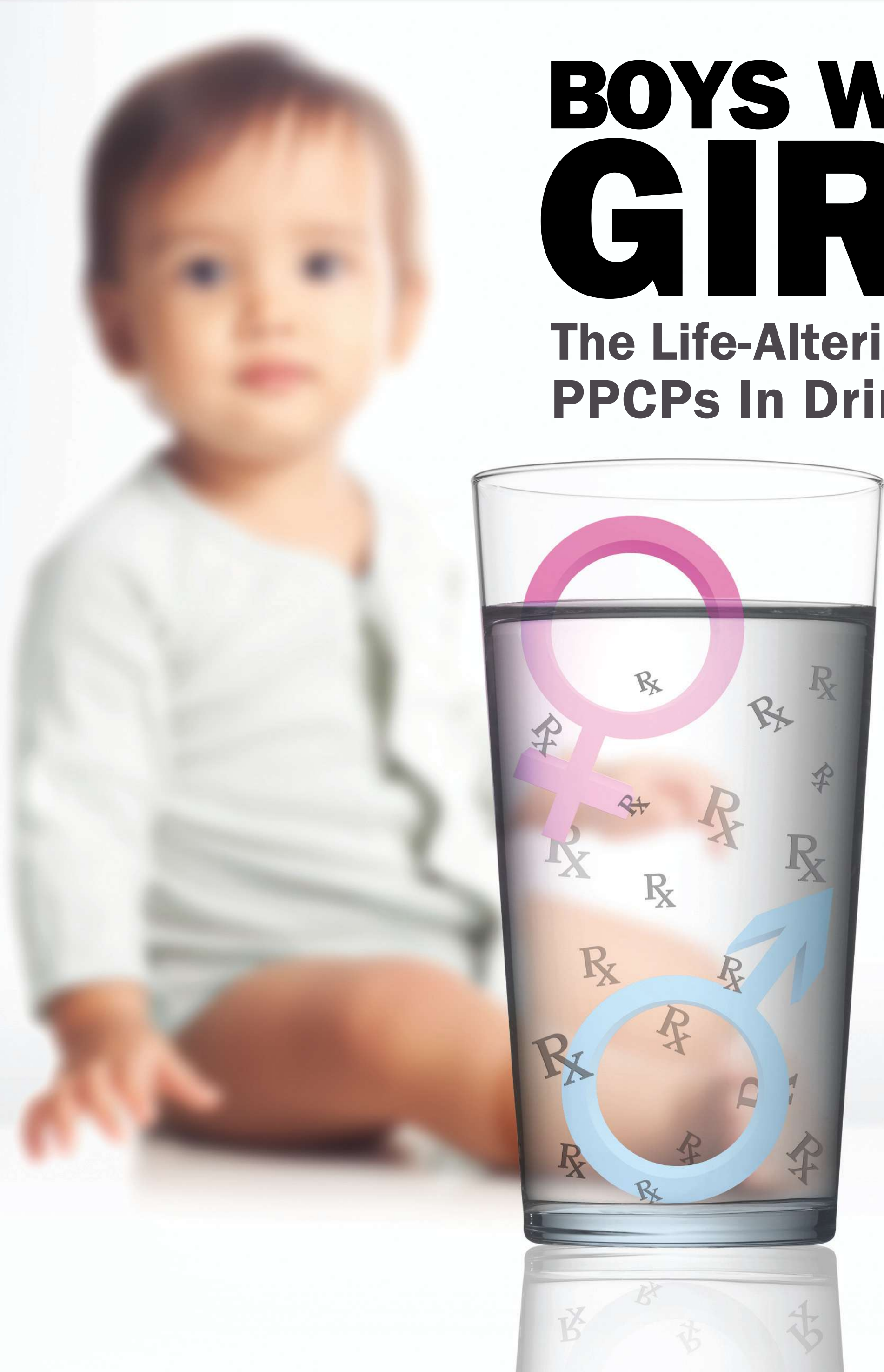
A VertMarkets Publication

Water Online

www.wateronline.com
Digital Magazine
Drinking Water Edition



BOYS WILL BE GIRLS

The Life-Altering Effects Of PPCPs In Drinking Water

Also In This Issue:

10 Steps To Optimum Meter Reading

Taking The Guesswork Out Of RO System Design

How To Best Reduce DBPs

FEATURED ADVERTISERS

A VertMarkets Publication

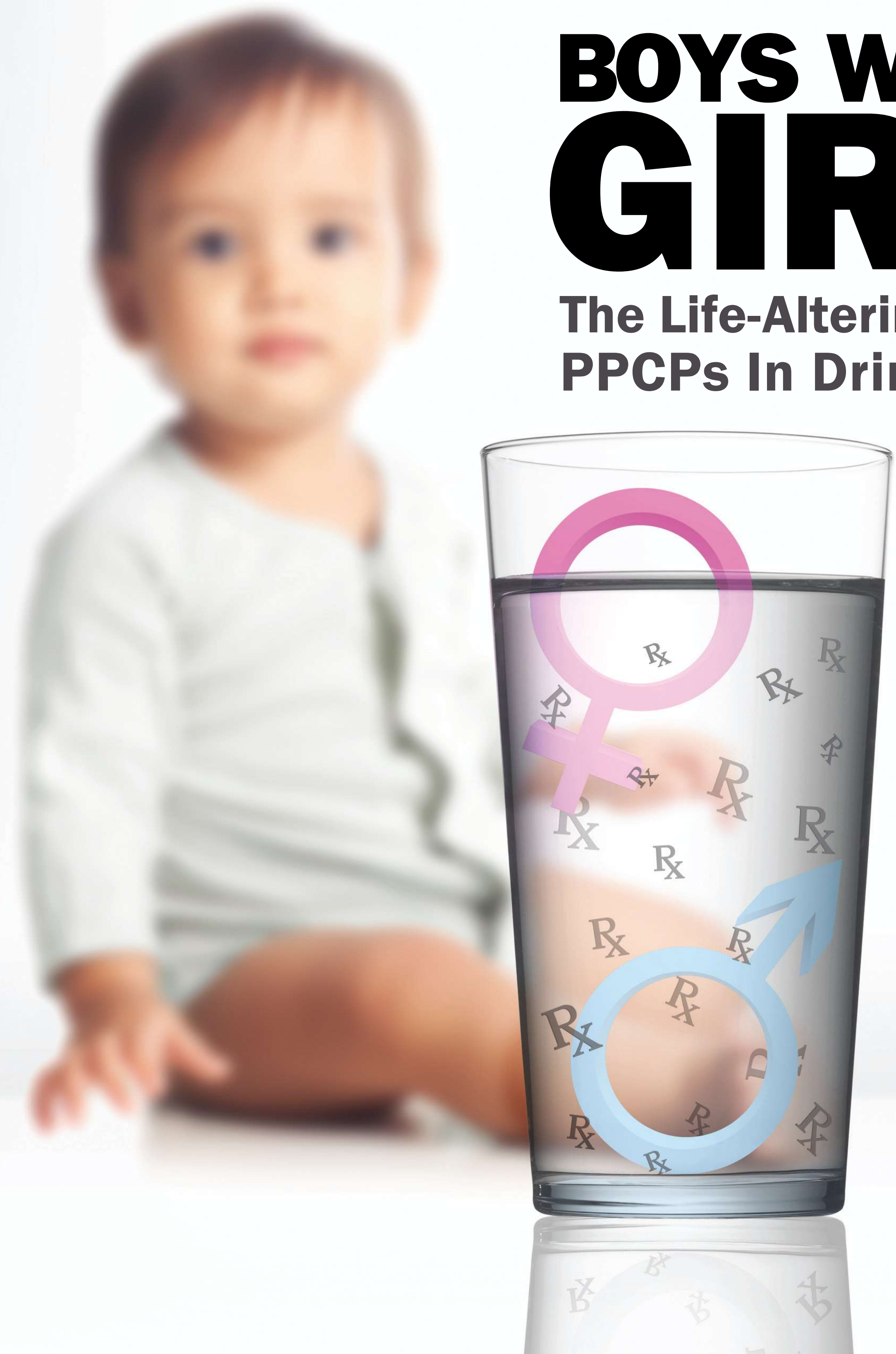
Water Online

www.wateronline.com Digital Magazine

Drinking Water Edition

BOYS WILL BE GIRLS

The Life-Altering Effects Of PPCPs In Drinking Water



Also In This Issue:

10 Steps To Optimum Meter Reading

Taking The Guesswork Out Of RO System Design

How To Best Reduce DBPs


LEOPOLD
a xylem brand
ONCE AGAIN, THE
ARCH
SYMBOLIZES A
TRIUMPHANT
ACHIEVEMENT.
The Revolutionary Leopold® Type XA™ Underdrain. Leopold has transformed the underdrain to provide superior uplift resistance and superb backwash performance over longer lateral runs. The Type XA is engineered for quick, easy construction and reliable performance. This interior arched underdrain design is sure to start a revolution.
For more information visit booth 1443 and 3940 at WEFTEC '13 in Chicago - Oct. 7-9.
xyleminc.com
xylem
Let's Solve Water

WEDECO
a xylem brand

The WEDECO LBXe Series is the ideal UV solution when wastewater is under pressure. Proven in more than one thousand installations worldwide, with validated units according to UVDGM and NWRI guidelines, LBXe units provide energy-efficient disinfection for pressurized waters having a low UV transmittance like wastewater, water reuse, surface water and stormwater overflow.

A variety of sizes and alternative shapes and flanges make LBXe units an extremely flexible solution that can be customized to fit within site-specific arrangements.

The LBXe Series also delivers low life-cycle costs by using high efficiency ECORAY® UV lamp and ballast technology and OptiDose™ UV sensor-based dose control for low energy consumption and long lamp life. And no other system is easier to use or maintain due to WEDECO'S operator-friendly EcoTouch™ controller and a chemical-free automatic wiping system.

Put the proven solution to work for you.
The WEDECO LBXe Series.

For more information visit booth 1443 and 3940 at WEFTEC '13 in Chicago - Oct. 7-9.

You Tube

xyleminc.com

xylem
Let's Solve Water

CONTENTS

Editor's Letter

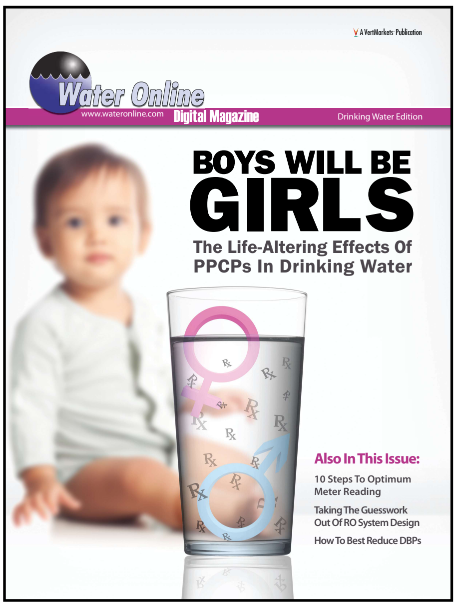
6 **For Drinking Water Utilities, The Heat Is On**

Keeping our water supply sustainable and safe in the face of a changing climate will require considerable planning and foresight.

Feature

8 **Boys Will Be Girls: The Life-Altering Effects Of PPCPs In Drinking Water**

Are man-made chemicals unmaking man? Studies suggest action may not only be needed, but overdue.



Exclusive Editorial

12 **Taking The Guesswork Out Of RO System Design**

Engineers at CH2M HILL have developed a tool to evaluate energy-recovery devices (ERDs), enabling wise decision-making and lower-cost reverse osmosis (RO) desalination.

14 **A 10-Step Method For Optimum Meter Reading**

With demand for efficiency at an all-time high, utilities are provided a guide to better meter reading.

18 **How To Best Reduce DBPs: A Comparison Of Centralized And Decentralized Treatment**

Air stripping and granulated activated carbon were applied at different points in the distribution system to evaluate effective removal of disinfection byproducts (DBPs).

22 **New Process May Hold The Key To "Economically Viable" Desalination**

An energy-saving alternative to reverse osmosis (RO) desalination promises to reduce costs by more than 82 percent.

24 **Is Private Capital A White Knight For America's Water Infrastructure?**

Understanding and acceptance of public-private partnerships continue to grow as the gap between infrastructure needs and funding widens.

Advertiser Index

Advertiser	Page
Adedge Technologies	19
Krohne	11
Master Meter	5
Severn Trent	7
Xylem	C2

MASTER METER®

Octave® Ultrasonic Meter

THE METER WE MASTERED.

You can't manage what you don't measure. The Octave® Ultrasonic Meter is the embodiment of precisely crafted measurement science. Aggressive starting flow as low as 1/16 GPM means measuring flow where other meters typically give water away for free. The Octave is the fresh approach to metering – with no moving parts – simplified installation – and complete integration with SCADA and AMR/AMI systems.

Call 800.765.6518 or visit us online at www.mastermeter.com to learn more.

For Drinking Water Utilities, The Heat Is On

The Water Online offices lie just outside the confines of Philadelphia, where this summer we experienced the wettest June in 143 years of record-keeping. We also set a one-day record in July, recording over eight inches in a matter of hours. The incessant rainfall, oddly enough, made me think of water scarcity.

Moreover, I pondered the juxtaposition of East Coast weather conditions with those in the Southwest: too much rain versus too little. Both issues, though at opposite ends of the spectrum, have far-reaching impacts on nearly every facet of society, and society turns to the water industry to solve them.

Too much rain will overwhelm old infrastructure, resulting in wet-weather discharges. Sanitary and combined sewer overflows (SSOs and CSOs) can compromise water quality and make life very difficult for drinking water utilities when they occur upstream from source water intakes. In severe cases, sewage overflows can even infiltrate clean water lines.

When "superstorm" Sandy wreaked its havoc on the Northeast in October of 2012, the state of the nation's inadequate infrastructure received some high-profile attention. It was notable because the worsening problem of our aging and crumbling infrastructure pitted (and losing) against Mother Nature goes largely ignored by the public — and usually by public officials. The number of storm events, property damage, and lives it takes before the pleas for action are actually heeded remains to be seen.

If only we could move those rain clouds out west, where the population continues to expand as water reserves simultaneously dry up. For many fast-growing communities, water needs to be brought in from neighboring municipalities, sometimes across state lines.

Losing water reiterates the idea that adequate supply is inextricably linked to quality of life — as well as a healthy economy. The energy sector, particularly the oil and gas and power industries, is extremely water-intensive, and rising costs for those industries have a trickle-down effect for virtually everyone. Charles Anderson, former president (as of ACE13 in June) of the American Water Works Association (AWWA), has noted there are cities in Texas that are "90 days away from having no water." Another prominent voice on the subject, Patricia Mulroy, general manager of the Southern Nevada Water Authority (SNWA), recently called the falling water levels of Lake Mead, the largest reservoir in the U.S., "an incredible warning sign."

A Climate Of Change

The elephant in the room is that these seemingly disparate issues of too much/too little rain are caused, at least in part, by the same phenomenon: climate change. The extent to which global warming has been caused by human activity may be debatable, but climate change itself is a reality. While most are now convinced (Thankfully, the pool of climate-change deniers is ever-shrinking — like so many reservoirs), taking action is another story.

Mulroy and SNWA do their part as members of the Water Utility Climate Alliance, an organization comprising 10 of the nation's largest water providers, all dedicated to collaborating and fixing climate change issues affecting drinking water utilities. Methods promoted to resolve water scarcity include conservation, water/energy efficiency measures, water reuse, and desalination.

Meanwhile, a U.S. EPA survey recently estimated investment needs for our drinking water infrastructure to be $384 billion through 2030. A large portion of that would be dedicated to outdated pipes and under-capacity treatment plants. The answer for dealing with too much water is to invest and rebuild. Support and buy-in for the effort, however, will only be gained through a true understanding of what comes from doing nothing — more destruction wrought by more storms, resulting in persistent threats to the public's health and well-being.

Indeed, keeping our water supply sustainable and safe in the face of a changing climate will require considerable planning and foresight. One thing's for sure: We won't see our way out of it if we put our heads in the sand.

Kevin Westerling
Editor
editor@wateronline.com

Water Online The Magazine

101 Gilbraltar Road, Suite 100
Horsham, PA 19044
PH: (215) 675-1800
FX: (215) 675-4880
Email: info@wateronline.com
Website: www.wateronline.com

GENERAL MANAGER
Bill King
(215) 675-1800 ext. 100
bking@vertmarkets.com

EDITOR
Kevin Westerling
(215) 675-1800 ext. 120
kwesterling@vertmarkets.com

PUBLISHER
Travis Kennedy
(215) 675-1800 ext. 122
tkennedy@vertmarkets.com

ASSOCIATE PUBLISHER
Patrick Gallagher
(215) 675-1800 ext. 129
pgallagher@vertmarkets.com

MANAGING EDITOR
Michael Thiemann
(814) 897-9000, Ext. 340
michael.thiemann@jamesonpublishing.com

PRODUCTION DIRECTOR
Dianna Gross
(814) 897-9000, Ext. 255
dianna.gross@jamesonpublishing.com

DIRECTOR OF AUDIENCE DEVELOPMENT
Martin Zapolski
(814) 897-7700, Ext. 337
martinz@jamesonpublishing.com

DIRECTOR Of ONLINE DEVELOPMENT
Art Glenn
art.glenn@jamesonpublishing.com

Reprints, Eprints, and NXTprints
The YGS Group (800) 290-5460
VertMarketsReprints@theYGSgroup.com
www.theYGSgroup.com

ADDRESS CORRECTIONS
Send to Water Online at above address, or email circ@vertmarkets.com. Please give old and new address, and enclose or reference your latest mailing label.

Copyright © 2013, VertMarkets, Inc.

PRINTED WITH SOY INK

Get maximum uplift resistance, lower installation costs and even air and water distribution with TETRA® LP Block™ dual parallel lateral underdrains. LP Blocks feature the patented GroutGrip™ and new Anchor-Rite® designs. GroutGrip delivers maximum uplift resistance while Anchor-Rite securely bolts the underdrain to the floor. Additionally, fewer lateral lengths are required for installation due to the LP Block's wide, low-profile construction.

– Effective filtration of potable water & pre-treatment for desalination applications
– Equal distribution of backwash air/water
– Low headloss
– No moving or wearing parts
– Exceptional installation strength, integrity and maintenance-free life
– Reduced volume of backwash water produced and lower operating costs

For more information on TETRA® water and wastewater filtration systems visit **WEFTEC 2013 booth #1401**

www.severntrentservices.com

UNDERSTANDING
A VALUABLE RESOURCE

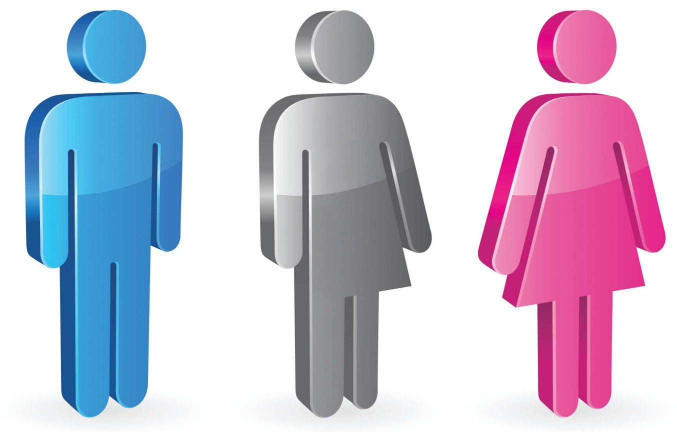
SEVERN
TRENT
SERVICES

Boys Will Be Girls: The Life-Altering Effects Of PPCPs In Drinking Water

Are man-made chemicals unmaking man? Studies suggest action may not only be needed, but overdue.

By Kevin Westerling

It has long been known that there are trace amounts of PPCPs (pharmaceutical and personal care products) that escape our wastewater treatment plants and end up in waterways, including drinking water sources. However, they appear in such trace amounts — parts per billion (ppb) or parts per trillion (ppt) — that they have thus far been considered essentially harmless and therefore unregulated by the U.S. EPA. But something fishy is going on in the water, and not just with the fish. Recent research suggests that exposure to PPCPs in drinking water may subject humans, particularly males, to gender-morphing and other reproductive system alterations.



Though unregulated, PPCPs are on the EPA's radar via the Third Contaminant Candidate List (CCL3) and the Unregulated Contaminant Monitoring Rule (UCMR) — precursors to possible regulatory action. The EPA defines PPCPs as "any product used by individuals for personal health or cosmetic reasons or used by agribusiness to enhance growth or health of livestock. PPCPs comprise a diverse collection of thousands of chemical substances, including prescription and over-the-counter therapeutic drugs, veterinary drugs, fragrances, lotions, and cosmetics."

When you consider that chemicals are used to produce 96 percent of manufactured consumer goods and that there are more than 85,000 chemicals on the market,[1] wastewater and drinking water facilities do a tremendous job in keeping all but those miniscule amounts of them out of our water. Unfortunately, with PPCPs so ubiquitous, and with treatment systems not designed to handle them, they do creep into the environment. The resulting chemical cocktail makes analysis difficult, especially when trying to determine specific cause and effect for statistical oddities in PPCP-laden water — like why is the male birthrate dropping?

Startling Statistics

Fish being as small as they are, and therefore more susceptible to even tiny doses of PPCPs, it stands to reason that the PPCP-related statistical anomalies will first show up in aquatic populations. A 2008 study conducted by researchers from the University of Calgary indicated that male longnose dace were disappearing from the Oldman and Bow Rivers in Alberta, Canada. Since these same waters are a source of drinking water, the focus turned to human birth ratios. The findings were revealed in the book *Down the Drain: How We Are Failing To Protect Our Water*, published in May 2013 and co-authored by the acting chair of the Canadian Water Issues Council at the University of Toronto, Ralph Pentland.

According to the book, researchers noticed a shift in the sex ratio starting in 1970, with male births in the Atlantic provinces of Canada dropping 5.6 per 1,000 live births over 25 years. For the year 2010, it was estimated that 850 Canadian boys went "missing" from the population.[2] Looking at a roughly 30-year timeframe in the U.S. and Japan, the journal *Environmental Health Perspectives* reported that a quarter of a million boys went missing compared to the number that would have been born if the birth ratio in 1970 remained unchanged.[3]

Casting the net wider, a Canadian Broadcasting Company documentary, *The Disappearing Male*, cites the following statistics:[4]

Recent studies, as well as observations in the wild, can serve as the proverbial canary in the coal mine in warning us of a developing and disturbing worldwide trend.

- The birthrate for boys has declined every year for the past 30 years in more than 20 heavily industrialized nations — amounting to 3 million fewer males born.
- The number of boys born with penis abnormalities such as cryptorchidism (undescended testicle) and hypospadias (abnormal location of the urethra) has risen 200 percent in the past 20 years.
- The average sperm count of North American college students has declined more than 50 percent over 50 years.
- Up to 85 percent of the sperm in a healthy male is DNA-damaged.
- There has been a 300 percent increase in testicular cancer, which is linked to damaged sperm, in the past half-century.

The Smoking PPCP

If PPCPs are to blame for such trends, it is likely due to the endocrine disrupting compounds (EDCs) among them. Though the quantities (per compound) in drinking water are slight, the impact of endocrine disruptors is significant by their very definition: compounds that mimic hormones or disrupt hormone regulation.[5] In some cases, as with birth control pills, hormone manipulation is precisely the point. More than 100 million women worldwide take the pill, which contains the female hormone estrogen. That's a logical place to start when considering female-skewing alterations of gene expression.

Like other pharmaceuticals, the pill is not completely absorbed by the body and thus ends up in wastewater. But it is far from the only source of estrogen in the water supply; in fact, it contributes very little to the total amount of estrogen in drinking water. According to a 2010 Environmental Science & Technology report, animal waste is a far greater contributor of natural and pharmaceutical hormones. Livestock produce 13 times more solid waste than humans, and the excretions often enter the waterways without treatment.[6]

The agriculture industry also uses pesticides with EDCs that mimic estrogen, as many chemicals do. Phthalates, for instance — found in soap, shampoo, deodorants, fragrances, hair spray, and nail polish — are among the most potent and worrisome EDCs. The incidence of these raging hormone-disruptors is linked to "feminization" within the animal kingdom. In 2008, the Associated Press conducted an investigative report on pharmaceuticals acknowledging that "Pharmaceuticals in waterways are damaging wildlife across the nation and around the globe."[7] Examples include hermaphroditic "male" cane toads and polar bears; abnormal testes in bears, panthers, turtles, sea lions, whales, and birds; genitalia deformities in alligators and otters; and egg-yolk proteins in male fish, amphibians, and birds.[2] There's also that extremely lopsided sex ratio of longnose dace in Canada to consider.

"It brings a question to people's minds that if the fish were affected … might there be a potential problem for humans?" said Vickie Wilson, an EPA research biologist interviewed by the AP.

Strong evidence of the effect of EDCs on birth ratios comes from the Aamjiwnaang First Nation. This community of about 850 Chippewa (Ojibwe) aboriginal peoples lives in southwestern Ontario, Canada, just across the U.S. border from Port Huron, MI — and downstream from a number of chemical plants. Environmental Health Perspectives notes that while the normal birthrate percentages for boys and girls break roughly 50/50, the birth ratio between 1999 and 2003 for the Aamjiwnaang was dramatically altered to 33 percent boys and 67 percent girls.[8]

The Aamjiwnaang is the first community on record with more than two girls to every boy, a fact that undoubtedly points to the volume of EDCs to which they were exposed. But what about the more common scenario of low-dose exposure to PPCPs and EDCs? That is the question and the debate for scientists, and ultimately for water and wastewater treatment professionals.

Low-Dose Impact

A fundamental tenet of toxicology states that "the dose makes the poison" — in other words, as the dose increases, so does the effect. For many, this tenet translates that PPCPs in the parts-per-billion range have little to no effect. Disputing this is a 2012 paper, "Hormones and Endocrine-Disrupting Chemicals: Low-Dose Effects and Nonmonotonic Dose Responses," written by 12 scientists and based on a review of 800 scientific studies, concluding that it is "remarkably common" for extremely small amounts of hormone-disrupting compounds to have significant and adverse human-health effects.[9]

The U.S. EPA remains wary but unconvinced, at least not enough to enact regulations. Benjamin H. Grumbles, the agency's assistant administrator for water at the time of the report, told AP investigators, "We recognize it is a growing concern and we're taking it very seriously."[7] Meanwhile, the EPA website currently states, "To date, scientists have found no evidence of adverse human health effects from PPCPs in the environment."

That's not exactly true.

After reviewing hundreds of scientific reports, analyzing federal drinking water databases, and interviewing more than 230 officials, academics, and scientists, the AP commented that "Emerging scientific studies indicate that over time, humans could be harmed by ingesting drinking water contaminated with tiny amounts of pharmaceuticals."

When it comes to human birth ratios, the impact is not immediately apparent, because the end result is a healthy bundle of joy — albeit a girl that might have otherwise, without hormone disruption in utero, been a boy. Recent studies, as well as observations in the wild, can serve as the proverbial canary in the coal mine in warning us of a developing and disturbing worldwide trend.

The volume – and impact – of pharmaceuticals entering the water supply is of increasing concern.

Theo Colborn, a professor of zoology at the University of Florida and a leading voice on EDCs (In fact, she coined the term "endocrine disruptor" in 1991), noted the correlation between animals and humans: "In the animals, it was at the population level that we really began to realize what was going on. If we're going to wait to see population effects for all of these concerns that we have in the human population, it's going to be too late."[2]

What's A Water Treatment Professional To Do?

While awaiting consensus from the scientific community or regulations from the EPA, there are steps that drinking water treatment facilities can take to protect their customers from dangerous PPCPs. The AP notes in its report that, "One technology, reverse osmosis, removes virtually all pharmaceutical contaminants."

A 2009 report published by the University of New Mexico (UNM) echoed the endorsement of reverse osmosis, while also finding that activated carbon (both powder and granular) is "highly effective in removing most targeted compounds to a high degree."[10] The UNM study further acknowledged the ability of advanced oxidation processes (AOPs) such as ozone and UV/H2O2 (ultraviolet radiation in the presence of hydrogen peroxide) to completely oxidize many targeted PPCPs and EDCs.

On the flipside, UNM reported that most conventional oxidants, namely chlorine, are not very effective at degrading PPCP compounds. The AP goes one step farther, warning, "There's evidence that adding chlorine, a common process in conventional drinking water treatment plants, makes some pharmaceuticals more toxic."

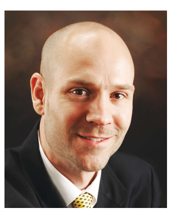
Because PPCPs are so pervasive, with different properties that may require different treatment strategies, it's unrealistic to expect to completely eliminate them from our environment and drinking water any time soon. The focus, then, should be on identifying and removing the most harmful among them. Water utilities should urge the EPA to not only consider the latest studies, but aslo to conduct many more in determining a strategy for the mitigation of PPCPs.

If high occurrence of PPCPs is already suspected or known by local officials, utilities may want to preempt regulatory actions by the EPA and adopt one of the aforementioned treatment techniques deemed most effective. At the very least, they should advise consumers to never flush unused pharmaceuticals down the toilet, which was once the recommended disposal technique before the EPA and FDA got wise.

While a complete understanding of the effects of PPCPs and EDCs still escapes us, common sense suggests that the continuous, increasing, and haphazard introduction of manmade chemicals into the environment, especially proven endocrine disruptors, is not without consequence. Just this year, the World Health Organization (WHO) and the United Nations Environment Programme (UNEP) acknowledged in a joint study that "Known EDCs are only the 'tip of the iceberg' and more comprehensive testing methods are required to identify other possible endocrine disruptors."[11] In other words, the impacts are likely worse than we realize. The study concluded that, "As science continues to advance, it is time for both management of endocrine disrupting chemicals and further research on exposure and effects of these chemicals in wildlife and humans."

It may be too late for the boys that never were, but it's a step in the right direction for the sons and daughters — especially the sons — of the future. ■

References
1. http://www.anh-usa.org/chemicals-in-your-home-are-toxic/
2. http://thetyee.ca/News/2013/06/17/Gender-Bending-Chemicals/
3. Environ Health Perspect. 2007 Jun;115(6):941-6. Epub 2007 Apr 9.
4. http://www.cbc.ca/documentaries/doczone/2008/disappearingmale/infertility.html
5. http://medical-dictionary.thefreedictionary.com/Endocrine+Disruptor
6. Environ Sci Technol. 2011 Jan 1;45(1):51-60. doi: 10.1021/es1014482. Epub 2010 Oct 26.
7. http://hosted.ap.org/specials/interactives/pharmawater_site/
8. Environ Health Perspect. 2005 Oct;113(10):1295-8.
9. Endocrine Reviews March 14, 2012 er.2011-1050
10. "State of Knowledge of Pharmaceutical, Personal Care Product, and Endocrine Disrupting Compound Removal during Municipal Wastewater Treatment," April 17, 2009. Carson O. Lee, Dr. Kerry J. Howe, P.E., BCEE, Dr. Bruce M. Thomson, P.E.
11. WHO/PCS/EDC/02.2



Kevin Westerling has served as the editor of Water Online, the Internet's premier source for water and wastewater solutions, since 2008. Kevin's education includes a bachelor's degree in English Literature, a minor in Journalism, and certification as a Web Content Developer. He can be reached at editor@wateronline.com.

KROHNE

achieve more

You're searching for an efficient flow measurement solution? No problem with KROHNE.

As one of the world's market leaders for flow measurement instrumentation, we've been serving our customers in the process industries for more than 85 years with innovations that set the standard for our markets.

KROHNE has the widest range of technologies and unique expertise. Our know-how applies to general applications, and also to requirements that demand tailor-made solutions.

There's practically no fluid that our devices can't measure reliably and securely: Aggressive or abrasive; high or low temperature, pressure or viscosity; media mixtures with high solids content or high purity fluids as well as saturated or superheated steam.

KROHNE – process measurement engineering is our world.

weftec 2013
the water quality event
Visit KROHNE at Booth #1654
October 7-9, Chicago, IL

info@krohne.com
Tel: 1-800-FLOWING
http://us.krohne.com

www.krohne.com

Taking The Guesswork Out Of RO System Design

Engineers at CH2M HILL have developed a tool to evaluate energy-recovery devices (ERDs), enabling wise decision-making and lower-cost reverse osmosis (RO) desalination.

By Steve Alt, Jim Lozier, and Tyler Nading

Did you know energy consumption accounts for the largest part of a desalination plant's total operating costs? As a result, desalination plants look to energy-recovery devices (ERDs) to cut back on operating costs by reusing energy from the reverse osmosis (RO) process. However, with numerous ERDs available on the commercial market, such as energy-recovering turbines or pressure-exchanging technologies, it can be a time-consuming and tedious process to determine which, if any, ERD is best suited to meet the needs of an existing or new plant.

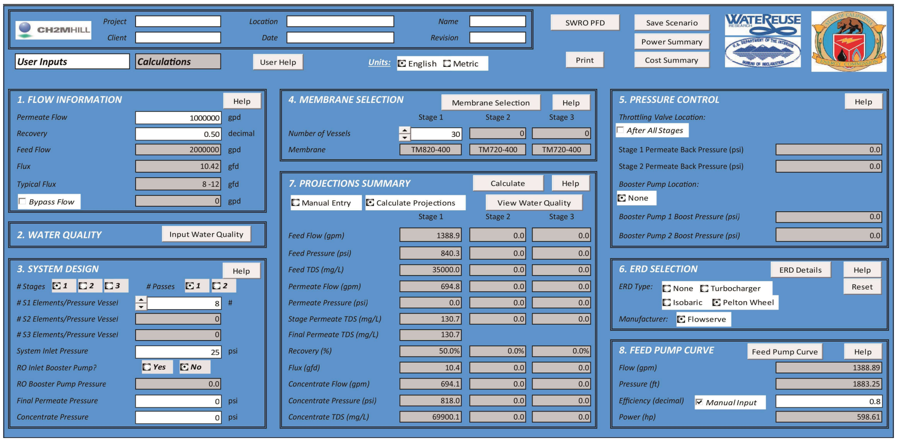


Figure 1: The input page allows users to make ERD comparisons based on system design and specifications.

As part of a WateReuse Research Foundation study, CH2M HILL designed and engineered a new desalination tool to assess ERDs and their use in RO systems. By integrating mass-balance RO projection software with energy-recovery calculations and life-cycle estimates, the tool makes it easier for engineers and plant operators to identify whether adding an ERD to the RO system would result in a reduction in the cost of desalting water with an acceptable payback period.

If you are wondering how the tool works or why it would be beneficial, here is a quick overview of how this technology is used to save time, address ways for desalination plants to reduce energy consumption, and save substantial operating costs.

User-Friendly Interface Leads To Faster Analysis

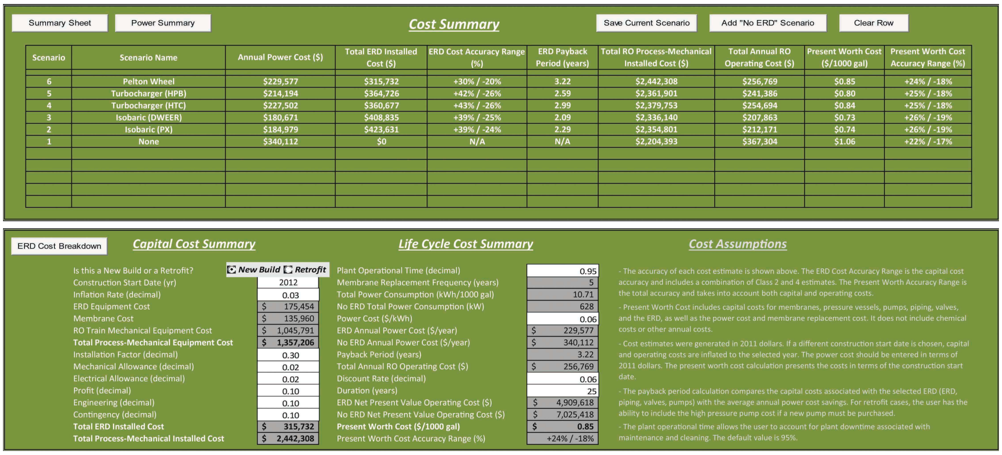
The tool is built as an Excel-based model. The intuitive design and single interface makes it easy for users to input basic RO system parameters as well as select the ERDs plant designers would like to consider in their analysis. The model incorporates standard municipal requirements and ERD product information into a comprehensive, easy-to-use tool.

Historically, engineers, plant designers, and operating staff spend hours or even days evaluating the cost and performance specs of ERDs. ERD suppliers often provide information on performance and life-cycle costs for each product; however, with the projection tool, the analysis is streamlined and includes an estimate of the installed capital cost. The tool makes it simple to compare and contrast options available in the commercial market, reducing analysis time to approximately 30 minutes for numerous ERDs.

Wide Water Source Use

ERDs can play a fundamental role in minimizing the operating costs of desalination plants, and selecting the proper ERD can save millions of dollars in operational and capital expenses over the life of the plant. The tool considers not only which ERD would be best for the plant, but it also gives the user the option to run the comparison when no ERD is included.

The tool can be used to evaluate the applicability treatment for the full range of impaired water supplies, including seawater, brackish ground and surface waters, and wastewater.



Scenario	Scenario Name	Annual Power Cost ($)	Total ERD Installed Cost ($)	ERD Cost Accuracy Range (%)	ERD Payback Period (years)	Total RO Process-Mechanical Installed Cost ($)	Total Annual RO Operating Cost ($)	Present Worth Cost ($/1000 gal)	Present Worth Cost Accuracy Range (%)
6	Pelton Wheel	$229,577	$315,732	+30% / -20%	3.22	$2,442,308	$256,769	$0.85	+24% / -18%
5	Turbocharger (HPB)	$214,194	$364,726	+42% / -26%	2.59	$2,361,901	$241,386	$0.80	+25% / -18%
4	Turbocharger (HTC)	$227,502	$360,677	+43% / -26%	2.99	$2,379,753	$254,694	$0.84	+25% / -18%
3	Isobaric (DWEER)	$180,671	$408,835	+39% / -25%	2.09	$2,336,140	$207,863	$0.73	+26% / -19%
2	Isobaric (PX)	$184,979	$423,631	+39% / -24%	2.29	$2,354,801	$212,171	$0.74	+26% / -19%
1	None	$340,112	$0	N/A	N/A	$2,204,393	$367,304	$1.06	+22% / -17%

Capital Cost Summary

Is this a New Build or a Retrofit?	New Build / Retrofit
Construction Start Date (yr)	2012
Inflation Rate (decimal)	0.03
ERD Equipment Cost	$ 175,454
Membrane Cost	$ 135,960
RO Train Mechanical Equipment Cost	$ 1,045,791
Total Process-Mechanical Equipment Cost	**$ 1,357,206**
Installation Factor (decimal)	0.30
Mechanical Allowance (decimal)	0.02
Electrical Allowance (decimal)	0.02
Profit (decimal)	0.10
Engineering (decimal)	0.10
Contingency (decimal)	0.10
Total ERD Installed Cost	**$ 315,732**
Total Process-Mechanical Installed Cost	**$ 2,442,308**

Life Cycle Cost Summary

Plant Operational Time (decimal)	0.95
Membrane Replacement Frequency (years)	5
Total Power Consumption (kWh/1000 gal)	10.71
No ERD Total Power Consumption (kW)	628
Power Cost ($/kWh)	0.06
ERD Annual Power Cost ($/year)	$ 229,577
No ERD Annual Power Cost ($/year)	$ 340,112
Payback Period (years)	3.22
Total Annual RO Operating Cost ($)	$ 256,769
Discount Rate (decimal)	0.06
Duration (years)	25
ERD Net Present Value Operating Cost ($)	$ 4,909,618
No ERD Net Present Value Operating Cost ($)	$ 7,025,418
Present Worth Cost ($/1000 gal)	**$ 0.85**
Present Worth Cost Accuracy Range (%)	+24% / -18%

Cost Assumptions

- The accuracy of each cost estimate is shown above. The ERD Cost Accuracy Range is the capital cost accuracy and includes a combination of Class 2 and 4 estimates. The Present Worth Accuracy Range is the total accuracy and takes into account both capital and operating costs.
- Present Worth Cost includes capital costs for membranes, pressure vessels, pumps, piping, valves, and the ERD, as well as the power cost and membrane replacement cost. It does not include chemical costs or other annual costs.
- Cost estimates were generated in 2011 dollars. If a different construction start date is chosen, capital and operating costs are inflated to the selected year. The power cost should be entered in terms of 2011 dollars. The present worth cost calculation presents the costs in terms of the construction start date.
- The payback period calculation compares the capital costs associated with the selected ERD (ERD, piping, valves, pumps) with the average annual power cost savings. For retrofit cases, the user has the ability to include the high pressure pump cost if a new pump must be purchased.
- The plant operational time allows the user to account for plant downtime associated with maintenance and cleaning. The default value is 95%.

Figure 2: The "Cost Summary" page presents capital cost and life-cycle cost for various ERDs, allowing users to compare and contrast the options.

Today, the majority of modern seawater RO systems (SWROs) have installed ERDs, with great success and a typical payback period of less than three years. The high salinity of seawater increases the residual energy in RO concentrate and increases the value of the ERD. With an ERD, approximately 50 percent of the initial pumping energy in the RO treatment step can be recaptured and recycled, reducing the overall energy consumption used by SWROs.

However, for source waters with lower salinity, such as wastewater or brackish waters, the new tool becomes especially useful because the residual energy in the concentrate is significantly lower. Plants treating lower salinity waters have less residual energy to recover, and, therefore, ERDs are not always cost effective regarding payback period. Using the tool to evaluate the costs and benefits of including an ERD becomes especially important.

Evaluates Payback Period And Capital Costs For Optimal RO System Design

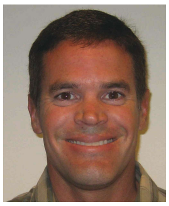
The decision on whether including an ERD in an RO system is economically feasible is based on the payback period. If the payback period is less than the projected ERD and associated equipment life, then ERD inclusion will save money over the duration of the equipment life. Using ERD product information and RO system parameters to perform a series of calculations, the tool calculates the payback period and capital costs associated with including an ERD into both new and existing RO systems. Displaying results in a simple summary table, the tool makes it easy for users to identify the optimal RO system design by comparing the present cost of desalting water and the payback period.

As existing plants seek ways to conserve energy, the tool can also help engineers evaluate ERD retrofit options. However, the existing RO system must be closely evaluated to determine whether the energy savings gained by including a retrofitted ERD would outweigh the installed capital cost.

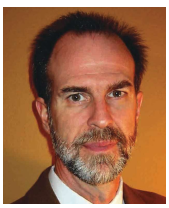
While taking the payback period into consideration is important, ERD selection should be based on the present worth of equipment cost and energy, not on payback period or ERD efficiency alone. The tool calculates both present-worth RO system project costs and payback period. The ERD providing the lowest present worth of RO equipment and energy will have the lowest cost to desalt water, regardless of the ERD efficiency or payback period.

Therefore, when planning to update or build a new plant, engineers and operators will find exceptional value in this tool for determining the optimal RO design.

The ERD tool and the related full report, funded by the WateReuse Research Foundation, the California Energy Commission, and the United States Bureau of Reclamation, are available for free at http://www.watereuse.org/product/08-14-1. ■



Steve Alt, a chemical engineer and membrane and desalination technologist with CH2M HILL's Water Business Group, has more than 16 years of membrane technology experience on a variety of environmental water and wastewater projects. He was the process lead and technical expert for WRF-08-14.



Jim Lozier is one of only five Technology Fellows within the CH2M HILL Water Business Group's global technology organization and works on a worldwide basis on the application of desalination technologies for the production of drinking and high-quality industrial water.

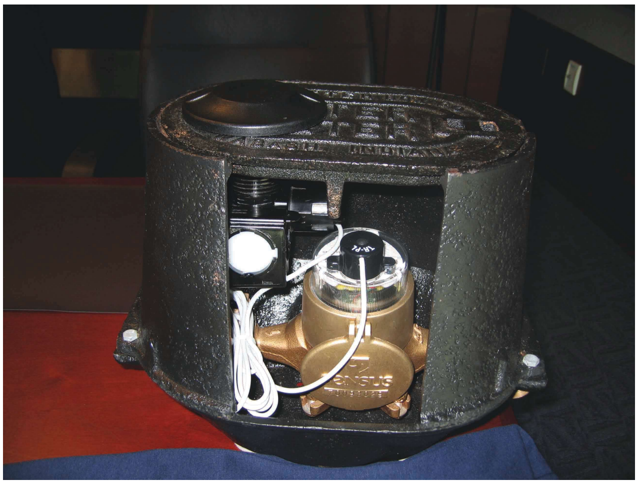
Tyler Nading is a process engineer with four years of experience in water treatment with CH2M HILL. Tyler's experience includes design, pilot plant operation, construction, and start-up for water and wastewater treatment plants. He served as the project manager and lead programmer for WRF-08-14.

A 10-Step Method For Optimum Meter Reading

With demand for efficiency at an all-time high, utilities are provided a guide to better meter reading.

By Stephen Davis

Technological advances in water customer demand metering and new ways to collect and transmit metering data can provide answers to many complex questions facing water utility managers today. More frequent meter readings than once a month for billing and improved metering analytics provide opportunities for better informed decision-making and water infrastructure management.



A water meter and endpoint (radio) in a meter box, showing the antenna through the metal meter box lid (needed for propagation of the radio signal)

Mining of advanced metering infrastructure (AMI) data improves water resource use efficiency, customer accountability, and utility response, while facilitating better water loss definition and cost-effective mitigation. Additionally, by collecting multiple reads during peak use periods, the utility can better characterize right sizing of meters and right sizing of water delivery infrastructure. Customers can benefit from web-based access to their own usage patterns. Utility customer service personnel, armed with real-time and more detailed specific-customer, short-interval water use information, can address customer concerns quickly and confidently.

How does each utility determine the optimum meter reading system that meets its specific current and future needs with the available technical and monetary resources? This article presents a successfully applied comparative economic evaluation and analysis method which considers automatic meter reading (AMR), advanced metering infrastructure (AMI), and hybrid AMR/AMI systems. The approach should aid decision-makers in leveraging utility optimization goals, addressing stakeholder concerns, and developing a defensible economic business case.

Major Driving Forces For Water Utility AMI

Most water utilities implement AMI to generate more actionable water usage data and the analytics needed to improve operational efficiency, water conservation, and customer service. With this new data, utilities can:

- Enable more accurate monthly automatic meter reading, interim reads, and special reads to significantly reduce the labor and resources needed for billing.
- Provide expanded information to answer customer questions regarding usage trends.
- Effectively monitor water consumption patterns.
- Generate daily leak reports for each individual customer.
- Identify the presence of system and customer leaks.
- Provide web-based customer usage access.
- Evaluate and monitor conservation efforts by account or customer classification.
- Generate daily zero-consumption reports to identify stuck meters.
- Better correlate production data for water balance.
- Reduce NRW (non-revenue water).
- Link acoustic monitoring equipment to record pipe noise at quiet night periods.
- Rank leak locations as "probable," "possible," or "unlikely" based on high and low noise and historical noise frequencies through system leakage monitoring.
- Optimize hydraulic models and other utility planning tools.

There are logical, sequential steps to determine how benefits and tradeoffs of manual, AMR, AMI, or hybrid reading systems affect a specific utility

- Right-size water supply and delivery infrastructure to meet peak requirements.

Utility managers discover that accurate, reliable, customer-specific water use data help reduce human error and potential conflicts with unionized meter readers. Given increased billing accuracy and the ability to check for the source of billing anomalies, staff spends less time investigating bills and leaks, less time processing bill credit adjustments, and more time on revenue-generating outcomes.

The greatest reported benefit is from customers having access to their own time-specific use data and comparison with local per-capita or per-account benchmarks or customer-specific water use targets, empowering them to make individual conservation decisions. An additional conservation benefit derives from polling the expanded database to generate more frequent exception reports for customer water use changes and excessive water use, including customer-side leaks.

Real-time AMI monitoring is especially valuable for cutting the costs of customer service investigations into theft or leaks. Improved leak auditing and detection identify problems quickly, speeding repairs and reducing associated water and revenue losses. Additionally, there are noise-listening devices that can be placed near customer meters to help diagnose potential service line leakage. Customers respond positively to tips on self-monitoring and leakage repair, especially when they learn of leakage on their side of the meter. Proactive communication between utility and customer builds confidence and trust, magnified when the utility finds ways to reduce customer water bills.

Finally, access to individual customer and customer- class water use comparisons helps target water conservation efforts while prioritizing policies, methods, and devices to achieve the largest water savings at least cost to the utility.

How To Determine The Optimum Meter-Reading Strategy

Even though advanced meter-reading technology demonstrates multiple advantages over a manual read system, each utility must evaluate its own water resource, service area, and affordability situations to assess costs and benefits. There are logical, sequential steps to determine how benefits and tradeoffs of manual, AMR, AMI, or hybrid reading systems affect a specific utility. These steps have been applied in various utility situations throughout the U.S. with different recommendations for incremental and ultimate implementation. The following outline represents an effective, 10-step approach to create a defensible basis for upgrading meter-reading technology.

1. Determine/assemble internal utility stakeholders

- Utility management, operations, customer service, engineering
- Information technology, GIS, finance

2. Educate stakeholders through interactive workshops

- AMI/AMR terminology
- Hardware/software capabilities
- Multiple vendor offerings and costs

3. List short- and long-term functional needs and wants

4. Collaboratively prioritize meter-reading needs and wants

5. Develop a utility-specific dynamic build-out economic business case

- Compare functional costs today with AMR and AMI costs
- Develop key assumptions and cost information
- Assume a 15-year AMI equipment life
- Determine present worth, capital, and operating costs

6. Compare functional costs today with costs of AMI, AMR, and hybrid systems

7. Determine what is affordable now and over the planning horizon

8. Develop a financing plan

- Current revenues, savings in labor costs
- Green project grants and loans (saves energy and greenhouse gas emissions)
- Revenue bond funding
- Performance-based incentive contracts

9. Develop an implementation plan

- Automate large meters first?
- Implement high-cost meter read routes?
- High demand meter read routes with NRW recovery?
- Specific pressure zones or geographic areas?
- Include concurrent meter replacement?
- How much annual investment?

10. Market the implementation plan

- Educate decision makers
- Educate customers
- Include non-economic benefits

Developing Short- And Long-Term Functional Requirements

As suggested in step 3 of the 10-step approach, it is important to collaboratively determine short- and long-term required and desired meter-reading system functional requirements. AMI can support an ever-growing list of requirements, since meter reading application functionality is expanding as rapidly as AMI technology itself. Solutions may also come from the growing array of add-on devices that monitor other related activities, such as noise, pressure, and water quality.

Desirable water utility reading system functions include:

- Accurate/reliable readings for billing
- End-to-end cybersecurity for AMI database
- Both manual and AMI capability in the utility meter readers
- A demonstrated migration path (from drive-by AMR to fixed network AMI without hardware change)
- On-cycle and off-cycle meter reading for customer service and demand trending
- Detection of leaks, tampering, or theft of service
- Reverse-flow detection
- Customer web portal access to data
- Conservation monitoring and enforcement.

Additional desired functionality may include non-revenue water measurement, distribution system leak detection, system-wide peak demand characterization, integration with supervisory control and data acquistion (SCADA) (production, storage, pumping, etc.), integration with SAP/Oracle/SQL, linkage to geographic information systems (GIS), linkage to an asset management system, and reliable and secure data storage and transmission. Each element of functionality has a cost associated with independent manual activity and a cost for AMR, AMI, or hybrid system enhancement. Specific cost assumptions

Figure 1: Example assumptions for business case cost comparisons

Item	Description	Manual Read	AMI (Fixed)
1	Hourly labor cost (meter reader)	$40.00	$40.00
2	Number of meter readers	31	0
3	Miles per month for reading per vehicle	2000	0
4	Number of persons handling re-reads, etc.	49	10
5	Manual turn on/off and re-reads per day per person	10	10
6	Number of re-reads per month	2577	0
7	Remote turn on/turn off		$150.00
8	Miles per month for re-reads per vehicle	7731	0
9	Average industry cost per meter read	$1.00	
10	Daily meter reads per reader (average)	450	no limit
11	Mileage unit cost	$0.510	$0.510
12	Number of turn on/turn off per month	5000	5000
13	Turn on/turn off cost per order	$40.00	$40.00
14	Number of endpoints	200,000	200,000
15	Unit price endpoint hardware		$120.00
16	Unit price endpoint installation		$50.00
17	Collector base stations - number	0	28
18	Collector base stations - unit cost	0	$70,000.00
19	Initial software licensing/configuration cost		$50,000.00
20	New AMR/AMI compatible Encoder cost	$0.00	$60.00

Benefits of a well-thought-out system usually outweigh costs, especially over the long term.

must be developed for reading system comparisons. Figure 1 shows a sample comparison of some elements of manual functionality compared to AMI functionality. Often, 50 to 100 separate assumptions are developed and used in a linked MS Excel workbook to calculate present-worth cost of various meter reading alternatives.

Example Cost Comparison For Business Case

Following the development of assumptions for different meter-reading scenarios and technologies, best estimated costs for a specific AMI (or AMR) system are calculated. Figure 2 provides an example tabulation of comparative present worth costs for manual and AMI reading systems for a large utility having 200,000 metered customers. Capital and annually recurring operational costs are tabulated and compared to determine total present worth. This information also helps calculate the years for capital cost payback. The comparative economic differentiator is generally the savings in annual operating costs of AMI over manual read systems.

Figure 2: Meter reading system cost comparison

COST ITEM	Manual Read	AMI (Fixed)
Number of Meters		
Manual	200,000	
AMI		200,000
Monthly Meter Reading O&M Cost		
Field reading	$ 200,000	$ 10,000
Turn on/Turn off	$ 200,000	$ 200,000
High bill complaints	$ 225,000	$ -
Re-reads	$ 103,080	$ 500
Customer leak adjustments	$ 150,000	$ -
Vehicle travel	$ 3,943	$ 398
Meter reader lost time	$ 13,333	$ -
Hardware/software maintenance	$ -	$ 3,333
Radio/software licensing	$ -	$ 8,333
Wire communication & power	$ -	$ 5,040
Subtotal per month	$ 895,356	$ 227,605
Subtotal per year	$ 10,744,274	$ 2,731,256
Equipment Purchase and Installation		
New Encoder registers (200000)	-	12,000,000
New Meter Endpoints	-	34,000,000
Permalog Endpoints	-	510,000
SCADA Endpoints	-	150,000
SCADA Integ. Hardware and Software	-	10,000
Handhelds and Wands	15,000	4,500
Initial Licensing and Configuration Cost	5,000	50,000
Computers	5,000	-
Repeaters/base stations	-	1,960,000
Subtotal	25,000	48,684,500
Total OM&R (15 years)	61,164,106	40,968,840
Present Worth of Annual OM&R	111,520,834	28,349,236
Present Worth of Capital Cost	23,810	46,366,144
SUM OF METER READING Present Worth	$111,544,643	$74,715,380

Contemplating Outside The Meter Box

The cost savings of AMI systems are typically understated, so deferring a decision on at least piloting the technology only renders a utility behind the industry in collecting and mining information critical to future operational efficiency, water conservation, and superior customer service. Benefits of a well-thought-out system usually outweigh costs, especially over the long term. The effort spent developing a good business case and analyzing the ROI and implementation timeframe helps all involved understand the details that put utility management in a good position to optimize these systems for the future. ■

Stephen Davis is a technical expert for ARCADIS with more than four decades of experience in potable water system evaluation, planning, modeling, design, and research. Prior to becoming a consultant, Mr. Davis spent 10 years with the City of Tucson Water and Sewer Utility. He is chairman of the AWWA Customer Metering Practices Committee (currently rewriting M22) and a member of the Water Loss Control Committee (currently re-writing M36).

How To Best Reduce DBPs: A Comparison Of Centralized And Decentralized Treatment

Air stripping and granulated activated carbon were applied at different points in the distribution system to evaluate effective removal of disinfection byproducts (DBPs).

By Chandra Mysore, Ph.D., James Fletcher, Bill Roberts, and Mark Xerxis

Background and objectives — Stage 2 of the Disinfectants and Disinfection Byproduct Rule (D/DBPR) — require total trihalomethanes (TTHMs) and haloacetic acids (HAAs) to be below 80 parts per billion (ppb) and 60 ppb, respectively, at each monitoring location in the distribution system. As an alternative to treating the entire flow at a centralized facility, many utilities are considering treating only a partial flow in the distribution system to be in compliance with the Stage 2 D/DBPR requirements. The City of Scottsdale uses Central Arizona Project (CAP) as the source water and uses granular activated carbon (GAC) treatment for reduction of DBPs. Over the years, the cost of this centralized GAC treatment (treating the entire flow ~ 40 MGD) has increased and is not effective at reducing TTHM levels at distant locations within the water distribution system. Localized or decentralized treatment at the point of non-compliance is a cost-effective option, as only the flow that is necessary is treated, to be in compliance with the Stage 2 regulations. The focus of this project was to compare and contrast the merits and demerits of centralized versus decentralized treatment for the reduction of DBPs through bench- and pilot-scale studies.

The objective of the project was to identify the most reliable and cost-effective treatment to meet the requirements of Stage 2 of the D/DBPR.

Approach And Results

To meet the objectives, the approach consisted of several major tasks:

- Conduct pilot-scale studies to compare the centralized (GAC) and decentralized (air stripping or GAC) approach
- Bench-scale studies to determine DBP reformation potential after decentralized treatment
- Develop lifecycle costs for centralized and decentralized treatment.

Air stripping pilot studies:
The decentralized treatment focused on conducting air stripping pilot studies with units supplied by various manufacturers. These studies were conducted in the water distribution system at the Desert Mountain location (Site 92B) that has historically experienced higher TTHM levels. Each unit was operated at air:water ratios of 30:1, 40:1, 60:1, and 120:1. Several scenarios were tested that included blending of treated and untreated water in treated water:untreated water ratios of 25:75, 50:50, and 75:25. Water quality data collected included pH, temperature, total organic carbon (TOC), alkalinity, chlorine residual, bromide, TTHMs, and HAA5s (the sum of five HAAs: monochloroacetic, dichloroacetic, trichloroacetic, monobromoacetic, and dibromoacetic acids). Figure 1 shows the results from the two air stripping units. At an air:water ratio of 30:1, a TTHM removal of 68 percent was observed. The effect on

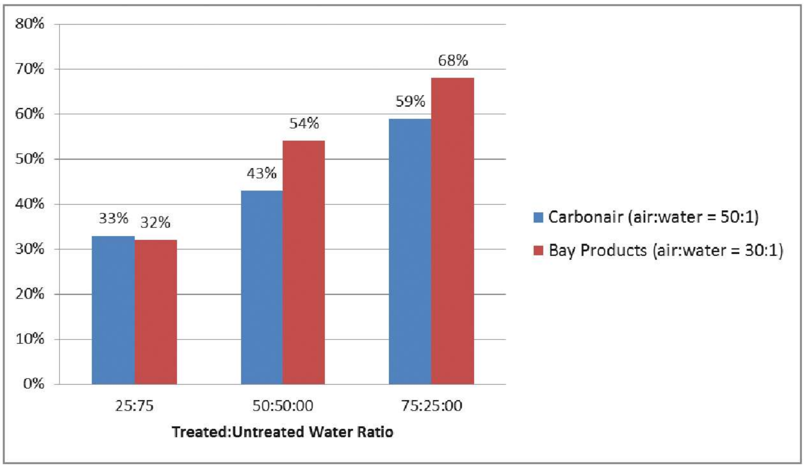


Figure 1: TTHM removal percentages for the two air stripping units

Water Treatment Technology

Arsenic, Iron & Manganese, Uranium, Fluoride, Nitrates, and other heavy metals

AdEdge™
water technologies

Adsorption, Ion Exchange, Coagulation, Filtration, Membrane Technology

1-866-823-3343

www.adedgetechnologies.com

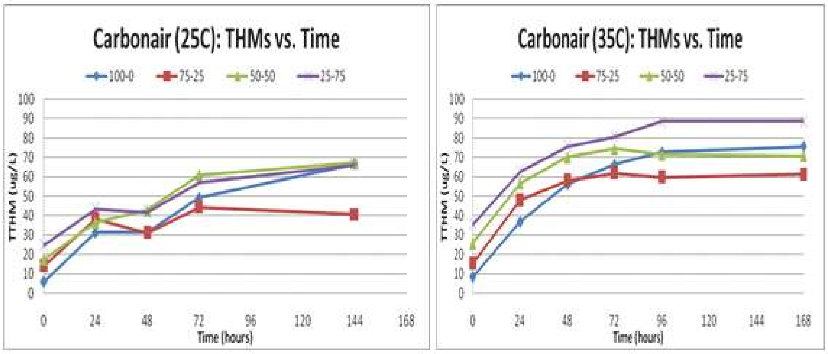


Figure 2: Reformation of TTHMs at two different temperatures for the Carbonair unit

chlorine residuals after air stripping was minimal.

Bench-scale studies were conducted to determine the reformation potential of DBPs after rechlorinating the effluent from the air stripping system. The results demonstrated that TTHM reformation occurs, and the formation levels in some instances exceeded the 80-ppb limit between the 72-hour and 96-hour sampling points (Figure 2). Several blending ratios were tested, and reformation potential was the least for a blending ratio of 75:25 (treated:untreated).

GAC pilot studies:

The pilot test system consisted of a GAC column apparatus from Batelle. The GAC column apparatus featured three glass columns connected in a parallel configuration allowing for simultaneous testing of multiple columns. Each column was 48" long with a 2" diameter. The GAC column apparatus was fastened to a 4"x4" steel frame, which was anchored to the ground (cement slab) and equipped with the appropriate valves and flow meters. Two GAC sources were tested and evaluated in this project: FILTRASORB® 400-M, a bituminous-based GAC; and OLC 12x40, a coconut shell-based GAC. Both FILTRASORB 400-M and OLC 12x40 are manufactured by Calgon Carbon Corporation.

Influent water quality was monitored weekly for temperature, free chlorine, trihalomethanes (THMs), dissolved organic carbon (DOC), and UV-absorbing organic constituents (UV254) throughout the duration of the project. In addition, a THM hold test was performed on the influent samples at 0, 2016, 4020, 5748, 7758, 10494, and 12516 bed volumes. Effluent samples from GAC-loaded columns were tested for column flow rate, temperature, free chlorine, THMs, DOC, and UV254. This testing was done daily for the first eight weeks and then weekly for the last six weeks of the project. The simulated distribution system (SDS-THM) tests were performed on the effluent samples at 2016, 4020, 5748, 7758, 10494, and 12516 bed volumes.

The OLC 12x40 GAC (coconut shell) showed very fast DOC breakthrough and nearly complete breakthrough (90 to 100 percent) toward the end of the project. However, this coconut shell-based carbon, due to its internal structure very high in micropores, exhibited very high efficiency in THMs removal even when DOC breakthrough was nearly complete. The FILTRASORB 400-M (bituminous), on the other hand, showed excellent DOC removal and relatively good THM removal. This bituminous-based carbon, with the internal structure that contains more mesapores than the coconut shell-based carbons, exhibited balanced adsorption over a broad range of high (NOM and DOC fragments) and low (THMs) molecular weight species. The correlation between DOC and TTHMs adsorption for coconut shell- and bituminous-based carbons is illustrated in Figure 3. The spikes in the removal of DOC and TTHMs can be attributed to the varying influent water quality.

The simulated distribution system (SDS)-THM data was evaluated against THM hold test data at 72 hours (three days) and 168 hours (seven days). For the first 4,000 bed volumes of the operation, the two carbons removed THMs very efficiently at both 72 and 168

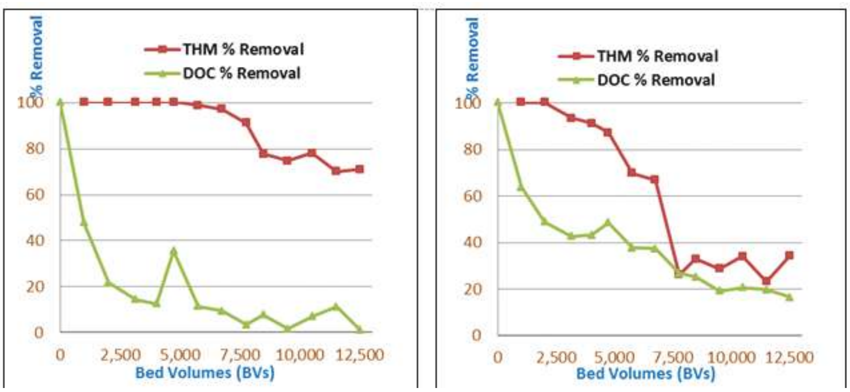


Figure 3: TTHM and DOC removal percentages for GAC effluent (Left graph is for coconut shell-based GAC; right graph is for bituminous coal-based GAC)

The objective of the project was to identify the most reliable and cost-effective treatment to meet the requirements of Stage 2 of the D/DBPR.

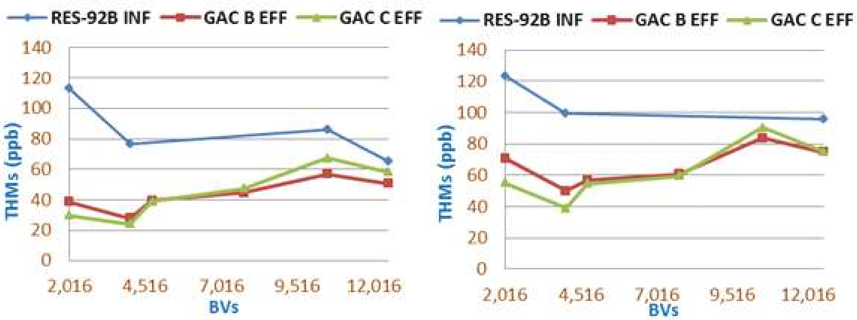


Figure 4: SDS-THM data against THM hold test data at 72 hours (left graph) and 168 hours (right graph); GAC B= coconut shell; GAC C=bituminous coal

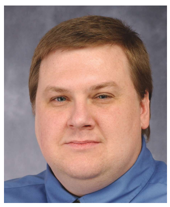
hours. The use of the OLC 12x40 (coconut shell) resulted in a 65 percent decrease in THM formation at 72 hours and a 20 percent decrease at 168 hours. Likewise, FILTRASORB 400-M (bituminous) showed a 70 percent decrease in THM formation at 72 hours and a 45 percent decrease at 168 hours. The effectiveness of the GAC media in THM mitigation dramatically decreased toward the end of the pilot project (12,516 bed volumes) due to the diminished carbon adsorption capacity. The two carbons showed THM reduction in the 10 to 20 percent range for both 72 and 168 hours. Figure 4 illustrates THM formation potential, at 72 and 168 hours, as a function of bed volumes.

Conclusions

Both air stripping and GAC treatment are effective approaches for reduction of TTHMs in the distribution system. The coconut shell-based carbon showed very fast DOC breakthrough but exhibited very high efficiency in THM removal, even when DOC breakthrough was nearly complete. The bituminous-based carbon showed excellent DOC removal and relatively good THM removal. Under the conditions tested, coconut shell-based GAC slightly outperformed the bituminous-based GAC. The reformation of TTHMs is of concern, and the chosen decentralized treatment system will be designed to achieve a lower target treated-water TTHM level that will provide a buffer of a magnitude sufficient to ensure that TTHM levels do not exceed the 80-ppb limit with reformation. ■

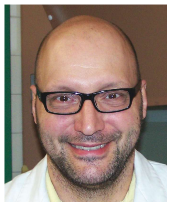
The authors would like to acknowledge the assistance of the water quality staff and O&M crew for the City of Scottsdale, as well as the equipment manufacturers who provided the pilot units for testing.

Dr. Chandra Mysore is a national practice leader for Water at GHD, Inc., specializing in innovative solutions for water quality and treatment, reuse, and desalination.



Bill Roberts is a service group manager at GHD Inc. He has been planning, designing, and building water and wastewater improvements since 1995.

James Fletcher serves as a process controls engineer at GHD Inc. He has specialized in water and wastewater design and modeling for more than 12 years.



Mark Xerxis is a principal scientist for the City of Scottsdale with 20 years of experience in the field of environmental testing and water treatment.

New Process May Hold The Key To "Economically Viable" Desalination

An energy-saving alternative to reverse osmosis (RO) desalination promises to reduce costs by more than 82 percent.

By Neil A. McCarthy

The sea, the blue sea – the phrase reminds one of the classic song, "La Mer", written by Charles Trenet in 1946. It's still blue, it composes 71 percent of the world's surface, but alas it's still full of salt. Desalination is a process that has been used with varying success for centuries; the problem is the cost of turning seawater into fresh water. Reverse osmosis (RO) has been the technology most favored by water suppliers and agencies because of its proven track record. However, RO is costly.

The Passarell Vapor Exchange System (P-VES) was designed as a highly efficient method of producing distilled water from saltwater. The simplicity of P-VES lies in its "single flash vapor" exchange. Seawater is raised to a vaporized state (steam) and pulled through differential pressures to an adjoining cell where, as it cools, the vapor recondenses to liquid as pure distilled water. A small amount of distillate, along with all the heavier-than-air particles (i.e., minerals/salts), is used to heat the next batch of incoming seawater. The P-VES is the only desalination process that recycles the thermal energy.

A small amount of distillate, along with all the heavier-than-air particles (i.e., minerals/salts), is used to heat the next batch of incoming seawater.

RO requires pretreatment of feed water due to scaling which occurs on RO membranes during desalination. As the concentration of the solids increases, they exceed the RO membranes' ability to absorb them. The additional stacking of unwanted solids builds rapidly. Some of the unwanted compounds found are calcium carbonate (CaCO3), calcium sulfate (CASO4), barium sulfate (BaSO4), and strontium sulfate (SrSO4). This, in turn, requires the use of sodium hydroxide (NaOH) to remove the soluble Ca and Mg; in addition, sulfuric acid (H2SO4) or hydrochloric acid (HCl) is used to deal with CaCO3 buildup. The removal of these unwanted compounds is costly, as it requires downtime of the cells within the RO array and corresponding labor in handling them. P-VES technology does not produce any of these compounds — P-VES uses polypropylene, which does not allow said compounds to anneal to the surface.

Cost Comparison Vs. RO Desalination

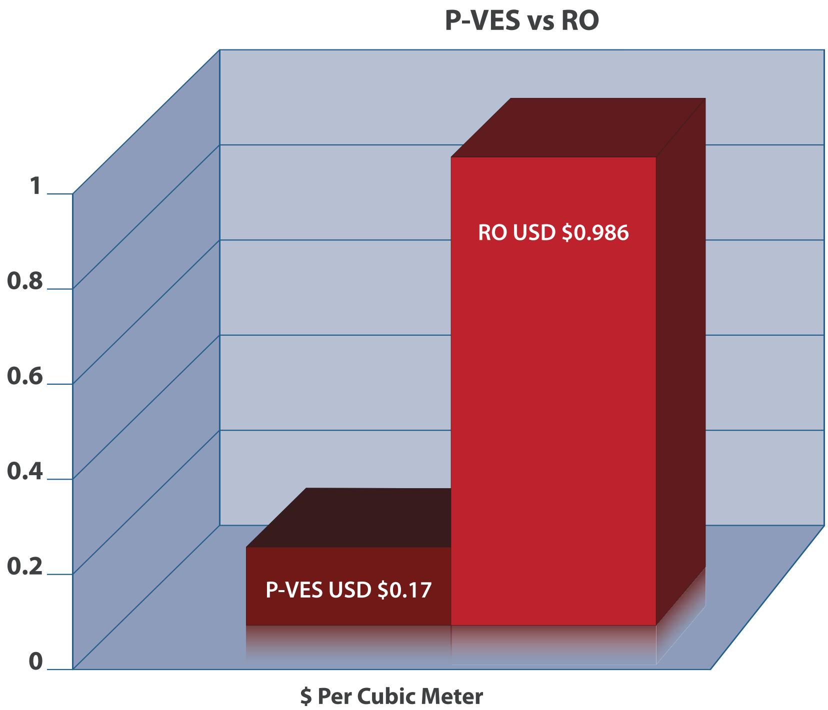
Consider the estimate of cost using RO at the Basra, Iraq plant as cited by the National Renewable Energy Laboratory. RO primarily uses electricity as its source of power. The cost for this RO per cubic meter (m^3) is US$0.986/$m^3$.[1] This cost is consistent with current RO installations.

A corresponding study conducted by California Polytechnic University, San Luis Obispo (Cal Poly) stated the following: "However, overall, it seems as though RO desalination will only become economically viable if either the RO process becomes less expensive or the price of surface-delivered water rises above that of desalinated water."[2]

A cubic meter (m^3) is the internationally accepted standard used to measure efficiency, cost, and amount. One m^3 has 264.17205 gallons. Each gallon of seawater weighs 8.556 pounds (lbs.) for a total of 2,260.26 lbs. per m^3. A British thermal unit (BTU) is defined as the amount of heat required to raise the temperature of 1lb. (0.454 kg) of liquid water by one degree F (0.56 degree C) at a constant pressure.

The P-VES plant is designed to recover all of the thermal energy required to operate the process, except loss of thermal energy to the atmosphere. It is completely insulated to retain all BTUs from being lost, as thermal energy is recycled from the concentrated and removed salt leaving the process. A quantity of

Figure 1: P-VES vs. RO cost comparison



The P-VES plant is designed to recover all of the thermal energy required to operate the process, except loss of thermal energy to the atmosphere.

now distilled, high-temperature water leaving the heat exchanger is drawn from the heat exchanger and passed back through the heat exchanger. This water's residual heat supplies the additional heat to the steam generator and further reduces BTU consumption. There is also potential for cogeneration, using waste heat from other adjacent operations and/or solar to further reduce the energy cost.

Simulation studies of P-VES have shown no more than 10 BTUs are needed per pound of seawater, but Water Desalination International (WDI) is confident that the BTU usage could be considerably less. Assuming 10 BTU per pound as our base, that equals 22,602.6 BTU per m^3. There are 28,400,000 lbs. in an acre-foot (AF) of water; multiplying that by 10 BTUs per pound equals 28,400,000 (or 28.4 million) BTUs per AF. Current natural gas shows a market price of USD $7.54 per 1 million BTUs[3], and 28.4 multiplied by $7.54 equals $214.00, which is the cost of energy per AF. Correspondingly, one m^3 of P-VES-produced distilled seawater would cost $0.17. This shows a cost that is more than 82 percent less than RO and represents the lowest consumption of energy compared to all other desalination processes that we know.

WDI is currently working with partners to beta test the process. The patent for P-VES desalination is among seven held by Frank Passarelli, whose skill lies in taking accepted limits of a process and finding a far more simple and efficient design to maximize results and minimize cost. P-VES, he says, is his gift to a world seeking water. Inquiries can be sent to nam@waterdesalination.com. ■

1. http://wrri.nmsu.edu/conf/conf11/reverse_osmosis_deep.pdf (see pg. 8 of 13)
2. http://digitalcommons.calpoly.edu/cgi/viewcontent.cgi?article=1021&context=braesp (pg. 24 of 59)
3. http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CC0QFjAA&url=http%3A%2F%2Fwww.eia.gov%2Fneic%2Fex perts%2Fheatcalc.xls&ei=LiTLUa74LLKMigK0k4DYBA&usg=AFQjCNEI3O4-27x7XDhiFFJKOpjvhEZHsA&sig2=st3DotqvRTaAld-lfSf8GQ&bvm=bv.48340889,d.cGE interactive excel spreadsheet

Neil A. McCarthy, BA, MSEd, is currently a middle school math teacher at a South-Central Los Angeles parochial school. He previously worked for Golden State Water (formerly Southern California Water Co.) and has consulted with Frank Passarelli for 16 years on research and presentations. McCarthy holds both multi- and single-subject credentials issued by the state of California.

Is Private Capital A White Knight For America's Water Infrastructure?

Understanding and acceptance of public-private partnerships continue to grow as the gap between infrastructure needs and funding widens.

By Frank McGrew and Jay Gorman

We are in the midst of a water infrastructure crisis in the United States, with the American Society of Civil Engineers recently grading the quality of America's wastewater infrastructure a "D." A confluence of factors including outdated pipes and facilities, population shifts, and inadequate maintenance, has combined to leave our water infrastructure in a state of overstress. In order to meet the challenge of modernizing our water infrastructure, more than $1 trillion of capital investment is needed. The good news is providers of institutional private capital are extremely keen on the water sector and stand ready to provide the funding needed to restore our infrastructure to necessary standards. While political, cultural, and structural hurdles exist in deploying this capital, the private sector is now an integral piece of our water infrastructure puzzle. In this article, we will explore how localities are overcoming these hurdles and using a myriad of private sector solutions, ranging from consulting arrangements to full private ownership, to meet regulatory requirements, modernize facilities, unlock hidden value, and ultimately better serve their customers.

Is it time to consider a new model?

A Fundamental Problem

To fully appreciate the scope of the issue, one must look at the capital gap in water infrastructure spending in this country. In 2010 the functional and qualitative deficiencies of our water infrastructure system necessitated capital spending of around $90 billion; however, only $36 billion of funding was allocated. As crucial as this capital is to the construction process and restoration of infrastructural integrity in the U.S., inadequate funding is a trend that is expected to continue into the future, with the cumulative capital spending gap projected to surpass $770 billion by 2020.[1]

So how did we land in such a dire place? To answer this question one must examine the fundamentals of the municipal water industry. The United States has over 54,000 community water systems, with 85 percent of the population served by municipal-owned utilities. Similarly, the wastewater sector is comprised of over 15,000 community systems, over 95 percent of which are municipally owned. Waters' tie to local municipalities is problematic for two main reasons. First, it ties funding and usage rates to the political process where capital must often compete with much more visible projects (i.e., new parks, increased education spending, etc.) and rate increases are viewed like tax increases (subjecting approving politicians to being voted out). Second, water is a high capital cost, low marginal cost product to produce, which makes budgeting for replacement cycles extremely difficult in a politicized environment. If there is one thing politicians excel at it is kicking the can down the road, delaying difficult and costly decisions and often making them more costly in the long run.

To prevent water utilities from deferring investment to a point which threatens water safety, the federal government regulates utilities to ensure they meet certain water quality standards. Since the formation of the U.S. Environmental Protection Agency (EPA) in 1970 and the passage of the Clean Water Act in 1972, an abundance of regulations has been implemented in an effort to assure utilities are providing customers safe water. However, as regulation has become more extensive and complex, water utilities have struggled to make the upgrades necessary to comply, resulting in record numbers of EPA fines and consent decrees. Particularly hard hit have been smaller utilities, which often lack the scale, capital, and expertise to meet the requirements of an ever-changing regulatory landscape.

The P3 Solution(s)

With government budgets increasingly strapped for cash, more and more municipalities are turning to the private sector to partner in solving this problem. Through contractual agreements between a public agency and a private sector entity, the parties form what is commonly referred to as public-private partnerships (P3s). Through these agreements, the skills and assets of each sector are shared in delivering a service or facility for the use of the general public. P3s are becoming an increasingly viable vehicle for private investors to participate in the water space.

P3 models encompass a wide spectrum of degrees of participation by the private sector, ranging from 3- to 5-year consulting contracts, all the way to investor-owned projects with lives extending past 25 years. The commonality among these partnerships is the utilization of private resources to help drive additional efficiencies in the system. Utilizing private sector expertise and capital to increase plant efficiency through enhanced operations, economies of scale, and positive net-present-value upgrades enables water utilities to improve their systems more rapidly and with less impact to customers than relying exclusively on public capital financed by tax or rate increases.

The most commonly witnessed forms of the P3 model are the Investor-Owned and Operations and Maintenance (O&M) Management and Support models. In the Investor Owned model, a private entity completely privatizes the water system, assuming all the responsibility and control for every facet of the water enterprise. The O&M Management Support model is structured upon the practice whereby municipalities "outsource" the operational demands and necessary maintenance of the system to the private sector, with examples of successful implementation including the metropolitan water systems of Milwaukee and Buffalo. One limitation of traditional O&M contracts is they often only addresses the issue of infrastructure and facility upkeep, leaving the need for long-term capital expenditures and systems development still unresolved.

The public's apprehension over complete privatization through the Investor-Owned model combined with the limitations of the O&M model has led to the increasing popularity of the Concession Lease model. Often with more than 20-year time horizons, the Concession Lease model allows the distribution of maintenance and restoration costs along an extended time period, offering a more acceptable risk-to-reward payoff for the sizable initial expenditure necessary for new or newly upgraded facilities.

Variations of the O&M principle exist in the form of the Design-Build-Operate-Maintain (DBOM) and the Design-Build-Operate-Maintain-Finance (DBOMF) Infrastructure Contracts. The DBOM and DBOMF models are fundamentally similar to the O&M model, with the exception of an added infrastructure engineering and construction component. These arrangements provide the benefit of the operator leveraging the efficiencies of a brand new, state-of-the-art facility they designed from the ground up. Surprisingly, these new facilities can often be constructed at lower cost than retrofitting existing facilities and with the added benefit of lower operating costs. The DBOMF model adds the component of financing the facility privately, eliminating the municipalities' need to raise initial and ongoing capital.

The P3 Track Record

Many municipalities have begun to adopt these partnerships, recognizing that P3s offer unparalleled opportunities for infrastructure improvement, heightened efficiencies, and extraordinary benefits for communities. In December of 2012 private equity firm Kohlberg Kravis Roberts (KKR) and United Water, a subsidiary of Suez Environnement, announced a joint venture to acquire a 40-year water and wastewater concession from the City of Bayonne, NJ. The agreement stipulated an initial payment to the Bayonne Municipal Utilities Authority (BMUA) of $150 million for the concession, plus another $157 million to be invested in the infrastructure over the life of the contract, 90 percent of which will be funded by KKR. According to the contract, the BMUA will retain ownership of the system to ensure rate stability and quality adherence, while allowing United Water to operate the system under an O&M agreement.

The Santa Paula Water Recycling Facility in California is another great example of a P3 delivering a cost-effective solution to quality-assurance issues. Constructed in 1939, the facility was completely outdated and the source of more than 3,700 quality violations. As a result, the city had entered into a consent decree where the system had until December 2010, three years from the decree, to comply with these violations or be subject to $8 million in fines. After spending nearly $11 million in engineering consulting fees, it was estimated that upgrading Santa Paula's existing wastewater facility would cost nearly $85 million, well beyond the city's investment capacity. PERC Water of California submitted a comprehensive solution to the problem that provided the city a brand new treatment facility at a cost $20 million less than upgrading its existing facility. After Santa Clara's acceptance, PERC Water and private investment firm Alinda Capital created a joint venture, Santa Clara Water, LLC, in a collaborative effort to meet both the construction and capital requirements of the project. Through Santa Clara Water, PERC and Alinda were able to guarantee water quality, meet all compliance deadlines, fund 100 percent of the project using private capital, ensure 30 years of contractually exacted water costs, and generate recycled water for Santa Paula to reuse. In May of 2010, only two years after winning the award for the project, the Santa Clara facility was complete — seven months early.

Despite their noted successes, P3s are seldom implemented without some attendant complications. Political obstacles are some of the most prevalent issues that must be overcome when attempting to cultivate a P3. Oftentimes, public works directors have close connections to the consulting and engineering firms tasked with building and upgrading facilities under the traditional Design-Bid-Build model and are hesitant to allow new entrants with different operating models into the fold. Additionally, the term "privatization" is perceived negatively by many politicians and members of the public who fear a private entity will deliver service unreliably or monopolistically, leading to higher costs and substandard service.

For municipalities adrift without funding, public-private partnerships (P3s) may be a viable solution.

Such fears are not completely baseless, as some P3s have yielded less than stellar results. Veolia's O&M arrangement with Indianapolis Water is an example of a P3 that failed to live up to its original billing. While both sides would certainly debate the extent to which Veolia did or did not meet its commitments, what is clear is that a myriad of lawsuits and consumer complaints ultimately led the city to terminate the arrangement 12 years early at a cost of $29 million and sell the operation to the non-profit Citizens Energy Group.

Keys To Successful Implementation

In the end, the key to overcoming these obstacles and perpetuating more P3 success stories is to promote much greater transparency across the planning, operations, and pricing (POP) of community water:

Planning: Fostering greater transparency as to how capital and investments decisions are planned for at community water systems will help eliminate conflicts of interest and ensure all options, both public and private, are given a fair chance to deliver what is best for the customer.

Operations: Providing greater transparency around and education on how a community water system operates and what can actually change under a P3 is critical to gaining public trust of the model. By better educating consumers on the checks P3s are subject to, such as environmental regulations, PUC approvals, and other contractual safeguards like fixed pricing terms, consumers can gain comfort that private involvement in water won't gouge their wallets or compromise their safety. Additionally, providing independent and transparent oversight of P3s, once operating, is key to avoiding issues such as those experienced in Indianapolis.

Pricing: For both public and private water systems to operate efficiently in the long run, consumers must understand the true cost to produce water and be made to bear its full economic cost. As long as water is subsidized, it depends on revenue derived from sources which don't receive its benefit, thus perpetuating the capital tug-of-war that has left our infrastructure in a state of disarray. Once consumers pay water's full economic cost in return for its full economic benefits, market equilibrium will ensure its adequate provision over time.

While easier said than done, achieving greater transparency around the POP of community water will help break down the political barriers and cultural myths that have perpetuated our unsustainable municipal water model, ultimately enabling private capital to help solve our massive water infrastructure problem.

1. The National Council for Public-Private Partnerships, American Society of Civil Engineers: *Failure to Act – The Economic Impact of Current Investment Trends in Water and Wastewater Treatment Infrastructure*

Frank A. McGrew IV, managing director in the Raymond James General Industrials Group, has represented numerous public, private, and closely-held firms in both an advisory and principal role on such issues as strategic management, corporate growth, financing, restructuring, and overall capitalization . During his nearly 20-year career, he has raised more than $4 billion in capital and advised on nearly $5 billion of strategic transactions for numerous private and public entities throughout the world and recently completed the sale of Ashbrook Simon-Hartley to Alfa Laval AB.

Jay Gorman, VP in the Raymond James General Industrials Group, has more than 10 years of corporate finance experience having worked on a myriad of successful acquisitions, divestitures, joint ventures, partnerships, and other strategic initiatives for diversified industrial and basic manufacturing companies.