M E M O R A N D U M

TO: Peter Kavounas, City of Glendale Department of Water and Power

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SUBJECT: Summary of Expert Panel Workshop on "Chromium 6 Removal Demonstration Facilities"

INTRODUCTION

An expert panel workshop for the Tailored Collaboration project "City of Glendale, California Chromium 6 Removal Treatment Demonstration Facility – Phase III Bridge" (Bridge Project) was held on October 12, 2006 at the City of Glendale Council Chambers. The expert panel meeting was co-hosted by the USEPA, Glendale Water and Power, and the AWWA Research Foundation (AwwaRF).

The expert panel members at the workshop included Pankaj Parekh from LADWP, Sun Liang from MWDSC, Bruce Macler from USEPA, Richard Sakaji from California DHS, Mel Suffet from UCLA, Laurie McNeill from Utah State University, Arup SenGupta from Lehigh University, and Gary Amy from UNESCO (attending via teleconference). The panel discussion was moderated by Traci Case from AwwaRF.

The expert panel meeting was open to the public. More than 30 people interested in chromium 6 issues attended the event. The City of Glendale also broadcast the meeting live on Glendale public television and over the internet via streaming media.

CHARGE TO THE EXPERT PANEL

Glendale's charge to the Expert Panel was to identify cost-effective Chromium 6 treatment technologies that are appropriate for further testing at the demonstration scale (approximately 500 gpm or 1,000 gpm treatment capacity) based on the technical information presented at the meeting.

The criteria the panel was charged to consider in the evaluation process included the following:

- Technology maturity
- Probable success in Glendale and elsewhere
- Cost of the treatment facilities
- Ease of operations and maintenance, including future reliability of the treatment processes
- Required permitting and approval processes

CHROMIUM 6 TREATMENT TECHNOLOGIES CONSIDERED

In response to the public concern about the presence of Chromium 6 in drinking water, the City of Glendale, along with Cities of Los Angeles, Burbank, and San Fernando, initiated a comprehensive four-phase program to develop a technology (or technologies) for Chromium 6 removal from drinking water supplies. The four-phase program includes: Phase I - A bench-scale study to improve the understanding of fundamental chromium chemistry and to screen promising treatment technologies; Phase II - A pilot-scale study to further evaluate the promising technologies under flow-through conditions; Phase III - A demonstration-scale study to finalize the technology evaluation and address other related issues (e.g. cost and residuals disposal); and Phase IV - Full-scale implementation of a treatment technology. So far, Phases I and II are complete. The expert panel meeting was part of the Phase III study, in which one or more technologies was recommended for demonstration-scale testing.

Based on Phases I, II and III research efforts, three technologies emerged as leading candidates for consideration in demonstration testing:

- Reduction/Coagulation/Filtration (RCF) using ferrous sulfate,
- Fixed Bed Weak Base Anion Exchange Resin (WBA) with constant pH control, and
- Fixed Bed Strong Base Anion Exchange Resin (SBA) with brine treatment.

SUMMARY OF THE EXPERT PANEL DISCUSSIONS

Expert panel discussions about the three technologies are summarized below according to the technology.

RCF System

Brief Description

During the RCF process, Chromium 6 is first reduced to Chromium 3 with the addition of excess ferrous iron (Fe^{2+}), which is oxidized to ferric iron (Fe^{3+}). Chromium 3 then either precipitates or forms a co-precipitate with the ferric iron. The ferric iron/chromium 3 forms larger floc particles during the coagulation (aeration) stage. Particles are then removed by a dual-media filter (or other filter, such as a microfiltration membrane) in the final step.

Advantages

The expert panel generally favored this technology for the following reasons:

- The mechanism of RCF treatment is fully understood
- RCF is a proven technology for the application of Chromium 6 removal, as evidenced by the successful operation of a similar system at Topock, California
- RCF can be optimized during the demonstration-scale study to accommodate potential rising Chromium 6 concentrations in the influent water
- California DHS permitting will likely be easier for the RCF system compared to the other two technologies

Disadvantages

The panel expressed the following disadvantages of the RCF system:

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- The capital cost of construction the RCF system is very high (a preliminary cost estimate indicated that the construction of a 500 gpm RCF system could cost $2.8 million, and a 1000 gpm system could cost $3.5 million)
- RCF may require frequent operator oversight and continuous monitoring to optimize the removal of Chromium 6
- A related treatment process is an accepted best available technology (BAT) for arsenic removal, but DHS does not permit its use in small systems due to operational complexities

WBA System

Brief Description

The mechanism of Chromium 6 removal by WBA resins was originally believed to be similar to that of strong base anion exchange (SBA) resins, except that the WBA resins are only useful in the acidic pH range where the functional groups are protonated and thus act as positively charged exchange site to attract Chromium 6 (as chromate ion). However, the WBA resin (Duolite A7 resin provided by Rohm & Haas) tested in the Phase II pilot study showed a much greater Chromium 6 removal capacity compared with all of the other SBA resins tested (approx. 20 times). Other observations, such as leakage of Chromium 3 during periods of low pH, indicated that an ion exchange mechanism alone could not explain the high capacity of the WBA resin.

As part of the Phase III study, a range of WBA resins were tested for capacity and the impact of pH on capacity. Duolite A7 resin again showed a high Chromium 6 capacity along with another WBA resin (ResinTech SIR-700, which did not perform quite as well as the Duolite A7 initially but improved over time). It has been confirmed that more than 95% Chromium 6 retained on both resins was converted to Chromium 3, as evidenced directly by x-ray absorption spectroscopy. So far, the true mechanism of Chromium 6 removal and retention by the WBA resins has not been fully understood but is known to involve a reduction process.

Advantages

The expert panel discussed the advantages of the WBA system, including the following:

- WBA resins have demonstrated a high Chromium 6 removal capacity (approximately 20 times higher than the conventional SBA resins tested)
- The operation of WBA system is comparatively easy, especially for a small system
- The WBA resins will be used in a single-pass, disposable mode, eliminating the need for resin regeneration with brine
- The WBA system can absorb the fluctuations in influent Chromium 6 concentrations, although resin replacement will be more frequent at higher influent concentrations

Disadvantages or Uncertainties

The WBA resin was the most thoroughly discussed technology during the expert panel meeting, primarily because the mechanism for Chromium 6 removal is not fully understood. Pilot studies have indicated that besides ion exchange, reduction/oxidation and/or complexation could also play a role in Chromium 6 removal by the WBA resins. One panel member then raised the question: “Do we want to select a technology where mechanism is not understood?”

The expert panel also expressed other concerns regarding the WBA system besides an incomplete understanding of the mechanism, including:

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- Nitrosamine (including NDMA) leaching from the WBA resins
- Potential for formation/release of organic resin byproducts (e.g. formaldehyde or phenol, which are resin constituents)
- Taste and odor issues related to the use of the resins if formaldehyde or phenol are released
- Cost of the WBA system (the highest annualized treatment cost among the three technologies)
- The need to pre-condition the resins, which may explain the improved removals over time for the SIR-700 resin
- California DHS permitting may be difficult since the removal mechanism is not well understood
- The need for strict pH control of the influent water

SBA System

Brief Description

SBA resin is a commonly used technology in drinking water treatment for anion removal. Chromium 6 is retained on the SBA resin (as chromate ion) by exchanging with chloride previously bound to the resin. The SBA resins can be reused by regenerating the resins with concentrated brine (salt) solutions. Pilot testing demonstrated up to seven regeneration cycles.

BasinWater provided a proposal for a regenerable SBA system for Chromium 6 treatment. By contrast, US Filter did not provide a follow-up proposal since they no longer offers regenerable SBA for Cr(VI) removal. During recent testing in Colby, Kansas, US Filter encountered difficulty in regenerating the resin to full capacity after approximately 12 to 15 regeneration cycles. Consequently, US Filter now markets only the WBA system and a single-pass SBA system.

Advantages

The advantages of the SBA system discussed by the expert panel included:

- SBA is an established technology for other contaminants and the mechanism is well understood
- The overall Chromium 6 treatment cost using the SBA system (including capital and O&M cost) is the least among the three technologies
- The SBA system can absorb fluctuations in influent Chromium 6 concentrations

Disadvantages

Disadvantages and uncertainties associated with the SBA system at this time were discussed by the expert panel, including:

- Brine disposal: The high concentration of total dissolved solids (TDS) and chloride in the brine may ultimately limit its discharge into the sanitary sewer systems. At the Northern well site (in Glendale), the Glendale Wastewater Treatment Plant will not accept high chloride brine. It is uncertain as to whether Hyperion would accept brine discharge at the Southern well site (which is located in Los Angeles). To avoid these problems, BasinWater proposes to truck the treated brine to a sewer connection leading to the Hyperion Wastewater Treatment Plant. It was deemed uncertain that this connection would be available into the future and could be depended upon.
- Quantity of brine BasinWater claims to generate is orders of magnitude lower than other SBA ion exchange technologies in the area for other contaminants, which either reflects efficiency in the BasinWater system or a lower-than-actual estimate or brine production
- Uncertainty in the ability to repeatedly regenerate SBA resin

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EXPERT PANEL RECOMMENDATIONS

At the end of the meeting, the expert panel provided the following overall recommendations:

- All panel members recommended that the RCF system be tested in the demonstration scale study
- All panel members recommended that the mechanism of the WBA resins be thoroughly investigated in additional bench-scale studies. The understanding of the WBA mechanism will not only help Glendale in the demonstration-scale study but also provide a new solution to other water utilities needing chromium treatment
- If funding is available, the demonstration-scale study should include both RCF and WBA systems
- The SBA system should not be further tested at demonstration-scale

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