TESTIMONY OF

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BEFORE THE COMMITTEE ON SCIENCE AND TECHNOLOGY
UNITED STATES HOUSE OF REPRESENTATIVE
Subcommittee on Energy and Environment

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Good morning Chairman Lampson, Ranking Member Inglis, and distinguished members of the Subcommittee on Energy and Environment. I want to thank you for the opportunity to testify before the Subcommittee today. I especially want to thank Chairman Gordon for his leadership on this issue and for producing the legislation that we are providing testimony on today. I am Mark Shannon, Director of the Center of Advanced Materials for the Purification of Water with Systems, a National Science Foundation Science and Technology Center headquartered at the University of Illinois at Urbana-Champaign. This Center focuses on finding solutions to the coming water crisis through revolutionary advances in science and technology. We also have partnerships with major stakeholders in the water sector with an active Industrial Affiliates program of companies across the U.S. with interests in solutions to water problems. [1] I am also the Co-Founder of the United States Strategic Water Initiative, which is a consortium of companies, academic researchers, and water associations acting together to advance the science of water purification and to accelerate delivery of new U.S. technologies necessary to increase

[1] Industrial Affiliates and Partners: Archer Daniels Midland (ADM), Applied Membrane Technologies (AMT), Biolabs/Chemtura, Clorox-Brita, Cargill, Culligan, Damon S. Williams Associates (DSWA), ITT, Metropolitan Water Reclamation District of Greater Chicago, Pentair, Porex Porous Products, PPG, Praxair, Siemens, UOP/Honeywell, Water and Wastewater Equipment Manufactures Association (WWEMA).

and protect fresh water supply.[2] The premise of these activities and partnerships is that significant and technological advances are a critical component to meeting the future water needs of our country and world. Our objectives are to develop new water purification technologies that can reduce the amount of energy and chemicals currently used to treat water, and to create new methods to desalinate, reuse, decontaminate, and disinfect waters so that we can gain new waters for human use from different types of sourcewaters, including those that are not now considered usable. By doing so, we will be able to expand the U.S. water supplies, without needing to transport fresh waters over long distances at huge costs in capital and energy usage.

The different water using sectors (agriculture/livestock, energy, industry and mining, and domestic use) have different needs and requirements, for withdrawal, consumption, and discharge of waters. Importantly, what will work for one water use sector may not work for another. However, as supplies become more constrained, the impact of one sector on another becomes more important, and they are coupled to each other. Moreover, due to the extent of river systems and aquifers, along with the interdependencies of use, the effect on water supplies is no longer just a local issue. For the Federal government to adequately address all these issues across sectors, it is imperative that coordination and cooperation occur across the different agencies working to find solutions to the water supply and availability issues.

I appreciate this opportunity to provide input to the Committee on the National Water Research and Development Initiative. In my view, this visionary initiative is the right effort at

[2] List of signers: Ken Kirk - National Association of Clean Water Agencies; Mark Shannon, Jian-Ku Shang, Michael Plewa, Eberhard Morgenroth, Timm Strathmann, Richard Sustich - *WaterCAMPWS*/University of Illinois at Urbana-Champaign; Kofi Bota, Eric Mintz - *WaterCAMPWS*/Clark Atlanta University; Rishi Shukla - Archer Daniels Midland; Greg Pepping - University of Wisconsin; David Henderson - XPV Capital Corporation; Richard White - Lawrence Livermore National Laboratory; Shaurya Prakash - Rutgers University; Lutgarde Raskin - University of Michigan; Slav Hermanowicz - University of California at Berkeley; Tanna Borrell - University of Michigan; Scott Husson - Clemson University; Eva Steinle-Darling - Stanford University; Wen-Tso Liu - National University of Singapore; Daniel Brunelle - GE Global Research; Mark Rigali - Sandia National Laboratories; Darren Sun - Nanyang Technical University; Franz Hoffman – Procorp Enterprises, Milwaukee.

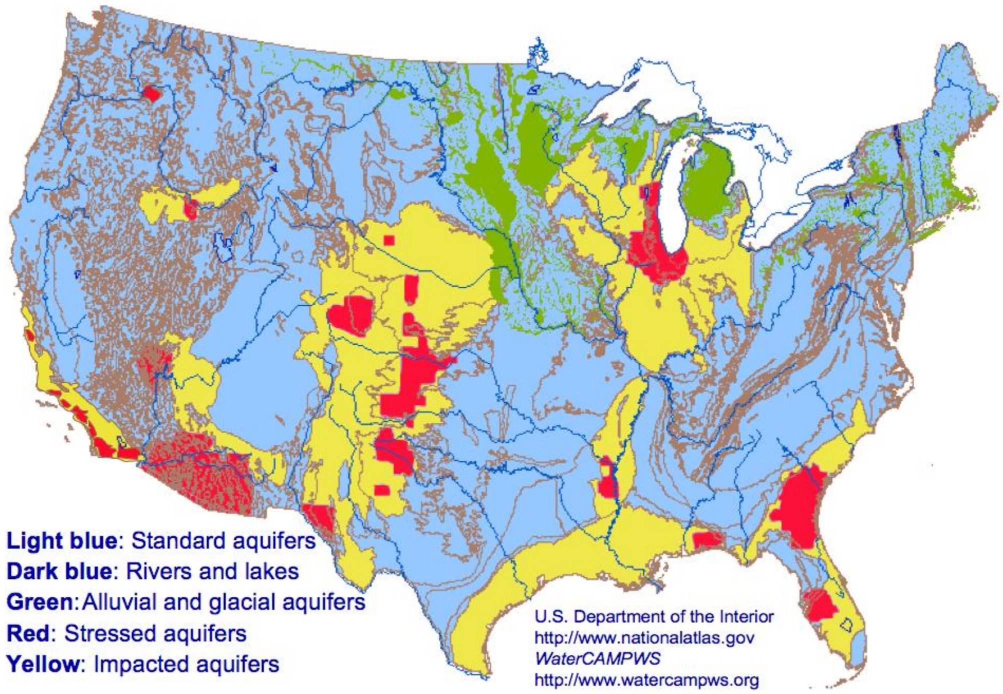
the right time to ensure that we stimulate water-related research and development (R&D) that simultaneously lead to new opportunities for U.S. companies, not those of foreign countries, while solving current and future problems in water supply and quality. This can be accomplished by improving and enhancing federal research, development, demonstration, education, and technology transfer in water use, supply, and demand, as well as conservation and management.

As the Committee is aware, water R&D in the United States is well more than a century old, and is carried out by a wide range of research organizations at all levels of government (Federal, State, and Municipalities), by technology developers and vendors, water associations, and the academic community. While the water technology sector invests approximately $7 million and research foundations such as the American Water Works Association Research Foundation, Water Environment Research Foundation, and the WateReuse Foundation collectively invest another $24 million annually, their efforts are directed at applied research focused on specific issues of interest to their subscribers. A great deal of additional research is done at U.S. universities, water associations and State and local units of government. Beyond their work, there are a number of key areas in which direct and sponsored research at the federal level is essential. I would like to speak to what I believe those key areas in Science and Technology are that the proposed Bill can address.

Water Availability and Sourcewater Protection

The United States lacks sufficient knowledge regarding the actual amount of water stored and recharged in currently utilized fresh water aquifers. Current data indicate that levels in some monitored aquifers are dropping rapidly. For instance, regions of the High Plains Aquifer south of the Canadian River in New Mexico and Texas experienced water level declines of more than

60 feet between 1980 and 1999. While there are regional efforts to look at these issues, a nationwide effort to inventory and quantify the existing fixed and recharging supplies of fresh,

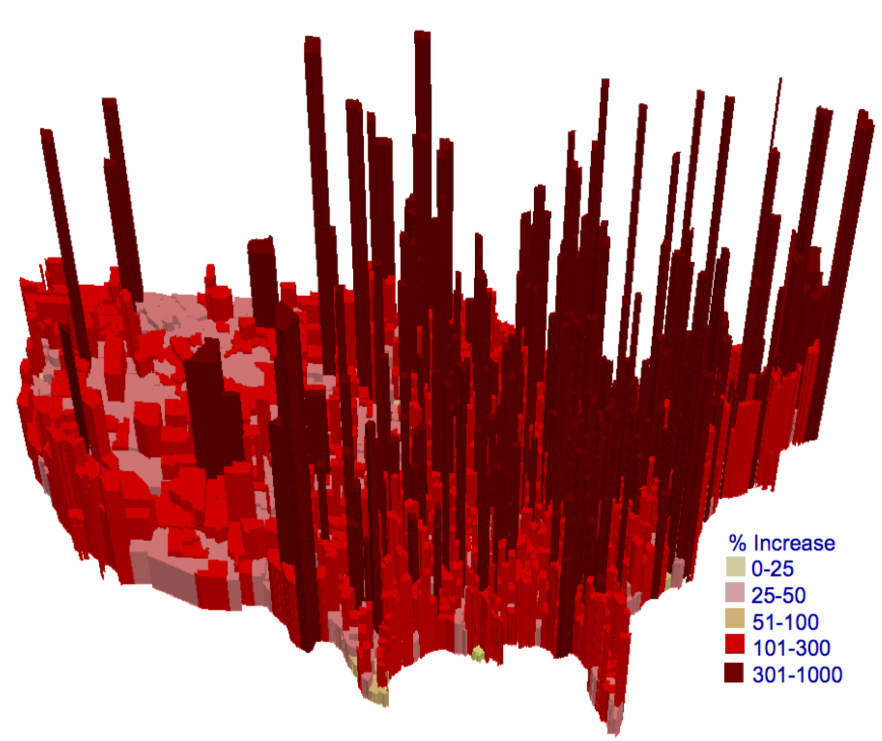


A U.S. Map of all rivers, lakes, standard and "fossil" groundwater aquifers. Alluvial and glacial waters were deposited thousands of years ago, and are slowly replenished if at all. Over-pumping can stress aquifers, and can impact water supplies. Estimates are shown of the stressed (red) and impacted (yellow) aquifers occur throughout the U.S., which are expected to grow over the next 20 to 40 years. More data is needed to know the rates of depletion and recharge, and interconnection of the sourcewaters.

brackish and saline water is critical not only for projecting water availability and sustainable withdrawal capacities, but also for helping scientists, engineers, and planners choose water supply and community development solutions that will be viable. The effects of withdrawal and consequent salting on lands and lakes, as well as contamination rates of aquifers also need to be quantified. Critical issues for federal R&D include assessment of (i) the waters contained in *both* freshwater and saline/brackish aquifers, (ii) the withdrawal and recharge rates of both, (iii) the amount of communication between surface and both types of ground waters and adjacent watersheds, and (iv) the degree of cross-contamination occurring between sourcewaters.

Research Needs for Development of New Water Supplies

Local water demands from population and economic growth will vary throughout the United States, with many areas likely to experience very high growth rates over the next 30 years. Conventional sources of water may not be available or too expensive to develop, and conservation and efficiency may not be enough to ease demand. New water supplies will be needed for these areas.



Predictions of increase in local water use by 2030, as a percentage increase over year 2000. Note that percentage increase does not reflect the total local increase, as increases in southern California are greater at 101 to 300% than Denver at 301 to 1000%. However, percentage increases do reflect the need of local systems to increase water supplies.

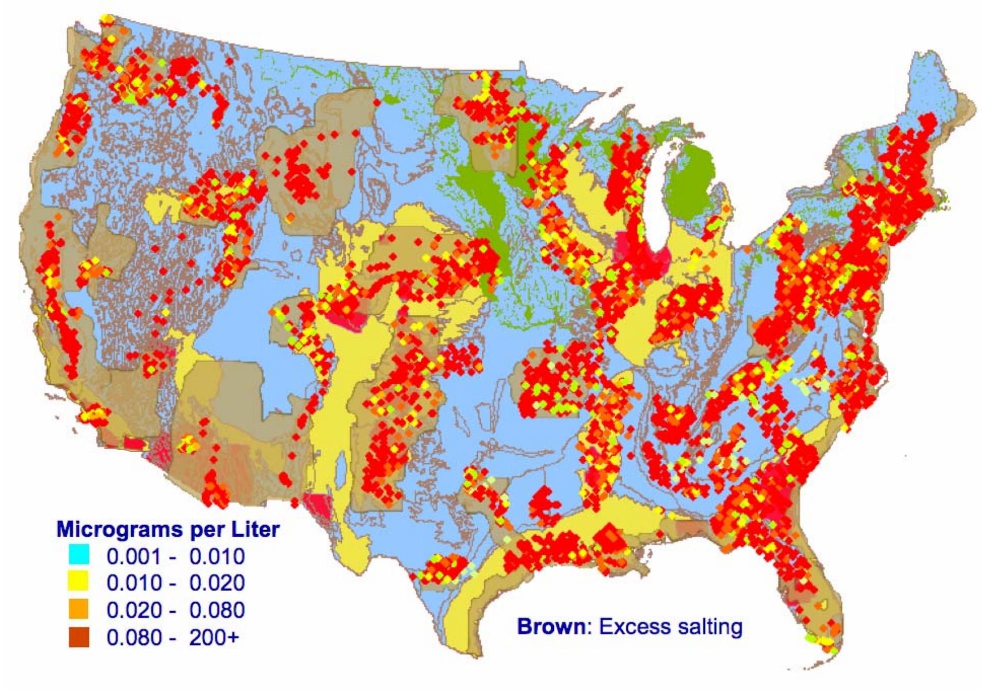
Population data and projections from U.S. Census Bureau (http://www.census.gov/population/www/projections/stproj.html, http://www.census.gov/popest/datasets.html)
Water Use Data from USGS (http://web1.er.usgs.gov/NAWQAMapTheme/index.jsp)
Projections for water use based on Texas Water Use 60 yr projections (http://www.twdb.state.tx.us/publications/reports/State_Water_Plan/2007/2007StateWaterPlan/2007StateWaterPlan.htm)

Meaningful increases in potable water supplies can only be achieved through reuse of existing wastewater and development of brackish and saline sources – to gain new supplies everywhere from the “sea to sink to the sea again.” This effort will need to focus on augmenting water supplies via desalination of seawater and brackish aquifers, as well as through direct reuse of municipal, agricultural, and produced wastewaters from energy and industrial operations. From a purification standpoint, brackish aquifers and wastewaters present even greater challenges than seawater desalination. Crucial issues to utilizing inland brackish lakes and aquifers include developing methods and materials that can separate hard water dissolved solids with minimal fouling, and minimizing residuals created during desalination and reclamation of contaminated and brackish source waters. Critical issues for federal R&D include (i) establishment of standards for potable and non-potable waters derived from these sources, (ii) education of the public of the need and safety of potable waters derived from sources that meet the standards to gain widespread acceptance, and (iii) development of resource recovery methodologies for concentrate residuals and brine from brackish and saline sources, and energy and chemicals from wastewater.

Contaminant Detection, Decontamination and Removal

An emerging trend impacting water supplies is that contamination of sourcewaters, in particular groundwater aquifers that were previously clean, is either reducing supplies or is requiring costly cleanup or extensive treatment of the waters to be used by humans. To maintain the viability of these and new sourcewaters, efficient removal of contaminants from all types of water sources is needed, to get the “drop of poison out of an ocean of water.”

Current treatment technologies are typically not contaminant-specific, resulting in excessive use of energy and chemicals during treatment, as well as necessitating the removal of benign constituents and excessive generation of residuals requiring further processing and disposal. Efforts to develop more marginal water sources, due to increasing demand and depletion of existing sources, will likely become prohibitively expensive using conventional approaches. A major cost factor in removing



Map of the aquifers of the United States, with the EPA's Critical Drinking Water Pollutants and excess salting regions (surface and intrusion into aquifers) superimposed on top. Note the close correlation of the pollutants and salting with stressed and impacted aquifers. Over pumping increases cross-contamination, reducing availability of clean water supplies or needing intensive cleanup and treatment where little to none was required before.

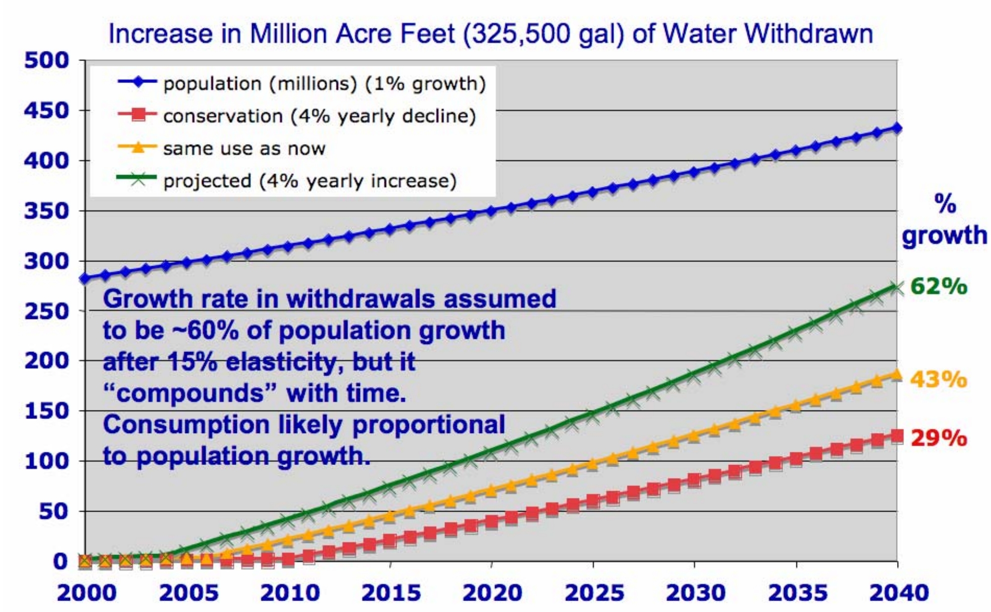
trace amounts of critical contaminants from sourcewaters is that large quantities of benign, potable constituents are also removed. Using treated low-cost materials such as naturally derived Chitosan from crustaceans, or new and reusable swellable glass sorbents that can selectively and affordably remove contaminants such as heavy metals and petroleum distillates, freeing up waters for human use. Additionally, real-time, in situ detection, adsorption, and/or catalytic destruction of potential warfare/terrorism agents are major challenges for the water industry. If we can know in near real time what contaminants are present in sourcewaters, and mitigate potential dangers from contaminants, we can prevent major losses in water supplies to large number of our people in times of crisis. Critical issues for federal research include (i) establishment of what classes of contaminants need to be removed together, (ii) determination of necessary contaminant detection levels and reliability of in-situ monitoring, and (iii) standards for disposal of contaminants recovered from reused and reclaimed waters.

Pathogen Detection and Removal

Similar to chemical contamination, waterborne pathogens can sicken significant numbers of people, and if introduced to water systems naturally or deliberately, or via cross-contamination with waste systems, can render even major water supplies unusable. Moreover, treatment for pathogens can also inadvertently introduce toxic compounds to water supplies. Disinfection technologies that effectively deactivate known and emerging pathogens without producing toxic substances are needed to "beat chlorination." New and affordable materials, methods, and systems are necessary to provide drinking water free of harmful viral, bacterial and protozoan pathogens, while avoiding the formation of toxic by-products or impairing the treatment of other contaminants. Low cost materials such as proteins from harvested Moringa seeds can remove pathogens such as viruses from water, and new sunlight activated catalysts can potentially disinfect waters from a host of pathogens without using additional chemicals or energy. A key unsolved problem is the detection and removal of new and/or evolving infective viruses, and resistant pathogens to standard chemical treatment. Critical issues for federal R&D include (i) development of standards and accepted modalities for determining infectivity of pathogens in water for near real time detection, and (ii) establishment of risk assessment and mitigation for disinfection by-products from current and new treatment methods.

Water Conservation and Reuse

Population growth projections show that conservation alone will not be enough to meet future water demand in many parts of the United States. Projected population growth of 100 to 130 million people over the next 32 years in the U.S. will put further stress on water demand.



The average overall increase in population of the United States is shown in blue, assuming a 1% (between the low and high estimates). Three estimates for the growth in water supplies needed to sustain the population growth, assuming a projected increase in per capita consumption to account for higher use of energy and economic expansion (in green) of 62% by 2040 (using current technologies), use at current levels (in orange) of 43%, and a drop in per capita use of 4% per annum from increased conservation and efficiency (in red) of 29%. The conservation projection requires by 2040 60% less in domestic use, 30% less for energy production, and 20% for agriculture and livestock, which requires new technologies.

Population Data form US Census Bureau: Lowest estimate at 0.9% per annum through to 2030
The Blueprint 2030 forecast of the revised United States population growth from 2000 to 2030 was 1.14%

With current growth in consumption patterns with respect to domestic, industrial, agricultural, and energy usage, the U.S. will need to increase total water supplies by up to 60 percent using current technologies. Moreover, combined with changing demographics, this population growth will cause increases of over 100 percent for many cities and large metropolitan areas across the U.S., likely causing critical water shortages. Even if we are able to maintain per capita consumption at 2000 levels, we will need more than a 40% increase in water supply capacity by 2040. Reduction in per capita water consumption must therefore be an essential part of our national strategy to extend the service capabilities of current and future water supplies and associated infrastructure. A key issue is that leakage of drinking water from the distribution network, and water main breaks is the same as loss in supply. Reducing leakage in the infrastructure will not only effectively increase water supplies, but it will reduce the amount of energy and chemicals used to create and transport potable water, and the overall operation and maintenance costs. Conservation via improved efficiencies and reduction in waste can dramatically reduce overall costs of providing clean water. Research efforts that focus on minimizing the withdrawal of water and on the conversion of direct draw applications to reuse systems have the potential to substantially reduce projected water needs, particularly for specific watersheds and aquifers. Critical issues for federal R&D include (i) assessment of interactions between different water use sectors (agriculture, livestock, mining, energy, domestic, and industry) on water use, conservation, and reuse, and (ii) understanding the environmental impact of changing withdrawal, consumption, and discharge patterns on overall water systems.

Scalability, Ramp-Up and Technology Diffusion

We have the scientific and engineering capabilities in our universities and government and national laboratories to make great discoveries and find sustainable solutions to our problems, but unless a means to move these advances from the laboratory to full production is possible, these innovations will, unfortunately, remain in the laboratory. Further, many novel approaches to problems, while scientifically intriguing, may not take into consideration the costs of mass production or implementation. Scalability focuses on capacity for researchers to incorporate benchmarking and manufacturing scale-up considerations as well as facilitating the testing and movement of new materials and procedures to industry. For a technology to be successful the total life cycle costs must be favorable and it must win in the marketplace. Moreover, with respect to potable water systems, a history of performance efficacy and costs of installation and operation must be available for water managers to select with confidence one technology over another. Because of its oversight role with respect to drinking water, wastewater and environmental quality, research into, and development of low-cost, highly-adaptable technology verification methods is appropriate at the federal level to encourage diffusion and adoption of innovative water technologies under various State and local programs.

Perhaps just as importantly, developing new innovative and cost effective technologies in water purification can help position U.S. companies to compete in the rapidly expanding worldwide markets for water technology. Many nations around the world (China, India, Singapore, Switzerland, and within the EU) are pouring money and resources into developing new science and technologies for increasing water supplies and for new purification methods. While the U.S. still leads in basic science, we are falling behind in technology diffusion into the marketplace. The *WaterCAMPWS* Industrial Affiliates and the signers of the U.S. Strategic Water Initiative are anxious to develop new products to solve the critical problems facing the U.S. and world and to actively compete in this growing market for water products and systems.

Comments on the draft National Water Research and Development Initiative legislation

Now I would like to shift my comments to the draft National Water Research and Development Initiative legislation before the Committee.

We certainly concur with the Committee that our nation will benefit substantively from the establishment of a National Water Research and Development Initiative, and the creation and execution of a National Water Availability Research and Development Plan. There are many water-related research and management activities across the federal agencies, from Agriculture, to Energy and the Defense Departments, to EPA, to NASA and to NOAA, just to name a few. Not only will lateral coordination across agency activities enhance the return on current water investments across the agencies, but it will also facilitate the identification and evaluation of further research opportunities for future investment.

Recommendation for National Water Research and Development Advisory Committee

We have initiated a similar effort, known as the United States Strategic Water Initiative (USSWI), including stakeholders from federal, state and municipal research programs, academia, water technology developers, and major water users such as the agriculture and energy sectors. The goals of USSWI are to:

- Increase basic science and technology research of water purification in academic and government research laboratories to enhance innovation and American competitiveness;
- Provide feedback from water associations, suppliers, users, practitioners, government officials, and the public on water purification needs, technologies, and product performance to S&T researchers;
- Provide a direct path for new ideas and technologies created in research laboratories to be evaluated, demonstrated, verified, and certified;
- Foster public and private investment in water purification research, and accelerate the diffusion of technologies (implementation, commercialization, and adoption) that emerge from such research;
- Establish a cooperative research agenda including a prioritized list of gaps, needs, and opportunities in water science and technology.

Because a substantial water research and development effort already exists outside the federal agencies, we believe that input from this external community is essential to the successful development and implementation of the Plan envisioned in the Act. We therefore recommend that the Act include establishment of a standing National Water Research and Development Advisory Committee under the Federal Advisory Committee Act, to provide advice and counsel to the Interagency Committee and information on extra-mural water research and development activities to the National Water Initiative Outreach Office.

We strongly support the creation of national interdisciplinary research Centers with participation from U.S. universities, water associations and research foundations, and the private sector including technology companies, innovators, and finance, to accelerate the diffusion of new science and technologies from Federal, State, and local research laboratories, as well as university and foundation funded research, into the marketplace. The Centers should likely be independently managed with governing boards that include the participating stakeholders along with relevant agencies.

National Water Availability Research and Assessment Plan Outcomes

We are very pleased with the desired outcomes of the Plan, and would like to offer several minor revisions aimed at enhancing the practical value of the Plan for improving water management:

a) implementation of a National Water Census, which shall include the collection of water data to create a comprehensive water database that includes information on available quantity, quality, consumption, recharge capacity and threats to ground water and surface water resources;

b) development of a new generation of water monitoring techniques in support of the other outcomes of this subsection;

c) development and expansion of technologies for enhancing reliable water supply, management and reclamation;

d) development of innovative, maximally-efficient water-use technologies and tools to enhance public acceptance;

e) development of collaborative tools and processes for U.S. water solutions;

f) advancement of understanding of the water-related ecosystem services, ecosystem needs for water, and opportunities for ecosystem management through beneficial water reclamation;

g) improvement of hydrologic prediction models and their applications;

h) enhancement of technology transfer to, and technology adoption by the water management community;

i) analyses of the energy needs and identification of energy conservation opportunities in providing water supplies across the country;

j) assessment of, and mitigation strategies to address, the impacts of economic, demographic, climatic, and technological changes that have contributed to changes in our nation's water availability and quality;

k) creation of national research and technology Centers for accelerating the diffusion of science and technology from Federal and other government funded research to practice.

Minimum Funding for Act-Related Activities – Section 2(b)(4)(B)

We are concerned that the Act does not authorize the appropriation of funds to carry out the objectives of the Act, but relies on contributions from the agencies represented on the Interagency Committee. To the extent practicable, we recommend that an aggregated contribution sufficient to carry out the objectives of the Act be included in this section. To fully accomplish the research objectives under the Plan, we anticipate that substantial increases in appropriations to participating Federal agencies will be necessary. To create new national research Centers additional funding will be needed. Other nations establishing such Centers, such as two in Singapore, are funding them at $30 million per year per Center for periods of 5 to

10 years, with similar investments by the private sector. A greater amount is being expended in Switzerland (~$100 million/year) to develop new technologies to reduce water usage in the domestic and particularly the energy sectors. It is likely that a greater level of funding will be needed in the U.S. to solve the larger problems the U.S. faces over several sectors and over disparate geographic regions. The basic research in water science and technology for increasing water supplies, efficiency, and conservation that I am aware of is funded at about $12 million/year between the NSF, EPA, and DoE. To rapidly increase water R&D, we recommend that this Act authorize a federal funding level of $100 million per annum beginning in FY 2010 with annual increases of 5% through 2019.

In closing, on behalf of the academic research community and the water technology sector commend the Committee for recognizing the need for coordination across the breadth of federal agencies conducting water-related research. The proposed National Water Research and Development Initiative is vital for the United States. The Initiative is visionary and will ensure the U.S. will be the leader in creating solutions for the pending crisis in water availability that has is already impacting the quality of life of many U.S. citizens, and this is only the beginning of the coming problems. For our part, we stand committed to assisting the proposed Interagency Committee in the development of a National Water Availability Research and Assessment Plan and in coordinating our own work in furtherance of such a Plan. It is our fervent belief that this coordination is essential to the Nation’s success in addressing water management issues, both now and in the future.

Thank you, Mr. Chairman and members of the Committee for this opportunity to provide this testimony. I would be happy to answer any questions you may have.