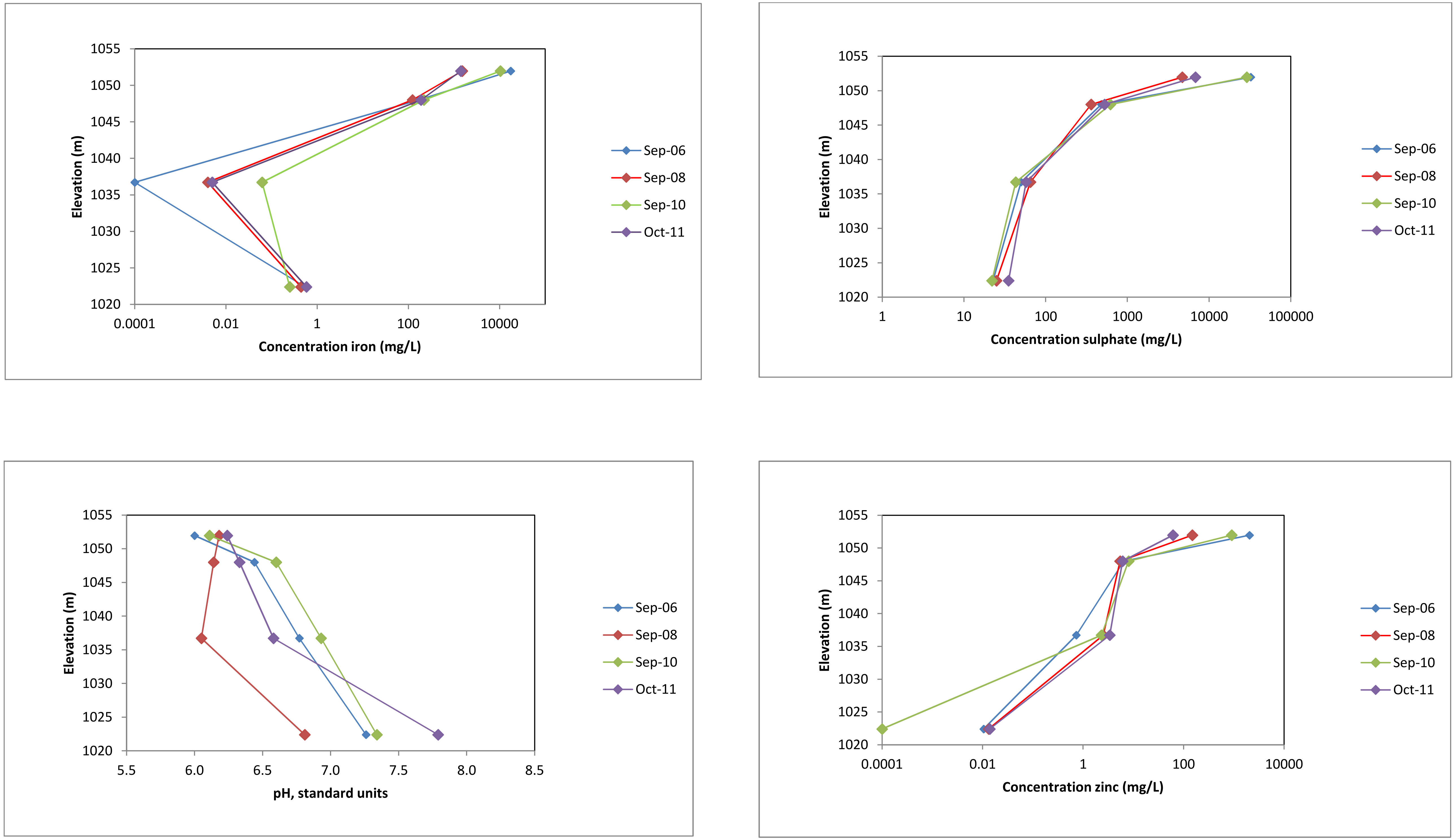


FIGURE 6a

Vertical Profiles of RCTA Groundwater Sampling, P03-01

Faro Mine Remediation Project

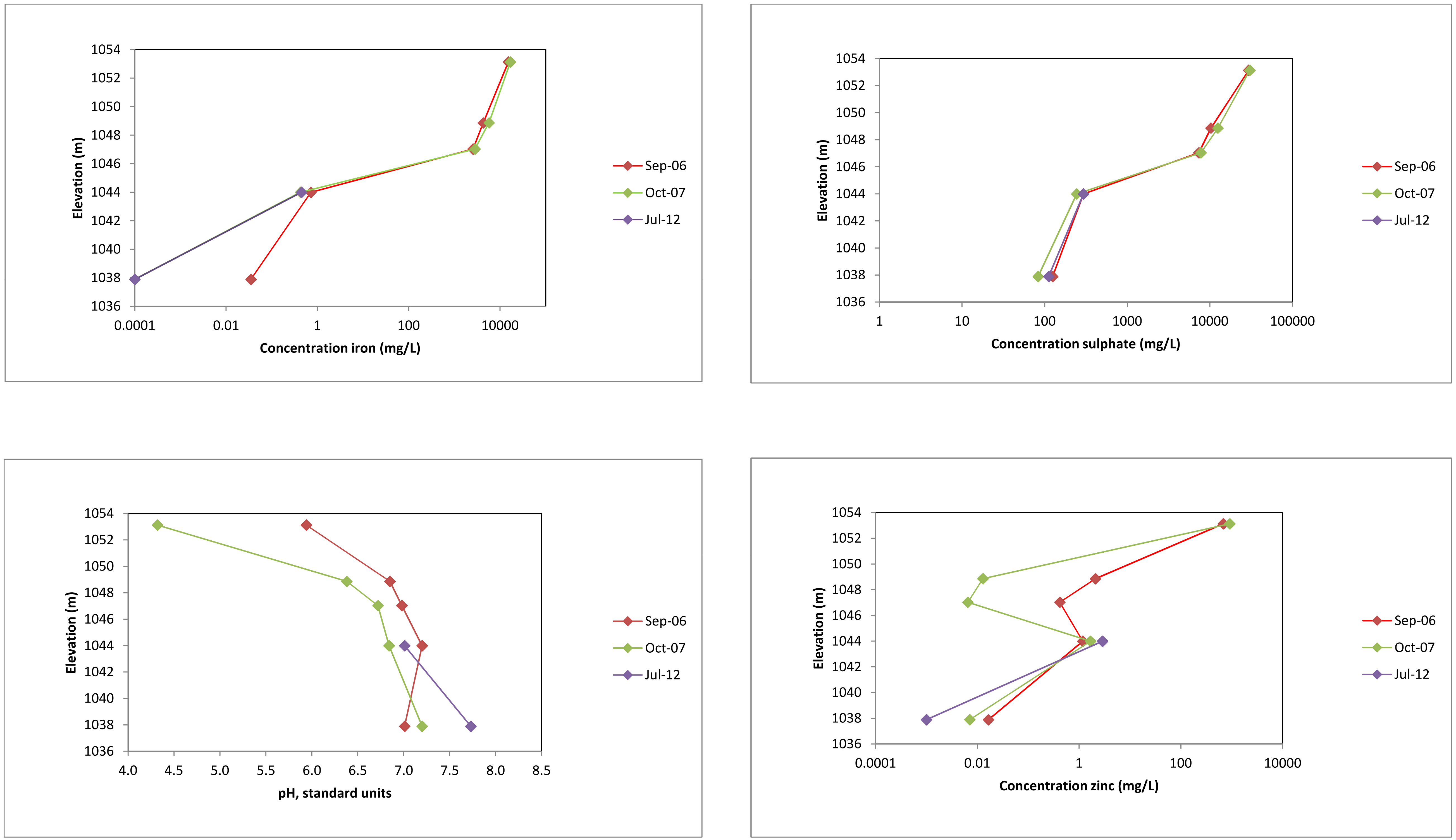


FIGURE 6b

Vertical Profiles of RCTA Groundwater Sampling, P03-02

Faro Mine Remediation Project

CH2MHILL.

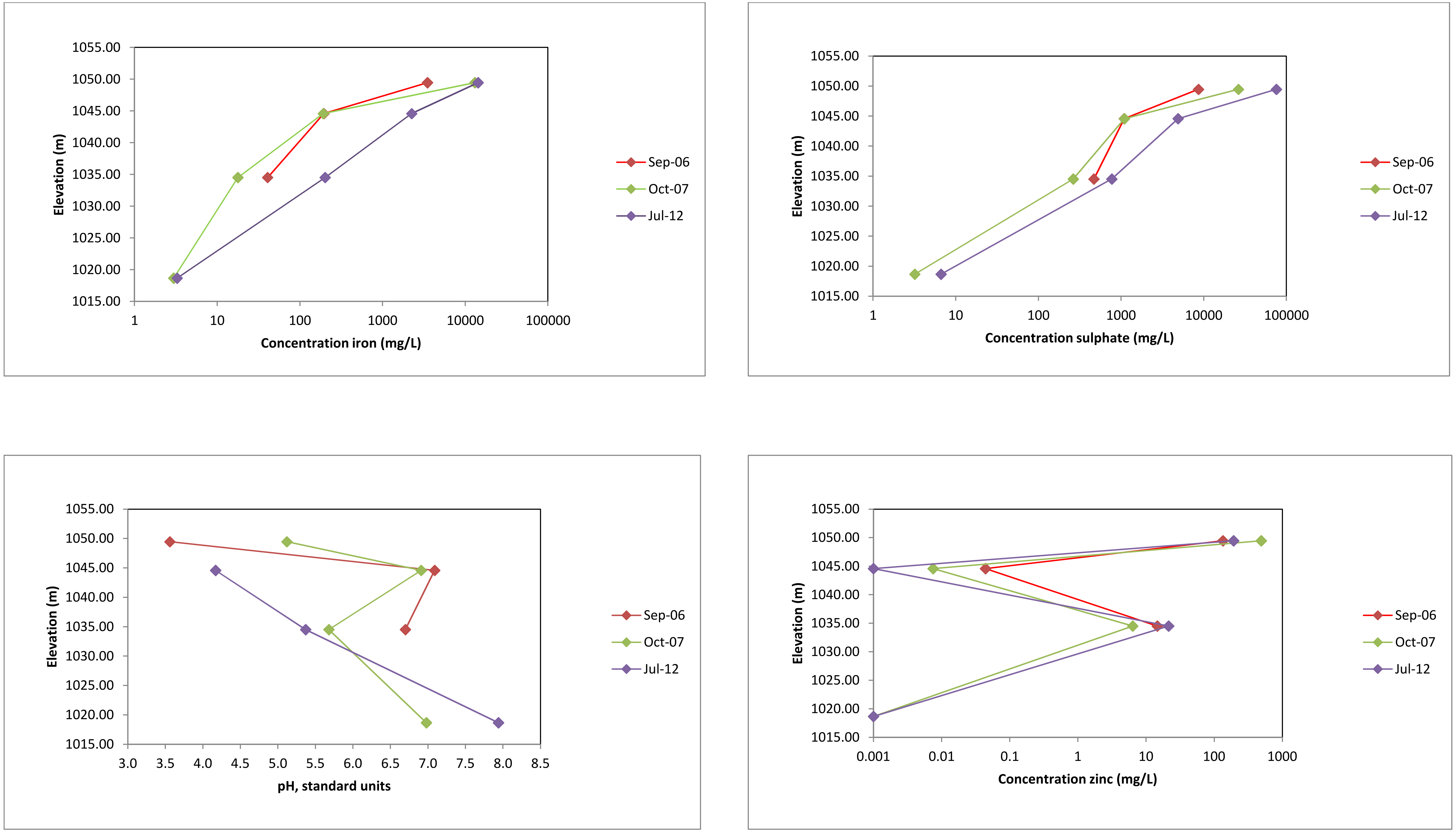


FIGURE 6c

Vertical Profiles of RCTA Groundwater Sampling, P03-03

Faro Mine Remediation Project

CH2MHILL.

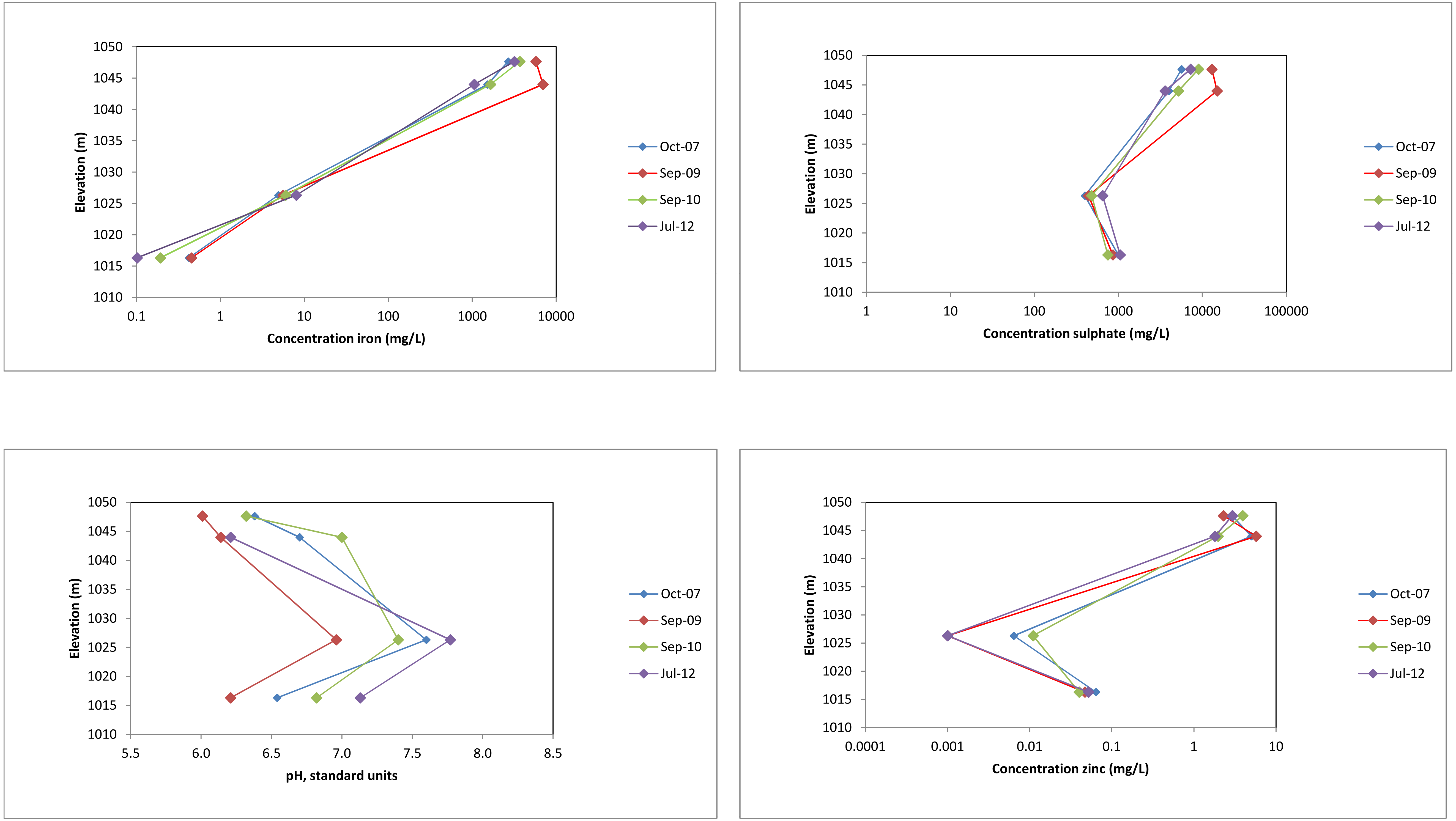


FIGURE 6d

Vertical Profiles of RCTA Groundwater Sampling, P03-04

Faro Mine Remediation Project

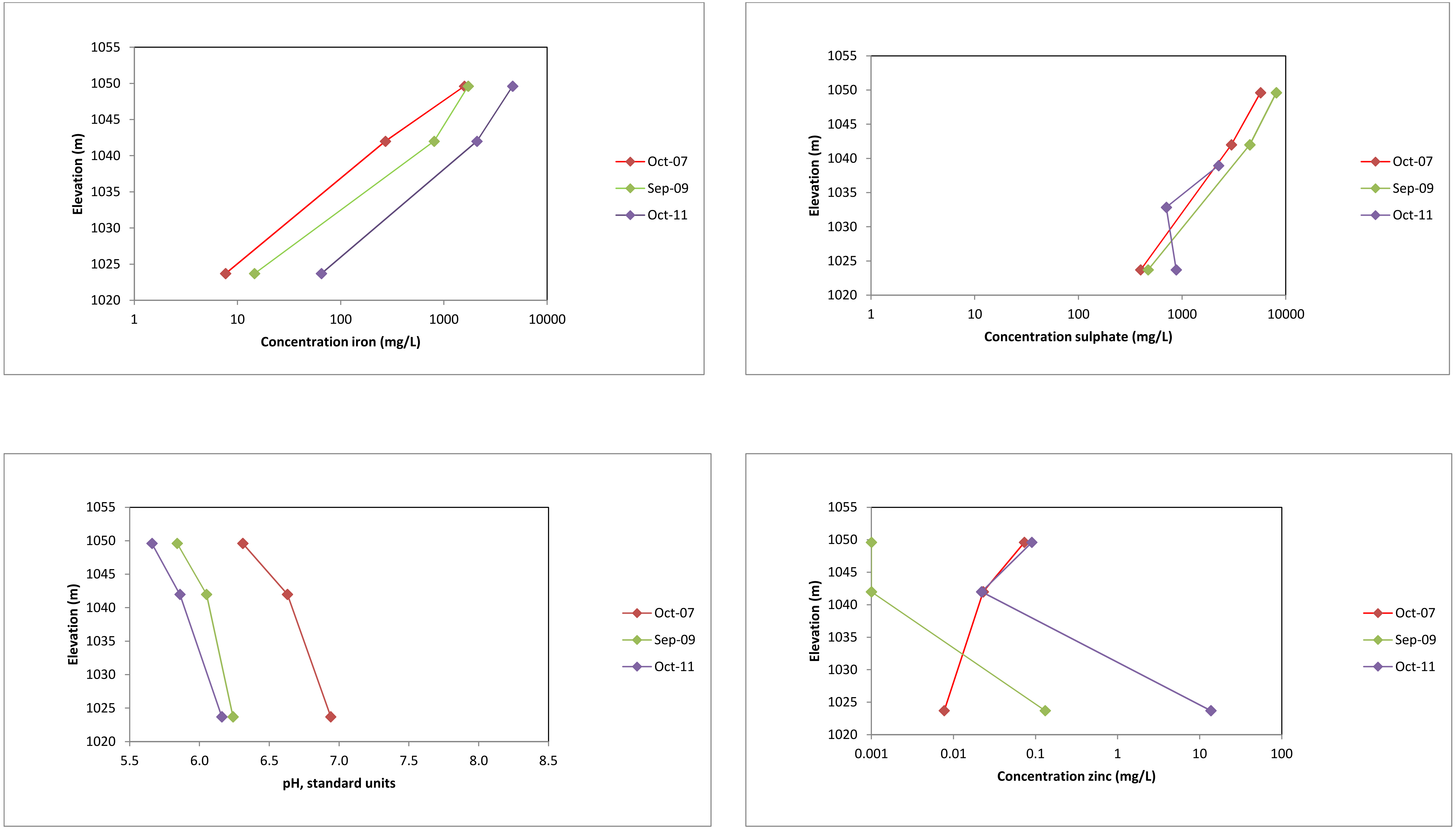


FIGURE 6e

Vertical Profiles of RCTA Groundwater Sampling, P03-05

Faro Mine Remediation Project

CH2MHILL.

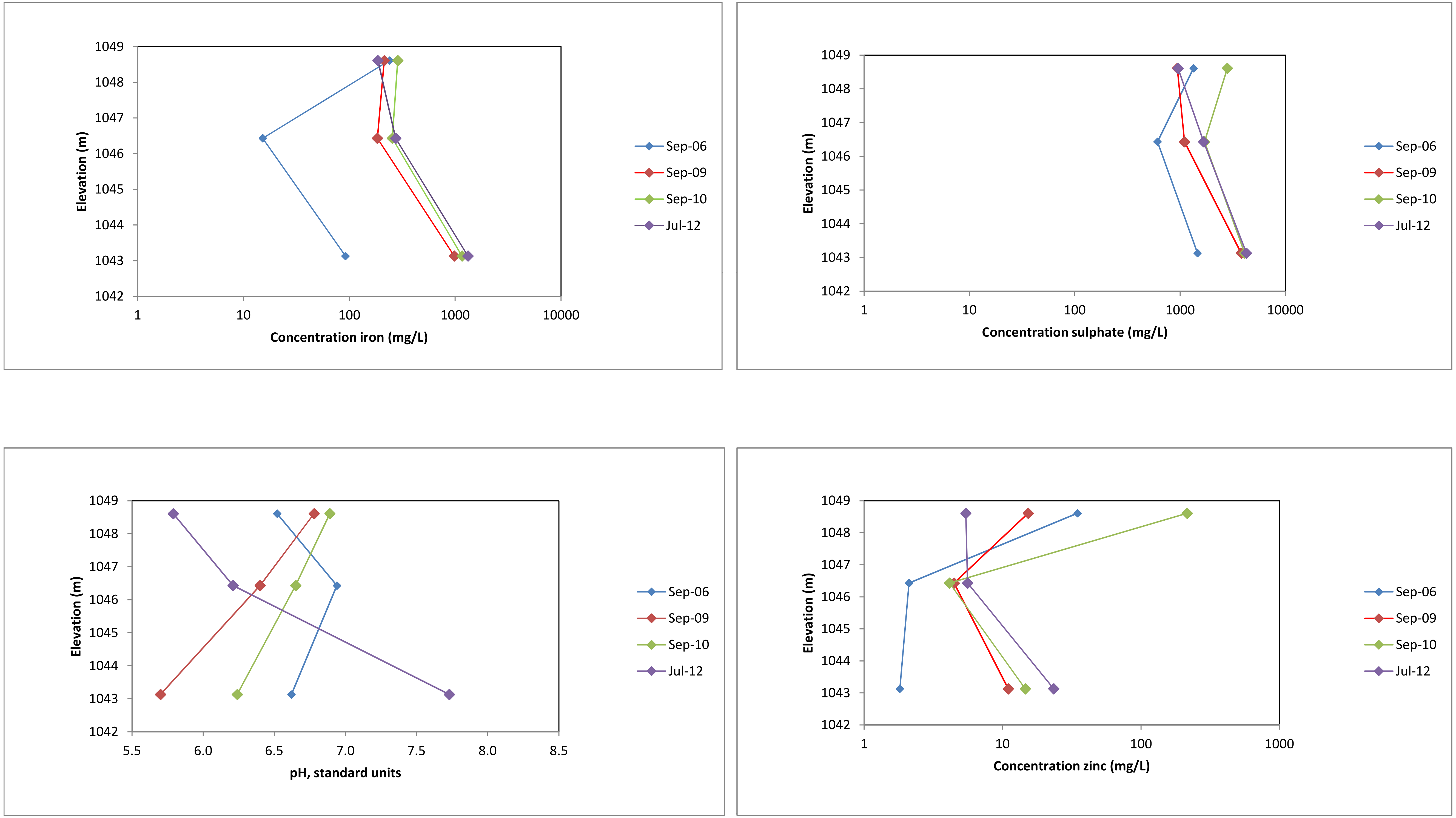


FIGURE 6f

Vertical Profiles of RCTA Groundwater Sampling, P03-06

Faro Mine Remediation Project

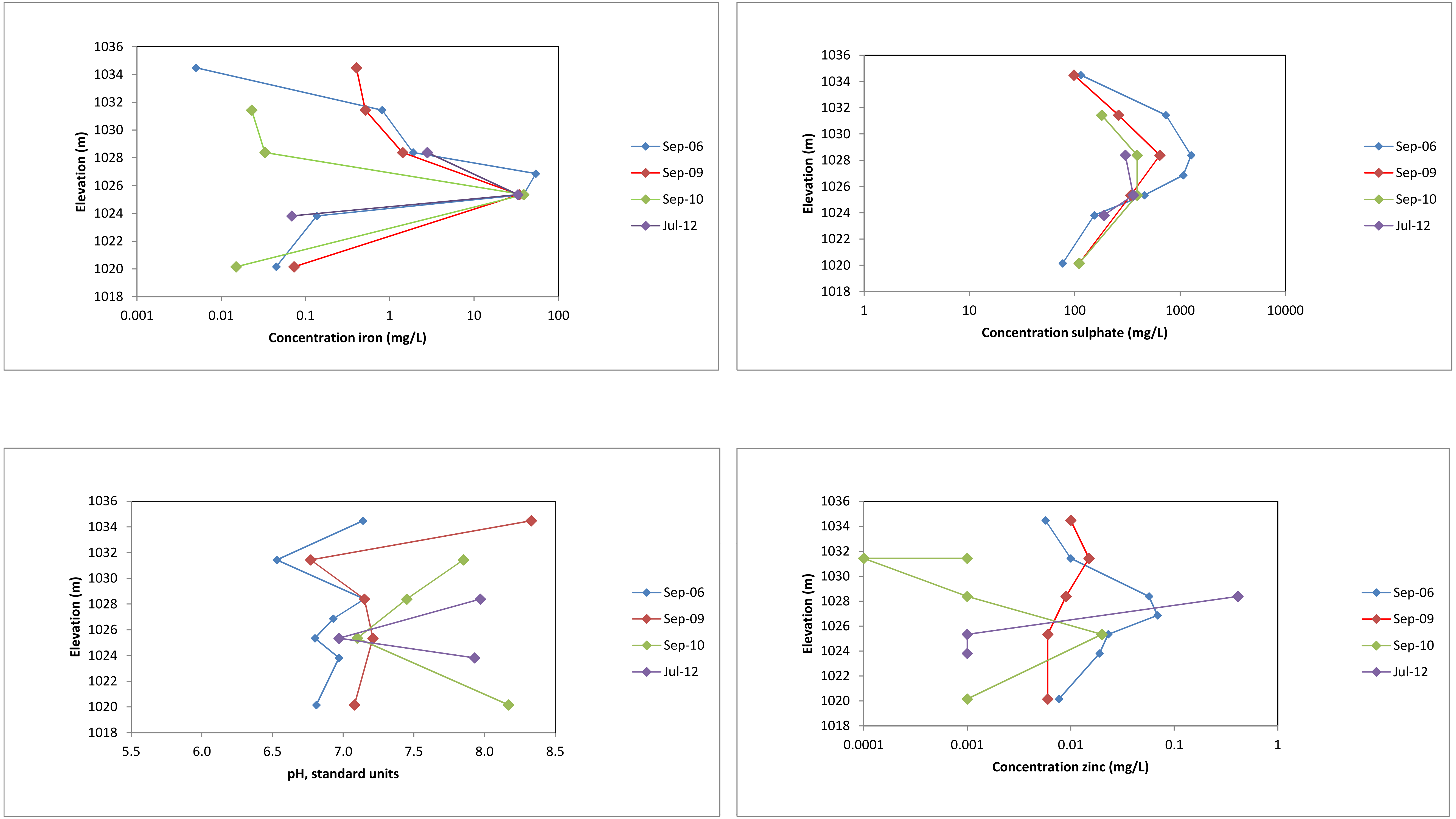
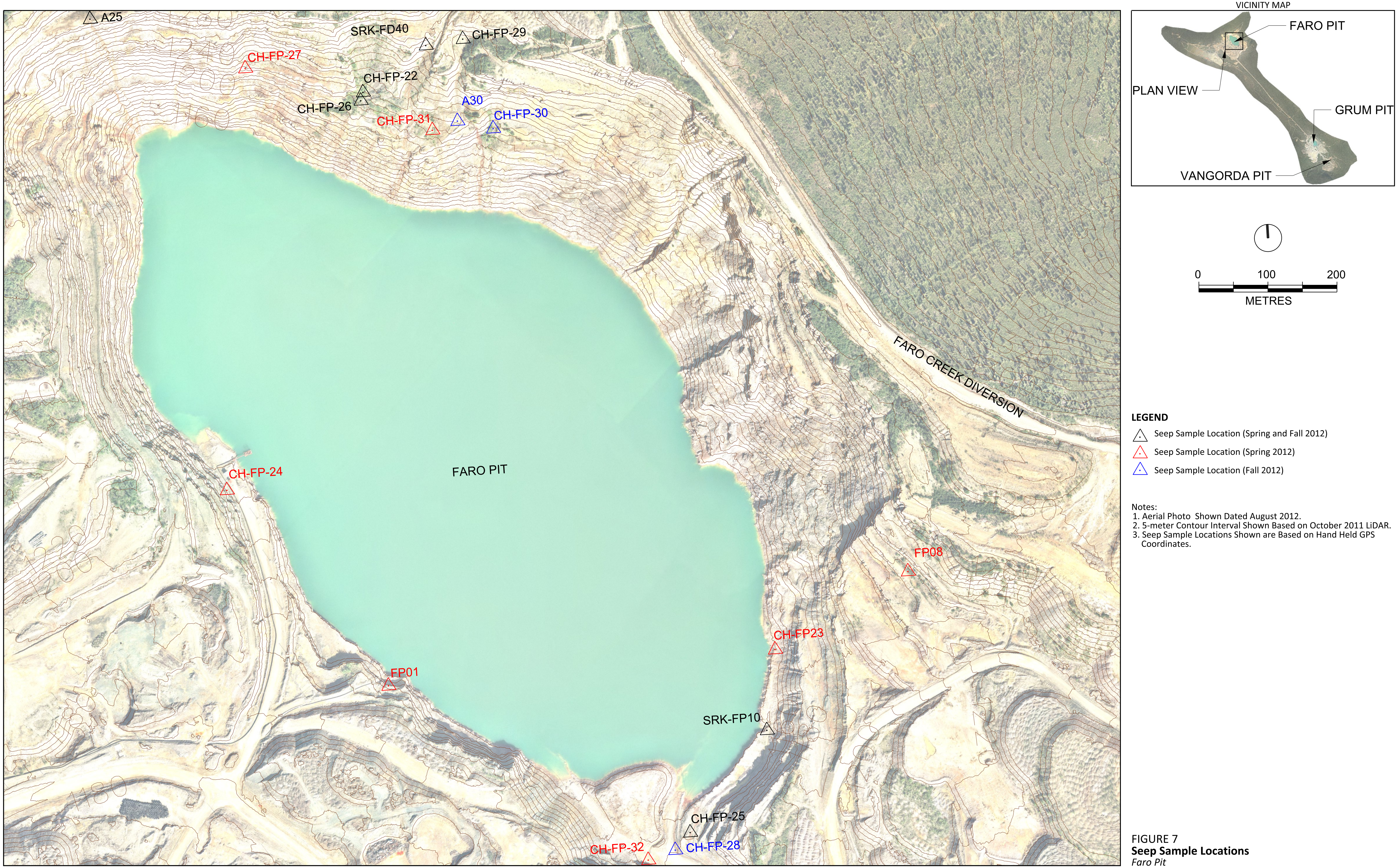


FIGURE 6g

Vertical Profiles of RCTA Groundwater Sampling, P03-08

Faro Mine Remediation Project

CH2MHILL.



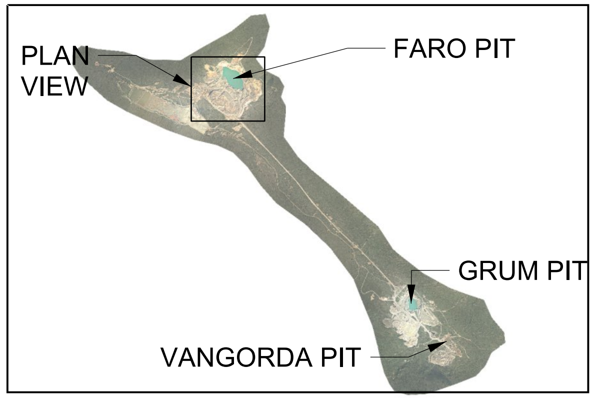
LEGEND

- △ Seep Sample Location (Spring and Fall 2012)
- △ Seep Sample Location (Spring 2012)
- △ Seep Sample Location (Fall 2012)

Notes:
1. Aerial Photo Shown Dated August 2012.
2. 5-meter Contour Interval Shown Based on October 2011 LiDAR.
3. Seep Sample Locations Shown are Based on Hand Held GPS Coordinates.

FIGURE 7
Seep Sample Locations
Faro Pit

VICINITY MAP



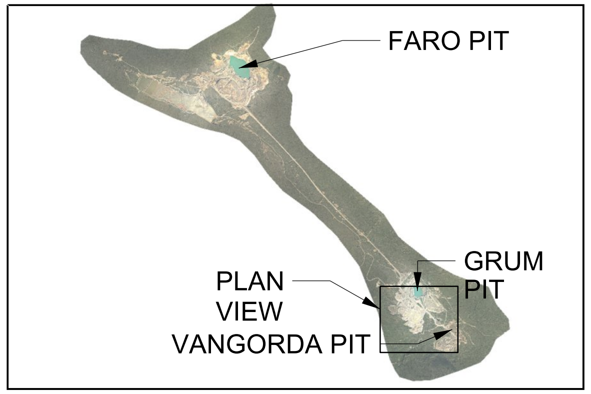
LEGEND

△	Seep Sample Location (Spring and Fall 2012)
△	Seep Sample Location (Spring 2012)
△	Seep Sample Location (Fall 2012)

Notes:
1. Aerial Photo Shown Dated August 2012.
2. 5-meter Contour Interval Shown Based on October 2011 LiDAR.
3. Seep Sample Locations Shown are Based on Hand Held GPS Coordinates.

FIGURE 8
Seep Sample
Faro Mine Waste Rock Dumps

VICINITY MAP



LEGEND

△ Seep Sample Location (Spring and Fall 2012)

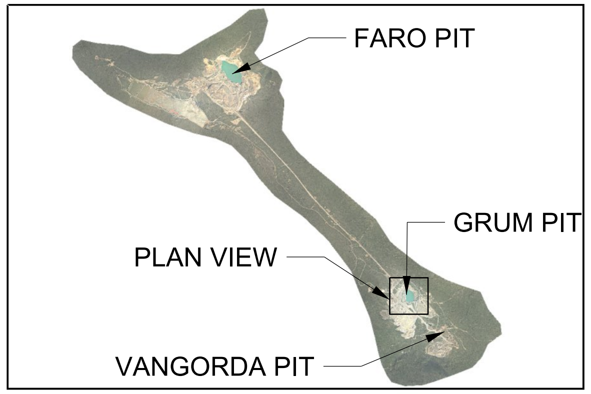
△ Seep Sample Location (Spring 2012)

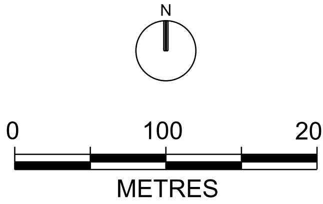
△ Seep Sample Location (Fall 2012)

Notes:
1. Aerial Photo Shown Dated August 2012.
2. 5-meter Contour Interval Shown Based on October 2011 LiDAR.
3. Seep Sample Locations Shown are Based on Hand Held GPS Coordinates.

FIGURE 9
Seep Sample Locations
Vangorda/Grum Waste Rock Dumps

VICINITY MAP





LEGEND

- △ Seep Sample Location (Spring and Fall 2012)
- △ Seep Sample Location (Spring 2012)
- △ Seep Sample Location (Fall 2012)

Notes:
1. Aerial Photo Shown Dated August 2012.
2. 5-meter Contour Interval Shown Based on October 2011 LiDAR.
3. Seep Sample Locations Shown are Based on Hand Held GPS Coordinates.

FIGURE 10
Seep Sample Locations
Grum Pit

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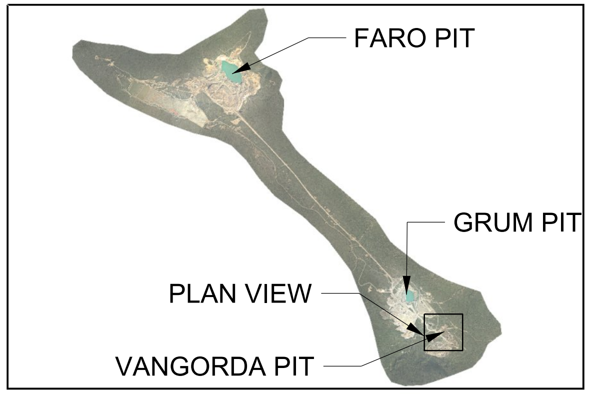
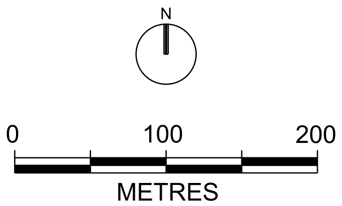
VICINITY MAP





LEGEND

- △ Seep Sample Location (Spring 2012)
- △ Seep Sample Location (Fall 2012)

Notes:
1. Aerial Photo Shown Dated August 2012.
2. 5-meter Contour Interval Shown Based on October 2011 LiDAR.
3. Seep Sample Locations Shown are Based on Hand Held GPS Coordinates.

FIGURE 11
Seep Sample Locations
Vangorda Pit

CH2MHILL.

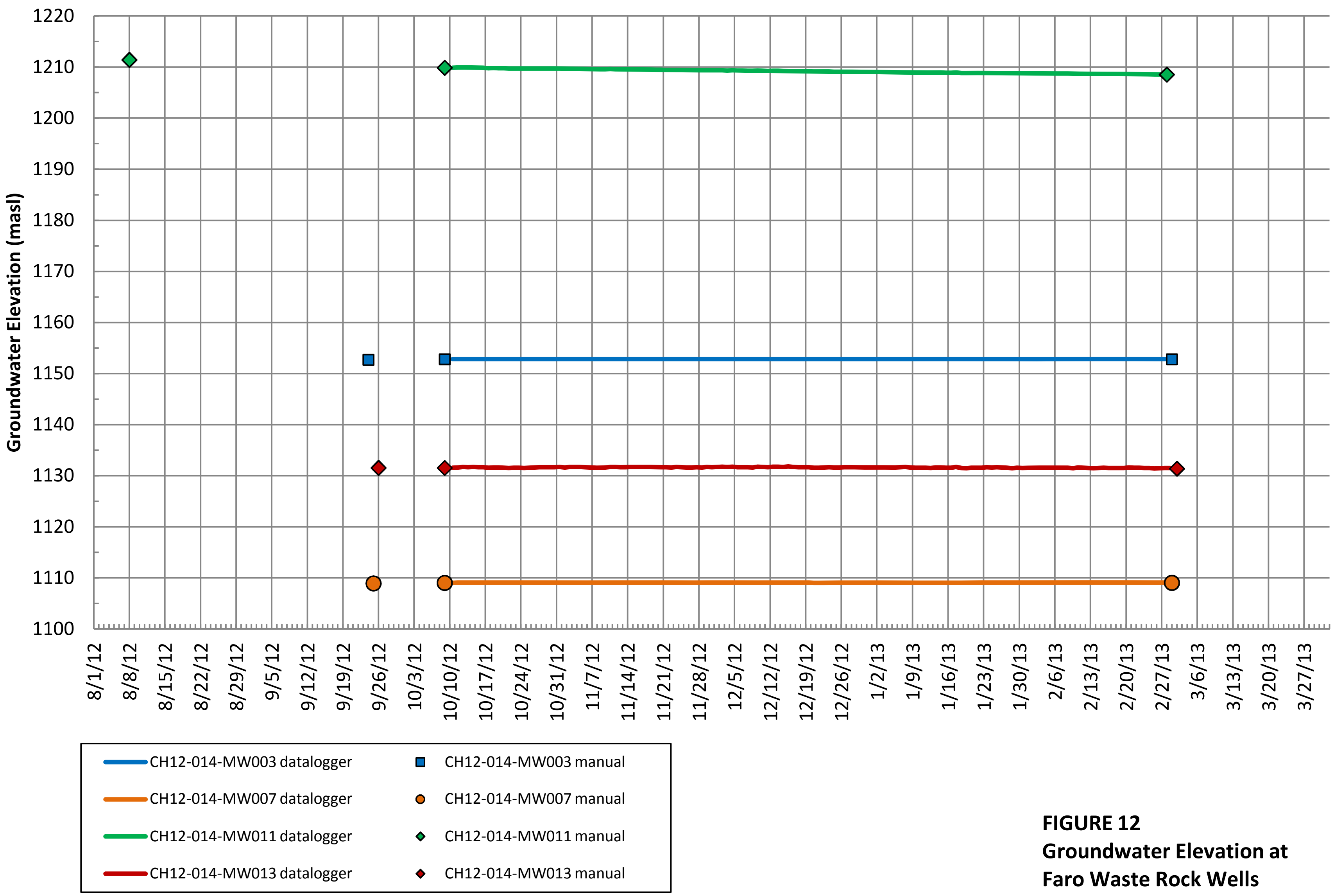


FIGURE 12
Groundwater Elevation at Faro Waste Rock Wells

Faro Mine Remediation Project

CH2MHILL

VICINITY MAP

LEGEND

△ Weirs

● Pumping Well

DataType

⊕ Hand

◐ Transducer

Roads Unpaved

Stream

Lake, Pond, or Pool

Notes:

1. Aerial photography acquired by Peregrine Aerial Surveyors Inc. and Eagle Mapping in August 2012.
2. Orthophotography prepared by Critigen Canada Corp.
3. Yellow label indicates well was used in model.

N

0 50 100 150 200

Metres

Created by:
CRITIGEN

FIGURE 13

Aquifer Test Well Locations

Faro Mine Remediation Project

UNK R:\FAROMINE_20000342\MAPFILES\WATERMODELANALYSISRPT\FIGB-01.MXD ECLARK 3/1/2013 11:33:48 AM

CH2MHILL.

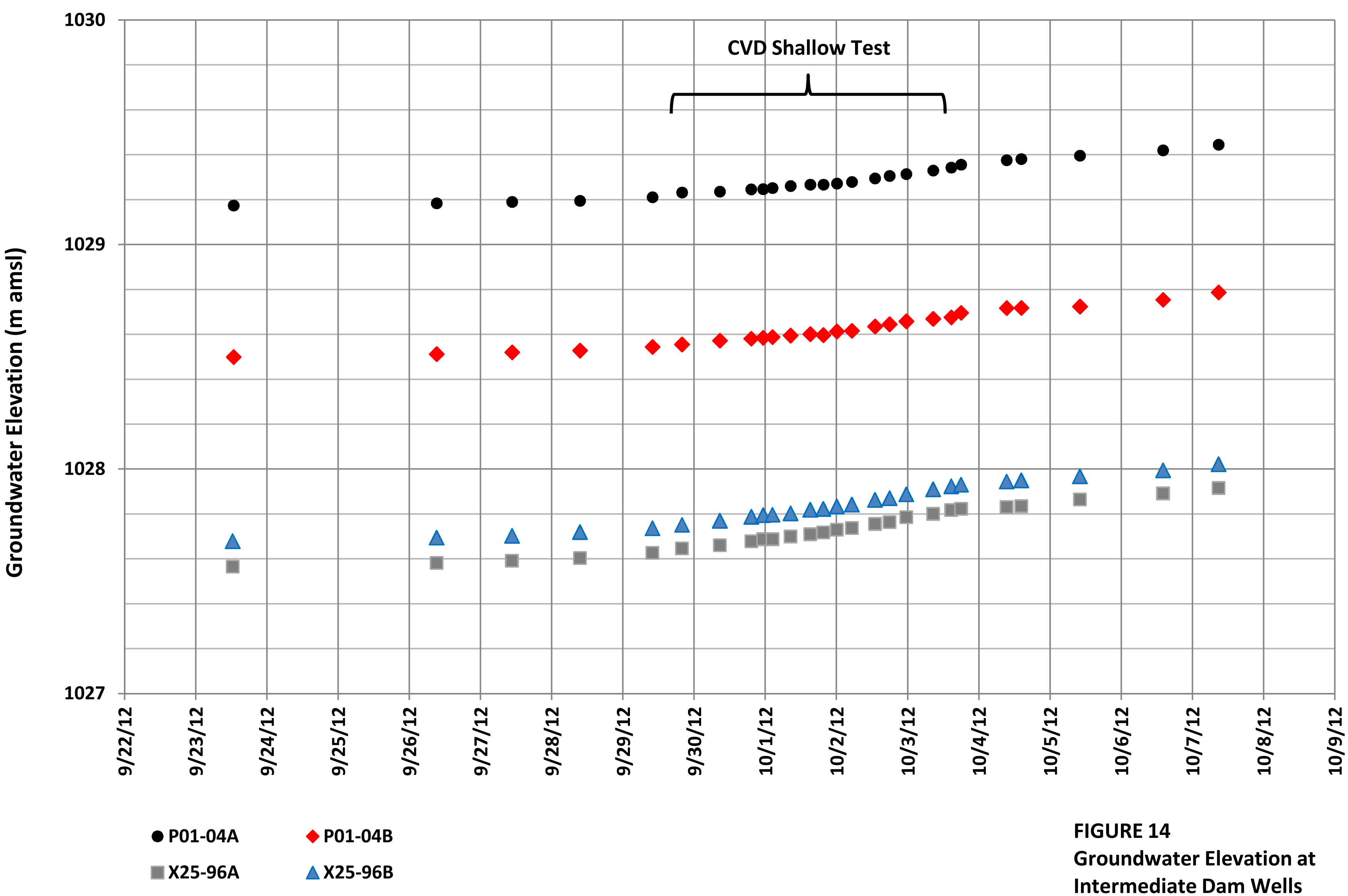


FIGURE 14
Groundwater Elevation at
Intermediate Dam Wells
Faro Mine Remediation Project
CH2MHILL

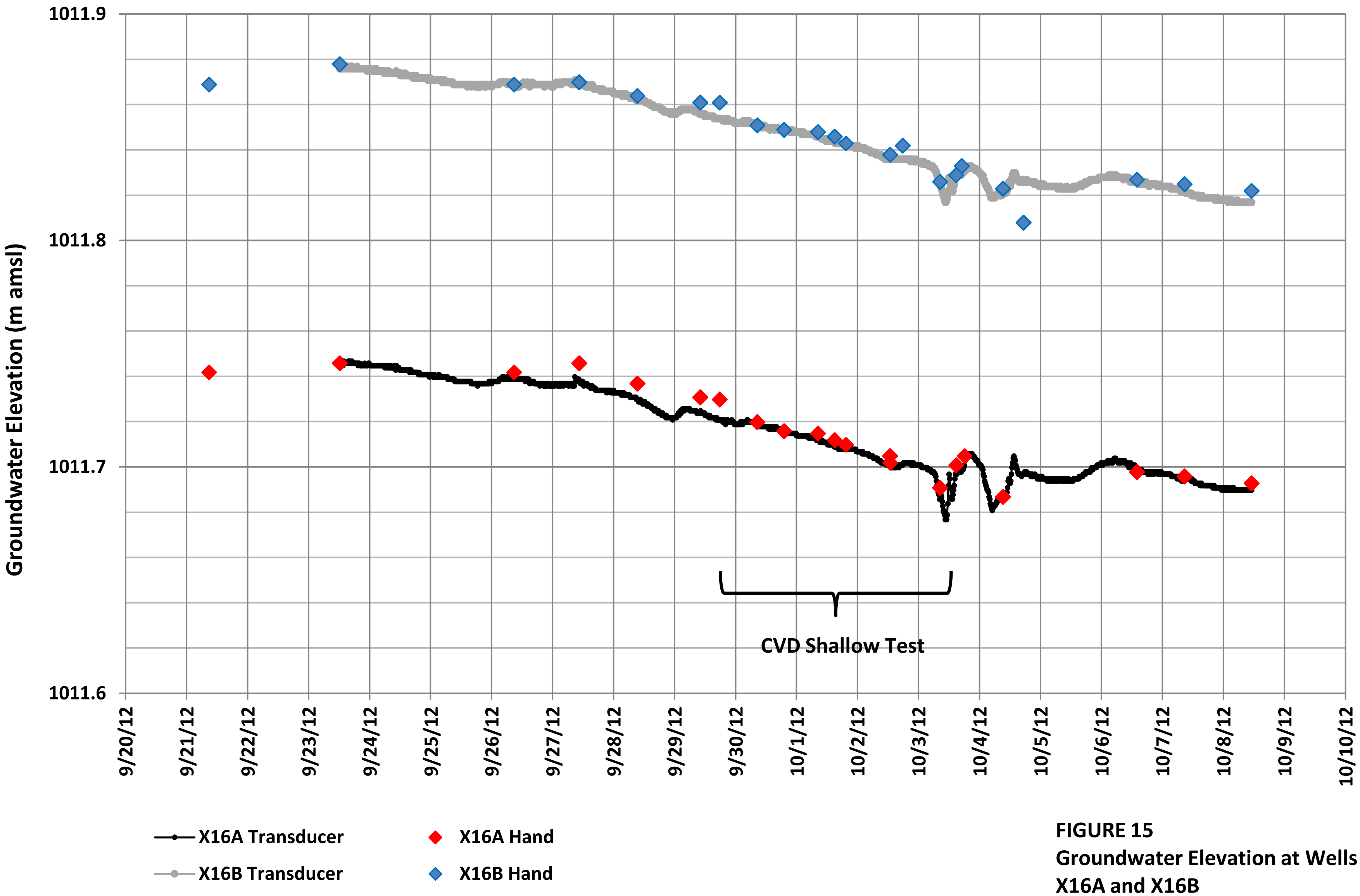


FIGURE 15
Groundwater Elevation at Wells X16A and X16B
Faro Mine Remediation Project

CH2MHILL

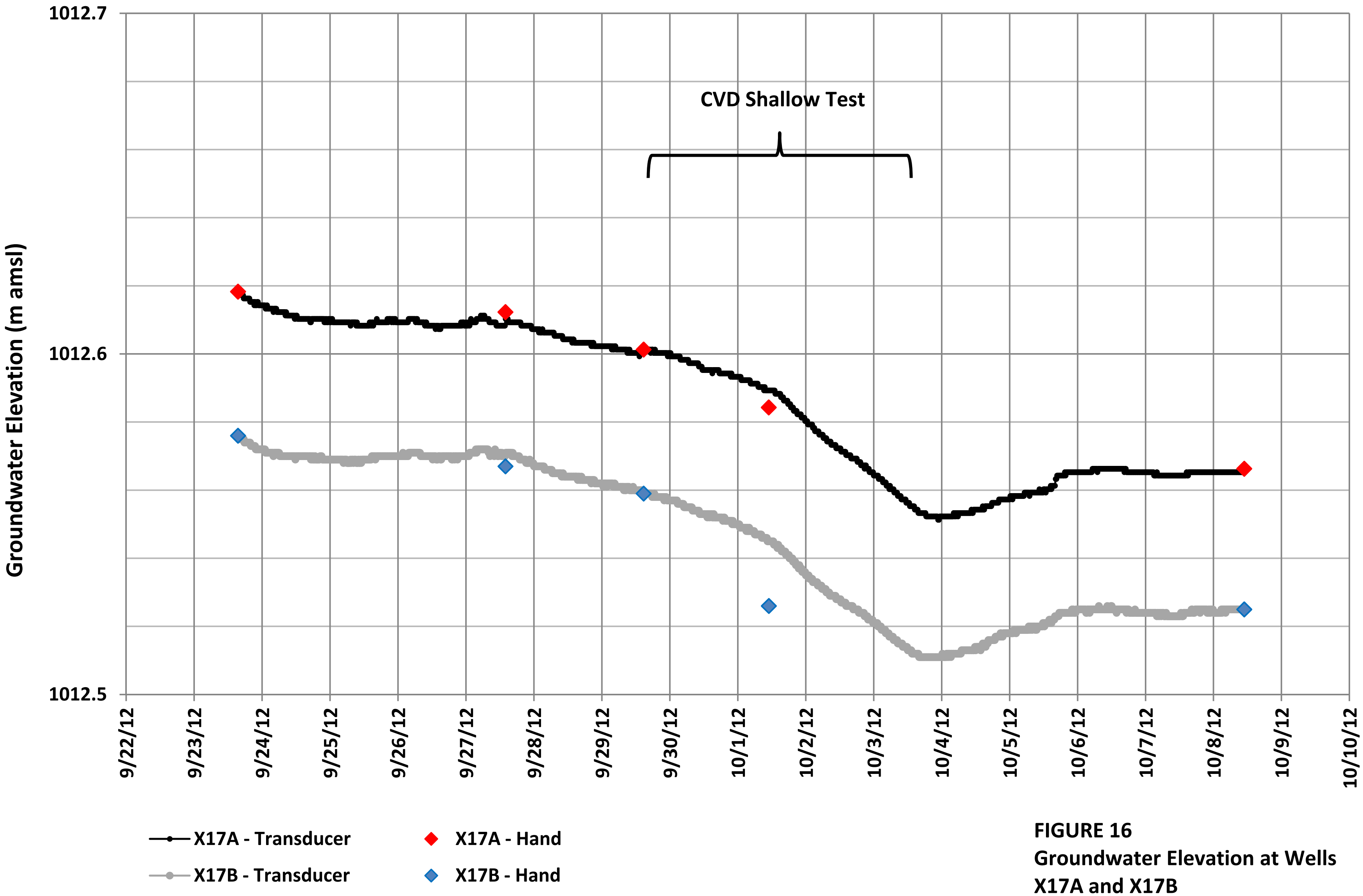


FIGURE 16
Groundwater Elevation at Wells X17A and X17B

Faro Mine Remediation Project

CH2MHILL

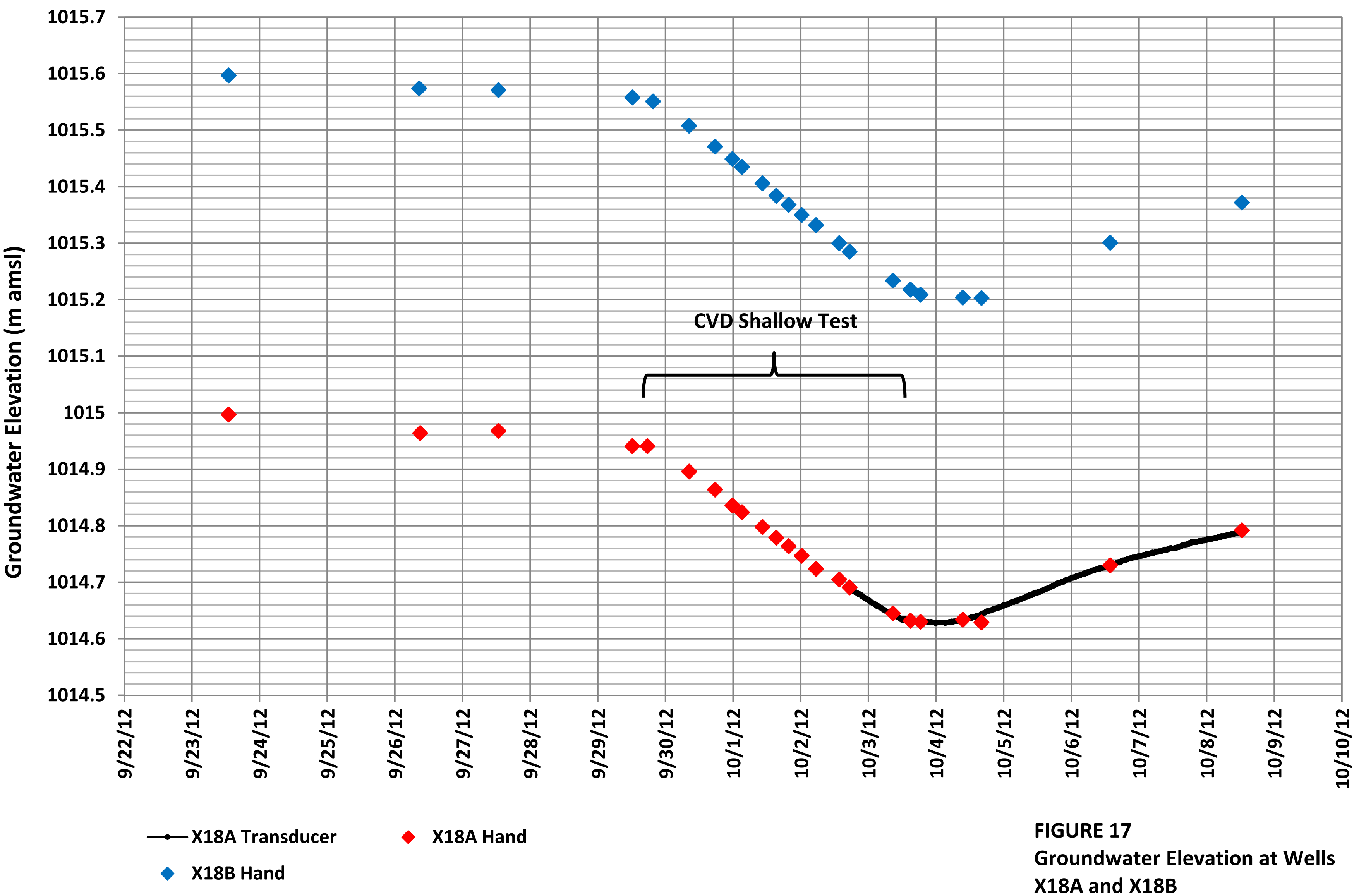


FIGURE 17
Groundwater Elevation at Wells X18A and X18B
Faro Mine Remediation Project

CH2MHILL

VICINITY MAP

LEGEND

- 🔺 Streambed Piezometers -Upward VHG
- 🔺 Streambed Piezometers - Downward VHG
- 🟨 Surface Water Monitoring Stations

Notes:
1. Locations of CH12-204-SP04C, CH12-204-SP10 and CH12-204-SP11 are approximate.
2. VHG = Vertical Hydraulic Gradient.
3. Downward VHG indicates losing stream conditions, upward VHG indicates gaining stream conditions.

0 50 100
Metres

N

FIGURE 18
Streambed Piezometer Locations
and Direction of Vertical Hydraulic Gradient,
Fall 2012
Faro Mine Remediation Project

CH2MHILL.

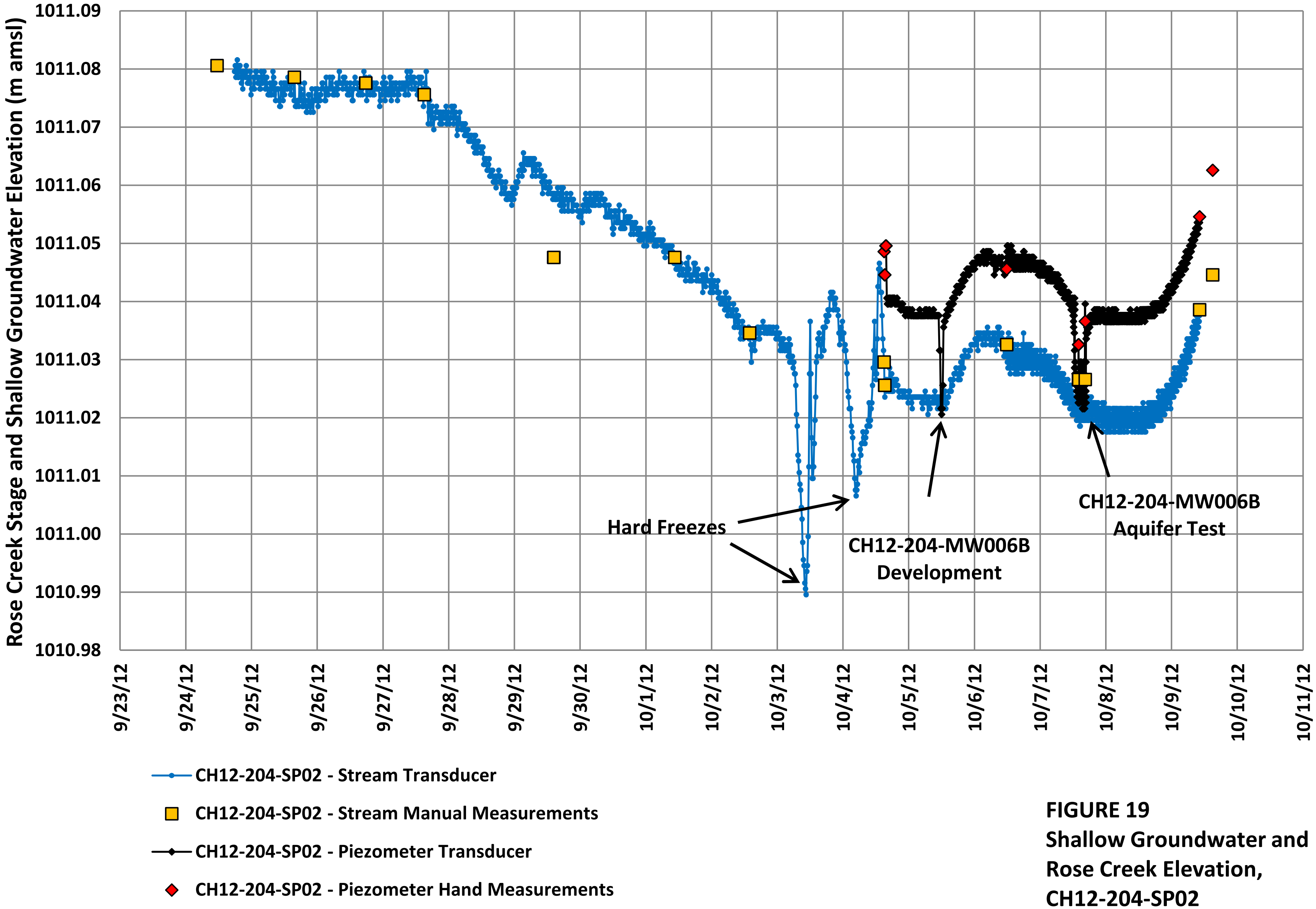


FIGURE 19
Shallow Groundwater and Rose Creek Elevation, CH12-204-SP02
Faro Mine Remediation Project

CH2MHILL

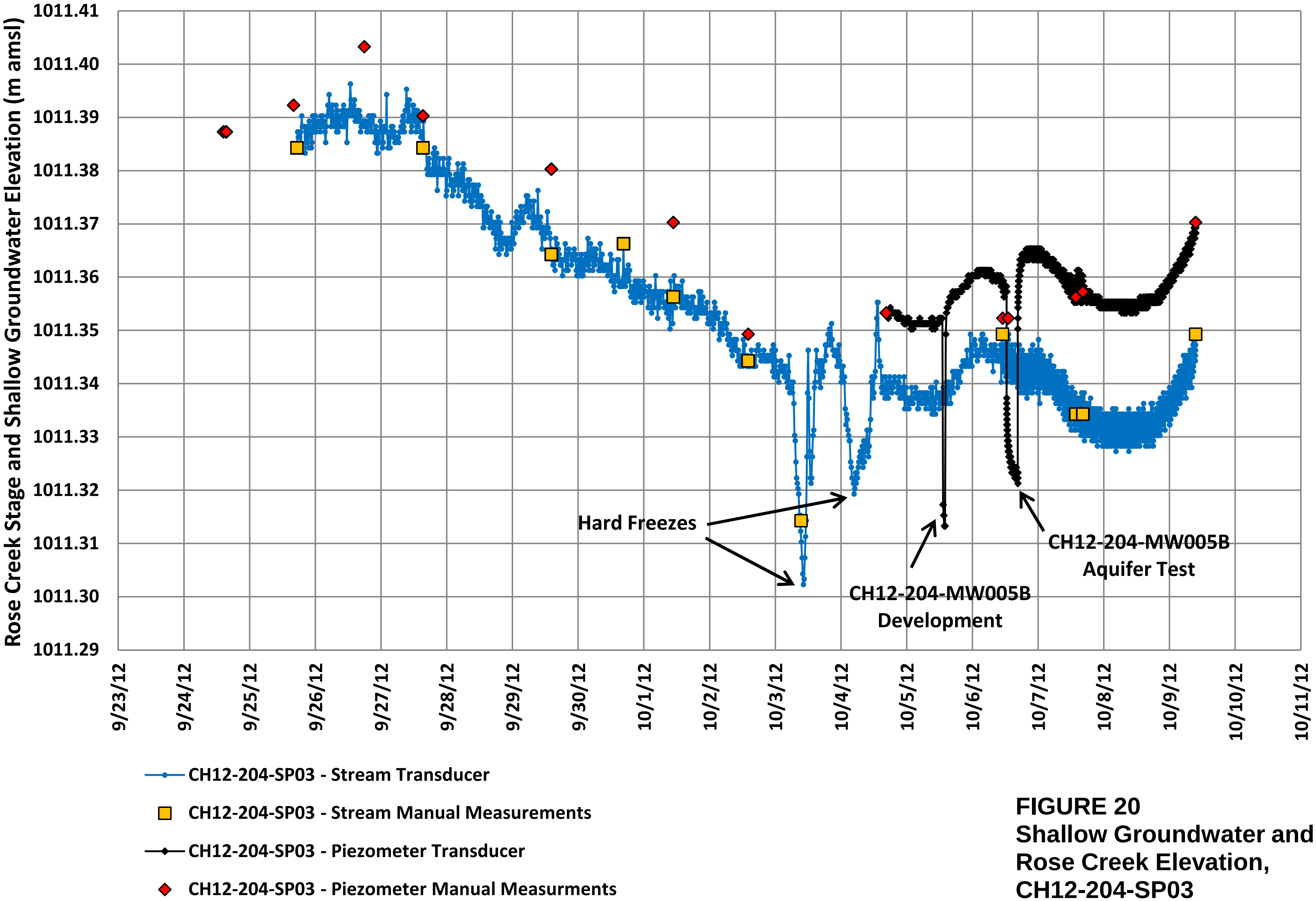


FIGURE 20
Shallow Groundwater and Rose Creek Elevation, CH12-204-SP03

Faro Mine Remediation Project

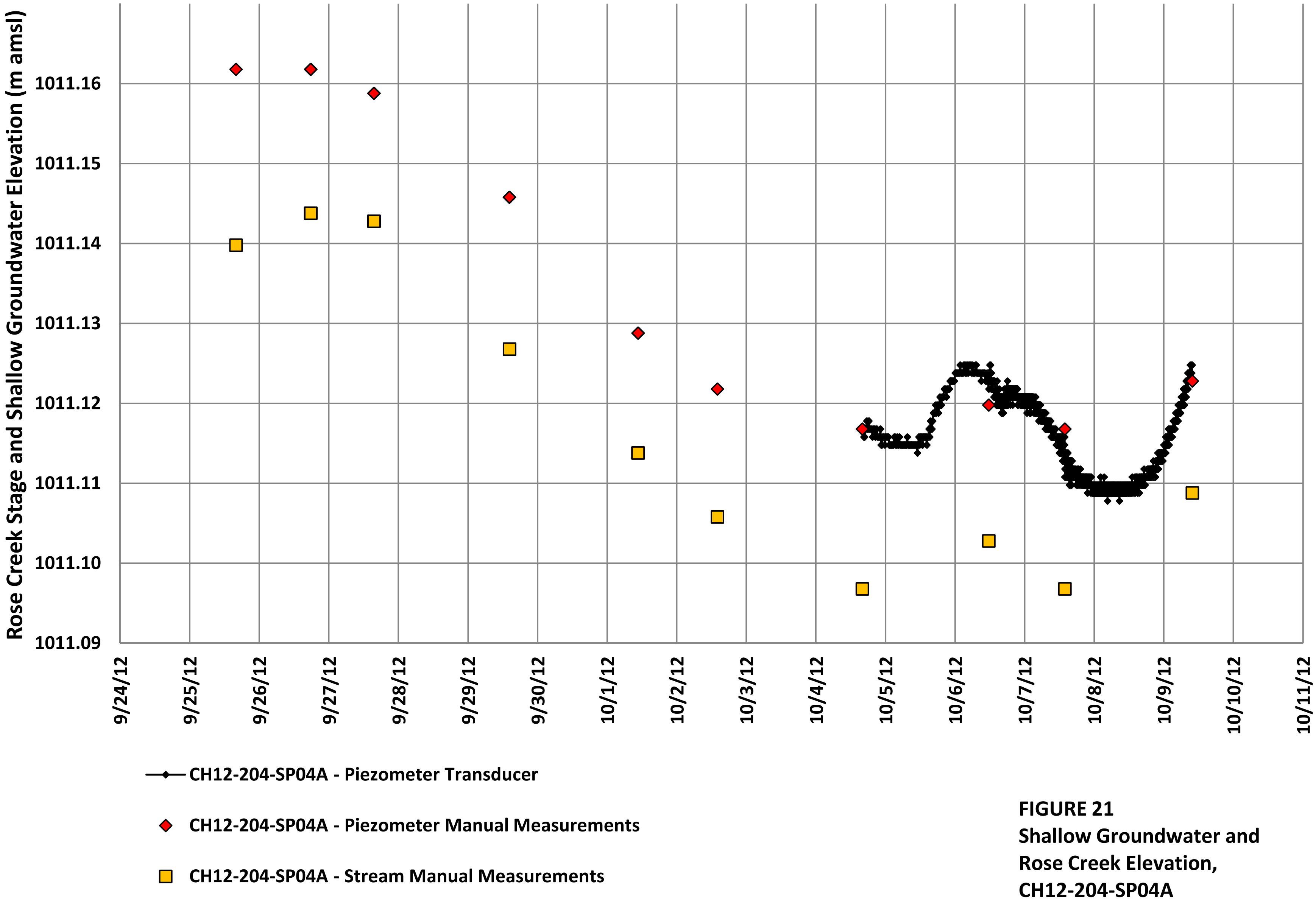


FIGURE 21
Shallow Groundwater and Rose Creek Elevation, CH12-204-SP04A

Faro Mine Remediation Project

CH2MHILL

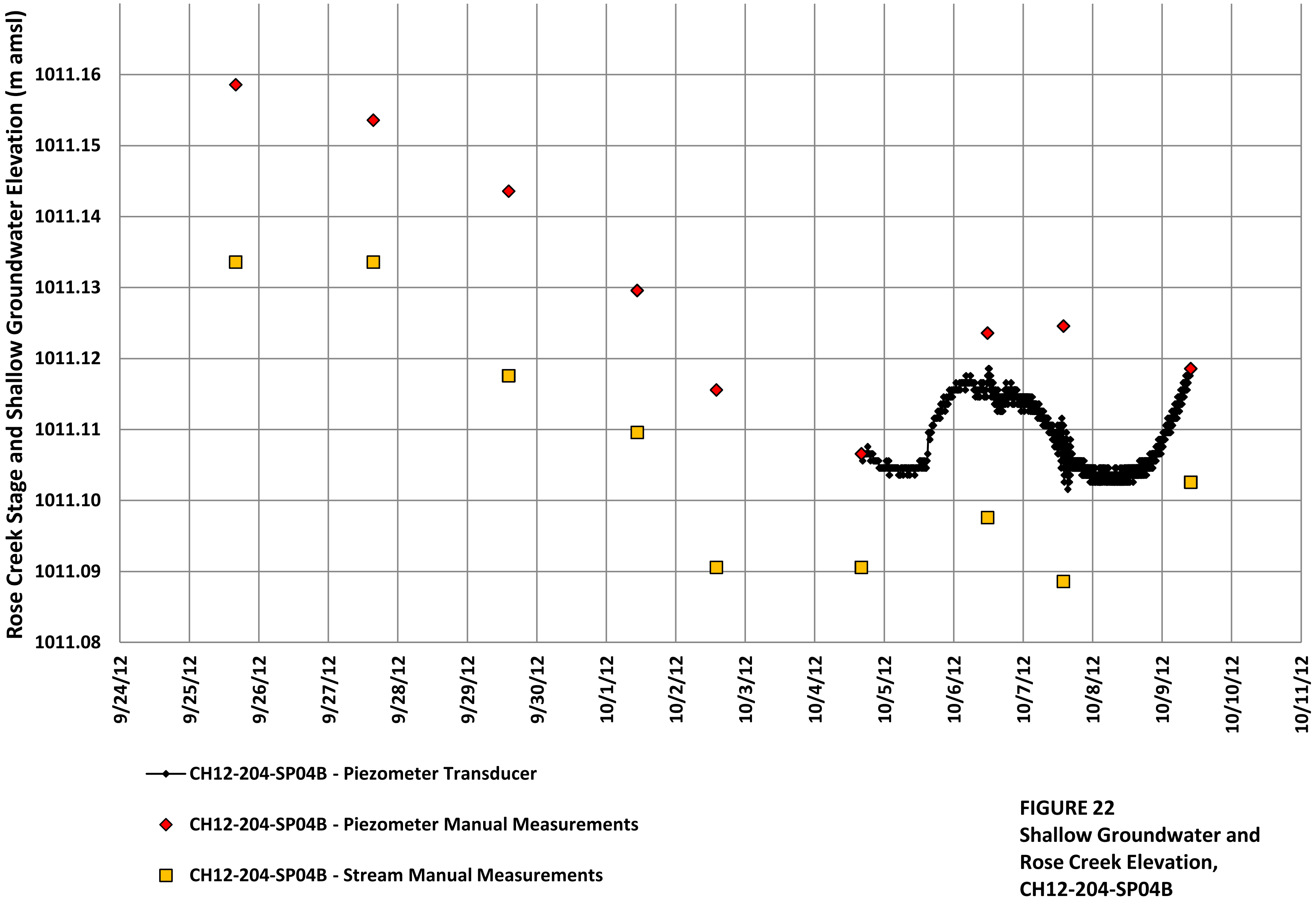


FIGURE 22
Shallow Groundwater and
Rose Creek Elevation,
CH12-204-SP04B

Faro Mine Remediation Project

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