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TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

August 27, 2007

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AUG 29 2007

CDM DALLAS

Ms. Susan Crawford, P.E.
Camp Dresser & McKee Inc.
8140 Walnut Hill Lane, Suite 1000
Dallas, Texas

Subject: Second HF Membrane Wastewater Reuse Pilot Study Report Protocol for the Treatment of Wastewater Effluent from the River Road WWTP
City of Wichita Falls – PWS ID #2430001
Wichita County, Texas

Dear Ms. Crawford:

The City of Wichita Falls (City) previously piloted Zenon's ZeeWeed® 500B and 1000 hollow-fiber (HF) ultrafiltration (UF) membranes for treating the wastewater effluent from the City's River Road Wastewater Treatment Plant (WWTP) in 2001. The City had requested that the Texas Commission on Environmental Quality (TCEQ) grant an exception to use one of these HF UF membrane treatment processes and be able to use this filtrate as a raw water source for the Jasper and Cypress Surface Water Treatment Plant's (SWTP) where additional water treatment will be received prior to distributed as potable water. In the TCEQ's letters dated July 31, 2002, January 7, 2004, and September 22, 2004, we granted an exception for the use of the Zenon ZeeWeed® 500B or 1000 HF UF membrane and the associated piloted treatment scheme for the proposed reclaim of wastewater effluent and use as a raw water source for the City's Jasper and Cypress SWTPs with specific design and operating conditions. Your letter dated October 11, 2005, requested that the TCEQ grant the same exceptions for the Pall and Siemens Memcor membranes. In the TCEQ's letter dated September 12, 2006, we stated we were unable to complete our review of the Siemens Memcor pilot study and that the Pall pilot study was unacceptable.

We have completed our review of the proposed second HF membrane pilot study protocol received on April 24, 2007. It is our understanding that the City now wishes to pilot the Pall Microza® USV 6203 HF microfiltration (MF) and the Siemens Memcor 4S10V HF MF membranes in accordance with the TCEQ's accepted pilot study protocol. In addition, Zenon wishes to pilot their HF UF membranes again. It is noted that several changes have been made to Zenon's membranes since the original pilot study and they would no longer be able to provide the membrane modules originally piloted. It was also noted that the City saw the need for denitrification of the WWTP's effluent prior to the membranes as a result of the previous pilot study. If this treatment process has been installed, then the feed water quality would be different from that piloted in 2001. Based on our review, we find that the submitted HF membrane pilot study protocol is **generally acceptable if amended to include:**

1. The log removal value verified by each membrane vendors direct integrity test (DIT) as calculated using the EPA's Membrane Filtration Guidance Manual – EPA 815-R-06-009, November 2005. Each DIT should be conducted at test pressures that result in a resolution of 3.0-microns to ensure removal of *Cryptosporidium* oocysts and *Giardia lamblia* cysts.

Ms. Susan L. Crawford, P.E.

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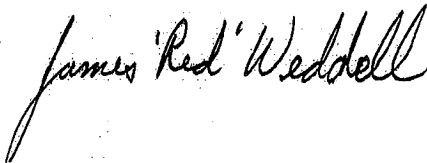
August 27, 2007

2. The pilot study's effluent must be returned to the WWTP (discharging through and air gap) and disposed of in accordance with the City's TCEQ permit.
3. At least twice during the pilot study, the raw water in the Jasper SWTP's terminal raw water basin must be tested for total coliform, viruses, nitrates, nitrites, ammonia and any other chemical constituent in the City's WWTP effluent and Jasper SWTP's source waters that exceed the maximum containment levels specified in 30 TAC Chapter 290, Subchapter F. These analyses will establish baseline data for the raw water prior to blending with the proposed HF membrane filtration facility's effluent.

This pilot study shall be conducted for **at least 50 continuous days** as previously agreed to by the TCEQ Public Drinking Water Section staff. Stage 1 will be conducted for a period of approximately 10 days to verify the coagulant dosage, Stage 2 for at least 30 days and Stage 3 for at least 10 days. It is agreed that all three vendors have collected data in the past to satisfy Stage 1 piloting.

If you have any questions or comments concerning this letter, or if we may be of further assistance, please contact me at the letterhead address or by telephone at (325) 481-8056.

Sincerely,



James "Red" Weddell, P.E.
Technical Review & Oversight Team
Public Drinking Water Section (MC 155)
Water Supply Division

JSW/av

Enclosures: Review of Pilot Study Protocols for Membrane Filtration
 Review of Pilot Study Reports for Membrane Filtration

cc: TCEQ Abilene Regional Office – R3
 Ms. Marlo Wanielista Berg, P.E., Team Leader, Technical Review & Oversight Team (MC 155)
 Mr. John Schildwachter, Team Leader, Source Water Protection Team (MC 155)
 Ms. Alicia Diehl, Ph.D., E.I.T., Team Leader, Drinking Water Quality Team (MC 155)
 Mr. Daniel Nix, City of Wichita Falls, P. O. Box 1440, Wichita Falls, Texas 76307-7532
 Mr. Scott Taylor, City of Wichita Falls, P. O. Box 1431, Wichita Falls, Texas 76307-1431

PILOT TESTING PROTOCOL FOR MEMBRANE FILTRATION FOR WATER REUSE

CITY OF WICHITA FALLS RIVER ROAD WASTEWATER TREATMENT PLANT AND JASPER WATER TREATMENT PLANT

April 7, 2007

I. GENERAL

A. Wichita Falls Water Supply Background

Wichita Falls obtains its raw water supply from Lake Kickapoo and Lake Arrowhead. Water from these lakes is pumped to the secondary reservoir system located within the City. The secondary reservoir system consists of two basins with a total storage capacity of 75 million gallons (MG). A future basin is planned that will add an additional 30 MG storage to the secondary reservoir system. Water from the secondary reservoir flows by gravity to the Jasper Water Treatment Plant (WTP) and is pumped to the Cypress WTP. Water is treated at these WTPs to potable water quality that meets the requirements of the Texas Commission on Environmental Quality (TCEQ) and EPA's Safe Drinking Water Act (SDWA). Currently the City system has a "Superior" rating based on TCEQ guidelines.

B. Purpose of Reuse Pilot Study

The City is completing a water supply program to increase its available water supply and expand and upgrade its water treatment plants. This program also includes a water reuse pilot study to investigate reuse of treated wastewater effluent. Currently, River Road WWTP discharges 12.5 mgd of treated wastewater effluent into the Wichita River. Some, if not all, of this flow could be reused to supplement the City's raw water supply or reduce demands on the potable water supply.

In 2000, the City and their consultants (Corlett, Probst & Boyd / CDM) submitted a reuse membrane pilot study protocol to TCEQ (then TNRCC) for approval of a membrane pilot study that would support design of a membrane plant for indirect potable reuse. The TCEQ has stated that to obtain approval for indirect potable reuse, advanced treatment with microfiltration (MF) or ultrafiltration (UF) membrane processes would be required. The purpose of this reuse pilot program is to evaluate the MF/UF membrane processes for treating wastewater effluent. The pilot testing results will provide necessary information to determine the feasibility and effectiveness of membrane filtration, develop the design and operational parameters for a membrane filtration facility, and evaluation the size and cost of facilities for a proposed reuse membrane plant that would be located adjacent to the Jasper WTP.

The membrane pilot study was performed in 2000 and 2001 using two membranes from Zenon Environmental. From 2002 to 2004, additional membrane pilot studies were also performed independently by the Pall Corporation and Siemens Memcor

to evaluate their respective membranes. The Zenon pilot study was accepted by TCEQ, however the Pall and Memcor pilot studies were not.

Follow-up discussions with TCEQ in October 2006 indicate that they would require additional pilot testing by Pall and Memcor for at least 50 days, which includes an optimization period and the required 30-day design condition pilot test run followed by a CIP and a 10-day follow-up pilot test run to determine any loss of original specific flux and if irreversible fouling has occurred. Because at least five years has passed since Zenon last ran their pilot study, Zenon would also like to perform another pilot study to determine if they can improve on their design parameters.

C. Pretreatment

1. The reuse water provided to the membrane manufacturers for the pilot study will be wastewater effluent discharge from the River Road WWTP, prior to entry into the Wichita River.
2. Coagulation with ferric sulfate will be provided (coagulant addition followed by static mixing).
3. All chemicals used during the pilot study will be the same as those proposed in the full scale membrane installation and will conform to the American National Standards Institute/National Sanitation Foundation (ANSI/NSF) Standard 60 and be certified by an organization accredited by ANSI.

D. Membrane Units

1. Each membrane unit being tested will be of the same design and contain fibers of the same length and type as that being evaluated for the full-scale membrane filtration water treatment plant. All membrane vessels being tested will conform to the ANSI/NSF Standard 61 and be certified by an organization accredited by ANSI.
2. The membranes used will be "preconditioned", if required, in accordance with the manufacturer's recommendations. Preconditioning, if required, will be completed prior to beginning Stage 1 of the pilot study.

E. Clarifications and Questions

1. Please direct any questions or clarifications to:

Ms. Susan L. Crawford, P.E., BCEE
Camp Dresser & McKee
(214) 346-2800 phone
(214) 987-2017 fax
CrawfordSL@cdm.com

II. PILOT STUDY PROTOCOL

A. General

1. The pilot study will be conducted for a period of 54 days during a season that represents typical operating conditions for a full-scale membrane installation.
2. Prior to beginning each stage where a CIP is specified, a CIP procedure and direct integrity test will be conducted. The membrane manufacturer is required to run the CIP and direct integrity testing prior to Stages 2 and 3. The CIP procedure and direct integrity test will be conducted on the last day of the previous stage. If new membrane units are used, a CIP procedure will not be required prior to Stage 1 testing. A direct integrity test of each tested membrane unit will be conducted after each CIP procedure by one of the following methods:
 - Diffusive air flow test;
 - Air pressure-hold (pressure or vacuum decay) test;
 - A TCEQ acceptable equivalent direct integrity test.
3. The continuous integrity of each manufacturer's tested membrane unit will be monitored during the pilot study. Acceptable methods are as follows:
 - On-line particle counters/monitors capable of identifying particle sizes in the 1-15 micron range, continuously monitoring the filtrate/permeate, and reporting the total particle counts in this range for each five-minute period to a recorder with coincidence error of less than 10 percent.
 - Hach's FilterTrak laser turbidimeter (Model HF660) with the ability to continuously monitor the filtrate/permeate and report the maximum turbidity level for each five-minute period to a recorder.

B. Stage 1

1. Stage 1 of the test period will be used to pilot the membrane units under different coagulant dose conditions. This stage will establish site-specific and full-scale pretreatment and operating parameters for each membrane unit being tested.
2. The following general conditions will be tested on the wastewater effluent discharge from the River Road WWTP 24 hours per day, 7 days per week:
 - Membrane filtration with ferric sulfate coagulant added in varying dosages followed by static mixing (14 days).
3. The following data will be collected during Stage 1 of the study.
 - Backwash/backflush/reverse flow direction;
 - Backwash/backflush/reverse flow frequency;
 - Backwash/backflush/reverse flow rate;
 - Feed water flow rate;
 - Range and average filtrate flux;
 - Range and average transmembrane pressure (TMP);
 - Specific and filtrate flux rate (temperature adjusted to 20°C);
 - Percent element recovery (crossflow) or percent system recovery (dead-end flow);
 - Expected time frame between chemical clean-in-place (CIP) procedures;
 - Frequency, duration, and procedure for each CIP and chemicals used during each CIP;

- Frequency, duration, procedure and chemicals for any other chemical cleaning procedures such as vendor referenced "mini CIP," "chemical enhanced backwash" (CEB), and "chemical soaking;" and
 - Pretreatment requirements.
4. Additional CIP Procedures followed by direct integrity testing will be conducted as dictated by the site specific feed water quality, tested operating parameters, and manufacturer's recommendations.

C. Stage 2 (30 days)

1. Stage 2 of the test period will test the membrane unit under the optimized conditions chosen in Stage 1, and the pilot plant operating 24 hours per day, 7 days per week, for 30 days.
2. Stage 2 will start with a CIP and direct integrity test followed by 30 days of operation at the membrane full-scale plant design conditions.
3. If unscheduled downtime occurs for more than 24 hours, TCEQ will be contacted to determine if Stage 2 of the testing needs to be restarted.
4. If a membrane unit fouls to a point that a CIP is required prior to the end of the 30-day test period, the membrane manufacturer will be disqualified from further consideration.
5. If a membrane unit has not fouled to a point of where a CIP procedure is required prior to the end of the 30 day period, a CIP procedure and direct integrity will be conducted after the 30th day.

D. Stage 3 (10 days)

1. Stage 3 will be conducted to determine the percent loss of original specific flux and if irreversible fouling has occurred.
2. Stage 3 will be conducted under the same simulated full-scale water treatment plant conditions used for Stage 2. The duration will be for 10 days after the CIP and direct integrity test performed at the end of Stage 2.
3. The duration of testing for Stage 3 may be extended if the Engineer believes more time is needed to determine if an undesirable percent loss of original specific flux or irreversible fouling has occurred under the selected operating parameters.

III. ANALYTICAL METHODS AND EQUIPMENT

A. Analytical Methods

1. All flow measuring devices, rate-of-flow controllers, and laboratory equipment will be calibrated as specified by the manufacturers prior to beginning Stage 1 of the pilot study. A description of calibration methods and frequency will be included for verification with the data that will be collected.
2. Frequency of calibration will be in accordance with Title 30 TAC Chapter 290.46(s).
3. Analytical requirements will be in accordance with Title 30 TAC Chapter 290.110(d).
4. Analytical requirements for turbidity will be in accordance with Title 30 TAC Chapter 290.111(d).

5. Analytical procedures will be in accordance with Title 30 TAC Chapter 290.119.
6. Log Removal values will be calculated as follows:

$$\text{Calculated maximum log removal (LR}_{\text{max}}) = \text{LOG}[Q_{\text{filtrate}}/\text{CF} \cdot Q_{\text{breach}}]$$

Where, Q_{filtrate} is the actual design flow, CF is the concentrate factor, and Q_{breach} is the flow rate through a 3.0-micron breach in a module's membrane, o-rings or epoxy as detected by the required direct integrity test.

B. Analytical Equipment

1. On-line particle counter: raw and filtrate (ChemTrac Model PC-2400D, US Filter WPC 1028 or Met One PCX)
2. On-line turbidimeter: raw (Hach 1720D or Hach 1720E) and filtrate (Hach Model FilterTrak HF660)
3. On-line pH meter or grab sample: raw, feed, and filtrate (Emerson Model 399 or Burkert Model 8025)
4. On-line temperature meter: raw (Endress & Hauser TST11)

IV. DATA COLLECTION

A. General

1. Due to the extensive data collection requirements during the pilot study, data will be recorded electronically.
2. The date, duration and amount of all rainfall events during the pilot study will be recorded.

B. During All Stages

1. During all stages of the pilot study, the following data will be collected:
 - All pretreatment units will be identified and the following pretreatment conditions will be monitored and recorded at least once each day and any time they are altered.
 - i. Flow rate and hydraulic detention time for each pretreatment unit;
 - ii. Type of chemicals being fed and their dosages; and,
 - iii. Chemical injection and monitoring points.
 - The following indirect integrity monitoring data will be recorded at specified intervals or more frequently:
 - i. Feed water turbidity at 15-minute intervals (a Hach FilterTrak turbidimeter is not acceptable for monitoring membrane feed water due to its inaccuracy at levels greater than 1.0 NTU) or feed water particle counts in the 2-15 micron range at 15-minute intervals.
 - ii. Filtrate/permeate water turbidity level at 5-minute intervals using a Hach FilterTrak laser turbidimeter or filtrate/permeate water total particle counts in the 2-15 micron range at 5-minute intervals using particle counters and monitors;
 - The following grab-sample water process control data will be recorded at the intervals specified and any time the raw water quality changes:

- i. Raw (from secondary reservoir), Feed (wastewater effluent discharge), and Filtrate water turbidity; (twice per day)
- ii. Raw, Feed and Filtrate water pH; (twice per day)
- iii. Raw and Filtrate water alkalinity; (twice per day)
- iv. Raw and Filtrate water hardness; (twice per day)
- v. Raw and Feed water temperature; (twice per day)
- vi. Raw and Filtrate water True and Apparent Color; (once per day)
- vii. All disinfectant dosage levels at application points, if applicable; (once per day)
- viii. All disinfectant residuals at monitoring points, if applicable; (once per day)
- ix. Feed water disinfectant residual levels, if applicable; (once per day)
- x. CIP, mini CIP, chemical enhanced backwash and chemical soaking solutions' pH, disinfectant residual and temperature levels; (once per day)
- xi. Backwash/backflush/reverse flow supply water's disinfectant residual and pH levels if adjusted; (once per day) and,
- xii. Filtrate/permeate water's disinfectant residual levels. (once per day)

C. During Stage 1

1. During Stage 1 of the pilot study, the following operational data will be recorded at least once each day and each time an operational parameter is changed.
 - Membrane rack/tank inlet pressure in pounds per square inch (psi);
 - Membrane rack/tank outlet pressure in psi;
 - Filtrate/permeate pressure in psi;
 - Feed water flow rate in gallons per day (gpd);
 - Instantaneous filtrate/permeate flux rate in gallons per square-foot of feed water side of the membrane per day (gfd);
 - Reject/bleedby/concentrate water flow rate in gpd; and,
 - Recycle water flow rate (if applicable) in gpd.

D. During Stage 2

1. During Stage 2 of the pilot study, the following operational data will be recorded at four-hour intervals or more frequently.
 - Membrane rack/tank inlet pressure in pounds per square inch (psi);
 - Membrane rack/tank outlet pressure in psi;
 - Filtrate/permeate pressure in psi;
 - Feed water flow rate in gallons per day (gpd);
 - Instantaneous filtrate/permeate flux rate in gallons per square-foot of feed water side of the membrane per day (gfd);
 - Reject/bleedby/concentrate water flow rate in gpd; and,
 - Recycle water flow rate (if applicable) in gpd.
2. The following water quality data will be recorded at least once during Stage 2.
 - Raw and feed water's algae counts;
 - Raw, feed and filtrate water's TOC and DOC concentrations;
 - Feed water total hardness as calcium carbonate;

- Feed and water iron, manganese, and aluminum;
- Feed water TSS;
- Raw, feed and filtrate water's TDS;
- Raw, feed and filtrate water's UV₂₅₄;
- Filtrate water TTHMs;
- Filtrate water HAA5s;
- Raw, feed and filtrate water's total coliforms;
- Raw, feed and filtrate water's pesticides;
- Raw, feed and filtrate water's metals (As, Cd, Cr, Cu, Pb, Se, Zn, Ag, Hg);
- Raw, feed, and filtrate water's fecal coliforms;
- Raw, feed, and filtrate water's viruses^a;
- Raw, feed, and filtrate water's chlorides;
- Raw, feed and filtrate water's sulfates;
- Raw, feed and filtrate water's nitrates;
- Raw, feed and filtrate water's nitrites;
- Raw, feed and filtrate water's bromides;
- Raw, feed and filtrate water's chlorites; and,
- Raw, feed and filtrate water's boron.

^aTo be taken following a CIP, at a minimum.

E. During Stage 3

1. During Stage 3 of the pilot study, the following operational data will be recorded at four-hour intervals or more frequently.
2. Membrane rack/tank inlet pressure in pounds per square inch (psi);
 - Membrane rack/tank outlet pressure in psi;
 - Filtrate/permeate pressure in psi;
 - Feed water flow rate in gallons per day (gpd);
 - Instantaneous filtrate/permeate flux rate in gallons per square-foot of feed water side of the membrane per day (gfd);
 - Reject/bleedby/concentrate water flow rate in gpd; and,
 - Recycle water flow rate (if applicable) in gpd.

F. At Least Every 30 days

1. At least every 30 days during the pilot study, the following water quality parameters will be recorded. (Note: One set is already required during Stage 2.)
 - Raw and feed water's algae counts;
 - Raw, feed and filtrate water's TOC and DOC concentrations;
 - Feed water total hardness as calcium carbonate;
 - Feed and water iron, manganese, and aluminum;
 - Feed water TSS;
 - Raw, feed and filtrate water's TDS;
 - Raw, feed and filtrate water's UV₂₅₄;
 - Filtrate water TTHMs;
 - Filtrate water HAA5s;
 - Raw, feed and filtrate water's total coliforms;
 - Raw, feed and filtrate water's pesticides;

- Raw, feed and filtrate water's metals (As, Cd, Cr, Cu, Pb, Se, Zn, Ag, Hg);
- Raw, feed, and filtrate water's fecal coliforms;
- Raw, feed, and filtrate water's viruses;
- Raw, feed, and filtrate water's chlorides;
- Raw, feed and filtrate water's sulfates;
- Raw, feed and filtrate water's nitrates;
- Raw, feed and filtrate water's nitrites;
- Raw, feed and filtrate water's bromides;
- Raw, feed and filtrate water's chlorites; and,
- Raw, feed and filtrate water's boron.

END OF DOCUMENT