America's Authority in Membrane Treatment

AMTA American Membrane Technology Association

Improving America's Waters Through Membrane Filtration and Desalting

PRETREATMENT solutions

Summer 2015

Revere Osmosis Pretreatment Chemicals

Optimizing Reverse Osmosis Pretreatment Chemicals in Orange County's Groundwater Replenishment System

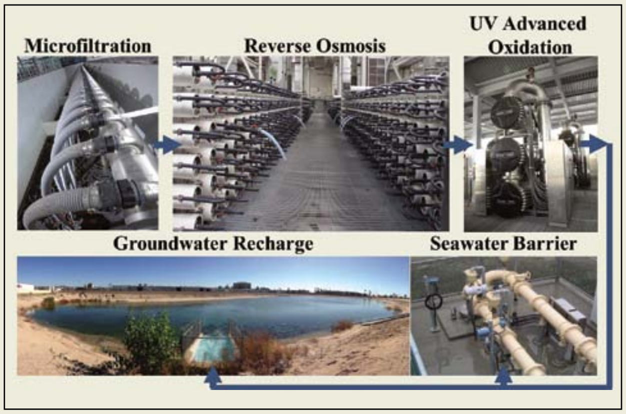
Tom Knoell, Orange County Water District*
Raul Gonzalez, Orange County Water District
William Dunivin, Orange County Water District
Mehul Patel, Orange County Water District
**Corresponding Author*

Introduction

California is in a drought. Consecutive dry years have pushed the State toward unprecedented water conservation measures. With imported water sources strained and the lowest Sierra snowpack in recorded history, the State Water Resources Control Board adopted mandatory, and enforceable statewide reductions – all aimed at limiting the excessive draw on remaining potable water supplies. The State ultimately has few options when it comes to its water supplies. Water reuse, however, provides the opportunity to capitalize on local sources to produce a sustainable potable water supply. Advances in water treatment technology have compelled traditional attitudes toward potable reuse to be challenged. This is especially true in regions which rely exclusively on the use of imported water.

Located in arid Southern California, the Orange County Water District (OCWD) operates the Groundwater Replenishment System (GWRS) – a 100mgd advanced wastewater purification facility. The GWRS is considered an indirect potable reuse (IPR) facility – one that incorporates planned use of an environmental buffer, including surface spreading for groundwater recharge. This constitutes the final process in what is considered full advanced treatment (FAT) - the multi-barrier approach of microfiltration (MF), reverse osmosis (RO) and UV advanced oxidation. This facility provides purified water for groundwater recharge and maintenance of a seawater intrusion barrier. Source water to the GWRS consists of secondary municipal wastewater provided by the Orange County Sanitation District. Specifically, this source water is a blend of activated sludge effluent and trickling filter effluent. The GWRS facility treatment processes are illustrated in Figure 1.

Figure 1
The Groundwater Replenishment System.



GWRS RO Process

Facility. The GWRS RO process represents the most critical step in this water reuse scheme due to its removal capability of both organic and inorganic constituents. The RO facility consists of 21, 5mgd units, each configured in a 3-stage array. With 1,050 RO elements per unit, the total number facility-wide exceeds 22,000. Images of the 70mgd RO facility and the recently completed 30mgd RO expansion are presented in Figures 2 and 3, respectively.

Operations. The RO system receives secondary municipal wastewater treated by a low pressure, submersible MF process followed by cartridge filtration. The MF process is highly effective in removing bacteria and other microbial detritus larger than the nominal pore size of 0.2 microns. While a

continued on page 4

President's Message

Scott Freeman

Welcome to the Summer 2015 issue of our "Solutions" newsletter, which is focused on pretreatment, a challenging topic ably addressed by our editors and authors. Thinking about AMTA overall, these are exciting times for us and membranes. Certainly droughts in California, Texas, and elsewhere are focusing media and public attention on desalination by reverse osmosis as well as reclaiming water from effluent with filtration and desalination membranes. As we all know that's just partial tips of the membrane iceberg, but very important ones.

In conjunction with this new attention, AMTA staff and volunteers, including Board members, are moving AMTA forward with new activities, partially geographical, partially organizational. Geographically speaking, AMTA's service area has included Canada and Mexico for a long time, but we have not been proactive in those countries. That's changing! Our first workshop in Toronto was held in July and we are planning an event in Mexico in 2016. And we may host a technical session in Spanish at the MTC-2016 in San Antonio next year.

Regarding working with other organizations, AMTA has signed two new cooperative agreements – one with the Water Environment Federation (WEF) and one with the WateReuse Association – to expand the promotion of membrane technologies/applications and to broaden membrane understanding within WEF and WateReuse's audiences. We have had challenges and success blending the strengths of AWWA and AMTA on the jointly conducted MTC conference. Many AMTA members have told me they like the combined MTC. Now we will try to broaden that success with cooperation between us, WEF and WateReuse. This is new ground we are plowing, so if you have suggestions, please feel free to pass them along. My 'door' is open and my email is FreemanSD@bv.com

Looking to next year, as you probably know we will have MTC-2016 in San Antonio in early February 1-4. In addition to membrane talks and networking, we'll have the River Walk, Tex-Mex, and the Alamo. Remember MTC! Looking forward to seeing you there.

Scott Freeman, P.E.

Current Executive Committee

President
Scott Freeman
Black and Veatch.

First Vice President
Christine Owen
Tampa Bay Water

Second Vice President
Lynne Gulizia
Toray Membranes USA, Inc.

Treasurer
Greg Wetterau
CDM Smith

Secretary
Karen Lindsey
Avista Technologies, Inc.

Past President
Mehul Patel
Orange County Water District

AMTA Staff

Executive Director
Harold G. Fravel, Jr.
hfravel@amtaorg.com

Administrative Director
Janet L. Jaworski, CMP

American Membrane Technology Association
2409 SE Dixie Hwy.
Stuart, FL 34996
772-463-0820
772-463-0860 (fax)
admin@amtaorg.com
www.amtaorg.com

Editors
Tom Seacord, P.E. and
Monica Pazahanick

PUBLICATION SCHEDULE

Summer
Pretreatment

Fall
Innovative Reuse

Winter
To be determined

Spring
To be determined

AMTA *Solutions* is published quarterly for the members of AMTA. AMTA *Solutions* is mailed to AMTA members and published on the AMTA website.

From the Editor

Dave MacNevin, PE, PhD.

In this issue, we are pleased to share with you three compelling articles highlighting innovative approaches to membrane pretreatment in potable reuse, water reclamation, and potable groundwater treatment.

The Orange County Water District (OCWD), California, has the largest potable reuse treatment facility in the United States, recently expanded to have over 100 mgd of advanced wastewater purification, with membrane processes including microfiltration and three-stage reverse osmosis treatment. Shortly after commissioning it was found that third-stage permeability in all 15 RO units had significantly declined. In this article, staff from the OCWD share their insights gained into membrane troubleshooting, scale inhibitor selection and optimization, and acid dose reduction. Given the large size of this facility, maximizing recovery, and minimizing chemical usage can result in substantial cost savings. By raising the feed water pH, OCWD saved more than $500,000/yr in operating costs. This article also explains a new concept of "dynamic dosing" of scale inhibitor, which could lead to higher recovery and more efficient chemical use potentially saving more than $100,000/yr.

One of the most elusive challenges in membrane treatment is to remove monovalent ions, like sodium and chloride, while leaving other stabilizing constituents in the water like calcium and bicarbonate. When reclaimed water TDS increased beyond 1,000 mg/L, the Scottsdale Water Campus in Arizona commissioned a pilot study, summarized in this article, which investigated the viability of a dual stage nanofiltration reverse osmosis (NF-RO) process to selectively remove sodium and chloride from reclaimed water, to help avoid increased maintenance costs for area golf courses. Results indicate that this approach can cut sodium and chloride concentration in the reclaimed water by more than 50%. By keeping more multivalent salts in the reclaimed water, the mass of salt in the reverse osmosis concentrate is reduced by 40%, providing multiple benefits for concentrate disposal and potential concentrate minimization.

Controlling biological fouling of RO membranes is often a challenge for many water treatment plants, and selecting the appropriate types of pretreatment can be particularly challenging. In this article, you will learn how one Louisiana WTP used adenosine triphosphate (ATP) testing to pinpoint the source of biological fouling in their pretreatment system, devise a new disinfection and operational strategy, and validate its effectiveness in reducing biofouling. The authors also propose a new membrane fouling index using ATP tests.

We hope you enjoy these articles and find them relevant to some of your membrane applications. We welcome and appreciate your feedback. If you have feedback on this issue, or are interested in submitting an article to a future edition of *Solutions*, these submissions can be sent to Dave MacNevin (dave.macnevin@tetratech.com).

SUBMIT YOUR ARTICLE TODAY!

AMTA *Solutions* continually solicits technical articles for future issues. We are currently collecting articles in a variety of water treatment subject areas such as Pretreatment, Water Quality, New Facilities and Membrane Residuals. Contact AMTA for additional information.

Figure 2
The GWRS 70mgd capacity RO system.

bulk of the larger macro-size materials are effectively removed, a majority of dissolved constituents remain for subsequent removal by the downstream RO system. A typical water quality profile of inorganic constituents in the GWRS RO feed water is presented in Table 1.

The GWRS operates at an average recovery of 72% and is broken down as follows: MF process – 90%, RO process – 85% and misc. – 3%. The relatively high recovery contributes to the cost-effectiveness of the treatment process. At-the-same-time, operating the RO system at higher recoveries poses issues that can challenge the efficiency of this treatment technology. As RO recovery increases to push the limits of overall production, so does the concentration of sparingly soluble salts as water travels through the system (Figure 4). RO recovery of 85% translates into a concentration factor of 6.67. For highly rejected constituents such as divalent cations (e.g., Ca^{++} and Mg^{++}), this translates into approximately 500mg/L and 167mg/L in the RO brine, respectively (based on Table 1 values). For other constituents such as silica, this equates to 140mg/L in the concentrate stream. As a result, antiscalants and pH suppression are typically employed to limit the precipitation of sparingly soluble salts from developing in the tail-end stages of an RO unit. For the GWRS RO system, pretreatment chemicals are an integral and necessary component of the process if it is to operate successfully at higher recoveries.

GWRS RO Mineral Scaling

Occurrence. After 14 months of operating the newly commissioned GWRS in 2008, it was discovered that third-stage permeability in all 15 RO units had significantly declined. Membrane autopsies conducted by OCWD staff on third-stage, tail-end elements revealed that the principal foulant was inorganic, based on loss on ignition (LOI) analysis – a method that provides an approximate percentage of organic/inorganic material in the sample. Images of the fouled membranes and material scraped from the surface are presented in Figure 5. Additional analyses, including ICP-MS and SEM/EDX revealed high concentrations of the following constituents: Si, Fe, Al and Ca, with Si found in the highest concentration. A review of typical solubility characteristics suggested that silica should remain undersaturated in the third-stage concentrate based on pH, RO operating conditions and WQ data presented in Table 1 [Walther and Helgenson (1977), Iler (1979)]. At the same time, impurities and trace metals such as aluminum significantly reduce silica solubility [Sheikholeslami and Bright (2002)]. In the presence of aluminum, it has been documented that the crystallization induction time can be altered – which directly challenges the effectiveness of antiscalants [Wen-Yi Shih et al. (2006)]. Due to the immense complexity of RO concentrate

Figure 3
The GWRS expansion 30mgd capacity RO system.

of wastewater origin, silica chemistry is more appropriately synonymous with its behavior and solubility in waste tailings. The GWRS third-stage RO concentrate is no exception.

Third-stage RO permeability decline is exacerbated as silica polymerizes on the membrane surface. Increasing hydraulic resistance results in reduced permeate flux. As discrete (small) spherical particles develop, they serve as nucleation sites that transform into larger particles (through condensation reactions). At elevated pH, silica particles repel each other, but particle growth continues void of aggregation. In the presence of cationic species such as calcium, aluminum and iron, the repulsive charge between ionized silica is reduced – resulting in aggregation. Factors which also influence the kinetics of aggregation include solution pH, temperature, size and concentration of silica [Iler (1979)]. High-resolution scanning electron microscopy (SEM) images of silica scale on a third-stage element removed from the GWRS RO system are illustrated in Figure 6. The corresponding energy dispersive X-ray analyses (EDX), listing the inorganic constituents associated with these SEM images, is shown in Table 2.

Figure 4
RO system recovery and concentration factor.

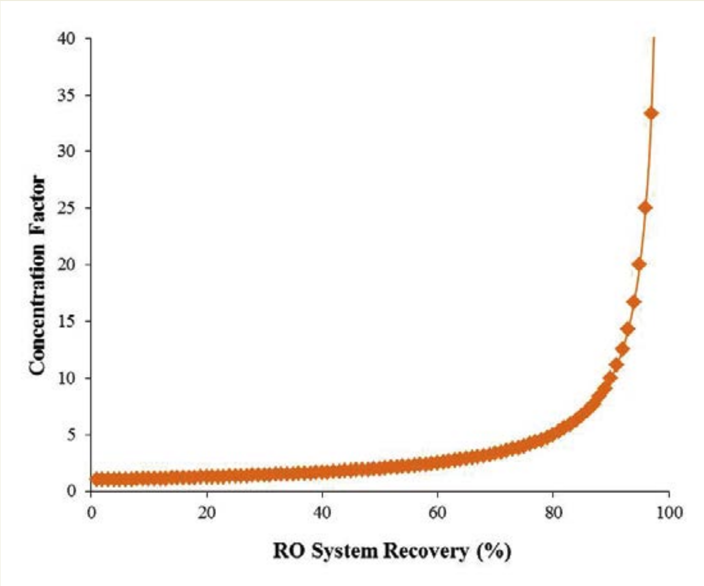


Figure 5
Images of a third-stage RO element removed for autopsy.

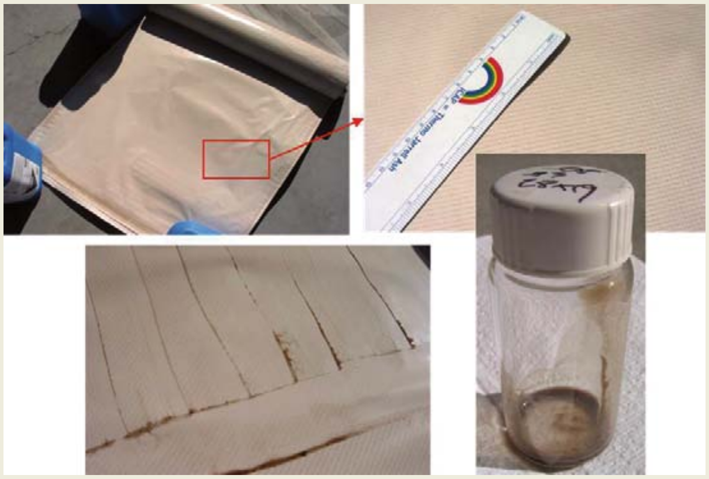


Table 1
GWRS RO Feed Water Profile

Parameter Name	Units	RO Feed
Electrical Conductivity	µmhos/cm	1,520
Total Dissolved Solids	mg/L	921
Turbidity	NTU	0.13
pH	UNITS	6.80 (6.90)
Total Hardness (as $CaCO_3$)	mg/L	291
Calcium	mg/L	75.3
Magnesium	mg/L	25.1
Sodium	mg/L	192
Potassium	mg/L	17.1
Bromide	mg/L	N/A
Chloride	mg/L	235
Sulfate	mg/L	218
Hydrogen Peroxide	mg/L	N/A
Bicarbonate (as $CaCO_3$)	mg/L	156
Nitrate Nitrogen	mg/L	9.19
Nitrite Nitrogen	mg/L	0.20
Ammonia Nitrogen	mg/L	3.71
Organic Nitrogen	mg/L	0.13
Total Nitrogen	mg/L	13.2
Phosphate Phosphorus	mg/L	0.21
Iron	µg/L	119
Manganese	µg/L	44.9
Aluminum	µg/L	5.45
Arsenic	µg/L	1.45
Barium	µg/L	28.9
Boron	mg/L	0.40
Cadmium	µg/L	<1
Chromium	µg/L	0.17
Copper	µg/L	11.3
Cyanide	µg/L	1.94
Fluoride	mg/L.	N/A
Lead	µg/L	<1
Mercury	µg/L	0.13
Nickel	ugL	7.38
Perchlorate	µg/L	N/A
Selenium	µg/L	1.95
Silica	mg/L	21.1
Silver	µg/L	<1
Zinc	µg/L	39.9

Table 2
EDX Profile of Inorganic Constituents Found on the Autopsied Membrane

Element	Atomic Percentage by Weight
Carbon	31.2
Oxygen	29.3
Sodium	0.5
Magnesium	1.0
Aluminum	6.1
Silicon	22.9
Phosphorus	1.1
Sulfur	1.2
Calcium	1.6
Iron	5.1

continued on page 6

Optimizing Reverse Osmosis Pretreatment
Continued from page 5

Challenge. Since discovering third-stage mineral scaling 14 months into operation, its occurrence has been pervasive and its control elusive. Staff continues to collaborate with leading chemical manufacturers, with the ultimate goal of identifying an antiscalant that will ***eliminate*** mineral scaling from occurring. Simply slowing its progression is an intermediary step. Selecting an antiscalant, however, is extremely challenging. Unlike other bulk chemicals (e.g., acids, disinfectants, etc.), a variety of antiscalant products exist with varying chemistries and capabilities. Mineral scale control is dependent not only on the antiscalant product, but a host of other parameters (Figure 7). Years of antiscalant research at OCWD has determined that success is more than simply identifying an antiscalant product. Rather, efforts now focus on the development of a comprehensive pretreatment strategy – one that includes a host of parameters. Identifying the correct product and conditions present a tremendous opportunity to optimize facility operations. The right combination of product pricing, dosage and RO feed water pH can all equate to significant cost-savings if successfully identified. Despite vendor claims and projections, performance is tied to a host of variables and not just to the product itself (Figure 7). Success at one facility in no way guarantees success at another.

Reward. Recognizing the potential savings in operating cost, coupled with the quest to eliminate mineral scaling, OCWD has continued its program to develop an effective RO pretreatment chemical strategy – an initiative that dates back to 2005. In treating microfiltered secondary effluent via RO, many of the scale-forming constituents are well controlled. Phosphates are often present in elevated concentrations, which can lead to calcium phosphate precipitation. Since phosphate is a multivalent and therefore can exist in different forms (and solubilities), pH suppression is typically employed. The past few years have seen an increase in antiscalant products claiming to exhibit calcium phosphate control under increasing alkaline conditions. At the same time, antiscalant effectiveness is linked to the operating pH of the system, since these chemicals are still incapable of exclusively controlling for mineral scaling (in water reuse applications). Suppression of RO feed water pH (through acid addition) is still required. OCWD has identified this as a potential for significant cost-savings, if products were procured which allow for operations at an elevated pH. The following graph illustrates the GWRS RO facility acid usage in relation to feed water pH - normalized to an annual production of 72,000af (64 mgd AADF) (Figure 8). (With the recent completion of the GWRS expansion project, these figures would be higher – reflective of the increase in capacity to 100mgd.) Operating at a feed water pH6.8 vs. pH6.7 resulted in a reduction of approximately 2,000 tons of acid. Assuming the current market price of sulfuric acid ($151/ton), this equates to approximately $300,000 in savings. Increasing from pH6.8 to pH6.9 resulted in a further reduction of 1,500 tons ($240,000). Staff identified this as a cost center for optimization, and has continued to engage the industry toward developing antiscalant products that push the limits of operating at elevated pH levels.

Figure 6
SEM images of material on a GWRS RO third-stage element.

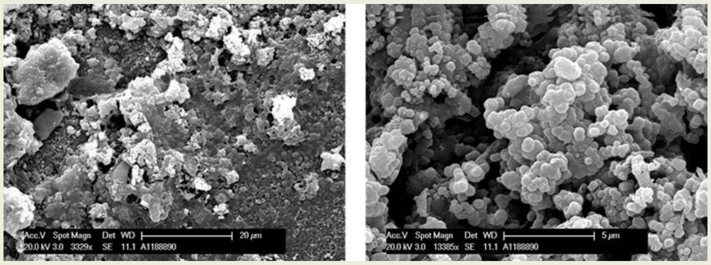
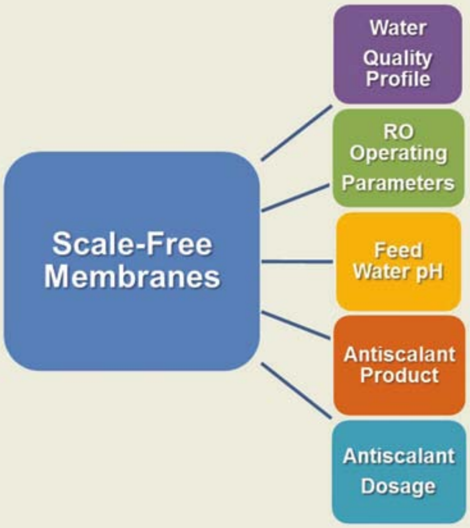


Figure 7
Parameters associated with RO mineral scale control.



In addition to optimizing the RO feed water pH, another cost center identified for optimization is the antiscalant dose. In the RO facility, antiscalant is dosed at a concentration of 3.50mg/L. This is solely based on the conditions during which the product was evaluated. As feed water and operating conditions change, there is no reason to believe that the current antiscalant dose will remain the correct dose. Significant cost-savings can be realized if the antiscalant dose was optimized to reflect the latest operating conditions. Based on an annual production of 72,000af, the GWRS RO system uses 430 tons of antiscalant (at 3.50mg/L). If the dose could be optimized – lowered by 5-10%, this would reduce the annual usage by 22 tons and 43 tons, respectively (Figure 9). Given the market price of antiscalant, this equates to a savings in excess of $100,000.

RO Pretreatment Chemical Strategy: T.I.M.

Trialing. OCWD operates a series of pilot RO systems at its Engineering Research Center – a facility dedicated to evaluating water treatment technologies and optimizing operations of the GWRS. Process changes to the GWRS operations are always born out of extensive trialing at the Center. Over the past two years, OCWD collaborated with leading chemical providers, including Avista Technologies, Inc. (San Marcos, CA) and Alkema Solutions (Plant City, FL). During this period, in excess of a dozen antiscalant formulations and operating scenarios were evaluated. In addition, a series of what were termed “run-to-failure” tests were conducted. These tests involved operating the RO systems void of antiscalant, but at varying influent pHs from pH6.6 to no acid adjustment (pH7.2). These tests were conducted to determine: a. the principal constituents to precipitate and b. the kinetics of precipitation based on altering the ionic environment of the feed water.

A formulation manufacturer by Alkema Solutions underwent long-term trialing at the Center. The extensive duration in which this, and all products (and pretreatment strategies) are evaluated is unique in the industry – but absolutely required based on District experience. Products must be evaluated for a minimum of 5-6 months of continuous operation. Pretreatment chemical failure, as defined by third-stage permeability decline, typical manifests itself in the first 30-days of operation, but has been observed after 4-5 months. Alkema Solutions’ product was evaluated at an operating pH6.8 and a dose of 3.50mg/L. The pH and dosage set point were established as the baseline based on historical, long-term trialing. Over the course of 190-days, the product demonstrated effectiveness in controlling for mineral scaling. The feed water pH was then increased to pH6.9 and a dose of 3.50mg/L. A unique feature of the RO pilot systems operating at the Center include the monitoring of permeability in three distinct areas: total system, last stage and tail-end element within the last stage. This provides an increased level of sensitivity in which product failure can be detected much quicker than simply monitoring total system permeability. Figure 10 illustrates the normalized specific flux of these three regions for operating conditions at pH6.8 and pH6.9. The total time of operation at each pH range was 190-days and 231-days, respectively. Trials are now underway at a feed water pH7.0. As to be expected when operating on municipal wastewater, the specific flux declined in all three regions as the trial progressed. With-respect-to evaluating antiscalant effectiveness, however, the most important aspect is the extent in which permeability declines in the tail-end of the process relative to the total system (Figure 11). The specific flux ratios remained relatively stable.

Implementation. In June 2014, after extensive trialing, a new RO pretreatment chemical scenario was introduced into the GWRS, and included a change in antiscalant product and feed water pH. The new operating scenario included an antiscalant dose of 3.50mg/L, feed water pH6.9 and a RO system recovery of 85% - all reflective of the conditions evaluated during trialing. Prior to implementation, a number of steps were taken to ensure the transition proceeded without issue. Staff contacts and site addresses were confirmed to ensure prompt and uninterrupted delivery. Bulk chemical storage tanks were prepared, which included draining, flushing and pre-inspection by the delivery service to confirm compatibility with tanker truck chemical transfer equipment. Upon product arrival,

Figure 8
Annual acid usage in the GWRS RO facility based on operating pH.

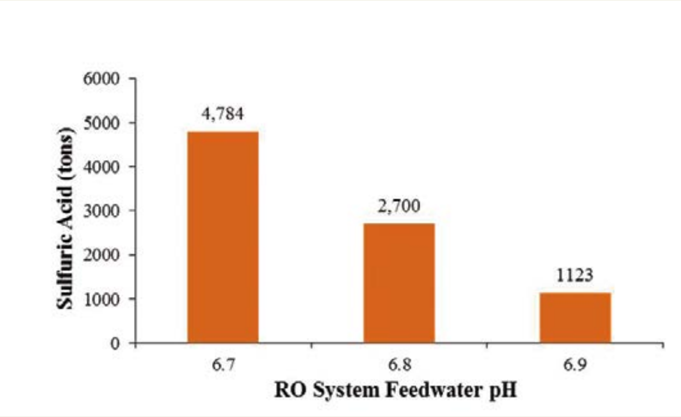


Figure 9
Annual antiscalant usage in the GWRS RO facility.

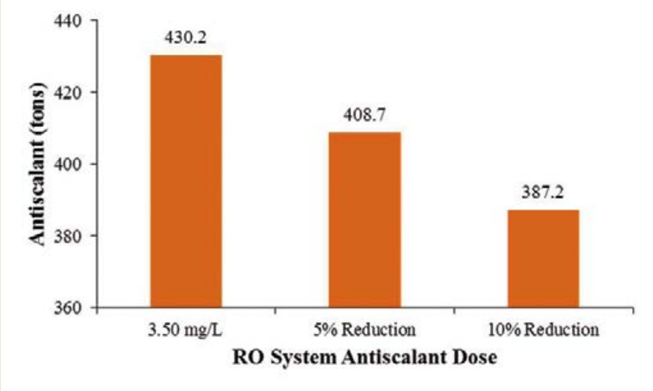
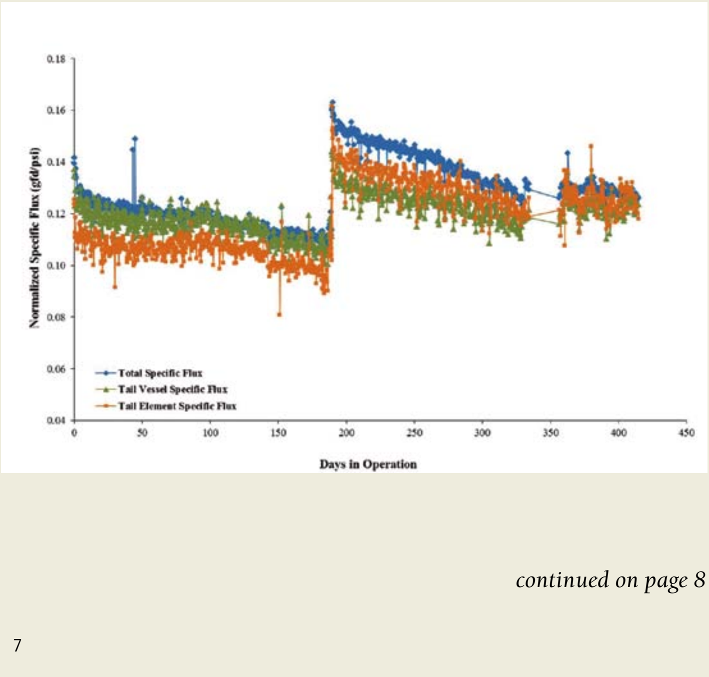


Figure 10
Normalized specific flux during the Alkema Solutions trial.



continued on page 8

Continued from page 7

documents, including Certificates of Analysis and Safety Data Sheets, were provided and reviewed.

Monitoring. All too often an RO pretreatment chemical strategy is implemented and then forgotten – only to be revisited once tail-end permeability has significantly declined. By that time, it becomes increasingly difficult to remove the foulant. In the case of silica scaling, this is especially true as silica begins to polymerize as it proliferates. Early detection allows for easier remove of this particular scale from the membrane surface. To that end, OCWD operates a series of monitoring systems – acknowledging that proactive monitoring is critical to the success of the RO process and its pretreatment chemical program.

The pilot system used during trialing continues to operate even after the new product is implemented into the full-scale system. This will provide advanced warning regarding impending declines in tail-end permeability associated with mineral scaling. A second system also operates to monitor for permeability decline. This system was designed, constructed and installed by OCWD staff on the third-stage feed to one of 21, 5mgd RO units (Figure 12). Two additional systems are also in operation and serve in a similar capacity. This system contains seven, 4-inch diameter RO elements, identical in total length to a full-scale, third-stage pressure vessel. Each element is housed in a series of pressure vessels, with the last three elements contained in discrete 1M vessels. All pressure vessels are connected in series. Isolating individual elements allows for real-time monitoring of membrane performance within each vessel. The system was started with new membranes shortly after the switch in antiscalant was made. Figures 13 and 14 illustrate the specific flux and specific flux ratio data. This system continues to operate and monitor for permeability decline – especially in the tail-end of the system. Relative to the specific flux of the entire vessel, individual vessel specific flux values have remained relatively stable (Figure 14).

Additional monitoring systems were designed, constructed and operated by District staff to further enhance monitoring for RO mineral scaling. These systems are connected to the third-stage concentrate of three, 5mgd RO units. A single element is housed in a 1M pressure vessel, and operated at a flux comparable to a full-scale element in the tail-end position of the third-stage. Element recovery is nominal, but still accountable for a slight increase in constituent concentration, which provides an added level of reassurance (Figure 15). At regular intervals (regardless of performance), these "sacrificial" elements are removed and autopsied to investigate for signs of early-stage mineral scaling. Detection of inorganic constituents typical of those observed in previous full-scale autopsies (e.g., silica, phosphate, iron, aluminum, etc.) would suggest commencement of a similar scaling event.

Enhanced Water Quality Monitoring

In addition to monitoring third-stage membrane performance, the District increased the frequency of sampling for two RO feed water constituents - iron and phosphate. Typically, all water quality analyses required of the GWRS are conducted through the OCWD Advanced Water Quality Assurance Laboratory (AWQAL). For iron and phosphate, these constituents are analyzed monthly. Given the increased sample frequency and impending impact on the AWQAL, efforts were undertaken to search out analytical techniques that could be performed by the District's Water Production staff. Over a one year period, split samples were analyzed by the AWQAL (using ICP-OES and FIA methods [Figure 16]) and Water Production (using spectrophotometric methods from Hach Co.). For phosphate and (digested) iron, both methods produced comparable results (data not shown). Efforts continue to validate the spectrophotometric methods as viable alternatives. Since historically only monthly sampling had been conducted, it is difficult to ascertain the true extent in which iron and phosphate concentrations fluctuate. Weekly RO feed water sampling data for iron and phosphate is presented in Figure 17. With these methods in place, Water Production staff will be moving toward daily sampling to further increase the resolution of these profiles.

Increasing the frequency of constituent monitoring was not arbitrary by any means. Through collaborative research with Alkema Solutions, it was empirically determined that iron significantly influenced antiscalant effectiveness. Laboratory simulations were conducted using the full range of historical GWRS RO feed water iron and phosphate concentrations. (The seven year silica average has remained relatively stable: 21.5mg/L, s.d. 1.53mg/L.) Simulations also included the temperature range exhibited in the GWRS feed water. Additionally, based on pilot system trialing and the desire to continue minimizing acid usage for pH adjustment, simulations were carried out at pH levels from 6.8 to no pH adjustment. A full series of dosing curves, including the one highlighted in Figure 18, were developed. This particular curve is based on an RO feed water iron concentration of 110ug/L, phosphate concentration of 0.80mg/L and a temperature range from 27oC to 29oC. The RO feed water iron and phosphate concentrations average 100ug/L and 0.44mg/L, respectively (Figure 17). The GWRS RO process operates at a feed water pH of 6.90 and an antiscalant dose of 3.5mg/L. At a maximum of 110ug/L iron, the curve suggests the optimal antiscalant dosage would be closer to 3.0mg/L. Operating at a higher antiscalant dose, combined with referencing a higher (iron)-based dose curve, provides a margin of safety against increasing influent iron concentrations.

As mentioned earlier, all too often an RO pretreatment chemical strategy is implemented and then quickly forgotten. This includes the antiscalant dosage. The conditions during which the antiscalant was initially evaluated may have changed to the point where there's no reason to believe the current dose remains the correct dose. Antiscalant dosing remains static in a majority of cases. What if the dose changed in response to changing constituent concentrations, such as iron? A concept conceived by OCWD, termed *"dynamic dosing,"* would alter the dosage based on specific water quality constituents known to interfere with the antiscalant's ability to control for mineral scaling. Similar to traditional chemical dosing that

Figure 11
Specific flux ratio during the Alkema Solutions trial.

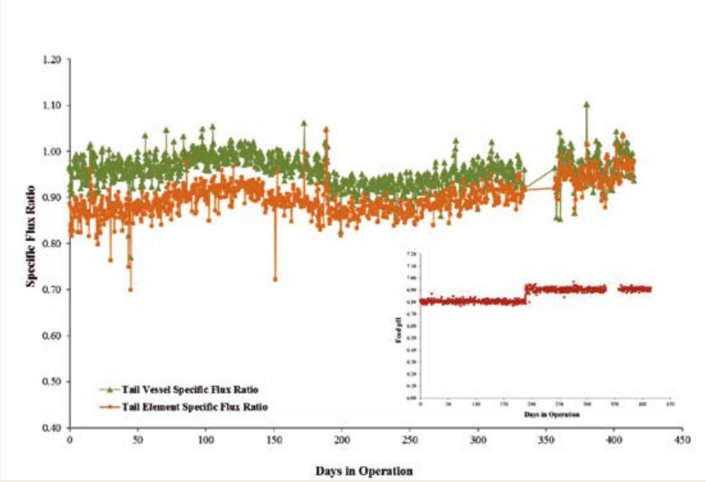


Figure 12
Third-stage monitoring system.

Figure 13
Normalized specific flux in the third-stage monitoring system.

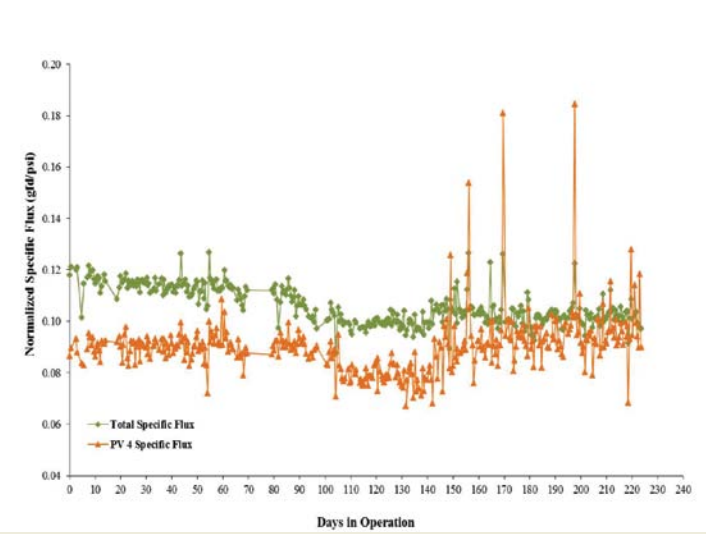


Figure 14
Specific flux ratio in the third-stage monitoring system.

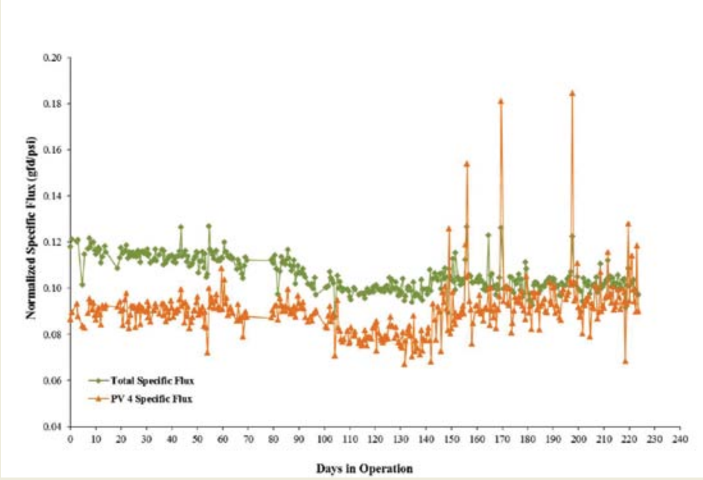
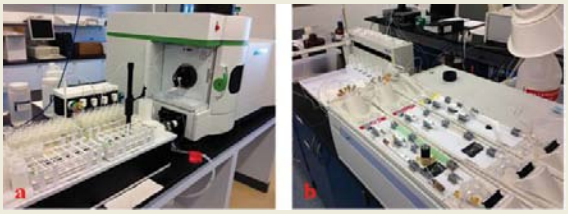


Figure 15
Third-stage monitoring system on RO concentrate.

Figure 16
AWQAL instrumentation - a. ICP-OES for iron, b. FIA for phosphate.



continued on page 10

Continued from page 9

incorporates in-line sensors coupled to PID-controlled dosing pumps, instantaneous feedback alters dose based on measured concentrations. For many constituents (e.g., <100ug/L iron), in-line sensor technology is either not widely available or offered only with higher detection limits. Given the tools and methods developed to date, it is feasible that tracking moving averages could reveal substantial seasonal fluctuations in influent iron and phosphate levels. Antiscalant dosage could then be adjusted accordingly to optimize the process.

Conclusions

A new RO pretreatment chemical strategy, including antiscalant product, dose and operating pH, was recently introduced in the GWRS RO facility. This strategy was born out of extensive collaborative research and trialing at the Engineering Research Center at OCWD. Developing and managing a successful RO pretreatment chemical strategy encompasses a three step, dynamic process: **T**rialing, **I**mplementation and **M**onitoring. The comprehensiveness in which chemicals are evaluated and used in the RO system ensures District operations remain as efficient as possible. Given the potential for additional optimizations and cost-savings, staff continues to evaluate RO pretreatment chemicals, with the objective of identifying antiscalants and operating strategies capable of prohibiting mineral scaling within the 100mgd GWRS RO facility.

References

R. K. Iler (1979), *"The Chemistry of Silica,"* John Wiley & Sons, NY.

Sheikholeslami, R. and J. Bright (2002), *"Silica and metal removal by pretreatment to prevent fouling of reverse osmosis membranes,"* Desalination (143) pp. 255-267.

Walther, J.V. and H. C. Helgeson (1977), Am. J. Sci. 277, 1315.

Wen-Yi, S., Gao, J., Rahardianto, A., Glater, J., Cohen,Y. and C. J. Gabelich (2006), *"Ranking of antiscalant performance for gypsum scale suppression in the presence of residual aluminum,"* Desalination (196) pp. 280-292.

Acknowledgments

District staff is acknowledged for their continued support of research aimed at optimizing the GWRS operations. This includes the Water Quality Department (Nira Yamachika) and the AWQAL (Lee Yoo, Jeremy Davis, Phil Harrington, Frank Duarte, Stephanie Giraud, Melissa Hill, Tam Nguyen, Melany Rich, Sterling Vamvas and Sumedha Weeratunga). Avista Technologies, Inc. (Rob Goodlett, Dan Comstock, Sara Pietsch and Dave Walker) and Alkema Solutions (Mo Malki and David Russell) are acknowledged for collaborating to support the District's research efforts to advance RO treatment through the development and use of new pretreatment chemistries.

Figure 17
Enhanced monitoring for iron and phosphate in the GWRS RO feed water.

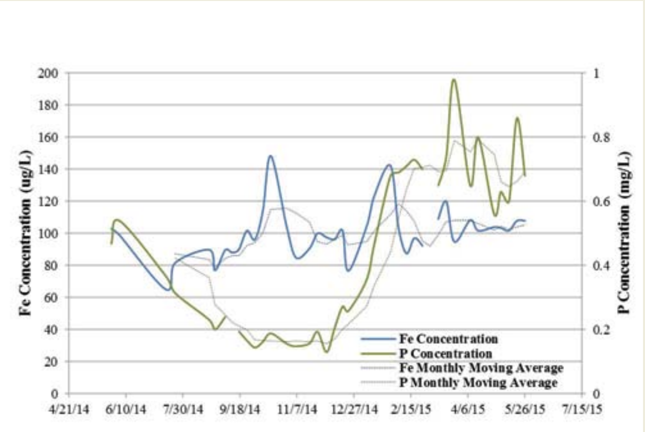
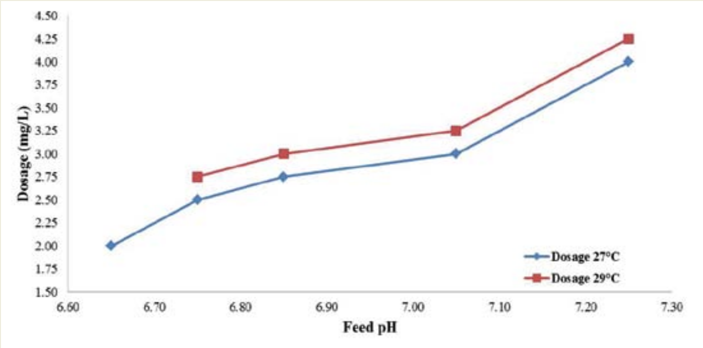
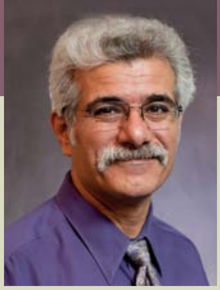


Figure 18
Antiscalant dosing curve based on 110ppb iron concentration.



Tom Knoell, Orange County Water District

Tom Knoell is the Principal Process Specialist for the Orange County Water District. Tom currently oversees the District's engineering research center as well as programs aimed at optimizing operations of the District's advanced wastewater purification facility - the Groundwater Replenishment System. Tom holds an M.S. degree and is a certified water quality analyst and water treatment operator. He also serves on the Board of Directors for the Southwest Membrane Operator Association - an affiliate of AMTA and an organization dedicated to educating membrane operators in the Southwest United States.



By: Ben Movahed, PE, BCEE

If you have a tip or a suggestion for a future design article, please contact Ben Movahed 240-780-7676 movahed@watek.com

Impact of the proposed reduction of Fluoride level in drinking water on Membrane De-Fluoridation Plants

A little history and background

On April 27 2015, the U.S. Department of Health and Human Services released its recommendation for "the optimal fluoride level in drinking water to prevent tooth decay." The department advocates that the level should not exceed 0.7 mg/L. This is a drop down from the previous recommendation range of 0.7 to 1.2 mg/L (issued in 1962). The American Dental Association (ADA) supports 0.7 mg/L level and believes that this adjustment will provide an effective level of fluoride to reduce the incidence of tooth decay while minimizing the rate of fluorosis in the general population.

Fluoridation of drinking water in the United States dates back to the 1940's as dentists believed it would prevent several types of tooth disease. In 1945, Grand Rapids, MI became the world's first city to add fluoride to its drinking water. Six years later, a study found a dramatic decline in tooth decay among children there, and the U.S. surgeon general endorsed water fluoridation. Today, nearly 75% of the country's population drink water that contains fluoride.

The recent proposed reduction in fluoride level is because it is believed that now most people have access to more sources of fluoride, such as toothpastes, processed beverages, tea, fluorinated pharmaceuticals and mouthwashes than they did when fluoridation was first practiced.

In 2004, the World Health Organization published a report indicating long-term ingestion of large amounts of fluoride can lead to potentially severe skeletal problems. In 2006, the National Academy of Sciences found dental fluorosis, breakdown of tooth enamel, discoloration and pitting were caused by too much fluoride. Because of these reports and the anti- fluoride campaign, questions began to surface about the benefits and potential health risks associated with the current Fluoride standard.

Currently several cities such as Portland and many cities in Oklahoma and Canada are not fluoridating their drinking water. Ireland legislation, currently under consideration, would not only universally ban fluoridating the water, it would also confer jail time for anyone who adds it!

Fluoridation opponents believe water supply is an inappropriate way to deliver "medicine". They argue that with other medicines, it is the patient, not the doctor, who has the right to decide which drug to take. Therefore they argue that the new lowered standard is still too high.

To Fluoridate or Not Fluoridate, That is NOT Our Question!

Obviously if you are currently adding Fluoride, the proposed regulations are good news for you. You will be purchasing less chemicals. However, for the few membrane facilities that are removing natural Fluoride from their source water using membrane systems (de-fluoridation), this may be a bad news.

These facilities typically have an RO system with well water blend, which was designed for meeting a certain fluoride concentration in the blended water. The two facilities that I have been involved are targeting blend fluoride level of less than 1.0 – 1.2 mg/L. If the proposed level becomes a rule and if the local regulatory agency require de-fluoridation facilities to comply with the 0.7 mg/L goal, then these facilities may have to make changes. Changes may include one or more of the following measures:

- Increasing hours of operation
- Running the RO skid at a higher flux
- Reducing bypass-blend
- Adding more membranes on skids
- Increasing plant capacity
- Increasing post chemical dosages

So stay tuned. If the rule is finalized, contact your regulatory agency and see if your de-fluoridation plant has to comply with the lowered levels.

Meanwhile, I highly recommend testing Fluoride from your raw, permeate and blended finished water samples, make plans and be prepared. ■

Pilot Test of Nanofiltration Membranes for a Novel Approach to Water Reclamation

Robert R. McCandless, Brown and Caldwell

This study was conducted to evaluate the viability of an innovative membrane system configuration for desalting reclaimed water that is impacted by high levels of sodium chloride. The study consisted of a pilot test and desktop analysis. The pilot study was conducted to gather data and understand the factors affecting passage (or rejection) of various dissolved ions, particularly sodium chloride using nanofiltration (NF) membranes. Additional data was collected regarding the rejection of organics, nitrogen compounds, phosphates and pharmaceuticals and personal care products (PPCPs). Using data from the NF study, a desktop analysis was performed for the reverse osmosis (RO) component and concentrate treatment. These results were compared with a traditional approach to desalting using RO with a blending strategy to achieve the water quality objectives.

Background

In arid climates, reclaimed water is a key component of many utilities' water resource portfolio. Reclaimed water often has a total dissolved solids (TDS) content 400 to 600 parts per million (ppm) greater than the drinking water source. In some cases, the elevated TDS has deleterious effects on turf and other landscape irrigation through elevated sodium adsorption ratio and high chloride content.

For over 15 years, the City of Scottsdale Water Campus (COSWC) has used reclaimed water for aquifer recharge and irrigation of golf courses. Historically, this water has been delivered to over 20 golf courses in the north Scottsdale area for irrigation and lake make-up. The reclaimed water TDS content has increased to over 1000 milligrams per liter (mg/l), which has resulted in increased maintenance costs for the golf courses that use the reclaimed water. To address impacts due to high salinity, several of the golf courses funded an expansion of the RO system for the purpose of providing water with lower sodium levels.

Figure 1 shows the distribution of the main dissolved inorganics found in the City of Scottsdale's reclaimed water compared to the finished water leaving the drinking water treatment plant. The most notable difference between the two is the much higher concentrations of sodium (Na) and chloride (Cl) in the reclaimed water.

There are several contributing factors to the elevated TDS, but one of the major contributors is the use of sodium zeolite exchange softeners. Existing efforts to reduce the sodium and chloride levels in the wastewater have focused on source control. Some measures include switching from automatic softeners to portable exchange units, using potassium chloride instead of sodium chloride as regenerant, using non-salt regenerating softeners, or bypassing high salt flows to a larger WWTP.

Most of the other dissolved ion content of the reclaimed water is not detrimental for irrigation of turf or harmful to aquatic organisms, at least not at the concentrations found in wastewater.

A membrane process that could remove the sodium chloride while retaining the 'good' ions (i.e. those that help to maintain water stability such as calcium, magnesium and sulfate) would improve the quality of the reclaimed water and reduce costs for turf management. A flow scheme that involves a two-pass membrane system, as shown in Figure 2 could achieve this objective. The flow scheme uses a NF system in the first pass followed by RO in the second pass. Multivalent ions in the first pass are retained and blended with permeate from the second pass to achieve a more stable product water with minimal, if any post-treatment chemical addition. And since the feed to the second pass is softened and particulate-free, higher recoveries are possible with minimal chemical pretreatment.

For this approach to succeed the NF pass would ideally exhibit low rejection of monovalent ions and high rejection of multivalent ions and ideally, this could be manipulated through process control.

Principles of Membrane System Salt Passage

Typical nanofiltration and reverse osmosis (NFRO) systems use a plug flow regime which provides good salt rejection (low salt passage) at a fixed or narrow range of operating recoveries. In contrast, systems with concentrate recirculation allow for operation over a wider range of recoveries and variable-feed water quality. Systems with concentrate recirculation require higher pumping energy than plug flow systems. Benefits of the internal recirculation include a reduced risk of fouling due to higher crossflow and more uniform pressure (and recovery) across multiple elements in series.

Several factors contribute to passage (or conversely, rejection) of salts. Salt passage increases with increasing concentration on the feed side of the membrane. Salt passage also increases with increasing system recovery. In plug flow systems, the salt passage increases linearly with respect to system recovery. Salt passage using internal concentrate recirculation increases at an exponential rate with respect to system recovery. This phenomenon is described in Dow's Technical Manual. The

Figure 1
City of Scottsdale Drinking and Reclaimed Water Quality – Fall 2014

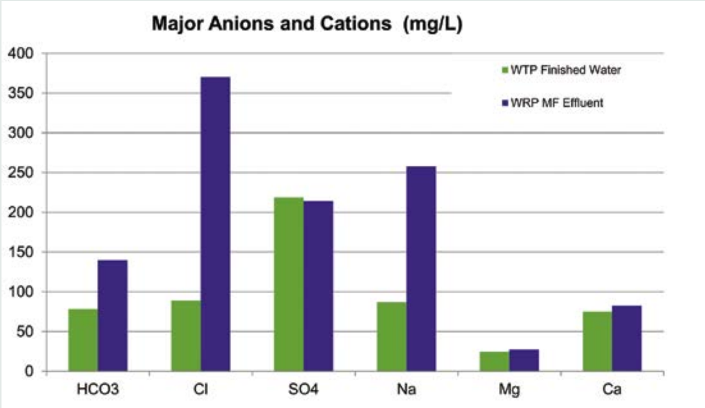
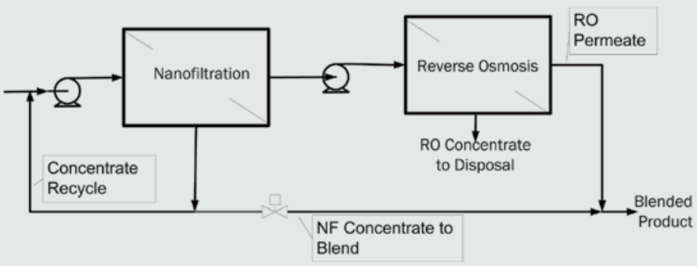


Figure 2
NF-RO Two-Pass System



difference in salt passage for plug flow and concentrate recycle systems is demonstrated in Figure 3.

Our approach assumed that different dissolved ion species will exhibit different rates of salt passage using a nanofiltration membrane. NF membranes allow lower molecular weight, lower ion charge species to pass more readily than higher molecular weight and higher charge species. Our investigation sought to discover whether it is possible to use a combination of the right membrane, recovery and recirculation to optimize the separation of multivalent ions (e.g. calcium, magnesium, and sulfate) from monovalent ions (e.g. sodium and chloride). Pilot testing of the nanofiltration membrane was deemed necessary as the membrane manufacturer's software models do not account for the influences of constituents such as phosphate and organics.

Pilot Test Approach

The approach of the pilot scale testing was to examine the salt passage characteristics for the major monovalent ions (sodium and chloride) and divalent ions (calcium and sulfate) in the reclaimed water source using nanofiltration membranes. The test system included a simple, two-element membrane unit with concentrate recycle as shown in Figure 4.

Three different nanofiltration membranes were tested, each with different properties. Each membrane run lasted approximately two weeks including a 4 to 5 day initialization period to allow membrane performance to stabilize at a modest recovery rate. Each membrane run included three recovery settings with three recycle rates for each recovery setting. Samples were collected from the feed, permeate and

Figure 3
System Salt Passage for Plug Flow and Concentrate Recycle Configurations

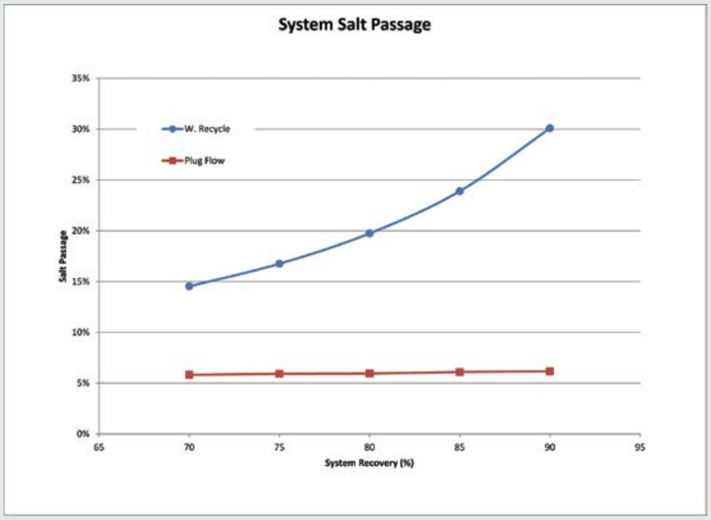
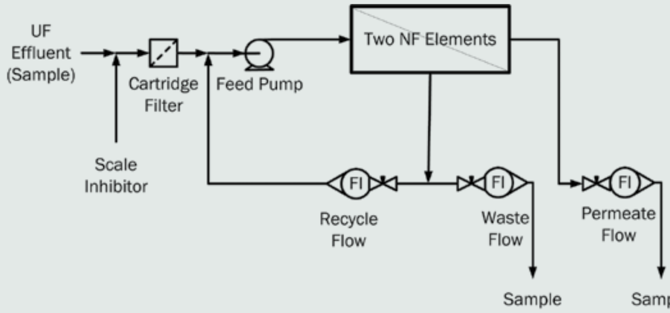


Figure 4
Single-Stage Nanofiltration with Recycle



concentrate daily. A scale inhibitor was added at a constant rate through each run and the membranes were not cleaned. The concentrate recycle allowed recoveries between 65 and 75 percent with acceptable loss of membrane performance for our short term test.

Test Results

Figures 5 and 6 depict the salt passage for the test series of membrane A, a 'loose' nanofiltration membrane. Salt passage for monovalent and divalent ions are shown, using circles for monovalent and squares for divalent. The different recycle rates are indicated by Low R, Med R, or High R. Theoretical salt passage curves, built using projection software, are shown using lines. The salt passage for plug flow is linear and is less than the recycle model in all cases. The salt passage for recycle flow model is non-linear and this is exhibited with the salt passage curves for calcium and sulfate. However, for the monovalent ions in each case, the recycle salt passage model appears linear. The models did not provide reliable prediction of salt passage for individual constituents in this case.

As expected for this membrane, salt passage is high for sodium, calcium, and chloride. Sulfate passage was lower. Increasing recirculation rates had a perceptible effect on salt passage, but any quantitative conclusions are difficult to ascertain. While sodium and chloride passage rates would meet the project

continued on page 14

objectives, the passage of divalent cations is too high to be useful. In our example, sodium and chloride passage greater than 85% achieves meaningful reduction in the final blended product, while a divalent cation passage ideally is 30% or less.

Figures 7 and 8 depict the salt passage for the test series of nanofiltration membrane B, a softening NF membrane. The results closely parallel the model results, although pilot test results were several percentage points lower than the model result.

While the salt passage rates for sodium and chloride are much too low to be useful for this application, this series of tests gave some very good demonstration of the principles studied. There is good demonstration of increased salt passage with increasing recovery and increasing internal recirculation rate. What is interesting to note is that the magnitude of variation of salt passage with variable internal recirculation rate is different for the monovalent ions versus the divalent ions. This is exactly the characteristic we want for this process.

Figures 9 and 10 depict the salt passage for the test series of membrane C, a high sulfate rejection membrane.

Results for membrane C were similar to membrane A. The trend of increased passage with increased recovery is less pronounced as is the increased salt passage with increasing internal recirculation rate. At 70% recovery, the passage of sodium and chloride is adequate to meet the process goals at approximately 85% and 93% respectively. The passage of calcium is higher than optimal (approaching 60%), but still low enough for consideration as a workable solution.

Results for Total Organic Carbon and Nitrogen

The total organic carbon and nitrogen content in the blended product could be problematic for some discharge permit limits, but typically these are not problematic for reuse applications, particularly irrigation. Low TOC is desirable for higher recovery reverse osmosis systems and for concentrate volume reduction processes. Table 1 summarizes the average rejection, feed, and permeate concentrations of TOC and nitrogen species for each membrane. The testing plan did not include daily analyses for these constituents. The values shown are based on five or six samples over the full range of recovery and internal recirculation rates.

TOC rejection is high for all three membranes. These results indicate that the majority of the TOC will end up in the final blended product and not the concentrate.

TKN rejection is low to moderate and this is expected based on previous studies. Likewise, ammonia is low to moderate. Ammonia rejection is pH-dependent and, over the range of pH values during our test, there is some ammonium ion and some ammonia present. Nitrate rejection is expected to be low for NFA, a looser membrane, and higher for NFB, a tighter membrane. For NFC, the high passage of nitrate is similar to the high passage of chloride ion, which has the same ion charge number, and less like sulfate which has a more similar

Figure 5
Membrane A Cation Passage

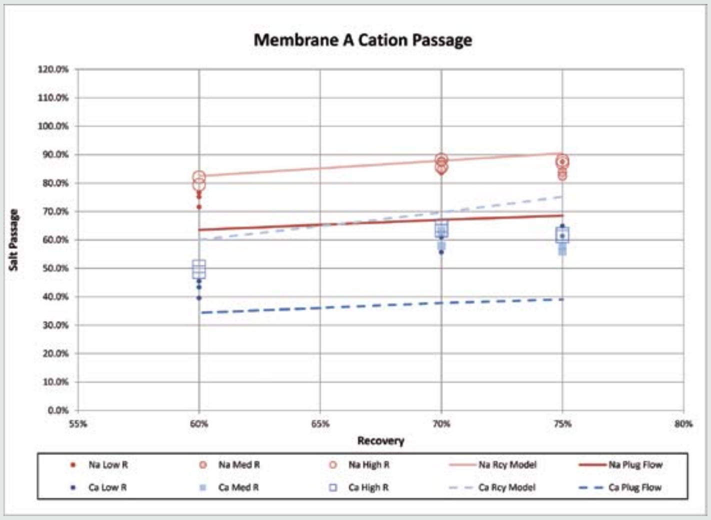


Figure 6
Membrane A Anion Passage

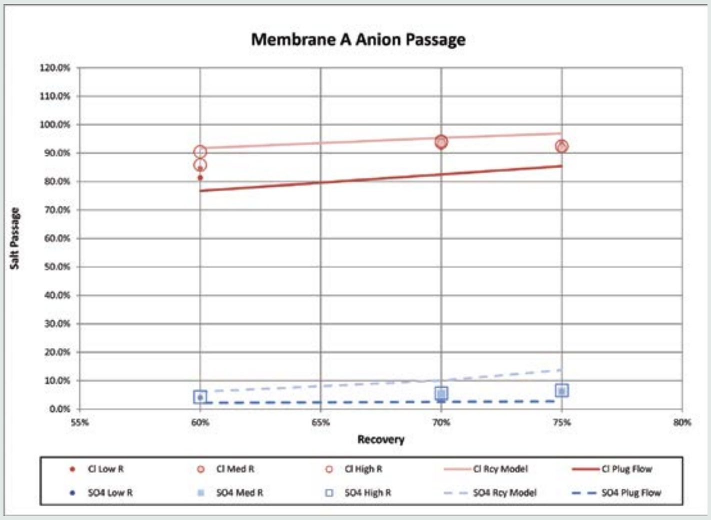


Figure 7
Membrane B Cation Passage

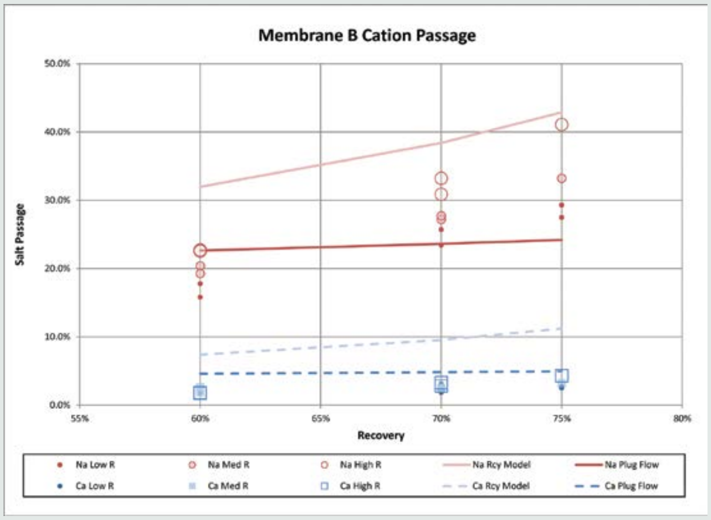


Figure 8
Membrane B Anion Passage

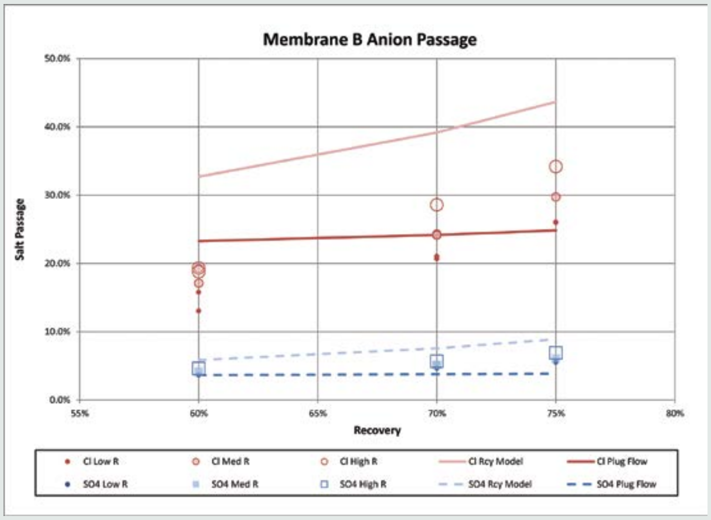


Figure 9
Membrane C Cation Passage

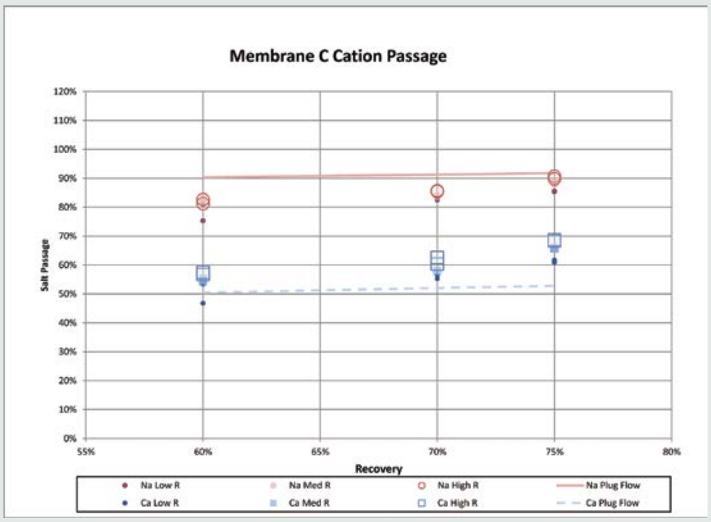
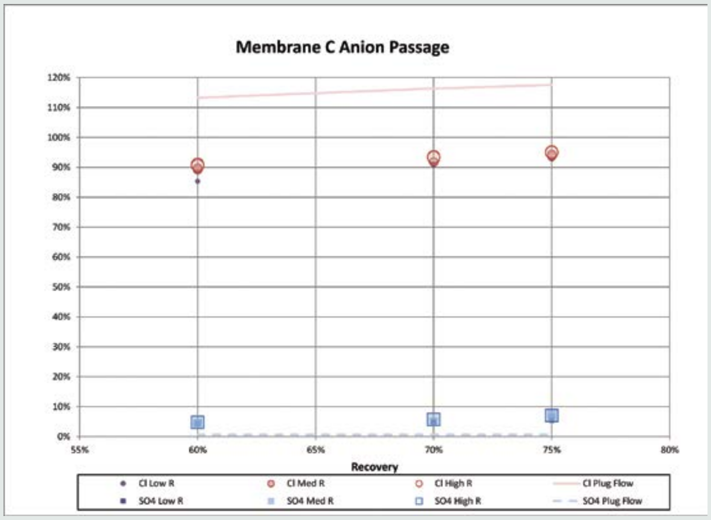


Figure 10
Membrane C Anion Passage



continued on page 16

Continued from page 15

molecular weight but higher charge number. Even though the NFC membrane has a lower MWCO rating than NFB, the influence of particle charge and membrane properties play a significant role in rejection. Recall that the NFC membrane was specifically formulated for a high rejection of sulfate and high passage of sodium chloride. The bottom line is that a high fraction of TKN, ammonia, and nitrate will end up in the NF permeate and ultimately in the RO concentrate, as these constituents are all fairly well rejected by RO membrane.

Table 1
Average Rejection for Total Organic Carbon and Nitrogen Species

Table 1. Average Rejection for Total Organic Carbon and Nitrogen Species

	A	B	C
TOC			
Average Feed, mg/l	2.4	2.3	2.3
Average Permeate, mg/l	0.5	0.3	0.0
Average Rejection	81%	>79%[1]	>89%[1]
TKN			
Average Feed, mg/l	2.0	3.4	1.8
Average Permeate, mg/l	1.2	1.3	0.8
Average Rejection	38%	59%	57%
Ammonia-N			
Average Feed, mg/l	1.2	1.8	1.2
Average Permeate, mg/l	0.9	0.6	0.9
Average Rejection	28%	59%	30%
Nitrate-N			
Average Feed, mg/l	4.0	3.9	4.1
Average Permeate, mg/l	4.2	1.2	4.4
Average Rejection	1%	68%	N/A

Several permeate samples were 'non-detect' for TOC. To calculate the rejection, a value of ½ of the detection limit was used.

Results for Silica and Orthophosphate

Silica and calcium phosphate scales are often the limiting factor for establishing RO recoveries and the need for chemical treatment. Table 2 summarizes the average rejection, feed and permeate concentrations of each membrane for silica and orthophosphate.

These results are significant for evaluating the potential for fouling in the second pass RO system. The orthophosphate rejection was found to be quite high for all of the NF membranes. This is good news for the second pass RO process because this reduces the potential for calcium phosphate scale and could benefit concentrate volume reduction processes. Phosphate chemistry is not predicted with most projection software and is a common challenge in RO systems treating reclaimed water. Silica rejection was low for membranes A and C and moderate for membrane B. It is likely that silica scale could become the limiting factor for the second pass RO if high recovery is necessary.

Table 2
Rejection of Silica and Orthophosphate

Table 2. Rejection of Silica and Orthophosphate

	A	B	C
Silica			
Average Feed, mg/l	13.9	15.2	15.7
Average Permeate, mg/l	12.2	3.4	14.0
Average Rejection	12%	78%	11%
Orthophosphate			
Average Feed, mg/l	1.3	1.1	1.0
Average Permeate, mg/l	0.0	0.0	0.2
Average Rejection	92%	90%	89%

Resulting Product Water Quality

The laboratory analysis results from the 75 percent recovery and medium rate recycle for membrane C were applied to our desktop analyses. The NF permeate water quality profile was used to simulate the second pass RO feed and the NF concentrate blended with the RO permeate.

Figure 11 shows the resulting product water quality compared to the original drinking water and the reclaimed water. The modeled results for the NFRO shows that a significant fraction of sodium chloride is removed while other ions deemed beneficial for water stability are retained. In this example, chloride is reduced by approximately 57% and sodium by approximately 54%.

Comparison of NFRO to Traditional RO Approach

A comparison of the more traditional scheme (i.e. blending RO permeate with a fraction of the feed water) to the proposed NFRO scheme was prepared. Projections were performed for both schemes using a feed flow of 700 gpm and a membrane recovery set point of 85%. Overall system recovery for both schemes is 88.8%. Table 3 summarizes some of the key differences of each system, including the relative membrane area, chemical consumption, energy requirements, quantity, and salinity of brine. The NFRO system is predicted to require less scale inhibitor, no sulfuric acid and less than a quarter of the lime to meet the same product water stability index as the conventional approach. The NFRO system requires more membrane area and slightly higher power consumption even when applying a turbo booster to the NF internal recirculation. Benefits of the internal recirculation include a reduced risk of fouling and more uniform pressure (and recovery) across multiple elements in series.

In this comparison, we sought to evauate each system at the same recovery and to minimize sulfuric acid and lime addition. It is easy to configure the NFRO model to maximize recovery and/or minimize threshold inhibitor instead. In fact, greater cost savings in total chemical consumption could be realized if threshold inhibitor dose was offset with acid. As for costs of concentrate disposal, volume is often more critical than salt content where disposal to an outfall, sewer, or evaporation pond is used.

Figure 11
Comparison of Major Dissolved Inorganic in Potable, Reclaimed and Predicted Results

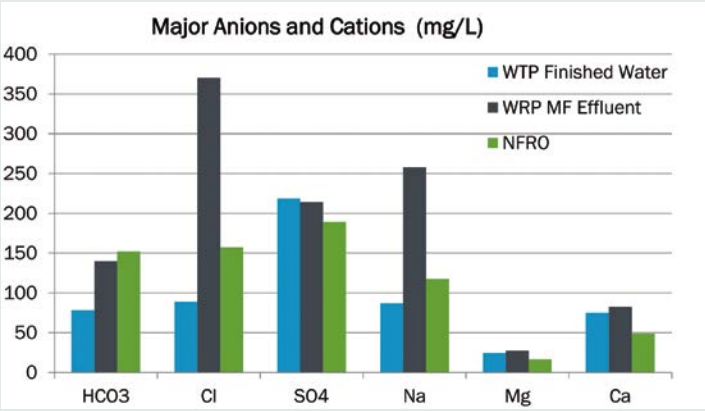


Figure 12
Comparison of Major Dissolved Ions in Concentrate

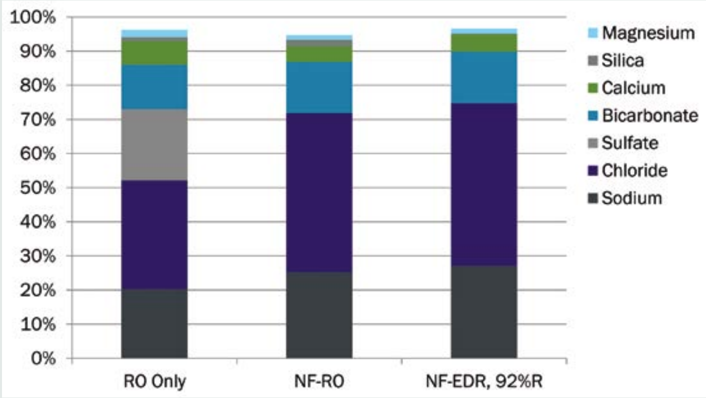


Table 3
Comparison of RO/Blend with NFRO per 1 mgd Feed

Table 3. Comparison of RO/Blend with NFRO per 1 mgd Feed			
Item	Unit	RO with Blend	NF RO
Total Membrane Elements	Ea.	195	252
Average Flux	gfd	11.2	NF 14.9 RO 11.6
Approx. Feed Pressure	psi	120	NF 80 RO 110
Relative Power Consumption		1.0	1.3
Sulfuric Acid,	pounds per day (lb./day)	176	0
Threshold Inhibitor	lb./day	NF 3.3 RO 8.1	13.3
Lime	lb./day	199	44
Concentrate TDS	ppm	7,998	4,849

Comparison of Concentrate Quality

Figure 12 summarizes the quality of concentrate from the conventional RO system and the NFRO system. Note that the NFRO concentrate is comprised of 73% sodium chloride compared to 52% with the conventional RO. For the same concentrate flow rate, the total TDS of the NFRO concentrate is about 60% of the conventional RO; a 40% reduction of mass of salts generated for disposal. Of particular interest are the lower levels of calcium, barium, strontium, sulfate, phosphate and TOC. The absence of these salts has good implications for reducing costs for concentrate volume reduction and zero liquid discharge processes.

Conclusion

A two-pass membrane system consisting of nanofiltration and reverse osmosis (NFRO) is proposed for waters impaired by high levels of sodium chloride. Through a pilot study the salt passage characteristics of monovalent and divalent ions were evaluated for multiple nanofiltration membranes operating over a range of recoveries and concentrate recirculation rates. These results formed the basis for a desktop comparison of the proposed NFRO process and a conventional RO system with feed-water blending. The pilot study results and desktop study demonstrated good removal of sodium chloride, while retaining dissolved ions beneficial for water stability.

The study demonstrates that the proposed NFRO process can provide improved water quality by selectively removing sodium chloride, reduces chemical consumption, and can reduce the cost of concentrate treatment and disposal.

Acknowledgements

The author would like to acknowledge the City of Scottsdale Water Resources staff at the Water Campus for their assistance and a special thanks to the laboratory staff for their effort and helpfulness.

References

Dow Chemical Company (web page accessed 2012). “Filmtec Membranes System Design: Plug Flow Versus Concentrate Recirculation” Technical Manual (Excerpt) Accessed from DowWaterandProcess.com, 3.6:1-4.

About the Author

Robert McCandless is an Associate at as Brown and Caldwell in Phoenix, Arizona. Robert has over 25 years experience in the water and wastewater field. He has worked on a variety of projects for wastewater treatment, water reuse, and drinking water and has focused on membrane systems for the past 9 years. He currently serves as Membrane Systems Specialist and manger of the Phoenix Water/Wastewater Treatment Group. Brown and Caldwell rmccandless@brwncald.com

LONG TERM BENEFITS OF ENHANCED BIOLOGICAL MONITORING STRATEGIES ON MEMBRANE FILTRATION OPERATIONS

Bill Travis, Thornton, Musso & Belleminand / Dave Tracey, LuminUltra Technologies Ltd.

Introduction

The groundwater that a southern Louisiana water utility supplies to local residents has traditionally carried a high amount of organic material and color. In the past, the organics were oxidized and broken down by chlorination, but this practice had gone out of favor due to production of disinfection by-products (DBPs) such as Trihalomethanes (THMs) and Haloacetic Acids (HAAs).

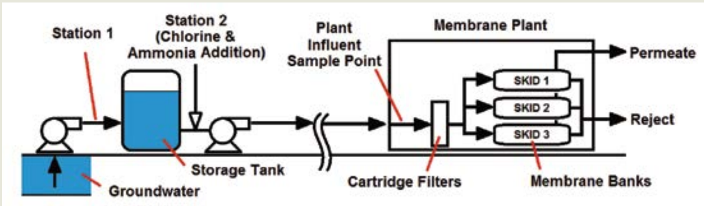
The utility therefore decided to construct a water purification plant to remove organics and microbial content rather than rely on pre-chlorination at the storage tank. The plant consisted of a bank of cartridge pre-filters followed by three parallel skids of dual-stage reverse osmosis (RO) membranes. A process flow diagram of the plant is shown in Figure 1.

While the plant performed well initially, significant problems developed once pre-chlorination was shut off. The pre-filters and membranes became severely fouled with a thick film and had considerable odor. It became apparent that the problem was a serious one that required an intensive investigation to characterize the nature of the fouling issue and where it originated.

Rather than relying on culture-based microbiological tests which take several days to return results and fail to detect a large portion of the biological population, it was decided that ATP (Adenosine Triphosphate) monitoring technology would be utilized as a guidance tool. This enabled the immediate determination of the source of fouling, whether it be biological or mineral-based, and the degree to which it has occurred. If the issue was found to be biological, ATP tests would be used to help monitor the efficacy of both disinfection and membrane treatment throughout this optimization study.

Because all living cells contain ATP, all living microorganisms in a sample will contribute to the ATP measurement. Conversely, a heterotrophic plate count only recovers a small portion of metabolically active organisms and results will vary a great deal according to the method used. Results have indicated that in drinking water systems, only 0.1-1% of the total microbial population is detected by HPCs. In fact, when considering all known species of microbe, only 0.01% of waterborne microorganisms are considered to be heterotrophic bacteria (Bartram et al, 2003).

Figure 1
Groundwater Treatment PFD



Results

Initially, the pre-chlorination dosage was set to a reduced rate compared to the previous dosage during the mid-summer months in hopes of establishing a middle ground where DBP formation was reduced while still cutting down the organics loading and color in the raw water. After several days, the following results in Table 1 were seen compared to before the change in chlorine dosing:

While the reduced chlorination prior to membrane filtration resulted in less DBP formation than in the past, the microbial loading at the plant inlet became significantly higher. The treated water quality also suffered, as was seen from the Skid 3 Permeate test. Following this, plant personnel decided to continue for the time being since permeate quality was still deemed to be acceptable.

After an additional week under these conditions, though, the treatment plant was shut down due to excessively high pressure differentials across the membranes. The ATP results at the time of shut-down were as shown in Table 1.

The effects of reduced pre-chlorination are clearly seen here by the significant increase in microbial loading to the plant between the Station 1 Effluent and the Plant Influent. At the time of this measurement, the raw water carried no chlorine residual (neither free nor total) so there were no barriers to the proliferation that occurred in the pipeline. This increased loading resulted in significant fouling of the pre-filters and eventual microbial breakthrough and significant fouling of the membranes downstream. Membrane fouling was confirmed by testing the surfaces of the end cap of a membrane (1,260 pg ATP/in^2) in addition to a deposit that was removed from the membrane surface (5,380 pg ATP/in^2).These values for surface buildup were 10-100 times higher than the tolerable

Table 1
Effects of Pre-Chlorination on Microbial Loading

Table 1: Effects of Pre-Chlorination on Microbial Loading
(< 10pg/mL = Acceptable, > 10pg/mL = Contaminated)

Sample Point	[ATP] (pg/mL) Historical Pre-Chlorination Strategy (2ppm Total, 0.15ppm Free)	Reduced Pre-Chlorination (< 1ppm Total, 0ppm Free)	Effects of Long Term Removal of Pre-Chlorination (at Plant Shutdown)	After Membrane Cleaning	Chloramination Point Moved after the Storage Tank
Station 1 Effluent	6.3	2.8	2.4	-	5.7
Plant Influent	5.3	33	87	-	6.3
Skid 1 Permeate	3.2	-	17	0.4	10.5
Skid 2 Permeate	2.8	-	620	-	1.8
Skid 3 Permeate	6.9	8.3	680	-	2.1
Skid 3 Reject	-	210	240	-	6.3

Figure 2
Summary of Results Under Each Control Scheme

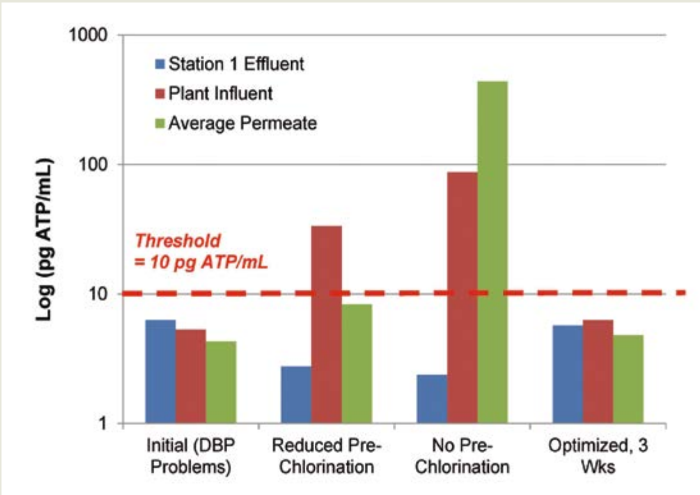
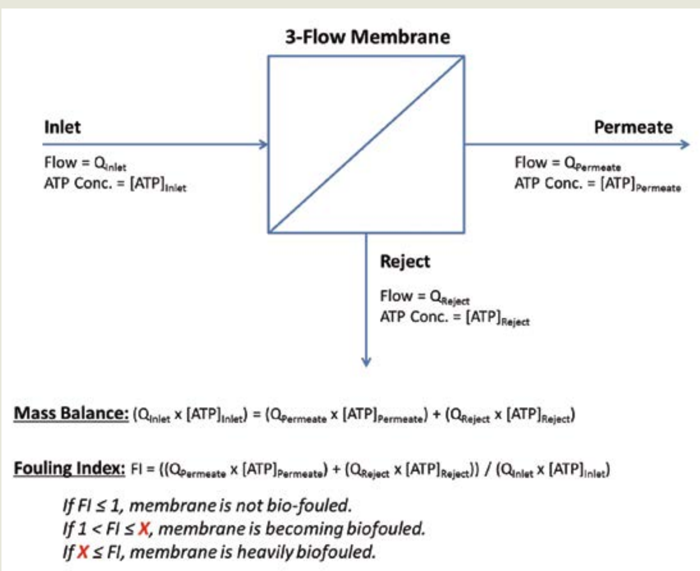


Figure 3
Membrane Mass Balance Concept Overview



ATP biofilm density of (100 pg/in2), although they were not surprising considering the magnitude of the bioburden in the water feeding the membranes. Upon seeing this, a series of membrane cleanings took place to remove the fouling that had developed. Table 1 illustrates the efficacy of this cleaning, with the Skid 1 combined permeate being reduced to 0.41 mg/ LAccording to this result, it is clear that the cleaning cycle did an excellent job to clean the fouled membranes. The product water quality is now in the acceptable range (< 10pg/mL) and therefore carries a lower risk for microbial proliferation downstream assuming that an acceptable disinfectant residual is maintained. It was now clear that a certain degree of pre-treatment was necessary to minimize fouling of the pre-filters and membranes in the plant, so after the cleaning process, the following changes were instituted to the operating procedure:

1. Chlorine was discontinued prior to the storage tanks.
2. Chlorine and Ammonia (Chloramine) was instead fed to the water as it left Station 1 to inhibit microbiological growth in the transmission line from Station 1 to the Plant Influent.
3. De-chlorination was moved from before the prefilters to behind them.

After three weeks of running under these new conditions, another set of samples collected and analyzed with the results shown in Table 1.

While the overall cleanliness of the product water has risen slightly, the overall picture is significantly better than when the membranes had become fouled earlier in the summer. The plant's strategy was then to perform semi-routine tests on the water downstream of the pre-filters as well as the combined membrane product water to detect deviations from baseline conditions to take a more pro-active stance. The following graph shows a summary of results from the beginning compared to the optimized conditions (expressed as Log(pg ATP/mL)):

Following the modifications made in the spring of 2012, the plant continued to run much more effectively than under previous conditions but other opportunities for improvement became apparent. This was determined by establishing a monitoring strategy involving a mass balance using flow rates and ATP concentrations around each membrane. Essentially, ATP load in must be approximately equal to that which exits. If more ATP exits than what enters, it is indicative of a fouled membrane in which biological growth and breakthrough occurs. This "Fouling Index" concept is illustrated below in Figure 3.

The data collected to date was loaded into this model to assess the degree of fouling around the membranes historically compared to following the movement of disinfectant point and switch to Monochloramine. Results are shown in Figure 4.

The "X" term listed in the biofouling assessment table can be considered to be a baseline measurement for a given site. That is, a membrane could operate effectively while maintaining a small degree of fouling. In the case above, a fouling index of 5 could be considered the point at which fouling becomes accelerated.

continued on page 20

Longterm Benefits
Continued from page 19

While membrane performance clearly improved and fouling reduced due to the initial design and operational modifications, fouling was clearly not completely eliminated as was evident from the results from Skid 3. This initiated discussion involving the loading applied on the membranes and whether it was too much for the three primary membranes to handle.

With this in mind, it was decided that rather than having three skids of two membranes in parallel, they should be operated as six parallel membranes all operating as single-stage units. This change was implemented in the fall of 2012 and after a routine cleaning, the membranes were operated in this arrangements as a long-term solution. The resulting filtered water purities are shown below in Figure 5.

As expected, reduced fouling in the membranes as achieved through the switch to six single-stage membranes produced a significantly better quality product water. This was seen almost immediately after the switch and has actually gotten better over time. During this period, the electricity usage at the plant had also dropped so significantly due to the reduced pumping back pressure that plant personnel have observed reductions exceeding $1,000 on a month-to-month basis following the switch.

Conclusions

Because of its speed, ease-of-use, and specificity to total living organisms, ATP monitoring serves as a very valuable method for rapid water quality assessment. It not only facilitates routine maintenance and troubleshooting but also helps maintain water quality by detecting microbial contamination at the earliest signs so that they can be dealt with as quickly as possible.

The results of ATP monitoring as it applied to membrane treatment process was able to quickly identify elevated microbial content not only in the raw and treated water, but also within the membranes themselves. This enabled personnel to assess the effects of decreased pre-chlorination, diagnose the fouling issue as a biological problem, and assess the efficacy of the membrane cleaning process within minutes of sample collection.

Upon further review of the modified arrangement, the process was further modified by switching to six parallel single-stage units as opposed to three sets of two in series as a result of fouling investigations using ATP test results in the feed, permeate, and reject streams of each membrane. Once the feed was spread over a larger number of units, fouling decreased even further and product water has been consistently of a very high quality ever since.

References

1. Bartram, J., J. Cotruvo, M. Exner, C. Fricker, and A. Glasmacher; *Heterotrophic Plate Counts and Drinking-water Safety: The Significance of HPCs for Water Quality and Human Health*, Published on behalf of the World Health Organization by IWA Publishing, Alliance House, 12 Caxton Street, London SW1H 0QS, U

Figure 4
ATP Fouling Index on membranes throughout initial observation period

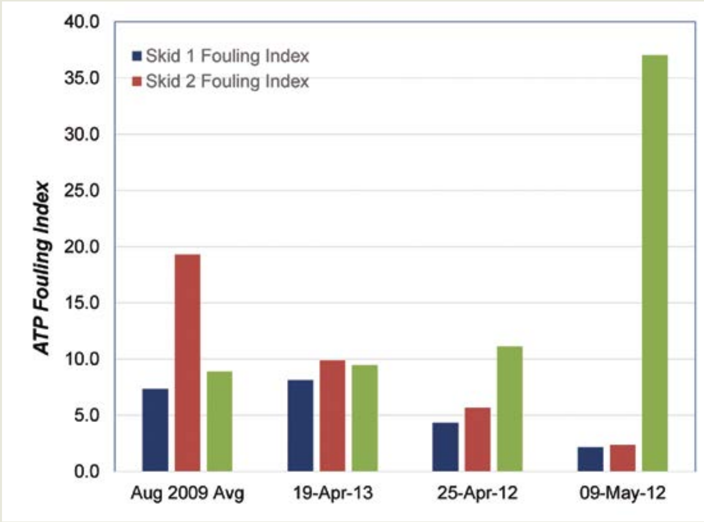
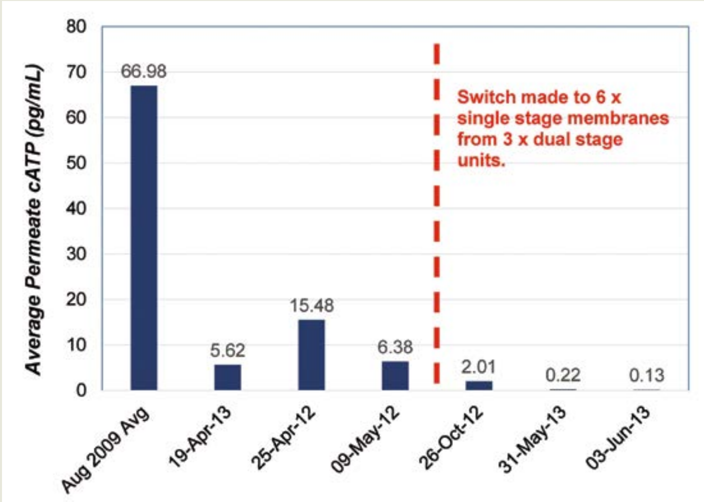


Figure 5
Final product water quality over the entire observation period



About the Authors

Mr. Travis has been involved with the water treatment industry for 18 years, While dealing with industrial and storm waters as well as generator fuel preservation, his practice centers around municipal challenges in the potable and wastewater area. His work with the firm of Thornton, Musso and Bellemin has expanded over the years from the north shore area of Louisiana into Mississippi and in to Texas. A 1977 graduate of Louisiana State University, he currently lives in Hammond, Louisiana.

Mr. Tracey is a registered Professional Engineer and the Director of Sales for LuminUltra Technologies Ltd, based on Fredericton, New Brunswick, Canada. He has 13 years of experience in the development and implementation of novel microbiological monitoring and control strategies in drinking water, wastewater, and industrial processes.

Bill Travis

Dave Tracey

Harold Fravel
Executive Director

All in all it was just a brick in the wall

-Pink Floyd

I recently attended an opening session at which the keynote speaker told a story about a turtle being released into the ocean after years in captivity. When the turtle was placed in the water from a boat it began to swim but paused after four stokes. After a moment it started swimming again. The speaker replayed the video and commented that the exact distance the turtle swam initially was the length of the tank in which it had been living for the past ten years. It paused at the wall that it knew would be there. When it realized there was no real wall but only one perceived, it continued its trek forward into the open ocean.

How many of us have "walls" that are holding us back? What barriers do you believe are in your way towards accomplishing a goal or getting something done? How many times have we not attempted to make a change or shared an idea because we felt that it would not be accepted, heard, implemented or acknowledged?

Can't get the funding. Not enough time to attend a meeting or prepare a presentation. The fees are too high. No one would be interested in what I have to say. And more. Are they real or perceived? Is there some other approach to do what you want to do? Can you break down the wall? Step around it? Step over it when you realize how small it really is? Try to put a door in it. Do you reinforce it and make it higher and thicker than you first believed or find a way to destroy it?

Membrane technology is making great things happen. We can produce safe clear water from a variety of sources for drinking water or perhaps process use. It allows processing of milk to give extended shelf life free from bacteria and spoilage. The energy needed to make Maple syrup from tree sap can be reduced with a nanofiltration system. Drought issues can be addressed using seawater desalination. The wall to accept potable water from waste waters in direct or indirect reuse situations is high but the possibilities of a new source of water while minimizing the waste water discharge into our lakes and rivers is enviable. Concentrate disposal from a reverse osmosis plant can be a wall but efforts on zero liquid discharge, new methods of operating an RO plant, advances in chemicals that enable higher recoveries are all chipping away at that wall.

I challenge you to scale your wall, pole vault over it, dig under it, drill holes in it, see it for what it is and step over it. Take that next stroke and swim forward. As your Executive Director, I am challenging the walls that are holding back new members from joining an organization that advocates for membrane technology while providing networking opportunities and venues to learn about membrane technology. ■

Welcome New Board Members

John Tracy - Appointed on May 21, 2015 for At-Large (Term 2015-2017)

Russ Swerdfeger - Appointed on July 16, 2015 to fill Board Vacancy in Div. 2 (Term 2015 2017)

Website Update

Karen Lindsey - Publication Chair and Website Committee Chair
Contact: klindsey@avistatech.com

AMTA has made a commitment to preserving the technical contributions and personal narratives of professionals in our industry and providing access to that information to the water treatment community. Our landmark Chats with the Pioneers interviews began that legacy and now we're expanding on it. In June, we proudly launched our comprehensive new Digital Library, accessed through the AMTA website at www.amtaorg. This new feature gives AMTA members exclusive access to over 1,000 papers and presentations authored by the industry's most respected and experienced professionals. And, we're in the process of adding 1,000 more with the addition of MTC materials from membrane conferences held from 2012 to 2015.

For years, AMTA has organized and hosted technical workshops, symposiums, and conferences across the United States, branching out into Canada in 2015 and Mexico in 2016. Copies of the papers and presentations were provided to attendees as part of their registration fee and that was the extent of their limited distribution. But the information they contain has an enduring value to people who were unable to attend our events or new generations of professionals who weren't involved in our industry at the time.

The Digital Library changed that. AMTA members can now enjoy free unlimited access to view and download over 2,000 papers and presentations showcased in over a decade of AMTA and affiliate events. Topics include direct and indirect potable reuse, seawater desalination, applications and innovations in all membrane types including RO, MF, UF, and MBR, concentrate disposal, regulatory issues, case studies and innovative research in membrane treatment and processes.

Because there is so much material, we worked hard to make the search feature intuitive so that members can easily find the specific information they're looking for. Contents of the Digital Library can be found using a number of search parameters including keywords, specific AMTA events, presenter or company names, or by date. New material will be downloaded throughout the year, ensuring the Digital Library continues to be an essential go-to resource for membrane system operators, designers, regulators, and vendors who understand the value of ready access to industry information and innovation.

Your support and membership allows us to take on projects like these that help share information and experience, preserve the legacy of our industry, and advance the benefits of membrane treatment, and we thank you. ■

PRESS RELEASE

TO: Membrane Industry & Media Publications

FROM: Harold Fravel, AMTA Executive Director

CONTACT: hfravel@amtaorg.com / 772-463-0844

DATE: June 24, 2015

SUBJECT: AMTA Awards 2015 ADC Fellowships

The American Membrane Technology Association (AMTA) is pleased to announce that three students have been awarded the ADC Fellowship Awards for 2015.

In 2011, the Affordable Desalination Collaboration (ADC) established a fund to provide financial support to students involved in membrane research and directed the American Membrane Technology Association (AMTA) to distribute those monies in the form of Fellowships.

AMTA received a number of highly qualified submittals in June 2015 and after committee review the following graduate students were chosen to receive part of the $10,000 allocated for this annual award:

Samantha Jeffery, University of Central Florida, Orlando, FL

Sarah Dischinger, University of Colorado at Boulder, CO

Paula Monaco, Texas Tech University at Lubbock, TX

Each of the recipients will attend the 2016 Membrane Technology Conference and Exposition (MTC) to be held in San Antonio, Texas on February 1-4 and personally present their work as a paper or poster presentation. The award monies are intended to support their research and to provide financial assistance for travel expenses related to the MTC attendance. ■

Christine A. Owen
Legislative Affairs & Regulatory Programs Committee Chair

HOT TOPICS

Algal Toxins

On March 6, 2015, EPA issued new health advisory values for the algal toxins microcystin and cylindrospermopsin. The recommendations include separate values for young children, school age children and adults based on a 10-day exposure period. The advisory level for microcystin for children (young and school age) is 0.3 micrograms per liter and 1.6 micrograms per liter for adults. For cylindrospermopsin, the values are 0.7 and 3.0 micrograms per liter, respectively.

The advisory levels were released just prior to the Agency's scheduled public meeting and webinar "Potential Actions To Prepare for and Respond to Cyanotoxins in Drinking Water." EPA is will be working to finalize the health advisory levels as well as develop the supporting guidance and technical materials needed prior to the peak summer algal bloom season.

Waters of the State Final Rule

The U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency have issued a final rule regarding the definition of "Waters of the United States" under the Clean Water Act (CWA) on May 27, 2015. The final rule will take effect 60 days from the date it is officially published in the Federal Register. The final rule's expansive definition of "tributary" and the inclusion of waters and wetlands within the 100-year floodplain of a tributary provides for the regulation of large areas without site specific evidence of a connection to a navigable water. This could results in the inclusion of isolated features located a great distance from navigable waters which would be problematic for many entities in the arid West. Most affected parties assert that this action represents the most expansive interpretation of CWA jurisdiction since the original 1972 law was enacted. While the agencies claim that the rule provides clarity to the CWA, it is certain that opposition from regulated parties will result in litigation and difficult implementation. Grandfathering is provided for in the proposed final rule; however, it is limited to existing jurisdictional determinations in issued permits and will only remain valid until the current authorization or permit expiration.

The CWA is the authority that provides jurisdiction to the Corps and EPA to regulate all "navigable waters," which the law defines only as all "Waters of the United States." A clear understanding of what constitutes the "Waters of the United States" is critical because it identifies the regulatory programs and permits that a landowner must acquire before undertaking activities on their land. The programs include CWA sections which cover oil spills (311), water quality (402), discharges (402) and dredge and fill activities (404).

The final rule clarifies the prior regulatory definition of "Waters of the United States" with eight categories of waters. Three categories are jurisdictional by rule, identical to the prior rule definition and cover (1) traditional navigable waters (all waters used in interstate or foreign commerce), (2) all interstate waters (including wetlands), and (3) territorial seas (coastal water up to three miles from shore).

Three additional categories are now jurisdictional by rule and include: impoundments, tributaries and adjacent waters. The rule defines a tributary as a water that is "characterized by the presence of the physical indicators of a bed and banks and an ordinary high water mark" which could cover areas miles away from a traditional navigable water. "Adjacent waters" covers all waters adjacent to tributaries, and defines "adjacent" as "bordering, contiguous and neighboring" and would include (1) waters separated from a tributary by a barrier such as a "constructed, dike or barrier, natural river berms, beach dunes and the like", (2) waters located within the 100 year floodplain and not more than 1500 feet from the ordinary high water mark of the tributary, (3) waters for which any portion is within 1,500 feet from the high tide line of a traditionally navigable water, interstate water or the territorial sea or within 1,500 feet of the ordinary high water mark of the Great Lakes.

The final two categories are defined through a case-specific process and include (1) listed significant nexus waters and (2) other significant nexus waters. "Listed Significant Nexus Waters" are five categories of waters that are subject to a case-specific "significant nexus" analysis and include prairie potholes, Carolina and Delmarva Bays, pocosins, western vernal pools and Texas coastal prairie wetlands. "Other Significant Nexus Waters" covers adjacent waters, such as wetlands, ponds, and impoundments in which normal farming, ranching and silvicultural activities occur and are located within the 100-year floodplain of or within 4,000 feet of the high tide line of defined jurisdictional waters.

"Significant nexus" by rule includes all activity in the water under consideration that could have a significant effect on or contribution to the chemical, physical, or biological integrity of a traditional navigable water, interstate water, or the territorial seas.

This effect must be "more than speculative or insubstantial." The following functions are considered in this evaluation: sediment trapping, nutrient recycling, pollutant filtering, flood water retention, runoff storage, flow contribution, organic matter export, food resource export, and essential aquatic habitat. This is a broad approach that allows for substantial regulatory discretion and is consistent with recommendations from an EPA Science Advisory Board (SAB) panel.

Exclusions to the definition of "Waters of the United States" include those from the current regulations (normal farming activities, waste treatment systems and prior converted cropland). Exclusions which have been routinely applied in practice (and are expected to continue) include:

1. irrigated areas on dry land
2. groundwater
3. man-made lakes, ponds, reflecting pools, swimming pools, and ornamental waters created on dry land
4. pits incidental to mining or construction
5. ditches with ephemeral or intermittent flow that are not a relocated tributary or excavated in a tributary
6. erosion features
7. stormwater control features created on dry land and,
8. wastewater recycling structures constructed on dry land.

The federal impact assessment estimates that the rule will increase the scope of regulated waters by 3 percent. The increased costs to regulated entities, state and local governments range from $162 to $279 million dollars per year, largely through increased permitting costs. The 2014 proposed rule was highly controversial and elicited over one million comments from public agencies, state and local governments, industry, mining, agriculture and other business interests.

Hydraulic Fracking

The USEPA has released the results of a four year study of hydraulic fracturing which concludes that the controversial drilling method has not caused "systemic" damage to drinking water but does pose certain risks. The EPA said it lacked complete information on "the number and location of hydraulically fractured wells, the location of drinking water resources, and information on changes in industry practices." It noted that the report relied heavily on information voluntarily provided by the hydraulic fracking industry.

This work has been called "the most complete compilation of scientific data to date," and included more than 950 published papers, technical and scientific reports as well as input from stakeholders and interested parties. It also documents the agency's problems in gathering information, including the

continued on page 26

Continued from page 25

industry refusal to cooperate with some testing. Limitations on data available to the agency, the report said, prevented a determination "with any certainty" of how frequently water supplies had been affected by fracking activities.

The draft found that "while fracking operations have not led to widespread, systemic impacts on drinking water resources, there are potential vulnerabilities in the water lifecycle that could impact drinking water." There is evidence and specific instances where fracking well integrity and wastewater management activities had affected drinking water resources. However, these instances "were small compared to the large number of hydraulically fractured wells across the country."

The agency said the relatively small number of negative instances "could reflect a rarity of effects on drinking water resources, but may also be due to other limiting factors." These factors include: insufficient data on the quality of drinking water resources both before and after fracking; no long terms studies; and "the inaccessiblity of some information on hydraulic fracturing."

When outlined in 2010, the study was expected to include initial baseline testing of sites where wells were to be drilled, with longitudinal testing during and after fracking operations were conducted. Those plans were halted after the industry declined to cooperate. ■

Updates on Proposed and Pending Rules

Carcinogenic Volatile Organic Compounds (cVOCs)

Proposal: February 2018

Final: August 2019

Status: In 2011, the Agency announced plans to develop a single national primary drinking water regulation (NPDWR) for up to 16 VOCs; currently they are conducting evaluations and supporting materials

Fourth Contaminant Candidate List (CCL4)

Proposal: February 4, 2015

Final: December 2015

Status: Proposed CCL4 list was published February 2015; after Agency review of comments, a final CCL4 is expected late 2015

Fourth Unregulated Contaminant Monitoring Rule (UCMR4)

Proposal: June 2015

Final: January 2017

Status: EPA is evaluating potential contaminants for inclusion in the final list of 30 to be monitored

Lead and Copper Rule: Regulatory Revisions

Proposal: September 2015

Final: June 2018

Status: The National Drinking Water Advisory Council (NDWAC) workgroup is expected to provide suggestions on rule options in 2016

Perchlorate

Proposal: March 2017

Final: October 2018

Status: EPA continues to evaluate supporting materials and modeling approaches at the recommendation of the ad hoc SAB committee report on setting the MCLG

Radon Rule

Proposal: November 1999

Final: To be determined

Description/Status: The Agency continues the rule status as "to be determined"

Revised Total Coliform Rule Finished Water Storage Inspection Requirements

Proposal: June 2018

Final: To be determined

Status: The Agency continues its evaluation of options for regulation

Wastewater Pretreatment: Effluent Guidelines for Unconventional Oil and Gas Extraction Including Coal Bed Methane and Shale Gas

Proposal: Anticipated 2014

Final: February 2016

Status: Effluent guidelines and pretreatment standards for wastewater associated with coal bed methane and shale gas extraction continue to be in Agency development

Harmful Algal Blooms and Associated Cyanotoxins

Proposal: March 2016 Health Advisories

Final: June 2015 Health Advisories

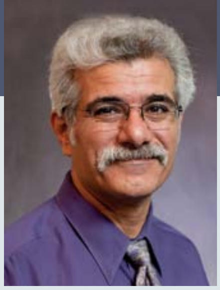
Status: The Agency announced health advisory levels for microcystin and cylindrospermopsin on March 6. Final advisories and guidance is expected by June 15, 2015

Strontium

Proposal: TBD

Final: TBD

Status: The Agency issued a positive preliminary regulatory determination in October 2014 and is in the process of working towards a final regulatory determination in 2015 ■



By: Ben Movahed, PE, BCEE
MF-UF Ad-Hoc Committee Chair

MF/UF/MBR Procurement Document Ad Hoc Committee is well underway

A successful membrane project starts with an effective, efficient and fair-minded procurement and pre-purchase document. Unfortunately, there is currently no standard procurement documents for low pressure membranes (MF, UF and MBR). As a result, warranty conditions, liability clauses, responsibilities, engineering requirements and procurement specifications vary widely from project to project. The lack of such a standard procurement document has resulted in extra costs and frustration for all involved by requiring legal review of the specifications and bids each time, potential project delays for bid exceptions and occasionally a re-bid situation due to excessive clarifications and exceptions.

The AMTA Board of Directors formed an Ad Hoc Committee to look into developing MF/UF/MBR Procurement Documents. Interested individuals from manufacturers and engineering companies met at the MTC-15 in Orlando on March 3, 2015 to discuss the need for such a document, its purpose, limitations and subsequently volunteered to assist with the document preparation.

It is envisioned that this document would satisfy 70–80% of the general conditions and terms in a pre-prepared format. Then project specific information and custom supplements would be developed by each project to fully define a specification and bidding document.

The committee currently has 15 active members participating in conference calls and reviewing currently available documents to prepare draft sections of this procurement document.

As you can imagine, this is a huge task. If you are interested in helping the committee with any segment of the document preparation or reviewing of the draft documents, please contact me. Your contributions are welcome. The more the merrier! ■

David L. Brown
AMTA Membership Chair

Since our last newsletter we have welcomed 42 new members!

Tyler Abercrombie
GHD, Inc.

Wayne R Beckermann
Texas A&M University

Nathalie Benhamou
Advanced Mem Tech

Mark M. Benjamin
University of Washington

Nicholas P. Black
Kimlely-Horn & Associates

Howard S. Brewen
City of San Luis Obispo, Water Resource Recovery Facility

Gordon Carter
Oasys Water, Inc.

Junghoon Choi
LG Electronics - Commerical Water Business Division

Maqsud Chowdhury
University of Conneticut

Jason Cocklin P.E.
Freese and Nichols, Inc.

Greg Colman
Federal Screen Products, Inc.

Rob Cormier
PALL Corporation

Michael A. Crawford

Peter C Dent
CDG Enviornmental, LLC

Gary O Engelgau

Ric Feldt
Jeff Smith & Associates, Inc.

Steven M. Gabriel
Victaulic Company

William E Gasque
DOWL

Robert Gregson
Pall Corporation

Gary Griesenbeck

Andreas Hauser
TUV SUD Water Services

Nancy C Heuman
Digital Mentor Inc.

Jiahao Hu
Northeastern University

Michael Izzo
Henkel Corporation

Taylour Johnson
Koch Membrane Systems

Noriaki Kanamori
Meiden America Inc.

Joseph M. Kelly
Wigen Water Technologies

Jun Kim
Rice University

David J Lamphere
Pall Corporation

James Lee
CSM (TCK Membrane America Inc.)

Hildebrando Loayza
WET Chemical Peru S.A.

Guy Marchesseault

Shannon K. McCarthy

Paula A Monaco
Texas Tech University

Aidous Pabon
TriSep Corporation

Soubhagya Kumar Pattanayak Ph.D.
TÜV SÜD Asia Pacific Pte Ltd

Christopher J. Plotz
North Carolina State University

Bruce Richardson

Jeffrey D. Smith
Jeff Smith & Associates, Inc.

John E. Tracy
Oasys Water

Emillo Washing
WET Chemical Peru S.A.

Scott D Wenger
Digital Mentor Inc.

Carefree, AZ AMTA/SWMOA Workshop

AMTA and SWMOA joined forces to present a workshop in Carefree, AZ titled “Membranes in the Dry – Squeezing Every Last Drop”. The workshop provided some of the best presentations we’ve seen addressing drought and inland water management issues. There were talks on concentrate management, case studies in the Southwest, high recovery options and operating RO systems in remote locations along with discussions on direct and indirect potable reuse.

A plant tour of the Scottsdale Water Campus was included as part of the workshop. Scottsdale has been on the forefront of using membranes for water reuse. Their plant utilizes both Microfiltration and Reverse Osmosis for advanced treatment of wastewater helping to alleviate stresses on the potable water supply in this arid region by reinjection of the treated water into the ground that ultimately percolates to the aquifer below. The attendees had an opportunity to see the three 16” RO diameter membrane trains on site that can produce 3MGD each as well as the 14 trains that use 8” RO membrane elements.

We all enjoyed a unique networking event with a local Hopi Indian storyteller who connected the importance of water and caring for our resources with his long and proud heritage.

AMTA workshops are tailored to the particular water issues of each region we visit. Although some general information is always presented, attendees will learn about specific concerns, regulations, case studies and lessons learned for their area. This focus on regional issues is unique to AMTA workshops and one reason we travel across North America to bring this information directly to those using membrane technologies to solve their water treatment issues.

Please join us for our next regional workshop in Knoxville in October 27–29, another area that has a different perspective on when, where and how to apply membrane technology to fit their distinct needs. It will center on low pressure membrane technology that is so prevalent in the region.

Mark your calendars for the premier 2016 Membrane Technology Conference in San Antonio

By: Ben Movahed, P.E., BCEE, MTC-16 Program Co-Chair

Once again, for the fifth year, AWWA and AMTA are joining forces to present the latest developments in membrane water treatment technologies. The 2016 AWWA/AMTA Membrane Technology Conference and Exposition will be held in in San Antonio, Texas, February 1-5, 2016. This conference will explore the research, development, implementation, operation and maintenance of membrane facilities and technologies including ceramic membranes, forward osmosis and other emerging product. In addition the attendees can learn how to treat impaired water supplies with membranes, discover how membranes enhance water reliability and water quality, and uncover new directions in water treatment technologies and wastewater membrane bioreactor applications.

With the conference being in Texas, the program will include a variety of presentations, round table discussions and panels focused specifically on Texas water challenges, Direct and Indirect Potable Re-use and Texas Desalination issues and achievements.

In recent years, as the result of this partnership between AWWA and AMTA, the conference has grown to over 1000 attendees and has become the premier event for membrane technology and applications in North America.

This year, the MTC will highlight the following key topics at our pre-conference workshops, technical papers, poster presentations and facility tours:

- Membrane Filtration (MF/UF)
- Brackish Water Desalination (NF/BWRO)
- Seawater Desalination (SWRO)
- Wastewater & Reuse
- Residuals Management and Zero Liquid Discharge
- Industrial Applications
- Project Planning and Implementation
- Membrane Plant Operation and Management
- Regional Issues and Regulations
- Research and Innovations

The program will focus on key areas of membrane use, including budgeting, planning, management, regulations, design and operations.

Additionally, the 2016 Membrane Technology Conference & Exposition will connect you and your company to a qualified and high profile audience entirely interested in the membrane industry with a full exhibit hall featuring innovative membrane products and services.

Bring the family and take a tour of the Alamo, explore the San Antonio Zoo and/or Aquarium, enjoy a family outing at one of San Antonio's theme parks or simply relax and walk down to the famous River Walk, a poopular city gem that includes dining, entertainment, shopping and countless other attractions.

For more information, visit www.awwa.org/amta/membrane2016 or call 1.800.926.7337. ■

"Low Pressure Membrane Technology in the Smokey Mountain region" KNOXVILLE, TN October 27-29 2015

The Southeast Desalting Association (SEDA) and the American Membrane Technology Association (AMTA) are combining forces to host a Technology Transfer Workshop in Knoxville, TN, October 27 – 29, 2015. A full program has been arranged to feature microfiltration, ultrafiltration and membrane bioreactors with a theme of "Low Pressure Membrane Technology in the Smokey Mountain region". The workshop will start with some MF/UF basics but turn to operations, design, cleaning , automation and more. Several case histories will be given in which actual experiences from operating plants will be shared. There will be a tour of the South Blount Utility District's Membrane Facility. In addition to the technical presentations and case histories, there will be a discussion about regulations in the region. Tuesday evening there will be an optional tour of the AquaChem facilities in Knoxville for all interested people.

Lunch will be provided and there will be a Networking Event for all attendees. Both offer great networking opportunities since all of the attendees have a keen interest in membrane use and activity.

AMTA is taking a little different approach to promoting this event and will not be mailing printed brochures. Members of AMTA and SEDA will receive an email with the brochure attached and several eblasts announcing the event will be sent to our contacts. We are asking all of our members to forward the information to contacts that they feel might be interested in attending a regional Technical Transfer Workshop on membrane technology. There are still some sponsorship opportunities and table top exhibits will be at the workshop.

Part of AMTA's mission is to bring quality membrane related workshops to different regions of the Americas. Plan to attend this workshop in the fall. ■

America's Authority in Membrane Treatment

AMTA

American Membrane Technology Association

Improving America's Waters Through Membrane Treatment and Desalting

SEDA — Serving and Promoting Membrane Treatment Operations

AMTA/SEDA Joint Technology Transfer Workshop

"Low Pressure Membrane Technology in the Smokey Mountain Region"

Knoxville, TN - Oct. 27-29, 2015

Tuesday, October 27th

3:00 - 5:00	**Early Registration & Exhibitor Set-Up**
6:00 - 8:00	**Aqua-Chem - Sponsored Tour (Optional)**

Wednesday, October 28th

7:30 - 8:15	**Registration and Continental Breakfast**
8:15 - 8:30	**Introductions & Opening Remarks** David Laliberte, Workshop Co-Chair
8:30 - 12:00	**SESSION 1: Membrane Processes**
Moderator:	Jason Bailey, Avista Technologies, Inc.
8:30 - 9:10	**MF/UF Technologies** Kelly Lange-Haider, P.E., Dow Water & Process Solutions
9:15 - 9:50	**MF/UF Technologies in Operation** Russell Ferlita, Ph.D., P.E. and Shaleena Smith, Doosan Hydro Technology, LLC
9:50 - 10:20	**Refreshment Break**
10:20 - 11:00	**Potable Reuse** Katie Bell, CDM Smith
11:00 - 11:30	**Membrane Operator Certification Training** Jarret Kinslow, P.E., Tetra Tech
11:30 - 12:00	**MF/UF Technologies in Automation** Paul Bartlett, H2O Innovation
12:00 - 1:00	**Lunch**
1:00 - 4:45	**SESSION 2: Membrane Plant Tour**
Moderator:	Bob Oreskovich, H2O Innovation
1:00 - 1:30	**South Blount Utility District Plant Overview** Thomas Flynn, South Blount County Utility
1:30 - 2:00	**On Bus in Route to Facility Tour**
2:00 - 4:00	**South Blount Utility District Plant Tour**
4:00 - 4:45	**On Bus in Route back to Hotel**
5:30 - 7:00	**Networking Reception**

Thursday, October 29th

8:00 - 8:30	**Continental Breakfast**
8:30 - 12:00	**SESSION 3: Case Studies & Applications of MF/UF/MBR**
Moderator:	Jarrett Kinslow, P.E., Tetra Tech
8:30 - 9:00	**Case Study: KONSOLIDATOR Tubular Membranes Industrial Installations** Francis Brady, Koch Membrane Systems, Inc.
9:00 - 9:30	**Case Study: Cleaning MF/UF** Jason Bailey, Avista Technologies, Inc.
9:30 - 10:00	**MBR Technologies and Issues** Dennis Livingston, Ovivo USA, LLC
10:00 - 10:30	**Refreshment Break**
10:30 - 11:00	**Initial Critical Steps in the Design of Successful Membrane Plants** Ben Movahed, P.E., BCEE, WATEK Engineering Corp.
11:00 - 12:00	**Panel Discussion of MF/UF Configurations**
12:00 - 1:00	**Lunch**
1:00 - 3:00	**SESSION 4: Case Study & Regulatory Issues**
Moderator:	Christine Owen, Tampa Bay Water
1:00 - 1:30	**Membrane Integrity Testing and Piloting** Russ Swerdfeger, Evoqua Water Technologies LLC
1:30 - 2:00	**Regulatory Requirements in Permitting UF/MF Membrane Plants** Saya Qualls, Hazen and Sawyer
2:00 - 2:30	**New Developments in Hollow-Fiber/Nanofiltration** Frans Knops, Pentair Filtration Solutions, LLC
2:30 - 2:45	**Workshop Wrap-Up** Bob Oreskovich, Workshop Co-Chair

This AMTA & SEDA Technology Transfer Workshop will focus on Membrane Treatment in the Heart of the Great Smoky Mountains. Attendees will learn about a basic overview of various membrane technologies including MF, UF and MBR followed by an overview of the South Blount Water Treatment Plant. The first afternoon will include an onsite facility tour. The workshop will also highlight SEDA's Membrane Operators Certification Training module for membrane plant operators, a must for all membrane facility operations personnel. The first day will conclude with a Fun Networking Event. The second day will include case studies and design issues followed by an eight member panel discussion led by the major leading low pressure vendors primarily concentrating on low pressure membrane advances and impending issues. The second day afternoon sessions will conclude with a Membrane Integrity Testing presentation, local Regulatory & Permitting discussion and further talk during a presentation of new developments in the hollow fiber/nanofiltration industry.

REGISTRATION INFO

Workshop will be held at the Knoxville Marriott Hotel

For Workshop Registration Information Please visit the AMTA Website:

http://www.amtaorg.com/calendar

or call AMTA at 772-463-0820

American Membrane Technology Association

2409 SE Dixie Hwy.
Stuart, FL 34996

Non Profit Org.
U.S. Postage
PAID
West Palm Beach, FL
Permit #2085

Newsletter Advertisement is Available.

Please Contact AMTA for rates and availability.

Janet L. Jaworski
American Membrane Technology Association
2409 SE Dixie Hwy. • Stuart, FL 34996
772-463-0820 • 772-463-0860 (fax)
admin@amtaorg.com

A form is available on the website at
www.amtaorg.com/publications.html


PRETREATMENT
solutions
Optimizing Reverse Osmosis Pretreatment Chemicals in Orange County's Groundwater Replenishment System
Introduction
GWRS RO Process
Revere Osmosis Pretreatment Chemicals

Calendar of Events

2015 Events

Aug. 20, 2015	SEDA Cleaning Workshop, North Miami Beach, FL
Aug. 25, 2015	NWMOA Workshop, Arch Cape, OR
Aug. 30, 2015	**AMTA Pre-Conference Workshop at IDA 2015 World Congress, San Diego, CA**
Aug.31-Sep. 4, 2015	IDA 2015 World Congress on Desalination and Water Reuse, San Diego, CA
Sept. 23-25, 2015	SEDA MOC-I School – Introduction to Membrane Systems, Hilton Head, SC
Sept. 30, 2015	NWMOA Jt. w/ PNWAWWA Workshop, Anacortes, WA
Oct 1, 2015	NWMOA Workshop, Myrtle Creek, OR
Oct. 8, 2015	SWMOA Workshop, No. San Diego County CA
Oct. 27-29 2015	**AMTA/SEDA Technology Transfer Workshop, Knoxville, TN**
Oct. 29 2015	**AMTA Board Meeting, Knoxville, TN**
Nov. 10, 2015	SWMOA Workshop, Irvine, CA
Nov. 12, 2015	SCMA Workshop, El Paso, TX

2016 Events

Feb. 1-5, 2016	**AMTA/AWWA, TXAWWA, SCMA - Pre-Conference Workshops, San Antonio, TX**
Feb. 1-5, 2016	**AWWA/AMTA Membrane Technology Conference & Exposition, San Antonio, TX**
Feb. 6, 2016	**AMTA Board Meeting, San Antonio, TX**
Apr. 26-28, 2016	**AMTA Technology Transfer Workshop, Houston, TX**
Apr. 28, 2016	**AMTA Board Meeting, Houston, TX**

Contact the following organizations for more information regarding their listed events:
AMTA – 772-463-0820, admin@amtaorg.com, www.amtaorg.com
AWWA – 303-794-7711, awwamktg@awwa.org, www.awwa.org
CaribDA – 772-781-8507, admin@carbida.com, www.caribda.com
IDA – 978-887-0410, paburke@idadesal.org, www.idadesal.org
SCMA – 512-617-6529, admin@scmembrane.org, www.scmembrane.org
SEDA – 772-781-7698, admin@southeastdesalting.com, www.southeastdesalting.com
SWMOA – 888-463-0830, admin@swmoa.org, www.swmoa.org
NWMOA – 208-577-6519, admin@nwmoa.com, www.nwmoa.com