APPENDIX B TO PERMIT UGW450002

BARRICK RESOURCES (USA) - MERCUR MINE

VALLEY FILL LEACH AREA 3
GROUNDWATER QUALITY DISCHARGE PERMIT
FINAL CLOSURE PLAN

Original: October 28, 1991
Revision 1: January 13, 1995
Revision 2: January 1996
Revision 3: August 1996
Final: December 1997

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1.0 GENERAL

Appendix B to Permit UGW450002 provides a narrative of historic events involved in the permitting, operation and closure of Valley Fill Leach Area No.3 (VFL3). A construction permit for VFL3 was issued on July 13, 1990, by the Utah Department of Environmental Quality, Division of Water Quality (UDWQ). Conditional Groundwater Quality Discharge Permit No. UGW450001 was issued on July 10, 1990, with an expiration date of July 10, 1995. The conditional Approval to Operate the facility was issued in December 1991. The facility continued to operate with the approval of the UDWQ through 1997.

The formal renewal process for UGW450001 was accelerated from January 1995 to August 1994 to expedite necessary changes in ground water quality protection levels and operating conditions for VFL3. A renewed Ground water Quality Discharge Permit No. UGW450001, with conditions, was issued December 12, 1994, and expired December 12, 1999.

The following conditions were specified in Part I.H.1-3 of the renewed permit:

- Necessary revisions to the Quality Assurance/Quality Control Plan (QA/QC) as required by Part E.5.a of the renewed permit were submitted as Appendix A by January 13, 1995.

- Necessary revisions to the Conceptual Closure Plan as required by Part I.D.8 and I.H.2 were submitted as Appendix C by January 13, 1995. This revised Conceptual Closure Plan contained the following information:

    (1) Discussion of spent ore neutralization techniques
    (2) Discussion of final site contouring, drainage, and cover design
    (3) Discussion of post-closure ground water monitoring program
    (4) Discussion of post-closure facility monitoring

Submittal of a final VFL3 Closure Plan, pursuant to Part I.H.3 of the permit, was required no later than 90 days prior to the closure date of the facility. The original closure date for VFL3 was expected to be December 1997. Exhaustion of ore earlier than modeling predicted necessitated Barrick to call for cessation of leaching in mid-1997. Submittal of final proposed closure plans were strategically delayed until December 1997 to await results of the bioremediation activities for VFL3 and the installation of the dewatering well.

The UDWQ reviewed the January 13, 1995, revised conceptual plan and raised additional issues in correspondence dated October 6, 1995. Barrick responded to these additional concerns by incorporating changes into Revision 2 and submitting the plan on January 8, 1996.

On April 19, 1996, Barrick Mercur Mine management met with the UDWQ to discuss revisions to the conceptual closure plan. The UDWQ requested that Barrick perform column rinse studies to evaluate rinsing options for VFL3. As a result of the meeting, Barrick agreed with the UDWQ to perform column rinse studies. The results of these studies were presented in the August 1996 Conceptual Closure Plan (Revision 3) as Attachment 2 to the document.

The August 1996 Conceptual Closure Plan was approved by the UDWQ on May 23, 1997.On June 4, 1997, Barrick Mercur Mine management met with the UDWQ to discuss the operating plan for the detoxification of VFL3 using bioremediation techniques. Results of the bioremediation activities are documented in “Cyanide Bioremediation of Barrick Mercur’s VFL#3 Heap Leach Pad” contained in Appendix A to this closure plan.

During the June 4 meeting, Barrick also discussed the submission of a plan for installation of a vertical dewatering well in VFL3 to remove residual saturation from the sub ore during closure activities. The dewatering well plan and technical specifications were submitted to the UDWQ on June 15, 1997 and approved by the UDWQ during July 1997. The well was drilled and completed between the dates of October 20 through October 28, 1997. Details of the construction of the well are contained in “Dewatering Well Installation, Valley Fill Leach Area #3, Barrick Mercur Gold Mine”, Appendix B to this closure document.

It should be noted that the closure plan for VFL3 is only one component of the overall Mercur Mine Comprehensive Final Closure Plan. The development and implementation of the Mercur Final Closure Plan is a dynamic activity and may necessarily require minor modifications in any ultimate VFL3 closure plan scenario. The Mercur Closure Plan was developed pursuant to the cessation of mining activities in 1997 and milling activities in 1998 and submitted to the Utah Division of Oil, Gas, and Mining as well as to the UDWQ for their respective jurisdictional approvals.

2.0 FACILITY DESCRIPTION

VFL3 was utilized for the cyanide leaching of subore from the Mercur Mine from December 1990 to October 1997. Ore loading ceased in February 1997. The facility operated until October 1, 1997 for gold recovery. Gold recovery continued through bioremediation between the dates of June 16 through October 1, 1997. VFL3 has been closed. Section 3.0 describes the closure procedures implemented and post-closure physical and ground water quality monitoring at VFL3.

3.0 CLOSURE PROCEDURES

3.1 Neutralization

Following optimum resource recovery from VFL3, the application of cyanide solution for gold leaching was discontinued in June 1997. Cyanide and reagent storage, support systems, and all non-essential elements of the VFL3 plant were converted for bioremediation purposes. Carbon tanks were used to polish rinse solutions with activated carbon. Pumping, piping, and all essential elements of the existing plant necessary to carry out the neutralization and closure program were utilized during bioremediation activities, which were carried out between the dates of June 16 through October 1, 1997. Solution application systems used for cyanide application were converted for the use of neutralization solution and bioremediation application. Upon completion of the bioremediation process, the plant was dismantled.

VFL3 was neutralized in 1997 primarily for cyanide-WAD and pH using the following methodologies:

- An initial neutralization using recycled VFL3 barren solution without cyanide fortification in order to reduce the cyanide-WAD levels;
- Incidental rinsing with natural precipitation to provide additional make up water to the system;
- Bioremediation treatment through inoculation of recycled barren solution.

The goal of the 1997 neutralization effort was to achieve rinsate solution characteristics that will, under long-term infiltration conditions, be protective of the ground water regime underlying VFL3. Bioremediation treatment using inoculation of indigenous bacteria was accepted in the August 1996 Conceptual Closure Plan as the preferred method of treatment. Bioremediation was initially evaluated through column rinse test studies (Attachment to the August 1996 Revised Conceptual Closure Plan). Both the column rinse test results using process waters from VFL3, and the bioremediation effort during 1997 at VFL3 indicated that this method of rinsing provided a relatively rapid decline in cyanide-WAD concentrations while minimizing the addition of water to the system. Reductions in the levels of arsenic, mercury, copper, and nickel were also achieved. Results of rinsing VFL3 during 1997 with the addition of bacteria are contained in Appendix A to this document.

Experience obtained in the neutralization of previously closed Valley Fill Leach Areas 1 (VFL1) and 2 (VFL2) was also drawn upon during the VFL3 neutralization effort. VFL1 experienced limited fresh water application followed by an extended period of natural precipitation infiltration prior to capping. VFL2 was rinsed with tailings reclaim solution, fresh water, natural precipitation, and reclaim solution treated with ferric sulfate. The final closure plan for VFL2 was approved in May 1995 and is currently being implemented.

Barrick did not anticipate additional rinsing of the VFL3 sub ore (with the exception of natural precipitation) beyond the 1997 rinsing performed during the bioremediation of the heap. Any additional applied fresh water may increase the level of environmental impact associated with water balance considerations during the closure of the tailing impoundment. Samples taken from the dewatering well at VFL3 indicated that the bioremediation achieved the goals of neutralization.

The schedule of events for VFL3 neutralization included:

- May 1997: Cyanide solution application for gold leaching was discontinued. All solutions were managed at the VFL3 plant and recirculated within VFL3. Rinsing of VFL3 spent ore was accomplished using barren recycle solution for additional incremental gold recovery and physical displacement of residual free and WAD cyanide.

- Bioremediation treatment was initiated through inoculation of the recycled barren solution being applied to the heap between the dates of June 16 through October 1, 1997.

- A 6-inch vertical dewatering well was completed to 174.5 feet below grade in the deepest portion of the cistern basin. The well was completed and tested on October 27, 1997. All neutralization waters were managed within VFL3 and to the tailing impoundment following neutralization. The schedule for this activity was subject to water balance considerations within the tailing impoundment and incorporated neutralization "'rest–periods''.

- November 1997-1999: Natural precipitation intermittently infiltrated the VFL3 neutralized ore and was managed within VFL3 prior to dewatering to the tailing impoundment. No application of pumped potable water was used.

1998 activities consisted of completing design infiltration and plume transport modeling efforts and initiating physical closure activities. Physical closure activities were initiated at the beginning of the construction season in 1998, and included:

1. Grouting both the upper the lower leakage collection system pipes and removing the LCS tankage. Grouting the leakage collection system was completed because the upper leakage collection system discharged at a de minimus average rate of 26 gallons per month while the lower leakage collection system was always dry.

2. Subsoil cover placement on the sub ore.

3. Topsoil placement and seeding.

4. Dismantling and removal of reagent storage, support systems, and all non-essential elements of the VFL3 plant.

Solution characteristics were monitored pursuant to the applicable VFL3 Ground Water Quality Discharge Permit UGW450001 and associated Quality Assurance/Quality Control Plan.

3.2 Dewatering

The removal of solutions from VFL3 will be managed by pumping solutions to the East Bay where the water can be treated for nitrate and arsenic and be discharged into the Golden Gate Basin

3.3 Facility Decommissioning

Upon approval from the UDWQ that the neutralization effort had achieved acceptable rinsate characteristics, all distribution piping was decommissioned. The operating pumping system will be operated as long as the system is required to maintain pumping from VFL3 to the East Bay and then decommissioned in favor of the vertical dewatering well. The dewatering well will remain intact for the term of the permit. Upon completion of all spent ore dewatering activities, the plant site, cistern, dewatering well, and all associated components will be dismantled and disposed of or salvaged in accordance with applicable law. Power supply components, ground water wells, area lighting, and associated devices will remain to accommodate the post-closure ground water monitoring period.

3.4 Shaping / Contouring

VFL3 was loaded at a 3:1 horizontal:vertical configuration to accommodate final shaping. Drawing Valley Fill Leach Area 3, 3:1 Contour, December 16, 1994, which was provided with the August 1996 Conceptual Closure Plan, depicts this configuration.

Following the decommissioning of the solution distribution piping, the spent ore was contoured and shaped to a configuration and bearing capacity sufficient to support a final cover. Approximately 70 percent of VFL3 was constructed with an overall side slope of 3:1.

The two upgradient drainages were filled with mine overburden material to an elevation consistent with the two roadways passing around the VFL3 site on the west and east sides. The tops of these filled areas were topsoiled, and the drainages routed to tie into the above-mentioned channels.

3.5 Cover Placement

The final cover placed in 1998 consists of two distinct zones: (1) a nominal three-foot layer of subsoil, and (2) a nominal one-foot layer of topsoil which demonstrates application of Best Available Technology. Justification for this conceptual cover design is provided in the report entitled "Infiltration and Solute Transport Analysis, August 1996, TriTechnics Corporation for Barrick Mercur Mine" which was provided with the accepted August 1996 Conceptual Closure Plan. The cistern and vertical dewatering well pumping systems will be removed and cover installation completed in these limited areas only after the decision is made by UDWQ/Barrick that additional pumping of residual heap solutions is not warranted as a result of cover effectiveness.

3.6 Erosion Control / Revegetation

The final topsoil cover was graded to prevent significant ponding of water. Additionally, Best Management Practices to mitigate erosion potential were practiced. Concurrent with the erosion control placement, the topsoil was seeded by hydroseeding or other methods approved by the Utah Division of Oil, Gas & Mining. A seed mixture of native grasses, legumes and shallow-root brushes were utilized at VFL3. All seed mixtures were applied with appropriate mulch and fertilizer.

3.7 Post-closure Facility Monitoring

Post-closure monitoring will ultimately be designed to satisfy the various regulatory agencies with applicable oversight. Monitoring of the revegetative effort will continue while ground water post-closure monitoring is being performed. The goal of the revegetation is to achieve adequate plant growth that is self-propagating within a period of three growing seasons, in accordance with the Utah Department of Natural Resources, Division of Oil, Gas & Mining surety bond release provisions. Monitoring of facility stability and erosional impacts, and general security matters will be maintained until Barrick has accomplished all site responsibilities. Monitoring of the final cover will consist of quarterly inspections during the revegetation period for cover erosion, settlement, animal burrows, drainage ditch conditions, and plant growth. Immediate repairs will be undertaken as necessary to return the spent ore cover to the original post-closure conditions.

Access to the reclaimed VFL3 may remain open indefinitely utilizing the historical public access road to the east side of the site up Meadow Canyon, as mandated by Barrick's conditional use permit with Tooele County and agreements with adjacent landowners. Alternate routing away from VFL3 will be evaluated as well as protective barriers for VFL3 access.

4.0 POST-CLOSURE FACILITY GROUND WATER QUALITY MONITORING

Permanent closure and final reclamation of the VFL3 was initiated in 1998 as part of a mine-wide closure. Under previous versions of these permits, permanent closure and final reclamation requirements that are protective of ground water were incorporated. Ground water monitoring during the post-operational phase of VFL3 will be governed by applicable permit conditions. Ground water quality monitoring will continue for the life of the permit.

Compliance

Technology

Innovative Systems for the
Remediation of Mine and
Industrial Process Waters

Cyanide Bioremediation of Barrick Mercur's VFL #3
Heap Leach Pad

November 4, 1997

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Executive Summary

Active cyanide detoxification was pursued at Barrick Resources (USA) Inc., Mercur Mine Valley Fill Leach #3, (VFL #3) heap leach pad to ensure that low levels of residual WAD cyanide could be achieved. Testing of several detoxification methods showed that bioremediation was capable of increasing the rate of cyanide destruction

A bioreactor was constructed at the VFL #3 process area. The purpose of the bioreactor was to grow large numbers of cyanide-degrading bacteria in a short period of time. Laboratory testing had shown that the VFL #3 process solution contained indigenous cyanide-degrading bacteria and that these bacteria populations could be increased to high numbers (lO8 cells/mL) using brewers yeast extract as the bacterial nutrient.

The bioreactor consisted of a 4000-gallon, stirred tank to which VFL #3 process solution and nutrient were added on a continuous basis. The bioreactor was heated using an immersion heater and air was bubbled into the tank to maintain aerobic conditions. The bioreactor produced a high bacteria inoculum that flowed into the barren surge tank. Solution flow through the bioreactor was initiated June 16, 1997. The bioreactor was operated until October 1, 1997.

Within a month after initiation of bacteria addition, the WAD cyanide concentration in the VFL #3 pregnant solution decreased from about 29 mg/L to less than 0.56 mg/L. Much of this initial decrease was natural degradation of free cyanide. By October 1, 1997, the entire surface of VFL #3 had been sprayed with bacteria inoculum. The resultant rinsate from all parts of the pad contained between 0.20 and 0.56 mg/L WAD cyanide; the target WAD cyanide concentration of 0.20 mg/L was achieved on a sporadic basis through the inoculum period

The concentrations of metals present as WAD cyanide complexes also decreased, indicating that the bacteria were indeed destroying the WAD cyanide. The copper concentration in the pregnant solution dropped from 0.97 to 0.0 18 mg/L, while mercury concentrations decreased from 1.3 to 0.002 mg/L. Nickel, which forms a particularly strong WAD cyanide complex, dropped from 1.3 to 0.02 mg/L. Since arsenic in the VFL #3 process solution is not present as a cyanide complex, cyanide bioremediation did not have a significant effect on the arsenic concentration.

Introduction

Options for cyanide detoxification of Barrick Mercur's 5-million ton Valley Fill Leach #3 (VFL #3) heap leach pad were evaluated in May of 1996. Column rinse tests were performed at this time to compare five rinsing/detoxification techniques. These techniques included barren solution recycle, fresh water rinsing, hydrogen peroxide treatment, ferrous sulfate treatment and bioremediation. Although fresh water rinsing provided the fastest detox, this technique would generate a large amount of rinsate requiring handling problems at the tailing impoundment. Of the other methods tested, bioremediation provided the quickest reduction in cyanide and was chosen as the method for detoxification of the VFL #3 heap. These column rinse test results were summarized in a report to Barrick Mercur dated July 22, 1996.

Bioremediation involves growth and application of cyanide-degrading bacteria *(Pseudomonas pseudoalcaligenes)* to the heap leach pad. These bacteria metabolize the cyanide, utilizing the nitrogen to form amino acids, while the carbon is either taken into the bacteria cellular structure or released as carbon dioxide. Consequently, byproducts from cyanide bioremediation are nontoxic.

A lab-scale continuous bioreactor was operated to determine full-scale operating conditions and best nutrient. This testing indicated that a 2400-gallon bioreactor with a continuous flow of 3.3 gpm would result in a bacteria population of 10^6 cell/mL in the barren solution flow to the pad. The nutrient which provided the best growth of bacteria was Amberex 1003AG, an agglomerated brewers yeast extract.

Conversion of the Cyanide Tank to a Bioreactor

Cyanide bioremediation was performed at the VFL #3 heap leach pad by growing cyanide degrading bacteria to a high population in a continuous flow-through bioreactor and adding these bacteria to the barren solution sprayed on the pad. A 4000-gallon tank capable of achieving the designed flowrate and population of bacteria was converted to a bioreactor. The bioreactor was configured according to Figure 1. The following modifications were made to the tank:

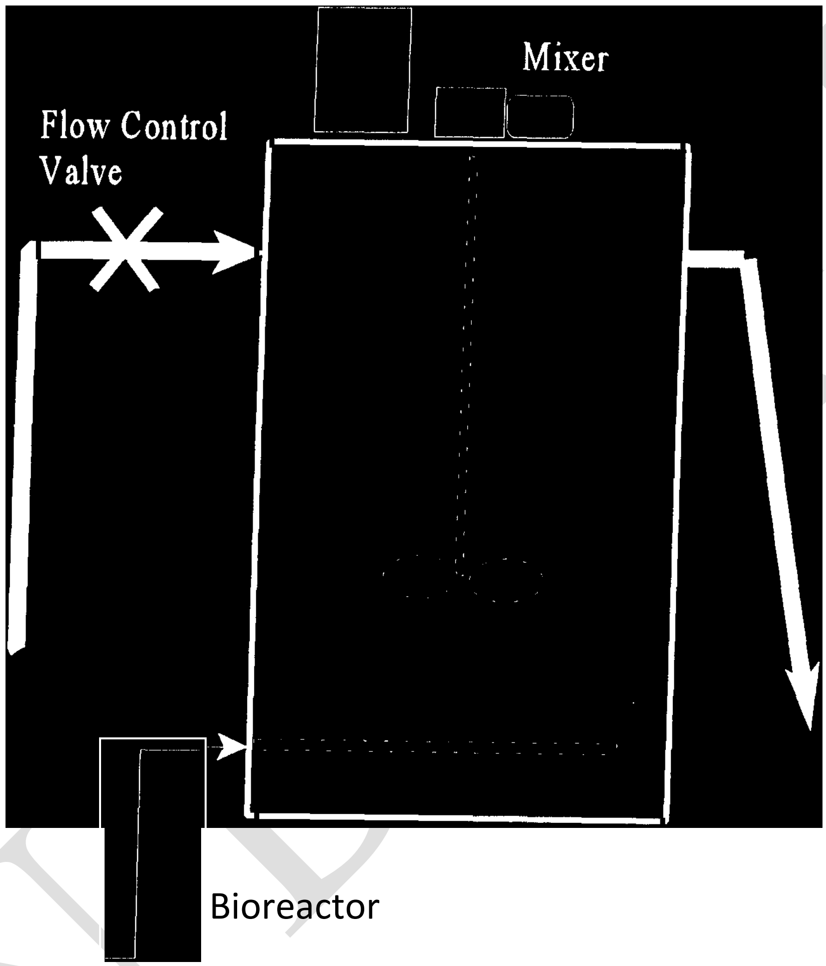
- The original cyanide mix tank was used to feed the bioreactor because a pump and flowmeter already existed at the discharge of this tank which could control flow to the bioreactor in the range of 0 to 5 gpm. In addition, the mix tank contained a heater which could preheat the barren solution.

- The mixer, which had one impeller mounted on a 4-ft shaft, was overhauled to handle continuous service.

- A small vane-type air compressor, capable of delivering 9 cfm air, was mounted to the sideof the tank to provide air for the aerobic bacteria. The air was fed to the reactor via a 1-inch pipe mounted horizontally across the tank below the mixer. Small holes were drilled

FIGURE 1 Full Scale Bioreactor

Dry Yeast Feeder



Preg Solution from Holding Tank

To

Barren

Surge

Bioreactor

Tank

4000 -

_ The outlet of the bioreactor was piped to allow the tank to maintain a full level at all times. Thus, the tank was operated by solution overflow. The outlet drained directly to the carbon column discharge surge tank.

_ A dry-powder screw feeder (Accu-rate) was installed on top of the mix tank to feed the Amberex 1003AG. The discharge of the feeder was enclosed to prevent wind loss of the nutrient .

_ .Thermostatically-controlled immersion heaters were used in both the bioreactor and the holding tank to maintain a temperature of about 70^0F (heating the pad runoff from *45* to 70^0F significantly increases the growth rate of the bacteria)

Initiation of Bacteria Growth

The growth of bacteria in the bioreactor was initiated the week of June 9, 1997 by filling the bioreactor with barren solution One forty pound bag of Amberex lOO3AG was added to the reactor. The mixer was turned on and air flow to the reactor was initiated. Indigenous bacteria in the barren solution began to multiply. By June 16, 1997 the bacteria population in the bioreactor had increased to 5.6 x lO^8 cells/mL No barren solution or nutrient was added during this growth period. Bacteria populations were measured with a microscope using a Petroff-Hauser counting chamber.

Continuous-Flow Operation

On June 16, 1997, solution flow through the bioreactor was begun, thus, initiating the bacteria inoculation into the barren surge tank; the bacteria-laden barren solution was then sprayed onto the pad. Amberex 1003 AG was continuously fed to the reactor with the screw feeder. The bioreactor was operated from June 16, 1997 until October 1, 1997 with intermittent shut-downs. The shut-downs were caused by power outages; problems with the air compressor and the mixer also caused shutdowns. Some of the interruptions required that the bacteria population be allowed to increase before restarting flow-through operation.

The bioreactor was monitored for pH, dissolved oxygen, temperature, solution flow and nutrient feeder setting (Table 1). A bacteria population of 10^7 to 10^9 cells/mL was maintained in the bioreactor during flow-through operation. Bioreactor temperature was maintained at 64 to 78^0F. During flow-through operation, the dissolved oxygen concentration remained below 1 mg/L which is an indication of significant biological oxygen consumption An unsuccessful attempt was made to increase the oxygen concentration in the bioreactor by adding baffles to increase mixing efficiency. The bacteria produced in the bioreactor during continuous operation were aerobes even though the dissolved oxygen concentrations were low. Conditions in the bioreactor may have become anaerobic on two occasions when solution flow through the tank was disrupted.

In addition to monitoring the bacterial population in the bioreactor, bacteria cell counts were measured in the pregnant solution to determine if bacteria addition to the pad was affecting the bacteria population at the bottom of the heap. Table 2 shows the pregnant solution bacteria population from April 21, 1997 through September 25, 1997. Bacteria populations varied significantly throughout bioremediation.

WAD Cyanide Detoxification During Water Rinsing and Bioremediation

During the period of bioreactor operation, June 16 to October 1, 1997, barren solution sprays were moved across the pad, inoculating the entire surface of VFL #3 with bacteria. Table 3 shows the volume of solution sprayed onto VFL #3 during bioreactor operation.

Table 4 shows the WAD cyanide concentration, temperature, dissolved oxygen and pH of the pregnant solution from the pad which was measured periodically by Compliance Technology. Figure 2 shows this data graphically. The WAD cyanide concentration in the pregnant solution was above 26 mg/L before initiation of bioremediation on June 16, 1997. This concentration decreased to below 0.6 mg/L by July I0 and remained in the range of 0.20 to 0.56 mg/L throughout the remaining period of bioremediation. The main reason the WAD cyanide concentration did not continue to decrease is that barren solution was applied to portions of the pad not yet inoculated with bacteria. This flushed out cyanide from areas not yet remediated. By the time bioremediation was suspended on October 1, 1997, the entire surface of the pad had seen bacteria inoculums and solution spray. The consistency in WAD cyanide analyses over several months gives some assurance that the WAD cyanide concentration is between 0.20 and 0.56 mg/L in the process solution throughout the entire pad.

The decrease in the WAD cyanide concentration of the pregnant solution may not be fully attributable to bioremediation. During rinsing of heap leach pads in general, free cyanide concentrations will decrease relatively quickly even without active treatment. Once the free cyanide is gone, the remaining cyanide is tied up in metal/cyanide complexes. For example, the VFL #3 process solution contained copper, nickel and mercury cyanide complexes. Based on the original concentrations of these metals in the VFL #3 process solution, the rate of cyanide detoxification should have significantly slowed when the WAD cyanide concentration reached 3 to 4 mg/L. The rate of cyanide detoxification did not slow until the WAD cyanide concentration reached 0.5 mg/L, indicating bioremediation may be partially responsible for the quick rate of cyanide detoxification.

Dissolved oxygen levels in the pregnant solution were generally less than 1 mg/L after June 30, 1997 indicating the oxygen was being consumed within the pad. Pumping through the process plant and spraying the pad reoxygenated the solution. Measurement of oxygen in the barren solution returning to the pad showed a near saturated concentration of 7 mg/L

WAD Metals Reduction During Bioremediation

Metals analyses were conducted by AEC Laboratory **(**a State of Utah certified lab) on samples of pregnant solution every one to two weeks; analytical reports from AEC are appended to this report. Samples were analyzed for arsenic copper, mercury, nickel, and silver. Mercury was measured using hydride generation atomic absorption; the other metals were analyzed using an inductively coupled plasma technique. The concentrations of metals which form WAD cyanide complexes (copper, mercury, nickel and silver) are shown in Table 5 and in Figures 3, 4 and 5. The concentrations of these metals decreased as a result of cyanide detoxification.

Copper. The concentration of copper in the pregnant solution decreased from about 1 mg/L to below the detection limit of 0.05 mg/L during bioremediation as shown in Figure 3. The sample taken on October 1,1997 was analyzed by JCP/mass spectroscopy which gave a lower detection limit. The copper concentration in this sample was 0.018 mg/L.

Mercury. The mercury concentration in the process solution was above 1 mg/L during leaching and water rinsing. Once bioremediation was begun, the mercury concentration in the pregnant solution decreased to about 0.003 mg/L as shown in Figure 4. Reducing the mercury concentration is important due to the particularly low drinking water MCL of 0.002 mg/L.

Nickel. The nickel concentration decreased slowly from about 1 .3 mg/L to less than the detection limit of 0. 1 mg/L during the period of rinsing and bioremediation as shown in Figure 5. The final sample was analyzed by ICP/mass spectroscopy to lower the detection limit. The nickel concentration in this sample was 0.020 mg/L

Silver. The silver concentration in process solution was relatively low (<0.05 mg/L)

Arsenic Concentration during Bioremediation

The arsenic concentration in the process solution remained between 0.36 and 1. 1 mg/L during leaching and bioremediation as shown in Figure 6. In heap leach process solutions, arsenic is generally present as arsenite, AsO_2 or arsenate, AsO_4-^{3}, not as a cyanide complex; thus, cyanide bioremediation does not have a significant effect on reducing the arsenic concentration.

Conclusions

Several conclusions can be made from the data presented in this report, including:

_ Cyanide-degrading bacteria were successfully grown and applied to the VFL #3 leach pad

_ The combination of natural degradation and bioremediation reduced the WAD cyanide concentration in the rinsate from all portions of VFL #3 to less than 0.56 mg/L

- The concentrations of the WAD cyanide metals (copper, mercury, nickel and silver) were significantly reduced. The total concentration of these metals as of October 1, 1997 was less than 0.05 mg/L, indicating almost complete destruction of the WAD cyanide complexes.

APPENDIX b TO FINAL CLOSURE PLAN

GROUND WATER QUALITY DISCHARGE PERMIT
UGW450002

DEWATERING WELL (DW-20) INSTALLATION
VALLEY FILL LEACH AREA #3
BARRICK RESOURCES (USA) Inc.
- MERCUR MINE FINAL REPORT

DEWATERING WELL (DW-20) INSTALLATION
VALLEY FILL LEACH AREA #3
BARRICK RESOURCES (USA) Inc. - MERCUR MINE
FINAL REPORT

December 21, 1997

GLOBAL ENVIRONMENTAL TECHNOLOGIES, L.L.C.
Salt Lake City, Utah

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1.0 INTRODUCTION

On October 27, 1997, Barrick Mercur Mine completed the installation of a vertical dewatering well (DW-20) at the Mercur Mine Valley Fill Leach Area #3 (VFL3). The concept of the dewatering well was modeled in the "Infiltration and Solute Transport Analysis, Valley Fill Area #3, Barrick Mercur Mine" dated August 15, 1996, included as an attachment to the Interim Conceptual Closure Plan for VFL3, submitted in August 1996. The plan was approved by the Utah Division of Water Quality (UDWQ) on May 23, 1997. The installation of the dewatering well was discussed during a joint meeting between Barrick and the UDWQ on June 4,1997, and the specifications for the well and engineering drawings were presented in a document to the UDWQ on June 15, 1997. The purpose of the well is to provide maximum dewatering capability to VFL3 following cessation of leaching and sub ore neutralization, and to minimize the potential for infiltration through the liner during closure and following placement of the engineered cover. Operation of the dewatering well is expected to follow the modeled duration used in VFL3 infiltration model. The well was located using VFL3 as-built drawings and survey datum taken during the construction of VFL3. As-built drawings were used to provide the location of the deepest portion of the permanent process pool, and to ascertain elevations for the liner and the top of the Golden Gate Tailing Blanket. The boring was collared at a surveyed elevation of 7211.37 feet msl at coordinates N. 27303.13, E. 20891.14. This location was confirmed by a licensed professional surveyor prior to initiation of drilling. Barrick provided access to this location and constructed a drill pad location prior to drilling. Location of the well is shown on Figure 1. The well bore was advanced through approximately 170 feet of leached sub ore that was loosely consolidated to unconsolidated. Spent ore materials rest on historic Golden Gate Tailing, used as a blanket liner. This is shown on as-built drawings to have a thickness of 4 to 5 feet, and directly overlies a polyethylene flexible membrane liner (FML). VFL3 covers approximately 26 acres. The facility is located in the southern end of the Oquirrh Mountain Range in Meadow Canyon, within the northwest quarter of Section 5, Township 6 South, Range 3 West, and the south-west quarter of Section 32, Township 5 South, Salt Lake Base and Meridian. VFL3 has been in operation since December 1990.

1.1 Scope of Work

Barrick contracted the drilling, well installation, and well development for the dewatering well. Barrick issued technical specifications for well construction to the drilling contractor. Well drilling was performed by Layne Christensen of Salt Lake City, Utah. Well construction oversight, development, testing and sampling of the neutralized process water was performed by Global Environmental Technologies (GET) personnel. Barrick contracted the laboratory analysis to CHEMTECH Ford Chemical Laboratory in Salt Lake City, Utah. GET provided quality assurance, engineering and geological services during the field activities. The objectives of services provided by GET were to:

- Observe drilling and well construction activities in order to provide Barrick with quality assurance control, and;

- Collect and evaluate technical information.

The scope of services performed by GET included:

- Observation of drilling and well construction activities to evaluate conformance with technical specifications for dewatering well DW-20;
- Observation of well drilling to document that the optimum depth of drilling had been achieved, and the boring did not penetrate the liner materials;
- Development and pump installation;
- Compilation and interpretation hydrologic information. The boring was logged and hydraulic conditions were evaluated following the performance of well testing;
- Preparation of this summary report. Details of field activities are included in the appendices.

2.0 FIELD ACTIVITIES

Field activities included technical observation of the drilling and installation of well DW-20 and performance of well testing. Water quality samples were collected during the specific capacity test by GET. The results of the initial water quality analysis are presented in this report in Attachment A.

2.1 Drilling and Well Construction

Drilling, well installation, well development, and well testing were performed by Layne Christensen Drilling of Salt Lake City as contracted directly with Barrick. The boring was drilled with a Schramm 685 drill rig using ODEX reverse drilling methods. Drilling fluids included only air. The boring was drilled to a total depth of *174.7* feet below grade, and the outer ODEX casing was advanced directly behind the drill bit to avoid collapse of the loosely consolidated sub ore materials. Ore materials consisted of sand to boulder size particles that were loaded onto the valley fill through dumping from trucks. Air monitoring for cyanide was conducted throughout drilling and well construction activities. Air monitoring indicated that no cyanide was encountered in the boring during drilling or construction of the well.

The well was constructed using 6-inch Schedule 80 PVC materials in accordance with specifications issued by Barrick. No significant unforeseen conditions were encountered, and no modifications were made to construction procedures. Figure 2 shows the schematic construction details of the well.

Ten—inch ODEX casing was advanced through the neutralized ore to a depth of 173 feet. At this depth, drilling characteristics indicated that a softer (Golden Gate Tailing blanket) had been intercepted, which was confirmed by the nature of the return cuttings from the cyclone. Drilling commenced for approximately 1 additional foot into the tailing material.
The 10-inch casing was left in place, and a Mills Knife was lowered to the bottom of the casing. Four knife slots per foot of steel casing section were made between depths of 174 to 154 feet below grade.

The 20-foot section of PVC screen was lowered into the steel casing, with stainless steel centralizers attached at the base, middle and top of the screen. A PVC end cap was used to close the bottom of the screened assembly. Screen slot size was 0.040 inches. The screen was gravel packed using tremie methods. The gravel pack was a 8-16 cleanwashed Colorado Silica Sand, which extended from the bottom of the boring to 138.5 feet below grade. A 6-foot bentonite pellet seal was placed directly on the gravel pack to a depth of 132.5 feet. A neat-cement grout, placed using tremie methods was used to seal the well to the surface.

<u>2.2 Well Development and Testing</u>

The well was developed initially using a bailer to remove development sand and fine materials generated during the drilling of the boring. Water discharged from the well was collected in a container and inspected for the presence of sand pack and cuttings materials. Development was considered complete when the presence of these materials was negligible.

Attachment B contains detailed information on well development and testing. A short-term specific capacity test was conducted to provide estimates of specific capacity for the well in order to size pump requirements. The well was initially pumped at a constant rate. Throughout the testing, the pumping rate was increased and held in order to assess the changes in drawdown relative to the changes in pumping. Water levels initially dropped during each step of increase in discharge rate, but then began to recover as the increased rate was held constant. This recovery made assessment hydraulic parameters, such as transmissivity or hydraulic conductivity difficult to estimate with any degree of reliability. Water levels were measured periodically using an electric water level probe. Well DW-20 was pumped at rates varying from approximately 13.5 to 22 gpm, the fullest capacity of the pump.

2.3 Water Level Measurements

Prior to and after well completion and development, depth to water was measured using an electric probe and measuring to the nearest 0.01 foot. Water levels fluctuated between 162.15 to 163.50 feet below grade.

2.4 Water Quality Sampling

Water quality samples were collected by GET during the test on October 28, 1997. An initial sample was obtained at the beginning of the specific capacity test (DW-20-0), and then at approximately 2 hours into the test (sample DW-20-45), and a final set (DW-20-90) obtained after about 4.5 hours of pumping. Samples were analyzed by CHEMTECH Ford Analytical Laboratory of Salt Lake City, Utah. Attachment A contains water quality analyses for well DW-20.

Based upon the October 28, 1997 sampling analytical results of well DW-20, water quality indicates the following:

- The pH of the water remained constant at 7.10 throughout the test, and;

- Weak acid dissociable (WAD) cyanide concentrations consistently dropped throughout the test, from 0.70 mg/I to 0.082 mg/I at the end of the test.

3.0 Summary and Conclusions

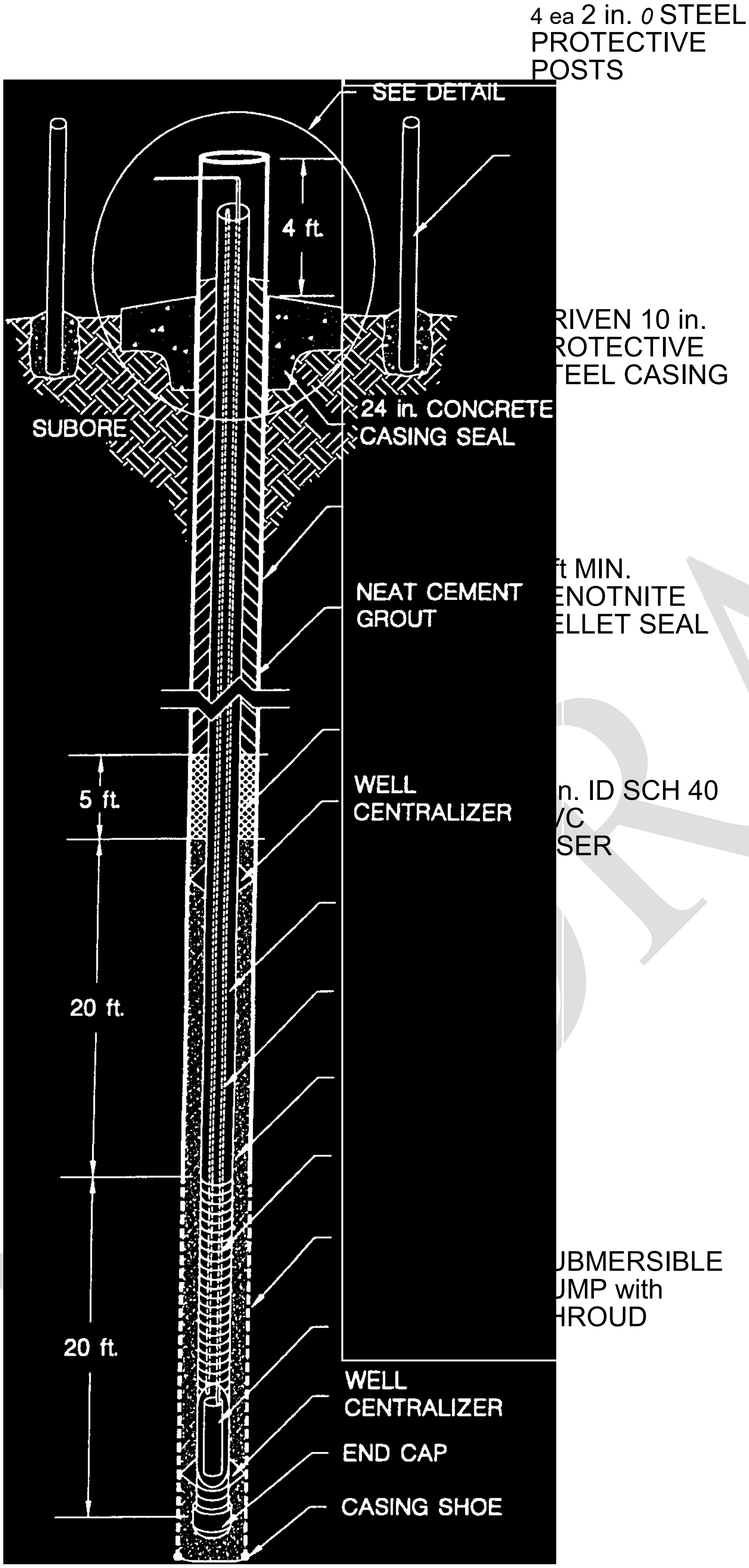
Results and conclusions of this study are summarized as follows:

1. Well DW-20 was drilled through neutralized sub ore to a total depth of 174 feet where the Golden Gate Tailing blanket was intercepted. The VFL3 liner was not reached or disturbed during drilling or construction.

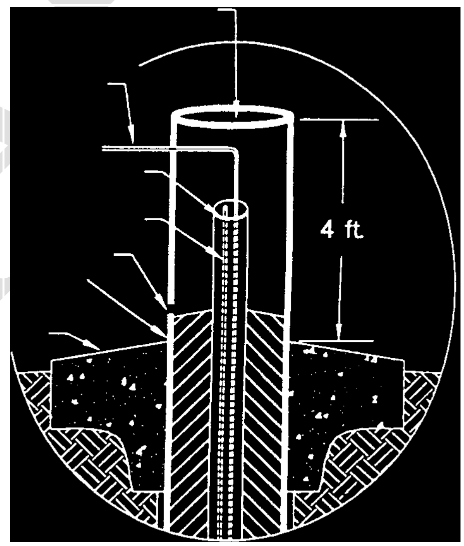
2. Completed installation depth of the vertical dewatering well will allow for essentially complete dewatering of VFL3 to a level above the liner that was modeled in the Infiltration and Solute Transport Analysis submitted with the August 1996 Conceptual Closure Plan for VFL3.

3. DW-20 was pumped at rates up to 22 gpm. Specific capacity was estimate to be 13 gpm per foot of drawdown at the end of the test. Hydraulic conductivity could not be estimated from the data.

4. Measurements of pH and cyanide-WAD obtained from the final water samples during the specific capacity test indicate that the neutralization of the sub ore through bioremediation techniques achieved the goals of the neutralization for both parameters.



ATTACHMENT A



WATER QUALITY CERTIFICATES OF ANALYSIS

ATTACHMENT B1
WELL TEST METHODS, DATA AND ANALYSIS

1.0 INTRODUCTION

A short-term specific capacity pumping test was conducted in well DW-20 on October 28, 1997 to estimate the specific capacity of the well. The average pumping rate and total drawdown measured during the test and the specific capacity, estimated from the test are estimated from measurements taken during the test. This attachment describes field methods used to conduct the test, presents the data obtained from the test, and summarizes the analytical methods used to estimate specific capacity.

2.0 FIELD METHODS AND DATA

The short-term specific capacity pumping test of well DW-20 was conducted using a temporary 4-inch submersible pump. On the day of the pumping test the pump was turned on from approximately 11:36 AM to 13:07 PM to adjust the pumping rate. Pumping rate measurements were made using a calibrated bucket and stop watch. The water level was allowed to recover for about 7 minutes after the pump was turned off before capacity test was started. The pumping test was conducted from 13:14 to 16:27 PM, a total pumping period of 193 minutes. Recovery measurements were obtained, but were not useful data because the water from the pumping column drained into the well.

Water level measurements were made during the test using an electric water level meter. Depth to water measurements, the time of each measurement, and the drawdown, recovery, and residual drawdown calculated were recorded during the test.

3.0 EVALUATION OF DATA

The recorded pumping rates ranged from 13.5 to 22.5 gpm. For most of the test the pumping rate was 20 gpm. A maximum drawdown of 2.4 feet was observed after about 3 minutes of pumping. The water level observed during the rest of the test rose up to about a foot or more, despite the increases in pumping rates during the test. The reason for the rise in water levels is unclear, because it does not appear to coincide with the snowmelt that was occurring during the test. A possible explanation for the rise in water levels is a decrease in pumping rate that occurred in the first few minutes of the test caused by the head loss associated with lifting water from the pumping water level to the ground surface. The first pumping rate measurement was made after approximately 3 minutes of pumping.

The water level rose to above the static water level during the recovery because the pump was not equipped with a check valve, which allowed water in the discharge pipe to flow back into the well.

4.0 Specific Capacity

According to Lohman (1972), specific capacity is equal to the pumping rate divided by the observed drawdown at a specified time during pumping. The drawdown observed at the end of the test (1.61 feet) was divided into the pumping rate measured at the end of the test (21 gpm) to obtain an estimated specific capacity of 13 gpm/foot for well DW-20.

REFERENCES CITED

Lohman, S.W., 1972, Ground-Water Hydraulics: U.S. Geological Survey Professional Paper 708, 70 p.