

## UNITED STATES ENVIRONMENTAL PROTECTION AGENCY REGION IX

75 Hawthorne Street San Francisco, CA 94105 Mail Code: W-6-3 June 27, 1996

Mr. John Kline BHP Florence Project 14605 East Hunt Highway Florence, AZ 85232

RE: TECHNICAL REVIEW OF THE BHP IN-SITU COPPER MINING PROJECT

Dear Mr. Kline:

We have completed the Technical Review of the Florence In-Situ Copper Mining Project. Based on our review of BHP's Class III Underground Injection Control (UIC) permit application and BHP's request for an aquifer exemption, we raised the following issues. Please examine our responses and reply at your convenience. The questions or concerns produced from our review are open for discussion and we encourage you to call our office with your questions. We have broken the comments into two parts. John Hillenbrand's hydrogeology comments are provided as Part I. My overall comments are provided as Part II.

We have enjoyed working on this exciting project and look forward to discussing these technical matters with you and your staff.

Sincerely,

Gregg Olson

Environmental Engineer

Gregg Olson

cc: Shirin Tolle, ADEQ

## Part I: Hydrogeology Technical Review of the BHP Florence Project

John Hillenbrand, EPA Reg. 9 (415) 744-1912

BHP submitted a permit application to extract copper from the subsurface using underground injection, solvent extraction and electrowinning. This in-situ operation requires an Aquifer Protection Permit from the State of Arizona and an Underground Injection Control Permit and aquifer exemption from U.S. EPA.

This review has concentrated on the geologic and hydrogeologic aspects of the APP and UIC permit applications, specifically Chapter 4 and associated Appendices of Volume II. It will not emphasize the modelling or ground surface APP issues because those issues are addressed by others.

This project is the first commercial, large-scale project of it's kind. This project will be injecting pollutants through a drinking water source into an exempted aquifer. This project is relying heavily on modeling to project the movement of fluids in fractured media. Because of this, the following areas of hydrogeological concern exist:

- 1. Excursions of contaminants to a source of drinking water. Excursion of fluids could happen in several ways:
- A. More groundwater input into the system then it can handle. Based on the information presented during the teleconference meetings, The facility should be able to pump and remove a sufficient amount of groundwater and injectate to maintain hydraulic control. The facility will install safeguards to prevent injection without proportional extraction. A written explanation of these safeguards should be provided.
- B. The inability to maintain hydraulic control through fluid removal because of rapidly changing unanticipated conditions such as clogging pores, pump failure, power loss, or formation collapse from dissolution. The failure of any one well or several wells should be able to be adsorbed by an increase in pumping rates from other, surrounding wells. A written version explaining the ability of the system to deal with a change in hydrologic conditions should be submitted.
- C. A highly permeable conduit between the pressurized, active leaching zone and areas not intended to be leached. This conduit could be a depositional feature, fault, joint set, core hole, well, or mine workings. The possibility for releases of this nature has not been adequately addressed by BHP. The potential for this kind of a contaminant release to the aquifer is possible given the unknowns presented in the application. A discussion of this is given below under Conduits.
- 2. <u>Proper groundwater monitoring to detect unanticipated releases.</u> The proposed groundwater monitoring is inadequate based on the amount of possible excursion mechanisms. The additional monitoring needed to reasonably assure detection of a release is outlined below

## CONDUITS

- Primary Depositional Permeability A very significant issue at this site is the ability of material to move across the contact between the oxide bedrock zone and the LBFU. An essential component of determining the magnitude of the potential for excursion is the permeability difference between the lower basin fill aquifer and the oxide zone. Section 4.3.2 (II) and /or Chapter 4 tables discuss an oxide and LBFU permeability range of over three orders of magnitude (.007 to 25 ft/day for oxide and .02 to 28 ft/day for LBFU). Locations at the bedrock-oxide interface could easily experience a significant difference in permeability to facilitate liquid excursion. The variations in permeability across the oxide - LBFU contact and the inability to predict them, causes concern and should be addressed by additional monitoring as outlined below.

The topographic configuration of the top of the bedrock surface further complicates this situation. Provide a discussion of BHPs plans for a configuration of injection and recovery wells which will have a buffer zone of non-leached oxide between the injection zone and sedimentary rocks above.

- Secondary Permeability This type of conduit is related to features that occurred after the sediments were laid down but unrelated to human activities. This includes faults and fractures.

The following pump test highlights the concern about fault induced conduits that could promote excursions. Primary permeability features are most likely also at work in the following description. In Block 8, the draw-down in the 120 foot screened UBFU pumping well P8-GU was 6.9 feet as was a nearby observation well (O8-GU, 118 foot screen, UBFU, same interval, 6.9 foot draw-down). During this same pump test, three 180 foot screened wells in the oxide bedrock zone indicated a greater draw-down then the pumping well (P8-1-O,9.2 feet; P8-2-O,9.5 feet; and 08-O,8.9 feet). All of these five wells are horizontally within 175 feet of each other. The greater drawdown in the observation wells is unusual.

In a later test on the same five wells, the oxide well P8-1-O was pumped (screened over 180 feet, drawn-down 212 feet). The observation oxide well (P8-2-O), that is approximately 175 feet from the pumping well, indicates only 4.5 feet of draw-down while observation well O8-O, with a similar oxide screened interval and horizontal distance as the above two wells has a draw-down of 75 feet. Well P8-GU had a drawdown 0.49 feet and O8-GU had no drawdown. The two wells with such different drawdown in close proximity probably indicates a fault similar to the one depicted in Figure 4.3-1 (II).

This suggests an unusually high vertical permeability opposite of each other in both the oxide zone and the UBFU. A fault is most likely responsible in combination with a depositional feature. A manmade vertical conduit may also be involved. The fault appears to be a low permeability feature in the clay gouge zone and a very high permeability in the rubble and

fracture zone which blankets the fault plane. This configuration results in an extremely high permeability conduit from the oxide bedrock to the LBFU. This problem needs to be addressed by BHP.

- Tertiary Permeability This type of permeability is from human activities such as coreholes, wells or mine shafts. What are the plans for the mine shafts? Since the shafts are cased with 3/8 inch steel and grouted they may be considered isolated and not a conduit. If left open, monitoring should be required. The 5,490 feet of drift and crosscut workings may serve to short circuit the system and/or cause an excursion.

The presence of coreholes in the area is probably one of the largest potential excursion problems of the project. The several hundred cased, lost coreholes, most of which penetrate the ore body, are capable of transporting contaminants from the uncased orebody into the lower and upper basin fill aquifers. To deal with these lost coreholes more groundwater monitoring should be instituted in the sedimentary units in addition to a more extensive search and abandonment at the surface. The use of geophysics (magnetometer or ground penetrating radar) may be the solution. Attachment A provides specific requests to change the abandonment procedures for coreholes that can be found.

## GROUNDWATER MONITORING

As agreed to in the teleconferences, the uniqueness of this project requires additional start-up monitoring of the project will be required to receive a permit. This additional monitoring will focus on the first block to be mined and a later block to confirm continued safe operation.

As discussed in teleconferences between ADEQ, BHP, and EPA staff, an extensive monitoring network examining both vertical and horizontal groundwater gradients in the space around the injection area will be required. This monitoring included the UBFU, LBFU and the oxide zone. The objectives of the monitoring are listed below.

<u>Upper Basin Fill Unit</u> The three wells listed as UBFU monitoring wells are inadequate. Additional wells are needed to monitor the upgradient and downgradient groundwater resulting from the plant, surface impoundments, and mine area. The areas to be monitored in the mine area would cover pollution sources resulting from piping pressurized with mining fluids (injection and extraction wells and headers) and improperly abandoned coreholes.

<u>Lower Basin Fill Unit</u> Monitoring in this unit will be for chemical excursions from the oxide zone and improperly abandoned coreholes.

#### Oxide Zone

A ring of wells in the oxide zone would be placed to detect a horizontal excursion and to monitor water levels to confirm the hydraulic control of the injectate. These wells would be placed around the perimeter in locations that would be used when the neighboring block is developed. For Block 10, this would entail monitoring wells in Blocks 1, 9,11, and 14 in the locations that abut Block 10. These wells should be monitored for water level and TDS and/or conductance.

#### Attachment A

Corehole abandonment Volume V, Appendix E, Section 2.5. The abandonment procedures do not appear adequate to prevent migration in the holes that can be located. The following are comments on the Tasks listed on page 7 of Appendix E:

- 1. Will air lift or bailing methods be sufficient to lift to the surface the potentially large grains (gravel) that has caved into the hole? Some of the core holes may need to be reamed out if they cannot be properly cleaned out to get an adequate grout placement
- 2. If the holes are only cleaned to the bedrock interface, as outlined above, then how will they be grouted to 20 feet below the bedrock-sedimentary unit contact as stated in this step?
- 3. The existing corehole casing will not serve as a tremie pipe. A tremie pipe is a small diameter pipe designed to be removed as material is placed, prevent bridging and avoid dilution as the cement falls through hundreds of feet of groundwater. A separate tremmie pipe needs to be used.
- 5. The cement must be placed under pressure in the tremmie pipe in order to fill the voids through the perforated casing.
- 6. Type V cement grout should be placed in the zone where the Middle Basin Fill Unit is expected.

# Part II: Overall Technical Review of the BHP Florence Project

Gregg Olson, EPA Reg. 9 415-744-1828

## Aquifer exemption:

#### Comment 1

Under 40 CFR Parts 146.4(a) and 146.4(b)(1), the aquifer meets the exemption requirements as it does not currently serve as a source of drinking water and it has been demonstrated to have minerals which are commercially producible. However, the request for a "minor" aquifer exemption should be explained. According to "EPA Region 9 Aquifer Exemption Guidance, March 1993" (page 4), a major aquifer exemption is required if the exemption is approved under 146.4(b).

## Comment 2

The proposed aquifer exemption boundary has been defined in the plan view. The proposed aquifer exemption boundary should be explicitly defined in 3 dimensions (i.e., in terms of its areal extent and depth).

#### Comment 3

The area to be surveyed for drinking water wells should extend a minimum of 1/4 mile around the mine site. BHP has successfully addressed this requirement by surveying and proposing to re-locate all wells within 1/2 mile of the mine site. However, this "buffer zone" should not be considered as exempted. To exempt an aquifer there must be minerals which are commercially producible. The aquifer exemption boundary should be placed on the edge of the mine site, immediately before the point of compliance (POC) wells.

#### Comment 4

All drinking water wells and agricultural wells located within 1/4 mile of the mine boundary shall be shut in prior to the issuance of an aquifer exemption. Furthermore, it is BHP's responsibility to ensure that no new drinking water wells or agricultural wells are drilled within 1/4 mile of the mine site during the 15-year mining life.

#### Closure:

### Comment 5

BHP has established that at a sulfate concentration of 750 mg/L, all constituents are below primary MCLs and closure will be complete. Using sulfate as an indicator is acceptable. However, BHP should document that this is an appropriate indicator by showing that the concentrations of other constituents fall below primary MCLs (or AWQS) when sulfate reaches 750 mg/L. This demonstration should consist of more than one test (i.e., it should be a series of statistically significant tests).

## Monitoring:

#### Comment 6

The monitoring array should be increased. Monitoring wells should surround the site in all potentially affected formations and along all faults. Furthermore, if the aquifer exemption is for the oxide zone only, it would be reasonable to place monitoring wells in the center of the mining area, above the oxide formation. Mining wells in the center of the mine site would demonstrate that there are no vertical excursions.

The direction of groundwater flow can change with changes in weather, agricultural pumping, and municipal pumping. Although the emphasis of the monitoring program should clearly be in the direction of historic flow (northwesterly), a skeleton monitoring array should cover any potential changes throughout the life of the project. Over a 15-year mining life and a 30-year post-closure period, it is possible, at least temporarily, for flow to change directions and move in a more southerly or easterly direction. This is particularly important since the Town of Florence and public water supply wells are located southeast of the site.

#### Comment 7

Tritium and the sulfur isotope appear to be good indicators of vertical excursions, however, according to Table 5.3-1 and Table 5.3-2, BHP has proposed not to monitor these isotopes. BHP should monitor at least one of these isotopes to verify that there are no vertical excursions. Although no isotopes were listed in Table 5.3-1 (Level I parameters), on page 9 of Volume III, the sulfur isotope ratio is listed as a Level I parameter. BHP should clarify their isotope monitoring proposal.

### Comment 8

For clarification, in Table 5.3-1 and Table 5.3-2, does "NA" (not applicable) mean that the parameter will be measured and reported but there will be no alarm level or aquifer quality limit assigned to it?

#### Comment 9

On page 4-22, it is stated that "the net volume out will exceed the net volume into the system on a monthly average basis." On page 6-6, it is stated that the "recovered solution from the barrier and production wells must exceed the injection volume on an average daily basis every day." This hydraulic control action limit should be clarified and the technical basis for the chosen averaging time should be established.

### Comment 10

The method of reporting/demonstrating hydraulic control should be established. As presented by BHP in one of the teleconferences, head vs. time (days) plots of well pairs in the north, south, east, and west directions appear to be an excellent approach to summarize this hydraulic control data. In addition to these plots, there should probably be a numeric summary of this plotted data which shows that no hydraulic control action limit was

exceeded. Hopefully, the hydraulic control component of a quarterly report could be interpreted like an MCL violation (i.e., by comparing a limit to a measured value).

#### Comment 11

BHP should demonstrate that all hazardous constituents and by-products of the organic used in the solvent extraction process are included in the monitoring program. For example, if benzene is a component of the solvent, benzene should be listed as a monitoring constituent with an AQL (the MCL for benzene is 5 ppb).

## Maximum pressure calculation:

Comment 12

A fracture gradient of 0.64 psi/ft has been established for the maximum pressure calculation. Is the 0.64 multiplier based on a depth measured from ground surface to the top perforation?

### Mechanical integrity tests:

Comment 13

For clarification, are the MIT methods described on page 2-6 (cement log, pressure test, and survey) proposed for all new wells?

#### Corehole and well abandonment:

Comment 14

BHP should submit calculations or test data that show that a 500-foot plugging and abandonment radius is reasonable. Typically, EPA requires that wells within 1/4 mile of an injection well are properly plugged and abandoned. If the permit applicant can show that the radius of pressure influence is less than 1/4 mile, EPA may reduce the requirement accordingly. It should be noted that these estimates should not be masked by hydraulic control. The radius should be conservative in that a loss of hydraulic control would not allow a vertical excursion.

#### Surety Bond:

Comment 15

BHP must establish a surety bond which covers all closure costs at any one point of the project.