Review of Pit and Pond Water Elevations Faro Mine Remediation Project

PREPARED FOR: Government of Yukon

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Overview

This technical memorandum (TM) is in response to Task Authorization Component (TAC) 009-N, Water Elevations and Peak Flows, and addresses the following objectives of TAC 009-N:

- Review the water elevations for each onsite storage reservoir or pit (e.g., Cross Valley Pond [CVP], Intermediate Dam Pond [ID pond], Faro Pit, Zone II Pit, Vangorda Pit, Grum Pit, and Little Creek Dam Pond).
- Provide recommendations regarding revised target elevations for the end of the 2013 operating season.
- Provide an updated table of target water elevations and document recommended water management changes, including the rationale for the changes.

Current Water Management

In 2012, CH2M HILL reviewed and provided updated recommendations pertaining to the 2011 Freshet Water Management Plan (WMP) (Brodie Consulting [Brodie], 2011). These recommendations were developed with the objective to limit water of deteriorated quality from migrating offsite, and to provide storage capacity, in case of extreme environmental conditions or unexpected delays to operations (CH2M HILL, 2012a). This draft TM provides recommendations based on current site conditions and site operations in FY 2012 and 2013.

Several important operational changes to water management at the Faro Mine Complex (FMC) between 2012 and 2013, including the following:

- The Faro Mill WTP was not operated in 2013
- A temporary mobile filtration system was installed and operated at the CVP
- A conveyance system was constructed to transfer water between the ID Pond and the Faro Pit, as well as between the ETA and Faro Pit (instead of conveying ETA water to the Faro Mill WTP)
- The new Zone II Pit dewatering well (CH12-Z2-PW01) began operations
- A conveyance system was constructed to transfer water from the Grum Pit to the Vangorda Pit
- The conveyance system to transfer water between Grum-V15 and the Vangorda Pit began operating

Table 1 provides target water elevations for 2013. It also describes the water management location, including the water's source and destination, the target elevation and target objective, the recommended start and end dates, contingencies, and additional comments.

The document contained herein should be considered Final as approved by the Government of Yukon on August 27, 2014 with no changes made since the draft submission

YG requested CH2M HILL provide a recommendation for 2013 end-of-season target elevations, given the following unique site conditions as of September 2013:

- The Faro WTP was not operated in 2013
- The Vangorda WTP shut down for the season
- Water elevations in the Grum Pit exceeded the target levels

These conditions preclude maintaining water levels below previously established elevations for the Grum and Vangorda Pits. On October 10, 2013, YG decided to stop seasonal water transfer from the Grum Pit to Vangorda Pit based on its evaluation of relative risk associated with the Grum and Vangorda Pits.

The next section of this TM describes the GoldSim model used to inform water management targets. The remaining sections describe each management location listed in Table 1.

GoldSim Water Management Tool

A simplified model was developed from our GoldSim model v2 (CH2M HILL, 2013). The model simulates the Faro, Vangorda, and Grum Pits, as well as the CVP and ID Pond, and existing connections between these storage reservoirs along with loading from collection systems (e.g., the Emergency Tailings Area [ETA], S-wells, Zone II, and Grum-V15). The simplified model uses total monthly inflows to the storage reservoirs, plus flows from these collection systems, as boundary conditions. Inflow values were the average of a stochastic run from the GoldSim model v2, using annual precipitation data from 1978 to 2011. The model considered stochastic variability based on the historical precipitation change from average, and its output was compared with a water balance spreadsheet model to facilitate calibration.

The GoldSim model was set to run for 1 year (from September 9, 2013 until September 9, 2014) on daily time steps, and included 250 stochastic realizations. September 9, 2013, was selected as the initial date because the most recent available water level are from September 9 to September 12 (Table 2). The 250 stochastic realizations allow a range of flows to be evaluated and therefore assess potential wet, dry, and average year conditions.

Table 2 provides initial conditions and assumptions regarding storage volumes and elevations. Table 3 provides the scenarios considered to support end-of-season target water elevations. In Table 3, blue-highlighted cells with bold text indicate value(s) that changed in the scenario.

Scenario 1 provides the base case, which assumes water from Faro Pit is not treated in 2013. Although interim water treatment is planned for 2014, the simulations did not include this treatment capacity because it is not critical to developing 2013 target elevations. It assumes discharge from the CVP occurs at 13,100 cubic metres per day (m3/day) (2,400 US gallons per minute [USgpm]) via the filtration trailers and allows 14,400 m3/day (2,600 USgpm) by-pass (siphon) release until September 30, 2013. The average historical CVP elevations are used to estimate winter pond releases.

The ID Pond is dewatered at a rate of 9,800 m3/day (1,800 USgpm), which is assumed to continue until September 30, 2013. The Vangorda WTP has ceased operations for 2013; we have assumed it will start up on May 1, 2014, at 10,900 m3/day (2,000 USgpm). The scenario also assumes Grum Pit dewatering has stopped for 2013 and that when it begins again in May 2014, it will do so at 9,300 m3/day (1,700 USgpm). Grum-V15 transfers to Vangorda Pit are also assumed to have stopped in August. This scenario is the base case because it relies on the least amount of active water management intervention.

The simulated scenarios adjust individual areas of the model, one at time, to evaluate the effect different water management scenarios would have. Scenarios 2 and 3 adjust CVP water management to evaluate the effect on CVP water levels and potential winter release volumes. Scenario 2 allows the CVP water elevation to rise to the lower spillway elevation without considering winter releases, which would need to take place before the water elevation reached the lower spillway. Scenario 3 reduces the total discharge from the CVP in September to evaluate how much more winter release will be required if the CVP does not reach the target elevation by September 30. For this scenario, the assumed discharge rate from the CVP was 6,500 m^3/day (1,200 USgpm), which would correspond to the filtration capacity if one of the two mobile filtration trailers was operational and there was no siphon release. Scenario 4 evaluates continued dewatering of the ID Pond through October. This scenario helps assess whether the target elevation can be reached, and predicts the effect this additional water will have on the Faro Pit.

Scenarios 5 and 6 assess the effect continued Grum Pit dewatering would have on Grum and Vangorda Pit water levels. Scenario 5 continues pumping the Grum Pit water to the Vangorda Pit for another 20 days beginning in mid-September and Scenario 6 continues the pumping for 25 days beginning in mid-September. Scenario 7 assesses the effect of delayed Vangorda WTP operation on Vangorda Pit water levels if WTP start-up is delayed from May to June, 2014.

Figures 1 through 8 provide the scenario results, including the minimum, mean, and maximum result from the stochastic runs.

Water Management Locations

Faro Water Treatment Plant

The Faro WTP is not operational and did not operate in 2013. During the 2013 treatment season, water from the ID Pond and ETA has instead been conveyed to the Faro Pit, raising its water level.

An interim WTP is planned for operation in 2014. Interim treatment should be implemented as soon as possible, at a high enough rate to control and reduce Faro Pit water levels and the potential for increased seepage towards the Zone II Pit, the ETA, or both.

Cross Valley Pond

The CVP is part of the active water management program at the FMC. Although the Faro WTP did not discharge treated water to the CVP in 2013, the CVP still requires active management to remove water from inputs such as rainfall and seepage. In previous years, water was released from the CVP via a siphon to Rose Creek at monitoring station X5. In 2013, turbidity exceeding the discharge limit (15 Nephelometric Turbidity Units [NTU]) made it necessary to use temporary mobile filtration units that could process up to 13,100 m^3/day (2,400 USgpm). These mobile treatment units did not arrive onsite until August.

The water elevation in the CVP has historically ranged between 1,026.3 and 1,030.3 metres (m) (Denison Environmental Services [Denison], 2012; Tlicho Engineering and Environmental Services Ltd. [TEES], 2013a). The crest of the CVD is 1,033.1 m, and the lower spillway is reported at 1,030.68 m (Domingue, 2013, personal communication).

The drawdown of water in the CVP has three constraints: (1) the water quality in Rose Creek, (2) the maximum rate of daily drawdown, and (3) the ability to maintain water cover over accumulated sludge beds. The volume of releasable flow is controlled to achieve acceptable water quality in Rose Creek (particularly at X14, the surface water quality monitoring station and compliance point). BGC Engineering (BGC) recommended a maximum drawdown of 100 millimetres (mm) per day because of concerns about the Intermediate Dam's geotechnical stability (BCG, 2008).
Operational experience at the FMC indicates the water elevation in the CVP should not be lowered below about 1,027.5 m. If it is, sludge beds could be exposed and sludge particulate suspended, which may impact water quality and the ability to discharge from the CVP (Parkin, 2013a, personal communication).

The GoldSim base case scenario indicates if additional capacity in the CVP is required to accommodate spring flows, winter discharge will be required (Figure 2). The base case uses average historical water elevations in the CVP to approximate the past site operations but does not necessarily reflect the timing or magnitude of monthly winter releases. CVP winter releases could also have been simulated by setting a winter discharge target to represent site operations, but the same conclusion would have been reached: spring storage capacity can be available if winter releases occur. Site operations will determine the timing and magnitude of releases.

Based on the historical range of precipitation, and seepage inflow estimates to the CVP, Scenarios 2 and 3 predict the following results:

- Scenario 2: If the target elevation (1,027.5 m) is reached by September 30, 2013, the water elevation could reach the lower spillway after 173 days (Figure3)
- Scenario 3: If the target elevation (1,027.5 m) is not reached by September 30, 2013, and the water is only lowered to 1,028.5 m, the water elevation could reach the lower spillway after 92 days (Figure 4)

The recommended target water-level elevation in the CVP is 1,027.5 m, which provides the maximum storage capacity considering the elevation of the sludge beds: approximately 670,000 m^3 (3.18 m) of freeboard between the target elevation and the lower spillway elevation. Winter release is recommended when conditions allow.

Intermediate Dam Pond

Water and tailings are retained behind the Intermediate Dam, which is approximately 650 m long, 7 m wide, and 32 m high, with a crest elevation at 1,049.2 m (Klohn Crippen Berger Ltd. [KCB], 2012) and has a spillway elevation of 1,047.7 m (Denison, 2012). The water level in the ID Pond has historically ranged between 1,043.0 and 1,047.6 m (Denison, 2012; TEES, 2013a). In 2013, ID Pond water was pumped to the Faro Pit.

There are two constraints on the drawdown of water in the ID Pond: (1) a maximum drawdown per day of 40 mm; (2) the operations regime prescribed by KCB (2012) because of concerns about the ID's geotechnical stability (CH2M HILL, 2012b). No changes are recommended for the ID Pond target water levels.

The GoldSim base case scenario indicates that, considering accumulated winter inflows, ID Pond water levels may reach the spillway elevation if dewatering ceases on, or before, September 30. Scenario 4 suggests continued dewatering of the ID Pond at a rate of 9,800 m^3/day through October will bring the water elevation towards its target, although the target will not be reached by the end of October. Considering predicted accumulated winter inputs to the ID Pond, the water elevation is not expected to reach the spillway elevation before dewatering begins again in May 2014 (Figure 5), although the water will rise above the recommended upper elevation of 1,045.2 m, the top of the lower riprap. The Faro Pit water elevation is predicted to rise by 0.4 m, because of water being transferred from the ID Pond in October (Figure 1).

Maintaining the ID Pond's elevation at between 1,045.2 m (the top of the lower riprap) and 1,044.2 m (the bottom of the lower riprap) will limit the potential for the upstream face of the Intermediate Dam to erode. Operation outside this range could take place as a contingency measure, to prevent uncontrolled releases of ID Pond water. If the ID Pond elevation is maintained below the bottom of the lower riprap (1,044.2 m), the dam face should be monitored for erosion and will likely require maintenance in the future (i.e., erosion repair and riprap replacement). CH2M HILL (2012a) provides more discussion about this situation. CH2M HILL recommends pumping from the ID Pond while site conditions allow, to draw the ID Pond level down towards 1,044.2 m.

Faro Pit

The Faro Pit receives groundwater seepage, direct precipitation, runoff, Faro Creek Diversion seepage, and water from managed sources such as the ID Pond, the ETA, S-Wells, and Zone II Pit. From 2004 until 2012, the water-level elevation in Faro Pit was maintained between approximately 1,140 m and 1,143 m (Denison, 2012; TEES, 2013a). During the 2013 treatment season, source areas that used to go to the Faro WTP (which did not operate in 2013) went to the Faro Pit, which raised its water elevation above this range. On September 9, 2013, the Faro Pit water elevation was 1,146.1 m.

The end-of-season target elevation (between 1,140 and 1,141 m) and the maximum recommended elevation (1,144.3 m) (Denison, 2012) have been exceeded. CH2M HILL recommends dewatering activities begin at Faro Pit as early as possible in 2014, at a high enough rate to control and reduce the Faro Pit water level and the potential for seepage increases towards Zone II Pit or towards the ETA.

Emergency Tailings Area

The ETA is an area of historical tailings deposition between the Mill Building and RCTA. In previous years, water from the ETA was collected at a cut-off trench and dual sump and then pumped to the Faro WTP. In 2013, water was not initially collected at the ETA; however, as the season progressed, water was collected and pumped from the ETA to the Faro Pit via the old tailings box and a booster pump located east of the former Mill Building. There is no target elevation for the ETA, but the objective is to collect as much water as practical based on the system capacity. This will limit water of deteriorated quality from seeping downgradient to the ID Pond and the underlying Rose Creek Aquifer, and will reduce the volume of water in the ID Pond.

S-Wells and S-Wells Bypass

The S-Wells are located between the Intermediate Waste Rock Dump (WRD) and the North Fork of Rose Creek (NFRC) and consist of two parts: the S-Wells and the S-Wells Bypass (or Shallow Interception Trench). There were no changes to water management for the S-Wells in 2013. CH2M HILL (2012a) provides additional details about this system.

Zone II Pit

The Zone II Pit is located directly southeast of the Faro Pit and northwest of the NFRC. The Pit was mined in the late 1970s and early 1980s and subsequently filled with about 40 million tonnes of unclassified waste rock from mining operations at other areas at the FMC (Robertson Geoconsultants Inc. [RGC], 1996). The Zone II Pit base is at an elevation of about 1,094.5 m (RGC, 1996) and the current surface topography is at an elevation of about 1,166 m. If water rose above 1,128 m, it would spill over the buried rim and seep toward the NFRC. Between the base of the Zone II Pit and an elevation of 1,128 m, the backfilled Pit has about 480,000 m^3 of storage capacity, assuming 30 percent porosity of the backfilled waste rock (SRK, 2007). In 1991, a pumping well was installed to manage the water level and limit water from migrating towards the NRFC. In 2012, a replacement pumping well (CH12-Z2-PW01) was added. The water-level elevation at Zone II Pit has been managed at approximately 1,107 m and has ranged between about 1,103 and 1,111 m since October 2010 (Denison, 2012). However, this elevation leaves a hydraulic gradient between the groundwater elevation in the Pit and the stage elevation of the NFRC (about 1,096 m). The expired water licence (QZ03-059) required the groundwater elevation in Zone II Pit to be maintained lower than 50 metres below ground (mbg), or 1,116 m.

X26 (Zone II – Old Well)

X26 was not used to dewater the Zone II Pit in 2013. The well is still used to monitor the water elevation in the Zone II Pit. CH2M HILL (2012a) provides additional details about this pumping well. Table 1 does not provide a target elevation for this location.

CH12-Z2-PW01 (Zone II – New Well)

During the summer of 2012, CH2M HILL oversaw the drilling and installation of CH12-Z2-PW01. This well extends to a total depth of 77.4 mbg, with a screened interval between 1,091.7 and 1,114.0 m and a sump extending below 1,091.7 m to the end of the hole at 1,088.6 m (CH2M, 2012c). The lithology consisted of waste rock to a depth of approximately 69.45 mbg (1,096.5 m) (i.e., within 2 m of the reported base of the Pit). The purpose of this well was to replace X26 and allow the groundwater levels within the Pit to be managed so they are lower than those previously achievable. The objective of this deeper well was to lower the groundwater elevation below the stage elevation of the NFRC, to reverse the hydraulic gradient. CH2M HILL understands the water conveyance system installed at this location consists of an insulated high-density polyethylene (HDPE) pipeline, heat-traced for year-round operation. According to the 2011 WMP (Brodie, 2011), the pipeline is positioned to discharge water at 30 m below the surface of the Faro Pit lake. The recommended target elevation for the water level in Zone II Pit is at or below 1,096 m. Groundwater collection should continue from Zone II Pit year-round.

Faro Valley Dumps

The Faro Valley Dumps refers to an area of ponded water along the alignment of the original Faro Creek Channel, upstream from the Faro Valley WRD on the north–northeast side of the Faro Pit. There were no changes to water management for the Faro Valley Dumps in 2013. CH2M HILL (2012a) provides additional details about the system.

Grum Pit

The Grum Pit receives groundwater seepage, direct precipitation, runoff, and Grum Northeast Interceptor Ditch seepage. The Adaptive Management Plan (AMP) threshold level to trigger a response to rising water levels (1,210.8 m) was surpassed in October 2011. The trigger and maximum water elevation was set under AMP Event 6

(Gartner Lee Limited [GLL], 2005) to manage water level increases in the Grum Pit, which was a requirement of the expired water licence (QZ03-059).

This is the first year water elevations in the Grum Pit have been actively managed. The objective is to prevent water of deteriorated quality from reaching downstream receptors and to provide additional storage capacity to retain water received in the Grum Pit. In August 2013, water transfer from Grum Pit to Vangorda Pit began (TEES, 2013b).

SRK (2009) indicated the overflow elevation to be 1,232.3 m, which is the lowest elevation of the Pit walls in the Grum Slot, located at the southern end of Grum Pit. The maximum recommended elevation, 1,213.4 m, allows storage capacity for a 1-week probable maximum flood before the water reaches the contact elevation of the overburden and bedrock (at 1,216 m) near the Grum Slot (Denison, 2011a). The permeability of the overburden above the bedrock contact was estimated to be about $5x10^{-4}$ metres per second (SRK, 2009). The 2011 Annual Review, AMP Report (Denison, 2012) suggests a revised maximum pit water elevation between 1,214.3 and 1,216.1 m, considering potential hydraulic containment south of the Pit (CH2M HILL, 2012a provides additional discussion). This suggested elevation range is based on the storage capacity between this range of elevations and the elevation of the potential hydraulic containment, as well as the estimated volume of water that could drain to Grum Pit during an extreme precipitation event or breach of the Grum Northeast Interception Ditch.

Observed groundwater elevations in the monitoring wells installed in the Grum Slot are higher than the water elevation in Grum Pit. This condition could contain the water within Grum Pit. However, groundwater elevations in the Grum Slot monitoring wells fluctuate seasonally and there are limited monitoring locations. As a result, there is uncertainty about the effective level of hydraulic containment provided by groundwater under the Grum Slot. Continued dewatering of the Grum Pit would slow the steadily rising water levels, so the water level could be managed to remain below the overburden/bedrock contact. Maintaining the water level below an elevation of about 1,213.4 m will limit potential seepage and provide storage capacity during an estimated 1-week probable maximum flood (Denison, 2011a). Given the water elevation in Grum Pit in mid-September, the water elevation cannot be lowered below 1,213.4 m during this operating season.

The base case scenario (Figure 6) indicates if no additional water is transferred from the Grum Pit to the Vangorda Pit, the Grum Pit water elevations will stay above the overburden/bedrock contact until about a month after transfers begin in 2014. Scenarios 5 and 6 estimate the Grum Pit water level if additional pumping takes place starting in mid-September2013 for 20 and 25 days, respectively (Figure 6). These scenarios consider winter accumulations and suggest that pumping down Grum Pit water levels for another 20 days in 2013 at a rate 9,300 m^3/day (to an elevation of about 1,215 m) will maintain the water elevation below the overburden/bedrock contact until May 2014 (Figure 6). Pit water above the documented overburden/bedrock contact could allow seepage, and less storage capacity would be available in case of an extreme rainfall event or if the interceptor ditch was breached.

On October 10, 2013, YG decided to stop seasonal water transfer from the Grum Pit to Vangorda Pit based on its evaluation of relative risk associated with the Grum and Vangorda Pits. Hence, the decision on the end-of-season water elevation has been made for the Grum Pit.

Grum Sulphide Cell Sediment Control

In 2010, an engineered cover was placed over the Grum Sulphide Cell (GSC) to limit infiltration, and in 2011, a series of surface water management upgrades were completed to improve this remedial measure. Before 2010, runoff from the GSC discharged to Moose Pond, along with runoff from areas upgradient of the Pond. Moose Pond discharges to Vangorda Creek (Denison, 2012). CH2M HILL (2012a) provides additional details about the system.

In 2013, a ditch along the north and east perimeters of the GSC was constructed to intercept and redirect runoff generated in the catchment upstream of the GSC. These two ditches direct the collected water to Vangorda Pit.

Grum V15 Seep and Grum Creek Seeps

Seepage from the Grum WRD surfaces at V15 and Grum Creek, downgradient from the waste rock pile on the southeastern side. If such seepage is not otherwise collected, it discharges to Moose Pond, west of Vangorda Creek, after V15 and the Grum Creek intersect at the Grum weir. After the high runoff conditions in 2011, a seepage collection system was constructed to manage peak spring runoff conditions and constituents of concern in seepage from the Grum WRD. The pumping system at V15, located east of the Grum WRD, consists of an insulated and heat-traced, 76-mm HDPE pipeline, a power supply, and pumps (Denison, 2011b). The system can redirect seepage from the Grum WRD (V15, Grum Creek, or both) to the Vangorda Pit all year.

In 2013, the V15 conveyance system was operated to transfer water collected from V15 and Grum Creek to Vangorda Pit. However, the conveyance system is not operated year-round. When it is not operated, discharge flows to Moose Pond (Parkin, 2013b, personal communication). The V15 and Grum Creek have no target elevation; however, the target objective is to limit water of deteriorated quality from seeping to downstream receptors (i.e., Vangorda Creek).

Vangorda Pit

Vangorda Pit receives groundwater seepage, direct precipitation, runoff, and Vangorda Creek Diversion seepage, along with water from managed sources such as the Little Creek Pond and the GSC Pond. In 2013, additional sources were placed in Vangorda Pit, including Grum Pit water, discharge collected from V15 and the Grum Creek, and discharge collected in the ditch around the northeast perimeter of the GSC and from dewatering the sludge ponds. There is uncertainty around the timing and magnitude of transfers to Vangorda Pit for these new sources, which are not fully accounted for in the GoldSim model. The water-level elevation in Vangorda Pit has averaged near 1,085 m since 2004, and has ranged between 1,074.6 and 1,094.1 m (Denison, 2012, TEES 2013a). Based on water levels from 2010 to 2012 (Denison, 2012), water elevations in the Vangorda Pit appear to have been lowered to 1,083 m or lower at the conclusion of dewatering activities. They were then allowed to rise throughout the fall and winter, reaching about 1,088 m in the spring.

In 2012, TEES lowered the Pit water elevation to 1,076.8 m at the end of August and stopped dewatering activities (TEES, 2013a). The water elevation was at 1,081.6 m on October 1 and reached 1.084.4 m by early May. The water elevation peaked around mid-June at 1,088.8 m. The water level exceeded the maximum recommended water elevation of 1,091.8 m once in 2008 and once in 2009. Since then, as a result of annual pumping, the water level appears to have been maintained below the maximum recommended level (Denison, 2012). At the maximum recommended water level in the Vangorda Pit (1,091.8 m), which was the limit in the now expired water licence QZ03-059, there is about 3 Mm^3 of storage capacity in case of diversion failure or an extreme storm event.

The base case scenario (Figure 7) suggests water elevations will be below the maximum recommended level, until the Vangorda WTP starts up in May 2014. This considers winter water accumulation and assumes no additional water is actively transferred to the Vangorda Pit in 2013. The base case scenario predicts the May 1, 2014 Pit water elevation will reach between 1,084 and 1,086 m.

Scenarios 5 and 6 evaluate the Grum Pit transfers assuming the Vangorda WTP will not operate for the remainder of 2013. The scenarios estimate the Vangorda Pit water levels considering additional pumping in 2013 for 20 and 25 days beginning in mid-September, respectively (Figure 7).These scenarios suggest the Vangorda Pit water elevation in spring 2014 will be below the maximum recommended level if the end-of-season elevation is below 1,086 m. If Vangorda Pit receives water from Grum Pit until mid-October, its elevations on May 1, 2014 will range from approximately 1,087 m and 1,089 m. However, Vangorda Pit water levels will continue to rise with spring inflows (natural and transfers).

Scenarios 5 and 6 suggest a 2013 end-of-season elevation in Vangorda Pit of 1,086 m or lower accommodates inflows below the 1,091.8 maximum recommended water level, if dewatering of the Vangorda Pit begins on May 1, 2014. The final water elevation will depend on the timing and magnitude of inflows (natural and transfers), as well as the start-up date of the Vangorda WTP in 2014.

Scenario 7 suggests even if no additional water is transferred from the Grum Pit to the Vangorda Pit in 2013, the maximum recommended water level may be exceeded if the Vangorda WTP does not start until June 1, 2014 (Figure 8).

As discussed previously, on October 10, 2013, YG decided to stop seasonal water transfer from the Grum Pit to Vangorda Pit based on its evaluation of risk. This decision effectively determines the end-of-season water elevation for the Vangorda Pit. Dewatering activities should begin at the Vangorda Pit in 2014, as soon as practical, and should continue until the storage capacity is restored.

Little Creek Pond

The Little Creek Pond collects runoff and seepage from the Vangorda WRD via a seepage collection ditch. There were no changes to water management for Little Creek Pond in 2013. CH2M HILL (2012a) provides additional details about the system.

Sheep Pad Ponds

The Sheep Pad Ponds are located south of the Grum Overburden Pile. They collect runoff from upslope areas, and discharge to the lower portion of the Vangorda Creek Diversion (KCB, 2012). There were no changes to water management for Sheep Pad Ponds in 2013. CH2M HILL (2012a) provides additional details about the system.

Vangorda Watering Hole

The Vangorda Watering Hole is understood to be located in the original Vangorda Creek Channel, upstream from the Vangorda Creek Diversion. Since 2002, a sump at this location has collected runoff from the local catchment and pumped it to the Vangorda Creek Diversion (Denison, 2011C). There were no changes to water management for Vangorda Watering Hole in 2013. CH2M HILL (2012a) provides additional details about the system.

Vangorda Waste Rock Dump

A seepage collection ditch along the southern and western basal perimeter of the Vangorda WRD collects and redirects seepage toward Little Creek Pond. There were no changes to water management for Vangorda WRD in 2013. CH2M HILL (2012a) provides additional details about the system.

Summary and Recommendation

The 2013 water elevation targets (see Table 1) were established to limit water of deteriorated quality from migrating offsite, and to provide potential storage capacity in case of extreme environmental conditions or unexpected delays to operations. Changed site conditions and facility operations were also considered when providing recommendation on target elevations.

The target water elevations should be reviewed annually to address changing site conditions and varying environmental factors.

Works Cited

BGC Engineering (BGC). 2008. *Intermediate Dam Trigger Levels.* May 15.

BGC Engineering (BGC). 2006. *Task 20B. Plug Dam Conceptual Design.* Prepared for Deloitte & Touche Inc. on behalf of Faro Mine Closure Planning Office. *November 9. 2006.*

Brodie Consulting (Brodie). 2011. *2011 Freshet Water Management Plan*. Version 2 KF. April 7.

CH2M HILL Canada Limited (CH2M HILL). 2013. *Fiscal Year 2012 Site-wide Water Quality Modelling Report, Faro Mine Remediation Project.* Draft. Prepared for Government of Canada as represented by Aboriginal Affairs and Northern Development Canada and the Government of Yukon. March 27.

CH2M HILL. 2012a. *Response to Objectives 2 Task Authorization Component 009-D Water Management Support, Faro Mine Remediation Project*. Technical memorandum. Prepared for Government of Yukon. August.

CH2M HILL. 2012b. *Review of Klohn Crippen Berger Ltd. Report*. Technical memorandum. Prepared for Government of Yukon. June.

CH2M HILL Canada Limited (CH2M HILL). 2012c. *Task Authorization 007, Summary of Zone II Drilling Activities, Faro Mine Remediation Project.* Prepared for Government of Canada as represented by Aboriginal Affairs and Northern Development Canada and the Government of Yukon. November.

Denison Environmental Services (Denison). 2012. *2011 Annual Environmental Monitoring and Activities Report*. *Faro Mine Complex*. *Faro Mine Complex – Faro, YT.* Prepared for Government of Yukon. February 29.

Denison Environmental Services (Denison). 2011a. *2010 Annual Review, Adaptive Management Plan. Faro Mine Complex – YT*. Prepared for Government of Yukon. Department of Energy, Mines and Resources. March 8.

Denison Environmental Services (Denison). 2011b. *Project Completion Report, V15 Pumping System Construction*. *Faro Mine Complex – Faro, YT*. Prepared for Government of Yukon. Prepared for Government of Yukon, Department of Energy, Mines and Resources, Assessment and Abandoned Mines Branch. February 24.

Denison Environmental Services (Denison). 2011c. *2010 Annual Environmental Monitoring and Activity Report*. *Faro Mine Complex – Faro, YT*. Prepared for Government of Yukon. March 11.

Domingue, Eric/Tlicho Engineering and Environmental Services Ltd. (TEES) Project Manager. 2013. Personal communication with Jim Stefanoff/CH2M HILL. July 11.

Gartner Lee Limited (GLL). 2005. Anvil *Range Mine Complex 2004 Annual Environmental Report Water Licence QZ03-059*. Prepared for Deloitte & Touche. February 28.

Klohn Crippen Berger (KCB). 2012. *Faro Mine Remediation Project, Drawdown Rate of Intermediate Pond*. June 15.

Parkin, Tracey/Tlicho Engineering and Environmental Services Ltd. (TEES) Environmental Coordinator. 2013a. Personal communication with Steve Momeyer/CH2M HILL. July 17.

Parkin, Tracey/Tlicho Engineering and Environmental Services Ltd. (TEES) Environmental Coordinator. 2013b. Personal communication with Steve Momeyer/CH2M HILL. September 19.

Robertson GeoConsultants Inc. (RGC). 1996. *Anvil Range Mining Complex – Integrated Comprehensive Abandonment Plan*. Prepared for Anvil Range Mining Corporation. November.

SRK Consulting Engineers and Scientists (SRK). 2009. *Faro Mine Complex. 2009 Groundwater Investigations. Draft. Prepared for Government of Yukon*. January.

SRK Consulting Engineers and Scientists (SRK). 2007. *Anvil Range Mining Complex Continued Seepage Investigation Zone 2 Pit Outwash Area*. 2005/06/Task 20e. January.

SRK Consulting Engineers and Scientists (SRK). 2006. *Anvil Range Pit Lakes Evaluation of In-Situ Treatment. 2005/06 Task 20c*. Prepared for Deloitte & Touche Inc. July.

Tlicho Engineering and Environmental Services Ltd. (TEES). 2013a. *Elevations data to September 12, 2013.xls. 2013 Annual Environmental Monitoring and Activities Report*. *Faro Mine Complex* (in progress). Prepared for Government of Yukon. September.

Tlicho Engineering and Environmental Services Ltd. (TEES). 2013b. *Appendix K - 2013 Water Moved.xls. 2013 Annual Environmental Monitoring and Activities Report*. *Faro Mine Complex* (in progress). Prepared for Government of Yukon. September.

Tables

TABLE 1
Faro 2013 Water Management Targets
Faro Mine Remediation Project

Management Location		Target Elevation (m)	Target Objective	Start	End	Contingency	Comments
Source	Destination						
Cross Valley Pond	Release at X5 or via mobile treatment system to Rose Creek	1,027.5 m	Maximum achievable drawdown of water level until 1,027.5 m Transition to inflow equals outflow once water elevation at target *Limitations* *+ WQ criteria at X14* *+ Max drawdown of 100 mm/day* *+ Lowering below 1,027.5 m exposes sludge beds*	As early as practical per seasonal site constraints	Cease as required based on seasonal constraints	See site emergency response plan	1,027.5 m provides 3.18 m of freeboard (~670,000 m^3 of storage) between the target elevation and the lower spillway elevation (1,030.68 m). This provides an estimated average of 173 days of water accumulation based on the historical range of precipitation and seepage inflow estimates to the CVP, before the water elevation reaches the spillway elevation (i.e., from October 2013 until the end of March 2014). Winter release, as conducted in previous years, should be performed when conditions allow.
Intermediate Dam Pond	Faro Pit (pump to)	Between 1,044.2 and 1,045.2 m	This range is recommended to prevent erosion of the dam face. [a] *Maximum drawdown 40 mm/day*	As early as practical per seasonal site constraints	When target level reached	See site emergency response plan	It is recommended that the water level elevation be maintained as practical between elevations 1,045.2 m, which is the top of the lower riprap, and elevation 1,044.2 m, which is the bottom of the lower riprap, as per the 1991 as-built drawings. Operation outside this range could be performed as a contingency measure to prevent uncontrolled releases of IP water; however erosion monitoring should occur and future maintenance on the dam face will likely be required.
Faro Pit	None currently available	1,141 m	Target end of season water level elevation is 1,141 m, however it is not possible to achieve this elevation in 2013.	As early as practical per commissioning of interim water treatment plant.	Cease as required based on seasonal constraints	None currently available	Faro WTP not currently operational. During the 2013 treatment season IP and ETA water have been placed in Faro Pit raising the water level. Recommended that interim treatment be implemented as soon as possible in 2014 at a rate high enough to control and begin to reduce Faro Pit water level and therefore potential increases of seepage towards Zone II Pit and/or towards the ETA.
Emergency Tailings Area (ETA)	Faro Pit (pump to)	N/A	Collect as much water as practical based on system capacity.	Commence collection as early as practical per seasonal site constraints	Cease collection as required based on seasonal constraints	If problem is encountered, repair system as soon as practical.	
S Wells	Faro Pit (pump to)	N/A	Target objective is to limit bypass of water of deteriorated quality from reaching the receiving environment. Pump to sump to be conveyed to Faro Pit.	Year-round operation		If problem is encountered, repair system as soon as practical.	Capacity of pumping system should be evaluated
S Wells bypass (Shallow Aquifer Interception Trench)	Faro Pit (pump to)	N/A	Target objective is to limit seepage bypass from reaching receiving environment. Pump to main sump to be conveyed to Faro Pit.	As needed to prevent seepage into NFRC		If problem is encountered, repair system as soon as practical.	Capacity of pumping system should be evaluated
X26 (Zone II - Old Well)	Faro Pit (pump to, surface)	-	-	-	-	-	Replaced by CH12-Z2-PW01
CH12-Z2-PW01 (Zone II - New Well)	Faro Pit (pump to, depth)	1,096 m	Target objective is to limit the hydraulic gradient and thus seepage of water of deteriorated quality from the Zone II Pit from reaching the NFRC and underlying alluvial aquifer.	Year-round operation		If problem is encountered, repair system as soon as practical.	Target elevation lowered from 1,103 m to 1,096 (approximate stage elevation of NFRC to the east) to utilize new well screened depth.
Faro Valley Dumps	Faro Creek Diversion Channel	-	-	-	-	-	[b]Water quality does not meet criteria to enable active water management from this location
Grum Pit	Vangorda Pit (pump to)	-	Target end of season water level elevation is not possible to achieve in 2013. [c]AMP trigger: 1,210.8 m; [c]AMP maximum elevation: 1,213.4 m [b]2011 AMP review suggests increasing maximum level to between 1,214.3 and 1,216.1 m.	As early as practical given site constraints	When target level reached	See site emergency response plan	Pit water elevation above the documented overburden/bedrock contact at 1,216 m allows possible seepage and there is a decrease in storage capacity in the case of an extreme rainfall event or breach of interceptor ditch. On October 10, 2013, YG decided to stop seasonal water transfer from the Grum Pit to Vangorda Pit based on its evaluation of relative risk associated with the Grum and Vangorda Pits. Hence, the decision on the end-of-season water elevation has been made for the Grum Pit.

TABLE 1

Faro 2013 Water Management Targets

Faro Mine Remediation Project

Management Location		Target Elevation (m)	Target Objective	Start	End	Contingency	Comments
Source	Destination						
GSC sediment control	Vangorda Pit (pump to)	N/A	Prevent unacceptable water from entering the receiving environment.	When water starts flowing into lined storage pond at toe of GSC	As allowed by pond inflows	Unlined 9,000 m^3 storage pond located to southwest of lined storage pond	-
Grum V15 Seep and Grum Creek Seep	Vangorda Pit (pump to)	N/A	Collect as much water as practical based on system capacity.	Year-round operation		-	[d]TEES reports that the system was shutdown in August. "Normal" flow volumes currently report to Moose Pond. High spring flows will be pumped to Vangorda Pit.
Vangorda Pit	Vangorda/Grum WTP	-	Based on operational experience, the target end of season water level elevation is 1,083 m, or lower, however, it is not possible to achieve this elevation in 2013. Recommended maximum water level is 1,091.8 m, which is consistent with the limit in the expired water licence (QZ03-059) and provides about 3 Mm^3 of storage capacity in the event of diversion failure or an extreme storm event.	As soon as practical per seasonal site constraints	When target level reached	See site emergency response plan	Additional 2013 inputs to Vangorda Pit include Grum Pit, Grum-V15 transfers and runoff collected by the perimeter ditch around the northeast portion of the GSC. On October 10, 2013, YG decided to stop seasonal water transfer from the Grum Pit to Vangorda Pit based on its evaluation of risk. This decision effectively determines the end-of-season water elevation for the Vangorda Pit. Vangorda WTP operation should begin as soon as practical per seasonal site constraints in 2014 to restore storage capacity.
Little Creek Pond	Vangorda Pit (pump to)	1,108 m	Target elevation is 1,108 m; however, the operational management level since 2010 has been 1,106.5 m. Maintain minimum 3 m freeboard; Licence limit is 1,111.8 m	When water starts flowing in Vangorda rock pile collection ditch	When target level reached; historically, fall freeze-up	See site emergency response plan	[e]September 19, 2013 TEES reports that operations shut down for season. Elevation reached 1,107.9 m.
Sheep Pad Pond	Vangorda Creek (siphon)	N/A	Produce water of sufficient quality for discharge to Vangorda Creek.	When water starts flowing in Grum overburden ditch	As allowed by pond inflows	See site emergency response plan	-
Vangorda - Watering Hole	Vangorda Creek Diversion	N/A	Intercept run-off and reduce the volume of water entering Vangorda Pit by pumping into the Vangorda Creek Diversion.	As early as practical given site constraints	As required by inflow volumes	See site emergency response plan	-
Vangorda Waste Rock Dump	Little Creek Pond (via seepage collection ditch)	N/A	-	-	-	-	-

Notes:

°C - degrees Celsius

AMP - adaptive management plan

GLL - Gartner Lee Limited

GSC - Grum Sulphide Cell

KCB - Klohn Crippen Berger

m - metre(s)

mm - millimetre(s)

m^3 - cubic metres

Mm^3 - million cubic metres

masl - metres above sea level

max - maximum

N/A - not applicable

NFRC - North Fork Rose Creek

TDS - total dissolved solids

TEES - Tlicho Engineering and Environmental Services Ltd

WQ - water quality

WTP - Water Treatment Plant

[a]Klohn Crippen Berger (KCB). 2012. *Faro Mine Remediation Project, Drawdown Rate of Intermediate Pond*. June 15.

[b]Denison Environmental Services (Denison). 2012. *2011 Annual Environmental Monitoring and Activities Report*. *Faro Mine Complex* . *Faro Mine Complex – Faro, YT*. Prepared for Government of Yukon. February 29.

[c]Gartner Lee Limited (GLL). 2005. Anvil *Range Mine Complex 2004 Annual Environmental Report Water Licence QZ03-059*. Prepared for Deloitte & Touche. February 28.

[d]Parkin, Tracey/Tlicho Engineering and Environmental Services Ltd. (TEES) Environmental Coordinator. 2013b. Personal communication with Steve Momeyer/CH2M HILL. September 19.

[e]Tlicho Engineering and Environmental Services Ltd. (TEES). 2013b. Appendix K - 2013 Water Moved.xls. 2013 Annual Environmental Monitoring and Activities Report. Faro Mine Complex (in progress). Prepared for Government of Yukon. September.

TABLE 2

Pit and Pond Elevations

Faro Mine Remediation Project

Location	Water Elevation[a] (m)	Date of Water Elevation Measurement (m)	Pit Crest or Spillway Elevation (m)	Overburden/ Bedrock Contact (m)
Faro Pit	1,146.1	9-Sep-13	1,158[b]	1,147 to 1,157[c]
Grum Pit	1,216.0	9-Sep-13	1,232	1,216[d]
Vangorda Pit	1,082.2	9-Sep-13	1,130	1,122[e]
Intermediate Dam Pond	1,045.8	12-Sep-13	1,047.7	N/A
Cross Valley Pond	1,029.0	12-Sep-13	1,030.68	N/A

Notes:

N/A - not applicable

[a]Tlicho Engineering and Environmental Services Ltd. (TEES). *Elevations data to September 12, 2013.xls. 2013 Annual Environmental Monitoring and Activities Report. Faro Mine Complex* (in progress). Prepared for Government of Yukon. September.

[b]An elevation of 1,158 m for the Faro Pit represents the elevation of the southeast access road where it intersects the Zone II Pit.

[c]BGC Engineering (BGC). 2006. *Task 20B. Plug Dam Conceptual Design.* Prepared for Deloitte & Touche Inc. on behalf of Faro Mine Closure Planning Office. November 9.

[d]SRK Consulting Engineers and Scientists (SRK). 2009. *Faro Mine Complex. 2009 Groundwater Investigations. Draft.* Prepared for Government of Yukon. January.

[e]Denison Environmental Services (Denison). 2012. *2011 Annual Environmental Monitoring and Activities Report. Faro Mine Complex. Faro Mine Complex – Faro, YT.* Prepared for Government of Yukon. February 29.

TABLE 3

GoldSim Model Scenarios

Faro Mine Remediation Project

		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
	Starting Date	9/9/2013	9/9/2013	9/9/2013	9/9/2013	9/9/2013	**09/18/2013**	9/9/2013
	End Date	9/9/2014	9/9/2014	9/9/2014	9/9/2014	9/9/2014	**09/18/2014**	9/9/2014
Faro Treatment	Start	no Start	no Start	no Start	no Start	no Start	no Start	no Start
	Faro Storage Capacity(USgpm)	No pumping out of Faro Storage 0	No pumping out of Faro Storage 0	No pumping out of Faro Storage 0	No pumping out of Faro Storage 0	No pumping out of Faro Storage 0	No pumping out of Faro Storage 0	No pumping out of Faro Storage 0
ID Pond pumping to Faro	Max pumping (USgpm)	1800	1800	1800	1800	1800	1800	1800
	Pumping Season	May1st-Sep30th	May1st-Sep30th	May1st-Sep30th	**May1st-Oct30th**	May1st-Sep30th	May1st-Sep30th	May1st-Sep30th
	ID Pond Target Elev (min during Treatment Season)	1044.5	1044.5	1044.5	1044.5	1044.5	1044.5	1044.5
CVP	CVP X5 capacity (USgpm)	5000	5000	**1200**	5000	5000	5000	5000
	CVP Operation	To Keep pit Elevation at target - rule curve 1	**Allow pond to rise to emergency spillway elevation 1030.68 over winter**	**Allow pond to rise to emergency spillway elevation 1030.68 over winter**	To Keep pit Elevation at target - rule curve 1	To Keep pit Elevation at target - rule curve 1	To Keep pit Elevation at target - rule curve 1	To Keep pit Elevation at target - rule curve 1
	CVP Target Elev (min during Treatment Season)	1027.5	1027.5	1027.5	1027.5	1027.5	1027.5	1027.5
Vangorda Treatment	Start	Start in May 2014	Start in May 2014	Start in May 2014	Start in May 2014	Start in May 2014	Start in May 2014	**Start in June 2014**
	Treatment capacity(USgpm)	2000	2000	2000	2000	2000	2000	2000
	Vangorda Treatment window	May1st-Sep30th	May1st-Sep30th	May1st-Sep30th	May1st-Sep30th	May1st-Sep30th	May1st-Sep30th	May1st-Sep30th
	Vangorda Pit Target Elevation(m)	1083	1083	1083	1083	1083	1083	1083
Grum to Vangorda Pumpi	Start	Start in May 2014	Start in May 2014	Start in May 2014	Start in May 2014	**Operate until end of Sept 2013 (effective 20 days)**	**Operate from Sept 18 to Oct 15 2013 (effective 25 days)**	Start in May 2014
	Max Capacity (USgpm)	1700	1700	1700	1700	1700	1700	1700
	Window	May1st-Sep30th	May1st-Sep30th	May1st-Sep30th	May1st-Sep30th	May1st-Sep30th	na	May1st-Sep30th
	Grum Pit Target Elevation	1213.4	1213.4	1213.4	1213.4	1213.4	1213.4	1213.4

Notes:

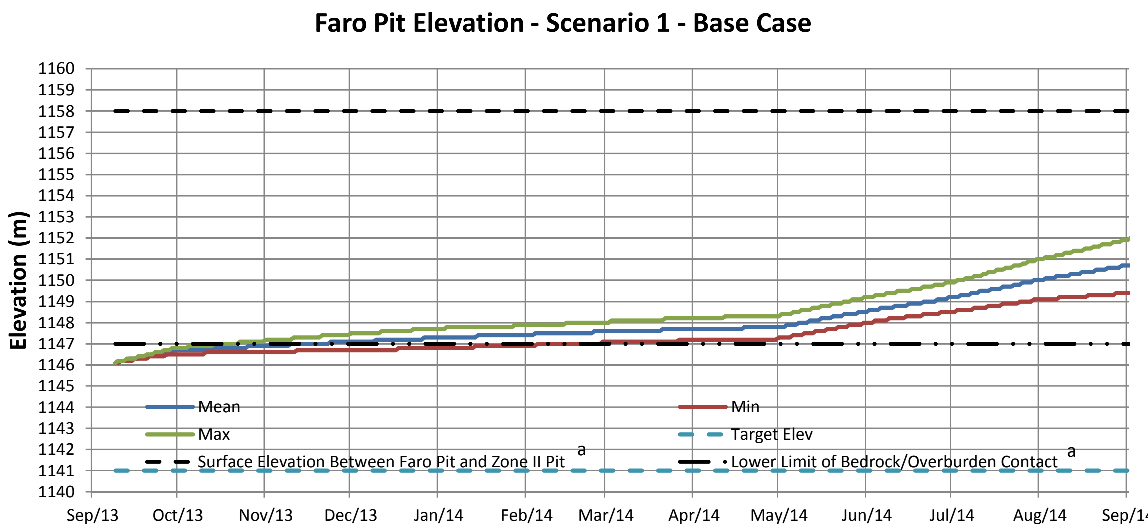
Cells with blue highlight and bold text indicate the value(s) changed in the scenario

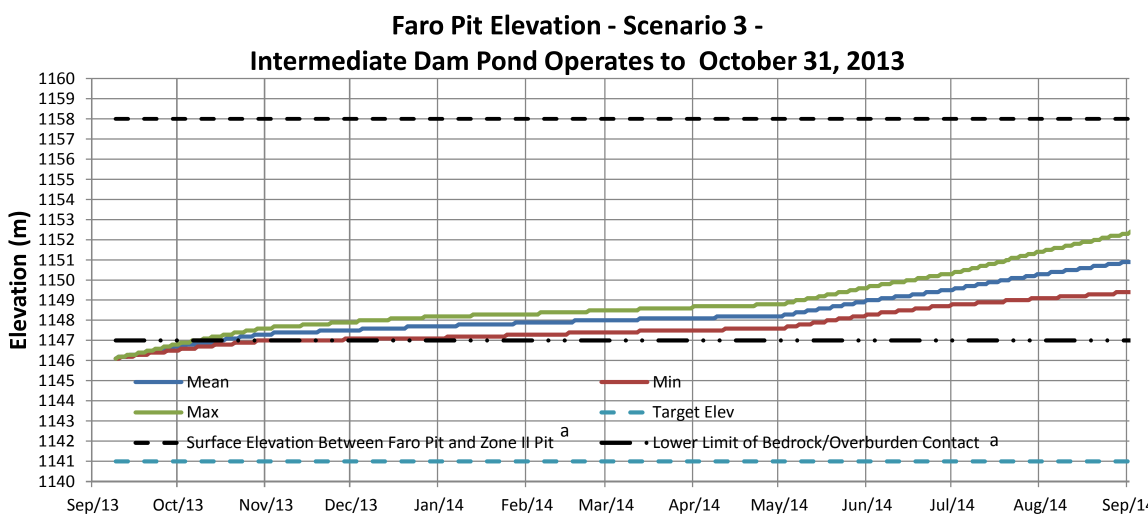
CVP - Cross Valley Pond

ID Pond - Intermediate Dam Pond

USgpm - US gallons per minute

Figures





[a]The range of elevations presented reflect the surface elevation of the southeast access road where it intersects the Zone II Pit (1,158 m) and the lower identified bedrock/overburden contact (1,147 m) between the Faro Pit and Zone II Pit (BGC, 2006).

Scenario 1: Base Case

Scenario 3: Intermediate Dam Pond pumped to Faro Pit until October 31, 2013

Figure 1
Faro Pit Elevations
Faro Mine Remediation Project

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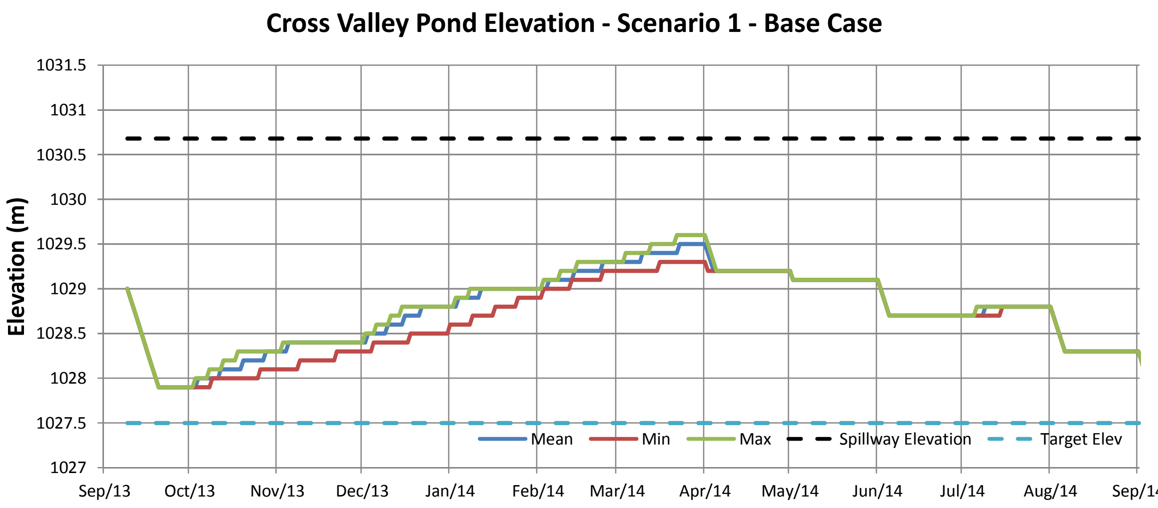
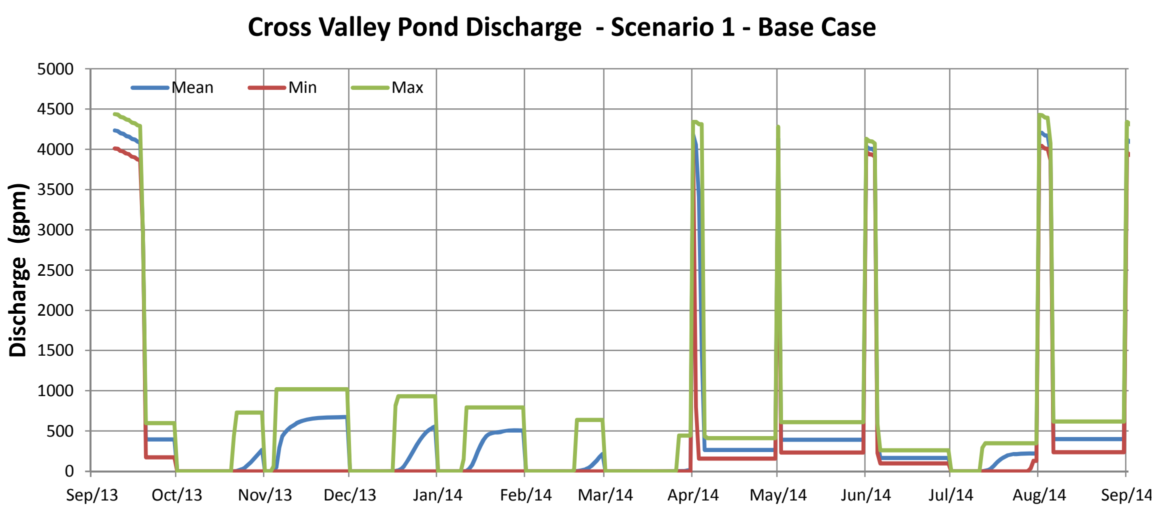
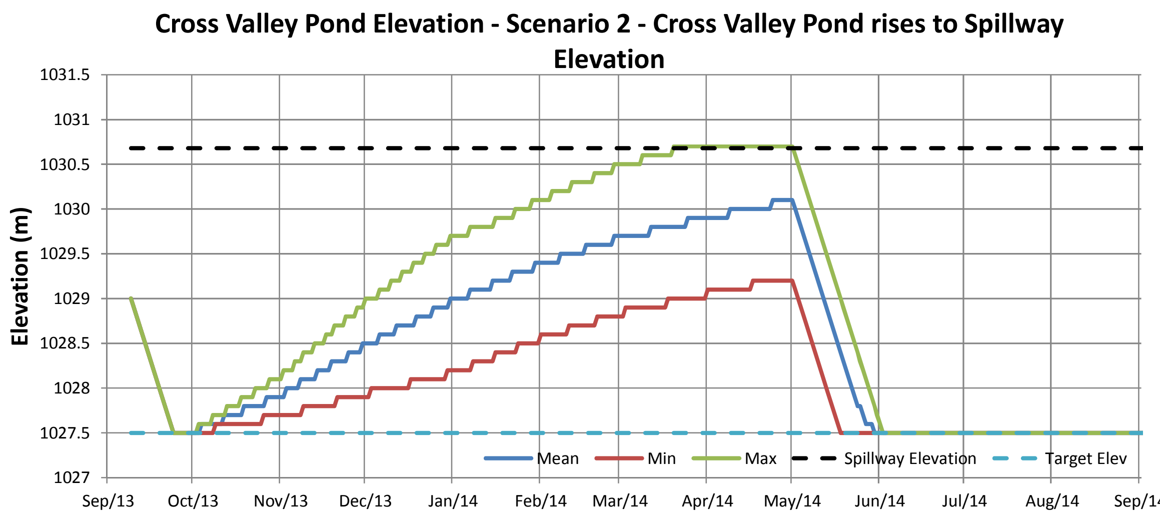




Scenario 1: Base Case

Figure 2
Cross Valley Pond Elevations
Faro Mine Remediation Project

CH2MHILL.



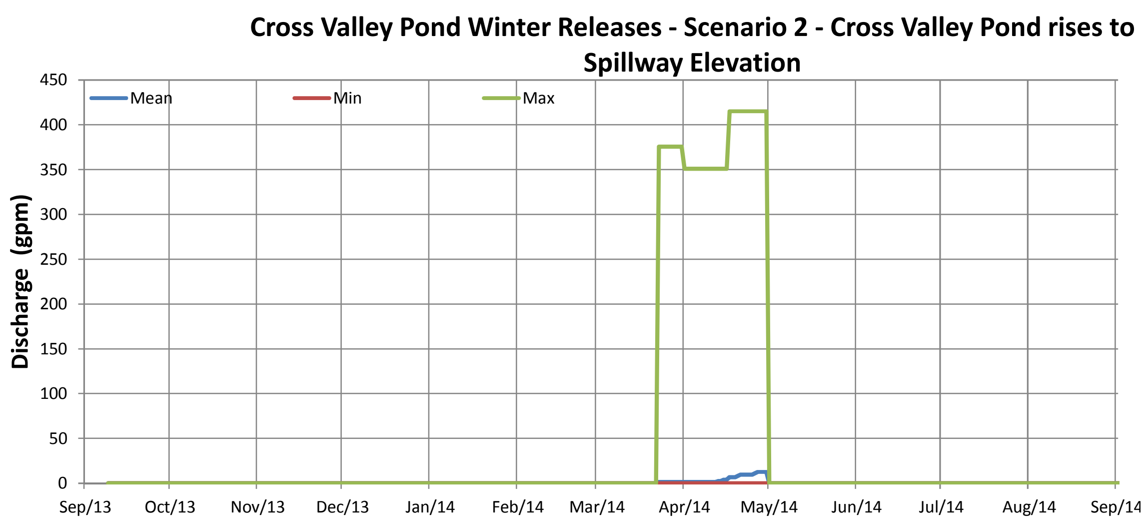


Figure 3

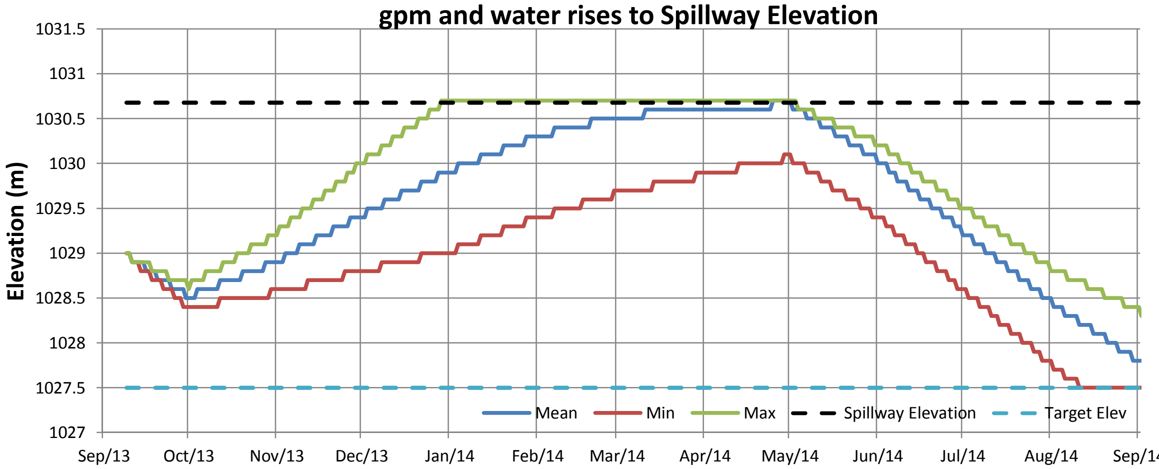
Cross Valley Pond Elevations

Faro Mine Remediation Project

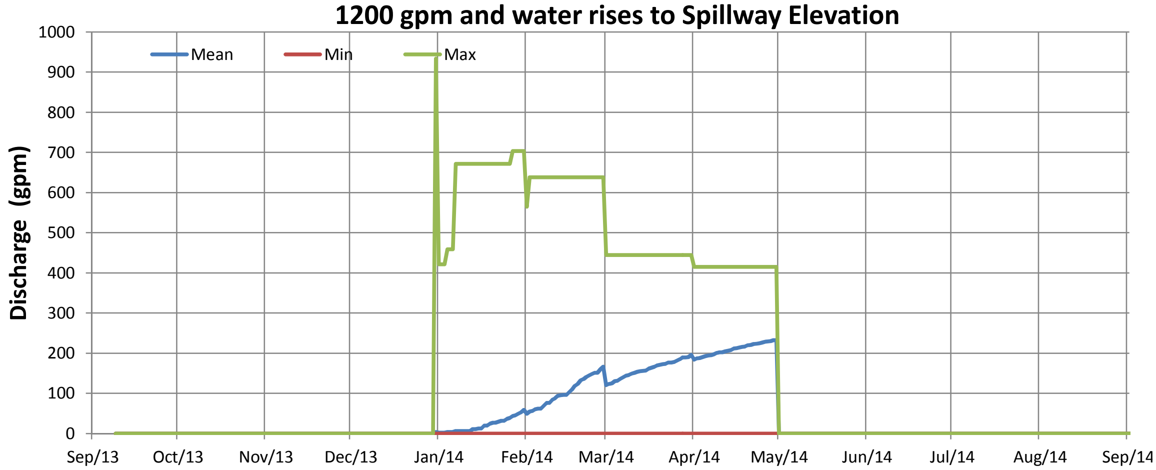
Scenario 2: Cross Valley Pond rises to spillway elevation over winter

CH2MHILL.

Cross Valley Pond Elevation - Scenario 3 - Cross Valley Pond Discharge 1200 gpm and water rises to Spillway Elevation



Cross Valley Pond Winter Releases- Scenario 3 - Cross Valley Pond Discharge 1200 gpm and water rises to Spillway Elevation



Scenario 3: Cross Valley Pond discharge capacity limited to 1200 gpm

Figure 4
Cross Valley Pond Elevations
Faro Mine Remediation Project

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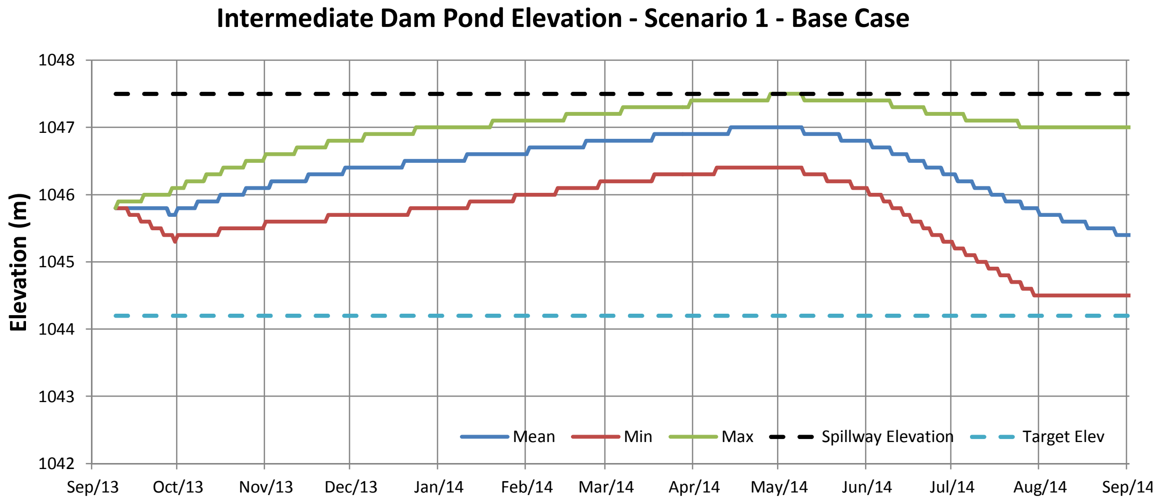

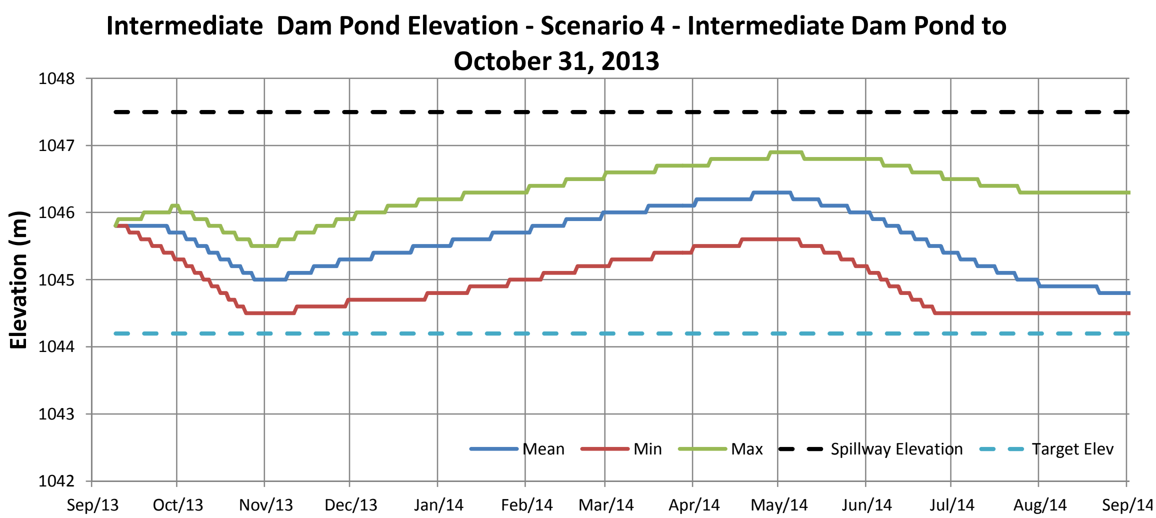

Figure 5
Intermediate Dam Pond Elevations
Faro Mine Remediation Project

Scenario 1: Base Case
Scenario 4: Intermediate Dam Pond pumped to Faro Pit until October 31, 2013

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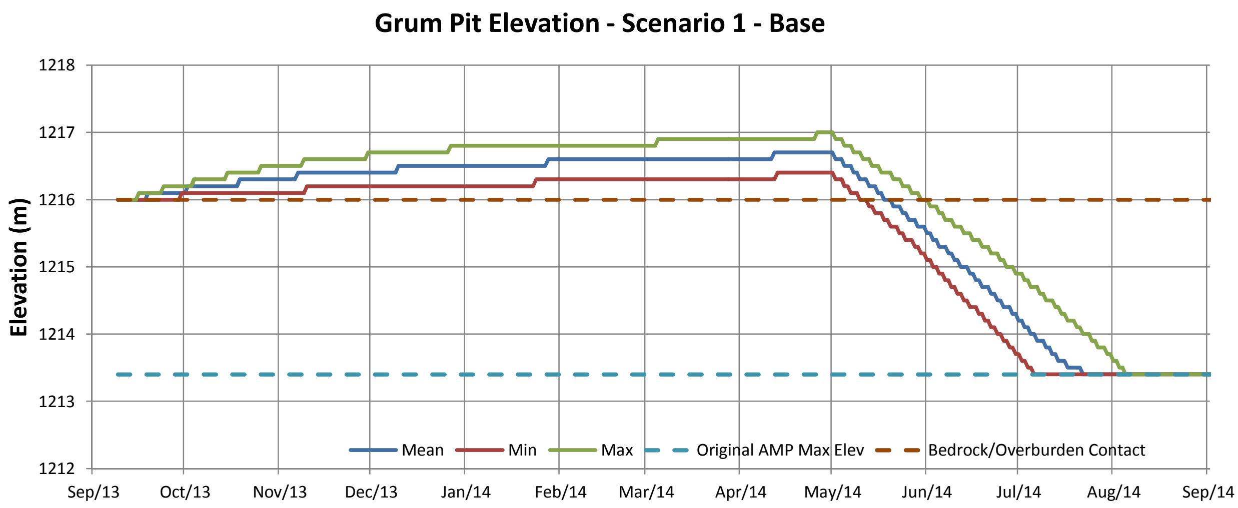

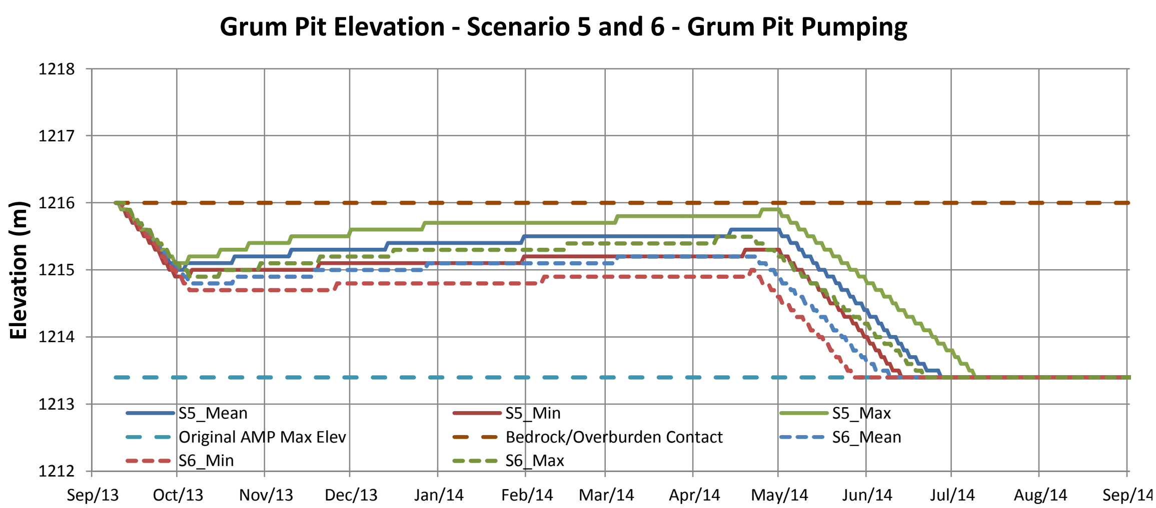

Scenario 1: Base Case
Scenario 5: Grum Pit pumping continues additional 20 days in 2013
Scenario 6: Grum Pit pumping continues additional 25 days in 2013

Figure 6
Grum Pit Elevations
Faro Mine Remediation Project

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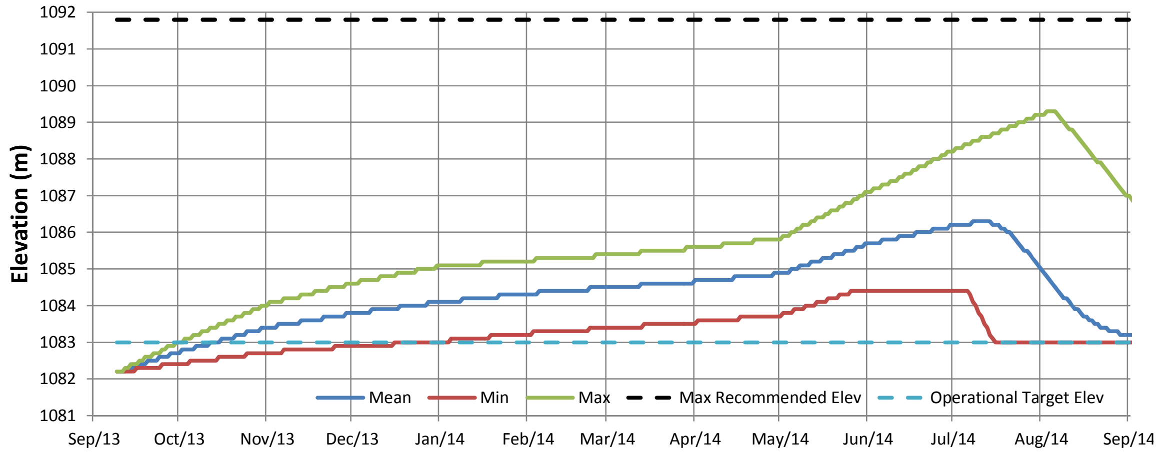
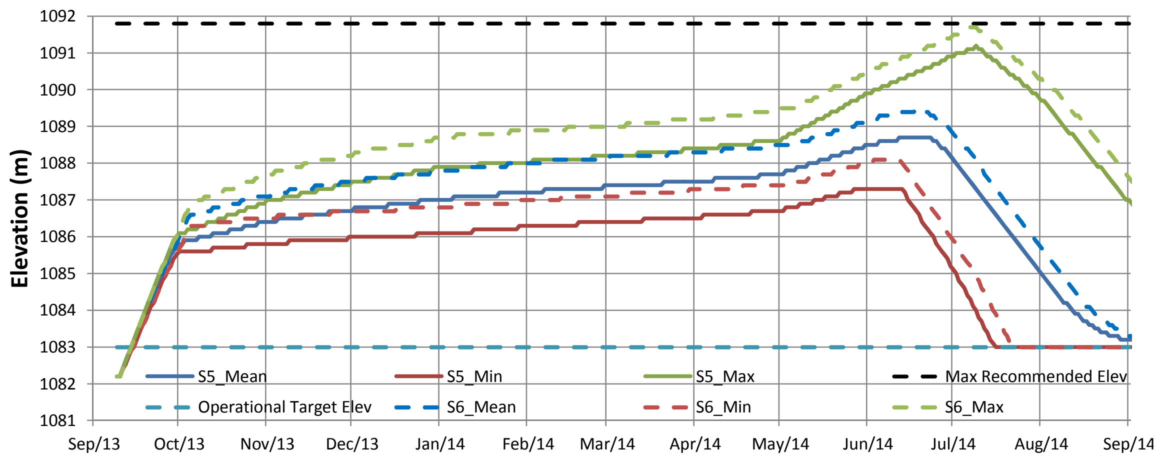
Vangorda Pit Elevation - Scenario 1 - Base



Vangorda Pit Elevation - Scenario 5 and 6 - Grum Pumping



Scenario 1: Base Case
Scenario 5: Grum Pit pumping continues additional 20 days in 2013
Scenario 6: Grum Pit pumping continues additional 25 days in 2013

Figure 7
Vangorda Pit Elevations
Faro Mine Remediation Project

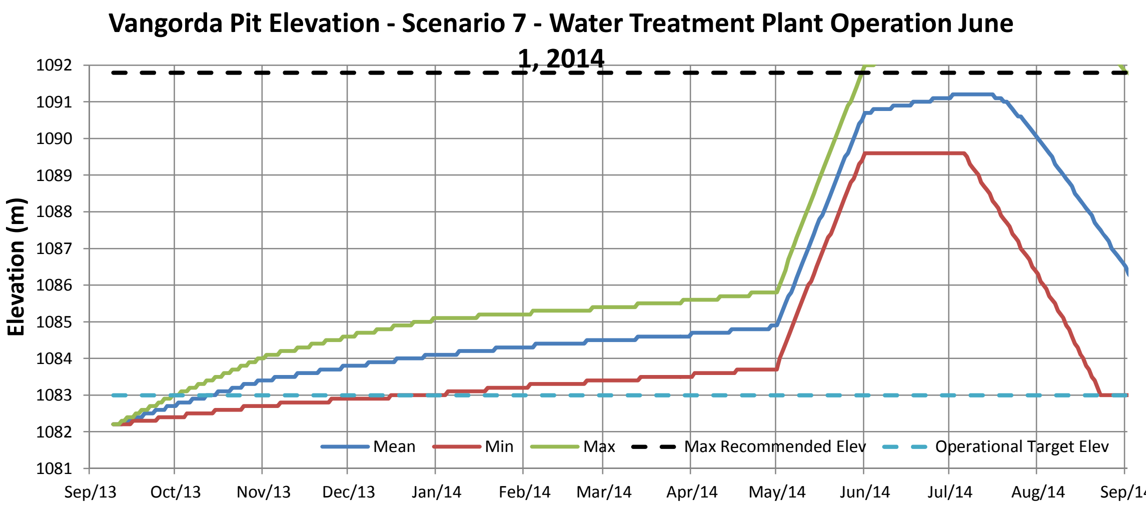


Figure 8
Vangorda Pit Elevations
Faro Mine Remediation Project

Scenario 7: Vangorda Water Treatment Plant does not start until June 1, 2014

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