Faro Mine Remediation Project
Water Treatment Plant Workshops

ATTENDEES:	Stephen Mead/YG	John Spitzley/CH2M HILL
	Kaori Torigai/YG	Jim Stefanoff/CH2M HILL
	Karen Furlong/YG	Marcelo Reginato/CH2M HILL
	Peter Mackenzie/AANDC	Raymond Chin/CH2M HILL
	John Brodie/AANDC	John Herbert/CH2M HILL
	Randy Knapp/IPRP	Garry Ng/CH2M HILL
	Alan Van Norman/IE	Joe Bogdanic/CH2M HILL
	Mike Ferguson/CH2M HILL	Darrell Yong/CH2M HILL
	Lawrence Benjamin/CH2M HILL	
FROM:	Lawrence Benjamin/CH2M HILL	
VENUE:	CH2M HILL, Burnaby, BC – Saltspring Room	
MEETING DATE:	October 16 – 18, 2012, with lunch provided	
SOURCE DOCUMENTS:	Hard copies of technical memorandums (TMs) and presentations to be provided at the meeting.	
	Electronic versions are saved on the Project SharePoint site: https://deliver.ch2m.com/sites/FaroMine/TM/TA013WTPDesign/Deliverables/2012 10 15 WTPWorkshop	

Day 1 – October 16, 2012	Influent Characterization and Plant Capacity Phasing, and Plant Siting Workshop
Day 2 – October 17, 2012	One Water Treatment Plan (WTP) vs. Two, and Value Engineering Workshop
Day 3 – October 18, 2012	Schematic Design Workshop

Day 1 – October 16, 2012

Influent Characterization and Plant Capacity Phasing, and Plant Siting Workshops

Purpose: The purpose of these workshops is to review the evaluations completed on Influent Characterization and Plant Capacity Phasing, as well as Plant Siting; discuss and receive feedback; and agree on the recommendations that will be taken forward for Schematic Design. More specifically, the questions that need to be answered as an outcome of the workshop are:

Influent Characterization and Plant Capacity Phasing

- What will be the WTP's hydraulic capacity?
- What will be the design water quality?
- Should the plant be implemented in phases, and if so, how?

Plant Siting

- Where should the WTP be located?

Clear answers to these questions are required in order for significant Schematic Design to be accomplished on this next phase of work.

Agenda

8:30 a.m. – 9:00 a.m.	**Introductions and Safety Moment** (Lawrence Benjamin)
9:00 a.m. – 10.00 a.m.	**Agenda Review and Goals for Workshop** (Lawrence Benjamin) a. Opening comments by Stephen Mead b. Workshop objectives, YG and CH2M HILL c. Expected outcomes d. High-density sludge (HDS) treatment overview
10:00 a.m. – 10:10 a.m.	**Break**
10:10 a.m. – 12:00 p.m.	**Influent Characterization and Plant Capacity Phasing** (Jim Stefanoff) a. Presentation by CH2M HILL i. Background ii. Related tasks – One WTP vs. Two, Plant Siting, Piloting (results from Pilot Plant Trials) iii. Treatment process – reason for HDS process, and design parameters iv. Key influent parameters v. Other considerations - Faro Pit storage - Role of WTP in site care and maintenance (C&M) - Evolution of source water qualities - Timing of remedial and treatment needs - Discharge requirements - Availability of funding and WTP phasing vi. Prediction of future treatment needs vii. Interim GoldSim results viii. Interim pilot results ix. Interim equipment sizing x. Interim CH2M HILL Parametric Cost Estimating System (CPES) estimates xi. Interim WTP capacity and phasing recommendations xii. Other recommendations

Agenda

12:00 p.m. – 1:00 p.m.	Lunch at CH2M HILL
1:00 p.m. – 3:00 p.m.	a. Additional discussion, as needed b. Confirmation of recommendations
3:00 p.m. – 3:10 p.m.	**Break**
3:10 p.m. – 5:00 p.m.	**Plant Siting** (Raymond Chin) a. Presentation by CH2M HILL i. Background ii. Alternative sites - Mill Site - BXL Site - Gravel Pit Site iii. Technical evaluation iv. Cost evaluation v. Cost estimate for alternatives vi. Noneconomic considerations vii. Recommendations b. Discussion **Agreement/Confirmation of Recommendations**

Day 2 - October 17, 2012

One WTP vs. Two, and Value Engineering Workshops

Purpose: The purpose of these workshops is to review the evaluations completed for One WTP vs. Two, and Value Engineering; and discuss, receive feedback, and agree on the recommendations that will be taken forward for Schematic Design. More specifically, the questions that need to be answered as an outcome of the workshop are:

<u>One WTP vs. Two</u>

- How many WTPs should be built?

<u>Value Engineering</u>

- Do CH2M HILL's recommendations provide YG with what they want?
- Are there viable options to optimize the recommendation to obtain better value for YG?

Agenda

8:30 a.m. – 9:00 a.m.	**Introductions and Safety Moment** (Lawrence Benjamin)
9:00 a.m. – 9:30 a.m.	**Agenda Review and Goals for Workshop** (Lawrence Benjamin)
9:30 a.m. – 9:40 a.m.	**Break**
9:40 a.m. – 12:00 p.m.	**One WTP vs. Two** (Raymond Chin) a. Presentation by CH2M HILL i. Background ii. Basis for comparison iii. Discussion of alternatives iv. Cost estimate for alternatives v. Noneconomic considerations vi. Recommendations b. Discussion with YG c. Confirmation of recommendations
12:00 p.m. – 1:00 p.m.	**Lunch at CH2M HILL/General Discussion**
1:00 p.m. – 3:00 p.m.	**Value Engineering** (John Herbert) a. WTP sizing and overall configuration b. Redundancy c. Use of Faro Pit for storage d. Constructability
3:00 p.m. – 3:10 p.m.	**Break**
3:10 p.m. – 5:00 p.m.	**Value Engineering, continued** (John Herbert) e. Level of automation f. Number of operators g. Items agreed upon

Day 3 – October 18, 2012

Schematic Design Workshop

Purpose: The purpose of this workshop is to obtain input from YG on preferences, requirements, and critical factors in the design of the WTP for the following aspects: Operations; Process; Instrumentation and Control (I&C); Architectural and Structural; Heating, Ventilation, and Air Conditioning (HVAC); Electrical; Site Civil; and Deliverables.

Agenda

8:30 a.m. – 9:00 a.m.	**Introductions and Safety Moment** (Lawrence Benjamin)
9:00 a.m. – 9:30 a.m.	**Agenda Review and Goals for Workshop** (Lawrence Benjamin)
9:30 a.m. – 10:30 a.m.	**Value Engineering, continue if needed** (John Herbert)
10:30 a.m. – 10:40 a.m.	**Break**
10:30 a.m. – 12:00 p.m.	**Overview** (Garry Ng) a. Project Overview b. Construction Schedule c. Four-Phase Delivery System d. YG's Critical Success Factors **Operations** a. Operating Season b. Operating Staff **Process** a. HDS Lime System b. WTP Facility: Three Main Areas c. Mechanical Equipment Selection Criteria d. Major Equipment Procurement e. Operation f. Winterization g. Preferred Equipment and Suppliers **I&C** a. Control Locations b. Controller Types c. Supervisory control and data acquisition (SCADA) system d. Programmable logic controller (PLC) e. Tag Numbering Scheme f. Computer-Aided Design (CAD) Tool Standards g. Network Communication Cabling Standards h. Report Generation i. Control/Viewing from Remote Site
12:00 p.m. – 1:00 p.m.	**Lunch at CH2M HILL/General Discussion**
1:00 p.m. – 4:00 p.m.	**Architectural and Structural** (Garry Ng) a. Exterior and Interior Treatment b. Rooms **HVAC** a. HVAC Concepts b. Preferred Equipment and Suppliers

Agenda

Electrical

a. Emergency Generator Power
b. Building and Site Security Alarms
c. Public Address System and Paging
d. Level of Site Lighting
e. Preferred Equipment and Suppliers

Site Civil

a. Client Drawing Standards
b. Environmentally Sensitive Areas
c. Road Access Requirements and Parking
d. Noise Issues
e. Winter Features

Client Technical Contacts

a. Existing Site Information
b. Local Officials

Deliverables

a. Drawings
b. Specifications
c. Contract and Bid Forms

4:00 p.m. – 5:00 p.m. **Other Business** (Lawrence Benjamin)

a. Review Comments on TM's
b. PDD Report

Water Treatment Plant Design – Influent Characterization/Plant Capacity Phasing
Faro Mine Remediation Project

PREPARED FOR: Government of Yukon

PREPARED BY: CH2M HILL Canada Limited

DATE: October 9, 2012

PROJECT NUMBER: 436662.13.PD.01

1. Introduction

The purpose of this technical memorandum (TM) is to present the current results of the influent characterization/ plant capacity phasing assessment being performed. This work relies on ongoing modelling work that continues after the submission of this TM. Further updates will be presented at an upcoming workshop with the Government of Yukon (YG). This TM is part of a series of TMs under the Task Authorization 013 work program. The other TMs include the following:

- *Faro WTP Design Definition – One versus Two Plant Comparison Faro Mine Remediation Project* (One versus Two WTPs, TM2), September 4, 2012
- *Faro WTP Design Definition – Plant Siting, Faro Mine Remediation Project* (Alternative Site, TM3), October 3, 2012
- *High-density Sludge Treatment Pilot Testing Report* (TM4), in preparation
- *Faro WTP Design Definition – Procurement and Construction Contracting Plan Faro Mine Remediation Project* (Procurement and Contracting Plan, TM5), September 21, 2012

This TM is organized as follows:

- Section 1 describes the TM's purpose.
- Section 2 provides a summary of the recommendations from the other TMs.
- Section 3 provides a description of the High-density Sludge (HDS) process and key design parameters.
- Section 4 describes other factors to consider for determining plant capacity needs and phasing.
- Section 5 describes the current predictions of future water treatment needs.
- Section 6 presents interim pilot test results.
- Section 7 presents estimated equipment sizes based on each water quality pilot tested and for a range of flows.
- Section 8 presents cost estimates developed to date for various plant sizes and for alternatives with and without filters, as well as for new influent, effluent, and sludge disposal pipelines.
- Section 9 provides interim recommendations for plant capacity and phasing for discussion at the water treatment plant (WTP) workshop to be held in Vancouver, British Columbia, October 16–18, 2012.

2. Results of Related Tasks

2.1 One versus Two WTPs

This TM evaluated the merits of building and operating separate WTPs (one on the Faro side of the Faro Mine Complex (FMC) and one on the Grum/Vangorda side) against construction and operation of a single WTP with a cross-site pipeline to transfer water from Vangorda/Grum to the Faro plant. The two options were evaluated on the basis of life-cycle cost and noneconomic technical factors. The life-cycle cost of the single plant with cross-site pipeline is approximately 3 to 5 percent lower than for two WTPs.

The noneconomical evaluation ranked the single plant with cross-site pipeline with a significantly higher score than the two separate plants because it offered a simpler system with decreased mechanical complexity, easier operation, less maintenance, and less compliance monitoring and reporting.

2.2 Plant Siting Study

This TM evaluated three candidate sites to locate the consolidated Faro WTP:

1. Near the existing Faro Mill
2. The BXL site on the east end of the Tailings Area, as identified in the *Faro Mine Complex, Closure and Remediation Plan, Project Description – DRAFT 4A* (SRK, 2010)
3. A gravel pit borrow area northwest of the Cross Valley Dam (CVD)

Overall, the site near the Faro Mill was selected as the best site for economical and technical reasons. This site has the best location for long-term operations and already has significant supporting infrastructure to facilitate more economical and rapid construction of the new plant. This site also provides the lowest life-cycle cost, even when extra costs to pump influent water from the Intermediate Dam (ID) Pond and from the future Down Valley Seepage Collection wells are considered.

2.3 Pilot Testing

Pilot testing of the HDS process, the process to be used for the new WTP, was performed at the site in August and September 2012. The results provide important insight into the sensitivity of treatment equipment sizing with respect to influent quality. A pilot test report is being prepared. Interim results are discussed in Section 6.

2.4 Procurement and Contracting Plan

The purpose of this TM is to evaluate procurement and construction issues for the WTP, and to prepare a procurement and construction contracting plan. A schedule was developed considering timeframes needed for contracting as well as the constraints posed by the Faro-area climate. Initial site clearing and preparation is scheduled for late summer of 2013 to facilitate completion of critical earthwork and subsurface construction and construction of the process building during the 2014 construction season. The balance of the plant construction, consisting primarily of mechanical and electrical work, would occur during the 2015 construction season. The plant would be ready for startup and commissioning in fall 2015.

3. Summary of Treatment Process and Design Parameters

3.1 Process Selection

YG selected the HDS lime treatment process, with filtration (sand filters) for suspended solids polishing, as the preferred method for treatment of mining-influenced water at the FMC (SRK, 2010). YG has also determined that the sludge created by the HDS process is to be pumped into Faro Pit for disposal.

3.2 High-density Sludge Process Description

Several similar configurations have been developed to densify metals precipitation sludges, but CH2M HILL Canada Limited (CH2M HILL) routinely uses the original HDS configuration and nomenclature that was first developed by Bethlehem Steel Corporation in 1967. Figures 1 and 2 show a process bock flow diagram and process flow schemantic for the HDS process, respectively.

The HDS process is a modification of conventional lime treatment that uses a high degree of sludge recycle to an additional small, mixed, sludge conditioning reactor (A Reactor), where lime is mixed with recirculated sludge solids before introducing them to the mining-influenced water in a larger, mixed and aerated, neutralization and oxidation reactor (B Reactor). This configuration precipitates metals as (oxy)hydroxides directly onto the lime-coated solids, yielding larger and denser sludge particles. The HDS process relative to conventional lime treatment provides the following advantages:

- It produces larger and denser solids particles that settle faster.
- It produces thicker settled sludge, typically 20 to 30 percent solids or greater (versus 1 to 3 percent solids for conventional lime treatment).
- It yields much lower waste-sludge volumes, frequently less than one-tenth of the sludge volume produced by conventional lime treatment.
- It produces free-draining sludge that dewaters more quickly and thoroughly, often to greater than 40 percent solids.
- It is resistant to scaling (e.g., from gypsum).
- It improves filter performance and operability.

FIGURE 1
HDS Process Block Flow Diagram
Faro Mine Remediation Project

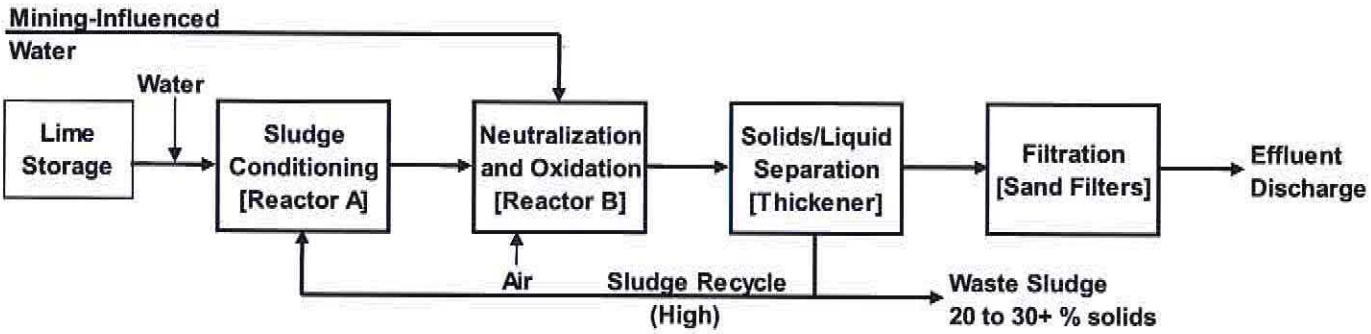
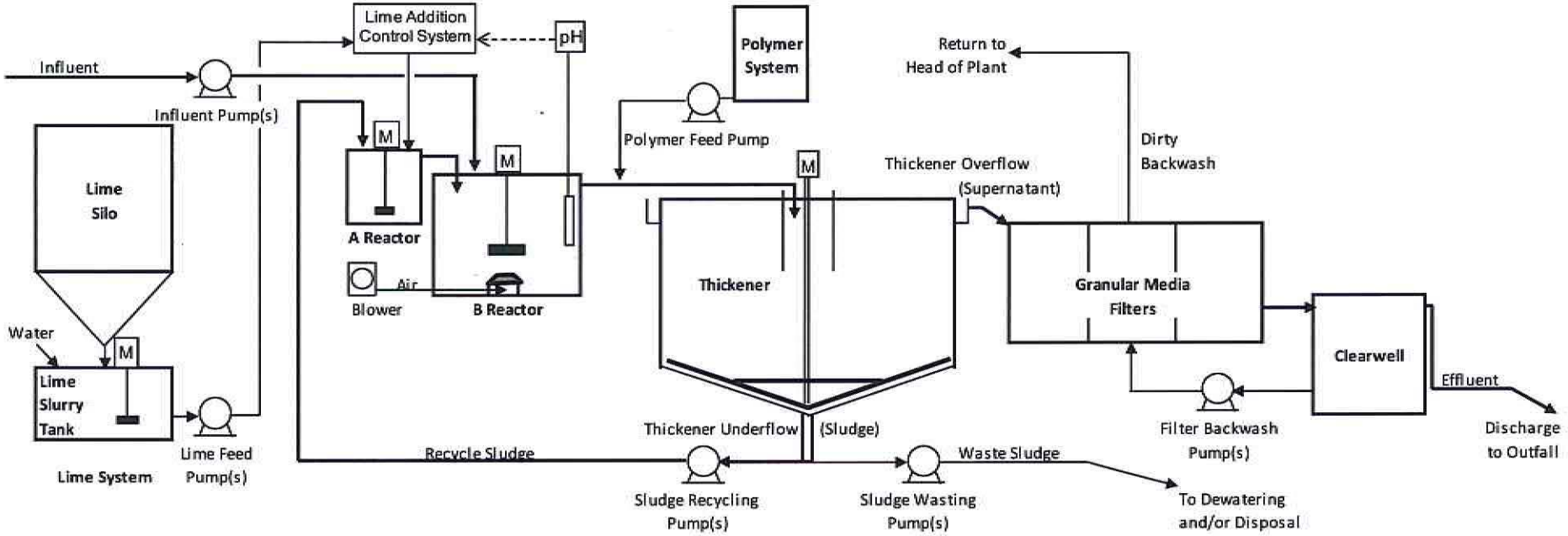


FIGURE 2
HDS Process Flow Schematic
Faro Mine Remediation Project



3.3 Key Process Design Considerations

The key to the HDS process is that instead of being added to the mine water, lime slurry is contacted with recirculated thickener underflow sludge in a sludge reaction and conditioning tank (A Reactor) where the lime adheres to the recirculated sludge particles. The lime-treated sludge overflows to a neutralization and oxidation reactor where it is contacted with incoming mine water. In this process, precipitates form preferentially on the surface of the lime-coated sludge particles rather than as freely nucleating solids. Numerous recirculations of the sludge particles result in the growth of larger and denser particles, which enhances its settling rate and dewaterability compared to those formed by conventional lime neutralization. Combining recirculated sludge with lime in a separate reactor is a key modification that produces a higher-density sludge.

A principle HDS process consideration is the amount of sludge to recirculate to A Reactor. Enough solids must be recirculated to provide sufficient particle surface area for the adherence of the lime. If there is insufficient particle surface area, the non-adhered portion of the lime will cause free nucleation of a floc-like precipitate rather than precipitation on the lime-coated sludge particles. Free nucleation forms a less dense sludge because these newly created precipitates are generally smaller, less dense, and have more waters of hydration than the typical HDS particles.

Solids recycle ratio (SRR), is commonly used to describe the mass of sludge solids recirculated relative to the mass of solids that would form in the absence of sludge recirculation. SRR is defined as the dry weight of sludge solids being recirculated divided by the dry weight of new sludge solids being created during the same period because of the incoming mine water and the addition of lime. The required SRR will vary, depending on the characteristics of the water being treated, but it typically is within the range of 10:1 to 50:1. Smaller SRRs are typically associated with higher-strength waters and particularly those having higher mineral acidity and higher concentrations of sulphate, such as significantly in excess of about 2,000 milligrams per litre (mg/L). This is because, under these conditions, the sulphate in excess of about 2,000 mg/L is precipitated as gypsum, which is a very good adsorber of lime in the A Reactor. Gypsum is readily formed because of crystalline growth processes encouraged by the HDS process.

If the SRR is too low, the HDS process will not be optimized because the solids surface area in the A Reactor will not be sufficient to adsorb the lime, resulting in formation of non-HDS particles in the B Reactor and a larger final sludge volume to dispose of.

If the SRR is too low, the recycle pumps and pipes must be bigger and more power would be used. A typical design approach is to use variable-speed pumps and one or more recycle pipes to allow a range of recycle rates to accommodate a range of influent water strengths. Pilot test results show that an SRR between 16:1 and 40:1 would be required, depending on the strength of water to be treated. This is discussed in more detail in Section 6.

The thickener can be considered the "heart" of the HDS process. The thickener settles suspended solids, producing an overflow suitable for discharge or filtration, and it removes excess water from the settled solids so they can be efficiently pumped to the A Reactor or to final disposal. Sizing of the thickener must consider these two functions. Too small of a thickener will result in higher than desirable solids in the overflow water or too much water in the underflow sludge, leading to a larger volume of sludge to dispose of. Sizing for sludge thickening is based on the floor area needed to thicken a given amount of solids per unit of time, such as square metres of floor area needed per tonne of solids entering the thickener per day (m^2/tonne/d). Sizing for solids settling is based on the hydraulic retention time (HRT) (the average time that water stays in the thickener). It is often the case that the area needed for sludge thickening is greater than the area needed for solids settling (assuming the same depth of tank). This is the case for the FMC, as demonstrated by the recent HDS pilot testing. It is often the case that HDS particles thicken more efficiently when they contain a higher proportion of gypsum to metal (oxy)hydroxides. This is also the case for the FMC, as discussed in Section 7.

Thickener mechanisms are very reliable and rarely fail if properly maintained. Because of this success rate, redundant thickeners are seldom used. Thickeners are expensive given their size, especially if they must be covered, such as at FMC. Thus, it is most cost-effective to meet treatment requirements by using a single thickener. This also precludes the need to split flow between thickeners, thereby simplifying operations.

As described previously, the two HDS reactors serve fundamentally different purposes and are sized accordingly. An A Reactor can be small because the adsorption of lime onto the surface of the recirculated sludge happens very quickly. An HRT of less than 5 minutes is often used. Longer HRTs are not detrimental to the lime adsorption process, but they reduce the responsiveness of the pH control process in a B Reactor because of the longer time needed for a lime addition change to propagate through the A Reactor into the B Reactor. An HRT of 4 minutes is under consideration for the Faro HDS plant.

An A Reactor is a relatively small tank and requires much less mixing energy than a B Reactor; thus, costs considerably less. An A reactor performs well over a wide range of HRTs because of the very quick kinetics of lime adsorption onto the sludge. The quick kinetics allows a single size of reactor to be used for a wide range of sludge recycle and lime feed rates. Thus, the cost of an A Reactor is a relatively small part of overall plant costs.

The B Reactor needs to be sized to provide enough time to allow complete precipitation for oxidation of reduced iron and manganese. Experience shows that an HRT of between about 20 and 40 minutes is required; 30 minutes is suitable for most water. The flow rate of mine water typically controls HRT, because mine water flow is greater than the recycled sludge flow. An HRT of 20 minutes can sometimes be suitable, especially for lower-strength water if the tank contents are sufficiently agitated. A total HRT of 30 minutes is under consideration for Faro, split between two B Reactors at 15 minutes each and operating in series.

Although not required for good HDS process performance, the use of two B Reactors has several benefits to the use of one B Reactor:

- It provides a level of redundancy
- It improves pH control and oxidation
- It requires a lower building ceiling height

However, use of two B reactors is more costly to construct and operate than a single, larger reactor. A single reactor can be used if necessary.

Media (sand) filters are required to remove residual suspended solids and their associated metal from thickener overflow water. Filter sizing is performed based on a hydraulic loading rate, cubic metres per square metre per hour ($m^3/m^2/h$ *or* m/h). The appropriate rate is a function of the type of media used in the filter, the nature of the solids being filtered, and how efficient the filtration must be to meet discharge limits. CH2M HILL experience has shown that HDS solids filter better than simple lime neutralization solids because of their larger size and the reduced amount of occluded water. Hydraulic loading rates of 10 to 12 m/h (4 to 5 United States gallons per minute per square foot [USgpm/ft^2]) provide very good results. Use of a relatively deep bed (approximately 2 metres [m]) of monomedia sand for the filter media provides excellent filtration efficiency. CH2M HILL is considering 10 m/h (4 USgpm/ft^2) for the Faro filtration system hydraulic loading rate as well as 2 m of monomedia sand.

The cost of a media filtration system is largely driven by the flow rate of water to be treated, because filter area is proportional to filter flow rate. Thus, the filtration equipment cost is insensitive to influent water strength, similar to the cost of B Reactors.

3.4 Key Influent High-density Sludge Design Parameters

This section describes the following five key influent water parameters whose characteristics must be known for HDS plant design:

1. Maximum flow rate
2. Maximum lime demand
3. Maximum solids formed
4. Maximum oxygen demand
5. Specific constituent concentrations

The maximum flow rate to be treated is a basic design requirement and controls B Reactor and filtration system sizing, as discussed previously. An understanding of lesser influent flow rates is also needed for selection of

chemical feed equipment (e.g., lime and polymer) and to determine how the SRR may vary. In general, HDS plant unit operations are very flexible and operate well at flows significantly less than the maximum design flow (they have considerable" "turndown capacity"). An exception to this general rule is the filter system. As discussed previously, the filters are designed for a specific hydraulic loading rate. Although there is some operational flexibility, it is important that a sufficient number of filters be operational for the flow to be filtered.

Lime demand is defined as the mass of lime (calcium hydroxide) needed to treat a volume of water. Units of gallons per litre (g/L) or pounds per thousand gallons are often used. While calcium oxide (quicklime) is the type purchased for Faro, calcium hydroxide is the type used for this parameter because it is fed into the A Reactor. In HDS plants, calcium oxide is slaked into a calcium hydroxide slurry that is stored in a mixed feed tank. Lime slurry is pumped from this tank through a recirculation loop, from which a portion is drawn off and fed to A Reactor. Multiplying the maximum lime demand by the maximum influent flow rate determines the size of lime system needed for pH control. The number of days needed for onsite lime storage determines the size of the lime silo.

Solids formed is defined as the mass of solids created from treatment of a unit volume of influent, as previously described. Combined with maximum flow rate and SRR, solids formed sets the size of the sludge recycle system and controls thickener sizing for a given thickener unit area requirement.

Oxygen demand controls the amount of air needed to in the B Reactors to oxidize ferrous iron (the predominant form of iron in Faro WTP influent). Manganese also has an oxygen demand and needs to be considered, although, currently, there is no treatment requirement for manganese. Maximum oxygen demand is determined by multiplying the maximum influent flow rate by the associated maximum ferrous iron and manganese concentrations as well as their respective oxygen requirements. The maximum oxygen demand is then used to specify the maximum oxygen transfer rate needed in the B Reactors. This, in turn, sets the size of the aeration blowers and reactor sparge caps, and it affects mixer impellor selection.

The concentrations of specific constituents in the influent, such as cadmium, iron, sulphate, and zinc, are important to understand for several reasons (ferrous iron, manganese and sulphate, have already been discussed). The concentrations of all constituents of environmental concern are important for comparison to treatment requirements and especially related to pH control (for removal of dissolved metals) and filter sizing (for removal of suspended solids in thickener overflow). The specific blend of constituents also has a role in removal of some metals by co-precipitation.

4. Other Considerations

4.1 Operational Season

The HDS plant will be designed for a 5-month operational season, from May to September, in accordance with YG direction. This provides reduced operations and maintenance costs and avoids the challenges of cold weather operations.

The Faro Pit provides a large storage volume to collect year-round influent sources (e.g., seepage interception system [SIS] water) during nonoperational periods.

Because the WTP would operate only 5 out of 12 months, the required plant treatment capacity is increased by a factor of 2.4 (12/5) relative to a plant that operates year round.

4.2 Role of Faro Pit Storage

The storage volume in Faro Pit is sufficient for storage during the non-operational season of a given year and storage of influent from one year to the next. This would allow the peak WTP size to be reduced. For example, if there is a year of extraordinarily high precipitation, the plant would not have to treat all of that year's water; the excess could be stored in Faro Pit for treatment the next year. However, this means a greater volume for treatment in the subsequent year.

The storage volume, elevation, and refined operation for the pits were not originally included in the GoldSim Model provided by YG; this component is now being created. Also, actual historical precipitation data from the

Faro Airport weather station was not previously considered; this is now being analyzed for the impact on storage. Detailed results are not yet available.

Monthly precipitation data from 1978 to 2011 is available for the Faro Airport, which is located at a lower elevation than the FMC. The correlation between Faro Airport precipitation and FMC precipitation is currently being updated but expected to be 7 to 10 percent higher than the Faro Airport according to previous developed correlations (AECOM, 2009). From the historical precipitation data, the year 1991 represents the highest annual precipitation value (441 millimetres [mm]). One preliminarily finding is that a WTP sized for approximately 38 megalitres per day (ML/d) (approximately 7,000 USgpm), would be required to treat influent resulting from precipitation in 1991 (this makes the conservative assumption of no carryover of collected flows in the Faro Pit). This provides an example of how annual differences in precipitation can alter treatment volume requirements.

4.3 Role of Water Treatment Plant in Site Care and Maintenance

The Faro WTP is envisioned to be the future centre of site long-term care and maintenance (C&M), similar to the role currently played by the Guardhouse, with the addition of being a centralized control facility for site-wide automated systems. It is also expected that other required site support facilities would eventually be constructed near the WTP, such as a worker's change and shower facility, lunch room, meeting room, laboratory, office space, storage buildings, and shops. The WTP will likely also be the centre of site communications.

Although these facilities and systems eventually will be needed, they are not required as part of initial WTP construction, because the existing facilities are still viable. Currently, it is planned to include a unisex bathroom, a small break room, and a small laboratory for performing plant process control tests. The other facilities and plant areas would be added later, as site remediation progresses.

4.4 Evolution of Source Water Qualities

The quantity and quality of water needing treatment will vary over time and by water source. Considerable assessment of this has been performed in the past and will be performed in the future. There is inherent uncertainty regarding these types of predictions because of many complex factors that cannot be accurately measured or projected into the future. This is why the GoldSim Model uses a statistical and stochastic approach to predict future seepage and receiving water quality (Gomm, 2010). However, it is generally accepted that seepage water quality from many locations around the FMC will worsen over time (as will groundwater, which is influenced by seepage water), such as the Rose Creek Aquifer below the CVD.

CH2M HILL is refining the GoldSim Model to prediction future water quality and support remedial decision making and remedial design. This work is described in the *Water Modelling Work Plan, Faro Mine Remediation Project* (CH2M HILL, 2012a). This work is ongoing and is expected to continue well beyond the current schedule for WTP influent characterization to support design. A draft TM, dated August 17, 2012 (CH2M HILL, 2012b) presented interim GoldSim Model analysis in support of the Faro WTP design. This information has been considered, along with more recent GoldSim Model results after additional updates and improvements to the model. It is important to emphasize that the GoldSim Model is still evolving and being updated to accommodate the logic necessary to perform more detailed analysis like the one related to storage versus WTP capacity mentioned in Section 4.2. Despite the current updates and anticipated future improvements, the model still has limitations. Thus, GoldSim Model results of future water treatment needs are being considered with appropriate engineering judgment.

One use of the GoldSim Model has been to help identify the water quality to be tested in the HDS pilot study. Figure 3 in the *Interim Water Modelling Analysis in Support of the Faro Water Treatment Plant Design, Faro Mine Remediation Project* (CH2M HILL, 2012b) shows modelled iron, sulphate, and zinc concentrations in WTP influent from 2010 through 2210. These results were from the "as-received" model provided to CH2M HILL. A maximum concentration of sulphate near 8,000 mg/L was indicated, along with nearly 700 mg/L of zinc and 1,000 mg/L of iron. These results provided the rationale for pilot testing the worst-case water evaluated in pilot test system HDS-3, which consisted of water from the Emergency Tailings Area (ETA) SIS. HDS-1 was run on water simulating the current water being treated at the Faro Mill WTP. HDS-2 was run on water expected to be about midpoint in strength between HDS-1 and HDS-3. The revised and updated model is now predicting lower constituent concentrations, which are discussed in Section 5. Interim results of HDS pilot testing are provided in Section 6.

4.5 Timing of Remedial Actions and Treatment Needs

Two other important factors having considerable uncertainty but a great influence on the quality and quantity of water to be treated are the timing for implementing remedial actions and their effectiveness. These factors are also incorporated into the GoldSim Model. Tables 1-1, 1-2, and 1-3 in Attachment 1 list the years in which each remedial action is assumed to be implemented. Each of these actions influences the quality of water to be treated. The overall modelled impacts of the remedial actions on WTP influent flow rate and quality is discussed in Section 6. The implementation of the covers will reduce flows to the WTP and reduce concentrations. The implementation of collection systems will increase WTP flows and, in general, concentrations. Those two activities happen in different years of the first 20 years of the simulation. After that, all the planned covers and collection systems are assumed to be in place, and changes in flows and water quality are related only to changes in waste rock dump (WRD) chemistry and precipitation.

4.6 Discharge Requirements – Current versus Future

The current lime treatment plant at Faro Mill WTP is regulated by Yukon Water Board Licence QZ03-059 (see Attachment 2). Although this water licence expired in February 2009, the standards stated therein are still in effect. It is expected that this licence will continue to apply to the newly constructed HDS plant until a new water licence is issued. The timing of the new water licence is uncertain, but it could be in effect within 10 years. Table 1 summarizes the effluent quality standards in Water Licence QZ03-059.

TABLE 1
Summary of Effluent Quality Standards in Water Licence QZ09-059
Faro Mine Remediation Project

Parameter	Standard
Suspended Solids	≤ 15 mg/L
pH	≥ 6.5 pH units
Colour	≤ 20 Pt-Co units
Turbidity	≤ 15 NTU
Ammonia (as N)	≤ 1.30 mg/L
Antimony	≤ 0.10 mg/L
Arsenic	≤ 0.05 mg/L
Barium	≤ 1.0 mg/L
Cadmium	≤ 0.02 mg/L
Copper	≤ 0.20 mg/L
Cyanide	≤ 0.05 mg/L
Lead	≤ 0.20 mg/L
Mercury	≤ 0.005 mg/L
Molybdenum	≤ 0.50 mg/L
Nickel	≤ 0.50 mg/L
Selenium	≤ 0.05 mg/L
Silver	≤ 0.10 mg/L
Zinc	≤ 0.50 mg/L

Notes:

≤ = less than or equal to
≥ = greater than or equal to
Pt-Co = platinum colour unit
N = nitrogen
NTU = nephelometric turbidity unit

The discharge limitations that will be specified in a future water licence for the site are unknown at this time. They may be more stringent than those in the existing licence. Some insight on future water licence may be inferred by the clause in the current licence stipulating that "the long term water quality in Rose Creek, downstream of the tailings facilities shall comply with the *Canadian Water Quality Guidelines for the Protection of Aquatic Life.* (CWQGPAL), prepared by the Canadian Council of the Ministers of the Environment, 1999, updated 2001."

Table 2 summarizes some of the relevant effluent quality parameters in the current CWQGPAL guidelines (Canadian Council of the Ministers of the Environment [CCME], 2007).

TABLE 2
Summary of Effluent Quality Standards in CWQGPAL
Faro Mine Remediation Project

Parameter	Guideline
Suspended Solids, mg/L	–
pH, pH units	6.5 to 9.0
Colour, Pt-Co units	–
Turbidity, NTU	–
Aluminum	0.10[a]
Ammonia (unionized), mg/L	0.019
Antimony, mg/L	–
Arsenic, mg/L	0.005
Barium, mg/L	–
Cadmium, mg/L	0.000017[b]
Copper, mg/L	0.002 to 0.004[b]
Cyanide, mg/L	0.005
Lead, mg/L	0.001 to 0.007[b]
Mercury, mg/L	0.000026
Molybdenum, mg/L	0.073
Nickel, mg/L	0.025 to 0.15[b]
Selenium, mg/L	0.001
Silver, mg/L	0.001
Thallium	0.0008
Zinc, mg/L	0.030

[a]For pH greater than 6.5

[b]Hardness dependent

In general, the standards in the CWQGPAL are stringent and would represent the extreme case of maximum stringency in a new licence. These CWQGPAL values apply to a point downstream from the discharge point, after effluent has mixed with and been diluted by Rose Creek water.

Other recently completed closed mine sites using the HDS process, such as the Britannia Mine, have permits that are more similar to the existing FMC licence requirements than the CWQGPAL standards.

4.7 Availability and Timing of Funding and Water Treatment Plant Phasing

The initial WTP capacity constructed may be limited by the availability of funding. The availability of funding may also limit when parts of the treatment system can be constructed. These limitations will affect how the WTP is phased over time. The following attributes present options for staged phasing at the Faro WTP:

- Plant capacity
- Addition of filters

- Addition of site-related facilities previously described (such as the shop and worker change/shower room)
- Replacement pipelines (influent and effluent)

Plant capacity could generally be phased providing an initial capacity (Phase 1) and adding additional capacity in the future (Phase 2). Phase 2 could be implemented by either increasing the size of Phase 1 piping and equipment, or by adding a second and parallel treatment system (train). An in-between approach could also be used whereby some of the initial Phase 1 equipment may be sized to treat the projected Phase 2 flow when it can be done cost-effectively and then adding the balance of the required piping and equipment as Phase 2 is implemented.

The addition of filters could be accomplished by using the same phased approach as for plant capacity. It is also possible to delay addition of filters to a "Phase 1b," which would occur when the new water licence is acquired. Under this scenario, the WTP would discharge into the Cross Valley Pond (CVP), as currently done by the Faro Mill WTP, to settle residual suspended solids before discharge via siphon over the CVD through Monitoring Station X5.

The addition of the other site-related facilities could be performed any time after Phase 1 construction. The timing of this is more dependent on site C&M needs and when the existing facilities are to be replaced. However, it is important that planning of how these facilities would be added is considered during Phase 1 design. This can be done via preparation of an overall WTP master plan to confirm sufficient space requirements are considered as well as the location of utilities.

One advantage of constructing the WTP at the Mill Yard is accessibility to the existing influent and effluent piping. These can be readily tied into to route Intermediate Pond (IP), Faro Pit, and ETA water into the new plant, and to send effluent to the CVP. At some point in the future, new pipelines may be constructed, which could be buried or placed on the surface similar to the existing lines.

5. Prediction of Future Treatment Needs

The Faro Mill WTP has a capacity of about 27 ML/d (5,000 USgpm). The new WTP, at a minimum, should have this much capacity. The CVD SIS is expected to generate, on average, about 6.5 ML/d (1,200 USgpm), which will be a year-round flow. This equates to about 15.5 ML/d (2,900 USgpm) over a 5-month treatment season. This water will be considerably more dilute than the blend of waters currently treated at the Faro Mill WTP. The current timing of CVD SIS startup is within about 10 years. A date of 2022 is used in the current GoldSim Model. The other SIS systems will generate considerable less flow but will have more concentrated water than the CVD SIS.

The tables in Attachment 1 summarize the assumed timing of the remedial actions used in the GoldSim Model. The first set of WRD covers are shown as occurring in 2023, with all covers in place by 2031. The tailings cover is shown as being installed in 2027. Treatment of Grum/Vangorda-area water, if done in a single plant, is not expected to occur until 2021 or 2022 at the earliest. Reconstruction of the Faro Creek Diversion is shown as occurring in 2022. This may reduce seepage into Faro Pit if the new diversion can be made more watertight.

The effect of climate change on annual volumes requiring treatment is currently being evaluated. Various climate prediction models suggest that the Faro area may experience an increase of 20 to 30 percent in annual precipitation over the next 30 years. This would increase the volume to be collected and treated.

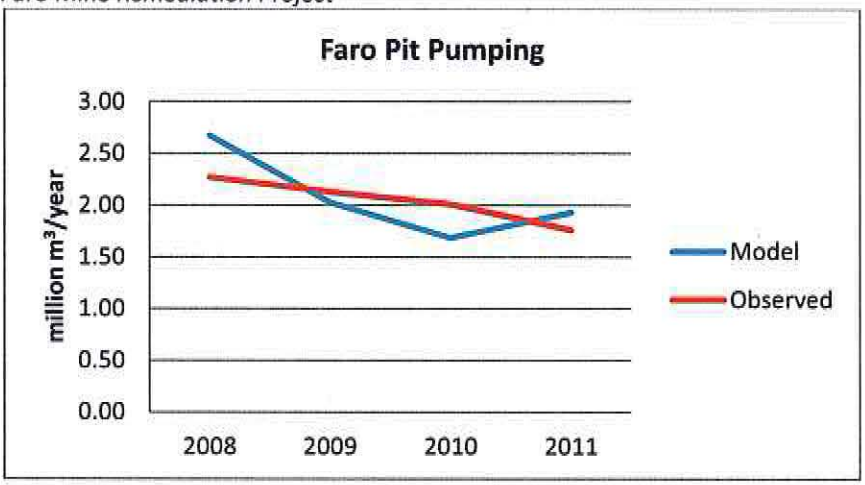
Section 4 described the uncertainty associated with predicting future treatment requirements. This section discusses the current thinking on future treatment requirements based on the anticipated timing of future remedial actions and the most recent GoldSim Model results. This section is not intended to provide a full description of the GoldSim Model, because that is beyond the scope of this TM and because the model will be refined over the next several months.

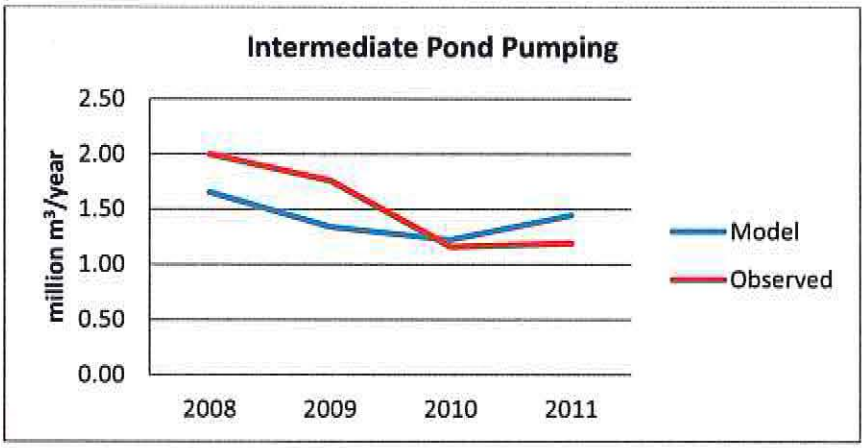
5.1 Maximum Water Treatment Plant Influent Flow Rate Capacity

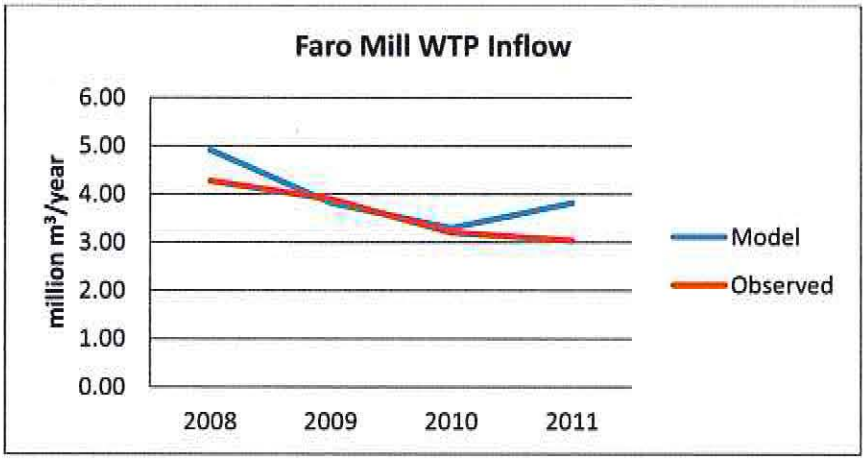
Figure 3 shows how the current model (Version 0926012) with historical precipitation data and proportional adjustment to flows at the site calibrated against the last 4 years of site operation. Figure 3 shows total annual volumes pumped from the Faro Pit, ID Pond, and the total volume treated in the Faro Mill WTP. The observed

volumes were reported in the *2011 Annual Monitoring Report* (Deninson Environmental Services [DES], 2012). The model matches the actual volumes fairly well. Work is ongoing to refine model results.

FIGURE 3
Comparison of GoldSim Model to Actual
Faro Mine Remediation Project







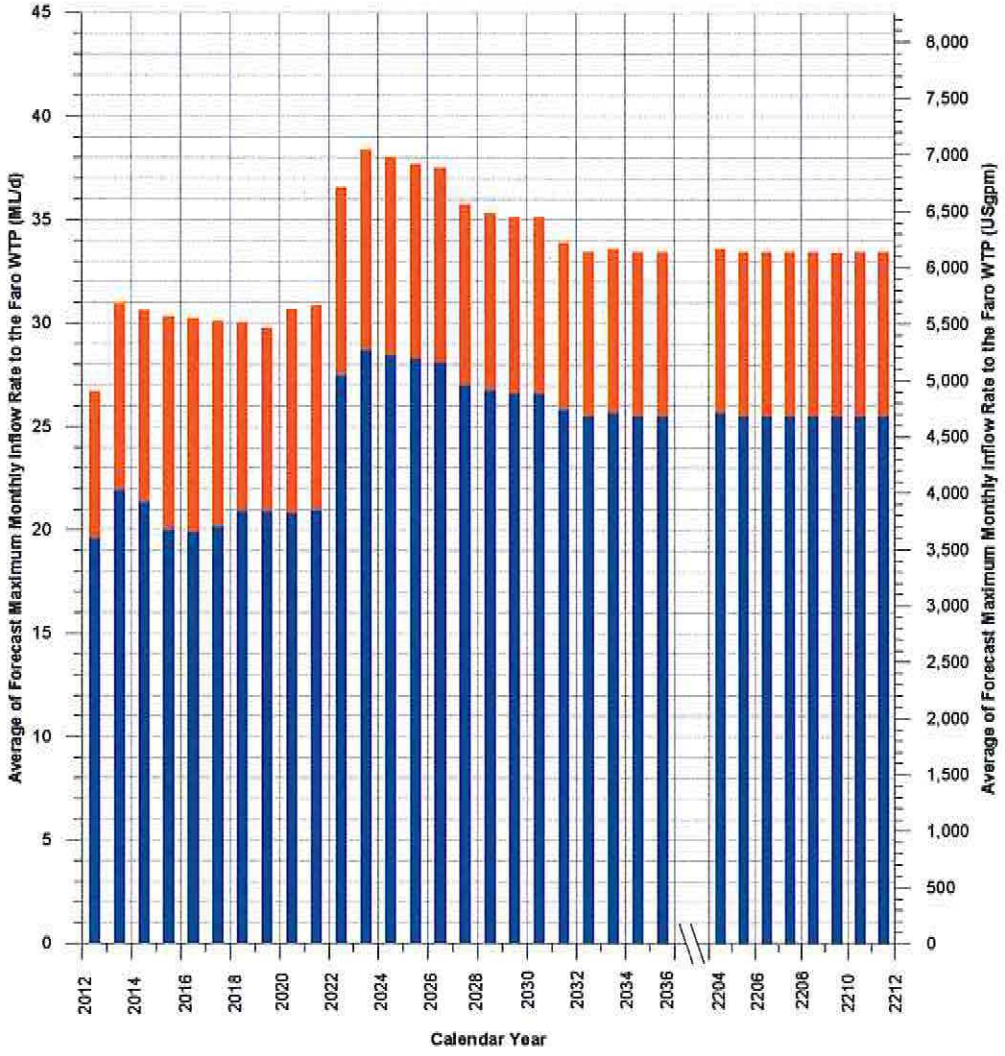
Figures 4 and 5 show results of the modelled average 5-month annual WTP influent flow rates for two WTPs (Scenario 1) or a single WTP (Scenario 2). For Scenario 1 the model assumes that two plants are in operation from time zero (2012). Scenario 2 assumes a single plant is in operation from time zero. These plots show predicted maximum values from Version 09262012a (Case A) and Version 0962012b (Case B). Case A uses the fixed annual precipitation rate of 357 millimetres per year and the associated mean annual runoff values used within the original model provided to CH2M HILL. Case B uses the annual precipitation recorded at the Faro Airport in 1991, which was then adjusted up by 25 percent. A previous report (AECOM, 2009) estimates the precipitation at the FMC is between 7 and 10 percent higher than Faro Airport. The extra 15 percent has been added as a calibration value to the current model to better match observed site flows with a model results from a run that uses observed precipitation. It is noteworthy mention that The Faro Airport had several missing data months since 2006, and the missing monthly precipitation values were replaced by long-term monthly averages that could be significant lower than the actual values. Case B is considered to represent the upper range of what may occur, because 1991 has the highest precipitation over the period of record (1978 to 2011).

For a point of comparison for Figure 4, the actual average 5-month flow rate needed to treat Faro Mine Area water between 2008 and 2011, as reported in the 2001 Environmental Monitoring Report (DES, 2012), was about 23 ML/d (4,300 USgpm).

Common assumptions for both versions include the following:

- Faro Creek leaks at an average rate of 20 percent into Faro Pit. This leakage does not stop when the diversion is reconstructed.
- Leakage from the Rose Creek Diversion is fixed at 5 percent.
- Treatment of water from the Down Valley Tailings SIS begins in 2022 and is expected to be close to 6 ML/d (1,100 USgpm).
- Treatment of ID Pond water stops in 2027 when the cover system is placed on the tailings.
- Annual ETA collection efficiency is 70 percent until 2020, then increases to greater than 99 percent when the collection system is improved.

Figures 4 and 5 suggest that the maximum influent capacity needed for a Faro WTP under Scenario 1 (two WTPs) is between about 29 ML/d and 39 ML/d (5,300 and 7,100 USgpm) (see Figure 4), and between about 33 ML/d and 43 ML/d (6,000 and 7,900 USgpm) for Scenario 2 (single WTP; see Figure 5). In the figures, the low end of each range is the highest value of the blue bars, and the upper end is the highest value of the orange bars. These capacities assume that Faro Pit is used to equalize flow throughout the 5-month treatment season. These maximum rates are predicted to occur soon after the Down Valley Tailings SIS system becomes operational (assumed to be in 2022) and are predicted to continue until 2027 when the tailings are covered. After that, flows are expected to drop further in response to placement of covers on the WRDs. It is important to note that the current model assumes all water currently being treated from the ID Pond can be discharged to Rose Creek with no treatment after the cover is in place. This assumption was in the model received by CH2M HILL and needs to be evaluated because some portion of this water may actually need treatment, and if so, would increase the required WTP size.

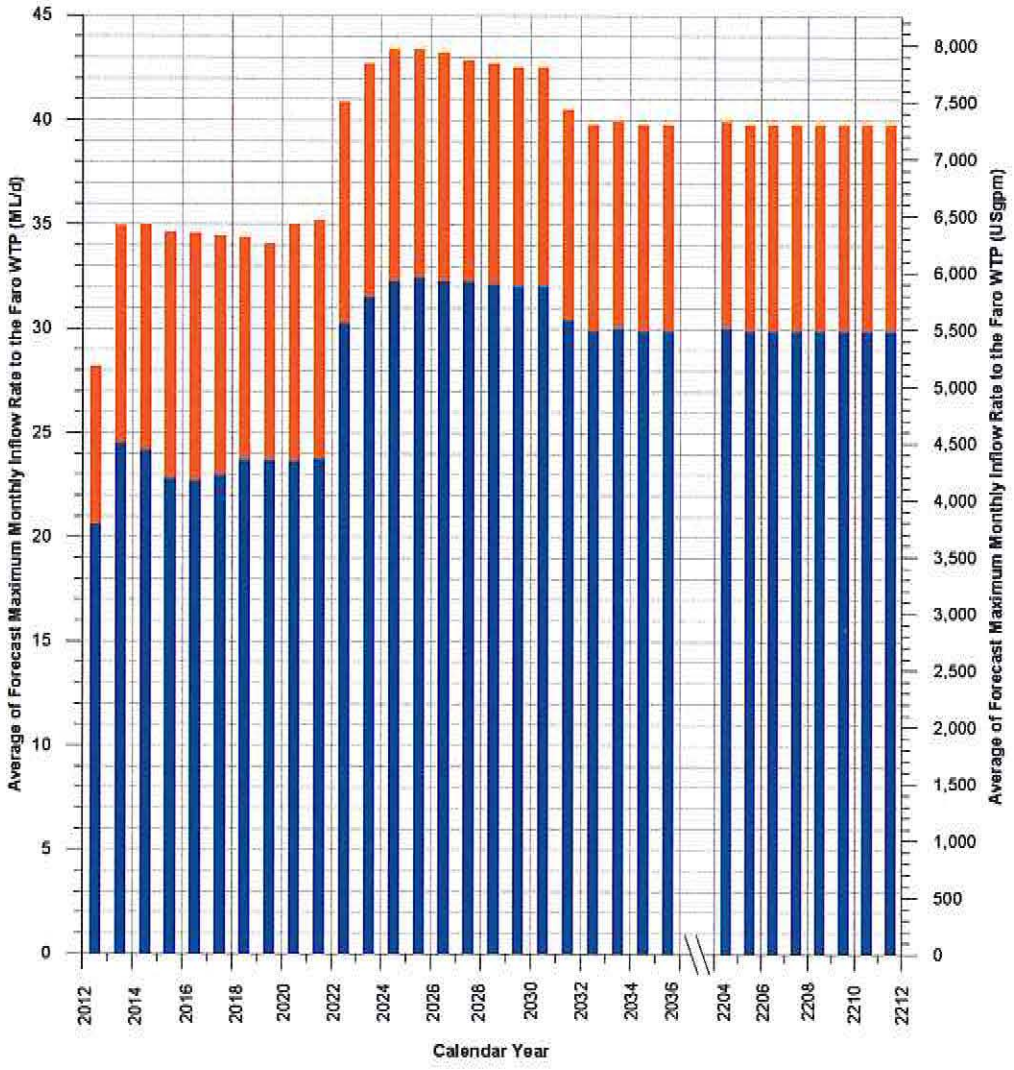


Notes:

1. Plotted values represent the average of maximum monthly values during the five month treatment season from the 25 stochastic realizations that were forecast with the GoldSim Model.
2. The break in the x-axis is included because the forecast monthly inflow rates to the Faro WTP do not change substantially after Calendar Year 2035.

FIGURE 4
Average of Forecast Maximum Inflow Rates to the Faro WTP - Scenario 1 Faro Mine Remediation Project

CH2MHILL



Legend

Case A

Case B

Notes:

1. Plotted values represent the average of maximum monthly values during the five month treatment season from the 25 stochastic realizations that were forecast with the GoldSim Model.
2. The break in the x-axis is included because the forecast monthly inflow rates to the Faro WTP do not change substantially after Calendar Year 2035.

FIGURE 5
Average of Forecast Maximum Inflow Rates to the Faro WTP - Scenario 2
Faro Mine Remediation Project

C:\Data\Yukon Government\014227\Faro\Graphics\Modeling\Phase1_WTP_Design_TM\Figures\2RPAverage_Inflow_Figs\FaroWTP_Avg_Inflows_Scenario2.gif

CH2MHILL.

5.2 Maximum WTP Influent Water Quality

Figures 6 and 7 show predicted concentrations of iron, sulphate, and zinc in Faro WTP influent over time. Figure 6 is for Version 09262012a (Case A), and Figure 7 is for Version 09262012b (Case B). Both sets of plots suggest the highest concentrations occur about year 2080, after water quality worsens from consumption of available waste material alkalinity. In the nearer term, concentrations are predicted to drop in response to more efficient collection of ETA water and the dilution effect caused by the startup of the Down Valley Tailings SIS. Over the next 30 years, sulphate is expected to range between about 200 and 1,800 mg/L for both Scenario 1 and Scenario 2. Zinc is predicted to vary between about 20 and 300 mg/L and iron between about 10 and 250 mg/L. The wide range results from the many combinations evaluated by stochastic simulations.

The next section discusses the pilot test interim results and average concentrations of iron, sulphate, and zinc in the three test waters.

6. Pilot Test Interim Results

The pilot testing program operated three pilot-scale HDS plants treating the following three water strengths:

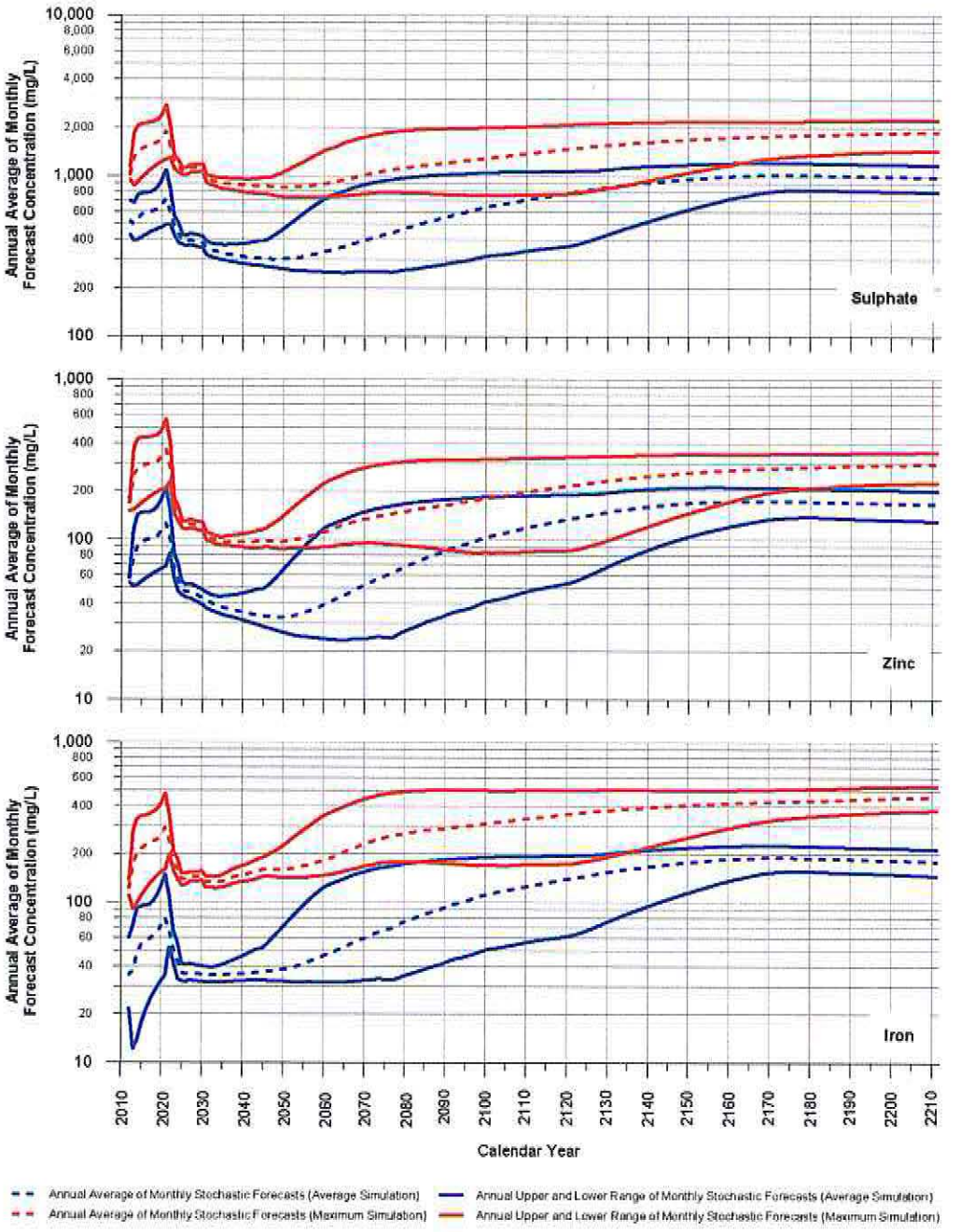
- The current strength of Faro Mill WTP influent water (HDS-1)
- The potential maximum strength influent water represented by ETA water; this represents a future worst-case scenario predicted by the GoldSim Model received by CH2M HILL (HDS-3)
- Water strength about midway between HDS-1 and HDS-3 based on constituent concentrations, such as sulphate, iron, and zinc (HDS-2)

The pilot plants were not operated with filters because their small size does not produce sufficient effluent water to evaluate filtration effectiveness. CH2M HILL evaluates filtration needs by using pilot test results in consideration of with previous project experience. Thus, during pilot testing, emphasis is placed on determining attainable dissolved metal concentrations.

The effluent water quality for dissolved metals obtained from all three waters met the existing water licence requirements. When operating at a higher pH of 10.2, the effluent dissolved metal concentrations for HDS-1 met the more stringent CCME guidelines for most metals (2007), with the possible exception of cadmium (depending on the interpretation of the cadmium guideline value, which varies with hardness). Final effluent results for HDS-2 and HDS-3 are pending, as are HDS-1 results using sulphide addition.

Full-scale HDS plants typically perform as well or better than the pilot plants for similar influent quality. The reactors and clarifiers typically work better at full-scale than at pilot-scale.

Filtration may not be necessary for the initial plant implementation to meet the discharge criteria under the existing water licence, as discussed in Section 4.

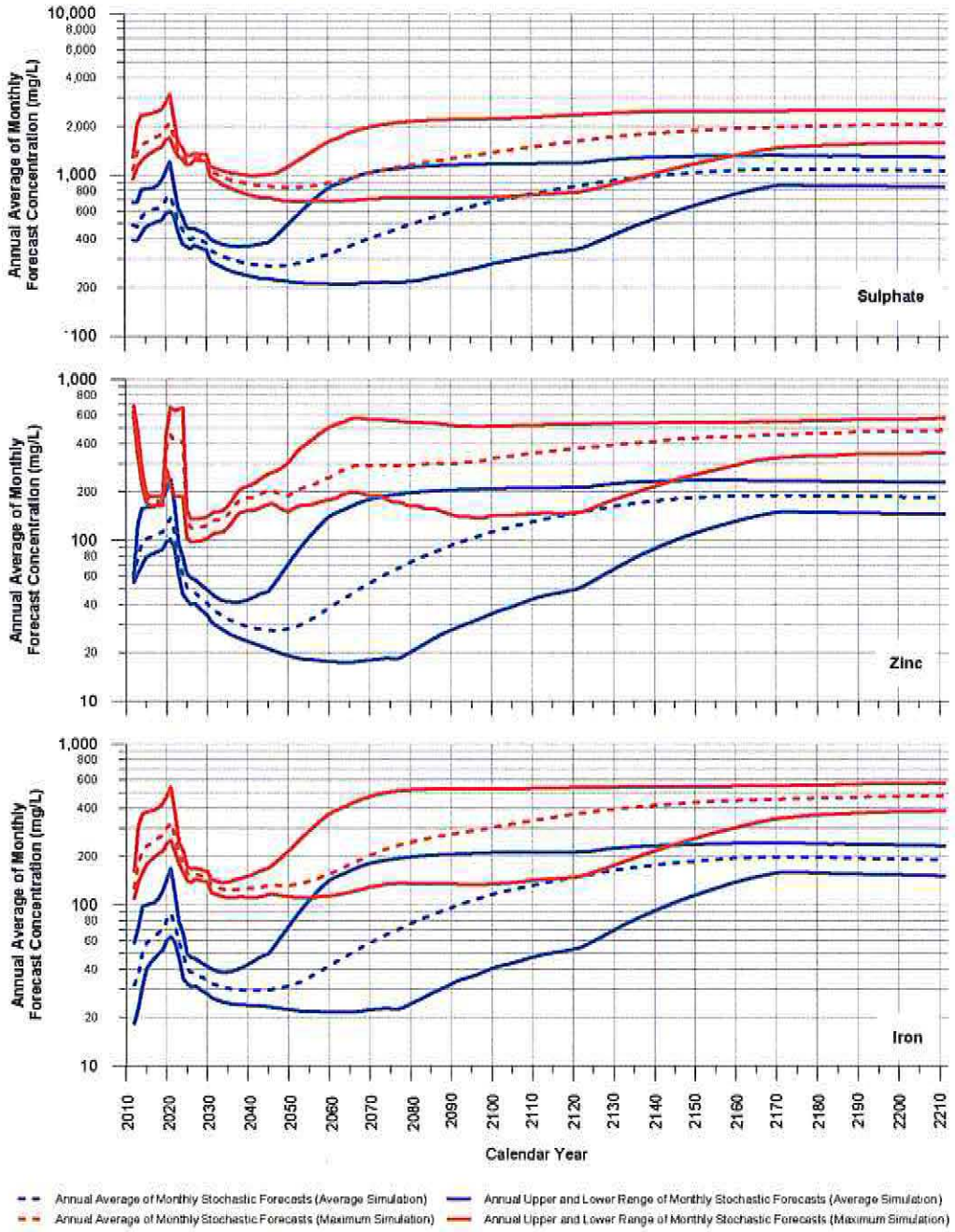


Note:

1. "Average Simulation" refers to use of average values of historical seepage constituent concentrations as input to the GoldSim Model, whereas "Maximum Simulation" refers to use of maximum values for this purpose
2. Annual average forecast concentrations are based on monthly forecasts from May through September of each Simulation (Calendar) Year because these are the months of assumed operation of the Faro WTP in the GoldSim Model.

FIGURE 6
Forecast Influent Concentrations of Selected Constituents to the Faro WTP Under Case A Scenario 1 Assumptions
Faro Mine Remediation Project

CH2MHILL



Note

1. "Average Simulation" refers to use of average values of historical seepage constituent concentrations as input to the GoldSim Model, whereas "Maximum Simulation" refers to use of maximum values for this purpose.
2. Annual average forecast concentrations are based on monthly forecasts from May through September of each Simulation (Calendar) Year because these are the months of assumed operation of the Faro WTP in the GoldSim Model.

FIGURE 7
Forecast Influent Concentrations of Selected Constituents to the Faro WTP Under Case B Scenario 1 Assumptions
Faro Mine Remediation Project

CH2MHILL.

Table 3 summarizes some of the results that most affect equipment sizing. These are preliminary results; data validation is in progress.

TABLE 3
Preliminary Pilot Test Results
Faro Mine Remediation Project

Parameter	Average Result		
	HDS-1	HDS-2	HDS-3
Influent pH	5.6	5.1	4.8
Influent Sulphate (mg/L)	1,040	3,470	7,040
Influent Dissolved Zinc (mg/L)	48	301	591
Influent Dissolved Iron (mg/L)	17	181	471
Lime Demand, Calcium Hydroxide (g/L)	0.18	1.00	2.08
Solids Formed (g/L)	0.23	1.39	3.46
SRR (X:1)	40	20	16
Sludge Percent Solids (wt%)	20	25	30
Thickener Unit Area Requirement (m^2/tonne/d)	2.6	1.7	1.0
Thickener Unit Area Requirement (ft^2/t/d)	24.9	16.3	10.0

Notes:

g/L = grams per litre
wt% = percent weight

The pilot plant sludge generation was within the range expected. HDS-1 reached a thickener underflow solids concentration of approximately 20 wt%; HDS-2 and HDS-3 reached about 25 and 30 wt%, respectively.

A 40:1 SRR was effective for HDS-1; an SRR of 20:1 was needed for HDS-2 and 16:1 was needed for HDS-3. The reason for the lower SRRs needed for HDS-2 and HDS-3 is because these influent waters were stronger and contained sufficient sulphate to precipitate gypsum, which densifies well within the HDS process, as previously described.

Thickener unit area requirements decreased as influent strength increased, similar to the SRRs. This decreases thickener size, as does lower SRRs. An important finding is that even though HDS-2 and HDS-3 influent waters were considerably stronger than HDS-1 water, their required thickener sizes are not much greater than HDS-1 because their SRRs and thickener unit area requirements are lower. This will be discussed further in the Section 7.

7. Preliminary Water Treatment Plant Component Sizing for Pilot Plant Test Waters – HDS-1, HDS-2, and HDS-3

Preliminary sizing of major WTP components has been performed over a range of assumed maximum influent flow rates for each water quality pilot tested. This was done to assess how sensitive sizing is to influent flow rate and strength. The results are summarized in Table 4.

TABLE 4
Preliminary Major Component Sizing
Faro Mine Remediation Project

	Units	HDS-1 Water Quality[a]				HDS-1.5 Water Quality[a]				HDS-2 Water Quality[a]				HDS-3 Water Quality[a]			
Influent Flow Rate	ML/d	27	33	38	44	27	33	38	44	27	33	38	44	27	33	38	44
	USgpm	5,000	6,000	7,000	8,000	5,000	6,000	7,000	8,000	5,000	6,000	7,000	8,000	5,000	6,000	7,000	8,000
A Reactor																	
Diameter	m	1.5	1.7	1.8	1.8	2.0	2.1	2.3	2.4	2.1	2.4	2.5	2.3	2.5	2.7	2.8	3.0
Sidewall Height	m	2.5	2.6	2.7	2.8	2.9	3.1	3.2	3.3	3.2	3.3	3.4	3.3	3.5	3.6	3.7	3.9
Liquid Volume	m^3	2.9	3.7	4.3	4.9	6.4	7.7	9.0	10.3	7.7	9.3	10.8	12.3	12.6	15.2	17.7	20.2
B Reactor (each of two)																	
Diameter	m	7.5	8.0	8.4	8.8	7.6	8.1	8.5	8.9	7.6	8.1	8.5	8.9	7.8	8.2	8.7	9.1
Sidewall Height	m	8.7	9.2	9.6	10.0	8.8	9.3	9.7	10.1	8.8	9.3	9.7	10.1	9.0	9.5	9.9	10.3
Liquid Volume	m^3	328	394	460	526	341	410	478	546	346	416	485	554	365	439	512	585
Thickener																	
Diameter	m	29	32	34	36	44	48	52	55	41	45	49	52	46	50	54	58
Sidewall Height	m	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Liquid Volume (excludes cone)	m^3	2,778	3,334	3,890	4,446	6,417	7,700	8,983	10,267	5,727	6,873	8,018	9,164	6,999	8,399	9,799	11,199
Filters																	
Filter Total Area	m^2	144	172	201	230	145	174	203	232	146	175	204	233	149	178	208	238
Lime System																	
Feed Rate (quicklime)	t/d	3.7	4.4	5.2	5.9	12	15	17	20	21	26	30	34	43	51	60	68

[a]HDS-1, HDS-2, and HDS-3 water quality was pilot tested. HDS-1.5 water quality was not pilot tested. HDS-1 component sizing performed by interpolating between pilot test results for HDS-1 and HDS-2.

Note:

t/d = tonnes per day

The following are conclusions from the information presented in Table 4:

- A Reactor size increases as influent flow rate and strength increases, but its size is small compared to the B Reactor, and the differences in the required A Reactor size will not significantly affect overall plant cost.
- B Reactor size increases primarily as a function of influent flow rate rather than strength. Thus, a B Reactor sized for a specific flow will accommodate a wide range of influent strength.
- Thickener size increases as a function of influent flow rate and strength, but the required diameter varies over a fairly narrow range. Diameters between 29 and 59 m span the entire range of all influent flow rates and strengths considered, and diameters between 29 and 51 m span the range needed for HDS-1 and HDS-2.
- Filter area increases primarily as a function of influent flow rate rather than influent strength.
- Lime system size increases as a function of flow rate and strength.

In summary, component size is driven more by maximum influent flow rate than strength. Although the size of the A Reactor and the lime system are driven by rate and strength, the size of the B Reactors and filters are controlled by influent flow rate. Thickener size is affected by both, but the size range is not overly large for the full span of flow rates and water qualities.

8. Interim CH2M HILL Parametric Cost Estimating System Estimates

Order-of-magnitude, Association of the Advancement of Cost Engineering Class 4 capital cost opinions have been developed for several possible treatment plant influent flow rate capacities and strengths. This has been done to assess the sensitivity of capital cost for these two important plant sizing factors. These opinions have been developed using CH2M HILL's Parametric Cost Estimating System (CPES) tool, which is a proprietary, firm-wide conceptual cost estimating tool. The purpose of CPES is to generate quick, detailed cost opinions at the conceptual stage of a project, before design work begins. The system contains many "mini-models" or cost estimates of facilities that are based on real projects. These mini-models have relationships (or algorithms) built into them that allow the system to adjust their costs based on project-specific information. Conceptual designs are used to support CPES. These have been developed using the pilot test results and CH2M HILL's proprietary HDS plant sizing tool. Tables 5 and 6 summarize these estimates. Costs have not been escalated to the expected midpoint of construction. Costs in Tables 5 and 6 include connecting to the existing pipelines from the IP, Faro Pit, and the ETA. They also include costs to construct the sludge disposal pipeline to Faro Pit.

It is important to emphasize that these cost opinions are budgetary in nature and, as such, are suitable for budget planning only. Cost opinions are nonbinding and are provided for discussion and planning purposes. The cost opinions provided have been prepared to guide project evaluation of the information available at the time of preparation and the current level of project definition. The actual cost of the project will depend on the level of definition required, selected scope of work, actual labour and material costs, competitive market conditions, schedule implementation, and other variable factors. Therefore, the final project costs will vary from the opinions presented in this TM. Project feasibility and funding needs must be carefully reviewed prior to making specific financial decisions related to proper project evaluation and adequate funding.

TABLE 5
WTP Cost Opinions for Pilot Plant HDS-2 Influent Strength
Faro Mine Remediation Project

HDS Plant Capacity	With or Without Filters	Assumed Influent Strength	$ Million (Canadian)
27 ML/d (5,000 USgpm)	With	HDS-2	51
	Without	HDS-2	38
38 ML/d (7,000 USgpm)	With	HDS-2	59
	Without	HDS-2	43

Table 6 summarizes cost opinions for plants ranging between 27 and 44 ML/d, if filters are included or not, and for an influent strength estimated to be approximately midway between pilot test HDS-1 and HDS-2 strengths (referred to as HDS-1.5). Costs for this strength of water were developed because it appears that HDS-2 water is overly strong to use for a WTP design basis, particularly for the next 30+ years, as can be seen by comparing Table 3 sulphate, zinc, and iron values to Figures 6 and 7.

TABLE 6
WTP Cost Opinions for HDS 1.5 Influent Strength
Faro Mine Remediation Project

HDS Plant Capacity	With or Without Filters	Assumed Influent Strength	$ Million (Canadian)
27 ML/d (5,000 USgpm)	With	HDS-1.5	51
	Without	HDS-1.5	38
33 ML/d (6,000 USgpm)	With	HDS-1.5	56
	Without	HDS-1.5	40
38 ML/d (7,000 USgpm)	With	HDS-1.5	58
	Without	HDS-1.5	42
44 ML/d (8,000 USgpm)	With	HDS-1.5	63
	Without	HDS-1.5	45

Figure 8 shows the relative cost of major WTP components as a function of flow rate for HDS-1.5 water quality. All component costs essentially vary linearly in proportion to flow rate. The apparent break from linearity for the filter system is due to how the CPES model calculates required filter area (it assumes that an even number is required). An odd number of filters could be constructed. The same size lime system is assumed for each WTP size. This is a good assumption because costs for lime systems do not vary appreciably with respect to capacity over the range being evaluated.

The two most costly components, by a significant degree, are the thickener and the filter system. The next most costly are the B Reactors. Costs for the chemical feed systems (lime and polymer) are significantly lower. The cost of the A Reactor is the lowest.

Because of the relatively high costs associated with the thickener, it is most cost effective to install a single thickener rather than two smaller ones for the same are requirements, particularly in the size range needed for the new Faro WTP. It would also be most cost effective to install a single thickener sized to accommodate all anticipated future treatment needs rather than to add a second unit as part of a later Phase 2 upgrade.

Filters are much more modular and lend themselves more readily to phased implementation than thickeners. For this reason, adding a second set of filters as part of a Phase 2 upgrade would defer significant capital expense, especially if Phase 2 occurs far enough in the future to allow appreciable net present value (NPV) savings.

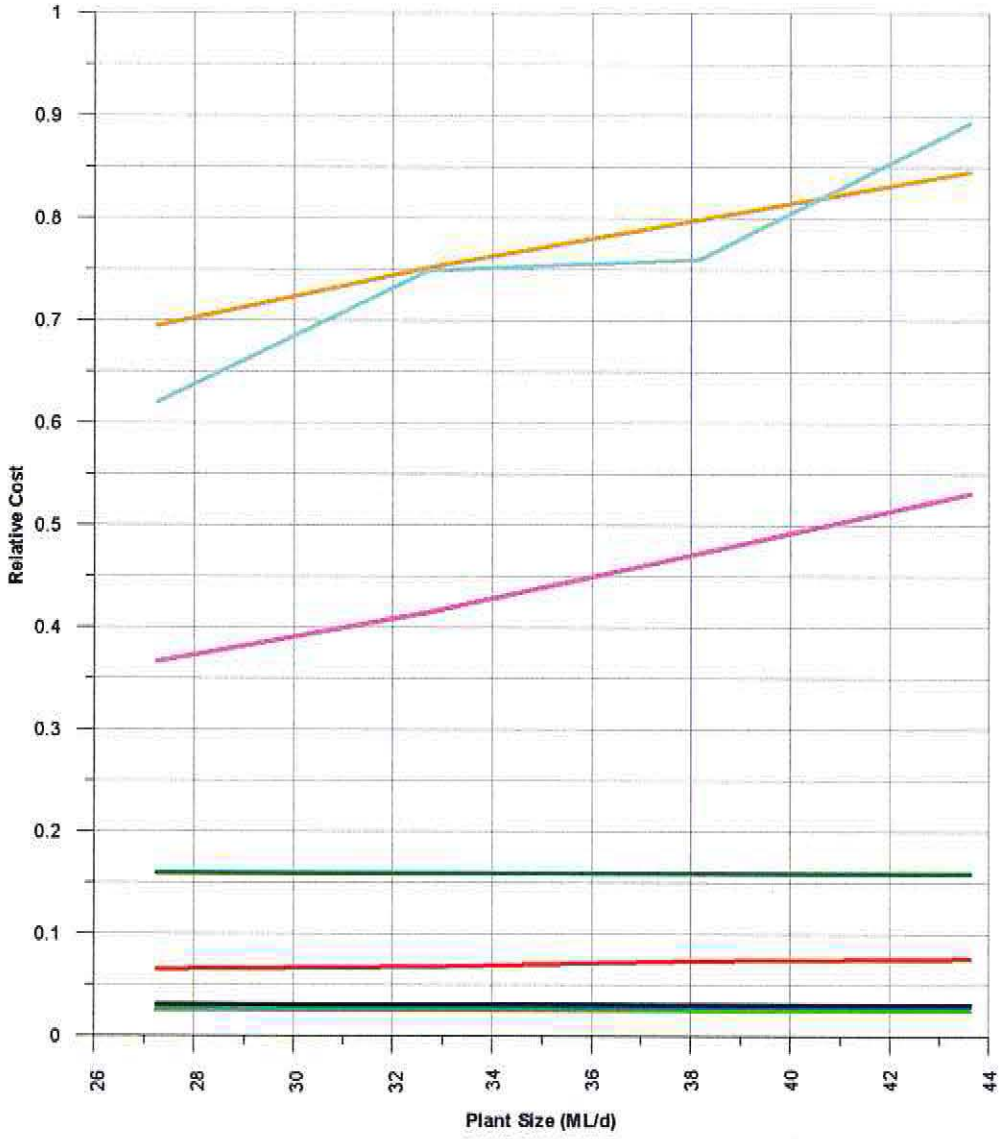


FIGURE 8
Relative Cost of Project Facilities
Faro Mine Remediation Project

\\Oakproj\Yukon Government\064262\Faro\Groundwater\Modeling\Phase1_WTP_Design_TM\Figures\GIS\WTP_Capital_Costs.gpf

CH2MHILL.

9. Interim Water Treatment Plant Capacity and Phasing Recommendations

This section presents interim conclusions and recommendations for Faro WTP plant capacity and phasing based on the current results of the WTP design task and the ongoing development of the GoldSim Model. Further updates will be presented at an upcoming workshop with YG.

9.1 Maximum Influent Flow Rate

It is recommended that the maximum influent design flow rate be sufficient to accommodate the following:

- Existing Faro Mine Area water treatment needs; this is about 23 ML/d (4,300 USgpm) based on the last 4 years of site operations
- Down Valley Tailings SIS water; this is about 15 ML/d (2,800 gpm) based on the current results of groundwater modelling
- Grum/Vangorda Area water treatment needs if a single WTP (Scenario 1) is selected; this is about 5.6 ML/d (1,000 USgpm) based on the current GoldSim Model and historical Vangorda Pit treatment volumes and Grum Pit fill rates

The rationale for including capacity to treat Down Valley Tailings SIS water is because there is considerable uncertainty as to when this SIS will need to be operational. Monitoring results suggest that the system may be needed sooner than the assumed 10 years (2022) used in the GoldSim Model. The current schedule for WTP construction is to have the plant operational by fall 2015 (3 years from now). If capacity for Down Valley Tailings SIS water is added later as a second phase of plant construction, work would need to begin in 2020 to have the plant ready by 2022. This would mean that there would only be 5 years from the end of the initial WTP to the start of construction of the upgrade. Considering NPV, the amount of money saved by deferring construction would likely be less than the extra costs incurred due to procurement and mobilization of a second contractor. Building Down Valley Tailings SIS capacity now also provides onhand capacity in case the Down Valley Tailings SIS needs to be operational sooner.

The recommendation to add sufficient capacity to accommodate Grum/Vangorda Area water treatment needs is contingent on the selection of Scenario 1. Currently, the earliest that such capacity is needed is 2021–2022. If this is the correct timeframe, then adding capacity as part of Phase 1 is likely more cost efficient then a second phase of construction for the same reason discussed for the Down Valley Tailings SIS.

In summary, the recommended maximum influent flow rate to use for WTP hydraulic design is 44 ML/d (8,000 USgpm) if the single WTP option is selected (Scenario 1). It is acknowledged that 44 ML/d is greater than the maximum predicted values of the current GoldSim Model, which is about 40 ML/d. As mentioned previously, the model is a work in progress and is being refined. Further refinement and a greater level of confidence in modelling results may provide justification to lower the recommended 44 ML/d design capacity.

9.2 Maximum Strength Influent Water

It is recommended that the maximum strength influent water be that of HDS-2. Although this appears to be conservative based on the current GoldSim Model predictions (see Figures 6 and 7), it has been shown that maximum influent flow rate affects WTP capital cost more than water quality. Use of HDS-2 water quality over HDS-1 water quality provides additional lime feed and solids handling capacity in case water quality becomes stronger than predicted.

9.3 Recommended Phasing Approach

It is recommended that the Faro WTP be implemented using the three phases of construction described in the following sections.

Phase 1: Initial Buildout

It is recommended that Phase 1 include construction of the following:

- 44 ML/d (8,000 USgpm) influent flow rate capacity
- HDS-1.5 water quality
- A single 55-m-diameter thickener
- A single A Reactor
- Two B Reactors providing a total of 30 minutes of HRT
- A single lime system
- No filters constructed at this stage but provision for future implementation
- Minimum support facilities

Construction of a single 55-m-diameter thickener is recommended because of the significant cost to add a second one. This size will accommodate virtually all foreseeable future needs. This size also precludes the need to split flow between thickeners, thereby simplifying operations. Experience has shown that thickener mechanisms are very reliable and rarely fail if properly maintained. Because of this success rate, redundant thickeners are seldom used unless required by either a lack of influent storage capacity or a critical demand placed on the discharge water.

Only a single A Reactor is needed for the HDS process. These reactors are small and have a low capital cost.

Two B Reactors sized to provide 30 minutes of HRT are recommended to provide a high degree of process performance, as well as operational flexibility. Having two allows one to be taken offline for maintenance while the other stays operational. Operating two in series also provides a better flow regime for pH control and oxygen transfer.

A single lime system should be installed and sized to accommodate the maximum lime demand. Sufficient silo capacity should be constructed to provide reasonable storage in the event of lime delivery interruption.

It is not recommended that filters be included in Phase 1, because of their significant cost and because they are not expected to be needed until after the new water licence is obtained, which may be 10 years from now. Until then, the CVP can provide residual settling of suspended solids. This recommendation assumes that the current discharge limits remain in force, and that they can be met without filtration. This is expected to be the case given the performance of the current treatment facility, which does not have filters, although it may be that the HDS plant needs to be operated at a lower SRR to obtain a low enough overflow total suspended solids to assure settling in the CVP. This would be assessed during plant commissioning.

It is recommended that no site-wide support facilities be constructed in Phase 1 and the existing facilities be used. It is also recommended that a unisex bathroom be a small laboratory to perform process-control-related tests, and a small break room be included in Phase 1. A plant control room would be included.

Phase 2: Addition of Filters

It is recommended that filters be added as a second phase of plant construction and after the new water licence is obtained, or when the requirements are known. This defers the filter-related costs and also provides time to obtain a better understanding of the updated treatment requirements, which will facilitate filter system design and equipment selection. Additional site support facilities could be constructed at the time the filters are added.

Phase 3: Required Upgrades Based on Long-term Operating Experience

Phase 3 of plant construction would occur in the more distant future, such as in 30+ years when more is known about maturation of waste rock and tailings seepage and its influence on treatment requirements. This phase would involve addition of a second lime system and a larger sludge recycle system. Additional sludge wasting capacity to Faro Pit may be needed as well, or the existing system could be operated for a longer duration each time sludge is wasted to the pit.

9.4 Other Recommendations

The following recommendations may influence selection of the Faro WTP influent design basis and how the plant is phased in over time:

- The GoldSim Model should continue to be refined and calibrated to increase its expected accuracy. Additional modelling should be conducted during the remainder of design definition to assess whether the recommended 44 ML/d (8,000 USgpm) maximum design influent flow rate should be modified. Reservoir analysis should also be conducted using historical precipitation records to assess the likelihood of year-to-year water carryover in Faro Pit.
- If constrained by funding, it is recommended that Phase 1 be reduced to a maximum influent flow rate of 27 ML/d (5,000 USgpm) and that additional capacity be deferred until funding is available. This flow rate essentially provides replacement capacity for the Faro Mill WTP. If this is done, it would be desirable to still construct a 55-m-diameter thicker, because the addition of a second thickener would be much more costly than construction of a single larger unit.

10. Works Cited

AECOM Canada Ltd., 2009. Faro Mine Complex Closure and Reclamation – Project Proposal Current Environmental Conditions Supporting Document. Prepared for Assessment and Abandoned Mines, Government of Yukon. AECOM Project Number 107403. March 2009.

Canadian Council of Ministers of the Environment (CCME). 2007. "Summary Table." *Canadian Water Quality Guidelines for the Protection of Aquatic Life*. Update 7.1. December.

CH2M HILL Canada Limited (CH2M HILL). 2012a. *Water Modelling Work Plan, Faro Mine Remediation Project.* Draft. Prepared for Government of Yukon. August 17.

CH2M HILL Canada Limited (CH2M HILL). 2012b. *Interim Water Modelling Analysis in Support of the Faro Water Treatment Plant Design, Faro Mine Remediation Project.* Technical Memorandum. Prepared for Government of Yukon. August 17.

Deninson Environmental Services (DES). 2012. *2011 Annual Environmental Monitoring and Activities Report, Faro Mine Complex*. Prepared for Yukon Government. February.

Gomm Environmental Engineering and Consulting (Gomm). 2010. *Faro Mine Complex Closure and Remediation, Site Wide Water Quality Model, Draft 1.* Prepared for Yukon Government, Assessment and Abandoned Mines. April 19.

SRK Consulting (SRK). 2010. *Faro Mine Complex, Closure and Remediation Plan, Project Description – DRAFT 4A.* Prepared for Yukon Government. March 29.

Attachment 1
Schedule of Remedial Actions

TABLE 1-1
Waste Rock Dump Cover Schedule
Faro Mine Remediation Project

	Waste Rock Dump Covers	Cover Implementation Year (0=2012)	Calendar Year
Faro Area			
FVN	Faro Valley North	19	2031
FVS	Faro Valley South	19	2031
MGSP	Medium Grade Stockpile	11	2023
CHSP	Crusher Stockpile	11	2023
OXSP	Oxide Fines Stockpile	11	2023
LGSPA	Low Grade Stockpile A	11	2023
NWU	Upper Northwest Dump	19	2031
NWM	Middle Northwest Dump	19	2031
NWL	Lower Northwest Dump	19	2031
MMW	Mt. Mungly West	13	2025
MME	Mt. Mungly East	13	2025
FTW	Fuel Tank Dump W	19	2031
FTE	Fuel Tank Dump E	19	2031
UPL	Upper Parking Lot Dump	19	2031
LPL	Lower Parking Lot Dump	19	2031
SBP	Stock Piles Base1	19	2031
SWPWD	Southwest Pit Wall Dump	13	2025
LGSPC	Low Grade Stockpile C	11	2023
MESC	Main East Sulphide Cell	12	2024
IDSC	Intermediate Dump Sulphide Cell	12	2024
RD	Ranch Dump RD	19	2031
RZD	Ramp Zone Dump	19	2031
MDW	Main Dump West	19	2031
MDE	Main Dump East MDE	19	2031
ID	Intermediate Dump	19	2031
OHRW	Outer Haul Road West	19	2031
OHRE	Outer Haul Road East	19	2031
NELS	Lower Northeast sulphide cell	12	2024
NEO	Outer Northeast Dump	19	2031
ZIIW	Zone II West	19	2031
ZIIE	Zone II East	19	2031
NEL	Lower Northeast Dump	19	2031
NEU	Upper Northeast Dump	19	2031

TABLE 1-1
Waste Rock Dump Cover Schedule
Faro Mine Remediation Project

	Waste Rock Dump Covers	Cover Implementation Year (0=2012)	Calendar Year
Vangorda/Grum Mine Area			
G1-S	Main dump Sulphide Cell	19	2031
G1-B	Main Dump	19	2031
G2	Southwest Dump	19	2031
G3-O	Overburden Dump	12	2024
V1-S	Main Dump Sulphide Cell	19	2031
V1-B	Main Dump	19	2031
V2	Barite Dump	19	2031
V3-O	Overburden Dump	19	2031
OTP		19	2031
VPL1		19	2031
VPL2		19	2031
VPL3		19	2031

TABLE 1-2
SIS Schedule
Faro Mine Remediation Project

		SIS Startup Year (0=2012)	Calendar Year
Faro			
DVT	DVT (Down Valley Tailings or Tailings SIS)	10	2022
RCV	Rose Creek Valley	N/A	N/A
X23	X23	8	2020
GHL	Lower Guard House	13	2025
GHU	Upper Guard House	N/A	N/A
NFRC/ZII	North Fork Rose Creek/ZII	10	2022
X2	X2	0	2012
Vangorda/Grum			
G2	Grum V8	N/A	N/A
GWRD	Grum Intercept	15	2027
VWRD	Vangorda Intercept	15	2027

TABLE 1-3
Other Time Sensitive Actions
Faro Mine Remediation Project

	Implementation Year (0=2012)	Calendar Year
DVT Cover Placement	15	2027
NFRC Lined	20	2032
Faro Creek Leakage Stopped (Only for Model Version 09172012)	10	2022

Attachment 2
Yukon Water Board Licence

YUKON WATER BOARD

Pursuant to the *Waters Act* and *Regulation*, the Yukon Water Board, hereinafter referred to as the Board, hereby grants to

Deloitte & Touche Inc.
(in its capacity as Interim Receiver of Anvil Range Mining Corporation)
Suite 1900, 79 Wellington Street West
Toronto, Ontario M5K 1B9

hereinafter called the Licensee, the right to use water and deposit a waste subject to the restrictions and conditions contained in the *Waters Act* and *Regulation* made hereunder and subject to and in accordance with the conditions specified in this licence.

Licence Number: QZ03-059 **Water Management Area:** 02 Yukon

Licence Type: A **Nature of Undertaking:** Quartz Mining

Water Sources: Rose Creek, Vangorda Creek, Little Creek Dam Pond, Faro Pit, Zone II Pit, Vangorda Pit, Grum Pit, Grum/Vangorda Freshwater Supply Pond.

Tributaries of: Pelly River

Minimum Latitude: 62° 14' 00" N **Maximum Latitude:** 62° 29' 30" N

Minimum Longitude: 133° 07' 30" W **Maximum Longitude:** 133° 32' 45" W

Purpose: To divert and alter a flow of water, store water, modify the bed and banks of a watercourse and deposit a waste.

Effective Date of Licence: The date that the signature of the Minister of the Executive Council Office is affixed.

Expiry Date of Licence: February 28, 2009

Dated this ___ day
of March, 2004.

YUKON WATER BOARD

_____
Witness

_____
Vice-chairperson

Approved this ___ day
of _____, 2004

_____
Witness

_____
Minister, Executive Council Office

PART A - GENERAL CONDITIONS

Definitions

1 a) "Act" means the *Waters Act* and any amendments thereto.

b) "Application" collectively means Water Use Application QZ03-059 and any additional submissions and/or revisions submitted to the Board by the Licensee up to the date of the Board's decision to issue this licence.

c) "Board" means the Yukon Water Board.

d) "Inspector" means any person designated as an Inspector under the Act.

e) "Regulation" means the *Waters Regulation.*

f) "Waste" means any substance defined in Section 2 of the Act.

g) "Dam Safety Guidelines" means the Dam Safety Guidelines issued by the Canadian Dam Association (1999) or its most recent revision.

Representations, Warranties and Undertakings

2. The Board has relied on the representations, warranties and undertakings provided by the Licensee in the material filed in the Application. Such representations, warranties and undertakings are considered by the Board to be a part of the licence, but shall be subject to, and may be modified by, the conditions of the licence.

3. Where there is a discrepancy between the Application and the conditions of this licence, the conditions of this licence shall prevail.

Other Uses

4. If, subsequent to the issuing of this licence, the Licensee uses water and/or deposits waste in one or more ways not authorized in this licence, and the combined effect of those uses and/or deposits of wastes, as determined by an Inspector:

a) has no potential for significant adverse environmental effects;
b) does not interfere with existing rights of other water users or waste depositors; and
c) satisfies the criteria set out in column 2 of Schedule 7 of the *Regulation*,

then no amendment to this licence will be required for that use of water and/or deposit of waste.

Other Laws

5. No condition of this licence limits the application of any other federal, territorial, first nation or municipal legislation.

6. All work authorized by this licence shall occur on property that the Licensee has the right to enter upon and use for that purpose.

Correspondence

7. Where any direction, notice, order, or report under this licence is required to be in writing, it shall be given:

   a) To the Licensee, if delivered, faxed or mailed by registered mail to the following address:

   Deloitte & Touche Inc.
   (in its capacity as interim receiver for Anvil Range Mining Corporation)
   Suite 1900, 79 Wellington Street West
   Toronto, Ontario M5K 1B9
   Fax: (416) 601-6390

   and shall be deemed to have been given to the Licensee on the day it was delivered or faxed, or seven days after the day it was mailed, as the case may be.

   b) To the Board, if delivered, faxed or sent by registered mail to the following address:

   Yukon Water Board
   Suite 106, 419 Range Road
   Whitehorse, Yukon Y1A 3V1
   Fax: (867) 456-3890

   and shall be deemed to have been given to the Board on the day it was delivered or faxed, or seven days after the day it was mailed, as the case may be.

Non-Compliance

8. In the event that the Licensee fails to comply with any condition of this licence, the Board may, subject to the *Act*, cancel the licence.

Deleterious Substances

9. Subject to the conditions of this licence, deleterious substances shall be used, transported, stored and disposed of in such a manner that they are not deposited in, or allowed to be deposited in, any waters.

Term of Licence

10. The term of this licence is from the effective date to February 28, 2009.

Reports

11. All monitoring data, reports, plans, studies, study results, designs or manuals required by this licence shall be submitted to the Board in an unbound printed form that is reproducible by standard photocopier and shall be accompanied by 5 copies.

12. All monitoring data, reports, plans, designs or manuals shall also be submitted in digital form, using an IBM compatible format that is readable using commonly available software.

Annual Reports

13. Annual reports shall be submitted to the Board by the Licensee. The reports shall cover the period from January 1 to December 31 of each year and shall be submitted to the Board on or before February 28 of the following year.

14. Annual reports shall include the information required by this licence and by the *Regulation*, including, but not necessarily limited to:

    a) summaries of all data generated as a result of the monitoring requirements of this licence, including analysis and interpretation by a qualified individual or firm and a discussion of any variances from base line conditions or from previous years' data; and

    b) a detailed record of any major maintenance work carried out or planned to be carried out that could have an impact on water.

Monthly Reports

15. Unless otherwise specified in this licence, the Licensee shall forward to the Board a copy of all data collected as part of the monitoring programs of this licence no more than 30 days after the conclusion of the month in which that data was collected.

Contingency Plans

16. No later than 30 days after the effective date of this licence, the Licensee shall submit contingency plans to the Board. The Licensee shall keep the plans current and shall submit any revisions to the Board within 10 days of the revision. The contingency plans shall include measures to address:

    a) fuel spills;

    b) pipeline breaks;

c) loss of electrical power;

d) pump failure;

e) loss of road access to the site; and

f) loss of communications to the site.

17. The Licensee shall immediately contact the 24-hour Yukon Spill Report telephone number (867) 667-7244 and implement the most recent spill contingency plan that has been filed with the Board, should a spill or an unauthorized discharge occur. A detailed written report on any such event, including but not limited to, dates, quantities, parameters, causes and other relevant details and explanations, shall be delivered to the Board not later than 10 days after its occurrence.

18. As part of the contingency plans, the Licensee shall submit a communication plan that addresses how communities and downstream water users will be notified of accidents, malfunctions and spills at the site.

Hazardous Materials Storage

19. A complete inventory of chemicals, fuels, oils, lubricants and other hazardous materials relating to the water uses authorized by this licence shall be maintained by the Licensee.

20. Hazardous materials, except for those required to operate and maintain equipment relating to the water uses authorized by this licence, shall be stored or transferred a minimum of 30 metres from any watercourse.

PART B - OPERATING CONDITIONS

21. Subject to the terms of this licence, the Licensee is hereby authorized to:

a) divert the flow of Rose Creek, Vangorda Creek, Little Creek, Faro Creek and Guardhouse Creek; and

b) obtain water at a maximum rate of 65,465 m^3/day from Rose Creek, including the Faro Main Pit and the Faro Zone II Pit; and

c) obtain water at a maximum rate of 19,930 m^3/day from Vangorda Creek, including the Vangorda Pit, the Grum Pit, the Grum/Vangorda freshwater supply pond, and the Little Creek Dam Pond; and

d) deposit Waste into Rose Creek and Vangorda Creek,

all as described in the Application, and subject to the terms and conditions of this licence. Where there is a discrepancy between the Application and this licence, the terms of this licence shall prevail.

22. Except as authorized by this licence, no Waste shall enter any watercourse as a result of any operation carried out by the Licensee.

23. Water shall be pumped from the Faro Main Pit if the water level in the pit is at or above elevation 1178.35 metres (mine datum).

24. Water shall be pumped from the Faro Zone II Pit if the water level in the pit is at or above 50.00 metres below ground level, as determined by the Licensee. The Licensee shall provide a description of the datum for ground level in the first annual report and this datum shall be used for all measurements relating to this clause.

25. Water shall be pumped from the Vangorda Pit if the water level in the pit is at or above elevation 1092.00 metres above sea level.

26. Water shall be pumped from the Little Creek Dam Pond as necessary to maintain the water level no less than 1 metre below the invert of the overflow structure.

PART C - EFFLUENT QUALITY STANDARDS

27. No waste discharge shall exceed the following limits:

Suspended Solids	not greater than 15mg/L
pH	not less than 6.5 pH units
Colour	not greater than 20 Pt-Co units
Turbidity	not greater than 15 NTU
Ammonia (as N)	1.30 mg/L
Antimony (Sb)	0.10 mg/L
Arsenic (As)	0.05 mg/L
Barium (Ba)	1.00 mg/L
Cadmium (Cd)	0.02 mg/L
Copper (Cu)	0.20 mg/L
Cyanide (as CN)	0.05 mg/L
Lead (Pb)	0.20 mg/L
Mercury (Hg)	0.005 mg/L
Molybdenum (Mo)	0.50 mg/L
Nickel (Ni)	0.50 mg/L
Selenium (Se)	0.05 mg/L
Silver (Ag)	0.10 mg/L
Zinc (Zn)	0.50 mg/L

28. No Waste shall contain floating solids.

29. No visible, or floating, oils or grease shall be present in any waste discharge.

30. All waste discharges shall pass a 100% 96-hour LC_{50} bioassay using Rainbow Trout.

31. The effluent quality standards specified in this licence shall be met at all points of entry into all receiving waters, including, but not limited to, monitoring locations X5, X13, V2 and V25BSP.

PART D – MODIFICATION AND CONSTRUCTION

32. Where minor modifications are required to be made to existing facilities and structures authorized by this licence, the Licensee shall submit plans, specifications and construction schedules for any such modifications no less than 90 days prior to the start of the construction work.

33. All dams and diversions shall be designed to withstand the 1:475 year return period earthquake.

34. All designs shall be sealed by a Professional Engineer licensed to practice in Yukon.

35. At least 10 days prior to the proposed date of commencement of construction of minor modifications, the Licensee shall submit to the Board a written notification, together with a detailed construction schedule and the name and contact number(s) of the construction superintendent.

36. Where site conditions require minor modifications to the designs submitted to the Board, the Licensee shall notify the Board, in advance, of the details of the modifications or variations from final detailed designs, specifications and quality assurance/quality control procedures previously submitted to the Board. The notice shall include an explanation of the reasons for the change and an assessment of the potential impact on the performance of the works. The notice shall be sealed by a Professional Engineer licensed to practice in Yukon.

37. As-constructed (record) drawings and construction reports, including quality assurance and quality control documentation, for all structures and facilities shall be submitted to the Board within ninety days of the completion of construction. Each submission shall be sealed by a Professional Engineer licensed to practice in Yukon.

PART E – CARE AND MAINTENANCE

38. Throughout the term of this licence, the Licensee shall maintain all works in good order.

39. The Vangorda Creek Diversion shall have a capacity to carry a 1:100 year design flow.

40. The Rose Creek Diversion shall have a capacity to carry a 1:500 year design flow.

41. The spillways on the Intermediate Dam and the Cross Valley Dam shall have a capacity to carry a 1:500 year design flow of Rose Creek.

42. The overflow structure on the Rose Creek Diversion Dam shall be maintained to ensure that peak flows can freely pass through it.

43. All waste rock dumps shall be maintained in accordance with sound engineering practices and in a way that minimizes the potential for acid generation.

44. A footbridge may be maintained across Rose Creek in the vicinity of monitoring station X14 for the purposes of obtaining flow measurements. The bridge shall not have footings or pilings in the creek.

45. As an interim measure, and subject to clause 5 of this licence, pending completion of a terrestrial effects study a salt lick shall be maintained in the vicinity of the Emergency Tailings Area to discourage wildlife from entering the tailings area.

PART F – STUDIES AND PLANS

46. All studies shall be carried out by persons qualified to do so by education and/or experience.

47. All further work proposed in the studies or plans that are submitted as a requirement of Part F of this licence shall be carried out according to the schedule identified in those studies or plans. However, should the Board notify the Licensee prior to the date of commencement of the study or plan that a public hearing will be held to review the study or plan, then the Licensee shall not proceed with the study or plan until such time as the public hearing has been convened and the Board has concluded deliberations.

48. The reference conditions for the purposes of studies and plans required by Part F of this licence shall be the period of 1999-2002 for areas downstream of the tailings impoundment and the period of 1998-2000 elsewhere. Studies and plans submitted to the Board shall describe how these reference conditions have been used.

Terrestrial Effects Study

49. A terrestrial effects study, as described in the application, shall be carried out. The completed study shall be submitted to the Board by December 31, 2005.

Town of Faro Water Supply Study

50. A study shall be carried out to determine the relationship between water flowing in Vangorda Creek and water obtained from the Town of Faro water supply wells, and to assess the potential for contamination from Vangorda Creek to enter the wells. The

results of the study shall be submitted to the Board as part of the annual report for the year 2005.

Water Treatment Sludge Management Study

51. A water treatment sludge management plan shall be prepared and submitted to the Board by June 30, 2004.

Grum Pit Water Management Plan

52. A water management plan for the Grum Pit shall be prepared and submitted to the Board by June 30, 2004.

Aquatic Life Sampling and Testing Program

53. A plan for an aquatic life sampling and testing program shall be developed and submitted to the Board by April 30, 2004. The plan shall detail the proposed program including sampling locations, study species, study parameters and protocols. Sampling for fish presence and metals in fish tissue shall be a component of the plan.

Adaptive Management Plan

54. An adaptive management plan for the facilities authorized by this licence shall be prepared and submitted to the Board by June 30, 2004. The plan shall identify the indicators and triggers for action, the measures of statistically significant changes to be tracked, the monitoring locations and parameters, the sampling frequencies, the methods to be used to analyze and evaluate the data, and the actions to be taken.

Comprehensive Risk Assessment

55. The Comprehensive Risk Assessment ("CRA"), April 2002 submitted as part of the application shall be implemented. The CRA shall be updated annually and submitted to the Board as part of the annual report.

Rose Creek Tailings Facility Water Management Plan

56. A water management plan for the Rose Creek Tailings Facility shall be prepared and submitted to the Board by March 31, 2005. The plan shall include an evaluation of tailings oxidation and alternative water discharge scenarios.

Plan for the Management of Oxide Fines

57. A long term plan for the management of oxide fines shall be prepared and submitted to the Board by July 30, 2004 or no later than 90 days prior to the proposed implementation date, whichever comes first.

Final Closure and Reclamation Plan

58. A final closure and reclamation plan for the facilities authorized by this licence shall be prepared and submitted to the Board by December 31, 2006. The plan shall be premised on the following:

    a) all decommissioned tailings-related facilities and structures shall be designed to withstand the Maximum Credible Earthquake (MCE) and the Probable Maximum Flood (PMF);

    b) long term physical stability of all watercourses and tailings deposits shall be ensured, with minimal post-operational maintenance; and

    c) the long term water quality in Rose Creek downstream of the tailings facilities shall comply with the *Canadian Water Quality Guidelines for the Protection of Aquatic Life*, prepared by the Canadian Council of the Ministers of the Environment, 1999, updated 2001.

PART G - MONITORING AND SURVEILLANCE

59. The Licensee shall comply with the water quality monitoring program contained in Schedule A. All data collected in accordance with Schedule A shall be submitted to the Board as part of the monthly report.

60. In addition to the monitoring described in Schedule A, Part IV, water samples shall be collected in spring and fall ("SF") at observed surface seeps at the toe of rock dumps not included in the list in Schedule A, Part IV. The samples shall be tested/measured for ICP-T, ICP-D, Other and Flow, all as defined in the Schedule A, Part II.

61. The Licensee shall conduct four LC_{50} bioassays per year, per station, from water collected at monitoring stations X5, X13, V2 and V25BSP.

62. As a component of the first annual report, the Licensee shall submit UTM coordinates for the monitoring stations listed in Schedule A, Part I.

63. All sampling and analysis shall be conducted in accordance with the current edition of *Standard Methods for the Examination of Water and Waste Water*, prepared and published jointly by the American Water Works Association and the Water Pollution Control Federation.

Biological and Sediment Monitoring Program

64. The Licensee shall comply with the monitoring program contained in Schedule B. All data collected in accordance with Schedule B shall be submitted to the Board as part of the annual report.

Water Treatment Plant Performance Evaluation

65. As a component of the annual report, the Licensee shall submit a performance evaluation report for all water treatment plants. The evaluation shall be carried out by an independent specialist with training and experience relevant to the types of treatment plants being operated. At a minimum, the evaluation shall include:

a) an analysis of the plants' performance in terms of treatment efficiency, capacity, and compliance; and
b) a review of daily operators' logs; and
c) any recommended remedial actions.

Physical Inspections and Monitoring

66. An annual inspection of all earthworks shall be carried out by a Professional Engineer licensed to practice in Yukon. A report on the inspections shall be submitted as a part of the annual report. The report shall document the inspection locations and methodologies, the results of the inspection, all problems identified, remedial measures recommended, and remedial measures implemented. The status of implementation of any recommended remedial measures shall be included in the report. The earthworks to be inspected shall include but not be limited to:

a) Intermediate Dam;

b) Cross Valley Dam;

c) Rose Creek Diversion Canal including containment dyke and backslope;

d) North Fork Rock Drain including the crest and slopes of the haul road in the vicinity and the crest and slopes of adjacent rock dumps;

e) Faro Creek Diversion Channel;

f) Vangorda Creek Diversion Flume including the rock and soil slopes above the flume;

g) Vangorda Rock Dump;

h) Grum Rock Dump;

i) Grum Interceptor Ditch/Sheep Pad Pond;

j) Little Creek Dam;

k) Grum/Vangorda Water Treatment Plant Freshwater Supply Pond; and

l) Grum/Vangorda Water Treatment Plant Clarification Pond.

67. The monitoring schedule and locations for readings of geotechnical performance monitoring instrumentation shall follow the recommendations of a Professional Engineer licensed to practice in Yukon. The Licensee shall maintain, repair or install additional instrumentation as recommended by the Professional Engineer.

68. Monitoring data collected for the Rose Creek Diversion Canal shall be collected no less than twice annually, in the spring and in the fall, and shall be analyzed by a Professional Engineer licensed to practice in Yukon. The results of the analysis shall be submitted as a component of the annual report. At a minimum, the data shall be analyzed to determine:

    a) Thermal regime and degradation of permafrost;

    b) Stability of the excavated canal wall;

    c) Settlement and stability of the canal dyke;

    d) Areas and rates of seepage from the canal;

    e) Performance of any waste piles adjacent to the canal; and

    f) Other areas of concern.

69. Glaciation in the Rose Creek Diversion Canal shall be monitored monthly during the winter season to assess and document the ice build up. Any corrective or preventative measures to address ice build up shall be documented and reported as a component of the annual report.

70. A comprehensive dam safety review for all water retaining structures shall be carried out in the summer of 2007. The review shall be completed and reported to the Board as part of the annual report for that year. The review shall be conducted in accordance with the *Dam Safety Guidelines*.

71. Details of any maintenance, inspection and/or surveillance activities undertaken in the previous year in relation to dam safety shall be included in the annual report.

SCHEDULE A, PART I
MONITORING STATIONS

Faro Mine Site:

Station	Location
X2	North Fork of Rose Creek at access road
X3	Pumphouse pond
X4	Intermediate pond at spillway
X5	Cross Valley pond surface outflow
X5P	Cross Valley pond at spillway
X11	Cross Valley Dam North Seep
X12	Cross Valley Dam South Seep
Weir 3	Cross Valley Dam Central Seep
X13	Cross Valley Dam Combined Seepage
X14	Rose Creek after mixing downstream of the diversion canal confluence
X22b	Faro Main Pit at Pumping Barge
X23	Old Faro Creek channel near the toe of the main (southwest) rock dumps.
X26	Faro Zone II Pit Pumped Discharge
R1	South Fork Rose Creek upstream of pumphouse pond
R2	Rose Creek downstream of mixing zone
R3	Rose Creek mid length
R4	Rose Creek just above Anvil Creek
R5	Anvil Creek just below the confluence of Rose Creek
R6	Anvil Creek immediately upstream of Rose Creek
Faro Cr	Outlet of Faro Creek Diversion
R7	North Fork of Rose Creek upstream of the confluence with the Faro Creek Diversion
R8	North Fork of Rose Creek, 100 m downstream of confluence with Faro Creek Diversion
R9	North Fork of Rose Creek, adjacent to Zone 2 Rock Dumps
R10	North Fork of Rose Creek, downstream of Zone 2 Rock Dumps and 100 metres downstream of R9
X16	Downstream of Rose Creek Tailings Facility
X17	Downstream of Rose Creek Tailings Facility
X18	Downstream of Rose Creek Tailings Facility
X21-96	Rose Creek Tailings Facility
X24-96	Rose Creek Tailings Facility
X25-96	Rose Creek Tailings Facility
P01-01 to 11	Rose Creek Tailings Facility
TH86-26	Upstream of Rose Creek Tailings Facility
BH1	Zone 2 Rock Dumps
BH2	Zone 2 Rock Dumps
BH4	Zone 2 Rock Dumps
BH12	Northeast Rock Dumps
BH13	Northeast Rock Dumps
BH14	Northeast Rock Dumps
P96-6	Main/Intermediate Rock Dumps
P96-7	Main/Intermediate Rock Dumps

Faro Mine Site (continued):

Station	Location
P96-8	Main/Intermediate Rock Dumps
S1	Main/Intermediate Rock Dumps
S2	Main/Intermediate Rock Dumps
S3	Main/Intermediate Rock Dumps
FDU	Faro Creek Diversion, upstream end
FDL	Faro Creek Diversion
FCO	Old Faro Creek, upstream of Faro Valley Dump
A30	Flow to Main Pit from Faro Valley Dump
A25	Main Pit, northwest wall
SP5/6	Internal Surface Flow on Faro Rock Dump
NE1	North Seep to North Fork from Northeast Dumps
NE1	Central Seep to North Fork from Northeast Dumps
NE1	South Seep to North Fork from Northeast Dumps
NF1	Upstream side of rock drain
NF2	Downstream side of rock drain
W5	East Dump
W8	Upper Guardhouse Creek downstream of Northwest Dump
W10	Upper Guardhouse Creek upstream of Northwest Dump
GDHSECK	Guardhouse Creek at Intermediate Pond
IDSEEP	Intermediate Dam toe seep, south side
X7	Seep downstream of emergency tailings area
K8	Tributary of Rose Creek upstream of the site of the freshwater dam
Grum Corner	Tributary of Rose Creek upstream of the site of the freshwater dam
Anvil Cr	Anvil Creek above the confluence with the Pelly River

Vangorda Mine Site:

Station	Location
V1	Vangorda Creek upstream of Vangorda Pit
V2	Grum Creek upstream of confluence with Vangorda Creek
V2A	Grum Creek upstream of confluence with Moose Pond
V4	Shrimp Creek upstream of confluence with Vangorda Creek
V5	West Fork of Vangorda Creek at gravel pit
V6A	AEX Creek
VG Main	Main Stem of Vangorda Creek
V8	Lower Vangorda Creek at the footbridge
V14	Grum Rock Dump at North toe seep
V15	Grum Rock Dump at central toe seep
V16	Grum Rock Dump at South toe seep
V17A	Creek from Grum ore transfer pad
V19	Vangorda Pit northwest diversion ditch
V20	Vangorda Pit, northeast diversion ditch
LCD	Little Creek Dam Pond at old pumphouse
V22	Vangorda Pit at pumping barge

Vangorda Mine Site (continued):

Station	Location
V23	Grum Pit at Haul Road
V24	Influent to water treatment plant
V25	Effluent from clarification pond
V25BSP	Grum Interceptor Ditch below Sheep Pad Pond
V27	Main Stem of Vangorda Creek upstream of Shrimp Creek
V29	Vangorda Dump drain #2
V30	Vangorda Dump drain #3
V31	Vangorda Dump drain #4
V32	Vangorda Dump drain #5
V33	Vangorda Dump drain #6
V37	Vangorda Rock Dump, GW94-01
V38	Vangorda Rock Dump, GW94-02
V39	Vangorda Rock Dump, GW94-03
V40	Vangorda Rock Dump, GW94-04
P96-9	Grum Rock Dump
P01-01 to 03	Vangorda Rock Dump

SCHEDULE A, PART II
MONITORING SCHEDULE LEGEND

Frequency:

C = Continuously
WD = Weekly when discharging
MD = Monthly when discharging
M = Monthly
SF = Spring and Fall
SSF = Spring, Summer and Fall
WS = Winter and Summer
Q = Quarterly

Parameters:

ICP-T = ICP Total Metals including all metals listed in the effluent quality standards specified in Part C of this licence.

ICP-D = ICP Dissolved Metals including all metals listed in the effluent quality standards specified in Part C of this licence.

Other = field pH, field temperature, field conductivity, total suspended solids, sulphate (SO_4), ammonia (as N). For groundwater samples, "Other" also includes purge volume, purge rate, purge time and sampling time.

SCHEDULE A, PART III
MONITORING SCHEDULE
(FARO MINE SITE)

	Parameter				
Station	**ICP-T**	**ICP-D**	**Other**	**Hardness**	**Flow/Level**
X2	M	M	M	M	M
X3	M	M	M	M	-
X4	M	M	M	-	M
X5	WD	WD	WD	WD	WD
X5P	M	M	M	-	M
X11	WS	WS	WS	-	W
X12	WS	WS	WS	-	W
Weir 3	WS	WS	WS	-	W
X13	M	M	M	M	W
X14	WD/M	WD/M	WD/M	WD/M	C
X22B	M	M	M	-	M
X23	M	M	M	-	M
X26	MD	MD	MD	-	M
R1	WS	WS	WS	WS	WS
R3	WS	WS	WS	WS	WS
R4	WS	WS	WS	WS	WS
R5	WS	WS	WS	WS	WS
R6	WS	WS	WS	WS	WS
Faro Cr	M	M	M	-	-
R7	M	M	M	-	C
R8	M	M	M	-	-
R9	M	M	M	-	-
R10	M	M	M	-	-
X16	-	SF	SF	-	SF
X17	-	SF	SF	-	SF
X18	-	SF	SF	-	SF
X21-96	-	SF	SF	-	SF
X24-96	-	SF	SF	-	SF
X25-96	-	SF	SF	-	SF
P01-01to 11	-	SF	SF	-	SF
TH86-26	-	SF	SF	-	SF
BH1	-	SF	SF	-	SF
BH2	-	SF	SF	-	SF
BH4	-	SF	SF	-	SF
BH12	-	SF	SF	-	SF
BH13	-	SF	SF	-	SF
BH14	-	SF	SF	-	SF

	Parameter				
Station	**ICP-T**	**ICP-D**	**Other**	**Hardness**	**Flow/Level**
P96-6	-	SF	SF	-	SF
P96-7	-	SF	SF	-	SF
P96-8	-	SF	SF	-	SF
S1	-	SF	SF	-	SF
S2	-	SF	SF	-	SF
S3	-	SF	SF	-	SF
FDU	SF	SF	SF	-	SF
FDL	SF	SF	SF	-	SF
FCO	SF	SF	SF	-	SF
A30	SF	SF	SF	-	SF
A25	SF	SF	SF	-	SF
SP5/6	SF	SF	SF	-	SF
NE1	SF	SF	SF	-	SF
NE2	SF	SF	SF	-	SF
NE3	SF	SF	SF	-	SF
NF1	SF	SF	SF	-	SF
NF2	SF	SF	SF	-	SF
W5	SF	SF	SF	-	SF
W8	SF	SF	SF	-	SF
W10	SF	SF	SF	-	SF
GDHSECK	SF	SF	SF	-	SF
IDSEEP	SF	SF	SF	-	SF
X7	SF	SF	SF	-	SF
K8	M	M	M	M	-
Grum Corner	M	M	M	M	-
Anvil Cr	WS	WS	WS	-	-

SCHEDULE A, PART IV
MONIORING SCHEDULE
(VANGORDA MINE SITE)

	Parameter				
Station	**ICP-T**	**ICP-D**	**Other**	**Hardness**	**Flow/Level**
V1	Q	Q	Q	Q	Q
V2	M	M	M	M	M
V2A	M	M	M	-	M
V4	SSF	SSF	SSF	SSF	-
V5	M	M	M	M	Q
V6A	Q	Q	Q	Q	Q
VGMain	M	M	M	M	-
V8	M	M	M	M	C
V14	SF	SF	SF	-	SF
V15	M	M	M	-	M
V16	SF	SF	SF	-	SF
V17A	SF	SF	SF	-	SF
V19	SF	SF	SF	-	SF
V20	SF	SF	SF	-	SF
LCD	SF	SF	SF	-	M
V22	Q	Q	Q	-	M
V23	Q	Q	Q	-	M
V24	WD	WD	WD	-	WD
V25	WD	WD	WD	-	WD
V25BSP	WD/M	WD/M	WD/M	WD/M	WD/M
V27	SSF	SSF	SSF	SSF	-
V29	-	SF	SF	-	SF
V30	-	SF	SF	-	SF
V31	-	SF	SF	-	SF
V32	-	SF	SF	-	SF
V33	-	SF	SF	-	SF
V37	-	SF	SF	-	SF
V38	-	SF	SF	-	SF
V39	-	SF	SF	-	SF
V40	-	SF	SF	-	SF
P96-9	-	SF	SF	-	SF
P01-01 to 03	-	SF	SF	-	SF

SCHEDULE B
BIOLOGICAL AND SEDIMENT MONITORING PROGRAM

1. Sampling Points:

Rose Creek:

a) R1: Above the confluence of the North Fork and South Fork of Rose Creek.

b) R2 (same location as X14): In the mixing zone downstream of the intersection of the Rose Creek Diversion Canal.

c) R3: Rose Creek about one-half way to Anvil Creek.

d) R4: Rose Creek just above Anvil Creek.

e) R5: Anvil Creek just below the confluence of Rose Creek.

f) R6: Anvil Creek immediately upstream of Rose Creek.

g) R7: North Fork of Rose Creek upstream of the confluence with the Faro Creek diversion.

Vangorda Creek:

a) V1: Vangorda Creek upstream from the mine and Blind Creek Road.

b) V5: West Fork of Vangorda Creek upstream of mine access road.

c) V8: Vangorda Creek near bridge to Town of Faro water supply.

d) V27: Main Stem of Vangorda Creek just upstream of confluence with Shrimp Creek.

2. The Licensee shall collect three replicate samples of benthic invertebrates every second year from each station using an artificial substrate sampler for approximately 5 weeks.

3. Water samples shall be collected and analyzed for total hardness, alkalinity, sulfate, suspended solids, ammonia and for a complete ICP scan of total and dissolved metals that includes copper, iron, lead and zinc.

4. Water samples shall be collected according to standard sampling protocols and field measurements of pH, temperature and conductivity shall be recorded.

5. Flow shall be measured at each location, except that flow may be calculated at one of locations R4, R5 or R6.

6. Sediment samples shall be collected in triplicate, passed through a 100 mesh (0.15 mm) stainless steel sieve. The portion passing through the sieve shall be analysed for all total metals listed in the effluent quality standards of Part C of this licence.

7. Sample collection, identification, enumeration and data interpretation shall be done by independent, qualified personnel.

8. The Licensee shall compile a report of all data collected and shall submit the report to the Board as a component of the annual report.

Faro WTP Design Definition – One versus Two Plant Comparison Faro Mine Remediation Project

PREPARED FOR: Government of Yukon

PREPARED BY: CH2M HILL Canada Limited

DATE: September 4, 2012

PROJECT NUMBER: 436662.13.PD.02

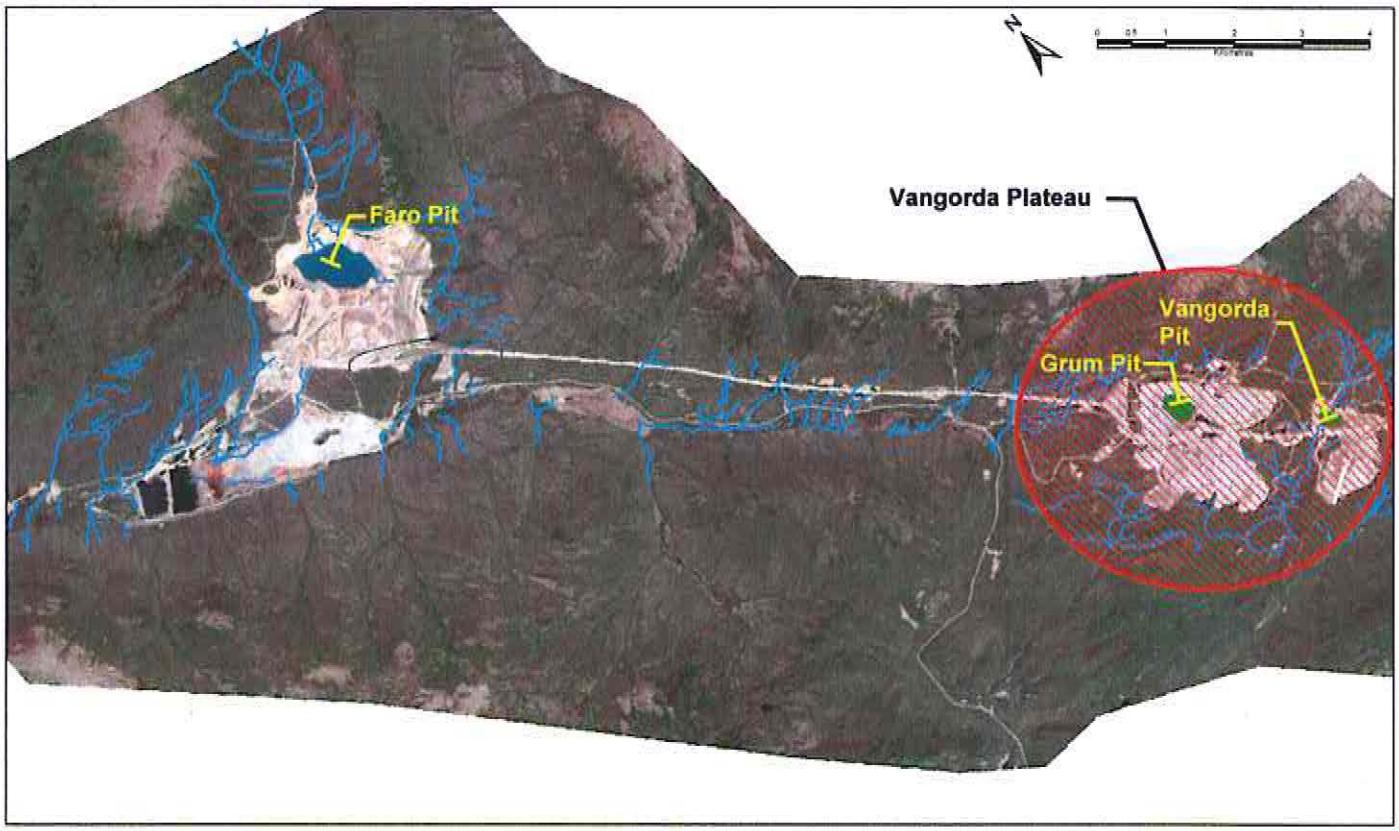
Purpose

The purpose of this technical memorandum (TM) is to compare providing one or two water treatment plants (WTPs) at the Faro Mine Complex (FMC), and recommend a preferred alternative for implementation.

Background

The FMC, 350 kilometres (km) northeast of Whitehorse, Yukon, was in operation for about 30 years, starting in the 1960s, producing primarily lead and zinc. The FMC includes three areas: the Faro Mine Area, the Rose Creek Tailings Area (RCTA), and Vangorda Plateau, which incorporates the Grum Pit and Vangorda Pit (Figure 1).

FIGURE 1
FMC Area
Faro Mine Remediation Project



As a result of past mining activities, there are now some 70 million tonnes of tailings and 376 million tonnes of waste rock subject to acid generation and release of heavy metals into the environment.

The FMC's Closure and Remediation Plan (C&R Plan) (SRK, 2010) describes the long-term plan for site water treatment. The C&R Plan generally consists of using two high-density sludge (HDS) WTPs (hereafter referred to as the Two WTPs Alternative) to treat water that is seasonally stored in the Faro Pit and Vangorda Pit. One of these WTPs would be located on the Faro side of the FMC; the other would be located on the Grum/Vangorda side. Both WTPs would likely include granular media filtration to remove thickener overflow solids. A proposed design capacity of 27 million litres per day (ML/d) (5,000 United States gallons per minute [USgpm]) is listed for the Faro plant; the Grum/Vangorda plant is listed for 2.7 ML/d (500 USgpm), with the potential to expand to 13.5 ML/d (2,500 USgpm).

The Independent Peer Review Panel (IPRP) suggested that the Government of Yukon (YG) evaluate the potential for constructing a single 38-ML/d (7,000-USgpm) WTP (referred hereafter to as the One WTP Alternative), rather than the two that are presented in the C&R Plan. The idea is to collect and pump the Grum/Vangorda Area water to a single WTP on the Faro side. The primary benefits for this include reduced operations and maintenance (O&M) costs and more centralized site operations, including a single sludge stream.

Specific issues identified for evaluation included the following:

- The cost-effectiveness of the single plant system compared to the two plant system
- The effectiveness of the cross-site pumping system, and the ability to prevent leaks to the environment
- Protection of Vangorda Creek water (since no plant would exist on that side of the site)

Basis of Comparison

This evaluation was carried out using the information available to date and is representative and accurate enough for the purposes of cost comparison of one single plant versus two plants. Both economic and noneconomic factors were considered. The economic factors are the capital, O&M, and life-cycle costs. The noneconomic factors include technical considerations, such as short- and long-term effectiveness, reliability, robustness, and protection of the environment from leaks.

Influent Flows and Characteristics

Predicting the long-term water flows and water chemistry from the pits is a complicated procedure, as these flows will change over time due to mine closure activities and natural events, including oxidation and weathering. CH2M HILL Canada Limited (CH2M HILL) is performing a larger modelling exercise using GoldSim to forecast future flows and loads.

To date, CH2M HILL's work with the GoldSim model has identified a number of important modifications required to more accurately represent current and future site conditions. For example, the model received did not account for near-term treatment of water from the Intermediate Dam Pond (ID Pond), and it assumed that upon capping all water from behind the Intermediate Dam, the water would require no treatment. It also assumed that once the Faro Creek Diversion is reconstructed, leakage into Faro Pit would be reduced by 5.5 ML/d. It assumed, as well, that the X23 Seep has reached full geochemical maturation, whereas more recent monitoring data suggests that this may not be the case.

CH2M HILL is currently evaluating these and other important assumptions that significantly affect projections of future treatment requirements. In the meantime, the following basic design parameters will be used for the purposes of evaluating one versus two WTPs.

System Sizing

Feasibility-level designs were developed to provide a basis of comparison between the alternatives. These are based on a number of key HDS process parameters, as described in Table 1.

TABLE 1
Summary of Key Design Parameters for High-Density Sludge Plant Sizing
Faro Mine Remediation Project

Design Parameter	Design Value
Faro Area associated Total Influent Flow, ML/d	27
Grum Area associated Total Influent Flow, ML/d	5.5
Vangorda Area associated Total Influent Flow, ML/d	5.5
Lime demand, g/L	1
Solids formed, g/L	1.5
Thickener sizing basis, m^2/t/day	2
Solids recycle ratio	20
Lime-sludge mix tank HRT, min	4
Reactor tank total HRT, min	30
Filtration loading rate, m/h	9.8
Influent manganese, mg/L	100
Influent ferrous iron, mg/L	200

Notes:
g/L – grams per Litre
HRT – hydraulic retention time
m^2/t/day – square metres per tonne per day
mg/L – milligrams per litre
min – minute
m/h – metres per hour

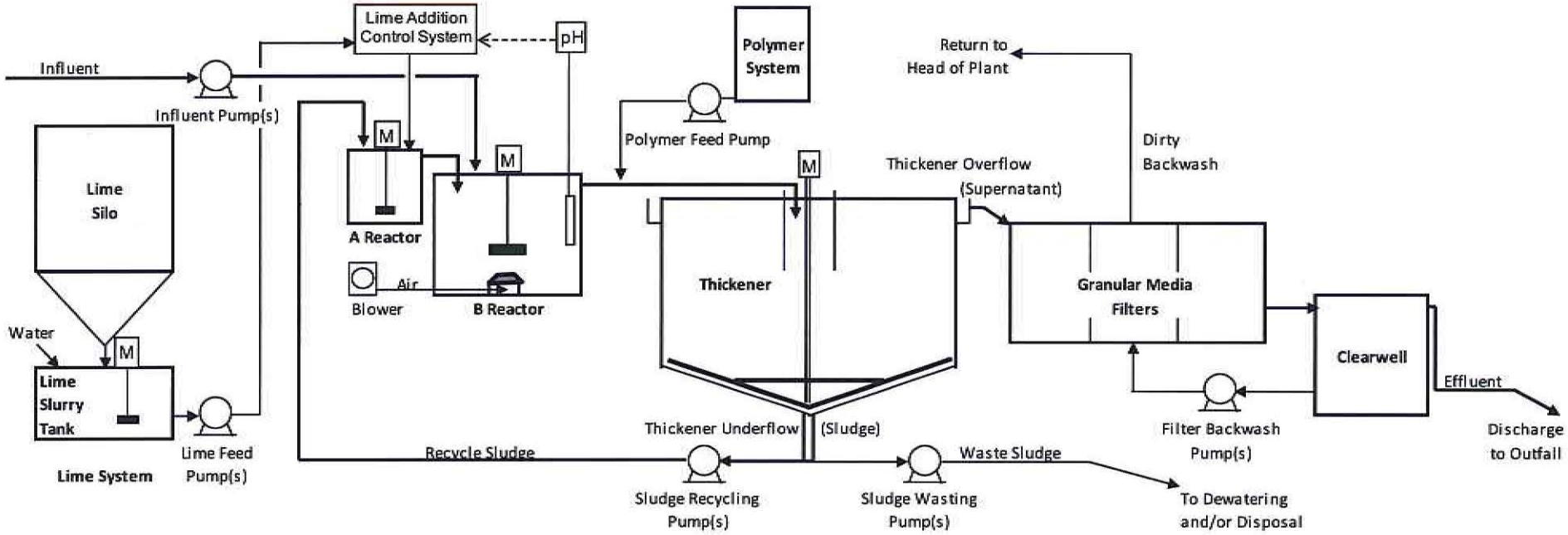
Description of Alternatives

Both the One WTP and Two WTPs Alternatives will use the HDS process. Figure 2 shows a process flow diagram of this process.

The HDS process is a modification of conventional lime treatment that utilizes a high degree of sludge recycle to an additional small, mixed, sludge conditioning reactor (Reactor A), where lime is mixed with recirculated sludge solids before introducing them to the mining-influenced water in a larger, mixed and aerated, neutralization and oxidation reactor (Reactor B). This configuration results in precipitation of metals as (oxy)hydroxides directly on to the lime-coated solids, yielding larger and denser sludge particles. Compared to conventional lime treatment, HDS provides the following advantages:

- Produces larger and denser solids particles that settle faster
- Produces thicker settled sludge – typically 15- to 30-percent solids or greater (versus 1- to 3-percent solids for conventional lime treatment)
- Yields much lower waste-sludge volumes – frequently less than one-tenth of the sludge volume produced by conventional lime treatment
- Produces free-draining sludge that dewaters more quickly and thoroughly – often to greater than 40-percent solids
- Is resistant to scaling – for example, from gypsum
- Improves filter performance and operability

FIGURE 2
High-Density Sludge Lime Treatment Process
Faro Mine Remediation Project



In the One WTP Alternative, a single HDS plant will be constructed at the Faro Mill site for treatment of water from the Faro Area, as well as water from the Grum/Vangorda side, which will be conveyed by a new cross-site pipeline.

In the Two WTPs Alternative, one HDS plant will be constructed at the Faro Mill site and a second plant at the Vangorda Pit for treatment of Grum/Vangorda water.

In both cases, the plants are sized to treat the total anticipated contaminated flows during a 5-month plant operational period from May to September.

Each HDS WTP will include the following:

- Lime silo, slaking equipment, slurry tanks, slurry loops, and feed control valves
- Lime sludge mix tank (Reactor A)
- Twin main reactor tanks (Reactors B-1, B-2)
- Polymer makeup and dosing system
- Sludge thickener - concrete basin and dome covered, with underground tunnel to access the cone
- Sludge recycle pumps
- Waste-sludge transfer pumps
- Media filters for effluent polishing prior to discharge
- Supervisory control and data acquisition (SCADA) system and instrumentation for process monitoring and control

Each plant will be configured as three separated, weather-protection-enclosed areas:

1. Lime system and reactor equipment housed in a building
2. Thickener area with own dome cover
3. Effluent filters, housed in a building

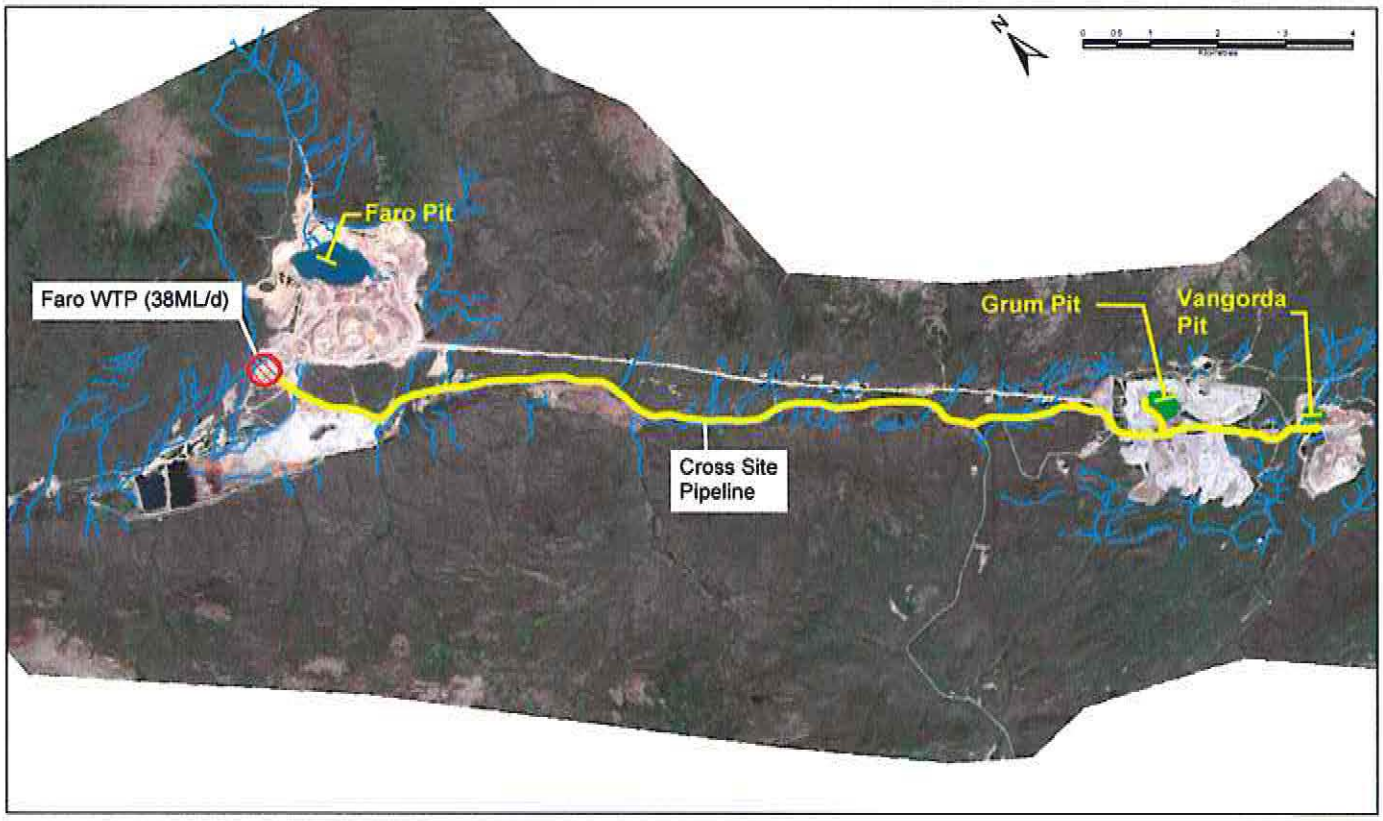
For both alternatives, the Faro plant site has sufficient space to accommodate future expandability of the Faro plant. Provision will be made for ease of future expandability and an adequate level of redundancy in unit operations. These details will be considered during design.

One WTP Alternative

For the One WTP Alternative, a 38-ML/d plant will be constructed in the Faro Mill Area of the FMC (Figure 3).

This size of plant would provide treatment capacity for the combined flow from the Faro Mine Area and the combined flows from the Grum/Vangorda Mine Areas. A cross-site pipeline will be constructed between the two areas.

FIGURE 3
One WTP Alternative
Faro Mine Remediation Project



The flows to the single Faro WTP will include:

- Water collected in the Faro Pit which will be pumped to the WTP from May to September, including water pumped from the Zone 2 Pit, as well as from the S-Wells seepage interception system
- Water from the Grum Pit and the Vangorda Pit
- Water from the ID Pond which will be pumped to the WTP from May to September when the WTP is operational
- Water from the Emergency Tailings Area (ETA) collection system which will be pumped to the WTP when it is operational, and otherwise to the Faro Pit once the system is expanded for year-round operation
- Intercepted groundwater from the Down Valley Groundwater Seepage collection wells once these are installed, which will be pumped to the WTP from May to September and to the Faro Pit during the rest of the year

The WTP will discharge treated water by gravity, below the Cross Valley Dam (CVD) and near the present location of Monitoring Station X5. Excess HDS generated in the WTP will be pumped from the thickener to the Faro Pit.

Cross-Site Pipeline

The One WTP Alternative is contingent on the constructability and long-term viability of operating a long-distance (approximately 16.5 km), cross-site pipeline from the Vangorda Plateau to the Faro WTP or Faro Pit. A separate feasibility study, preliminary design, and cost estimate was prepared for this pipeline. The study determined that the pipeline is feasible. A preliminary design was prepared with features to provide long-term viability and safeguard of the environment. All of this is described in a separate, yet-to-be published TM tentatively titled *Cross-Site Conveyance System;* key points are discussed in the following paragraphs.

The pipeline will have a capacity of 11 ML/d (2,000 USgpm) and be constructed in heavy-walled, high-density polyethylene (HDPE) material for strength and durability (Standard Dimension Ratio [SDR] 7.3, with 70-millimetre [mm] wall thickness). Pipe joints will be heat-fused, creating joints as strong as the pipe material itself. The entire pipeline would be pressure tested to demonstrate integrity.

The pipeline preliminary design and cost estimate assumes an alignment that follows the main access road alignment. It also assumes the pipeline to be buried on the north (uphill) side of the road for protection against vandalism and accidental vehicle damage. An alternative and more direct alignment of locating the pipeline along the Haul Road was briefly considered. However, since the Haul Road is due to be decommissioned, this alternative was not pursued further.

Freeze protection of the pipeline during winter is a critical concern. To this end, the pipeline will be sized to accommodate the required flow transfer during the summer months (June to September). Before winter, the pipeline will be emptied by means of compressed-air-driven pigs. Pigging stations will be provided to facilitate this operation. The road profile along this route will be re-graded at select areas to reduce the number of low and high spots in the pipeline.

The water chemistry in Grum Pit and Vangorda Pit are different. To minimize fouling of the pipeline from iron (oxy)hydroxide precipitate, flow from each pit will be pumped in alternation at 11 ML/d. Each pit will have a separate pump barge which will deliver water from each pit to a high point at the water shed divide (near the Ore Transfer Pad Area, beyond the western edge of the Grum Pit). From there, the pit water will flow by gravity to the Faro WTP (or, when required, to the Faro Pit). The pump barges and cross-site pipeline infrastructure are sized to allow for alternating duty. The capability to clean out the pipeline by pigging will be provided.

Two WTPs Alternative

For the Two WTPs Alternative, a 27-ML/d WTP will be constructed at the Faro Mill Area, as shown in Figure 4. The plant will be a smaller version of the single Faro plant previously described. It will have similar influent (less the flows from Grum/Vangorda Pits) and discharge effluent and sludge, as described previously.

A separate 11-ML/d WTP will be constructed at the Vangorda Plateau (southeast of the Vangorda Pit) for the treatment of flows from Grum and Vangorda Pits only, as shown in Figure 5. The treated effluent from this second WTP will be discharged by gravity to Vangorda Creek. Excess high-density lime sludge will be pumped to the Vangorda Pit.

FIGURE 4
Two WTPs Alternative
Faro Mine Remediation Project

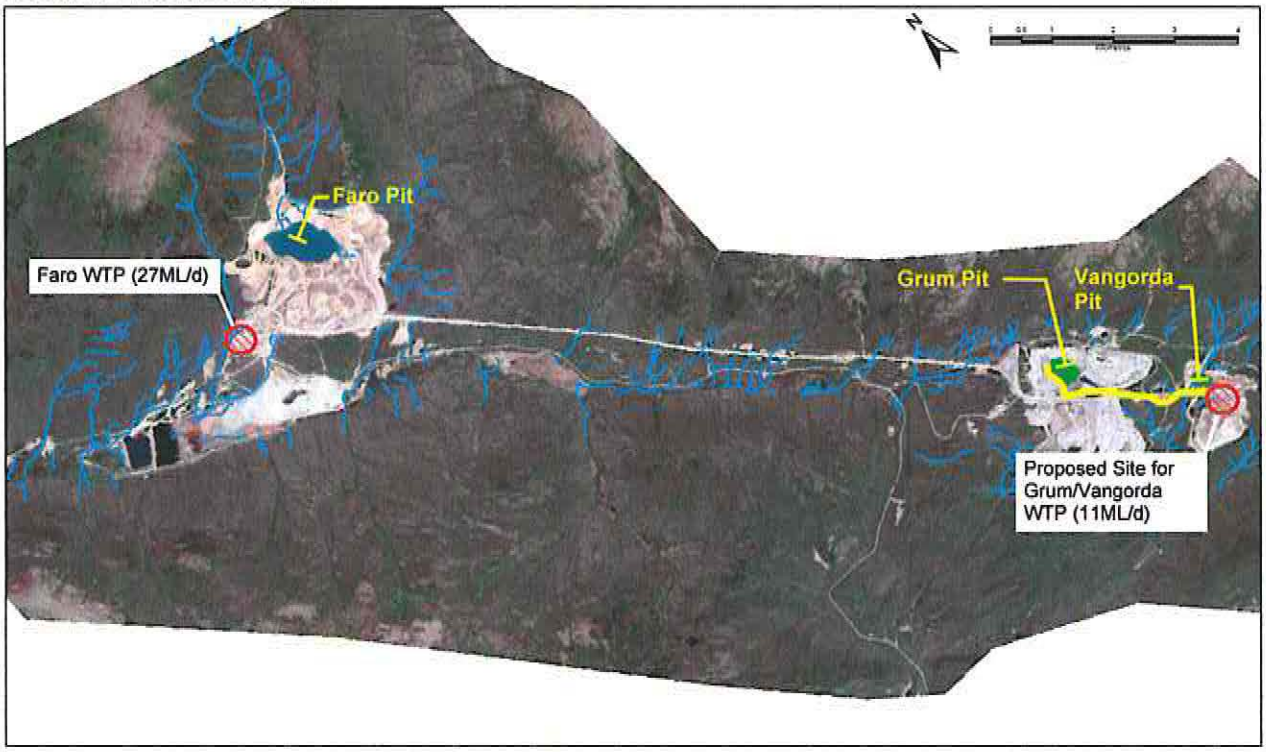


FIGURE 5
Vangorda Plant Site
Faro Mine Remediation Project

Cost Estimates

Capital Costs

Cost estimates were prepared using CH2M HILL'S Parametric Estimating System (CPES).

CPES is a spreadsheet-based application that generates Class 5 cost estimates for projects at the conceptual stage, before little or any design work has taken place. Based on historical project costs and project-specific information, CPES provides capital, operating, maintenance, life-cycle, and energy-use costs.

CPES includes modules for pipelines, pump stations, and many different water treatment processes, including HDS process. It allows for local construction cost variations and individual unit cost adjustments (e.g., concrete and stainless steel pipe) so that the developed costs are as close to existing market conditions as possible.

Table 2 provides a summary of the capital cost estimates prepared for the two alternatives.

TABLE 2
Capital Costs for One and Two WTP Alternatives
Faro Mine Remediation Project

Alternative	Component Description	Capital Cost $ Million
One WTP	38-ML/d HDS WTP	59
	Cross-site pipeline	17
	Grum and Vangorda pump barges and pipelines to high point	7
	One Plant Total Capital Cost	**83**
Two WTPs	27-ML/d HDS WTP	51
	11-ML/d HDS plant	29
	Grum and Vangorda pump barges and pipelines to plant	5
	Two Plants Total Capital Cost	**85**

Attachment A provides details of the capital cost estimates.

The capital costs for the two alternatives are considered equal within the tolerance of estimating accuracy.

Life-Cycle Costs

Life-cycle costs were estimated using a net present value (NPV) approach, including initial capital costs, annual O&M costs, and periodic capital upgrade costs. Life-cycle costs are tallied at 30 years, 50 years, 100 years, 300 years, and 500 years.

A discount rate of 3 percent was used for future cash flows, which includes interest and inflation (negligible). Annual costs were not inflated for future years.

It was assumed that all the construction occurs at the same time for both alternatives. That means that for the Two WTPs Alternative, both plants would be constructed at the same time. For the One WTP Alternative, the pipeline is constructed at the same time as the WTP. It is recognized that the timing could potentially be offset, but this is not expected to have a material impact on the results.

O&M costs have been developed for the purpose of evaluating the two alternatives and include O&M costs representative of the two treatment plant alternatives and pumping cost differences between the two alternatives. They should not be compared with the site-wide O&M cost estimates based on historical data.

Other assumptions are as follows:

Labour Costs. The plants are assumed to have a high level of automation to facilitate remote operation and monitoring via the SCADA system during the evenings and weekends.

Four staff (O&M) were allocated for operating two shifts at a single plant and the cross-site pipeline and pumping barges.

Six staff (O&M) were allocated for the operation of both plants in the Two WTPs Alternative.

The annual labour cost, with benefits, was assumed to be $130,000 per staff member. However, staff cost are allocated to the WTP operations only during the 5 months of the year when the plant(s) are in operation ($54,200 per staff/year). During the off-season, staff costs are assumed attributed to other mine site activities.

Chemical Costs. Chemical costs include lime and polymer.

Unit lime costs were valued at $200/tonne of calcium oxide, delivered (based on historical cost information from the existing lime treatment facilities). The long-term average lime dosage was assumed to be 0.5 grams (g) calcium hydroxide per litre (L) (about twice the present demand). The annual lime cost is approximated at $310,000 and is the same for both one and two plants, since a single water quality was used.

Polymer costs were based upon a unit polymer cost of $4/kilogram (kg), with an assumed dosage of 3 mg/L. The estimated annual polymer cost is $54,000 for both one and two plants.

Electricity Costs. Electricity costs are based on a unit rate of $0.165/kilowatt hour (kWh), as derived from analyzing historical power charges. For each plant or combination of plants, a total operating load was multiplied by the operating time and power rate. This data is shown in Attachment B. The major loads include influent pumping, lime-sludge mixer, reactor mixers, aeration blowers, sludge recycle pumps, waste-sludge pumps, thickener drive, lime slaker, lime slurry recirculation loop, polymer, miscellaneous loads, lighting, and heating.

Analytical Costs. Analytical testing is necessary for regulatory monitoring requirements, as well as for process monitoring and control. Analytical costs cover sample transportation, analysis, and reporting by third-party laboratories. An annual allowance of $20,000 was assumed for one operating plant. For two operating plants, the allowance was $40,000.

Maintenance Materials and Outsourced Repairs. Maintenance includes parts, supplies, tools, specialty items, and outsourced repairs. The annual value allocated for this was estimated at 1 percent of the subtotal of the initial hard capital cost (excluding contractor markups, escalation, market adjustment factors, and nonconstruction costs). The budgeted annual amounts are generous for a typical year, allowing for surpluses to be held in reserve for periodic major plant refurbishments.

Life-Cycle Cost Summary

Table 3 is a summary of life-cycle costs for 30 years, 50 years, 100 years, 300 years, and 500 years. Attachment B provides additional details.

TABLE 3
Life-Cycle Cost Comparison
Faro Mine Remediation Project

Evaluation Period Years	One WTP Alternative Life-Cycle Cost $ Million	Two WTPs Alternative Life-Cycle Cost $ Million	Additional Life-Cycle Cost for Two WTPs Alternative %
30	108	112	4
50	117	121	3
100	125	130	4
300	127	133	5
500	127	133	5

For the evaluation periods from 30 to 500 years, the additional life-cycle cost for the Two WTPs Alternative is 3 to 5 percent. The life-cycle cost difference of the Two Plant Alternative could increase by a further 1 to 3 percentage points if the assumption of minimal operational labour were replaced by a higher labour component. The additional life-cycle cost for two plants is significant but not huge. Therefore, other noneconomic decision factors should also be considered.

Noneconomic Factors

Attachment C provides a summary and relative comparison of approximately 40 noneconomic factors pertaining to one plant compared to two. The factors are organized according to project stages, including: field investigation, design, contractor procurement, construction, facility operations, and reliability.

Given the overall goal of protecting the environment, and the relatively remote site location, reliability is considered the most important noneconomic factor. In this regard, the One WTP Alternative is superior to the Two WTPs Alternative.

The gravity-flow pipeline in the One WTP Alternative is inherently simpler, and will be less prone to problems and less expensive to operate than the additional treatment plant that must be built and operated for the Two WTPs Alternative.

Both alternatives require pumping systems to lift water from the Grum and Vangorda Pits. The One WTP Alternative requires somewhat higher pump lift from the pit pumps. However, once constructed, the pit pumping systems for either alternative will operate essentially the same, delivering water to either the Vangorda plant or the elevation high point from where the gravity-flow cross-site pipeline begins. In essence, the reliability comparison of the two alternatives compares a gravity-flow, heavy-wall pipe and robustly constructed pipeline against an 11-ML/d WTP. The 11-ML/d plant is much more complex than the gravity-flow pipeline, and over the long-term, it will require more O&M efforts.

The One WTP Alternative provides a single, consolidated location of mechanical complexity and single point of environmental compliance and sludge disposal. Furthermore, it provides easier site security and lower site impact due to reduced vehicle access to the Vangorda Plateau Area. These factors accrue benefit over the long-term. From an administrative, project management, and environmental compliance standpoint, the One WTP Alternative will simplify long-term site care and maintenance, and provide the robust functionality needed to reliably manage site water.

Conclusion and Recommendation

Based on the foregoing and the slightly lower life-cycle costs, the One WTP Alternative is the preferred alternative for implementation of water treatment at the FMC.

Works Cited

Independent Peer Review Panel (IPRP). 2010. *Comments on Draft 4A of the Project Description for the Faro Mine Complex Closure and Remediation Plan*. August 15.

SRK Consulting Engineers and Scientists (SRK). 2010. Faro Mine Complex, Closure and Remediation Plan, Project Description – Draft 4A. Prepared for Yukon Government. March 29.

Attachment A
Capital Cost Estimate Details

TABLE A-1

Summary of Capital Costs for One Water Treatment Plant vs. Two Water Treatment Plants

Faro Mine Remediation Project

Water Treatment Plant at Faro Mill Site				
38-ML/d (7,000-gpm) WTP Project Cost - Subtotal			$	18,972,000
Additional Project Cost				
Overall Site work		3.10%	$	589,000
Plant Computer System		1.40%	$	266,000
Yard Electrical		4.30%	$	816,000
Yard Piping		5.50%	$	1,044,000
SUBTOTAL with Additional Project Costs			$	21,687,000
Pipeline Costs				
Treated Effluent			$	674,000
Sludge			$	1,425,000
ETA			$	433,000
Faro Influent			$	674,000
Tailings			$	584,000
Total			$	3,790,000
SUBTOTAL with Pipeline Costs			$	25,477,000
Contractor Markups				
Overhead	10%	$ 25,477,000	$	2,547,700
Subtotal			$	28,024,700
Profit	5%	$ 28,024,700	$	1,401,235
Subtotal			$	29,425,935
Mob/Bonds/Insurance	5%	$ 29,425,935	$	1,471,297
Subtotal			$	30,897,232
Contingency	30%	$ 30,897,232	$	9,269,170
SUBTOTAL with Markups			$	40,166,401
Location Adjustment Factor	1.3825	$ 40,166,401	$	55,530,050
Market Adjustment Factor	5%	$ 55,530,050	$	2,776,502
TOTAL - CAPITAL COST			$	58,306,552
Currency Conversion	Canadian Dollar	1.007766	**$**	**59,000,000**

Water Treatment Plant at Faro Mill Site				
27-ML/d (5,000-gpm) WTP Project Cost - Subtotal			$	15,964,000
Additional Project Cost				
Overall Site work		3.10%	$	495,000
Plant Computer System		1.40%	$	224,000
Yard Electrical		4.30%	$	687,000
Yard Piping		5.50%	$	879,000
SUBTOTAL with Additional Project Costs			$	18,249,000
Pipeline Costs				
Treated Effluent			$	674,000
Sludge			$	1,425,000
ETA			$	433,000
Faro Influent			$	674,000
Tailings			$	584,000
Total			$	3,790,000
SUBTOTAL with Pipeline Costs			$	22,039,000
Contractor Markups				
Overhead	10%	$ 22,039,000	$	2,203,900
Subtotal			$	24,242,900
Profit	5%	$ 24,242,900	$	1,212,145
Subtotal			$	25,455,045
Mob/Bonds/Insurance	5%	$ 25,455,045	$	1,272,752
Subtotal			$	26,727,797
Contingency	30%	$ 26,727,797	$	8,018,339
SUBTOTAL with Markups			$	34,746,136
Location Adjustment Factor	1.3825	$ 34,746,136	$	48,036,534
Market Adjustment Factor	5%	$ 48,036,534	$	2,401,827
TOTAL - CAPITAL COST			$	50,438,360
Currency Conversion	Canadian Dollar	1.007766	**$**	**51,000,000**

Water Treatment Plant at Vangorda Pit Site				
11-ML/d (2,000-gpm) WTP Project Cost - Subtotal			$	10,046,000
Additional Project Cost				
Overall Site work		3.10%	$	312,000
Plant Computer System		1.40%	$	141,000
Yard Electrical		4.30%	$	432,000
Yard Piping		5.50%	$	553,000
SUBTOTAL with Additional Project Costs			$	11,484,000
Pipeline Costs				
Treated Effluent			$	528,896
Sludge			$	347,272
Total			$	876,168
SUBTOTAL with Pipeline Costs			$	12,360,168
Contractor Markups				
Overhead	10%	$ 12,360,168	$	1,236,017
Subtotal			$	13,596,185
Profit	5%	$ 13,596,185	$	679,809
Subtotal			$	14,275,994
Mob/Bonds/Insurance	5%	$ 14,275,994	$	713,800
Subtotal			$	14,989,794
Contingency	30%	$ 14,989,794	$	4,496,938
SUBTOTAL with Markups			$	19,486,732
Location Adjustment Factor	1.3825	$ 19,486,732	$	26,940,407
Market Adjustment Factor	5%	$ 26,940,407	$	1,347,020
TOTAL - CAPITAL COST			$	28,287,427
Currency Conversion	Canadian Dollar	1.007766	**$**	**29,000,000**

One Water Treatment Plant		**Two Water Treatment Plants**	
38-ML/d HDS Plant at Faro Site	$ 59,000,000	27-ML/d HDS Plant at Faro Site	$ 51,000,000
Cross-Site Pipeline from high point to Faro Site	$ 17,000,000	11-ML/d HDS Plant at Vangorda Site	$ 29,000,000
Pumping barges and Pipes to high point	$ 7,000,000	Pumping barges and pipes to Vangorda plant	$ 5,000,000
One Plant Total	**$ 83,000,000**	**Two Plant Total**	**$ 85,000,000**

CH2M HILL Parametric Cost Estimating System (CPES)

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 7/12/2012 | Click for CPES QA/QC | To Concrete Wall Thickness Help | To Cost Summary Matrix | To Unit Cost Database

Project Capactiy: >>>		Project Unit: >>>		(For example: MGD, HP, GPM...)

Project Name:	Faro Mine Remediation Project	
Project Number:		
Project Manager:	Lionel Etheridge	
Estimator:	Jason Curl	
Project Description:	New Faro 7000 gpm HDS WTP (excludes influent/effluent pipelines)	Roundup to the nearest:
Project Location (City):	Faro	$1,000
Project Location (State):	YUKON	
Project Location (Country):	CANADA	
Construction Start (Month):	Apr	☐ This Report is for INTERNAL Distributio
Construction Start (Year):	2013	
Construction Duration (months):	33	
Mid-Point of Construction:	Sep/2014	☒ This Report is for EXTERNAL Distributio

Item	Is This Facility Included in Project? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	IWP Mixing Tank: ReactorA	$247,000
	Yes	IWP Mixing Tank: ReactorB	$3,937,000
	Yes	IWP Filters: FaroFilter	$5,289,000
	Yes	Dry Chemical: Polymer	$446,000
	Yes	Liquid Chemical: H2SO4	$301,000
	Yes	In-Plant PS: BWRecy	$791,000
	Yes	U.D. Facility: LimeSlaker	$1,276,000
	No	U.D. Facility: Backfill	$0
	Yes	IWP GT Conc Basin: Thickener	$6,685,000

SUBTOTAL - PROJECT COST			$18,972,000
ADDITIONAL PROJECT COSTS:			
Demolition	0.0%		$0
Overall Sitework	3.1%		$589,000
Plant Computer System	1.4%		$266,000
Yard Electrical	4.3%		$816,000
Yard Piping	5.5%		$1,044,000
UD #1 Default Description	0.0%		$0
UD #2 Default Description	0.0%		$0
UD #3 Default Description	0.0%		$0
SUBTOTAL with Additional Project Costs			$21,687,000
TAX:	0.00%	$21,687,000	$0
SUBTOTAL with Tax			$21,687,000
CONTRACTOR MARKUPS:			
Overhead	10%	$21,687,000	$2,169,000
Subtotal			$23,856,000
Profit	5%	$23,856,000	$1,193,000
Subtotal			$25,049,000
Mob/Bonds/Insurance	5%	$25,049,000	$1,253,000
Subtotal			$26,302,000
Contingency	30%	$26,302,000	$7,891,000
SUBTOTAL with Markups			$34,193,000

All Rights Owned by CH2M HILL /
All Rights Reserved.

ESCALATION (to Mid-Point of Construction)	0.0%	$34,193,000	$0
SUBTOTAL with Escalation			$34,193,000
LOCATION ADJUSTMENT FACTOR	138.25	$34,193,000	$47,272
SUBTOTAL - with Local Adjustment Factor			$47,272,000
SUBTOTAL - CONSTRUCTION COST with Red Flags			$47,272,000
MARKET ADJUSTMENT FACTOR	5%	$47,272,000	$2,364,000
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			$49,636,000
Your CPES Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		Curl	Click for Reviewe
Name of Estimator Reviewer		Meyer	
MAXIMUM CONSTRUCTION COST			$49,636,000
NON-CONSTRUCTION COSTS:			
Permitting	0%	$49,636,000	$0
Engineering	0%	$49,636,000	$0
Services During Construction	0%	$49,636,000	$0
Commissioning & Startup	0%	$49,636,000	$0
Land / ROW	0%	$49,636,000	$0
Legal / Admin	0%	$49,636,000	$0
Other Default Description	0%	$49,636,000	$0
SUBTOTAL - Non-Construction Costs			$0
TOTAL - CAPITAL COST			$49,636

Currency Conversion of TOTAL CAPITAL COST:

Currency	Unit of Measure	Conversion Rate	Converted Amount
CAD	Canadian Dollar	1.00776	50,000,000

All Rights Owned by CH2M HILL /
All Rights Reserved.

CH2M HILL Parametric Cost Estimating System (CPES)

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 7/12/2012 | Click for CPES QA/ QC | To Concrete Wall Thickness Help | To Cost Summary Matrix | To Unit Cost Database

Project Capactiy: >>>		Project Unit: >>>		(For example: MGD, HP, GPM...)

Project Name:	Faro Mine Remediation Project
Project Number:	
Project Manager:	Lionel Etheridge
Estimator:	Jason Curl
Project Description:	New Faro 5000 gpm HDS WTP
Project Location (City):	Faro
Project Location (State):	YUKON
Project Location (Country):	CANADA
Construction Start (Month):	Apr
Construction Start (Year):	2013
Construction Duration (months):	33
Mid-Point of Construction:	Sep/2014

Roundup to the nearest: $1,000

☐ This Report is for INTERNAL Distributio

☑ This Report is for EXTERNAL Distributic

Item	Is This Facility Included in Project? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	IWP Mixing Tank: ReactorA	$221,000
	Yes	IWP Mixing Tank: ReactorB	$2,971,000
	Yes	IWP Filters: FaroFilter	$4,343,000
	Yes	Dry Chemical: Polymer	$431,000
	Yes	Liquid Chemical: H2SO4	$250,000
	Yes	In-Plant PS: BWRecy	$618,000
	Yes	U.D. Facility: LimeSlaker	$1,276,000
	No	U.D. Facility: Backfill	$0
	Yes	IWP GT Conc Basin: Thickener	$5,854,000

SUBTOTAL - PROJECT COST			$15,964,000
ADDITIONAL PROJECT COSTS:			
Demolition	0.0%		$0
Overall Sitework	3.1%		$495,000
Plant Computer System	1.4%		$224,000
Yard Electrical	4.3%		$687,000
Yard Piping	5.5%		$879,000
UD #1 Default Description	0.0%		$0
UD #2 Default Description	0.0%		$0
UD #3 Default Description	0.0%		$0
SUBTOTAL with Additional Project Costs			$18,249,000
TAX:	0.00%	$18,249,000	$0
SUBTOTAL with Tax			$18,249,000
CONTRACTOR MARKUPS:			
Overhead	10%	$18,249,000	$1,825,000
Subtotal			$20,074,000
Profit	5%	$20,074,000	$1,004,000
Subtotal			$21,078,000
Mob/Bonds/Insurance	5%	$21,078,000	$1,054,000
Subtotal			$22,132,000
Contingency	30%	$22,132,000	$6,640,000
SUBTOTAL with Markups			$28,772,000

All Rights Owned by CH2M HILL /
All Rights Reserved.

ESCALATION (to Mid-Point of Construction)	0.0%	$28,772,000	$0
SUBTOTAL with Escalation			$28,772,000
LOCATION ADJUSTMENT FACTOR	138.25	$28,772,000	$39,778
SUBTOTAL - with Local Adjustment Factor			$39,778,000
SUBTOTAL - CONSTRUCTION COST with Red Flags			$39,778,000
MARKET ADJUSTMENT FACTOR	5%	$39,778,000	$1,989,000
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			$41,767,000
Your CPES Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		Curl	Click for Reviewe
Name of Estimator Reviewer		Meyer	
MAXIMUM CONSTRUCTION COST			$41,767,000
NON-CONSTRUCTION COSTS:			
Permitting	0%	$41,767,000	$0
Engineering	0%	$41,767,000	$0
Services During Construction	0%	$41,767,000	$0
Commissioning & Startup	0%	$41,767,000	$0
Land / ROW	0%	$41,767,000	$0
Legal / Admin	0%	$41,767,000	$0
Other Default Description	0%	$41,767,000	$0
SUBTOTAL - Non-Construction Costs			$0
TOTAL - CAPITAL COST			$41,767

Currency Conversion of TOTAL CAPITAL COST:

Currency	Unit of Measure	Conversion Rate	Converted Amount
CAD	Canadian Dollar	1.00776	42,000,000

All Rights Owned by CH2M HILL /
All Rights Reserved.

CH2M HILL Parametric Cost Estimating System (CPES)

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 5/30/2012 | Click for CPES QA/ QC | To Concrete Wall Thickness Help | To Cost Summary Matrix | To Unit Cost Database

Project Capactiy: >>>		Project Unit: >>>		(For example: MGD, HP, GPM...)

Project Name:	Faro Mine Remediation Project
Project Number:	
Project Manager:	Lionel Etheridge
Estimator:	Jason Curl
Project Description:	5000 and 7000 gpm HDS WTP influent/effluent pipeline
Project Location (City):	Faro
Project Location (State):	YUKON
Project Location (Country):	CANADA
Construction Start (Month):	Apr
Construction Start (Year):	2013
Construction Duration (months):	33
Mid-Point of Construction:	Sep/2014

Roundup to the nearest: $1,000

☐ This Report is for INTERNAL Distributio

☐ This Report is for EXTERNAL Distributio

Item	Is This Facility Included in Project? (Yes or No)	SCOPE OF PROJECT		Cost
	No	Pressure Pipe: Vangorda1		$0
	No	Pressure Pipe: Vangorda2		$0
	No	Pressure Pipe: Grum		$0
	Yes	Pressure Pipe: ClarEff		$674,000
	No	Pressure Pipe: Gravity		$0
	No	Pressure Pipe: Faro		$0
	Yes	Pressure Pipe: EffSludge		$1,425,000
	Yes	Pressure Pipe: ETA		$433,000
	Yes	Pressure Pipe: FaroInfl		$674,000
	Yes	Pressure Pipe: Tailings		$584,000
SUBTOTAL - PROJECT COST				$3,790,000
ADDITIONAL PROJECT COSTS:				
Demolition		0%		$0
Overall Sitework		0%		$0
Plant Computer System		0%		$0
Yard Electrical		0%		$0
Yard Piping		0%		$0
UD #1 Default Description		0%		$0
UD #2 Default Description		0%		$0
UD #3 Default Description		0%		$0
SUBTOTAL with Additional Project Costs				$3,790,000
TAX:		0.00%	$3,790,000	$0
SUBTOTAL with Tax				$3,790,000
CONTRACTOR MARKUPS:				
Overhead		10%	$3,790,000	$379,000
Subtotal				$4,169,000
Profit		5%	$4,169,000	$209,000
Subtotal				$4,378,000
Mob/Bonds/Insurance		5%	$4,378,000	$219,000

All Rights Owned by CH2M HILL / All Rights Reserved.

	A	B	C	D	E
55	*Subtotal*				$4,597,000
56	*Contingency*		30%	$4,597,000	$1,380,0
57	*SUBTOTAL with Markups*				$5,977,0
58					
59	*ESCALATION (to Mid-Point of Construction)*		0.0%	$5,977,000	$0
60	*SUBTOTAL with Escalation*				$5,977,000
61					
62	*LOCATION ADJUSTMENT FACTOR*		138.25	$5,977,000	$8,264,000
63	*SUBTOTAL - with Local Adjustment Factor*				$8,264,000
64					
94					
95	*SUBTOTAL - CONSTRUCTION COST with Red Flags*				$8,264,000
96					
97	*MARKET ADJUSTMENT FACTOR*		5%	$8,264,000	$414,000
98	*SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor*				$8,678,000
99	*Your CPES Estimate MUST be reviewed by a Process person AND an Estimator:*				
100	*Name of Process Reviewer*			Curl	Click for Reviewe
101	*Name of Estimator Reviewer*			Meyer	
102	*MAXIMUM CONSTRUCTION COST*				$8,678,000
103					
104	*NON-CONSTRUCTION COSTS:*				
105	*Permitting*		0%	$8,678,000	$0
106	*Engineering*		0%	$8,678,000	$0
107	*Services During Construction*		0%	$8,678,000	$0
108	*Commissioning & Startup*		0%	$8,678,000	$0
109	*Land / ROW*		0%	$8,678,000	$0
110	*Legal / Admin*		0%	$8,678,000	
111	*Other Default Description*		0%	$8,678,000	
112	*SUBTOTAL - Non-Construction Costs*				$0
113					
114	*TOTAL - CAPITAL COST*				$8,678,000
115					
116	*Currency Conversion of TOTAL CAPITAL COST:*				
117		*Currency*	*Unit of Measure*	*Conversion Rate*	*Converted Amount*
118		CAD	Canadian Dollar	1.00776	$ 9,000,000.00

All Rights Owned by CH2M HILL /
All Rights Reserved.

C H2M HILL P arametric Cost E stimating S ystem (CPES)

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 7/12/2012 | Click for CPES QA/ QC | To Concrete Wall Thickness Help | To Cost Summary Matrix | To Unit Cost Database

Project Capactiy: >>>		Project Unit: >>>		(For example: MGD, HP, GPM...)

Project Name:	Faro Mine Remediation Project
Project Number:	
Project Manager:	Lionel Etheridge
Estimator:	Jason Curl
Project Description:	New VanGorda 2000 gpm HDS WTP (excludes influent/effluent pipelines)
Project Location (City):	Faro
Project Location (State):	YUKON
Project Location (Country):	CANADA
Construction Start (Month):	Apr
Construction Start (Year):	2013
Construction Duration (months):	33
Mid-Point of Construction:	Sep/2014

Roundup to the nearest: $1,000

☐ This Report is for INTERNAL Distributio

☑ This Report is for EXTERNAL Distributio

Item	Is This Facility Included in Project? (Yes or No)	SCOPE OF PROJECT	Cost
	Yes	IWP Mixing Tank: ReactorA	$184,000
	Yes	IWP Mixing Tank: ReactorB	$1,482,000
	Yes	IWP Filters: FaroFilter	$2,412,000
	Yes	Dry Chemical: Polymer	$430,000
	Yes	Liquid Chemical: H2SO4	$245,000
	Yes	In-Plant PS: BWRecy	$361,000
	Yes	U.D. Facility: LimeSlaker	$827,000
	Yes	U.D. Facility: Backfill	$363,000
	Yes	IWP GT Conc Basin: Thickener	$3,742,000

SUBTOTAL - PROJECT COST			$10,046,000
ADDITIONAL PROJECT COSTS:			
Demolition	0.0%		$0
Overall Sitework	3.1%		$312,000
Plant Computer System	1.4%		$141,000
Yard Electrical	4.3%		$432,000
Yard Piping	5.5%		$553,000
UD #1 Default Description	0.0%		$0
UD #2 Default Description	0.0%		$0
UD #3 Default Description	0.0%		$0
SUBTOTAL with Additional Project Costs			$11,484,000
TAX:	0.00%	$11,484,000	$0
SUBTOTAL with Tax			$11,484,000
CONTRACTOR MARKUPS:			
Overhead	10%	$11,484,000	$1,149,000
Subtotal			$12,633,000
Profit	5%	$12,633,000	$632,000
Subtotal			$13,265,000
Mob/Bonds/Insurance	5%	$13,265,000	$664,000

All Rights Owned by CH2M HILL /
All Rights Reserved.

Subtotal			$13,929,000
Contingency	30%	$13,929,000	$4,179,000
SUBTOTAL with Markups			$18,108
ESCALATION (to Mid-Point of Construction)	0.0%	$18,108,000	$0
SUBTOTAL with Escalation			$18,108,000
LOCATION ADJUSTMENT FACTOR	138.25	$18,108,000	$25,035,000
SUBTOTAL - with Local Adjustment Factor			$25,035,000
SUBTOTAL - CONSTRUCTION COST with Red Flags			$25,035,000
MARKET ADJUSTMENT FACTOR	5%	$25,035,000	$1,252,000
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			$26,287,000
Your CPES Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		Curl	Click for Reviewe
Name of Estimator Reviewer		Meyer	
MAXIMUM CONSTRUCTION COST			$26,287,000
NON-CONSTRUCTION COSTS:			
Permitting	0%	$26,287,000	$0
Engineering	0%	$26,287,000	$0
Services During Construction	0%	$26,287,000	$0
Commissioning & Startup	0%	$26,287,000	$0
Land / ROW	0%	$26,287,000	$0
Legal / Admin	0%	$26,287,000	
Other Default Description	0%	$26,287,000	$0
SUBTOTAL - Non-Construction Costs			$0
TOTAL - CAPITAL COST			$26,287,000

Currency Conversion of TOTAL CAPITAL COST:

Currency	Unit of Measure	Conversion Rate	Converted Amount
CAD	Canadian Dollar	1.00776	27,000,000

All Rights Owned by CH2M HILL /
All Rights Reserved.

C H2M HILL P arametric Cost E stimating S ystem (CPES)

FACILITIES DESIGN & CONSTRUCTION COST MODULE

File Version: 7/11/2012 | Click for CPES QA/ QC | To Concrete Wall Thickness Help | To Cost Summary Matrix | To Unit Cost Database

Project Capactiy: >>>		Project Unit: >>>		(For example: MGD, HP, GPM...)

Project Name:	Faro Mine Remediation Project
Project Number:	
Project Manager:	Lionel Etheridge
Estimator:	Jason Curl
Project Description:	Effluent Pipelines for 2000 gpm VanGorda WTP
Project Location (City):	Faro
Project Location (State):	YUKON
Project Location (Country):	CANADA
Construction Start (Month):	Apr
Construction Start (Year):	2013
Construction Duration (months):	33
Mid-Point of Construction:	Sep/2014

Roundup to the nearest: $1

☐ This Report is for INTERNAL Distributio

☒ This Report is for EXTERNAL Distributio

Item	Is This Facility Included in Project? (Yes or No)	SCOPE OF PROJECT	Cost
	No	Pressure Pipe: VGPit	$0
	No	Pressure Pipe: GrumPit	$0
	Yes	Pressure Pipe: TreatEff	$528,896
	Yes	Pressure Pipe: SludgeEff	$347,272

SUBTOTAL - PROJECT COST			$876,168
ADDITIONAL PROJECT COSTS:			
Demolition	0%		$0
Overall Sitework	0%		$0
Plant Computer System	0%		$0
Yard Electrical	0%		$0
Yard Piping	0%		$0
UD #1 Default Description	0%		$0
UD #2 Default Description	0%		$0
UD #3 Default Description	0%		$0
SUBTOTAL with Additional Project Costs			$876,168
TAX:	0.00%	$876,168	$0
SUBTOTAL with Tax			$876,168
CONTRACTOR MARKUPS:			
Overhead	10%	$876,168	$87,617
Subtotal			$963,785
Profit	5%	$963,785	$48,190
Subtotal			$1,011,975
Mob/Bonds/Insurance	5%	$1,011,975	$50,599
Subtotal			$1,062,574
Contingency	30%	$1,062,574	$318,773
SUBTOTAL with Markups			$1,381,347
ESCALATION (to Mid-Point of Construction)	0.0%	$1,381,347	$0

All Rights Owned by CH2M HILL /
All Rights Reserved.

SUBTOTAL with Escalation			$1,381,347
LOCATION ADJUSTMENT FACTOR	138.25	$1,381,347	$1,909
SUBTOTAL - with Local Adjustment Factor			$1,909,
SUBTOTAL - CONSTRUCTION COST with Red Flags			$1,909,713
MARKET ADJUSTMENT FACTOR	0%	$1,909,713	$0
SUBTOTAL - CONSTRUCTION COST with Market Adjustment Factor			$1,909,713
Your CPES Estimate MUST be reviewed by a Process person AND an Estimator:			
Name of Process Reviewer		Curl	Click for Reviewe
Name of Estimator Reviewer		Meyer	
MAXIMUM CONSTRUCTION COST			$1,909,713
NON-CONSTRUCTION COSTS:			
Permitting	0%	$1,909,713	$0
Engineering	0%	$1,909,713	$0
Services During Construction	0%	$1,909,713	$0
Commissioning & Startup	0%	$1,909,713	$0
Land / ROW	0%	$1,909,713	$0
Legal / Admin	0%	$1,909,713	$0
Other Default Description	0%	$1,909,713	$0
SUBTOTAL - Non-Construction Costs			$0
TOTAL - CAPITAL COST			$1,909,713

Currency Conversion of TOTAL CAPITAL COST:

Currency	Unit of Measure	Conversion Rate	Converted Amo
None	U.S.Dollar	1	2,000,000

All Rights Owned by CH2M HILL /
All Rights Reserved.

Attachment B
Life-Cycle Cost Details

TABLE B-1

Comparison of Life-Cycle Cost of One Plant at Faro Site vs. Two Plants at Faro and Vangorda

Faro Mine Remediation Project

	One Plant: 38 ML/d (7,000 gpm)								2 Plants: 27 ML/d + 11 ML/d (5,000 gpm + 2,000 gpm)								
Year	Capital	Labour	Chemicals	Electricity	Analyticals	Maint. Materials	Total	NPV	Capital	Labour	Chemicals	Electricity	Analyticals	Maint. Materials	Total	NPV	% increase
0	$83,000,000								$85,000,000								
1		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
2		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
3		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
4		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
5		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
6		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
7		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
8		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
9		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
10		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
11		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
12		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
13		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
14		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
15		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
16		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
17		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
18		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
19		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
20		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
21		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
22		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
23		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
24		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
25		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
26		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
27		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
28		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
29		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
30		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667	$ 108,000,000		$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000	$ 112,000,000	4%
31		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
32		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
33		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
34		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
35		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
36		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
37		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
38		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
39		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
40		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
41		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
42		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
43		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
44		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
45		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
46		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
47		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
48		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
49		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
50		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667	$ 117,000,000		$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000	$ 121,000,000	3%
51		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
52		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
53		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
98		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
99		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
100		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667	$ 125,000,000		$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000	$ 130,000,000	4%
101		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
102		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
103		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
298		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
299		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
300		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667	$ 127,000,000		$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000	$ 133,000,000	5%
301		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
302		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
303		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
498		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
499		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667			$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000		
500		$ 216,667	$ 484,000	$ 330,000	$ 20,000	$ 267,000	$ 1,317,667	$ 127,000,000		$ 325,000	$ 484,000	$ 366,000	$ 40,000	$ 280,000	$ 1,495,000	$ 133,000,000	5%
							$ 658,833,333								$ 747,500,000		

Assumptions:

Discount rate = 3%

Annual ops costs = Labour + Chemicals + Analyticals + Maintenance Materials + Electricity

Labour: one plant = $325,000/yr; two plants = $625,000/yr

Chemicals: same for both 1 plant and 2 plants.

Analyticals: 1 plant = $20K/year; 2 plant = $40K/yr

Maintenance and materials: 1 plant = $200K/yr; 2 plant = $250K/yr Assumes 1% of CPES subtotal project cost before markups

Electricity: based on major connected loads and utilization factors - see attached electricity cost summary sheet

Lime: Assume $200/tonne delivered for CaO based on site historical costs

Assume lime demand as $Ca(OH)_2$ averages 0.5 g/L over the project life, based on ~2X HDS-1 lime consumption for pilot test.

Assume 38 ML/d (7,000 gpm) treated over 5 months, and that the same amount of lime used if 1 or 2 plants.

Annual volume of water treated = 5,700 ML

Annual $Ca(OH)_2$ demand, tonnes = 2,850

Annual lime cost = $ 430,000

Polymer: Assume 3 mg/L dose = 0.000025 lb/gal

Assume $2/lb delivered

Assume 38 ML/d (7,000 gpm) average treatment rate for 5 months

Assume same amount of polymer used if either 1 or 2 plants.

Annual polymer cost = $ 54,000.00

Total Chemicals: $ 484,000.00

TABLE B-2

Faro Mine Summary of HDS WTP Operations - Annual Electrical Power Cost Estimate

Faro Mine Remediation Project

Plant Size --->	11 ML/d			27 ML/d			38 ML/d			Notes
ITEM	# of Motors	Running Power kW	Annual Electricity Cost $	# of Motors	Running Power kW	Annual Electricity Cost $	# of Motors	Running Power kW	Annual Electricity Cost $	
Influent Pumping	1	88	$ 52,396	1	170	100000	1	170+90	$ 134,000	Static lift varies, depending on source and destination
Lime-Sludge Mixer	1	1.0	$ 583	1	2.5	$ 1,458	1	3.4	$ 2,041	Based on 5 months of operation and 16.5 cents/kWh
Reactor Mixers	2	21	$ 24,488	2	52	$ 61,220	2	72	$ 85,708	Based on 5 months of operation and 16.5 cents/kWh
Blowers	1	3	$ 1,796	2	5	$ 5,800	2	7	$ 8,766	Based on 5 months of operation and 16.5 cents/kWh
Sludge Recycle Pumping	1	5	$ 3,075	1	13	$ 7,686	1	18	$ 10,761	Based on 5 months of operation and 16.5 cents/kWh
Sludge Waste Pumping	1	0.3	$ 28	1	8	$ 782	1	11	$ 1,095	Based on intermitted waste flow
Thickener Drive	1	0.5	$ 500	1	1.0	1000	1	1.4	$ 1,407	Based on 5 months of operation and 16.5 cents/kWh
Lime Slaker and Recirc Pump + Polymer System	lot	15	$ 8,910	1	40	$ 23,760	1	50	$ 29,700	Based on 5 months of operation and 16.5 cents/kWh
Misc. Other Power	lot	5	$ 2,970		12	$ 7,290		17	$ 10,260	Based on 5 months of operation and 16.5 cents/kWh
Lighting	lot	2	$ 1,188		5	$ 2,916		7	$ 4,104	Allowance
Heating	lot	30	$ 25,000	1	40	$ 33,000	1	50	$ 42,000	Keep facility from freezing during winter
Total Annual Electrical Cost Estimate			**$ 121,000**			**$ 245,000**			**$ 330,000**	

Attachment C
Comparison of Noneconomic Factors for One or Two WTPs

TABLE C-1

Comparison of Noneconomic Factors for One or Two WTPs

Faro Mine Remediation Project

Feature	One WTP	Two WTPs	Reason
Field Investigations			
Additional Field Work Required	Equal or more work	Equal	Cross-site pipeline requires more additional field work than the Vangorda plant site
Subcontracting	Equal	Equal	Additional subcontracts required for field investigations
Health and Safety	Equal	Equal	No discernable difference
Impact to Access Roads	Less favourable	More favourable	Drilling at multiple locations near road
Impact to Pristine Areas	Less favourable	More favourable	Requires cross-site pipeline field investigations
Uncertainties	Less favourable	More favourable	Pipeline longer, so there is more uncertainty (e.g., depth to rock, permafrost, etc.)
Design			
Hydraulic Capacity Sizing Analysis	Equal	Equal	Both require similar effort
Water Chemistry/Loading Analysis	Equal	Equal	Both require similar effort
Detailed Design Efforts	More favourable	Less favourable	One WTP with pipeline simpler than Two WTPs
Time Frame for Design	More favourable	Less favourable	One WTP with pipeline quicker than Two WTPs
Client and External Review Effort	More favourable	Less favourable	One WTP with pipeline simpler than Two WTPs
Regulatory Approval	Less favourable	More favourable	Cross-watershed transport adds complexity
Contractor Procurement			
Cost	Less favourable	More favourable	Assuming separate contract for pipeline vs. single contract for two plants
Public Relations	Equal	Equal	No difference identified
Health and Safety	Equal	Equal	No difference identified
Risk of Suitable Contractors	Equal	Equal	No difference identified

TABLE C-1

Comparison of Noneconomic Factors for One or Two WTPs

Faro Mine Remediation Project

Feature	One WTP	Two WTPs	Reason
Risk of Bids Exceeding Budget	Equal	Equal	No difference identified
Construction			
Subcontracting	Equal	Equal	No difference identified
Constructability	More favourable	Less favourable	Pipeline simpler than Vangorda WTP
Construction Sequencing	More favourable	Less favourable	Pipeline simpler than Vangorda WTP
Construction Duration	More favourable	Less favourable	Pipeline simpler than Vangorda WTP
Construction Risks	Slightly higher	Slightly lower	More subsurface uncertainty with pipeline than WTP
Public Relations	Equal	Equal	No difference identified
Health and Safety	More favourable	Less favourable	WTP involves more complex tasks (e.g., welding, electrical, cranes)
Facility Operations			
Operations Complexity	More favourable	Less favourable	Pipeline simpler than Vangorda WTP
Public Relations	Equal	Equal	No difference identified
Health and Safety	More favourable	Less favourable	Pipeline simpler than Vangorda WTP
Access Roads Maintenance	More favourable	Less favourable	One WTP has less truck traffic to Vangorda site
Site Security	More favourable	Less favourable	One WTP is easier to secure
Influent Pumping Energy	Less favourable	More favourable	Higher pump lift for cross-site pipeline
Overall Carbon Footprint	More favourable	Less favourable	One WTP has less traffic and lower heating costs
Effluent Quality	Equal	Equal	No difference identified
Ability to Adjust to Future Changes in Flow/Load Conditions	More favourable	Less favourable	Easier to adapt/expand one WTP

TABLE C-1

Comparison of Noneconomic Factors for One or Two WTPs

Faro Mine Remediation Project

Feature	One WTP	Two WTPs	Reason
Ability to Adjust to Future Changes in Discharge Regulations	More favourable	Less favourable	Easier to modify one central WTP
Process Control System Simplicity	More favourable	Less favourable	Pipeline system easier to operate than second WTP
Operational Flexibility	Equal or more favourable	Equal or less favourable	Process modification easier at one single site
Operating Labour Requirement	Fewer operators required	More operators required	Two WTPs requires additional staff
Sample Collection and Analysis	More favourable	Less favourable	One point of effluent compliance
Data and Recordkeeping	More favourable	Less favourable	One point of compliance reporting
Regulatory Reporting	More favourable	Slightly higher	One point of compliance reporting
Ability to Minimize Environmental Risk	Equal or more favourable	Equal or less favourable	One WTP reduces potential for process upsets
Chemical Delivery Scheduling	More favourable	Less favourable	One WTP has simpler inventory
Reliability			
Adverse Weather Reliability	More favourable	Less favourable	Easier to operate one facility in adverse weather
Firm Capacity (plant capacity with equipment out of service)	More favourable	Less favourable	Easier to upgrade firm capacity at one site (e.g., thickener, substation)
Chemical Delivery Reliability	More favourable	Less favourable	Deliveries more reliable for one site
Spares – Level of Inventory	More favourable	Less favourable	Reduced level of spares on hand is favourable
Maintenance Labour Requirement	Fewer staff required	More staff required	Pipeline simpler than Vangorda WTP

Faro WTP Design Definition – Plant Siting
Faro Mine Remediation Project

PREPARED FOR: Government of Yukon

PREPARED BY: CH2M HILL Canada Limited

DATE: October 3, 2012

PROJECT NUMBER: 436662.13.PD.02

Purpose

The purpose of this technical memorandum (TM) is to select a location for the new Faro Area water treatment plant (WTP).

Background

In March 2012, as part of Task Authorization (TA) 004 of the Faro Mine Remediation Project, CH2M HILL Canada Limited (CH2M HILL) completed an evaluation of the Faro Mill Water Treatment Plant (Mill WTP) and its appurtenances, for the purpose of assessing its ability to continue operating and providing effective treatment of contaminated water over the next several years. A primary purpose was to provide a recommendation to the Government of Yukon (YG) on the timing for replacement of the Mill WTP with a new system.

The Mill WTP was initially constructed more than 10 years ago by reusing existing ore-processing equipment that was not intended for water treatment use, and which was already 30 years old. The Mill WTP was never intended to have a long service life; the design life was understood to be 5 years, but it has been in operation far longer. In general, CH2M HILL found the system to be subpar compared to typical industrial standards. In terms of operability, health and safety, and level of corrosion, it was the worst full-scale WTP the CH2M HILL team had ever inspected. Based on the considerations of reliability, operability, ability to meet treatment goals, and cost evaluated, CH2M HILL recommended replacement of the Mill WTP as soon as practical. YG placed an urgent priority on constructing a new high-density sludge (HDS) plant to replace the Mill WTP.

The *Faro Mine Complex, Closure and Remediation Plan, Project Description – Draft 4A* (C&R Plan) (SRK, 2010) recommended that the Faro HDS plant be constructed at the former BXL site, at the eastern end of the tailings area (BXL Site), as shown in Figure 1. While this site has a number of good features, it also has some significant drawbacks.

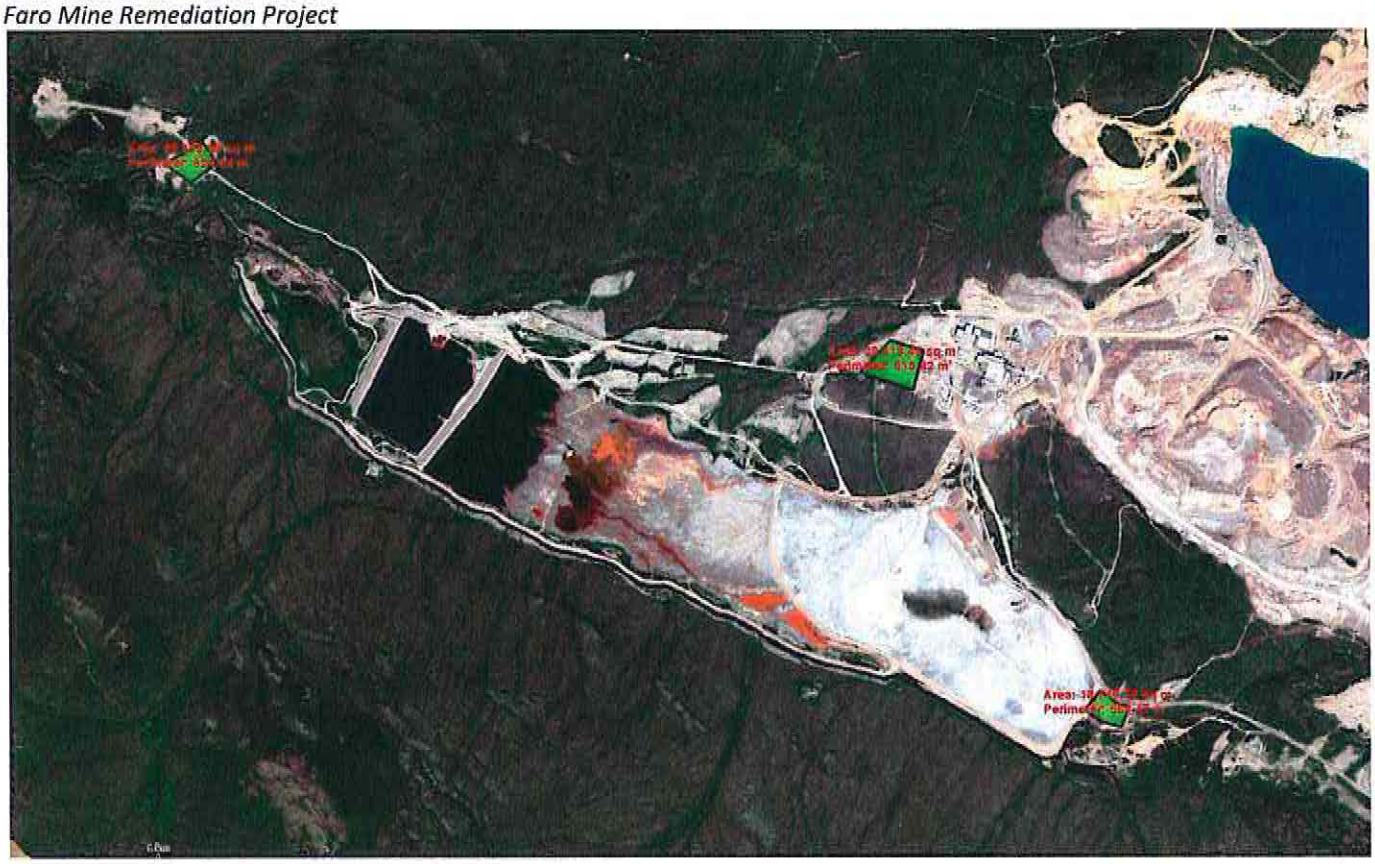
CH2M HILL identified an alternative site south of the existing mill (Mill Site, see Figure 1) that is closer to existing support infrastructure, is more cost-effective through strategic reuse of the existing facilities, and would allow the new plant to be brought online more quickly. This alternate site also has other advantages over the BXL Site.

YG acknowledged the benefit of the Mill Site over the BXL Site, and in 2012, provided authorization to undertake boreholes and geotechnical assessment at the Mill Site. This work is now complete.

A disadvantage of the Mill Site is a higher pumping lift requirement from the Intermediate Dam (ID) Pond and future Down-Valley Seepage Wells to the WTP during the 5 months of plant operations. In this regard, CH2M HILL also identified a third WTP site (Gravel Pit Site) at the gravel borrow pit, downstream of the tailings area. This site has adequate space for a new plant and offers the lowest pump lift for influent from the ID Pond and future Down-Valley Seepage Wells.

As part of TA 013(A), this TM documents the selection process and rationale for the location of the WTP based on technical, long-term cost, and operations and maintenance (O&M) considerations.

FIGURE 1
Three Candidate Plant Site Locations
Faro Mine Remediation Project



Description of Candidate Sites

Mill Site

The Mill Site (Figure 2) is located to the southwest of the existing Mill Building. The site, as shown, has approximately 39 hectares (ha). There is adequate space for the initial plant construction, with space to double the plant capacity. There is adequate space for temporary construction staging purposes, as well. The approximate elevation (EL) of the site is 1,140 metres (m) above mean sea level (amsl).

The Mill Buildings were a central hub of activity during the mine's operation and was converted to a temporary lime treatment facility which is still in use. As such, this site has developed infrastructure, including: pipelines, roads, electrical substation, communications, and parking facilities that can be reused/adapted. The construction of a new HDS plant at this site requires the least level of infrastructure development, compared to other sites. For example, much of the existing pipelines to/from the existing Mill Site temporary plant could be reused with short lengths of tie-ins.

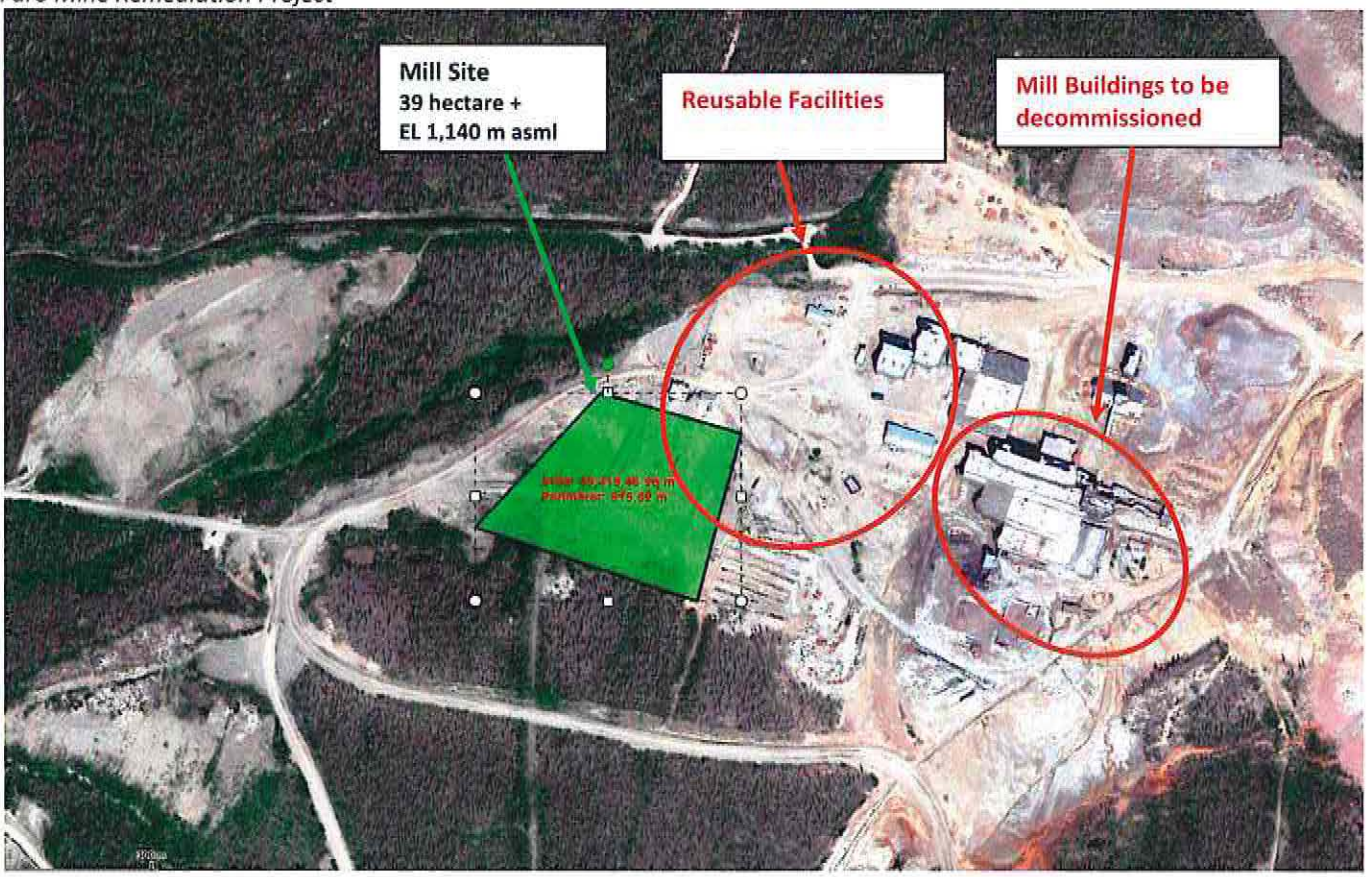
The proposed location is sufficiently removed from the existing buildings that locating a WTP at the proposed site will not pose a significant barrier to subsequent decommissioning activities that will be required for future mine closure activities.

This site provides the topographical relief necessary to implement gravity flow through the plant profile (including a lower bench for the filters) without an undue level of site regrading. It would provide the fastest and most economical implementation of a new HDS plant. A number of the existing shop, administration, and support building facilities can be reutilized for the new HDS plant, thereby achieving cost savings.

The site is also suitable as a long-term operations centre, within the overall site remediation strategy, with parking areas for the fleet of trucks/machines necessary for ongoing maintenance of the closed Faro Mine Security gates

can be provided to direct vehicular traffic towards this location as the initial entry point to the Faro Mine. Of all the potential sites, the Mill Site also has the largest available space for future expansion.

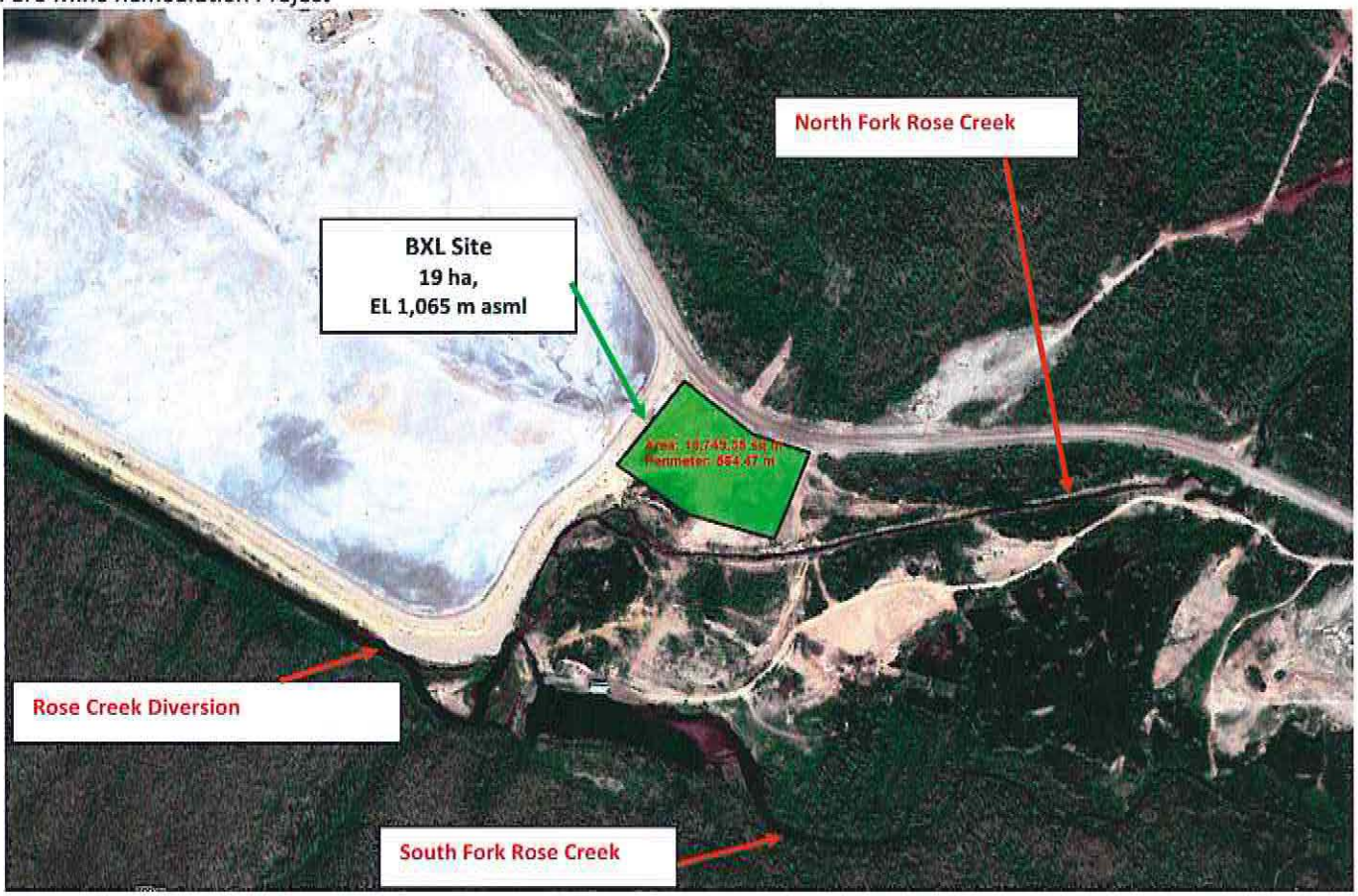
FIGURE 2
Mill Site Location
Faro Mine Remediation Project



BXL Site

The BXL site (Figure 3) is located on the eastern edge of the tailings pond, wedged between the main access road into the FMC and North Fork Rose Creek (NFRC). The site, as shown, is nearly 19 ha in size. It provides adequate space for current capacity, with the provision for doubling the HDS plant capacity in the future. This site has less space than the Mill Site and does not appear to have space for further expansion beyond 19 ha.

FIGURE 3
BXL Site Location
Faro Mine Remediation Project



The BXL Site was identified in the C&R Plan (SRK, 2010) as the preferred location due to two primary reasons:

1. It is out of the way of other closure activities at the FMC.
2. It is located along the access road into the FMC and in the future, the WTP, could serve as a guard house.

In addition, the location is also close to a clean water source and an effluent discharge location into Rose Creek.

This site has a number of disadvantages (relative to the Mill Site). It requires much more infrastructure construction to support the new treatment plant, as well as a geotechnical investigation, including: influent and sludge piping, site work electrical substation, power poles, communications, administrative facilities, parking facilities for service trucks, roadway turnarounds, water, and sewage. The provision of this infrastructure will add cost and will delay the implementation of the new HDS plant.

As the BXL Site is located in the Rose Creek Valley, there is a concern about flood risk. CH2M HILL's work scope does not include hydraulic analysis on this stretch of NFRC, but the project team obtained output from HEC-RAS model, which includes portions of NFRC, upstream of the confluence. The model was created by northwest hydraulic consultants ltd. (nhc)[1]. The profiles from the model (Attachment B) indicate that the BXL Site (at approximate EL of 1,065 m asml) is vulnerable to flooding. Given that this plant would need to be operated for a long time, the suitability of this site is poor.

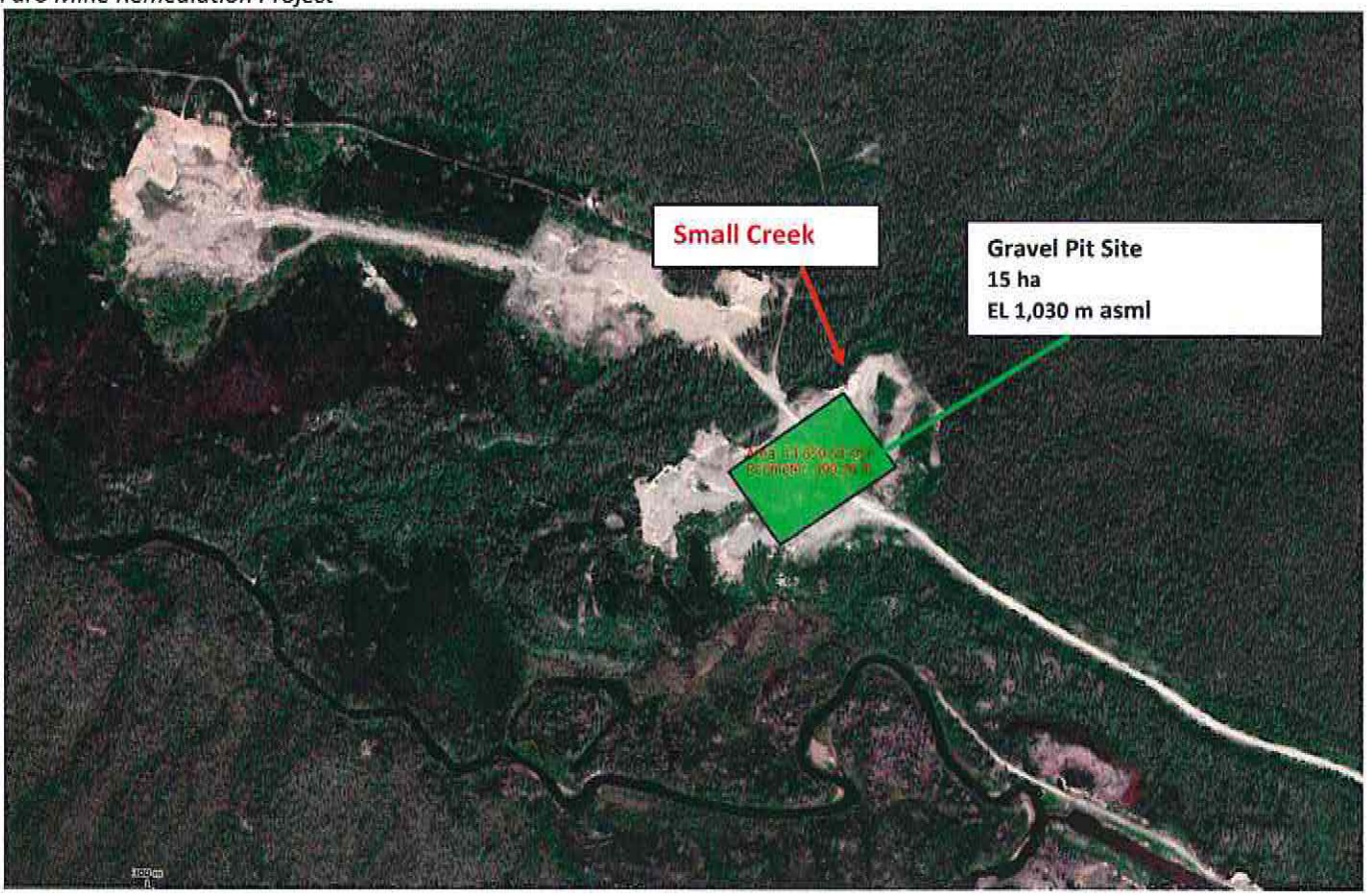
Gravel Pit Site

The Gravel Pit Site (Figure 4) is the first (highest EL) of a series of three benches (used as gravel pits), located below the Cross Valley Dam (CVD). It is at an approximate EL of 1,030 m asml and has approximately 15 ha of

[1] CH2M HILL was not involved in this work and has not performed a peer review.

available space, which is less than the BXL Site and the Mill Site. The available space is adequate for current needs and has provision for doubling the HDS plant capacity in the future (6 ha) but is rather constrained for construction-related space. This site is limited for further expansion without considerable grade changes.

FIGURE 4
Gravel Pit Site Location
Faro Mine Remediation Project



This site is the most remote of the three. It requires the highest investment in infrastructure development to support the new treatment plant, including: influent and sludge piping, electrical power, communications, administrative facilities, water, and sewage.

While detailed investigation was not performed, this site may also have a flood risk due to its low EL. Visually, it appears to be some distance above the Rose Creek Valley bottom, but there is also a smaller creek that runs by the site to the north.

The reason this site is being evaluated is because it represents the scenario for the lowest influent pumping lift/pumping energy from the ID Pond and future Down-Valley Seepage Wells. This evaluation provides insight into the economic value of pumping energy savings over a long period of evaluation.

This site has been identified in the C&R Plan as a borrow area (for cap and cover activities). Clean granular fill is a relatively scarce resource. The construction of a WTP at this location would necessitate replacement of this borrow site.

Technical Evaluation of Alternative Sites

The primary basis of evaluation was based on the technical merit of each site. Each of the three sites was ranked by CH2M HILL on a number of technical requirements, necessary to meet the short- and long-term goals of the project. Rankings were assigned on a scale of 1 to 5, with 5 being best. A total score was tallied for each site. The highest score represents the most favourable site.

The secondary basis for evaluation was to quantify extra pumping costs associated with the sites at higher elevations and the extra infrastructure costs required for the more remote sites to provide a comparison of these cost factors.

System Sizing

The plant size used for evaluation of candidate sites is a 27 megalitres per day (ML/d) (5,000 United States gallons per minute [USgpm]) HDS plant. This facility is expected to be suitable for the needs in the short-term (20 to 30 years), with space allowed for a future expansion to double the capacity to 54 ML/d (10,000 USgpm). The footprint for this facility, with support infrastructure, is approximately 7 ha.

The description of the HDS plant, including process flow diagram, major components, and summary of design parameters, is included in a separate TM (CH2M HILL, 2012). That TM evaluated a single HDS plant with a cross-site pipeline against two separate HDS plants and recommended that a single plant with cross-site pipeline be built, rather than two plants.

For construction purposes, an allowance of 5 ha of space at the plant site is suggested for temporary construction offices, laydown, equipment parking, staging, and other construction-contractor-related uses.

Technical Criteria

The following characteristics are desirable for the WTP location:

- Generally flat area, of sufficient size to accommodate the main process building and equipment, as well as potential expansion of the WTP or construction of a parallel WTP in the future
- Additional flat space nearby to use as a laydown area, base materials stockpile, and for other purposes during construction
- Sufficient topographical relief adjacent to the selected area to locate the filter system at a lower EL and allow gravity flow from the thickener to the filters, and from the filters to the plant discharge pipeline
- Adequate distance from the Mill Building and other contaminated materials to avoid interference with demolition and remediation activities
- Good road access
- Convenient location for access to existing pipelines (e.g., influent lines from Faro Pit, ID Pond, and Emergency Tailings Area [ETA]; and effluent line to Cross Valley Pond [CVP] and Rose Creek), electrical power, potable water, sewer system (e.g., septic tank/drain field), and other utilities, as appropriate
- Satisfactory subsurface conditions for foundations, which would not require an undue amount of work in solid rock
- Suitability for the new plant to be constructed and operational in a short timeframe, consistent with YG's medium-term site remediation construction objectives and schedule
- Effectiveness of location as long-term operational base of the closed Faro Mine
- Low risk of site flooding and other detrimental weather-related impacts

Technical Evaluation

Table 1 summarizes the rankings from a technical ranking of each site.

TABLE 1
Summary of Technical Ranking of Three HDS Plant Sites
Faro Mine Remediation Project

Technical Factor	Mill Site	Gravel Pit Site	BXL Site
Available area for short-term needs (existing Mill treatment replacement)	5	5	5
Available area for long-term expansion	5	3	3
Space for construction staging purposes	5	3	3
Topographical relief for gravity feed to filters	5	1	1
Adequate distance from existing areas that require demolition/remediation	4	4	4
Road and parking infrastructure	5	2	3
Convenient location for new pipelines and tie-in to existing pipelines	5	1	2
Access for electrical power	5	1	3
Access for potable water and sewer	5	3	3
Communications access	5	1	2
Allows for rapid implementation of new plant	5	1	2
Low risk of flood	5	3	1
Long-term effectiveness as operational base	4	1	4
Total Score	**63**	**29**	**36**

The Mill Site ranks as the preferred location for the new HDS treatment plant by a wide margin over the other two sites. It provides the opportunity for quickest implementation, and provides the safest and most flexible site over the long-term.

Cost Evaluation

Additional Infrastructure Costs

Relative to the Mill Site, the extra utilities required at the Gravel Pit Site are estimated to be in the range of $4 to $6 million, including the following:

- Detailed site investigation and site preparation
- Additional influent pipelines from the Mill Site
- Additional sludge pipe from the Mill Site
- Upgrade road services and parking
- Electrical power and communications

Relative to the Mill Site, the extra utilities required at the BXL Site are estimated to be in the range of $3 to $5 million, including the following:

- Detailed site investigation and site preparation
- Additional influent pipelines from the Mill Site
- Additional sludge pipe from the Mill Site
- Upgrade road services and parking
- Electrical power and communications

Pumping Costs

The pumping cost of the three sites were analyzed and compared. Only the differences in pumping energy related to the WTP site location were considered for evaluation. Pumped commodities with equal pumping costs, regardless of WTP site location, were not considered. The evaluation focused on two pumped commodities:

1. Influent from the ID Pond and future Down-Valley Seepage Wells
2. Sludge from the WTP to the Faro Pit

The Mill Site is at the highest elevation of 1140 m. The BXL Site is at 1065 m, while the Gravel Pit Site is at 1030 m. When the plant is in operation (5 months of the year), there will be a difference in pumping energy for the stated influent flows, depending on the elevation of the WTP site. In the nonoperational 7 months, there is no difference in pumping costs because the water is pumped to Faro Pit regardless of WTP location. Pumping from Faro Pit to the WTP is the same regardless of plant location because of the topographical high point at the crest of the pit.

Waste sludge needs to be pumped from the WTP thickener to Faro Pit. In this case, the Mill Site has the lowest lift requirement and the shortest pipe routing. The sludge volumes are much smaller than the influent volumes and serve to offset the power savings advantage of the lower elevation sites.

Table 2 summarizes the results of the pumping energy cost analysis; Attachment A provides the details of the analysis.

TABLE 2
Summary of Additional Influent Pumping Costs Relative to Lowest Elevation Gravel Pit Site
Faro Mine Remediation Project

	Net Present Value of Additional Pumping Cost		
Evaluation Period (years)	**Gravel Pit (baseline) ($ million)**	**Mill Site Pumping, relative to Gravel Pit Site ($ million)**	**BXL Site Pumping, relative to Gravel Pit Site [a] ($ million)**
12	0	1.4	0.95
30	0	2.2	1.5
50	0	2.7	1.8
100	0	3.3	2.2

Notes:

[a] Based on ratio of relative EL differences between BXL, Pit, and Mill Sites

The cost savings in pumping energy for the Gravel Pit Site relative to the Mill Site, over a 100-year operating period, is estimated at approximately $3.3 million. This is a relatively small cost premium for pumping energy and is less than the cost of additional infrastructure required for the Gravel Pit Site. Therefore, the Gravel Pit Site does not offer any economical advantage over the Mill Site.

The cost savings in pumping energy for the BXL Site relative to the Mill Site, over a 100-year operating period, is estimated at approximately $2.2 million[2], less than the additional $3 to $5 million for additional infrastructure costs for the BXL Site. Therefore, the BXL Site does not offer any economical advantage over the Mill Site.

Conclusion and Recommendation

Based on the foregoing, the Mill Site provides:

- The quickest implementation period
- The lowest cost for support infrastructure
- The largest site size and flexibility for future expansion

[2] Cost proportional to elevation differences between each of these to the Gravel Pit site.

- The safest location against flood risk
- A good centralized location for long-term operation

In conclusion, the preferred site to build the HDS plant is at the Faro Mill Site.

Works Cited

CH2M HILL Canada Limited (CH2M HILL). 2012. *Technical Memorandum No. 2. Faro WTP Design Definition – One versus Two Plant Comparison. Faro Mine Remediation Project*. Prepared for Government of Yukon. September 4.

northwest hydraulic consultants ltd. (nhc). HEC-RAS hydraulic model of North and South Forks of Rose Creek, upstream of confluence.

SRK Consulting Engineers and Scientists (SRK). 2010. *Faro Mine Complex, Closure and Remediation Plan, Project Description – Draft 4A*. Prepared for Yukon Government. March 29.

Attachment A
Additional Influent Pumping Cost Evaluation

Faro HDS Treatment Plant Site Selection Evaluation
Comparison of Lifecycle Cost of Pumping Energy Differences Between Mill Plant Site and Gravel Pit Site

Discount rate 0.03

Year		Mill site construction Mill site energy cost	Pit site Construction Pit site energy cost	Difference	Present Worth	Notes
2016	1	$ 174,677	$ 24,085	$ 150,592		WTP operation begins
2017	2	$ 174,677	$ 24,085	$ 150,592		
2018	3	$ 174,677	$ 24,085	$ 150,592		
2019	4	$ 174,677	$ 24,085	$ 150,592		
2020	5	$ 174,677	$ 24,085	$ 150,592		
2021	6	$ 174,677	$ 24,085	$ 150,592		
2022	7	$ 174,677	$ 24,085	$ 150,592		Down Valley Seepage Collection Begins
2023	8	$ 328,519	$ 177,927	$ 150,592		
2024	9	$ 328,519	$ 177,927	$ 150,592		
2025	10	$ 328,519	$ 177,927	$ 150,592		
2026	11	$ 328,519	$ 177,927	$ 150,592		
2027	**12**	$ 248,540	$ 168,365	$ 80,174	**$ 1,400,000**	Intermediate Pond flow reduced to 25% of initial
2028	13	$ 248,540	$ 168,365	$ 80,174		
2029	14	$ 248,540	$ 168,365	$ 80,174		
2030	15	$ 248,540	$ 168,365	$ 80,174		
2031	16	$ 248,540	$ 168,365	$ 80,174		
2032	17	$ 248,540	$ 168,365	$ 80,174		
2033	18	$ 248,540	$ 168,365	$ 80,174		
2034	19	$ 248,540	$ 168,365	$ 80,174		
2035	20	$ 248,540	$ 168,365	$ 80,174		
2036	21	$ 248,540	$ 168,365	$ 80,174		
2037	22	$ 248,540	$ 168,365	$ 80,174		
2038	23	$ 248,540	$ 168,365	$ 80,174		
2039	24	$ 248,540	$ 168,365	$ 80,174		
2040	25	$ 248,540	$ 168,365	$ 80,174		
2041	26	$ 248,540	$ 168,365	$ 80,174		
2042	27	$ 248,540	$ 168,365	$ 80,174		
2043	28	$ 248,540	$ 168,365	$ 80,174		
2044	29	$ 248,540	$ 168,365	$ 80,174		
2045	**30**	$ 248,540	$ 168,365	$ 80,174	**$ 2,200,000**	
2046	31	$ 248,540	$ 168,365	$ 80,174		
2047	32	$ 248,540	$ 168,365	$ 80,174		
2048	33	$ 248,540	$ 168,365	$ 80,174		
2049	34	$ 248,540	$ 168,365	$ 80,174		
2050	35	$ 248,540	$ 168,365	$ 80,174		
2051	36	$ 248,540	$ 168,365	$ 80,174		
2052	37	$ 248,540	$ 168,365	$ 80,174		
2053	38	$ 248,540	$ 168,365	$ 80,174		
2054	39	$ 248,540	$ 168,365	$ 80,174		
2055	40	$ 248,540	$ 168,365	$ 80,174		
2056	41	$ 248,540	$ 168,365	$ 80,174		
2057	42	$ 248,540	$ 168,365	$ 80,174		
2058	43	$ 248,540	$ 168,365	$ 80,174		
2059	44	$ 248,540	$ 168,365	$ 80,174		
2060	45	$ 248,540	$ 168,365	$ 80,174		
2061	46	$ 248,540	$ 168,365	$ 80,174		
2062	47	$ 248,540	$ 168,365	$ 80,174		
2063	48	$ 248,540	$ 168,365	$ 80,174		
2064	49	$ 248,540	$ 168,365	$ 80,174		
2065	**50**	$ 248,540	$ 168,365	$ 80,174	**$ 2,700,000**	
2066	51	$ 248,540	$ 168,365	$ 80,174		
2113	98	$ 248,540	$ 168,365	$ 80,174		
2114	99	$ 248,540	$ 168,365	$ 80,174		
2115	**100**	$ 248,540	$ 168,365	$ 80,174	**$ 3,200,000**	
2116	101	$ 248,540	$ 168,365	$ 80,174		
2514	499	$ 248,540	$ 168,365	$ 80,174		
2515	**500**	$ 248,540	$ 168,365	$ 80,174	**$ 3,300,000**	

Summary of Assumptions:
Faro HDS WTP construction completion by Fall 2015;
WTP Operation Begins 2016.
All operating costs equal, except: Intermediate Pond pumping and waste sludge pumping, which are WTP elevation dependant.
Year 2022 (operational year 7) Down Valley Seepage well pumping begins
Year 2027 (operational year 11) Intermediate Pond pumping reduced to 25% by covers and Storm Water Diversion

Gravel Pit to Mill = 110 m elevation difference
BXL to Mill = 75 m elevation difference.
75/110 = 68%
Approximate the pumping cost difference between BXL and Mill as 68% of the cost difference between Gravel Pit to Mill

Faro Mine High Density Sludge WTP
Plant Site Investigaton

Scenario 1 Synopsis
HDS plant located at mill site. Years 1-7
Intermediate pond water pumped up to HDS plant for 5 months in summer
Down Valley Seepage collection wells pumped to HDS plant for 5 months in summer and up to Faro Pit for 7 months in winter

This scenario assumes the Rose Valley tailings are capped 12 years from start (2024). This assumes that permitting for
closure work is complete in 2017 and that capping begins in 2022 (Year 5 of site closure) and is complete in 2023
It also assumes that the flow requiring collection and treatment is 25% of the pre-capping flow, and starts in Year 13

Year	Units	Faro Pit Pumping	IP Pumping	ETA to Mill WTP	Total
2008	million m³	2.27	2.00		4.27
2009	million m³	2.13	1.76		3.89
2010	million m³	2.01	1.16	0.03	3.2
2011	million m³		1.19		
2008-11 total	million m³		6.11		
2008-11 Avg	million m³/y		1.53		
2008-10 contribution	% of total				

Jim Stefanoff, P.E.
Principal Technologist
Mine Restoration
CH2M HILL, Suite 301, 309 Strickland Street
Whitehorse, Yukon Territory, Canada, Y1A 2J9
Office Phone: 867-668-2201 Ext. 2021
Cell Phone: 509-981-5015
Jim.Stefanoff@ch2m.com

Data and Constants

Mill Site		elevation	1140 m
Down Valley Sepage Collection system		elevation	1015 m
Intermediate Pond normal water level	*From Jim*	elevation	1044 m

Scenario 1 HDS WTP at Mill Site

Component Cost A - Pump Intermediate Pond to HDS Plant in summer

HDS plant located at Mill Site		elevation	1140	m		
Intermediate pond pumped to HDS plant during months of May 1 to September 3(		Vol of water	1,530,000	m3	1.53 million m3/yr, from 2008 to 2011 data. tailings Cap: decrease to 385,000 m3/y (to 25%)	
Intermediate pond assumed water level elevation			1,044	m		
Average flow			0.1	m3/s	1871 gpm	
Static lift			99	m	325 ft	141.18 psi
Assumed transfer pipe nomial size and rating			16" DR 9 (200 psi)			
Assumed transfer pipe size ID			313	mm	12.31 inch	
Hazen Williams friction loss calculation from IP to HDS plant						
Pipe ID, m			0.31			
C factor			130			
pipe length			2600.0	m		
pipe flow velocity , m/s			1.5	m/s		
minor loss factors (total K)			4.0			
Hm, minor losses, m			0.5			
Hf, friction losses, m			18.6		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L	
Ht, total losses, m			19.1			
Pump TDH			118.1	m	387 ft	168.46 psi
Theoretical pump power	= *pghQ*		136.80	kW	182.41 hp	
Assumed pump efficiency			80%	percent		
Actual pump power	= *theoretical power/ pump efficiency*		171.00	kW	228.01 hp	
Cost of electricity			0.165	$/kWh		
Electricity cost during period of pumping		$	**101,577**			

Component Cost B - Pump Down-Valley Seepage Collection System to HDS Plant in summer (5 months)

HDS plant located at Mill Site		elevation	1140	m	*Reactor is at contour 1137 m. Assume reactor is 3 m tall*	
DVS wells - assumed water level elevation			1,015	m		
DVS Average flow	*from Jim/ Pete Lawson - use 1155 gpm*		0.073	m3/s	1155 gpm	
Static lift			125	m	410 ft	178.26 psi
Assumed transfer pipe nomial size and rating			16" DR 9 (200 psi)			
Assumed transfer pipe size ID			313	mm	12.31 inch	
Hazen Williams friction loss calculation from DVS transfer station to HDS plan						
Pipe ID, m			0.31			
C factor			130			
pipe length	*from section generated by Lisa*		3100.0	m		
pipe flow velocity , m/s			0.9	m/s		
minor loss factors (total K)			4.0			
Hm, minor losses, m			0.2			
Hf, friction losses, m			9.1		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L	
Ht, total losses, m			9.3			
Pump TDH			134.3	m	440 ft	191.52 psi
Theoretical pump power	pghQ		96.04	kW	128.06 hp	
Assumed pump efficiency			80%	percent		
Actual pump power	= theoretical power/pump efficiency		120.05	kW	160.07 hp	
Cost of electricity			0.165	$/kWh		
Electricity cost during period of pumping		$	**71,311**			

Component Cost C - Pump Down-Valley Seepage Collection System to Faro Pit in winter (7 months)

Faro Pit, highest point in pipeline to		elevation	1192	m	*From Profile generated by Lisa*	
DVS wells - assumed water level elevation			1,015	m		
DVS Average flow	*from Jim/ Pete Lawson - use 1155 gpm*		0.073	m3/s	1155 gpm	
Static lift			177	m	581 ft	252.42 psi
Assumed transfer pipe nomial size and rating			16" DR 6.3 (300 psi)			
Assumed transfer pipe size ID			270	mm	10.615 inch	
Hazen Williams friction loss calculation from DVS transfer station to HDS plan						
Pipe ID, m			0.27			
C factor			130			
pipe length	*from section generated by Lisa*		4900.0	m		
pipe flow velocity , m/s			1.3	m/s		
minor loss factors (total K)			4.0			
Hm, minor losses, m			0.3			
Hf, friction losses, m			29.6		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L	
Ht, total losses, m			29.9			
Pump TDH			206.9	m	679 ft	295.12 psi *exceeds 300 psi pipe rating slightly*
Theoretical pump power	pghQ		148.00	kW	197.33 hp	
Assumed pump efficiency			80%	percent		
Actual pump power	= theoretical power/pump efficiency		185.00	kW	246.66 hp	
Cost of electricity			0.165	$/kWh		
Electricity cost during period of pumping						

Component Cost D - Sludge Pumping from Plant Thickener Underflow to Faro Pit (5 months)

Thickener Underflow elevation			1137	m		
High point of Faro Pit			1192	m		
Waste Sludge flow			0.011	m3/s	176 gpm	Flow during 4hr pumping period/day, for Medium chemistry
Static lift			55	m	180 ft	78.43 psi
Assumed transfer pipe nominal size and rating			6" DR 6.3 (300 psi)			
Assumed transfer pipe size ID			119	mm	4.7 inch	
Hazen Williams friction loss calculation from thickener Underflow to Faro Pit (high elevation point						
Pipe ID, m			0.12			
C factor			130			
pipe length			2500.0	m		
pipe flow velocity , m/s			1.0	m/s		
minor loss factors (total K)			4.0			
Hm, minor losses, m			0.2			
Hf, friction losses, m			24.5		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L	
Ht, total losses, m			24.7			
Pump TDH			79.7	m	261	
Underflow Sludge Specific Gravity			1.3			
Theoretical pump power	pghQ*SG		10.84	kW	14.46 hp	
Assumed pump efficiency			60%	percent		
Actual pump power	= theoretical power/pump efficiency		18.07	kW	24.10 hp	
Cost of electricity			0.165	$/kWh		
Electricity cost during 5 month period of pumping (4hrs/day pumping		$	**1,789**			

Sum of Annual Pumping Electricity Costs $ **174,677**

Faro Mine High Density Sludge WTP
Plant Site Investigation

Scenario 1 Synopsis
HDS plant located at mill site. Years 8-11
Intermediate pond water pumped up to HDS plant for 5 months in summer
Down Valley Seepage collection wells pumped to HDS plant for 5 months in summer and up to Faro Pit for 7 months in winter

This scenario assumes the Rose Valley tailings are capped 12 years from start (2024). This assumes that permitting for closure work is complete in 2017 and that capping begins in 2022 (Year 5 of site closure) and is complete in 2023
It also assumes that the flow requiring collection and treatment is 25% of the pre-capping flow, and starts in Year 13

Year	Units	Faro Pit Pumping	IP Pumping	ETA to Mill WTP	Total
2008	million m³	2.27	2.00		4.27
2009	million m³	2.13	1.76		3.89
2010	million m³	2.01	1.16	0.03	3.2
2011	million m³		1.19		
2008-11 total	million m³		6.11		
2008-11 Avg	million m³/y		1.53		
2008-10 contribution	% of total				

Data and Constants

Mill Site		elevation	1140 m
Down Valley Seepage Collection system		elevation	1015 m
Intermediate Pond normal water level	*From Jim*	elevation	1044 m

Jim Stefanoff, P.E.
Principal Technologist
Mine Restoration
CH2M HILL, Suite 301, 309 Strickland Street
Whitehorse, Yukon Territory, Canada, Y1A 2J9
Office Phone: 867-668-2201 Ext. 2021
Cell Phone: 509-981-5015
Jim.Stefanoff@ch2m.com

Scenario 1 HDS WTP at Mill Site

Component Cost A - Pump Intermediate Pond to HDS Plant in summer

HDS plant located at Mill Site		elevation	1140	m			
Intermediate pond pumped to HDS plant during months of May 1 to September 3(		Vol of water	1,530,000	m3	1.53 million m3/yr, from 2008 to 2011 data. tailings Cap: decrease to 385,000 m3/y (to 25%)		
Intermediate pond assumed water level elevation			1,044	m			
Average flow			0.1	m3/s	1871 gpm		
Static lift			99	m	325 ft	141.18 psi	
Assumed transfer pipe nominal size and rating			16" DR 9 (200 psi)				
Assumed transfer pipe size ID			313	mm	12.31 inch		
Hazen Williams friction loss calculation from IP to HDS plant							
Pipe ID, m			0.31				
C factor			130				
pipe length			2600.0	m			
pipe flow velocity , m/s			1.5	m/s			
minor loss factors (total K)			4.0				
Hm, minor losses, m			0.5				
Hf, friction losses, m			18.6		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L		
Ht, total losses, m			19.1				
Pump TDH			118.1	m	387 ft	168.46 psi	
Theoretical pump power	= *pghQ*		136.80	kW	182.41 hp		
Assumed pump efficiency			80%	percent			
Actual pump power	= *theoretical power/ pump efficiency*		171.00	kW	228.01 hp		
Cost of electricity			0.165	$/kWh			
Electricity cost during period of pumping			$ 101,577				

Component Cost B - Pump Down-Valley Seepage Collection System to HDS Plant in summer (5 months)

HDS plant located at Mill Site		elevation	1140	m	*Reactor is at contour 1137 m. Assume reactor is 3 m tall*		
DVS wells - assumed water level elevation			1,015	m			
DVS Average flow	*from Jim/ Pete Lawson - use 1155 gpm*		0.073	m3/s	1155 gpm		
Static lift			125	m	410 ft	178.26 psi	
Assumed transfer pipe nominal size and rating			16" DR 9 (200 psi)				
Assumed transfer pipe size ID			313	mm	12.31 inch		
Hazen Williams friction loss calculation from DVS transfer station to HDS plant							
Pipe ID, m			0.31				
C factor			130				
pipe length	*from section generated by Lisa*		3100.0	m			
pipe flow velocity , m/s			0.9	m/s			
minor loss factors (total K)			4.0				
Hm, minor losses, m			0.2				
Hf, friction losses, m			9.1		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L		
Ht, total losses, m			9.3				
Pump TDH			134.3	m	440 ft	191.52 psi	
Theoretical pump power	pghQ		96.04	kW	128.06 hp		
Assumed pump efficiency			80%	percent			
Actual pump power	= theoretical power/pump efficiency		120.05	kW	160.07 hp		
Cost of electricity			0.165	$/kWh			
Electricity cost during period of pumping			$ 71,311				

Component Cost C - Pump Down-Valley Seepage Collection System to Faro Pit in winter (7 months)

Faro Pit, highest point in pipeline to		elevation	1192	m	*From Profile generated by Lisa*		
DVS wells - assumed water level elevation			1,015	m			
DVS Average flow	*from Jim/ Pete Lawson - use 1155 gpm*		0.073	m3/s	1155 gpm		
Static lift			177	m	581 ft	252.42 psi	
Assumed transfer pipe nominal size and rating			16" DR 6.3 (300 psi)				
Assumed transfer pipe size ID			270	mm	10.615 inch		
Hazen Williams friction loss calculation from DVS transfer station to HDS plant							
Pipe ID, m			0.27				
C factor			130				
pipe length	*from section generated by Lisa*		4900.0	m			
pipe flow velocity , m/s			1.3	m/s			
minor loss factors (total K)			4.0				
Hm, minor losses, m			0.3				
Hf, friction losses, m			29.6		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L		
Ht, total losses, m			29.9				
Pump TDH			206.9	m	679 ft	295.12 psi	*exceeds 300 psi pipe rating slightly*
Theoretical pump power	pghQ		148.00	kW	197.33 hp		
Assumed pump efficiency			80%	percent			
Actual pump power	= theoretical power/pump efficiency		185.00	kW	246.66 hp		
Cost of electricity			0.165	$/kWh			
Electricity cost during period of pumping			$ 153,842				

Component Cost D - Sludge Pumping from Plant Thickener Underflow to Faro Pit (5 months)

Thickener Underflow elevation			1137	m			
High point of Faro Pit			1192	m			
Waste Sludge flow			0.011	m3/s	176 gpm	Flow during 4hr pumping period/day, for Medium chemistry	
Static lift			55	m	180 ft	78.43 psi	
Assumed transfer pipe nominal size and rating			6" DR 6.3 (300 psi)				
Assumed transfer pipe size ID			119	mm	4.7 inch		
Hazen Williams friction loss calculation from thickener Underflow to Faro Pit (high elevation point							
Pipe ID, m			0.12				
C factor			130				
pipe length			2500.0	m			
pipe flow velocity , m/s			1.0	m/s			
minor loss factors (total K)			4.0				
Hm, minor losses, m			0.2				
Hf, friction losses, m			24.5		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L		
Ht, total losses, m			24.7				
Pump TDH			79.7	m	261		
Underflow Sludge Specific Gravity			1.3				
Theoretical pump power	pghQ*SG		10.84	kW	14.46 hp		
Assumed pump efficiency			60%	percent			
Actual pump power	= theoretical power/pump efficiency		18.07	kW	24.10 hp		
Cost of electricity			0.165	$/kWh			
Electricity cost during 5 month period of pumping (4hrs/day pumping			$ 1,789				

Sum of Annual Pumping Electricity Costs $ 328,519

Faro Mine High Density Sludge WTP
Plant Site Investigation

Scenario 1 Synopsis
HDS plant located at mill site. Years 12-500
Intermediate pond water pumped to up to HDS plant for 5 months in summer
Down Valley Seepage collection wells pumped to HDS plant for 5 months in summer and up to Faro Pit for 7 months in winter.

This scenario assumes the Rose Valley tailings are capped 12 years from start (2024). This assumes that permitting for closure work is complete in 2017 and that capping begins in 2022 (Year 5 of site closure) and is complete in 2023.
It also assumes that the flow requiring collection and treatment is 25% of the pre-capping flow, and starts in Year 13.

Year	Units	Faro Pit Pumping	IP Pumping	ETA to Mill WTP	Total
2008	million m³	2.27	2.00		4.27
2009	million m³	2.13	1.76		3.89
2010	million m³	2.01	1.16	0.03	3.2
2011	million m³		1.19		
2008-11 total	million m³		6.11		
2008-11 Avg	million m³/y		1.53		
2008-10 contribution	% of total				

Data and Constants

Mill Site		elevation	1140	m
Down Valley Seepage Collection system		elevation	1015	m
Intermediate Pond normal water level	*From Jim*	elevation	1044	m

Jim Stefanoff, P.E.
Principal Technologist
Mine Restoration
CH2M HILL, Suite 301, 309 Strickland Street
Whitehorse, Yukon Territory, Canada, Y1A 2J9
Office Phone: 867-668-2201 Ext. 2021
Cell Phone: 509-981-5015
Jim.Stefanoff@ch2m.com

Scenario 1 HDS WTP at Mill Site

Component Cost A - Pump Intermediate Pond to HDS Plant in summer

HDS plant located at Mill Site		elevation	1140	m			
Intermediate pond pumped to HDS plant during months of May 1 to September 30		Vol of water	382,500	m3	1.53 million m3/yr, from 2008 to 2011 data. tailings Cap: decrease to 385,000 m3/y (to 25%).		
Intermediate pond assumed water level elevation			1,044	m			
Average flow			0.030	m3/s	468 gpm		
Static lift			99	m	325 ft	141.18 psi	
Assumed transfer pipe nominal size and rating			16" DR 9 (200 psi)				
Assumed transfer pipe size ID			313	mm	12.31 inch		
Hazen Williams friction loss calculation from IP to HDS plant							
Pipe ID, m			0.31				
C factor			130				
pipe length			2600.0	m			
pipe flow velocity , m/s			0.4	m/s			
minor loss factors (total K)			4.0				
Hm, minor losses, m			0.0				
Hf, friction losses, m			1.4		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L)		
Ht, total losses, m			1.5				
Pump TDH			100.5	m	330 ft	143.27 psi	
Theoretical pump power	= *pghQ*		29.09	kW	38.78 hp		
Assumed pump efficiency			80%	percent			
Actual pump power	= *theoretical power/ pump efficiency*		36.36	kW	48.48 hp		
Cost of electricity			0.165	$/kWh			
Electricity cost during period of pumping		$	21,598				

Component Cost B - Pump Down-Valley Seepage Collection System to HDS Plant in summer (5 months)

HDS plant located at Mill Site		elevation	1140	m	*Reactor is at contour 1137 m. Assume reactor is 3 m tall*		
DVS wells - assumed water level elevation			1,015	m			
DVS Average flow	*from Jim/ Pete Lawson - use 1155 gpm*		0.073	m3/s	1155 gpm		
Static lift			125	m	410 ft	178.26 psi	
Assumed transfer pipe nominal size and rating			16" DR 9 (200 psi)				
Assumed transfer pipe size ID			313	mm	12.31 inch		
Hazen Williams friction loss calculation from DVS transfer station to HDS plant							
Pipe ID, m			0.31				
C factor			130				
pipe length	*from section generated by Lisa*		3100.0	m			
pipe flow velocity , m/s			0.9	m/s			
minor loss factors (total K)			4.0				
Hm, minor losses, m			0.2				
Hf, friction losses, m			9.1		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L)		
Ht, total losses, m			9.3				
Pump TDH			134.3	m	440 ft	191.52 psi	
Theoretical pump power	pghQ		96.04	kW	128.06 hp		
Assumed pump efficiency			80%	percent			
Actual pump power	= theoretical power/pump efficiency		120.05	kW	160.07 hp		
Cost of electricity			0.165	$/kWh			
Electricity cost during period of pumping		$	71,311				

Component Cost C - Pump Down-Valley Seepage Collection System to Faro Pit in winter (7 months)

Faro Pit, highest point in pipeline to		elevation	1192	m	*From Profile generated by Lisa*		
DVS wells - assumed water level elevation			1,015	m			
DVS Average flow	*from Jim/ Pete Lawson - use 1155 gpm*		0.073	m3/s	1155 gpm		
Static lift			177	m	581 ft	252.42 psi	
Assumed transfer pipe nominal size and rating			16" DR 6.3 (300 psi)				
Assumed transfer pipe size ID			270	mm	10.615 inch		
Hazen Williams friction loss calculation from DVS transfer station to HDS plant							
Pipe ID, m			0.27				
C factor			130				
pipe length	*from section generated by Lisa*		4900.0	m			
pipe flow velocity , m/s			1.3	m/s			
minor loss factors (total K)			4.0				
Hm, minor losses, m			0.3				
Hf, friction losses, m			29.6		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L)		
Ht, total losses, m			29.9				
Pump TDH			206.9	m	679 ft	295.12 psi	*exceeds 300 psi pipe rating slightly*
Theoretical pump power	pghQ		148.00	kW	197.33 hp		
Assumed pump efficiency			80%	percent			
Actual pump power	= theoretical power/pump efficiency		185.00	kW	246.66 hp		
Cost of electricity			0.165	$/kWh			
Electricity cost during period of pumping		$	153,842				

Component Cost D - Sludge Pumping from Plant Thickener Underflow to Faro Pit (5 months)

Thickener Underflow elevation			1137	m			
High point of Faro Pit			1192	m			
Waste Sludge flow			0.011	m3/s	176 gpm		Flow during 4hr pumping period/day, for Medium chemistry
Static lift			55	m	180 ft	78.43 psi	
Assumed transfer pipe nominal size and rating			16" DR 6.3 (300 psi)				
Assumed transfer pipe size ID			119	mm	4.7 inch		
Hazen Williams friction loss calculation from thickener Underflow to Faro Pit (high elevation point)							
Pipe ID, m			0.12				
C factor			130				
pipe length			2500.0	m			
pipe flow velocity , m/s			1.0	m/s			
minor loss factors (total K)			4.0				
Hm, minor losses, m			0.2				
Hf, friction losses, m			24.5		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L)		
Ht, total losses, m			24.7				
Pump TDH			79.7	m	261		
Underflow Sludge Specific Gravity			1.3				
Theoretical pump power	pghQ*SG		10.84	kW	14.46 hp		
Assumed pump efficiency			60%	percent			
Actual pump power	= theoretical power/pump efficiency		18.07	kW	24.10 hp		
Cost of electricity			0.165	$/kWh			
Electricity cost during 5 month period of pumping (4hrs/day pumping)		$	1,789				

Sum of Annual Pumping Electricity Costs $ **248,540**

Faro Mine High Density Sludge WTP
Plant Site Investigation

Scenario 2 Synopsis
HDS plant located at Pit site. Years 1-7
Intermediate pond water pumped to up to HDS plant for 5 months in summer
Down Valley Seepage collection wells pumped to HDS plant for 5 months in summer and up to Faro Pit for 7 months in winter

This scenario assumes the Rose Valley tailings are capped 12 years from start (2024). This assumes that permitting for
closure work is complete in 2017 and that capping begins in 2022 (Year 5 of site closure) and is complete in 2023
It also assumes that the flow requiring collection and treatment is 25% of the pre-capping flow, and starts in Year 13

Year	Units	Faro Pit Pumping	IP Pumping	ETA to Mill WTP	Total
2008	million m³	2.27	2.00		4.27
2009	million m³	2.13	1.76		3.89
2010	million m³	2.01	1.16	0.03	3.2
2011	million m³		1.19		
2008-11 total	million m³		6.11		
2008-11 Avg	million m³/y		1.53		
2008-10 contribution	% of total				

Jim Stefanoff, P.E.
Principal Technologist
Mine Restoration
CH2M HILL, Suite 301, 309 Strickland Street
Whitehorse, Yukon Territory, Canada, Y1A 2J9
Office Phone: 867-668-2201 Ext. 2021
Cell Phone: 509-981-5015
jim.Stefanoff@ch2m.com

Data and Constants

HDS plant at gravel pit below Cross Valley Dam	*From GIS map 1025 m + 3 m reactor height*	elevation	1028 m
Down Valley Seepage Collection system	*From profile - ground el at well heads.*	elevation	1015 m
Intermediate Pond normal water level	*From Jim*	elevation	1044 m

Scenario 2 HDS WTP at gravel pit below Cross Valley Dam

Component Cost A - Pump Intermediate Pond to HDS Plant in summer

HDS plant located at Mill Site		elevation	1028	m	
Intermediate pond pumped to HDS plant during months of May 1 to September 3(		Vol of water	1,530,000	m3	1.53 million m3/yr, from 2008 to 2011 data. tailings Cap: decrease to 385,000 m3/y (to 25%)
Intermediate pond assumed water level elevation			1,044	m	
Average flow			0.1	m3/s	1871 gpm
Static lift			(13)	m	(43) ft (18.54) psi
Assumed transfer pipe nominal size and rating			16" DR 9 (200 psi)		
Assumed transfer pipe size ID			313	mm	12.31 inch
Hazen Williams friction loss calculation from IP to HDS plant					
Pipe ID, m			0.31		
C factor			130		
pipe length	*length is really 1900 m but use longer to simulate siphon make cost*		2900	m	
pipe flow velocity , m/s			1.5	m/s	
minor loss factors (total K)			4.0		
Hm, minor losses, m			0.5		
Hf, friction losses, m			20.8		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L
Ht, total losses, m			21.3		
Pump TDH			8.3	m	27 ft 11.80 psi
Theoretical pump power	= *pghQ*		9.59	kW	12.78 hp
Assumed pump efficiency			80%	percent	
Actual pump power	= *theoretical power/ pump efficiency*		11.98	kW	15.98 hp
Cost of electricity			0.165	$/kWh	
Electricity cost during period of pumping		$	7,117		

Component Cost B - Pump Down-Valley Seepage Collection System to HDS Plant in summer (5 months)

HDS plant located at Upper Gravel Pit		elevation	1028	m	*Reactor is at contour 1137 m. Assume reactor is 3 m tall*
DVS wells - assumed water level elevation			1,015	m	
DVS Average flow	*from Jim/ Pete Lawson - use 1155 gpm*		0.073	m3/s	1155 gpm
Static lift			13	m	43 ft 18.54 psi
Assumed transfer pipe nominal size and rating			16" DR 9 (200 psi)		
Assumed transfer pipe size ID			313	mm	12.31 inch
Hazen Williams friction loss calculation from DVS transfer station to HDS plant					
Pipe ID, m			0.31		
C factor			130		
pipe length	*from section generated by Lisa*		3100.0	m	
pipe flow velocity , m/s			0.9	m/s	
minor loss factors (total K)			4.0		
Hm, minor losses, m			0.2		
Hf, friction losses, m			9.1		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L
Ht, total losses, m			9.3		
Pump TDH			22.3	m	73 ft 31.80 psi
Theoretical pump power	pghQ		15.94	kW	21.26 hp
Assumed pump efficiency			80%	percent	
Actual pump power	= *theoretical power/pump efficiency*		19.93	kW	26.57 hp
Cost of electricity			0.165	$/kWh	
Electricity cost during period of pumping		$	11,839		

Component Cost C - Pump Down-Valley Seepage Collection System to Faro Pit in winter (7 months)

Faro Pit, highest point in pipeline to		elevation	1192	m	*From Profile generated by Lisa*
DVS wells - assumed water level elevation			1,015	m	
DVS Average flow	*from Jim/ Pete Lawson - use 1155 gpm*		0.073	m3/s	1155 gpm
Static lift			177	m	581 ft 252.42 psi
Assumed transfer pipe nominal size and rating			16" DR 6.3 (300 psi)		
Assumed transfer pipe size ID			270	mm	10.615 inch
Hazen Williams friction loss calculation from DVS transfer station to HDS plant					
Pipe ID, m			0.27		
C factor			130		
pipe length	*from section generated by Lisa*		4900.0	m	
pipe flow velocity , m/s			1.3	m/s	
minor loss factors (total K)			4.0		
Hm, minor losses, m			0.3		
Hf, friction losses, m			29.6		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L
Ht, total losses, m			29.9		
Pump TDH			206.9	m	679 ft 295.12 psi *exceeds 300 psi pipe rating slightly*
Theoretical pump power	pghQ		148.00	kW	197.33 hp
Assumed pump efficiency			80%	percent	
Actual pump power	= *theoretical power/pump efficiency*		185.00	kW	246.66 hp
Cost of electricity			0.165	$/kWh	
Electricity cost during period of pumping					

Component Cost D - Sludge Pumping from Plant Thickener Underflow to Faro Pit (5 months)

Thickener Underflow elevation			1025	m	
High point of Faro Pit			1192	m	
Waste Sludge flow			0.011	m3/s	176 gpm Flow during 4hr pumping period/day, for Medium chemistry
Static lift			167	m	548 ft 238.16 psi
Assumed transfer pipe nominal size and rating			6" DR 7.3 (250 psi)		
Assumed transfer pipe size ID			119	mm	4.7 inch
Hazen Williams friction loss calculation from thickener Underflow to Faro Pit (high elevation point					
Pipe ID, m			0.12		
C factor			130		
pipe length			6250.0	m	
pipe flow velocity , m/s			1.0	m/s	
minor loss factors (total K)			4.0		
Hm, minor losses, m			0.2		
Hf, friction losses, m			61.2		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L
Ht, total losses, m			61.4		
Pump TDH			228.4	m	749 ft 325.66 psi
Underflow Sludge Specific Gravity			1.3		
Theoretical pump power	pghQ*SG		31.08	kW	41.44 hp
Assumed pump efficiency			60%	percent	
Actual pump power	= *theoretical power/pump efficiency*		51.81	kW	69.07 hp
Cost of electricity			0.165	$/kWh	
Electricity cost during 5 month period of pumping (4hrs/day pumping		$	5,129		

Sum of Annual Pumping Electricity Costs $ **24,085**

Faro Mine High Density Sludge WTP
Plant Site Investigation

Scenario 2 Synopsis
HDS plant located at Pit site. Years 8-11
Intermediate pond water pumped to up to HDS plant for 5 months in summer
Down Valley Seepage collection wells pumped to HDS plant for 5 months in summer and up to Faro Pit for 7 months in winter.

This scenario assumes the Rose Valley tailings are capped 12 years from start (2024). This assumes that permitting for closure work is complete in 2017 and that capping begins in 2022 (Year 5 of site closure) and is complete in 2023.
It also assumes that the flow requiring collection and treatment is 25% of the pre-capping flow, and starts in Year 13.

Year	Units	Faro Pit Pumping	IP Pumping	ETA to Mill WTP	Total
2008	million m³	2.27	2.00		4.27
2009	million m³	2.13	1.76		3.89
2010	million m³	2.01	1.16	0.03	3.2
2011	million m³		1.19		
2008-11 total	million m³		6.11		
2008-11 Avg	million m³/y		1.53		
2008-10 contribution	% of total				

Data and Constants

HDS plant at gravel pit below Cross Valley Dam	*From GIS map 1025 m + 3 m reactor height*	elevation	1028 m
Down Valley Seepage Collection system	*From profile - ground el at well heads.*	elevation	1015 m
Intermediate Pond normal water level	*From Jim*	elevation	1044 m

Jim Stefanoff, P.E.
Principal Technologist
Mine Restoration
CH2M HILL, Suite 301, 309 Strickland Street
Whitehorse, Yukon Territory, Canada, Y1A 2J9
Office Phone: 867-668-2201 Ext. 2021
Cell Phone: 509-981-5015
Jim.Stefanoff@ch2m.com

Scenario 2 HDS WTP at gravel pit below Cross Valley Dam

Component Cost A - Pump Intermediate Pond to HDS Plant in summer

HDS plant located at Mill Site		elevation	1028	m		
Intermediate pond pumped to HDS plant during months of May 1 to September 30		Vol of water	1,530,000	m3	1.53 million m3/yr, from 2008 to 2011 data. tailings Cap: decrease to 385,000 m3/y (to 25%).	
Intermediate pond assumed water level elevation			1,044	m		
Average flow			0.1	m3/s	1871 gpm	
Static lift			(13)	m	(43) ft	(18.54) psi
Assumed transfer pipe nominal size and rating			16" DR 9 (200 psi)			
Assumed transfer pipe size ID			313	mm	12.31 inch	
Hazen Williams friction loss calculation from IP to HDS plant						
Pipe ID, m			0.31			
C factor			130			
pipe length	*length is really 1900 m but use longer to simulate siphon make cost*		2900	m		
pipe flow velocity , m/s			1.5	m/s		
minor loss factors (total K)			4.0			
Hm, minor losses, m			0.5			
Hf, friction losses, m			20.8		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L)	
Ht, total losses, m			21.3			
Pump TDH			8.3	m	27 ft	11.80 psi
Theoretical pump power	= *pghQ*		9.59	kW	12.78 hp	
Assumed pump efficiency			80%	percent		
Actual pump power	= *theoretical power/ pump efficiency*		11.98	kW	15.98 hp	
Cost of electricity			0.165	$/kWh		
Electricity cost during period of pumping		$	7,117			

Component Cost B - Pump Down-Valley Seepage Collection System to HDS Plant in summer (5 months)

HDS plant located at Upper Gravel Pit		elevation	1028	m	*Reactor is at contour 1137 m. Assume reactor is 3 m tall*		
DVS wells - assumed water level elevation			1,015	m			
DVS Average flow	*from Jim/ Pete Lawson - use 1155 gpm*		0.073	m3/s	1155 gpm		
Static lift			13	m	43 ft	18.54 psi	
Assumed transfer pipe nominal size and rating			16" DR 9 (200 psi)				
Assumed transfer pipe size ID			313	mm	12.31 inch		
Hazen Williams friction loss calculation from DVS transfer station to HDS plant							
Pipe ID, m			0.31				
C factor			130				
pipe length	*from section generated by Lisa*		3100.0	m			
pipe flow velocity , m/s			0.9	m/s			
minor loss factors (total K)			4.0				
Hm, minor losses, m			0.2				
Hf, friction losses, m			9.1		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L)		
Ht, total losses, m			9.3				
Pump TDH			22.3	m	73 ft	31.80 psi	
Theoretical pump power	pghQ		15.94	kW	21.26 hp		
Assumed pump efficiency			80%	percent			
Actual pump power	= *theoretical power/pump efficiency*		19.93	kW	26.57 hp		
Cost of electricity			0.165	$/kWh			
Electricity cost during period of pumping		$	11,839				

Component Cost C - Pump Down-Valley Seepage Collection System to Faro Pit in winter (7 months)

Faro Pit, highest point in pipeline to		elevation	1192	m	*From Profile generated by Lisa*		
DVS wells - assumed water level elevation			1,015	m			
DVS Average flow	*from Jim/ Pete Lawson - use 1155 gpm*		0.073	m3/s	1155 gpm		
Static lift			177	m	581 ft	252.42 psi	
Assumed transfer pipe nominal size and rating			16" DR 6.3 (300 psi)				
Assumed transfer pipe size ID			270	mm	10.615 inch		
Hazen Williams friction loss calculation from DVS transfer station to HDS plant							
Pipe ID, m			0.27				
C factor			130				
pipe length	*from section generated by Lisa*		4900.0	m			
pipe flow velocity , m/s			1.3	m/s			
minor loss factors (total K)			4.0				
Hm, minor losses, m			0.3				
Hf, friction losses, m			29.6		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L)		
Ht, total losses, m			29.9				
Pump TDH			206.9	m	679 ft	295.12 psi	*exceeds 300 psi pipe rating slightly*
Theoretical pump power	pghQ		148.00	kW	197.33 hp		
Assumed pump efficiency			80%	percent			
Actual pump power	= *theoretical power/pump efficiency*		185.00	kW	246.66 hp		
Cost of electricity			0.165	$/kWh			
Electricity cost during period of pumping		$	153,842				

Component Cost D - Sludge Pumping from Plant Thickener Underflow to Faro Pit (5 months)

Thickener Underflow elevation			1025	m			
High point of Faro Pit			1192	m			
Waste Sludge flow			0.011	m3/s	176 gpm		Flow during 4hr pumping period/day, for Medium chemistry
Static lift			167	m	548 ft	238.16 psi	
Assumed transfer pipe nominal size and rating			6" DR 7.3 (250 psi)				
Assumed transfer pipe size ID			119	mm	4.7 inch		
Hazen Williams friction loss calculation from thickener Underflow to Faro Pit (high elevation point)							
Pipe ID, m			0.12				
C factor			130				
pipe length			6250.0	m			
pipe flow velocity , m/s			1.0	m/s			
minor loss factors (total K)			4.0				
Hm, minor losses, m			0.2				
Hf, friction losses, m			61.2		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L)		
Ht, total losses, m			61.4				
Pump TDH			228.4	m	749 ft	325.66 psi	
Underflow Sludge Specific Gravity			1.3				
Theoretical pump power	pghQ*SG		31.08	kW	41.44 hp		
Assumed pump efficiency			60%	percent			
Actual pump power	= *theoretical power/pump efficiency*		51.81	kW	69.07 hp		
Cost of electricity			0.165	$/kWh			
Electricity cost during 5 month period of pumping (4hrs/day pumping)		$	5,129				

Sum of Annual Pumping Electricity Costs $ **177,927**

Faro Mine High Density Sludge WTP
Plant Site Investigation

Scenario 2 Synopsis
HDS plant located at Pit site. Years 12-500
Intermediate pond water pumped to up to HDS plant for 5 months in summer
Down Valley Seepage collection wells pumped to HDS plant for 5 months in summer and up to Faro Pit for 7 months in winter.

This scenario assumes the Rose Valley tailings are capped 12 years from start (2024). This assumes that permitting for closure work is complete in 2017 and that capping begins in 2022 (Year 5 of site closure) and is complete in 2023.
It also assumes that the flow requiring collection and treatment is 25% of the pre-capping flow, and starts in Year 13.

Year	Units	Faro Pit Pumping	IP Pumping	ETA to Mill WTP	Total
2008	million m³	2.27	2.00		4.27
2009	million m³	2.13	1.76		3.89
2010	million m³	2.01	1.16	0.03	3.2
2011	million m³		1.19		
2008-11 total	million m³		6.11		
2008-11 Avg	million m³/y		1.53		
2008-10 contribution	% of total				

Jim Stefanoff, P.E.
Principal Technologist
Mine Restoration
CH2M HILL, Suite 301, 309 Strickland Street
Whitehorse, Yukon Territory, Canada, Y1A 2J9
Office Phone: 867-668-2201 Ext. 2021
Cell Phone: 509-981-5015
Jim.Stefanoff@ch2m.com

Data and Constants

HDS plant at gravel pit below Cross Valley Dam	*From GIS map 1025 m + 3 m reactor height*	elevation	1028	m
Down Valley Seepage Collection system	*From profile - ground el at well heads.*	elevation	1015	m
Intermediate Pond normal water level	*From Jim*	elevation	1044	m

Scenario 2 HDS WTP at gravel pit below Cross Valley Dam

Component Cost A - Pump Intermediate Pond to HDS Plant in summer

HDS plant located at Mill Site		elevation	1028	m		
Intermediate pond pumped to HDS plant during months of May 1 to September 30		Vol of water	382,500	m3	1.53 million m3/yr, from 2008 to 2011 data. tailings Cap: decrease to 385,000 m3/y (to 25%).	
Intermediate pond assumed water level elevation			1,044	m		
Average flow			0.0	m3/s	468 gpm	
Static lift			(13)	m	(43) ft	(18.54) psi
Assumed transfer pipe nominal size and rating			16" DR 9 (200 psi)			
Assumed transfer pipe size ID			313	mm	12.31 inch	
Hazen Williams friction loss calculation from IP to HDS plant						
Pipe ID, m			0.31			
C factor			130			
pipe length	*length is really 1900 m but use longer to simulate siphon make cost*		2900	m		
pipe flow velocity , m/s			0.4	m/s		
minor loss factors (total K)			4.0			
Hm, minor losses, m			0.0			
Hf, friction losses, m			1.6		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L)	
Ht, total losses, m			1.6			
Pump TDH			(11.4)	m	(37) ft	(16.21) psi
Theoretical pump power	= *pghQ*		(3.29)	kW	(4.39) hp	
Assumed pump efficiency			80%	percent		
Actual pump power	= *theoretical power/ pump efficiency*		(4.11)	kW	(5.49) hp	
Cost of electricity			0.165	$/kWh		
Electricity cost during period of pumping		$	(2,444)			

Component Cost B - Pump Down-Valley Seepage Collection System to HDS Plant in summer (5 months)

HDS plant located at Upper Gravel Pit		elevation	1028	m	*Reactor is at contour 1137 m. Assume reactor is 3 m tall*	
DVS wells - assumed water level elevation			1,015	m		
DVS Average flow	*from Jim/ Pete Lawson - use 1155 gpm*		0.073	m3/s	1155 gpm	
Static lift			13	m	43 ft	18.54 psi
Assumed transfer pipe nominal size and rating			16" DR 9 (200 psi)			
Assumed transfer pipe size ID			313	mm	12.31 inch	
Hazen Williams friction loss calculation from DVS transfer station to HDS plant						
Pipe ID, m			0.31			
C factor			130			
pipe length	*from section generated by Lisa*		3100.0	m		
pipe flow velocity , m/s			0.9	m/s		
minor loss factors (total K)			4.0			
Hm, minor losses, m			0.2			
Hf, friction losses, m			9.1		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L)	
Ht, total losses, m			9.3			
Pump TDH			22.3	m	73 ft	31.80 psi
Theoretical pump power	pghQ		15.94	kW	21.26 hp	
Assumed pump efficiency			80%	percent		
Actual pump power	= theoretical power/pump efficiency		19.93	kW	26.57 hp	
Cost of electricity			0.165	$/kWh		
Electricity cost during period of pumping		$	11,839			

Component Cost C - Pump Down-Valley Seepage Collection System to Faro Pit in winter (7 months)

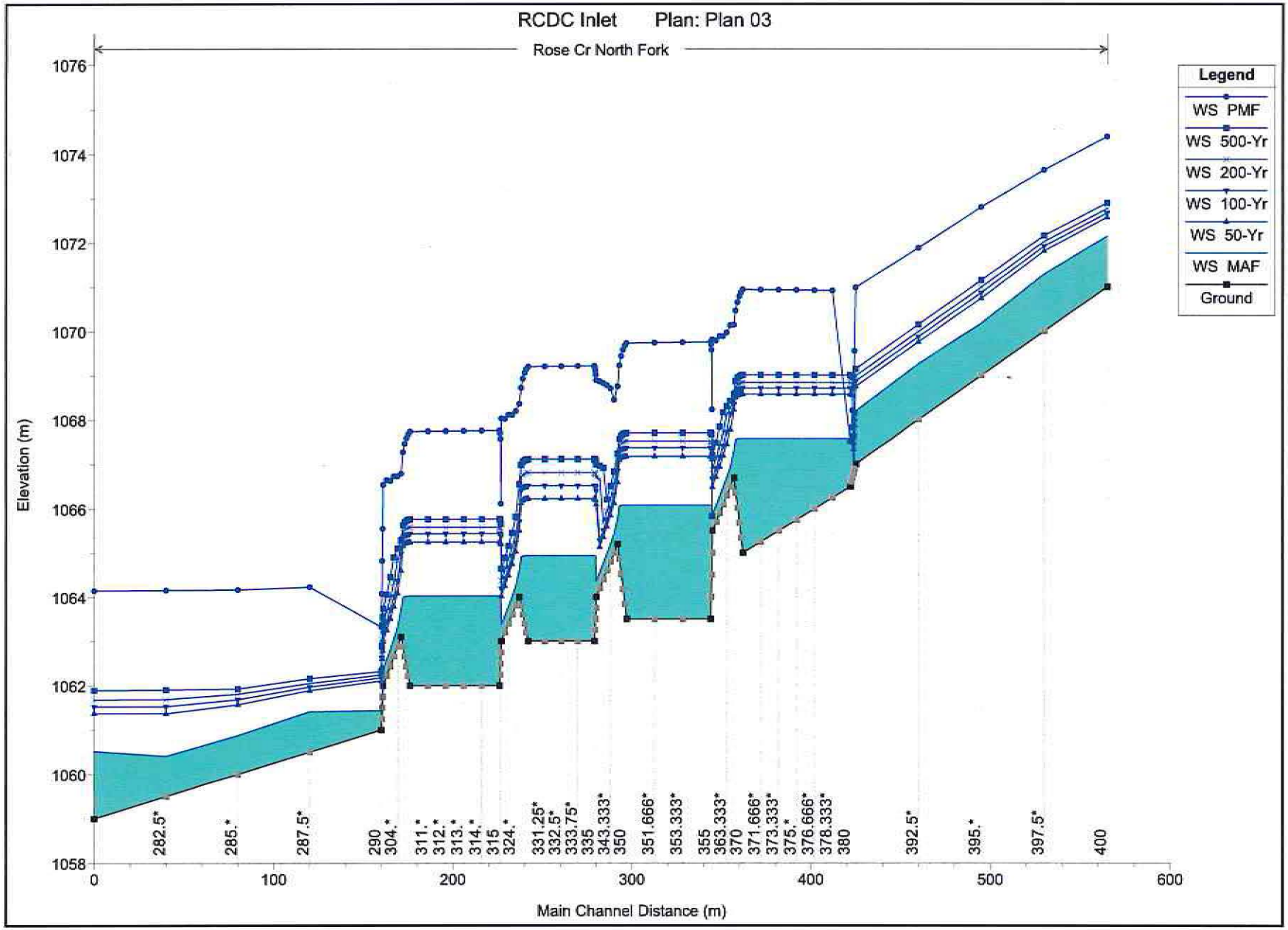
Faro Pit, highest point in pipeline to		elevation	1192	m	*From Profile generated by Lisa*	
DVS wells - assumed water level elevation			1,015	m		
DVS Average flow	*from Jim/ Pete Lawson - use 1155 gpm*		0.073	m3/s	1155 gpm	
Static lift			177	m	581 ft	252.42 psi
Assumed transfer pipe nominal size and rating			16" DR 6.3 (300 psi)			
Assumed transfer pipe size ID			270	mm	10.615 inch	
Hazen Williams friction loss calculation from DVS transfer station to HDS plant						
Pipe ID, m			0.27			
C factor			130			
pipe length	*from section generated by Lisa*		4900.0	m		
pipe flow velocity , m/s			1.3	m/s		
minor loss factors (total K)			4.0			
Hm, minor losses, m			0.3			
Hf, friction losses, m			29.6		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L)	
Ht, total losses, m			29.9			
Pump TDH			206.9	m	679 ft	295.12 psi *exceeds 300 psi pipe rating slightly*
Theoretical pump power	pghQ		148.00	kW	197.33 hp	
Assumed pump efficiency			80%	percent		
Actual pump power	= theoretical power/pump efficiency		185.00	kW	246.66 hp	
Cost of electricity			0.165	$/kWh		
Electricity cost during period of pumping		$	153,842			

Component Cost D - Sludge Pumping from Plant Thickener Underflow to Faro Pit (5 months)

Thickener Underflow elevation			1025	m		
High point of Faro Pit			1192	m		
Waste Sludge flow			0.011	m3/s	176 gpm	Flow during 4hr pumping period/day, for Medium chemistry
Static lift			167	m	548 ft	238.16 psi
Assumed transfer pipe nominal size and rating			6" DR 7.3 (250 psi)			
Assumed transfer pipe size ID			119	mm	4.7 inch	
Hazen Williams friction loss calculation from thickener Underflow to Faro Pit (high elevation point)						
Pipe ID, m			0.12			
C factor			130			
pipe length			6250.0	m		
pipe flow velocity , m/s			1.0	m/s		
minor loss factors (total K)			4.0			
Hm, minor losses, m			0.2			
Hf, friction losses, m			61.2		friction Loss, Hf = ((V/ (0.85* C * (D/4) ^ 0.63) ^ 1.85 * L)	
Ht, total losses, m			61.4			
Pump TDH			228.4	m	749 ft	325.66 psi
Underflow Sludge Specific Gravity			1.3			
Theoretical pump power	pghQ*SG		31.08	kW	41.44 hp	
Assumed pump efficiency			60%	percent		
Actual pump power	= theoretical power/pump efficiency		51.81	kW	69.07 hp	
Cost of electricity			0.165	$/kWh		
Electricity cost during 5 month period of pumping (4hrs/day pumping)		$	5,129			

Sum of Annual Pumping Electricity Costs $ 168,365

Attachment B
HEC-RAS Profile – nhc


RCDC Inlet Plan: Plan 03
Rose Cr North Fork
Legend
WS PMF
WS 500-Yr
WS 200-Yr
WS 100-Yr
WS 50-Yr
WS MAF
Ground
Elevation (m)
Main Channel Distance (m)
1076
1074
1072
1070
1068
1066
1064
1062
1060
1058
0
100
200
300
400
500
600
282.5*
285.*
287.5*
290
304.*
311.*
312.*
313.*
314.*
315
324.*
331.25*
332.5*
333.75*
335
343.333*
350
351.666*
353.333*
355
363.333*
370
371.666*
373.333*
375.*
376.666*
378.333*
380
392.5*
395.*
397.5*
400

Faro WTP Design Definition – Procurement and Construction Contracting Plan
Faro Mine Remediation Project

PREPARED FOR: Government of Yukon

PREPARED BY: CH2M HILL Canada Limited

DATE: September 21, 2012

PROJECT NUMBER: 436662.13.PD.15

1. Introduction

1.1 Purpose

The purpose of this technical memorandum (TM) is to evaluate procurement and construction issues for the proposed Faro Water Treatment Plant (WTP), and prepare a Procurement and Construction Contracting Plan for the plant.

1.2 Background

The Faro WTP, a key element of the Faro Mine Complex (FMC) Closure and Remediation Plan (C&R Plan) (SRK, 2010), will help address the release of heavy metals into the environment from tailings and waste rock produced by past mining activities. To date, various engineering activities in support of the WTP have been completed or are ongoing, including:

- Pilot Testing
- Influent Characterization/Plant Capacity Phasing Study
- Plant Siting Study
- One versus Two WTPs Plant Comparison, Technical Memorandum No. 2 (TM 2) (CH2M HILL, 2012a)

Based on lower life-cycle costs and noneconomic factors, in particular, reliability, TM 2 recommended the One WTP Alternative as the preferred alternative for implementation of water treatment at the FMC. The WTP would be located at the Faro Mill site and treat water from the Faro side, as well as water from the Grum/Vangorda side, which will be conveyed by a new cross-site pipeline (see Figure 1).

Design of the WTP is being carried out in four primary phases:

Phase 1: Project Design Definition. In this current phase of work, the overall project design criteria are being developed and existing site constraints and features identified.

Phase 2: Schematic Design. Specific design criteria will be developed by each discipline, the process design will be developed, and the site and WTP layout will be developed in more detail as part of the current approved design phase.

Phase 3: Design Development. All disciplines will begin preparation of plan and section drawings and prepare the first draft of equipment and material specifications.

Phase 4: Contract Documents. All drawings and specifications will be prepared, culminating in a complete set of contract documents suitable for tendering.

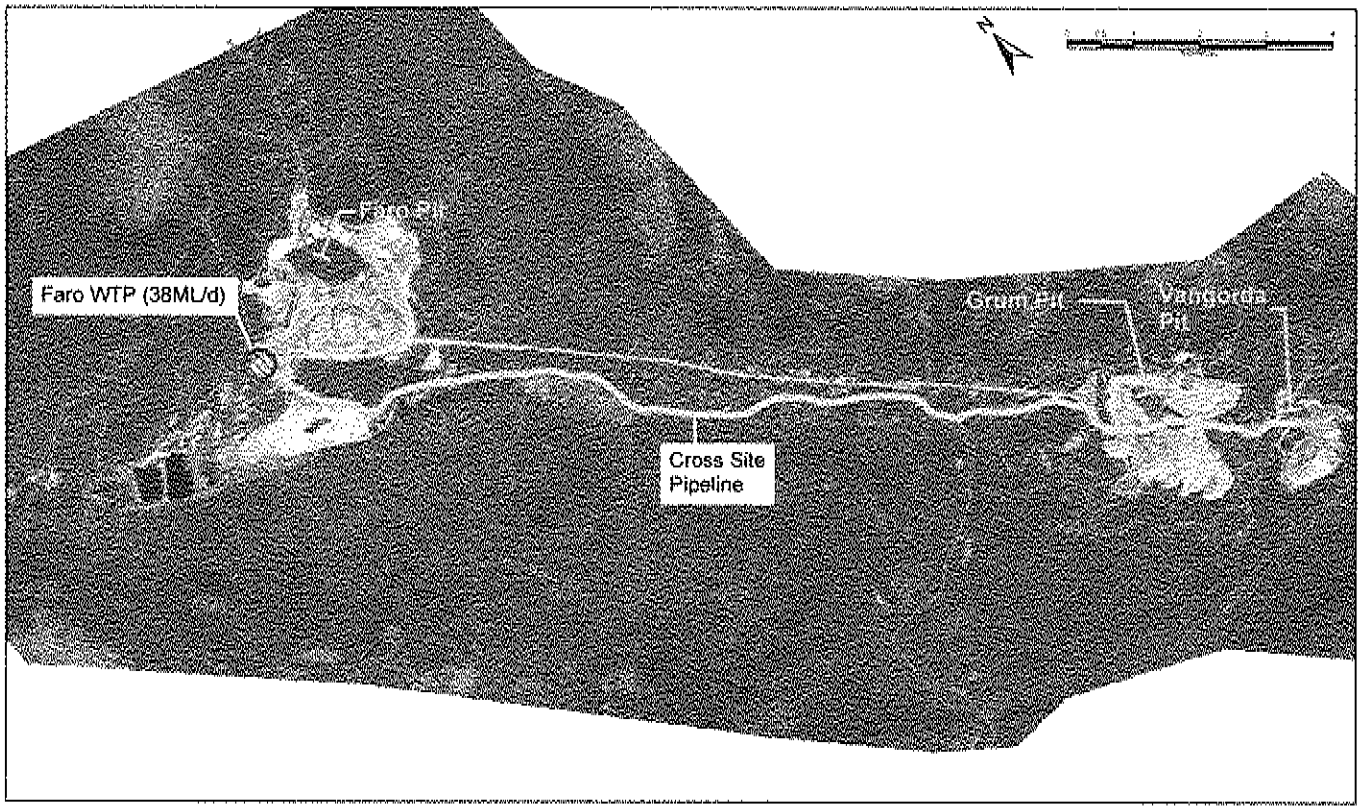
The schedule is to complete Phases 1 and 2 by January 2013, and start Phases 3 and 4, the detailed design, at the beginning of April 2013. Construction can then take place over two good-weather seasons in 2014 and 2015.

In developing the Procurement and Construction Contracting Plan, factors which need to be considered include:

1. Will the construction be done as a single project, or should it be split into two separate projects over two construction seasons?
2. There is a benefit to the pre-purchase of equipment by the Government of Yukon (YG).
3. The construction work should be planned to allow for construction indoors, assuming new buildings can be erected before the end of the good-weather construction period.

A further important consideration is how to involve Yukon labour and contractors.

FIGURE 1
Faro WTP
Faro Mine Remediation Project



1.3 Project Assumptions

The following assumptions were used in the development of the Procurement and Construction Contracting Plan:

- The Faro WTP will be a single plant located at the Faro Mill yard with a pipeline from the Grum/Vangorda Pits, as described in Section 2.1. The cross-site pipeline is not included as part of this plan but is part of future work.
- Sludge will be pumped into the Faro Pit.
- The plant will be operated in the warmer season (May through September).
- The WTP will be constructed in 2014 and 2015. Generally, the civil works and buildings will be completed during the first year and the mechanical/electrical (M&E) work during the second year, although there will be some overlap.

- The approximate construction cost of the WTP will be $40 to $60 million, depending on the exact configuration developed in detailed design. The cash flow will be split over the 2 years of construction. This memo assumes YG has available funding.
- Tendering for the construction contract will start in November 2013, with award of contract in January 2014.

1.4 Project Objectives

For the FMC, the following overall project objectives have been established:

1. Protect human health and safety.
2. Protect and, to the extent practicable, restore the environment, including: land, air, water, and wildlife.
3. Return the FMC to an acceptable state of use that reflects pre-mining land use where practicable.
4. Maximize local and Yukon socio-economic benefits.
5. Manage long-term site risk in a cost-effective manner.

The construction of the WTP is primarily to help achieve Objectives 1, 2, and 3. Objectives 4 and 5 were taken into consideration in the development of this Procurement and Construction Contracting Plan.

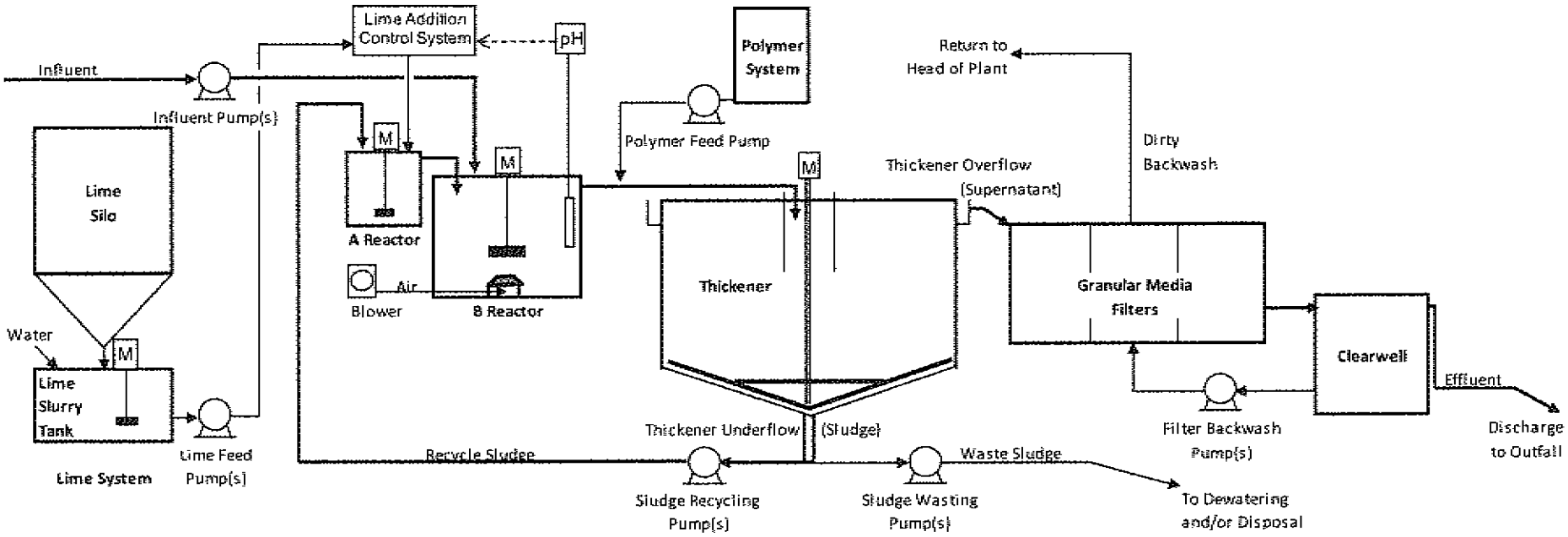
2. Procurement and Construction

2.1 Project Description

The Faro WTP will use the high density sludge (HDS) lime treatment process shown in Figure 2, which will include the following:

- Lime silo, slaking equipment, slurry tanks, slurry loops, and feed control valves
- Lime sludge mix tank (Reactor A)
- Twin main reactor tanks (Reactors B-1, B-2)
- Polymer makeup and dosing system
- Sludge thickener - concrete basin and dome covered, with underground tunnel to access the cone
- Sludge recycle pumps
- Waste-sludge transfer pumps
- Media filters for effluent polishing prior to discharge (as required or developed during detailed design)
- Supervisory control and data acquisition (SCADA) system and instrumentation for process monitoring and control

FIGURE 2
High-Density Sludge Lime Treatment Process
Faro Mine Remediation Project



The WTP will be configured as three separated, weather-protection-enclosed areas:

1. Lime system (except silo) and reactor equipment housed in a building
2. Thickener area with its own dome cover
3. Effluent filters, housed in a building

Each structure will be constructed as a prefabricated building designed as occupied space, including electrical and heating, ventilation, and air conditioning (HVAC) systems. A substation with transformer and switchgear and a standby generator may be required, as developed during the detailed design. The plant site has sufficient space to accommodate future expandability of the WTP. Provision will be made for ease of future expandability and an adequate level of redundancy in unit operations.

2.2 Construction Issues

Project-specific construction issues that need to be addressed by this Procurement and Construction Contracting Plan and then the successful contractors include the following:

Worker Safety and Medical Attention: Challenges of the location and measures required to treat injured workers onsite or get injured workers to medical facilities in Whitehorse or elsewhere will need to be carefully addressed.

Remote Location: The project is remote but accessible by major highways. The delivery of the equipment and materials may be affected by the availability of cranes or loaders. A construction camp will likely be required to house the workers during construction. The worker housing and facilities should be planned around working at least into the shoulder seasons of March/April and October/November (such as hoarding and lighting). Quality assurance (QA)/quality control (QC) testing subconsultants will be required and will need to be scheduled and coordinated.

Winter Construction: Temporary heating/power and snow removal will be required if working indoors through the winter. Availability and reliability of electricity, including the existing site backup generator, needs to be understood. Seasonal limitations on road use and on highway maintenance need to be factored in, including freeze/thaw cycles. This will impact the daily deliveries for supplying the project, such as fuel and food. Construction should follow, as appropriate, the Aboriginal Affairs and Northern Development Canada (AANDC) *Cold Regions Cover System Design Technical Guidance Document* (2012), which was prepared for abandoned mine sites in cold regions.

Maintenance and Protection of Site during Winter Shutdowns: Design, construction, and budgeting must also recognize the need to protect incomplete work.

Technical Specifications: Specifications related to electrical cabling, welding, earthworks, concrete placement, and assembly of prefabricated components should all reflect limitations imposed by cold weather. To varying degrees, each will have limitations on allowable ambient temperatures.

Filter Media Installation during Construction: A large volume of water will be required for the installation and cleaning of the filter media. A plan to obtain water and dispose of the dirty wash water will be required. Media will need to be installed during the warmer weather.

2.3 Contracting Alternatives and Options

The contracting strategy provides the basis for project planning and schedule development. Several factors were considered in developing the contract package arrangements for the construction of the Faro WTP, including:

- Safety
- Availability of local resources
- Meeting YG's schedule objectives
- Number of contractors
- Construction cost variability
- Construction quality

The use of alternative project delivery methods was discussed in a previous project workshop (Attachment A) (CH2M HILL, 2012b). From this, the following is a brief summary of the different delivery methods and their pros and cons.

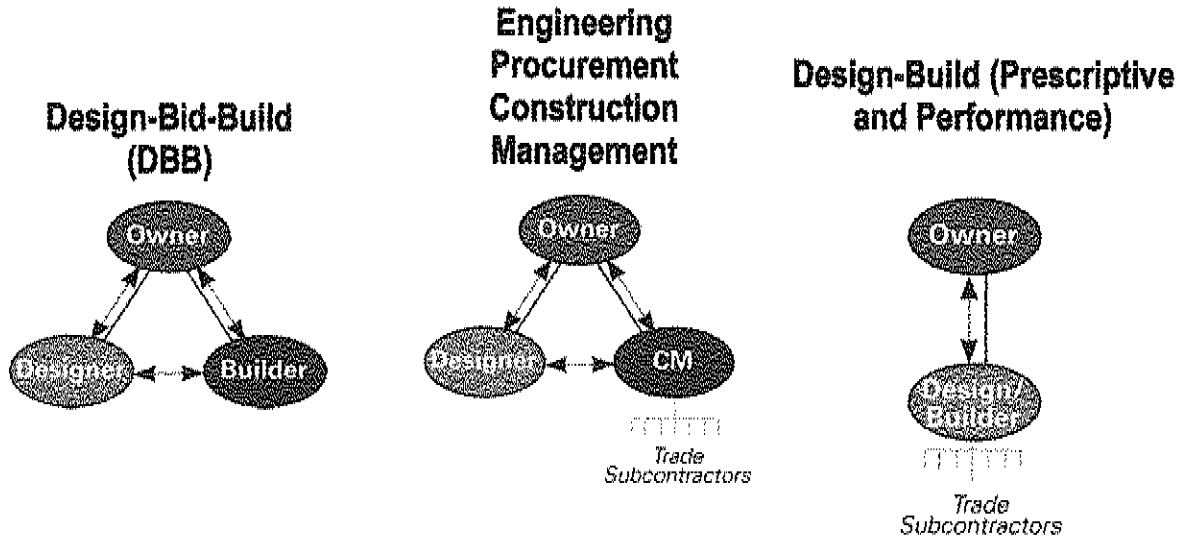
Design-Bid-Build (DBB) is the traditional delivery method for infrastructure projects. This process involves the engineers' and owners' collaboration for the final design. The completed design is let out to tender and then awarded to the successful bidder for construction. The designer or other engineering company monitors the construction activity prior to handover of the completed project to the owner. This delivery method provides for the most direct control for the owner and also the most involvement in terms of time and quality management. There are typically multiple contracts to manage by the owner.

Engineering-Procurement-Construction Management (EPCM) is a hybrid between traditional delivery and alternative delivery. The owner still has significant input in the design and involvement in the delivery of the infrastructure. The EPCM team, however, takes more responsibility for the day-to-day management of the detailed design, equipment procurement, and contractor management during construction of the infrastructure. This delivery method can reduce the overall project schedule through coordinating the detailed design with the construction activities.

Design-Build (DB) gives the owner control of the performance requirements but leaves the detailed engineering and construction to the contractor-engineer team. This delivery method has the least involvement of the owner in the day-to-day management of the infrastructure delivery. It can reduce the overall project schedule by allowing the detailed design to progress in parallel with the construction activity and significantly reduces the initial owner procurement for construction. Other benefits are reduced scope for change orders and cost variability. It can also promote innovation in the design and delivery of the infrastructure.

Figure 3 shows the owner involvement and contractual relationships with the designers and constructors for the three delivery methods.

FIGURE 3
Infrastructure Delivery Methods – Owner Relationship and Involvement
Faro Mine Remediation Project



2.3.1 Preferred Contracting Alternative

Local Resources

Ideally, local labour and contractors should be used in as great capacity as possible to minimize costs and maximize local benefits. This aligns well with one of the project objectives.

Another project objective is to manage the long-term risks by providing a high-quality WTP that is robust and reliable. This will require a contractor with previous experience in building WTPs and wastewater treatment

plants (WWTPs). There are no large contractors in the Yukon with this experience. Considering these factors, the best fit for local contractors for the Faro WTP would be as subcontractors supporting larger, more experienced contractors from elsewhere.

Schedule

Schedule is one of the drivers for this project. Originally, the intent was to have the Faro WTP online by the fall of 2014, and earlier if possible. It made sense to consider EPCM and DB because of their ability to deliver the work as fast as possible. Now, with the evolvement of the project and changes in project funding, the plan is for the construction to take place over two seasons during 2014 and 2015. The primary need for using EPCM or DB goes away, and DBB becomes the preferred alternative because of the additional control and quality that this method of project delivery offers.

2.4 Contractor Capability and Availability

A previous market analysis was performed to assess the contractor capability and interest in this project and is included in Attachment B. Table 1 identifies all of the large contractors contacted and is included here for reference. There are several (out-of-province) contractors with the capability of delivering a high-quality project of this size and scope who are interested in pursuing this opportunity in Faro. Table 1 presents an initial list of contractors capable of submitting qualified bids for this project. CH2M HILL has worked with most of these contractors previously on similar projects.

TABLE 1
Large General Contractors *(from Market Analysis TM1 In Attachment B)*
Faro Mine Remediation Project

Contractor	Contact Information	Services Offered	Interest In Project	Comments
EllisDon	David McFarlane dmcfarlane@ellisdon.com 604.247.1072	Construction	Yes	Interested – would depend on timing.
Graham Construction	Patrik E. patrike@graham.ca 604.940.4500	Construction	Yes	High level of interest in this project.
Kenaidan	Hesam Haque hhaque@kenaidan.com 604.270.7670	Construction	Yes	High level of interest in this project – requesting additional information.
Kiewit	General Inquiries info@kiewit.com 604.629.5419	Construction	–	Awaiting response.
Ledcor	Gary Stewart gary.stewart@ledcor.com 604.681.7500	Construction	–	Awaiting response.
Lockerbie & Hole	Rob Brown rbrown@lockerbiehole.com 604.777.5950	Construction	Yes	High level of interest – preparing an information package for CH2M HILL that includes a very similar WTP recently completed.
Maple Reinders	Peter Kuipers pkuipers@maple.ca 403.216.1455 Bodo Papke bodo@maple.ca 250.765.8892	Construction	Yes	High level of interest in this project – requesting additional information.
Nahanni Construction	http://nahannincl.com/	Construction	–	Awaiting response.
North American Construction	Alex Black ablack@nacsworld.com 519.821.8000	Construction	Yes	High level of interest in this project – preparing an information package for CH2M HILL.

TABLE 1
Large General Contractors *(from Market Analysis TM1 In Attachment B)*
Faro Mine Remediation Project

Contractor	Contact Information	Services Offered	Interest in Project	Comments
PCL	www.pcl.com	Construction	No	Decided not to pursue project.
Pelly Construction	Dan Russell dan@pelly.net 867.667.6161	Civil earthworks	Yes	Interested in providing earthworks construction services.

2.4.1 Yukon Labour and Subcontractors

To facilitate local input for the project, a list of local Yukon and First Nations contractors, suppliers, and QA testing companies with their respective capacities could be supplied with the tender documents. The initial list is included in Attachment C. The key areas for local involvement include the site preparation, excavation, and earthworks; site services; HVAC; general electrical; concrete and asphalt supply; and site safety and QA testing services, such as surveying, compaction testing, and concrete testing. Local suppliers of fill materials, concrete, and asphalt will also be required.

There will be cost benefits for out-of-province general contractors to use local subcontractors to perform some of the work. Many of the contacted large contractors have worked with First Nations companies and prefer to use as local subcontractors, labour (skilled and unskilled), and materials as much as possible to keep the travel/shipping costs and allowances to a minimum.

The tender documents could include a statement or requirement similar to "10% of the contract needs to be performed by Yukon subcontractors or local labour." Or the contractors could be asked to submit a plan outlining its approach to enhancing the participation of First Nations and Yukon businesses within the delivery of the work. Any tender document language or mechanism used to maximize local content will need to be easily understood, be transparent, and include wording to minimize the chance for dispute.

2.5 Procurement Options

Coordinating the delivery of the equipment and materials for this project will have to be well managed for the successful project completion on schedule. Following are options for procuring equipment for the Faro WTP that can help meet the schedule goals.

Pre-Identification of equipment is part of all specifications in design projects. Typically, this involves the identification of three or more qualified vendors or specific products for each piece of equipment or material. Shop drawings are based on these pre-approved products, and generally, features and dimensions are confirmed during the shop drawing approval process. The shop drawing approval cycle is typically fast. The allowance of substitutions requires additional engineering during the construction period and should be avoided, unless the identified products or vendors cannot supply the equipment on schedule.

Pre-Selection of equipment is the next step towards 100 percent complete construction documents. This involves pre-selecting some of the more complex equipment (such as motor control centres [MCCs]), systems (such as polymer makedown), or custom-fabricated/long-lead items (such as thickener mechanisms), and including the details about specific equipment in the design drawings. Pre-selection provides for the approval of shop drawings prior to the construction contract and removes this activity from the construction schedule. It also provides for more final drawings and, therefore, less variability in the field, which also compresses the construction schedule. Pre-selection does not apply to commodity equipment, such as pipes, small valves, conduit or cable trays, or items that are easily field-fit.

Disadvantages are a vendor not delivering on time and potentially reducing competition. The first disadvantage could be managed by working with a well known and reputable vendor and providing protective language in a

purchase order. The second disadvantage could be managed through competitive pre-purchasing. This is similar to pre-purchase except that the contractor purchases the pre-selected equipment.

Pre-Purchase of the equipment and materials by the owner is typically used when there are long-lead items and schedule constraints. While it addresses these issues, it can potentially open up other issues on deliveries, storage, connections, startup responsibilities, and warranties. These issues can be covered off in contract specifications. The Faro WTP schedule is long enough to allow the general contractor to manage the procurement of the equipment and materials.

The more significant schedule constraint is that there are only 5 months available for outdoor construction. This includes all of the civil works until the buildings are enclosed, as well as the unloading of equipment. The work sequence will need to be managed critically on this project; deliveries of materials for the civil work have to arrive in May/June of the first season. The M&E equipment needs to arrive at specific times to allow the work flow to progress.

Pre-Staging of critical equipment in a warehouse or laydown area in Whitehorse, Edmonton, or Vancouver would provide for better management of equipment deliveries to the project site. This would allow confirmation of the correct equipment and bill of lading, and coordination with the work activities onsite and availability of cranes. Pre-staging would minimize any disruptions due to late deliveries, and allow alternate or temporary measures to be employed if an equipment delivery was going to be late.

Procurement Allowances for missing, damaged, or replacement equipment; maintenance checks; and additional startup support could be used to mitigate any delays for these reasons. For example, each piece of equipment could have a line item allowance of $20,000 included for use on an as-required basis as directed by the engineer or owner. If the allowances are not used, they would be credited back to the owner.

For the Faro WTP, all of these options apply except pre-purchase of the equipment (as discussed in Section 2.5.1). All of the equipment will be pre-identified in CH2M HILL specifications. The contractor should use pre-staging, an experienced expediter to confirm deliveries to site are correct, or a combination of these methods. Procurement allowances can be used when and if needed so that the startup schedule is maintained. Pre-selection and pre-purchase are discussed in more detail in the following section.

2.5.1 Procurement Lead Times

Contracting, preparation, and approval of shop drawings, fabrication, delivery, and installation of major equipment typically will span over 1 year. Table 2 identifies major equipment and building components for the Faro WTP, and the typical procurement and installation durations. These durations have been confirmed by multiple vendors, but are subject to order placement and manufacturing queues. The equipment list will be developed and finalized during the detailed design phase (Phase 3). This table is included to identify long-lead-time equipment and any impacts to the construction schedule. The long-lead items for delivery include the thickener equipment, electrical instrumentation and controls (I&C) equipment, and prefabricated buildings.

TABLE 2
Faro WTP Procurement and Installation Durations
Faro Mine Remediation Project

Equipment	Shop Drawing Submittals (months)	Fabrication (months)	Installation (months)	Startup and Testing (months)	Total [a] (months)
Lime Slurry Equipment	3	4	1.5	0.5	9.5
Lime Dosing System	2	4	1	0.5	8
Polymer Makeup System	2	4	1	0.5	8
Polymer Dosing System	2	4	1	0.5	8
Thickener Equipment and Dome Cover	3	5	2	0.5	11
Filter Media	2	2	2	0.5	6.5

TABLE 2
Faro WTP Procurement and Installation Durations
Faro Mine Remediation Project

Equipment	Shop Drawing Submittals (months)	Fabrication (months)	Installation (months)	Startup and Testing (months)	Total [a] (months)
Sludge Pumps	2	3	1	0.5	7
Backwash Pumps	2	3	1	0.5	7
Gates and Valves	2	3	1	0.5	7
Sludge Filter Press	3	3	1	0.5	8
I&C Equipment	3	4	2	1.5	11
Electrical Equipment • Transformer • Switchgear • MCC	3	4	2	0.5	10
Generator	2	4	1	0.5	8
HVAC	3	3	1	0.5	8
Prefabricated Buildings	3	5	2	0.5	11
Bridge Crane	2	4	1	0.5	8

Notes:

[a] Includes 0.5 months for delivery. Edmonton to Whitehorse is 2,000 km or 28 hours. Vancouver to Whitehorse is 2,400 km or 34 hours.

km – kilometre

Reviewing the lead times and the proposed construction schedule, there will be enough time to allow the contractor to purchase all of the equipment. However, the prefabricated buildings should be pre-selected during the detailed design so that the contractor can issue an early purchase order to the prefabricated building supplier so that the delivery of the building components will occur in time to erect the buildings before the winter season. It would be beneficial to the schedule to pre-select the buildings so that the building vendor is fabricating the components for delivery to site early. CH2M HILL will work with building vendors during detailed design to select the best option for long-term value to include in the contract documents.

2.5.2 Vendor Contacts

Table 3 indentifies a partial list of vendors who could supply process and M&E services for the Faro WTP. There are many vendors for each type and piece of equipment who could be included in the specifications. CH2M HILL has worked with many of these vendors on similar projects. There are representatives for all or most of the process equipment in the Vancouver, Calgary, and Edmonton areas who could provide regional support to the products they represent.

TABLE 3
Local Vendor Contact Information
Faro Mine Remediation Project

Vendor	Contact Information	Products Offered	Location
Mequipco	Devlin Wing dwing@mequipco.com 604.273.0553	Process Mechanical Equipment	Richmond, BC
BowRio Water Technologies Inc.	Murray Blair mblair@bowriowater.ca 604.592.2464	Process Mechanical Equipment	Surrey, BC

TABLE 3
Local Vendor Contact Information
Faro Mine Remediation Project

Vendor	Contact Information	Products Offered	Location
GE Power and Water	General Enquiries www.ge.com 866.439.2837	Water and Process Technologies	Edmonton, AB
Siemens	General Enquiries www.siemens.ca 604.233.1700	Electrical and Controls	Vancouver, BC
ABB	General Enquiries www.abb.ca 604.434.2454	Electrical and Controls	Burnaby, BC
ProMinent	Sales Department www.prominent.ca sales@prominent.ca 888.709.9933	Metering Pumps, Polymer Systems	Calgary, AB
National Process Equipment	Sales Department webinquiries@natpro.com 604.521.7867	Metering Pump Systems	Coquitlam, BC
Wajax Industrial Components	Sales Department wic-surrey@wajax.com 604.552.3185	Progressive Cavity Pumps, Sludge Pumps	Surrey, BC
Netzch	Dave Hinecker dave.hinecker@netzsch.com, www.netzch.ca 403.990.7950	Sludge Pumps	Calgary, AB
Spartan Controls	General Enquiries info@spartancontrols.com, www.spartancontrols.com, 403.207.0700	Instrumentation and Valves	Calgary, AB
Westech Industrial Ltd.	Head Office sales-west@westech-ind.com, www.westech-ind.com 403.252.8803	Process control, clarifier/thickener equipment, analyzers, engineered systems	Calgary, AB
GL&V	Head Office www.glv.com 514.284.2224	Clarifier/thickener equipment, water treatment solutions	Montreal, QC

Notes:

Representative list of vendors; to be developed further during the detailed design phase.

AB – Alberta
BC – British Columbia
QC – Quebec

2.5.3 Procurement Packages

Pre-selection the prefabricated buildings would allow for the delivery of building components during the middle of the first season in 2014, and allow the erection of the buildings before the winter. This would provide for weathered-in spaces over the first winter season. The generator may also be a good candidate for pre-selection, to provide power through the first winter season. This can be confirmed during detailed design.

The remainder of the process and M&E equipment could be procured through the general contractor and easily be delivered to site for the second construction season. The general contractors interested in this project have previously installed similar equipment, and there is no reason that the equipment cannot be installed in the 5-month second construction season. Some of the process equipment could be delivered during the first construction season for installation during the winter, if feasible.

Contract language to mitigate delays due to the remoteness of the site, such as milestone payments for early delivery, can be included for the general contractor to use in purchase orders. Alternatively, the contract could provide a sliding scale of bonus milestone payments or single milestone payment for early submittal *and* approval of key shop drawings for the contractor.

2.6 Construction Packages

For the Faro WTP, two construction packages are proposed.

2.6.1 Construction Package 1: Site Clearing and Preparation

This contract would be given to a local general contractor in preparation for the mobilization of the general contractor for the main construction contract. This contract would provide the initial site clearing and preparation, temporary power, construction camp, and site office. The baseline survey for the proposed construction area could be completed. Contractor laydown, borrow pits, and stockpile areas could be identified on the survey. Areas could be cleared and levelled for construction camp trailers and site offices. The main construction area could be graded. Any demolition and removal of existing facilities could be completed. Temporary construction power could be installed. Preliminary review of the geotechnical conditions indicate that conventional cut-and-cover methods for excavation of buried utilities and shallow foundations for the structures can be used. Blasting is not believed to be required at this point. No special foundations or ground improvements are required for construction on the proposed site. This contract would need to be completed by the end of the 2013 construction season and be coordinated in parallel with the detailed design of the main plant. This would allow the main general contractor to be working potentially 1 month earlier on the main construction package and maximize the construction season. This construction package is beneficial to the overall schedule for delivery of the WTP, but is contingent on available funding in 2013 for up to $500,000.

2.6.2 Construction Package 2: Main Construction Contract

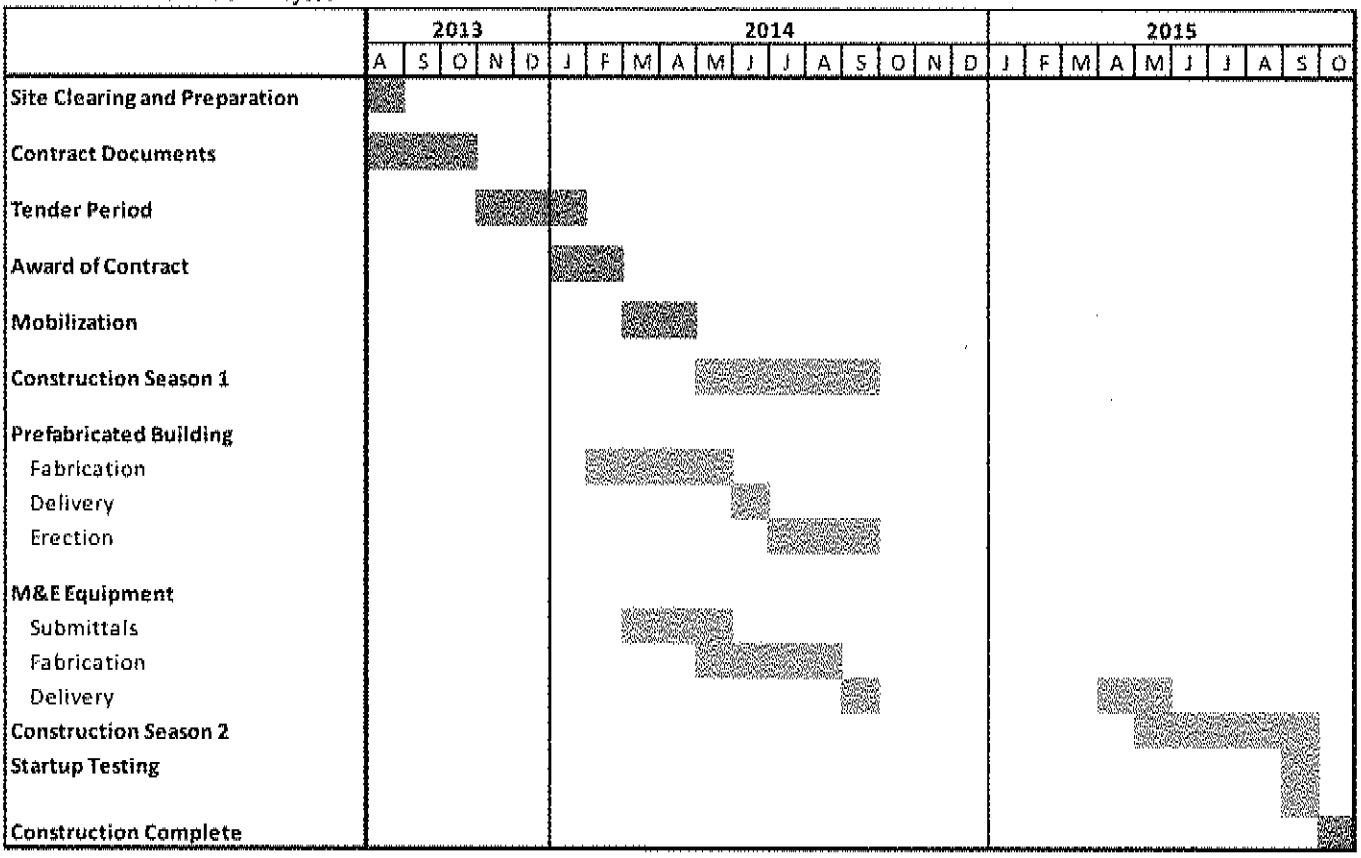
The main construction contract would comprise all other work for the new WTP. The package would include site development, civil, structural, architectural, process, M&E, and plant automation work. This contract would be completed over 2014 and 2015, as shown in the project schedule in Figure 3. The goal of the first construction season would be to complete the site civil and structural work, and have weathered-in buildings to allow some activity over the first winter if needed. This could include final building finishing, such as electrical, lighting, and heating installation. The second construction season would include all of the process M&E installation work. The equipment and processes would also have to be tested and commissioned for plant acceptance by the owner prior to draining the entire plant for the second winter season.

The size and scope of this contract lends itself to be delivered by a general contractor with civil and M&E trades, and experience in delivery of WTPs and WWTPs. The general contractor would also manage the local subcontractors and vendors. Having a single, experienced general contractor responsible for all the work, except site clearing and preparation, will provide a single point of responsibility, and minimize scope gaps and conflicts by coordinating between the subcontractors or subtrades.

2.7 Proposed Project Schedule

Figure 3 shows a high-level schedule based on the scope of work and project constraints. Based on the construction activities, this schedule is achievable through proper planning and execution of an experienced contractor. The construction seasons are short, but the opportunity for completing the required number of labour hours is achievable.

FIGURE 3
Faro WTP Construction Schedule Overview
Faro Mine Remediation Project



2.7.1 Construction Scheduling

The management of the construction schedule will be critical to making this project a success. Project Controls (planning, scheduling, and reporting) will need to be very strong on this project, and should be a high priority. A line item allowance of $100,000 could be included in each bid so that the bidders provide budget for a senior project controls coordinator. A statement of minimum qualifications and duties should be added to the bidding documents for this role. A junior project coordinator should not be allowed to manage this task on this project. The efficient coordination of delivering material, equipment, and people to this project site will determine this project's success.

3. Procurement and Construction Contracting Plan

Based on the foregoing, the recommended contracting plan for the Faro WTP is:

- Pre-identify all equipment in specifications and contract documents.
- Develop contract and non-contract mechanisms for maximizing local Yukon and First Nations subcontractors.
- Pre-select the prefabricated buildings vendor. CH2M HILL will work with prefabricated building vendors during detailed design to select the building vendor and products. These products will be included in the design drawings and specifications. This will allow for the completion of the buildings and provide weathered-in spaces for construction indoors over the winter season.
- Pre-qualify the main contractors based on previous experience constructing projects of similar scope and scale, their health and safety record, their project controls experience, and the experience of their superintendent and project manager.

- Tender, award, and manage Contract 1: Site Clearing and Preparation in summer 2013.
- Tender, award, and manage Contract 2: WTP Construction Contract over 2014 and 2015.

4. Works Cited

Aboriginal Affairs and Northern Development Canada (AANDC). 2012. *Cold Regions Cover System Design Technical Guidance Document*. MEND Report 1.61.5c. July.

CH2M HILL Canada Limited (CH2M HILL). 2012a. *Technical Memorandum No. 2. Faro WTP Design Definition – One versus Two Plant Comparison Faro Mine Remediation Project*. Prepared for Government of Yukon. September.

CH2M HILL Canada Limited (CH2M HILL). 2012b. *Contracting and Procurement Mechanisms for Faro WTP Workshop Notes*. Prepared for Government of Yukon.

SRK Consulting Engineers and Scientists (SRK). 2010. *Faro Mine Complex, Closure and Remediation Plan, Project Description – Draft 4A*. Prepared for Government of Yukon. March 29.

Attachment A
Contracting Workshop Notes

Contracting and Procurement mechanisms for HDS Water Treatment Plant Faro Mine remediation

Notes from the Meeting

Present

Stephen Mead – Director, Assessment and Abandoned Mines, Yukon Territory
Frans Lotz – independent consultant to YG, Vidal Advisory Inc
Ralph Davidson – RBGM & Corporate Sponsor for Faro Project, CH2M HILL
Matthew Elliott – BD Manager WBG, Wastewater Treatment Expert, CH2M HILL
Danny Daoust – Manager, CH2M HILL Constructors Canada, CH2M HILL
Lionel Etheridge – Project Manager, Faro Project, CH2M HILL

Background

- Lionel Etheridge provided a background to the site and also the proposed HDS WTP process overview. An outline of the TAR (TAR 13) for the design of the WTP was also provided.
- It was noted that regarding logistics
  - Town of Faro has 450 population
  - 350km from Whitehorse
  - No grocery store
  - Over 300m of water depth in Faro pit and hence substantial ability to draw down and utilize potential storage capacity
- The YG objectives for the site and WTP are as follows:
  - Protection of Environment
  - Maximize Yukon Socio-economic involvement
  - Return to acceptable state of use where possible
  - Manage risk in a cost effective manner
- Replace existing plant
  - Using current discharge standards
  - Able to potentially be modified to achieve emerging water standards
  - Ability to vary to cater for varying flow rates
  - Operation as current – mid April to mid October (no extended period which would require heating/ insulating costs)
  - Should consider higher flow rates instead of longer operation. However, need to assess equipment and pipe capacity to ensure they could cope
  - Do not add scope or complexity to TEES contract for site care & maintenance

Yukon Involvement

- Yukoner Capability
  - Three large civil contractors
    - Pelly Construction
    - Sidhu
    - Cobalt Constructors
  - Procurement approach
    - Can go through a Request for Qualifications (RFQ) to focus the field of bidders
    - YG approach can be a technical pass or fail followed by 85% on price and 15% on Yukoner content as:

        - 10% on local subcontractor costs
        - 2% on training
        - 3% on Employment
    - Use of local electrical contractors
    - Try to create legacy for Town of Faro (model of process plant, or perhaps a web cam at the site?)
    - Possibility of setting up a "construction camp" in Faro?

Construction

- ***Should consider onsite concrete batch plants***
    - An onsite batch plant would provide cost effective approach and opportunity for local engagement
    - Has flexibility – batches to recipe enable quality assurance
    - Noted that there is a batch plant in Whitehorse – they may be interested in establishing a plant at site?
- Clarifier/ Thickener
    - Noted that one large thickener is more cost effective than multiple smaller ones
- Quality Expectations
    - ***Quality should be a driver given the expected life of operation***
    - Schedule is important but quality is the driver
    - ***Hence need to have an early quality strategy and quality assurance plan***
    - Plant needs to be mechanically simple and only semi-automated so that it can be manually operated to fit with the need to engage the local work force.
    - Need to understand the life cycle of the equipment and relationship with the building longevity
- ***Thickener/ Clarifier mechanicals require 6 to 18 month lead time. Currently these items are in big demand and hence critical procurement long lead equipment items***
    - Need to prioritize foundations and building and procure mechanicals. Leave clarifier/ thickener base and mix tanks to later.
    - Replacement vs. changeable liners etc. Challenge will be that the pipes and tanks will be empty for periods during winter.
    - Need to decide early on concrete or steel, steel with glass lining or plastic coating.
    - ***Concrete work should be split into two seasons and pre-purchase mechanicals.*** This will assist cash flow position
    - Use pre-engineered building
        - Bridge crane
        - Building to allow for expansion at one end, and potential to mirror with a parallel process stream
    - Electrical – local contractors
        - ENI $5M+
        - ***Indications are that a 1MW plant would be required given the other Faro site requirements.*** Although the current power to the site is OK it needs to be reviewed especially given the potential for loss of power incidents.

Preferred Contracting Vehicle

- **Two basic approaches to procuring and constructing the WTP**
  - ***Prime / General contractor***
    - Need to have at least three prequalified bidders to get a reasonably competitive bid. Concerns that there may not be enough qualified willing bidders
    - Would need to produce record drawings from civil construction to enable process, mechanical and electrical contract terms
    - CM would do the final record drawings with "red lines" for the contractor.
    - Possible performance (cost, schedule or quality) incentive approach for the contractor
    - Preselect multiple local subcontractors and then novate to the prime. ***This was not considered a good approach.***
  - ***PM/CM with EPC capability*** where multiple local construction contractors and prequalified equipment vendors are contracted directly to YG and managed by the PM/CM for YG.
    - ***Allows for a wider catchment of local qualified contractors*** giving a more cost effective result due to increased competition
    - The MSA secondary clause would potentially allow YG to retain CH2M HILL in this capacity
    - ***Would potentially provide for a more compressed timeline with continuity from design through procurement to construction.***
    - ***PM/CM takes on the integration role and this reduces YG risk*** which could otherwise arise if two consecutive Prime contractors were engaged (i.e. a civil and a process contractor)
    - ***The PM/CM would provide all record drawings and integration services.***
    - ***PM/CM would act as general contractor for the purposes of HS&E etc.***
    - Potential to incentivize the PM/CM with benefit to both YG and PM/CM
- ***CH2M HILL agreed to do a prequalification "survey" which would help inform the best approach***
  - Those interested to participate as Prime / General Contractor
  - Those interested as specialist suppliers and contractors
  - Various trades

  Needs to be conducted **ASAP**. Utilize existing templates and processes to extent possible, draw from CH2M HILL Constructors documents and procedures.

Procurement Approaches

- ***Early preselect and pre-purchase of long lead and specialty equipment items. This could require an upfront payment of 25% given the current demand?***
- Possible maintenance shop for general large jobs at Grum but use a nearby contractor constructed facility for general plant maintenance
- Letter of surety should be obtained from contractors, could be demanded depending on contractor risk profile
- Plant Construction – Rule of thumb is 40% Civil cost / 40% Construction cost / 20% PM/CM

- Mainly spread over two seasons, third season is tuning & deficiencies only
- Y1 2013/14 – Excavate, foundations, building potentially up to $15M
  - Civil "light" package
    - Excavate + slabs + building ($2M)
    - Procure long lead items
- Y2 2014/15- Clarifier/ Thickener and reactors potentially up to $34M
- Y3 2015/16 – Process shakedown and optimization. $1M

- YG will only enter a contract with a single contracting body
- YG's procurement website will be a key information posting site

Value Add and Risk

- ***Need to have a Project Risk Workshop*** within 4 weeks time, then regular risk reviews as part of our overall PM and Project control
- ***Need to ensure that Value engineering workshop*** is included during the conclusion of the Design Definition phase of the 4P design process (as outlined in the TAR). Informal process – not necessary to bring in an outside VE consultant
- ***Need to understand the Federal funding risk*** and the perception that a similar plant would potentially cost only about $15 to $20M as seen from the Britannia plant example (includes many items not in Faro, like administration and lab facilities).
- Pro-rated for throughput, this would indicate the Faro plant would be in the order of $20M, conversion for inflation would add perhaps another 25%, site location and logistics could add additional costs.
- Need to rationalize the design to ensure that it is fit for purpose, but not excessive, and justify any higher cost for the Faro plant
- ***Risk drivers*** (not necessarily captured in a normal risk consideration)
  - Funding priorities shift due to a new emergency, and existing plant is operated for longer period while new priority is dealt with.
  - TEES refuses to operate existing plant due to H&S concerns.
  - Feds suspend investment in Faro, meaning existing plants is operated longer.
  - H&S incident shuts down plant or another part of the operation.
  - First Nations negotiations include unattainable objectives for plant operations.
  - Faro capacity to accommodate workforce is inadequate (off-camp needs like fuel, local supply, off-camp recreation demands, etc.).
  - Power outages
  - Fire
  - Failure of road to site
  - High treatment cost due to increased regulation (escalation)

Attachment B
WTP Contractor Market Analysis

Faro Mine Remediation Project - WTP Market Analysis

PREPARED FOR:	Lionel Etheridge/WTY, CH2M HILL Canada Limited (CH2M HILL)
PREPARED BY:	Paul Bourdon/VBC, CH2M HILL
COPIES:	Lawrence Benjamin/VBC, CH2M HILL
DATE:	June 5, 2012
PROJECT NUMBER:	436662.1E.13.01

The purpose of this memorandum is to report on initial investigations into general contractors with the capability and interest in delivering the Faro Mine Water Treatment Plant (WTP). The intent was to gauge contractor level of interest – not to engage in a formal request for qualifications.

Background

The Government of Yukon (YG) has made a commitment to clean up the Faro Mine site area with a remediation project. This project includes replacing the existing WTP, which currently treats acid mine drainage (AMD).

The proposed WTP will have a capacity of approximately 40 megalitres per day (ML/d), and be in operation from April to October. The treatment process will involve high-density sludge (HDS) – calcium oxide (CaO) slaked and added to the water in an initial mixing reactor. Another reactor will then add the recycled lime sludge, which will eventually flow to a thickener clarifier.

The plant will include the following components:

- Lime storage/slaking
- Lime mixing tank
- Reactor(s)
- 50-metre (m)-diameter clarifier/thickener
- Lime sludge recirculation
- Sludge forcemain

The initial cost estimate for the project is $30 - 50M.

Approach

A list of potential general contractors was generated by contacting experienced CH2M HILL project managers in our Vancouver and Calgary offices, as well as staff in the Whitehorse office. These contractors were then contacted and asked to provide a statement indicating their level of interest in the Faro WTP project, as well as a few sample projects that are similar in nature.

Market Analysis – Initial Findings

Based on the foregoing, Table 1 shows the contractor feedback, and Appendix A provides additional information on each of the firms that have shown a high level of interest in the WTP project.

Of 11 firms identified and contacted, 5 general contractors have shown a very strong interest in the Faro WTP project, and 4 firms have shown some interest. Most of the contractors have requested additional information, and some have stated they would like to prequalify for the work. One of the firms is interested in providing heavy earthworks services during construction.

COPYRIGHT 2012 BY CH2M HILL CANADA LIMITED • ALL RIGHTS RESERVED • COMPANY CONFIDENTIAL

TABLE 1
General Contractors

	Contractor	Contact Information	Services Offered	Interest in Project	Comments
1.	EllisDon	David McFarlane dmcfarlane@ellisdon.com, 604.247.1072	Project/construction management	No	Declined
2.	Graham Construction	Patrick Eliasson, patrike@graham.ca, 604.685.1243	Construction services	Yes	High level of interest in this project
3.	Kenaidan	Hesam Haque, hhaque@kenaidan.com, 604.685.1243	Construction services	Yes	High level of interest in this project – requesting additional information
4.	Kiewit	Justine Estey-Jones, justine.estey-jones@kiewit.com, 604.629.5419	Construction services	Yes	Interested
5.	Ledcor	Gary Stewart, gary.stewart@ledcor.com, 604.681.7500	Construction services	Yes	Interested
6.	Lockerbie & Hole	Rob Brown, rbrown@lockerbiehole.com, 604.777.5950	Construction services	Yes	High level of interest – preparing an information package for CH2M HILL that includes a very similar WTP recently completed
7.	Maple Reinders	Peter Kuipers, pkuipers@maple.ca, 403.216.1455; Bodo Papke, bodop@maple.ca, 250.765.8892	Construction services	Yes	High level of interest in this project – requesting additional information
8.	Nahanni Construction	Dwight, Dwight@nahannincl.com, 1.867.873.2975; http://nahannincl.com/	Construction services	Yes	Interested
9.	North American Construction	Alex Black, ablack@nacsworld.com, 519.821.8000	Construction services	Yes	High level of interest in this project – preparing an information package for CH2M HILL
10.	PCL	Kevin Lew, klew@pcl.com, 604.241.5200; www.pcl.com	Construction services	No	Declined
11.	Pelly Construction	Dan Russell, dan@pelly.net, 867.667.6161	Heavy earthworks	Yes	Interested in providing earthworks construction services

COPYRIGHT 2012 BY CH2M HILL CANADA LIMITED IGHTS RESERVED • COMPANY CONFIDENTIAL

Appendix A – General Contractor Overview

Graham Construction

Services Offered

Graham Construction's Infrastructure department specializes in water and wastewater treatment facilities, as well as water management and storage structures. Graham Construction is currently working on several projects throughout northern British Columbia (BC) and Alberta (AB), and has had success working with CH2M HILL in the past. The following statement appears on Graham Construction's website (www.graham.ca):

> *"The Infrastructure Division's services include pre-construction, general contracting, civil and underground installation, concrete batching and placing, pre-cast concrete and structural erection. Our capabilities extend beyond the construction phases to commissioning and operations/maintenance. We offer the full spectrum of contract approaches including design-build, partnerships and P3 project delivery."*

Example Projects

1. Pine Creek Water Management Centre
   - Location: Calgary, AB
   - Contract Value: $305M
   - Prime Consultant: CH2M HILL
   - Completion Date: October 2009
2. City of Red Deer - Wastewater Treatment Plant
   - Location: Red Deer, AB
   - Contract Value: $31M
   - Prime Consultant: Stantec Consulting Ltd.
   - Completion Date: November 2009
3. Willmar Wastewater Treatment Facility
   - Location: Willmar, Minnesota, United States (U.S.)
   - Contract Value: $49M
   - Prime Consultant: Donohue & Associates
   - Completion Date: November 2010

Also, please see attached company qualification package.

Kenaidan Contracting Ltd.

Services Offered

Kenaidan Contracting Ltd. (Kenaidan) provides general contracting, design/build, construction management, and pre-construction services, with water and wastewater treatment facilities being one of their specialties. Kenaidan offers construction services throughout North America, and has completed numerous successful projects with CH2M HILL throughout Canada. Additional information can be found on their website: www.kenaidan.com

Example Projects

1. Lorne Park Water Treatment Plant Expansion & Jack Darling Park Sewage Pumping Stations
   - Client: Region of Peel, Ontario (ON)
   - Contract Value: $75.7M

COPYRIGHT 2012 BY CH2M HILL CANADA LIMITED • ALL RIGHTS RESERVED • COMPANY CONFIDENTIAL

- Prime Consultant: AECOM

2. Ajax Water Treatment Plant
   - Client: Regional Municipality of Durham, ON
   - Contract Value: $61.2M
   - Prime Consultant: Simcoe Engineering Group Ltd.
3. Bradford Water Pollution Control Plant - Expansion
   - Client: The Town of Bradford, West Gwillimbury, ON
   - Contract Value: $37.8M
   - Prime Consultant: Totten Sims Hubicki Associates
4. Barrie Water Pollution Control Centre - Expansion
   - Client: The City of Barrie, ON
   - Contract Value: $69.8M
   - Prime Consultant: CH2M HILL Canada Limited

Lockerbie & Hole

Services Offered

Lockerbie & Hole are able to provide a wide variety of construction services, including those related to water and wastewater treatment facilities. Following is a statement from their website (www.lockerbiehole.com):

> *"For over 45 years Lockerbie & Hole has been constructing water and wastewater treatment plants in Western Canada and around the world. From treatment plants, pumping stations and reservoirs in small Western Canadian towns, to plants for major municipalities and large industrial facilities, to treatment plants in various Chinese provinces, Lockerbie & Hole's construction professionals are among the best in the business."*

Example Projects

1. Britannia Water Treatment Plant
   - Location: Britannia, BC
   - Contract Value: $12M
   - Owner: EPCOR Water Services
   - Completion Date: November 2005
2. Lulu Island Wastewater Treatment Plant
   - Location: Richmond, BC
   - Contract Value: $32M
   - Prime Consultant: ABR Consultants Ltd.
   - Completion Date: February 1999
3. Annacis Wastewater Treatment Plant
   - Location: Vancouver, BC
   - Contract Value: $31.1M
   - Prime Consultant: ABR Consultants Ltd.
   - Completion Date: November 1998

COPYRIGHT 2012 BY CH2M HILL CANADA LIMITED • ALL RIGHTS RESERVED • COMPANY CONFIDENTIAL

Maple Reinders

Services Offered

Maple Reinders offers a wide variety of construction services related to water treatment, and provide solutions that focus on safety, quality, and promoting green solutions.

Following is a statement from their website (www.maple.ca) that relates to their ability to offer a variety of project delivery methods:

> *Custom-Tailored Solutions for Maximum Success*
>
> *One of the most intimidating aspects of any construction project is choosing the appropriate project delivery vehicle. Maple Reinders can help make that decision easier.*
>
> *We recognize that one size does not fit all. Our team will assess your requirements, challenges, sensitivity to risk, and in-house expertise, then custom-tailor a project delivery vehicle to your unique specifications.*
>
> *Ultimately, we're on your side ... we'll go above and beyond to minimize your risk, ease the process, and provide responsive support at every stage of the project. At Maple Reinders, we truly believe that your success is our success and we'll go out of our way to achieve it.*

Example Projects

1. Wasaga Beach Water Pollution Control Plant
2. Black Mountain Water Treatment Plant
3. Powers Creek Water Treatment Plant

Also, please see attached company qualification package.

North American Construction

Services Offered/Recent Project Information

Please see attached prequalification document for company details.

COPYRIGHT 2012 BY CH2M HILL CANADA LIMITED • ALL RIGHTS RESERVED • COMPANY CONFIDENTIAL

Graham Construction
Company Qualification Package

Lockerbie & Hole
Company Qualification Package

Municipal

Britannia Mine Water Treatment Plant

Client:
EPCOR Water Services

Value:
$20 million

Location:
Britannia, British Columbia

Completion:
2005

References:
Dave Rector
(604) 270-9236

Project Details:

A design build lump sum contract to clean one of the largest heavy metal pollution sources in North America.

Lockerbie Stanley Inc.'s scope of work includes the design and construction of a 1,050 cubic meter per hour water treatment plant at the mine site and an additional pumphouse on the Howe Sound shoreline. The pumphouse will transfer ground water from 13 wells to the plant for processing.

Lockerbie Stanley Inc. faced numerous challenges including:

- Building on the side of a mountain
- Extensive ground water remediation measures
- Extensive contaminated soils mitigation measures
- Extensive mine adit upgrades
- Deep water outfall
- Mountain hydraulic challenges

Maple Reinders
Company Qualification Package

Maple Reinders Corporate Profile

The Maple Reinders Group has grown to become one of the most respected, highly qualified and trusted construction firms in Canada today. With its reach into all provinces of Canada and extending to international markets, the Maple Reinders Group has earned a solid reputation for quality, competence and integrity.

With offices in Kelowna, Calgary, Edmonton, Mississauga and Cambridge, the Maple Reinders Group has successfully completed over 2,200 projects. Current annual volume of construction work within the Buildings and Civil/Environmental Divisions is approaching $300 million with individual project values ranging from $15,000 to $100 million+.

Maple Reinders' civil/environmental expertise encompasses completion of over 600 water and wastewater treatment and transmission facilities. **We have own-forces qualifications in process mechanical installations as well as excavation, dewatering, demolition, concrete forming and site piping work**. This in-house capability allows in-depth critical path scheduling and detailed assessment of manpower requirements and resources control. We are also able to perform start-up and commissioning services as part of the contract.

Furthermore, we strive for excellence and support the CCA Gold Seal Program. Maple Reinders retains over 50 key personnel who have successfully acquired their Gold Seal Certification.

As part of our environmental commitment, we have several LEED® Accredited Professionals to handle the stringent environmental requirements for project owners wishing to pursue LEED® (Leadership in Energy and Environmental Design) Certification.

Recently, Maple Reinders was named one of the "50 Best Managed Companies in Canada". This is one of the country's leading business award programs recognizing excellence in Canadian-owned and managed companies and evaluating the calibre of their management abilities and practices.

Relevant Project Experience

Since its inception 45 years ago, Maple Reinders has focused on the construction of municipal infrastructure, water/wastewater treatment plants, large civil works, with recent specialization in biogas and solid waste treatment technology. The company continues to be a leader in this industry today, having completed over 600 water and wastewater treatment plant projects with an aggregate value totalling over $600,000,000.

Maple Reinders' team has a wide-ranging array of experience that demonstrates an ability to handle difficult and challenging jobs from small aerated lagoon systems up to advanced treatment systems capable of providing high levels of treatment. Many of our projects take place within existing infrastructure, requiring stringent work plans and phasing to maintain operations. Often these projects are also situated in urban/residential communities which require an open, communicative approach with several stakeholders.

The following is a representative listing of MRI's project experience in the past 10 years:

Project	Description	Owner / Consultant Contacts
Kelowna Wastewater Treatment Facility Kelowna, BC	Plant expansion to include new influent screens, primary clarifier, biofilter, fermenter, bioreactor & secondary clarifiers, taking plant from 40ML/d to 70 ML/d. Also added one DAF and one centrifuge to improve solids treatment and disposal. **Contract Value:** $38,994,600 *Note: We have completed six upgrades totaling $65,000,000 in upgrades at the Kelowna Facility over 15 years.*	City of Kelowna Mr. Joel Shaw (250) 469-8739 Stantec Consulting Mr. Jim Kental (250) 860-3225
Vernon Water Reclamation Facility Vernon, BC	Project / Construction Management of the construction of a new 27 ML/day water reclamation plant, employing BNR treatment technology, final effluent filtration, UV disinfection and extensive odour control technologies. **Contract Value:** $29,700,000	City of Vernon Mr. Serge Kozin (250) 545-1361 Stantec Consulting Mr. Rob Fortuin (now with Focus Engineering) (250) 980-5500
Kamloops Sewage Treatment Centre Upgrade Kamloops, BC	Upgrades to WWTP including five buildings (administration, headworks, DAF, UV, and Cell 2C blowers); two 44 m Ø concrete clarifiers, with a recycle pump station; aeration systems; DAF, centrifuge, and influent screen; UV disinfection; pump stations and yard piping; lagoon mixers, baffles and partition wall; sludge pumping system; anaerobic lagoon cover with gas extraction and flare; and a new outfall into the Thompson River. **Contract Value:** $26,817,000	City of Kamloops Mr. Dion Silversides, AScT, LEEDAP (250) 828-3457 Urban Systems Ltd. Mr. Chris Town, PEng (250) 374-8311
Lorne Park Water Treatment Plant Mississauga, ON	New membrane filtration building, with 500 ML/d capacity; structural, mechanical & electrical modifications to existing plant. **Contract Value:** $62,606,380	Region of Peel Mr. Jeff Hennings (905) 274-9616 AECOM Mr. Adel Youssef (905) 855-7700 x224

Project	Description	Owner / Consultant Contacts
Picton Wastewater Treatment Plant Picton, ON	***Design-Build*** greenfield WWTP replacement incl. preliminary treatment, septage receiving station, secondary treatment (extended aeration), tertiary treatment, UV disinfection, aerobic sludge digestion and sludge dewatering. **Contract Value:** $25,382,058	Prince Edward County Mr. Lynn Morgan (613) 476-3537 Dillon Consulting Limited Mr. Louis Tasfi (519) 438-1288 x1320
Halifax Eastern Passage Wastewater Treatment Facility Halifax, NS	***Design-Build*** replacement/ upgrade including new headworks, primary & secondary clarifiers, extended aeration tanks, UV disinfection, effluent pumping station, and odour control system. **Contract Value:** $61,886,000	Halifax Regional Water Commission Mr. Ian Guppy (902) 490-5212 Dillon Consulting Mr. Louis Tasfi (519) 438-6192
Penticton Advanced Wastewater Treatment Plant Penticton, BC	Upgrade to the 27.7 ML/d Penticton WWTP, comprising new effluent filters, primary clarifiers, sludge dewatering equipment, foul air collection & treatment system, plus renovations to the administration building. **Contract Value:** $20,733,300	City of Penticton Mr. Len Robson (250) 490-2543 AECOM Mr. David Lycon, PEng (250) 762-3727
Powers Creek Water Treatment Plant Westbank, BC	Construction of a new 54 ML/d water treatment plant including an 8,000 m^3 filtered water reservoir & employing coagulation, mechanical flocculation, dissolved air filtration, granular media filtration and gaseous chlorination. A UV Facility was added under a separate contract with MRI. **Contract Value:** $16,839,855	Westbank Irrigation District Mr. Brian Jamieson (250) 768-5154 AECOM Mr. Brett DeWynter (250) 762-3727
Duteau Creek Water Treatment Plant Lavington, BC	New 160 ML/d clarification facility using conventional DAF process. Also incl. all buried pipework/ connections, 10 ML treated water reservoir, and hypochlorite facility. **Contract Value:** $22,309,000	Regional District of North Okanagan Mr. Al Cotsworth (250) 550-3702 AECOM Mr. Brett DeWynter (250) 762-3272

Project	Description	Owner / Consultant Contacts
Lac La Biche Wastewater Treatment Plant P3 Project Lac La Biche, AB	P3 project involving ***design, build and operation*** of a new BNR wastewater treatment facility, in addition to a new lift station and forcemain. WWTP includes bioreactor and secondary clarifier, headworks (fine screening), septage receiving, thickening and dewatering, blower room, MCC room, control room, maintenance room, alum storage, pump room, filtration, UV disinfection. **Contract Value:** $17,929,800	Lac Lac Biche County Mr. Erwin Duigou (780) 623-1747 AECOM Mr. Tim Fairley (403) 270-9200
Pine Creek Wastewater Treatment Plant Calgary, AB	Construction, start up and commissioning of effluent filtration and UV disinfection facilities including associated channels, utilities and accessories. LEED Silver. **Contract Value:** $26,930,840	City of Calgary Mr. Andrew Dutton (403) 268-1697 CH2M Hill Mr. Steve Rowe (403) 237-9300
Westside Wastewater Treatment Plant Upgrades Westbank, BC	Plant upgrades include a new biofilter, Primary Clarifier 3, Fermenter 2, Secondary Clarifiers 3 & 4, a new bioreactor, final effluent pump station (screw pumps) & related civil, chemical & electrical works. ETLS upgrades include an expanded building & the installation of new above-grade pumps, related piping as well as ferric chloride system & standby power. **Contract Value:** $10,914,000	Regional District of Central Okanagan Mr. Charlie Cameron (250) 763-4918 AECOM Mr. Les Nemeth (250) 762-3727
Banff Wastewater Treatment Plant & Biosolids Composting Banff, AB	***Design-Build-Operate*** contract to upgrade and operation for a ten year term of the existing WWTP. Included in-vessel composting facility for biosolids. **Contract Value:** $9,840,000	Town of Banff Mr. Bruce Bedwell (403) 762-1200 Associated Engineering Mr. Richard Watson (403) 262-4500
Jasper Wastewater Treatment Plant & Biosolids Composting Jasper, AB	***Design-Build*** contract for new WWTP including new primary clarifier, combined treatment units, sludge composting facility, UV disinfection system and septage receiving station. **Contract Value:** $16,000,000	Municipality of Jasper Mr. Keith Quackenbush (780) 852-1562 AECOM Mr. Andy North (604) 298-6181

Project	Description	Owner / Consultant Contacts
Nanaimo Pollution Control Centre Digester Upgrade Nanaimo, BC	Construction of a new sludge digester, mixed sludge tank, sludge control building, electrical room, and service tunnel. **Contract Value:** $9,459,600	Regional District of Nanaimo Mr. Sean De Pol (250) 390-6547 AECOM Mr. David Lycon (604) 444-6487
Strathmore Wastewater Treatment Plant Strathmore, AB	***Design-Build*** contract to increase the capacity of the existing wastewater treatment plant to 20 ML/d, as well as convert the entire treatment process to a conventional continuous flow BNR configuration, and effectively retrofit the two existing SBR reactors into BNR reactors. **Contract Value:** $19,914,380	Town of Strathmore Mr. Dwight Standford (403) 934-3133 AECOM Mr. Vern Gharabegian (403) 270-9164
Six Nations Water Treatment Plant Ohsweken, ON	New 1800 m^2 water treatment plant on First Nations reserve including sedimentation conduits; low lift station; raw water intake; UVAOP system; membrane treatment system; pre-treatment system; BAC filter system; chemical feed system; overhead cranes; site preparation and grading; filter press; septic system; diesel generator system. **Contract Value:** $36,570,000	Six Nations of the Grand River Mr. Dayle Bomberry (519) 445-4242 First Nations Engineering Services Ltd. Mr. Justin Gee (519) 445-0040
Dawson Creek Reclaimed Water Facility Dawson Creek, BC	Reclaimed Water project involves construction of the reclaimed water treatment building and a truck filling station. Treatment works have the capacity to produce 4,000 cubic meters per day of reclaimed water for irrigation use. LEED Gold. **Contract Value:** $5,763,000	City of Dawson Creek Mr. Greg Dobrowolski (250) 784-3622 Urban Systems Ltd. Mr. Jaimes Adams (250) 785-9697
Pemberton Wastewater Treatment Plant Pemberton, BC	***Design-Build*** construction of a "green-field" wastewater treatment plant & outfall, based on Sanitaire ICEAS SBR technology, with influent screening, aerobic digestion, belt filter press dewatering, odour control & administration building. **Contract Value:** $4,000,000	Village of Pemberton Mr. Hedley Crowther (604) 894-6135 Associated Engineering Mr. Paul Dufault (604) 293-1411

North American Construction Company Qualification Package

June 1, 2012

CH2M Hill
245 Consumers Road, Suite 400
Toronto, ON
M2J 1R3
Attn: Matthew Elliott

RE: Faro Mine Rehab Water Treatment Plant Project Information Package

Dear Mr. Elliott,

In Response to your invitation to submit an information package outlining our qualifications to provide construction services, we are pleased to provide the following submission in support for the above noted project.

North America Construction (1993) Ltd. is well suited for the construction of the Faro Mine Rehab Water treatment Plant Project since we specialize in water and wastewater treatment facilities throughout Canada. NAC's strengths are derived from our in-house abilities and labour force to perform civil, mechanical, electrical and instrumental work. As a specialist in this type of work with 75% of our annual sales coming from water and wastewater construction, the above noted project is extremely important to NAC. NAC is accustomed to providing construction services in Northern Canada including Yukon and North West Territories and having experience in remote camp environments.

Yours truly,
North America Construction (1993) Ltd.

Alex Black, P.Eng.
Vice President, Municipal

North America Construction (1993) Ltd. • NAC Constructors Ltd.
21 Queen Street, Morriston, Ontario N0B 2C0
Tel: 519-821-8000 Fax: 519-821-1111
www.nacsworld.com

CCDC 11 – 1996
Contractor's Qualification Statement

Contractor's Qualification Statement

Standard Construction Document

CCDC 11– 1996 (R2006)

This document is intended to provide information on the capacity, skill, and experience of the Contractor. Applicant may supplement information requested with additional sheets if required.

Project Number:

Project Title: Faro Mine Rehab Project Water Treatment Plant

Location: Yukon

1. Submitted to:

Firm Name: CH2M Hill

Address: 245 Consumers Road, Suite 400
Toronto, Ontario
M2J 1R3

Phone: (416) 495-7928 Fax: (416) 499-4687

E-mail:

2. Submitted by:

Firm Name: North America Construction (1993) Ltd.

Address: 21 Queen St
Morriston, ON
N0B 2C0

Phone: (519) 821-8000 Fax: (519) 821-1111

E-mail: nac@nacsworld.com

3. Legal Structure of Contractor:

Year Established: 1993

☐ Joint Venture, ☑ Corporation, ☐ Partnership, ☐ Registered, ☐ Sole Proprietor ,

Other:

Names and Titles of Officers, Partners, Principal:

Name	Title / Position
Mr. Scott McPherson	President
Mr. Jim Prytula	Vice President of Finance
Mr. Alex Black	Vice President of Municipal Operations
Mr. Keith Burrow	Vice President of Strategic Development

I declare the information in this form to be true and correct to the best of my knowledge

Name of Contact Person:

Mr. Alex Black

Title of Contact Person:

Vice President of Municipal Operations

Apply CCDC 11 copyright seal here.

Use of a CCDC 11 document not containing a CCDC 11 copyright seal constitutes an infringement of copyright. Use of this form with a CCDC 11 copyright seal demonstrates that it is intended by the parties to be an accurate and unamended version of CCDC 11 - 1996 (R2006).

CCDC Copyright 1996 (R2006)
Canadian Construction Documents Committee

Contractor's Qualification Statement

4. Financial References

a. Bank Name: Toronto Dominion Bank

Address: 20 Milverton Drive
Mississauga, Ontario
L5R 3G2

Contact Person(s): Ms. Vicky Grisafi, Account Manager

Phone: (905) 568-3620 Fax: (905) 890-4121

E-mail: grisav@td.com

b. Bonding Company: Zurich Insurance Company

Address: 400 University Avenue, 21st Floor
Toronto, Ontario
M5G 1S7

Contact Person(s): Mr. Michael Gross, Senior Surety, Account Executive

Phone: (416) 586-3000 Fax: (416) 586-2980

E-mail: Michael.gross1@zurich.com

5. Annual value of construction work for the past five years

Year	Value
2011	$ 196,000,000
2010	$ 123,000,000
2009	$ 193,000,000
2008	$ 237,000,000
2007	$ 182,000,000

6. Key office personnel proposed for the project
(e.g. Principal in Charge, Project Manager, Estimator, etc)
attach resume of qualifications and experience:

Name	Title / Position
Alex Black	Vice President of Municipal Operations
Neil Hillstrom	Civil Operations Manager
Rob Poland	Mechanical Operations Manager
Keith Jantzi	Electrical Operations & Commissioning Manager

7. Key site personnel proposed for the project
(e.g. Project manager, Superintendent, Foreman, etc)
attach resume of qualifications and experience:

Name	Title / Position
TBD	Project Manager
TBD	Project Superintendent
TBD	Project Coordinator
TBD	Health & Safety Coordinator

8. Principal projects completed in the past five years. Listed in Appendix A.
9. Similar or related projects completed. Listed in Appendix B.
10. Major construction projects underway this date. Listed in Appendix C.

APPENDIX A
Principal projects completed in the past five years.

Project Title Duffin Creek WPCP Stage 3 Liquids Process Expansion Project/Liquid Modules Expansion

Date Completed: 2010 Project Value: $ 213,000,000

Location: Pickering, Ontario

Owner: The Regional Municipality of York
Contact Person(s): Mr. Euan Ferguson
Phone: (905) 830-4444 Fax: (905) 427-3839
E-mail: euan.ferguson@york.ca

Consultant: CH2M Hill Canada Ltd.
Contact Person(s): Mr. Bob Hook
Phone: (416) 499-0090 Fax: (416) 499-4684
E-mail: bob.hook@ch2m.com

Description:

The scope of work consists of the addition of the following processes, six new longitudinal sludge primary clarifiers, six new fine bubble aeration tanks, new blower building, six new longitudinal secondary clarifiers, two new chlorine contact tanks, new disinfection building, new effluent pumping station, New Headworks and Odour Control Facility.

Project Title Seymour-Capilano Filtration Plant

Date Completed: February 15, 2009 Project Value: $ 192,000,000

Location: North Vancouver, BC

Owner: Greater Vancouver Water District
Contact Person(s): Mr. Mark Ferguson
Phone: (604) 432-6341 Fax: (604) 451-6180
E-mail: mark.ferguson@metrovancouver.org

Consultant: Pacific Liaicon & Associates Inc.
Contact Person(s): Mr. Joe Cohrs
Phone: (604) 982-3179 Fax: (604) 987-6847
E-mail: joe.cohrs@metrovancouver.org

Description:

Construction of the world's largest UV disinfection facility forming and placement of 37,000 m3 of concrete and the erection of 900 tonnes of structural steel for the follwong structures, inlet blending, 12 flocculation cells, 48 filter cells, equipment galleries, an operations and maintenance complex, backwash equalization and treatment facilities.

APPENDIX A
Principal projects completed in the past five years.

Project Title Horizon Oil Sands Projects

Date Completed: August 31, 2009 Project Value: $ 100,000,000

Location: Ft. McMurray, Alberta

Owner: Canadian Natural Resources Limited

Contact Person(s): Mr. Sean Fleming

Phone: (403) 213-7108 Fax: (403) 517-7392

E-mail: jeremy.hamilton@CNRL.com

Consultant: N/A

Contact Person(s): N/A

Phone: Fax:

E-mail: N/A

Description:

The completed work included approximatley 2000 drilled and driven piles, over 20,000m3 of reinforced concrete for foundation and slabs, 13,000 meters of deep underground services & ten large diameter tank pads complete with liner systems and plant wide finished grading.

Project Title Integrated Grain Processors Cooperative Inc. / IGPC Ethanol Inc.

Date Completed: October 15, 2008 Project Value: $ 120,000,000

Location: Aylmer, Ontario

Owner: Integrated Grain Processors Co-Operative Inc.

Contact Person(s): Mr. Jim Grey

Phone: (519) 765-2575 Fax: (519) 765-2775

E-mail: jgrey@igpc.ca

Consultant: J.L Richards & Associates Ltd.

Contact Person(s): Mr. Brian Davies, P.Eng

Phone: (613) 728-3571 Fax: (613) 728-6012

E-mail: BDavies@JLRICHARDS.ca

Description:

Construction of the Aylmer Ethanol Plant is a design build facility using ICM technology set to produce 40 million US GPY of de-natured ethanol spanning a relatively short 16 month construction window. The plant is designed to process 40,300 bushels of corn per day requiring an annual supply of 14,230,000 bushels.

APPENDIX A
Principal projects completed in the past five years.

Project Title Lakeview WTP-Contract 4

Date Completed: October 15, 2007 Project Value: $ 59,600,000

Location: Mississauga, Ontario

Owner: Region of Peel
Contact Person(s): Mr. Dan Cafarreli
Phone: (905) 791-7800 Fax: (905) 453-2501
E-mail: dan.cafarreli@peelregion.ca

Consultant: CH2M Hill Canada Ltd.
Contact Person(s): Mr. Bob Christopher, P.Eng.
Phone: (416) 499-9000 Fax: (416) 499-4687
E-mail: Bob.Christopher@ch2m.com

Description:

Expansion to the existing plant includes the addition of a 250 MLD Zenon Ultrafiltration and Fuji Ozone Disinfection facility consisting of 55,000 m3 of rock and earthwork excavation and 14,000 m3 of new concrete. Also housed within the new facility are five BAC contactors complete with stainless steel internals and media, various chemical systems and storage tanks.

Project Title Colwood Refueling Facility Upgrade

Date Completed: February 28, 2005 Project Value: $ 55,600,000

Location: Victoria, BC

Owner: National Defence
Contact Person(s): Mr. John Laverdiere
Phone: (613) 995-8470 Fax:
E-mail: john.lavenerdiere@forces.gc.ca

Consultant: Acres International
Contact Person(s): Mr. Richard Cousins
Phone: (604) 683-9141 Fax:
E-mail: N/A

Description:

Construction of a new 285 m long x 13 m wide concrete refuelling and berthing jetty supported by large diameter vertical piles; a new tank farm and containment berm with marine distillate, JP-5, on-spec oil, waste oil and oily waste water, and other tankage; a compensating water system with tanks and pumping system; a fuel transmission system with steel lines, and multiple pumps.

APPENDIX A
Principal projects completed in the past five years.

Project Title East End Water Pollution Control Plant

Date Completed: April 17, 2007 Project Value: $ 47,000,000

Location: Sault Ste. Marie, Ontario

Owner: The Corporation of the City of Sault Ste. Marie

Contact Person(s): Mr. Don Elliott

Phone: (705) 759-2500 Fax: (705) 541-7165

E-mail: d.elliott@cityssm.on.ca

Consultant: AECOM Canada Ltd.

Contact Person(s): Mr. John Myatt, P.Eng

Phone: (519) 673-5975 Fax: (519) 673-5975

E-mail: john.myatt@aecom.com

Description:

Major retrofit and expansion to the existing East End WPCP included the sequenced mass demolition of one primary and four secondary circular clarifiers, new bioreactor facility, new disinfection facility, a new odour control biofilter facility, selective demolition and retrofit of the existing sludge dewatering facility, coupled with extensive yard piping and siteworks.

Project Title Lemieux Island WPP Filter Expansion

Date Completed: December 22, 2009 Project Value: $ 42,000,000

Location: Ottawa, Ontario

Owner: City of Ottawa

Contact Person(s): Mr. Theodore Woytowich

Phone: (613) 582-2400 Fax: (613) 582-2495

E-mail: theodore.woytowich@ottawa.ca

Consultant: CH2M Hill

Contact Person(s): Mr. Norm Newman

Phone: (613) 723-0233 Fax: (613) 723-4489

E-mail: norman.newman@CH2M.com

Description:

The work at Lemieux Island consists of expansion to the existing 12 cell filter gallery plus significant retrofit to the existing facility involving numerous tie-ins and shut downs.

APPENDIX A
Principal projects completed in the past five years.

Project Title Lakeview WWTP

Date Completed: July 31, 2006 Project Value: $ 40,000,000

Location: Mississauga, Ontario

Owner: Region of Peel

Contact Person(s): Mr. William Fernandes, P.Eng,

Phone: (905) 791-7800 Fax: (905) 274-3508

E-mail: william.fernandes@peelregion.ca

Consultant: AECOM Canada Ltd.

Contact Person(s): Mr. Peter Bradley

Phone: (905) 459-4780 Fax: (905) 274-1134

E-mail: peter.bradley@aecom.com

Description:

Expansion and retrofit including; addition of two new travelling bridge type primary clarifiers, six new fine bubble diffuser aeration tank processes, eight new longitudinal type secondary clarifiers, and modifications to each of fourteen existing fine bubble diffuser aeration tanks.

Project Title Port Hope WWTP

Date Completed: June 15, 2009 Project Value: $ 33,500,000

Location: Port Hope, Ontario

Owner: Municipality of Port hope

Contact Person(s): Mr. Peter Angelo

Phone: (905) 885-2431 Fax: (905) 885-7698

E-mail: Pangelo@porthope.ca

Consultant: AECOM

Contact Person(s): Mr. Troy Briggs,M.Eng.,P.Eng.

Phone: (905) 747-7651 Fax: (905) 886-9494

E-mail: TroyBriggs@aecom.com

Description:

Expansion and retrofit to the existing complex consists of a new Headworks facility, two new aerobic digesters, three new aeration tanks, six new chain & flight secondary clarifiers, two chlorine contact tanks, a new sludge dewatering facility with centrifuge and associated equipment, new effluent pumping systems, a new sludge storage building, new transformer station.

APPENDIX B
Similar or related projects completed.

Project Title Duffin Creek WPCP Stage 3 Liquids Process Expansion Project/Liquid Modules Expansion

Date Completed: 2010 Project Value: $ 213,000,000

Location: Pickering, Ontario

Owner: The Regional Municipality of York

Contact Person(s): Mr. Euan Ferguson

Phone: (905) 830-4444 Fax: (905) 427-3839

E-mail: euan.ferguson@york.ca

Consultant: CH2M Hill Canada Ltd.

Contact Person(s): Mr. Bob Hook

Phone: (416) 499-0090 Fax: (416) 499-4684

E-mail: bob.hook@ch2m.com

Description:

The scope of work consists of the addition of the following processes, six new longitudinal sludge primary clarifiers, six new fine bubble aeration tanks, new blower building, six new longitudinal secondary clarifiers, two new chlorine contact tanks, new disinfection building, new effluent pumping station, New Headworks and Odour Control Facility.

Project Title Seymour-Capilano Filtration Plant

Date Completed: February 15, 2009 Project Value: $ 192,000,000

Location: North Vancouver, BC

Owner: Greater Vancouver Water District

Contact Person(s): Mr. Mark Ferguson

Phone: (604) 432-6341 Fax: (604) 451-6180

E-mail: mark.ferguson@metrovancouver.org

Consultant: Pacific Liaicon & Associates Inc.

Contact Person(s): Mr. Joe Cohrs

Phone: (604) 982-3179 Fax: (604) 987-6847

E-mail: joe.cohrs@metrovancouver.org

Description:

Construction of the world's largest UV disinfection facility forming and placement of 37,000 m3 of concrete and the erection of 900 tonnes of structural steel for the follwong structures, inlet blending, 12 flocculation cells, 48 filter cells, equipment galleries, an operations and maintenance complex, backwash equalization and treatment facilities.

APPENDIX B
Similar or related projects completed.

Project Title Lakeview WTP-Contract 4

Date Completed: October 15, 2007 Project Value: $ 59,600,000

Location: Mississauga, Ontario

Owner: Region of Peel
Contact Person(s): Mr. Dan Cafarreli
Phone: (905) 791-7800 Fax: (905) 453-2501
E-mail: dan.cafarreli@peelregion.ca

Consultant: CH2M Hill Canada Ltd.
Contact Person(s): Mr. Bob Christopher, P.Eng.
Phone: (416) 499-9000 Fax: (416) 499-4687
E-mail: Bob.Christopher@ch2m.com

Description:

Expansion to the existing plant includes the addition of a 250 MLD Zenon Ultrafiltration and Fuji Ozone Disinfection facility consisting of 55,000 m3 of rock and earthwork excavation and 14,000 m3 of new concrete. Also housed within the new facility are five BAC contactors complete with stainless steel internals and media, various chemical systems and storage tanks.

Project Title East End Water Pollution Control Plant

Date Completed: April 17, 2007 Project Value: $ 47,000,000

Location: Sault Ste. Marie, Ontario

Owner: The Corporation of the City of Sault Ste. Marie
Contact Person(s): Mr. Don Elliott
Phone: (705) 759-2500 Fax: (705) 541-7165
E-mail: d.elliott@cityssm.on.ca

Consultant: AECOM Canada Ltd.
Contact Person(s): Mr. John Myatt, P.Eng
Phone: (519) 673-5975 Fax: (519) 673-5975
E-mail: john.myatt@aecom.com

Description:

Major retrofit and expansion to the existing East End WPCP included the sequenced mass demolition of one primary and four secondary circular clarifiers, new bioreactor facility, new disinfection facility, a new odour control biofilter facility, selective demolition and retrofit of the existing sludge dewatering facility, coupled with extensive yard piping and siteworks.

APPENDIX B
Similar or related projects completed.

Project Title Lemieux Island Water Purification Plant Filter Expansion

Date Completed: December 22, 2009 Project Value: $ 42,000,000

Location: Ottawa, Ontario

Owner: City of Ottawa
Contact Person(s): Mr. Theodore Woytowich
Phone: (613) 582-2400 Fax: (613) 580-2495
E-mail: theodore.woytowich@ottawa.ca

Consultant: CH2M Hill
Contact Person(s): Mr. Norm Newman
Phone: (613) 723-0233 Fax: (613) 723-4489
E-mail: norman.newman@CH2M.com

Description:

The scope includes; six new filter cells and gallery extension over the existing south reservoir, extensive concrete refurbishing and baffle installations within each reservoir, sequenced retrofit to the existing floc tanks including baffle installations, a new blower building, new flow metering chambers, new sections of CPP piping requiring multiple tie-ins completely re-directing process flow.

Project Title Lakeview WWTP

Date Completed: July 31, 2006 Project Value: $ 40,000,000

Location: Mississauga, Ontario

Owner: Region of Peel
Contact Person(s): Mr. William Fernandes, P.Eng,
Phone: (905) 791-7800 Fax: (905) 274-3508
E-mail: william.fernandes@peelregion.ca

Consultant: AECOM Canada Ltd.
Contact Person(s): Mr. Peter Bradley
Phone: (905) 459-4780 Fax: (905) 274-1134
E-mail: peter.bradley@aecom.com

Description:

Expansion and retrofit including; addition of two new travelling bridge type primary clarifiers, six new fine bubble diffuser aeration tank processes, eight new longitudinal type secondary clarifiers, and modifications to each of fourteen existing fine bubble diffuser aeration tanks.

APPENDIX B
Similar or related projects completed.

Project Title Port Hope WWTP

Date Completed: June 15, 2009 Project Value: $ 33,500,000

Location: Port Hope, Ontario

Owner: Municipality of Port hope

Contact Person(s): Mr. Peter Angelo

Phone: (905) 885-2431 Fax: (905) 885-7698

E-mail: Pangelo@porthope.ca

Consultant: AECOM

Contact Person(s): Mr. Troy Briggs,M.Eng.,P.Eng.

Phone: (905) 747-7651 Fax: (905) 886-9494

E-mail: TroyBriggs@aecom.com

Description:

Expansion and retrofit to the existing complex consists of a new Headworks facility, two new aerobic digesters, three new aeration tanks, six new chain & flight secondary clarifiers, two chlorine contact tanks, a new sludge dewatering facility with centrifuge and associated equipment, new effluent pumping systems, a new sludge storage building, new transformer station.

Project Title Lakeview WTP Low Lift Pump Station

Date Completed: August 1, 2011 Project Value: $ 24,000,000

Location: Mississauga, Ontario

Owner: Region of Peel

Contact Person(s): Mr. Andrew Farr

Phone: (905) 274-9616 Fax: (905) 274-3508

E-mail: fara@region.peel.on.ca

Consultant: CH2M Hill Canada Ltd.

Contact Person(s): Mr. John Mills

Phone: (416) 499-9000 Fax: (416) 499-4687

E-mail: John.Mill@ch2m.com

Description:

This is a low lift pump building being added to the existing Water Treatment Plant, and will consist of major mechanical and electrical work in later stages of the project.

APPENDIX B
Similar or related projects completed.

Project Title Herridge Reservoir & Pumping Station

Date Completed: July 31, 2011 Project Value: $ 22,000,000

Location: Mississauga, Ontario

Owner: Region of Peel
Contact Person(s): Ms. Heather Jefferson
Phone: (905) 791-7800 Fax: (905) 274-3508
E-mail: Heather.Jefferson@peelregion.ca

Consultant: R.J. Burnside & Associates Limted
Contact Person(s): Mr. Ron Alkema
Phone: (416) 213-1060 Fax: (416) 213-1070
E-mail: Ron.Alkema@rjburnside.com

Description:

The project consists of a concrete buried reservoir replacing an existing reservoir, buried distribution center directing flow to the appropriate reservoir, overflow pond, 27.6 Kv substation, and new valve and flow meter chambers. NAC self performed all concrete work, rebar installations, excavations, yard piping, mech. & elec. works for this project.

Project Title Arnprior Water Pollution Control Centre & Expansion

Date Completed: June 21, 2011 Project Value: $ 17,255,000

Location: Arnprior, Ontario

Owner: Town of Arnprior
Contact Person(s): Mr. Mike Trumble
Phone: (613) 623-4234 Fax: (613) 623-9232
E-mail: mtrumble@arnprior.ca

Consultant: J.L Richards
Contact Person(s): Mr. Mike Duivenvoorden
Phone: (613) 728-3571 Fax: (613) 728-6012
E-mail: mduivenvoorden@jlrichards.ca

Description:

The Arnprior WPCC expansion project will increase treatment capacity by constructing additional,Primary,Aeration,Secondary and Chlorine Contact process tanks.A second automated inlet screen,a third aeration blower,additional pumps and updating to the current SCADA/admin area.New Digestion/ Bio-solids management building complete with a centralized odour treatment system

APPENDIX C
Major construction projects underway as of the date of submission.

Project Title Clarkson Wastewater Treatment Plant

Scheduled Completion Date: November, 2013 Project Value: $ 75,000,000

Percent Completed: 30%

Location: Mississauga, ON

Owner: Region of Peel

Contact Person(s): Mr. William Fernandes, P.Eng

Phone: (905) 791-7800 Fax: (905) 274-3508

E-mail: william.fernandes@peelregion.ca

Consultant: AECOM

Contact Person(s): Ignatius IP, P.Eng.

Phone: (905) 886-7022 Fax: (905) 886-9494

E-mail: ignatius.ip@aecom.com

Description:

This liquids phase consists of some 29,000 cubic meters of concrete, 4,000 tons of rebar, 133,500 cubic meters of excavation, and 320,000 total combined civil, mechanical & electrical man hours of labour productivity.

Project Title Red Deer Wastewater Treatment Phase 4 Upgrades

Scheduled Completion Date: August 2014 Project Value: $ 56,000,000

Percent Completed: 5%

Location: Red Deer, Alberta

Owner: The City of Red Deer

Contact Person(s): Alex Monkman

Phone: (403) 342-8750 Fax:

E-mail: Alex.monkman@reddeer.ca

Consultant: Stantec Consulting Ltd.

Contact Person(s): Stephen Weiniger

Phone: (703) 341-3320 Fax:

E-mail: Stephen.weninger@stantec.com

Description:

The work at Red Deer Wastewater Treatment Plant consists of an expansion to the existing facility totaling some $56 million of construction over 30 months. The expansion consists of expanding the existing site to handle more flow as the developing areas in and around Red Deer grow at a rapid rate.

APPENDIX C
Major construction projects underway as of the date of submission.

Project Title City of Brandon Water Reclamation Facility- Phase III Upgrade Contract 2 Industrial WWTF Expansion

Scheduled Completion Date: August 31, 2013 Project Value: $ 25,000,000

Percent Completed: 10%

Location: Brandon, Manitoba

Owner: City of Brandon

Contact Person(s): Mr. Patrick Pulak

Phone: (204) 729-2477 Fax: (204) 726-8546

E-mail: p.pulak@brandon.ca

Consultant: AECOM

Contact Person(s): Terry Kjartanson, P.Eng

Phone: (204) 477-5381 Fax: (204) 284-2040

E-mail: Terry.Kjartanson@aecom.com

Description:

Expansion of Industrial Waste Water Treatment Facility for City of Brandon that includes a new Inlet Structure, Bioreactor, expansion to the chemical building, expansion to the Membrane Building, and associated yard piping to tie all the new process together. The process technology that the City of Brandon elected to utilize is a GE Membrane system.

Project Title Mississippi Mills Wastewater Treatment Plant

Scheduled Completion Date: April, 2012 Project Value: $ 25,000,000

Percent Completed: 75%

Location: Almonte, Ontario

Owner: Town of Mississippi Mills

Contact Person(s): Mr. Cory Smith

Phone: (613) 256-2064 Fax: (613) 256-4881

E-mail: csmith@mississippimills.ca

Consultant: The Thompson Rosemount Group

Contact Person(s): Mr. Jamie Fawthrop

Phone: (613) 933-5602 Fax: (613) 936-0335

E-mail: jfawthrop@trg.ca

Description:

Construct a new wastewater treatment plant complete with all mechanical, process, electrical, structural, architectural and siteworks. Demolition and modifications to the existing Sewage Treatment Plant buildings. Mechanical and electrical works at the Gemmills Bay Pumping Station. Forcemain between Gemmills Bay Pumping Station and the new WWTP.

APPENDIX C
Major construction projects underway as of the date of submission.

Project Title Burlington Skyway Wastewater Treatment Phase II Expansion

Scheduled Completion Date: July 2014 Project Value: $ 107,550,000

Percent Completed: 5%

Location: Burlington, Ontario

Owner: Region of Halton

Contact Person(s): David Ohashi

Phone: (905) 825-6000 Fax: (905) 825-0267

E-mail: david.ohashi@halton.com

Consultant: CH2M Hill

Contact Person(s): TBA

Phone: (416) 499-9000 Fax: (416) 499-4687

E-mail: TBA

Description:

The general scope of the project is to provide additions to the existing system to allow for additional capacity that includes expanding the Aeration Tanks, Grit Tanks, Secondary Clarifiers, new pumps, new blowers, and additional conduits. The project also includes a new Tertiary Building that houses UV and BAC Under drains.

Project Title

Scheduled Completion Date: Project Value: $

Percent Completed:

Location:

Owner:

Contact Person(s):

Phone: Fax:

E-mail:

Consultant:

Contact Person(s):

Phone: Fax:

E-mail:

Description:

North America Construction (1993) Ltd.
Aboriginal Business Policy

North America Construction (1993) Ltd.
NAC Constructors Ltd.
Aboriginal Business Policy

North America Construction (1993) Ltd. is fully committed to providing maximum opportunities for Canada's Aboriginal People's. The very nature of our target markets often places us in close proximity to First Nations communities and traditional territories across this vast country. NAC's goal is to always leave these communities better off for NAC having been there through one or more of the following methods;

- Relationship building with the community
- direct training and employment
- subcontracting to local Aboriginal businesses
- direct supply of materials
- joint venture partnerships or work agreements

Once awarded a project, NAC's Aboriginal liaison establishes an open channel of communication with the local band Chief and Council. A meeting is normally held to introduce NAC to the ruling elders and to explain the goals of the project. Concurrently, NAC's human resource professionals travel to the nearest population center to the project and hold a job fair at a local hotel or community center. This job fair is publicized through local news agencies well in advance, thus allowing local Aboriginal Peoples and other community members to see what opportunities exist and to apply for either direct employment with NAC or apply for subcontractor/supplier status. Those who qualify for direct employment, apprenticeships, or pre-apprentice training are then offered positions with the company under our CLAC labour agreement which allows local hiring. On the job safety training as well as task specific training is then provided in accordance with both the client's and NAC's internal safety and quality policies.

Examples of previously completed NAC/Aboriginal Projects;

Examples of previously completed NAC projects in which target levels for aboriginal employment were established include;

- St. Mary Dam Spillway Project in Alberta which required 50% aboriginal employment from the local **Blood Tribe (Kaiwai Nation)**
- Port Simpson Water Treatment Plant located in British Columbia completed for the **Lax Kw'Alaams** Band Council
- Mine Raise Collars Project at the remote Mussellwhite Gold Mine in Northern Ontario.
- Detour Gold Early Works Packages in partnership with the **Wahgoshig First Nation** – Cochrane, Ontario.

Further to this, NAC has also entered into various partnership arrangements with First Nations communities. We currently have numerous active partnerships with First Nations organizations as follows:

Taykwa Takamou First Nation, Cochrane, Ontario.

NAC has a current Memorandum of Understanding (MOU) with Taykwa Takamou First Nation to develop a hydroelectric project in Ontario as well as a biomass and bioenergy project in Northern Ontario.

Muncee Delaware First Nation, London, Ontario

NAC has a current partnership with the Muncee Delaware First Nation to assist them with the development of the ***Muncee Delaware Nation's Ethanol Development Project***. This assistance includes the creation of the First Nation's Ethanol Development Corporation, site selection screening and sourcing of financing for the project in effort to provide a full EPCM service for the construction and commissioning of the future ethanol plant.

Wahgoshig First Nation, Cochrane, Ontario

NAC has a long term, mutually exclusive partnership with the Wahgoshig First Nation of Northern Ontario. This exclusive partnership covers all potential mining projects for the entire province of Ontario.

Nisga'a First Nation, British Columbia

NAC has a joint venture with the Nisga'a First Nation to help them build capacity through the collaboration of resources for numerous BC projects, including the North West Transmission Line Right or Way for BC Hydro, as well as the Avanti Molybdenum Mine near Kitsalt, BC.

Long Term Thinking

NAC's interests go far beyond creating *short-term partnerships* that only last for the duration of our projects. We want to build *relationships* instead, that will last for many years to come. Because of our desire to create long-term *relationships* with Aboriginal communities, we have partnered with some key organizations to learn more about how to do this successfully. We are a member of the **Aboriginal Human Resource Council's Leadership Circle**; whose mandate is to advance the full participation of Aboriginal people in Canada's labour market on a national level. The Leadership Circle builds bridges between Canada's corporate world and the Aboriginal community through connections, partnerships and mutually beneficial solutions.

We also sit on the Construction Council Sector's "Breaking Ground into Construction Trades" Advisory Committee. The committee is a partnership between **Six Nation's G.R.E.A.T. (Grand River Employment and Training) group and the CSC**. This project's focus is to increase **awareness**, improve **access** and create employment **action** for the Aboriginal population.

We have also started a partnership with G.R.E.A.T. outside of the CSC committee to work with them to develop training and employment opportunities for Aboriginal people across the country.

Business Opportunities

NAC has expressed a strong desire on past projects to maximize the opportunities for Aboriginal Groups and associated companies and will explore all options for the supply of goods and services for projects of this nature, and will look to local aboriginal businesses for the opportunity to partner with. NAC's Estimating and Purchasing departments are committed to contacting these businesses to identify as many opportunities as possible to work together.

Sustainable Business Development

NAC is prepared to work with Aboriginal entrepreneurs in developing businesses that will sustain themselves post construction and into the operating project life with the intention of becoming a revenue source after the project is complete.

NAC is committed to assisting local Aboriginal Gropus with establishing a task force with the expectation of brainstorming in order to establish business opportunities which can be implemented.

Employment & Training Opportunities

Again, NAC believes in creating an inclusive workplace that attracts Aboriginal people. We are committed to providing as many meaningful business and employment opportunities for Aboriginal people as possible.

Although NAC is a general contractor, we are unique in that we do about 90% of our work with our own in-house trades people. Our union affiliation is with CLAC, which has no hiring hall. All employees are interviewed by NAC staff and are hired directly as employees of NAC. Because of this, when we make a commitment to offer employment opportunities, we are able to keep that commitment.

Although the nature of our work takes us all across the country, whenever we go into a community to start a project, we always look to the community first for new employees. We are often working in a community for 1-3 years depending on the size of our project, and because of this, it is important to us that we become part of the community in every way possible. Often times when we are finished a project in a community, many of the "local" workers will decide to continue working with NAC and to travel across the country with us. This is how we have built up our loyal workforce over the years. We bring those loyal workers with us to each new community, and hire local employees as well. We have found that despite these workers' desire to travel with NAC, they will usually return to their home towns as often as possible (sometimes every weekend depending on the location of our work), and will choose their home towns to establish their lives & families. Because of this, local communities are still able to benefit financially from employment with NAC long after we have left the community.

Recruitment & Training:

We are always excited to learn the many new strategies and programs available to Aboriginals as we explore work opportunities all across Canada. Based on our past experience and discussions with other aboriginal groups NAC is committed to the following Recruitment & Training Plan:

- Work with local First Nations to explore all Aboriginal employment opportunities for the project.
- Hold a job fair for the local Aboriginal community. We are highly experienced in this, and have found a lot of success doing this before. We will give a presentation about our company, and will schedule interviews for anyone who is interested. Qualified candidates will be placed on a "to hire" list so they can be contacted as employment opportunities become available.
- Advertise employment opportunities on the local radio station & local newspaper as necessary..
- As we secure work on the project, offer other apprenticeship positions to train people in the following possible disciplines: Concrete Carpentry, Electrical, Plumbing / Pipefitting, Millwrighting, etc.
- Interview (with the hopes of hiring) interested Aboriginal candidates looking for positions in the office as well, including those wanting opportunities to advance to management positions. We are prepared to offer training positions such as Jr. Project Coordinators, Jr. Labour Relations Coordinators, etc. We will train those who lack experience, but demonstrate the desire we are looking for.

- If we are successful on future packages beyond initial bids, we would also be interested in hiring a full time Labour & Training Coordination Manager on site to manage our training initiatives and labour relations on the project. We would prefer to hire that person from the local First Nation community.
- Offer long-term positions to local Aboriginal members who work with NAC on this project and who may want to travel with us, once this project is finished. Again, employees who travel with us for work generally return to their communities to establish their homes and families, which allows the community to continue to benefit from their employment for years to come.

Community Involvement

The following are some of the initiatives we are prepared to offer the community:

Employability Initiatives:

NAC has numerous resources available to us that could be of benefit to the community which will make people more employable in many industries, not just mining. Local Aboriginal members could also use the following initiatives to capitalize on some of the opportunities that will become available to them throughout the duration of the project;
:

- NAC will put on workshops in the community on Employability Skills (skills that can be used in any line of work in any industry)
- NAC will put on workshops on Resume-building & Writing Cover Letters
- NAC will run Safety Training Courses to train local First Nations members in WHMIS, Fall Arrest, First Aid, etc.

Community Relations:

- We will encourage our employees to start up sports leagues as they often do in communities, and NAC will sponsor the teams.
- NAC will sponsor and participate in other community events.
- NAC will sponsor and participate in local charities / fundraisers.
- A vast majority of our current workforce comes from rural communities across Canada. They are avid fishers & hunters and enjoy all types of Northern activities. The community will benefit not only from the business that comes from these types of activities, but also from the camaraderie.

NAC.

Highlighted Projects

North America Construction (1993) Ltd.
NAC Constructors Ltd.
21 Queen Street. Morriston, Ontario N0B 2C0
www.nacsworld.com

Duffin Creek WPCP Liquid Modules Expansion

The work at Duffin Creek consists of a major capacity expansion to the existing facility totaling some $400 million of construction over 36 months.

This first phase of work deals only with the liquids stream expansion currently at its limit in capacity. This work is to be sequenced in with the solids expansion to the facility for a synchronized timely completion of both liquids and solids phases.

This liquids phase consists of some 83,000 cubic meters of concrete, 12,000 tons of rebar, 133,500 cubic meters of excavation, and 550,000 total combined civil, mechanical & electrical man hours of labour productivity.

The overall scope of work consists of the addition of the following processes, equipment, piping systems and electrical distribution; six new longitudinal sludge primary clarifiers, six new fine bubble aeration tanks, a new blower building, six new longitudinal secondary clarifiers, two new chlorine contact tanks, a new disinfection building, a new effluent pumping station, new effluent channels, new & upgraded electrical power feeds, new HVAC and building services, and a new SCADA system for the expanded facility.

Project Type:	Water Treatment
Location:	Pickering, Ontario
Owner:	Regional Municipalities of York and Durham
Contract Value:	$168,000,000
Start Date:	October 1, 2007
Completion Date:	November 5, 2010

North America Construction (1993) Ltd.
NAC Constructors Ltd.
21 Queen Street. Morriston, Ontario N0B 2C0
www.nacsworld.com

Replacement Dam & Spillway Bluefish Hydroelectric Facility

The work at Bluefish consists of the construction of a new dam, slot trench, bottom outlet structure, overflow spillway structure, and adjacent access roads to replace the existing dam at the Bluefish Hydroelectric Facility.

Bluefish dam is in a challenging and remote location, 30 km northeast of Yellowknife. Access to the site will include various periods of ice road trucking, barge and helicopter services as traditional roadways are not available.

The first phase of work began in February of 2011, when crews begin the clearing and grubbing of the site and general lay down areas as well as beginning construction on the temporary bridge.

Project Type:	Energy: Dam
Location:	Yellowknife, Northwest Territories
Owner:	The Northwest Territories Power Corporation (NTPC)
Contract Value:	$15,000,000
Start Date:	February 2011
Completion Date:	Present

North America Construction (1993) Ltd.
NAC Constructors Ltd.
21 Queen Street. Morriston, Ontario N0B 2C0
www.nacsworld.com

Kam Kotia Mine Rehabilitation

The work at the Kam Kotia Mine Rehabilitation site consisted of the construction of an interceptor ditch and lime treatment plant to collect and treat ground and surface drainage from acid generating tailings in a 500 hectare area from previous mining operations. The project also included the removal, relocation, and treatment of acid tailings and was the largest undertaking by the Ontario Ministry of Northern Mines and Development within the Abandoned Mines Rehabilitation Program.

Project Type:	Mining
Location:	Timmins, Ontario
Owner:	Ministry of Northern Development and Mines
Contract Value:	$5,400,000
Start Date:	October 2001
Completion Date:	March 2002

North America Construction (1993) Ltd.
NAC Constructors Ltd.
21 Queen Street. Morriston, Ontario N0B 2C0
www.nacsworld.com

Detour Gold- Mechanical Temporary Installation

Work covered by this contract includes the installation of mechanical & electrical connections of construction camp and construction site buildings and equipment. These installations include; the dormitories to house nearly 850 workers, kitchen facilities capable of serving 1000meals/hr, potable water treatment plant, tanks, lift station & pumps, fire protection pump station and hydrants, sewage treatment plant, holding tank, lift stations & pumps, engineering offices, medical clinic and emergency shelter vehicles, contractor's villages 1 & 2 and concrete batch plant

Project Type:	Mining
Location:	185km North East of Cochrane, Ontario
Owner:	Detour Gold Corporation
Contract Value:	$1,000,000
Start Date:	August 23, 2010
Completion Date:	Present

North America Construction (1993) Ltd.
NAC Constructors Ltd.
21 Queen Street. Morriston, Ontario N0B 2C0
www.nacsworld.com

Detour Gold- Electrical Temporary & Medium Voltage

Work covered by this contract includes the supply of all labour and the performance of all work necessary to provide a fully functioning Temporary Power Plant, MV Network and onsite electrical services.

Detour Gold Corporation has purchased generators to supply electrical energy to the construction camp and construction site for the implementation of the future plant. A Temporary Power Plant will be built on the border of the old airstrip located between the construction camp and the construction site.

NAC will supply and install nearly 10km of 13.8kV overhead lines alongside of the truck road, of which some parts will be underground. The line will feed the construction site and construction camp. NAC will also supply and install all service connections along the MV Network.

Project Type:	Mining
Location:	185km North East of Cochrane, Ontario
Owner:	Detour Gold Corporation
Contract Value:	$4,000,000
Start Date:	August 23, 2010
Completion Date:	Present

North America Construction (1993) Ltd.
NAC Constructors Ltd.
21 Queen Street. Morriston, Ontario N0B 2C0
www.nacsworld.com

Detour Gold- Earthworks & Excavation

Work covered by this contract include, Plant and crusher area site dewatering, including pumping of water and, as required, excavation of temporary drainage trenches and sedimentation ponds, loading, hauling, and disposal of un-reusable materials to the Waste Organic and Overburden Stockpile; Grubbing, including removal of bushes, brush, tree-stumps, in-situ waste and organic material, including hauling for disposal to the Waste Organic and Overburden Stockpile; Excavation of native soils (except for peat), including loading and hauling to the crusher site area for reutilization. Peat disposal shall be at the Waste Organic and Overburden Stockpile; Drilling and blasting of rock to the theoretical lines indicated on the drawings, including submittal of blasting schedule; Rock excavation (mucking), including hauling of excavated material and reutilization within the plant site area; Loading, hauling, placing, and compaction of borrow processed material (from RT Structural Backfill Borrow Pit) and plant site excavated soils deemed acceptable for reuse to underside of foundation levels and sub-grade levels, including subgrade preparation and compaction.

Project Type:	Mining
Location:	185km North East of Cochrane, Ontario
Owner:	Detour Gold Corporation
Contract Value:	$18,000,000
Start Date:	December 10, 2010
Completion Date:	Present

North America Construction (1993) Ltd.
NAC Constructors Ltd.
21 Queen Street. Morriston, Ontario N0B 2C0
www.nacsworld.com

Detour Gold- Concrete Works

Perform all work necessary to complete concrete work, installation of the Buried Corrugated Metal Structures (BCMS). Prior to commencement of concrete work, the Contractor shall verify the existing conditions in the field and ensure that elevations and dimensions shown on the design drawings are representative of the existing conditions. Concrete work, including reinforcing steel, form work, anchor rods (bolts), grating covers, hand rails, embedded steel items, floor drains. Pouring of reinforced concrete, including placement, pumping, vibrating and curing. Installation of electrical grounding grid system. Supply, driving and welding of steel caissons, placement of rebar and pouring of concrete fill. Supply and installation of reinforcing steel, supply and installation of accessories such as water-stops, joint sealants, rock anchors, anchor bolts, embedded parts, grating covers, checkered plate covers, embedded steel pieces, installation of Buried Corrugated Metal Structures (BCMS Tunnels), and waterproof membrane around the BCMS tunnels. Supply and installation of waterproof membrane on the first 12 m of the crusher building foundation walls. Supply and installation of Geomembrane under leach tanks containment area, wall and sump pit.

Project Type: Mining
Location: 185km North East of Cochrane, Ontario
Owner: Detour Gold Corporation
Contract Value: $62,000,000
Start Date: February 11, 2011
Completion Date: N/A

North America Construction (1993) Ltd.
NAC Constructors Ltd.
21 Queen Street. Morriston, Ontario N0B 2C0
www.nacsworld.com

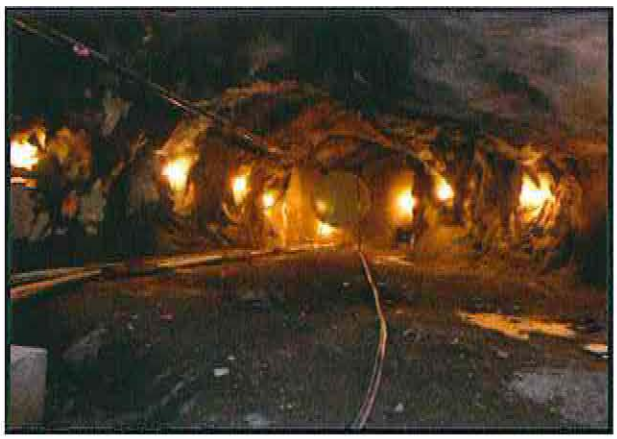
Aishihik Generating Station

Installation of owner-supplied 136kV and 15kV disconnect switches in the switchyard including modifications to existing cabling, structures and controls. Installation of 15kV switchgear and controls, trays, duct banks and cabling.

The construction of switchgear building, foundations, structures, and related work, Installation of owner supplied Turbine, Generator, and associated equipment in the underground tunnel area, including assembly of turbine and interconnection of all components.

Supply and installation of approximately 11m of 1500mm diameter and 52m of 800mm diameter steel penstock pipe and related supports, thrust blocks and appurtenances.

Project Type: Energy
Location: Yukon Territory
Owner: Yukon Energy Corp.
Contract Value: $7,500,000
Start Date: October 1, 2010
Completion Date: Present



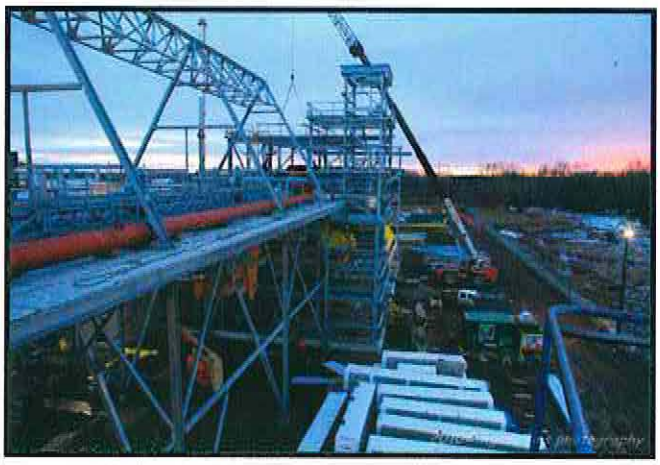
North America Construction (1993) Ltd.
NAC Constructors Ltd.
21 Queen Street. Morriston, Ontario N0B 2C0
www.nacsworld.com

Fort Nelson Generating Station

The scope of work includes piling and underground foundations for several structures on site, as well as grade beams, footings and slabs. The supply and install of a structural steel building including cladding and footing is also included. There are additionally owner supplied structural elements.

Mechanical activities for this project include associated work for the building, installation of the owner supplied Air Cooled Condenser (ACC) and elements of the Once through Steam Generator (OTSG).

Project Type: Energy
Location: Fort Nelson, British Columbia
Owner: British Columbia Hydro and Power Authority
Contract Value: $10,600,000
Start Date: May 3, 2010
Completion Date: November 30, 2010



Attachment C
Local Yukon and First Nation Company Information

LOCAL GENERAL CONTRACTORS

Contractor:	*Contact Information:*	*Services Offered:*	*Location:*
1. Ketza Construction	General Enquiries, cholmes@ketza.ca, www.ketza.ca, 867.668.5997	Commercial/industrial building construction, concrete installation, structural steel, drilling, blasting, earthworks, water & sewer systems.	Whitehorse, YT
2. TSL Contractors Ltd.	General Enquiries, www.tslcontractors.yk.ca/, jk@tslcontractors.yk.ca, 867.667.6156	Building construction services.	Whitehorse, YT
3. Dowland Contracting Ltd.	General Enquiries, info@dowland.ca, www.dowland.ca, 867.668.6614	Design/build, construction management, mechanical, general contractor, logistical services, electrical, pump-stations.	Whitehorse, YT
4. Cormode & Dickson	Yukon Operations, clientdevelopment@cormode.com, 867.668.2670	Building construction, pre-fabricated buildings, design/build services.	Whitehorse, YT
5. NGC Builders Ltd.	General Enquiries, dainius@narrowgauge.ca, 867.668.4578	Commercial construction, general contractor services; past WTP project experience.	Whitehorse, YT
6. Wildstone Construction & Engineering	Tim Frank, www.wildstone.com, 867.668.7211	Steel buildings, process facilities, sewage/water treatment, design/build, construction management, engineering and general construction services.	Whitehorse, YT
7. Pelly Construction	Dan Russell, dan@pelly.net, 867.667.6161	Civil earthworks.	Whitehorse, YT

* Representative list of General Contractors to be further developed during the Detailed Design phase.

LOCAL MATERIAL SUPPLIERS, TRADES & QA/QC COMPANIES

Company Name:	*Contact Information:*	*Services Offered:*	*Location:*
1. EBA Tetra Tech	www.eba.ca, 867.668.3068	Compaction testing.	Whitehorse, YT
2. Chilkoot Geological Engineers Ltd.	867.667.6673	Compaction testing.	Whitehorse, YT
3. Underhill Geomatics Ltd.	General Enquiries, whse@underhill.yk.ca, 867.668.2048	Surveying services.	Whitehorse, YT
4. Yukon Engineering Services	General Enquiries, www.yes-group.ca, 867.668.2000	Surveying services.	Whitehorse, YT
5. Challenger Geomatics Ltd.	General Enquiries, whitehorse@challengergeomatics.com, 867.668.6940	Surveying services.	Whitehorse, YT
6. Territorial Contracting	867.668.5194	Concrete batch plant.	Whitehorse, YT
7. Skookum Asphalt Ltd.	867.668.6326	Asphalt plant.	Whitehorse, YT
8. Macpherson Rentals	www.macphersonrentals.com, 867.633.4426	Equipment rentals.	Whitehorse, YT
9. AGF – Alberta Rebar	www.alberta.agfsteel.com, 403.720.5450	Rebar services.	Calgary, AB
10. Canasteel Rebar Services	www.canasteel.com, 250.562.5025	Rebar services.	Prince George, BC
11. Harris Rebar	www.harrisrebar.com, 250.562.0065	Rebar services.	Prince George, BC
12. Comstock Canada Ltd.	Jeff Tyers, www.comstockcanada.com, 289.208.0920	Structural steel.	Hamilton, Ontario
13. Canron Western Constructors Delta	thernandez@canronbc.com, 604.524.4421	Structural steel.	Delta, BC
14. RKM Services Ltd.	www.rkmservices.com, 604.454.7211	Structural steel.	Langley, BC

* Representative list of companies to be further developed during the Detailed Design phase.

FIRST NATIONS CONTRACTORS

Contractor:	*Contact Information:*	*Services Offered:*	*Location:*	*Comments:*
1. Han Construction	867.993.5220	Construction services.	Dawson, YT	–
2. Castle Rock Enterprises	Contact Info, castlerock@northwestel.net, 867.668.6188	Construction services.	Whitehorse, YT	–
3. Hi-Grade Holdings	Contact Info, cholway@klondiker.com, 867.633.5833	Earthworks, heavy equipment operation.	Whitehorse, YT	–
4. Yukon Engineering Services	Contact Info, www.yes-group.ca/index.php, 867.668.2000	Surveying services.	Whitehorse, YT	–
5. Ralph Hotte Contracting Ltd.	Ralph Hotte, ralphhotte@northwestel.net, 867.634.2104	General contracting and equipment operation.	Haines Junction, YT	–
6. Tana Contracting	Contact Info, 867.634.2404	Construction services.	Haines Junction, YT	Approximately 3 employees at this location.
7. Kluane Drilling	Contact Info, kluanedrilling@northwestel.net, 867.633.3641	Construction services.	Whitehorse, YT	–
8. 3 Aces Construction	N/A	N/A	–	Unable to locate contact details.

* Representative list of contractors to be further developed during the Detailed Design phase.

Contents

The Project Delivery Experts.....5

About Graham.....6

Capacity and Capability.....7

Graham Toolbox™.....8

Health, Safety and Environment.....9

An Experienced LEED® Builder.....10

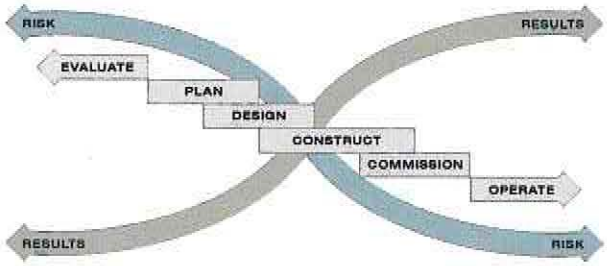
Quality Assurance and Control.....11

Compelling Experience.....12

The Project Delivery Experts

Graham is a leading contractor with more than eight decades of project delivery experience in North American markets. As a valued and respected project partner, we have earned a solid reputation for success based on:

- A continuous corporate history that spans more than 80 years;
- Our diverse portfolio, which demonstrates capacity to deliver commercial, industrial, infrastructure, earthworks and underground, and masonry projects of every scope, scale and complexity;
- A confirmed ability to succeed through all project delivery phases—and to conceptualize, plan, finance, construct and operate facilities; and
- Our robust, web-enabled information system, which allows us to capture, analyze and share information through every step of the project delivery continuum.



In addition, Graham has a growing reputation for versatile and innovative project delivery strategies. Our significant corporate resources include professional teams dedicated to specialized services such as:

- Quality Assurance and Control;
- Safety and Loss Prevention;
- Estimating, Procurement and Project Control;
- Risk Management and Surety;
- Value Engineering; and
- Design and Engineering Services.

As an integrated organization with advanced networking and a web-enabled project information system, Graham is able to deploy expertise and critical resources to projects as needed—without the traditional constraints imposed by geography, time zones and reporting structures.

Graham offers a particular strength in identifying opportunities to better manage risk and financial commitment through all phases of the project delivery continuum. We provide—and blend—best-fit delivery options, including:

- Construction Management;
- Design-Build and Design-Bid-Build;
- Guaranteed Maximum Price; and
- Public-Private Partnerships.

◀
Graham's project delivery experts manage every project phase—from preplanning and design to construction, commissioning and operation.

About Graham

Commitment. Integrity. Reliability.

Graham delivers project services to clients across North America. We have operated continuously since 1926, and are now recognized as a respected builder with resources and capacity to successfully deliver projects of every scope, scale and complexity.

Since restructuring as an employee-owned and operated company in 1984, we have become an industry leader and one of Canada's top five construction firms by revenue. Graham was recently awarded Platinum status as one of Canada's top 50 best-managed private companies.

Our corporate head office is in Calgary AB. Current operations include US Headquarters in Seattle WA, plus permanent offices in Calgary, Edmonton, Fort McMurray, Kelowna, Minneapolis, Omaha, Points North Landing, Regina, Saskatoon, Seattle, Spokane, Toronto, Vancouver and Winnipeg.

FINANCIALLY CAPABLE

With 2010 revenues exceeding $1.9 billion, Graham is a financially strong contractor with the capacity to handle significant project commitments.

INVESTED IN OUR PEOPLE

Graham is owned and operated by its employees. Our senior management team is supported by over 1,100 dedicated project management, engineering, estimating, technical and administrative professionals working closely with experienced field support teams.

With a solid reputation as an industry-leading employer, Graham attracts and retains skilled professionals and tradespeople. A proactive retention policy, coupled with succession planning and performance-based rewards, encourages excellence in service.

Corporate investment in continuing education and improvement encourages professional development, self-directed learning, and active participation in industry, trade and professional associations. Graham University, an on-line learning system, provides web-based access to courses related to Graham's business processes, safety practices, and project management systems, as well as basic software skill development.

RESPECTED PROJECT PARTNER

Because we are committed to collaborative, team-based work strategies and open, effective communication, we integrate easily into project delivery teams. We foster cooperation and communication among all team members and stakeholders to ensure that project requirements are met.

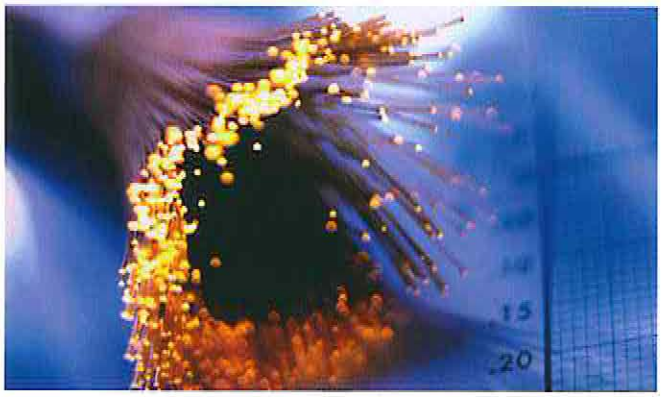
Throughout our history, we've established and maintained positive, long-term relationships with clients, architects, consultants, suppliers, subcontractors and trades. We maintain excellent working relationships that are based on mutual respect for and understanding of strengths, abilities, roles and responsibilities.

Because we bid hundreds of projects annually, we have detailed knowledge of industry workload and availability of resources. As a successful contractor in a number of markets, Graham has superior access to key suppliers, subcontractors and trades.

STATE-OF-THE-ART INFORMATION TECHNOLOGY

Graham's robust information technologies facilitate collaboration, accelerate schedules, control costs, and promote accountability.

A dedicated in-house team of information infrastructure, development and support specialists works closely with stakeholders to ensure that applications and features reflect the real-world need to deliver accurate, meaningful information anywhere, at any time.



Capacity and Capability

The best people and the right tools for any job

COLLABORATIVE, TEAM-BASED APPROACH

Graham advocates early involvement on every project and collaborates closely with owners, designers, suppliers and other stakeholders to ensure success through all project phases. Often, these close working relationships lead to management or design alternatives that are more flexible, cost-effective and efficient.

OWN-FORCES CAPACITY

Graham is a full-service constructor with in-house resources to self-perform fundamental scopes of work. We have a permanent staff of more than 1,100 project management, engineering, and administrative professionals and a construction workforce of nearly 5,000 skilled tradespeople and construction workers. Graham's owned equipment fleet is valued at nearly $300 million, and we maintain strategic alliances with regional equipment suppliers.

Our continuing commitment to provide own-forces support for Graham projects gives us a competitive edge in the construction industry, and ensures that our cost database is current and reflects prevailing trends in our regional markets.

A COMMUNITY BUILDER

As an employee-owned company with deep roots and legacy projects across North America, Graham understands how important it is to build community.

No matter what the project, Graham works closely with local communities to maintain open communication, minimize disruption and inconvenience, and understand and address local concerns throughout the project delivery continuum.

As much as possible, Graham maximizes involvement of local trade contractors, suppliers (including equipment) and workers. We also collaborate with local organizations to provide opportunities for skills acquisition and upgrading and deliver project-specific training programs.

Graham Toolbox™

The right information to the right person at the right time

THE GRAHAM SOLUTION

Whether it's a single project or a multi-site, multi-year construction program, keeping a project team organized, informed and on track is a significant challenge. Project team members—clients, consultants, project managers, general contractor, sub-trades and suppliers—are often distributed geographically, and may operate in different time zones.

Graham has developed Toolbox™, a secure, web-enabled information system that simplifies—and encourages—communication and collaboration through all phases of the project delivery continuum. This system comprises four key elements:

Graham Toolbox™: This award-winning suite of integrated software applications is tailored to the specific needs of project management and construction. Used by all Graham employees, Toolbox™ is central repository for all project-related data. It touches every part of a project's life cycle—from bid management and estimating all the way through to final billing.

Toolbox™ Online: This easy-to-use online version of Graham Toolbox™ provides secure, web-based access to Graham projects. Through Toolbox™ Online, authorized project team members have real-time access to project data at any time, from anywhere.

State-of-the-art Broadband Network: Graham's in-house network provides fast, reliable service to Graham offices and work sites across North America, and supports online access for authorized project team members, clients and business partners. All network services meet or exceed industry benchmarks for security, disaster recovery, service reliability and load management.

In-house Development Team: Graham's in-house developers work closely with stakeholders and subject matter experts to enhance Toolbox™ functionality. Help Desk specialists monitor and resolve end-user issues, and network professionals ensure that essential services are always available. Together, this expert team ensures consistent and continuous improvement.

THE RESULT

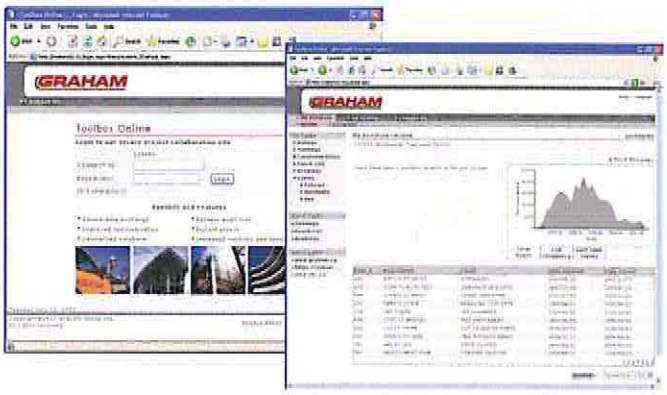
No matter where they are or when they work, authorized team members have immediate access to real-time project data. All it takes is a basic computer equipped with a standard browser and a working internet connection.

Budgets, schedules, drawing approvals, requests for information, meeting minutes, photographs, specifications, procedures, and safety reports are all accessible from a single source. Team members can review reports, add comments, issue notices, provide instruction, respond to requests, publish drawings and manage other project-related tasks.

When the project is complete, its data is safely archived and always accessible.

THE BENEFITS

- Instant scalability, with no limits to the number of team members or organizations participating;
- Instant and inexpensive access from a basic computer with a working internet connection;
- Improved access to information and better data compatibility;
- Enhanced collaboration and faster communication among team members;
- Greater transparency and better auditability;
- Improved implementation of standards, specifications, policies and procedures;
- Reduced costs related to printing, distribution, storage, management and retrieval of project information;
- Improved accuracy; and
- Permanent archive of project knowledge.



Health, Safety and Environment

Safe practices, safe work, safe teams

Health, Safety and Environment (HS&E) plays a significant role in every project. Safe work is more productive. Safe work leads to better quality. Most importantly, safe work leads to healthy lives and a clean environment.

CORPORATE COMMITMENT

Graham has developed and implemented a comprehensive corporate HS&E management program that meets established standards for:

- Policy and management commitment and leadership
- HS&E Management System governance
- Employee participation
- Worker competency and training
- Inspection and audit
- Incident investigation and analysis
- Emergency response planning
- Contractor management
- Health promotion and wellness
- Hazard assessment and risk management
- Environmental management
- Security
- Home safety
- Ergonomics
- Behaviour-based safety
- Communication
- Management review

Graham is also committed to on-going educational programming related to:

- Principles of health and safety management
- Auditor training
- Leadership for safety excellence
- Train-the-trainer

As a leader in HS&E, Graham complies with established industry standards and regulatory requirements, and participates in safety audits performed by an approved and certified safety auditor.

SITE-SPECIFIC PROGRAMS

Graham recognizes that incidents and injuries are preventable. Through all project phases—from planning and design to construction and commissioning—every Graham project team emphasizes HS&E. Graham's HS&E specialists work closely with project partners, subcontractors and suppliers to develop, deliver and enforce comprehensive HS&E programs tailored to specific project needs. Our on-site project safety coordinators ensure that all site activities meet or exceed governing regulations and standard industry best practices and procedures. The safety of our employees and of the public is always our primary objective.

The site specific safety plan will include the following elements:

- Roles and responsibilities
- Project documentation requirements
- Policies and company rules (posting package)
- Project hazard and risk assessment, abatement and communication
- Fall protection plan
- Security
- Emergency response planning
- Orientations
- Safety meetings
- Toolbox topics
- Training
- Behaviour-based safety
- Inspections
- PPE and equipment maintenance
- Equipment certifications
- Corrective action
- Investigations
- Claim management
- Safety statistics
- Practices, standards and procedures
- Client specific requirements
- Review and monitor performance

An Experienced LEED® Builder

Environmentally responsible project delivery

As a certified LEED® builder, Graham has successfully delivered many projects with stringent LEED® requirements.

Kelowna's River Street Water Treatment Plant, certified LEED® Gold, incorporates a constructed wetlands that provides irrigation for the plant site as well as a nearby parkland. The Operations, Maintenance and Administration Building at Pine Creek Wastewater Treatment Facility, originally targeted LEED® Silver, was recently certified LEED® Gold—a testament to the abilities of the construction team. Pine Creek's plant campus is projected LEED® Silver, as is the Whistler Wastewater Treatment Plant Expansion in Whistler BC.

On every project, Graham takes a leadership role in environmental stewardship. Through all delivery phases, we work closely with project stakeholders to implement appropriate and project-specific procedures to:

- Control erosion, sediment and dust; minimize soil loss due to wind and water erosion; prevent sedimentation of storm sewer systems and reduce air pollution through effective control and abatement procedures.
- Thoroughly test and commission systems to verify proper installation, calibration and performance. All testing is carefully planned to reduce electricity demand loads and minimize the impact on project power supply.
- Recycle or reuse materials wherever possible and feasible. Graham recycles metals, cardboard and demolished concrete as part of daily operations. Other materials are recycled or redirected to the original manufacturer for recycling or disposal.
- Reduce or eliminate contamination of permanent building materials. Smoking in enclosed spaces—including site trailers and temporary structures—is prohibited on all Graham sites.
- Enforce indoor air quality management where appropriate or required. If permanent heating systems are in place, regular filter replacement and system testing ensure pollutant control and minimize or eliminate contamination of permanent building materials.
- Implement other initiatives as requested by facility owners or designers.

◂ *At the River Street Water Treatment Plant, a constructed wetlands provides irrigation for adjacent parkland.*

Quality Assurance and Control

The best job possible, from start to finish

At Graham, we commit to plan, manage and deliver all contracted work in a safe, cost efficient manner that complies with applicable codes and standards and meets all defined project requirements. We believe that superior quality is fulfilled by skilled workers, careful planning, suitable tools and procedures, clearly defined job requirements and appropriate supervision.

Graham's Quality Assurance and Control Program defines plans and procedures for work performance and documentation, and describes organizational responsibility within a project team to ensure compliance. Quality is verified through continuous monitoring, inspection, testing, reviews, and audits of work activities. Consistent data gathering, documentation and reporting systems are key components of Graham's program.

INSPECTION AND TESTING

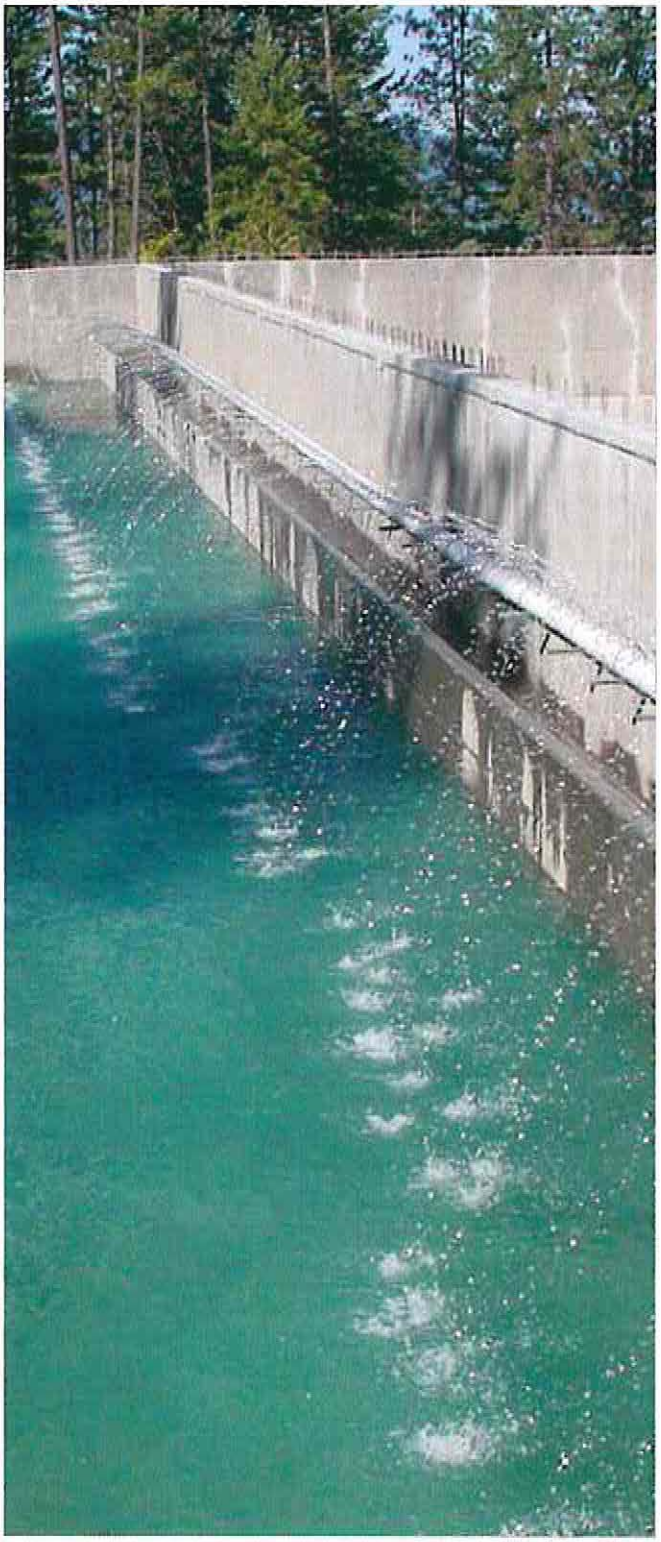
At the start of every project, Graham leads the development of a detailed Inspection and Test Plan that draws together all quality requisites for the project, and identifies any applicable codes, standards and engineering specifications, as well as the specific requirements of project participants.

AT THE WORK SITE

Graham develops quality assurance and control manuals that are specific to work-site activities and conditions. These manuals govern all work from site preparation through construction to commissioning. Manuals for project components governed by specific technical or regulatory requirements are reviewed and approved by appropriate governing authorities prior to implementation.

ADMINISTRATION AND REPORTING

Graham Toolbox™ provides integrated, real-time, web-based access to essential project information. Drawings, manuals, meeting minutes and other key documentation and reports are always available to authorized team members.



Graham installed twin 4.5-million-litre (1.2-million-gallon) main tanks, as well as a control building and chlorine contact chamber, at the mountaintop site of St. Maries Slow Sand Filtration Water Treatment Plant in Idaho.

Compelling Experience

Graham builds solutions

PINE CREEK WASTEWATER TREATMENT FACILITY
CALGARY, AB

The Pine Creek Wastewater Treatment Facility is a state-of-the-art plant with a design treatment capacity of 100 million litres (26 million gallons) per day. Phased construction includes influent pump station; headworks; blowers; DAF; odor control; primary clarifiers; gas handling; sludge storage; bioreactors; secondary clarifiers; power generation and heating building; and operations, maintenance and administration (OM&A) building.

The project includes over 90,000 cubic metres (3.2 million cubic feet) of cast-in-place concrete as well as precast concrete, structural and miscellaneous steel and masonry. Plant works include process and underground piping, process equipment, electrical and instrumentation. Architectural features include aluminium curtain walls, zinc cladding, brick veneer, green roofs and gabion walls.

The plant campus is projected LEED® Silver. The OM&A Building, originally projected LEED® Silver, was recently certified LEED® Gold.

This project was phased to accommodate plant start-up after just 33 months. Overall, construction will be complete in less than 54 months with a daily average workforce of more than 200.

Client:	City of Calgary
Consultant:	CH2M Hill Canada Ltd.
Completion:	Multiple completion dates
Value:	Multiple contracts totalling more than $300 million

WHISTLER WASTEWATER TREATMENT PLANT
WHISTLER, BC

This expansion of an existing plant is designed to meet planned growth at the popular mountain resort of Whistler.

The project includes construction of four new process buildings, as well as an administration building, bioreactor, clarifier and fermenter, plus underground process and yard piping. In addition, the existing electrical system will be completely overhauled and various process mechanisms will be retrofitted.

Existing facilities remain fully operational through all project phases. To maintain schedule, more than 4,000 cubic metres (140,000 cubic feet) of concrete was placed during Whistler's snow-heavy winter.

The expansion is projected LEED® Silver.

Client:	Resort Municipality of Whistler
Consultant:	Stantec Consulting Ltd.
Completion:	Autumn 2009
Value:	$28.0 million

WILLMAR WASTEWATER TREATMENT PLANT
WILLMAR, MN

This new wastewater treatment plant for the City of Willmar has an operating capacity of 28 million litres (7.5 million gallons) per day, with a peak capacity of 102 million litres (27 million gallons) per day. Construction comprises 18 new structures, including headworks, selector basins, oxidation ditches, clarifiers, sludge storage tanks and other process buildings. Site work includes yard piping, process piping and equipment, plumbing, heating, ventilation, air conditioning, electrical, and instrumentation and controls.

Graham will install an ultraviolet disinfection system, pumps, clarifiers, sludge thickeners, oxidation ditch aerators, and other process equipment and instrumentation. Also included are modifications to and integration of existing biosolids storage facilities.

More than 16,000 cubic metres (20,000 cubic yards) of concrete will be placed during construction.

Client: City of Willmar

Consultant: Donohue & Associates

Completion: July 2011

Value: $49.1 million

RED DEER WASTEWATER TREATMENT PLANT PHASE 3
RED DEER, AB

Expansion of this existing plant includes construction, start-up and commissioning of a new UV disinfection facility, bioreactor, secondary clarifier and RAS pump house. Also included is installation of a new centrifugal aeration blower, replacement of internal mechanisms for four existing secondary clarifiers, modifications to an existing RAS pump house, and installation of new WAS pumps.

Client: City of Red Deer

Consultant: Associated Engineering Alberta Ltd.

Completion: October 2009

Value: $31.0 million

Compelling Experience

Graham builds solutions

RIVER STREET WATER TREATMENT PLANT
KAMLOOPS, BC

When it opened, this new facility in Kamloops was the largest water treatment plant in Western Canada and the first to use membrane filters to remove biological and mineral contaminants.

The facility incorporates many innovative techniques to minimize environmental impact, and includes a partial green roof to reduce energy requirements. The administration building—certified LEED® Gold—houses classrooms, a laboratory and research equipment for the Centre for Safe Water Excellence. This unique education and research facility is a partnership between the City of Kamloops, Zenon Environmental Inc. and Thompson River University. It was the first training and research facility built within a municipal water plant in North America.

The structure consists of precast and structural steel exterior walls, a precast roof, and mostly cast-in-place concrete interior walls. Interior work included a large amount of large-diameter stainless steel process piping. A constructed wetlands provides on-site and adjacent parkland irrigation.

Client: City of Kamloops

Consultant: Stantec Architecture Ltd.

Completion: September 2004

Value: $23.6 million

SEYMOUR-CAPILANO FILTRATION PLANT, CLEARWELLS
NORTH VANCOUVER, BC

This project included the construction of a 200-million-litre (53-million-gallon) reinforced concrete reservoir as well as an attached post-treatment building, large diameter underground piping and services, overflow structures, and settlement ponds.

Graham produced all concrete on site using its own Vance-Hagan batch plant and a fleet of eight ready mix trucks. Other major equipment included three tower cranes, bridge finishing machine, earthmoving equipment and 65-tonne (72-ton) hydraulic mobile crane.

Client: Greater Vancouver Water District

Consultant: Pacific Liaicon and Associates Inc.

Completion: December 2005

Value: $40.6 million

LITTLE MOUNTAIN RESERVOIR RECONSTRUCTION VANCOUVER, BC

This project consisted of demolishing an existing underground reservoir and constructing a new 175-million-litre (46-million-gallon) reinforced concrete tank with an attached multi-level valve chamber building. Altogether, 25,000 cubic metres (890,000 cubic feet) of concrete were demolished. Over 4,700 cubic metres (165,000 cubic feet) of shoring, 26,000 cubic metres (918,000 cubic feet) of new concrete, and more than 22,000 square metres (236,000 square feet) of high-load roof membrane were installed.

Unusual aspects of the work included pouring continuous walls with heights of 9 to 13 metres (30 to 43 feet) and use of high-fly-ash ecosmart concrete. A fast-track schedule ensured that half of the project was operational within eight months. Graham custom-designed low clearance wall forms, steel columns forms, and a unique sliding soffit system for the roof.

Because Little Mountain Reservoir is located in the middle of Queen Elizabeth Public Park, special precautions were taken to protect park visitors and the surrounding environment throughout construction.

Client: Greater Vancouver Water Project

Consultant: Sandwell Engineering Services Ltd.

Completion: November 2003

Value: $27.5 million

TIMMINS WATER FILTRATION PLANT TIMMINS, ON

For this project, existing tanks were demolished, then existing systems were converted to a new raw water clarification system and residual management system. Construction included a new two-cell buried equalization storage tank that receives pre-treated wastewater from the new high rate clarification system as well as backwash wastewater from existing filters.

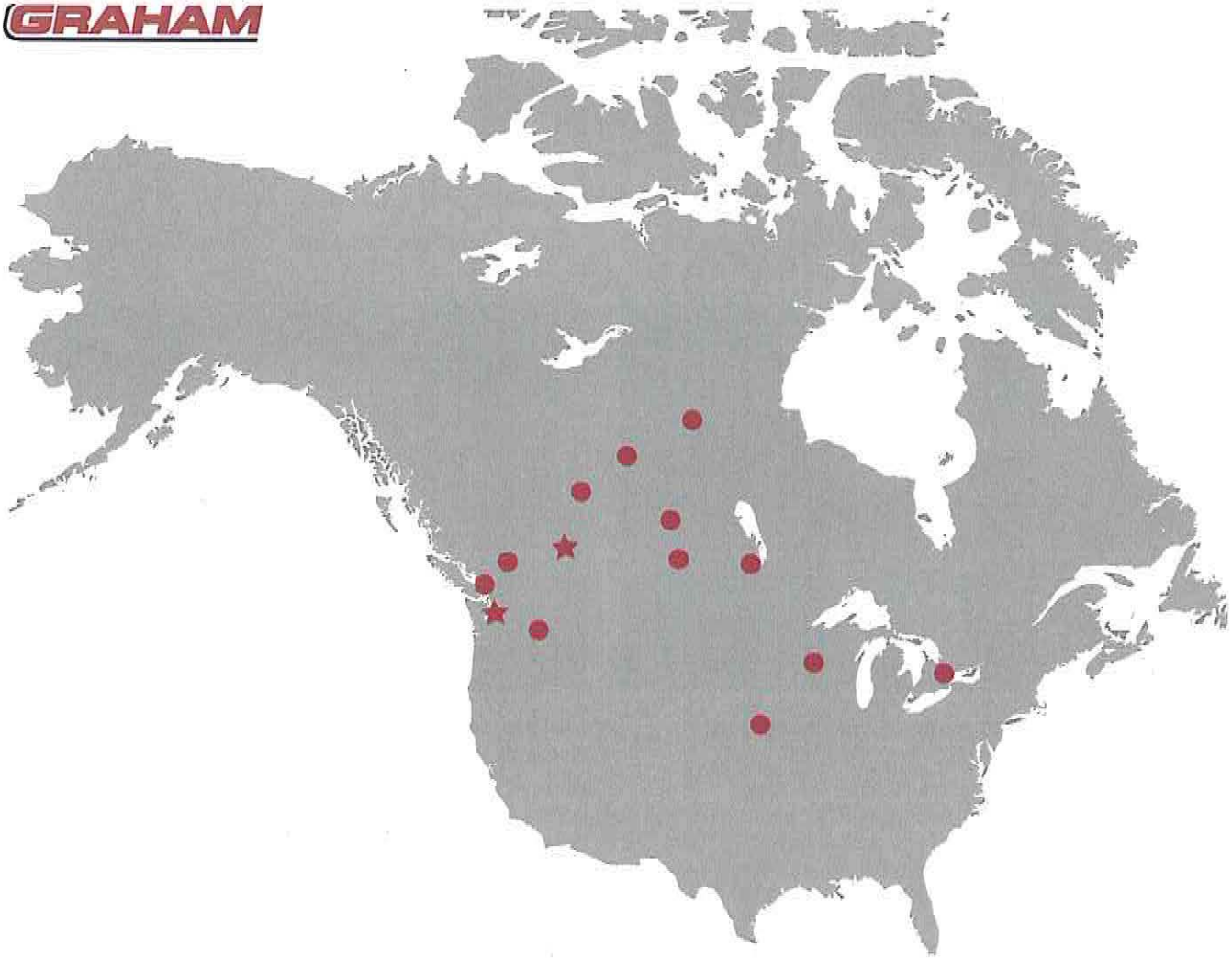
A new shoring system was constructed to minimize large potential dewatering volumes and protect the new installation from settlement of nearby existing structures. Other new construction included a new ancillary equipment storage building and pipe chase building to house all the chemical storage and feed systems supporting the new raw water clarification and residual management systems.

Client: City of Timmins

Consultant: Genivar Ontario Inc.

Completion: September 2008

Value: $17.2 million



HEADQUARTERS

Corporate Head Office
10840 27 Street SE
Calgary AB T2Z 3R6 | 403.570.5000
www.graham.ca

US Headquarters
9709 Third Avenue NE, Suite 300
Seattle WA 98115 | 206.729.8844
www.grahamus.com

CANADA

Calgary Operations
10909 27th Street SE
Calgary AB T2Z 3V9 | 403.253.1314

Edmonton
8404 McIntyre Road
Edmonton AB T6E 6V3 | 780.430.9600

Fort McMurray
9902 Franklin Avenue
Ft. McMurray AB T9H 2K5 | 780.743.0414

Kelowna
101, 184 Adams Road
Kelowna BC V1X 7R2 | 250.765.6662

Regina
290 Hodsman Road
Regina SK S4N 5X4 | 306.721.1444

Saskatoon
875 57th Street East
Saskatoon SK S7K 5Z2 | 306.934.6644

Toronto
6108 Edwards Boulevard
Mississauga ON L5T 2V7 | 905.694.4000

Vancouver
7216 Brown Street
Delta BC V4G 1G8 | 604.940.4500

Winnipeg
126 Commerce Drive
Winnipeg MB R3N 1T9 | 204.897.4600

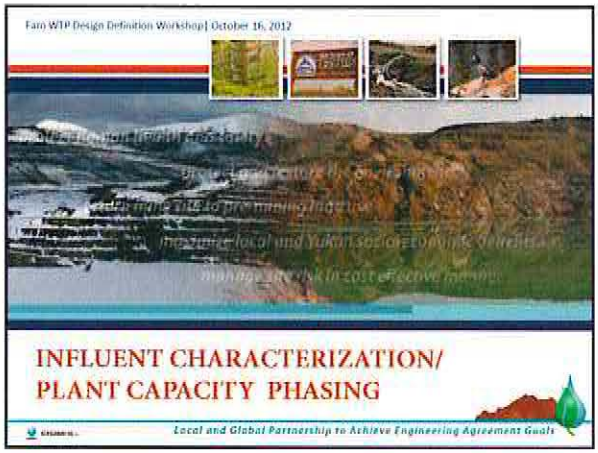
U.S.A.

Omaha
13210 Centennial Road, Suite 1
Omaha NE 68138 | 402.891.9651

Minneapolis
#1, 2995 Lone Oak Circle
Eagan MN 55121 | 651.687.0648

Seattle
9709 Third Avenue NE, Suite 300
Seattle WA 98115 | 206.729.8844

Spokane
331 N Fancher Road
Spokane WA 99212 | 509.534.1030



Workshop Objectives

- Review evaluations completed on Influent Characterization and Plant Capacity Phasing
- Discuss, receive feedback, and agree on the water treatment plant (WTP) recommendations that will be taken forward into Schematic Design:
  - Hydraulic capacity
  - Design water quality
  - Implement in phases, and if so, how?

Presentation Overview

- High-density sludge (HDS) process description
- Why use at Faro Mine Complex (FMC)?
- Key design parameters
- HDS plants and equipment
- Plant capacity and phasing considerations
- Predictions of future water treatment needs
- Pilot test results
- Preliminary equipment sizing
- Cost estimates
- Recommendations

HDS History

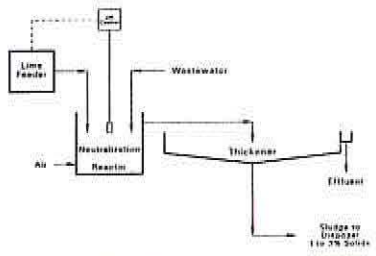
- HDS = High-Density Sludge
- Developed in late 1960s by Bethlehem Steel Corporation, Pennsylvania
- Initial focus was coal mine drainage
- Developed to improve metal removal treatment of acidic waters and reduce sludge volumes
- Increases pH and removes dissolved metals by precipitation

Pennsylvania

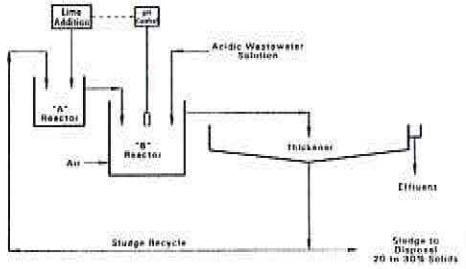
How Conventional Lime Treatment Works

- Takes advantage of "mother nature"
- Many dissolved metals can be removed by raising pH (increasing OH^-)
- As OH^- goes ↑, Metals go ↓
- Adding lime adds OH^-
- Lime = Calcium hydroxide = $Ca(OH)_2$
- $Ca(OH)_2 \rightarrow Ca^{+2} + 2(OH^-)$ (in water)
- Metal + $(OH^-) \rightarrow$ Metal (OH) (a precipitate, or "sludge")
- $SO_4^{-2} + Ca^{+2} \rightarrow CaSO_4 2H_20$ (gypsum)

Conventional Lime Treatment



HDS Lime Treatment

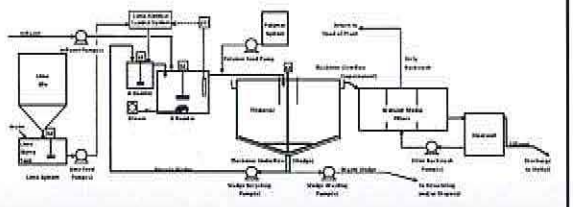


Typical HDS Process Expectations vs. Conventional Neutralization

- 10X to 15X less sludge volume
- Significantly less scaling
- More stable process
- Better gypsum removal
- Removal of more metals at a single pH
- Better lime utilization

Nearly Eliminates Scaling

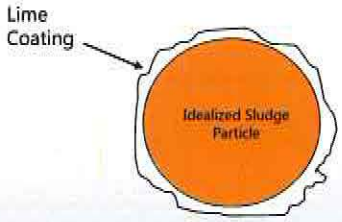
HDS Plant Flow Schematic



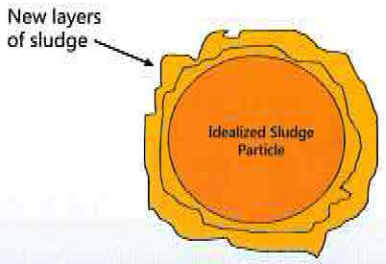
Reactor A (Sludge/Lime Mix Tank)

- **Purpose**: Provide mixing of recycle sludge and lime
- **What Happens**: Lime coats sludge particles
- **Why**: Lime "scales" onto sludge due to its low solubility in water and the high surface area of sludge particles

Reactor A (Sludge/Lime Mix Tank)



Reactor B

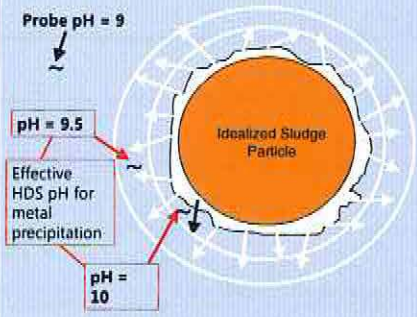


Particles "grow" with every recycle

Reactor B (Neutralization/ Oxidation Tank)

- **Purpose**:
  - Provide precipitation of dissolved metals
  - Provide oxidation of reduced iron
- **What Happens**: New precipitates form on recycle sludge
- **Why**: Low solubility of metal hydroxides at elevated pH

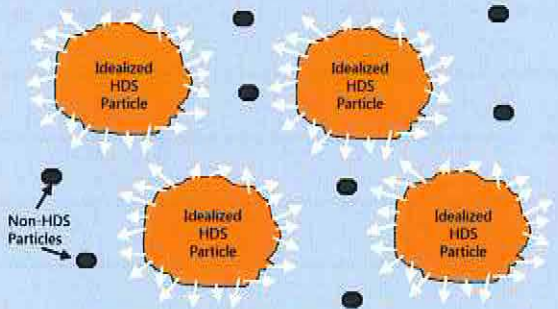
Inside Reactor B



Lime dissolves away, so pH is higher closer to the particle. This is why HDS removes more metals better at a "single pH" than conventional lime treatment.

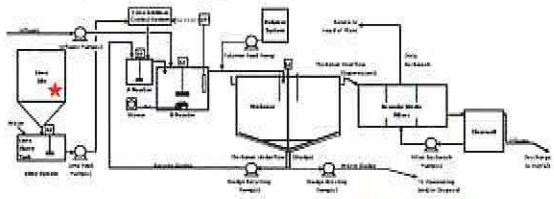
HDS removes 1 – 1.5 pH units higher than measured in soln

Inside Reactor B (continued)



We do **NOT** want non-HDS particles because they will attract new precipitates—we want the new precipitates to grow on the HDS particles.

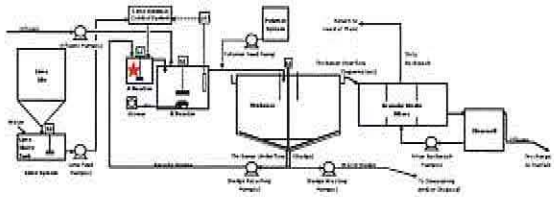
Lime System Design-Keys to Success



- ✓Provide sufficient lime feed capacity
- ✓Provide sufficient silo storage
- ✓Design for ease of maintenance

Local and Global Partnership to Achieve Engineering Agreement Goals

Reactor A Design-Keys to Success



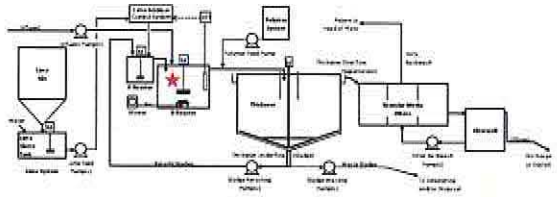
- ✓Provide "enough" residence time (2 to 5 minutes), but too much residence time slows pH response in Reactor B
- ✓Provide rapid mixing
- ✓Position close to Reactor B

Local and Global Partnership to Achieve Engineering Agreement Goals

Small, not expensive
- B - steel - pumped some into recycled sludge pipeline & it worked.

Want tank so we can see & test water

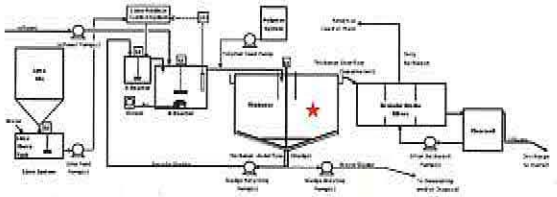
Reactor B Design-Keys to Success



- ✓Provide enough residence time for precipitation and oxidation reactions: hydraulic retention time (HRT) = 20 to 30 minutes
- ✓Provide aggressive mixing
- ✓Provide efficient aeration

80,000 Gal reactor

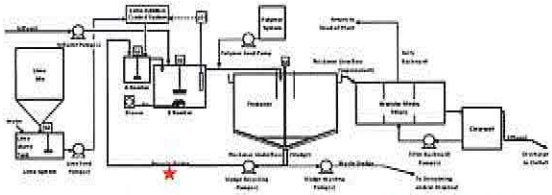
Thickener Design-Keys to Success



- ✓Provide sufficient time to settle solids
- ✓Provide sufficient time to thicken sludge: Time for sludge is usually greater

Thickener Bridge, Feedwell, Rake, and Tank

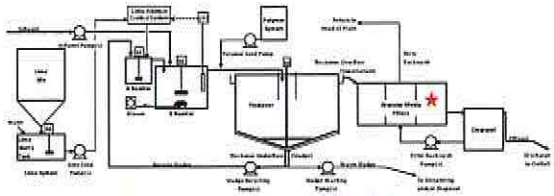
Sludge Recycle Design-Keys to Success



- ✓ Provide enough recycle sludge surface area to adhere "all" lime
- ✓ Too much recycle wastes energy but does not hurt process
  - ➢ It is impossible to adhere all lime: some dissolves into the recycle sludge water, which inherently limits HDS sludge density

PM – Is there precipitation inside the lines? Not really; thickener is stuff "sticking" to the particles – in the pipes small surface area; all precipitation happens in the tank.

Filter Design-Keys to Success



- ✓ Provide sufficient time to filter solids
- ✓ Provide efficient media type and size

Iron Mountain Mine, California

- 35 ML/d (6,500 USgpm)
- 85-m Thickener
- Two B reactors
- Large lime system
- No filters
- No polymer

Resolution Copper, Arizona

- 14 ML/d (2,500 USgpm)
- Two 30-m Thickeners
- One B reactor
- Lime and soda ash systems
- Sand filters

Britannia Mine, British Columbia

- 34 ML/d (6,200 USgpm)
- 33-m Thickener
- Two B reactors
- Single lime systems
- No filters

Bunker Hill Mine, Idaho

- 27 ML/d (5,000 USgpm)
- 72-m Thickener
- Single B reactor
- Two lime systems
- Filters being added
- Being expanded up to 164 ML/d (30,000 USgpm)

Key HDS Design Parameters

- Influent flow rate (Q)
- Lime demand (LD)
- Solids formed (SF)
- Solids recycle ratio (SRR)
- Ferrous iron and manganese
- Thickener unit area (UA)
- Filter hydraulic unit loading

Faro WTP Sizing/Phasing Considerations

- Evolution of site water quantity/quality:
  - Timing of seepage interception systems (SIS)
  - Timing and effectiveness of covers
  - Timing of diversions and leakage
  - Geochemical maturation of sources
  - Climate change
- Discharge requirements:
  - Current requirements in effect until new water licence received
  - Future requirements likely more stringent and risk-based
- Funding timing and plant phasing:
  - Plant capacity
  - Addition of filters
  - Addition of site C&M-related facilities
  - Replacement pipelines (influent and effluent)

Prediction of Future Treatment Needs

- **Knowns**
  - Existing Faro WTP Capacity = 27 ML/d (5,000 USgpm)
  - CVD SIS to generate more water in ~10 years (~2,800 gpm/5 months)
  - Collection of additional ETA water will add significant load
  - Covers to decrease flows and loads requiring treatment
  - WRD seepage WQ to get worst over time
- **Unknowns**
  - Magnitude of future flows and loads
  - Timing of future flows and loads
  - Timing and impact of climate change
  - Effectiveness of stream diversions to decrease flows
  - Effectiveness of cover systems and SISs

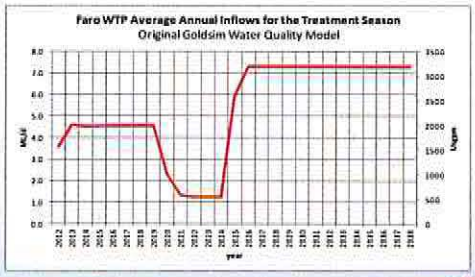
GoldSim Model

GoldSim Model Development

- **Initially developed by SRK as an Excel model to evaluate site water quality for next ~200 years**
- **Switched to GoldSim by Leslie Gomm**
- **CH2M HILL received the model from YG**
- **Main Model Improvements:**
  - Intermediate Pond and Cross Valley Pond now modelled
  - Pit Elevations now modelled
  - WTP capacity as user defined
  - Uses historical precipitation
  - Performed a mass balance check for flows and loads
  - Have performed initial calibration using historical site data

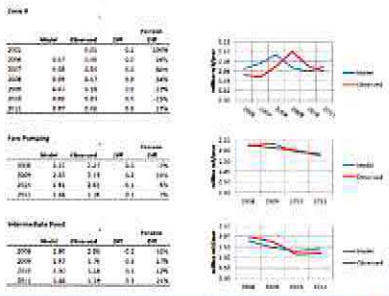
Original Model WTP Predictions

- Did not include IP water
- Assumed no Faro Creek Leakage after Year 7



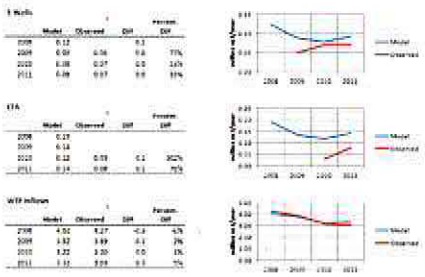
Comparison of Model Results vs. Values from 2011 Annual Environmental Monitoring in Activities Report

Units: millions m³/year



Comparison of Model Results vs. Values from 2011 Annual Environmental Monitoring in Activities Report

Units: millions m³/year



Modelled Cases

- Case A 357mm/yr Precip
  - 2 WTPs
    - Average Water Quality
    - Maximum Water Quality
  - 1 WTPs
    - Average Water Quality
    - Maximum Water Quality
- Case B 551mm/yr Precip
  - 2 WTPs
    - Average Water Quality
    - Maximum Water Quality
  - 1 WTPs
    - Average Water Quality
    - Maximum Water Quality

Common Model Assumptions

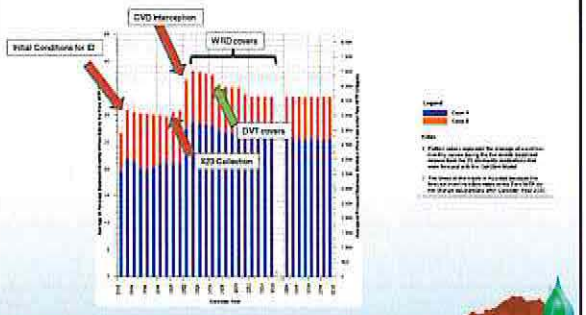
- Seepage into the Ponds: Intermediate Dam (ID) estimated at 20% and Cross-Valley Dam (CVD) estimated at 10%
- Rose Creek Diversion (RCD) Leakage:
  - Fixed, estimated as 5% of the RCD flows (ICAP estimated 7%)
  - None of the RCD flows are captured by the CVD subsurface SIS
  - ID is assumed to be covered the same year the CVD SIS is implemented; runoff and seepage would then flow to CVD or X14
- Faro Creek seepage into Faro Pit does not stop (20% of Faro Creek)
- Local Faro Pit flows, S-wells, and ZII pumping always go to Pit first and then pumped to WTP
- Emergency Tailings Area (ETA) efficiency, 70% until Year 7, stochastic groundwater (GW) interception efficiency after Year 7
  - ETA is routed to ID before CVD SIS and to Faro Pit/WTP after Down Valley Tailings (DVT) SIS implementation

Common Model Assumptions (continued)

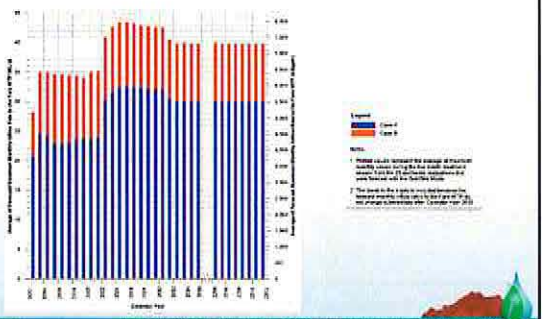
- WTP effluent and upper GH and lower GH flows to x14: flows need eventually to be routed to ID
- No biotreatment; all Grum Pit inflows go to Vangorda WTP on the second year of simulation
- New waste rock dump (WRD) implementation schedules (10-year shift from original years)
- Updated on Faro Pit and ID based on observed concentrations on January 2012
  - Sulphate (SO_4) updated to 250 mg/L for Faro Pit

Impact of System Variables on WTP Size

Maximum Influent Flow Capacity Predictions
Scenario 1 (2 WTPs): Data for Faro WTP



Maximum Influent Flow Capacity Predictions
Scenario 2 (1 WTP): Data for Faro WTP



Climate Change

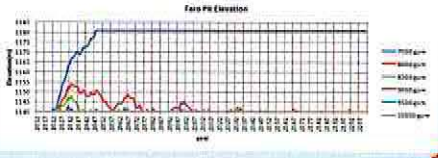
- **Climate change evaluated because precipitation drives treatment demand**
- **WTP life expected to be 30+ years**
- **Evaluated information from two sources**
  - Climate Wizard internet-based tool (Univ. of Washington)
  - Northern Climate Exchange 2011. Hydrology of the Bennet Lake Watershed: Contemporary Conditions and Potential Impacts of Climate Change. June 2011
- **Both predict 20 - 40+% annual precip increase in Yukon over next 30**

Faro Pit Storage vs. WTP Size

Scenario 2a (1 WTP at Faro) 357mm/yr precipitation with ramping increased precipitation (Medium High Climate Change projections) (A1B)

Scenario 2: Historical Precipitation and 34-Year Monthly Precipitation Sequence with Medium High Climate Change Projections (A1B)

Scenario 2: Historical Precipitation and 34-Year Monthly Precipitation Sequence with Modest Climate Change Projections (B)



Modelled Cases

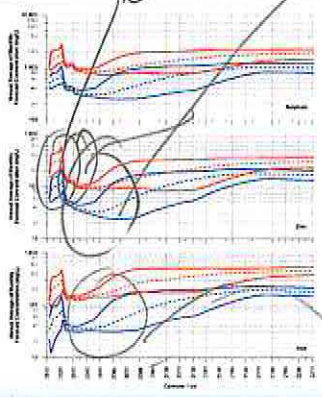
- Case A 357mm/yr Precip
  - 2 WTPs
    - Average Water Quality
    - Maximum Water Quality
  - 1 WTPs
    - Average Water Quality
    - Maximum Water Quality
- Case B 551mm/yr Precip
  - 2 WTPs
    - Average Water Quality
    - Maximum Water Quality
  - 1 WTPs
    - Average Water Quality
    - Maximum Water Quality

Common Assumptions

- **Two seepage load scenarios: maximum and average**
- **Tailings Water Quality (WQ):**
  - SRK model output loaded as time series for SO_4 and zinc (Zn)
  - Other WQ constituent loads are scaled based on those two
- **Faro Pit wall loads from SRK model**

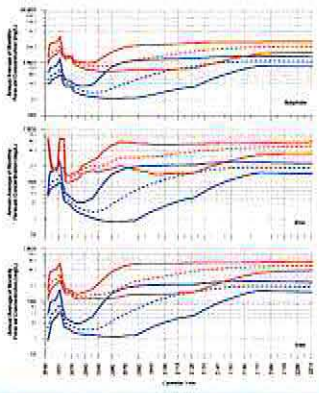
ETA covers.

Expected Influent Water Quality
Scenario 1 (2 WTPs): Data for Faro WTP



residual alkalinity being late up

Expected Influent Water Quality
Scenario 2 (1 WTP): Data for Faro WTP



HDS Pilot Testing

- **Conducted at site August – Early October**
- **Tested three water qualities**
  - HDS-1 (Current Faro WTP water)
  - HDS-2 (Mid-point WQ)
  - HDS-3 (ETA water quality)
- **Did not test filtration**

HDS Pilot Test Setup

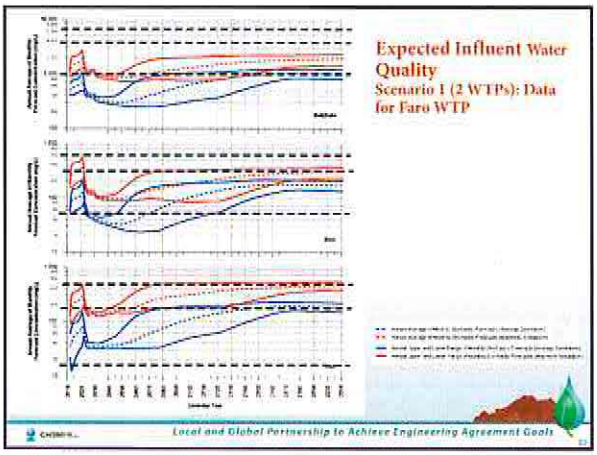
Three pilot systems.

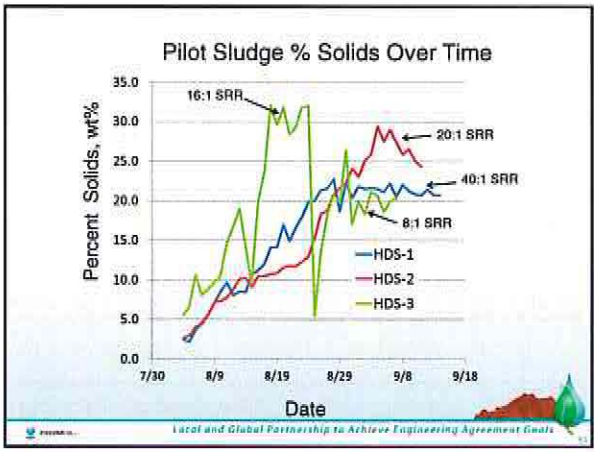
Pilot Test Waters and Results

Parameter	Average Result		
	HDS-1	HDS-2	HDS-3
Influent pH	5.6	5.1	4.8
Influent Sulphate (mg/L)	1,040	3,470	7,040
Influent Dissolved Zinc (mg/L)	48	301	591
Influent Dissolved Iron (mg/L)	17	181	471
Lime Demand, Calcium Hydroxide (g/L)	0.18	1.00	2.08
Solids Formed (g/L)	0.24	1.39	3.46
SRR (X:1)	40	20	16
Sludge Percent Solids (wt%)	20	25	30
Thickener UA Requirement (m^2/t/d)	2.6	1.7	1.0
Thickener UA Requirement (ft^2/t/d)	24.9	16.4	10.0

Notes:

ft^2/t/d = square feet per ton per day
g/L = grams per litre
m^2/t/d = square metres per tonne per day
mg/L = milligrams per litre
wt% = percent weight

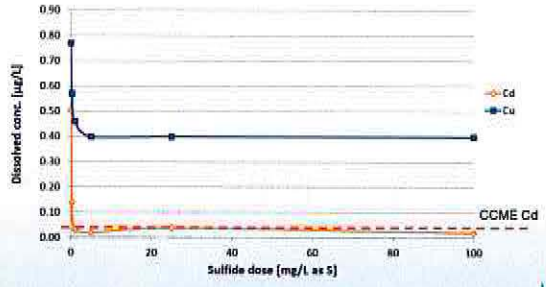




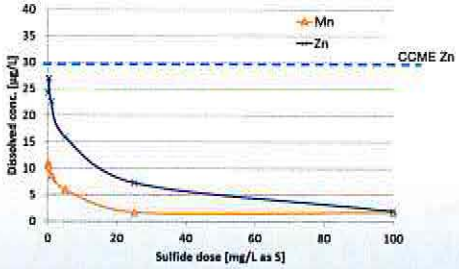
Pilot Plant Effluent

- Met all existing limits on a dissolved metals basis
- Met all CCME guidelines for HDS-1 on a dissolved metals basis without sulfide
- Supplemental sulfide addition further lowered dissolved metals

Sulfide Jar Testing Results



Sulfide Jar Testing Results



Equipment Sizes for HDS-1 WQ

		Units				
Influent Flow Rate		ML/d	27	33	38	44
	WQ	USgpm	5,000	6,000	7,000	8,000
A Reactor Diameter	HDS-1	m	1.5	1.7	1.8	1.8
	HDS-2	m	2.1	2.4	2.5	2.6
B Reactor Diameter	HDS-1	m	7.5	8.0	8.4	8.8
	HDS-2	m	7.6	8.1	8.5	8.9
Thickener Diameter	HDS-1	m	29	32	34	36
	HDS-2	m	41	45	49	52
Filter Area	HDS-1	m²	144	172	201	230
	HDS-2	m²	146	175	204	233
Lime Feed	HDS-1	t/d	3.7	4.4	5.2	5.9
	HDS-2	t/d	21	26	30	34

Preliminary Equipment Sizing Conclusions

- Reactor A is small and doesn't change appreciably enough to significantly affect costs
- Reactor B varies by flow rate, not WQ
- Thickener size varies by both flow and strength, but size is generally within a small range
- Filters vary by flow rate, not WQ
- Lime feed varies both due to flow and strength
- In general flow changes WTP more than WQ

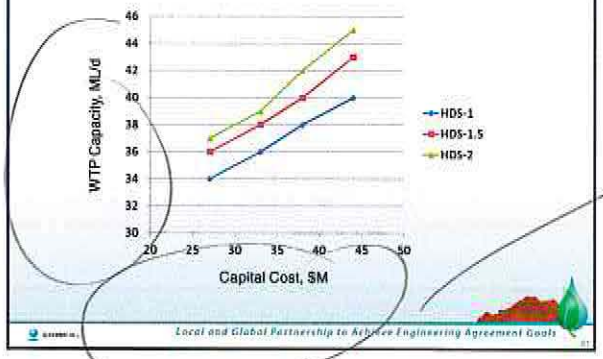
Capital Cost Evaluation

- CH2M HILL Parametric Estimating System (CPES)
- Proprietary spreadsheet-based system using cost database that is kept up to date and adjusted for local factors
- CPES has modules for various unit processes
- Generates Class 5 estimates at conceptual stage
- Estimates allow relative comparison of concepts

Capital Cost Estimate Summary
($Millions)

Capacity	HDS-1 WQ		HDS-1.5 WQ		HDS-2 WQ	
ML/d	w/o	w/	w/o	w/	w/o	w/
27	$34	$47	$36	$49	$37	$50
33	$36	$52	$38	$54	$39	$55
38	$38	$54	$40	$56	$42	$58
44	$40	$59	$43	$61	$45	$63

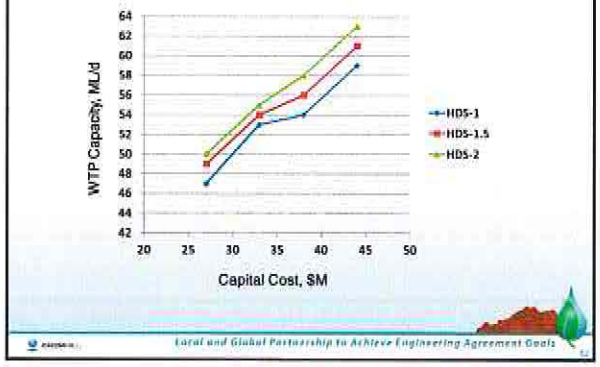
Capital Cost w/o Filters



Local and Global Partnership to Achieve Engineering Agreement Goals

Switch Labels for axes.

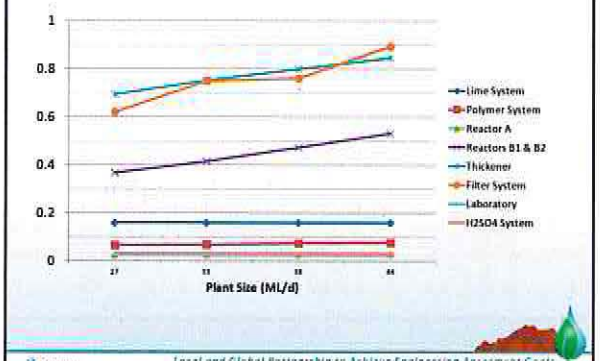
Capital Cost w/ Filters



Local and Global Partnership to Achieve Engineering Agreement Goals

11 11

Relative Cost of Major Equipment



Local and Global Partnership to Achieve Engineering Agreement Goals

WTP Capacity Recommendations

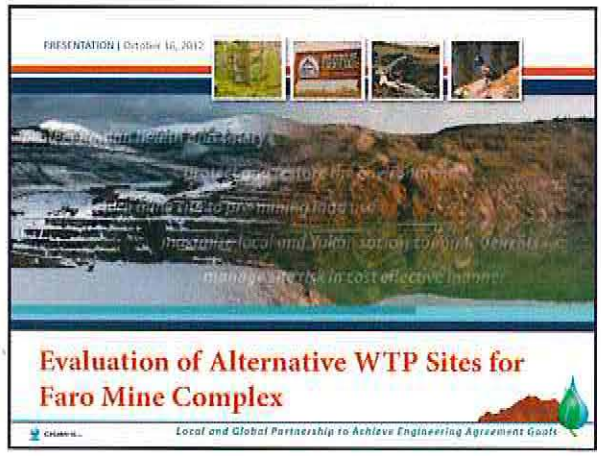
- Select maximum influent flow rate to accommodate:
  - Existing Faro Mine Area water treatment needs: approximately 23 ML/d (4,300 USgpm) based on the last 4 years of site operations
  - DVT SIS water: approximately 15 ML/d (2,800 gpm) based on the current results of groundwater modelling
  - Grum/Vangorda Area water treatment needs if a single WTP (Scenario 1) is selected; approximately 5.6 ML/d (1,000 USgpm) based on the current GoldSim model and historical Vangorda Pit treatment volumes and Grum Pit fill rates
- Recommend 44 ML/d based on:
  - Single WTP for Faro and Grum/Vangorda
  - Accommodation of CVD SIS water which may occur sooner than 10 years
- Recommend HDS-2 water quality:
  - Flow rate affects cost more than strength
  - Provides safety factor in event future water quality is stronger than predicted

WTP Phasing Recommendations

- Phase 1: Initial Build Out
  - 44 ML/d (8,000 USgpm) influent flow rate capacity
  - HDS-2 water quality
  - A single lime system
  - Two B Reactors providing a total of 30 minutes of HRT
  - A single 55-m-diameter thickener
  - No filters
  - Minimum C&M support facilities
- Phase 2: Addition of filters and C&M Support Facilities
  - Defer until required by new water licence
  - Allows better understanding of filter performance requirements
  - Construct additional C&M support facilities when filters are added
- Phase 3: Done in 30+ years
  - Add additional lime feed capacity and sludge systems if needed
  - Add additional sludge recycle and wasting capability if needed

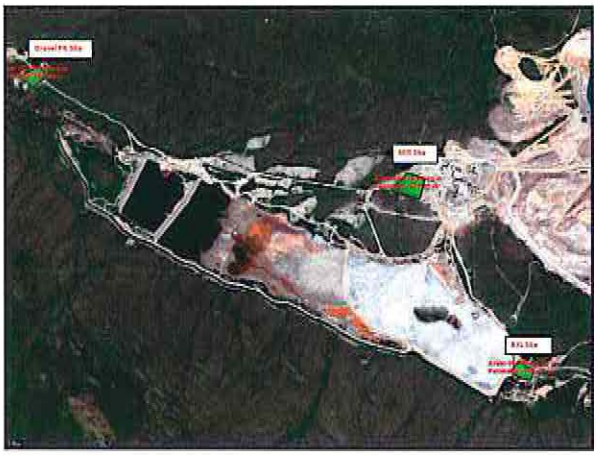
Other Recommendations

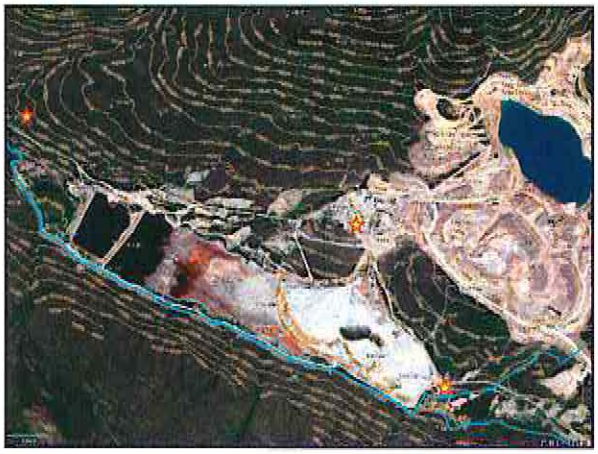
- Continued GoldSim model refinement and calibration through design definition phase
  - Evaluate maximum influent flow rate and strength, as well as timing
  - Perform reservoir analysis
  - Further evaluate potential climate change
- Recommended phasing approach if constrained by funding
  - Construct 27 ML/d (5000 USgpm) treatment capacity and HDS-2 WQ
  - Construct a 55-m thickener
  - Postpone filters
  - Add other equipment later



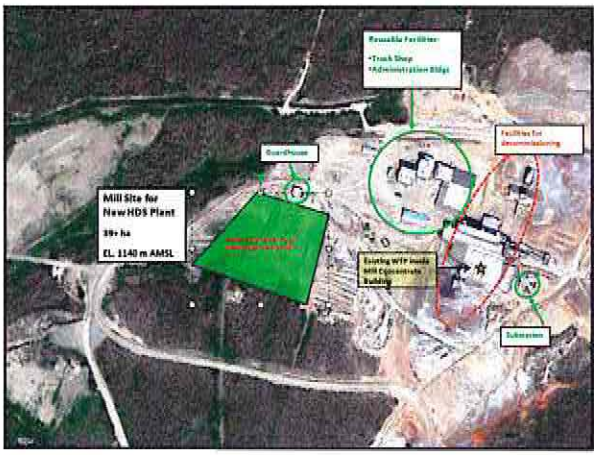
Workshop Objectives

- Present findings of TM3, which evaluated three potential sites for the new high-density sludge (HDS) water treatment plant (WTP)
- Review recommendations for preferred new HDS plant site
- Obtain agreement among Government of Yukon (YG) and workshop participants for path forward





BXL Site
19 ha
El. 1065 m AMSL



Representative Faro HDS Plant Size

- 27 ML/d (5,000 USgpm) initial construction, expandable to 54 ML/d
- Plant footprint ~7 hectares (ha)
- Construction staging needs ~5 ha
- Total minimum footprint ~12 ha

Comparison of Space Availability

Candidate Site	Max Available Area (ha)
BXL	19
Mill	39+
Gravel Pit	15

Representative HDS Plant 27 ML/d, expandable to 54 ML/d:
Footprint = 12 ha

HDS Plant Site Desirable Features

- Generally flat, sufficient size for initial construction and expansion, plus construction staging
- Topographical relief for gravity flow regime
- No interference with future decommissioning and remediation activities
- Good road, utilities, and pipeline access
- Good geotechnical conditions
- Facilitate rapid construction of new plant
- Effective location as long-term operational base
- Minimizes flood and weather risks

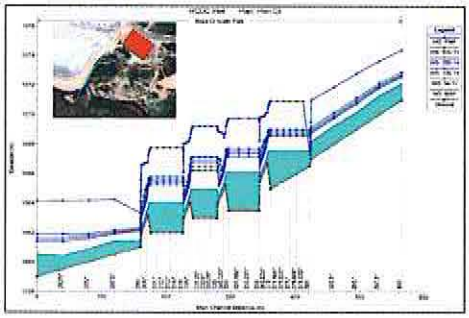
Technical Evaluation

Technical Factor	Mill Site	Gravel Pit Site	BXL Site
Available area for short-term needs (Existing Mill Treatment Replacement)	5	5	5
Available area for long-term expansion	5	3	3
Space for construction staging purposes	5	3	3
Topographical relief for gravity feed to filters	5	1	1
Adequate distance from existing areas that require demolition/remediation	4	4	4
Road and parking infrastructure	5	2	3
Convenient location for new pipelines and tie-in to existing pipelines	5	1	2
Access for electrical power	5	1	3
Access for potable water and sewer	5	3	3
Communications access	5	1	2
Allows for rapid implementation of new plant	5	1	2
Low risk of flood	5	3	1
Long-term effectiveness as operational base	4	1	4
Total Score	**63**	**29**	**36**

BXL Site Photos

BXL Site
19 ha
EL. 1065 m AMSL

North Fork Rose Creek Flood Elevations
(from northwest hydraulic consultants ltd.)



Mill Site Photos

Local and Global Partnership to Achieve Engineering Agreement Goals

Gravel Pit Site Photos

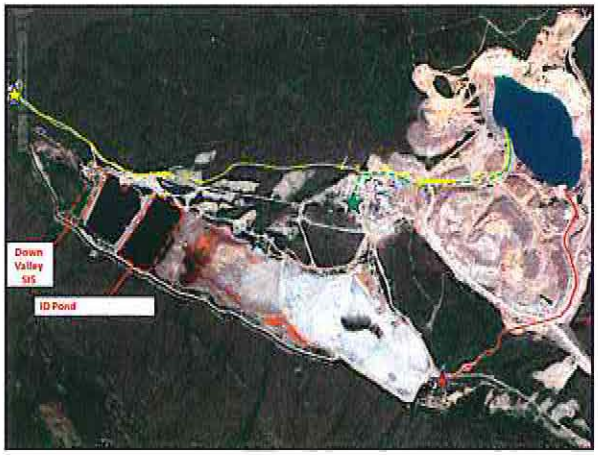
Technical Evaluation Summary

The Mill Site offers:

- The best existing infrastructure – lowest capital costs
- Best future flexibility (largest site area)
- Good geotechnical conditions (confirmed)
- Lowest flood risk
- Good location for long-term operations
- Quickest completion for new plant

Economic Evaluation

- Mill Site has lowest capital cost for support infrastructure
- Mill Site has higher cost for influent pumping from Intermediate Dam (ID) Pond and Down Valley seepage interception system (SIS) (for 5-month operating period only)
- Mill Site has lowest sludge pumping costs to Faro Pit



Additional Infrastructure Capital Costs

Plant Site	Additional Infrastructure Capital Costs, $million
Mill	0 (baseline)
BXF	3 to 5
Gravel Pit	5 to 7

Additional Pumping Costs

	NPV of Additional Pumping Costs, $million			
Plant Site	12-Year	30-Year	50-Year	100-Year
Gravel Pit	Baseline pumping costs			
BXF	1	1.5	1.8	2.2
Mill	1.4	2.2	2.7	3.3

Capital cost savings of Mill Site outweigh small pumping energy savings (during 5 months of plant operation) over 100-year evaluation period.

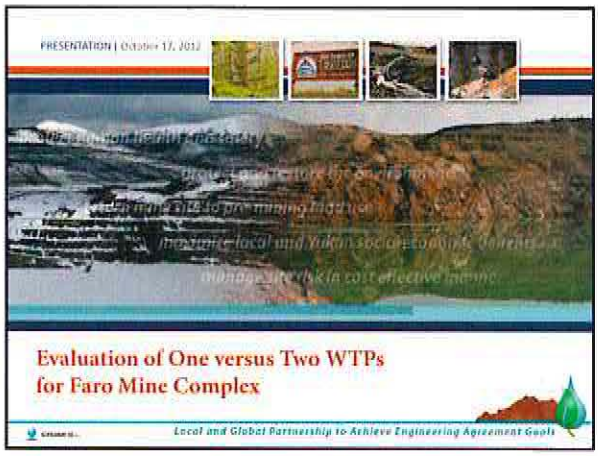
NPV – net present value

Conclusions

- Mill Site is the preferred WTP site:
  - Lowest capital cost for support infrastructure and lowest lifecycle cost
  - Fastest implementation time for new WTP
  - Largest site, most flexibility for future expansion
  - Safest location against flood and weather risks
  - Good location for long-term operation

Recommendations

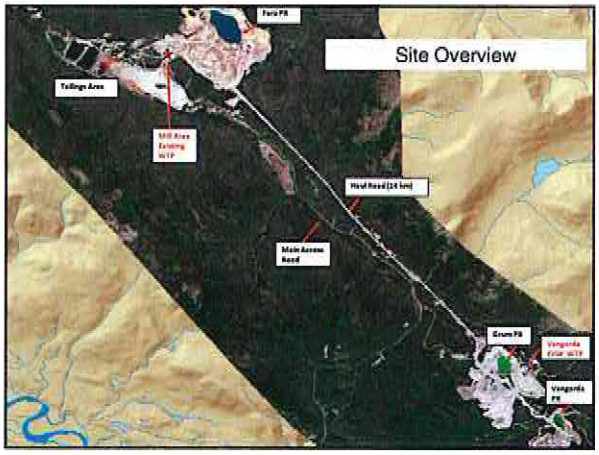
- Proceed with design of new HDS plant at Mill Site
- Provide flexibility in design for anticipated and unforeseen future conditions
- Perform detailed review of existing infrastructure to determine reuse potential

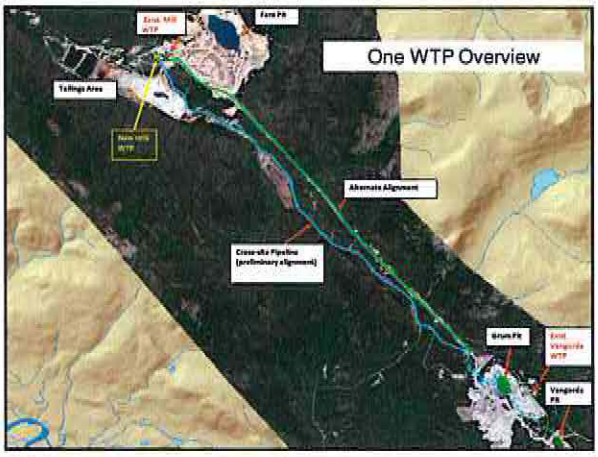


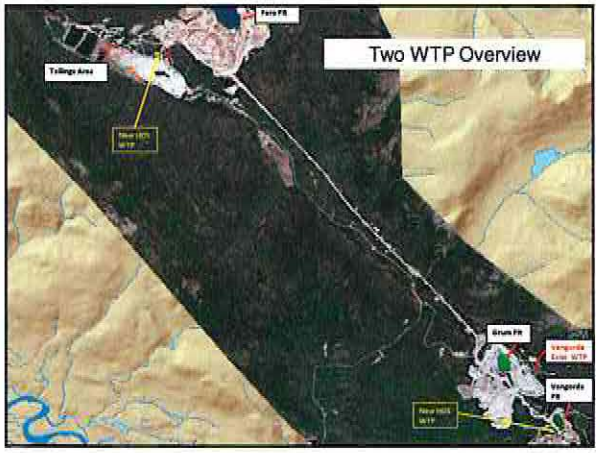
Workshop Objectives

- Present findings of TM2, which evaluated constructing two separate water treatment plants (WTPs) for Faro and Vangorda versus construction of a single treatment plant with a cross-site pipeline
- Review recommendations and obtain agreement among Government of Yukon (YG) and workshop participants for the path forward

Local and Global Partnership to Achieve Engineering Agreement Goals




One WTP Overview
Tailings Area
Alternate Alignment
Cross-site Pipeline
(preliminary alignment)
Grum Pit
Vangorda
Pit

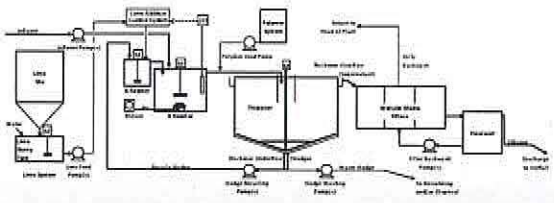

Two WTP Overview
Tailings Area
Grum Pit
Vangorda
Pit

Mill Site for
New HDS Plant
(> 10 ha)

Representative High-Density Sludge (HDS) Plant Sizes

- One Plant
  - Faro WTP = 38 ML/d (7,000 USgpm)
  - Cross-site pipeline from Vangorda to Faro
- Two Plants
  - Faro WTP = 27 ML/d (5,000 USgpm)
  - Vangorda WTP = 11 ML/d (2,000 USgpm)

HDS Plant Flow Schematic



HDS Plant: Three Enclosed Areas

1. Lime system, reactor equipment (in building)
2. Thickener area (dome cover)
3. Effluent filter area (separate building)

Cross-Site Pipeline Design Concepts

- No mixing of Grum/Vangorda water (to avoid precipitation products)
- Alternate duty from each pit
- New pumping barges at Grum and Vangorda Pits and parallel pipelines to high point (Ore Transfer Pad [OTP])
- Gravity flow in cross-site pipeline from OTP to Faro WTP (or Faro Pit)
- Pipe operation period is June to September (permafrost)

Cross-Site Pipeline Design Concepts (continued)

- Pipeline materials are high-density polyethylene (HDPE), high-strength (PE 4720 resin)
- Butt-fused joints (as strong as pipe)
- Twin 300 mm, DR 6 (400 psi) from Vangorda to OTP
- 500 mm, DR 7 (335 psi) from Grum to OTP
- 500 mm, DR 7.3 (317 psi) cross-site pipeline

Cross-Site Pipeline Design Concepts (continued)

- Buried pipelines approximately 2-m cover
- On high side of Main Access Road
- Thermal contraction/expansion forces:
  - Guidelines: Plastics Pipe Institute (PPI) *Handbook of Polyethylene Pipe*, PPI piping calculator, American Water Works Association (AWWA) M55 (PE pipe design), manufacturer guidelines
  - Concrete thrust collars to transfer forces to soil
  - Allow pipe to move in specific locations

Faro Plant Flows

- Faro Pit water, includes Zone 2 and S-Wells (May to Sept)
- Intermediate Dam (ID) Pond water (May to Sept)
- Emergency Tailings Area (ETA) seepage interception system (SIS) water (May to Sept)
- Grum/Vangorda water, *future* (June to Sept)
- Down Valley Groundwater SIS, *future* (May to Sept)

Capital Cost Evaluation

- CH2M HILL Parametric Estimating System (CPES)
- Proprietary spreadsheet-based system using cost database that is kept up to date and adjusted for local factors
- CPES has modules for various unit processes
- Generates Class 5 estimates at conceptual stage
- Estimates allow relative comparison of concepts
- CPES estimates checked against rule-of-thumb principles

Capital Cost Summary

Alternative	Component Description	Capital Cost $ Million
One WTP	38-Ml/d HDS WTP	59
	Cross-site pipeline	17
	Grum and Vangorda pump barges and pipelines	7
	One Plant Total Capital Cost	83
Two WTPs	27-Ml/d HDS WTP	51
	11-Ml/d HDS WTP	29
	Grum and Vangorda pump barges and pipelines to plant	5
	Two WTP Total Capital Cost	85

Capital Cost Discussion

- Capital costs are identical within the accuracy of estimate
- Cross-site pipeline costs are conservative:
  - Thick-walled pipe
  - Potential shorter alignment (along Haul Road)
  - Early estimate contingencies

Life-cycle Cost Evaluation

- Net Present Value Analysis
  - 30 year
  - 50 year
  - 100 year
  - 300 year
- Assumed all capital costs expended at beginning of period
- Discount rate = 3%

Life-cycle Cost Evaluation (continued)

- Annual O&M Costs
  - Labour
  - Chemicals
  - Electricity
  - Analyticals (outside laboratory)
  - Maintenance

Labour Cost Assumptions

- High level of automation for remote operation via Supervisory Control and Data Acquisition (SCADA) system during evenings and long weekends
- One plant with pipeline: 4 staff, two shifts
- Two plants: 6 staff, two shifts
- $130K annual cost (only 5 months attributed to WTP cost; 7 months to other accounts)

Chemical Cost Assumptions

- Unit lime cost at $200/tonne calcium oxide (CaO) (from historical data)
- Polymer 3 mg/L at $4/dry kg

Electricity Cost Assumptions

- $0.165/kWh (historical data)

Analytical Cost Assumptions

- $20,000 annual cost for one plant
- $40,000 annual cost for two plants

Maintenance Cost Assumptions

- 1% of "hard" capital costs (excludes markups, escalation, management, administration)
- Generous for typical year
- Surplus held in reserve for periodic major refurbishments

Lifecycle Cost Summary

Evaluation Period Years	One WTP Alternative Life-cycle Cost $ Million	Two WTPs Alternative Life-cycle Cost $ Million	Additional Life-cycle Cost for Two WTPs Alternative %
30	108	112	4
50	117	121	3
100	125	130	4
300	127	133	5
500	127	133	5

Economic Analysis Summary

- Capital Cost basis
  - One plant and two are identical
- Life-cycle Cost basis
  - One plant and two are very close
  - One plant slightly lower by $4 to $6 million (3-5%)
  - Significant?

Noneconomic Analysis

- Considered approximately 40 noneconomic factors:
  - Field investigations
  - Design
  - Contractor procurement
  - Construction
  - Facility Operation
  - Reliability
- Not a formal weighted analysis evaluation

Noneconomic Analysis (continued)

- *Give out copy of TM2 Attachment C*

Noneconomic Analysis Summary

Overall, single plant is favoured:

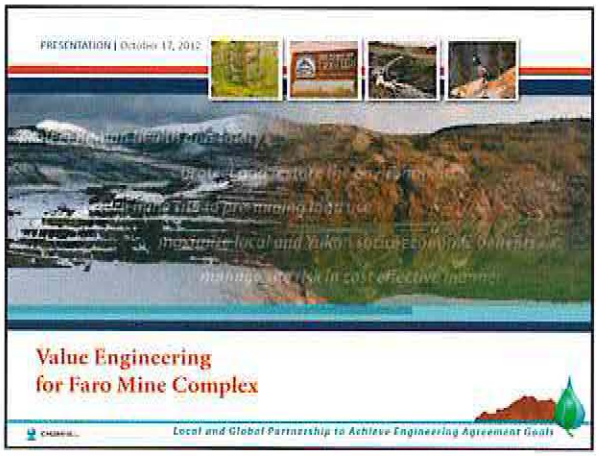
- A gravity flow pipe is inherently simpler than an additional plant
- Single, consolidated location of mechanical complexity
- Single point of environmental compliance, sludge disposal, site security

Convergence

- If one plant is selected, the cross-site pipeline will not be built for 10+ years
- If two plants are selected, the Vangorda Plant will not be built for approximately 10 years
- Effectively, in the near-term: design and construct the Faro Plant
- Focus on initial size the Faro Plant now

Recommendations

- Proceed with design and construction of Faro Plant, allowing for future expandability, flexibility
- Preference for single plant, but final decision does not need to be made now
- The mine and weather systems are dynamic; further operating experience with new HDS plant will provide data on influent quality and quantity to inform future decisions
- Review the upgrade of existing Vangorda Plant vs. new plant



Objective of Value Engineering

The objective of value engineering (VE) is to provide a water treatment plant (WTP) that meets the owner's performance requirements at the lowest capital and operating cost while maintaining operational reliability and convenience. That is, its purpose is to maximize the value of the facilities, where:

$$\text{Value} = \frac{\text{Worth (efficiency, reliability, flexibility, convenience, quality)}}{\text{Cost (materials, equipment, labour, energy, time)}}$$

Benefits of Value Engineering To Challenge Assumptions

- WTP complex – multidiscipline teams
- Time and budget constraints
- Design habits/biases
- Political realities, community concerns
- Owner/operator sacred cows
- Aesthetic demands

Benefits of Value Engineering
Reduce Costs

- Sizing of facilities
- Life-cycle rather than capital costs
- Making better use of existing assets
- VE process heightens the overall sensitivity to project costs

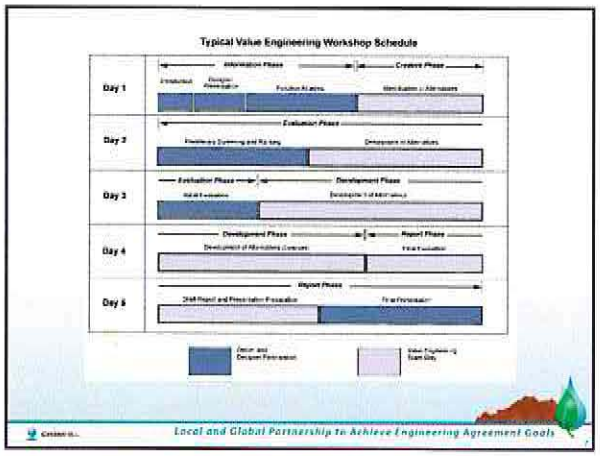
Benefits of Value Engineering
Increase Worth

- Improve process to enhance efficiency
- Increase reliability
- Build in flexibility
- Plant safety
- Decision making improved – the VE process can help solve disagreements between project team members

Pre-workshop

- Owner, designer, VE team meet
- VE team make up peers of design team not involved in project
- Designer team
- Guidelines and constraints of VE
- Information required

Workshop
VE Report



Value Engineering Schedule for Today

- Designer presentation summary
- Constraints
- Brainstorm long list
- Initial evaluation
- Takeaway

Local and Global Partnership to Achieve Engineering Agreement Goals

TECHNICAL MEMORANDUM NO 2 - ATTACHMENT C

Comparison of Non Economic Factors for One or Two WTPs

Faro Mine Remediation Project

Feature	One WTP	Two WTPs	Reason
Field Investigations			
Additional Field Work Required	Equal or more work	Equal	Cross Site Pipeline requires more additional field work than Vangorda Plant Site
Subcontracting	Equal	Equal	Further subcontracts for field investigations.
Health and Safety	Equal	Equal	No discernable difference
Impact to access roads	Less favorable	More favorable	Drilling at multiple locations near road
Impact to pristine areas	Less favorable	More favorable	Cross site pipeline field investigations
Uncertainties	Less favorable	More favorable	Pipeline longer more uncertainty. eg. depth to rock, permafrost, etc.
Design			
Hydraulic capacity Sizing Analysis	Equal	Equal	Both require similar effort
Water Chemistry / Loading Analysis	Equal	Equal	Both require similar effort
Detailed Design Efforts	More favorable	Less favorable	One WTP with pipeline simpler than Two WTP
Time Frame for Design	More favorable	Less favorable	One WTP with pipeline quicker than Two WTP
Client and External Review Effort	More favorable	Less favorable	One WTP with pipeline simpler than Two WTP
Regulatory Approval	Less favorable	More favorable	Cross watershed transport adds complexity
Contractor Procurement			
Cost	Less favorable	More favorable	Assuming separate contract for pipeline vs single contract for two plants
Public Relations	Equal	Equal	No difference identified
Health and Safety	Equal	Equal	No difference identified
Risk of Suitable Contractors	Equal	Equal	No difference identified
Risk of Bids Exceeding Budget	Equal	Equal	No difference identified

TECHNICAL MEMORANDUM NO 2 - ATTACHMENT C

Comparison of Non Economic Factors for One or Two WTPs

Faro Mine Remediation Project

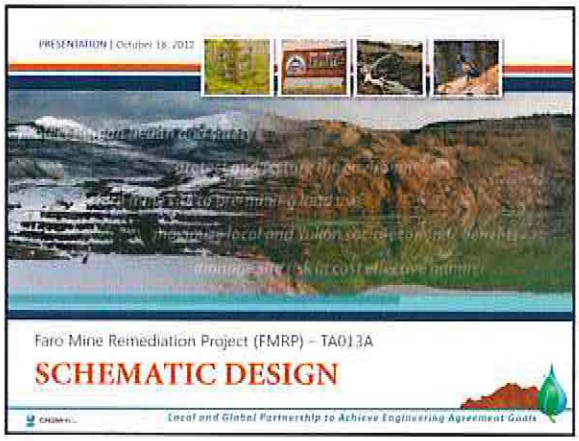
Feature	One WTP	Two WTPs	Reason
Construction			
Subcontracting	Equal	Equal	No difference identified
Constructability	More favorable	Less favorable	Pipeline simpler than Vangorda WTP
Construction Sequencing	More favorable	Less favorable	Pipeline simpler than Vangorda WTP
Construction Duration	More favorable	Less favorable	Pipeline simpler than Vangorda WTP
Construction Risks	Slightly higher	Slightly lower	More subsurface uncertainty with pipeline than WTP
Public Relations	Equal	Equal	No difference identified
Health and Safety	More favorable	Less favorable	WTP involves more complex tasks eg. welding, electrical, cranes.
Facility Operations			
Operations complexity	More favorable	Less favorable	Pipeline simpler than Vangorda WTP
Public Relations	Equal	Equal	No difference identified
Health and Safety	More favorable	Less favorable	Pipeline simpler than Vangorda WTP
Access roads maintenance	More favorable	Less favorable	One WTP has less truck traffic to Vangorda site
Site Security	More favorable	Less favorable	One WTP is easier to secure
Influent Pumping Energy	Less favorable	More favorable	Higher pump lift for cross site pipeline
Overall Carbon Footprint	More favorable	Less favorable	One WTP has less traffic and lower heating costs
Effluent Quality	Equal	Equal	No difference identified
Ability to adjust to future changes in flow/ load conditions	More favorable	Less favorable	Easier to adapt/expand one WTP
Ability to adjust to future changes in discharge regulations	More favorable	Less favorable	Easier to modify one central WTP
Process Control System Simplicity	More favorable	Less favorable	Pipeline system easier to operate than second WTP
Operational Flexibility	Equal or More favorable	Equal or Less favorable	Process modification easier at one single site

TECHNICAL MEMORANDUM NO 2 - ATTACHMENT C

Comparison of Non Economic Factors for One or Two WTPs

Faro Mine Remediation Project

Feature	One WTP	Two WTPs	Reason
Operating Labor Requirement	Fewer operators required	More operators required	
Sample Collection and Analysis	More favorable	Less favorable	One point of effluent compliance
Data and Record Keeping	More favorable	Less favorable	One point of compliance reporting
Regulatory Reporting	More favorable	Slightly higher	One point of compliance reporting
Minimize Environmental Risk	Equal or more favorable	Equal or less favorable	One WTP reduces potential for process upsets
Chemical Delivery Scheduling	More favorable	Less favorable	One WTP has simpler inventory
Reliability			
Adverse Weather Reliability	More favorable	Less favorable	Easier to operate one facility in adverse weather
Firm Capacity (plant capacity with equipment out of service)	More favorable	Less favorable	Easier to upgrade firm capacity at one site. eg, thickener, substation
Chemical Delivery Reliability	More favorable	Less favorable	Deliveries more reliable for one site
Spares - Level of Inventory	More favorable	Less favorable	Reduced level of spares on hand is favorable
Maintenance Labor Requirement	Fewer staff required	More staff required	Pipeline simpler than Vangorda WTP



Introductions

- Government of Yukon (YG)
- Government of Canada as represented by Aboriginal Affairs and Northern Development Canada (AANDC)
- Independent Peer Review Panel (IPRP)
- Independent Engineer (IE)
- CH2M HILL

Health and Safety Moment

Health and Safety Moment
Have a Safe Halloween

- Wear flame-resistant costumes and costumes that do not block vision
- Use reflective tape on costumes and bags to help drivers see you and your children
- Carry a flashlight
- Walk in groups or with an adult
- Walk on sidewalks or on the road facing traffic
- Look both ways before crossing the street, and use crosswalks
- Examine all treats for tampering and choking hazards before eating them

Agenda Review

- Goals for Meeting
- Water Treatment Plant (WTP) Project Overview
- Construction Schedule
- Project Delivery Approach and Schematic Design Phase
- Client's Critical Success Factors
- Operations
- Deliverables
- Disciplines
  - Process
  - Instrumentation and Control (I&C)
  - Architectural and Structural
  - Heating, Ventilation, and Air Conditioning (HVAC)
  - Electrical
  - Site Civil

Goals for Meeting

- Obtain input from YG on preferences, requirements, and critical factors in the design of the WTP for the following aspects:
  - Operations
  - Deliverables
  - Process
  - I&C
  - Architectural and Structural
  - HVAC
  - Electrical
  - Site Civil

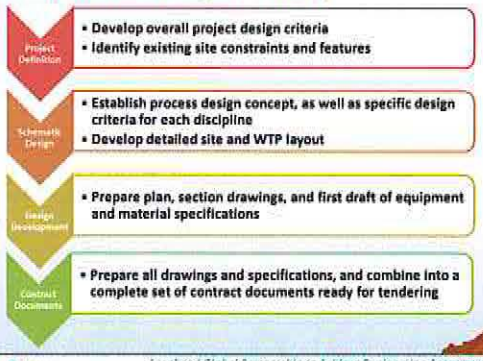
WTP Project Overview

- The existing Faro Mill WTP was constructed using existing ore-processing equipment
- The Mill WTP began operation in 2001, and the tanks are now at least 40 years old (Hatch, 2009)
- In 2012, a WTP evaluation was performed by CH2M HILL under Task Authorization (TA) 004
- Based on the considerations of reliability, operability, ability to meet treatment goals, and costs, the recommendation was to replace the Mill WTP as soon as practical
- The high-density sludge (HDS) process was recommended to be used

Construction Schedule

- 2013 Summer: Tender, award, and manage Contract 1 – Site Clearing and Preparation. Assumes funding available.
- 2014 Winter/early spring: Tender, award, and manage over 2014 and 2015 Contract 2 – WTP Construction Contract.
  - 2014: Earthwork and subsurface construction complete; erect the process building
  - 2015: Balance of the construction consisting of mechanical and electrical (M&E) work

Four-Phase Design Delivery



Four-Phase Delivery System

- This process provides for:
  - Design efficiency
  - Coordination between the various disciplines performing the design work
  - Quality control (QC)
  - Client review and input

Schematic Design Phase

- The primary goal of the Schematic Design (SD) Phase is:
  - To establish a sound basis for the project design
  - To make key decisions before starting production of the drawings and specifications that are included in the Contract Documents
- Done by evaluating engineering discipline alternatives, and establishing specific design criteria based on code requirements, owner preferences, and CH2M HILL experience
- Deliverable is a Schematic Design Report that will consist of:
  - Discipline technical memorandums
  - SD drawings, including preliminary process and instrumentation diagrams (P&IDs), equipment and building layouts, general arrangements, site plan, and electrical one-lines

YG's Critical Success Factors

- Design a WTP that will meet the short-, medium-, and long-term requirements of the Faro Mine Complex (FMC), and provide the required treatment performance for local conditions
- Protect the environment
- Manage risk in a cost-effective manner
- Deliver a quality product to YG
- Do not exceed design budgets without proper change order authorization
- Meet all milestones for deliverables
- Ensure the health and safety of all involved

Operations

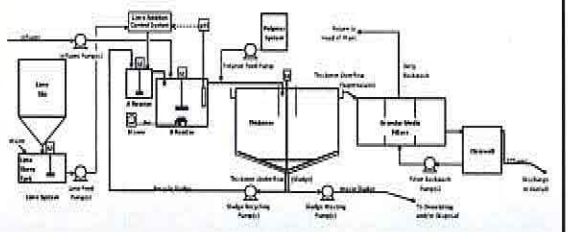
- The WTP will be designed for a 5-month operational season (May to September)
  - Consider a 7-month period for startup and shutdown (April to October)
- Operating staff
  - Who will operate the WTP?
    - YG's Care and Maintenance (C&M) contractor (TEES)
  - Level of staffing?
  - Anticipated work hours and days per week?
  - Is there existing staff?
  - Who will maintain the WTP?
  - Who will maintain I&C?

Deliverables

- Drawings:
  - Bentley MicroStation
  - Client-specific drawing standards or drawing frames
- Specifications:
  - Based on CH2M HILL master specifications
- Design Standard Details:
  - Based on CH2M HILL standard details
- Contract and Bid Forms:
  - Based on CH2M HILL standard forms

WTP Facility Design Disciplines

HDS Process



WTP Facility: Three Main Areas

1. Chemical Treatment Building

   Process Areas:
   - Lime Handling Facility
   - Polymer Handling Area
   - Reactor Tanks (Reactors A, B-1, and B-2)
   - Equipment Gallery: Pumps and blowers

   Non-Process Areas:
   - Control Room
   - Electrical Room
   - HVAC Room
   - Truck Loading Area
2. Thickener (Outdoor) – with tunnel access
3. Filtration Building (Future)

Process Mechanical Design Considerations

- Mechanical equipment selection criteria:
  - Durability and low maintenance requirement
  - Vendors who provide local support
- Major mechanical equipment procurement:
  - Lime slurry system
  - Polymer system
  - Sludge pumps
  - Blowers
  - Thickener
  - Service water booster system

Process Mechanical Design Considerations (continued)

- Operation:
  - Bridge crane in the Chemical Building
  - 100% equipment redundancy on major process equipment
  - Standby power for key process equipment: blowers and pumps
- Winterization:
  - Buildings:
    - HVAC will be designed for occupancy for 7 months
    - 5 months is the minimal heating requirement for equipment protection during freezing months
  - Thickener: concrete basin and dome covered

Other Design Considerations

- YG-specific requirements for operational access around equipment?
- YG-preferred equipment suppliers?

I&C

- *How simple should the type of controls be?*
- Control Locations (Where are the push buttons?)
  - At the machine for maintenance (Hand/Off/Auto selection): Basic minimum level of control
  - At the Control Room: Includes control switches and status indicators
- Controller Types:
  - Basic push buttons are sufficient for basic local manual/remote manual/simple auto
  - For alarm history, historical trend graphing – contemporary designs use a supervisory control and data acquisition (SCADA) computer (with a graphical user interface [GUI] for operators)
  - For complex automation, contemporary designs use programmable logic controllers (PLCs)

I&C (continued)

- SCADA:
  - Prefer to use vs. Avoid the use of SCADA
  - Preferred suppliers
- PLC:
  - Prefer to use vs. Avoid the use of PLCs where practical
  - Preferred suppliers

I&C (continued)

- Tag Numbering Scheme/Nomenclature:
  - Client-specific Tag Number Standards
  - CH2M HILL Standard :
    - Facility Number – Equipment Type – Number
    - e.g., 10-P01-01 stands for "Process/Area 10, Pump 01, Train 01"
- CAD Tool Standards:
  - Bentley Open Plant PowerPID vs. 2D Bentley MicroStation V8i
- Any network communication cabling standards (Ethernet and fibre optic cable)
- Automatic process report generation requirements
- Control/Viewing from remote site (e.g., Headquarters)

Architectural and Structural

- Exterior and Interior Treatment:
  - Pre-fabricated structure
- Rooms:
  - Small Break Room
    - Types of appliances anticipated
  - Plant Control Room:
    - Furniture requirements (copier, scanner, shelving, desks, and tables)
  - Small Laboratory:
    - Purpose
    - Laboratory equipment (fume hood, fume canopy)
  - Bathroom (unisex)
    - Barrier Free required?
  - Electrical Room
  - Others

HVAC

- Heating and Ventilation Concepts:
  - Air handling units with tempered heating
  - Heating fuel type (electric, natural gas, hydronic)
- Client-preferred Requirements and Equipment Suppliers

Electrical

- Emergency Generator Power:
  - For heating, ventilation, lighting, critical processes
- Building and Site Security Alarms
- Public Address System, Paging
- Level of Site Lighting:
  - Light pollution issues
- Client-preferred Requirements and Equipment Suppliers

Site Civil

- Client drawing standards for pipe drawing profiles
- Environmentally sensitive areas
- Road access requirements, parking
- Property boundary issues
- Noise issues
- Winter features: car block heaters

Client Technical Contacts

- Existing Site Information:
  - As-Builts
  - Utility Maps
- Local Officials:
  - Building Permit
  - Fire Marshall
  - Electrical Authority
  - Electrical Utility