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# ANVIL RANGE
# MINING CORPORATION

# INVESTIGATION OF TREATMENT METHODS FOR VANGORDA PIT WATER

**Prepared by:**



## CANADIAN ENVIRONMENTAL & METALLURGICAL INC.

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August 31, 2000

Anvil Range Mining Corporation
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Attention: Mr. Eric Denholm

**Reference : Investigation and Budgetary Cost Study for Reactivation of the Water Treatment Plant and a Review of Caustic and Other Technologies for Vangorda Pit Water**

The enclosed document is in response to the site visit of the treatment plant at the Anvil Range mine site for treatment of Vangorda pit water. The treatment options investigated were starting up the water treatment plant, which was shut down when the mine closed operations. In-situ treatment using lime slurry, sodium hydroxide and other economically viable treatment technology.

The report discusses the water pumping system, treatment plant, instrumentation upgrade for remote monitoring, budgetary costs (within 25%), and an absorption technology. The activated silica gel process appears to be attractive from the easy operation, operating cost, and sludge disposal point of view. A pilot plant investigation is recommended as this technology has been installed at 4 sites. The neutral pH of the contaminated water makes it an ideal feed for this process as it eliminates pH modification to remove zinc. The process is not very sensitative to temperature and a budgetary capital cost estimate is based on a yearly operation with a flow rate of 90 gpm. A larger plant would increase the capital cost if a shorter operational time is required.

I hope we have addressed your concerns and I look forward to your comments.

Sincerely,

Sohan S. Basra
President, CEO
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# 1.0 Introduction & Terms of Reference

A number of options are available at Anvil Range in the management of water accumulating in the Grum and Vangorda open pits. Currently both of these waters are mildly contaminated with Zinc. It is anticipated that within the next year or two water from the pits must be treated.

CEM Inc has been asked to review the 1990 water treatment plant that treated pit water during the active mining operations and comment on the suitability of this plant to treat pit water on a seasonal basis, and estimate the costs related to rehabilitating the plant. In addition CEM Inc will review the costs of automating the plant so that it can be monitored remotely and have minimal daily operator attendance. CEM Inc will briefly review alternative treatment technologies to determine if they offer any benefit in the treatment of waters containing relatively low levels of contamination. In addition a general review of the proposed operations is provided.

# 2.0 Summary and Conclusions

The water treatment plant at Faro appears to be in generally good condition with relatively little work required to re-activate it. Because no power was available at either the plant or pump station it was impossible to test any of the equipment. Prior to energizing any of the electrical systems they need to be thoroughly checked for potential ground faults.

Two of the pumps at the pump station seem to have been modified (they have 125HP motors rather than the 60HP units initially supplied) and the extent of these modifications needs to be determined.

The treatment plant appears to be in good order. The lime loop needs to be modified and rerun as it was poorly designed &/or installed. This should resolve most of the problems historically experienced with the plant. The rest of the plant requires clean up and checking but otherwise appears ready for operation once the pH probes are replaced.

The settling pond should probably be dredged prior to being put back into service. It does not appear that the underdrain is likely to be serviceable except in the short term and so it should not be re-activated.

Technologies based on Silicates, either zeolites (a natural silicate, although the properties may be enhanced by chemical and/or thermal treatment) or Silica Gel have shown promise in their selectivity for heavy metals over alkali and alkali earth metals. This appears to be one of the most promising technologies for application at Anvil Range. The activated Silica Gel should be closely examined as it would minimize the reagents costs. The only reagents required would be small amounts of dilute sulphuric acid for stripping and caustic for regeneration of the activated silica gel. The stripped product would be very high in zinc content and may be shipped off site for processing, which minimizes the sludge storage and handling liability (details of Silica Gel process are provided in section 3.4.8).

# 3.0 Discussion

## 3.1 Overview

The Grum/Vangorda water treatment plant (WTP) and associated pump stations was designed and built in about 1990 by CESL Engineering to treat contaminated water pumped from the active mining operations in the Grum and Vangorda pits. The principal mode of treatment to remove Zinc is an elevation of pH from the natural level of pH 6.5-7.5, (where zinc is quite soluble) to a pH of 9.3 (9.5-10.5 in terms of current Faro pit operations) where zinc should precipitate. Attached (appendix 1) is a reprint of the solubility of various metal hydroxides with pH and it can be seen that Zinc has a relatively high solubility (0.095mg/L) at its minimum solubility (pH 9.2), and that its solubility sharply increases as the pH differs from the minimum solubility in either direction. The pH is adjusted by the addition of a hydrated lime slurry, which is made on site by slaking quicklime.

The facilities exist principally of:

1) The water treatment plant located to the North of the Grum Pit including lime storage and slaking system and the treated water clarification pond.
2) A pump station located on the north-west side of Little Creek Dam.
3) A buried pipeline from the Little Creek Dam pump station to the water treatment plant.
4) The Vangorda Creek diversion Flume.
5) The Sheep Pad polishing ponds.
6) Sundry other channels, pipes, valve stations and ponds.

Water to be treated through the water treatment plant enters the plant from a single pipe. Just outside the water treatment plant this pipe receives water from the in-pit pump(s) in the Grum pit and Vangorda pit water via the Little Creek Dam pump station and buried pipeline. The control of the valves on these two incoming lines is manual.

Water enters the first neutralization tank where lime is added. This tank then overflows to a second reactor tank where precipitation reactions are completed and then to the flocculator, where flocculant is added prior to the overflow gravitating to the settling pond. A lime storage bin, and slaking facility make hydrated lime from quicklime for use in the plant. An Allied Colloids Percol mixing and feeding system provides flocculant to the floculator.

The settling pond has a distributor on the feed to the pond (a perforated pipe), and a similar pipe is provided for the discharge. In addition the pond was designed to have an under drain through a gravel bed, bit of this bed now appears to be blocked off.

Clear water leaving the pond gravitates through additional settling ponds (the Sheep Pad ponds) before it is discharged to Grum Creek.

## 3.2 Vangorda Pit Water: The Little Creek Dam and Pump Station

Water from the Vangorda pit would normally be pumped to the Little Creek Dam. The water in Vangorda Creek is intercepted and canalized in a flume to divert it around the pit, thus reducing the amount of water requiring treatment. The high wall of Vangorda pit contains exposed sulphides and the ability to control the oxidation of these sulphides and maintain uncontaminated pit water is the subject of other studies. If Vangorda metal dissolution from the exposed walls can be controlled, the existing water in the pit may be treatable by pumping water from the pit, adjusting pH to precipitate metals and returning water to the pit with excess lime to precipitate further zinc.

However at this point the assumption is that the water in the Vangorda pit will follow its historical path to the Little Creek Dam. The Little Creek Dam is connected by pipe to wet well sump in the Little Creek Dam pump station. The wet well is fitted with 3 pumps. All pumps are Peerless vertical turbine pumps supplied by Chamco to deliver 700ft head. In the original installation one pump was a 10LB with a 125 HP motor (rated at 500 usgpm), the other two being 8LB with 50 HP motors (rated at 220usgpm each). Currently all pumps are fitted with 125 HP motors. The base plates of the pumps differ slightly (reflecting the original installation) and it is thought that the systems may have been modified to increase the pumping rate. Chamco (both Vancouver and Edmonton offices), the suppliers of the pumps, are unaware of any changes that were made to the pumps. The pumps will have to be pulled and inspected prior to any firm statement about pump station capacity. They should be pulled anyway for mechanical inspection prior to energizing the motors.

Anecdotal evidence suggests that the pump station was capable of delivering up to 1200 usgpm to the water treatment plant which is more than the nominal capacity of all 3 pumps (940 usgpm) in their original configuration. If however the system head was slightly lower (say 600ft) the pumps in their original configuration would deliver almost 1200 usgpm, but the motors would be running into the service factors.

The vertical turbine pumps have 6" discharges, which join into a common 10" steel header. The original manuals note the pipeline as 10" HDPE, although other documents note it at 12" HDPE. The velocity off 1200usgpm in schedule 80 steel pipe would be about 3.79 fps with a head loss of approximately 0.371 ft/100ft pipe. Head losses in 10" HDPE would be about 60% of steel pipe (say 0.225 ft/100ft). In 12" HDPE this loss would be about 0.135 ft/100 ft. The design data notes the pipeline is 2311m (7580 ft) and has a static head of 192m (630ft). It is estimated that at 1200 usgpm we would have a dynamic loss of about 170 ft in 10" HDPE to give a total head close to 800ft. In 12" HDPE the dynamic head would be about 102 ft for a total system head of 732 ft whilst pumping 1200 usgpm. If 1200 usgpm can really be delivered to the WTP, the wet ends of the pumps must have been modified as well as the motors changed and we need to know the nature of those modifications.

The plant was originally installed with a Clayton Surge Relief valve, but this has been removed by the operators as it was giving problems . This is almost certain because the pressure rating on this valve was inadequate for the new system pressure after pump station modifications. A new valve properly rated for the system needs to be purchased once the current pump configuration is determined (a conversion kit for the current valve may be available). The pressure rating on the HDPE pipe needs to be confirmed to ensure that pump modifications are not endangering the integrity of the pipe, and pipe size confirmed.

Detailed review of the instrumentation is in a separate section of the report. However from a process and control perspective monitoring pond level should be done instrumentally, to allow WTP and pump operation to maintain the pond level in a safe range. Level indication can be done by a number of methods including non-contact methods. The current pumps must be started locally in order to properly control flows in the pipeline. This is because the starting procedure requires a number of manual valve manipulations. Whilst it would be possible to put controllers on the valves to allow remote starting of the pump station with the necessary valve manipulation, I do not believe this would offer any significant benefit as it is intended that the plant and associated systems would be physically inspected on a daily basis during the potential operating season, and if the remote pond level indication suggested plant operation should take place, the pond would be visually inspected and the pump station started manually.

## 3.3 Grum Pit Water

The pipe connection and pipe where the grum water enters the header entering the water treatment plant is still in place. The pumps are no longer installed in the pit. It is probable that Grum pit water could be treated in situ, and as very little sulphide is exposed (once the pit is flooded), it is possible that Grum pit water may not require treatment through the plant.

## 3.4 The Water Treatment Plant

### 3.4.1 Incoming Water

The water from Grum and Vangorda are combined into a common header just outside the treatment plant (the G/V Valve station). The insulated below grade valve station takes the two 10" lines from the respective water sources and combines them into a common 16" line that enters the plant. Note that the Valving Detail drawing (6.8 on page 6-19 of the operations manual) indicates two 10" joining into a 16" HDPE pipe, P&ID drawing P662-A-007 rev 3 indicates a 14" line, and the drawing of the Little Creek pumphouse (6.5 Little Creek Pumphouse on page 6-12 of the operations manual) indicates the little creek pipeline as being 12" HDPE. Most of these pipes were not visible for inspection (the valve station was flooded and the HDPE at the Little Creek Dam starts outside the pumphouse and is buried).

A flowmeter on the incoming line is one of the parameters used to control lime addition.

This valve station may be obsolete depending on how Grum water management is conceived.

### 3.4.2 The Water Treatment Plant (Water Treatment Section).

Water entering the plant from the main header enters the primary reactor tank. This is an agitated tank (dual impellers) to which lime is added from a lime loop. The pH of the tank is measured and this is one of the prime inputs into control of the lime addition (along with incoming flow). The residence time in this tank is about 5 minutes at peak design flow of 2000usgpm (456 $m^3$/hr). Both plant input flow and primary tank pH is recorded on strip charts.

Overflow from the primary reactor enters the secondary reactor. This is also a mechanically agitated tank (dual impellers) but with 15 minute residence time at peak design flow. The pH in this tank is monitored and recorded on a strip chart.

The overflow from the secondary reactor enters the flocculator tank where diluted flocculant is added from the flocculant system. The agitator mechanism is fixed speed, which with the potential for variable plant input may not be ideal.

Overflow from the flocculator is piped to the settling pond.

The plant has sample points on incoming and outgoing lines and in the pipes between tanks.

The condition of the neutralization part of the plant appears to be in good condition. Reactivation is unlikely to present any major problems.

Instrumentation in the plant is basic, but adequate. The pH probes, which are still hanging in the empty tanks, would need to be replaced. The transmitters are clean and sealed and are probably in good working order but would need to be checked. The chart recorders look to be in reasonable condition. It does not look as if reactivating the instrumentation and controls within the water treatment plant would present any major problems.

### 3.4.3 Lime Handling, Storage, Slaking and Feeding

Outside the main WTP building is the Lime system. Stanco/Mequipco who supply similar lime systems on a regular basis supplied the complete system as a package. The system consists of:

1: Lime Hopper where shipping containers are dumped. The hopper can be covered.
2: Blower and pipe to transfer lime from the Hopper to the Silo.
3: The storage silo, which is a bolted pre-engineered structure. On the top is a bin vent with filter bags. The silo has a live hopper bottom and a rapper.
4: A lime slaker located in a room below the silo.
5: A lime tank located in a room below the slaker, fitted with agitator and pumps.
6:The lime loop with outward and return lines and a timer and air solenoid controlled pinch valve to feed lime into the primary reactor.

Lime is delivered to the Faro site in standard shipping containers. Opening the container doors and tipping the container, through some protective screen, into a hopper, off load lime. The hopper has a hinged cover, which is closed when unloading is not actively taking place. The system is simple but prone to significant dusting. The lime being transported from Seattle by barge, where shipping containers are conveniently handled, dictates the system. Road delivery in tanker truck from a Canadian source is reported to be more expensive.

Blower transfers lime from the hopper to the storage silo. This is the normal way of handling lime. All the lime should be transferred out of the hopper as soon as possible after delivery to control moisture takeup.

The operation of the offloading and transfer to the silo are manual operations, and should remain so. The truck driver is present during the offloading so can ensure that everything is functioning. The only part of the operation that has any justification for automation is the switching off of the transfer blower at the completion of the transfer.

The Silo is a conventional bolted silo, with extensions below the hopper bottom to allow housing for the slaker and lime slurry storage tank. The silo has 40 tonnes capacity. At the top of the silo is a bin vent with filter bags to allow transfer air (and displaced air) to escape without spreading lime. The bottom of the bin has a live hopper bottom to prevent hangups, but recently a rapper/vibrator has been added so presumably some problems with hangups were experienced. A de Zurick Knife gate valve provides shutoff at the bottom of the hopper and a screw feeder controls discharge from the bin. All of these items are totally conventional. The control of the screw feeder is linked to slaker operation. The shutoff valve would be left open during normal operation and only shut of for maintenance. The live bottom and/or rapper would be activated on a timer.

The slaker is located directly under the silo in a circular room integral with the tank structure. The unit is a Wallace & Tiernan detention slaker one of the most widely used types. Lime is fed to the slaker by screw feeder. Water is also added, and this would be water at ambient temperature as no provision appears to exist for heating water. Frequently slakers are fitted with equipment for grit removal, but the Anvil range unit allows grit to join the lime slurry and this grit will report with the precipitated solids. Slaked lime overflows from the slaker and gravitates to the lime slurry storage tank, which is located in another room directly under the slaker. Control of slaker operation appears to be on level control from the slurry storage tank (a perfectly sound strategy).

A mechanical agitator agitates the lime slurry storage tank. Access to the agitator is through a port in the floor of the slaker room. Lime is pumped to the first neutralization tank by one of two slurry pumps via a lime loop. There are two installed pumps (one running, one standby) feeding a single lime loop. The lime loop is poorly designed and is reported to have given a lot of operating problems: in particular the lime takeoff to the neutralization tank is of the top of the pipe close to the high point, the return line is the same size as the outward line, and the system was controlled at the end of the return line by a diaphragm valve. This system would be difficult to run with degritted lime and is impossible with lime that has not been degritted, as at Anvil Range. Fortunately the work required to correct the system is quite simple. Lime addition to the neutralization tank is controlled by the pH set point on the pH meter in tank 1. Lime is added by opening and closing the pinch valve on a side arm to the lime loop by an air solenoid, the time the valve remains open being a function of the pH. This is a very normal control system.

### 3.4.3.1 Replacing the neutralization agent (lime) with Caustic Soda

Historically a lot of the problems related to the neutralization plant have been related to proper lime delivery and pH control. I believe the poor design of the lime loop has much to do with these problems. With modification of the lime loop the system should be operable with little operator attention.

However the amount of lime required is small as mine water requires a very small adjustment to precipitate zinc at approximately pH 9.3. An alternative to running the slaker and lime loop may be a simple metering system based upon liquid Caustic Soda solution delivered in totes. The required system would consist of a manifold to which two or three totes can be attached. Normally only one valve would be open so that a single tote would be in active supply service. A metering pump (and standby) would be attached to the Manifold and caustic soda would be metered into the first neutralization tank as a function of the pH set point. The operator would change totes as and when required. An alternative to liquid caustic, caustic can be shipped in pellet form and this would require on site make up system. The present lime system can be used to dissolve the caustic and keep it agitating which would have some mechanical energy input to lower the risk of freezing. The caustic make up may have some safety concerns during preparation as heat will be generated.

The disadvantages of using Caustic Soda rather than lime are as follows:

1: Cost. Although caustic soda is more expensive than lime the consumption will be sufficiently low that this will not be a significant factor and savings can be realized through reduced labour.
2: Settling. Caustic is a dispersing agent whilst lime causes particles to flocculate. If caustic is used to replace lime some problems may be experienced with particles settling in the pond.
3: In cold weather freezing may occur and the storage facilities for caustic would require heating.

The advantages of using Caustic Soda rather than lime are as follows:

1: Solids. Caustic soda will be a solution so all the problems related to solid suspension disappear. No agitated holding tank and no reagent loop with potential for line blockage. Alternatively, bagged caustic can be made up on site using the existing lime slurry tank.

### 3.4.4 Process/Fresh Water

In the main treatment plant is a water tank located directly underneath the primary neutralization reactor. This tank has two water distribution pumps attached these are used supply water to lime slaking (one pump), flocculant mixing and pump glands (second pump).

Water is supplied to the water tank by a vertical well pump that was not seen during the site visit. No provision was made for heating water for either slaking or flocculant mixing.

The water system seems adequate and if no problems were experienced with slaking with cold water then there is no reason to change the system.

### 3.4.5 Flocculant Mix System

The flocculant mix system is a standard Jet Wet system supplied by Allied Colloids for mixing their flocculant. It is a skid mounted package unit. The system consists of a dry flocculant hopper which is filled with dry flocculant that is delivered in plastic bags. A blower delivers dry flocculant to the jet wet head where the flocculant is dispersed in water as it enters the mix tank. Flocculant is mixed with water for several hours to allow it to dissolve and fully hydrate (at about 0.5% solids), and then gravitates to a holding tank. From the holding tank flocculant is pumped by a variable speed progressing cavity pump via a static mixer (where 10:1 dilution with water takes place) to the flocculator in the water treatment plant.

Mixing is initiated automatically by low holding tank level, and the mixing sequence is fully automatic. Flocculant addition rate is set as a function of the incoming water flow. The system needs to be checked but appears to be in good condition and probably in working order.

### 3.4.6 Sludge Settling Pond

Flocculated sludge leaves the flocculator and gravitates to the sludge settling pond. It enters the pond trough a header (a perforated pipe) and after the solids have settled, clear water exits by one of two means. The base of the pond has a gravel bed with underdrain pipes embedded in it. This system however is reported to be blocked off, although it is not clear that the functioning of the control structure was fully understood. The alternative exit for clarified water is by an overflow pipe similar to the feed header. It is strongly suggested that prior to any re-activation of the system the solids are removed from this pond. However this is not a critical item and no costs are budgeted for removal of accumulated solids. No attempt to should be made to rehabilitate the underdrain as it would appear that it would block off again soon after the system is re-activated.

The pond area is a little less than half a Hectare, which should be adequate as a settling pond for the design flow. The control structure on the discharge consists of a well and overflow weir on the underdrain, a bypass on the underdrain and a control valve on the overflow header.

Some concerns have been expressed as to the open area in the feed header: as much of the sludge has accumulated at the side of the pond nearest the treatment building it suggests the open area is adequate.

### 3.4.7 Other Issues

The clarified water leaving the settling pond gravitates through further clarification ponds, the Sheep Pad ponds before the water enters the Grum Creek water system. No problems are reported with this system and as it has no mechanical components it was not studied in any detail. An attempt should be made to estimate the quantity of sludge that has accumulated in these ponds, and if significant it should be removed prior to plant reactivation.

### 3.4.8 Alternative Technologies

The level of zinc contamination in the waters emanating from the Grum/Vangorda pits is low, and the pH is essentially neutral and in itself does not require adjustment. An alternative to precipitation technologies, where the whole water flow has to have the pH adjusted in order to precipitate minor amounts of metal, may be one of the absorption technologies.

#### 3.4.8.1 In-situ Treatment

There are a number of problems associated with in-situ treatment in materials handling and obtaining sufficient mixing in the pit to raise the pH of the contained water to precipitate the zinc. This option does not appear to be attractive as it present some challenges in the delivery and missing of lime.

#### 3.4.8.2 Biological System

Biological systems are extremely sensitive to temperature and flow changes and after a long dormant winter period, the bacterial response time is not predictable. Homestake Mining is using bacterial

treatment and the treatment costs are very high as the water is heated to above 18°C. The biological treatment in our view is not an attractive treatment option for the Anvil Range site.

### 3.4.8.3 Absorption Technology

Resin ion exchange is one such technology but selectivity for zinc against alkali metals may not make this the preferred medium at Anvil Range. A system based on resin has been proposed for Red Dog in Alaska to treat very low contaminated (3mg/L Zn) water at essentially neutral pH.

Technologies based on Silicates, either zeolites (a natural silicate, although the properties may be enhanced by chemical and/or thermal treatment) or Silica Gel have shown promise in their selectivity for heavy metals over alkali and alkali earth metals. This appears to be one of the most promising technologies for application at Anvil Range.

**Activated Silica Gel Process**

Heavy metals are removed by chelation on immobilized ligands, called Octolig. Octolig has an extremely high selectivity for heavy metals. By using an Octolig Metal Removal Plant, heavy metals are reduced to the required levels by a simple operation at a low cost.

The cations of sodium, potassium, and magnesium are not complexed and retained, which extends the absorption capacity of the activated silica gel unlike ion exchange resins. Since the for mentioned elements are not harmful in waste streams, not removing them is an advantage, because all of the metal-removing capacity of the silica gel is retained for heavy metals.
The advantages of the silica gel process to treat water are:

- Lower costs than other treatment processes,
- Removal of heavy metal concentration to parts per billion,
- Extremely high selectivity for heavy metals,
- Removes multiple heavy metals in a single treatment,
- No selectivity for benign alkali ions ($Na^+$, $K^+$, $Ca^+$),
- May be loaded and regenerated hundreds of times,
- Easy to operate and highly reliable.

A 42 inch column can treat up to 25 gpm of direct feed and any number of columns can be assembled in parallel to achieve the flow requirements. The silica gel is extremely insoluble and is stable in aqueous solutions in pH range of 0.5 to 10.5 and in the temperature range of 0°C to +80°C.

Octolig is an immobilized ligand that is chemically bound to a silane that is chemically bound to silica gel. The ligand chelates heavy metals as contaminated water is passed through the column. Octolig acts as host to the heavy metals. The heavy metals are retained on the Octolig in a one-molecule-thick layer on the surface of the silica gel as a result of chelation. Since all chelation reactions take place on the surface, contact time between the heavy metals and the Octolig are not critical.

A budgetary capital cost for a all year treatment would require 4 columns and filtering before and after treatment and all the associated pumps for stripping and regenerating the silica gel would be approximately $700,000 to $850,000 (the cost does not include precipitate handling). A more detailed cost can be generated after an 8 week onsite pilot plant testing. The onsite pilot plant would be carried by CEMI supplying the pilot plant and training a local operator to carry out continuous testing to

determine the loading capacity. The cost of onsite pilot plant study would be approximately $25,000 to $30,000.

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**References Plants**

There are 4 activated silica gel treatment plants in operation:

- Liberty Industrial, Long Island, New York – treating heavy metals contamination (Cd,Cr) with a flow rate of 200 gpm
- Hendricks Mine, Nederland, Colorado
  Treating 3 ppm zinc down to 0.02 ppm with a flow rate of 4,200,000 gpm
- Nordic Brass AB, Vasteras, Sweden – treating zinc and copper down to 0.02 ppm zinc and 0.032 ppm copper
- Mid-America Plating, Denver, Colorado – treating 4.2 ppm zinc down to 0.7 ppm zinc.

Further information can be provided on flow rates, water chemistry upon request.

It is suggested that a laboratory programme to test the efficiency of some of these absorption technologies should be carried out. If it is possible to remove zinc selectively without having to consume significant amounts of caustic used in the regeneration process and sulphuric acid for stripping, it should be preferable from both an operating cost standpoint and also environmentally.

## 4.0 Work Programme and Cost Estimate

The systems reviewed above appear to be in reasonable condition and do not appear to present significant problems in reactivating the plant. None of the systems inspected were energized so it was impossible to check the actual functionability of the components. In particular all electrical contacts are potentially corroded/oxidized and condensation could have occurred in all motors making checking and taking required corrective action critical. The property has a number of power lines and transformer stations. An up to date single line diagram needs to be reviewed so that a coherent electrical distribution plan can be established which minimizes power costs without having to get into a comprehensive project relocating transformers etc. Below is a proposed activity programme necessary to confirm the functionability of the existing systems and modify them where required to ensure that **if** water needs to be treated a fully functioning system is available. Because the level of work required depends on initial findings this work schedule should be viewed as a guide only. In particular the pond pumps need to be pulled and inspected before an assessment of the work actually required can be made. It is possible that on inspection they need to be sent to the Chamco shop in Alberta for rebuilding. The initial electrical inspection, which would include ground fault determination, may indicate a different level of work than the minor level envisioned below.

The possibility of a conversion of the system to Caustic Soda rather than Lime service is unlikely to have significant cost implications. The installation of a manifold and two new metering pumps and delivery line to the reactor tank would replace all the work related to re-piping the lime loop, and checking the pumps and other components of the system. The detailed costs of the Caustic system are as follows (this assumes it is an extension to other site activity). It is assumed that the totes are free with reagent purchases. The pumps are probably 110v requiring minimal electrical work.

## 4.1 Caustic Soda System (costs in the table below represent only the caustic system)

| Activity | Engineering & Supervision (hrs) | Site Work (hrs) | Costs ($) |
|---|---|---|---|
| 1: Design System and Specify Equipment | 40 | | 3800 |
| 2: Purchase 2 Pumps & Controllers | 10 | | 5000 |
| 3: Build and Install Manifold | 10 | 40 | 2950 |
| 4: Electrical Installation | 10 | 24 | 2150 |
| 5: Instrumentation Installation | 16 | 16 | 2160 |
| 6: Mechanical Installation | 10 | 16 | 1750 |
| 7: Commissioning | 105 | 5 | 10,225 |
| 8: Project Management | 40 | | 3800 |
| **Total** | **241** | **101** | **31,835** |

## 4.2 Plant Reactivation

| Activity | CEMI Engineering & Supervision (hrs) @ $95/hr | Site Work (tradesmen hrs) @ $50/hr | Costs etc. ($) |
|---|---|---|---|
| 0A:Mobilization (2 Visits by CEMI Engineer/s travel to & from site)<br>0B: Kick off Meeting and establishing base criteria, including all discussion prior to actual first site visit | 36<br>30 | | 6270 |
| 1A: Check main electrical distribution drawings to plan electrical distribution<br>1B: Check transformers, Power lines & other systems deemed required<br>1C: Re-energize the system | 10<br>16<br>4 | <br>16<br>4 | 3850 |
| 2: Check & Clean MCC at pump station and Treatment plant | 8 | 16 | 1560 |
| 3: Mega motors and dry (warm) as required | 10 | 20 | 1950 |
| 4: Check panel instrumentation | 20 | 8 | 2300 |
| 5: Purchase and Replace pH probes | 4 | 4 | 3000 |
| 6: Re-pipe lime loop | 4 | 40 | 2380 |
| 7: Pull pumps at pump station and check components. | 10 | 10 | 1450 |
| 8: Check Flocculant system | 4 | 16 | 1180 |
| 9: Check lime system | 8 | 24 | 1960 |
| 10: Check & Repack Pumps | 4 | 24 | 1580 |
| 11: Start-up Assistance, commissioning | 105 | 10 | 10,475 |
| 12: Project Management | 40 | | 3800 |
| 13: Commissioning Report | 32 | | 3040 |
| **TOTAL** | **345** | **192** | **44,795** |

## 4.3 Instrumentation Upgrade For Remote Monitoring

Budgetary quotation to upgrade the water treatment plant for remote control and alarming via an existing phone line system. This quotation is based on the presumption that all the instruments at the plant are still useable and that a new controller is necessary to control the plant. This design will also be based on the P&ID drawings P662-A-006 rev 3 and P662-A-007 rev 3.

| Item | Description | Cost |
|---|---|---|
| 1 | I/O Panel Manufacturing | 9,200 |
| 2 | PLC Hardware (Allen Bradley equipment) | 13,500 |
| 3 | Additional Instrumentation/Hardware | 2,800 |
| 4 | Control/Alarm Software (Wonderware etc.) | 7,500 |
| 5 | Control Computer (PIII 800MHz NT workstation) x 2 | 6,000 |
| 6 | Project management and procurement (130hrs) | 12,350 |
| 7 | Engineering (280hrs) | 26,600 |
| 8 | Electrical installation (estimated at 150 hrs) | 7500 |
| 9 | Electrical control cables and supplies | 1500 |
| 10 | Commissioning (100hrs) | 9,500 |
| | Total | $96,450.00 |

The following are not included in the above tables and should be added for budgetary purposes:

1. Travel and expenses during site visits and commissioning.
2. Applicable taxes

## 4.4 Operating Costs

The operational costs for a lime and a caustic plant are difficult to determine for reagent costs, however the labour cost does not offer any advantages with one system or the other. A similar plant with the instrumentation capable of an alarm system requires operator presences for 5 to 8 hours per day. However during seasonal freshet conditions a higher level of operator presence is recommended to insure proper operation during increased water throughput and a visual inspection of ponds, etc. For budgetary estimates operator requirement for a continuous operation will be 2 operators with overlapping shifts 5 days a week, an on call operator to respond to alarms during weekend, off hours, and holidays, and an overall manager/supervisor. The equipment in the plant does not require too much attention other than the pumps. A standard maintenance contract with a local fabrication shop would require routine inspection once per month and plant operators will be responsible for minor repairs, lubrication, oil levels, motor and gearboxes overheating, etc. Inmet Mining Corp. Samatosum WTP (HDS plant with much more equipment and monitoring requirements) operates with 2 operators on part time basis with the manager working out of the Ontario Office. The instrumentation upgrade will enable operation with less operator presence, thereby lower overall operating costs.

The silica gel process does offer a number of advantages in that it requires reduced operator presence as there would be no need for lime/caustic preparation, flocculant preparation, and sludge settling pond. The operator would only be required during stripping and regenerating times and for visual inspection of the feed pump system. Based on the zinc and other metal concentrations the stripping regenerating will occur approximately 8 to 10 times a year (this can be determined from the onsite pilot plant study). The instrumentation upgrade will enable monitoring of process from town site and minimize the daily travel to the mine site. There would be less moving equipment in the plant, which would reduce labour and maintenance costs. This could have a significant savings on the operating budget through lower labour, maintenance, reagent consumption (provided pH of contaminated water stays neutral) and no sludge pond dredging. The stripped zinc hydroxide would typically be 2 to 4 g/L, which can be treated further to precipitate zinc hydroxide, filtered and shipped to a smelter for processing. The precipitated zinc hydroxide could potentially have some commercial value. The silica gel offers a number of areas of potential savings and a further evaluation recommended.

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