2010 WATER RESEARCH FOUNDATION PROJECTS

The Water Research Foundation research budget in 2010 is $6.25 million. The Foundation's Board of Trustees selected 21 projects for 2010 funding at their January 15, 2010 meeting. The Foundation will fund 18 of these projects competitively, issuing requests for proposals (RFPs).

The Foundation's $6.25 million research budget will be leveraged with partnerships and in-kind support to an anticipated total research value of $15 million. Some 30 percent of this total will fund research under the Foundation's three strategic initiatives: climate change; distribution system water quality; and endocrine-disrupting compounds/pharmaceuticals and personal care products.

Solicited and Partnership Projects

- ***An Operational Definition of Biostability in Drinking Water (#4312)***
  Water treatment professionals seeking to minimize regrowth in distribution systems have identified biological stability as a goal; however, biostability of treated water is a loosely defined parameter in North America. The term biostability is better defined in various European countries, although it is likely that the European definition is not appropriate for North America because of the maintenance of high residual disinfectant levels in North American distribution systems. Depending on the type of treatment technology employed and the type of residual disinfectant used, the biostability of water could potentially be defined differently in different systems. These differences could also translate into varying impacts on regrowth within the distribution system. Water utilities in North America have a strong need to have an operational definition of biostability of treated waters and also will benefit from best practice guidelines to achieve a high degree of biostability as a function of treatment characteristics.

  Biologically stable water can be defined as water that does not change with respect to microbiological growth or decay as it travels through the distribution system. The goal of treatment can be to produce water that is not likely to support bacterial growth (biofilms) in distribution systems and premise plumbing. European systems have been designed to produce biologically stable water in the absence of a secondary disinfectant, which is contrary to common practice in North America. In addition, the measurement methods available to assess biological stability are often expensive and cumbersome. If the concept of producing biologically stable water is to gain acceptance in North America, it will be necessary to adapt existing information from the experiences of other countries and North America into practical guidelines for operating treatment plants to produce this high quality water and also to identify areas where critical impediments to implementation of these practices exist.

  This project will be an extension of Foundation Project 4129, "Potable Water Biological Treatment." The goal of this on-going work is to conduct a survey to assess the state of the art of biological treatment in US systems. The work should also build upon Investigation of the Biological Stability of Water in Treatment Plants and Distribution Systems (2000, Order #90794). The investigators on this project noted that measurements for determining the biological stability of water were not always straightforward, and that disinfection affected biological stability. The outcome was a need for improved models to predict biofilm growth. A second Foundation project, Optimizing Filtration in Biological Filters (2000, Order #90793), provides design objectives for biological filtration and guidance for selecting biofilter media and backwashing procedures. The focus was on single stage filters, but the scope was limited to pilot scale tests and a very small number of full scale facilities. The project also noted that there is a need for developing guidelines for biodegradable organic matter because this information is critical for the design and operation of biological treatment methods. To date, this need has not been addressed. The proposed project may address this need as part of the guidelines for producing biostability. A third completed project, Microbial Impact of Biological Filtration (1998, Order #90743), showed that biological treatment did not adversely impact the microbiological quality of water and in general could improve finished water quality. The proposed project can build on this project and determine if biological treatment affects biostability.

The objective of the project is to develop a practical and operational definition of biologically stable drinking water and to develop guidance for water professionals on how to optimize treatment prior to water distribution to produce biologically stable water that will not promote the growth of pathogens.

- ***Business Continuity Plans for Water Utilities (#4319) (partnership with American Water Works Association)***

  Disasters occur in many forms: civil (9/11), economic (chemical shortages, large business failures, natural (pandemics, hurricanes), technical (Y2K, Northeast Blackout of 2003). When disaster strikes, either suddenly or gradually, locally or widespread, businesses and public sector agencies respond using plans developed for emergencies. However, this is not the only response framework that should be activated. A Business Continuity Plan (BCP) is also needed to sustain the organization as it responds to public or stakeholder needs. One analogy is that Emergency Response Plans (ERP) "stop the bleeding" and Disaster Recovery Plans (DRP) "heal the wounds." Business Continuity Plans "keep the heart beating" so the organization can effectively carry out not only its emergency response activities, but also disaster recovery activities.

  Despite their role as critical infrastructure stewards, few water utilities have specifically developed BCPs. As a result, when they must implement their ERP, they often do so without a systematic business plan for supporting their emergency response and disaster recovery activities. In major events, the normal standard operating procedures (SOP) are not adequate to meet the challenge, and the absence of a BCP puts water utilities at risk of being unable to avoid unnecessary adverse customer and community impacts. A BCP is an umbrella plan that enables utilities to respond effectively and sustainably to continue essential operations and business functions while conducting emergency response and disaster recovery responsibilities.

  The Water Sector Coordinating Council (WSSC) identified providing "guidance on business continuity/continuity of operations planning (COOP) in the water sector" as one of the eight top priority activities needed to significantly mitigate risk in the water sector, noting that there are limited resources available for BCP/COOP development and training

(WSCC Strategic Roadmap, 2008). The Water Research Foundation and AWWA have budgeted funds for this project to address the resource limitations and develop guidance, tools, training materials and training opportunities to meet this need.

Business continuity planning, like many concepts, is not so much a new idea as it is an idea that has drawn more attention in the past few years. The Y2K efforts worldwide in the late 1990s are a good example of anticipated potential technical disaster and preparing for continuity. The NYC World Trade Center collapse in September 2001, while a major disaster, did not engulf the NYC water supply infrastructure, but has certainly had a huge impact globally on preparations for business continuity, particularly in development of greater security safeguards. Hurricane Katrina offers another example of how emergency response plans and activities were insufficient to cope rapidly and effectively with a major disaster that overtook most public infrastructure itself, as many employees were unable to report to work, and those that could struggled to do their best with little support available from their organizations. In 2006-2007 the British Standards Institution released a new independent standard for BCP. The International Organization for Standardization published business continuity guidelines in 2007 as ISO/PAS 22399:2007.

Although we have not made a similar comprehensive effort yet in the United States, efforts in several sectors offer models that could be useful in the development of BCP guidance for water utilities. Examples include:

Fire Protection: the National Fire Protection Association's NFPA 1600, "Standard on Disaster/Emergency Management and Business Continuity Programs" http://www.nfpa.org/aboutthecodes/AboutTheCodes.asp?DocNum=1600, and NFPA 1620 "Recommended Practice for Pre-Incident Planning" (2003 edition), with new editions underway.

Local government finance: "Stepping Back from the Edge of Disaster; capital Planning for Resiliency," http://www.gfoa.org/downloads/Capital_Resiliency_GFR_dec07.pdf

BCPs can range in complexity from a minimalist plan for a small organization, up to very complex and major undertaking for a large utility. In its most basic form, it would consist of a manual available for reference before, during and after disruptions, would outline different types of disruptions and identify basic assignments and activities for utility staff. At its most complex level, it could take the form of an electronic system for BCP management and communications that incorporates changes as they are made to the plan and pushes them out to all staff and cooperating agencies before, during and after a disruption.

In terms of content and practice, all BCPs should include specific components such as a list of essential functions (EF), staff in charge of each EF, operations of each EF, and identification of the mechanisms for transitioning from normal Standard Operating Procedures to new ones that are contained in the BCP, ERP and DRP. These may be hazard-specific, or at least anticipated by such events. Additional components may include identification of critical documents, development of an umbrella framework for linking all ERPs and DRPs in the organization (possibly in a matrix), identification of and preparation for alternate locations for business operations, identification of critical customers, methods of handling widespread service disruption, and specific plans to adapt to changing circumstances during an event.

The objectives of this project are to:

- Provide water utilities with an understanding of the nature, triggers and components of business continuity planning, and how a BCP is different from but complementary to an ERP and DRP.
- Provide a sample business case, including cost-benefit analysis, as to why BCPs are important to utilities and how they fit into the organizational structure.
- Using case studies, provide water utilities with an understanding of how business continuity plans have been developed and implemented in water utilities, and how they have performed.
- Provide water utilities with an overview of different levels of investment in BCPs, and guidance such as decision support tools (including a size-sensitive template, and a business case template) for utilities to select the approach that will work best for their circumstances.
- Provide training materials that can be used by water utilities as a basis for developing and implementing a BCP.

- ***Effective Microbial Control Strategies in Response to Main Breaks and Depressurization (#4307) (partnership with United Kingdom Drinking Water Inspectorate)***

While data are limited and different estimates have been made, main breaks occur frequently, over 700 times per day in the United States (Cromwell et al., 2001). When a pipe break takes place along with depressurization, the potential exists for influx of external contamination from soil, groundwater, or surface runoff into the distribution system. This external contamination can introduce undesirable microorganisms, chemical compounds, debris, and particulate matter into the distribution system. Even if depressurization does not occur when there is a pipe break, the integrity of the pipe has been compromised, and external contaminants can later enter the pipeline if pressure fluctuations occur.

One of the biggest concerns about intrusion events associated with pipe breaks is the fate of introduced pathogens and the relative effectiveness of repair practices along with disinfection residuals in the distribution system. Maintenance of a disinfectant residual is considered an important parameter to sustain the integrity of a distribution system. It is believed that a disinfectant residual helps control distribution system contamination, limits bacterial growth, inhibits biofilm formation, stabilizes water quality, and provides a sentinel when contamination has occurred (Kirmeyer et al. 2001, U.S. EPA 2006). However, if intrusion associated with a main break occurs, disinfectant residuals decrease due to disinfectant demand from external contamination or reaction with organic matter from external sources. Thus, in circumstances where a main break occurs, intrusion of pathogenic contaminants and decay of the disinfectant residual could result in some level of exposure to pathogens and related waterborne illness. The Foundation project (order #90835) “Pathogen Intrusion into the Distribution System” identified that main break sites are one of the high risk pathogen routes of entry to the distribution system.

In Cabool, MO, waterborne contaminants entered the distribution system through main breaks and service meters, causing an outbreak of hemorrhagic E. coli serotype O157:H7 (Geldreich et al. 1992). In the United Kingdom, five waterborne disease outbreaks were linked to microbiological contamination of water mains (Galbraith et al. 1992). In addition, recent reports indicate that more waterborne outbreaks result from breaches in distribution system integrity than from problems in the watershed or treatment process (Craun and Calderon 2001, Committee on Public Water Supply Distribution Systems 2006).

Furthermore, increased disease incidence was specifically associated with main breaks in situations where repairs were made under pressure but there was no disinfectant residual (Nygaard et al. 2007). Therefore, it is important to understand what disinfection strategies and operational practices are necessary to control pathogens introduced during main breaks and subsequent repairs.

Main breaks can be broken down into five stages, each of which has its own distinct microbial contamination scenarios: 1) the initial break with or without significant depressurization; 2) the controlled shutdown and isolation of the break site; 3) the repair; 4) post repair practices such as flushing; and, 5) return to service. For most utilities, the definition of "break" varies and most "breaks" are repaired by clamps or similar means that do not require depressurization or a complete shutdown, and may involve very limited risk if the response to the break is carried out well. In these cases, any associated microbial contamination would be similar to an intrusion scenario (i.e., small amounts of contamination into large volumes of flowing drinking water). However, when a large break or a blow out occurs, dirt, soil, trench water and more can gain access to the system, and a very different contamination scenario unfolds. Information is needed to address these differing scenarios and to determine where and when microbial risk is important.

The objective of this project is to validate the efficacy of chlorine and chloramine along with additional operational strategies for mitigating exposure and risk to pathogens during main breaks and depressurization, and to identify parameters that could be used to quantify the level of control achieved during such events.

- ***Identifying Meaningful Opportunities for Health Risk Reduction (#4310) (partnership with American Water Works Association and United Kingdom Drinking Water Inspectorate)***

  The Safe Drinking Water Act (SDWA) is based on changes in regulations that are made when "meaningful opportunity for risk reduction" occurs. This decision must be made within the constraints of "best available information"; the available information is often incomplete, and frequently the regulatory decisions are made without fully understanding the opportunity for actual risk reduction. Consequently, public concern and utility resources are directed toward issues that may offer de minimus risk reduction. Utilities often follow this national example when allocating resources to improve the treatment process. As a result, improvements are typically prioritized in response to regulatory compliance without regard to what improvements will give the greatest risk reduction.

  Using a comprehensive risk cup paradigm for future regulatory decisions can better direct limited resources toward reducing contaminants, which will result in the greatest risk minimization. The risk cup is a risk assessment concept that estimates total contaminant exposure and risk using the best available information. A full cup represents the total amount of contaminant-related toxicity (or more generally, harm) that an individual receives from drinking water, food, and environmental exposures. The rim of the risk cup is defined as the level of cumulative toxicity that results from routine exposure over a lifetime that does not result in significant health risk.

  It is necessary to evaluate the risk cup methodology against historical record, and to evaluate potential approaches for applying a risk-cup-methodology-based decision-making process into utility-specific and national regulatory decision making. Preparing this risk cup methodology will face several challenges beyond information scarcity, as the methodology must be sensitive to (1) utilities operating within a triple-bottom-line decision environment and (2) necessity to capture risk management across exposure media (e.g., where does reduction in risk through the medium of drinking water represent the most cost-effective risk management strategy).

In spite of these challenges, such a proven methodology would be beneficial to drinking water utilities. No processes, including regulations or other external drivers, currently exist to provide guidance in assisting individual water systems to help prioritize the expenditure of resources to achieve health risk reduction. Once established, this methodology will provide a useful tool to aid utilities in prioritizing risk reduction measures for specific drinking water contaminants and also in communicating the relative risk posed by specific contaminants from drinking water.

The project will develop an alternative health risk assessment methodology that captures cumulative health risk associated with drinking water. Once established, this process will provide a useful tool to utilities to aid in prioritizing risk reduction measures for specific drinking water contaminants, and also to help in communicating the relative risk posed by specific contaminants from drinking water. Utility case studies will illustrate use of the assessment methodology.

- ***Information Optimization for Water Utilities: Strategic Vision, Integration, and Investments (#4316)***

  In 1993, the Water Research Foundation published a review of state-of-the-art and emerging technologies and applications of computer based monitoring, control and management of water utility operations, Instrumentation and Computer Integration of Water Utility Operations (order 90588). The book introduced and defined the concepts of computer-based instrumentation and integration and identified the drivers for water utilities to employ these tools to optimize utility operations. Challenges to optimization were also identified. The book has been heavily used as a reference for utility IT managers since its publication. Nonetheless, computer-based monitoring, control and management have advanced significantly since the publication of that book, and new topic areas have also arisen. An update is overdue.

  The book identified the state-of-technology, predicted future development, and research needs for:

- General technology and principles (sensors, control devices, types of controllers, SCADA, operator-process interface)
- Control systems (pumping, supply management, treatment, distribution)
- Information systems (metering, CIS, Mapping and GIS, LIMS, MMS, leakage, and emergency response)
- A range of challenges was also identified and discussed at length: organizational and personnel, standardization and the standards development process, strategic IT planning, and research needs for managing these challenges.
- Water utilities need an overview document of information technologies and their potential that provides up-to-date information on the new and emerging technologies and their applications; identifies opportunities for creating computer interoperability of systems and technologies; and projects future needs. Such a guide will help water utility managers educate staff who are unfamiliar with the potential and limitations of the technologies, advocate the bigger picture, and leverage the interoperability of systems. Such a guide serves as a resource that will help managers promote collaborative and interoperable development and implementation of projects and prevent ‘siloed'

development and implementation.

- Information technology spans every function within a utility, and is indispensable for large utilities. Despite its importance to efficient and cost-effective operations, monitoring, business processes, and communications, IT is often brought in to business discussions after the strategic decisions have been made. Opportunities are lost for better alignment with business processes, cost savings through more efficient design and use of IT, and greater effectiveness in serving the mission of a utility. In project 4097, "Optimizing Information Technology Solutions for Drinking Water Utilities" (publication pending) identified several research needs for optimizing information technology. The update to the 1993 publication will include an expansion of the portions of the publication regarding strategic planning to address several of the issues identified in project 4097.

The objective of this project is to provide a comprehensive update of the Water Research Foundation (previously Awwa Research Foundation) 1993 publication Instrumentation and Computer Integration of Water Utility Operations (order 90588), which is a guidance manual for instrumentation, automation, and computed-based integrated operation of water utilities. This update will:

- Include reviews of state-of-the-art and emerging technologies and applications of computer-based monitoring, control and management of water utility operations, from capturing raw water at the source through treatment and delivery to customers, including all of the supporting systems.
- Address new concepts since the initial publication and provide linkage (cross-reference) to other research projects of the Water Research Foundation.
- Expand the publication through addressing several IT research needs identified in project 4097, "Optimizing Information Technology Solutions for Drinking Water Utilities" (publication pending) regarding the development of a strategic vision that incorporates IT as an essential partner in utility business planning, guidance on implementing the business-IT integration, and development of a business case methodology to evaluate potential IT investments and the communication of the business case for those investments.

- ***Legacy of Manganese Accumulation in Water Systems: Assessment, Consequence, Remediation and Prevention (#4314)***

Manganese in drinking water has long been regarded as only an aesthetic problem. Unfortunately, many decades of accumulation in distribution systems and periodic re-release of significant quantities of manganese and other adsorbed compounds associated with the manganese deposits can cause more than the traditional aesthetic issues.

The ongoing Water Research Foundation project, "Assessment of Inorganics Accumulation in Drinking Water System Scales and Sediments," will touch on the mechanisms of inorganic accumulation, including that of manganese (Mn), in the distribution system. Another Foundations Project, Occurrence of Manganese in Drinking Water and Benefits of Enhanced Manganese Control (#91147), found that problems associated with manganese are much more common than previously thought. Geographically, manganese can occur throughout the United States and be present in both ground and surface waters. According to the same project, both high and low concentrations of manganese in treated water result in either chemical or biochemical deposition of manganese oxides on pipeline surfaces. The progression of deposition through the distribution system is generally affected by the concentration of manganese and the capacity of the pipeline surface to adsorb the manganese oxide. Once the capacity of the pipeline is exceeded or when higher flow rates occur, the manganese oxide coating will detach causing water quality problems at the tap.

The tightening of environmental regulations in some states and local sewer authorities pertaining to Mn has restricted the discharge of backwash water to lagoons and sanitary sewer systems. An alternative is the recycling of backwash water in the water treatment plant itself. Mn in the recycle stream can cause undesirable accumulation within the water treatment plant facility and may result in a number of problems including periodic "slugs" of high levels of Mn water entering the distribution system, premature failure of pumping equipment, a buildup of Mn coating on the plant's master flow meters and general additional costs related to cleaning and maintenance.

Changes in water main flow direction and velocity caused by distribution system main failures, valve closures, hydrant use, surge valve malfunctions, and local construction (i.e. blasting, vibratory rollers) can result in periodic massive black water events affecting thousands of customers and fouling both residential and commercial (restaurant) point of use filters. Loss of customer confidence and utility credibility can occur due to significant release events (black water). Utilities may also find themselves in a position of issuing press releases that the water is "safe to drink" when the color of the water coming out of the tap is black from the release of Mn.

Mn may have health effects that were previously unknown in the drinking water industry. For instance, there are studies indicating that long-term inhalation of, or overexposure to, Mn could have permanent effects on the nervous system. Recent research on pipe scales throughout water distribution systems has revealed several additional areas of concern with respect to health issues, such as: the association lead and copper to deposits rich in Mn; the possible association of Mn with other metals or radionuclides; and, the impacts of waterborne Mn and Mn-rich scales on chlorine and corrosion inhibitor demand, biofilm growth, and disinfection effectiveness.

Studies have shown that even a relatively thin coating of Mn on raw water and finished water transmission main interior walls can drastically increase friction and cause wasted pump energy costs. At a time in our nation when energy costs have risen dramatically and the addition of greenhouse gases from additional energy production is contributing to global warming, any method of improving the efficiency of water systems is worth pursuing. Removal of the thin layer of Mn coating can restore the normal C-factor of the pipeline, drastically reducing energy costs and reducing the creation of additional greenhouse gases. Manganese particles and coatings can damage customer water meter internal components, resulting in meters slowing down and failing. Manganese particles can clog customer owned "whole house" filters, essentially stopping all flow to the customer facility. Manganese particles can also clog customer owned internal components leading to potential flooding of bathroom facilities.

This project will provide an improved understanding of the variety and magnitude of problems caused by Manganese (Mn) that has already accumulated ("legacy" manganese) and that is continuing to accumulate in water systems throughout North America.

This project will gather information to inform water utilities and their managers on several important topics, and which will concurrently identify potential participants in a subsequent research project on manganese deposition, speciation, and control. The topics to be covered in this project are:

- Identify manifestations of legacy manganese and consequent operational difficulties, increased cost burden, lost revenue, and other detriments suffered by utilities and their customers
- Loss of customer confidence
- Potential emerging issues related to health effects and implications for the continued feasibility of sequestration practices versus the necessity of Mn removal at the treatment plant
- Regulatory and logistical issues surrounding disposal of accumulated manganese from treatment plant backwash water and from distribution pipe cleaning projects
- Present current knowledge of legacy manganese removal options and utility experience with them

- ***Non-Intrusive Methodology for Assessing Lead and Copper Corrosion (#4317)***

The levels of lead and copper in drinking water are regulated by the 1991 Lead and Copper Rule (LCR) (as revised and clarified in 1999, 2004 and 2007). The LCR requires utilities to monitor lead and copper levels at household taps in targeted homes within the service area. This monitoring can help identify when corrosion control is not optimized and therefore initiate action by the water utility. Optimization of corrosion control programs to minimize lead and copper release is the essential element of the LCR and is applicable to every community water system. In the last decade a number of incidents have shed light on the ability for slight changes in water quality to impact corrosion control. Given these concerns, drinking water utilities have had to pay close attention to corrosion chemistry during both treatment and source water changes.

Evaluating corrosion control effectiveness under the current regulatory framework is becoming increasingly challenging. The regulatory LCR sampling protocol requires at least a six hour stagnation time before sampling. This requirement dictates that virtually all water systems rely on customers to take the requisite samples from within their homes, which results in lower quality data for a variety of reasons. The dependence on single-family households also represents an imposition on customers and, consequently, it is hard to locate sampling sites that are most desirable or allow a long-term history of sampling at any one point. Available sample sites meeting appropriate LCR criteria are decreasing, not distributed evenly throughout the distribution system, and qualifying households are experiencing participation fatigue. Moreover, there is increasing interest in copper corrosion, and current LCR sample sites are given priority based on potential lead release. These difficulties associated with LCR monitoring prevents most utilities from maintaining sound compliance monitoring to evaluate if slight changes in water quality affects corrosion control effectiveness within the distribution system.

Consequently, a cost-effective corrosion monitoring technology that that can be deployed at a variety of locations throughout a distribution system to gauge the effectiveness of corrosion control management would be a valuable tool for utilities. The technology must be standardized in format but sufficiently flexible in construction to allow the utility to tailor plumbing materials to its own distribution system. By placing multiple test devices at various locations in the distribution system, the utility would be able to monitor changes in water quality that may warrant further investigation or remediation actions for their unique systems. As an additional benefit to utilities, the device could also allow for testing of new infrastructure or equipment. It is hoped that such devices would facilitate utility compliance with the LCR and, perhaps, with appropriate regulatory vetting, become a surrogate for in-home at-the-tap sampling. However, obtaining regulatory approval for this monitoring technology is not a part of this project.

To date, a variety of different pipe-loop (metal release) designs have been used (generally in a pilot-testing mode) to help utilities prepare for changes in treatment or corrosion control. Pipe-loop testing is a long term monitoring commitment requiring substantial analytical effort and yielding results only after several months of testing. This project will develop a more easily implemented device that can be used to evaluate corrosion control effectiveness and provide insight into potential lead and copper levels at premise plumbing locations that contain various combinations of lead and copper components.

The objective of this project is to develop, validate, and demonstrate a portable device that will allow water utilities to monitor lead and copper values without engaging in household tap sampling. This monitoring will provide insight into potential premise plumbing metal release and changes in the rate of metal release to evaluate corrosion control effectiveness.

- ***Opportunities and Challenges of Nanomaterials in Drinking Water (#4311)***

With the recent proliferation of engineered nanomaterials and the rapid development of nanotechnology, there is an urgent need to summarize the state of the knowledge and investigate research needs specific to nanotechnology's impact on the drinking water industry. The use of nanomaterials in a wide array of products and processes has greatly increased in the last few years, and that trend is expected to continue exponentially into the foreseeable future. Studies have shown that nanomaterials may present risks to the drinking water industry because of their unique properties and increasing presence in environmental systems. There are also potential opportunities to utilize a variety of nanomaterials in water treatment processes. Membrane filtration, corrosion resistant coatings, high strength materials, and water quality sensor technologies are examples of potential uses of nanomaterials in drinking water.

Research has been conducted on developing nanomaterials with specific properties and in using these materials in a wide range of manufacturing processes. However, the drinking water industry is struggling to fully understand the developments in this field. There is a need to summarize the nanotechnology issue into an understandable form and to develop research strategies to understand its potential impact. This continued understanding is critical to ensure that nanotechnology remains a focus for the drinking water industry.

This project will summarize information and identify research needs on emerging nanotechnology-enabled water treatment processes and potential risks of nanomaterials in drinking water systems.

- ***Process Benchmarking for the Ten Attributes of Effectively Managed Water Utilities (#4313)***

The U. S. Environmental Protection Agency (EPA), in collaboration with the American PublicWorks Association (APWA), the Association of Metropolitan Water Agencies (AMWA), the American Water Works Association (AWWA), the National Association of Clean Water Agencies (NACWA), the National Association of Water Companies

(NAWC), and the Water Environment Federation (WEF) collaborated to develop a framework for utility management that would result in effectively managed water utilities. . The collaborative effort resulted in the identification of ten attributes of effectively managed water sector utilities, including product quality, customer satisfaction, employee and leadership development, operational optimization, financial viability, infrastructure stability, operational resilience, community sustainability, water resource adequacy, and stakeholder understanding and support. These attributes provide reference points for utility managers seeking to improve organization-wide performance and are discussed in the 2008 publication, Effective Utility Management: A Primer for Water and Wastewater Utilities.

The Primer also identifies keys to management success and utility characteristics that support each of the ten attributes. The Primer does not offer specific or discrete recommendations on how a water or wastewater utility would develop and implement the attributes.

The AWWA QualServe program provides a framework for water and wastewater utilities to continually improve using a Plan-Do-Check-Act framework. It currently offers a well-developed toolbox of a self-assessment, peer review, and benchmarking for water and wastewater utilities. The self-assessment consists of an employee survey to gauge their opinions and to build buy-in and support for improvements. It asks questions that cover five business systems that are typical to water and wastewater utilities in North American, including: Leadership and Organizational Development; Business Operations; Customer Relations; Wastewater Operations; and Water Operations.

Coincidentally, AWWA, in collaboration with IWA, is preparing a guidance manual, scheduled for completion at the end of 2009, which describes "how to" guidance for conducting a benchmarking project. The manual will also describe and illustrate a roadmap and definitions associated with completing such efforts.

The components that are missing from both the Primer and the AWWA QualServe Program include an explicit identification of the best practices used by water utilities to support the ten attributes and to excel in the various QualServe business systems areas, and the associated metrics. A structured process benchmarking exercise could help water utilities to identify best practices to help water utilities achieve excellence in their performance.

The research will identify best practices and metrics used by water utilities to support each of the ten attributes of effectively managed water utilities that were developed by the consortium of water utilities and the EPA in Effective Utility Management: A Primer for Water and Wastewater Utilities (2008); develop and document a framework, methodology and tools to do process benchmarking for this project; develop a means of maintaining and updating practice information; and conduct process benchmarking with major group of water/wastewater utilities.

- ***Update and Expand Residential End Uses of Water (1999, Project 241) (#4309)***

  Water resource managers at drinking water utilities need to understand the many end uses of their delivered water in order to better plan for future resources and make efficient use of existing resources. The Water Research Foundation published Residential End Uses of Water in 1999 and the information contained in that report is still being used as the baseline for single-family indoor use by most utilities. The information is a decade old, may be outdated and excludes key end use scenarios like multi-family buildings, new construction, statistically correlated irrigation use to lot size and some seasonal or annual modeling of use, and the maturation of low flow fixture use and other conservation programs.

Multi-family buildings are a rapidly growing and significant water use sector. There has not been a large scale end use study completed in this sector where major demand management opportunities exist. The update to the 1999 research needs to be expanded to study multi-family buildings including units and common area water uses.

The research should also compare residential end use trends between water utilities with mature conservation programs and those that have had little investment in this area. New construction and Green Building principals also need to be considered in this work.

This project will update the 1999 report Residential End Uses of Water and include key end uses and categorization of socioeconomic variables not covered in the original research. This information is essential for demand forecasting and conservation program development.

Climate Change Strategic Initiative Projects

- ***Analysis of Reservoir Operations under Climate Change (#4306)***

  In the past, water planning and management relied on the assumption that future climate would be the same as the past. Therefore, assessments of the impacts of climate change on water supply often assumed static operation of reservoirs (i.e., fixed rule curves) for ease of analysis. However, such an approach constrains water utility managers to exercise their judgment and operational knowledge to adapt to the impacts of climate change.

  Expected impacts of climate change on water resources include higher temperature, changes in the intensity, severity, and timing of major storms, increased precipitation and evaporation, and changes in patterns of rainfall, snowfall, and snowmelt. All these changes will directly impact water supply systems which need to be "reengineered" to address the potential impacts of climate change. Water agencies should consider re-examining engineering design assumptions, operating rules, system optimization, and planned water-management systems under a wider range of climatic conditions than traditionally used (AWWA, 1998).

  Active, dynamic management of reservoirs is one potential example of how water systems can be managed in light of climate change. Water agencies should start looking into what parameters influence and/or control reservoir operations, what attributes of a water system (supply, water quality, flood management, environmental releases etc.) are affected by reservoir management, what other stakeholders can be affected by and/or have influence over reservoir operations and how important is the access to real time weather information and other data monitoring systems is. There is a need to analyze reservoir operations under climate change, develop case studies of systems that have utilized dynamic reservoir operations under changing conditions and identify what issues need to be considered and what institutional, informational and technical "infrastructure" needs to be in place to deploy dynamic reservoir management.

  The objective of this research is to identify how reservoir operations may need to be adjusted in order to adapt to hydrologic changes associated with climate change. The project will address issues such as dynamic rule curves and how they affect water quantity, water quality, flood management and environmental release responsibilities of water utilities.

- ***Drinking Water Pump Station Design and Operation for Maximum Life Cycle Energy Efficiency (#4308)***

  While water utilities will experience the negative impacts of global climate change, they must acknowledge that they also contribute to the problem by emitting greenhouse gases, primarily from electricity consumption. Between 80-90% of the average water utility's carbon footprint comes from their electricity use. The Water Research Foundation funded research, Energy Index Development for Benchmarking Water and Wastewater Utilities (2008) notes that about 99% of the electricity use at ground water plants and 91% of the electricity used at surface water plants goes to pumping. Testing of over 11,000 water utility pumps through Southern California Edison's Hydraulic Services (Pump Test) Program found an average wire-to-water efficiency of about 55%. Current standard design calls for wire-to-water efficiencies be greater than 80%. This is points to a huge opportunity for the water industry.

  How do efficiencies get this low? The primary causes of sub-optimum pump efficiency include: poor or overly conservative initial design, change from original design operating condition (e.g. decreased system operating pressure or falling aquifer water levels), corrosion of pump wetted parts, use of inefficient variable speed drives (VSDs), inappropriate use of VSDs, and mechanical wear of moving parts. Historically, new pump stations are 2-4% less efficient than designed due to the sum of conservative estimates during design and the tendency to oversize the pumping capacity and head.

  Inappropriate design and specification, including of variable speed drives, is an issue where utilities would benefit from this guidance.

  The objective of this research is to develop a guidance manual focused on drinking water pump station design and operation to minimize the energy consumption and associated carbon footprint of a water utility. This manual will allow pump station designers to:

  1. Improve pump wire-to-water efficiency in the water industry
  2. Design pump stations to ease annual pump efficiency testing, and/or continuous real time pump efficiency readings,
  3. Address the appropriate design/application of variable speed drives, and
  4. Estimate the potential annual energy, cost, and carbon savings from pump station efficiency improvements.

- ***Ground Water Sustainability Under Climate Change (#4325)***

  To date, the vast majority of the research on the impacts of climate change on water resources has focused on the impacts on supply, specifically surface water supply. One expected impact of climate change will be on groundwater levels due to changes in the rate of recharge.

  Groundwater recharge is driven by precipitation. Recent studies indicate that changes in groundwater may actually be much greater than the precipitation changes themselves. For example, model runs indicate that in places where annual rainfall may increase by 20 percent as a result of climate change, the groundwater might increase as much as 40 percent. Conversely, model runs also indicate that in some cases just a 20 percent decrease in rainfall could lead to a 70 percent decrease in the recharging of local aquifers - a potentially devastating blow in semi-arid and arid regions. The exact effects on groundwater depend on a complex mix of factors such as soil type, vegetation, and the exact timing and duration of rainfall events.

While literature searches turn up numerous references to groundwater and climate change, recently released USGS circular 1331, which is a synopsis of federal activity on climate research, notes that the impacts of climate change on groundwater and related impacts on surface water is an information gap. This perceived information gap is critical as groundwater is the primary source of supply for many water systems and plays an essential role in the ecology of regions around the country.

The objective of this research is to provide preliminary evaluation of potential impacts of climate change on groundwater resources, identification of potential impacts for groundwater systems and development of suggested scope for further investigation into this topic.

- ***Water Quality Impacts of Extreme Weather-Related Events (#4324)***

  Climate changes are anticipated to result in the increased frequency and/or intensity of extreme weather-related events. Typical examples include the increased frequency and severity of hurricanes; however, other events may include prolonged droughts, increases in source water temperatures, and changes in precipitation patterns (increases in intensity and/or changes in timing of runoff). Utilities need to understand and anticipate these types of events and their potential impacts on source water quality and ability to comply with water quality regulations. By identifying the characteristics of extreme weather-related events, better characterizing the impacts of these events on water quality, and documenting the "lessons learned" from such events, it is anticipated that utilities will be better equipped to identify appropriate adaptive and mitigation strategies to lessen vulnerabilities to such events in the future. In addition, by better understanding potential impacts, it will be possible to better define potential monitoring strategies to document changes in water quality resulting from climate change. Results of this work become instrumental in better anticipating impacts of extreme events since such events may become more common and/or even more extreme in the future and how to respond to such events quickly and efficiently.

  The objective of this research is to identify water quality impacts of extreme weather-related events on water quality. Results should include qualitative and quantitative impacts as well as "lessons learned" from case studies of previous events. Findings are intended to identify water quality vulnerabilities of existing systems and will help water supply planners anticipate the types of water quality problems that they are likely to face as a result of climate change.

<u>Distribution System Water Quality Strategic Initiative Projects</u>

- ***Acute Health Effects of Chloramine use in Drinking Water (#4320)***

  The USEPA requires all public water systems (PWSs) using surface water to disinfect the water provided to their customers. In addition, these PWSs are required to maintain a residual disinfectant through the water distribution system. PWSs have several options to provide a residual disinfectant, but the most prevalently used are chlorine and chloramine. Because chloramine produces fewer of the drinking water disinfection by-products that are currently regulated by the USEPA, using chloramine as a residual (or secondary) disinfectant is becoming more common. Chloramine is produced by combining chlorine and ammonia in water and, under the usual conditions, monochloramine is the principal end product and disinfectant. Chloramine has been approved for use by the USEPA.

While there are benefits to the use of chloramine as a residual disinfectant, there are also concerns about health effects associated with use and exposure to chloramine. Groups opposed to the use of chloramine in drinking water have identified a number of health effects that they attribute to the use of and exposure to chloramine. Some examples of these groups include Citizens Concerned about Chloramine (www.chloramine.org) in the San Francisco bay area, and People Concerned about Chloramine (PCAC) and Vermonters for a Clean Environment (www.vce.org) both in Vermont. However, many of the health effects that they cite are general and sometimes anecdotal, or can result from reasons other than exposure to chloramine. The USEPA, and the CDC have conducted studies and prepared information to address concerns about chloramine use. Some examples of these studies and/or information sources include information from the USEPA (www.epa.gov/ogwdw/disinfection/chloramine/index.html) and the San Francisco water department (sfwater.org/mto_main.cfm/MC_ID/13/MSC_ID/166/MTO_ID/399 amongst others. Although some work has been done, further studies are needed to more conclusively confirm or refute the complaints associated with chloramine use, especially rashes and dry skin.

The main objective of this project is to determine if there can be found significant justification to study acute health effects of exposure to chloraminated drinking water. This project will use water utility case studies and health data (from cities that have active health agencies, from health insurance records, etc.) to determine if potential acute health impacts (e.g., skin rashes, respiratory problems, etc.), could be measured from chloramine use as a residual disinfectant. This project will identify data sources and assess health data to provide objective data from a population-based study on potential acute health impacts for future communication and management efforts related to chloramine use in drinking water.

- ***Case Studies on Utility Pressure Management, Baseline to Optimized Monitoring (#4321)***

Maintaining a positive pressure in potable water distribution systems is a baseline concern of distribution system operations, and can be considered one of the many multiple barriers to water quality degradation in the distribution system. Most States have a minimum pressure requirement, such as 20 psi (Water Supply Committee of the Great Lakes, 2003). However, some recent work has highlighted factors that may increase the susceptibility of distribution systems to low and negative surge pressures. If a cross connections exists and the pressure in the distribution system is lower than the pressure exerted by the connection, then backflow, the undesirable reversal of flow into the distribution system, may occur. Similarly, these low and negative pressure surges can also increase the risk of intrusion of contaminants (drawing in of environmental water through holes and leaks and cracks) from outside a pipeline due to lack of physical integrity of the distribution system. Although many utilities may have cross connection control and/or leakage management programs in place, the practices for locating pressure monitors, monitoring and recording pressure, and responding to low pressures and pressure fluctuations is not standardized and is variable from utility to utility.

Similarly, although many states and utilities have established minimum pressure thresholds in the long-term, until recently little has been done to identify optimized pressure management practices for the distribution system. An ongoing research project, "Criteria for Optimized Distribution Systems" (which is co-funded by the Partnership for Safe Water [PSW], and is exploring a possible expansion of PSW into distribution systems), has begun identifying measureable optimization criteria that are useful and practical in defining excellent management practices for distribution systems, including excellence in pressure management and monitoring.

The optimized pressure management goals currently identified in "Criteria for Optimized Distribution Systems" are:

1. above 0 psi during emergencies such as main breaks and power outages,
2. above 20 psi under maximum day demand and fire flow conditions,
3. above 35 psi under normal conditions,
4. less than 100 psi under normal conditions,
5. within ± 10 pounds per square inch (psi) of average pressure; greater than 95% of the time.

Along with these criteria there are also recommended minimum monitoring practices. These monitoring practice recommendations currently include a minimum of two pressure monitors in all pressure zones, with these monitors to be placed at the locations expected to have the minimum and maximum head. These monitors do not need to generate data every hour of every day, but instead must be used a minimum of 96 hours (four days) per month, generating average hourly pressures during those periods of monitoring.

While these criteria are preliminary and still evolving, they are based on recent work conducted by the Foundation, EPA, and others, in establishing an improved understanding of pressure and pressure fluctuations in the distribution system. Some of the key research findings that informed these preliminary optimization criteria and monitoring practices are found in Foundation reports *Pathogen Intrusion into the Distribution System*, 2001, *Verification and Control of Pressure Transients and Intrusion in Distribution Systems*, 2004, *Susceptibility of Distribution Systems to Negative Pressure Transients*, 2006, and *Leakage Management Technologies*, 2007. An interesting result of the latter study was drawing a possible link between reduced average water pressures and reduced incidence of main breaks in distribution systems.

The goal of this project is to better define the existing practices along with the potential for improvements in water pressure monitoring and data management for water quality and infrastructure maintenance purposes at public water systems in the United States. This would include case studies of systems that have made improvements as well as a representative sampling of small, medium and large systems for current practices and capabilities.

Endocrine Disrupting Compounds / Pharmaceutical and Personal Care Products Strategic Initiative Projects

- ***Consumer Perceptions and Attitudes towards EDCs and PPCPs in Drinking Water (#4323)***

For more than 30 years EDCs and PPCPs have been known to occur in source waters, but recent media coverage of occurrence studies and information linking these chemicals to impacts on aquatic species has brought the issue to the forefront. Water utilities are generally not prepared to address such concerns to their consumers due to a lack of relevant and accessible risk information.

The Water Research Foundation has funded research on communication strategies for utilities, including Customer Attitudes, Behavior, and the Impact of Communications Efforts (2004, order #90975), Risk Communication for Emerging Contaminants (2004, order #91047F), and "Contaminant Risk Management: Communication Strategies and Tools" (project #4001); and the Water Environment Research Foundation has also published guidance to help utilities communicate about the presence of trace organic contaminants in water (Deeb, 2009). The WateReuse Foundation has funded a project "Risk Assessment Study of PPCPs in Recycled Water to Support Public Review," which will provide quantitative human health risk assessment results for pharmaceuticals and personal care products in recycled water for a representative set of treatment and non-potable use cases. It will develop communication strategies and messages to advance the public understanding of relative risks associated with recycled water use. However, this research has all been predicated on the notion that consumers are indeed concerned about EDCs and PPCPs in drinking water and the reports written from the perspective of the water industry. While it is clear that the media thinks that pharmaceuticals in drinking water is a concern for consumers due to their large-scale coverage, this is not necessarily supported by customer interactions at utilities highlighted in the media coverage. Before investing resources in responding to a perceived concern, the water industry would benefit from understanding how important EDCs and PPCPs are to consumers relative to other issues (e.g., compared to other water quality issues, other environmental issues, the economy, war, etc); whether they perceive current regulatory activities as being adequate; whether they think reducing the risk from EDCs and PPCPs is worth the cost and energy trade-offs of the additional treatment that would be required to remove them; and other such information.

Surveys conducted to date to gauge public opinions about EDCs and PPCPs have indicated concern but have not necessarily avoided bias in their approach. Moreover, a survey that looks at sources of information and media coverage, and the influence of these on consumers' perceptions and attitudes, has not been conducted for EDCs and PPCPs.

Consumer perceptions and attitudes are shaped by a range of information availability and communication trends that vary and evolve over time. One example is that analytical capabilities have improved drastically over the past decade and will continue to improve, making new information available. The levels of EDCs and PPCPs currently detected in drinking water would not have been detectable even ten years ago. There is a need to investigate whether consumers expect water to contain zero-levels of contaminant and whether there is a level below which they are comfortable. There is also a need to investigate whether the source of the contaminant (i.e., wastewater) affects consumer perceptions. Another example is that communication and social marketing tools have enabled greater interactivity with consumers and have changed consumption patterns of communications. Additionally, American public media cultural patterns have shifted in tone in the past generation, with more extreme opinions bathing the public in an atmosphere of greater divisiveness. Thoughtful consideration of opposing points of view is rarer than in the past and could impact consumers' attitudes towards new risks and lower trust in institutions to protect public health. This project will assess consumer perceptions and attitudes towards EDCs and PPCPs, taking into account the potential impacts and opportunities from evolving analytical capabilities and communication patterns and tools.

Surveys of public concerns, perceptions, and preferences have often not been assessed accurately by water utility managers, leading to uncertainty and inaccuracy in the water industry's knowledge about its consumers. Methodologies used in previous Foundation projects to assess public perception on topics other than EDCs and PPCPs may help overcome this problem and provide guidance on cost-effective methods to use in this project. Tools and Methods to Effectively Measure Customer Perceptions (2001, order #90856) reviewed quantitative and qualitative methods for gathering input from customers and identified specific techniques potentially able to measure risk perceptions about the water industry such as visual cues, willingness to pay, and a psychometric approach. This project should explore and consider these techniques and draw upon robust methods used in communications and behavioral sciences (social, political, economic) to provide tools for the accurate assessment of consumers' knowledge of, perceptions of, and attitudes towards EDCs and PPCPs. The tools developed, resulting assessment, and understanding gained from this project will be a logical progression from ongoing Foundation projects "Water Utility Framework for Responding to Emerging Contaminant Issues" (#4169) and "Building a National Utility Network to Address EDC/PPCP Issues" (#4261).

The objective of this project is to develop and apply tools to gain an understanding of consumers' perceptions and attitudes towards endocrine disrupting compounds, pharmaceuticals, and personal care products (EDCs/PPCPs) in drinking water and improve future communications and responses by the drinking water industry.

- ***Evaluating the Removal of Perfluorinated Compounds by North American Water Treatment Practices (#4322)***

Perfluorinated compounds have been used in industrial applications (e.g., firefighting foam) and a number of consumer products because of their unique properties resulting from their molecular structure and composition. At present, two PFCs, perfluorooctanoic acid (PFOA or C8) and perfluorooctanesulfonic acid (PFOS), are raising the most concern. PFOA and PFOS are comprised of straight alkyl chains in which all of the hydrogens have been replaced with fluorine and the molecule contains one non-alkyl structural moiety. PFOA contains a carboxylic acid group on the end of a seven carbon fluorinated alkyl chain, and PFOS contains a sulfonic group attached to the end of an eight carbon chain. Because of their chemical structures, these compounds are resistant to wetting by oil, grease, and water, and have been used to produce popular stain resistant fabric treatments. However, the carbon-fluorine bond is a strong stable bond that is not amenable to attack by other oxidants, making these compounds relatively stable in the environment. In addition, human and environmental health concerns regarding PFCs have been raised by papers in the scientific and technical literature. These papers document the accumulation of PFCs in the tissues of fish, birds, and other wildlife and have linked PFOA to the impairment of function in organs that are part of the human endocrine system, i.e., the liver, thyroid, and immune system.

Recently the United States Environmental Protection Agency (USEPA) published the third Candidate Contaminant List (CCL3), which includes only two of the myriad of PFCs, PFOA and PFOS. As part of their review process to select those compounds that will be further evaluated for potential maximum contaminant level development, the USEPA will need to assess the magnitude of the problem in the United States, determine the fate of these compounds under current operating practices, and identify those operational changes that might be necessary, should the agency choose to regulate these compounds. The Europeans have recognized the significance of PFCs as a group of contaminants for some time and have conducted research on the occurrence and fate of these compounds through their water treatment plants. Such research has shown most conventional drinking water treatment processes to be ineffective at removing PFCs. On the other hand, advanced treatment processes, including granular activated carbon (GAC), reverse osmosis, and nanofiltration, have been demonstrated to be effective at removing PFCs from water. While there are similarities between European and North American water treatment practices, there are significant differences as well. Water treatment technologies that might be considered commonplace in Europe, such as riverbank filtration, advanced oxidation, or nanofiltration, are not as common in North American water treatment. Therefore, North American utilities and regulatory agencies can draw upon the European experience to determine what might be "best available treatment technology" for the range of PFCs that might be encountered, but there is still need to conduct a limited assessment in North American water treatment plants to validate findings from the literature.

The objectives of this project are to conduct a literature review covering the global occurrence and treatability of perfluorinated compounds (PFCs). Following the literature review, researchers will conduct a limited, strategically targeted assessment to determine the fate of these compounds in North American water treatment plants (from source to finished water) in order to validate the findings from the literature.

ADDITIONAL PROJECTS

The following three additional projects were funded by the Board of Trustees in January. RFPs are not expected to be issued for these projects.

- ***Advanced Condition Assessment and Failure Prediction Technologies for Optimal Management of Critical Water Supply Pipes(#4326) (collaborative program with Water Services Association of Australia)***
  This project, actually a $10M research program, is a partnership among six research organizations in the US, UK, Canada and Australia along with eight Australian utilities and three Universities. The objective of this partnership is to develop new tools and approaches to improve the technological and financial management of critical large diameter, pressurized water pipelines or mains. Condition assessment, failure predictions and pipeline lifetime forecasts are critical components of a proactive Asset Management (AM) Program and will be the focus of this work. This research will develop tools to provide better and more complete information for the AM process. Specific projects undertaken within the program will be selected and guided by Management committee composed of financial contributors to the effort.

- ***Optimizing Conventional Treatment for Removal of Cyanobacteria and their Toxins (#4315) (partnership with Water Quality Research Australia)***

  The incidence of harmful cyanobacterial blooms is increasing. Due to global climate change, toxin-producing cyanobacteria are spreading into more temperate regions and becoming a more widespread problem. Continued urbanization and demand for higher agricultural productivity is leading to increased nutrient loading of source waters, which is degrading water quality. This phenomenon may contribute to more frequent and intense cyanobacterial blooms in drinking water sources.

Many approaches have been assessed for removal of cyanobacteria and their toxins during drinking water treatment, but none of them are broadly applicable and effective under various operating conditions. Ongoing Foundation project 2839, "Treatability of Algal Toxins Using Oxidation, Adsorption, and Membrane Technologies," evaluated the use of several advanced treatment processes for the removal of microcystin-LR (m-LR). The project showed that high-pressure membranes were the most effective at removing m-LR. Granular activated carbon (GAC) was also effective. However, the GAC may need to be replaced at a more frequent rate that most utilities currently use. The removal of m-LR by ozone and ultraviolet/hydrogen peroxide (UV/H_2O_2) was highly impacted by the water matrix background. Biofiltration is potentially a very cheap option if existing filters can be encouraged to perform this function. However, there is insufficient information on the best media formulation to encourage microbial growth and degradation of cyanobacterial metabolites. Removal by GAC can be a combination of chemical interactions with the carbon and also biodegradation due to attached microflora. It may provide a cheaper long-term option compared to powered activated carbon for dealing with cyanobacterial toxins.

Because most drinking water utilities still rely on conventional treatment processes, there is a need to further optimize these processes for removal and control of cyanobacteria and their toxins. For example, in addition to producing trihalomethanes and haloacetic acids, chlorine, the most used pre-oxidant, has the disadvantage of lysing cyanobacterial cells and, thus, releasing their toxins into the water. A different pre-oxidant may kill cyanobacterial cells while keeping the cells intact and the toxins within the cells.

This project will evaluate and optimize coagulation, flocculation, sedimentation, and filtration for removal of cyanobacteria and their toxins and will investigate non-lytic inactivation of cyanobacteria as an alternative to chlorine or other pre-oxidants.

- ***Long-term Performance Prediction of Steel Pipe (#4318) (partnership with Commonwealth Scientific & Industrial Research Organization, Australia)***

  Approximately four percent of U.S. water mains are steel. Although comprising only a small percentage of the total pipe used in drinking water systems, steel pipes tend to be large diameter, and their performance is thus critical to system service and reliability. The use of steel pipe by drinking water utilities dates back some 100 years, with some of the earlier large diameter pipe being of riveted construction, but most of the pipe has been installed since the 1940s. Steel deteriorates differently and generally more quickly than cast iron pipe. With every passing year, the risk of failure of this pipe asset class grows. Steel pipe is subject to corrosive action by soil, ground water, and stray electrical currents.

  Much information on steel pipe is available from the oil and gas industry, such as the research completed by Gas Technology Institute (GTI) (http://www.gastechnology.org). While much can be learned from those results, the drinking water industry has its own unique issues in terms of steel pipe installation, connection, maintenance, and assessment. Due to the different product transported through the pipe, and the different coatings and joints, the deterioration mechanisms of steel water in the potable water community can be different from other industries. A number of publications on steel water pipe design, lining, coating, joints, and installation can be found from the American Water Works Association

(AWWA), including journal articles, manuals, design standards, and conference proceedings. However, no comprehensive studies of the steel pipe deterioration have been conducted.

This project will identify condition assessment techniques, evaluate and recommend accelerated material life testing methods, and develop life expectancy methodologies for carbon steel pipes. Drinking water utilities will use this report to help determine the most cost-effective rehabilitation alternatives, including operational changes.