SAFETY OF OUR NATION'S WATER

Statement of

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<u>H.R. 3178 and the Development of Anti-Terrorism Tools for Water Infrastructure</u>

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Statement to the House Committee on Science on the Safety of Our Nation's Water

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Good morning, Chairman Boehlert and members of the committee. Thank you for the invitation to discuss the security of our nation's water systems. I am Richard G. Luthy, a professor of environmental engineering at Stanford University and chair of the National Research Council's (NRC) Water Science and Technology Board. The National Research Council is the operating arm of the National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, chartered by Congress in 1863 to advise the government on matters of science and technology. The focus of our board's work is water resources, science, technology, and policy. Our results have been presented to this committee before. I have prepared remarks relevant to the current high interest in safe water supplies. These remarks are based on my knowledge and experience and the knowledge and experience of several of my colleagues, some of them also from the Water Science and Technology Board. The following comments explain the water system, how it may be vulnerable to intentional acts, and what actions should be taken and research done to better protect and improve the water system infrastructure. I hope this information is useful to your Committee as you consider the important business of refining and implementing H.R. 3178 and the development of anti-terrorism tools for the nation's water infrastructure.

Water is essential to life and it is obvious that an adequate supply of clean potable water is essential not only for personal health but also for maintaining our nation's economic wellbeing. One of our greatest engineering accomplishments of the twentieth century was the development of our nation's water systems. These water systems comprise a number of integrated components: 1) <u>the water supply system</u>, including dams, reservoirs, rivers, and aquifer systems and water wells that are the source of our water, and the associated conveyance devices for delivering water where it is needed for domestic, commercial, and agricultural uses; 2) <u>the water treatment system</u>, including water treatment plants that remove impurities and harmful agents and which makes water suitable for domestic consumption and other uses; and 3) <u>the water distribution system</u>, comprising networks of pipes, pumps, and storage tanks that deliver clean water on demand to homes, commercial establishments, and industries.

Beginning about 100 years ago and continuing throughout the twentieth century, cities and states and the federal government made enormous investments in water systems to provide adequate supplies of water for use in the home, industry, and agriculture. Enormous gains in public health were realized by protecting our source waters and installing water treatment plants to provide chemically and microbiologically safe water. These successes are evident by the virtual elimination of the most deadly water-borne diseases including typhoid and cholera. Today, because of our water supply, treatment, and distribution systems, we enjoy the best drinking water quality of anywhere in the world. This was achieved by unparalleled accomplishments in integrating and developing the components of the nation's water systems.

Since the sad events of September 11, we now question the vulnerability of our water systems to deliberate attack or sabotage. Although recognized in the past, the vulnerability of our water systems to deliberate acts has not received sufficient attention. The reasons include the fact that simply developing and maintaining our existing water systems received primary attention. Aside from concerns about the vulnerability of our water systems to intentional acts, another reality is that many components of our water systems are aging and need repairs, replacements, or upgrades. This state of affairs is not new. We have heard repeated concerns about our aging infrastructure. But now in the context of September 11 we are looking at the infrastructure of our water systems in a new light and thinking about things that must be done to protect our water systems from intentional acts. While driven by a sense of urgency because of recent events, we should not act precipitously. We need to consider carefully what is possible and what can be done with new approaches that ensure both the security of our water systems while at the same time using such investments to enhance the reliability and capability of such systems. After all, the fundamental mission of such water systems is to protect human health and insure economic wellbeing, and we should be asking ourselves whether there are better ways to do that.

Some issues that need to be better understood to protect our water supply systems from intentional acts include the following. The answers to these questions require engineering analysis and problem solving, scientific advances, and evaluation of institutional arrangements and water policies.

What elements of the water system are most vulnerable to physical damage? How do concerns for physical damage vary depending on the source of water? How can we protect water systems from physical damage? Dams and aqueducts and pumping stations that capture and convey water over long distances are especially vulnerable to physical damage. But even water supplies taken from rivers or lakes may suffer if intakes are damaged. Similarly, groundwater withdrawn from wells relies on pumps and infrastructure delivery. The control of human access to critical water supply system components is an important issue and responses are likely to be much different for water supply systems located in parks and public places versus remote areas. While steps have been taken in the last twenty years, like fencing and covering reservoirs, more is needed to prevent intentional acts. Some aqueducts are hundreds of miles long; protecting these systems is especially challenging. Water supply systems are designed to withstand natural disasters. In-place systems for natural disaster monitoring and response could serve as platforms to incorporate intrusion sensors and quick response to intentional damage. The distribution system is more difficult to secure; though potentially affecting a smaller population, mass exposure is not needed if the goal is fear and anxiety.

What chemicals, biological agents or toxins may do the most harm to human health and disrupt the beneficial uses of water? What points in the water supply, water *treatment, and water distribution system are most vulnerable to release of such agents? What amount of such agents would harm humans or disrupt service?* It is believed for many toxic chemicals that truck-load quantities are needed to cause harm to the water supply system because of the very large volumes of water being handled. But this matter needs thoughtful analysis. Small quantities of toxic chemicals, even if not directly harmful, may cause panic and great economic disruption. Who would want to consume water with intentional addition of low levels of lead or cyanide? Biological agents and especially their toxins may be harmful at very low levels. The infective dose for certain spores or protozoan oocysts may be fewer than ten, and thus small volumes of these agents in concentrated form may contaminate very large volumes of unfiltered water. These issues are relevant to both surface water systems and those relying on groundwater as their source, especially those using water from carbonate or other aquifers in which the water residence times are relatively short. Elevated portions of distribution systems are a concern, being more vulnerable to entry of chemical or biological agent than pressurized conduits. Something added to water does not have to be toxic; merely introducing taste or odor would be very disruptive if the goal is fear and anxiety.

How can we achieve early detection of chemical or biological agents in the water supply system in time to take corrective action before water gets to a water treatment plant or into the distribution system? We need better monitoring for early warning of the intentional addition of chemical or biological agent to the water supply. Water supplies are monitored routinely for a small number of contaminants and much less frequently for a large number of contaminants. Conventional laboratory methods are time consuming and require skilled analysts. Together, this means that problems arising from intentional acts may not be detected until chemical or biological agents are at the treatment plant, or worse, in the distribution system (some large U.S. systems, notably that of San Francisco and New York City have no treatment, other than disinfection). However, much can be done to improve this situation. Most analytical equipment is highly automated and could very likely be made more autonomous with new technologies. The chemical industry and some of our national laboratories are developing 'chemical analysis on a chip' for hand-held, portable, chemical analysis systems, and 'canary on a chip' for detection of hazardous compounds in the work place. With modification, such systems may be useful in routine monitoring of water supplies for a broad spectrum of compounds, both known and unknown. Innovations in immunoassays and nanotechnologies hold promise for rapid screening of chemical and biological agents. We shouldn't overlook time-tested methods like increased chlorine demand, taste and odor, turbidity, and other measures as useful surrogate indicators in conjunction with new procedures.

How can water supply system operations be reconfigured to provide greater interconnectedness among source water supplies and among potable water distribution systems? What might be the potential for groundwater or irrigation water resources shoring up contaminated surface supplies on an emergency basis? Interconnectedness means that in-place conduits allow the transfer from one water supply system to another. Interconnecting water supply systems offers greater assurance that if one component of the water supply system is lost then other water supplies may be put online to transfer water through stand-by conduits. Similarly, water distribution systems could be interconnected so that one locality may help another under emergency conditions. Mutual aid pacts could include water supply, laboratory resources, operating assistance, and repair response. Aside from the technical issues, how this systems approach, often called "regionalization," would work in practice requires cooperation on a regional (often watershed) basis. Historically, because of the fragmented nature of the water supply industry, there has not been as much attention to design for interconnectedness unless prompted after the fact by a chemical spill or natural disaster. Our nation has experienced sabotage of local water supply systems with alternative water supply being brought in while the system was flushed or repaired. Greater interconnectedness results in inherently greater stability and flexibility, as systems comprising standby networks are more resilient to upset than monolithic entities. In the arid west, separate water supply systems are in place for agriculture and domestic use. Since so much more water is used in agriculture than by municipalities, conceivably interconnecting the agricultural water supply or groundwater systems could augment the domestic supply in an emergency. Again, there are many questions, both technical and institutional, on how this would work.

What changes in system operations and what new technologies may provide a safeguard against chemical or biological agents? How may multiple barriers be incorporated in treatment plant operations and in the distribution system to ensure greater safety in our domestic water supply? As mentioned above, we should think of new ways of supplying and treating water. Examples include the installation of robust, stand-by systems that could deal with chemical or biological threats. New technologies and augmented conventional technologies are needed. Fortunately, advances in membrane, sorptive, and oxidative technologies can be brought to bear on this problem. In water reuse, a fundamental design paradigm is to install multiple barriers that provide adequate safeguards in converting wastewater to potable water. Such systems are not dependent on one process but several in a train that provide backup protection. Similarly, we need to extend the multiple barrier concept to create a series of hurdles that guarantee greater assurance that we can cope with chemical and biological agents. These barriers may extend from the water treatment plant to include the distribution system and point of use. Multiple barriers comprising storage capacity, enhanced treatment systems, and mutual aid provide the means and time to address a problem.

Are our water supply systems vulnerable to cyber attack and what can be done to safeguard against such threats? Historically most of the concerns for the safety of the water supply system have focused on natural phenomenon. Not to be overlooked, however, is the realization that essentially every component of the water supply system is highly automated. This includes electronic control of water pumping and storing, water treatment operations, and water transmission. Although these operations are backed up by manual controls, great damage could be done if the control of these systems were lost for a period of time due to cyber attack. Electronic security and emergency control backup capabilities of the water supply system need careful analysis and possible re-engineering. This concern could be just as real as chemical or biological threats.

Among the items listed, top priority should be given to protect physical structures for water storage that serve large populations and that would be very difficult to replace, and to maintaining water quality through better monitoring and new treatments and incorporating the concept of multiple barriers.

In closing, the issues discussed above are crosscutting among disciplines and institutions. Answers to these questions and designing effective solutions to key problems will require broad-based studies comprising university and governmental research establishments, professional organizations, practitioners, and operators, as well as advice from groups like the National Research Council. The challenges are great but so are the resources to make our water safer than ever before. H.R. 3178 appears to have great potential to help assure the future safety of our nation's water. While an important step in this direction, the appropriation request of $12 million is inadequate given the enormity, complexity, and diversity of issues outlined above. A $50 million program would seem to be the minimum for engineering analysis and problem solving, scientific developments, and evaluation of water policies for the breadth of issues confronting the safety of our nation's water supply, treatment, and distribution systems. It will be critical that any new research program be organized and administered with great rigor, including an independent peer review process, to assure that the best research is pursued and the best results are obtained. The needs are too great to do otherwise.

Again, thank you for the opportunity to discuss the safety of our nation's water systems. I will be happy to answer any questions you may have.

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