SUSTAINABLE WATER INFRASTRUCTURE

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New Federal Policies

Sustainable water systems in the future will use, treat, store, and reuse water efficiently at a small scale and will blend designs into restorative water hydrologies.

Federal policies to promote these designs include:

- **Research and demonstration projects**
- **Cleantech venture capital funding**
- **Tax incentives for builders and homeowners**
- **National standards for water-efficiency and reuse**
- **Support for utilities that implement sustainable designs**
- **Integrated water, energy, and resource management**
- **Federal facility use of sustainable water systems**
- **Green collar job education and training**

Introduction

The debate over the recently enacted economic stimulus package has renewed discussion about whether the nation should be investing billions of dollars to rebuild our aging infrastructure. Water lines, sewer mains, and treatment plants—many built over a hundred years ago—are leaking, collapsing, and overflowing. Utilities wanted federal money to help fix these problems, but pressure to slim down the package quieted that discussion temporarily.

Why not use the reality of deteriorated infrastructure as a rationale for investing in next-generation technologies and designs?

There is a concept in asset management called "run to failure," where it is efficient to stop repairing the old system and eventually to replace it with something new. Since much of our water and wastewater infrastructure seems to be well on its way to breaking, we have a golden opportunity to leapfrog into the future—as developing countries like China and India are beginning to do. Calling our essential infrastructure's failure an "opportunity" may seem counter-intuitive, but if we had kept these systems in good shape, we would actually have fewer openings to shift to something new.

We can all find examples of "running to failure" in our own financial choices, such as maintaining an old, rundown car. We still change the oil regularly, and we keep the brakes working. Otherwise, we stop investing in the car, and start saving every last dime for a new one—maybe a more efficient car this time, or a hybrid.

In the mid-1800s, we started piping clean water into cities and building drainage and sewer pipes to take away stormwater and wastewater. This system has saved lives by reducing pathogen exposures and preventing periodic flooding. But this big-pipe, centralized infrastructure is not sustainable over the long term. These municipal systems consume too much water, disrupt too many ecosystems, and use too much energy to move water and wastewater around. Growing populations, increasing land development, and climate change will make these problems much worse.

Solutions

Some homeowners are already using water-efficient washing machines and recycling sink and shower water to irrigate lawns. Rain gardens and green roofs can collect stormwater and prevent flooding and sewer overflows. A new idea is to recapture energy and nutrients from wastewater.

In Seattle, Philadelphia, and Chicago, officials are designing water services in ways that also improve air quality, restore urban streams, and replace pavement with parks and urban gardens. Groups in Georgia and California are learning that more efficient next-generation systems that reuse water and replenish aquifers are critical for dealing with deepening drought conditions. New subdivisions can now be built that need virtually no imported water.

New York City's Battery Park City has several new high rises that treat stormwater runoff and wastewater and recycle it back into landscaping, cooling towers, and toilet flushing. Officials are offering incentives for such approaches because every gallon of fresh water they do not need to pipe in, and every gallon of wastewater and stormwater they do not need to pipe out, reduces pressure on the city's aging underground water and sewer systems.

It is nice to see these scattered models in the US, but other countries dwarf our investment in next-generation approaches. The cities of Shanghai, Singapore, and Abu Dhabi are devoting staggering amounts to research and demonstration projects for a sustainable water infrastructure, prompting US companies and engineering firms to look abroad for the big next-generation markets. Part of our problem is a legacy of well-intentioned rules and regulations, like the Clean Water Act, that continue to support use of wasteful and disruptive technology. Municipal utilities have to comply with national permit requirements for old best practices that are costly and leave little room for creativity.

What will it take for our nation to get on the path to sustainable water infrastructure?

For a start, we need to restore research funding to lead the development of new technologies and capturing jobs and profits in the global marketplace. We should provide tax incentives that encourage builders, architects, and homeowners to adopt and implement these systems. We need to rewrite federal legislation so that the best—not the most conventional—technologies can be used in our cities and towns.

As for the "sunk" costs of our aging infrastructure, we need to shift our national investments toward the future. We need to keep old pipes working well enough at critical points to protect public health.

But, instead of using federal funds to repair and replace these pipes and treatment plants in the old way, it may be wiser to pivot federal investments into the new infrastructure.

Traditional	New Sustainable
♦ Rapid conveyance—underground concrete pipes and large treatment plants	♦ Opposite of rapid conveyance—keep a significant portion of the source, use, treatment, and/or disposal at the local level (site or neighborhood)
♦ First goal of public health protection—clean water delivery and wastewater disposal, flood control channels Later—water quality protection in receiving waters	♦ Not just public health and water quality—additional environmental and social pressures for a lighter ecosystem footprint and enhanced community benefits
♦ Industrial model of specialization	♦ Integrate water, wastewater, stormwater in designs, management, planning
♦ Siloed infrastructure, funding, and regulations—water, wastewater, and stormwater independently managed	♦ Multiple uses and reuses (mimic nature)
♦ Economies of scale in treatment costs as the driving rationale—the bigger the better, from financial perspective	♦ True cost pricing—more than just economies of scale—multiple values and internalized environmental costs
♦ Potable water for all uses	♦ Water quality sufficient for the intended use
♦ Community expectations for safe drinking water and protection of lakes, rivers, and beaches	♦ Community tailoring of infrastructure to restore and protect ecosystems, preserve community character and open space, improve quality of life, create jobs, and achieve other local benefits
♦ Public management and oversight of the infrastructure	♦ Private sector also engaged in management, under public oversight
♦ Public infrastructure located in public rights of way	♦ Installations on private, as well as public, property
♦ Federal regulations and funding oriented around centralized delivery and collection and point-source discharges	♦ Federal subsidies and tax incentives allow for decentralized alternatives, and federal regulations are re-oriented around resource efficiencies and reduced discharges

Potential Hybrid (Decentralized and Centralized) Infrastructure of the Future

A birds-eye view of the future infrastructure in cities would be substantially greener. Rain gardens and trees would be used to retain stormwater. Streams and habitat would have been restored by reducing the groundwater flows into sewers, minimizing stormwater runoff into streams, and by reducing the overall demand for potable water.

The actual infrastructure would be a combination of enhanced performance of the aging centralized infrastructure and multiple decentralized installations across the city. Water-efficient appliances might be found in scattered homes or buildings across the city, while integrated water/stormwater/wastewater reuse systems might be found in urban infill developments designed around the specific challenges and opportunities of the site.

Municipal utilities would also decommission large wastewater treatment plants that reach the end of their service life. They would build satellite facilities that treat wastewater for reuse and aquifer recharge and recover energy and nutrients from the sewage.

A trio of decentralized technologies and designs would be used to reduce the flows of water in the aging water lines by stressing efficiencies and reuse of stormwater and wastewater and to reduce the flows of stormwater and wastewater in the drainage and sewer systems.

A birds-eye view of rural and suburban areas would be of continued reliance on onsite and cluster water, stormwater, and wastewater systems. Water-centric subdivision planning, in particular, would push toward “off-the-grid” efficiencies and a minimal impact on natural water flows and hydrologies in the watershed.

Both the urban and greenfield infrastructure would be integrated with energy and nutrient recovery from the wastewater. The following table outlines patterns of decentralization.

Pattern	Description
Onsite and Neighborhood Use and Reuse	Closed-loop water systems in residential and commercial buildings, where water is used efficiently and where stormwater and wastewater are treated and reused for landscape irrigation, toilet flushing, and cooling
Green Infrastructure	Rain gardens that trap stormwater and sustain trees and plants. These plants restore beauty and improve air quality, moderate energy flows, and provide potential food sources
Smart Growth	Patterns of neighborhood development that interconnect nature and the built environment, preserve open space, and respect natural drainage flows
Green Cities	Restoration of natural cycles of water infiltration and evaporation in cities and towns through localized treatment and groundwater recharge, trees, parks, and roof gardens, and stream daylighting and restoration
Watershed Restoration	Restoration of natural watershed flows and functions through localized water use and recycling into natural wetlands, groundwater, and air. These systems will restore and preserve habitat and wildlife
Climate Moderation	Slowing of global warming through rehydration of soils and vegetation that absorb heat and increase water vapor in the atmosphere

The Federal Government Perpetuates Unsustainable Water Infrastructure

The federal government has played a significant role in perpetuating the hard-path (centralized) approach. Regulatory structures were devised that assumed that modern sanitation and safe drinking water could only be provided through centralized distribution or collection and treatment. Federal subsidies to local projects from a host of federal agencies were built around those assumptions as well.

Progress in small towns was achieved, for example, when public water lines were extended to all homes, or when failing private septic systems were replaced by public sewers and point-source treatment plants. Therefore, local water protection advocates typically have to ask their communities to buck federal and state regulators, as well as give up federal subsidies, if they are to advance a soft-path (decentralized) solution.

Multiple federal agencies have also gotten involved in a piecemeal fashion in one or another aspect of water infrastructure—through water supply or water quality concerns, flood control, housing, rural development, etc. But, rarely is a serious integrated water perspective taken at any level. This "siloing" of mission and the lack of coordination among agencies have led to federally-mandated and federally-funded projects, which have collectively overstressed the environment and wasted resources.

Government Policies to Promote Sustainable Water Systems

National, state, and local agencies can promote the development and adoption of sustainable water systems by several measures.

Short-Term Strategies

The public sector can help promote innovation through a series of low-cost, short-term measures to facilitate and coordinate better information to assist local decisionmakers and community stakeholders in the water sector. These include:

- Pilot and demonstration projects
- Guidance manuals
- Evaluations of new products and designs
- Education through conferences, newsletters, and training
- Labeling and standard-setting initiatives

The federal government should also establish a national interagency project to articulate a vision for federal action to achieve long-term sustainability in the water resource infrastructure sector.

Agencies with responsibilities for water include:

- Environmental Protection Agency (EPA)
- United States Department of Agriculture (USDA)
- Department of Energy (DOE)
- Department of the Interior (DOI)
- Housing and Urban Development (HUD)
- National Oceanic and Atmospheric Administration (NOAA)
- Department of Defense (DOD)
- National Science Foundation (NSF)

Long-Term Research

The public sector is uniquely positioned to take the lead in long-term research in many areas.

Area of Research	Projected Result
Micro-Scale Biology	Facilitate breakthroughs in treatment technologies and controls, including membranes and advanced oxidation
Macro-Scale Ecological Studies	Improve watershed-scale management
Climate-Water Systems Research	Explore the impacts of "rehydrating" soils and vegetation in cities and towns
Social and Economic Studies and Large-Scale Demonstration Projects	Support the evolution of institutions and practices, such as: ♦ Expansion of green building and sustainable water system markets ♦ Private sector management and maintenance of decentralized systems ♦ Adaptive and performance-based approaches to regulations and ordinances ♦ Collaborative neighborhood design ♦ Greater participation by individuals and communication networks in the adoption and diffusion of sustainable practices

Collaborative funding of research projects can include public agencies, private companies, and academic institutions. Key agencies for support of long-term research include NSF, NOAA, and DOD, which can:

- Fund the formation of several Centers of Excellence at universities or research institutes
- Stimulate private and non-profit foundation investments in research by signaling a long-term commitment to greater efficiencies and a lighter footprint in the infrastructure

Financing Incentives

Governments are typically financing large-scale public water supply, drinking water, wastewater, stormwater, and flood control projects without considering decentralized system alternatives or the disruptive externalities of these "siloed" systems. Financial reform should include:

- Requirements for integrated water resource management planning and evaluation of all direct and indirect costs
- Subsidies and tax incentives for water capture, conservation, treatment, and reuse, which are usually on private property
- Installation of efficient "closed-loop" water systems at federal facilities

- Financial incentives for utilities to adopt decentralized approaches with subsidies from EPA's Clean Water and Drinking Water State Revolving Funds, and USDA, HUD, Commerce, and other federal grant and loan programs

Regulatory Reform

Historically, regulations and ordinances have been written to require and set standards for large, centralized systems in separate parts of the water cycle. Regulations should be reformed to include:

- Permits to utilities for oversight of privately-owned decentralized systems to meet statutory requirements
- Integrated standards for utilities to meet water supply, water quality, public health and ecosystem needs
- Models for state and local design codes, as well as for oversight of pricing and service by new design-build-operate companies, so that expanding private markets are equitable and are consistent with broader water resource plans

Long-Term Infrastructure Sustainability

As the externalities of existing settlements on the nation become more apparent, and the benefits of "lighter footprint" decentralization and integration emerge, communities across the country should be looking across the board to more sustainable infrastructure in water, energy, transportation, and housing.

For synergies and multiple benefits to emerge, the federal financial disincentives and regulatory barriers must be replaced by sustainable infrastructure incentives and, potentially, minimum standards for long-term sustainability of public infrastructure should be required by new federal legislation.

In the short-term, projects on federal property that are using federal funds, such as public housing projects, should be energy efficient, required to implement sustainable infrastructure plans—including rain or roof gardens, water-efficient fixtures, and reuse—and use renewable energy sources.

Expert Opinions

The following page contains quotes from experts on the topics of:

- Funding
- Research
- Climate change moderation
- Cleantech support

"Fundamental research is needed to allow advances in basic nano- and bio-technology to be adapted and integrated into the technologies which are enabling the evolving breakthrough water management paradigm…Individual elements of this developing paradigm, consisting of aggressive conservation, distributed stormwater management and rainwater harvesting, and decentralized water reuse have been demonstrated, but these components are synergistic and the full benefit can be observed only when they are integrated into complete systems."

—Glen Daigger, Senior Vice President and the Chief Technology Officer for the Civil Infrastructure Client Group for CH2M HILL, Testimony to the House Committee on Science and Technology, 2007

"The new paradigm of green cities will connect transportation needs and infrastructure with drainage and receiving waters, be ecologically based and acceptable to and desired by the public. It will incorporate surface and underground drainage infrastructure and landscape that will (1) store and convey water for reuse, provide ecological flow to urban flow deprived rivers, and safe downstream uses; (2) treat and reclaim polluted flows; and (3) integrate the urban hydrologic cycle with multiple urban uses and functions to make it more sustainable…The US must join the worldwide research of inventing and implementing new urban water and ecology-related infrastructure to not fall behind and lose the competitiveness in what will be a trillion dollar industry of urban conversion to sustainable and resilient urban water infrastructure management."

—Vladimir Novotny, CDM Chair Professor of Environmental and Water Resources Engineering, Northeastern University

"The key for the solution of global water crises and global cooling of the Earth is in keeping more rainwater within the country to get more evaporated water into the atmosphere, and in having more clouds and a saturated water cycle. It also means more water for people, foodstuffs, nature, smaller risks due to failures in weather, prevention against natural disasters and changing yellow, dried out landscapes into fertile greenery…It is necessary to introduce a whole series of measures and changes in the legislation, in the way of cultivation of woodlands and agricultural lands, as well as urbanization of the country, management of water resources and technological processes in order that rainwater penetrates into the soil and evaporates from there into the atmosphere."

—Michal Kravcik, People and Water, Slovakia

"And as we move into the second decade of the twenty-first century, the water industry will look increasingly like the clean-energy sector, with new distributed technologies and business models emerging…there will still be room for innovators who develop new technologies and deploy service-centric business models that pull water from the air, turn wastewater and seawater into potable water, leverage nanotechnologies for state-of-the-art filtration, and serve the emerging markets of India, China and Africa. The ability to transform salt water, polluted well and surface water, and wastewater into clean, high-quality water is one of the last great frontiers of human industrialization…For clean tech to thrive, governments at a range of levels must embrace and support fledgling clean-tech industries with supportive policies and incentives."

—Ron Pernick and Clint Wilder, "The Clean Tech Revolution: The Next Big Growth and Investment Opportunity"