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SUSTAINABLE INFRASTRUCTURE MANAGEMENT

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ABSTRACT AND BENEFITS

In recent years, the federal government has been encouraging municipal water, stormwater, and wastewater utilities to operate more efficiently and effectively as a means to sustain services in the future. In response to various studies identifying gaps in available funding to fix aging infrastructure, the EPA has developed a “Sustainable Water Infrastructure” initiative (US EPA 2006). The EPA produced a report on this initiative titled, “*Sustaining Our Nation’s Water Infrastructure.*”

This report suggests that “sustainability” in water infrastructure is an issue of assuring long-term ecosystem functions and water supplies, as well as enhancing the quality of life in communities. These values will be achieved through the systematic integration of decentralized water, stormwater, and wastewater systems into the existing centralized grids of underground pipes and treatment plants.

This White Paper recommends a broadening of levels of service measures to include a fully integrated water quantity, water quality, energy, and other resource management approach and co-creation of community benefits with other agencies and stakeholders.

This White Paper also recommends redirecting the “Four Pillars” of the EPA’s “Sustainable Water Infrastructure,” as outlined in the following table.

Table 1-1: Suggested Redirection of EPA’s Four Pillars

EPA Pillar	Suggested Redirection
Better management	Focus on long-run environmental and community sustainability, leverage the role of the private sector in system management and Green Building, and collaborate more actively with stakeholders Working with utilities
Full cost pricing	Promote “true cost pricing”
Water efficiency	Expand the water-efficiency program to include decentralized stormwater and wastewater reuse systems
Watershed approach	Broaden the approach to include water quantity and quality concerns, as well as other resource issues in the watershed

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Chapter 1

SUSTAINABLE INFRASTRUCTURE MANAGEMENT

As Steve Allbee from the EPA stated in a 2005 article, “America’s Pathway to Sustainable Water and Wastewater Systems,” *“the costs of maintaining current levels of services to the customer and of removing pollutants at treatment plants are rising dramatically. The infrastructure is aging, populations are growing, and land development is putting pressure on the system for expansion of sewer and water lines”* (Allbee 2005).

While Allbee suggests a 3% per year increase in water and sewer rates would cover the costs, he recognizes that at least a quarter of the public will find these higher rates unaffordable. It is therefore urgent for utilities to apply more *“business-like decision rules and processes under a well thought out and deliberate strategy for achieving outcomes.”* Allbee also suggests that the “paradigm shift” for water and wastewater uses a *“transition from ‘building and operating’ to ‘managing’ assets, extending assets, optimizing maintenance and renewal, and developing accurate long-term funding strategies.”* (Allbee 2005)

Allbee’s charts show that by 2020, almost half of America’s water and wastewater pipes will be in poor, very poor, or life-elapsd condition. *“The largest aspect of meeting the emerging challenge is that for the first time, in addition to making new investments, the repair, renewal, and replacement of existing systems is projected to become a large and growing aspect of the managerial and financial requirements.”* (Allbee 2005)

The Four Pillars

The EPA has focused on a number of measures that it believes will enhance the performance of municipal water, stormwater, and wastewater systems. The goal is to help utilities maintain or “sustain” effective services into the future, by professionalizing their internal management, as well as by raising new revenues. A wide variety of conferences, guidance documents, and case studies have been organized, and Congress is considering requiring one of the recommendations for better management, “asset management,” as a requirement for receiving federal Clean Water State Revolving Fund loans. The Four Pillars included in this initiative are:

- ◆ **Better management**—to shift the utility management model beyond compliance to sustainability and improved performance by focusing on utility management systems, such as environmental management systems (EMS) and asset management, capacity development, and selection of innovative, cost-effective technologies
- ◆ **Full cost pricing**—to help utilities recognize their full costs for providing service over the long-term and to implement pricing structures that effectively recover costs and promote environmentally sound decisions by customers
- ◆ **Water efficiency**—to promote water efficiency in the resident and commercial sector through WaterSense, a new market enhancement program for water efficient products and services

- ◆ **Watershed approach**—to encourage adoption of watershed management principles and tools into utility planning and management practices, so that key decisionmakers consider watershed-based, cost effective alternatives along with traditional treatment technology investment choices. Watershed management approaches include, but are not limited to, source water protection, water quality trading, centralized management of decentralized systems, and smart growth approaches to stormwater and wastewater management

The EPA’s initial priority was to advocate for asset management techniques that document the condition of assets—in this case the age and condition of aging water and sewer lines—and then focus repairs and replacements on those segments that are most likely to fail and entail the greatest risk to public health and the environment if they do.

Large cost-savings (up to 20%) and improved levels of service had been demonstrated by utilities using these management techniques in New Zealand and Australia. More recently, the definition of “better management” has been broadened somewhat.

An Alternative Version of Sustainability and Innovation

This White Paper argues that the paradigm shift to a more sustainable water infrastructure entails a shift from a traditional focus on public health and water quality protection to a focus on lightening the environmental footprint and achieving multiple community benefits from the infrastructure. The following table compares the traditional water infrastructure with its stable set of practices and institutions to the new sustainable water infrastructure, which represents daunting changes.

Table 1-1: Traditional vs. New Water Infrastructure and Institutional Paradigms

Traditional Water Infrastructure	New Sustainable Water Infrastructure
Rapid conveyance—underground concrete pipes and large treatment plants	Opposite of rapid conveyance—significant portion of the source, use, treatment, and/or disposal kept 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	Multiple uses and reuses (mimic nature)
Siloed infrastructure, funding, and regulations—water, wastewater, stormwater, etc. independently managed	Integrate water, wastewater, stormwater in designs, management, planning
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
Community expectations for safe drinking water and protection of lakes, rivers, and beaches	Community tailoring of infrastructure to restore and protect ecosystems, preserve community character and open space, improve quality of life, create jobs, and achieve other local benefits
Public management and oversight of the infrastructure	Private sector engaged in management functions
Public infrastructure located in public rights of way	Installations on private 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

In this context, it is arguable that the EPA’s emphasis on “efficient and effective” management can be counter-productive if it is not also supplemented by an investment in innovation. In the private sector, there is an emerging pattern of the best-managed American companies with the finest tuning of products to existing customer demand being knocked-off by upstart companies with cheaper and better products developed in overseas, emerging markets.

Clayton Christensen of the Harvard Business School is one of the first to document this pattern, but others have recently started to argue that the entire focus of innovation is now shifting from developed to developing countries. Similarly, 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.

The particular challenge for the US, then, is to find a way to create “*winds of creative destruction*” in the water sector. In effect, the US needs to responsibly, but quickly, harness forces of change and innovation in our own domestic markets. Otherwise, utilities will be in danger of becoming more and more efficient and effective in an outmoded and unsustainable approach.

Traditional, centralized infrastructure will not be thrown away, but new decentralized concepts and multiple-benefit approaches will be allowed to emerge to enhance the productivity of that infrastructure. The new approach mimics nature in the complexity and wealth of life at the local level that can be created, with water at the center of design.

At the highest, birds-eye-view level, the fact that the US has allowed so much of the underground piping to age and reach the end of its useful life may actually provide an opportunity for the more sustainable infrastructure approach outlined in this report to emerge. For example, should decentralized and integrated technologies be targeted for installation in neighborhoods or communities with the oldest pipes? Research by Harald Hiessl from Germany suggests that abandoning existing, aging centralized infrastructure for decentralized systems with heavy reuse components is preferable, when all environmental, economic, and social benefits are calculated (Hiessl 2000).

Redefining Better Management

As mentioned previously, an initial phase of supporting decentralized system innovation would be implementing Green Building and community demonstration projects as a means to learn more about what, in practice, works and what does not work. Cities and towns should seek demonstration project funding from the federal and state governments and foundations, as well as invest a portion of their own budgets. The following questions need to be answered in these projects:

- ◆ What technologies in the water chain, in which combinations, and at what scale should be in the toolbox (performance, costs, benefits)?
- ◆ How should decisions be made (planning) that consider the broader water system and community needs, and that identify the best mix of decentralized and centralized technologies to utilize in a given community?
- ◆ What management, financing, and regulatory structures need to be developed locally to support this new infrastructure?
- ◆ How are community benefits achieved through stakeholder participation in revitalizing ecosystems and communities?

In addition, the EPA and leading utilities should jointly explore how the Four Pillars can be expanded to reflect the changed elements in the new infrastructure paradigm, broader sustainability and community objectives, and an enhanced role of the private sector.

Chapter 2

LEVELS OF SERVICE—BROADEN THE MEASURES

A central role in asset management is played by the articulation of “levels of service,” or measures of performance that guide such things as operation and maintenance, capital construction, and financing. In a 2006 version of *Asset Management: A Guide for Water and Wastewater Systems* prepared by the New Mexico Environmental Finance Center, two key facets to asset management are described:

- ◆ *“Defining the level of service the system will strive to provide its customers over the long term”*
- ◆ *“Determining the most efficient and economical way to deliver that service (the least cost approach)”*

The EPA describes levels of service (LOS) as the *“collection of measurable attributes or characteristics of a product or service delivered”* to a customer. LOS is *“ultimately defined by customers and regulators through the agency’s Policy Board.”* Examples of a level of service in Seattle, where asset management approaches are well developed, are:

- ◆ *“Target for 2003 is less than 4% of customers (or 7200 properties) experience a cumulative outage of water from one or more events totaling greater than 4 hours in a year”*
- ◆ *“Less than 1.5% of customers (or 2700 properties) experience a pressure incident (where the water pressure to a property falls below 30 psi) at the point of connection of the property to the utility’s main during the peak hour other than as a result of: a water interruption, during a fire, or temporary operational problems”*

Recently, there have been discussions about broadening these measures to include more significant environmental and community concerns. In presentations at a 2007 *“Advanced Asset Management Workshop,”* Allbee attempts to broaden the *“key characteristics of sustainable utilities”* to include concepts such as *“Sustainable Objectives set for Economic, Social, and Environmental”* concerns (triple bottom line management), and *“Stewardship of the Total Water Cycle.”* Small steps are being taken in this direction.

A 2007 report developed by the EPA and six other national utility organizations includes a framework of five key management approaches and systems (Effective Utility Management Steering Committee 2007), including:

- ◆ Leadership
- ◆ Strategic business planning
- ◆ Organizational approaches—participatory culture, change management processes
- ◆ Measurement
- ◆ Continual improvement management framework—“plan, do, check, act”

The strategy suggests ten attributes of effectively managed utilities:

- ◆ Product quality
- ◆ Customer satisfaction
- ◆ Employee and leadership development
- ◆ Operational optimization
- ◆ Financial viability
- ◆ Infrastructure stability
- ◆ Operational resiliency
- ◆ Community sustainability
- ◆ Water resource adequacy
- ◆ Stakeholder understanding and support

A critical piece of this management approach is the establishment of measurable levels of service and performance objectives, such as:

- ◆ *“Percent of retail customers experiencing water outages for one or more events totaling more than X hours/year”*
- ◆ *“Percent of customer service complaints divided by number of active customer accounts”*
- ◆ *“Annual percentage of total and voluntary turnover”*

Nested among dozens of these specific measures are references to sustainability that this report suggests can be achieved from integrating decentralized infrastructure. These include:

- *“Does the utility integrate alternative, watershed-based approaches to potentially reduce future infrastructure costs (e.g., centralized management of decentralized systems, smart growth strategies, source water protection programs, low-impact development, etc.)?”*
- *“Has the utility promoted Green Building and related water conservation strategies, both for its own assets/buildings and in terms of promoting these throughout the larger community (e.g. working with local planning departments and developers on options for new construction)?”*
- *“Does the utility approach its business in a manner that provides tangible benefits to the community (e.g., by conducting neighborhood improvements)?”*
- *“Does the utility have a citizen advisory panel or other method to provide stakeholder input into the utility’s decision making, priority setting, etc.?”*

Nick Arhontes of Orange County Sanitation District spoke about their local efforts to implement the EPA’s Four Pillars. Arhontes pointed out, “*Our level of service is increasing.*”

Table 2-2: Level of Service Increase in Orange County Sanitation District

From...	To...
No disinfection	Disinfection by 2002
50% secondary treatment	100% by 2012
10 mgd reclaimed water	70 mgd by 2008
Odor impacts	
Air Toxics	
Security/Landscape	

Of particular interest is their inclusion of other regulatory and community considerations, including: odor impacts, air toxics, and security/landscape. The EPA should highlight and further develop these scattered references to a broader perspective. Many of them can be addressed by expanding and redirecting the focus of each of the Four Pillars.

A New Sustainability Paradigm

Broadening the measures of levels of service has two interrelated components:

- ◆ Moving from compliance with existing regulatory requirements to an integrated resource and community benefits approach
- ◆ Moving from a customer satisfaction perspective to a multiple agency and stakeholder decisionmaking process

These two components are interrelated, because the discovery of multiple benefits emerges in a multi-stakeholder process.

Moving From Compliance With Existing Regulatory Requirements to an Integrated Resource and Community Benefits Approach

As a New Mexico guidance document explains in addressing the minimum starting point for the LOS, “*all systems must operate within the state and federal regulations and requirements. These regulations are generally specified in the Safe Drinking Water Act for water systems and the Clean Water Act for wastewater systems, but there are additional rules and regulations at the state and federal level.*” A major problem in establishing a broader set of sustainability measures is that these regulations are siloed and focused around treatment plant performance. These regulations fail to account for significant externalities and cumulative impacts and lock in centralized technologies.

Ultimately, a major effort should be made to reform water-related statutes at the federal level. In the interim, the EPA and utilities should work to develop LOS measures that are more appropriate to the challenges the country will face in the future. As the 2007 water sector utility management strategy report explains, it is difficult to develop quantifiable measures that capture the multiplicity of goals for water and wastewater utilities, and that also reflect variations in both challenges and opportunities that each locality faces (Effective Utility Management Steering Committee 2007).

Glen Daigger of CH2MHill has recently suggested some quantitative environmental measures for water and wastewater utilities:

- ◆ Reduce the net water use in urban areas to half of the current value. When this reduction is achieved, reduce it again by half
- ◆ Reduce net energy use and greenhouse gas emissions to half their current values
- ◆ Economically recover 80% of the phosphorus contained in wastewater
- ◆ Recover 80% of the nitrogen in wastewater
- ◆ Affordably reduce the discharge of endocrine-disrupting and similar chemicals by 90%

Diane Taniguchi-Dennis from Albany, Oregon described in her presentation at the workshop, “A Roadmap to Sustainable Public Infrastructure: A Shift in Utility Management Mindset” a new city vision statement: “*A vital and diversified community that promotes a high quality of life, great neighborhoods, balanced growth and quality public services*” (Taniguchi-Dennis 2007). She compares the old and the new integrated project approach for city utilities:

- ◆ **The conventional approach**—Go it alone; build costly bricks and mortar to do the minimum to meet compliance with very little community amenity consideration
- ◆ **Our preferred, value-focused approach**—Start with desired environmental outcomes and create sustainable solutions to build community assets
 - Restore the environment and sustain the local economy
 - Build on the city’s Willamette River Heritage and the Governor’s Willamette River Legacy
 - Address regulatory challenges

An example of a new project that provides value-added services to community is a wetlands treatment, reuse, habitat restoration, and waterfall project that is “*restoring our land, protecting our river, and enriching our spirit.*”

Moving From a Customer Satisfaction Perspective to a Multiple Agency and Stakeholder Decisionmaking Process

The process of meeting multiple environmental and community objectives implies also a shift from customer service to multi-stakeholder engagement. The New Mexico guidelines suggest focus group meetings, surveys, and public meetings to elicit concerns and standards of treatment desired. This process also reinforces conventional practices, because utility managers pre-define the options to be discussed by the public and the customer is defined as the individual homeowner or business.

A synergy of benefits emerges from multi-stakeholder projects. In Green Building, for example, architects, builders, water and wastewater engineers, energy experts, landscape architects, and environmental groups are collaboratively discovering higher-value products and cost-savings. Similarly, non-governmental organization-led alliances are identifying new solutions to previously-intractable problems, and multiple environmental, economic, and social benefits are emerging. Guidelines, tools, and case studies of these expanded measures and collaboratives, like in Albany, Oregon, need to be supported and disseminated by the EPA.

Private Systems and Management

The role of the private sector will be significantly enhanced in a new paradigm of practice. Utilities will need to develop LOS expectations from these private sector projects.

- ◆ Private companies will be responsible for much of the management of treatment units on private property
- ◆ Developers and builders will incorporate new technologies in Green Building projects
- ◆ Entrepreneurs will invest in new technologies

In the Palo Alto workshop on “Viable Business Models,” it was recognized that there are currently scattered private sector initiatives in each of these arenas. However, in the long-term, public policies will need to be developed to assure that this private activity is in alignment with the public interest. Several specific concerns emerged in the workshop.

- ◆ The pattern of current activity suggests that decentralized technologies are being built primarily for affluent customers. Subsidies for low-income customers may be required, and eventually new ordinances may mandate technologies regardless of income
- ◆ New Greenfield developments are being built, typically without regard to regional water quality or land-use considerations. The Green Building movement, in particular, should develop standards that are site-based within the watershed
- ◆ Concerns continue about operation and maintenance of these systems. Certification of installers, spot inspections of systems, and shifting liability for performance to the maintenance company, are various measures to increase accountability in the program

Chapter 3

MORE WAYS TO EXPAND THE FOUR PILLARS

Expanding Full-Cost Pricing to True-Cost Pricing

The EPA has generally been concerned that utilities have put off routine maintenance, repair, and replacement of water and sewer lines and treatment plants, because the public has been opposed to higher water and sewer rates. The Agency’s goal in this second of its Four Pillars is to help utilities calculate full costs, meaning “*factoring all costs—past, present, and future operations, maintenance, and capital costs—into prices and rate structures*” and then to “*implement a pricing structure designed to recover costs and promote water efficiency.*”

This White Paper suggests broadening this initiative from “full cost pricing” to “true cost pricing.” One of six priority recommendations of this project’s final workshop was:

- ◆ 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

Peter Shelley of the Conservation Law Foundation in Boston described the “*Tragedy of the Commons*” in water, where individual projects in water, stormwater, or wastewater were built without regard to their cumulative impacts. His particular case study was of a regional wastewater system and ocean outfall that is draining water from aquifers and streams. Workshop discussions focused on the need for individual projects to calculate the total true costs, and the suggestion that if ratepayers were forced to pay for these and other cumulative impacts, there would be a great deal more interest in decentralized systems that use less water and have a lighter footprint in the environment.

Recognizing that many ratepayers would not be able to pay these true costs, low-income subsidies need to be considered. The recommendation was also made that utilities should be required to calculate true costs, even if those were not carried over to ratepayers. In the energy sector, such calculations are required when “portfolio” standards are set for renewable energy sources or energy-efficiencies, for example.

Another benefit of a “true cost pricing” mindset is that new efficiencies and new sources of revenue may emerge. For example, neighborhood redevelopment projects can blend transportation, parks, energy, water, and wastewater concerns and budgets. Waste can be reduced by collaborative planning, but in addition, for example, a transportation budget allocation can pay for landscaping that also functions as a stormwater treatment unit. A wastewater treatment system that recovers energy and nutrients can also receive funding from energy utilities and park systems.

Expanding the Water Efficiency Program

The EPA has posited in this third pillar that “*improved water efficiency can reduce the strain on aging water and wastewater utilities and can sometimes delay or even eliminate the need for costly new construction to expand system capacity.*” WaterSense is an EPA partnership to promote water-efficient products and services, in particular, through labeling and marketing programs. The Alliance for Water Efficiency was also formed with assistance from the EPA. Stormwater retention and reuse, and decentralized wastewater treatment, reuse, and resource recovery technologies should be incorporated into this program.

Broadening the Watershed Approach

Under this fourth pillar, the EPA is advancing a host of individual programs, including:

- ◆ Source water protection
- ◆ Water quality trading
- ◆ Decentralized onsite infrastructure management
- ◆ Watershed approaches to National Pollutant Discharge Elimination System (NPDES) permitting
- ◆ Sustainable watershed financing
- ◆ Watershed approaches to restoring impaired waters

These programs focus primarily on water quality concerns, arguing that efficiencies can be achieved by targeting the most cost-effective projects and that, in some cases, decentralized wastewater and other nonpoint source projects can be alternatives to construction of expensive centralized treatment systems.

As suggested under discussions about levels of service, utility management should be taking a larger view of environmental, social, and economic sustainability in the watershed. While current regulations support a siloed and traditional infrastructure, the EPA should be exploring the implications of “*integrated water and resource management*” that ties together water quantity, water quality, energy, habitat, and community benefits concerns.

Summary of Recommendations

In summary, the EPA should expand and redirect the Four Pillars of Sustainability 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 4

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