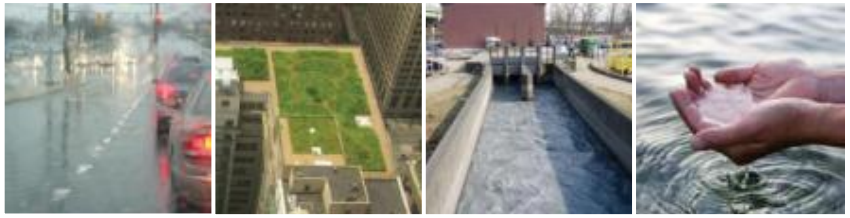
TETRA TECH

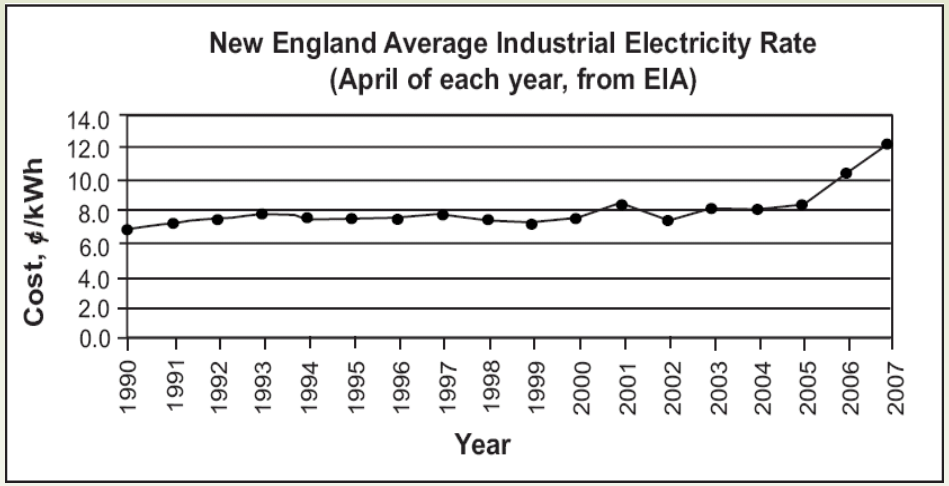
A Fundamental Change in Managing Our Community Water Infrastructure

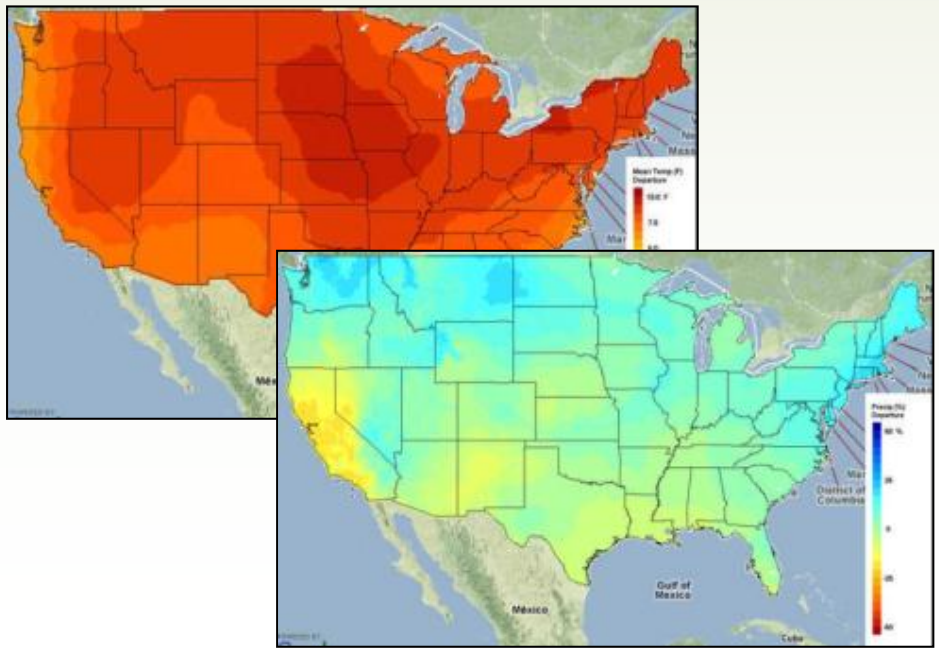
Trevor Clements

complex world | CLEAR SOLUTIONS™

Why Needed? – 21st Century Challenges

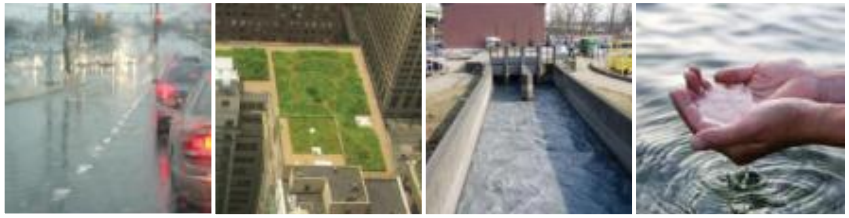






- Water quality impairment
  - 45 percent of U.S. waters
- Aging water infrastructure
  - Gap > $1T
- U.S. water-energy nexus
  - ~13% national electricity use
- Supply scarcity & uncertainty
  - Timing: drought, wet weather
- Community dynamics
  - Land use, population, politics, revenue

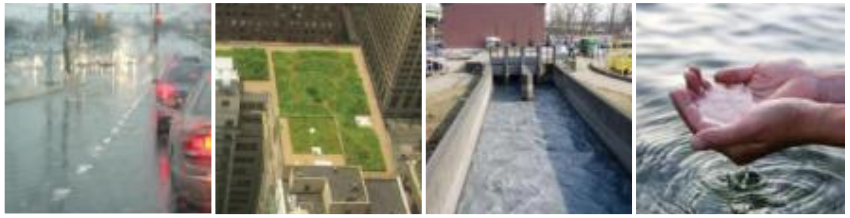
Change is Difficult…



“Faced with the choice between changing one's mind and proving that there is no need to do so, almost everyone gets busy on the proof.”

~John Kenneth Galbraith

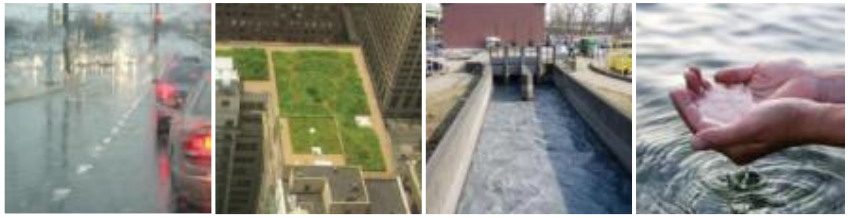
Evolution of urban water management



- Opportunistic Utilization of Readily Available Water
  - Use of easily accessed surface water and shallow groundwater
- Engineered Storage and Conveyance (Roman times)
  - Water storage facilities, aqueducts, and drainage facilities
- Addition of Water Treatment Technologies (20th Century)
  - Improved public health and water quality
- Non-Point Source Pollution Control (late 20th/early 21st)
  - In-progress efforts to manage stormwater runoff
- **Integrated land and water management for total hydrologic and mass balance (*new paradigm*)**
  - Water supply, stormwater, and wastewater managed in a closed loop

(from Brown and Novotny)

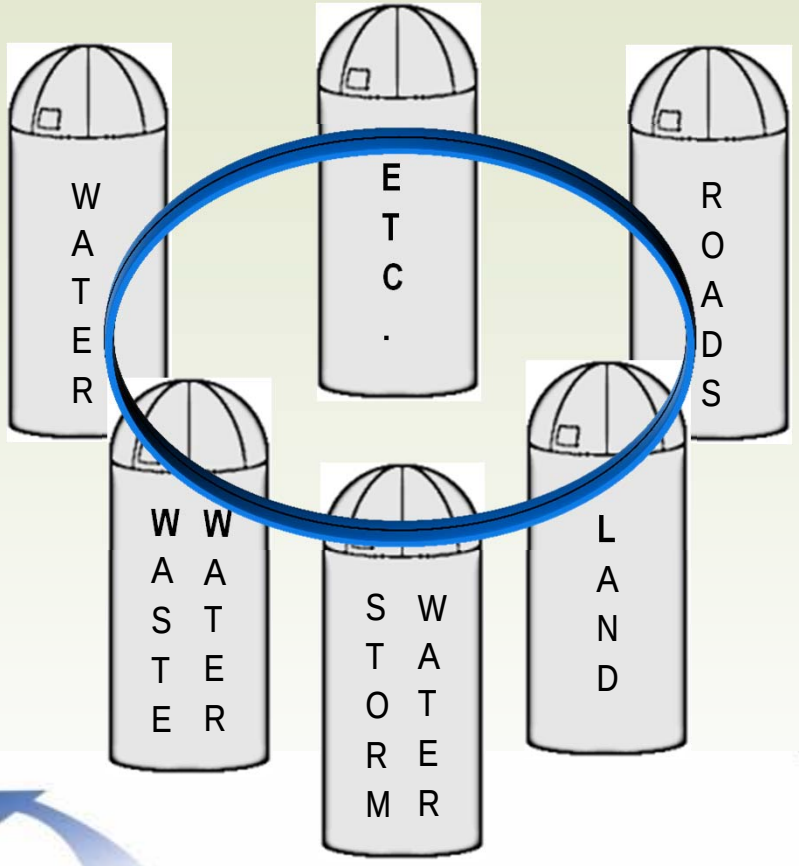
EPRI Project No 068143: Case Studies on a New Water Infrastructure Paradigm

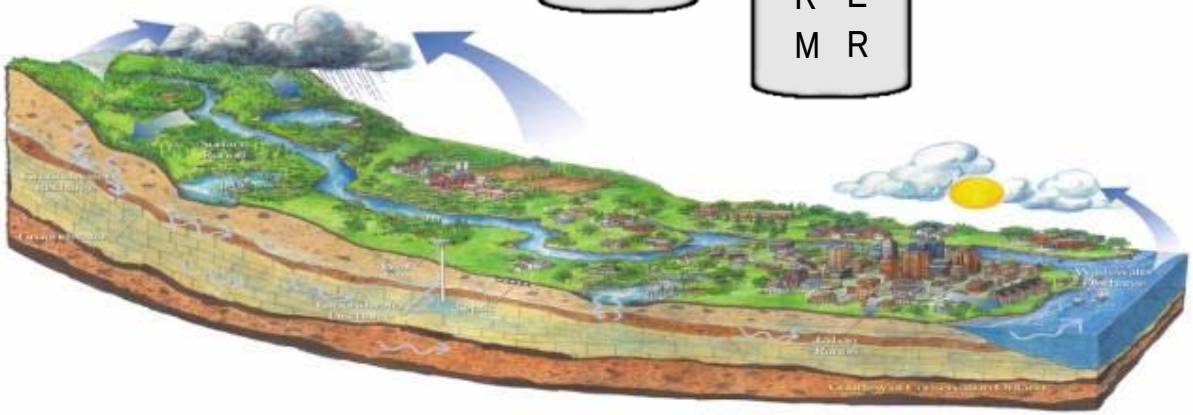


- 3-day retreat to define new paradigm
- Two case study communities: east & west
- 24 experts from variety of disciplines & organizations

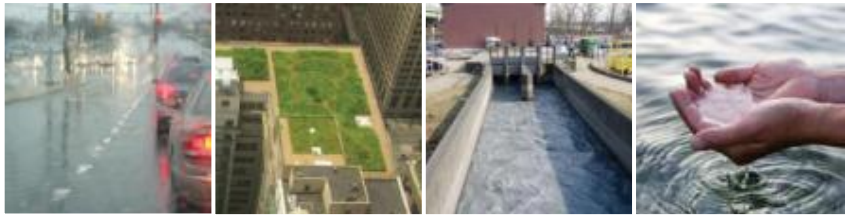
Integrated Resource Management

- Integrate water and land management
- Close the loop on resource cycles: water, nutrients, carbon/energy (biological, thermal, gravitational), etc.
- Address scarcity issues through alternative sources of supply
- Promote hydrologic and ecological restoration through management practices
- Achieve multiple watershed benefits
- Generate revenue



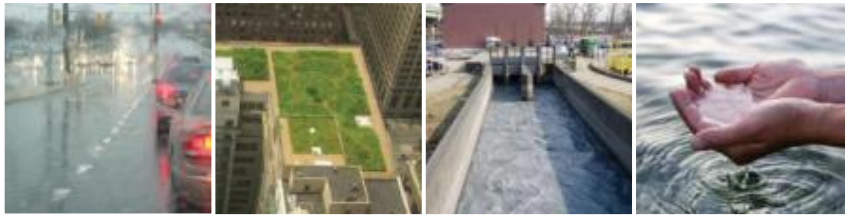


Nutrients as pollutants and resources



- Phosphorus
  - Finite (expected to be fully exploited in 60-150 years)
  - Agriculturally- and nutritionally-required
  - Largely disposed via wastewater discharges and landfilled sewage sludge
  - Difficult, if not impossible, to recover after dispersal into environment (Ashbolt and Goodrich 2009)

21st Century water management



Aerial view of a typical wastewater treatment plant

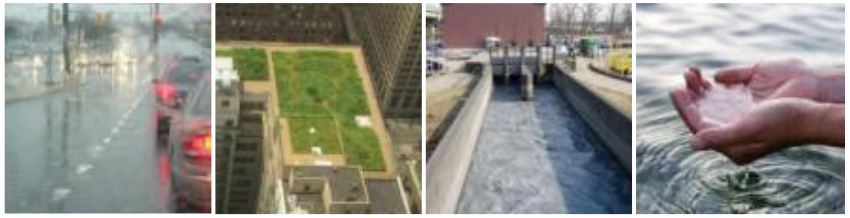
Old paradigm

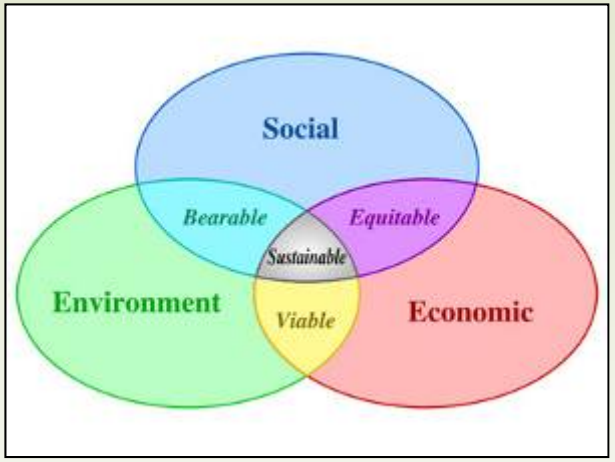
- *–Highly specialized*
- *–Centralized*
- *–Segregated*
- *–Linear*
- *–Extractive*
- *–Inflexible*

New paradigm

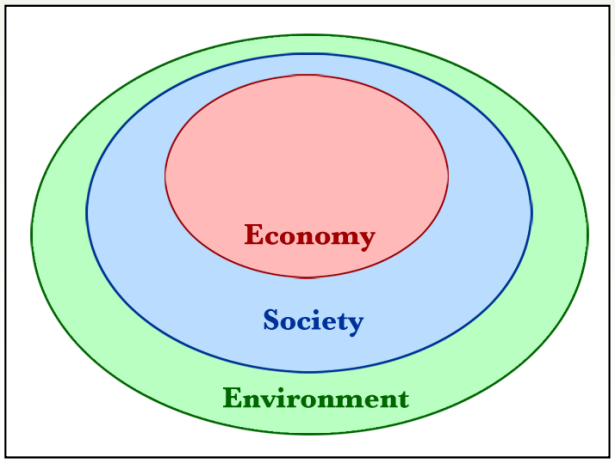
- *–Multifunctional*
- *–Decentralized*
- *–Integrated*
- *–Systemic*
- *–Restorative*
- *–Adaptive*

Sustainability (General Definition)





(Adams 2006)



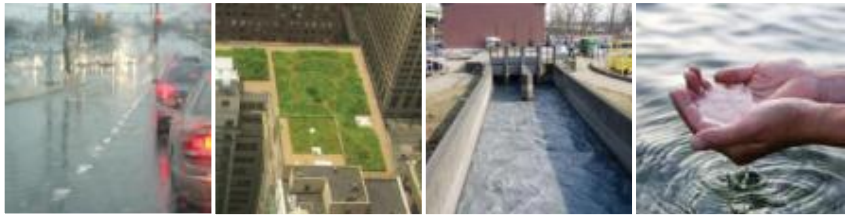
(Ott, 2004)

"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

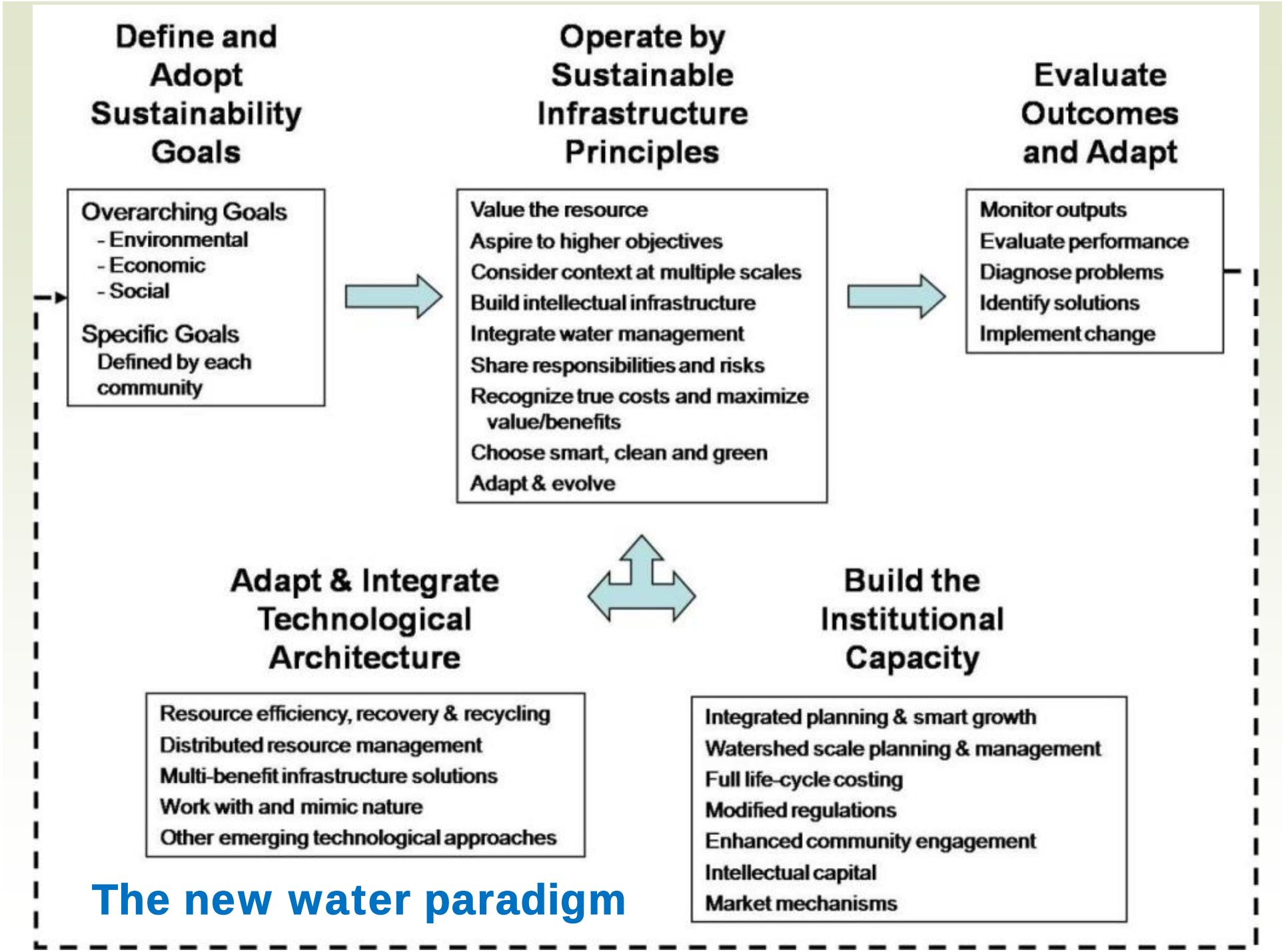
"Sustainability" def. – the capacity to endure

Three pillars or a "triple bottom line" of environmental, societal, and economic considerations

New water paradigm – driven by outcomes



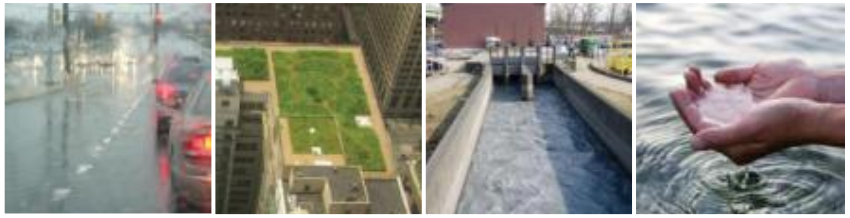
- Economic
  - Minimal debt and associated servicing – low life cycle costs
  - Lower external and imbedded costs
  - Robust in the face of economic and/or social disruption
  - Promotes economic opportunity across socioeconomic class
  - Promotes local “cleantech” industry growth
- Social
  - Provides clean and abundant water supply
  - Supports safe and secure food supply
  - Supports clean and stable energy supply
  - Supports healthy and enjoyable living, working, recreational space
  - Supports and enhances social connectedness
- Environmental
  - Carbon neutral or positive
  - Hydrologically neutral or restorative
  - Ecologically neutral or restorative
  - Nutrient (and other reusable/ recyclable waste resource materials) neutral
  - Neutral or positive air quality benefits


Define and Adopt Sustainability Goals
Overarching Goals
- Environmental
- Economic
- Social
Specific Goals
Defined by each community
Operate by Sustainable Infrastructure Principles
Value the resource
Aspire to higher objectives
Consider context at multiple scales
Build intellectual infrastructure
Integrate water management
Share responsibilities and risks
Recognize true costs and maximize value/benefits
Choose smart, clean and green
Adapt & evolve
Evaluate Outcomes and Adapt
Monitor outputs
Evaluate performance
Diagnose problems
Identify solutions
Implement change
Adapt & Integrate Technological Architecture
Resource efficiency, recovery & recycling
Distributed resource management
Multi-benefit infrastructure solutions
Work with and mimic nature
Other emerging technological approaches
Build the Institutional Capacity
Integrated planning & smart growth
Watershed scale planning & management
Full life-cycle costing
Modified regulations
Enhanced community engagement
Intellectual capital
Market mechanisms
The new water paradigm

New Paradigm (Sustainable) Operating Principles

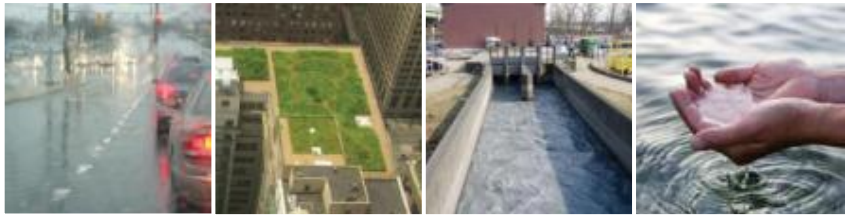
- Value the resource
- Aspire to higher objectives (that spawn better outcomes)
- Consider context at multiple scales
- Build intellectual capital
- Integrate water management
- Share responsibilities & risks
- Recognize true costs & maximize benefits
- Choose smart, clean & green
- Adapt & evolve

Key differences with existing practices

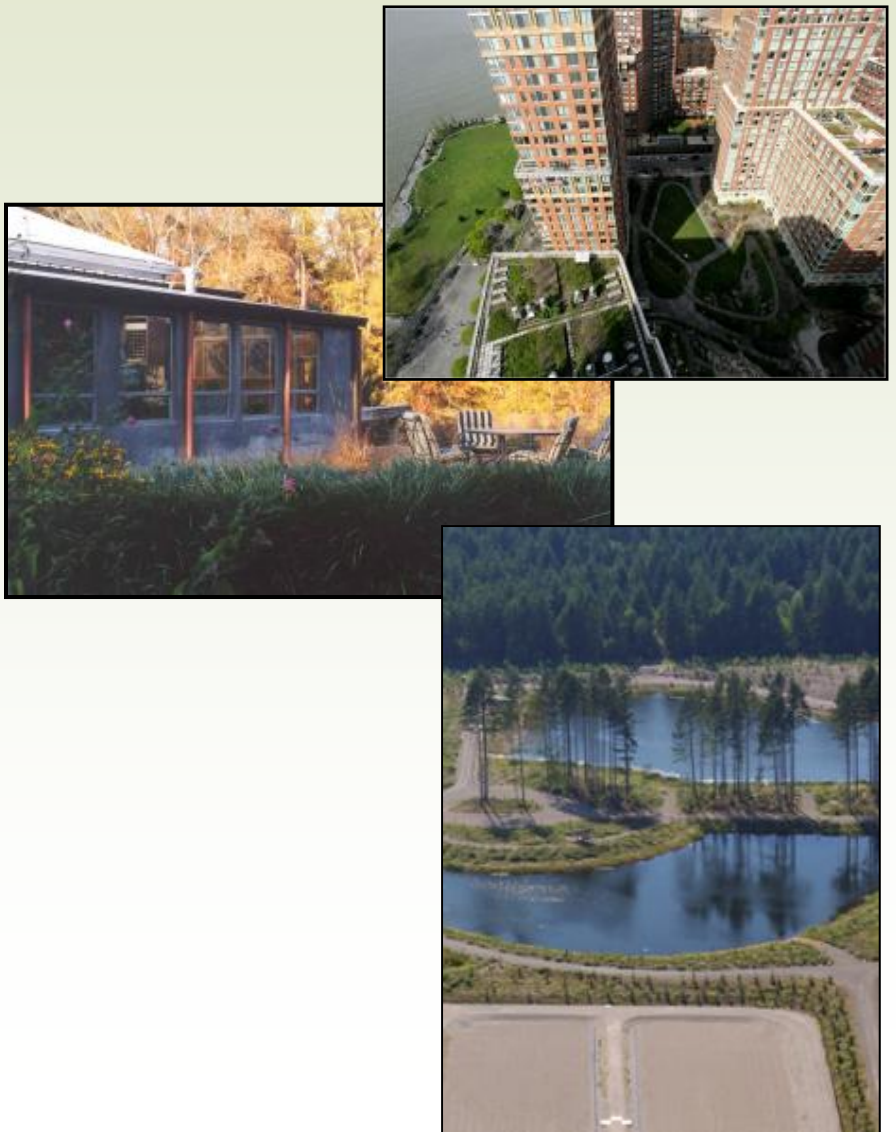


Topic	Current Practice	New Paradigm
Water Use	Single use before disposal	Reclaim/reuse water multiple times
Water quality supplied	Treat all water to potable standards	Level of water quality based on intended use
Waste	Dispose of	Recover resources
Stormwater	Convey offsite	Harvest onsite
Infrastructure type	Primarily gray, centralized	Integrate gray and green thru distributed approach
Infrastructure integration	Drinking water, stormwater, wastewater managed separately	Integrate as appropriate
Public Involvement	Stakeholders informed of pre-chosen solution	Stakeholders engaged in decision-making
Cost-benefit analysis	Focus on capital and recurring costs	Develop understanding of full cost and benefits

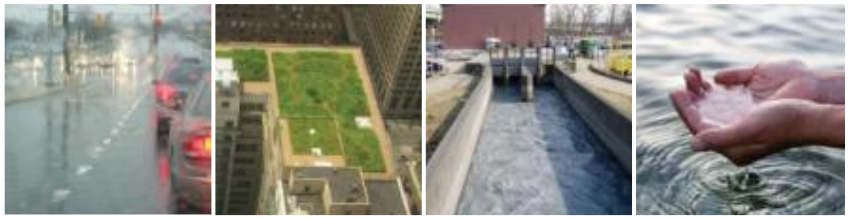
Technological Approaches

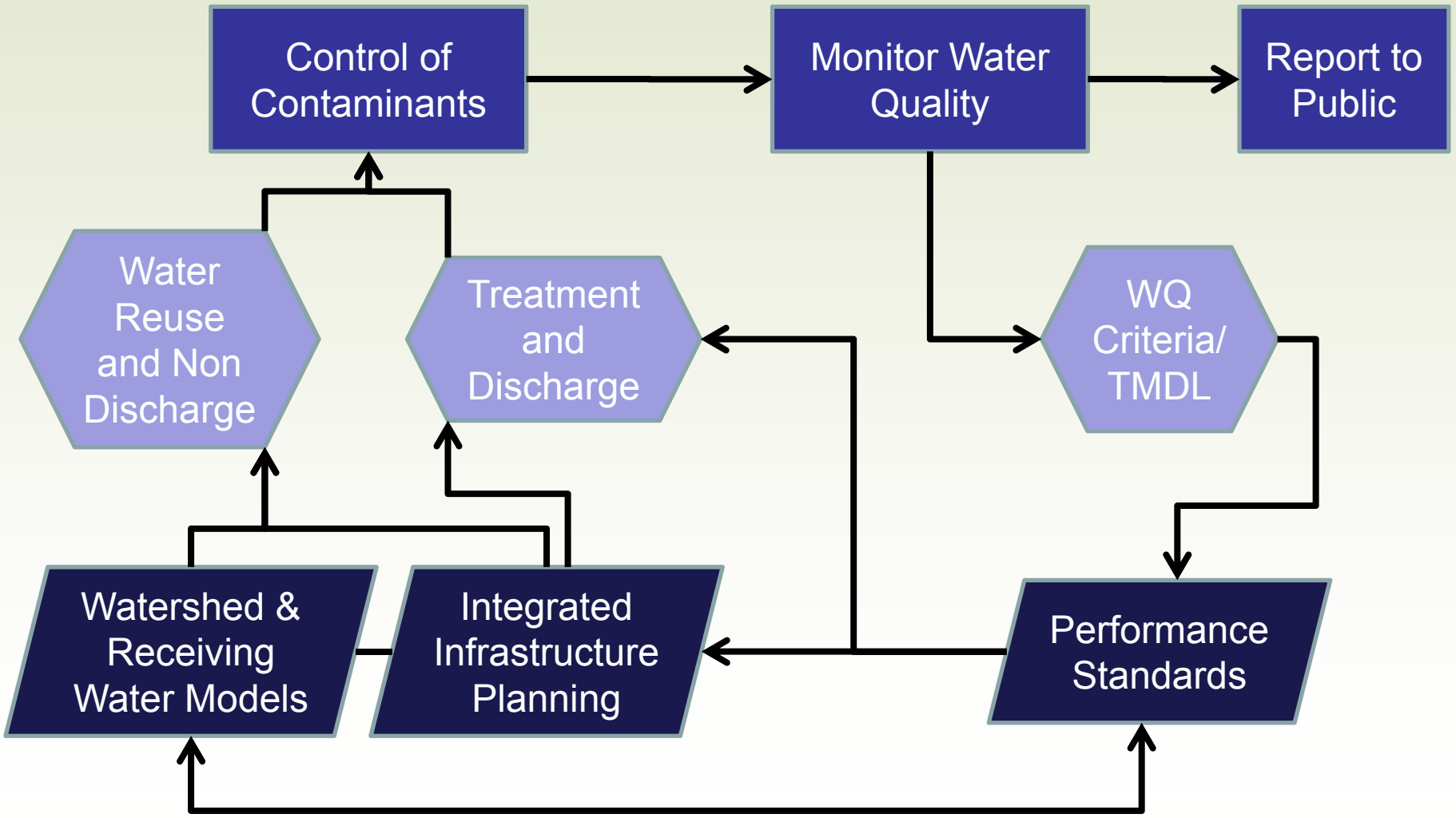


- Broader spectrum
  - Resource efficiency, recovery & recycling
  - Distributed
  - Mimic nature
  - Multi-benefit
  - Emerging
- Adapt and integrate
  - No single solution
  - Plan infrastructure systems together

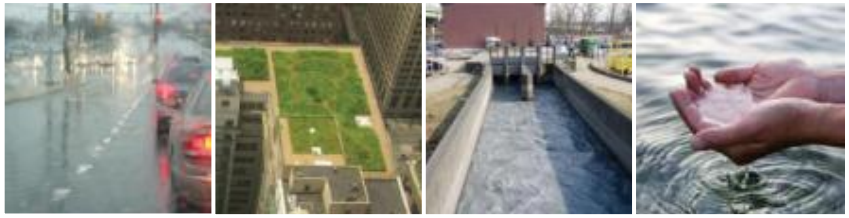


Integration with Regulatory Process



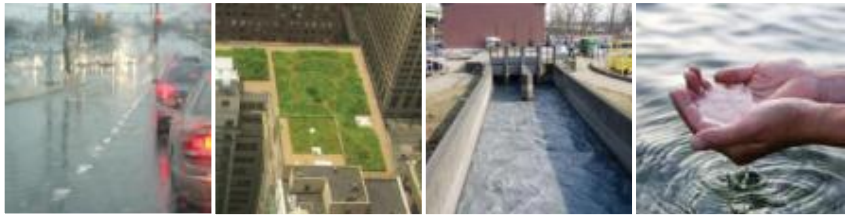


Two Case Studies



Two Ends of the Spectrum: All Communities Can Embrace Water Sustainability

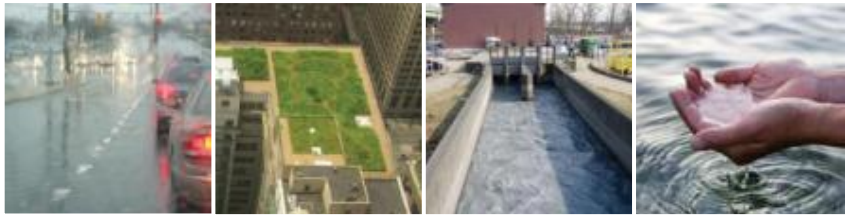
Case Study – Big City, USA



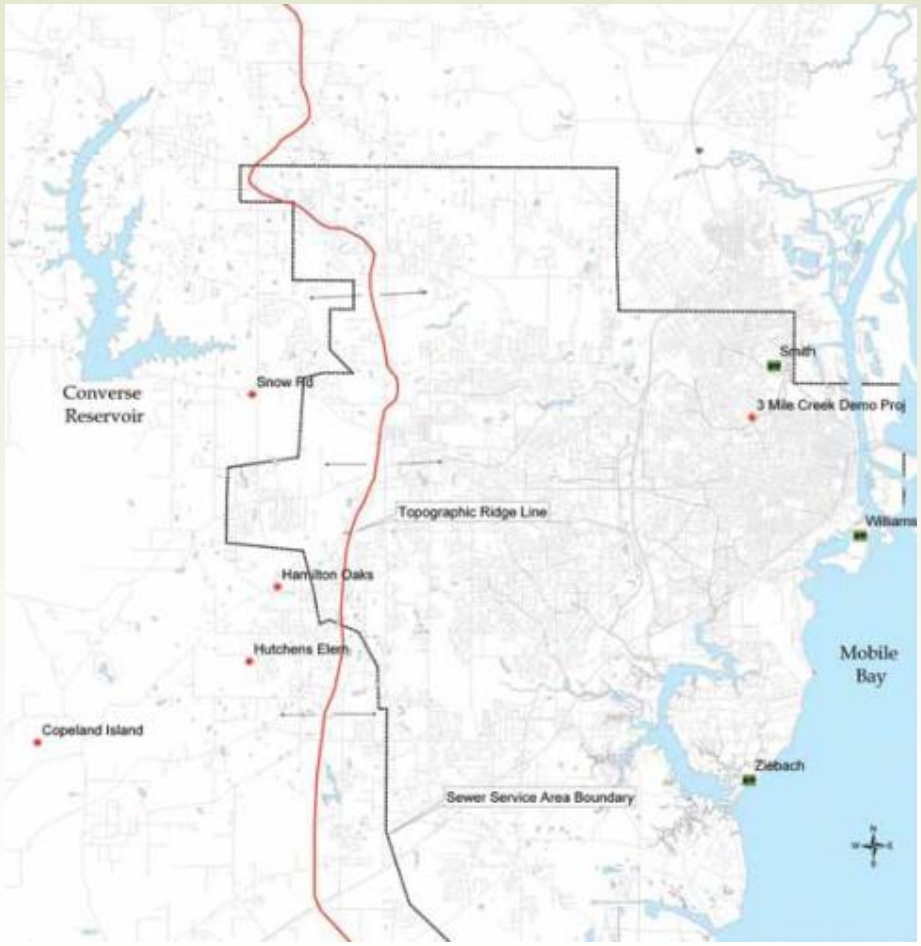
- Built-out urban core, water/sewer services extended to new suburban development
- Waterfront redevelopment drawing people back into the city core
- Aging infrastructure, some combined sewers.
- Wastewater effluent is discharged to surface waters (ocean outfall, river), with dead zone around it.

Aerial view of a typical wastewater treatment plant

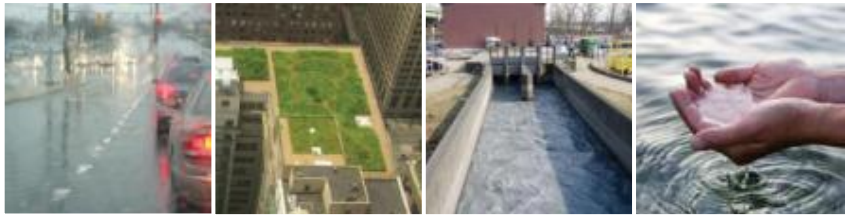
Case Study – Big City, USA



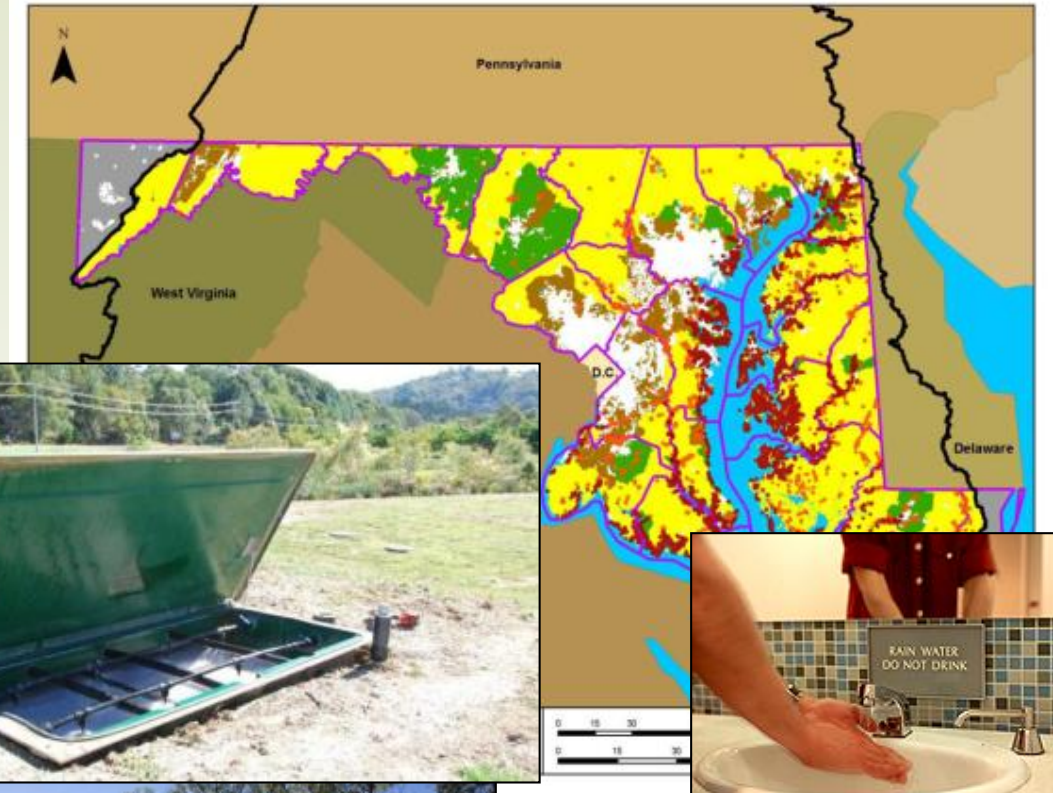
- Reservoir is tapped out
- Unregulated groundwater withdrawals are threatening aquifer
- Marsh drying up and eutrophying, hurting commercial/recreational fishing and threatening tourism
- Expensive new desal plant is looming



Case Study – Big City, USA



- Suburban solutions
  - Dispersed wastewater treatment
  - Reuse and soil discharge
- Urban solutions
  - Mining of sewer system for reuse
  - Co-digestion of sewage sludge and MSW
  - Water conservation initiatives in existing buildings
  - Decentralized reuse systems in new buildings



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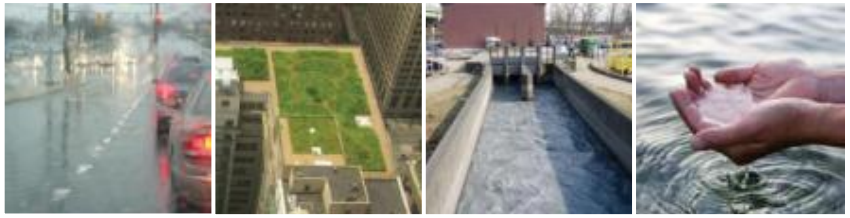
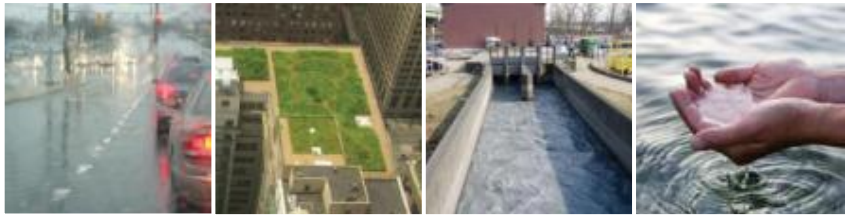


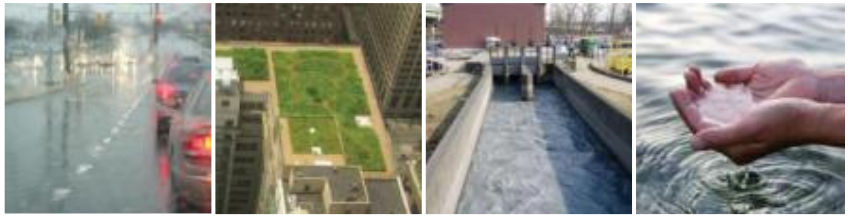
- Green stormwater infrastructure
  - protect marsh and recharge aquifer
  - comply with CSO consent order,
  - help revitalize blighted urban areas with greenery and gardens
  - reduce heat island effect, building energy costs, and carbon footprint
- Deferred/avoided costs associated with desal plant
- Installation and operation of dispersed SW and WW systems helped create new jobs in public and private sector
- Recovery of marsh improved commercial fishing and tourism.

Case Study – Big City, USA



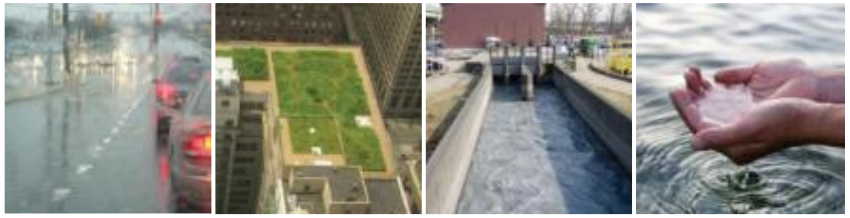
- Dispersed wastewater treatment with land application
  - Minimize costs
  - Robust
  - Hydrologically restorative/neutral
- Sewer mining/co-generation
  - Nutrient and carbon neutral
  - Supports clean/stable energy supply
  - Recovers revenue
- Green stormwater infrastructure
  - Supports/enhances living spaces, social connections, food supply
  - Hydrologically restorative/neutral
  - Carbon positive (sequestration)
  - Lower capital costs, enhanced multibenefit value
- Water conservation/reuse in buildings
  - Enhances water supply
  - Preclude/delay infrastructure costs

Case Study – Small Town, USA

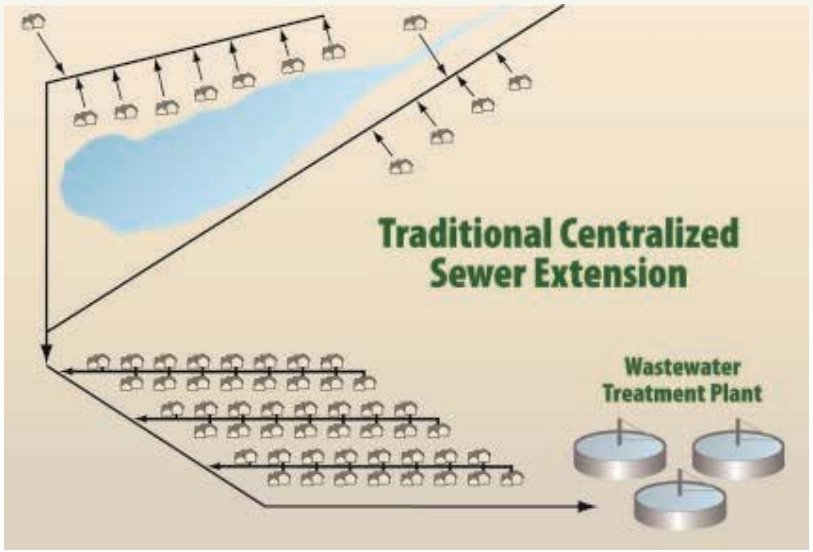


- Small town in rural county, built along the Green River
- Historic “main street” district with old water and sewer infrastructure – small WWTP and septics in town
- Water source (a small surface impoundment of Green River) is suffering from eutrophication from agricultural runoff.

Case Study – Small Town, USA



- Rapid conversion of crop and pasture land to suburban subdivision development
- Some large rural lots, overflow and second home population from nearby cities
- Demand for extension of water and sewer services, or use of private wells and septic systems.



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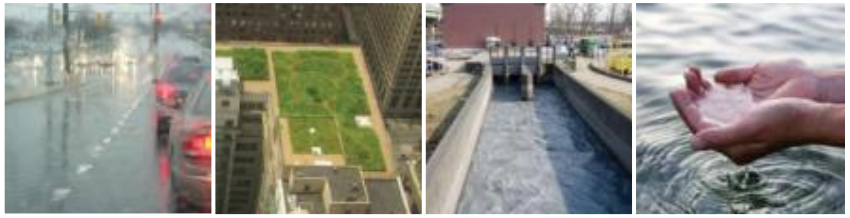
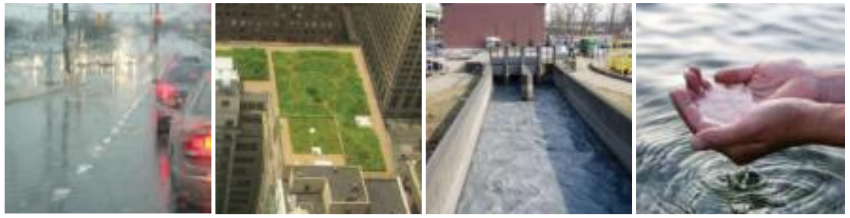
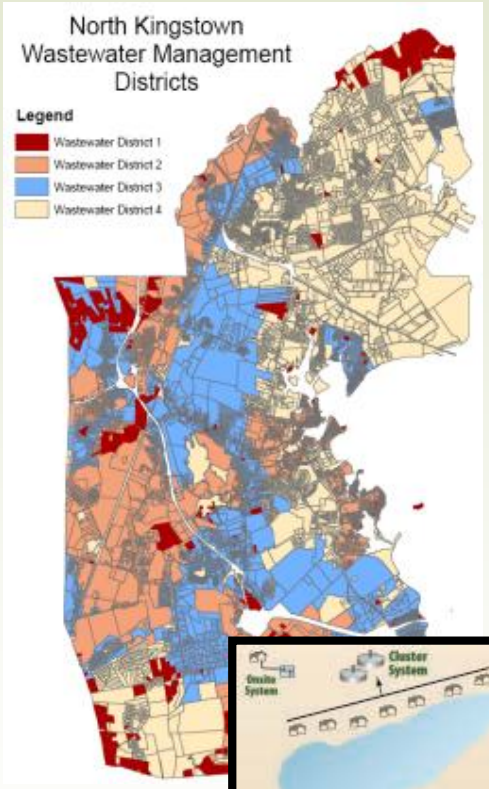


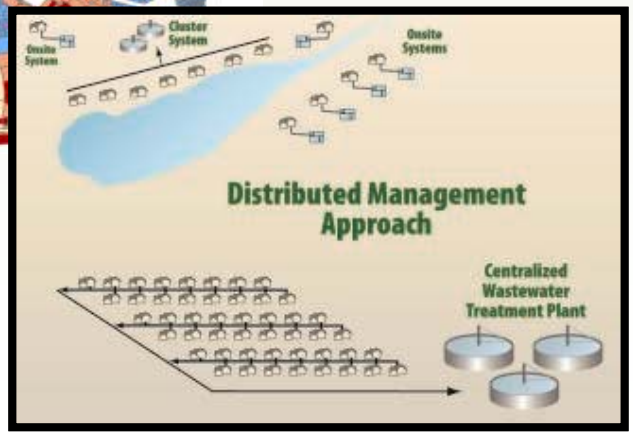
- Green River is home to threatened fish and invertebrates and is a premier wildlife viewing and birding area
- Suburban development is threatening the sensitive ecosystems associated with the river, as well as water quality itself

Case Study – Small Town, USA

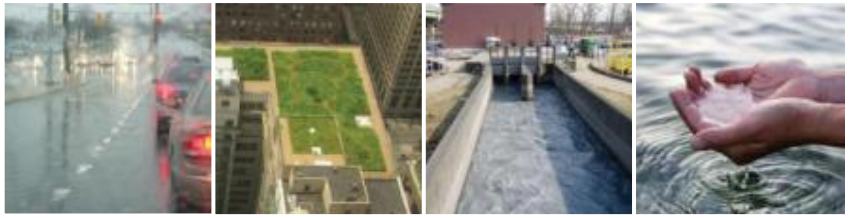


- Green River watershed planning process
  - Various stakeholders and the University
  - Develop agricultural BMPs
  - Improved land planning in the critical area around the source water supply
  - Improved wastewater management for existing and new development



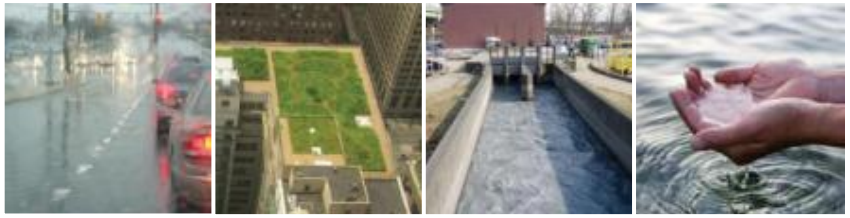


Case Study – Small Town, USA



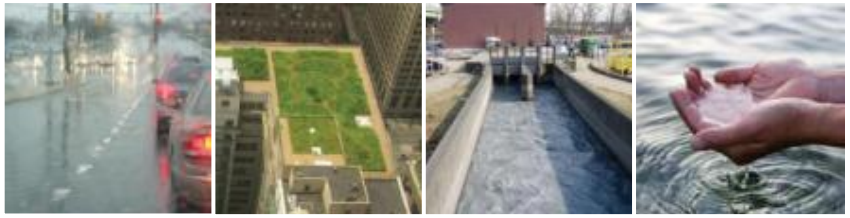
- New development
  - Clustered wastewater management with advanced treatment with irrigation reuse and soil discharge
    - Reuse for irrigation allows for robust vegetation in the new developments
  - Low impact development
    - Buffer areas along river and tributaries
    - Stormwater BMPs

Case Study – Small Town, USA



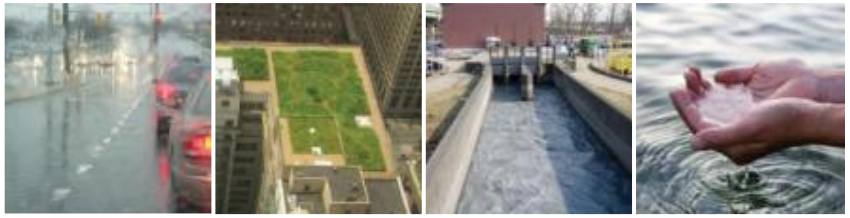
- Downtown system upgraded to a process that recovers nutrients
  - Nutrients provided to farmers
  - Agricultural BMPs help protect water quality in the region.
  - Recycling of nutrients helps expand the county's specialty agricultural sector
  - Increased protection for the ecosystem and water quality continues to grow the area's sustainable ecotourism economy
- Existing onlot systems creatively upgraded

Case Study – Small Town, USA



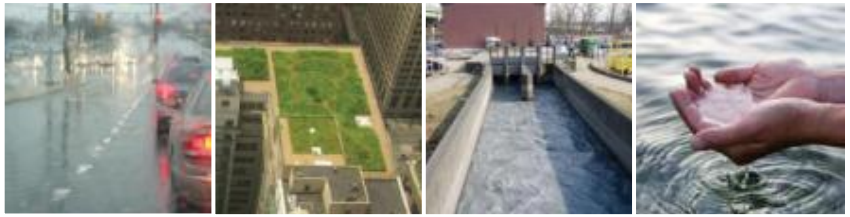
- Watershed management
  - Promote hydrologic, ecological neutrality
  - Protects water supply and quality
  - Engage community
  - Supports multi-benefit solutions that enhances social/economic conditions
- Cluster systems/water reuse
  - Hydrologically neutral
  - Lower life-cycle costs
  - Promote local cleantech economy
- Nutrient recovery
  - Nutrient neutral
  - Supports food supply
  - Recovers value and supports local economy
- Onsite upgrades
  - Lower life-cycle costs
  - Cheaper for residents
  - Promotes economic opportunities

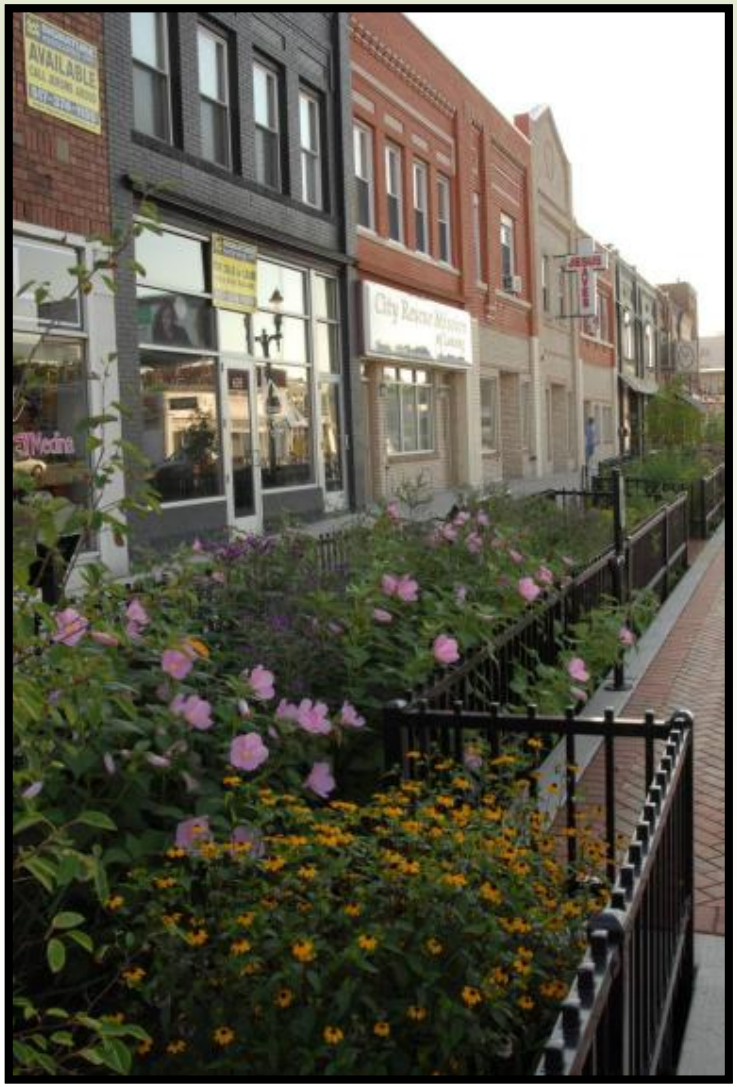
Philip Merrill Environmental Center, Annapolis, MD



- 32,000 sq. foot interpretive center, commercial office typically occupied by 80 people, 40 hours per person per week
- U.S. Green Building Council LEED-NC, v.1.0 Platinum
  - Solar hot water
  - Rainwater collection
  - Bioretention
  - Habitat restoration
- Waterless composting toilets
  - Reduced water use (only 80 gpd)
  - Reduce nitrogen impacts on bay
  - Compost used as landscape fertilizer

Green Streetscapes

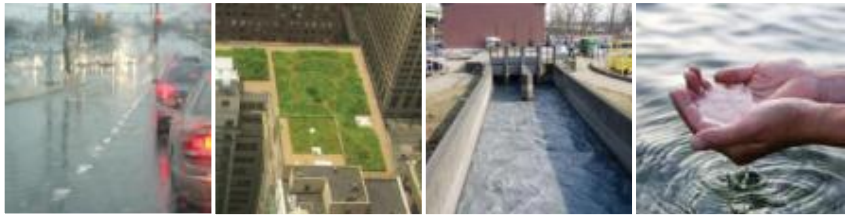




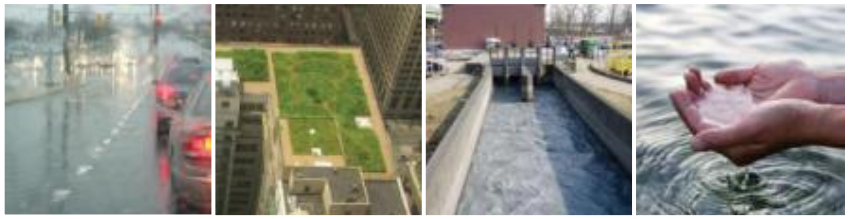
Fairfax County, VA
LID with Engineered BMPs

- Raingardens
- Grass Swales
- On-lot detention
- Rainbarrels
- Narrow sidewalks
- Narrow streets

Orange County NC
Conservation-LID Design

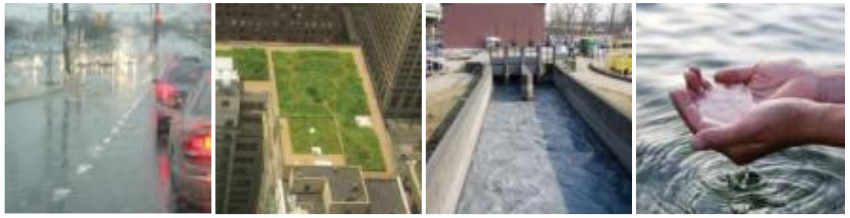


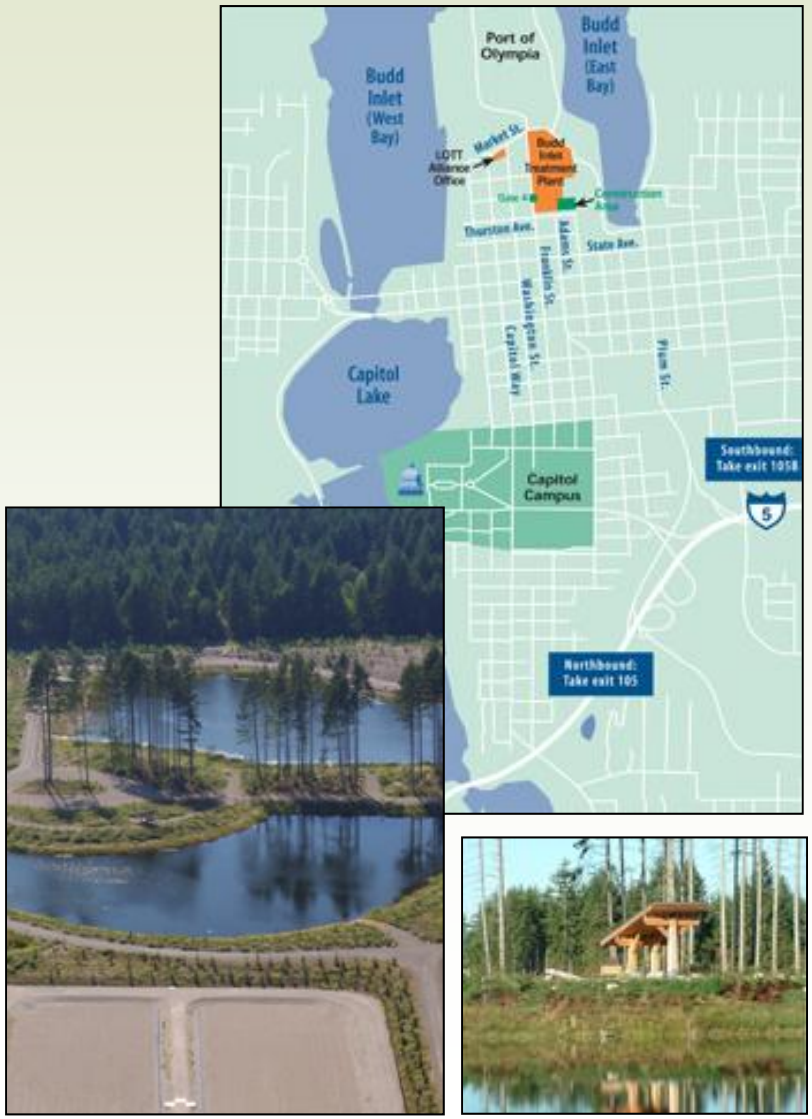
MAWSS, Mobile, AL



- Service area: 233 mi^2 includes ~1,300 mi. of gravity sewers, ~200 lift stations, ~120 miles of force main
- MAWSS owns and operates 2 conventional and at least 12 decentralized wastewater facilities
- On-site treatment/dispersal in Tricentennial Park adjacent to Three Mile Creek
  - Demonstrate use of decentralized facilities within centralized infrastructure
  - Wastewater mined from sewer line and treated using one of three different decentralized systems
  - Treated effluent is distributed through subsurface drip irrigation system to nourish the grass and shrubs in the park

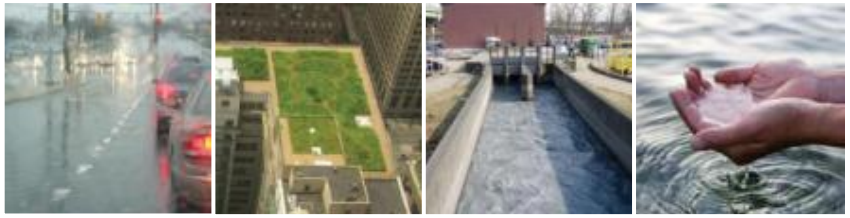
LOTT Alliance, Olympia, WA





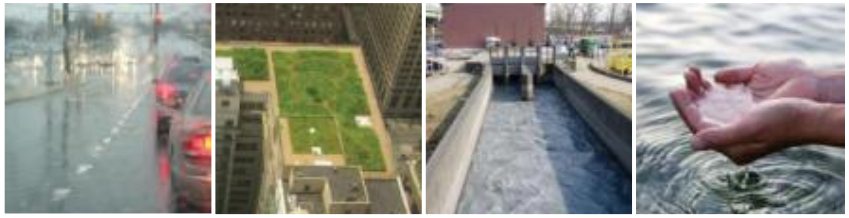
- Lacey-Olympia-Tumwater urban area
- 20-year plan calls for construction of three satellite reclaimed water treatment plants
- Each satellite built in small increments to allow "just-in-time" construction for future needs.
- Hawks Prairie Reclaimed Water Satellite
  - Reclaimed water feeds constructed wetland ponds/groundwater recharge basins
  - Provides opportunities for public education, recognition, and acceptance of reclaimed water
  - Serves as an amenity for visitors

Clean Water Services
Hillsboro, OR



- Ostara Nutrient Recovery System
- Controlled formation of mineral struvite recovers phosphorous and nitrogen
- Product sold as slow-release fertilizer
- Uncontrolled struvite formation clogs pipes and equipment
- Payback period < 5 years

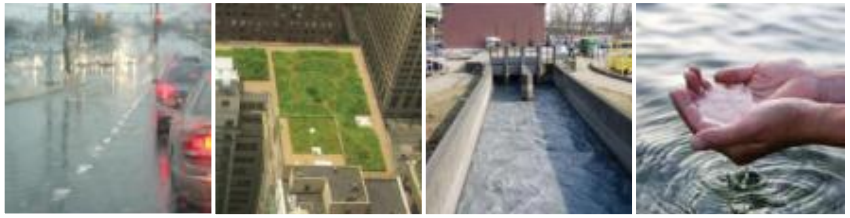
Solaire, Battery Park, Manhattan, NYC



- Decentralized reuse in highly urbanized area
- LEED Platinum
- Green roof filters and captures stormwater
- Wastewater and stormwater treated for reuse
  - Toilet flushing
  - Cooling tower supply
  - Irrigation of park
- 48% reduction in potable water consumption
- 56% reduction in wastewater discharge

Reference – Battery Park City Authority Manhattan Borough, NYC, The Solaire – Alliance Environmental, LLC

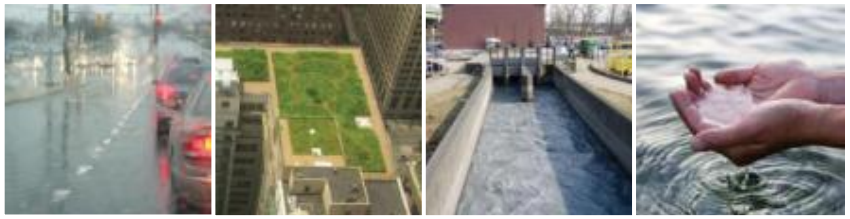
Moving Forward

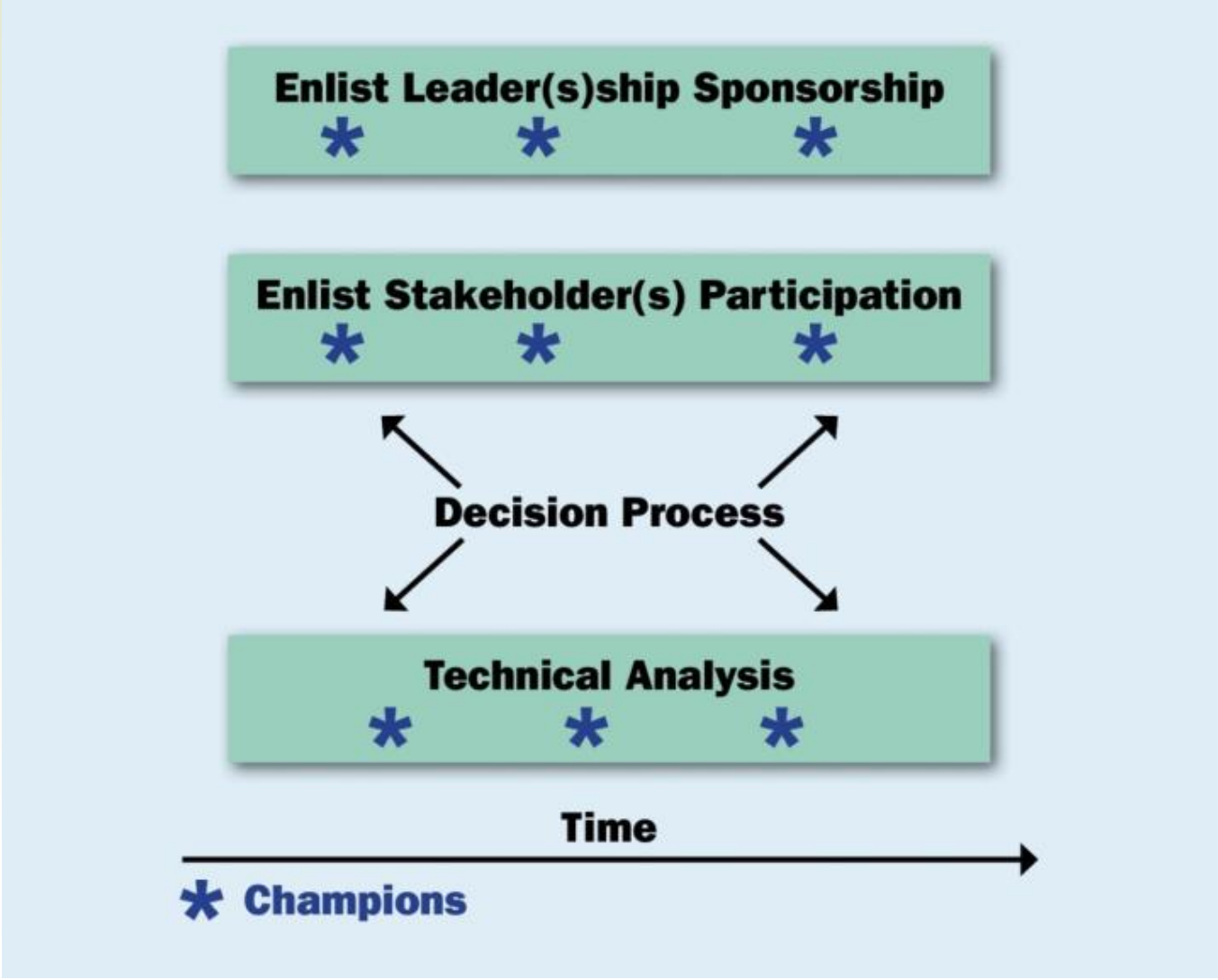


Ways to build institutional capacity, remove barriers, and guide technology….

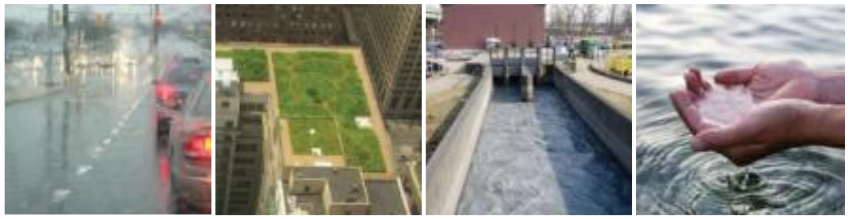
- Integrated local planning
- Watershed scale planning and management
- Full life-cycle costing
- Improved market mechanisms
- Improved regulations
- Enhanced community engagement
- Investment in intellectual capital

Leadership Is Critical

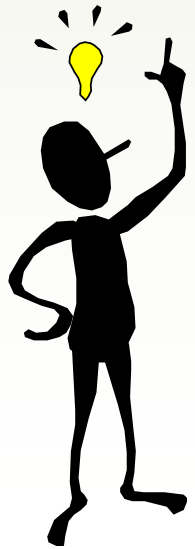




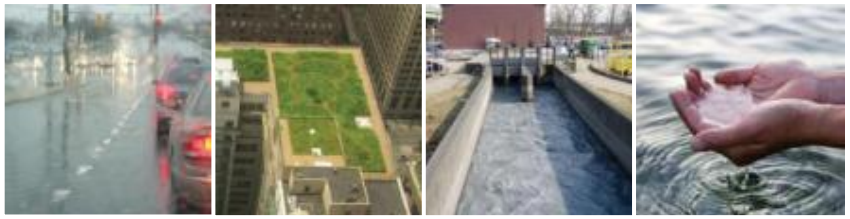
Take Home Points



- Current practices not capable of achieving environmental, economic and social goals
- Sustainable communities operate under a new set of principles
  - Valuing water
  - Integrating planning, design and implementation across multiple institutions and programs
  - Performance-based
  - Recognizing true cost
  - Adaptive

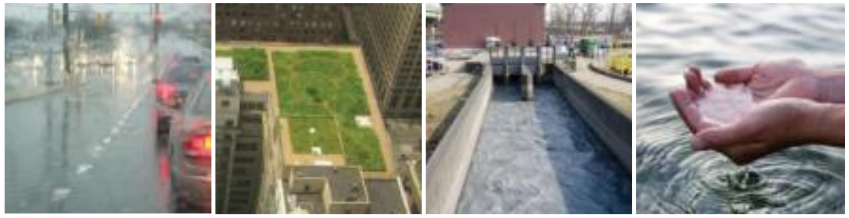


Take Home Points



- Current technologies exist and are being used for more sustainable solutions
- The new paradigm can work in urban, suburban, and rural areas
- New management and institutional approaches are the key to moving forward – these require champions.

Want more details?



- Final Report Publication
  - Sustainable Water Resources Management, Volume 3: Case Studies on New Water Paradigm, EPRI, Palo Alto, CA and Tetra Tech: 2009, 1020587
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