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NEW APPROACHES IN DECENTRALIZED WATER INFRASTRUCTURE

by

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ABSTRACT AND BENEFITS

Abstract

Decentralized water technologies and designs, such as water-efficient appliances, rooftop rain gardens, and onsite wastewater treatment and reuse, are the keys to enhancing the performance of the nation's aging centralized water and sewer systems and to assuring adequate water supplies and healthy ecosystems into the future. Decentralized systems also create a host of other benefits for communities, including energy savings, improvements in air quality, creation of green spaces, restoration of streams, aquifers, wetlands, and habitat, and stimulus for new green companies and jobs.

In spite of these multiple benefits, however, there is a realistic fear that inertia and drag in the public-private institutional framework of water infrastructure could forestall the adoption of decentralized designs. This project was intended to explore the various pressures or drivers—as well as the impediments—for a change in the fundamental "paradigm" of water management. A series of workshops with experts and advocates was convened to explore the institutional issues and to tease out various new strategies for jump-starting and easing a transition.

Recommended strategies include incorporation of water concerns into the Green Building movement and funding of community demonstration projects. A second strategy is to support a multi-faceted conversation about sustainable water infrastructure with academics, entrepreneurs, engineers, activists, public bureaucrats and managers, and the public. Finally, as more is learned about what works and what does not work, and as the new approach becomes better-understood and better-known across a broad range of constituencies, there can be enough of a groundswell of support for a serious restructuring of water institutions and policies.

This restructuring will include: an integration of planning, funding, and regulations across the currently segmented fields of water, stormwater, and wastewater; an expanded role for the private sector in technology development, systems management, and finance; a closer link between professional practice and community participation; and careful management and stimulus of continuous innovation and reform.

Benefits

- Summarizes the drivers and pressures for change in the water infrastructure paradigm
- Identifies the impediments to implementation of decentralized approaches
- Describes new models for more sustainable infrastructure design and community benefits
- Recommends strategies for triggering and easing a shift to a more sustainable water infrastructure paradigm

Keywords

- Decentralized wastewater treatment
- Green Building
- Green infrastructure
- Sustainable infrastructure
- Private management
- Watershed management
- Rainwater harvesting

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EXECUTIVE SUMMARY

Decentralized water technologies and designs are the keys to enhancing the performance of the nation's aging centralized water, stormwater, and sewer systems and to assuring adequate water supplies and healthy ecosystems into the future.

Examples of these technologies and designs include:

- Water-efficient appliances
- Green roofs and rain gardens
- Onsite wastewater treatment and reuse

Decentralized systems create a host of benefits for communities, such as:

- Reductions in per capita water use
- Less disruption of natural water systems and aquifers
- Reduced runoff and effluent disposal in surface waters
- Savings in stormwater and wastewater system costs
- Improved water quality
- Energy savings
- Improvements in air quality
- Creation of green spaces
- Restoration of streams and habitat
- Stimulus for new green companies and jobs

In the long run, the nutrients in wastewater may be of value, and synergies with distributed energy production and other infrastructure may also be important.

Why Decentralization Has Not Caught On

The impact of using decentralized infrastructure could be second only to better farming practices in setting the nation on a sustainable path in water. However, this potential has not been well articulated or widely known. Decentralized technologies are still at the margins of engineering practice, and construction of big-pipe water, stormwater, and wastewater infrastructure continues.

Part of the unrealized potential for decentralized alternatives can be explained by the continued segregation of advocates, entrepreneurs, and professionals into the three separate spheres of water supply, stormwater, and wastewater. They focus primarily on the individual technologies or "appliances," rather than their cumulative impact.

This "siloing" thwarts the emergence of the major benefits and values of the decentralized approach. It is only when all of water's sources, uses, and movements are thought about in an integrated fashion in a watershed and the trio of technologies is jointly considered—if not always implemented—at the site or neighborhood scale, that a dramatic synergy of value creation begins to occur.

Decentralized vs. Centralized Systems

The advantages of decentralization emerge as reuse is emphasized. Using and reusing water at the local site costs less than piping water in, wastewater out, and treated water back in for reuse. In addition, many of the new values being discovered from decentralization, such as green space, are by definition local and dispersed throughout the community.

Localized and integrated capture, use, treatment, and reuse of water would mimic how nature itself uses water. Nature moves water and minerals through large cycles of cloud formation, rivers, and groundwater flows, but it also uses, stores, reuses, and cleans water at the local level to support complex and abundant webs of life.

Until now, our centralized, big-pipe infrastructure has relied on an industrial model of specialization and economies of scale. This industrial model has more than adequately protected the public from pathogens and floods, largely by storing and piping clean water long distances into population centers and then transporting wastewater pollutants away.

But the approach is also wasteful, environmentally disruptive, and ultimately not sustainable as populations increase and more and more land is developed over time. Climate change-related extremes of heavy storms and droughts will place even greater stresses on this centralized, natural-manmade water system that we have uncritically built piece by piece.

Steps Toward Decentralization

A first essential step in realizing the potential for decentralized technologies is to transform the way professionals, advocates, and the public think about looming ecosystem crises and the unsustainable practices currently embodied in the water infrastructure. This transformation in thinking is difficult when conventional water engineering has been considered one of society's greatest accomplishments in public health and in clean water quality protection.

But, changing the infrastructure from an industrial model to a "biomimicry" model also entails a daunting set of changes in the governance and institutional framework of water management.

Sectors of the economy where public bureaucracies are closely intertwined with the private sector are much more difficult to transform than in a private market alone, where the "creative winds of destruction" can sweep aside outmoded products and practices. A realistic fear is that inertia and drag in this public-private institutional framework in water could actually forestall a transition to more sustainable technologies and designs.

This Project

This project was intended to explore the various pressures or drivers—as well as the impediments—for a change in the fundamental "paradigm" of water management. A series of workshops with experts and advocates convened to explore the institutional issues and to tease out various new strategies for jump-starting and easing a transition. They discussed key topics of science and technology development, market restructuring, and public participation.

Case studies and workshops showed that there are

- Scattered drivers for a paradigm shift in water management, including increasing drought conditions, flooding and wet weather pollution, and sprawl development
- New ways of thinking about biomimicry and market transformations
- Niche successes in building decentralized system alternatives by community activists and entrepreneurs

Some impediments to change are:

- Government funding and regulations that have been built up to support the traditional infrastructure
- Distorted pricing of water
- Risk aversion
- Conventional attitudes and expectations of the public
- Management utilities that are oriented around big-pipe infrastructure in public rights-of-way

Attempts to leverage one or another driver or to break down one or another impediment at a time are ineffective because there are so many interlocking pieces of the traditional paradigm that work to "lock-in" the approach.

Paradigm Innovation

The first essential strategy is to create spaces for multi-faceted "paradigm" innovation to occur. These initiatives include developing the water component in the Green Building movement where new products and new markets have already been successfully created in the parallel fields of energy and construction materials and supporting community demonstration projects where new institutional models can be structured for management, financing, and regulation.

These projects, over time, will clarify how the localized and integrated biomimicry model works to create multiple community values and engage new partners. Essentially, the trio of decentralized water-efficiency, stormwater retention and reuse, and wastewater treatment and reuse has the potential to reduce dramatically the amount of water taken out of aquifers and streams and to reduce wet weather runoff and sewer flows going back into the environment.

Another critical component of the new infrastructure is that it creates multiple other benefits as well, many of them from the plants and trees that "green" the cities and towns. Other resource benefits accrue from integrated, closed-loop planning where energy and nutrients are captured for reuse instead of being wasted.

Mimicking complex interdependencies of species in nature applies to the way that society can restructure its decisions and actions in water, as well. By expanding the participation of the private sector, community organizations, and the public, a significantly richer set of alternatives emerge. Conversations amongst diverse groups typically lead to much more creative and productive solutions than leaving the issues to a specialized profession.

In nature, individual species survive by "opportunistically" finding a niche in the web of life. Similarly, participants in a biomimicry model of infrastructure would find ways to take value from the model and simultaneously create value for other participants. For example, the private sector can make money from installing decentralized systems or inventing new technologies while reducing water use and enhancing green space in the process.

Conversation

A second strategy is to support a multi-faceted conversation about sustainable water infrastructure with academics, entrepreneurs, engineers, activists, public bureaucrats and managers, and the public.

Group	Course of Action
Researchers	Study the imminent water quantity and quality crises the nation will be facing and link those crises to the differential impacts of centralized, decentralized, and hybrid infrastructure alternatives. Dramatically improve the performance of membranes, telemetry, and ecosystem monitoring
Engineers	Develop collaborative design processes that generate creative, multiple benefits solutions
Activists	Question their continuing support for the traditional infrastructure and explore the benefits of decentralized alternatives
Public Bureaucrats and Managers	Take a larger, holistic view of water management and begin to collaborate with the private and non profit sectors in identifying higher-value alternatives
Private sector	Profit from installing decentralized systems or inventing new technologies while reducing water use and enhancing green space

Restructuring Institutions and Policies

Finally, as Green Building and community demonstration projects show what works and what does not work and clarify how new values are created in the decentralized model, and as the new approach becomes better-understood and better-known across a broad range of constituencies, there can be enough of a groundswell of support for a serious restructuring of water institutions and policies.

This restructuring will include:

- An integration of planning, funding, and regulations across the currently segmented fields of water, stormwater, and wastewater
- An expanded role for the private sector in technology development, systems management, and finance
- A closer link between professional practice and community participation
- Careful management and stimulus of continuous innovation and reform

US at Competitive Disadvantage

In this process of innovation, it must be recognized that the United States is at a disadvantage relative to the developing world. While we have a substantial investment and track record in clean water and sanitation, this sunk investment also makes it more difficult to shift to new approaches. Countries like China and India, with few water and wastewater services to begin with, are beginning to "leapfrog" over the US and to implement more quickly the new approaches discussed in this report. It is vital for the federal government to provide the leadership and financial resources to mobilize American universities and entrepreneurs, municipal utilities, builders, non-governmental organizations, and the public to respond to this competitive challenge.

Chapter 1

INTRODUCTION

Over the last decade, interest has grown in decentralized technologies and designs to provide water, stormwater, and wastewater services. Rural areas have used onsite wells and septic systems for years. However, these systems have been largely viewed as temporary solutions.

As the density of development increased, the modern and permanent model of infrastructure to protect public health was highly centralized water and sewer pipes and treatment plants along with large-scale stormwater drainage systems.

In the US, these "big-pipe" systems were built in cities starting in the 1800s. By reducing public exposure to polluted waters and floods, this infrastructure has been seen as a great public health achievement. The Clean Water Act in 1972 and the Safe Drinking Water Act in 1987 introduced more stringent requirements for wastewater treatment plants and water treatment plants. As a result, the 1970s and 1980s saw significant improvements in surface water quality.

More recently, the role that decentralized technologies and designs could collectively play in providing a more "sustainable" water, stormwater, and wastewater infrastructure has begun to be discussed. Concerns are growing that conventional, centralized infrastructure cannot meet the rising demands of population growth and urban/suburban land development without threatening the collapse of natural water hydrologies and ecosystems. Decentralized systems and reform in agricultural practices are the key innovations for reducing the demand for new water supplies and for lightening the ecological footprint of the infrastructure.

Trio of Decentralized Technologies and Designs

In general, the focus in decentralized systems has been on the various technologies and designs, or "appliances," in the separate spheres of water-efficiency, stormwater, and wastewater. The use of these systems has still been on the margins of the traditional, centralized model. Various alliances and Environmental Protection Agency (EPA) programs have emerged to advance these technologies and designs. Arguments have been made for how widespread use of these decentralized systems could enhance the performance of the existing infrastructure or provide multiple other benefits to communities.

Generally, the customer has been the homeowner or developer/builder, and municipalities have used both incentive programs and mandates to encourage the installation of the technologies, particularly in new construction.

Examples of this "trio" of technologies and designs, and their promoters include:

- Water efficiency and conservation
- Stormwater retention and reuse
- Decentralized wastewater treatment, reuse, and resource recovery

Water Efficiency and Conservation

The following approaches have been advanced by groups such as the new Alliance for Water Efficiency, which is a consortium of appliance manufacturers and environmental organizations:

- Water-efficient appliances, such as washing machines and low-flow toilets
- Landscaping practices and plants that use less water
- Point-of-use water treatment devices that reduce the demand for potable, drinking water
- Water meters and pricing that provides incentives for consumers to reduce their use of water

Peter Gleick at the Pacific Institute and Richard Pinkham at the Rocky Mountain Institute have helped shape the arguments for decentralized water-efficiency, or what they have called the "soft path."

The EPA has established a program to advance labeling and standards, called Water Sense, and one of the Four Pillars for a Sustainable Infrastructure is to help municipal utilities advance water-efficiency in their systems.

Generally, the argument for enhancing the performance of the traditional, centralized infrastructure has been to use water-efficient appliances and conservation practices as a means to reduce the demand for new water supplies, particularly in arid regions of the country. However, as in similar energy-efficiency programs, the new appliances and landscaping have often been of higher quality and design for the customer, as well.

Stormwater Retention and Reuse

The following approaches have been advanced by organizations such as the Low Impact Development Center and the Center for Watershed Protection, primarily for new "Greenfield" development:

- Rain gardens or rooftop plants
- Tree planting programs
- Cisterns to collect rainwater
- Reuse of stormwater for toilet-flushing, irrigation, and other non-potable uses
- Low-impact development designs for subdivisions, which allow for stormwater retention and filtering onsite

Recently, the EPA has established a "green infrastructure" program in collaboration with municipal utilities and environmental organizations, and has funded Sustainable Cities, a partnership of landscape architects and other non-governmental organizations (NGOs).

The arguments for decentralized stormwater systems have been to enhance water quality protection, on the one hand by reducing the impact of new development in rural and suburban areas, and on the other hand, by reducing stormwater overflows and runoff in urban areas with combined sewers.

However, advocates of green infrastructure have also pointed out the additional benefits of rain gardens and trees, including beautification, open space, better air quality, reduced heat island effects, and others. Stormwater can also be used for non-potable water purposes.

Decentralized Wastewater Treatment, Reuse, and Resource Recovery

Decentralized wastewater can be treated, reused, and provide resources in the following ways:

- Onsite and cluster wastewater treatment technologies and designs that produce high-level treatment at small scales
- Reuse of treated wastewater for toilet flushing, irrigation, firefighting, and other uses
- Recovery of energy from the organics in wastewater, including both methane and hydrogen
- Recovery of nutrients (nitrogen and phosphorous) for use as fertilizers in landscaping and agriculture

The National Onsite Wastewater Recycling Association (NOWRA), as a collaborative of manufacturers, academics, and regulators, has been the primary advocate for decentralized systems in unsewered areas.

The EPA has a decentralized wastewater program, which has produced technical guidance documents and promoted the concept of system "management" by utilities and others. Relatively minor projects in energy and nutrient recovery have been promoted by ecology engineering and eco-sanitation groups that have argued for minimizing the waste of resources in the wastewater.

The arguments for decentralized wastewater treatment have largely focused on cost-savings in avoiding the construction of conventional centralized infrastructure in previously unsewered areas. New ideas have included the advantages of decentralized treatment and effluent release into soils as a means to retain and restore groundwater levels and the use of decentralized wastewater treatment in urban redevelopment projects, such as the Solaire building in Manhattan.

Sustainable Infrastructure and the Trio of Decentralized Systems

Ultimately, the greatest promise for decentralized approaches will emerge both from an integrated consideration of the trio of technologies and designs at the building or neighborhood scale (water-efficiency and conservation, stormwater retention and reuse, and wastewater treatment, reuse, and resource recovery) and from an integrated perspective at the municipal or watershed level.

This integrated perspective will be defined by simultaneous planning for water quantity and water quality protection, and by the search for multiple community benefits in energy recovery, open space, "green job" creation, etc.

A community might continue with siloed programs to encourage or mandate decentralized installations in water-efficiency, stormwater, or wastewater, but it could also begin to support integrated, closed-loop systems.

Integrated Decentralized Technologies and Designs

Leading-edge engineers and planners are merging water-efficiency, stormwater, and wastewater systems at the site level.

- Closed-loop water systems in residential and commercial buildings, where water-efficient appliances cut demand for water, stormwater and wastewater are treated and reused for landscape irrigation, toilet flushing and cooling, and energy and nutrients are recovered from the wastewater
- Water-centric planning for new subdivisions and urban infill developments

Traditional and Potential New Infrastructure

It is not possible to define the precise suite of decentralized technologies and designs that will be used in the future, because scientific breakthroughs may expand the available technologies. Basic scientific research into biotechnology and nanotechnology can, for example, dramatically improve the performance of membranes, telemetry, and ecosystem monitoring. Nevertheless, a substantial change in the infrastructure pattern can be anticipated and envisioned.

Current Infrastructure

A birds-eye view of the current water, stormwater, and wastewater infrastructure in cities would show highly centralized and underground "rapid conveyance" piping networks and flood control channels, which transport potable water to homes and businesses for a variety of potable and non-potable uses. They also transport large volumes of stormwater and wastewater effluent to surface waters, and export groundwater that would otherwise be an element of base flows in streams and rivers. This infrastructure has also been called "gray" infrastructure, because cities using it are covered by impervious concrete streets and sidewalks, and have minimal green space.

In rural and suburban areas, the advance of centralized infrastructure would also be perpetuated with the continued construction of water and sewer lines in high-growth areas, thereby increasing utilization of water supplies and disruption of hydrologies in the watershed.

Potential Hybrid (Decentralized and Centralized) Infrastructure of the Future

A birds-eye view of the future infrastructure in cities would be substantially more "green." 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. Air quality and the heat island effects would have been improved.

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.

The 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 as well.

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.

Patterns of Decentralization

Table 1-1: Description of 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

Multiple Community Benefits

Decentralized water and wastewater infrastructure creates the following benefits:

- **Lower costs and reduced demand for wastewater and stormwater facilities as well as water supply**—costly water supply enhancements can be avoided through onsite water use efficiencies, wastewater reuse, and rainwater harvesting. Impacts of droughts can be moderated
- **Lower costs of maintaining existing infrastructure**—flow rates in existing water and sewer systems can be reduced through decentralized efficiencies and reuse in office buildings and infill developments
- **Lower costs for new infrastructure**—new developments can be accommodated with targeted small-scale infrastructure that is competitive with centralized infrastructure and with more benefit to the community and the environment
- **Greater resilience**—small-scale treatment units are more resilient than centralized systems in hurricanes and floods and less vulnerable to accidents and terrorism
- **Ecological restoration**—decentralized systems can reduce the discharge of pollutants, replenish aquifers, and restore streamflows and habitats
- **Resource efficiencies**—small-scale treatment units can save on energy costs and recycle nutrients into landscaping and agriculture
- **Community benefits**–green infrastructure has been shown to improve air quality, preserve open space, and create local jobs

- **Private financing**—small-scale treatment units on individual properties can be financed privately, thereby saving money for municipalities
- **International competitiveness**—American advancements in sustainable water systems can be utilized in developing countries, such as China and India, and high-tech research, manufacturing, and engineering jobs can be created in the US to serve these markets

Difficulties Inherent in Shifting to a New Hybrid Infrastructure

As advantageous as decentralized water, stormwater, and wastewater infrastructure can be, there are numerous institutional impediments to its adoption. In a private market, a good new product can begin with a niche market and quickly transform an entire sector, as can be seen with cell phones replacing landlines or automobiles replacing horse-drawn carriages. In a heavily regulated, public-private market like the water field, however, no process as economists have described as the "winds of creative destruction" exists.

Innovators have trouble selling their products and services in a system in which regulators, municipal utilities, engineers, unions, and other entrenched bureaucracies or interests can refuse to alter the rules and practices or retrain in new approaches. Often just one of these constituencies can block a new approach that a majority of local stakeholders might support.

In recent years, the EPA and others have adopted an incremental approach to incorporating decentralized systems into the traditional paradigm by providing information and guidance to communities on a number of decentralized technologies, such as low-impact development, decentralized wastewater treatment, and most recently, water-efficient appliances and green infrastructure.

This siloing of thinking has helped to keep decentralized systems at the margins of conventional practice, as for example, when the role of improved decentralized wastewater systems is still largely focused on rural, unsewered areas.

This project has taken a more radical approach, which suggests that sustainability of the nation's core infrastructure in urban, suburban, and rural communities will be achieved when decentralized systems have become the centerpiece of future responses to water quantity and quality crises, both in enhancing the performance of the existing infrastructure and the building of new infrastructure.

Paradigm Shift Needed from the Old to the New Infrastructure

Participants in decentralized infrastructure discussions have begun to refer to a need for a wholesale paradigm shift in the water field. American Heritage Dictionary defines a "paradigm" as a pattern or model, or as a set of assumptions, concepts, values, and practices that constitutes a way of viewing reality for the community that shares them, especially in an intellectual discipline. The term "paradigm shift" has been used to signal the scope and nature of change that will be required to implement a new infrastructure, including substantial changes in ways of thinking and practice, as well as in the participation of new stakeholders.

Useful lessons exist about how paradigm shifts occur or do not occur. First, the tendency of participants in an old way of thinking and practice is to react to new challenges by an increasingly complicated and expensive "incrementalism," rather than a significant rethinking of the approach. A 1998 WERF "futures" workshop of experts concluded that such a process has been occurring in the water sector, where increasingly stringent effluent requirements are being imposed on central treatment plants, while decentralized options that might reduce effluent releases are not considered. More recently, responses to water shortages are proposals for new large reservoirs and desalination plants, rather than a reduction in demand through water efficiencies and reuse.

Analysts of paradigm shifts in other fields also point out that "path dependencies," (Arthur 1989) such as intransigent institutional or market factors, can prevent the emergence of a new product or approach. Finally, institutional players can guide new markets toward sub-optimal products, if their marketing or political skills are superior. Concerns in this regard are that water sector institutions can block desirable changes in technology use, and that markets might evolve for affluent customers but not for lower-income customers.

Most analysts agree that it can never be predicted how, when, or whether a paradigm shift will actually occur. It appears that nothing is inevitable (Meadows 1997). And there are no absolute, surefire strategies for engineering a paradigm shift; rather, the best strategy is a combination of continued critiques of the old paradigm and support for those seeking to pilot the new technologies and ways of thinking. *Tipping Point* (Gladwell 2000) literature suggests that pressure for change will build and build, and the eventual shift may occur rapidly when the pressures for change are strong enough and "champions" of change have captured sufficient attention in the field.

Part of the reason why incremental change from the current paradigm to a more sustainable paradigm is unlikely to occur is that existing institutions are not well equipped to recognize the value in a new approach. The significant benefits of decentralization will emerge only when water problems are thought about holistically, when the various technologies and designs of water conservation, stormwater management, and wastewater reuse are combined at various scales to address these problems, and when water infrastructure is also designed with energy conservation and recovery, parks, habitat restoration, and other quality of life improvements in mind.

Some key structural changes entailed in the paradigm shift are shown in the table.

Table 1-2: Water Infrastructure and Institutional Paradigm

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 also sector 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

Chapter 2

THIS PROJECT: WORKSHOPS OF CASE STUDIES AND STAKEHOLDERS

Objective

The objective of this project was to explore the various pressures or drivers and impediments for a change in the fundamental "paradigm" of water management. A series of workshops with experts and advocates convened to explore the institutional issues and to tease out various new strategies for jump-starting and easing a transition.

Approach

The Coalition for Alternative Wastewater Treatment convened two series of workshops. Experts in the field of decentralized systems, including researchers, engineers, and practitioners, were brought together with a broad range of other constituencies, including utilities, environmental NGOs, home builders, architects, and community activists.

Advocates and experts from across the country provided case study presentations. Wide-ranging discussions on policy and markets were held and recommendations were developed for reform strategies. The author of these White Papers conducted additional literature review as well.

Documentation

Proceedings of the workshops, which describe case study presentations, discussions, recommendations, and lists of participants are available. Conference papers based on the workshops are also available. Four White Papers on topics of financing, institutional challenges and opportunities, education and outreach, and levels of service are also included in this report.

Schedule

The following is a list of workshops and presenters.

- **March 17–18, 2005—Viable Business Models for Decentralized System Management**
  - Valerie Nelson, Distributed Water Resource Management: *Provider Models, Services, and Markets*
  - Jerry Stonebridge, Stonebridge Environmental Inc.: *Model for Onsite Systems*
  - Tim Bannister, TCW Wastewater Management: *Model for Onsite Systems*
  - Ed Clerico, Applied Water Management: *A Decentralized Public Utility Going Beyond Individual Septic Systems*
  - Kevin White, University of South Alabama Department of Civil Engineering: *Neighborhood (Cluster) Wastewater Management in Mobile, AL*
  - Steve Moddemeyer, Seattle Public Utilities: *Distributed Water Resource Management: Rainwater Harvest and CSO Control in Seattle*

- Andy Lipkis, TreePeople: *The Case for Integrated Urban Watershed Management, Los Angeles*

♦ **November 10, 2005—Science and Technology Needs and Opportunities**

- Julian Sandino, CH2MHill: *Changing Infrastructure Paradigms: An International Perspective*
- Robert Siegrist, Colorado School of Mines: *Current Research Efforts and Potential New Directions*
- Mary Hansel, Carollo Engineers: *Biomimicry—Learning from Nature's Consummate Engineers*
- Keith Carns, EPRI Community Environmental Center: *Current Research Efforts and Potential New Directions*
- Mike Luzier, National Association of Home Builders Research Institute: *Market Transformation Strategies*

♦ **December 12, 2005—Funding, Planning and Regulatory Reform**

- Peter Shelley, Conservation Law Foundation, Boston, Massachusetts Water Initiative: *Water Quality and Supply in Massachusetts*
- Andy Lipkis, TreePeople Center for Community Forestry, Los Angeles
- Jim Stebbins, Project Design Consultants, San Diego: *Building Blocks of Sustainable Development*
- Kyle Dreyfus-Wells, Chagrin River Watershed Partners, Ohio: *Implementing Low Impact Development in the Chagrin Watershed*
- Craig Lindell, Aquapoint, Inc, Massachusetts: *Distributed Sewer: The Demand Side*

♦ **December 13, 2005—Public Awareness and Action**

- Harry Wiland, Eden's Lost and Found Filmmaker, California: *Grassroots Change*
- Brent Haglund, Sand County Foundation, Wisconsin: *Promoting Environmental Stewardship*
- Ken Jones, Green Mountain Institute, Vermont: *Success in Small Communities and Rural Areas*
- Nancy Lee, Social Marketing Services, Inc., Washington: *Social Marketing and Sustainable Development*
- David Johnston, What's Working, Colorado: *Engaging Diverse Culture in a Common Project*

♦ **January 19, 2006—Final Synthesis Workshop**

- Core group of organizations re-convened. One of the objectives was to develop an agenda of priority short-term research and development, institutional reform, and outreach projects

Stakeholders

Stakeholders who participated in one or more workshops included:

- John Berdes, Shore Bank Enterprise
- Matt Byers and Linda Bonner, National Onsite Wastewater Recycling Association (NOWRA)
- Bill Cagle, Orenco Systems
- Todd Danielson, Loudoun County Sanitation Authority
- Glendon Deal, US Department of Agriculture
- Mark DeKay, University of Tennessee
- Scott Drake, East Kentucky Power Coop
- Alex Duran, National Association of Homebuilders Research Center
- Alex Echols, Conrod Communications
- Ray Ehrhard, EPRI Community Environmental Center
- Steve Ellis and Autumn Hanna, Taxpayers for Common Sense
- Doug Fogel, Butte County Public health
- Sheila Frace, US EPA Office of Water
- Rod Frederick, EPA
- Drew Gangnes, Magnuson Klemenich Associates
- Ron Gold, Mason County Public Utility District (PUD)
- Robert Goldstein, EPRI
- Robert Goo, EPA
- Jim Graydon, Kennedy/Jenks Consultants
- Terry Hull, Puget Sound Action Team
- Scott Johnstone, Stone Environmental
- Chris Kloss, Low Impact Development Center
- Jim Kreissl, Environmental Consultant
- Karen Mancl, The Ohio State University
- Tracy Mehan, Cadmus Group
- Phil Miller, Elsinore Valley MWD
- Tracy Moir-McClean, University of Tennessee
- Phyllis Murdock, Butte County Public Health
- John Murphy, EPRI Community Environmental Center
- Howard Neukrug, Philadelphia Office of Water
- Betsy Otto, American Rivers
- Ron Pate, Sandia National Laboratory
- Glenn Patterson, US Geological Service
- Rick Phalunas, National Environmental Services Center
- Richard Pinkham, Booz Allen Hamilton
- Greg Powell, Commonwealth Wastewater Systems
- Sushama Pradhan, North Carolina State University

- Karl Rabago, Houston Advanced Research Center
- Paul Schwartz, Clean Water Action
- Vance Severin, Butte County Environmental Health
- Frank Shephard, Woods Hole Data Base, Inc.
- Nancy Stoner, Natural Resources Defense Council (NRDC)
- Heather Whitlow, Casey Trees
- Richard Wright, American Society of Civil Engineers

Workshop Findings

This introduction will summarize the key workshop findings that pertain to the larger concerns about a shift to a new sustainable water paradigm. Specifically, three questions covered in this report are:

- What are the critical "drivers" or pressures for a shift in the paradigm?
- What are the institutional and other "impediments" to a shift in the paradigm?
- What are key strategies to amplify the pressures for change and to leverage the critical tipping points of cascading effects or crystallizing impacts?

Note: For more detail on workshop proceedings and summary findings and conclusions, click on the title of the workshop from the Homepage.

Drivers for Change in the Paradigm

In the workshop series, three major pressures for change in the paradigm emerged:

- Water crises and other new societal demands on the infrastructure
- New ideas and design concepts
- Niche innovations by advocates and entrepreneurs

Impediments to Change in the Paradigm

The following impediments to change emerged in the workshop discussions:

- Government policies, funding, regulations built around centralized infrastructure
- Distorted pricing of water
- Balkanization of agencies
- Municipal authority and a limited role for the private sector
- Pervasive risk aversion and minimal research funding
- Stakeholder support for conventional solutions
- Lack of local models that combine technology, management, financing, and customer acceptance
- Opposition from threatened entities
- Classic market failures, such as lack of information, fragmentation

Strategies to Trigger and Ease a Paradigm Shift

A basic strategy for a water paradigm shift emerged in the workshops:

- Create spaces for local paradigm models to emerge, such as in green building and demonstration projects in cities and towns
- Support conversations and research among engineers, utility managers, non-governmental organizations, academics, and the public
- Incrementally begin work on reforming the big government structures of research, funding, and regulations

Drivers for—and Impediments to—Decentralization

The following table shows drivers for decentralization and the impediments to attaining it.

Table 2-1: Drivers and Impediments in Decentralization

Drivers for Decentralization	Institutional Challenges and Impediments to Decentralization
Water crises and other new societal demands on the infrastructure	Government policies, funding, regulations built around centralized infrastructure
♦ Droughts and water supply shortages	Classic market failures–fragmentation, no information
♦ Water quality and habitat degradation	Distorted pricing of water
♦ Climate change and resilience	Balkanization of agencies
♦ Aging infrastructure costs—repairs and expansion	Municipal authority and a limited role for private sector
♦ Alternatives to sprawl development (promoted by sewers and large-lot septic systems)	Civil society support for conventional infrastructure
♦ Quality of life in urban and rural communities—pervasive gray infrastructure	Pervasive risk aversion and minimal research funding
	Lack of local models that combine technology, management, financing, and customer acceptance
New ideas and design concepts—natural, social, economic systems	
Niche innovations by advocates and entrepreneurs	

Scattered and Siloed Innovation—Current Picture

Various characterizations of the current decentralized water infrastructure field were discussed in the workshops:

1 The current new decentralized paradigm development is scattered across the country and still generally siloed into water, stormwater, or wastewater.

At the Palo Alto meeting on Viable Business Models for Decentralized System Management, the conclusion was that *"a variety of players are emerging in a fragmented market, with each 'doing their own thing'."* Each area of the country is generating different models for wastewater and stormwater management, based on different issues and needs, such as densely developed coastal areas compared to new construction in the South and Midwest.

The problem now is getting businesses up and running, while in the future the challenge will be to regulate companies to achieve fair pricing and consistency with balanced growth plans. The Washington, DC workshops also characterized change as *"significant local action and innovation happening ad hoc at the local level."*

In Palo Alto, discussions suggested that management of wastewater (private sector) is also a completely different model from management of stormwater in urban areas (voluntary and public sector).

2 As a result, the key elements of a new decentralized water paradigm are unclear.

In DC, participants agreed, *"There is no model approach, institutional structure, clear principles, or full understanding of soft path (e.g. decentralized) application. The fact that the tools, benefits, and systems regarding soft path water are not clear enough raises important short- and long-term planning issues."*

Participants agreed there is still no clear sense of uniting core principles and values that are needed to bring a coalition together.

3 It is difficult to create a new model or paradigm in the midst of the old approaches.

As one participant characterized it, developing the new water paradigm is like *"building a car in a bicycle shop."* The current moment is *"interesting and complicated"* in the view of different actors. Therefore, we are dealing with a complicated change paradigm. We need *"to set funding and pilots so it begins to settle over time into a set of effective processes."*

Key Pressures for a Paradigm Shift

The workshop case studies and discussions provided descriptions of external pressures to move beyond the existing water paradigm. These forces highlight both the inadequacies of the existing approach and suggest new structures in a more sustainable paradigm.

- Water crises and other societal demands on the infrastructure
- New ideas and design concepts
- Niche innovations by advocates and entrepreneurs

These drivers are discussed in the next chapter.

Chapter 3

DRIVERS FOR A DECENTRALIZED PARADIGM

Climatic and societal forces will eventually lead to the collapse of the current, centralized water infrastructure. These pressures, as well as solutions, were emphasized in the workshops.

- Water crises and other societal demands on the infrastructure
- New ideas and design concepts
- Niche innovations by advocates and entrepreneurs

Water Crises and Other Societal Demands

The workshops provided examples of how a number of separate water crises and societal demands were beginning to highlight the costs and inadequacies of the current infrastructure approach of siloed and big-pipe systems, as well as the benefits of decentralization. In time, as climate change exacerbates the extremes of droughts and storm events, the entire hydrological cycle will need to be addressed with new restorative infrastructure designs. For the moment, however, there are a series of separate "doors" or entry points into questioning whether the current paradigm of centralized infrastructure is sustainable.

Droughts and Water Supply Shortages

Solution: Use water-efficient appliances, harvest rainwater for non-potable uses, and treat gray water and blackwater for non-potable reuses.

Several of the presentations in the DC workshops highlighted the growing concerns for water supply shortages across the US and the use of the trio of decentralized technologies to reduce the demand for and increase the efficiency of use of water, in particular of potable water.

- Andy Lipkis, from TreePeople in Los Angeles, began his career over twenty years ago with tree-planting programs throughout the city. Over time, he and his colleagues began to realize that urban forestry was an important tool in dealing with LA's increasing water demands. The city spends a billion dollars a year to bring fresh water from hundreds of miles away. However, rain gardens and cisterns that capture stormwater could provide an alternative source of water, in particular for landscaping. This stormwater retention and reuse could also reduce some of the costs of channeling stormwater flows into the ocean. Lipkis described recent work by TreePeople in Los Angeles to bring a variety of siloed agencies together in a pilot urban watershed program. The general concept was supported by an initial grant from the US Forest Service Urban Forestry Program, and now involves collaboration among the US Army Corps, the LA Department of Public Works, the Department of Transportation, the EPA, the School system, and others.

- Peter Shelley, from the Conservation Law Foundation in Boston, described the artificially-created water supply shortages that have resulted from construction of a huge regional wastewater system and ocean outfall in Eastern Massachusetts. Shelley described the *"one time water use model,"* that essentially "throws away" rainwater and groundwater. Little rainfall is returned to aquifers, and the groundwater system is drained by old and leaky sewer lines. As a result, streamflows are very low in the summer and communities are experiencing water shortages from the depleted aquifers. The state has had to impose more stringent water allocations, which is surprising for an area with more than adequate rainfall. The city of Brockton, south of Boston, has also chosen to build a desalination plant to make up for the groundwater losses. Shelley's suggested prescriptions included:
  - Linking the value of ecosystem services to the users
  - Engineering upgrades to reduce infiltration and inflow
  - Keeping stormwater and wastewater local
  - Providing financial incentives for local, decentralized infrastructure
  - Restricting inter-basin transfers of water
  - Mandating the development of municipal and watershed water in/water out budgets, flow trading, etc.
  - Integrating environmental organizations at the state level
- James Stebbins, of Project Design Consultants in California, described a proposed community called Rancho San Juan in Monterey, California, where the goal was for *"no imported water."* The proposed plan used the limitations of water supply in California as a starting point for a "water-centric" design that used onsite water only and that minimized the use of potable water by installing water-conserving appliances and landscaping, rainwater capture and reuse in landscaping and car washing, and decentralized wastewater reclamation back into the aquifer.

Related Examples and Studies

This pattern of growing concern for current and future water supply shortages and potential use of the trio of decentralized water, stormwater, and wastewater designs has started to emerge in regional and watershed studies. The Georgia Water Coalition, (Vinson 2006) formed in 2002 to suggest new approaches to shortages in Georgia, has recommended the trio of solutions to reduce the overall use of water. A recent American Water Works Association Research Foundation (AwwaRF) workshop on urban water management has highlighted decentralized systems in stormwater and wastewater and alluded to similar efforts in Australia, where drought conditions and water supply shortages are severe. A recent National Water Research Institute has similarly suggested the trio of decentralized technologies, among other short-term measures, for dealing with drought in the Western United States (Blomquist 2007).

Water Quality and Habitat Degradation

Solution: Use decentralized systems to slow and reduce runoff, to keep wastewater effluent out of surface waters, and to take less water out of and/or to recharge local streams and aquifers.

- Steve Moddemeyer, from Seattle, described the ongoing demonstration project efforts in Seattle to retain stormwater with cisterns, rain gardens, and soil storage as a way to manage stormwater runoff. Rain can overwhelm the city's sewer system, leading to flooding and contamination of streams with special protection for salmon. The city is looking to these distributed approaches as complements to, or even substitutes for, expensive combined sewer overflow (CSO) controls.
- Kyle Dreyfus-Wells, from the Chagrin River Watershed Partners, Inc. in Ohio, described their efforts to implement conservation or low-impact development practices, to *"minimize long-term infrastructure costs and maintain natural resource function."* This rural area of Ohio is beginning to see adverse effects of poorly designed "suburbanization," where flooding and water quality impairments are now more common. The Partners are working with towns to implement decentralized stormwater techniques, such as smaller driveway culverts, rain gardens, rain barrels, bioretention, and others. They have been funded by the Lake Erie Water Commission in its efforts to preserve Lake Erie water quality. The State of Ohio supports both "engineered" and "natural" systems.

Related Examples and Studies

These two cases are examples of widespread interest in stormwater management through distributed retention and low-impact development, which has led to a recent collaborative initiative in "green infrastructure." The EPA, NRDC, the Low Impact Development (LID) Center, National Association of Clean Water Agencies (NACWA), and others have agreed to investigate and promote the use of natural systems to retain stormwater.

Tracy Mehan facilitated an EPA workshop on integrated watershed management in 2006, which also highlighted the emerging concept among the attending utilities. A new International Water Association (IWA) book, "Cities of the Future," by Vladimir Novotny of Northeastern University and Paul Brown of CDM (Novotny and Brown 2007), has also focused on use of the trio of decentralized infrastructure as a means to achieve water quality improvements in urban areas.

Climate Change and Resilience

Solution: Enhance capacity to cope with both droughts and heavy rainfall and search for energy savings (move less water) and energy recovery (biogas digestors to produce hydrogen and methane from organics in wastewater)

Workshop participants alluded to the growing threat of climate change to the resilience of the existing water and wastewater infrastructure. This theme also emerged in the 2006 Wingspread conference, "Blue Water in Green Cities," (Novotny and Brown 2007) where a Tulane University professor stated that decentralized wastewater infrastructure would have survived Hurricane Katrina better than the big sewer systems that were in place at the time.

Similarly, NRDC's recent report on water and climate change, "In Hot Water," identifies the trio of decentralized infrastructure as being more sustainable than large piping networks in California. The trio can reduce the energy requirements for piping water and wastewater long distances and can make the water system more resilient to the predicted droughts and heavy rainfall events brought by climate change.

Research in Slovakia has also focused on impacts of water and wastewater infrastructure in drying soils and vegetation (Kravcik 2007). By depleting groundwater and moving wastewater out of basins and into oceans, there is less moisture content for cooling and water vapor in the atmosphere, which is a key factor in moderating global temperatures. Ultimately, deserts can be created by such patterns. More study is needed on the significant role of infrastructure designs in exacerbating global warming trends. The U.S. Geological Service has established a climate change research center at Princeton University, which is researching this link, among others.

Aging Infrastructure Costs—Repairs and Expansion

Solution: Use decentralized systems to reduce flows and thereby avoid big new water supply or wastewater treatment system costs.

Several participants suggested that the high costs of maintaining the conventional infrastructure were playing an important role in a greater interest in the trio of technologies in urban areas.

- Andy Lipkis described the public desire to eliminate waste and duplication in the conventional "rapid conveyance" systems of the past and came to see that rain gardens and cisterns could provide lower-cost services for both water supply and stormwater management.
- The Solaire building in Battery Park, New York City, includes a wastewater and stormwater treatment system designed by Ed Clerico, which provides non-potable water for toilet flushing, landscaping, and laundry. This system is supported by the city of New York, because, by reducing flows in the existing water and sewer systems, it helps both to avoid large expenditures on new water supplies and on combined sewer overflows.
- Ken Jones of the Green Mountain Institute suggested that middle class communities are *"motivated primarily by how much wastewater management will cost and who is going to pay."*

Participants in the workshops also expressed at several points the view that the financial costs of decentralized vs. centralized options would ultimately be the most important factor in a shift towards decentralization. As they summarized, *"crises may drive site-based actions (floods, boiled water and health advisories, growth/development explosion, etc.), but overall, the major driver is all about long-term costs."* At a later workshop, the following statement was made: *"Vibrant local level decentralization of water management will be driven by development responding to the issues of cost and timesaving."* Low impact development practices have shown that developers can both save money on stormwater infrastructure costs and sell the lots for more, because homebuyers value green space.

Alternatives to Sprawl Development (Promoted by Sewers and Large-Lot Septic Systems)

Solution: Use water conservation, low-impact development, and onsite and cluster wastewater systems to underpin appropriate development patterns (sewers and large-lot septic systems promote sprawl development)

- As stated above, Kyle Dreyfus-Wells described for the Chagrin River, the value of low-impact development and stormwater management practices in developing areas of the country. Several other speakers discussed the demand for more sustainable infrastructure in Greenfield developments, both for water quality and other environmental protection needs, and for finding lower-cost alternatives to conventional hard path infrastructure.
- Keith Carns from the Electric Power Research Institute described an emerging interest, in places like East Kentucky, for sustainable community design including distributed power generation and use, stormwater management, water use, and wastewater disposal.
- Kevin White described the recent emergence of the cluster wastewater system model in the Mobile, Alabama suburbs, where developers benefited from higher property value, lower infrastructure costs, and effluent reuse for landscape irrigation. Utilities also found cluster systems to be more efficient than extending sewer lines to new subdivisions.
- Craig Lindell described an example of a decentralized wastewater system installed in a suburb south of Boston, and suggested that this was a model for infrastructure that was *"flexible and adaptive, performance based, modular, scaleable, readily deployable, and designed and piped for redundancy and seasonal efficiency."* Lindell argued that this new decentralization option gave unsewered communities the opportunities to allow *"planning to be incremental, continuous, adaptive, and reflective."*
- Ken Jones also posited that affluent communities are interested in alternative wastewater approaches to achieve growth management.
- Two University of Tennessee professors, Tracy Moir-McClean and Mark DeKay, attended the workshops and handed out a Beaver Creek Watershed Green Infrastructure plan, which also shows how developing areas can utilize decentralized infrastructure. Similar to Dreyfus-Well's description of the Chagrin River, traditional development in the Beaver Creek watershed is leading to increased flooding, polluted streams, sprawl, open space loss, habitat fragmentation, and degraded rural character. Moir-McClean and DeKay have developed a concept of an integrated pattern of settled areas and stewardship lands and corridors that would both protect natural resources and enhance the quality of life for residents. Green infrastructure and nonstructural alternatives are seen as the least costly and most effective ways to reduce floods.

Related Examples and Studies

An earlier report by University of Rhode Island faculty, "Creative Community Design and Wastewater Planning" (Joubert *et al.* 2004) has provided many examples of how advanced onsite and cluster wastewater treatment systems could be utilized by communities trying to protect water supplies, water quality, and habitat, and to build in a fashion that the community desired. In the past, new sewer systems have often dictated where development occurs in a town.

Barry Tonning reports the adverse impacts on water quality of poorly-planned development, runoff, and regional wastewater infrastructure, and suggests: *"As the nation continues to grow over the next 20 years, millions of new homes and businesses will be built outside of existing urban and suburban areas. Communities need to make decisions about how best to manage this development … Individual onsite and clustered onsite systems can be the option of choice if properly managed. These systems, however, need to be considered in the context of a fully integrated water supply and treatment scheme that takes into account water uses, water resource quality, and wastewater treatment."* (Tonning 2007)

Quality of Life in Urban and Rural Communities—Pervasive Gray Infrastructure

Solution: View water as an asset for the community—stream daylighting, trees and green roofs for beauty, better air quality, reduced heat island effect, and "green jobs" for installing systems.

Several of the case studies presented in the workshops suggested that urban and rural residents were beginning to look to the trio of decentralized water, stormwater, and wastewater systems as major elements in achieving a higher quality of life in their communities.

In many of the case studies presented, the benefits of the trio of decentralized technologies were numerous.

- For an urban area, Andy Lipkis characterized the benefits of rain gardens and cisterns as: flood protection, water conservation, pollution prevention, energy savings, air quality improvements, improved public health, and environmental equity
- For a rural area, Stebbins described the benefits of water-centric planning and the trio of decentralized infrastructure as: compact development and urban form, replenish aquifer by locating park sites in areas where recharge capability is highest, preserve lands for wildlife corridor, respect rolling character of natural terrain within hillside areas, preserve historic architecture, keep schools, shopping, and parks within walking distance of residents, locate the town center next to open space and trail systems, encourage a complimentary mix of uses, maintain a jobs-to-housing balance
- Harry Wiland, producer of a PBS series "Edens Lost and Found," described a new environmental justice movement that has arisen in cities such as Chicago, Philadelphia, Seattle, and Los Angeles. Wiland suggests that residents have identified the trio of decentralized water, stormwater, and wastewater systems as pieces of a larger movement for multiple benefit infrastructure, including open space and public parks, urban forestry, watershed management, public art, waste disposal, recycling, green architecture, and mass transit alternatives

Related Examples and Studies

Support for the EPA's recent "green infrastructure" initiative is similarly built around multiple benefits from stormwater retention, including:

- Bill Clinton and environmental justice advocates, such as Van Jones, have begun to highlight the potential for "green job" development in urban areas. Clinton suggested, for example, that a widespread program to install green roofs in New York City would create thousands of high-quality jobs for low-income residents in the city (Clinton 2007)

Chapter 4

NEW DESIGNS THAT EMERGED FROM WORKSHOPS

In the workshops, a series of new designs emerged for how natural systems should be designed, how new markets could evolve, and how the public can become more engaged in the design of the infrastructure.

The central engineering paradigm for traditional infrastructure is composed of:

- "Rapid conveyance" piping systems moving water, stormwater, and wastewater long distances
- Economies of scale achieved in large systems–the marginal cost of adding new customers is low
- Municipal ownership and maintenance of the infrastructure

As suggested, this model emerged as a means to protect people from infectious diseases in polluted water and sewage and to control flooding. More recent technologies and designs can now ensure public health protection at the decentralized site level.

Biomimicry—Designs to Work With and Mimic Nature

The general concept of biomimicry is that nature can offer many lessons for how to solve engineering and design problems, either by utilizing natural systems or by mimicking nature in manmade products. Green infrastructure is a foremost example of using trees, stream buffers, plants in green roofs, and other natural systems to manage stormwater. Other examples were discussed in the workshops.

- Mary Hansel, of Carollo Engineers, introduced the term "biomimicry," which has been advanced by Janine Benyus (Benyus 1997) and others.

Living Machines and Ecological Engineering

There are also examples of ongoing research into biomimicry applications in wastewater technologies. For example, membranes have been a centerpiece of improving the capabilities of wastewater treatment at smaller and smaller scales. However, substantial amounts of energy are required to push effluent through these membranes.

Research in Europe and Asia, and recently in the US, is underway to understand how kidneys and livers filter pollutants without using pressure dynamics. These insights could lead to low-energy membranes. Similarly, research is underway on natural means to prevent clogging of filters, in effect by "bio-engineering" the bacteria in the sewage.

Patterns in Nature

In the project workshops, the primary emphasis was on a larger set of "patterns" in nature. Hansel suggested nature offers blueprints and design guidelines in forms, processes, and systems. She described some of nature's design principles as:

- Nature runs on sunlight
- Nature fits form to function
- Nature recycles everything
- Nature rewards cooperation
- Nature banks on diversity
- Nature demands local expertise
- Nature uses only the energy it needs
- Nature curbs excess from within
- Nature taps the power of limits

Many of the presentations in the workshops incorporated key principles on this list, in particular concepts of recycling, cooperation, diversity, local expertise, and responsiveness to environmental limits.

Water-Centric Planning—Fitting Form to Function

Jim Stebbins described the proposed water-centric designs of the Monterey community as mimicking natural processes. Key principles included, for example:

- One action must produce multiple benefits
- Use a low embodied energy solution
- Celebrate the design, do not hide it (fit form to function)
- Stebbins used the building blocks of water, wastewater, stormwater, land use, transportation and circulation, solar access/energy production and conservation, biological enhancements, and standards. Some of the designs included:
  - Community structure and land use—compact development and open space
  - Building blocks—use onsite water only, minimize use of potable water, reclaim what water is used, recharge/infiltrate whenever possible
  - Use water to set the development parameters, control types and amounts of different land uses

Sustainable Hydrology at the Site Level—Local Expertise and Value

Craig Lindell described decentralized infrastructure as *"enabling the site to define the technologies, processes, organizational structures, and operating skills that will most effectively achieve the desired environmental results."* Decentralized systems, he suggested, *"provide local government and its managers a variety of 'solution tracks' that meet the economic demands of a dynamic and growing economy, as well as the preservation of receiving natural systems."*

Lindell described decentralized infrastructure as distributed, flexible, and adaptive. It can be performance based, modular, scaleable, readily deployable, and designed and piped for redundancy and seasonal efficiency. It creates the opportunity to implement community preservation and watershed principles. It facilitates zoning for smart and green growth. It allows planning to be incremental, continuous, adaptive, and reflective. It encourages private investment, and provides for long-term self-sustaining sources of revenue for a community.

Lindell also described principles similar to Hansel. *"It is often easier and more cost-effective to find a common solution to a number of issues than it is to reduce the issues to individual problems for resolution."*

Lindell suggests that in the "new world of water," all water issues are inter-related. He quotes a 2003 statement by William Bertera, Water Environment Federation (WEF) Executive Director, as *"Almost everywhere in the world now, water is discussed and water-related policies are contemplated based on 'watersheds' or 'river basins' or other holistic terms. … Little, if any, distinction is made between drinking water or stormwater because all of them affect public health, the environment, and the quality of life for communities everywhere."*

Patterns: Land, People, and Towns as One Living Fabric

McClean and McKay from the University of Tennessee explained the underlying perspectives and principles of the Beaver Creek Watershed plan as the idea that the form of settlement grows out of an understanding of landscape context, both ecological and social.

Tapping the Power of Limits to Underpin Innovation

The growing crises of water supply shortages, water quality degradation, escalating financial costs of the conventional infrastructure, sprawl development, etc. are the fundamental drivers for innovation and exploration of decentralized systems.

Lindell offered a description of the synergistic power of this response: *"Our premise is that a "paradigm" or central organizing principle…has a useful life until the advancements of learning disclose additional issues which are not resolvable within its perspective or authority. These issues represent themselves as problems within the existing paradigm. A perfectly functioning septic system from a public health perspective is a risk to coastal ecology. For the paradigm, it is a problem. For the future, it is opportunity. For the public sector, it remains a problem until legislation and money resolve it. For the private sector it is a potential market."*

Abundance of Values Created in Nature

Lindell says, *"The value propositions and environmental issues at the site level are the result of prior policy decisions. Change a postulate and new perspectives and value propositions emerge. Change several and an entirely new. With this in mind there are environmental as well as economic and community values that may be advanced simultaneously with projects like this suburban, shared system."*

Related Examples and Studies

Amory and Hunter Lovins of the Rocky Mountain Institute, and Paul Hawken have written of similar design principles in *Natural Capitalism* (Hawken *et al*. 1999). David Del Porto has also suggested: "*nature's model shows us that complexity is the best way to manage resources"* (Del Porto 2006).

Biomimicry principles have until recently been a minor part of the conversation about water, stormwater, and wastewater infrastructure. A more common interest has been in materials science, for example. However, at the long-range planning meeting following the International Conference, Water for All Life, participants signed a "Baltimore Charter" (Clark *et al.* 2007) statement including the phrase: *"work with and mimic nature."*

Later explanations of this phrase included the following Principles of Design in Nature:

- Nature operates with patterns and principles that we can adapt to our treatment of water
- Nature creates order and builds from the bottom up with modular units
- Nature is multi-functional in its forms
- Nature adapts and adjusts to changing conditions
- Nature is cyclic and recycles, uses and reuses
- Nature creates beauty and abundance and no waste

A new international network called the Resilience Alliance has also been active in recent years. Resilience refers to the *"ability of a system to absorb disturbance and still retain its basic function and structure"* (Walker and Salt 2006). In resilience thinking, natural and social systems are intertwined and go through cycles of rapid growth, conservation, release, and reorganization. Resilient systems are collaborative, complex, diverse, and modular.

Excess stresses on the system can lead to collapse, with minimal opportunity for recovery. For example, once eutrophication of lakes and estuaries has occurred, it will be extremely expensive and difficult to restore water quality and marine life.

Market Transformations

In general, the EPA and other industry leaders have sought to break down barriers to more widespread use of decentralized systems. The 1997 *Response to Congress on Use of Decentralized Wastewater Systems*, for example, identified the need to educate homeowners on the value of management, open up federal financial aid programs to decentralized systems, develop and promote the adoption of management programs, streamline state regulatory structures that separate centralized and decentralized systems into separate agencies, and educate engineers. The EPA's decentralized wastewater program, in particular, has developed technology manuals and promoted the adoption of professional, rather than homeowner, management of onsite and cluster systems.

A goal of the workshop series was to explore alternative concepts for how to promote the adoption of decentralized systems. Various ideas about how market transformation occurs were discussed, because it was generally understood that breaking down barriers had not worked well yet as a national strategy.

Market Evolution—Nothing is Inevitable

Valerie Nelson presented the concepts of Michael Porter, author of *Competitive Market Strategies* (Porter 1980), from the Harvard Business School. Porter has suggested, based on his extensive research on the evolution of markets, that *"nothing is inevitable and much depends on luck and the skills of participants"* in moving from an "infant" industry to a "mature" industry.

Early Adopters and Diffusion

Mike Luzier, from the National Association of Home Builders Research Center (NAHBRC), described the Center's research on the diffusion of technology in the housing sector. Luzier described the industry as slower to adopt than industries in general, for reasons that are similar to the decentralized water infrastructure sector.

The industry

- Is highly-fractured with lots of small companies
- Is highly regulated at the local level with diverse regulations
- Heavily depends on subcontracting with low barriers to entry
- Is fraught with liability issues
- Lacks good data on customer preferences

The early adopters among builders need:

- Widespread demonstration of new technologies—multiple examples and geographically diverse
- Simple explanations of complex ideas—explain in a minute or two the main ideas
- Objective sources of information

Luzier described the Center's use of an adoption-diffusion model to organize its work (Conversation with Michael Luzier, NAHBRC). Substantial research is put into understanding the values and behavior of customers, and what products sell well and why. Homebuilders recognize that in their highly competitive market with thousands of small companies, federally-sponsored research is a necessity. Individual companies lack the resources or incentives to support research on their own.

The NAHBRC works on programs such as Zero-Energy Homes for the Department of Energy, where it is recognized that government subsidies or tax incentives are needed to induce homebuyers to install expensive energy-efficiency or renewables, such as solar or wind power that lack a short-term payback. The expectation is that, over time, costs of new technologies will fall dramatically as demand increases. In New York City, for example, green building costs fell from 20% to only 2-5% above conventional costs in just five years (NY Times).

Added Value

Luzier, from the NAHBRC, also highlighted experiences in product development and marketing from the building industry. Customers are willing to pay more for products that they perceive as having added value. It is a mistake to focus on costs of the product alone. This lesson pertains to infrastructure as well, since communities like Los Angeles are willing to pay more for non-traditional decentralized than traditional centralized stormwater infrastructure, if there are additional energy, air quality, and other "green space" benefits as well.

Social Marketing

Nancy Lee, of Social Market Services, discussed lessons about social marketing, as *"the use of marketing principles and techniques to influence a target audience to voluntarily accept, reject, modify, or abandon a behavior for the benefit of individuals, groups, or society as a whole."*

In general, a social market strategy targets

- **Greens**—have the value and the behavior
- **Sprouts**—have the value, but not the behavior
- **Browns**—do not have the value or the behavior

Greens and sprouts just need to be told or shown what to do. Browns, on the other hand, are unlikely to change their behavior.

Lee presented a number of recommendations for how government could more effectively change private behaviors, including:

- Overcoming barriers to change by creating better options and simpler choices
- Making messages vivid, personal, and concrete
- Getting pledges and using credible messengers

Lee suggested a few lessons for changing the behavior of the early adopters, including:

- Promote single, simple doable behaviors
- Understand and overcome barriers
- Include tangible objects and services
- Find a price that matters
- Make access easy
- Use effective communication techniques

Lee provided several applications of these principles in the environmental arena. Seattle found that the best target market for rainbarrels was avid gardeners, those interested in natural gardening, and those already having compost bins. These "greens" just need instructions on what to do. "Sprouts" need simple opportunities to change their behavior. "Browns" should probably be left alone, at least in the beginning, since they currently have neither the values nor the behavior that would support the goal of the new program.

Related Examples and Studies

Hilary Brown of New Civic Works outlined in a 2005 Harvard University conference on urban green water infrastructure how a classic private market adoption-diffusion curve, which tracks market penetration from a small niche to widespread use, could be influenced through public action (Brown 2005).

In this talk, Brown described how government could transform a sector through the following sequence of policies and initiatives:

- Financing laboratory research
- Building pilot and demonstration projects in public facilities or subsidized private facilities
- Financial and other incentives
- Regulations

This model was followed in the last five years, with city and the EPA support for green building pilots in New York City (EPA). A green building ordinance for large commercial buildings was adopted last fall, and the city has begun to turn its attention to wastewater recycling in housing projects in Battery Park. The city is exploring incentives, such as lower sewer rates when such recycling occurs.

Clayton Christensen at the Harvard Business School has also described how even the best companies with high-quality products and good customer ratings can be blind-sided by upstarts from other countries (Christensen 1997). "Disruptive" innovations, or paradigm shifts, are started by entrepreneurs outside the established field.

Malcolm Gladwell, in his widely-read book, *Tipping Point*, argues that in a complex and open society there are key individuals who, by virtue of their networks and leadership roles, can transform markets (Gladwell 2000). This concept was discussed at a 2005 Palo Alto conference on long-term management of soft path infrastructure, where it was agreed that educating a broad range of market participants was probably less effective than reaching a few key leaders in the field (Nelson 2006).

Integral Market Transformations

Cynthia Mitchell from Australia also suggested that a "leapfrog" can be achieved in water infrastructure designs, similar to the transition in telephones from land lines to mobile phones (Mitchell 2004). Synergies can be achieved from integration and co-evolution of energy, water, transport, and communications, where collaborative design can make *"the sum of the parts more than the whole."*

David Johnston, of What's Working, presented a definition of a market as a *"system that has definable rules, players and interactions that lead to financial transactions for products or services. Systems have predictable behavior that takes in-depth understanding in order to intervene to achieve a predictable change in outcome."* In the case of green building, he cited the three market forces important in driving adoption are market dynamics, buyer motivations, and stakeholder influence.

Johnston described the failures in the typical approach to green building:

- Seeing something wrong (resource depletion)
- Finding someone to blame (big bad business)
- Preaching to the choir (environmentalists)
- Wondering why things don't change

Conventional remedies include:

- Adopting new regulations to "force" change
- Blaming the homebuilding industry for building conventional housing
- Inventing new green approaches and assuming that they will be adopted
- Working through environmental groups to stimulate the market, as opposed to working with a range of stakeholders in the building industry

Johnston described an alternative "Integral Model for Market Transformation," which is based on understanding and leveraging the interests and behaviors of stakeholders, including both buyers and suppliers.

Market transformation occurs when the public sector, the non-profit sector, and the private sector are in alignment. Strategies can include policies and ordinances, ratings systems, websites and networking.

The San Francisco Bay Area "Build It Green Program," for example, includes builders and remodeling companies, product manufacturers, environmental non-profits, members of an affordable housing coalition, and a range of municipal agencies.

Social Transformations and Changes in Values

According to David Johnston, a key element in the projects of What's Working is the use of market segmentation concepts according to Don Beck's "Spiral Dynamics" approach. There are six basic stakeholder worldviews within people, organizations, and markets, each with different value systems and behaviors.

Johnston's examples of these worldviews, with color codes, and how they can be motivated for green building include:

Table 4-1: Johnston's Worldviews

Color	Cultural Synergies	Social Marketing
Purple	Concern with family security and health	Target their concern for protecting air quality for their children
Red	Values of personal express, individuality, "beating the system"	Target their desire for self-reliance (off the grid), unique use of straw bale construction
Blue	Traditional values of law and order, "Doing the right thing"	Market energy efficiency as saving money, good for the society
Orange	Achievement goals for status and affluence	Green building for greater profits, real estate appreciation, status
Green	Concerns for equality, community, consensus decisionmaking	Market products to further environmental goals
Yellow	Global concerns, balancing of ecosystems and human development	Appeal to planetary health and the future, transcend the ordinary through holistic solutions

In many instances, environmental protection bureaucracies and advocates have misunderstood their customers. For example, in both the cases of green building and the hybrid Prius, the initial marketing was aimed mostly at Greens (environmentally-oriented buyers). Later, both campaigns shifted to a multi-colored campaign, where the different values of the different constituencies were specifically targeted.

Activists and Entrepreneurs Finding Niches

The scattered, siloed innovation that characterizes the decentralized field is generally being pushed by activists in civil society and entrepreneurs in the private market. Activists, such as Andy Lipkis or Kyle Dreyfus-Wells, who presented case studies in the workshops, are finding openings for new approaches where they have identified a water supply or water quality crisis.

Entrepreneurs, such as Craig Lindell and Jim Stebbins, who also presented case studies at the workshops, are finding openings where there is unmet demand in the marketplace, usually of "early adopter" customers.

Ecological Stewardship and Local Activism

Brent Haglund, Director of the Sand County Foundation (SCF) in Wisconsin, described Aldo Leopold's philosophy for land conservation in 1939: *"A land ethic, then, reflects the existence of an ecological conscience, and this in turn reflects a conviction of individual responsibility for the health of the land"* By 1949, Leopold had come to understand that a land ethic was also needed for conservation on private land to work: *"When land does well for its owner, and the owner does well by his land; when both end up better by reason of their partnership, we have conservation. When one or the other grows poorer, we do not."*

The Sand County Foundation (SCF) has focused its projects on developing partnerships and approaches for conservation management on private property. Looking for alternatives to regulation, which Leopold saw as a last step when all else had failed, SCF advocates and develops pilot programs incorporating local solutions that empower citizens, allow for adaptive management and learning, and that use market approaches and incentives.

The SCF believes that affecting powerful, long lasting change comes from fostering community learning; empowering individuals to take action; and actively advancing responsible citizenship. Leopold's best friends were socialists and right-wing activists. Overcoming those differences will require building new and unlikely partnerships.

Community Environmental Justice Activism

Harry Wiland of Edens Lost and Found, described the PBS documentary series *Edens Lost and Found*, which describes efforts to improve the quality of life through urban "greening" in four American cities: Philadelphia, Chicago, Seattle, and Los Angeles. The series also shows how media can be used to reach a wide audience with a compelling message. Along with other media, such as website community-action guides, education curricula, and outreach, this series helps the story get out in ways that the government cannot. *"The film series is the rock in the water that has caused a ripple of information and influence outward."*

Described in each program are examples of local citizens envisioning sustainable urban ecosystems, including open space and public parks, urban forestry, watershed management, public art, waste disposal, recycling, green architecture, and mass transit alternatives.

Through this project, Wiland has come to believe that this movement of community activism and environmental justice is the issue of this era. Wiland says, *"We grew up thinking government would solve these problems for us. We are now realizing that many issues are related (housing, clean air, water, etc.) and we have a direct stake in improving our quality of life. This fact is promoting community knowledge and action."*

Related Cases and Studies

The approach of voluntary incentives that Haglund described as being at the core of Aldo Leopold's work on private land ethics is at the heart of the Bush Administration approach to environmental issues. James Connaughton, Chairman of the White House Council on Environmental Quality, described the Bush Administration approach to environmental innovation and reform in a 2003 speech, "Tapping the Power of the Quiet Revolution: Productive Harmony Through Integrated Environmental Policy." (Connaughton 2003) In this speech, he outlined the main elements of the Administration's vision for how the country would tackle environmental problems in a different, and they asserted, better way than under past "command-and-control" regulations at the federal level.

Connaughton posited that environmental reform is embedded in a "Quiet Revolution" of millions of people, including academics, business, citizens, and government at the local level. These innovators are starting to collaborate to find new solutions that would "harmoniously balance environmental, social, and economic needs for future generations." The main elements of this new environmental approach are:

- Focus on results
- Strengthening of personal and corporate "stewardship" of the environment
- Reliance on private market mechanisms, such as performance standards and incentives
- Innovative technologies
- Science-based decisionmaking based on identification of highest risks
- Shift from federal to local responsibility, or "ownership," of environmental solutions
- Shift from enforcement to voluntary compliance

These themes of private stewardship and local control are being implemented in a variety of programs across federal departments and agencies. As such, they serve as the backdrop for the EPA's national innovation strategy (EPA 2004), the Department of Interior's Water 2025 (US Department of Interior 2003), and the administration-wide support for "cooperative conservation" partnerships (US Department of Interior 2005).

Leopold's heirs in ecological stewardship and new environmental justice movements are two strands of this "quiet revolution," but there are others. Themes of local cooperation and community-building are also found in more progressive circles, such as the Bioneers or Ecological Engineering networks.

Entrepreneurship—Niches of Unmet Demand in the Market

As Craig Lindell pointed out in his presentation, the inability of existing institutions to respond to new demands has created opportunities for new businesses and markets to emerge. Four types of entrepreneurs have surfaced: management companies (discussed in the Palo Alto workshop); equipment manufacturers; architects and planners; and developers/builders.

At the Palo Alto workshop, Jerry Stonebridge of Stonebridge Environmental, Inc. and Tim Bannister of TCW Wastewater Management described their private companies installing decentralized wastewater companies, and Ed Clerico of Applied Water Management described a utility management approach to cluster system installation and maintenance.

Lindell's company, Aquapoint, both sells cluster wastewater technologies and installs systems. Jim Stebbins, from Project Design Consultants, represented the architectural design community, which is working with developers and builders to implement "water-centric" subdivisions.

Chapter 5

IMPEDIMENTS TO CHANGE IN THE PARADIGM

The following impediments to change emerged in the workshop discussions:

- Government policies, funding, regulations built around centralized infrastructure
- Distorted pricing of water
- Balkanization of agencies
- Municipal authority and a limited role for the private sector
- Pervasive risk aversion and minimal research funding
- Stakeholder support for conventional solutions
- Lack of local models that combine technology, management, financing, and customer acceptance
- Opposition from threatened entities
- Classic market failures–lack of information, fragmentation

Government Policies, Funding, and Regulations That Are Built Around the Traditional Infrastructure

Government plays a significant role in perpetuating the traditional, centralized approach. Regulatory structures were devised which assumed that modern sanitation and safe drinking water could only be provided through centralized distribution or collection and treatment. 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. Federal subsidies to local projects from a host of federal agencies were built around those assumptions as well.

What this means is that 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 solution.

Federal, state, and local policies, funding, and regulations were repeatedly discussed in the workshops as barriers to decentralization.

One particularly interesting comment was: *"What are we up against with the local regulatory system in the US? It's like swimming in quicksand, very difficult to get acceptance."*

Other comments were:

- *"Regulations are a huge problem right now. The current structure is not integrated, so it silos drinking water, wastewater, and stormwater projects and prevents the integration that is a driver in the cities or a source of ferment in the cluster system approach."*
- *"The regulatory system is problematic because it is a typically prescriptive, uncooperative approach. However, if the regs are right, then it can be a driver to get things done. Others thought that prescriptive codes are ok, but a lack of prescriptions for innovation remains problematic."*

Related cases and studies

An increasing number of workshops and reports are identifying government policies and regulations as a significant barrier to sustainable infrastructure. These include two recent WERF reports on barriers to use of decentralized wastewater systems and on sustainable water resources management (Etnier 2007; Thornton 2005).

Distorted Pricing

Peter Shelley introduced his presentation on the disruptions of conventionally-engineered infrastructure in Eastern Massachusetts by quoting Garrett Hardin's *Tragedy of the Commons*,

- *"Each man is locked into a system that compels him to increase his herd without limit—in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all."*

Shelley's point was that water was not adequately valued or priced to reflect the externalities of all the separate water and wastewater projects in the region. As a result, the natural water cycle was more and more disrupted, with depleted groundwater and streams and resulting water shortages. Shelley's final quote was, *"For long-term success, the value of ecosystem services must begin to flow back to their owners. Until it does, society will undervalue those services."*

True-cost pricing has a number of benefits that would raise water and sewer rates to cover the externalities of the infrastructure. There are several elements to the problem.

First, subsidized water rates encourage consumers to wastewater. Higher rates would lead to more efficient use of water supplies, purchase of water-efficient appliances, conservation landscaping, etc.

Second, "siloed" projects in water, stormwater, or wastewater are typically constructed without taking account of the eventual need for other projects to be built, or of the impacts on neighboring communities. For example, a typical scenario is the construction of water lines into a neighborhood. With greater use of water, septic systems are overloaded and eventually sewers are constructed. Another example is the construction of sewers to clean up affected surface water, followed by sewer-facilitated housing development and increased stormwater runoff. Congressional staff have stated that most of the authorized Bureau of Reclamation water and sewer projects are "mitigation" efforts to correct problems created by earlier projects funded without taking account of the regional and long-term impacts and externalities.

Third, benefit-cost calculations for infrastructure typically undervalue the loss of habitat and other damage to natural systems that these projects will entail.

True-cost pricing of the infrastructure could provide a substantial stimulus to decentralized wastewater and stormwater (DWSW) systems. As stated earlier, higher water rates that reflected the real costs and externalities of the infrastructure would encourage water-efficiency and conservation, as well as capture and use of rainwater and treated wastewater for non-potable uses.

Removal of subsidies for conventional infrastructure would make decentralized systems much more competitive, since they are typically unsubsidized. This newly-competitive market position would stimulate much more research and innovation by manufacturers and developers. Most importantly, decentralized systems have a lighter footprint in the environment and entail many more community benefits. A full accounting of all resource costs and benefits, including such factors as energy impacts, green space, jobs, etc. would dramatically increase the use of DWSW technologies.

These themes recurred in presentations and discussions in the workshops. Andy Lipkis pointed out that the direct costs of distributed stormwater infrastructure were higher than for conventional flood control channels, but that when the benefits of energy conservation and green space were taken into account, the distributed systems had significantly higher benefits. Participants pointed out that the costs of decentralized systems are currently higher than they would be if markets were expanded, with production and service costs brought down. An approach to dealing with this adverse price differential might be *"to internalize external costs as the best way to drive innovation."*

An extended discussion on the last workshop was about the need to value water appropriately. It was suggested that

- *"Valuing water from multiple aspects is the key component that forces different views of the issue."*
- *"The public needs to see a problem…We won't get buy-in from any sectors of society unless they see the value."*
- *"Full cost pricing (higher rates) would shift what consumers and utilities do."*

However, because of the recognition that poor populations would be adversely affected by higher water and sewer rates, the suggestion was made that the model of the energy sector could be followed. The electric industry has full cost accounting and demand side management, so that utilities must take account of all costs in order to be permitted for new facilities, higher rates, etc.

Related Cases and Studies

A report by Richard Pinkham on the economic advantages and disadvantages of decentralized wastewater treatment relative to larger scale, centralized solutions has similarly argued for consideration of a wide range of concerns (Pinkham *et al.* 2004). An NDWRCDP report on life-cycle costing methodologies has examined both long-term materials use and environmental externalities in analysis of wastewater infrastructure options (Kirk *et al*. 2005).

Balkanization of Agencies

Andy Lipkis described several of the key barriers to wider use of rain gardens and cisterns in the Los Angeles as compliments and substitutes for large water supply and flood control infrastructure as being *"siloed agencies, government turf wars, and lack of collaboration."* Each agency that would need to be involved in such a new approach was operating under its own guidelines. The US Army Corps of Engineers had its own single-purpose benefit-cost calculation for flood control, as did the county and city for water supply. Only through integrated infrastructure planning would the true values of decentralized systems emerge. Agencies also were disinclined to break down their silos and work together.

Jim Stebbin's project in Monterey suffered from the same balkanization of agencies. Various elements of the "water-centric" plan needed approval from the planning department, public works, or environmental health. Much of the plan was not adopted because one feature or another was turned down by just one of those three agencies. For example, use of gray water was approved by planning and public works, but not by environmental health. Permeable paving was approved by planning and environmental health, but not by the public works department. These regulatory barriers, of course, are a tremendous disincentive for developers.

Kyle Dreyfus-Wells also noted the problems for local communities in the Chagrin River Watershed of dealing with the separate bureaucracies if the US Army Corps of Engineers for flood control and the Ohio EPA for water quality.

Craig Lindell quoted Jim Nemke, from the Metropolitan Madison Wisconsin Sewer Authority, as saying: *"Water management plans have been abandoned because of the lack of an implementation authority beyond the point source permit program. The EPA, DNR, USDA and those concerned with state health can't cooperate sufficiently … and don't."*

Related Examples and Studies

The 2005 National Water Policy Dialogue urged more integrated approaches and a "harmonizing and reconciling" of national water policy. Participants stated that *"there is a need to reconcile the myriad laws, executive orders, and Congressional guidance that have created the current disjointed ad hoc national water policy and clearly define the 21st century goals and values that should be met",* and criticized the multiple, often conflicting, agency mandates (American Water Resources Association 2005). Proposals for the establishment of a Water Commission that would be tasked with examining these issues have been discussed in recent Hearings in the Congress (House of Representatives 2005).

In the Southwest, water supply allocations and public lands boundaries have largely determined growth and development patterns, which in turn have had substantial water quality impacts on rivers (Babbitt 2005). Recently, the majority of Bureau of Reclamation projects, according to Congressional staff, are in "mitigation" efforts to deal with hydrological disruptions and water quality impairment created by earlier infrastructure projects. In the future, integrated water resource planning should be a condition of water withdrawal projects, so that all regional water quantity and quality impacts are taken into account.

In the East, where until recently water supply has been more than adequate, water quality under the Clean Water Act and flood control under Army Corps of Engineers permits have been the predominant concerns. Here as well, there has been minimal coordination of efforts from the federal perspective, and local communities fail to take account of the integrated nature of the water resource. The Eastern Massachusetts example of a large central wastewater system and ocean outfall pipe drastically depleting drinking water wells and streamflows is a prime example of the costs of this splintered decisionmaking.

Municipal Utility Management of the Traditional Infrastructure

The traditional infrastructure paradigm relies on:

- Municipal authorities
- Infrastructure in public rights of way
- Public looks for safe water and sanitation as key services provided by utilities

Municipal management of the traditional infrastructure is an appropriate match of services to need. Water and wastewater utilities that centralize treatment and distribution in a community are prime examples of what economists would call public goods or natural monopolies, where provision by more than one provider is not realistic.

But, when individual or cluster treatment units are dispersed across many private properties, there is no structural necessity for one municipal utility to manage these services. Rather, a classic competitive market with multiple customers and multiple suppliers can be developed, ideally under public oversight that protects public health and the environment.

Of fundamental importance is the fact that decentralized, "soft path" infrastructure is usually on private property, whether at individual homes, subdivision developments, or commercial properties. In contrast, conventional treatment plants and conveyance systems are on public land and in public rights-of-way. This location of systems on private property, interestingly enough, both helps to explain the slow adoption of decentralized alternatives by mainstream utilities and engineers, and the unique opportunities for new private sector models to develop.

The presentations at the Palo Alto workshop on viable business models were intended to be "early adopters" in the areas of onsite wastewater system management, cluster wastewater system management, and urban distributed stormwater management.

Valerie Nelson described material from Michael Porter's book, *Competitive Strategy: Techniques for Analyzing Industries and Competitors,* in which he suggests that small, local providers will be the market model when:

- A personal service is provided (there is a customer's perception that individualized, responsive service declines with the size of the firm)
- Business depends on local image and local contacts
- There is a diverse product line and customization to individual users (vs. a tendency to standardize products and services by larger companies)
- There is a heavy creative content

Onsite wastewater system management, in these regards, is similar to the services of a local electrician or plumber. The homeowner appreciates the freedom to choose their own contractor, and the contractor enjoys dealing with the unique personality and needs of the homeowner.

In contrast, Porter's work suggests that larger utilities or companies can emerge when the service is not personal, and when the product is standardized across customers. Therefore, it is not surprising that utility management, or *"responsible management entities,"* would be emerging for cluster systems. For cluster systems, the utility model, in effect, mimics (at a smaller scale) the existing work of municipal utility staff familiar with large-scale pipe, pumping system, and treatment plant maintenance in public properties and rights of way, and with minimal involvement with individual property owners.

It is arguable that a fundamental flaw in the EPA's strategies has been their focus on trying to persuade mainstream utilities and engineers of the value of adding decentralized technologies to their portfolio of treatment options. The phrase *"centralized management of decentralized treatment"* has been the underpinning for arguments for "responsible management entities," in particular, municipal utilities and their consulting engineers to consider owning and managing treatment units on private property, as part of a "hybrid" of centralized and decentralized approaches.

A series of National Decentralized Water Resources Capacity Development Project (NDWRCDP) research projects, including studies of asset management and "barriers" in the engineering profession, also presumed that the "utility" model for individual home units was the desirable approach.

Risk Aversion and Lack of Support for Innovation

Because of public health concerns, the water and wastewater field has become cautious and risk-averse over time. Engineers and builders are concerned about liability. Politicians are concerned that innovative approaches may fail, as well. Craig Lindell described a decentralized system market analysis exercise that identified the risks of innovation as the "deepest driver" for blocking change. Public health regulations, he found, were the point of "greatest resistance."

There are public concerns about how soft path systems work over time, their life cycle, and who funds it. The paucity of specific monitoring creates intolerance for innovation.

The regulatory system is problematic because it is a typically prescriptive, uncooperative approach.

Ordinarily, society will cover the risks and costs of innovation through publicly-funded research and demonstration projects, or through carefully-managed innovation in the private sector. But, as Julian Sandino, of CH2MHill described, the US has drastically cut back on research funding since the 1980s, and privately-funded research has fallen in parallel.

For lack of research, Bob Siegrist pointed out that there remains:

- A lack of fundamental understanding of the science governing common systems and emerging technologies
- Absence of mathematical models that can be employed as part of a rational design practice
- Limited infusion of ideas, techniques, and technologies from complimentary disciplines and programs
- Continued controversial and unresolved views and beliefs, and highly varied, and often unsupported, practices

Related Examples and Studies

Innovation was built into the Clean Water Act through the primary vehicles of research and development programs authorized in 1972 at $100 million per year (over $300 million in current dollars) and, subsequently in 1977 Amendments, through incorporation of an additional subsidy and federal guarantee (15% more) for innovative and alternative systems. Many of these were decentralized cluster systems or constructed wetlands in small communities (EPA 1989). Numerous new technologies were streamed into the construction projects built with federal grants, and a lot of ideas are said to have emerged from federally-funded research carried out in universities, often by graduate students, who later developed technologies and carried them into production by setting up their own companies (Conversation with Julian Sandino, CH2MHill).

In the 1980s, these innovation strategies in the Clean Water Act were largely phased out. Two concepts took hold: first, that federal subsidies for wastewater systems promoted overly-expensive systems and displacement of local spending, and should be phased out; and second, that research was more properly the role of the private sector and the states (National Research Council 2004). The Reagan Administration assumed that the states and the private sector would pick up the slack in declining federal investments, but this has not been the case.

The National Academy of Sciences has issued several reports in recent years which describe the per capita decline since the 1980s in water-related R&D funding by the federal government (National Research Council 2001 and 2004). Funding has also shifted substantially from support of basic, long-term research to support of agency mission-related and short-term research projects (National Research Council 2004). In particular, there has been a decline in assistance for technology-related research and development, and most of the remaining funding for water-related technology innovation is in the Department of Defense (National Research Council 2004).

Stakeholder Support for Conventional Solutions

As participants in the workshops stated, *"the environmental community creates a problem here by forcing courts to stay with old systems."*

Related Cases and Studies

Despite the interesting grassroots projects occurring at the leading edge of a new paradigm, the preponderant influence of NGOs at all levels is still in reinforcing the conventional, hard path paradigm. At the local level, for example, environmental groups have used court cases and other pressure on municipalities to force very expensive conventional sewering and CSO-remediation projects, sometimes in spite of their marginal impact on water quality.

Groups such as the Nature Conservancy have strongly opposed decentralized alternatives in the Florida Keys. In Washington, D.C., environmental coalitions have stuck to big-pipe CSO approaches, even in the face of some interest in green infrastructure by the municipal utility. Similarly, in King County, Washington, a large new regional treatment plant will be built, while environmental groups that have supported Green Building projects in Seattle have remained silent.

At the federal level, a similar pattern can be seen where there have been a few instances of NGO support for soft path innovations. These include efforts to encourage Congressional interest in decentralized wastewater management, and more recently, the advocacy and collaboration of NGOs with the EPA on guidance to communities on "green infrastructure." Clean Water Network leaders, in particular Nancy Stoner from NRDC, Betsy Otto from American Rivers, and Paul Schwartz from Clean Water Action, have assisted in these re-framing projects "on the margins" of conventional practice. These three as "wet weather" committee chairs in the Network have also begun to hear of an interest in more sustainable approaches from their members at the local level.

The core influence of NGOs is still in reinforcing the hard path paradigm, where wastewater and stormwater problems are narrowly defined as surface water quality issues and do not include water quantity impacts. The engineering solutions are in large, rapid-conveyance sewer and water grids and treatment plants. The key levers NGOs try to exert on this system are in forcing and encouraging continued building and repairs to this conventional system through the two strategies of increased federal subsidies and through upholding and enforcing the National Pollutant Discharge Elimination System's (NPDES) permitting of hard path infrastructure.

National groups have, in general, been forced into a defensive mode by Supreme Court cases that have questioned the reach of Clean Water Act jurisdiction into "non-navigable" streams and wetlands, and by large proposed cutbacks in Clean Water and Drinking Water SRF funding by the current Administration. These realities have focused virtually all the NGO energies on attempts to pass the Clean Water Restoration Act, which would clarify the inclusion of isolated streams and wetlands, and on restoring CWSRF funding, as well as passing of a new Clean Water Trust Fund, proposed by the WIN network.

Lack of Robust Models or Packages

One of the problems with advancing decentralized systems is the lack of robust models or "packages" that have been demonstrated. Because the field is in an early stage of development, many diverse technologies and institutions are emerging, and the best have not been winnowed out. Comments included in the workshops are:

- There is currently tension between the push for technological diversity to enable a wider variety of approaches versus the increasing complexity of certification requirements and professionalism in the industry
- There are now more different types of decentralized systems. This will help industry move forward but also complicate training and operations. That is an up and a down side of this experimentation
- The next transformation in the infrastructure will require a new and stable mix of delivery and finance mechanisms to get the tasks done. Part of this will involve maximizing simplicity of the transaction
- We need to put order on the chaos of the fragmented market. Capture case-based examples in a rational way and put them in a clearinghouse

Opposition From Threatened Entities

Participants in the workshops described the danger that stakeholders in the current infrastructure paradigm would block change: "*Early efforts to obtain resources can be risky, and should avoid big power plays that cause the status quo powers-that-be to see this as a major threat."* Allusions were also made to "turf wars" among siloed agencies.

Related cases and studies

As Michael Porter of the Harvard Business School has pointed out, *"threatened entities will respond"* to market challenges (Porter 1980). In the case of water resource infrastructure, decentralized system innovators have to deal with powerful groups that would stand to lose from the emergence of soft path approaches, including:

- Cities that have used sewer extensions to annex new taxpayers in outlying areas
- Engineers who believe they make more money off larger hard path projects
- Developers who can build more homes when sewers are built
- Construction companies and unions that only do sewer and not soft path construction
- Bureaucrats who are risk-averse and resistant to the challenges of managing change

Each of these constituencies can stall innovation. In the late 1970s, for example, federal research on onsite wastewater approaches was ended when central system lobbies approached Congressional committees with their competitive concerns.

Classic Market Failures—Lack of Information and Fragmentation

The suggestion was made in the last workshop that: *"The soft path approach is a classic example of market failure and lack of information. There are great examples out there (e.g. Seattle, Portland). It's not clear how to get these examples scaled up and documented. How can we learn from the rest of the world? Garnering and distributing new information is the critical opportunity we have."*

The suggestion was made to:

- *"Capture case-based examples in a rational way and put them in a clearinghouse. Put order on the chaos of a fragmented market."*
- *"There are public concerns about how soft path systems work over time, their life cycle, and who funds it. The paucity of specific monitoring creates intolerance for innovation."*

Related Cases and Studies

Economics literature has recently included work on the distortions in the market created by imperfect information. In general, both demand and supply sides of the market cannot respond appropriately to achieve appropriate market equilibrium. Consumers do not understand product qualities and prices, etc. These problems have become the justifications for the EPA to produce guidance documents, fund conferences and websites, etc. as a means to provide the proper information to municipalities, consumers, and companies.

A second problem identified in the literature has been the fragmented markets created by widely-divergent local regulations and codes. Venture capitalists and large manufacturers do not enter the market for decentralized technologies until they see large national markets. Barring the imposition of national codes, a useful project is development of voluntary national standards, which are quite likely to be adopted by many states and localities. As one workshop participant suggested, *"The variety of multiple regulations, codes, and standards at the local level creates disincentives. The national model building codes provide a good example of an entire industry moving to uniform standards."*

Summary—Drivers and Impediments

The three drivers for a water infrastructure paradigm shift—ecosystem stresses and societal demands, new ideas and designs, and niche efforts by NGOs and entrepreneurs—are, as workshop participants suggested, still preliminary and scattered. However, population increases, land development, and climate change are all forces that will intensify and highlight the flaws in the traditional paradigm.

Biomimicry offers useful lessons on how a more sustainable infrastructure can be created, both in lightening the environmental footprint and in creating a higher quality of life in communities.

Central organizing principles, seen in the workshops, need to be in placing water at the center of design for multiple functions and benefits and in creating openings for new constituencies and the private sector to participate and create new value.

In the coming years, it will be important for the internal structures of a new paradigm to be more rigorously developed. Moving from a specialized and centralized model of infrastructure to an integrated and localized model means that a host of additional benefits can be achieved for the environment and for society, as well. A systematic search for joint resource efficiencies in water, stormwater, wastewater, and energy has only just begun, and the means and benefits of greening cities and more livable communities are in their early stages. Biomimicry offers lessons for how to harness the creative impulses and energies of new participants as well. The process of engaging multiple constituencies in solving problems with fresh eyes and in harnessing the motivations of the private sector and civic activists has also just begun.

While students of paradigm shifts acknowledge that the process of change is inherently unpredictable, this project suggests several large new strategies for triggering and easing such a shift. In the past, conversations about decentralized systems have been kept on the "margins."

Strategically, a larger, holistic conversation about the sustainability of water-related systems must begin, with integration as a hallmark of that conversation:

- Integration of water quantity and water quality concerns
- Integration of water, stormwater, wastewater, energy and other infrastructure planning
- Integration of the trio of decentralized systems at the building and neighborhood scale
- Integration of environmental services with other community benefits, such as job creation and quality of life improvements
- Integration of the private sector and civil society into the creation of a more resilient and more productive infrastructure paradigm
- Integration of surface water, groundwater, rainfall, soil moisture, and climate interactions

Any strategy that attempts to leverage the drivers and new ideas in the field must also consider a process for breaking down the impediments to change in the paradigm. Large structures of government at all levels were built around siloed, single-purpose infrastructure. Within this framework, the interrelated water challenges and the potential benefits of decentralized systems are neither recognized nor permitted and funded. The system is also highly risk-averse and minimizes incentives for private sector engagement. Broad groups of stakeholders have supported this traditional infrastructure model, in general looking to more funding and enforcement as the mechanisms for water quality improvements.

Another concern, therefore, is timing. In a Catch-22 situation, the large structures of government block the consideration and use of decentralized systems. With few openings for innovation, the field is held back into scattered, expensive, and siloed examples, with minimal incentives for technology development and institutional reform. With so few examples and so little documentation of the decentralized potential, there is no capability of mounting the arguments and constituencies for a fundamental change in government policies and practices.

In the short-term, then, workshop participants argued for as much innovation as possible at the local level. Over time, as knowledge and experience grows with the new paradigm, a concerted effort can be mounted to reform government, both in restoring federal research funding, and in restructuring federal research funding and regulatory approaches to support integrated planning and design, private sector engagement, multiple community benefits, and continuous innovation.

Chapter 6

STRATEGIES TO TRIGGER AND EASE A PARADIGM SHIFT

In a final workshop in January 2006, the core group of organizations re-convened. One of the objectives was to develop an agenda of priority short-term research and development, and outreach projects. This list was based on two criteria: first, areas of effort and activities that will have the greatest short-term impact in advancing the field; and, second, projects that have a high likelihood of being accomplished.

The following six priorities that were identified in the workshop can be divided into three basic strategies:

- **Create Spaces for Local Paradigm Models to Emerge**—Such as in green building and demonstration projects in cities and towns
  - Linking the decentralized water field to the "green building" movement and development of similar "standards" and "ratings"
  - Support for pilot and demonstration projects in federal facilities and in local communities
- **Support Conversations and Research**—Among engineers, utility managers, non-governmental organizations, academics, and the public
  - Support for a network of local advocates and experts, through education, tools, and capacity-building
  - Work with federal leadership and other "champions" to provide guidance on the benefits of decentralized approaches to federal agencies and to the nation.
- **Build Support for Big Government Shifts**—Incrementally begin work on reforming the big government structures of research, funding, and regulations
  - Research on full monetary and non-monetary benefits and costs of decentralized and centralized approaches, and pricing or other mechanisms to better align local decisions with long-run environmental and economic sustainability
  - Exploration of how to tie federal subsidies and permits to an integrated water supply and water quality plan in a watershed

Create Spaces for Local Paradigm Models to Emerge

Individual presentations, as well as general discussions, highlighted the need for and role of local models that provide for integrated infrastructure planning and design, build new institutional models, and engage multiple stakeholders. Two arenas for innovation are:

- **Site level**—Water-efficiency, stormwater retention, and wastewater treatment and resource recovery can be co-designed to achieve maximum benefits with energy, green space, air quality, aesthetics, and other factors
- **Municipal or watershed level**—Where the challenges of droughts, wet weather runoff, sprawl development, aging infrastructure, and deteriorating urban neighborhoods can be met with water-centric new infrastructure and institutions

A pervasive discussion in the workshops was the need for local paradigm models to be demonstrated. *"All levels of reform (private, local, federal) would have some role in driving change toward soft path water. However, the local scenario is likely to play a particularly important role. From process standpoint, local models tend to be more responsive and leadership finds viable solutions if voters want it. If the movement is localized in enough places, national momentum follows."*

It was recognized that existing regulations and bureaucracies stymie the development of new models, so spaces must be created for innovation. *"Integration of systems must happen through exemptions and exceptions to local regulations that currently do not accommodate integration. The road forward to integrated systems requires building sites through exception, obtaining permits for these systems, and leveraging these as precedents for other integrated systems."*

A common theme of suggestions for local models was for an integrated and multi-stakeholder approach: *"Another part of organizing is co-developing tools and participants to accelerate market transformation. What types of systems would best harness different motivations and values of participants? Institutional changes need to focus on key stakeholder interests, otherwise the movement is too large, dispersed, and chaotic."*

Comments were made in this regard:

- *"Creativity and energy in the cluster system model is achieved through integration—landscaping, reuse, land use planning."*
- *"The urban model MUST be an integrated system. Distributed water/wastewater in conjunction with stormwater and energy, parks initiatives drives the cost/benefit—in addition, multiple disciplines bring multiple budgets and advocates."*
- *"It is essential to make integrated thinking and planning happen. If you silo the projects they do not have the value."*
- *"Integrate public health and environmental agencies."*
- *"Develop integrated water resource models for different development patterns (large lot, cluster, new urbanist)."*

Keith Carns stressed that *"a cross-functional approach to the planning of the development of integrated infrastructure—water, stormwater, energy, wastewater—was needed."* Craig Lindell stated, *"If we are going to consider water in holistic and integrated terms, we need to consider infrastructure in holistic and integrated terms. We need technologies, organizations, partnerships, processes, skills, legislation and regulation—an entire architecture—that is equally holistic in its approach."* Lindell urged a search for a range of local options *"that include local self interest, tax incentives, limited partnerships, municipal sewer ordinances and environmental results permitting may be combined to accelerate watershed compliant infrastructure development."*

Harry Wiland said, "*Integrated resource planning combined with local community support have come together with bold strategies offering renewed hope to American cities to develop sustainable urban ecosystems including open space and public parks, urban forestry, watershed management, public art, waste disposal, recycling, green architecture, and mass transit alternatives."*

Brent Haglund described Aldo Leopold's approach as *"practical, ethical, and based on collaborative work among stakeholders such as the sportsman, federal agent, naturalist, ecologist, and landowner."* An example of results of collaboration occurred with a new dam removal alliance of non-traditional partners, in which a wide range of benefits were discovered: better safety, water quality improvements, enhanced fishery, lower flood risk, and lower taxes and expenses.

Specific recommendations in the workshops included:

- *"Find pressure point opportunities to retrofit a community. We need to focus on funding sources and drivers in new communities. Identify where large funds are being committed and understand how to make the case to those decisionmakers (and what influences them.)"*
- *"Another part of organizing is co-developing tools and participants to accelerate market transformation. What types of systems would best harness different motivations and values of participants?"*
- *"Institutional changes need to focus on key stakeholder interests; otherwise the movement is too large, dispersed, and chaotic."*

Green Building

One of the six priority recommendations of the workshop participants was linking the soft path water field to the "green building" movement and development of similar "standards" and "ratings"

Opportunities

A number of discussions turned to the opportunities in new subdivision and infill developments:

- *"There is a growing interest in green infrastructure—a movement—that can be tapped; we need a galvanizing force that varies by localities and a convener of key stakeholders."*
- *"We need to understand the values of constituencies and appeal to those values—find common ground, blending natural values with fast track cost-based approach in subdivision development."*
- *"Focus on new development. We need data regarding resource protection effectiveness and reduction of costs and sell it from a social marketing perspective."*

Green Building Challenges

Green building projects need to demonstrate new technologies and designs and their technical performance, as well as how to engage partners in the building sector, understand their motivations, and build new alignments of interests. Periodic references were made during the workshops to the success of the green building movement. The following elements are involved:

- **Technical**
  - What are the goals/elements of sustainability in water/wastewater/stormwater/reuse infrastructure and how are these met by building or subdivision-level technologies, whether separately or in combination?
  - Can energy be saved or generated from these systems (methane, hydrogen, etc)?
  - Can nutrients be recaptured?
  - How close to "off-the-grid" can these systems be?
  - What are the "risks" of technologies failing?
- **Costs and Benefits**
  - What are the direct and indirect costs of the old vs. proposed approach?
  - What benefits of parks, aesthetics, etc. accrue to the community at large?
- **Context**
  - What difference does it make where the building or subdivision is located?
  - How can a rating or other system incorporate the fact that soils, climate, hydrology, habitat, etc. vary so widely across a watershed or across the country?
  - Do we understand the cumulative impacts of decentralized systems and how do we account for location?

- **Practical**
  - Will builders be willing to incorporate these systems into their business?
  - Who will design these systems?
  - Are there the skills out there to do this kind of work?
  - How complex are the designs?
  - Will homeowners accept these technologies?
  - Will they be willing to pay more?
  - Is there additional value?
- **Institutional**
  - Will regulators permit these systems?
  - How can long-term maintenance be assured?
  - How will banks and mortgage lenders look at these systems?
  - Are there public funds available?
- **Motivational**
  - Who cares enough to work for incorporation of these approaches?
  - Are there clear "sustainability" benefits that would lead environmental NGOs to work to advance this approach?
  - Would builders see a market advantage to working with the new approach?
  - Will the decentralized technology industry back this approach?
- **Paradigm Models**
  - How do technical, benefit/cost, context, practicality, institutional, and motivational come together?
  - Where do these elements converge and not converge?
  - For a system to take off, it must be:
    - High-performance
    - Have a good benefit-cost ratio, including community benefits
    - Tailored to the wide variability in local needs
    - Implementable with ease and desired by customers (now or in the future when resource constraints are more severe)
    - Compatible with new or existing institutional frameworks
    - Compelling enough that all important groups will work for and not against the approach

Community Demonstration Projects

One of the six priority recommendations of the workshop participants was support for pilot and demonstration projects in federal facilities and in local communities.

New and infill green building developments can be major tools that a municipality could take to improve water infrastructure performance. In these projects, integrated designs of water-efficient appliances, stormwater retention and reuse, and wastewater treatment and resource recovery can be tested and refined. A municipality could also institute more conventional and siloed programs, for example, incentives for scattered homeowners, regardless of their site location, to purchase and install decentralized technologies.

But there are other roles and responsibilities for demonstration projects to develop, including in particular, defining the problem in an integrated fashion and developing institutions in management, finance, and regulatory oversight.

Participants summarized:

- The soft path approach amounts to a "big container" of tools and ideas. What is needed is documentation and clear mapping of where the gaps are
- Multiple city agencies need to be involved—code officials, building inspectors, public works, economic development, housing authority, planning department, planning commission, city council
- Multiple issues need to be addressed—concerns of safety, health, public order, voter satisfaction, tax revenue, city image, performance, social equity, environment
- Multiple policies and strategies can be utilized—city policy, permit requirements, city ordinances, regional guidelines, home ratings, presentations, workshops, websites, networking events

Craig Lindell posited an ambitious new paradigm for communities: *"Decentralization as Infrastructure—on demand and readily deployable, performance-based, modular, scalable, adjustable, and affordable; planning is continuous, iterative, and strategic but also adaptable. It enables the site to define the technologies, processes, organizational structures, and operating skills that will most effectively achieve the desired environmental results. It is a catalyst that enables if not encourages the formation of community to watershed and public to private partnerships where financial and environmental risks can be mediated to maximize community preservation and environmental results. It provides local government and its managers a variety of "solution tracks" that meet the economic demands of a dynamic and growing community, as well as the preservation of receiving natural system."*

Some of the earlier National Community Wastewater Demonstration projects are good examples of how federal financial support can help local multi-stakeholder groups of non-profit civic organizations, local officials, academics, and other experts in envisioning and promoting change. These change agents face near-insurmountable obstacles in trying to shift the water infrastructure paradigm. But with financial support for their time and other costs, and a sufficient level of flexibility from federal and state officials, there have been successes in reforming practice. In these scattered instances, the demonstration projects have functioned as R&D centers for the invention of new technology, planning, management, regulatory, and financing "systems" in decentralized wastewater. Similar efforts in stormwater, reuse, and integrated water management, more generally, should be mounted.

Similar Challenges as Green Building

Community demonstration projects need to respond to a similarly broad set of challenges as described above for Green Building, and develop a broad set of new stakeholder alliances and roles, as well.

- **System Goals**
  - How do you define the problem for the watershed or municipality?
  - How can you integrate water supply, water quality, habitat protection, energy, and a host of the community resource benefits into a "systems" model?
- **Technical**
  - What is the role for both site-specific, closed-loop systems and separate programs in each of the water-efficiency, stormwater, and wastewater areas that could be utilized without regard to site?
  - What is the technical performance of these systems?
- **Costs and Benefits**
  - What are the costs and benefits of integrating decentralized systems into the existing, aging grid of centralized infrastructure?
  - These calculations need to include both direct financial costs of design and construction, as well as a host of indirect costs, in particular externalities of environmental benefit or harm
- **Context**
  - How do local site conditions, such as climate, population density, etc. affect the optimal use of decentralized systems?
  - How does the use of new infrastructure, in particular, vary between arid and wet regions of the country?
  - How does use of decentralized systems vary with the age and condition of existing water and sewer lines and treatment plants?
- **Practical**
  - Is there sufficient political will in the community to develop and implement pilot projects?
  - Are there the skills and resources in the community to manage and build the new systems?
  - Will the public support "sustainability" objectives for the infrastructure?
- **Institutional**
  - Will federal water, stormwater, wastewater, transportation, housing and other agencies permit municipalities to utilize decentralized systems, in particular on a pilot basis?
  - Will financing be available from federal and state governments, private sources, or local agency budgets?
  - Will multiple local agencies be willing to collaborate on integrated, multiple benefit projects?
  - Will inter-municipal agreements be possible in the watershed?

- **Motivational**
  - Will there be public support for new approaches, based on an alignment of different values and interests among segments of the community?
  - Will environmentalist NGOs support innovation?
  - Will developers and the business community support innovation?
  - Will local contractors support pilot projects?
- **Paradigm models**
  - What are new, robust models, where a package of installation, maintenance, financing, regulatory oversight, and customer acceptance have been shown to work for a given technology?
  - For example, green roofs can be installed, managed, and financed by the private developer, and the municipality can provide financial incentives, "social marketing," and oversight inspections
  - Cluster wastewater systems can be managed by private utilities
  - Water-efficiency appliances can be sold directly to homeowners, and developed and marketed by large corporations

Conversations and Research

There is a need, at the national level, for promoting widespread conversations and research within and among a range of stakeholder groups, including academics, engineers, utilities, NGOs, and the private sector. Some of this conversation can emerge in Green Building and community demonstration projects. But, each group also needs to have its own internal conversation about what a shift to decentralized systems would entail and what their role in the paradigm shift would be. A collaborative conversation is needed, in particular, to develop a common "frame" and language of values and benefits.

Workshop participants concluded:

- *"A vision and benefits statement for the soft path approach is needed. The group should seek in further conversation the identification of common benefits of the soft path approach, priority work areas, and strategies to achieve specific goals. Demonstrate to stakeholders, including the engineering and architectural community, contractors, regulators, and homebuyers, of the affordability, popularity, and environmental soundness entailed in a sustainable land development."*

A number of comments and conclusions in the workshops referred to the need for an overarching vision statement to emerge.

- *"Identify the practical, supportable value proposition of a more integrated, synergistic approach, say, across water supply, water treatment, stormwater, energy, and agriculture."*
- *"How we frame the dialogue—public education and the words we use—make a big difference, e.g. 'low-impact growth' versus 'smart growth' terms make a big difference in public policy debate."*
- *"The right values and issue framing is key to gaining public will."*

- *"There is a key values set underlying the soft path water movement that has to do with fair access to resources, housing, environmental justice, and quality of life. A different framing that frames convergences of key issues in powerful ways may provide more leverage than a single-issue approach."*

David Johnston also highlighted the need for a common perspective among various groups. *"While there are different places to intervene in a system, the key is to have a mindset or a paradigm out of which the goals, rules, feedback and structure arise. Changing the market forces requires a 'core of intelligence' in each of the stakeholder groups (Sector Leaders)."*

In one of the workshops, it was concluded that an upstream approach will be necessary that influences how people think about water technologies. It is also important to meet people where they are and communicate to them in an effective way. Ultimately, soft path solutions must facilitate ways for people to get what is valuable to them.

Specialized Conversation and Research Is Also Needed Within Stakeholder Groups

On the subject of non-governmental organizations, workshop participants variously argued for

- *"…building steam at a 'grassroots' level"*
- *"Civic interests may be leveraged as a catalyst for change."*
- *"Inspired leadership for the community is needed to educate communities on the potential benefits of these type of systems: resource base, property values, good stewardship, cost savings."*
- *"A missing component is the importance of setting up local groups to address and assess the values, alternatives, costs and benefits. We need the ability to guide local groups to function more effectively at the grassroots level, especially since that's where most of the practical decisions are made."*

It is also important to seek non-traditional alliances.

Wiland posited one of the possible frames for non-governmental organizations: *"Environmental justice is the issue of this era. Most of us live in urban settings. We grew up thinking government would solve these problems for us. We are now realizing that many issues are related (housing, clean air, water, etc.) and we have a direct stake in improving our quality of life. This fact is promoting community knowledge and action."*

Haglund stressed the importance of NGOs working in non-traditional alliances. His themes were: *"Personal responsibility, sustaining partnerships, local solutions to local problems, adaptive management, long-term perspective, independent review. The way to effect powerful, lasting change is by: learning, empowering, empowering others, advancing citizenship."*

Participants also stressed the need to *"partner with other groups in sustainable development, smart growth, green building, clean energy, and low-impact development and collaborate with 'sustain lane' sustainable cities."* NGOs should reach out to builders. *"We must promote the cross-functional regulator/environmental developer dialogue prior to design and build in order to get the best project."*

Academic Research Community

Workshop participants recommended multi-disciplinary research in these areas:

Table 6-1: Areas Recommended for Multi-Disciplinary Research

Area	Example
Basic research	Applications from biology
Impacts/effects	Climate change, nutrients
Land use/ecosystems	Growth control/natural ecosystem services
New technologies	Stormwater harvesting, water reuse, monitoring
Planning and decisionmaking	Integrated water resource models for different development patterns and scales, long-run costs, decisionmaking tools
Organizational/programmatic	Research center, clearinghouse
Social/public/political acceptance	Public acceptance, value proposition
Financial	Full-cost pricing, tax incentives, innovative financing
Regulatory	Integrated framework that promotes innovation

Bob Siegrist suggested, *"long-term impact and sustainability of onsite and decentralized systems will be determined in large part, by the volume and quality of research that:*

- *Enhances understanding and fosters new methodologies, devices and technologies, and decision-support tools*
- *Provides a platform for continuing innovation*
- *Builds awareness of and respect for onsite decentralized wastewater management*
- *Helps enable proper site-specific planning and application*
- *Serves as a vehicle to engage and educate students and produce the next generation of scientists and engineers"*

The Private Sector

Workshop participants recognized the strengths of private sector engagement in decentralized water, stormwater, and wastewater infrastructure. Manufacturers, builders, and management companies can be very innovative, move quickly, provide good marketing, drive costs down, cover research costs, and create green jobs. Craig Lindell quoted Larry Seltzer of the Conservation Fund to the effect that new models would be led by the nonprofit and private sectors and not by government. Lindell points out that the private sector finds "opportunities" in solving what the public sector has defined as new "problems."

However, the private sector needs clearer signals for where markets will be opening and participants suggested the following concerns:

- Difficulty entering new markets where there is little information, or poor dispersion long-term
- Difficulty defining the market (Who is the customer? The end user? Utility? Other? Or is the market the technology itself?)
- Skepticism about public-private collaboration
- Lack of credibility—companies are just out to make a buck
- Need to get over the price curve—initial costs of new systems are very high
- Incorrect pricing—decentralized systems would compete if external costs of infrastructure were internalized

The private sector needs to take an active role in working with nongovernmental organizations and government in responding to these concerns and in better articulating the ways that the public interest aligns with their commercial interests. For example, new companies and utilities involved in managing more complex decentralized wastewater systems see the current phase as one of "establishing" business models, while recognizing that in the future, regulations will need to assure that there is equity and better land use control. Accountability, audits, and public oversight of system performance will also be required.

In turn, the public sector can help minimize the risks of private sector innovation by:

- Developing trust
- Reducing risk
- Finding contractual ways to reduce permitting cost
- Creating economic incentives

Needs of Builders and Developers

The potential for Green Building subdivisions and infill developments to be on the leading edge of innovation were repeatedly discussed. However, the development community needs to have the risks of innovation minimized by collaboratively working on the following issues:

- Trust development
- Clear evidence that decentralized systems save time and can address multiple development issues at once
- Assurance of approval from local boards and clear expedited process
- Proof that it is a better economic alternative and that it is worth the risk
- Good decentralized system models that they can follow
- A range of incentives to overcome risk and anxiety, with a focus on new construction and mitigation of permit liabilities

Regulatory Community Needs

The integrated approach will be developed at a regulatory level. It will come from the private sector finding opportunity and bringing parts of soft path together. The challenge seems to be establishing business models rather than regulating them for long-term public interest. This will change at some point in the future. It is at this juncture where public perceptions of problems are disguised demands that public-private interests may collaborate, form partnerships, and mutually benefit.

The following ideas could help develop the integrated approach:

- Enact model codes
- Develop federal and state "model" performance codes—performance with prescriptive fall back
- Develop economic planning tools—understanding the tax base, O&M, capital costs, life cycle costs, additional benefits such as water quality, open space, etc.; need models and ability to validate them
- Develop demonstration neighborhoods
- Create a larger scale demonstration of soft path technologies
- Link to multi-functional infrastructure
- Establish controls for comparisons
- Document carefully, monitor, use same analytical tools
- Establish similar neighborhoods across cities
- Have a clear frame: "Greener Infrastructure=Greener Cities"

General Public Needs

Citizens participate in advancing a more sustainable infrastructure as voters, advocates, and customers in the marketplace. As Jim Stebbins stated, *"sustainability starts and ends with the individual"* and Aldo Leopold stressed the importance of "ecological stewardship." Focus groups, surveys, and stakeholder meetings all need to be convened to develop the proper "frame" or message about decentralized systems that can be used in each of these arenas. Workshop participants suggested the following stories and approaches would include:

- Give them warm fuzzies (good feeling from using soft path)
- Show visual images of alternatives (movie star cache, picture of unidentifiable youth)
- Show personal benefits (self interest)
- Explain protecting future benefits for their kids
- Tell them it is the right thing to do
- Share inspirational stories (the hero myth)
- Integrate with green building
- Reveal costs and benefits

The Federal Role in Supporting Conversations and Research

Support for these multiple conversations and research is an appropriate role for the federal government 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:

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

Participants asserted: "*The feds are good at collecting, organizing, and making information available in effective and efficient ways (e.g. building data bases). They can also help to centralize best management practices, link agencies and funding sources. Feds could help with facilitating the costing and pricing of soft path approaches and funding pilot demonstration programs."*

Build Support for Big Government Shifts—A Long-Term Strategy

Workshop participants recognized that large-scale government impediments to adoption of decentralized systems existed, and that because the field is relatively undeveloped, it is hard to make the case for systemic change in public policies and practices. However, numerous comments suggested that momentum could be built over time for driving change.

Build Momentum for Change

- *"More common goals among various interest groups will drive more regulatory reform—environmental activists, planners, developers, and public desires"*

Partnerships can help.

- It is important to realize that politics is not rationalized. Change only happens when there is a convergence of actors, pilots, and messages
- *"Greater interest group involvement is needed in driving regulatory reform. Environmental and development groups could come together to drive change"*
- *"Local demonstration projects can also help: The Kennebec River dam removal is another powerful social movement success story. It is more evidence of how a power of grassroots engagement and how it can take a small environmental success and convert it to a successful larger social movement driven at the local level"*
- *"There is an evolutionary adoption pattern—new models/approaches are tested through pilot programs (current situation). With successes of these pilot programs, incentives will be put in place to encourage increased adoption. Once regulators are comfortable that this is a sustainable mode/approach, regulations will be created, encouraging more mainstream adoption"*

Assuring Equity

Discussions also suggested that some of the major public policy concerns of the future would be in assuring equity and shaping private sector involvement.

- *"Long-term issues of equity and sustainable land use development will need to be addressed."*
- *"Addressing the issues of a have and have not world with centralized structure systems is important, i.e. if society goes to a soft path in water, we will potentially create a bifurcated two-tiered system based on income."*
- *"The early adopters are almost always for affluent customers. There is an inequity here because the new stuff is paid for by the rich. But there needs to be federal and state support to low income communities. Communities should build in a method to get to lower income areas. There is not planning now for growth or land use. This means that we are allowing a lot of sprawl development across the country."*
- *"Balance public good with commercial interest—must have accountability/public oversight, audits are necessary."*

Overarching Themes

Several overarching themes were also posited for change in government policies and practices:

- *"All water needs to be under one roof."*
- *"Must help reform existing regulations to promote integration, innovation and rational adaptive management."*
- *"Utilities need an integrated planning requirement from regulatory agencies. Require water budgets from all municipalities and watersheds. They need the 50-year picture, not new band-aids."*

Reasonable Water Use Doctrine

Peter Shelley suggested a new *"reasonable water use doctrine"* was needed in Massachusetts that might lead to such coordinated measures, for example, as:

- Keeping pressure on wastewater and stormwater discharges
- Reducing inflow and infiltration to interceptors
- Keeping stormwater and wastewater local
- Protecting aquatic base flows from water withdrawals
- Restricting inter-basin transfers, especially the sewage infrastructure
- Mandating the development of municipal/watershed water in/water out budgets, flow trading
- Programming integration at such environmental agencies as the state's Executive Office of Environmental Affairs
- Solving the politics of water management before a whole new set of archaic technology and capital investments are locked in for another generation

Shelley's discussion of the Tragedy of the Commons and problems of distorted pricing in water were also the underpinning for two of the six priority recommendations made at the final workshop:

- Research on full monetary and non-monetary benefits and costs of soft and hard path approaches and pricing or other mechanisms to better align local decisions with long-run environmental and economic sustainability
- Exploration of how to tie federal subsidies and permits to an integrated water supply and water quality plan in a watershed

Potential Federal Role

Other characterizations of a potential federal role were:

- *"The federal government provides for equity, a clarity in the regulatory scheme drives market forces, R&D is a federal role, federal 'champions' provide credibility, the federal government acts as a role model, for example in federal facilities."*

Recommendations were to:

- *"Change federal accounting to encourage innovation by allowing commingling/integration of funds and activities; issue an executive order requiring audits, inventories, links of soft path programs across agencies; in the long-term eliminate the single purpose mentality through sustained leadership, funding, and regulatory authority; change to performance specifications vs. specific criteria."*

The following points were made at one of the December workshops:

- *"Without a strong federal leadership role, what is happening locally will be ad hoc and diffuse and the old centralized paradigm is likely to continue."*
- *"There is an important need for the US to get back in a leadership role regarding water management. Without large R&D to make this happen, the US approach of innovation will be piecemeal."*
- *"The federal government can take more of leadership role in science, technology, and opportunities for exporting knowledge overseas."*

Role of National, State, and Local Agencies

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

- Long-term research
- Financing incentives
- Regulatory reform

Long-Term Research

The public sector is uniquely positioned to take the lead in supporting long-term research in the following areas:

- Micro-scale biology that over time will facilitate breakthroughs in treatment technologies and controls
- Macro-scale ecological studies to improve watershed-scale management
- Social and economic studies and large-scale demonstration projects that will 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, non-profit foundations, private companies, and academic institutions.

Financing Incentives

Governments are now 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 for evaluation of all direct and indirect costs
- Subsidies and tax incentives for water capture, conservation, treatment, and reuse, which are usually on private property
- Diversion of funds to research and demonstration projects

Regulatory Reform

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

- Permit decentralized systems to be utilized to meet statutory requirements
- Develop integrated standards to meet water supply, water quality, public health and ecosystem needs through mandated efficiencies and reduced discharges
- Support sustainable development and redevelopment of human settlements through integrated planning of water, energy, and transportation infrastructure, which also works in synergy with buildings and landscapes

Chapter 7

THE FOUR WHITE PAPERS

Each of these five themes or ways of thinking about the decentralized, or soft path, water field that emerged from the workshops and literature is incorporated in the Four White Papers that follow. Key findings and recommendations were:

Institutional Challenges and Opportunities

Advocates of decentralized systems have argued that small-scale, integrated technologies work and are more sustainable in the environment. The failure of mainstream institutions to adopt these technologies is increasingly attributed to institutional and market barriers. The framework of institutions needs to be altered and expanded in the following key respects if decentralized and closed-loop systems are to be adopted over time:

- **Integrated water resource management**—management and regulations need to be integrated across the water chain. Much of the demand for closed-loop reuse of treated effluent, for example, will stem from reducing demand for new water supplies and the avoided cost of loadings to wastewater conveyance and treatment
- **Enhanced role of the private sector**—since most decentralized systems are on private property, the role for the private sector can be much enhanced. Private property owners generally prefer to choose a private contractor to construct and manage their system, rather than a public utility. So, the market model for decentralized systems will likely involve myriad small companies or utilities regulated by public authorities, greater involvement of homebuilders and developers in adopting new approaches, and leadership from Cleantech investors and companies
- **Multiple community benefits and stakeholders**—many of the benefits of decentralized systems are outside the water field:
  - Creation of parks and green space
  - Regeneration of neighborhoods and local jobs
  - Restoration of habitat and healthy ecosystems
  - Recapture of energy and nutrients from wastewater

Engineers and communities need to develop systems engineering approaches to triple bottom line planning, capital budgeting needs to be integrated across all municipal infrastructures, and multiple constituencies need to be involved in decisions

- **Continuous innovation**—as in all transitions to a new paradigm, the precise technologies and applications are still evolving and often higher in price than they can eventually be. All parties need to incorporate greater experimentation and innovation in their practice, including government funding of demonstration projects, municipal funding of pilot programs as part of responsible asset management, and early adoption by "green" customers of technologies that are new and more expensive

- **Streamlined institutional tools**—new, robust models need to be developed, where a package of installation, maintenance, financing, regulatory oversight, and customer acceptance have been shown to work for a given technology. For example, green roofs can be installed, managed, and financed by the private developer, and the municipality can provide financial incentives, social marketing, and oversight inspections. Cluster wastewater systems can be managed by private utilities. Water-efficiency appliances can be sold directly to homeowners, and developed and marketed by large corporations. These demonstrated "packages" then need to be broadly disseminated in the field

New Federal Financing Directions

Federal financing programs were designed to support the conventional centralized infrastructure of long-distance water, stormwater, sewer lines, and large treatment plants. For the potential of decentralized systems to be realized in the United States, these programs need to be altered in four fundamental ways:

- **Research and development**—restore research and development and demonstration project funding in water resource infrastructure
- **Integrated planning**—require integrated water supply and water quality management plans as conditions for all federal water project subsidies
- **Triple Bottom Line Financing**—require environmental, social, and economic benefits and costs, as well as embodied life-cycle costs, to be assessed for design alternatives
- **Subsidize private installations**—support the installation of decentralized systems on private property by expanding eligibilities in the public infrastructure pools of funding, as well as in tax and other incentives for property owners

Public Education and Outreach Strategies

The EPA's education and outreach strategies, which has focused on the education of homeowners, should be redirected to include:

- **Search for values**—explore the multiple benefits of an integrated water resource infrastructure paradigm–enhancing the "value proposition"
- **Early adopters**—focus on early adopters and champions rather than the general public and mainstream institutions
- **Mediating stakeholders**—work more with mediating institutions, including NGOs and other non-traditional businesses and professions, including environmental and community groups, architects, builders, and others outside the mainstream water field
- **Private property**—respect the public's attitudes about their private property and personal choices and revise management recommendations to reflect those values
- **Non-regulatory approaches**—develop non-regulatory approaches, such as social marketing and incentives

Sustainable Infrastructure Management

The EPA had developed the Four Pillars of Sustainability to enhance the efficiency and effectiveness of water infrastructure management. These Pillars should be expanded in the following ways:

- **Better management**—Managers should be responding more creatively to long-run challenges of environmental sustainability and to the opportunities for increasing community benefits. Managers should also be incorporating innovative institutions and tools, such as leveraging the role of the private sector in system management and Green Building, and collaborating with multiple agencies and stakeholders
- **Full cost pricing**—The EPA should promote true cost pricing, which goes beyond covering the costs of the infrastructure and includes long-term environmental and community externalities, such as energy savings, green space, and green job creation
- **Water efficiency**—This labeling and marketing program should be expanded to include decentralized stormwater and wastewater reuse systems
- **Watershed approach**—This largely water quality-oriented program should be expanded greatly to provide models for municipal water, stormwater, and wastewater utilities to work jointly on integrated water and other resource goals and management

These changes, in their overall impact, can begin to redirect the program from one that locks in the traditionally-built infrastructure to one that helps utilities move over time to a more sustainable approach.

Chapter 8

REFERENCES

American Water Resources Association. 2005. *Second National Water Resources Policy Dialogue: Summary*. Middleburg, VA.

Arthur, W. B. 1989. "Competing Technologies, Increasing Returns, and Lock-In by Historical Events," *97 Economic Journal.* 642–65.

Babbitt, B. 2005. *Cities in the Wilderness: A New Vision of Land Use in America*. Island Press. Washington, D.C.

Benyus, J. 1997. *Biomimicry: Innovation Inspired by Nature.* William Morrow and Company. New York, NY.

Blomquist, W. 2007. *Water 2010: A "Near Sighted" Program of Water Resource Management Improvements for the Western United States.* National Water Research Institute. Fountain Valley, CA.

Brown, H. 2005. "Greening Gray Infrastructure." *Green Infrastructure for Water in the City Symposium*. February 19, 2005. Harvard School of Design. Cambridge, MA.

Christensen, C. M. 1997. *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail*. Harvard Business School Press. Boston, MA.

Clark, M. *et al.* 2007. "Long-Range Planning for Decentralized Stormwater and Wastewater Treatment Research: Workshop Summary." WERF Project No. 04-DEC-8W, Stone Environmental, Inc.

Clinton, W. May 4, 2007. Presentation at Kennedy School of Government Conference. *The Looming Crisis: Can We Act in Time?* Harvard University, Cambridge, MA

Commonwealth Scientific Industrial Research Organisation. 2007. "Integrated Urban Water Management Approaches: Workshop: Preparatory Material and Workbook." AwwaRF Project Ref 4008. Sydney, Australia.

Connaughton, J. 2003. "Tapping the Power of the Quiet Revolution: Productive Harmony Through Integrated Environmental Policy." Presentation to Harvard University Center for the Environment. April 1, 2003. Cambridge, MA.

Del Porto, D. 2006. "Urban and Industrial Watersheds and Ecological Sanitation: Two Sustainable Strategies for On-site Urban Water Management." Chapter 17 in P. Rogers, Ed. *Water Crisis–Myth or Reality?* Taylor and Francis, London.

EPA. 1989. "Report to Congress on the Effectiveness of the Innovative and Alternative Wastewater Treatment Technology Program." Office of Water, Washington, D.C.

EPA. 2004. "Innovating for Better Environmental Results." Washington, D.C.

EPA. 2005. "Environmental Innovation Portfolio." Washington, D.C.

EPA. 2007. "A Watershed Approach to Utility Management: Forum Summary." Washington, D.C.

Etnier, C. *et al*. 2007. "Overcoming Barriers to Evaluation and Use of Decentralized Wastewater Technologies and Management." WERF Project No. 04-DEC-2, Stone Environmental, Inc., Montpelier, VT.

Gladwell, M. 2000. *The Tipping Point: How Little Things Can Make a Big Difference.* Little, Brown, and Company. Boston, MA.

Hawken, P. *et al*. 1999. *Natural Capitalism*. Rocky Mountain Institute. Snowmass, CO.

House of Representatives. 2005. Twenty-First Century Water Commission Act of 2005, HR 135. Washington, D.C.

Joubert, L., P. Flinker, G. Loomis, D. Dow, A. Gold, D. Brennan, and J. Jobin. 2004. "Creative Community Design and Wastewater Management." Project No. WU-HT-00-30. Prepared for the National Decentralized Water Resources Capacity Development Project, Washington University, St. Louis, MO, by University of Rhode Island Cooperative Extension, Kingston, RI.

Kirk, B., C. Etnier, E. Kärrman, and S. Johnstone. 2005 "Methods for Comparison of Wastewater Treatment Options." Project No. WU-HT-03-33. Prepared for the National Decentralized Water Resources Capacity Development Project. Washington University, St. Louis, MO, by Ocean Arks International, Burlington, VT.

Kravcik, M. *et al.* 2007. "Water for the Recovery of the Climate – A New Water Paradigm." www.waterparadigm.sk.

Meadows, D.H. 1997. "Places to Intervene in a System." *Whole Earth*, Winter 1997.

Mitchell, C. and S. Campbell. 2004. "Synergy in the City: Making the sum of the parts more than the whole." Presentation at International Water Association 2004 conference: Leading Edge Sustainability.

National Research Council. 2001. "Envisioning the Agenda for Water Resources Research in the Twenty-First Century." National Academies Press. Washington, D.C.

National Research Council. 2004. "Confronting the Nation's Water Problems: The Role of Research." National Academies Press. Washington, D.C.

Nelson, B. *et al.* 2007. "In Hot Water: Water Management Strategies to Weather the Effects of Global Warming." National Resources Defense Council. New York, N.Y.

Nelson, V.I. 2006. "Viable Business Models for Decentralized Wastewater and Stormwater System Management: Workshop Findings." *Proceedings of 15th Annual Conference and Exhibit of National Onsite Wastewater Recycling Association*, Edgewater, MD.

Novotny, V. and P. Brown, Editors. 2007. *Cities of the Future: Towards Integrated Sustainable Water and Landscape Management.* International Water Association, London, England.

Pinkham, R. *et al*. 2004. "Valuing Decentralized Wastewater Technologies: A Catalog of Benefits, Costs, and Economic Analysis Techniques." Rocky Mountain Institute. Snowmass, CO.

Porter, M.E. 1980. *Competitive Strategy: Techniques for Analyzing Industries and Competitors.* The Free Press. New York, NY.

Thornton, K. *et al*. 2005. "Moving Toward Sustainable Water Resources Management: A Framework and Guidelines for Implementation." WERF Project No. 00-WSM-6A. FTN Associates, Little Rock, AK.

Tonning, B. *et al.* 2007. "Integrated Planning for Onsite Wastewater Treatment Systems." American Society of Agricultural and Biological Engineers, St. Joseph, MI.

U.S. Department of Interior. 2003. Water 2025 Science and Technology Workshop. Washington, D.C.

U.S. Department of Interior. 2005. White House Conference on Cooperative Conservation, St. Louis, MO. Washington, D.C.

Vinson, C. 2006. "Protecting Water Quality: A Report to the Georgia Environmental Protection Division." Georgia Water Coalition, University of Georgia, Athens, Georgia.

Walker, B. and D. Salt. 2006. *Resilience Thinking: Sustaining Ecosystems and People in a Changing World*. Island Press. Washington, D.C.

Water Environment Research Foundation. 1999. "Research Needs to Optimize Wastewater Resource Utilization." Project 98-CTS-1. Alexandria, VA.