A Water Strategy for the United States

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Keywords: Water Policy, Water Strategy, Paul Simon Water for the Poor Act, American Southwest

ABSTRACT

The world faces a serious water crisis. The United States faces water stress and potential water disasters.

The only hope we have of establishing effective and to the degree possible unified water policies is to develop a set of goals and principles for water management to which we progressively conform our policies and actions. The U.S. statement of goals and principles that underpin our international policies are more coherent than are the principles underpinning our domestic policies.

Guiding goals and principles for domestic water management should be developed with an eye to our stated international principles. These principles include:

- Understand the Status and Trends in Water Resources
- Expand Partnerships and Coordination Across Federal, State, Local and Native American Government Organizations
- Continue Federal Investment in Water Infrastructure
- Connect Water Quantity, Water Quality and Environmental Land Use Planning
- Seek Sustainable Development – Bridge the Gap Between Public Good and Private Rights
- Seek to Expand Supplies
- Provide a Strong Scientific Base for Water Management Decisions
- Value Water Resources Appropriately
- Value Ecosystems and Their Human Benefits

The progressive application of these principles will require coordination of policy development and implementation of programs across Federal agencies. The now defunct National Water Council provides an interesting example of how our nation approached these same problems 50 years ago and may hold clues to how we should proceed in the future.

BACKGROUND

The International Situation

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The World is faced with a serious water crisis. Currently 1.2 billion people don't have access to clean drinking water and twice that many don't have access to sanitation (WHO, 2005). Every year 1.8 million people die from diseases caused by water pollution and the vast majority of these are children (UNDP, 2006). Worldwide, a child dies every 15 seconds from diarrhea (WHO and UNCF, 2006). According to United Nations sources, by the year 2020, as many as 76 million people could die from polluted water (Gleick, 2002). These projections indicate that by 2015 nearly half the world's population, more than 3 billion people, will find it hard, if not impossible to get pure drinking water.

The United States has made solving the world's water crisis a formal policy objective through passage of the Senator Paul Simon Water for the Poor Act (DOS, 2008). In passing this law, the United States Congress recognized the staggering humanitarian consequences, the derivative security, and disease ramifications.

Prior to implementation of this Act, the United State's efforts were weak at best. Erik Peterson of the Center for Strategic and International Studies sums up the state of affairs 2 years ago by saying:

> "According to the OECD, U.S. official development assistance commitments for water supply and sanitation in 1999-2000 amounted to less than two percent ($165m) of total national assistance—the lowest (with New Zealand) of any OECD member state.1 By 2003-2004 the U.S. level had grown to $521m, according to the same OECD statistics, but the lion's share of the rise was attributable to increased financial assistance directed to Iraq—and even at that level, total assistance was well below the corresponding level for Japan, the OECD leader in water spending. Of the water-related U.S. support not channeled into Iraq, moreover, a disproportionate percentage was allocated to the Middle East and not to regions such as sub-Saharan Africa where the problems are the greatest. In other words, politics are trumping need. Le plus ça change….
>
> In a recent report to Congress mandated by the Water for the Poor Act of 2005, the State Department maintained that in FY2006, the U.S. Government obligated $844 million in bilateral and multilateral assistance for "water, sanitation, and related activities around the world." 2 That level probably represents a better-than-best-case scenario because a very wide range of government activities were included. The reality, however, is that U.S. water-related foreign assistance is small in comparison with other OECD donors, concentrated in a relatively small number of countries in which water needs are less pronounced than elsewhere, and dispersed across many diverse parts of government." (Peterson, 2007)

Initial funding was included in the FY08 Federal Budget (PL 110-161, 2008) and continuation of the program has been proposed by the Senate for FY09 (Senate Report 110-425, 2008), but this is just an initial effort in a long process. Now we have to ensure continuity of the program, and use the funds wisely.

The Domestic Situation

To sustain the United States' current population of 300 million people, we withdraw around 345 billion gallons of water a day. This equals 30% of all the runoff in the United States. Of these withdrawals, approximately 30% is consumed. So approximately 10% of all surface runoff (our renewable supply) is consumed currently (SWAQ, 2007).

We use the remainder of the water to provide dilution of municipal, industrial and agricultural discharges; environmental water needs; river based transportation; energy production and support other needs. It is difficult to measure the fraction of the non-diversion capacity currently used.

Over-consumption, climate change, and significant population growth have caused the United States to begin to experience the effects of water shortage (BOR, 2005). Water stress is affecting almost every region within the United States (GAO, 2003).

Our domestic water issues can be seen most clearly in the American Southwest. Southern California, Nevada, Arizona and New Mexico are all experiencing significant and intense droughts and water shortages (National Academies, 2007).

At the center of the crisis is the Colorado River. Due to climate change, this river is at the lowest level ever recorded (Dean, 2003). This important river is the primary water source for the 30 million people who dwell within the American Southwest (Udall, 2006). Due to projected population growth and other demands, the Colorado River is going to out-strip the amount of water supply that will be available within the region and this could lead to chaotic conditions in the not-too-distant future (BOR, 2005). While most citizens of this region have adequate, clean water, there are third-world type conditions within certain regions of the country (Leeper, 2003). Among the communities most affected are Hopi and Navajo reservation lands. Many areas of these reservations have no physical infrastructure. Compounding the problem, there are also serious water quality problems and lack of adequate sanitation, resulting in illness among members of the community (Arizona Republic, 2008).

Numerous solutions to the nation's water problems have been proposed (Postel, 1999), however, conflicting water resources and sanitation policies along with lack of investment are allowing the water crisis in the U.S. to get worse (SWAQ, 2005).

NATIONAL WATER POLICY

The United States has grappled with the international and domestic water problems for many years, yet these problems persist. One reason is that various Federal policies and programs are based on different and occasionally non-aligned goals and principles.

International Goals and Principles

Our international goals are clearer than out domestic goals. In addressing the international water situation, the United States, through the Paul Simon Water for the Poor Act of 2005, established the following goals:

> "It is the policy of the United States—
>
> (1) to increase the percentage of water and sanitation assistance targeted toward countries designated as high priority countries …;
>
> (2) to ensure that water and sanitation assistance reflect an appropriate balance of grants, loans, contracts, investment insurance, loan guarantees, and other assistance to further ensure affordability and equity in the provision of access to safe water and sanitation for the very poor;
>
> (3) to ensure that the targeting of water and sanitation assistance reflect an appropriate balance between urban, periurban, and rural areas to meet the purposes of assistance …;
>
> (4) to ensure that forms of water and sanitation assistance provided reflect the level of existing resources and markets for investment in water and sanitation within recipient countries;
>
> (5) to ensure that water and sanitation assistance, to the extent possible, supports the poverty reduction strategies of recipient countries and, when appropriate, encourages the inclusion of water and sanitation within such poverty reduction strategies;
>
> (6) to promote country and local ownership of safe water and sanitation programs, to the extent appropriate;
>
> (7) to promote community-based approaches in the provision of affordable and equitable access to safe water and sanitation, including the involvement of civil society;
>
> (8) to mobilize and leverage the financial and technical capacity of businesses, governments, nongovernmental organizations, and civil society in the form of public-private alliances;
>
> (9) to encourage reforms and increase the capacity of foreign governments to formulate and implement policies that expand access to safe water and sanitation in an affordable, equitable, and sustainable manner, including integrated strategic planning; and
>
> (10) to protect the supply and availability of safe water through sound environmental management, including preventing the destruction and degradation of ecosystems and watersheds." (PL 109-121, 2005)

Domestically, we have widely distributed and sometimes conflicting goals resulting from an array of water related laws. It is impossible to list all these goals in this paper, but a few pieces of legislation that guide domestic water policy are listed in Appendix A.

Goals and Principles for Water Policy

Given the wide range of existing water policies with very different goals, the distribution of responsibility for establishing water policy issues across numerous Congressional committees and subcommittees, more than 20 agencies in the executive branch (SWAQ 2005), state and local governments**, the only hope we have of establishing effective and to the degree possible unified water policies is to develop a set of principles for water management to which we progressively conform our policies and actions**.

The following is list of key policy principles that should be considered.

Understand the Status and Trends in Water Resources

Water resources are part of a complicated set of natural and man-made systems. Management requires accurate, up-to-date, and appropriately consolidated information for decision-makers and citizens. Information is needed on water, land, status and trends, the hydrologic relationships across the system across, along with demand status and trends. Decision-makers and affected citizens need access to such information, as well as its assessment and interpretation, if they are to participate intelligently in the process of sustainable water management.

Collection of national water resources data appears to be a logical responsibility for the Federal Government. The U.S. Geological Survey, the National Oceanic and Atmospheric Administration, U.S. Department of Agriculture, and other agencies currently work to assess the extent of our national water resources. Initial characterization and long-term monitoring go hand in hand. One area of water monitoring – water quality – has received significant attention. The National Water Quality Monitoring Council, consisting of representatives of multiple agencies, has worked to:

> "champion and support water-quality information aspects of natural-resources management and environmental protection. The National Council has a broad mandate that encompasses water quality monitoring and assessment that includes considerations of water quality in relation to water quantity. The purpose of the National Council is to coordinate and provide guidance and technical support for the voluntary implementation of the recommendations presented in the Strategy for Improving Water-Quality Monitoring in the United States (the strategy) by government agencies and the private sector. The intent of the strategy …is to stimulate the monitoring improvements needed to achieve comparable and scientifically defensible information on interpretations and evaluations of water-quality conditions. The information is required to support decision-making at local, state, interstate, regional, tribal, and national scales" (NWQMC, 2005).

However, monitoring programs, their assessment, and mapping programs are progressively decreasing in size. For example, between 2004 and 2005, the U.S. Geological Survey has had to discontinue collecting stream gage information at 175 stations with over 30 years of continuous data and are facing the need to discontinue another 165 of the currently active 7,300 stations nation wide (or another 2%) if funding is not increased. The actual funding for these stream gauging programs has, at best, been stable. At the same time, a group of gauging advocates representing state and local government, and many national interests believe that the National Streamflow Information Program is only funded at 15% of what is needed (Senator Pete Domenici letter to Secretary Kempthorne, August 17, 2006).

The Federal role in assessing national resources seems clear,

> "The United States should accurately assess the quantity and quality of its water resources, should accurately measure how water is used, and should know how water supply and use change over time, … Today's decisions and policies will shape our water future. The effectiveness of those decisions depends on the quality of information and on incorporating knowledge about the reliability (or conversely, the uncertainty) associates with predictive management tools. In addition to improved water data, the United States should develop and expand a variety of forecasting and predictive models and systems. Scientists should improve our knowledge of how water resources change because of natural events and human actions. We should develop an array of tools, using behavioral, management, and other social sciences, to educate and influence water-use behavior of individual water users, businesses, industries, and resources managers"

However, the relative importance of this responsibility (funding priority) and which agencies have which roles is not (SWAQ, 2007).

<u>Expand Partnerships and Coordination Across Federal, State, Local and Native American Government Organizations</u>

At present, 20 Federal agencies and bureaus under six cabinet departments have responsibility for water resources management in some way and are directed by 13 Congressional committees with 23 subcommittees and 5 appropriations subcommittees (AWRA, 2007). Consolidation of these responsibilities would make the job of managing water resources easier, but is unlikely. Consequently, partnerships and coordination are the only way to bring integrated policies to bear.

The calls for cooperation are loud. While states strongly protect their rights to manage water within their boundaries, two of the top 5 Federal actions desired by state water managers were:

> " better coordinated federal participation in water-management agreements; and … more consultation with states on federal or tribal use of water rights." (GAO, 2003).

Non-profits and policy think tanks are in agreement. For example, the American Water Works Resources Association through their National Water Policy Dialogues, have advocated for 1) integrated water management approaches and 2) Federal roles in providing technology, information and collaborative solutions (AWRA, 2007) as means to stretch or expand water supplies.

Many water policy reviews haves identified a need for greater cooperation among local, state and Federal water management organizations to synchronize operations, policies and new development, for example:

> "At the national level there is no coordinated process for considering water resources research needs, for prioritizing them for funding purposes, or for evaluating the effectiveness of research activities." (NRC, 2004a)

The unresolved issues here revolve around the structure of coordination. Is there a Federal cross-agency national coordination role? Should coordination only occur at the local level and if so what is the best organizing structure? Does one size fit all across the nation?

Continue Federal Investment in Water Infrastructure

By definition, there are Federal responsibilities and national benefits derived from water management (see the list of legislation included in Appendix A). Federal investment accompanies and supports there Federal "benefits"

As of 1994, The Federal Government had invested $21.8 billion in 133 Western water infrastructure projects pursuant to the Reclamation Act of 1902. Of this, $16.8 billion is scheduled to be repaid (GAO, 1997) leaving a relatively small total investment of $5 billion over 90 years. The annual appropriation to the Bureau of Reclamation to implement operations, maintenance, new projects, undertake environmental activities and research hovers around $1 billion (BOR, 2007).

As of 2006, the Army Corps of Engineers maintained infrastructure with an estimated replacement cost of $217 billion. This is 14% of all the assets of the Federal Government including all military assets which make up 47% of the total. The Army Corps of Engineers holds the largest single set of non military assets making up 1/3 of all the non-military assets. The Corps annual appropriations hovers between $4 and $5 billion dollars annually to maintain and build new water infrastructure (Federal Real Property Council, 2006).

The Federal government has maintained a formal role in financing the nation's drinking water (e.g., Safe Drinking Water Act of 1974, Federal Water Pollution Control Act

Amendments of 1972) and wastewater systems (e.g., Water Pollution Control Act of 1948) for over fifty years. Since 1948, Congress has appropriated $77.6 billion including $25.5 billion in the State Revolving Fund capitalization grants to improve wastewater management. Congress has also appropriated $9.5 billion for the Drinking Water State Revolving Loan Fund through 2007 to strengthen drinking water systems.

The American Recovery and Reinvestment Act of 2009 provided $13.94B for various water, wastewater and watershed programs including the USDA for watershed and flood prevention ($340M) and Rural Utility Water and Wastewater disposal ($1.38B), Bureau of Reclamation ($1B), the U.S. Army Corps of Engineers ($4.6B), EPA for State and Tribal Assistance Grants ($6.4B), Dept of State for the International Boundary Water Commission ($220M). However, this large installment payment does not by itself eliminate the massive infrastructure development needs.

Nevertheless, the gap between what we need to invest in our infrastructure and the level of currently available investment is growing. In 2003, the Environmental Protection Agency estimated that national drinking water systems need to invest $276.8 billion over the next 20 years to meet current and new drinking water regulations, not including the cost to maintain and improve existing wastewater systems (Copeland and Tiemann, 2007).

The commitment to continue Federal funding exists, but there is conflict over how much Federal investment is appropriate. The Federal investment in fiscal year 2007 for the Clean Water State Revolving Fund grants was $1.08 billion and the investment for the Drinking Water State Revolving Fund grants was $837.5 million. The President's proposed budget for fiscal year 2008 for the Clear Water State Revolving Fund was $687.6 million or a decrease of over 30% from the amount enacted in 2007 (CRS, 2007).

Local municipal financing of the full life-cycle costs for water and wastewater is one of the four main policy positions of the Environmental Protection Agency. Nevertheless, the Agency has published a list of 88 Federal or local funding mechanisms that can be used by individual communities to pay for infrastructure improvements (EPA, 2007).

The examples provided here are not comprehensive in their description of the Federal investment in water-related infrastructure. However, they provide the flavor of the current investment and debate over the future. It is clear that the cost of infrastructure development, maintenance and operation is growing. The regulatory requirements, and therefore, the cost of current operations are increasing. The Federal government is not unified in its policy positions or its planning for future investment in water infrastructure. The dichotomy between providing assistance and advocating independence is maintained in nearly every Federal water infrastructure support program. Due to the enormous costs, this area of Federal responsibility is likely to remain contentious.

Connect Water Quantity, Water Quality and Environmental Land Use Planning

We are dependent on water, and everything our society does, affects it. As a consequence we must have a holistic view of water systems, water uses and our use of land and other resources that affect water. It is essential to include all forms of water (e.g., surface flow, ground water, precipitation, ice, snow pack); its characteristics (i.e., water quality); and our actions that impact water (i.e., land use management) in any management approach.

Consequently, we cannot separate our direct use of water and our actions in management of land resources with their indirect impacts on water. One indicator of this relationship is the degree of water quality degradation measured by the U.S. Geological Survey's water quality assessment program. A recent nationwide study of 178 streams found that low levels of pesticides were detected in all streams studied and a little over 83 percent of sample locations along streams in urban settings had concentrations that could impact aquatic life forms (Gilliom et al., 2006). The implication is that both our farming and urban land use directly impacts the quality of water resources.

The approach most commonly put forward to addressing this multi-aspect form of water resources management is called "Integrated Water Resources Management." While this concept is gaining acceptance and application, it is woefully under-used in our highly fractionated water management system in the United States.

The water encyclopedia describes Integrated Water Resources Management as,

> "Integrated water resources management is the practice of making decisions and taking actions while considering multiple viewpoints of how water should be managed. These decisions and actions relate to situations such as river basin planning, organization of task forces, planning of new capital facilities, controlling reservoir releases, regulating floodplains, and developing new laws and regulations. The need for multiple viewpoints is caused by competition for water and by complex institutional constraints. The decision-making process is often lengthy and involves many participants." (Grigg, 1996a; Grigg, 1996b)

The United Nations and the World Health Organization are ahead of the United States in implementing this policy position. They state,

> "The seventh Millennium Development Goal aims to ensure environmental sustainability, with its first target being the integration of principles of sustainable development into country policies and programmes and the reversal of the loss of environmental resources. With respect to water resources the World Summit on Sustainable Development (Johannesburg, 2003) resolved to include the formulation of national plans for Integrated Water Resources Management (IWRM) and for water use efficiency in this target." (WHO, 2008)

Additionally, we are already experiencing and anticipate greater impacts on hydrological systems due to climate change. The International Panel on Climate Change recent report states:

> "Climate, freshwater, biophysical and socio-economic systems are interconnected in complex ways. Hence, a change in any one of these can induce a change in any other. Freshwater-related issues are critical in determining key regional and sectoral vulnerabilities. Therefore, the relationship between climate change and freshwater resources is of primary concern to human society and also has implications for all living species." (Bates et al., 2008)

Seek Sustainable Development – Bridge the Gap Between Public Good and Private Rights

Sustainable Development is currently defined in Wikipedia as,

> "Sustainable development is a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but in the indefinite future. The term was used by the Brundtland Commission which coined what has become the most often-quoted definition of sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." (Wikipedia, 2008a)

While the term sustainability is somewhat difficult to define in a way that all stakeholders agree, the basis concepts are valid. Our use of current water resources needs to provide a long-term (verging on indefinite) supply for human and ecological uses that preserves the functions of the system. We need to treat water as we would any other scarce resource, we need to learn to live within our means.

A key issue raised in the debate over sustainability is whether adoption of "sustainability" as a principle, limit growth? - Over the last 25 years, our per-capita water use has decreased, allowing a degree of stability in total water withdrawals. In California, urban use has remained essentially the same as the state added over 3.5 million (around 10%) more residents in the last 10 years (CDWR, 2005). Greater efficiency allowed decoupling of increased water use from population growth.

However, we need to understand how long this "efficiency" approach can work? "Since 1975, per capita water use in the United States has fallen at an annual rate of 1.4 percent. Even absolute water withdrawals peaked about 1980. Industry, alert to technology as well as costs, exemplifies the progress, although it consumes a small fraction of total water. Total U.S. industrial water withdrawals plateaued about 1970, and have since dropped by one-third ... Also interesting is that industrial withdrawals per unit of GNP have dropped steadily since 1940. Then, 14 gallons of water flowed into each dollar of output. Now the flow is less than three gallons per dollar…Technology, law, and economics have all favored frugal water use.…Despite the gains, the United States is far from the most efficient practices. Water withdrawals for all users in the OECD countries range tenfold, with the United States and Canada the highest. Allowing for national differences in the

major uses (irrigation, electrical cooling, industry, and public water supply), large opportunities for reductions remain." (Ausubel, 1998)

At the same time, pressure on water supplies is mounting. Many southwestern cities have reduced per-capita domestic water use to 120-140 gallons per day and find it very costly and difficult to further reduce water consumption below these levels. Population in the United States is anticipated to grow by another 25% to around 390 million by the year 2050 (Cheeseman Day, 2007). It is highly unlikely that the entire increase in water demand due to population increase will be offset by efficiencies.

Withdrawals for the two largest non-domestic users of water, irrigation and thermoelectric power production, are about equal at 40% each (SWAQ, 2007). Dramatic changes in energy policy encouraging ethanol production including the President's call for 35 billion gallons of ethanol per year by 2017 (2007 State of the Union Address) and increased demand for electricity at least proportional to population growth will likely increase both these demands.

For electric power production, the water use per kilowatt hour produced has decreased by 2/3 since 1950 and an aggressive research agenda has been proposed to further reduce this dependence (EPRI, 2007). However, even with these encouraging results, total electricity demand is anticipated to increase by 41% by 2030 regardless of increases in energy efficiency (EIA, 2007). The result is a significant increase in water withdrawals for one or both of the two main uses of water.

It is likely therefore that each of the three main uses of water – agriculture irrigation, thermo-electric power production, and municipal-industrial uses – will all increase significantly in the near future.

An additional aspect of efficiency is flexibility under stress. Just as electric power generation excess capacity (ability to produce more electricity than normal demand) provides a buffer for short periods of high demand and is critical to long-term stability and reliability of the electricity supply, so too is excess capacity important in water supplies. During times of drought, water in storage and the ability to become even more efficient or conserve for short periods of time is important. As overall, average efficiency improves, the excess capacity diminishes and along with it the ability to react without huge societal disruption to drought periods.

Seek to Expand Supplies

Coupled with the need to be more efficient in order to meet sustainability goals, is the need to expand supplies. There are a couple of key methods: 1) expanding storage capacity in reservoirs and underground aquifers, and 2) treating low-quality water so it can be used or reused. Some consider these a form of efficiency.

The Government Accounting Offices reports that state water managers ranked their number one desire for Federal action as "financial assistance to increase storage and distribution capacity" (GAO, 2003).

The National Science and Technology Council, Committee on Environment and Natural Resources, Subcommittee on Water Availability and Quality identified water treatment as one of its three primary challenges that must be addressed to ensure adequate water supplies:

> "The United States possesses significant volumes of water that cannot currently be used because they are of marginal quality. The national water supply will be bolstered by the treatment and use of these marginal or impaired waters. Just as water managers now rely on information provided by scientists to make informed decisions about the use of existing water resources, so science and technology will help expand management choices and help expand the water supply. Expanding the water supply should be accomplished through technological means by making poor-quality water usable. Efficiency also plays an essential role; increased water efficiencies will be achieved through both technological and institutional mechanisms." (SWAQ, 2007)

California's water management challenges revolve around the Sacramento-San Joaquin River delta. This hot spot is the transfer point of water from northern and eastern rivers to the transport systems that takes the water to southern California. In addressing the states water problems, a key state advisory panel listed water treatment in the form of: 1) ocean and brackish desalination, 2) recycled municipal water, and 3) conjunctive management and groundwater storage as three of their eight primary methods for managing the water imbalances of the future (Governor's Delta Vision Blue Ribbon Task Force, 2008).

Provide a Strong Scientific Base for Water Management Decisions

Regardless of what humans want a natural system to be, produce or become, we are limited by the natural constraints on the system. The size and chemistry of an aquifer, a river's catchment size, the amount of rain or snow, temperature controls, and so forth are aspects of a natural system that limit what can and can't be done. Understanding how the natural system works and monitoring our impact on the system so we can adjust our management practices are key aspects of a viable water management scheme.

The first step is an adequate inventory or a scientific understanding of the total amount of water supply which exists within the U.S. groundwater and aquifer systems. Robert Hirsch, while the Associate Director for Water at the U.S. Geological Survey was a strong advocate for a national inventory.

> "We believe … that … expanding data acquisition and analysis to improve water management and ensuring that decision makers have reliable information about

> water resources and climate change impacts on water availability and energy production - are critically important." (Johnson and Hirsch, 2007)

The connection between continuous learning and management is termed, "adaptive management." Again Wikipedia provides a concise definition,

> "Adaptive management (AM), also known as adaptive resource management (ARM), is a structured, iterative process of optimal decision making in the face of uncertainty, with an aim to reducing uncertainty over time via system monitoring. In this way, decision making simultaneously maximizes one or more resource objectives and, either passively or actively, accrues information needed to improve future management. AM is often characterized as 'learning by doing.'" (Wikipedia, 2008b)

In this general form, Adaptive Management is well suited to incorporate adaptation for any variation in the system including but not limited to climate change.

Additionally, adaptive management presumes a systems understanding that couples not only the water resources elements but also connects to water uses and benefits in such a way that decision makers can assess and manage the whole as a dynamic system. The tools used to accomplish such a task are know as systems analysis or systems dynamics tools and are readily available and used (Stave, 2003; Winz and Brierly, 2007; Passell, Tidwell and Webb, 2002) but their application is very limited at present.

The Federal role in developing the scientific understanding upon which water management decisions are made, is hotly debated. However, scientific assessments and monitoring should be designed to take advantage of the efforts of all management organizations with a basin or other cooperative unit. Federal agencies have significant roles in the science and monitoring enterprise today. According to a definition used by the Office of Science and Technology Policy, the Federal role in water resources science or technology research depends on the degree of "public good" measured by whether the benefits of the research are widely dispersed and whether the research "is being or even can be addressed by institutions other than the Federal government" (SWAQ, 2007). This definition presumes some partnership between public and private investment that can and maybe should evolve so that if private or non-Federal government investments are sufficient to cover an area of research, the Federal interest and investment is diminished. At the same time it acknowledges that some activities are likely to be a permanent Federal responsibility.

Value Water Resources Appropriately

As discussed above, the cost of water management, resource expansion, environmental protection, infrastructure maintenance and so for is very high. The real costs for water is often unknown by the consumer because a portion of the cost is met through redistribution (Federal or state taxes returned to pay for local projects) or through deferred infrastructure maintenance (building up a debt to be paid later). As a

consequence, the direct cost of water has been relatively inexpensive in the United States. This has created a situation where relatively few citizens understand its worth and the need for constant investment to provide sustainable supplies.

At the same time, many communities are advocating for efficiency and conservation by their water consumers. Given our current attitude that real cost and the benefits of efficiency and conservation are disconnected, it is no wonder that the progress toward efficiency is difficult.

Internationally, the valuation of water has been recognized and has become a fundamental principle in United Nations project implementation (UN, 2003). And the principles of water valuation are fairly well understood (Savenije, 2000).

Transparency about the real cost of water should be a fundamental principle in our communication with water users, irrespective of the source of funds that underwrite the supply. This is somewhat akin to the financial accounting standards emplaced in 2002 where all costs (including deferred) need to be disclosed (PL 107-204, 2002).

Value Ecosystems and Their Human Benefits

Water is intrinsic to all ecosystem services. None can exist, be processed or be made available to man without some connection to water. Consequently, our management of water must account for the impact of our water use on other ecosystem services.

Rudimentary connections have been established through regulatory programs such as the Endangered Species Act of 1973 however, such regulatory approaches are limited in their flexibility and scope. For the purposes of sustainability described above, we need a different construct for water management. One not based entirely on minimal protections.

The National Research Council has tried to explain the importance of the broad array of ecosystem services:

> "The biota and physical structures of ecosystems provide a wide variety of marketable goods—fish and lumber being two familiar examples. Moreover, society is increasingly recognizing the myriad life support functions, the observable manifestations of ecosystem processes that ecosystems provide and without which human civilizations could not thrive…These include water purification, recharging of groundwater, nutrient recycling, decomposition of wastes, regulation of climate, and maintenance of biodiversity. Despite the importance of ecosystem functions and services, they are often overlooked or taken for granted and their value implicitly set at zero in decisions concerning conservation or restoration." (NRC, 2004b)

Our understanding of the basic functions of ecosystems, the array of benefits we derive from ecosystems (Mooney and Ehrlich, 1977), and the methods by which we value these

benefits is in its infancy (Ruhl, Kraft, and Lant, 2007). Nevertheless, we must include some form of valuation of these services in our national policies and approaches to water resources management.

IMPLEMENTATION

Our nation has faced the need to resolve its water policy options multiple times. The timing, short-term goals and public stress or drivers have varied, but there are some common lessons.

For example, in April 1959 the U.S. Senate created a Select Committee on National Water Resources motivated in part by one of the worst droughts in the Nation's history. After nearly two years, the Committee reported to the full Senate a series of major recommendations. They proposed that our nation needed:

> "1) Streamflow regulation through reservoir construction and watershed management; 2) Water quality improvement through more adequate pollution abatement programs; 3) Better use of underground storage; 4) Increased efficiency in water use and substitution of air for water cooling; 5) Increasing natural water yield by desalting, weather modification and other means."
>
> "The committee recommended that the Federal Government should undertake a coordinated scientific research program on water, aimed both at increasing available water supplies and making more efficient use of existing supplies. It was recommended that this would be accomplished primarily by: (1) expanding basic research programs, deemed essential by the committee for major breakthrough in water resources, (2) a more balanced and better constructed program of applied research for increasing water supplies, (3) an expanded program of applied research for water conservation and making better use of available water resources, and (4) evaluation of completed projects with a view to making them more effective in meeting changing needs and providing better guidelines for future projects." (Senate Report, 1969)

After significant debate, the recommendations resulted in passage of the Water Resources Research Act of 1964 (P.L. 88-379) and the Water Resources Planning Act of 1965 (P.L. 89-80). Additionally, the recommendations resulted in the 1961 amendments to the Water Pollution Control Act; extension of the saline water conversion program in 1961 and 1965; and research and development funding for weather modification techniques.

The Water Resources Planning Act of 1965 created the Water Resources Council in the Whitehouse and allowed for creation of multiple river basin commissions. The Water Resources Research Act of 1964 created the Water Resources Research Institutes at land grant colleges. (Senate Report, 1969)

Title I of the 1965 Water Resources Planning Act established a Water Resources Council to be composed of Cabinet representatives, including the Secretary of the Interior. Title II

established River Basin Commissions and stipulated their duties and authorities. The Council was empowered to maintain a continuing assessment of the adequacy of water supplies in each region of the U.S. In addition, the Council was mandated to establish principles and standards for Federal participants in the preparation of river basin plans and in evaluating Federal water projects. Upon receipt of a river basin plan, the Council was required to review the plan with respect to agricultural, urban, energy, industrial, recreational and fish and wildlife needs. Title III established a grant program to assist States in participating in the development of related comprehensive water and land use plans.

The law creating the Council was never repealed, but functions of the Council were redirected and the Water Resources Council was "defunded" and is therefore defunct.

Remnants remain. For example, the Water Resources Research Institutes are still with us, but do not function in a way as to carry a nation-wide research agenda due primarily to funding shortfalls and constant challenges to their organizational value.

A degree of these coordination and oversight responsibilities reside in the Council on Environmental Quality in the Whitehouse which, "coordinates federal environmental efforts and works closely with agencies and other White House offices in the development of environmental policies and initiatives" (CEQ, 2008). Nevertheless, CEQ historically has not indicated a strong interest in the coordination role of water resources development.

Additionally, the U.S. role in solving international water resources issues was not incorporated into the original Water Resources Planning Act of 1965 nor its successor organizations and thus, the disconnect between our international and domestic water programs remains.

It is possible that under new CEQ Executive leadership, or leadership from some new office or structure, that both the international and domestic water crisis could be jointly addressed and receive strong foreign and domestic policy White House priority.

In conceptualizing and implementing such a "coordination" function, it is essential that the key policy principles discussed here be carefully developed and then guide our integrated domestic and international actions.

Conclusions

When it comes to water resources and all that depends them, the planet is clearly at a crossroads. Poulation growth, increased demands and changes in our hydrological systems caused by climate change make addressing the water crisis an imperative.

Key to the manner in which the United States can assume global leadership is "setting a viable example" meaning we must solve our own drinking water and sanitation issues.

Additionally, our leadership is a critical element in solving the world's water problems which in turn helps improve the United States security situation.

In developing our domestic and international water policies, we need a consistent set of principles. We propose that these principles include:

- Understand the Status and Trends in Water Resources
- Expand Partnerships and Coordination Across Federal, State, Local and Native American Government Organizations
- Continue Federal Investment in Water Infrastructure
- Connect Water Quantity, Water Quality and Environmental Land Use Planning
- Seek Sustainable Development – Bridge the Gap Between Public Good and Private Rights
- Seek to Expand Supplies
- Provide a Strong Scientific Base for Water Management Decisions
- Value Water Resources Appropriately
- Value Ecosystems and Their Human Benefits

To fully define and implement integrated policies, we also need a new national coordination function. Such a function could be patterned after the now defunct National Water Council or some similar structure in the Executive Branch / White House.

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Appendix A: Authorities that guide US Water Policy

The following is not a comprehensive list, but provides some sense of the breadth of laws that underpin US Domestic water policy.

- Act of March 3, 1879 (45 Stat. 394, chapter 182; 43 U.S.C 31) or the USGS Organic Act
- Water Desalination Act of 1996
- Reclamation Wastewater and Groundwater Study and Facilities Act of 1992
- The Act of June 17, 1902 (43 U.S.C. 391 et seq.) commonly known as the "Reclamation Act of 1902"
- Reclamation States Emergency Drought Relief Act of 1991
- Foreign Assistance Act of 1961 parts I and II
- United States Information and Education Exchange Act of 1948
- Mutual Education and Cultural Exchange Act of 1961
- Colorado River Basin Salinity Control Act

- Federal Water Pollution Control Act
- Biomass Research and Development Act of 2000
- Clean Water Act
- Safe Drinking Water Act
- Endangered Species Act
- Clean Air Act
- Department of Agriculture Organic Act of 1862
- Bankhead-Jones Act section 1 Act of 1935
- Food and Agricultural Act of 1977
- National Agriculture Research, Extension, and Teaching Policy Act of 1977 containing the Food Security Act of 1985
- Farm Security and Rural Investment Act of 2002
- Public Health Service Act
- Comprehensive Environmental Response, Compensation, and Liability Act of 1980
- Energy Reorganization Act of 1974
- Federal Nonnuclear Research and Development Act of 1974
- Department of Energy Organization Act of 1977
- Energy Policy Act of 1992
- Energy Policy Act of 2005