

**INCREASING WATER RESILIENCY BY LEVERAGING  
PUBLIC AND PRIVATE INVESTMENT, EXPERTISE, & INNOVATION**

Discussion Paper

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**I. Introduction**

The federal government has an important direct role to play in promoting water resiliency in the United States. Through the Bureau of Reclamation, for example, the U.S. Department of the Interior provides water to roughly 10 million acres of cropland (approximately half of all the water used to irrigate land in the western United States) and over 30 million domestic users. As the manager of almost 190 million acres of National Forests, the U.S. Department of Agriculture (USDA) protects key watersheds nationwide. The Environmental Protection Agency (EPA) helps ensure both the supply and quality of the nation’s waters through wetland and pollution measures.

The federal government, however, can also advance water resiliency by encouraging and leveraging funding, expertise, and innovation through state, local, and tribal governments, and the nonprofit and private sectors. State, tribal, and local governments have principal responsibility in the United States for the allocation and delivery of water resources, with investor-owned utilities also playing a significant role in some regions. Private-public partnerships between public water suppliers and private technology firms are increasingly bringing additional expertise and funding to water operations. In many parts of the nation, private lands are central to effective watershed protection. Most new water technologies arise from universities and the private sector, increasingly supported by venture capital funding. Nonprofits are increasingly playing a major role in the protection of instream flows and aquatic ecosystems. Federal policies can help enhance resiliency by promoting the activities of this wide array of public and private organizations.

This discussion paper provides an overview of current federal programs and approaches designed to leverage greater investment and innovation of other public and private organizations, as well as the opportunities that these programs provide to increase water resiliency. The paper is not a comprehensive catalogue of such programs; instead, the paper’s goal is to highlight a number of programs and, in the process, show the effectiveness of leveraging non-federal resources and

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expertise. The paper also poses questions designed to trigger discussion at the upcoming White House Drought Symposium organized by the National Drought Resilience Partnership (NDRP) of additional steps that the federal government might take.<sup>1</sup>

## **II. Encouraging and Leveraging Funding**

Increased investments will be needed during the 21st century to ensure the resiliency of the nation's water systems. A 2002 report by EPA concluded that the nation faced a funding gap of over \$500 billion simply to replace the nation's aging water infrastructure over the next 20 years (EPA 2002). In 2010, the American Water Works Association estimated that the cost of ensuring that the nation has an adequate drinking water supply system would total \$1 trillion dollars by 2035 and \$1.7 trillion by 2050 (AWWA 2010). Additional investments will also be needed to build the new infrastructure to:

- Provide drought-resilient water supplies for the nation's growing population, including recycling, storm water capture, and desalination facilities,
- Increase water efficiency,
- Develop and implement innovative technologies that enhance our ability to effectively manage limited water resources,
- Increase the flexibility of water supplies through new conveyance and storage facilities,
- Protect and restore watersheds that are under stress from droughts and warming conditions,
- Develop green infrastructure that can enhance the resiliency of urban water systems, and
- Acquire existing water rights for instream flows.

The federal government historically has provided only a small fraction of the critical investments each year in the resiliency of the nation's water system. Water investment instead has been a local and state responsibility. California is relatively typical – each year, California invests about \$30 billion in replacing, modernizing, and expanding its water infrastructure and in protecting and enhancing the state's aquatic ecosystems. Cities and other local governments fund almost 85 percent of this investment, through water and sewer bills and local appropriations. The state provides another 12 percent, primarily through bond measures and general-fund appropriations. The federal government contributes only about four percent, and this percentage has been shrinking over time (PPIC 2015).

As investment needs increase, however, the federal government plays an increasingly important role in encouraging and leveraging additional investments by other levels of government and by

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<sup>1</sup> The NDRP is a partnership of the U.S. Department of Agriculture, the Department of the Interior, the National Oceanic and Atmospheric Administration, the Environmental Protection Agency, the Assistant Secretary-Civil Works, the Department of Energy, and the Federal Emergency Management Agency. The purpose of the NDRP is to harness and coordinate distinct efforts by individual agencies already underway to assist in building resilience to drought on the ground.

the private sector. As discussed below, the federal government has multiple tools that it can use to increase such investments, including:

- Education of state and local officials about funding opportunities and structures;
- Building connections between public and private organizations interested in making joint investments in water infrastructure and systems;
- Using federal funds to match, and thereby incentivize, investments by other levels of government and the private sector;
- Tax incentives designed to encourage such investments; and
- Regulatory programs, such as wetland mitigation banks, that encourage regulated entities to invest in water resiliency in return for regulatory flexibility.

#### **A. Federal infrastructure funding**

The federal government has long used loans and matching grants to encourage local governments to invest in water infrastructure. Through the State Revolving Funds (SRF) under the Clean Water Act (CWA) and the Safe Drinking Water Act (SDWA), for example, EPA provides loans that encourage local investments in wastewater and drinking water infrastructure, respectively. More recently, the federal government also has promoted the development of green infrastructure: a third of SRF loan funds can be used to protect water sources, including land acquisition. A fraction of these funds, moreover, can support voluntary and incentive-based measures. Ohio has used its SRF under the CWA to promote watershed protection by offering rate reductions for wastewater treatment projects where the recipient agrees to use a portion of the savings to invest in such protection.

More recently, as part of President Obama's Build America Investment Initiative, the federal government has launched several new programs designed to increase investments in drinking water and sewer infrastructure. In January 2015, for example, EPA launched a Water Infrastructure & Resiliency Finance Center with the goal of meeting the significant new investment needs for drinking water and wastewater management. EPA's new Finance Center explores and promotes new financial tools, with a particular focus on public-private partnerships, that can attract additional private capital into the water sector. As part of this effort, the Finance Center brings together investors and water suppliers, highlights promising opportunities, and offers workshops and toolkits. The Finance Center also explores ways to increase financial investments by integrating multiple benefits, including water efficiency, energy efficiency, water reuse, and green infrastructure. A new National Water Center launched by NOAA at the University of Alabama in May is poised to become an incubator for innovative breakthroughs in water prediction products and services.

The USDA similarly has launched a Rural Opportunity Investment Initiative (ROI Initiative) designed to: (1) identify new sources of private capital to support rural infrastructure projects, including water projects, (2) serve as a co-lender where useful, (3) reduce barriers to private investments, and (4) connect private investors with promising projects. The ROI Initiative already has succeeded in bringing new private capital to finance water projects and other rural

infrastructure. In one of the initiative's first public-private collaborations, CoBank and Capital Peak Asset Management created a \$10 billion U.S. Rural Infrastructure Opportunity Fund that includes capital for water and wastewater systems. As part of the initiative, USDA also helped launch a \$150 million Rural Business Investment Company that will, among other activities, invest in businesses that develop new improved farm technologies. Eight funds, including Advantage Capital Projects, are providing the initial funding for the company through money raised, with the help of USDA, from Farm Credit System banks and associations. USDA continues to promote private investments under the ROI Initiative through annual conferences and by leveraging private funding against the \$30 billion in USDA programs.

To further promote private investment in new water and wastewater infrastructure, the Obama Administration also has proposed creating Qualified Public Infrastructure Bonds (QPIB). Current public-private partnerships, including those designed to build and manage water and wastewater infrastructure, cannot take advantage of municipal bonds and their tax advantages. Under the Administration's proposal, such partnerships would be able to issue QPIBs and thus take advantage of a lower cost of capital. QPIBs would operate similarly to Private Activity Bonds, which have supported the construction of over \$10 billion in transportation infrastructure.

## **B. Conservation**

Conservation plays an important role in promoting the resiliency of both water supplies and aquatic ecosystems to droughts. For example, healthy watersheds can both promote regular flows of water and protect source-water quality. Unprotected watersheds almost inevitably deliver less reliable and dirtier water to downstream users (Postel & Thompson 2005). Healthy watersheds also ensure better water conditions for fish and other aquatic species. Riparian forests, for example, can help cool water and provide better habitat to many fish species. Protection of aquifer recharge areas can help protect groundwater infiltration, thereby ensuring greater groundwater availability, and protect groundwater quality. Soil conservation can help increase water infiltration to groundwater aquifers and increase the water available to plants.

### **1. Federal conservation programs**

The USDA has long used federal conservation programs under the federal Farm Bill and other statutes to promote conservation measures that increase the resiliency of watersheds and waterways. By providing matching funds, these programs leverage state, local, and private funds to increase the total amount of dollars going into conservation. The Environmental Quality Investment Program (EQIP), for example, has provided millions of matching dollars in recent years for projects that benefit resiliency by increasing irrigation efficiency and developing more reliable water sources. Each dollar of EQIP is matched by state, local, or private funds. Other programs that provide cost sharing for non-federal investments in conservation include the Conservation Reserve Program and the Conservation Stewardship Program, as well as the U.S. Fish and Wildlife Service's Partners for Wildlife program.

In 2014, the USDA launched the Regional Conservation Partnerships Program (RCPP), which provides federal funding on a competitive basis to conservation projects that provide significant

matching funds from non-profit organizations, producers, and non-traditional investors. Over the life of the program, RCPP will invest \$1.2 billion and aims to double the total investment through partner funding. In its first year of funding, RCPP awarded more than \$370 million in federal funds to 115 high-impact projects; this funding leveraged more than \$400 million in partner investments. The first round of funding included projects designed to increase the drought resiliency of farming and protect public water supplies. For example, selected projects will increase water use efficiency in the Lower Gunnison Basin of Colorado, restore stream flow in the White River of Oregon, and address irrigation water quantity concerns in Alabama.

Some matching-fund conservation programs are themselves partnerships. In 2011, for example, the USDA and the National Fish and Wildlife Federation jointly created the Conservation Partners Program to provide matching grants for critical conservation investments. Many of these investments have promoted water resiliency. In 2013, for example, the Conservation Partners Program provided matching funds to improve drainage from agricultural lands in California, helping to improve local streams and fisheries critical to coho salmon. To date, the Conservation Partners Program has leveraged about \$1 million in federal funds into more than \$3 million in investments.

## **2. Ecosystem service markets/conservation finance**

Interest has grown in recent years in ecosystem service markets where investors pay for conservation, at least in part, because of the private benefits that they receive (Guerry 2015). In some cases, investors are attracted to the green commodities that the conservation provides, such as timber, fisheries, or ecotourism. In other cases, investors are attracted to the payments they receive for the public benefits of the conservation either from the government or from regulated communities that need offsets or other regulatory relief.

According to a recent study by Credit Suisse, WWF, and McKinsey & Company, ecosystem service markets provide approximately 20 percent of the approximately \$50 billion in annual conservation investments in the United States. Of this amount, approximately two-thirds of the investments are attributable to green commodities, with the remainder attributable to public-benefit payments. Ecosystem service markets, moreover, tended to provide funding for small, segregated, and niche markets rather than at a larger geographic scale. The report nonetheless concluded that such markets offer significant potential. If institutional investors, high-net-worth individuals, and retail investors directed only one percent of their investments to such markets, for example, ecosystem services markets would generate from \$200 billion to \$300 billion each year – four to six times current conservation funding (Credit Suisse et al. 2014).

The federal government currently promotes ecosystem service markets in several ways. First, the federal government provides potential investors and beneficiaries with information about both opportunities for ecosystem service investments and market tools. For example, within USDA, the Office of Environmental Markets, established pursuant to the 2008 federal Farm Bill, provides information on emerging ecosystem service markets. The USDA's Forests to Faucets project identifies watersheds where ecosystem payments could potentially provide financing for the

conservation and management of forest lands providing valuable water supplies; in identifying options, the project looks at the ability of a watershed to provide clean water, the number of water users benefited, the amount of unprotected land, and the degree of the development threat.

Second, the federal government promotes the development of new information important to ecosystem service markets. EPA, for example, has extensively studied the quantification and valuation of ecosystem services and released several reports on how that information can be used in various decision contexts (e.g., EPA 2009). The revised Principles, Requirements and Guidelines for Water and Related Resource Implementation Studies (PR&G), recently released by the Council on Environmental Quality, requires an ecosystem services approach in the evaluation of costs and benefits. This requirement will encourage the development of significant new research and data on the value of ecosystem services.

Third, the federal government helps create markets for ecosystem services through the regulatory programs that it operates. Section 404 of the Clean Water Act, the federal Endangered Species Act, and the Federal Energy Regulatory Commission all create mitigation banking opportunities that in turn give rise to conservation markets. The government's operation of these programs, in turn, determines the effectiveness of these markets in generating investment dollars and maximizing the public benefits.

A 2011 study of 32 ecosystem service projects demonstrated the importance of federal grants and assistance in promoting ecosystem-service markets and leveraging funding from other sources. Some of the projects, particularly in the West, enhanced water provision, while the remainder, primarily in the Midwest and Northeast, reduced nutrient pollution. Nearly two thirds of the projects received federal support in the form of funding or technical assistance: 53 percent received funding, six percent technical assistance, and six percent both. The federal funding, however, leveraged far greater amounts of private, state, and local funding; only 19 percent of project funding came from the federal government (Majanen, Friedman, & Milder 2011).

### **C. Water-specific funding programs**

Some federal funding programs are specific to the water sector. Through its WaterSmart grants program, for example, the Bureau of Reclamation provides competitive cost-sharing for projects that will promote sustainable water supplies in the 17 western states and Hawaii through improved water efficiency, water conservation, new water technologies, and water markets. Since 1992, for example, WaterSmart has used slightly more than \$600 million in federal matching funds to attract more than \$1.8 billion in non-federal funds to design and construct water recycling facilities. Earlier this year, Reclamation awarded funds to save water in California that otherwise would be lost through seepage from unlined conveyance canals.

Some federal programs are directed at promoting water resiliency in particular regions of the nation with highly vulnerable water resources. USDA's Ogallala Aquifer Initiative (OAI), for example, seeks to reduce overdrafting of the Ogallala Aquifer by improving irrigation efficiency and promoting voluntary conservation on overlying agricultural lands. Federal investments in the

OAI have totaled \$6.5 million, but have leveraged even greater investments from states, local governments, research universities, and water consumers.

Key questions for discussion at the Symposium include:

- What are the largest untapped opportunities for promoting or leveraging investments in water resiliency by other levels of government and the private sector? What types of federal programs could help unlock these investment sources?
- Could existing federal programs be targeted to better leverage funding to promote drought resilience? If so, how?
- Are some types of funding programs more effective at leveraging state, local, and private funds than others? How might such programs be expanded?
- What are the major obstacles to the success of existing federal funding programs? How might those obstacles be removed?
- Are there restrictions in existing federal funding programs that prevent the programs from being as effective as they might be? For example, many of the rural communities that have been hardest hit by the current California drought rely on small systems and domestic wells and may not qualify for the Safe Drinking Water Act's State Revolving Fund.
- How should the effectiveness of federal investment programs be measured?
- Does the federal government create or promote any barriers to private investment in water resources? If so, how could these barriers be reduced or eliminated?

### **III. Development and Dissemination of Science and Information**

One of the most effective ways that the federal government can assist other levels of government and the private sector in the promotion of water resiliency is by providing scientific and factual information. Information is increasingly important in identifying and solving water challenges. However, many state and local entities, as well as private organizations, do not have the resources necessary to develop needed information on their own. The federal government, by contrast, enjoys tremendous economies of scale and can rely on established programs and agencies to develop and disseminate needed information on everything to climate to water use.

#### **A. Existing programs**

The federal government has long been the leading purveyor of information regarding water resources in the United States. The U.S. Geological Survey (USGS) plays a significant role. Water is one of the USGS's six science mission areas. The USGS provides information on streams, lakes, and reservoirs; the location, condition, and behavior of groundwater aquifers; the conditions and consequences of floods and droughts; and how water is used now and in the past. Over 3400 federal employees in over 180 offices work on developing and disseminating reliable, impartial, and timely information on the nation's water resources.

The USGS also collects hydrologic data and conducts water resource assessments in partnership with over 1000 state and local water agencies through the century-old Cooperative Water Program (CWP). In 2010, for example, the CWP supported approximately 4500 stream gauges and over 10,000 groundwater observation wells. This information remains a corner stone of effective and resilient water systems throughout the nation.

Leveraging expertise in land-grant universities across the United States, the federal government also has created 54 Water Resource Research Institutes (one for each state, as well as for DC, Puerto Rico, the U.S. Virgin Islands, and Guam). Each institute is located at a land-grant university or other college and cooperates with the USGS to support, coordinate, and facilitate research through grants and student programs. Among other functions, the institutes plan and conduct research on state and regional water problems and disseminate research results to state and local water agencies, as well as private water and wastewater companies, and to the ultimate water consumer.

Federal agencies also provide critical information to states, local governments, and environmental non-profits seeking to protect aquatic ecosystems in the face of increased threats and stresses. The U.S. Fish & Wildlife Service, for example, operates the Dexter National Fish Hatchery and Technology Center, which studies the life histories and genetics of endangered and threatened fish species in order to provide decision makers with the information needed to protect them.

In recent years, the federal government has increasingly focused on providing information, including forecasts, outlooks, drought assessments and analysis needed to improve understanding of the immediate and longer-term implications of climate change. In 2011, for example, the Cooperative Water Program announced that one of its high-priority program goals is to help measure the effects of climate change and variability on water resources. NOAA created Climate.gov as an information portal to convey climate-related information to the public and private sectors in formats that would be accessible and decision-relevant. Climate.gov furnishes a clearinghouse of reports, resources, and decision-support tools for planners and decision makers faced with climate-related risks and opportunities. It also serves as a portal for climate maps and data.

As the West has suffered through multiple droughts, the federal government also has launched new programs designed to provide water managers with the information needed to plan for and manage such droughts. According to its authorizing legislation, for example, the National Integrated Drought Information System (NIDIS) enables “the Nation to move from a reactive to a more proactive approach to managing drought risks and impacts.” Under NOAA’s principal leadership, NOAA, NIDIS provides drought monitoring, forecasting, and early warning and hosts Drought.gov to convey comprehensive information about drought across the United States. NIDIS, working through a broad network of state, Tribal, federal, and academic partnerships, also supports research on the physical and socio-economic impacts of droughts, develops planning and simulation tools for regions susceptible to serious droughts that enable proactive drought planning.

NIDIS investments consolidate information not only from federal agencies, but also from state and local partners and academic researchers.

Key questions for discussion at the Symposium include:

- Is there other critically important information that the federal government should be collecting and providing to state, local, and private decision makers in order to promote water resiliency?
- What information and tools will be needed to manage water in the face of climate change and an increased probability of severe droughts? Are such information and tools currently being developed?
- Are new drought indicators needed that integrate physical aspects of drought with environmental and socio-economic impacts?
- Given limited federal funds, how can the nation expand its monitoring of water availability and uses?
- What are the opportunities for expanding information about U.S. water availability and uses through satellites and remote sensing?
- What are the opportunities for obtaining additional information through the analysis of big data?
- Could existing collaborative networks of water information, such as the Open Water Data Initiative, be further expanded or improved? If so, how?

#### **IV. Promoting Innovative Technologies, Policies, and Practices**

The future resiliency of the nation’s water sector depends, in part, on the development and adoption of new innovative technologies and practices (Daigger 2011; US EPA 2014; Kiparsky et al. 2013). New technologies and practices can enable greater levels of economically affordable conservation and increase the productivity of available water sources through increased efficiency, reducing overall demand for water. For example, water supply technologies that recycle or desalinate water can provide the nation with additional sources of water that are better insulated from drought and other pressures affecting traditional water sources. New water technologies can help water managers identify risks to their water supplies, allowing them to then address and solve the challenges. New technologies similarly can equip water managers to better characterize and manage groundwater aquifers and river systems, permitting the nation to maximize the yield of the nation’s existing water sources. Contaminants of emerging concern and increasingly stringent drinking water goals call for new purification technologies that can help remove those contaminants and provide drinking water of even higher quality.

In comparison to the electric power sector, however, both investment in innovation and the level of productivity in the water sector has been extremely low in the United States (Adjami, Thompson, & Victor 2014). Indeed, many observers have concluded that the United States is suffering from an “innovation deficit” in the United States equivalent to the funding deficit

discussed earlier (Kiparsky et al. 2013). Investment by the savviest promoters of innovation – such as venture capital and corporate research and development – are strikingly low when compared with other major sectors of the economy. Technology investment in the water sector totaled only \$1.5 billion in 2012, compared to investment of \$69 billion in clean energy. As a result, innovation in the water sector also is low. Patent levels in the water sector, for example, have always been lower than similar levels in the energy sector, but while the number of patents in the clean energy sector has increased rapidly in the clean energy sector over the last decade, patent levels in new water technologies have remained relatively constant – further increasing the gap in technological innovation. Adoption and dissemination of new innovations by water suppliers also has been slow (Adjami, Thompson, & Victor 2014).

The causes of this relatively low level of innovation in the water sector are multiple and not easily eliminated. Urban and agricultural water prices, for example, fail to pass on the full cost of water supplies to consumers, undercutting the incentive to develop innovative new conservation technologies and limiting the water revenues that can be invested in new research and development. Outdated and inflexible regulations sometimes encourage the continued use of status quo technologies instead of new innovations. Limited mechanisms for raising capital also hinder the development of new technologies. Finally, industry conservatism, the inherent long lifespan of water infrastructure, and system fragmentation all inhibit innovation (Adjami, Thompson & Victor 2014).

#### **A. Federal roles and programs**

While many of these factors are outside of the federal government’s control , EPA and other federal agencies can nonetheless play – and are playing – a significant role in promoting additional innovation in the water sector. First, EPA, the Small Business Administration (SBA), and various federal agencies all run programs that offer funding and other resources for research, development, testing, and implementation of new technologies in the water sector through direct grants and joint venture opportunities. USDA’s program of Conservation Innovation Grants (CIG), for example, enabled the North Plains Groundwater Conservation District in Texas to pool technical and financial resources with Texas Tech University, the Texas Alliance for Water Conservation, and other local agencies to demonstrate emerging new irrigation approaches and other conservation technologies. In addition to CIG, other key federal funding programs supporting research that could lead to greater water resiliency include Science to Achieve Results (EPA), the Environmental Security Technology Certification Program (Defense), the Small Business Innovation Research Program (SBA), and the Strategic Environmental Research and Development Program (Defense).

While many of the Bureau of Reclamation’s R&D programs are limited to internal agency research, Reclamation also supports external research designed to promote the Bureau’s goals. For example, Reclamation’s Desalination and Water Purification Research Program (DWPR Program) invites private industry, universities, water utilities, and others to partner with it to address a broad range of desalting and water purification challenges. Illustrative of the

innovations that it seeks to promote, the DWPR Program is currently funding projects, among others, designed to overcome technical, economic, and social barriers to water potable reuse.

Second, federal agencies help showcase and promote new technological innovations, build and share knowledge about opportunities for technological innovation, and facilitate partnerships, joint ventures, and shared learning within the innovation community. EPA, for example, has developed a comprehensive strategy for how it can use its large network of programs and affiliations to promote innovative new water technologies (EPA 2014). As part of this effort, EPA has created a number of Environmental Technology Innovation Clusters that research new promising technologies, track and map new technological breakthroughs, verify the effectiveness of these innovations, connect entities working on similar challenges, and encourage best practices. In 2014, EPA also created the Green Infrastructure Collaboration, a network of federal agencies, non-profit organizations, and businesses designed to promote the adoption of new green infrastructure by facilitating shared inquiry and knowledge and leveraging joint effort.

Third, federal agencies like EPA have reviewed their regulatory authority to ensure that their regulations promote rather than impede technological advances. EPA, for example, is updating its Effluent Limitations Guidelines and Standards Program to more explicitly consider sustainable and innovative technologies when developing national standards for controlling water discharges. EPA is also exploring ways in which it could tailor NPDES permits under the Clean Water Act to promote technological innovation. More generally, EPA is working with a number of non-profit organizations in the water sector, including the Water Environment Federation and the American Water Works Federation, to identify and either lower or remove regulatory or policy barriers to the acceptance and adoption of innovative new water technologies.

Finally, federal agencies work with state and local officials to help them identify and pursue policies and practices that promote technological innovation in the water sector. For example, the Confluence Water Technological Innovation Cluster worked with state regulators from Ohio, Kentucky, and Indiana to develop a cooperative agreement that allows testing of new technologies to be approved by all three states at the same time, reducing the time it takes new technologies to reach the market.

Key questions for discussion at the Symposium include:

- What are the most important areas of technological innovation for the promotion of water resilience in the United States? What are the most important areas of innovation in water management?
- What other policy mechanisms should the federal government consider to further promote the adoption of innovative new technologies? For example, should the government offer insurance to protect local water agencies that adopt new technologies against the risks of cost overruns or operational failures from the new technologies?
- Should the federal government play a greater role in the testing and dissemination of new technologies?
- Are there major federal barriers to the adoption of new technologies in the United States and, if so, what are they?

## **V. Leveraging Federal Water Programs**

As noted earlier, the federal government plays a major, direct role in the provision and protection of the nation's water resources. The federal government can use this role to help further promote new technologies and develop valuable science and information. The federal government also can partner with other levels of government and the private sector in carrying out its direct responsibilities, thereby both drawing on their expertise and knowledge and helping to further strengthen these other sectors.

As a major purveyor of water in the western United States, the federal Bureau of Reclamation illustrates how the federal government can both leverage and enhance state, local, and private expertise to increase water resilience. Reclamation, for example, can support, test, and adopt new technological innovations – helping to legitimize and promote the innovations elsewhere in the water sector. Reclamation also can promote technology transfer. At the moment, for example, Reclamation is developing a Geospatial Services Strategic Plan to support the expanded, effective use of geospatial technology within the bureau. As part of this strategic plan, Reclamation is developing collaborative partnerships with other governmental and private entities both to share information on and promote geospatial technology and share and reuse geospatial data for better analyses, decision-making, and operations.

Reclamation can similarly promote new water practices that increase resiliency. Most observers, for example, believe that water markets are critical to drought resiliency by both allowing water users to trade water in times of drought and permitting non-profit and governmental agencies to acquire water for environmental instream uses (Thompson, Leshy, & Abrams 2013). In 2014, for example, water trading enabled some farmers in California to acquire the water needed to keep their orchards alive, and the Reclamation continues to facilitate water transfers. The rules that Reclamation uses for its own water supplies can promote (or impede) the development and use of water markets in the West. While the Central Valley Project Improvement Act allows for water trading, some observers believe that an improved authorization process is necessary to promote

valuable transfers (Hanak et al. 2015). Reclamation also has been a major purchaser of water rights for environmental purposes, helping to build the market for environmental water transactions in the western United States (although federal investments in environmental water transactions have declined in recent years) (WestWater Research 2003).

Reclamation also can take advantage of the expertise of different levels of government and the private sector, as well as enhance the capabilities of these sectors, by partnering with these sectors or delegating responsibilities to them. Reclamation, for example, has transferred the operation of its facilities to local agencies, with significant expertise in local conditions and needs, in a large number of cases. In some situations, Reclamation has even transferred title to Reclamation facilities where the transfer will provide public benefits. In 2014, for example, Reclamation transferred ownership of the Provo River Aqueduct to the Provo River Water Users Association as part of a transaction that also replaced an open canal with a 21-mile pipeline. The piping of the canal conserved thousands of acre feet of water, 8,000 of which will be used for flows to support the endangered June sucker.

Key questions for discussion at the Symposium include:

- How innovative are federal water agencies? What steps could be taken to increase innovation? How can federal agencies better leverage their innovation to promote innovation in the private water sectors?
- What, if any, barriers do federal policies present to water marketing and environmental water transactions? How could the federal government reduce the barriers presented by the laws and policies of some states?
- What, if any, barriers exist to effective partnerships between federal water agencies and private companies either for services or the provision of capital?

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