2014 Water Market Review

Running Out of Water: How Long Do We Have?

TALK IS CHEAP

WORLD ECONOMIC FORUM

CHANGING COURSE
HOW CLIMATE CHANGE IS CHANGING THE COURSE

WATER IS CHEAP

Steve Maxwell

TECHKNOWLEDGEY
STRATEGIC GROUP
Talk is Cheap, Water is Cheap
A Concise Review of Challenges and Opportunities in the World Water Market

I. Introduction

II. Our Global Water Challenges

III. The Key Drivers of the Water Business

IV. Key Industry Trends and Developments

1. Increasing Regulation
2. Failing Infrastructure
3. Greater Conservation and Efficiency
4. Focus on Recycling and Reuse
5. Steady Growth in Desalination
6. Increased Interdependence between Water and Energy
7. Water and Food Nexus
8. Enhanced Monitoring and Measurement
9. Smart Water
10. Green Infrastructure
11. Technological Advances
12. Residential Consumption Concerns
13. Controversy about Privatization
14. Water Security
15. Consistently Growing Commercial Markets
16. A Continuing Surge of Investment in the Industry
17. Ownership Changes and Industry Consolidation
18. Consolidation in the Public Sector As Well
19. Growing Concerns about the Impact of Global Climate Change:

V. Moving Towards Solutions

We Need to Develop Better Public Understanding of Water Issues
We Need to Think Globally, but Act Locally
We Need to Pursue Incremental Technological Advances and Solutions
We Need to Develop Smarter Laws and Policies

VI. Summary and Conclusions

We Need to Balance Our Resource Trade-offs in a Smarter Manner
We Need to Think About Water Consumption in Terms of Virtual Water
We Need to Develop More Holistic Approaches to Water
We Need to Prepare for the Inevitability of Rising Prices
I. Introduction:

The studies and reports continue to be issued at an accelerated rate, and the conferences and forums seem to fill up any remaining dates on the calendar. There is scarcely a week in the year when there is not a water summit or forum of some sort underway. New books geared to the broader public seem to be published every month or so. The popular media continues to cover water issues with increasing regularity. Water has now been on the agenda in the President's State of the Union message, and on stage at the Davos World Economic Forum. Bill Gates, Matt Damon and Pope Francis are all doing their part to raise awareness and find solutions. Everyone is talking about water. And the odd water crisis continues to pop up occasionally - as it did in Charleston, WV right after New Year's Day - that serves to remind some of us of the vulnerability of our water infrastructure. So, we must be making progress, right?

Among the many new studies that have come out very recently is a Carbon Disclosure Project/Deloitte report about water risks. Pointing out that water risks are more immediate and closer than many companies realize, and that some 50% of companies interviewed have already experienced detrimental business impacts, the report says that most companies still aren't doing enough. True. And the U.S. Environmental Protection Agency recently issued its sweeping review and assessment of the importance of water to the U.S. economy - underlying many of the same trends and challenges which we annually try to highlight in this report. The review notes the difficulty of accurately pinpointing or quantifying the value of water, because it depends upon so many multiple dimensions - "the volume of water supplied, where the water is supplied, when it is supplied, whether the supply is reliable, and whether the quality of the water meets the requirements of the intended use." The review concludes by saying that "protecting and efficiently managing our water resources is essential to maintaining a strong, vibrant economy." True. But don't we intuitively know all of this? Haven't dozens of preceding reports pointed out essentially the same issues and concerns?

The hard drive on my computer is practically over-flowing with such reports that have streamed out over the past ten years - 5 or 10 MB of storage space apiece, some with lots of nice color photographs, and most delving into detail about specific aspects of the world's water problems. Many of them are excellent and very informative reports - filled with good explanations of the challenge, and inspired by the best of intentions. I have reports from various governmental agencies - the Environmental Protection Agency, the Government Accountability Office, the U.S. Geological Survey, the U.S. Departments of Agriculture, Commerce and Interior. I've also got various reports from a range of independent non-governmental organizations and think tanks - the Aspen Institute, the Johnson Foundation, the Pacific Institute, CERES, the World Resources Institute, and several excellent reports from the World Business Council for Sustainable Development. I have series of annual reports and overviews from the major investment banking houses around the world, including Goldman Sachs, Credit Suisse, Morgan Stanley, Raymond James and a wide range of smaller institutions, as well as lots of good studies and reports issued by vendors and consultants from within the industry, including companies like CH2M Hill and Black & Veatch. Industry suppliers, like Xylem, have also conducted surveys of the marketplace.

And of course there are all of the overlapping trade associations which compete to serve the broader industry; most of them have developed their own initiatives to address the issue, and have published studies to promote their own positions and issues - the American Water Works Association, the Water Environmental Federation, the U.S. Water Alliance, the WaterReuse Association, the National Association of Water Companies, and so on. There are also trade groups from outside the water industry which are actively studying and reviewing how water scarcity may affect their own industry - groups like the Electric Power Research Institute (EPRI). There are over twenty different cities or regions in the country that are now promoting themselves as water technology centers, or "water clusters," and many of them are issuing reports and plans for addressing local or global water issues. There are multi-party industry groups, such as Growing Blue, trying to help address the problem; last year, we described the emerging "Value of Water" initiative. And finally, of course, there are various journals, magazines and reports that summarize the overall situation and challenge - like the one you are holding in your hand right now. In short, there are enough reports and studies out there to make your head spin.

We are getting pretty good at defining and recognizing the issues. We seem to be making progress in terms of explaining the problem and raising awareness across a larger cross-section of the public. But are we really making much progress in beginning to actually address the daunting water challenges that we face? Are we identifying and effectively promoting specific and actionable means of solving our water problems? In short, are we still spending too much time just "talking the talk?" Not to denigrate or question the intention of any of these fore-mentioned reports, studies and forums; I have no doubt that all of these efforts are genuinely committed and interested in solving the problem. Nonetheless, talk is cheap.

The other major challenge and related aspect of our problem - counter-intuitive though it may be to some people - is that water itself is also too cheap. Despite the increased public awareness, and the unfolding water crisis that we face, water remains - by almost any measure - pretty inexpensive. Yes, prices are starting to rise in most parts of the world, but water is still just too cheap for most people to spend much time worrying about it. Our water challenges are still not very high on the radar screen of a world that is facing other daunting and perhaps more immediate political, fiscal and public health crises. And things will probably stay that way until water prices rise to the point where they start to really "hit us in the wallet." As much as those of us in the water industry would like to believe
that water issues trump everything else, most political leaders are acting, believing and saying otherwise. "Yes, water issues are important, but they're not as immediate or critical as some of the other issues I'm dealing with."

The bottom line today is that water continues to be an under-appreciated and under-valued asset. But water prices will eventually start to rise more quickly - as a result of on-going population and demand growth, drought and increasing scarcity. More and more major urban areas are beginning to bump up against the challenges of true scarcity. And as water prices increase, we will gradually pay more attention and modify our behavior - toward improved conservation and more efficient use. As prices inexorably rise, we will eventually be forced to confront and solve these problems, and truly recognize water's fundamental value. But we aren't there yet.

These two factors - (1) the inability of serious studies and repeated warnings to so far generate much widespread concern or real change, and (2) the fact that prices remain generally low relative to true value - combine to yield a situation today where people still don't pay much attention and are often almost lackadaisical about water issues. Simply put, we have not reached the famous "tipping point" situation described in Malcolm Gladwell's recent book. To paraphrase from the cover of that book, we just haven't had enough "little things" happen yet to start to snowball and make a big difference. The droughts, water crises, or infrastructure breakdowns that we have had, have been too isolated, too far apart in time, or somehow not serious enough to really begin to generate that attention and momentum toward a real tipping point - where awareness accumulates a critical mass, attention starts to shift and things start to happen. All the reports and meetings have raised the awareness, but they haven't yet really led to comprehensive solutions.

We apparently need more frequent and more severe crises, in addition to more rational pricing. The droughts that many parts of the American west have experienced recently have put water scarcity issues up near the top of the political agenda. The decade-long drought recently suffered in southeastern Australia had a dramatic effect on water awareness, policy, and the legal institutions and frameworks around water resources in that country. Things actually changed. Studies, forecasts, reports and "Chicken Little" warnings may help, but there is nothing like the impacts of a serious crisis to really focus the public mind.

The water risks and challenges which we face as a planet will continue to compound and grow if we cannot learn relatively quickly how to think and act differently with regard to water. By the middle of this century, the earth will be home to an additional two billion people - bringing our total population to around nine billion. Finite food, energy and water resources will come under increasing pressure by this expanding, aging and more affluent population - leading inevitably toward the "stress nexus" that many experts are now forecasting. Water is the critical link.

We often hear that there is no "silver bullet" in the water industry - usually in reference to technology. However, the real silver bullet in the water marketplace would be a more rapid move toward smarter and full cost-based pricing. It's popular today to talk about "disruptive" technologies as a way of shaking up the status quo, or moving an industry or a society in a new and different direction. What the water industry needs today is more disruptive thinking - fundamental change in the way we view, manage and utilize our finite water resources. However, until then, the issue seems destined to remain somewhat obscure in the bigger picture - further down on the planetary "to do" list.

So we have two problems - talk is cheap, and water is cheap. Both things must change.

(Editors Note: We start our report this year with a quick review of background information in Section II - setting the general context in terms of where we are and specific details about the water challenges we face. This is followed by the main body of the report, Sections III and IV - a concise and updated overview of the critical drivers behind the water business, and an in-depth discussion of key trends in the broader water marketplace - new directions and developments which we judge to be most critical in characterizing today's marketplace.)

II. Our Global Water Challenges:

An understanding of the human and industrial impact on the earth's hydrologic cycle has taken a long time to develop - and even today we still don't fully understand the implications of our behavior. However, the last few decades have seen a steady stream of new reports, books (many of them fairly "doomsday" in nature) and forecasts about future water availability - and there is more evidence every day that we are converging toward a point where much of the planet's population will no longer have sufficient clean water to support a decent lifestyle. Today it is projected that almost half of the world's population will suffer from severe water shortages by the year 2050. A report issued recently by the World Economic Forum warns that we are quickly headed toward "water bankruptcy" and ranks water challenges as one of the world's most press-
Along similar lines, a recent World Bank report suggested that if drastic steps are not taken now, India will essentially run out of usable water within two decades. This past year, the EPA released its fifth Drinking Water Infrastructure Needs Survey and Assessment - which calls for the investment of $384 billion over the next twenty years, simply to maintain the U.S. drinking water infrastructure at acceptable levels. This needed investment amount continues to increase with each successive study. When analogous wastewater expenditures are added in, the total investment figure jumps to about $700 billion over the next twenty years - just to keep the existing system working. Other research groups and government agencies have estimated even higher capital spending requirements. And keep in mind that this is just the projected investment requirement in a single economically and technologically advanced country.

The fact is that human activities have been altering and damaging the earth's natural hydrologic cycle and processes for centuries. However, that impact has only started to become broadly evident during the last few decades. Today's water resource dilemma results from centuries of unfettered industrial expansion, exploding population growth, and population shifts - often to more arid regions. Worst of all, most of us continue to exhibit the nonchalant belief that our standard of living can somehow continue to absorb all the environmental insults that we throw at her. We have been creating problems for centuries, but we have only been investigating solutions for the past few decades.

Degradation of water resources originates in all corners of our modern society. Our industrial economy has caused extensive and often irreversible chemical pollution of many of the world's major waterways and aquifers. Tens of thousands of dams have changed the course of natural rivers for water supply, flood control and irrigation purposes; there are few significant "free" rivers left in the world. Poor resource management practices and over-grazing have promoted the unnatural expansion of deserts. Economic pressures to maximize agricultural yield continue to draw down major aquifers at accelerated rates.

Improper irrigation practices have left behind saline soils unsuitable for the support of flora or fauna. Perhaps most significantly, our increasing reliance on fossil fuels seems to be leading to irreversible planetary climatic change - and we are only beginning to understand the potential long-run effects of climate change on the hydrologic cycle and our future supply of water.

The list of environmental insults goes on. Countless reports and scholarly tomes have been written which detail the extent of our environmental predicament. I will just summarize a few salient facts and figures here, to demonstrate the breadth and magnitude of the world's water problems:

- Many of the world's largest cities still dump the untreated sewage of millions of inhabitants directly into natural waterways or oceans. A visit to sprawling coastal mega-cities such as Lagos, Accra or Mumbai can be shocking in this regard. Indeed, it makes one marvel at the natural treatment capabilities of our oceans. Given the amount of raw sewage that is still directly discharged, it is remarkable that our oceans are still as clean as they are in most areas.

- The United Nations estimates that more than ten million people a year die as a result of drinking dirty water. This is obviously a difficult statistic to accurately measure, since so many diseases are water-borne; in reality the true figure for water-related deaths around the world is probably much higher.

- The United Nations also estimates that some two and a half billion people have no access to basic sanitation - toilets and clean running water. This is almost 40 percent of the world's total population. Perversely, it has recently been documented that more people in Southeast Asia have cell phones than have access to toilets.

- The problem of decaying infrastructure is bad enough just here in the United States. Estimates of infrastructure investment requirements for the rest of the world run into the many trillions of dollars. And of course, many developing parts of the world don't enjoy any kind of water or wastewater distribution and transmission infrastructure at all. Because of this, there is a growing initiative and effort to search for the "cell phone" of sanitation - stand-alone toilets that don't have to be connected to a grid system and which don't require freshwater for waste transmission to another location.

- Despite the considerable progress made under forty years of the Clean Water Act, 40 percent of American rivers are nevertheless still categorized as polluted, while more than 75 percent of Chinese rivers are so designated, according to the United Nations.

- The emerging issue of pharmaceutical and personal care products (PPCPs) and other endocrine-disrupting chemicals is
continuing to receive greater attention. There is increasing evidence that there is nearly universal presence of these man-made chemicals in the natural waterways, albeit at very low levels. This loosely-defined group of compounds - including cancer treatment drugs, mood stabilizers, sex hormones, antibiotics, and a whole range of modern health, beauty and medical compounds - can have deleterious but as yet poorly understood effects on the endocrine and reproductive systems of humans and other organisms. Modern wastewater treatment plants were not designed for, nor are they capable of treating these types of ultra-low level contaminants. The eventual and collective impact of this broad group of contaminants on human health and reproductive systems is still unknown, but could potentially be staggering.

- 45,000 large dams around the world are estimated to have displaced some 80 million people in the last seventy-five years. The vast recent dam construction projects in China are only the most visible such projects. New projects to create major water diversions from the south to the drier northern part of China are now underway too, at a proposed cost of over $60 billion - an estimate which is sure to be exceeded. The ecological or social impacts of these massive diversion and dam projects can be long-lasting, while - as we are recognizing in the case of major federal water projects in the American Southwest - their economically useful lives may be relatively short due to sediment infill and evaporation. In short, we still live in a time when it is easier to move water to the people, rather than moving people to the water. This era may not last much longer.

- There are some 79,000 dams just in the U.S., an alarmingly large number of which are no longer functional or safe. It is increasingly realized that it is often cheaper to remove these dams rather than try to fix them. However, dam decommissioning and removal is in its infancy; only some 500 mostly much smaller dams have actually been removed. This is likely to be an expanding field of engineering endeavors in the future.

- Natural wetlands - ecologically designed by nature to regulate and clean our surface waterways - are being lost at a record rate, particularly around the urbanizing areas of the country, which might benefit most from them. Interestingly, one of the most active areas in wastewater treatment today is the attempt to copy or mimic natural systems in municipal applications; yet in the pursuit of economic development, we often let actual natural systems slip away at an increasing rate.

- Major aquifers around the world are being depleted or "mined" much faster than natural precipitation and percolation can replenish them. This is a problem which is going to reach the proverbial "tipping point" in the near future in certain areas. The Ogallala Aquifer, which underlies some 250,000 square miles of the "bread-basket" central region of the United States, has been drawn down at unsustainable rates for several decades now. The long-term impact for agriculture and world food supplies is potentially catastrophic. Many rapidly growing metropolitan areas, such as the southern tier of the Denver, Colorado suburbs, have been exhausting irrereplaceable deep aquifers for decades, and now find themselves struggling to locate and acquire new source waters to insure their future.

- There are also numerous secondary effects and impacts of different types of impending water shortages. For example, as aquifers deplete, not only do the inhabitants above run out of water, but the ground they live on may also lose its geologic structural support, and begin to actually collapse. This is becoming a significant problem in certain areas - Mexico City has seen substantial subsidence in recent decades.

- Remarkably, despite this growing planetary water shortage, most countries around the world still tolerate huge clean water losses as a result of dilapidated infrastructure and decaying pipes. According to the EPA, about 17 percent of treated water in the United States is lost due to leaky pipes; Boston loses 30 percent of its water, while it is estimated that the City of London loses almost 50 percent. What other industry would allow 50% of its product output to go wasted and unused? As mentioned, it will take something on the order of a trillion dollars to maintain and upgrade the water, wastewater, and storm water infrastructural systems in this country alone over the next twenty years.

We have been creating problems for centuries, but we have only been investigating solutions for the past few decades.

- Finally, as a grim summary of the various types of challenges briefly listed here, it is now widely predicted that half of the world's population will live with chronic water shortages by the year 2050. In short, we are rapidly creating a situation of severe "water stress" in many parts of the world.

Stress on our hydrologic cycle and competition over declining water resources will inevitably lead to political stress. Indeed, political conflict over water is not some sort of phenomenon waiting to happen in the future; water conflicts have been going on for hundreds if not thousands of years already. There are a number of "hot spots" around the world that could explode today. For example, India has strained relations with both its eastern and western neighbors - Bangladesh and Pakistan - over the two key rivers that flow between those countries, the Ganges and the Indus. The Jordan River rises on the Syrian-Lebanese border and is used by Jordan, Israel, and the Palestinian territories; the potential problems there are obvious.

Water issues have contributed to the recent crisis in the Darfur region of Sudan. Nine often contentious countries depend upon the Nile River for most of their water. Egypt depends almost wholly upon the Nile for its water, but several of the upstream countries are demanding a greater share - and are already planning new dams to take what they believe is theirs. Pre-existing political instability in many of these countries could lead to greater controversy or outright war in the future.

But perhaps the broadest unanswered question in future water resource management revolves around how incipient global climate change may affect the situation. We are once again wrapping up a year which exhibited some of the most extreme weather events ever seen. A little over a year ago, Hurricane Sandy impacted some 60 million people across the northeast - where much of the political and financial power of the country is concentrated - and estimates of the likely damage now exceed $50 billion. It is apparently now agreed that 2013 was the fourth hottest year ever. As I write this, the east coast is experiencing a so-called "polar vortex" - bringing some of the coldest weather the northeast has seen in decades. This continuing evidence has to push skeptics toward acceptance of the existence and inevitability of some sort of global climate change.

These changing weather trends and climatological events represent a myriad of new water resource challenges - well beyond what we can do justice to in this brief publication. But generally speaking, it looks like climate change will generally make a bad situation even worse. While we don't yet fully
understand the breadth and severity of global climate change on the hydrologic cycle, if global warming does continue, we may begin to find not only our supply sources, but also our existing water storage and transmission infrastructure to be woefully inadequate.

Witness the following handful of dire quotes from the Executive Summary of a recent report from the U.N.'s Intergovernmental Panel on Climate Change - a group of the world's leading meteorologists and climate scientists:

• …. observed warming over several decades has been linked to changes in the large-scale hydrological cycle...
• ….. (scientific models project) precipitation increases in high latitudes and parts of the tropics, and decreases in some sub-tropical and lower mid-latitude regions...
• ….. annual average river runoff and water availability are projected to increase as a result of climate change at high latitudes….
• ….. increased precipitation intensity and variability are projected to increase the risk of flooding and drought…
• ….. water supplies stored in glaciers and snow cover are projected to decline over the course of this century…
• ….. higher water temperatures … are projected to affect water quality and exacerbate many forms of water pollution…
• ….. changes in water quantity and quality due to climate change are expected to affect food availability, stability, access and utilization …
• ….. climate change affects the function and operations of existing water infrastructure - including hydropower, structural flood defenses, drainage and irrigation systems, as well as water management practices; and
• ….. climate change challenges the traditional assumption that past hydrological experience provides a good guide to future conditions.

The potential of global warming to shift the predictability, timing, and extent of natural rainfall patterns around the world could truly wreak havoc in terms of water availability.....

It is becoming clear that the impact of a changing climate on our existing water resource problems could be dramatic. The potential of global warming to shift the predictability, timing, and extent of natural rainfall patterns around the world could truly wreak havoc in terms of water availability, agricultural productivity, and food supplies. While scientists are parsing the potential long-term effects of global warming, water policymakers and economists are only just starting to think about how to deal with the potential economic and social effects.

There will always be room for disagreement about the timing or eventual extent of some of these problems, but it's hard to deny that they are coming - and quickly. As the world's population continues to grow, and as we continue to pollute and disrupt the earth's natural water systems, we are definitely headed toward a global water crisis. The only question is how severe it will be. Many of the issues mentioned above are inevitably going to reach a boiling point in the future - some perhaps in the quite near future. All of these pressing water resource problems must become more immediate policy priorities for governments around the world.

III. The Key Drivers of the Water Business:

Many different factors - economic forces, social pressures, and political realities - are combining to drive the growth of the commercial water market. But to over-simplify a bit, these key drivers of growth and expansion of the water industry can be reduced to the four interdependent factors briefly highlighted below.

First, to state the (by now) obvious - water quality and scarcity problems are reaching crisis proportions. This is particularly true in certain more arid or over-populated parts of the country, and the world. At a fundamental level, growing water quality and scarcity problems are the key drivers behind all the challenges, the increasing regulations, the expanding commercial business opportunities and ultimately, the projected growth for the water business over the coming decades. The impending shortage of clean water is one of the most serious and fundamental long-term threats facing mankind.

Here in the United States, it used to be the conventional wisdom to highlight water quality problems in the older and more industrialized east, while focusing on water quantity issues in the drier and less populated west. It is clear now, however, that we have both quantity and quality challenges right across the country. More humid cities in the east, such as Atlanta, are running short of water; the state of Georgia recently tried to redraw its border with Tennessee for the purposes of grabbing additional water. And on the other side of the country, we see large California and Arizona aquifers rendered unusable due to seawater intrusion, or contamination with perchlorates and other toxic chemicals used in the aerospace industry. In short, both quantity and quality problems are becoming more pervasive, and they are getting steadily worse in many places around world.

Second, public awareness and concern about these water problems is continuing to increase with each passing year. As water scarcity and quality problems have become more serious and more apparent, the public has gradually become better informed - and increasingly concerned - about the range of water problems that may be passed on to future generations. Again, one needs only to look at the front pages of the popular media to see how broad and widespread - though often over-simplified - this concern and recognition is becoming. And as the general populace becomes more aware and concerned about water, public perception gradually becomes a more important driver of public policy and ultimately, legislation. But despite this, larger-scale and more intensive public education programs are still sorely needed around the world to inform the public of the real nature of our water quality and quantity problems.

Third, legislation regarding water resource management - and enforcement of consequent regulations - continues to intensify. As public concerns grow, they inexorably get translated into greater government review, legislative and regulatory control, and enforcement. And as opposed to other more general environmental issues - where public interest, regulation and enforcement have waxed and waned during the past three decades - the American public seems consistent upon ever stron ger and broader regulatory protection when it comes to drinking water issues. The status of water protection regulations in the U.S. is certainly not perfect - there are countless areas of the federal legislation that could be clarified or improved upon.
There is a clear need for additional and more specific regulation in various areas. Those on the far right who call for eliminating the Environmental Protection Agency are uninformed and short-sighted.

Finally, as already highlighted, huge economic and human capital investments are required in order to address these challenges. For municipalities and industry to comply with the whole body of expanding regulations - and for the country to maintain and expand the necessary infrastructure - huge capital expenditures will be required. These investments must begin now, and will continue into the long-term future. The so-called "spending gap" - the shortfall between the current level of water infrastructure spending, and the spending levels required to really sustain our infrastructure into the longer-term future - continues to increase.

The question is how, not if, we should fund these required capital expenditures - and this seems likely to turn into a much larger and more contentious policy debate in coming years. Something will have to give. For example, the large metropolitan centers that often have the oldest and most run-down infrastructure with the greatest capital needs are often the very same areas with shrinking center-city populations and a declining tax base; the bankrupt city of Detroit comes to mind. It seems likely that the federal government will eventually have to step in and play a larger role in the maintenance of our infrastructure, but unfortunately, that may require some kind of catastrophe or major public health crisis before it will happen.

The mechanics and dynamics of these fundamental market drivers are solidly entrenched, and are very unlikely to change in the longer term future. Hence, the current investment and technology deficit represents a massive and unresolved future challenge - but it also constitutes a huge and sustained long-term opportunity for firms providing products, services and solutions to the water and wastewater treatment industry.

IV. Key Industry Trends and Developments:

These fundamental industry drivers combine to give rise to a number of important trends and developments in the water business - with respect to supply, demand, market and strategic conditions. In turn, these key trends will dictate how we manage our precious water resources, and how commercial markets will unfold and develop in the future. Each year we try to highlight what we believe to be some of the most important trends - past, present or emerging - that will shape the nature and size of the water market in the future. The next several pages highlight the most important of these recent trends.

1. Increasing Regulation: A huge volume of new regulation has been issued by federal, state and regional agencies over the past few decades. Regulatory controls covering water and wastewater are also becoming stronger in almost every other region of the globe. Public agencies and private companies struggle just to understand, let alone comply with, this rapidly expanding and ever more complex regulatory situation; indeed it has become a major expense and challenge for most water and wastewater utilities. Many smaller utility districts have great difficulty just staying current with the morass of existing regulations, let alone the steady stream of new requirements. And it is increasingly frustrating to water utilities that one compliance requirement may sometimes be at odds or in conflict with another. A few years ago, the Journal of the AWWA concisely described the situation as an "immense regulatory maze and administrative superstructure that .... may be at risk of collapsing under its own weight."

On the other hand - at a base level - it is these regulations which truly drive the day-to-day activities, spending levels, and commercial developments in the water industry. It may be difficult to directly link expanding regulation to the impact on commercial markets (it takes time for new regulations to be implemented, and their effect to be fully felt) but it is clear that regulation has a direct effect on new product innovation, technology advance, and commercial market growth.

Despite the extensive existing body of laws and compliance requirements, it seems likely that the extent and reach of regulatory controls will only continue to expand. Even in the economically advanced and most highly regulated countries like the United States, water pollution problems continue to grow. New contaminants continue to be unleashed and discovered. One study several years ago - the Environmental Working Group's National Assessment of Tap Water Quality - found that "tap water in 42 states is contaminated with more than 140 unregulated chemicals that lack safety standards" and suggested that EPA should be doing a far more thorough job of regulating drinking water - above and beyond the vast regulatory infrastructure that we already have in place. The recent experience of Charleston, West Virginia is but one example of this concern.

Pharmaceutical compounds and the broad range of so-called "emerging" contaminants have only recently been detectable at all. As our understanding of the chemistry of water contamination expands, and as analytical technologies improve, we are likely to discover more compounds in our waters that may present potential concerns to human health and well-being. This is in turn is likely to lead to more regulation and more controls. The EPA's current Unregulated Contaminant Monitoring Rule (UCMR-3) program is geared toward identification, better understanding and quantification of precisely this concern.

And regulations don't always work as intended. Difficult and challenging problems usually don't have simple answers, and frequently the outcome of a new regulation is not exactly what was expected. Sometimes, an apparent solution may create a new and unintended problem. This was dramatically illustrated a few years ago when it was recommended that Washington, D.C. eliminate dangerous trihalomethane by-products in its water system by replacing its chlorine disinfection system with alternative chloramine disinfection. As it turned out, the environmentally-friendlier chloramines were more aggressive in leaching lead out of Washington's ancient water mains and into the drinking water. In effect, the "solution" was worse than the problem, resulting in a major public hue and cry. These types of quandaries, difficult choices, outright conflicts and counterintuitive results are likely to continue to plague both water regulators and providers in the future.

Compounding all of these traditionally regulated areas is the concern about potentially "introduced" compounds in water distribution systems - a polite way of referring to potential terrorist activities - and other security concerns regarding the potential contamination of primary drinking water supplies. Although the post-9/11 furor has died down, it did serve the useful purpose of raising the visibility of a key issue; the lack of regulatory controls or testing of clean drinking water once it has left the drinking water treatment plant. Despite all of the advances in clean water that have been accomplished over the last fifty years, and the numerous regulatory standards which drinking water must meet, there is still essentially no monitoring of that clean water once it leaves the treatment plant and
runs out into more than a million miles of underground distribution piping. This area of post-treatment plant monitoring of drinking water quality will probably be the subject of considerable new regulation for utilities in the coming years. At the same time, it represents a significant commercial opportunity for testing and monitoring firms (discussed later).

In summary, although water and wastewater treatment regulations may be extensive, growing, often confusing and sometimes conflicting, they are only likely to expand and increase in the future.

2. Failing Infrastructure: The woeful and dilapidated state of the American water and wastewater treatment infrastructure is now well documented. However, here again, the actual extent and severity of the problem is still generally under-recognized by the American public, as well as by most decision and policy makers. For example, the American Society of Civil Engineers has consistently assigned a grade of "D minus" to both drinking water and wastewater infrastructure - the lowest grade issued in their annual overall assessment of the nation's overall infrastructure situation. As alluded to earlier, their recent report points out that we lose almost 7 billion gallons of clean water a day through leakage, and that we should be spending an additional $11 billion per year, simply to maintain the existing infrastructure.

In terms of the likely scale of future spending requirements, one can almost pick a random but very large number and find a study somewhere that will support it. In industry circles, the EPA estimates mentioned earlier are considered to be somewhat conservative. The major trade associations representing the water and the wastewater sectors of the business - respectively, the American Water Works Association, and the Water Environment Federation - have issued studies with higher projected spending needs. Other Congressional and federal agency studies have put the combined water and wastewater infrastructure spending requirement over the same twenty year period at close to a trillion dollars. Regardless of the study one picks, all predict huge future investment needs - with particularly strong spending in the transmission, distribution and storage sectors of the business.

Concerns about the impact of impending climate change will only intensify this trend, and will likely continue to increase the amount of money that we need to spend on moving water around and - particularly - storing it. As the magnitude of these looming expenditures becomes clearer, we will also see more creative solutions to many of these challenges. For example, water can be stored in underground aquifers rather than expensive surface impoundments and reservoirs that not only cost millions to construct, but also disrupt the environment and allow significant amounts of the water to evaporate anyway. Innovative technologies to rehabilitate existing underground transmission piping will also grow; studies suggest that it can cost up to five times more to rebuild an underground water main than to rehabilitate it in place. In the future, expect a lot of technology development activity, and a lot more dollars to be spent, in more creative ways, to maintain and upgrade the existing water and wastewater infrastructure.

Although the pressing need for vast infrastructure expenditures is becoming more widely understood, it seems to be simultaneously becoming less obvious where the requisite funding for these investments will eventually come from. Most local agencies and municipalities suffer from increasing fiscal constraints, and the federal government, at least at this point in time, shows no inclination to get involved in financing the water infrastructure challenge. Projections regarding practically unlimited future spending in water infrastructure must be tempered by the reality of national and global fiscal constraints.

In short, there are huge capital investment needs but few proposed sources of capital. Even with all the massive infrastructure spending and the economic stimulus packages following the Great Recession, only very moderate funding trickled down to the water business. Unfortunately, many skeptics believe that it may ultimately take a series of public health calamities - resulting one way or another from the decaying water infrastructure - to finally cause people to wake up, for local politicians to get focused on the issue, and to force federal attention toward the problem.

3. Greater Conservation and Efficiency: Historically in the water industry, we were primarily concerned about supply side management - developing and transmitting more water to the people who needed it. Now, however, we are more concerned with demand side management - i.e., better conservation practices and more efficient water usage. Conservation is increasingly viewed as a new "source" of water; reducing demand is just as important as creating "new" supply. Supply and demand are indeed two sides of the same coin, and - in most locales - better conservation and utilization practices are the best and most immediate opportunities on hand to extend the overall availability of water. And despite solid improvement and increasing attention to this area during the last several years, there is still a lot of "low-hanging fruit" - relatively easy improvements that can be made in terms of better conservation and utilization of our water resources.

For example, as mentioned, many water distribution systems incur leakage of as much as 20 percent to 40 percent of their treated drinking water. Loss rates in the main distribution systems - often referred to as "non-revenue water" - are as high as 50% in many parts of England and France where water mains may be well over a hundred years old. This is one of the first areas that should be addressed. It clearly makes more sense, and is more environmentally sound, to fix existing water infrastructure, than to build new infrastructure, like dams and reservoirs (some percentage of which would also go to waste). This consideration points to likely growth in the infrastructure equipment sector of the marketplace - pipes, valves, meters, pumps and tanks.

Several years of significant droughts across the western United States and in other areas of the world, have dramatically illustrated not only our vulnerability but also just how much water we all tend to routinely waste. Looking at droughts as teachable moments, they can also demonstrate how much water we can save - once we are forced to confront the issue. In some regards, droughts may be a good thing - just like $4 gasoline is a "good" thing - in that they force us to sit up and pay attention, and get smarter about conservation, reuse, recycling, and better allocation systems. Local conservation programs have started to show good results. Many southwestern cities like Albuquerque and Las Vegas have seen per capita consumption
drop from 200 to 300 gallons per day down into the neighborhood of 100 gallons per day or even less. Following the drought of 2002, Denver was able to lower its overall daily water production by almost twenty percent. The truth is - most of us could be far more efficient and conservative in our use of clean water without really having to make any major sacrifices.

One key sector that is particularly ripe for efficiency improvement is agricultural irrigation. Many arid regions are increasingly looking toward more efficient agriculture as the next new "source" of municipal drinking water. Almost 80 percent of our total water usage in more arid regions goes to agricultural irrigation, and almost half of our food supply now comes from artificially irrigated lands. As the researcher Sandra Postel said several years ago in her review of irrigation practices, Pillar of Sand, "irrigation unleashed a profound transformation in human development, and created a new foundation from which civilizations sprung and blossomed." However, irrigation as it is often practiced can be hugely wasteful of water. New technologies for more efficient use of agricultural water such as laser field leveling, drip irrigation - "more crop per drop" - deficit irrigation, and enhanced soil moisture monitoring offer great promise, and are another area of interesting investment opportunity.

As food prices rise, this will also force a closer review of our water use efficiency planet-wide - and more pressure to make sure we use water efficiently to grow the right kinds of crops in the most logical regions. Per capita world food demands are changing rapidly; the Chinese now consume 110 pounds of meat per capita per year, more than double the 44 pounds they consumed in 1985 - and it takes a lot of more water to produce a pound of beef than it does to produce a pound of rice. As prices for commodity crops like wheat and corn reach all-time highs, the impact on the price of all downstream food products has risen accordingly. According to the World Bank, food prices reached an all-time high in August of 2012. As mentioned, these price trends may not get as much media attention in the United States as they do in less developed parts of the world - where most people spend a much higher percentage of disposable income on food. Growing water shortages and rising world food prices will translate into greater food scarcities in the poorer and more under-nourished areas of the world - and could quickly exacerbate already pressing social and political problems.

More fundamentally, shortages and droughts are forcing us to rethink our agricultural priorities, and to carefully examine the principles of "virtual water" - the total amount of water necessary to produce a given commodity or product. For example, as water becomes scarcer, it may no longer make sense to grow highly water-intensive crops, such as cotton and alfalfa, in the deserts of western Arizona. Similar water allocation adjustments have led drought-stricken Australia to reorient its agricultural industry. Once one of the world's key exporters of water-intensive rice, Australia has now refocused its scarce water resources to other less water-intensive and/or more valuable crops such as grapes and citrus fruits. More efficient water application, better drainage systems, and increasing use of certain types of wastewater for agricultural irrigation, should all be important policy objectives, and can collectively add up to constitute this important new "source" of water.

In a somewhat counter-intuitive development, this drive to better conserve water has resulted in some paradoxical challenges for the water utility industry. As public education and conservation programs have begun to achieve some real success, the resulting lower water usage has translated into lower revenues for municipalities - and this comes at a time when additional funds are badly needed to invest in new infrastructure. In turn, this may also impact the credit rating of the city. In other words, by "doing the right thing" and conserving water, consumers have created a greater, rather than a lesser, financial burden for the water authority. In many areas, responsible customers are now being told to both use fewer gallons and to pay more for the gallons they do use. This is not a very palatable situation for either the utility or the customer, but it is representative of the new challenges which we will face in the future.

Today, most people don't pay a lot of attention to conservation and recycling of water, but they will when water prices begin to impact their pocketbook more significantly. Most western European countries pay considerably more for their water than we do in the United States. Consequently, most of their populations are far more cognizant of the value of water - and in turn per capita usage is much lower. A report a few years ago from The Economist reported that not only are water prices in the United States among the lowest in the world, but that we are also (predictably) one of the most wasteful nations in terms of water usage. As prices inevitably increase, we will pay more attention and become more efficient.

4. Focus on Recycling and Reuse: Closely related to and somewhat overlapping with conservation and efficient use is the whole arena of water recycling and reuse. In all of its varied forms, this remains one of the most robust sectors within the overall water business. Water recycling initiatives, from the individual residence to the large municipality or major industrial installation, are rapidly gathering steam, and also offer good opportunities for extending the overall water resource base. Yet, there is still a long way to go here too. Israel is by far the world leader in this area, reusing about 80% of its total water consumption. The next closest country is Spain at just 17%, and of course all other nations are much lower. These statistics are powerful documentation of the fact that we can do much better when we have to.

Because different terms are often used rather vaguely or interchangeably in this area, some definitions and clarifications may be helpful. Almost all wastewaters can be recycled and cleaned to levels where they can be reused for potable or other primary purposes. This can occur in both a direct and an indirect manner. The distinction between these two terms is critical. Indirect reuse of treated wastewater - that is, consumption of wastewater after it has been treated, discharged back into "nature" and then withdrawn from a river, or pumped out of an underground aquifer - has obviously been practiced one way or another since the dawn of history. Almost by definition, all of the water on our planet has been recycled and reused countless times.

For example, it is estimated that on some of the major river systems in the United States, water is used and reused in this fashion up to twenty times as it travels to the sea - the discharged water from one wastewater treatment plant essentially comprising the raw water supply at a primary drinking water plant a few miles downstream. Or as the popular bumper-sticker says "we all live downstream." Indeed, it is interesting to note that, as a result of forty years of steady progress under
the Clean Water Act, the treated effluent from wastewater treatment plants is sometimes cleaner than the supposedly "natural" rivers and streams into which it is discharged. And of course after all these effluents flow downstream into the sea, some of those same water molecules evaporate from the oceans, condense to form clouds and fall on land as rain, to begin the same cycle all over again - the hydrologic cycle.

What is often meant by the term water reuse today, however, and what tends to generate considerably more controversy, is the direct reuse of water - reusing water without that intervening and somehow magical purifying effect of "Mother Nature." Although direct reuse of wastewater has been technologically feasible for many years, any widespread direct reuse for drinking purposes still seems to be a long way in the future. The real reason for this is poor understanding and misplaced social concerns rather than technological challenges. Putting a "black box" on the outside of a home to treat sewage and recycle it directly back into the kitchen tap - often referred to as "toilet to tap" in the popular media - is clearly worrying and unpalatable to most people. Scare stories in the press tend to reinforce this reticence, even though from a technological perspective, it is fairly straightforward to recycle wastewater to drinking water standards. Although such direct potable reuse is only commercially practiced in a few arid or water-short locations around the world, it seems destined to become much more common in the future, out of sheer necessity.

When evaluating the potential impact of direct reuse as a means of extending our water resources, there is one very critical statistic to consider - a factor which should help make reuse much more feasible on a wide scale: only a small percentage of our primary water supply is actually used for drinking. Out of the roughly 120 gallons of water per capita per day that we currently treat to drinking water standards, most individuals drink less than a gallon a day. Even if we also include the water that we use to cook and clean with - which we might also wish to be treated to drinking water standards - this still represents only around 15 percent of total treated water consumption. Most of the rest of our highly treated drinking water is used for flushing toilets, watering lawns, washing cars, fighting fires and the like - applications where the water doesn't need to be treated to such highly exacting drinking water standards. In other words, much of our current consumption could be recovered and reused in a variety of applications without anyone ever having to drink directly "recycled" wastewater. This is critical; even if only small incremental gains could be made in terms of direct non-potable water reuse, overall water availability could be substantially improved.

Public resistance to broader use of directly recycled wastewater is a perfect example of poor public understanding about water issues - and the crying need for better public education programs. Popular worries about water reuse ignore the fact that all of the water we drink has already been recycled thousands of times - if not by man-made treatment plants, then by nature itself. Wider public acceptance of direct wastewater reuse is a major public education challenge, but eventually more and more direct reuse seems certain to happen, particularly with the intervening, if minor, impact of "nature." Cities and municipalities in the arid west are already paying top dollar for access to wastewater effluent streams - both as a means to recharge aquifers or to augment surface stream flows. One landmark transaction in Prescott Valley, Arizona a few years ago saw the rights to a wastewater effluent change hands at almost $25,000 per acre-foot - in a transaction valued at $70 million. Just as we said in the case of improved conservation methods, more efficient and widespread reuse of water must be recognized as a far cheaper source of additional supply than huge new reservoirs, massive pipeline transfer projects or desalination plants.

One thing is certain: as water prices continue to rise, there will be ever-increasing incentives for more careful recycling and reuse. With greater economic incentives, individuals, households and industries will begin to both use and reuse water more carefully. Industrial companies will rethink their approaches and retool their manufacturing systems, to utilize less water in the first place, and to better recycle the wastewater that they do create.

5. Steady Growth in Desalination: One other thing is certain, as water prices continue to rise - we are likely to see certain regions of the planet rely increasingly on the desalination of seawater as a major source of drinking water. Once thought to be prohibitively expensive, rapidly advancing technologies and the imminent exhaustion of alternative supply sources are leading to the rapid growth of both thermal and filtration-based desalination in select parts of the world. According to Global Water Intelligence, six million cubic meters of new desal capacity came on-line in 2013, up some fifty percent from 2012.

Notably, more and more of this growth is coming from the industrial sector - mostly very large-scale power plants and petrochemical refineries. Some of the traditional hot-beds of desal, like Australia and Spain, seem to have gotten ahead of themselves in terms of capacity. For example, in eastern Australia, plants that were conceived and built during the decade-long drought of the 2000s now represent excess capacity, and are only used occasionally as peak capacity. However, they will undoubtedly fill a critical gap eventually. Other new market areas, particularly China are booming; that country expects to double capacity by 2015.

In one major development domestically, the long-planned Poseidon plant near San Diego finally got the final go-ahead early in 2013, and there are several other plants in the planning stages along the west coast of Mexico and the United States. But the siting, permitting and construction of major desal facilities will undoubtedly continue to face strong public resistance and scrutiny in this country - at least until we thoroughly exhaust all other possible new sources of clean water, including draconian conservation measures.

From the broader perspective, desalination could obviously - but theoretically - provide virtually limitless new sources of clean water, particularly in certain coastal regions of the world where much of our population happens to be located. But it is short-sighted and dangerous to view desalination as a panacea, or the "silver bullet" to solve all our water problems. There are numerous energy issues, environmental questions, and geographic limitations of desalination which imply that it will only be economically practical in certain fairly restricted areas - generally arid coastal regions that have exhausted all other supply sources, and which have access to relatively cheap energy. Mobile sea-going desalination plants may be able to address some of the environmental questions, and may provide emergency supplies to population centers that are experiencing droughts or short-term breakdown in infrastructure.

6. Increased Interdependence between Water and Energy: The phrase "water-energy nexus" seems to be on the lips of virtually everyone around the water market today. Whereas the phrase was instructive and vaguely seductive a few years ago, it has become almost blasé today. But with increasing attention on issues like the worsening California water crisis,
the vast consumption of power in the Arabian Gulf to desalinate seawater for drinking, the huge consumption of water necessary to extract deep shale gas, nuclear plants having to be shut down as a result of low river flows, and so on, the critical intertwining of and trade-offs between water and energy is quickly becoming a focus of both policy-makers and the public.

It takes lots of water to produce energy, but it also takes lots of energy to treat and move water around - and the demand for one could begin to cripple our use of the other. As Michael Webber put it in the October 2008 edition of Scientific American, "Many people are concerned about the perils of peak oil - running out of cheap oil. A few are voicing concerns about peak water. But almost no one is addressing the tension between the two: water restrictions are hampering solutions for generating more energy, and energy problems, particularly rising prices, are curtailing efforts to supply more clean water ….. The situation should be considered a crisis, but the public has not yet grasped the urgency."

There are perplexing questions here - how many barrels of water will it take to produce a barrel of oil from the Canadian tar sands, and what can be done with the resulting contaminated process water? Or, closer to home, how many barrels of water will it take to frack a deep natural gas well in northern Colorado, and where will the necessary water come from? Or, on the other side of the globe, how many barrels of oil will it take in Saudi Arabia to produce a barrel of desalinated drinking water? The on-going modernization of Saudi Arabia and the arid Gulf States rests upon using a large portion of their natural energy reserves to "manufacture" - i.e. desalinate - water for their people. In water-rich Canada, huge amounts of water are needed to enable domestic energy security. From a global perspective, water and energy become increasingly intertwined and interchangeable.

It is said that almost twenty percent of California’s total energy consumption goes to moving water around the state and treating it. A similar figure for the nation as a whole is about six percent. China is preparing to invest almost $100 billion in capital expenditures and to commit massive future amounts of energy to move water from the south to the more arid northern part of the country. In more and more ways, we are recognizing that water and energy consumption are tied closely together.

At home, a large portion of our total water consumption goes to growing green grass, and then we use gasoline to cut it all down. As Webber says, "Someday we might look back with a curious nostalgia at the days when profligate homeowners wastefully sprayed their lawns with liquid gold to make the grass grow, just so they could then burn black gold to cut it down on the weekends. Our children and grandchildren may wonder why we were so dumb."

One of the most visible and controversial topics in the water industry over the past couple of years has been the rapid emergence of the deep shale gas industry, the hydro-fracturing or "fracking" technology that allows recovery of the gas, and the vast water requirements that will come with it. Recently discovered and increasingly economical shale gas deposits in the United States could go a long way toward achieving our ephemeral energy independence - but only at the cost of huge water consumption.

People have been falling over each other to get a stake in this emerging market - to provide water for the drilling process, to haul and dispose of contaminated fracturing water to collect and recycle the produced water, to build mobile on-site or centralized commercial treatment facilities, and so on. In certain areas of the American West recent drilling activity has caused the purchase and lease prices for water rights to skyrocket over the last twenty-four months. And although activity has waned over the past two years with the decline in gas prices, continuing investment interest in this sector has driven much of the merger and acquisition activity in this industry over recent years, as we will detail later.

The U.S. Water Alliance summarizes the situation succinctly in an early report, saying "Water will have a profound impact on the development of domestic energy sources in the 21st century - and vice versa."

7. Water and Food Nexus: In a closely related and sometimes competitive theme, we must also address the complex and increasingly controversial interconnectedness of food production and agriculture with the energy-water nexus - the three-way "F-E-W nexus" that we highlighted on the cover of our report last year. The inter-related nature of these key resource issues continues to become clearer at the same time as the various underlying causes and effects seem to become murkier and more complex. Changes in consumption, different utilization patterns, or efficiency gains in one of these three areas can no longer be considered independent of considerations and impacts in the other two areas. In other words, it is not very productive to analyze specific water challenges without simultaneously assessing the food or energy implications of the same issue … and vice versa.

Food prices continue to be high, causing widespread social unrest in many areas around the globe - and food doesn't grow without water. The amount of money spent on food production and processing relative to Gross National Product varies widely around the world, and might be considered a good indicator of future political conflict centers. In the U.S. for example, we spend only about seven percent of our disposable income on food - down from 25% in 1930 - so percentage price changes may not have quite as much impact on us. But in most developing countries the percentage is much higher. This goes a long way toward explaining the political unrest that we have recently witnessed in several African and south Asian countries, and will only intensify as the demands upon limited water resources continue to grow.

With these higher food prices, U.S. agriculture is experiencing a bit of a golden age. Good agricultural land prices have soared over the past few years. Investors that were previously buying land in order to acquire water rights - intending to dry up the land and send the water to cities - are suddenly realizing that the water may be more valuable left on the land, to produce the food that is suddenly becoming more valuable. Cities may need more water, but the people who live in them also need food. In many regions, including the arid western United States, we hear a lot about moving water out of agriculture and into municipal uses - to support expanding populations and economic growth. But in the final analysis, agricultural output is more important than economic growth.

8. Enhanced Monitoring and Measurement: The old adage - "you cannot manage what you cannot measure" - increasingly applies to the water business. The ability to monitor and track - and more importantly to understand the implications of - the physical and chemical composition of water is becoming increasingly important. Better and quicker information is critical to sustaining natural ecosystems and maintaining public health. Water treatment, storage and distribution infrastructure depends upon a plethora of monitoring data and analytical information in order to function efficiently. As a more informed public demands better information about its drinking water, as
more comprehensive regulatory controls evolve, and as new contaminant effects are better understood, it seems certain that testing and monitoring requirements will only continue to expand.

The monitoring of source waters is the critical first step in the water delivery process, whether that source be glacial, snowmelt, surface rivers and streams, or underground aquifers. Water quality parameters may change, depending upon recent weather conditions, time of year, seasonal biological activity, upstream human activities, etc. It is important to understand the physical and chemical quality of that incoming source water, in order to anticipate problems and maintain optimal conditions in the primary drinking water treatment plant.

Within the plant, monitoring of key operational parameters can improve productivity and enhance cost controls. Understanding the step-by-step quality and physical characteristics of the water as it flows through the treatment system enables the operator to maximize efficiency - saving on chemical costs for filtration and sedimentation, electrical power costs for aeration and mixing, and so on. This type of productivity-driven information has to be almost real-time in order to be useful.

Within the past decade or two, advanced real-time monitoring processes and dependable remote and field-deployable instruments and monitors have begun to be used on a wide scale. In earlier times, a manufacturer only knew it had water quality problems when it began to produce an off-spec product. The water utility only knew it had a contamination problem after the local emergency room began to fill up. Today, both industrial users and utilities monitor in-coming source waters and treated discharge waters on a much more real-time basis, so that they can anticipate problems rather than simply reacting to them after the fact.

There is extensive monitoring and testing at the point where the treated water is discharged into the distribution system. A large array of parameters must be measured on a regular basis in order to comply with Safe Drinking Water Act regulations, and in order to protect broader human health. Consumer Confidence Reports, which by regulation have to be sent to all consumers of public water utility systems once each year, report the observed levels of some 100 potential contaminants in the drinking water. As mentioned, although this requirement to measure and report has become a significant regulatory and cost burden on drinking water utilities, many critics believe that dozens of additional potential contaminants should also be tested.

One area of drinking water testing which has received considerably more attention during the past few years is post-treatment plant monitoring of the quality of water - after it leaves the treatment plant and runs out into the underground distribution system. Although drinking water is very heavily regulated and tested at the point of discharge from the treatment plant, it seems remarkable that there is almost no monitoring of its quality once it is discharged into the distribution system which carries it to our homes and businesses. Particularly given emerging concerns about aging pipelines, contaminant infiltration, and chlorine disinfection by-products, it seems likely that distribution system monitoring will be more heavily regulated in the future.

Water quantity monitoring is becoming much more important as well, particularly in those areas where water is scarcer. This area comprises a wide variety of instruments and systems geared toward more accurate and efficient tracking of water volumes, consumption and conservation habits - for example, broader use of water meters on individual homes. In source water applications, ultrasonic devices are increasingly used to measure flow rates in rivers and streams, so that users downstream can know how much water to expect. In agricultural applications, more precise measurement of soil moisture, or flow rates in irrigation ditches or center-pivot irrigation systems can be critical. As pointed out earlier, small percentage efficiency improvements here can free up massive amounts of water for municipal use.

In summary, there are numerous points in the water resource management cycle, and in wastewater treatment processes, where massive amounts of data are collected, either on an occasional basis, or on a continuous and real-time basis. And it's not just a matter of collecting the data. Aggregating, transmitting, and analyzing all of this information - turning these veritable mountains of data into actionable intelligence upon which decisions can be made - is also a huge undertaking. Such a massive amount of data may only be useful if one has an efficient automation and process control system, often referred to in the water industry as a SCADA (supervisory control and data acquisition system). These are systems which collect data from various sensors on a continuous basis, and automatically process the information to monitor, manage and optimize an overall process on a real-time basis. In short, systems to manage, transmit and evaluate the data are just as critical in the overall scheme of things as are the sensors and instruments which initially collect the data.

9. Smart Water: Closely related, another rapidly growing and "hot" sector of the global water marketplace is the "smart wa-

Boston loses 30 percent of its water, while it is estimated that the City of London loses almost 50 percent. What other industry would allow 50% of its product output to go wasted and unused?

ter" or "smart grid" arena - an analogy to efficiency and conservation gains that were developed over the past couple of decades in the electric power utility business. The capability to monitor and track water movement and usage on a micro level is leading to all sorts of potential efficiency gains; smart meters can alert residential users when their water consumption looks abnormal and warn of a potential leak in the system somewhere. Smart pipes - pipes outfitted with in-line sensors that can sense what is going on inside them - may someday become commonplace in process applications, so that industrial water users can keep track of water quality and quantity parameters in their treatment systems on a real-time basis.

The Smart Water Network Forum - an emerging industry group - describes the opportunity in the following way. "Online water monitoring is the use of data transmitted from network elements, meters and sensors for gaining operational knowledge and insight. The availability of cheap, easy-to-use data technologies, as well as external pressures on the water industry, means that water networks will see much greater sensor and controller density, and inevitably a more central role for all the data systems built on top of them." The adjacent and related field of water loss management - in terms of both products and services - is definitely an area of accelerating growth.

In short, smart water networks can improve the efficiency, reliability and life of the physical water distribution infrastructure by means of better monitoring, data collection, and data analysis. The Smart Water concept seems certain to make a major future contribution to the broader effort to provide sus-

© 2014, TechKNOWLEDGEy Strategic Group
tainable, affordable and clean water - and this whole sector is currently the subject of intense technological development and investment interest.

10. Green Infrastructure: A key emerging trend in the municipal sector is the concept of "green infrastructure" - design and construction techniques geared to more effectively utilizing storm-water, and keeping the run-off out of the combined sewer system. In some major urban areas, we have now paved over so much of the surface that rainwater no longer has any place to go. Each year, an estimated 10 trillion gallons a year of untreated storm-water runs off roofs, roads, parking lots, and other paved surfaces, rather than permeating into the ground as it did a hundred or two hundred years ago. Instead of allowing the hydrologic cycle to sustain our increasingly precious surface and underground water resources, we have unwittingly turned the resource of natural precipitation into a problem - a waste that has to be handled somehow.

That attitude is changing. Green infrastructure - including green roofs, permeable pavement, rain gardens, urban wetlands, street trees, and generally increased green space - can help address this problem by capturing rainwater and either storing it, or to work counter to the natural hydrologic cycle. All of these approaches are geared to "slowing it (storm-water) down, spreading it out, and soaking it in." When one considers that in many of our major urban areas as much as 60% or 70% of total surface area is now paved over and impermeable, the challenge of dealing with a mid-summer thunderstorm becomes pretty clear. Many cities are now experimenting with creative taxes or "user fee" approaches such as "impervious area fees" - charging land-owners with large amounts of impervious areas a special fee to help pay for storm-water management, or offering credits against such fees for the construction of localized green infrastructure.

Just as green infrastructure is perhaps a fancy name for just trying to let Mother Nature take her natural course in urban settings, we are seeing similar approaches in other areas as well. The agricultural community is also beginning to take similar "bigger-picture" approaches, and starting to institute more sustainable systems for water management and conservation. More holistic thinkers are starting to view the land itself as a natural water reservoir, and trying to create systems to maximize the "sequestration" of surface waters into the ground. Farmers are starting to view themselves as not only crop or livestock producers, but also as watershed managers. All of these more innovative types of approaches and thinking are simply based upon the concept of protecting, promoting and mimicking natural systems, rather than seeking to destroy them, or to work counter to the natural hydrologic cycle. Ten or fifteen years ago, this type of approach might have been considered "fringe" thinking on the part of a few tree-hugging environmental radicals; today it is increasingly the business mainstream.

11. Technological Advances: Although incremental technological advance is ubiquitous across the water industry, few observers believe that there are any truly revolutionary tech-
New applications of existing technologies or appropriately funded new technologies can go a long way toward solving many of the world’s water problems. But we cannot be lulled into thinking that new technologies will simply or automatically spring up to solve all our problems - there is no "silver bullet" awaiting us in water technology.

12. Residential Consumption Concerns: As the general public has become more aware and concerned about drinking water issues, consumer preferences are changing, and have become more significant factors in the water business. The most critical trend or consideration here is the growing concern among consumers, particularly the more affluent, that tap water may not be safe to drink. Primarily because utilities have not effectively marketed the true value of their product - and partly because real quality problems do occur occasionally - many consumers now believe they need to either buy bottled water or further treat the tap water coming into their homes. Right or wrong, this is a key driver behind several important trends in the water business.

This tap water quality issue is developing into something of a controversy between the water utility industry - the 55,000 agencies providing drinking water, most of which are municipally or government-owned - and the residential water treatment companies. The former group suggests that tap water is truly one of the great economic bargains of all time. The latter group - which includes point of entry/point of use (POE/POU) equipment manufacturers as well as bottled water suppliers - cautions that the only way you can ever really be sure your water is safe is to treat it within the confines of your own home, or drink it out of a pre-packaged bottle. The truth obviously lies somewhere in between, although it must be said that report after report has shown U.S. tap water to be remarkably safe. Nonetheless, these worries have strengthened the markets both for bottled water and for POE/POU home treatment products. In addition, new markets are beginning to emerge in areas such as residential water monitoring and testing services.

In reality, the explosive growth of the bottled water industry over the past few years is a spectacular example of how customer perceptions - right or wrong - can create and drive new markets. The extent of this phenomenon is staggering; it is now the second-largest beverage category in the United States, and Americans consumed some $10 billion worth of bottled water in 2009. According to the Beverage Marketing Corporation, the reasons are clear - bottled water is "a healthy, safe, ready-to-drink commercial beverage, which is becoming increasingly affordable - a great beverage alternative." Providers continue to market bottled water by promoting it as something completely different than tap water - a concept which apparently has been sold to a large swath of the American public.

The truth is (a) there is scant evidence that most bottled water is any different or safer than tap water; (b) the bottled water industry is not as closely regulated as the tap water business, and in many cases may be far less regulated; and (c) the "transportability" of water is easily accomplished by keeping a couple of empty bottles around the house. Nonetheless, the bottled water business has continued to boom - at a price of hundreds to thousands of times higher than tap water. At a time when many parts of the world face crippling water shortages, it is outrageous to many observers to witness the way the bottled water craze continues to captivate wealthier regions. But the fad may be moderating. Many restaurants are now promoting the virtues of tap water. With the economic hardships that much of the country has been enduring over the past few years, there has definitely been a change in the appetite of the American public to pay such high prices for essentially the same substance that comes out of their taps virtually free.

A considerably more substantive and serious question which arises out of the whole tap water safety debate has to do with point-of-use treatment, and larger policy questions about the efficiency of centralized water treatment versus "decentralized" or "distributed" treatment of water. This issue ties back to the very fundamental fact mentioned above - very little of our treated municipal water is actually used for drinking. Put simply, if we only drink one percent or less of all the water that is treated to our very stringent regulatory standards, does it make any sense from a broader perspective to treat all of our water to these exacting standards? Would it not make more sense to treat water to lower standards at centralized facilities, at much lower expense, and gradually develop an infrastructure where individuals treat water at the point of use for the specific intended purpose? In other words, would we save money overall if we quit building expensive centralized plants and instead required each home to treat the small amount of water that they drink, cook with or bathe in - at the point where it is actually consumed?

This would obviously require a massive rebuilding of the water infrastructure system in the country - and hence, it is not likely to happen any time soon. However, over time, we may indeed see more and more consumers taking matters into their own hands, and treating or retreating water to their own specifications at the point of use. The residential water treatment business is one of the more rapidly growing parts of the overall water business, and probably will accelerate in the future. Indeed, some utilities in California have already tried to bridge this gap, and are offering to provide POE treatment devices to their users in order to avoid the expense of investing in centralized treatment upgrades. This issue of decentralized treatment seems likely to represent another broad-ranging policy debate of the future.

13. Controversy about Privatization: There are many contentious issues in the water market, but none are as divisive and polarizing as the debate over the appropriate role of private capital and the private sector in the provision of water. Controversies about privatization, out-sourcing and the proper role of private companies are frequent and widespread - and they only seem to intensify in the United States, as the years roll by. The viewpoint on one end of this spectrum seems to propose that the water business would be better off if it were entirely privatized - as it has been for many years in France and the U.K. - while those at the far opposite end fervently believe that there should be no role for private industry in water whatsoever.

The truth behind all of these rigidly black and white positions obviously lies somewhere in between. These aren't simple questions - they are very complex issues, upon which reasonable people can disagree. However, simply spouting one extremist view or the other sheds little light on the problem. Participants in the water industry must move beyond the fruitless rhetoric occupying either extreme on this spectrum, and move toward the most effective balance between extreme points of view.

The basic arguments against privatization of water assets revolve around concerns about the motives of private, for-profit firms, and the philosophical sense that access to clean water, as a basic human right, should be equitably priced and pro-
vided to all. Many people simply believe that water resources are a part of our natural heritage which should never be entrusted to private companies to own, manage and disburse. Given the isolationist attitudes that have evolved in this country since 9/11, the fact that many of the water privatization and contract operations firms are foreign-owned has only led to further concern and suspicion.

However, the situation is far from a "greed gone wild" scenario of faceless, evil corporations jacking up prices and flagrantly gouging the poor - the scenario that is, unfortunately, often portrayed by privatization opponents. There are often fundamental and compelling economic drivers which tend to support the consideration of greater privatization in the water industry. For example, few municipalities enjoy over-flowing coffers, and few public officials who wish to be re-elected want large user fee or tax increases on their watch. Many public works managers are between a rock and a hard place - technical requirements, regulatory complexities and overall utility costs continue to increase, but the general public remains very resistant to increasing taxes and users fees. Sometimes, the best solution to this dilemma may be to turn to private companies and/or private capital to finance, build and operate the water or wastewater system under long-term contract. Typically unrecognized is the fact that, as natural monopolies, all private water utilities fall under extensive and strict regulatory control from State Public Utility Commissions. Indeed, privately-owned utilities are far more closely regulated in terms of price increases than are municipally-owned utilities.

It is worth noting that in many parts of the world, the private operation of drinking water systems is taken for granted, and in fact is the operational norm. The French, and more recently the English, are the world's major players in terms of private water management and operation. And privatization and contract water operations are significant and growing in many other parts of the world. Global Water Intelligence reports that about ten percent of the world's population is currently served by private operators - a figure that is expected to grow to 16 percent by 2015. More than 45 percent of the population in Western Europe is now served by private operators, with rapid growth occurring in the Mediterranean and North African regions.

Hence, it's quite ironic that the United States, which its defenders like to consider the home of free enterprise and the bastion of democratic capitalism, has such a resistance to private water systems, while in European countries that we tend to think of as marginally socialist, private water systems are common and widely accepted. One recent European report accuses the United States of maintaining a "bunker mentality" in terms of being close-minded to privatization, and the possible solutions this could bring to a variety of water infrastructure problems.

In summary, despite the cries and concerns of labor organizations and various public interest groups, the urgency of infrastructural needs and the political difficulties of increasing taxes or fees make it likely that privatization - under various names - will become a more important factor in the water business. Although the growth rate of out-sourcing has slowed a bit over the last few years, the fundamental drivers behind privatization and consolidation - huge capital needs, technological and operational synergies, limited public funds and a widespread aversion to higher taxation - remain strong. At the same time, it is clear that private operators are going to be judged by a very demanding and critical public.

Access to clean drinking water obviously has to be viewed as an inalienable human right. And poorer people, particularly in the developing world, should not and cannot be denied the right to water simply because they may be unable to afford to pay for it. Subsidies or other types of government involvement in markets must clearly protect those at the bottom end of the income scale. There is no serious industry observer who would argue with that. However, we also have to be practical and remember that clean drinking water costs hundreds of billions a year worldwide to store, treat and distribute - and that we as a society somehow have to pay those bills. Despite what some uninformed observers may claim, clean water certainly isn't - and can never be - free. The fact that access to water should be viewed as a fundamental human right does not imply that private capital and private companies shouldn't be involved in water.

We need to avoid arguing and wasting time debating these ideological extremes - the problems are pressing in many areas, and the time may be short. Water must be provided at reasonable cost to all, but a more market-oriented approach could go a long way toward making that possible. Privatization should not be viewed as the answer to all problems, nor should it be viewed as the enemy in helping clean water to flow for all. In the end, it should not matter whether the water provider is a private or public entity. What matters is that people have access to water, that the quality of that water is acceptable, that natural hydrological systems are preserved for future generations to use, and that prices and profit levels are reasonable.

**14. Water Security:** Discussions about the national security implications of water are being heard more frequently. A report from the National Intelligence Council (consisting of the FBI, CIA and other security agencies) released early last year warned of impending security threats that may develop as a result of growing water shortages. The report identified certain watersheds and regions of the world that are both strategically important to the U.S. but also likely to be subject to more serious water conflicts in the future. The Euphrates, Mekong, Jordan, Indus, Brahmaputra, and Amu Darya river basins are all associated with nations that are strategically important to the United States - illustrating the intersections between water challenges and U.S. national security. The report said, "During the next 10 years, many countries important to the United States will experience water problems - shortages, poor water quality, or floods - that will risk instability and state failure, increase regional tensions, and distract them from working with the United States on important US policy objectives. Between now and 2040, fresh water availability will not keep up with demand absent more effective management of water resources. Water problems will hinder the ability of key countries to produce food and generate energy, posing a risk to global food markets and hobbling economic growth. As a result of demographic and economic development pressures, North Africa, the Middle East, and South Asia will face major challenges coping with water problems." A concise but very alarming forecast of the next thirty years. National security-related perspectives on water challenges will undoubtedly draw more critically-needed attention as these challenges grow.
15. Consistently Growing Commercial Markets: The overall commercial water industry - both domestically and abroad - continues to show strong and consistent, if unspectacular, growth. Unfortunately however, investors have typically made one or two critical mistakes in evaluating the future potential of the commercial marketplace. First, they have assumed that the industry is some sort of monolithic entity, with standard growth and profitability rates across the board. Second, many have made the erroneous assumptions that the high growth rates they may have heard about in certain technology sectors, such as UV radiation treatment, also apply across the board to other parts of the water business. Neither assumption is correct; hence many investors have not been happy with their adventures in the water industry to date.

Although we all tend to loosely talk about the "water industry," strictly speaking, there is really no such thing as the water industry. What there really is instead is a broad collection of fundamentally rather different businesses - all of which have something to do with delivery of clean water, but which can't all be classified accurately under any one single heading. As most observers loosely use the term, the "water industry" includes a broad array of sectors: steel and concrete pipe manufacturers; specialty chemical producers; measurement, monitoring and testing firms; tank manufacturers; all kinds of treatment equipment manufacturers; new technology developers of all stripes; manufacturer's representatives who sell all of these things to different end users, engineers and consultants; contract operators of water plants, and many others. These sectors may be quite different from one another - in terms of growth rate, profitability, and market valuation. Indeed, their only real similarity may be that they are involved somewhere in the process of providing clean water. A quick look through one of the numerous manufacturers' directories serving the water business conveys the true breadth of "the water industry."

A diffuse and fragmented industry like this is difficult to classify and analyze. And obviously, when it is difficult to even define an industry accurately, it is much more difficult - if not impossible - to accurately estimate its size, growth character-

<table>
<thead>
<tr>
<th>The U.S. Water Industry</th>
<th>2013</th>
<th>2012-2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Segment</td>
<td>Revenue</td>
<td>Growth</td>
</tr>
<tr>
<td>Water Treatment Equipment</td>
<td>$11,900</td>
<td>4.0%</td>
</tr>
<tr>
<td>Delivery Equipment</td>
<td>$12,550</td>
<td>2.8%</td>
</tr>
<tr>
<td>Chemicals</td>
<td>$4,900</td>
<td>5.0%</td>
</tr>
<tr>
<td>Contract Operations</td>
<td>$3,180</td>
<td>3.3%</td>
</tr>
<tr>
<td>Consulting/Engineering</td>
<td>$10,740</td>
<td>4.3%</td>
</tr>
<tr>
<td>Instruments and Testing</td>
<td>$2,300</td>
<td>3.5%</td>
</tr>
<tr>
<td>Wastewater Utilities</td>
<td>$53,160</td>
<td>4.5%</td>
</tr>
<tr>
<td>Drinking Water Utilities</td>
<td>$52,600</td>
<td>3.6%</td>
</tr>
<tr>
<td>Total U.S. Water Industry</td>
<td>$151,330</td>
<td>3.9%</td>
</tr>
</tbody>
</table>

Modified from the Environmental Business Journal, 2013

At first glance, this appears to be a fairly simple table. These data were assembled by a general "supply-side aggregation" approach - identifying the primary and larger companies in each sector, adding up their annual revenues, estimating the magnitude and rough revenue size of the remaining smaller players, and then totaling everything up. A more thorough analysis of these summary figures however, and some of the more detailed assumptions reveals some interesting insights about the industry.

First, note that the fees that we all as individuals or businesses pay to utility organizations (either municipal or investor-owned) for drinking water and sewage treatment services comprise almost two-thirds of the estimated annual total spending on water in this country - i.e., the last two lines in this Table. From the business perspective, it is critical to understand that the vast majority of these revenues are paid to municipal and public agencies - some 55,000 water utilities and about 16,000 wastewater utilities - not private companies. Only about fifteen percent of Americans receive their drinking water from private companies; a much lower percentage applies to the wastewater treatment sector of the business. Hence, the majority of the dollars shown in the Table are not really "private industry" revenues - that is, they aren't really available to private companies or service providers, at least not in the short-term.

Second, notice that the right-hand column of this table underlines the sectoral variability mentioned earlier. Projected long-term growth rates for different sectors of the various water-related industries show considerable variation, and it's interesting to note that the fastest growing sector is projected to be the water utility industry itself - the largely publicly-owned water delivery agencies. This is, of course, primarily a manifestation of the rising water prices rather than consumption - once again the key and recurring theme across the world water industry.

Even though this Table breaks out several sectors of the water business, it is important to further note that each line here is in turn comprised of numerous "sub-niche" areas which may also have very widely differing characteristics. For example, the category of Water Treatment Equipment is estimated here to be growing at a rate of about four percent per year. However, within that broad sub-category, there are numerous different types of treatment technologies which are growing at considerably different rates. A recent report by the Union Bank of Switzerland (UBS), for example, estimated the following more detailed growth rates for various treatment technology sub-sectors: activated carbon treatment was estimated to be growing at 5.5 percent annually, ozonation at 8 percent, reverse osmosis treatment at 10 percent, ultraviolet radiation disinfection at 13 percent, microfiltration and ultrafiltration membrane treatment at 15 percent, and membrane bioreactors at 20 percent. This same qualification would apply to many of the other sectors highlighted in this Table - underlining again the variability and complexity of the water industry when one dives down to a deeper level.
Another key observation is that these growth rates of individual sectors are themselves changing as the industry changes - as water scarcity and quality problems become more severe, as technologies evolve and improve, and as public awareness and demand for new products grows. For example, even though water treatment chemicals comprise a fairly large piece of the commercial market, many observers believe that the average growth rate of this sector will gradually decline, as chemical treatment methods fall out of favor. Or, as another example, this Table used to show Contract Operations as one of the fastest growing segments of the commercial industry. However, with growing public opposition to privatization, forecasts for this sector have dropped off considerably. Nonetheless, as more and more public utilities - particularly the roughly 50,000 smaller ones - face daunting technology and regulatory challenges as well as fiscal squeezes, this sector may again enjoy higher growth rates in the future.

Growth rates in traditionally less glamorous sectors, such as the infrastructure equipment business, are also likely to increase in the future. Sectors like in-situ pipe rehabilitation, advanced infrastructure diagnostics and water loss management, are likely to exhibit increasing growth rates as more and more capital is poured into maintaining and upgrading the nation's infrastructure. When one peruses those EPA estimates of future capital expenditure requirements, it is clear that a high percentage of future spending will be going into things such as steel and concrete pipe, pumps, valves and storage tanks. This may not be the "sexy" side of the business, and the companies in this sector are only just beginning to attract attention from Wall Street analysts - but there is little doubt that this is where many of the dollars will be spent.

And what about the broader global water industry? If data for the U.S. market is sparse, then information for most of the rest of the world is truly speculative. While the U.S. is clearly the world's largest individual market, it is also increasingly clear that the water market in many other countries or regions is showing faster growth than the U.S. market - and that simply put, opportunities abound for water companies in the rest of the world. Conventional wisdom seems to suggest that the total world market is about four to five times the size of the U.S. market. Several reputable parties have pegged the level of world business at around this level. The English publication Global Water Intelligence (GWI) recently estimated the global market at about $550 billion per year.

Even though the water industry is already a diverse hodgepodge of different products and services, new business sectors and new opportunities continue to emerge all the time. New companies continue to emerge and older pre-existing companies continue to diversify - refashioning new products or services, and redefining themselves as water players. For example, as we mentioned earlier, water "loss management" services and control technologies seem to be emerging sectors of the market - products and services geared to locating, measuring and repairing the vast water losses that can occur due to decaying underground infrastructure. The types of products in this emerging sector include surface leak detection systems, robotic and video pipeline monitoring technologies, high-precision flow monitoring and metering technologies, and pipeline rehabilitation systems. Several companies have focused their strategic growth plans in this area - on the assumption that as water becomes scarcer and more valuable, one of the most immediate solutions is simply not to lose so much of the water that is already in the system. The Miyia Water Group was set up recently in Israel to deal with exactly these sorts of problems around the world. Several of the other conglomerates working to build an international presence in the water business, such as Idex Corporation, are also moving to provide broader solutions in this area.

Another rapidly emerging sector of the water market involves innovative systems and technologies for measuring and implementing more efficient agricultural water usage. The reasons behind this are pretty clear: in many arid parts of the world, agriculture is responsible for a high percentage of total water consumption - 80 percent or more in many arid western states, for example. Hence, better conservation and small percentage efficiency gains here can free up a lot of water for municipal and industrial usage. While firms such as Lindsay Manufacturing and Valmont (see pages 6 through 8) have long been publicly-traded companies active in the manufacture of center-pivot and other agricultural irrigation systems, they are now being joined by a bevvy of new and existing private companies looking at innovative new means of conserving irrigation water usage.

Companies that were scarcely thought of as water firms a few years ago - such as the Toro Corporation - are more and more being classified as water industry players. For example, the heavy agricultural equipment manufacturer John Deere made several significant acquisitions in this area in the last few years, but has stumbled in the integration process and now appears likely to exit. Not surprisingly, due to their very arid climate, Israeli companies are among the leaders in this emerging sector. And it is not just more efficient treatment or application systems that are of interest here; better monitoring and measurement capabilities are critical as well. Real-time and wireless micro-level soil moisture monitoring can improve agricultural productivity, save energy, reduce fertilizer usage, and at the same cut waste and free up scarce water for other uses.

Within the broader water treatment sector, many new technologies continue to be developed, and existing technologies continue to be applied for the first time to water treatment applications. A review of start-up and "venture capital-type" technology companies in this industry can make the head spin - such things as electrocoagulation, sonication, cavitation, demineralization, forward osmosis, ozonation, electro-deionization, biocidal disinfection, electrodialysis reversal, and multi-stage bubble aeration. As discussed, few of these new technologies are expected to revolutionize the industry, but incremental technological advance is ubiquitous in the water industry. Promoters of "better mousetraps" - as well as snake oil salesmen - are pervasive across the water industry, and growing numbers of early-stage venture investments are being made in new water treatment technologies. A particular recent focus has been concentrated on wastewater resource recovery - approaches and systems to not only treat wastewater, but also to recover valuable components, like phosphates, out of wastewater streams - not only because they promote undesirable biological activity downstream, but also because other natural sources of phosphate are rapidly declining.

One final example of an area that is emerging and beginning to crystallize into a specific sector of the marketplace involves the
ownership, trading and marketing of actual water rights, particularly in the western United States, and in other regions where scarce water rights are starting to be allocated by various types of nascent market mechanisms. The ownership and trading of water rights has, to date, generally been restricted to the more arid Great Plains and southwestern regions of the country where the "prior appropriation" doctrine of water ownership is employed. Most of the business transacted in water rights ownership has been between farmers or mining enterprises - who originally held the historical water right - and municipal agencies, which desperately need that water today.

There are a few private companies and investment funds getting involved in this area - in essence attempting to bring private capital to bear in the development of public water supply and development projects. There are also three public but tiny companies that are at least partially involved with acquiring and developing water rights - Cadiz Development, PureCycle, and the Vidler division of Pico Holdings. There are other companies that have tried and failed to get into this aspect of the water business in earlier years, including a former public company called Western Water that filed for bankruptcy in 2005. The Bass Brothers of Texas engaged in an unsuccessful effort to buy and develop water rights in the Imperial Irrigation District of southern California several years ago. Likewise, T. Boone Pickens had a famously unsuccessful experiment in west Texas, trying to corral extensive water rights for shipping east to the Dallas area. Some of these efforts may have been ahead of their time, and there is no doubt that this whole area is fraught with market and political uncertainties - and is subject to the whole controversy (detailed earlier) between public and private approaches to water resource management. Nonetheless, investment vehicles of various types are springing up, and more and more investors are taking a look at the possible opportunities here.

In terms of the overall water business, many analysts have predicted exploding growth over the near-term future, but as we mentioned at the beginning of this section, the real situation has been more one of somewhat lower but very consistent growth - a sort of "tortoise" rather than a "hare" situation. There can be no doubt that fundamental supply and demand considerations insure continuing - and probably somewhat accelerating - growth into the long-term future. Indeed, it is very difficult to construct any kind of reasonable future scenario in which this industry will be characterized by anything other than very steady and sustained growth. However, would-be investors in this business need to understand that very few sectors are growing at the 15 to 20 percent annual rates that are often bandied about by uninformed financial commentators. The growth of the overall "business" will probably continue in the neighborhood of five or six percent a year - or, generally speaking, a little in excess of GNP growth rates. For strategic planning and analytical purposes, it is more meaningful to talk about the growth and profitability characteristics of individual market sectors than to try to peg growth rates for the overall "industry."

While certain conventional wisdoms have taken hold within the industry, it is truly difficult to document growth rates or market size estimates with solid market data. Many studies have tried, but even when all of these individual sectors are defined and individually totaled up, we still don't have a very good idea of just how big this total pie really is. Suffice it to say, the world water market is huge, and in the final analysis, debating or trying to pin down the actual figure is probably not very productive. For most firms, rough estimates of specific end markets in certain geographical areas are much more meaningful - and thus more useful in terms of good business planning. Perhaps more important to recognize is the fact that many of the key geographic markets, such as China, are at an earlier and much more rapid stage of growth than is the United States. With a total market that is agreed to be somewhere in the range of hundreds of billions of dollars per year, and given the truly critical underlying human needs and factors which are driving the business, individual firms don't really need to worry whether the world market is $500 billion or $600 billion a year.

As water resource challenges are more broadly recognized and understood, and as more and more companies position themselves to provide goods and services to help solve critical water needs, there is anecdotal but increasing evidence that this Balkanized "industry" will gradually consolidate or coalesce into a more distinct and more definable whole. As that happens, and as more and more researchers, scholars and policy-makers turn their attentions toward water, better market information should eventually become available.

16. A Continuing Surge of Investment in the Industry: With broader recognition of the scale of world water problems and the emerging opportunities to provide innovative new products and solutions, thousands of strategic and financial buyers have swarmed into this industry over the past ten to fifteen years - in an attempt to establish a foothold in what they view to be one of the strongest industrial sectors in the future.

This has, first and foremost, included a large array of industrial consolidators and strategic buyers looking to diversify existing water businesses, to expand tangential exposure to the industry, or to establish a new platform in an industry which they (rightly) believe is certain to show long-term growth. These industrial buyers and recent industry consolidation trends are discussed in the next section of this report.

Over the last several years, the water business has also attracted the full range of investor types. For example, there are literally hundreds of private equity (PE) firms looking to establish a position somewhere in the broader water industry. As other popular investment opportunities have faded, and as the amount of cash held in private equity funds has exploded, a widespread interest and excitement regarding water-related businesses has developed. Despite the Great Recession of a few years ago, the total amount of capital sitting in private equity funds still remains near the all-time high, and PE fund managers find themselves today with huge amounts of capital which they need to invest, and invest relatively quickly. The water business is one attractive sector in which to explore for good investment opportunities.

The water industry is potentially attractive to private equity firms for several reasons. First, it represents a strong and very consistent growth opportunity over the long-term future; there is virtually no way that the size of the water industry is going to shrink. Many sectors of the business offer the allure of high profitability at the same time. Perhaps most critically from the PE perspective, it is still a relatively fragmented industry, ripe for consolidation. This offers PE firms the opportunity to consolidate various businesses together to build larger and more valuable companies (although experience is showing that many PE firms over-estimate the simplicity of implementing this type of industry growth plan). Indeed, the only significant drawback from the PE perspective is the huge premiums that are typically being paid for companies in this sector. Experience has also shown that on larger or more sought-after transactions, PE firms often cannot compete with strategic industry buyers - they simply cannot compete with the "strategic pre-
mum" values that corporate buyers may be able to justify. Finally, the longer-term nature of many parts of the water market means that a lot of industry sectors really lend themselves to the standard PE model of buying, building, consolidating, cutting costs, and then flipping to a new owner.

And there have been all manner of other types of financial investors investigating water opportunities as well. Venture capital investment in smaller, emerging technology firms has been a particularly active market the last few years. Country sovereign funds - in particular those burgeoning funds from oil-rich areas of the world like the Middle East and Norway - have been seriously investigating water opportunities, both public companies as well as large water resource development projects. Many family offices representing private wealth, both in Europe as well as the United States, have become keenly interested in water investments as well - whether it be stakes in a publicly-traded company, investment in smaller, private and emerging companies, or in large water resource development projects. More and more investors of all stripes are getting up to speed on the world water market, and the range of investment opportunities available.

Nor is this surge of investment interest in water just an industrial consolidation or a large investment group phenomenon. There is also an expanding awareness and interest in water investing on the part of the broader public as well. Existing publicly-traded water stocks, though relatively few in number in the United States, continue to be highly sought after by individual investors, as evidenced by continuing strong valuations, even in the tumultuous equities environment of the last few years. (See pages 6 to 8 for a listing of the primary water-focused publicly traded firms in the U.S.). Water-related hedge funds, exchange-traded funds, and other types of investment vehicles have proliferated during the past few years, though all are similarly hampered by the relative paucity of publicly traded U.S. water investment vehicles.

Although the market for initial public offerings (IPOs) in the water sector has not been as active as one might expect over the past few years, there have been a few new companies coming on to the public markets. Notable water IPOs over the last several years have included American Water Works (the largest investor-owned utility in the country, which was publicly traded prior to its acquisition several years ago by RWE, and then re-floated onto the New York Stock Exchange); Cascal Inc. (publicly traded for a couple of years, but then snapped up by a foreign acquirer, Sembcorp); Energy Recovery, Inc., Heckmann Corporation; Polypore, and others. Within the last couple of years, although the IPO market has not been strong, newly public companies coming on to the public exchanges have included Primo Water - a bottled water dispenser that issued at a huge multiple to revenues - and Xylem, the spin-out of ITT Corporation's water business, which is now one of the world's largest pure-play and publicly-traded water companies. Global Water Resources, a small Arizona water utility, managed a small public offering on the Toronto exchange, after withdrawing an attempted offering in the U.S. a couple of years ago. This year, HD Supply, a plumbing supply business, was the largest water-related IPO, and stands at a market cap of around $4 billion. There are also numerous private financial placements and underwritings going on all the time for small but growing water companies. Venture-type investments in newer start-up water companies across the whole "clean tech" spectrum have also picked up considerably over the past few years.

An interesting paradox continues to perplex many observers here in the arena of water investment. In many regards, the water industry has never been "hotter" from an investment and financial opportunity and investment perspective. As described, there is a huge volume of investment funds seeking to find an interesting and profitable home in the water industry. Indeed, the situation often resembles a veritable stampede of investors. Yet, all of these investors are chasing relatively few real investment vehicles - there simply aren't that many public companies in which to invest, or sizable transactions occurring in the industry. From the perspective of the transactional "market" there is an imbalance between the supply and demand of attractive vehicles, and the result is often an extremely high transaction valuation.

This situation represents a major dilemma for the water industry - and is often difficult to explain to newcomers, given the growth and robustness of the industry. On one side, hungry investors are complaining about the lack of good investment opportunities, and on the other, the public is clamoring for funds to accomplish the rebuilding and expansion of a dilapidated water system. Given the urgency of the world's water problems, this is a situation which cries out for new and more innovative approaches - for more creative financial vehicles and mechanisms which will allow private investors to put their money to work for the public good, and concurrently be able to earn a competitive rate of return on those monies in the process. There is a huge interest in water investment, and we clearly have huge needs - we must figure out better mechanisms and investment vehicles to connect this supply of "water dollars" with the obvious demand for water dollars.

Although the global economic crisis has clearly impacted the water industry over the last several years, water companies - particularly water utilities - are more recession-resistant than most other companies. If there is one thing that we don't cut back on much during tough economic times, it is probably the water that comes out of our taps. There may be some impact on water consumption, but it seems to be fairly limited. Hence, companies that provide water don't really experience much impact from sharp downturns - or for that matter, sharp upturns - in the general level of economic activity.

In turn, the product and service firms which sell things to water utilities are likely to be at least partially buffered from sharp economic downturns as well. Given this tendency, in combination with the urgency of water challenges in many parts of the world, and the generally dilapidated state of water infrastructure, it seems a safe overall bet that the water business will remain a very vital and growing industry for a very long time, largely irrespective of external economic conditions. Indeed, many market sages believe that water stocks - and water utility stocks in particular - represent the kind of fundamental value-based proposition - in some senses, a "store of value" like precious metals - that few other industries will be able to match.

17. Ownership Changes and Industry Consolidation: One impact of the exploding strategic interest in the water industry has been a strong trend of merger and acquisition activity within the industry, consolidation among the key suppliers and ven-

Please feel free to distribute this report to anyone and everyone who is interested in the world water situation. Please attribute TechKNOWLEDgey Strategic Group when citing information herein.
It may be instructive here to review a little recent history. The widely discussed "foreign invasion" of the U.S. water industry occurred in the mid-1990s, when British, French and German companies gobbled up many of the larger suppliers in the U.S. water business. These buyers were largely driven by the belief that the U.S. water utility business was entering a wave of privatization - similar to what was happening then in Europe and the U.K. - and they bought a range of U.S. product and service companies to strategically position for this projected bonanza. However, that supposed trend toward widespread privatization did not happen, and has not happened, as we saw earlier. As a result, many of these acquisitions were strategically misguided, ill-timed or over-priced - oftentimes all of the above. Hence, this cycle of European investment began to reverse direction in the early 2000's.

Major assets owned by these earlier foreign consolidators then began to change hands again, and many were purchased the second time around by major U.S. industrial corporations. Veolia, Suez, RWE, and most of the other major European water companies retreated back to their original infrastructure services and utility management businesses. Most of these companies have long since exited most if not all of their equipment businesses in the United States. Global industrial firms such as General Electric, Siemens, Danaher, ITT Corporation (now Xylem), Pentair and 3M have emerged as new diversified water service and equipment companies. General Electric's rapid-fire acquisition of Ionics, Osmonics and Zenon - at very high valuations - is the most often-cited example of this trend. Today, Severn Trent is the only major foreign water utility that still has a significant equipment business in the States.

There have been fewer "block-buster" deals during the past several years - probably more because of a dearth of large pure-play acquisition opportunities than because of any lull in strategic interest levels. Unfortunately, one result of the high prices that GE, Danaher, and other large consolidators paid for water companies is that they helped to drive average valuations up, and left in their wake an unrealistic set of value expectations for hundreds of smaller technology developers, inventors, and tinkerers - who now all seem to think that their "better mouse-traps" should also be worth ten to twelve times EBITDA.

This trend of huge over-valuation was at least temporarily corrected by the tough economic conditions imposed during the recession. Transaction activity basically ground to a halt during 2009 and the first part of 2010. However, in retrospect, the last three years have been quite a surprise in terms of merger and acquisition activity in the water business. Although observers had expected general economic conditions to gradually improve, and although a bit of "pent-up demand" for deal activity had clearly developed on the part of many acquisitive companies, few expected the volume and intensity of transactions that have once again transpired. More significantly, almost no one projected a return to the huge valuations of the early 2000s - but deal prices have sky-rocketed once again.

It is interesting to note that, as a result of forty years of steady progress under the Clean Water Act, the treated effluent from wastewater treatment plants is sometimes cleaner than the supposedly "natural" rivers and streams into which it is discharged.

During 2012 and 2013, water M&A activity has returned to a fever pitch. Perhaps the biggest transaction over the last couple of years was the merger of the Flow Control division of Tyco into Pentair - valued at about $5 billion. The deal was part of a bigger and more complicated break-up of Tyco. Until very recently, there has also been a mad frenzy to grab a piece of the rapidly growing oilfield environmental and water management services field. The Siemens water business was finally sold in late 2013, at a much higher price than expected, to a private equity firm called AEA Investors - hitherto uninvolved in the water industry. It will be interesting to see how this business, now renamed Evoqua, will perform going forward as an independent and privately-owned company. As always, new and different types of buyers continue to emerge, and there are numerous and on-going and smaller deals occurring all the time.

So what should we expect for deal activity going forward? It is abundantly clear that there remains a strong surplus of "deal demand" - hundreds of potential acquirers are out there roaming the countryside for opportunities in the water industry of the future. These hungry buyers range all the way from the standard list of "suspects" among the large domestic strategic buyers, to smaller industrial firms, large foreign buyers, firms in unrelated industries looking to get a toe-hold in water, and of course the untold hundreds of private equity firms. But there are only a few quality sellers - of a decent size - that come onto the market each year. Hence, it seems safe to project a continuing supply-demand imbalance, and continuing high relative valuations.

18. Consolidation in the Public Sector As Well: When we talk about industry consolidation, it is usually from the perspective of the private sector - private companies merging with or buying each other, in the commercial sector of the business. However, with the efficiencies and economies of scale of larger water and wastewater operations continuing to grow, it seems increasingly possible - indeed even necessary - that consolidation within the public sector, or the municipal utility business, will begin to occur as well. As observers are increasingly pointing out, this just makes too much sense for it not to happen.

Water and wastewater treatment are both very capital-intensive businesses, and there is no doubt that scale can convey distinct operating, technical and financial advantages - whether the entities are privately or publicly owned. Yet, as we've seen, the municipal side of the business is primarily made up of very small local players - about 90 percent of all municipal drinking water systems are categorized as "small" or serving less than 3,300 people. As regulatory and compliance requirements continue to pile up, and as the business becomes more technologically complex and expensive to run, it seems logical that some of these smaller utility operations should find a way to combine forces and take advantage of at least some of these scale efficiencies. There has been some consolidation among private investor-owned utilities - but, as we pointed out elsewhere, privately-owned utility companies only represent a small fraction of the overall infrastructure. Hence, a policy debate is emerging around the challenges and the potential benefits of combining smaller public water and wastewater utility operations.
Relative to private transactions, trying to combine or "merge" municipally or governmentally-owned systems is far more difficult financially, and is obviously fraught with a whole range of sensitive political and fiscal challenges. However, such "mergers" or combinations would definitely make good economic and operational sense. Many industry observers believe that we must figure out some politically workable and acceptable means of consolidating small and local water municipal utilities. The alternative, they say, will simply be increasing non-compliance, or even bankruptcy, as these small utilities will no longer be able to keep up in an increasingly complex business environment.

There are other broader and more vexing policy questions in terms of this potential consolidation of smaller and local utilities into larger "super-regional" utilities. How would a consolidation of the public water utility business affect the delivery of water and provision of sewerage services? Would such combinations include other municipal services, such as solid waste and highway maintenance, or would they be restricted to water and wastewater? Could such super-regional utilities privatize themselves, and or even consider floating public stock - like what happened in the U.K. 25 years ago? Would it make sense to facilitate the merger of water and hydro-based power utilities, to more effectively utilize their common resource - water? Despite all of these unknowns, it seems likely that we will see more consideration of public utility consolidation in coming years.

19. Growing Concerns About the Impact of Global Climate Change: As more and more evidence piles up to suggest that climate change is indeed real, it is becoming ominously clear that this will affect the hydrologic cycle, rainfall patterns and future water resource availability - in numerous and complex ways. Although we may still be a long way from understanding these complex interacting factors, one thing is clear - increasing temperatures and more volatile weather patterns will complicate and exacerbate an already dire water situation. Vast new storage and transmission infrastructure to accommodate shifting weather and precipitation patterns may come first - particularly in the arid west, where melting snow provides much of the water for spring and summer use.

However, and more ominously, shifting population trends and large-scale human migrations could well be the ultimate result decades from now. It may sound like heresy today, but from a very long-term perspective, it seems inevitable that the huge capital and energy costs of moving water to supply booming desert oases such as Las Vegas will one day reverse, and we will see the large-scale movement of people back to areas of more abundant water. Volumes could be written about this topic; it goes well beyond the scope of this report, but it is important to start to think about the complications and huge challenges which the water business may face in the future as a result of incipient climate change.

(Editors' Note: We conclude, in Sections V and VI, as we have the past two years, by reviewing what we consider to be the four most critical and recurring themes in the water market - and what these themes imply and suggest for moving toward long-term solutions to the water crisis.)

V. Moving Toward Solutions:

Although it is often easy to become discouraged with or overwhelmed by the vast water challenges we face, fortunately many water problems do lend themselves to small and incremental solutions in many areas. Each of us can begin to take steps to address water problems, as we will see, even if some are only baby steps. There are also many larger initiatives and solutions that we can help set in motion - both individually and collectively - to address and reverse some of the more fundamental and problematic trends, and to begin to move things in the right direction. Below, as in the last few years, we will briefly examine a few of these recommendations and ideas - taken from our 2011 book The Future of Water (see brief description on the inside back cover of this report).

We Need to Develop Better Public Understanding of Water Issues: We have already discussed this critical issue in detail at the outset of this report, but nevertheless, better public education programs are critical in helping the broader public understand and address our myriad water challenges. If the broader population had a better understanding of the nature and seriousness of the problem, then presumably more people would start to act more responsibly, and would make wiser water decisions. For example, understanding that recycled water can be clean and safe to drink; understanding the water implications of having a plate of beef versus having a plate of chicken; understanding the implications of flushing unused pharmaceuticals down the toilet; understanding that our infrastructure is decaying and that it will be costly to replace; and finally, understanding that water prices will need to rise in order to cover the costs of providing safe and sustainable drinking water. The list of items goes on and on, but better public understanding of general water issues could help create progress across the board in addressing our complex and intertwining challenges. We can only hope as more and more people gain a better understanding of the true scope of the water challenge and how they can impact it, that they will start to make wiser decisions.

We Need to Think Globally, but Act Locally: Unlike most other resource problems and constraints, water challenges are typically regional or even quite local in nature. While technologies, conceptual solutions, and broad policy approaches may be similar and applicable around the globe, the implementation of these policies and approaches needs to be carried out on a more location-specific basis.

If China burns cleaner coal, air pollution problems in Japan may lessen. Water is different; improved water conservation practices in California aren't going to help to alleviate water shortages in southern India (although, as we will see below, when water consumption is viewed from a virtual or "contained" perspective, things are not so simple.) Some areas don't really have any serious water problems yet, while others face severe near-term crisis; each area is different. Observers used to say that the western U.S. has a water quantity problem, while the east has a water quality problem, but now we recognize that the whole country has both quantity and quality challenges. Obviously, more arid regions generally tend to face more serious and more immediate supply issues, even though (counter-intuitively) it's not always reflected in the prices that local consumers pay.

Water issues or challenges do vary widely from one watershed basin to another, based on population, level of industrial activity, climatologic conditions and so on. Technological solutions - such as desalination - may be economically feasible in one area but not another, depending upon alternative supply sources, local energy costs, or distance to the sea. One solution may work best for us, while a completely different one might work for our neighbors. In water, locally-based systems and imple-
mentation will always tend to work better than centrally dictated plans.

This "local" perspective is most likely to follow the geographic footprint of a single river basin area, or watershed region. Within a watershed basin, all users tend to have the same problem or face the same set of circumstances, and hopefully will share similar objectives in terms of water resource usage and management. Within a single river basin, all users should be willing to address - and pay for - certain water quality and water availability on some sort of equivalent basis. Meanwhile, water problems may be quite different or possibly even non-existent in a neighboring watershed basin.

It's worth noting there are some 260 "major" river basins in the world, and that these watersheds cross 145 national boundaries. Furthermore, it is estimated that some 60 percent of the world's population lives within those 260 basins. As water becomes scarcer, these three simple facts point to the likelihood of serious political conflict in the future. Although we're obviously not going to start redrawing national boundaries, we should try to reform political and social institutions to reflect this more regional nature of water problems. In other words, we should try to build political decision-making machinery that will work to coordinate national and international governmental structures around regional or watershed-based issues or challenges.

We also need to build new international coalitions and frameworks, and find innovative ways to cooperate - particularly from the virtual water perspective. An example of this is the recent purchase of vast swaths of land, and the development of agricultural capacity in wetter central Asian countries by the parched but wealthy Arabian Peninsula countries - a direct acknowledgement that it makes more sense to grow crops where rainfall is more abundant. In short, while one water allocation or conservation solution may work better in one area, a different one may work better elsewhere. And as we move forward, there must obviously be some mix of "top-down" and "bottom-up" strategies for sharing, and more efficiently allocating and using water.

**We Need to Pursue Incremental Technological Advances and Solutions:** We already noted that there isn't likely to be any major technological fix or "silver bullet" which is going to miraculously emerge to solve all our water problems. However, technology will continue to march forward, and we can do much better in terms of financing, applying and sharing technology and scientific understanding to better manage our scarce water resources.

Even without the "iron hammer" of higher prices forcing us to make more rational water allocation decisions, new technologies and systems can help us more efficiently produce and consume water. For example, as we saw earlier, advances in soil moisture monitoring and smarter irrigation techniques will contribute important savings in agricultural water usage. More widespread and advanced residential metering technologies will help us to be more careful and smarter about the way we use water at home. Techniques for in-situ repair and extension of the life of existing infrastructure can mean less water loss and wastage - and in turn, more water put to efficient use. Rainwater harvesting - whether an individual tank on the roof of a house, or a new storm-water collection system in a city - will prevent available fresh water sources from slipping away to the sea. Storing water in underground aquifers instead of in surface reservoirs will reduce loss from evaporation, and the lining of earthen irrigation ditches will prevent water from seeping away.

Creative technology developers in this country are often frustrated by the myriad certification processes and regulatory hoops through which they must jump, before they can get their new technologies approved for widespread use. Policies to incentivize new technology development need to be revamped and streamlined so as to encourage, not discourage, developers of new ideas and products. Another oft-cited challenge for technology developers in this industry is the glacial pace at which municipal users tend to accept new or different technologies. Municipal clients, along with their external engineering consultants, should try to be a bit more adventurous and willing to try new approaches and ideas to address their urgent water or wastewater treatment needs. We should be doing whatever we can to improve the regulatory and certification process, as well as adjust consumer attitudes to promote and encourage technological advance in the industry.

Clearly, there are vast opportunities to put new technologies, innovative management systems, and bright minds to work in addressing the world's water scarcity challenges. Advancing technology can be a critical component in addressing global water problems, but it must be exploited in combination with more careful and conservation-minded attitudes, greater efficiency in water usage and smarter policies, legal frameworks and management approaches. At the same time, we have to remember that technology alone cannot be relied upon to solve all our water problems. It may ease the pressure or delay the day of reckoning, but none of technology's bright solutions should lull us into thinking that we don't need to continue to work hard on water challenges.

**We Need to Develop Smarter Laws and Policies:** Talk is cheap - it's easy to say that we need to reform the way in which we legislate and regulate water issues. However, it's a completely different challenge to actually figure out a way to enact such changes, and put them into practice.

It's apparent that we need to think about refashioning many of our long-standing policies, regulations and laws - indeed, our whole way of thinking about water. Government subsidies, major federally-funded water projects, and interstate water distribution and irrigation programs over the past hundred years or more may have all been undertaken for what might have been sound political or economic reasons at the time. However, in some cases, they may have seriously distorted the workings of localized markets, or led to usage and allocation decisions that may not be in the best interests of the broader population today. Our current regulatory structure, while well-intended, often creates conflicts or unnecessary hardships, and sometimes may not even protect us against many of the contaminants and health risks it was designed to avoid.

Although we have just argued for the need to develop specific and local solutions to water challenges, there are also many broad and over-arching policy questions and legal frameworks that must be addressed in a more holistic manner at the national or even international level. As mentioned, there are many critical watershed-based concerns that don't follow political
boundaries, and which can only be solved by international cooperation. Even more vexing are the challenges of trans-boundary underground aquifers, where the Texas-style "rule of capture" usually applies - "whoever has the biggest straw, can take the most water." In many of these international water issues, even where there may be treaties or legal precedents in place, there is typically no body or agency authorized to enforce such precedents.

To look at just the United States, the sheer number of different federal agencies involved one way or another with water tends to make policy coordination or change an almost impossible challenge. Presently, almost forty federal agencies or entities have some kind of authority over various water issues - and they often act in isolation with only their narrow objectives in mind. These entities are spread across six cabinet departments, thirteen congressional committees and some twenty-three subcommittees - all involved one way or another in water resource management. Hence, it's no wonder that federal water regulations and policies are sometimes confusing or contradictory - and all of this is at the federal level, before we even get down to state, local and regional watersheds authorities of various types. Consolidation of these responsibilities into some sort of coordinated department or agency would help get rid of the "silos" and make the job of holistically managing water resources easier - the concept of "one water" promoted by the Clean Water America Alliance (now the U.S. Water Alliance) and other interest groups. Most politicians today throw up their hands and say that such consolidation of power and control is impossible - but it's going to become more and more critical.

The whole arena of water resource ownership - the legal framework of both the prior appropriation and the riparian water rights doctrines - is coming more and more to the forefront of water resource and management issues, particularly in the arid western states. Questions and conflicts abound here, and resistance to any type of change in the legal framework could ever be reopened or changed, but some day they may have to be. • How will these legal and historical frameworks potentially be impacted by climate change? As we've discussed, this is currently one of the great unknowables of the whole water resource area.

Many observers have pointed out that we suffer not so much from an absolute shortage of water as from an inability to properly manage and allocate the water which we do have. This is a good perspective to keep in mind, but it requires us to resolve a lot of these intractable policy questions and to reformulate our political institutions. An *Economist* report from a few years ago concisely concluded that water is "ill-governed and colossally under-priced." Professor Asit Biswas of the Third World Centre for Water Management, a leading authority on international water management, has widely insisted that there is no water crisis, and that we have plenty of water to go around - we just need to get better at managing and using it. But, as Peter Gleick of the Pacific Institute put it in a recent report, "there is a vast amount of water on the planet - but we are facing a crisis of running out of sustainably managed water."

VI. Summary and Conclusions:

Now that we have reviewed many of the critical trends and recent developments in the broader world water market, in closing it is useful to turn our attention to *four critical themes* underlying and recurring themes which may offer ways of beginning to address and resolve our pressing water problems.

**We Need to Balance Our Resource Trade-offs in a Smarter Manner:** Water will become a more critical issue and key determinant in almost all personal, economic and business decision-making. This is already starting to happen - from personal and residential decision-making, to the corporate boardroom, where water is an increasingly important component of longer-term business strategy. But, despite our focus on water in this report, it's not the only factor or input that we should consider in making economic or social decisions. Unfortunately, a logical and well thought-out approach to more sustainable behavior with respect to one objective may often be at odds with another objective. For example, it's often not possible to minimize our carbon and water footprints at the same time. Buying asparagus grown in the central valley of California with scarce water transported from hundreds of miles away may not be very good for our water footprint. On the other hand, buying asparagus grown in Peru and shipped by air and truck to the local grocery store is not very good for our carbon footprint. As consumers, we will increasingly have to make trade-offs in terms of trying to achieve admirable but sometimes conflicting objectives.

Or, consider another example - the "buy local" consumer trend that is emerging in many areas as a means of promoting local agriculture, eating fresher food, and reducing the carbon footprint of large-scale food transportation around the world. The buy-local movement, while it has many attractive aspects, may often be in conflict with the concept of water footprint or indeed, simply the actual availability of water. Does it really make sense to use scarce water trying to grow vegetables in the desert outside of Santa Fe so that wealthy residents can enjoy the satisfaction of buying foodstuffs at local farmer's market? If one looks around at many of the major and growing cities in the Southwest, and elsewhere around the world, there simply isn't sufficient water or the appropriate climate to locally grow all the needed food.

And it's not just water or energy considerations that go into these difficult decisions and trade-offs. The other inputs or decision factors that we have been highlighting also enter into the equation. Labor costs and conditions are often issues. The capital costs of making a product in one place versus another place can often be quite different due to variable environmental regulations. This is one reason why we've seen so much mining and manufacturing move out of the United States over the past few decades. Geopolitical, moral and ethical considerations can also cloud and complicate these types of decisions. Should we buy jogging shoes made in a plant in Asia with poor working conditions, when boycotting those shoes may put the plant out of business altogether and drive those employees into even deeper poverty?

Sometimes, evaluating a decision or a behavior and trying to take into account all of these critical inputs can lead to some very interesting, or counter-intuitive conclusions. Said another way, when attempting to take into account energy consumption, food consumption, and implied water and carbon footprint in carrying out routine daily tasks, some researchers have come to some rather surprising, or even humorous findings. For example, it's been suggested that in some cases it may be
more environmentally sustainable to drive your car to the store to pick up a few items, than it is to bike or walk.

How can that be? Let's say you live in Norway - close to abundant fossil fuel production - but where much of your food has to be grown far away, say on farms in Spain. Those Spanish farms have to be irrigated and treated with chemical fertilizers. When they are ready to be harvested, those water and energy-intensive foodstuffs are flown in high carbon-footprint jets to Norway and then trucked to the store, where you buy them to provide your body with enough energy to walk or ride your bike. Taking all of these various concerns and inputs into consideration, researchers have (only half tongue-in-cheek) been able to show that it is better to just hop in the car, utilizing cheap local energy, if you need something from the store - and save all that caloric "energy" needed to walk or ride your bike there. And, as you might guess by now, this effect is even more pronounced depending upon whether you're a vegan or if you get your sustenance from eating beef.

On the other hand, if you don't ride your bike to the store, you won't have to use so much water to wash your sweaty clothes, and you won't have to dump as much phosphorus into the sewer from your detergents. But then again, water is plentiful in Norway. One can talk around and around in circles on some of these issues, but one can also begin to see the complexity of really looking at an issue or a given behavior from a broad environmental sustainability perspective. What is a unit of water worth, versus a unit of energy, versus an avoided bit of carbon into the atmosphere?

In summary, one approach or objective - like minimizing your water footprint - may appear very logical or elegant when viewed in isolation, but when it is viewed from a more holistic and integrated perspective, things become murkier, and we understand that many different approaches and objectives have to be considered and balanced. As we step back and take a more global view, it becomes clearer that all these issues are fundamentally tied together. We can't view any of these issues in isolation. For any individual person in any specific place around the globe, our carbon footprints, our water footprints, our agricultural footprints and food consumption are all tied together in different and complex ways.

We Need to Think About Water Consumption in Terms of Virtual Water: Virtual water is defined as the total amount of water that it took to produce the goods and services we buy - or that is required by the behaviors in which we engage. We must start to incorporate this concept of virtual or "contained" water into our consumption and commerce patterns. International systems which promote the growth of water intensive crops in more water-rich areas and exports to relatively drier countries would help free up water in the drier country for more critical uses. This might help to create a more stable political situation in the process. As water becomes scarcer and more expensive, this will naturally start to happen - but we need to devise ways of hastening this type of thinking. The liberalization of agricultural trade policies and tariffs is obviously another vexing political challenge, but progress here could contribute to better production decisions, and ultimately to the individual competitive advantage of nations.

At the same time, the concept of virtual water has serious limitations, and may in some cases conflict with other trade or consumer objectives, as we've discussed in the previous section. Because food requires so much water, international trade patterns in virtual water are essentially a reflection of trade patterns in agricultural commodities. Stronger industrial coun-

tries without as much agriculture will obviously tend to be net importers of water in the form of food, whereas less industrialized and more agrarian countries will tend to be agricultural (and water) exporters - regardless of their natural water resources. As Christopher Gasson of Global Water Intelligence put it recently "you cannot tell peasant farmers in North Africa or India that they should give up their land and become advertising executives or bank clerks because those professions use the least water." "Perverse" virtual water flows will continue, but what really needs to be addressed - as we have emphasized throughout - is the efficiency of water consumption where it is most scarce.

As we noted earlier, improved direct water conservation practices in Colorado are not going to help solve water problems in southern India. However, changing certain types of purchasing habits in Colorado may indeed contribute to solving water problems in southern India. Shifting patterns of food consumption, or changes in our consumer purchasing could potentially have a major impact on water availability elsewhere in the world. These are big issues, and things are not going to change overnight, but a better understanding of our real water usage will allow us to at least think about how to make better decisions.

We Need to Develop More Holistic Approaches to Water: We all talk about different "kinds" of water - drinking water, wastewater, storm water and so on - but hopefully this discussion has demonstrated, in the final analysis and from a more holistic perspective, that all of these different types of water are all just simply one thing - water.

Too often, however, we all still think and behave as though water were defined and characterized by these different labels. Too many of us still think of ourselves as "storm water managers" or "drinking water guys" or "wastewater experts." Storm waters and sewage are still typically thought of as a problem or wastes to be disposed of - not as potential resources to be harvested and productively used. Groundwater users are still treated to a different set of legal and regulatory requirements than surface water users - even though we understand now that surface and ground waters are often interconnected. And as we've just discussed, these perspectives and problems are unfortunately reinforced by an increasingly archaic and often conflicting set of federal and state laws, by a plethora of congressional and legislative committees with disparate jurisdictions, and by numerous water agencies with a single purpose or narrow mandate. And it's generally the same situation around the rest of the world.

We now understand that not only are most of our water problems inter-connected, but that they are also interrelated with many critical issues beyond water - energy supply, air pollution, urban development, endangered species, transportation and housing, and so on. The more we learn about a given water problem, the more often it requires us to stretch our thinking outside the traditional mindset of water sector professionals. We need to move beyond this patchwork type of approach. Our water policy is now too critical to be defined or governed by these types of historical approaches.

This type of constrained thinking is a major cause of dysfunction as we try to formulate more of a national water policy. The proverbial "silos" or "stovepipes" of different and often conflicting stakeholders may have made some sense at one time in the past, but in a collective sense they are now woefully outdated. And while many of us may be starting to grasp the concept of "one water," we still don't usually behave in the...
There is a huge interest in water investment, and we clearly have huge needs - we must figure out better mechanisms and investment vehicles to connect this supply of "water dollars" with the obvious demand for water dollars.

prescribed manner. It is much easier said than done - but we need to get rid of all these little tails that are still trying to wag the big dog. We need to think outside of these silos about all of our different types of water, and begin to consider all of them as just "one water."

Think for a moment about an astronaut circling in a spaceship far above the earth, gazing out the window and looking down at our spherical little planet Earth. From that perspective, it's pretty clear that we are a separate and self-contained little ball, mostly covered with water - a closed system, a zero-sum game, an isolated and solar-powered desalination plant quietly floating through space. We need to think of our water resources from the perspective of that astronaut. We have a lot of water - most of it is in the ocean right at the moment, some of it is raining down over the continents in various places, some of it is flowing down rivers and streams, some of it is sitting quietly in underground aquifers or polar ice-caps, some of it is dirty and waiting to be cleaned up - and some of it is flowing through our houses, businesses and bodies at the moment. Each one of us uses some of those molecules of water, we will make some of it dirty, we will clean it up again, and someone else will use it later. We can't create new water, and we can't destroy it, it is just there - water - and we can use it, over and over again.

We Need to Prepare for the Inevitability of Rising Prices: And finally we return to perhaps the most important theme in the water market today - the desperate need to better recognize the true value of water, and to move toward more realistic and full-cost pricing of water. If there is one single and inescapable conclusion resulting from any review and discussion of the world water situation, it must surely be this inevitability of continuously rising water prices over the longer-term - indeed, the urgent need for rapidly rising water prices in many parts of the globe, to better reflect that true value. As water prices rise, not only will they more accurately reflect the actual costs and the true value, but they will also help - in a gradually self-reinforcing manner - to facilitate many of the necessary changes in thinking, policies and usage that desperately need to occur.

Water has traditionally been priced so low that most users simply don't have any economic incentive to conserve it or use it wisely. People naturally don't pay much attention or conserve a commodity if they tend to view it as virtually free. Until recently, that is the way most people, particularly in the U.S., viewed water. And too many politicians around the world seem to think, "If you want to stay in office, you have to provide people with (essentially) free water."

The true cost of delivering clean water - as well as the average price of water - is continuing to creep slowly upwards in most localities, but in most areas, public pressures and governments have not allowed prices to rise at the kind of rates which will be necessary if we are going to upgrade and maintain our infrastructure on a truly sustainable basis. Almost all water utilization decisions and resource management issues would be far more efficient and solutions would begin to emerge more quickly if water was priced more realistically.

As prices rise, decisions about water usage will inevitably be-

gin to take on greater significance in the overall economy, and many of the incipient trends discussed above will gather steam - greater reliance on re-use and recovery, more emphasis on conservation, a continuing trend toward more private-public partnerships, and more rapid advances in technology.

Among observers and water policy leaders, there really isn't a lot of dispute about this. The key policy question here is not really whether prices should rise, but more how they should rise - gradually and "naturally" due to the market forces of supply and demand, weak and distorted though these forces typically are, or more through various government mandates and policies.

However, there is the critical flip side of this coin - higher water prices also inevitably raise the issue of the "ability to pay" by different people all across society, and the question of whether and how subsidies should be provided to certain parts of the population. This is an issue which may not be adequately addressed by market mechanisms, and which must receive careful attention from federal and local policy makers. Indeed, one of the great challenges of the future of water will be trying to simultaneously treat and manage water more like a commodity so as to manage it more efficiently, while at the same time recognizing that access to a certain amount of water is a fundamental human right. In the U.S., we've tried to work out that challenge with regards to food through the use of food stamps and various other federal and state programs - and we'll likely need something similar to assure adequate access to water for all.

So, we still have many challenges to face and solve in the water business. Yes, water frequently falls from the sky, and three-quarters of our planet is covered with water. And yes, fresh water is still abundant in many parts of the globe. But it's not always clean, it's not always where we need it, it's not always there when we need it, and it costs hundreds of billions of dollars a year to collect, clean, and distribute. Water itself may still be relatively abundant and cheap in many areas, but the cost of water services - to collect, clean and distribute water - are rapidly increasing. The twin challenges of water quantity and water quality represent an inexorable planetary crisis - perhaps, as many have called it, the defining crisis of the 21st Century. The world's population has increased four-fold over the last hundred years, but we still have the same amount of water. The problem has developed gradually, but its ultimate effect could be dire - thousands of people are already dying every day as a result of water scarcity and quality problems. And, unlike any other commodity, there is truly no substitute for water. We are facing serious water challenges in the near future, and we need to take more substantive and dramatic steps right now to begin addressing these problems.

Steve Maxwell (303) 442-4800
TechKNOWLEDGEy Strategic Group
443 Mountain View Road
Boulder, Colorado 80302
www.tech-strategy.com
@smaxwell_water
STEVE MAXWELL with SCOTT YATES
the
Future of Water

A STARTLING LOOK AHEAD
Foreword by Bruce Babbitt, former US Secretary of the Interior

"For a much more in-depth analysis of the world water situation, and the future water challenges we face, read our new book The Future of Water. Available now from the American Water Works Association, and from Amazon.com and other booksellers."

Praise for the Future of Water

"Steve Maxwell takes us straight into the realities of the water crisis that is now spreading through all parts of the country, and indeed of the entire world."

—From the foreword by Bruce Babbitt, former US Secretary of the Interior

"The Future of Water is sobering and exhilarating at the same time. It's sobering as Maxwell and Yates detail just how water touches so many aspects of modern life, and how dire the situation might be if nothing changes. However, this book is also exhilarating in the fast-paced way it examines the future of water, from our own kitchen sinks to massive dams in China."

—Bill Owens, former Governor of Colorado

"Water is our greatest global challenge and local opportunity, and yet it seems invisible to many and inexcusable to most. Maxwell connects the dots and drops to chart a more sustainable future for our blue planet and for your community watershed. We need to wake up and smell the water, change our old policies and paradigms, and begin to manage water as one resource, integrating and innovating from top to bottom, above and below."

—Benjamin H. Grumbles, President, Clean Water America Alliance, former EPA Assistant Administrator and Arizona Environmental Director

"This is the book the industry and the public it serves has been waiting for—a clear, concise, comprehensive, and authoritative look at just the future, but to the context from which that future is evolving. This is an important book that will become a reference for water professionals, policy makers, and private citizens concerned about our water future, and what we can do to craft it."

—Bill Bertera, former Executive Director, Water Environment Federation
How Are We Different?

- We have an unparalleled set of contacts in the industry – and a thorough knowledge of both the buyers and the sellers
- We work with clients whose revenues are less than $1 million and up to $20 billion
- We don’t charge an arm and a leg just to get started on your job - no large retainers
- “No “bait and switch” – Steve Maxwell manages each job, regardless of size
- We publish one of the industry’s most comprehensive sources of competitive and market information – the annual Water Market Review
- Our long experience has shown that, in the final analysis, the only deals that get done are ones that are fundamentally fair and equitable to both sides – and we strive to accomplish that in every deal

For information, references, or to discuss an assignment, contact:

Steve Maxwell, Managing Director
443 Mountain View Road, Boulder, Colorado 80302
Phone 303-442-4800 maxwell@tech-strategy.com
www.tech-strategy.com

MWH LABORATORIES has been acquired by

eurofins

We assisted the Seller.
July 2012

eureka has been acquired by

measurement specialities

We assisted the Seller.
July 2011

NEA

has been acquired by

Face Analytical

We assisted the Seller.
October, 2010