Tailored Collaboration

Research Effort to Investigate the Feasibility of Microfiltration in the RCF Process for Hexavalent Chromium Removal

Submitted to:
Water Research Foundation

Submitted by: The City of Glendale

In association with

Originally Submitted December 22, 2010
Revised and Resubmitted February 17, 2011

December 22, 2010

Ms. Hsiao-wen Chen
Project Manager
Water Research Foundation
6666 West Quincy Avenue
Denver, CO 80235-3098

SUBJECT: Glendale's Request for TC Funding to Continue the Hexavalent Chromium Removal Studies - Microfiltration

Dear Ms. Chen:

The Cities of Los Angeles, Glendale, Burbank, and San Fernando have appreciated the Water Research Foundation's (WRF) support for this three-phase research effort. You managed the Phase I bench-scale testing, and Glendale managed the Phase II pilot testing and Phase III demonstration scale testing. The overall cost of the research effort is seven million dollars. Once again, we request WRF's participation in the research effort by providing financial support for the Phase III Microfiltration (MF) Pilot Study under the Tailored Collaboration (TC) Program. At a recent meeting with our Project Advisory Committee (PAC), they recommended this Microfiltration (MF) Study.

Our request is for $150,000, combined with $150,000 in matching funds (WRF total of $300,000) and an additional $100,000 from the City, for a total of $400,000.

Hexavalent chromium in drinking water supplies continues to be a great concern to the community. You, along with several members of Southern California's water community, are extremely aware of this with your continued involvement in the chromium 6 issue. Most recently, the California Office of Environmental Health Hazard Assessment (OEHHA) has set a draft Public Health Goal (PHG) of 60 parts-per-trillion (ppt) for hexavalent chromium as part of a California law to set a Maximum Contaminant Level (MCL) chromium 6, lower than expected. This low number, while not a standard, requires further studies of the MF technology.

The City has an excellent PAC that has been working on this project in Phase III (and previous phases) that is made up of the following members:

- Heather Collins, California Department of Public Health
- Sun Liang, Metropolitan Water District
- Bruce Macler, U. S. Environmental Protection Agency
- Pankaj Parekh, Los Angeles Department of Water & Power
- Richard Sakaji, East Bay Municipal Utility District

The concerns with hexavalent chromium in water supplies are ongoing. Our research effort is being closely followed by a number of researchers, the industry that may have caused the contamination of water supplies, regulators, and other water agencies that have this contaminant in their supplies and are seeking its removal.

Glendale proposes to provide $250,000 towards this research effort. To further this effort, a draft application package has been prepared by Dr. Nicole Blute, Malcolm Pirnie, Inc. (MP). MP has assembled an outstanding team to complete this effort.

WRF's involvement in this final phase will give this project the stature it deserves in the research community, and benefit the water community desiring to provide a better quality drinking water.

The City appreciates your ongoing interest in this research effort. Please contact me at (818) 548-2137, or Donald Froelich of my staff at (949) 525-2672/ donaldfroelich@cox.net, to discuss the application package and your participation in this project.

Sincerely,

/s/ Peter Kavounas
Assistant General Manager - Water Services

DRF/PK:to
Attachments

Cc: Peter Kavounas, Glendale Water and Power
Nicole Blute, Malcolm Pirnie, Inc.
Heather Collins, CDPH
Leighton Fong, Glendale Water & Power
Donald Froelich, Glendale Water & Power
Sun Liang, MWD
Bruce Macler, U. S. EPA
Dorine Martirosian, Deputy City Attorney
Pankaj Parekh, LADWP
Rich Sakaji, EBMUD

B. Co-Funding Support Form

TC CO-FUNDING SUPPORT FORM

Note: Each co-funding organization (including the sponsoring utility) must complete a separate Co-Funding Support Form and include it in the proposal.

Co-Funding Organization: City of Glendale Water & Power

Type of Organization: X water utility ____consulting firm ____ manufacturer ____other (describe)

Is your organization eligible to participate in one of The Foundation's subscription programs? X Yes ____ No

Is your organization requesting that The Foundation match its funds? X Yes ____No

Is your organization eligible for The Foundation matching funds? X Yes ____No

Cash co-funding amount being provided by your organization (in USD) $ 250,000

Person responsible for contract matters for your organization:
Name: Donald R. Froelich

Address at which FedEx packages can be received: 141 N. Glendale Avenue - Level 4
Glendale, California 91206 (GWP Administration)

Phone/Fax/e-mail: 949-525-2672(phone); 818-552-2852 (fax); donaldfroelich@cox.net

Person responsible for accounting matters for your organization:

Name: Leighton Fong

Address at which FedEx packages can be received: 141 N. Glendale Avenue - Level 4
Glendale, California 91206 (GWP Water Engineering)

Phone/Fax/e-mail: 818-548-3982 (phone); 818-240-4754 (fax); lfong@ci.glendale.ca.us

What approvals will be required in order for your funds to be released to the Foundation? (e.g., City Council, Board of Commissioners)
City Council

Have these approvals been obtained? X Yes ____ No

Can approvals be obtained and co-funding agreements be signed within 120 days of award? X Yes ____No
(**Note:** 120 days after award notification the Foundation may cancel the award--see TC proposal guidelines for details.)

Are there any conditions of the Foundation Co-Funding Agreement that would prevent you from signing it as it is currently worded? X Yes ____No
If yes, please explain: (attach additional pages if required)
(See attachment)

The person signing below acknowledges they are authorized to commit their organization to the proposed work.

Signature____________________ Print Name James E. Starbird

Title City Manager Organization City of Glendale

Date ____________________ Phone (818) 548-4844

Mailing Address 141 N. Glendale Avenue - Level 4, Glendale, California 91206

<u>City of Glendale Comments to</u>
<u>Water Research Foundation Funding Agreement</u>

Attachment to Co-Funding Support Form

Page 1	First paragraph states that the agreement is between the Water Research Foundation ("Foundation"), the "organizations detailed in Exhibit 'C'", and the City. Exhibit "C" is blank/does not name the co-founders. Has the Foundation indicated who (if any) the co-founders are/will be?
Page 1	Section I(D) – "Co-Principal Investigator" – will this be only Malcolm Pirnie or can we have multiple Co-P.I.s? (as in M.P. and CDM?)
Page 4	Section V(B) – after Don's proposed sentence that all matching funds will come from the State, add another sentences stating: "Foundation acknowledges and agrees that, in the event any matching funds will be contributed from the Federal Government, Foundation and Sub-recipient will amend this PFA in order to comply with all applicable Federal requirements."
Page 10	Section XII(B) at the end of the paragraph add the following provision: "In the event the Sub-recipient acquires matching funds through federally funded grants, the parties shall amend this PFA in order to comply with all applicable Federal requirements and will secure written permission from the Environmental Protection Agency (EPA) for the Foundation to copyright all of the Foundation's intellectual Property generated from this Project."
Page 14	Dispute Resolution – Section XIII(C) can we request to have the venue of the mediation changed to California (instead of Denver County, Colorado)? We normally prefer to have dispute resolution conducted within California. Subsection (G) – can we request that the binding arbitration clause be deleted? (this would mean subsection G 1-4 in its entirety). We (CA's office) normally do not recommend binding arbitration as with binding arbitration, the arbitrator's decision is final and the City loses its right to have the matter adjudicated in court and before a jury where applicable. (Also, the provision as stated in the agreement, provides that binding arbitration shall take place in Colorado).
Page 21	Section XIV(V) – recommend that we request the applicable state law/venue to be changed from Colorado to CALIFORNIA throughout the paragraph/section.

C. Proposal Cover Worksheet

TAILORED COLLABORATION PROPOSAL COVER WORKSHEET

Proposal Title:
Research Effort to Investigate the Feasibility of Microfiltration in the RCF Process for Hexavalent Chromium Removal

Sponsoring Utility (Foundation Subscriber submitting proposal):
City of Glendale Water and Power

Contact at Sponsoring Utility:
Name: Donald R. Froelich
Address: 141 N. Glendale Avenue, Level 4, Glendale, CA 91206

Phone: (949) 525-2672 Fax: (818) 552-2852 e-mail: donaldfroelich@cox.net

Co-Funding and In-kind Summary: (attach additional sheet if needed)

Organization Name	Cash Co-fund Amount	In-Kind Contribution Amount
1. City of Glendale Water and Power	$150,000	(sponsoring utilities) **$100,000 (cost share)**
2.		
3.		
4.		
	Total cash $ 150,000	**In-Kind $100,000**

<u>Project Personnel</u>
<u>Principal Investigator</u> (i.e., researcher responsible for conducting research)
Name: Peter Kavounas, Assistant General Manager of Water Services
Organization: City of Glendale Water and Power
Address: 141 N. Glendale Avenue Level 4, Glendale, CA 91206

Phone: (818) 548-2137 Fax: (818) 552-2852 e-mail: PKavounas@ci.glendale.ca.us

<u>Person responsible for finalizing *Funding Agreement*</u> (i.e., research contract)
Name: James E. Starbird, City Manager
Address: 141 N. Glendale Avenue Level 4, Glendale, CA 91206

Phone: (818) 548-4856 Fax: (818) 547-6740 e-mail: JStarbird@ci.glendale.ca.us

<u>Person responsible for accounting matters of contractor:</u>
Name: Leighton Fong, Civil Engineer
Address: 141 N. Glendale Avenue Level 4, Glendale, CA 91206

Phone: (818) 548-3982 Fax: (818) 240-4754 e-mail: LFong@ci.glendale.ca.us

Foundation Funds Requested: $150,000 USD

Amount of Funds eligible for Foundation match: $150,000 USD

Amount of Funds not eligible for Foundation match: $100,000 USD

Total Cash Budget (Foundation Funds + All Co-Funding Cash): $400,000 USD

Total In-kind Contributions: $0 USD

Total Project Budget (Cash + In-kind): $400,000 USD

D. Project Abstract

For the past eight years, the City of Glendale with other utilities and partners have been conducting research to identify hexavalent chromium treatment technologies for removing Cr(VI) to low parts-per-billion (or sub-ppb) levels in drinking water supplies. Demonstration testing is currently underway to evaluate two technologies: reduction/coagulation/filtration (RCF) and weak-base anion exchange (WBA). Both technologies have been able to achieve low ppb treatment goals. However, California recently released a draft Public Health Goal (PHG) for Cr(VI) of 0.060 ppb and the ability of these two technologies to achieve levels below 1 ppb appears to be limited. Consequently, the Project Advisory Committee (PAC) consisting of water industry and regulatory leaders recommended that microfiltration (MF) may offer enhanced particle removal compared with granular media filtration, and hence lower chromium treatment concentrations.

This project will investigate the effectiveness of MF as a key component in the RCF treatment process. In the absence of a clarification step, this treatment process will be considered direct MF, which has not been tested for Cr(VI) removal. Limited studies on removal of other contaminants with direct filtration using an iron-based coagulant indicate that this technological application is possible but that several variables need to be tested to assess feasibility for sub-ppb Cr removal and design criteria for full-scale MF (including flux, system recovery, and cleaning procedures). Two MF types will be evaluated in this project – including two of encased polymeric, submerged polymeric, and ceramic. Testing of two types is recommended since iron fouling of membranes is expected to react differently based on the membrane material and arrangement.

Principal Investigators on this study will be Mr. Peter Kavounas of the City of Glendale and Dr. Nicole Blute of Malcolm Pirnie. The City of Glendale will be the submitting organization. Other utility partners and regulatory agencies have been involved at various stages, including the Cities of Los Angeles, Burbank, and San Fernando, USEPA, and CDPH.

Cr(VI) occurrence data across the nation suggests widespread contamination in drinking water supplies, particularly at levels in the single ppb range. In California where there has been close monitoring of Cr(VI) for the past decade, one in ten California drinking water sources would be impacted by a Cr(VI) MCL of 10 ppb, and one in five by an MCL of 5 ppb. The MF testing results emerging from this project will help utilities to select the proper filtration for their facilities without having to test all of the potential variables that will be investigated in this project, thus resulting in cost savings to other utilities. The existing demonstration-scale testing of the RCF technology at the City of Glendale offers a great cost advantage for the proposed MF testing, whereby the infrastructure for testing is already in place.

In this project, Glendale seeks $150,000 from WRF and will provide $250,000 for a total of $400,000.

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F. Project Description

Background

Chromium is a naturally occurring element that is typically present in several valence states, with trivalent, Cr(III), and hexavalent, Cr(VI), chromium being the most common. While Cr(III) is an essential nutrient for humans, Cr(VI) compounds have been found to be carcinogenic by inhalation and ingestion. Major uses of Cr(VI) include metal plating, manufacture of pigments and dyes, corrosion inhibitors, chemical synthesis, refractory production, leather tanning, and wood preservation. Although naturally occurring Cr(VI) can be reduced to Cr(III) by organic matter in the environment, Cr(VI) released by anthropogenic sources may persist in water and soils that contain low amount of organic matter (Johnson et al., 2006[1]; Loyaux-Lawniczak et al., 2001[2]; U.S. EPA, 1984[3]). Cr(VI) is considered to be more soluble in water than other types of chromium compounds (Loyaux-Lawniczak et al., 2001).

Cr(VI) is currently regulated under the federal limit for total chromium with a Maximum Contaminant Level (MCL) of 100 µg/L. The current MCL was based on allergic dermatitis rather than cancer[4]. In the past few years, the toxicology of Cr(VI) was re-evaluated in a National Toxicology Program (NTP) study. Based primarily on this study, the U.S. Environmental Protection Agency (USEPA) recently released its peer-review draft assessment of Cr(VI) toxicology for public comment in September 2010. The document identifies Cr(VI) as a carcinogen through ingestion, such as from drinking water, and proposes a reference dose of 0.0009 mg/kg/day, which is much lower than the current reference dose of 0.003 mg/kg/day for total chromium. The reference dose serves as a predecessor to an MCL. If the proposed Cr(VI) reference dose is finalized, a separate MCL at a low parts-per-billion level is possible for Cr(VI).

The State of California currently has a lower MCL of 50 µg/L for total chromium. California State law requires California Department of Public Health (CDPH) to set a Cr(VI)-specific MCL. Adoption of this MCL depends on the CA Office of Environmental Health Hazard Assessment (OEHHA)'s publication of a Public Health Goal (PHG). In August 2009, OEHHA released a draft PHG of 0.060 µg/L (parts-per-billion, or ppb) for Cr(VI), which was later lowered to 0.020 µg/L in December 2010. After the PHG is finalized, CDPH will perform cost-benefit analyses to set a Cr(VI) MCL. If the MCL is set at or below single-digit ppb levels, a significant number of sources in California would need treatment technologies for Cr(VI) removal. Throughout California, approximately 67% of sources tested for the Unregulated Chemical Monitoring Requirement (UCMR) had Cr(VI) at levels between 1 and 5 µg/L and 20% of sources had levels exceeding 5 µg/L. Further, California has a history of leading the charge in setting drinking water regulations that have been adopted nation-wide. **The potential for a low Cr(VI) MCL, and changes in the federal standards as well based on NTP findings of Cr(VI) carcinogenicity in laboratory animals, are the principal motivations for drinking water utilities to better understand how to effectively remove Cr(VI) in their water supplies.**

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[1] Johnson, J; Schewel, L; Graedel, T.E. (2006). The contemporary anthropogenic chromium cycle. *Environ. Sci. Technol.* 40:7060-7069.

[2] Loyaux- Lawniczak, S; Lecomte, P; Ehrhardt, J.J. (2001). Behavior of hexavalent chromium in a polluted groundwater: Redox processes and immobilization in soils. *Environ. Sci. Technol.* 35:1350-1357.

[3] U.S. EPA (1984). *Health assessment document for chromium.* Final report. Cincinnati, OH: Environmental Criteria and Assessment Office. EPA 600883014F.

[4] U.S. EPA website: http://water.epa.gov/drink/contaminants/basicinformation/chromium.cfm

Cr(VI) occurrence in drinking water sources is expected to affect utilities nation-wide. A survey of Cr(VI) occurrence in the United States estimated the mean Cr(VI) concentration was 4.9 µg/L for 1,654 groundwater sites that had water quality suitable for potable consumption as reported in the National Water Information System (NWIS) database[5]. The occurrence of elevated concentrations of Cr(VI) did not appear to be concentrated in any single geographic region but was distributed throughout the nation. Depending on the level at which a Cr(VI) MCL is set, a large amount of drinking water sources across the nation may need Cr(VI) treatment. However, treatment technologies for Cr(VI) removal have predominantly been developed for the treatment of industrial waste streams that contain Cr(VI) at levels significantly higher than that found in typical drinking water supplies (e.g. mg/L versus µg/L) and with treatment goals at the current MCL. The ability to remove Cr(VI) to low ppb levels was not certain before Glendale began their research campaign.

The City of Glendale, California and associated parties have been leading the research effort to identify and test low level Cr(VI) treatment technologies for drinking water since 2002. The current demonstration testing builds upon an 8-year effort involving bench and pilot studies to assess treatment technology feasibility, the ability to meet Glendale's and the water community's needs with respect to treatment goals, and develop a complete understanding of treatment options and consequences.

Glendale relies on eight drinking water wells as a source of supply, in addition to imported water. Two wells with relatively high concentrations of Cr(VI) were selected for testing in the demonstration study: GS-3 and GN-3. The water quality in these wells is shown in Table 1 below:

Table 1. Water Quality in Wells GS-3 and GN-3

Water Quality Parameter	**GS-3 (WBA water supply)**	**GN-3 (RCF water supply)**
Alkalinity (mg/L as $CaCO_3$)	210 -220	176 – 270^
Chromium, total (µg/L)	32 – 45	64 – 80
Chromium, hexavalent (µg/L)	32 – 42	65 – 85
Conductivity (µs/cm)	910	910
Dissolved Oxygen (mg/L)	Not available	5.5 – 7.6
Nitrate (mg/L as NO_3)	38 – 39	36 – 39
Phosphate (mg/L as PO_4)	0.16	0.3
Sulfate (mg/L)	120	96 – 110^
Silicate (mg/L as SiO_2)	39 – 40	26.5
pH	6.8*	7.5 – 8.1
1,1-Dichloroethylene (1,1-DCE, µg/L)	0.65	2.2
1,1-Dichloroethane (1,1-DCA, µg/L)	ND	38
1,2-Dichloroethane (µg/L, 1,2-DCA)	ND	1.3
cis-1,2-dichlorethylene (µg/L, 1,2-DCE)	ND	3.5
Carbon tetrachloride(µg/L)	0.99	8.4
Chloroform (trichloromethane) (µg/L)	0.78	4.7
Tetrachloroethylene (PCE) (µg/L)	15	15
Trichloroethylene (TCE) (µg/L)	22	461
Trichlorofluoromethane (µg/L)	0.94	ND
Total Trihalomethanes (µg/L)	ND	4.7

* AwwaRF (2007). *Hexavalent Chromium Removal Using Anion Exchange and Reduction with Coagulation and Filtration*.
^ Alkalinity data are reported for the periods of 1998 to 2007, and 2010. Sulfate data are for the period of 1998 to 2007.

[5] AwwaRF(2004). *Treatment Options for Low-Level Hexavalent Chromium Removal Tested at Bench Scale*.

Two technologies are being tested at the demonstration-scale: reduction/coagulation/filtration (RCF) and weak-base anion exchange resin (WBA). The relative advantages of the RCF technology over WBA include: 1) the treatment mechanism is fully understood, and 2) the process can be easily optimized to accommodate potential changes in Cr(VI) concentrations without incurring significant O&M cost increases. This proposal focuses on RCF and whether microfiltration can improve upon the existing granular media filtration approach.

The RCF process uses ferrous sulfate to reduce and co-precipitate chromium with iron oxyhydroxide particles. Pilot and demonstration testing have revealed that the reduction process is very effective at reducing Cr(VI) to Cr(III), resulting in Cr(VI) levels consistently below 1 ppb. Since Cr(III) is associated with particles in this pH, total chromium removal is therefore intrinsically tied to the effectiveness of particle removal by filtration. Granular media filtration (i.e., anthracite and sand) is currently being tested at the demonstration scale to offer a low-cost means of particle removal. Pilot testing showed that total Cr values at or below 1 ppb could be consistently achieved with the process. However, demonstration testing of granular media filtration has yielded fluctuations in filter effluent turbidity and hence chromium removals. Sub-ppb levels of Cr(VI) but not total Cr have been achieved (Figure 1a and 1b). MF testing will allow for an evaluation of whether MF can more reliably remove Cr(VI) and potentially to lower levels than granular media filtration. The draft California PHG at levels of 0.020 ppb has led Glendale to question how low is technologically possible at a reasonable cost.

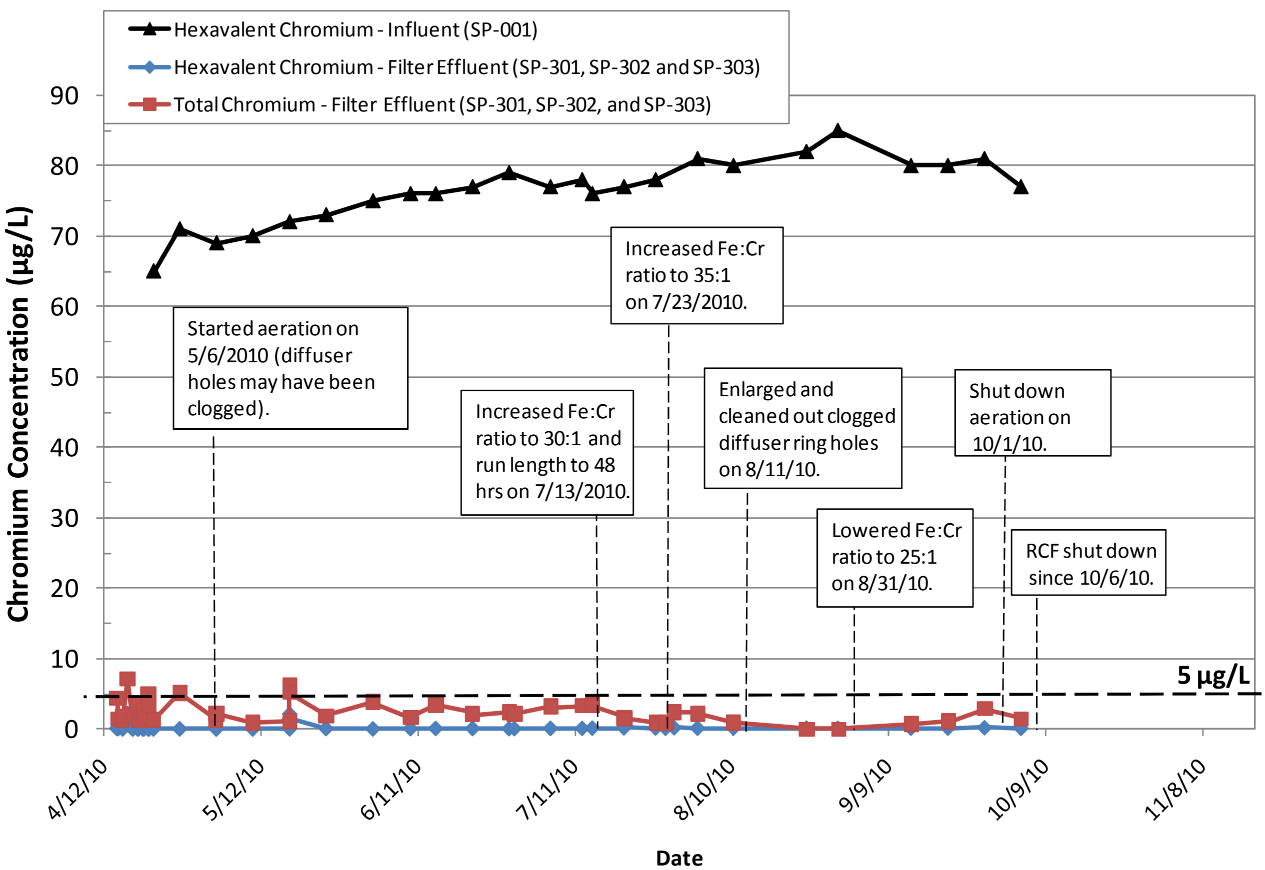

Figure 1. Hexavalent and Total Chromium at RCF Influent and Granular Media Filter Effluent

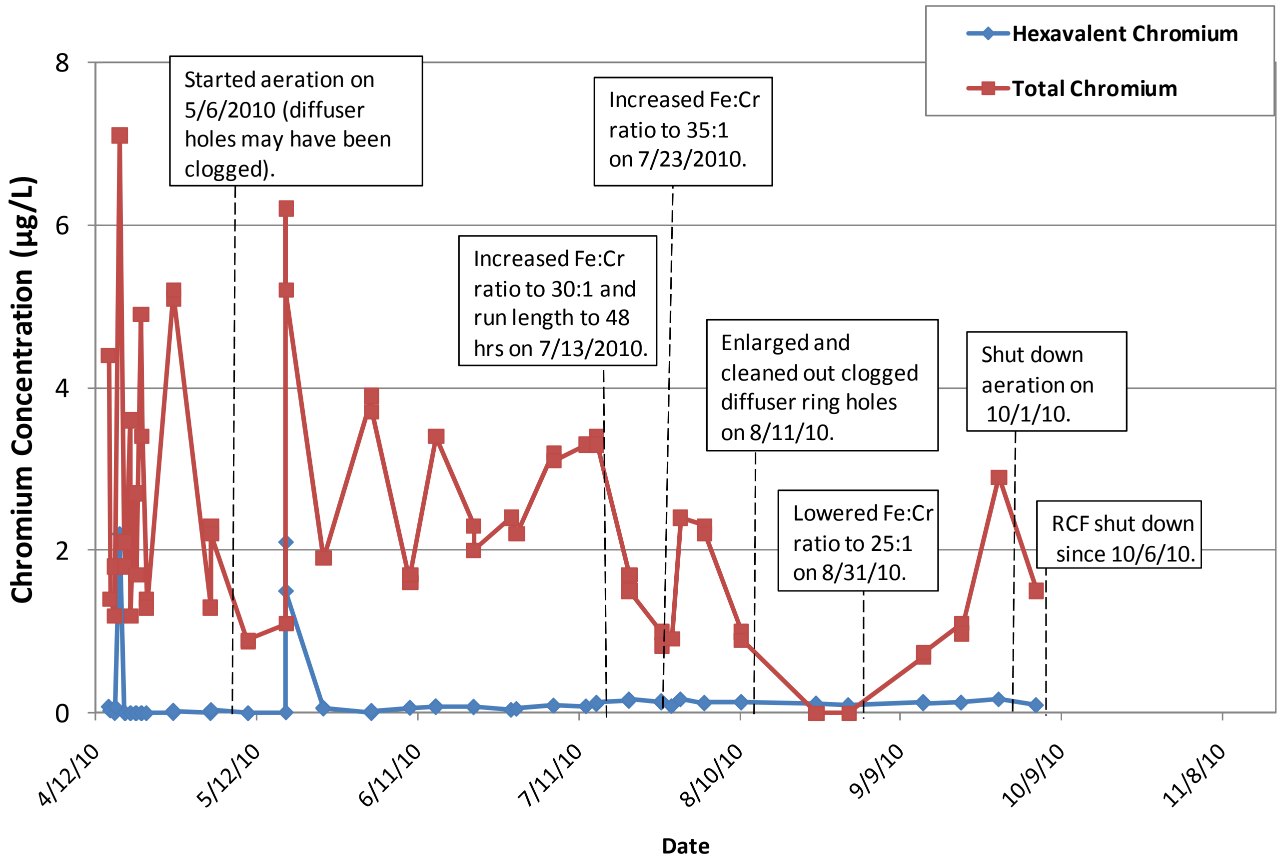

Figure 2. Enlarged y-axis Showing Hexavalent and Total Chromium Concentrations at the RCF Granular Media Filter Effluent

A meeting of the hexavalent chromium research study Phase III Project Advisory Committee (PAC) was held on September 9th, 2010 to discuss project status; PAC members include Dr. Bruce Macler of USEPA, Dr. Pankaj Parekh of LADWP, Dr. Sun Liang of MWDSC, Dr. Rick Sakaji of EBMUD (formerly with CDPH), and Ms. Heather Collins of CDPH. Committee members recommended that Glendale test microfiltration (MF) to achieve better particle, and hence chromium, removal in the RCF process.

MF has been shown to be effective in coagulation/filtration treatment processes using iron (e.g., for treating contaminants other than Cr)[6]. The advantage of MF over granular media filtration is physical removal of smaller sized particles using membranes, whereby small particles might not be captured in a granular media bed. Testing is needed to assess effectiveness for Cr removal, to determine design criteria for microfiltration, to identify any fouling that might occur in a system with upstream reduced iron, and to assess treatment costs.

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[6] Communications with Pall, Inc .Example installations of direct coagulation using ferric chloride: 6 MGD arsenic removal system at Washoe County, Nevada; 0.5 MGD arsenic treatment at Fallon, Nevada.

Research Approach

Microfiltration demonstration testing will be approached as an add-on to the current RCF facilities. This project will benefit from having the existing RCF infrastructure in place, thereby maximizing how much information can be learned for utilities facing the need for Cr(VI) treatment in the future. Current RCF demonstration testing is intended to last for one year from the start date in April 2010. MF testing is intended to be incorporated in the final months, overlapping if possible to minimize project O&M costs, such as analytical laboratory costs, chemicals, and staff resources.

Two primary types of membranes are used in MF drinking water treatment: polymeric and ceramic membranes. Of polymeric, submerged and encased are available, whereby submerged is generally considered to have a higher tolerance for solids loading (e.g., in membrane bioreactor applications). Since the demonstration process train does not have a coagulation/settling step, it is a direct filtration application. One membrane manufacturer is recommending a submerged polymeric membrane system for this application; others indicated that the doses that will be tested aren't problematic for their encased membrane systems. Minimal fouling is also a key benefit of ceramic membranes. Although capital costs are higher for ceramic, the costs can be similar on a life-cycle basis because polymer membranes might have to be replaced more frequently.

MF membrane suppliers (Pall, Siemens, GE/Zenon, Krueger, others) were solicited to preliminarily determine the availability of pilot skids, interest, and experience in this application (i.e., ferrous iron), and rental costs. In this project, a Request for Qualifications (RFQ) will be issued to the various vendors and the PAC together with Glendale will select two membrane suppliers for demonstration testing. During the RFP processes, we will ensure that vendors understand that information generated in the MF demonstration test will be shared with other vendors during bidding if MF is later selected for full-scale design (and if another vendor is selected, they will be required to do a confirmation 60 or 90-day pilot test to ensure that the flux and design conditions built into the bid documents can be met on Glendale's water). Since the water treated will serve customers during the demonstration testing, all MF pilot units require NSF certification for selection.

Figure 1 shows the locations at which the MF units will be integrated in the existing treatment process train. Flow rates for the MF skids generally range from 15 to 20 gpm each; remaining flow will be routed through the granular media filters. Two MF units will be tested in parallel. Both will be backwashed using the same water source as the granular media filters (i.e., raw GN-3 water). The media filter effluent is currently blended with other raw water sources and supplied to the Glendale Water Treatment Plant. However, pilot membrane units are expected to have been tested for various water qualities and the potential for contaminant introduction to the water exists even though the membranes are replaced with new NSF61 certified membranes between tests (except the Krueger ceramic membrane unit will be re-used). Thus, membrane filtrate will be discharged to the sewer. The remaining flow that will go through the granular media filter will be supplied to the GWTP.

A detailed test plan will be developed as the first task of this project. The MF testing is intended for a 3-month period (plus a month for re-plumbing and startup) to allow sufficient time to establish design criteria and to evaluate the effectiveness of several chemical clean-in-place events (typically 30-40 days apart). During this testing, the following items will be evaluated:

- Effectiveness at achieving treatment goals
- Membrane flux and treatment rate
- Fouling potential as measured by transmembrane pressure profiles

- Clean-in-place (CIP), maintenance cleans, and backwashing effectiveness and necessary frequency
- System recovery
- If possible for selected MF units, the impact of increasing ferrous sulfate dosage to assess the treatment process for higher Cr(VI) source waters

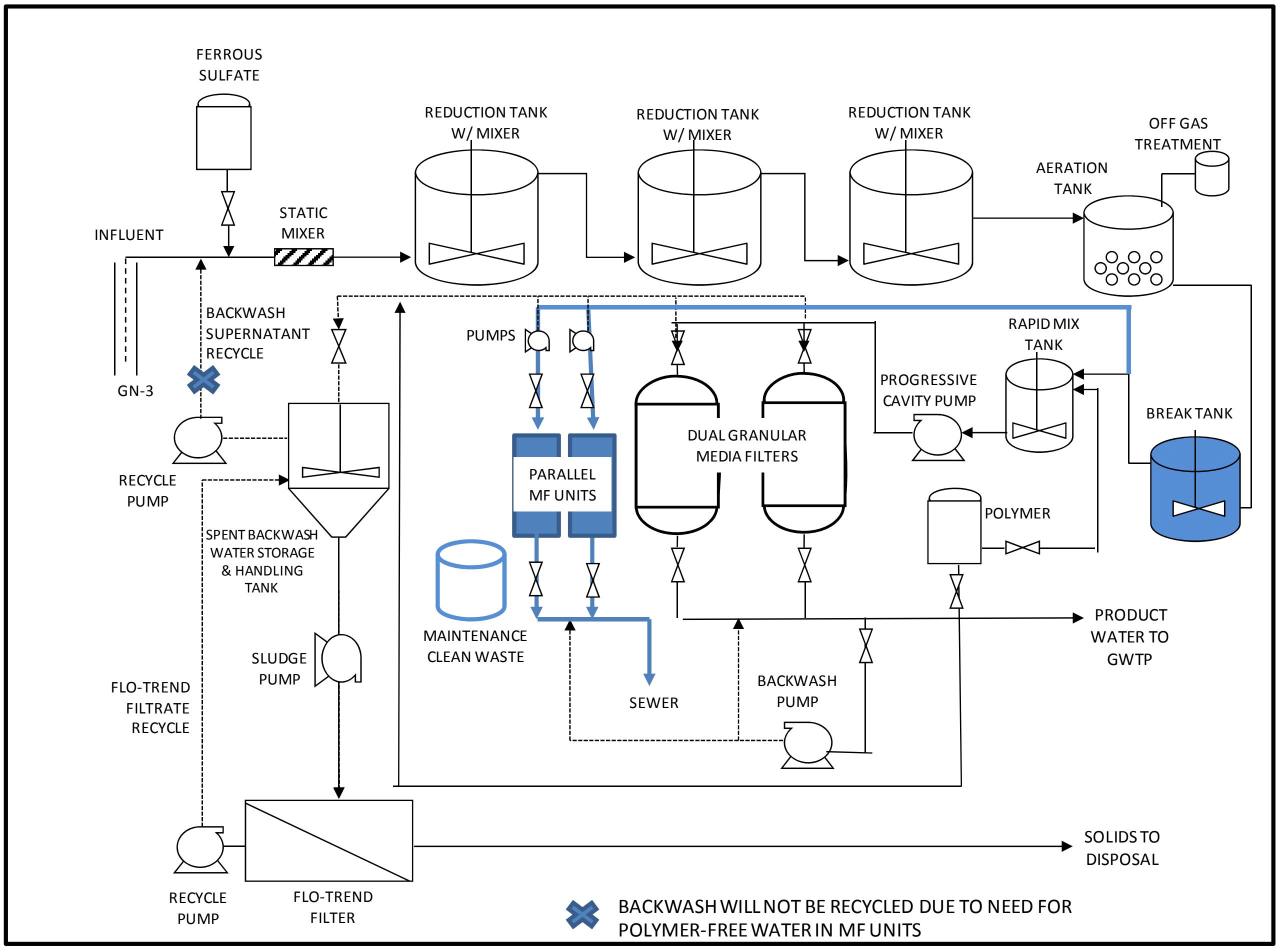

Figure 1. Process Flow Diagram Showing Integration of MF Pilot Units

In addition to testing the effectiveness of the MF process in achieving lower chromium and turbidity treatment goals than granular media filtration is able to achieve, a primary reason for conducting MF pilot testing is to develop design criteria that will be provided to vendors when the supply of the full-scale system goes out to bid. Given the unusual application of MF to a system feeding ferrous iron, the potential for fouling of membranes will be tested. Cleaning and backwashing frequencies and effectiveness in returning the membranes to their original state will be assessed. Post-mortem autopsies will also be conducted by the vendor on the polymeric membrane fibers to determine the degree of fouling (and a report on findings provided).

Evaluation Criteria

The potential utility of MF for achieving lower Cr(VI) treatment goals than granular media filtration will be tested in this project. Specific evaluation criteria to assess various project objectives are shown in Table 1.

Table 1. Project Objectives and Evaluation Criteria

Objectives	Evaluation Criteria
1. Determine if MF consistently achieves sub-ppb total Cr levels	• Cr(VI) and total Cr effluent concentrations collected at a frequency to evaluate removals during the post-CIP period, a moderately fouled condition, and more severely fouled condition • Turbidity levels in effluent water • Feed water temperature • Impact of VOCs on removals and fouling
2. Assess whether iron fouling is problematic in direct filtration mode of operation for the RCF process	• Transmembrane pressure (TMP) values measured continuously during operation and before and after backwashing, maintenance cleans, and clean-in-place cycles (recovery cleans) • Necessary frequency of backwashing and cleans • Test fouling impacts on two different kinds of membranes (of ceramic membranes, polymer encased membranes, and submerged membranes) • Post-mortem autopsy of membrane fibers to identify degree of fouling
3. Identify design criteria for full-scale MF in an RCF treatment process	• Target operating range for flux • Cleaning (maintenance and recovery) frequency • Backwashing frequency • System recovery

Statements of Qualifications (SOQ) submitted by all membrane vendors will be evaluated by Malcolm Pirnie, Glendale, and the PAC, and two qualified vendors will be selected based on overall scores. Membrane vendors will be evaluated according to the criteria listed below:

- Firm's capacity (financial and human resources) to complete this project
- Relevant experience of projects of similar nature and cost
- Demonstrated experience with treating water of similar quality
- State of California experience in drinking water treatment and permitting of MF/UF systems
- Availability of pilot units and ability to meet the schedule
- References
- Years of operation
- Clarity and presentation of SOQ
- Offer of in-kind service or cost-sharing with City of Glendale

Although a final test plan will be developed in the beginning of this project, we anticipate that the evaluation will include testing of the following parameters and frequency in addition to the existing samples for current RCF operations. Primary sampling points and analyses for assessing MF performance are shown in Table 2.

Cr(VI) and total Cr will be monitored three times every week. Assuming that the membranes will become fouled and a CIP is needed approximately every 30 days, the Cr(VI) and total Cr monitoring frequencies will provide at least three data points for each of the following periods prior to the CIP:

- Unfouled membranes
- Moderately fouled membranes
- Fouled membranes

Table 2. Preliminary Samples for MF Testing

Sample Point	Cr(VI) (Lab)	Total Cr (Lab)	Turbidity (Field)	Total Iron (Field)	Ferrous Iron (Field)	Temp. (Field)
SP-001 (Raw water)	3/W	3/W	1/M	1/M	-	-
SP-201 (Aeration tank effluent)	3/W	3/W	1/W	1/W	-	-
SP-601 (MF Skid 1 influent)	-	-	Con-tinuous	-	-	Con-tinuous
SP-602 (MF Skid 1 effluent)	3/W	3/W	Con-tinuous	1/W	-	-
SP-603 (MF Skid 2 influent)	3/W	3/W	Con-tinuous	1/W	1/W	Con-tinuous
SP-604 (MF Skid 2 effluent)	3/W	3/W	Con-tinuous	1/W	-	-
SP-605 (MF Skid 1 backwash effluent)	-	3/W	1/W	1/W	-	-
SP-606 (MP Skid 2 backwash effluent)	-	3/W	1/W	1/W	-	-

* Shaded cells show some of the samples currently taken for RCF operations that will be used to evaluate MF system operations.

* Refer to Section I for additional QA/QC samples. Briefly, field duplicates for lab samples will be collected for at least 10% of samples and a minimum of per sample collection. This QA/QC procedure results in approximately one extra Cr(VI) and total Cr sample per week.

Membrane operating parameters that will be tested and optimized include flux, transmembrane pressure (TMP), backwash parameters (i.e. frequency, aeration duration, backwash flow rate), enhanced maintenance cleaning parameters (i.e. frequency, chemicals and doses, duration), clean-in-place parameters (i.e. frequency, chemicals and doses, duration). The potential for extending periods of time between cleanings will be assessed (e.g., if vendors recommend testing two different types of chemicals). Membrane flux is a key design parameter for MF. Along with recovery and downtime for intermittent operating procedures, flux will determine the number of membrane racks, modules and footprint required for the full-scale system. Up to three flux rates will be tested during the pilot study to identify the proper flux at which desired chromium removal can be achieved. TMP is a measure for membrane performance, and will be used to assess fouling and backwash efficiency. TMP data will be used for membrane system pump sizing for the full-scale system. At each flux rate tested, backwash, enhanced maintenance cleaning and CIP parameters will be selected and tested to investigate the effectiveness of these cleaning procedures. Backwash and chemical cleaning intervals will affect system downtime and the membrane area for the full-scale system, thus, capital cost. In addition, backwash and chemical cleaning intervals and procedures also affect power, chemicals and labor costs, thus O&M cost. In addition to the operating parameters, membrane system recovery will be monitored for all test runs, which will be considered for O&M costs.

Particle counters for membrane feed and filtrate will be equipped in the pilot units or installed by CDM, which will provide numbers of particles per milliliter in different particle size ranges. Particle size distribution in membrane feed and filtrate combined with chromium removal results will help to understand the relationship between particle size and part-per-billion (or sub-ppb) level Cr(VI) removal, with the goal of improving chromium removal with the MF process.

We plan to initially test MF versus existing granular filter media operations to allow direct comparison for evaluation of MF performance. If the MF process is not able to successfully treat the water to less than 1 ppb total Cr, the Fe-to-Cr mass ratio may be altered to attempt to improve MF removal of Fe-Cr particles. However, initial testing will be conducted at the Fe-to-Cr mass ratio of 25:1 that has been successful in pilot testing for Cr reduction and iron particle formation and filtration.

G. Applications Potential

The primary product of this research will be a WRF report, publication in a peer-reviewed, mainstream journal like the *Journal of the American Water Works Association* and in conference presentations, which will be widely available to utilities interested in the research findings. The recent releases of a draft Cr(VI) toxicology assessment (i.e., reference dose, RfD) by USEPA and a draft public health goal (PHG) of 0.060 ppb released by the California Office of Environmental Health Hazard Assessment indicate interest in regulating Cr(VI) at both the federal and state levels. Cr(VI) occurrence data in California and across the nation suggest widespread contamination in drinking water supplies, particularly at levels in the single ppb range, as shown in the table below. One in ten California drinking water sources would be impacted by a Cr(VI) MCL of 10 ppb, and one in five by an MCL of 5 ppb, as shown in Table 3.

Table 3. Chromium-6 in drinking water sources 1997 through 2008 (Active and Standby Sources) - See Notes 1, 2, and 3

Peak level (µg/L)	No. of Sources	% of Detections
> 50	7	0.3
41 - 50	5	0.2
31 - 40	14	0.6
21 - 30	61	2.8
11 - 20	231	10.5
6 - 10	456	20.7
1 - 5	1,434	64.9
TOTAL	2,208	100

1. Data are extracted from monitoring results through January 2009. They will change with subsequent updates and should be considered draft.
2. "Sources" are active, standby, and pending sources reporting more than a single detection of chromium-6. Data may include both raw and treated sources, distribution systems, blending reservoirs, and other sampled entities. This table does not include inactive sources, abandoned or destroyed wells, agricultural wells, monitoring wells, or more than one representation of the same source (e.g., a source with both raw and treated entries is counted a single source).
3. For UCMR sampling, a number of sources may have been screened using a 1-ug/L reporting limit for total chromium. If total chromium was below the screening level, specific analysis for chromium-6 was not required.

Reference - http://www.cdph.ca.gov/certlic/drinkingwater/Pages/Chromium6sampling.aspx

The RCF process is similar to the coagulation-filtration process commonly used to remove arsenic from drinking water with the use of a coagulant chemical that is also a reductant for Cr(VI). As such, the RCF technology has significant applications potential. While WBA may be preferable at smaller flows such as wellhead treatment, RCF becomes more favorable in terms of cost when larger treatment systems are planned. WBA also has some flaws associated with high usage rates with high Cr(VI) concentrations and the impacts of other constituents on removal and disposal considerations.

To date, only granular media filtration has been tested as the filtration process in the RCF technology. Microfiltration offers the potential for increasing particle removal, and hence chromium associated with particles. This project will assess the effectiveness of RCF using MF (two of encased polymeric, submerged polymeric, and ceramic) for Cr(VI) removal to sub-ppb levels, and determine MF design criteria for full-scale application. The information to be gained in this project will be of interest to all utilities considering Cr(VI) treatment and also those performing direct filtration of low-dose iron coagulant with MF.

The project will be overseen by the City of Glendale, which provides utility involvement in the study. Glendale has gone to significant lengths to disseminate the information collected in this study through the years, both to the drinking water community and to the public, and will continue to do so in this project. Other utility partners and regulatory agencies have been involved at various stages, including the Cities of Los Angeles, Burbank, and San Fernando, USEPA, and CDPH. All testing conducted in the project so far, including the current demonstration-scale study, is based on assessing treatment technologies for utility application using potable water sources contaminated by Cr(VI). The MF pilot testing will be incorporated into the existing demonstration-scale testing as an add-on feature for consideration in full-scale implementation.

The MF testing results emerging from this project will help utilities to select the proper filtration for their own pilot testing without necessarily testing both, thus resulting in cost savings to other utilities. Further, parallel testing of two kinds of membranes will allow direct comparison of the two types of membranes for Cr(VI) particle removal, evaluation of membrane fouling, and identification of design criteria. If one of the membranes significantly outperforms the other, the proposed MF testing could save utilities the cost and effort in future testing of different membrane types. In addition, the existing demonstration-scale testing of the RCF technology at the City of Glendale offers a great cost advantage for the proposed MF testing, whereby the infrastructure for testing is already in place. In sum, this project offers the drinking water community needing Cr(VI) treatment a feasibility assessment of MF for filtration in the RCF process and design criteria to consider when weighing the type of filtration to select. The large number of utilities that would be impacted by an MCL even as low as 10 ppb highlights the importance of this project to the industry.

H. Summary of Related Research

The City of Glendale has been leading studies of Cr(VI) removal since 2002, comprised of Phases I, II, and III of the chromium research effort. Phase I included bench-scale studies to screen a wide range of potential technologies for Cr(VI) treatment. Phase II built upon Phase I and pilot tested six technologies at the Glendale site. Research findings in Phase II were used by the Project Advisory Committee to select technologies for demonstration testing in Phase III. RCF was one of the two selected technologies and is currently being tested at a 100-gpm demonstration-scale facility at Glendale. Initial results of the RCF system have indicated that the process cannot reliably achieve sub-ppb effluent chromium concentrations with the existing granular media filtration. As a result, the PAC recommended additional testing of microfiltration to investigate whether this alternative filtration approach can improve effluent water quality since a PHG of 0.060 ppb is currently proposed.

This project will focus specifically on evaluating MF for chromium and turbidity removal in the current RCF process. MF offers the potential for achieving lower chromium concentrations through enhanced particle removal. However, membrane filtration is typically installed downstream of a clarification step to remove most of the particles before reaching the membranes. The RCF process will be direct filtration without a clarification step to provide a comparison with the granular media filtration approach and to minimize the amount of infrastructure.

Direct membrane filtration has been studied for natural organic matter (NOM) removal, especially for surface waters with elevated NOM levels.[7, 8, 9] This approach has been taken primarily in small surface water treatment plants since late 1990s. In addition, direct MF has been tested for arsenic removal using ferric-salt coagulants.[10] Previous studies suggest the performance of direct MF on NOM and arsenic removal is site specific due to interactions between coagulants, feed water quality, membrane materials, and membrane systems used.[11] Coagulant dosage has an important effect on membrane fouling. While sufficient coagulant should be added to effectively remove NOM or arsenic, the dose must be below the upper limit that the membrane system can handle.

Direct MF has not been investigated for Cr(VI) removal, and this project will provide state-of-the-art applied research findings for the industry. The current understanding of the membrane fouling for a reduction/coagulation system with direct MF is not sufficient to predict basic design criteria for full-scale implementation. Results of the proposed testing will also be useful for determining treatability and estimating costs of MF for Cr(VI) treatment in comparison with granular media filtration.

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[7] Lahoussine-Tourcaud, V., Wiesner, M., Bottero, J.Y. and Mallevialle, J. (1990). Coagulation Pretreatment for Ultrafiltration of a Surface Water. *J. AWWA*, 80:11:76-81.
[8] Carroll, T., King, S., Gray, S.R., Bolto, B.A. and Booker, N.A. (2000). The Fouling of Microfiltration Membranes by NOM after Coagulation Treatment. *Water Research*, 34:11:2861-2868.
[9] Jack, A.M. and Clark, M.M. (1998). Using PAC-UF to Treat a Low-Quality Surface Water. *J. AWWA*, 90:11:83-95.
[10] Ghurye, G., Clifford, D. and Tripp, A. (2004). Iron Coagulation and Direct Microfiltration to Remove Arsenic from Groundwater. *J. AWWA*, 96:4.
[11] MWH (2005). *Water Treatment Principles and Design*. Published by John Wiley & Sons, Inc.

I. Quality Assurance/Quality Control (QA/QC)

A detailed Quality Assurance Project Plan (QAPP) was prepared for the original demonstration project in accordance with USEPA requirements. The QAPP will be amended to reflect changes to the QA/QC procedures necessary for MF testing in this project. Specific, proposed QA/QC procedures to ensure project data quality in this project are described below.

All laboratory analysis will be performed using analytical methods which conform to EPA guidelines and recommended test methods, including those in *Standard Methods for the Examination of Water and Wastewater* (APHA, 1999). Standard Operating Procedures (SOPs) will be used for all measurements. The effectiveness of the MF process will depend largely on Cr(VI) and total Cr analyses of the MF effluent. Demonstration testing has shown that the Cr is present as Cr(III) by the time the water reaches the filters, but it is important to ensure that total Cr is removed from the water since Cr(III) can re-oxidize to Cr(VI) in the distribution system.

Cr(VI) and total Cr will be analyzed using ion chromatography (EPA Method 218.6) and ICP-MS method (EPA Method 200.8), respectively, by an ELAP-certified laboratory. For Cr(VI), the method detection limit (MDL) is 0.020 ppb and the method reporting limit (MRL) is 0.050 ppb. Cr(VI) will be analyzed within 24 hours of sample collection and buffered using ammonium sulfate. For total Cr, the MDL is 0.088 ppb and the MRL is 1.0 ppb. Samples falling within the range of the MDL and the MRL will be flagged as “J values”.

Laboratory analyses, including Cr(VI) and total Cr measurements, will be subjected to numerous procedures to assess quality assurance objectives. The ion chromatograph for Cr(VI) measurements will be calibrated each analysis day. Acceptance criteria include a correlation coefficient for the linear calibration curve of greater than 0.999. An external laboratory control sample (LCS) with a concentration of 2 ppb will be analyzed for every batch of 20 samples or less. The acceptance percent recovery range for the LCS sample is within 90-110%. A 20 ppb instrument performance check (IPC) sample will be run after the initial calibration and subsequently after every 10 samples, with an acceptable percent recovery range of 95 to 105%. A laboratory reagent blank (LRB) will also be measured after every 10 samples and should be below the MRL of 0.1 ppb each time.

The ICP-MS for total Cr will also be calibrated each analysis day. Acceptance criteria include a correlation coefficient for the linear calibration curve of greater than 0.999. An initial calibration verification standard (ICV) will be analyzed immediately after the calibration curve with an acceptance percent recovery range of 95 to 105%. A continuing calibration verification standard (CCV) will be run subsequently after every 10 samples, with an acceptable percent recovery range of 90 to 110%. A continuing calibration blank (CCB) will also be measured after every 10 samples and should be below one-half of the MRL of 1.0 ppb each time.

Accuracy in Cr(VI) and total Cr analyses will be evaluated by determining percent recoveries in laboratory-spiked samples. A matrix spike (MS) will be performed on 10% of samples (or at least one sample per run), chosen at random. MS recoveries should be between 90 and 110% of the expected value for Cr(VI) and between 70 to 130% for total Cr. National Institute of Standards and Technology (NIST) traceable Cr(VI) solutions and ICS total Cr standard solutions will be used for matrix spikes. Accuracy will also be tested throughout the runs and after every 10 samples by analyzing a mid-range IPC sample and a laboratory reagent blank (LRB). The acceptance criteria for the IPC sample are between 95 and 105%. The LRB should be below one-half the MRL. If concentrations are outside of these ranges, corrective actions will be performed.

Precision (random error) will be investigated by performing repeat analyses on the same analytical instruments. For every batch of twenty samples, a LCS and a MS will be run. The acceptable ranges for these sample results are between 90 and 110% for Method 218.6 and 70 to 130% for Method 200.8. Laboratory replicates and matrix spike duplicates (MSD) will be analyzed for every batch of twenty samples with an acceptance criterion of less than 20% relative percent difference (RPD).

As the critical parameters in evaluating the success of the project, Cr(VI) and total Cr concentration data will also be subjected to paired sample analyses (i.e., Cr(VI) and total Cr samples collected at the same time). Paired samples will be used to assess the chromium speciation and ensure full reduction in the RCF process.

For field-measured water quality parameters including iron and turbidity, accuracy and precision acceptance criteria will be based on manufacturer specifications, which will be tested using standards prepared in the water matrices. In general, acceptance criteria for these analytes will be less than 20% for field-collected duplicate samples. For the field methods, precision will be analyzed every 20 samples from repeat analyses on known-concentration accuracy check standards, with an acceptance criteria of 80 to 120%.

QA/QC sampling will include field-collected duplicate samples and field blanks. Field-collected duplicate samples will serve to ensure acquisition of representative samples, consistency of sampling, and precision of the analytical methods. Field-collected duplicate samples will be collected for at least 10% of all samples. These duplicates will not be identified as QA samples when sent to the laboratory. Field blanks will be prepared by filling metal-free distilled water in sample bottles provided by the laboratory. These samples will be sent to test any possible contamination during sample handling, transport and storage. At least one field blank sample will be prepared for each shipment. Blanks submitted to the laboratory for analysis will not be identified as QA samples. Sufficient sample volume will be collected for the required analysis. Samples will not be composited to amplify sample volume or average samples over time. Split samples will be used to verify analytical precision.

All field and process equipment will be calibrated. Field equipment calibration will be performed in accordance with manufacturer specifications for each instrument. Certified standard solutions will be used to test the functionality and accuracy of each instrument within the range of measurements and a frequency specified by the manufacturer, or at least once per month. In addition to online meters, portable meters for turbidity and pH will also be used to verify the online meter measurements. In case of instrument malfunction, a back-up instrument will be obtained and calibrated for interim use while the malfunctioning instrument is under repair. Process equipment, such as pumps and flow meters, will be calibrated before the MF pilot units are brought online, and at the conclusion of the test, to avoid disturbing the membrane operation during the test period unless unexpected results warrant recalibration.

J. Schedule

We anticipate that the project will begin in April 2010. Table 4 shows the approximate 2011-2 project schedule. The first task will involve test plan development, which will be conducted in parallel with vendor solicitation using an RFP process. Vendors will be allowed approximately two weeks to respond to an RFP, and the two units will be selected the following week. A limiting factor is scheduling of MF testing skids and most vendors indicated they would need approximately six weeks from award of the contract to delivery at the site. Once the skids are delivered, installation will require approximately two weeks. The MF units will then be started up with troubleshooting over approximately two weeks. MF testing will be conducted for 3 months. Data analysis and report preparation will overlap with the testing period.

Quarterly progress reports will be produced for review by the PAC as shown in the schedule. The draft report will be submitted within three months of the last periodic report, and the final report by the beginning of 2012.

Table 4. 2011-2 Project Schedule

Task	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb
0. Project Management											
1. Test Plan Development											
2. Vendor Solicitation, Selection, and Scheduling											
3. MF Installation											
4. MF Startup and Testing											
5. Data Analysis											
6. Report Preparation											

☆ Progress Report ★ Draft Final Report ★ Final Report

The current RCF demonstration study is scheduled to end in June or July 2011. This project's schedule will be accelerated if possible to overlap with existing RCF operations and minimize costs.

K. Management Plan and Statement of Qualifications

The project team for the various entities in the MF project is shown in the organizational chart in Figure 2 and includes:

- Glendale – Mr. Don Froelich (Project Manager), Mr. Leighton Fong (Project Engineer), and Mr. Peter Kavounas (Assistant General Manager - Water Services and Principal Investigator)
- Malcolm Pirnie – Dr. Nicole Blute (Project Manager for MP), Dr. Ying Wu (Project Engineer)
- CDM – Mr. Charles Cron (Plant Manager), Mr. Rich Buday (Operations and Field Analysis)

The City of Glendale has worked closely with CDM and Malcolm Pirnie staff since the initial stages of the research effort. Continuity and institutional knowledge of the persons involved add tremendously to this study and minimize cost. To date, the City of Glendale (Peter Kavounas, Don Froelich, and Leighton Fong) have managed the effort and various subcontractors including CDM for operations and Malcolm Pirnie for study-related support. Camp, Dresser, and McKee (CDM) is the on-site operator of the Glendale Water Treatment Plant for VOC removal and also the Cr(VI) demonstration studies. CDM will be the constructors of the facility improvements in this project and the operators. They bring to the project a history of involvement in the studies since the beginning and hands-on operations of the facilities. Malcolm Pirnie adds to the team as the firm that has been scientifically leading the project direction and ensuring that the study is clearly defined and conclusions are well-founded, providing maximum benefit to the drinking water community as a whole.

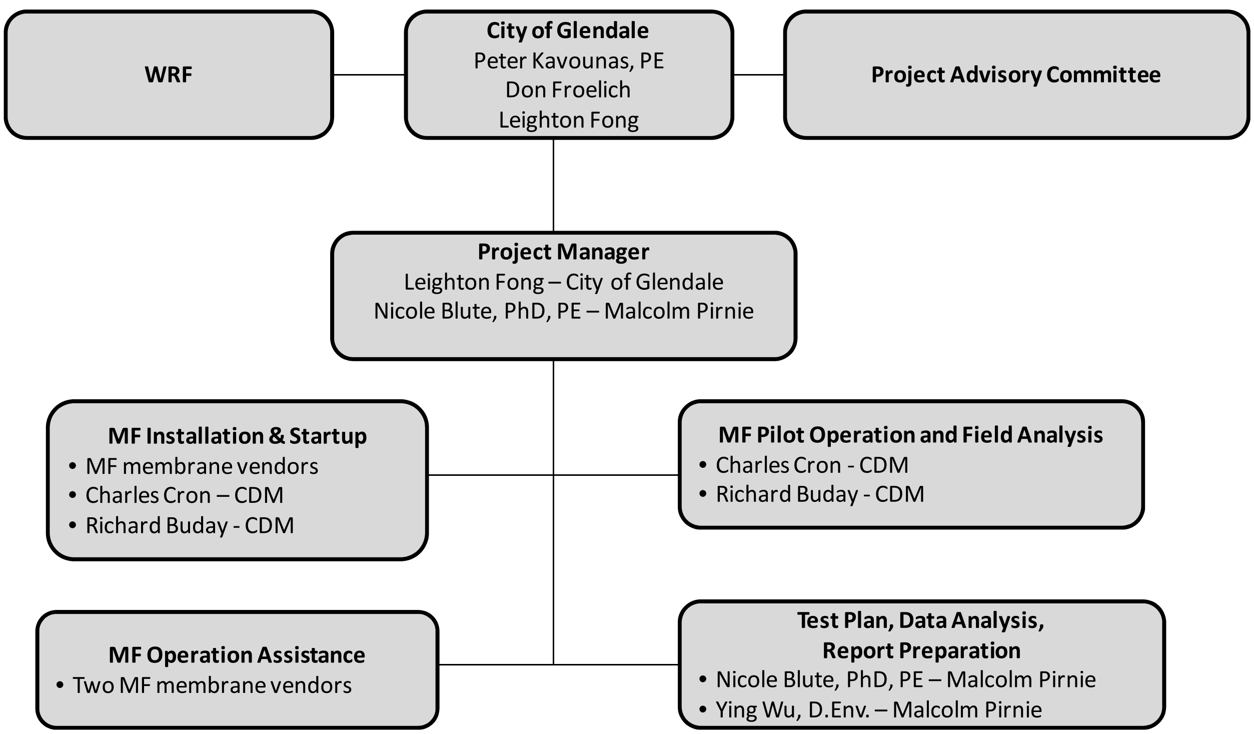

Figure 2. Project Team Organization Chart
Affiliations shown following individuals' names

Mr. Peter Kavounas will be the Principal Investigator, and Dr. Nicole Blute will be a co-Principal Investigator. They will maintain accountability through frequent project meetings, weekly updates of data analysis, and clearly delineated tasks identified in the project work plan. Both have been involved in the current project for most of its duration and have a thorough understanding of all aspects of the program.

Peter Kavounas, PE, City of Glendale. Mr. Kavounas is the Assistant General Manager - Water Services for the City of Glendale Department of Water and Power since 2004 and has 20 years of experience in the water industry. At Glendale, Mr. Kavounas is responsible for managing the operation, maintenance, and engineering activities of the water system serving the City's 200,000 residents. Most recently, his activities have focused on the EPA's groundwater cleanup activities in the Glendale area, construction of treatment facilities, and managing a number of studies in cooperation with other water agencies concerned about Cr(VI) issues in water supplies. Mr. Kavounas will assure the City's commitment to providing the support and resources necessary to locate pilot and demonstration facilities within the City's water system. Mr. Peter Kavounas replaced Mr. Froelich as the Water Services Administrator for the City of Glendale.

Donald Froelich, PE, City of Glendale. Mr. Froelich will act as the Project Manager for this research effort. Mr. Froelich, prior to his April 2004 retirement, was the Water Services Administrator for the City of Glendale with a long history of involvement in the EPA Superfund activities in Glendale, and the implementation of the four-phase Cr6 removal research program. Because of his long involvement in the Cr(VI) efforts, Mr. Froelich has been retained by Glendale to manage this research effort.

Leighton Fong, PE, City of Glendale. Mr. Fong will be the Glendale Project Engineer working with Mr. Froelich in managing the research effort. Mr. Fong has a long history in water quality activities, Superfund activities in the City of Burbank prior to being hired by the City of Glendale, managing water quality activities in Glendale, and participation in the pilot-testing program. He will manage the schedule and financial activities for this research project.

Nicole K. Blute, PhD, PE, Malcolm Pirnie, Inc. Dr. Blute is a Senior Project Engineer at Malcolm Pirnie, Inc. Dr. Blute has been working with Glendale on their Cr(VI) research effort since 2002 and brings an in-depth knowledge of all of the technical aspects of the technologies and research findings. For Glendale, she has prepared and presented study findings at more than a dozen forums ranging from public meetings and workshops to technical drinking water meetings. Dr. Blute will develop the test plan and ensure that the objectives of the testing and necessary project reporting are met.

Ying Wu, DEnv, Malcolm Pirnie, Inc. Dr. Wu is a Staff Environmental Specialist at Malcolm Pirnie, Inc. Dr. Wu has been actively involved in many projects focusing on drinking water treatment technology testing and implementation, including Glendale Cr(VI) research, and an on-going Cr(VI) feasibility study for City of Burbank, California. Dr. Wu conducted numerous bench-scale tests, led monitoring and operations of many pilot- and demonstration-scale studies, including tests of submerged microfiltration, pressure microfiltration and reverse osmosis at Coachella Valley. She will assist Dr. Blute with test plan development, data analysis, and report preparation.

Charles Cron, CDM. Mr. Cron is a Senior O&M Specialist for CDM and the Plant Manager for the Glendale Water Treatment Plant. He supported the Phase II pilot studies of Cr treatment and is currently overseeing the Phase III demonstration studies. Mr. Cron will continue in this role during the MF testing.

Rich Buday, CDM. Mr. Buday is a Senior O&M Specialist and an Operator for the Glendale Water Treatment Plant. Mr. Buday has extensive experience in operating a full-scale micro and nano filtration system for a Southern California water district. He is charged with the day-to-day operations of the RCF facility and will continue in this capacity for the MF testing.

Resumes for each of these key personnel are appended to this proposal.

L. Draft Communication Plan

The project team will coordinate and support the communication requirements of the Water Research Foundation for this project, including communications with WRF, PAC members, and the various contractors. Quarterly progress reports will be provided to all members of the project team, the WRF project manager, the PAC (Bruce Macler, Pankaj Parekh, Sun Liang, Rick Sakaji, and Heather Collins), and California DPH engineers (Jeff O'Keefe, Thomas Tsui, and Eugene Leung) on a monthly basis to keep the team fully informed of activities in a timely manner. A draft report detailing research findings will be submitted to WRF within three months following the last progress report and a final report by the end of 2011.

A formal Draft Communication Plan will be developed in conjunction with WRF as part of this project. The Plan will contain the following components, with additional details to the preliminary details shown below.

I. Target Audience
   - **a.** Water utility community
   - **b.** Public
   - **c.** Regulatory agencies (CDPH and USEPA; possibly other state health departments)

II. Deliverables
   - **a.** Work plan
   - **b.** Quarterly progress reports
   - **c.** Draft and final project report

III. Communication Activities – each will include a description of level of detail, content, and focus
   - **a.** Monthly project updates sent to a wide distribution list of interested parties
   - **b.** Final project results presentation to the PAC, water industry, and community
     - **i.** Broadcast on Glendale public access TV,
     - **ii.** Streaming on the web,
     - **iii.** Live at Glendale City Council chambers
     - **iv.** Press release intended for the public
   - **c.** Two webcasts of project findings to WRF subscribers
   - **d.** WRF final report in print
   - **e.** PowerPoint presentations at national AWWA conferences (e.g., ACE and WQTC), ACWA and others

The eight-year research program that Glendale has been leading has a long history of a multi-platform communication approach. The project team intends to continue the various outreach activities intended to reach everyone from the concerned public to the water industry end-user of the technology to disseminate WRF project findings.

M. Licenses and Inventions (as required)

The project is unlikely to produce patentable technologies or products that can be developed.

N. Third Party Contribution Letters of Commitment (as required)

No current third part contributions are in place. However, the vendor RFP will request in-kind services for MF skid rentals.

O. Participant Contribution Summary (PCS) Form

Participant Contribution Summary Form

Project Sponsor: City of Glendale Water and Power

Project Title: Research Effort to Investigate Microfiltration in the RCF Process for Hexavalant Chromium Removal

I. Project Participant Contribution Summary

THIS SECTION AUTOFILLS FROM THE INFORMATION ENTERED IN SECTIONS II AND III

A - Foundation Share	$ 300,000	This number is the sum total of all cash that will be managed by the Foundation and includes both Foundation and Co-Funder funds. *This amount should equal the Foundation Share share total in the completed Project Budget Form cost breakdown.*
B - Cost Share	$ 100,000	This number represents the dollar value of all contractor cost share that will be provided to the project. This amount should equal the Cost Share total in the completed Project Budget Form summary sheet cost breakdown.
C - Third Party Contributions	$ -	This number represents the sum of Third-Party cash contributions and the dollar value of all non-cash in-kind services provided by Co-Funders and Third-Party Contributors. *This amount should equal* ***K - Third Party Contributions*** *on the Project Budget Form.*
D - Total Project Budget	$ 400,000	This number represents the total of all cash and in-kind funding that will be provided by the Foundation, Co-Funders, Third-Party Contributors and Contractor Cost Share. The **Project Budget Total** on the Project Budet Form *must* equal this value.

Project Sponsor: City of Glendale Water and Power

Project Title: Research Effort to Investigate Microfiltration in the RCF Process for Hexavalent Chromium Removal

Co-Funder Contributions and Foundation Matching Guidelines:

- Organizations wishing to provide cash for a project **and have the Foundation manage the cash** should be listed below.
- Organizations who are providing cash to the project and are full paying subscribers wishing to have the Foundation match their cash contribution should indicate their request below.
- Organizations that wish to provide cash to the project but **will not be sending the funds to the Foundation** to be managed with other project funds should be listed on worksheet III under Third-Party Contributions
- All money managed by the Foundation, including co-funder cash, should be accounted for as Foundation Share on the main project budget form.
- Co-funders also contributing in-kind services should provide a dollar value for the services in the area indicated below.

SECTION II - Co-Funder Contribution and Requested Foundation Cash Match

Participant	Total	Co-Funder Cash	Foundation Cash Match	Co-Funder In-kind
City of Glendale	$ 300,000	$ 150,000	$ 150,000	$ -
	$ -			
	$ -			
	$ -			
	$ -			
	$ -			
	$ -			
	$ -			
	$ -			
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	$ -			
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	$ -			
	$ -			
	$ -			
	$ -			
	$ -			
	$ -			
Totals	Total Carried to Section I.A	$ 150,000	OK $ 150,000	Total Carried to Section III.A
Foundation Share = Co-Funder Cash + Foundation Cash Match (carries to Section I.A)	$ 300,000			$ -

Participant Contriubtion Summary

Project Sponsor: City of Glendale Water & Power

Project Title: Research Effort to Investigate Microfiltration in RCF Process for Hexavalent Chromium Removal

Third Party Contributions and Contractor Cost Share Guidelines:

- Third party contributions can be made by any entity interested in either providing cash or in-kind services to the project.
- Organizations that wish to participate by providing in-kind services alone should be listed below along with the estimated value of the in-kind service.
- Organizations that wish to provide cash to the project but **will not be sending the funds to the Foundation** to be managed with other project funds should be listed below.
- Cash and in-kind services provided by project contractors should be indicated in Section III.B below.
- Cash provided by third parties must be accounted for on the main project budget form under the Cost Share column.

SECTION III.A Third-Party Contributions

Participant	Cash	In-Kind Services	Total In-Kind
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
			$ -
Totals	$0.00	$0.00	$0.00
Co-Funder In-Kind (Carried from Section II)	⇨		$ -
Total Third-Party In-Kind Services (carries to section I.C)			$0.00

SECTION III.B Contractor Cost Share

Participant	Total
City of Glendale Water and Power	$ 100,000
Total Cost Share (Carries to Section I.B)	**$ 100,000**

P. Budget

Applicant Name:	CITY OF GLENDALE WATER & POWER	* Required fields are highlighted in yellow.			
Project Name:	Research Effort to Investigate the Feasibility of Microfiltration in RCF Process for Hexavalent Chromium Remova				
Preparation/Revision Date:	12/15/2010				
RFP # (if applicable):	n/a				

Note: The information above will carry over to subsequent pages/worksheets. All totals below will be automatically populated from the following pages/worksheets.

			Total	Foundation Share	Cost-Share
A	Key Personnel		-	-	-
B	Other Personnel		15,151.51	-	15,151.51
		Total Direct Labor and Fringe Benefits	15,151.51	-	15,151.51
C	Equipment Rental		-	-	-
	Special Equipment		-	-	-
D	Materials and Supplies		-	-	-
E	Travel		-	-	-
F	Subcontracts		370,000.00	300,000.00	70,000.00
G	Other Direct Costs		-	-	-
		Total Direct Costs	385,151.51	300,000.00	85,151.51
H	Indirect Costs		14,848.48	-	14,848.48
I	Fee		-	-	-
J	Surveys		-	-	-
		Total Direct and Indirect Costs	**400,000.00**	**300,000.00**	**100,000.00**
K	Third-Party Contributions		-	n/a	n/a
		Total Project Budget	**400,000.00**		

Applicant Name:	CITY OF GLENDALE WATER & POWER				*** Required fields are highlighted in yellow.**					
Project Name:	Research Effort to Investigate the Feasibility of Microfiltration in RCF Process for Hexavalent Chromium Removal									
RFP #	n/a									

A. Key Personnel *(Principal Investigator and Co-PIs only)*

Name	Project Role	Number of Hours	Direct Hourly Rate	% Time Allocated to Project	Subtotal Direct Labor	Fringe Benefit % of Direct Labor	Subtotal Fringe Benefits	Total	Foundation Share	Cost-Share
Peter Kavounas	PI	40.00	0.00	1%	0.00	0%	0.00	0.00		
(part of overhead)					0.00		0.00	0.00		
					0.00		0.00	0.00		
					0.00		0.00	0.00		
					0.00		0.00	0.00		
		Total Key Personnel			0.00		0.00	0.00	0.00	0.00

B. Other Personnel

Name/Position	Project Role	Number of Hours	Direct Hourly Rate	% Time Allocated to Project	Subtotal Direct Labor	Fringe Benefit % of Direct Labor	Subtotal Fringe Benefits	Total	Foundation Share	Cost-Share
Donald Froelich	Project Manager	60.00	73.00	3%	4380.00	40%	1752.00	6132.00		6132.00
Leighton Fong	Project Engineer	113.03	57.00	7%	6442.51	40%	2577.00	9019.51		9019.51
					0.00		0.00	0.00		
					0.00		0.00	0.00		
					0.00		0.00	0.00		
					0.00		0.00	0.00		
					0.00		0.00	0.00		
					0.00		0.00	0.00		
					0.00		0.00	0.00		
					0.00		0.00	0.00		
					0.00		0.00	0.00		
					0.00		0.00	0.00		
					0.00		0.00	0.00		
					0.00		0.00	0.00		
		Total Other Personnel			10822.51		4329.00	15151.51	0.00	15151.51

Applicant Name: CITY OF GLENDALE WATER & *** Required fields are highlighted in yellow.**

Project Name: Research Effort to Investigate the Feasibility of Microfiltration in RCF Process for Hexavalent Chromium Remov

RFP # n/a

C. Equipment Rental and Special Equipment Purchase

Equipment Rental (*List items and dollar amount for each item exceeding $1,000*)	Total	Foundation Share	Cost-Share
n/a			
Total Equipment Rental	0.00	0.00	0.00

Special Equipment Purchase (*List items and dollar amount for each item exceeding $5,000*)	Total	Foundation Share	Cost-Share
n/a			
Total Special Equipment Purchase	0.00	0.00	0.00

Applicant Name:	CITY OF GLENDALE WATER & *** Required fields are highlighted in yellow.**
Project Name:	Research Effort to Investigate the Feasibility of Microfiltration in RCF Process for Hexavalent Chromium Removal
RFP #	n/a

D. Materials and Supplies	**Total**	**Foundation Share**	**Cost-Share**
n/a			
Total Materials and Supplies	0.00	0.00	0.00

E. Travel	**Total**	**Foundation Share**	**Cost-Share**
None			
Total Travel	0.00	0.00	0.00

Applicant Name:	CITY OF GLENDALE WATER & *** Required fields are highlighted in yellow.**
Project Name:	Research Effort to Investigate the Feasibility of Microfiltration in RCF Process for Hexavalent Chromium Removal
RFP #	n/a

F. Subcontracts	**Total**	**Foundation Share**	**Cost-Share**
Malcolm Pirnie - includes Nicole Blute as co-Principal Investigator	80000.00	80000.00	0.00
CDM Constructors	290000.00	220000.00	70000.00
Total Subcontracts	370000.00	300000.00	70000.00

G. Other Direct Costs	**Total**	**Foundation Share**	**Cost-Share**
none			
Total Other Direct Costs	0.00	0.00	0.00

Applicant Name:	CITY OF GLENDALE WATER &	*** Required fields are highlighted in yellow.**	
Project Name:	Research Effort to Investigate the Feasibility of Microfiltration in RCF Process for Hexavalent Chromium Removal		
RFP #	n/a		

H. Indirect Costs ***(Attach copy of federally approved rates or detailed basis for rates)***

Cost Category	Rate %	Base $	Total	Foundation Share	Cost-Share
City of Glendale overhead only	98.0%	15,152	14848.48		14848.48
			0.00		
			0.00		
			0.00		
			0.00		
		Total Indirect Costs	14848.48	0.00	14848.48

I. Fee	%	Base $	Total	Foundation Share	Cost-Share
			0.00		
		Total Fee	0.00	0.00	0.00

J. Survey	Total	Foundation Share	Cost-Share
n/a			
Total Survey Costs	0.00	0.00	0.00

Applicant Name:	CITY OF GLENDALE WATER & *** Required fields are highlighted in yellow.**
Project Name:	Research Effort to Investigate the Feasibility of Microfiltration in RCF Process for Hexavalent Chromium Removal
RFP #	n/a

K. Third-Party Contributions

Participant	Total	In-Kind Services	Cash
none			
Total Third-Party Contributions	0.00	0.00	0.00

Q. Budget Narrative

The budget for this MF project is $400,000 as detailed in the table below by task. Major costs include MF pilot skid rentals, site improvements and hydraulic analysis to install MF into the existing treatment train (performed by CDM, the onsite operator), test plan development (Malcolm Pirnie), data analysis (Malcolm Pirnie), and report preparation (Malcolm Pirnie), and operations and analytical lab costs (CDM). Project oversight will be primarily conducted by Glendale with assistance by Malcolm Pirnie. All activities will occur within the calendar year of 2011.

			CDM					
	Glendale	**Malcolm Pirnie**	**Engin-eering**	**MF Rental**	**Construction / Installation**	**Operations**	**Analytics**	**Total**
Task 0. Project Management	$30,000	$10,000						**$40,000**
Task 1. Test Plan Development		$15,000						**$15,000**
Task 2. Vendor Solicitation, Selection, and Scheduling		$5,000	$5,000					**$10,000**
Task 3. MF Installation				$110,000	$110,000			**$220,000**
Task 4. MF Startup and Testing						$45,000	**$20,000**	**$65,000**
Task 5. Data Analysis		$20,000						**$20,000**
Task 6. Report Preparation		$30,000						**$30,000**
Totals	**$30,000**	**$80,000**	**$5,000**	**$110,000**	**$110,000**	**$45,000**	**$20,000**	**$400,000**

SCHEDULE OF ONGOING PROJECT COSTS
The City of Glendale is proposing to complete this project within 1 year. As a result, 100% of the Foundation share of the project will be expended within this first year.

PRIMARY CONTRACTOR BUDGET JUSTIFICATION
Salaries and Wages: Salary rates for City of Glendale employees (Donald Froelich and Leighton Fong) are established in conjunction with their employer, the City of Glendale Water and Power. No indirect/overhead costs are included in the hourly rates budget. PI Peter Kavounas will devote 1% of his time to planning and directing research activities, as well as monitoring the project budget and reviewing project reports. His costs are included in the overhead costs applied to the direct wages of Leighton Fong and Donald Froelich. Donald Froelich will devote 3% of his time to managing the project for the City of Glendale. Leighton Fong, as Project Engineer, will dedicate 7% of his time to coordination and execution of subcontracts and QA/QC of work.
Fringe Benefits: An estimate of 40% has been incorporated for Donald Froelich and Leighton Fong. Peter Kavounas' fringe benefits are included in the overhead costs.
Equipment Rental: No equipment will be rented directly by the primary contractor.
Materials and Supplies: No materials and supplies will be purchased directly by the primary contractor.

Travel: No travel is anticipated by the primary contractor.
Subcontract: The City of Glendale will enter into two subcontracts in this project. Malcolm Pirnie will be relied upon to develop the test plan, solicit vendor SOQs, schedule the vendors, conduct data analyses, and prepare the project report. CDM will be responsible for renting the pilot skids from the vendors, installing the units at the site, performing startup tasks, operating the units, collecting samples for laboratory analysis, and performing on-site analyses.
Other Direct Costs: Other direct costs are detailed in the Subcontractor budget narratives since they will be incurred by the Subcontractor rather than the Primary Contractor directly.
Indirect Costs: The contract mechanism to be used by the City of Glendale accounting for this project has no indirect costs associated with it.

SUBCONTRACTOR BUDGET JUSTIFICATION – MALCOLM PIRNIE
Salaries and Wages: The salary rates for Malcolm Pirnie are established by Malcolm Pirnie.
Co-PI Nicole Blute ($46,000 budgeted) will devote 10% of her time to managing the project, developing the test plan, coordinating the vendor SOQ process, analyzing data, and preparing the reports. She will oversee all project activities, data analysis and interpretation, and will be responsible for the reports.
A staff engineer, Ying Wu ($34,000 budgeted) will devote 10% of her time to test plan development, vendor coordination including SOQ request preparation, vendor scheduling, data compilation and trending, and support in project report preparation. She will also be available for limited MF skid troubleshooting as part of the data analysis task.
Fringe Benefits: Fringe benefits and overhead for Malcolm Pirnie are incorporated into the billing rates.
Materials and Supplies: No materials and supplies will be purchased by Malcolm Pirnie.
Travel: No travel is anticipated by Malcolm Pirnie except mileage to the site.
Other Direct Costs: No significant other direct costs are expected.
Indirect Costs: No significant indirect costs are expected.

SUBCONTRACTOR BUDGET JUSTIFICATION – CDM
Salaries and Wages: The salary rates for CDM are established by CDM.
Plant Manager Charles Cron ($12,000 budgeted) will devote 17% of his time to overseeing site installation, operations, and data interpretation.
Operator Rich Buday ($33,000 budgeted) will devote 71% of his time to working directly with the vendors for skid installation, operating the MF units, and performing field analyses.
Fringe Benefits: Fringe benefits and overhead for CDM are incorporated into the billing rates.
Materials and Supplies: We estimate that a total of $110,000 will be required for site preparation, components, and installation of the MF equipment and accessories for this project. A preliminary breakdown of the items contributing to this cost estimate is provided in the table below.

General Conditions	$ 5,900
Site Preparation	$ 2,800
Pumping Equipment	$ 10,500
MF Install	$ 6,500
Tanks	$ 8,500
Hangers/ Supports	$ 1,500
Valves	$ 2,000

Piping	$	14,000
Electrical/ Controls	$	30,000
Indirects/ O&P/ Contingency	$	28,300
TOTAL ESTIMATED	$	110,000

In addition, CDM will contract with two MF vendors for MF pilot skid rental. Based on vendor quotations obtained in December 2010, we estimate that each skid will cost $50,000-$60,000 for a 4-month period (including 1 month of installation and startup), for a combined total estimate for two skids of $110,000.

Travel: No travel is anticipated by CDM.

Other Direct Costs: Laboratory analytical costs will be paid through CDM and is anticipated to be approximately $20,000 for Cr(VI), total Cr, and TSS analyses. Other field analytical costs are not included in this budget because reagents and instruments were already purchased for prior testing and are available for use.

Indirect Costs: No significant indirect costs are expected.