TECHNICAL MEMORANDUM

MEMO No: 18

SUBJECT: Evaluation of Disposal of Reverse Osmosis By-product
Biological Treatment for Selenium Removal

TO: Stakeholder Forum

COPIES: Richard Bay, JVWCD
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FROM: Bryant Bench

DATE: April 13, 2004

EXECUTIVE SUMMARY

The concentrated selenium in the reverse osmosis (RO) by-product water might effectively be removed utilizing biological treatment technologies. However, given the unique characteristics of the by-product water, there are significant concerns and challenges which must be investigated to determine if the biological process is truly viable, cost effective, and reliable. Additional treatability studies, pilot investigations, and preliminary engineering evaluations are necessary to assess biological treatment process performance, reactor contact time, flushing frequency, biomass recovery time, flushing water treatment and sludge disposal methods, and scaling potential within the bioreactors. Potential for scaling is of greatest interest as it could adversely impact the cultured biomass and selenium removals.

BACKGROUND

Mining activities in southwestern Salt Lake Valley have created groundwater contamination, with elevated sulfate concentrations. A 1995 federal Consent Decree negotiated by Jordan Valley Water Conservancy District (JVWCD), Kennecott Utah Copper Corporation (KUCC) and Utah Department of Environmental Quality (UDEQ), established a natural resource damage Trust Fund, which was paid by KUCC. The Consent Decree established purposes for use of the Trust Fund as:

- remediating the aquifer
- containing the contamination plumes; and
- restoring the beneficial use by producing municipal quality water through treatment.

Dr. Dianne R. Nielson, Executive Director of UDEQ, has been appointed as Trustee of the Trust Fund and of projects to accomplish the Consent Decree purposes.

JVWCD and KUCC have submitted a Joint Proposal project to the Trustee to accomplish the Consent Decree purposes. The Joint Proposal involves one RO treatment plant and facilities to treat western Zone A deep groundwater; and one RO plant to treat eastern Zone B deep groundwater and Lost Use shallow groundwater. The Trustee held a public information and public comment period during August through November 2003.

As a result of the public comments, JVWCD withdrew its Zone B/Lost Use RO by-product water discharge permit to the Jordan River and renewed efforts to find a better disposal alternative. The Trustee established a Stakeholder Forum for southwest groundwater remediation issues in early 2004. JVWCD has sought input from the Stakeholders Forum as it considers various alternatives for disposal of Zone B/Lost Use RO by-product water.

Zone B/Lost Use by-product water is projected to have the following characteristics:

	Flow Rate	**TDS Concentration**	**Selenium Concentration**
	(cfs)	**(mg/L)**	(µg/L)
Zone B	1.24	8,300	25
Lost Use	0.51	8,200	47
Total	**1.75**		
Common Range		**8,200 -8,300**	**32-47**

PURPOSE

The purpose of this memo is to describe selenium treatment of the RO by-product water using a metal specific biological treatment technology and to present the potential benefits and challenges of implementing this new and emerging technology.

AUTHOR'S CREDENTIALS

Bryant Bench is a registered Professional Engineer specializing in the area of water treatment process selection and facility design. Mr. Bench holds a Bachelors degree in Civil Engineering and a Masters degree in Environmental Engineering. For the past 25 years, Mr. Bench has been working as a consulting engineer for public and private water utilities involved in the planning, design, and construction of public water treatment plants. He has provided engineering services for most of the major water treatment plants located in the Salt Lake Valley and along the Wasatch front. Mr. Bench has engineered advanced treatment technologies for water treatment including high-rate conventional treatment, managed filtration, ozonation, ultraviolet light (UV) disinfection, and reverse osmosis and other membrane separation processes.

BIOLOGICAL SELENIUM REMOVAL

Common practices for removing selenium from contaminated ground or surface waters have typically consisted of conventional chemical addition for precipitation or adsorption of the selenium followed by separation through gravity or other clarification means. Biological treatment for metals removal is an emerging technology for treating mine waste and similar waste discharges in Utah and other locations across the country. One such biological process is called the ABMet™ Water Treatment System as developed by Applied Biosciences Corporation located right here in Salt Lake City. This process utilizes microbes, cultured in bioreactor beds that create a ion-reducing environment for selenium removal. The bioreactors are typically sized to provide 2 to 12 hours of detention time depending on specific treatment requirements. The bioreactors are filled with granular activated carbon (GAC) which provides an abundant surface area for the biomass to flourish and grow. The microbes are kept alive and happy by feeding them a biodegradable nutrient blend, which contains molasses. The unique features of GAC is that this material contains significant cracks and crevices within its sphere for biological activity to occur. As the biomass develops, the beds become covered with a biofilm. The effect of the biomass and the microbial conditions within the bed create a reduced environment, which converts the selenate or selenite ions into its more elementary selenium form. In this state, the metal precipitates as a solid and is enmeshed and attached to the biofilm within the reactor. Over time, usually weeks or months, the reactors are flushed to remove the captured waste material. This waste stream is then treated by dewatering the solids and disposing of the high-concentration, selenium sludge.

This biological process has been pilot studied on mine drainage wastes at the Kenecott mine. Full-scale plants have recently been installed out of state. In most applications, the ABMet™ Water Treatment System has demonstrated selenium removals to below 2 micrograms per liter or parts per billion (µg/L). Current application for this biological metal removal is for treating acid mine drainage, surface mine waste streams, and industrial wastewaters.

APPLICATION POSSIBILITIES AND CONCERNS

Discussions with Applied Biosciences representatives about the application of the ABMet™ Water Treatment System for removing selenium from the RO by-product water yielded a number of potential advantages for this type of process:

1. Could potentially remove selenium to below 2 µg/L.

2. Process uses a biodegradable nutrient to maintain biomass. Other conventional processes require use of iron-based chemicals.

3. The biological process produces less sludge than the conventional chemical precipitation processes.

4. The biological process facility and operations costs could potentially be less than other selenium treatment technologies.

As discussed above, most applications for biological selenium removal have been implemented for acid mine drainage and other metal-laden waste streams. Although similar in concept, the RO by-product water has different chemical and physical characteristics than typical mine drainage. Potential concerns and challenges were also identified in applying this process for treating the by-product water. These concerns include the following:

1. There is a significant mineral scaling potential of the concentrated by-product water which could adversely impact biomass growth and performance within the reactors.

2. Biological processes are by nature tempermental. The biomass must be properly cultured and controlled.

3. Bioreactor tanks or chambers must be sized to provide 2 to 12 hours of contact time. The process might work in the two-hour time range, but this would have to be demonstrated.

4. Waste, flushed from the reactor, contains very high concentrations of selenium. As such, the waste has limited options for ultimate disposal. In addition, water used for flushing must be separated from the sludge. That requires properly designed dewatering equipment.

5. Once the reactors are flushed, there is a recovery time before the biomass returns to equilibrium and maximum selenium removal. This recovery time would need to be tested and evaluated as a result of each flushing sequence.

One significant challenge listed is that of mineral scale formation. As described previously in another Stakeholder Forum memo, the by-product water has tremendous scaling potential due high concentrations of calcium sulfate and carbonate ions. Upon scaling, the precipitate attaches itself or “plates-out” on a material surface. In the case of a concentrate pipeline, the surface is the pipewall located around the internal circumference of the pipe. In the case of the bioreactor, the available scaling or plating surface is the GAC material, which offers a tremendous area for scale to form. The GAC surface not only promotes biofilms growth, but is also an excellent environment for scale to occur. It is not known how effective the scale inhibitor, utilized as part of the RO process, would be in preventing scale under these untested conditions. It is also unknown what impacts scaling would exhibit upon biomass production and performance in reducing selenium. Scaling of the reactor and GAC media could cause the biological selenium treatment process to fail.

ADDITIONAL STUDIES

Biological removal of selenium from the RO by-product water using the ABMet™ Water Treatment System appears to be a potential treatment approach. However, additional studies must be conducted to demonstrate the viability of such treatment and to answer the concerns described in this memorandum. Pilot and engineering studies would need to be conducted investigating the following parameters specific to the unique water quality characteristics of the RO by-product stream:

- Selenium removal capability.
- Mineral scale potential and methods for controlling scaling within the bioreactor.
- Determine contact time within the bioreactor.
- Determine the frequency for bioreactor flushing and the microbial recovery time.
- Acceptable sludge dewatering and selenium disposal methods
- Develop preliminary capital and operating costs for implementing the biological treatment system.