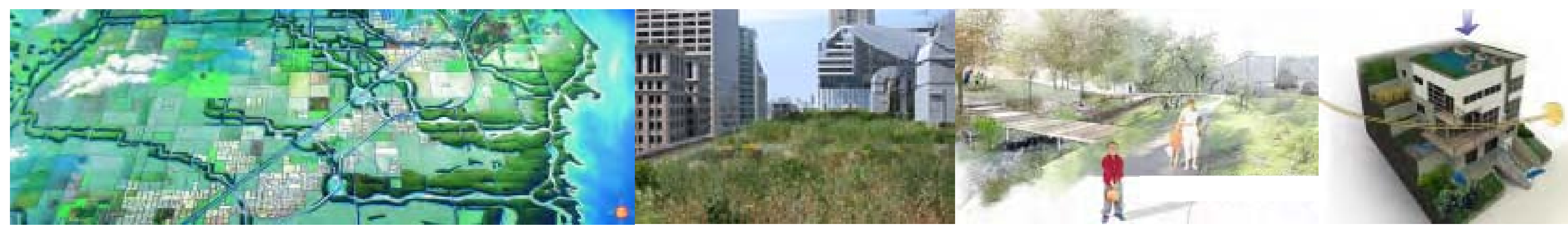
"All things arise from the principle of water." Vitruvius



The American Institute of Architects

WATER + DESIGN CONFERENCE REPORT

AIA Headquarters, Washington DC
September 8-9, 2006

The AIA Water + Design Initiative
Grant: EPA #AW 83247001

p r o t e c t i n g   w a t e r   t h r o u g h   a r c h i t e c t u r a l   a n d   u r b a n   d e s i g n

Daniel E. Williams, FAIA and Donald Watson, FAIA

Acknowledgments

Thank you to the participants many of who traveled across the earth to participate in this conference - we are indebted to them for their commitment and contribution.

A special thank you to the US/EPA for their Watershed Grants Program, a program that is central to both asking and answering questions of long term sustainability and the critical relationship to water - a limited yet essential resource.

I would like to acknowledge the considerable work the W+D Advisory Group did to make this a successful project, the success of the conference was largely due to their group efforts. And most importantly Donald Watson, FAIA, my co-author, for his creative and constant defining and refining of this report.

Thanks to John McCrae, FAIA who helped develop the initial grant proposal and to the AIA staff particularly Andrea Rutledge who administered this grant and conference and Katherine Roussel for her considerable assistance and input.

And finally to those reading this document who understand the value of *design as problem solving* and are committed to make the additional effort to understand the science of water and integrate it into their projects and sustainable design principles.

Daniel E. Williams, FAIA | 11.24.06

The Conference

Steering Committee

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Keynote Presentations:

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Nancy Stoner, Director, Clean Water Project, Natural Resources Defense Council
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design and planning ***can meet our nation's water resource goals.***

Through cross-disciplinary design we can achieve ***a higher quality of life and a sustainable future at a lower cost .***

The real promise of design lies in ***design and planning at community and regional scales.***

The AIA
Water + Design Initiative

Land use, and more specifically the *design of that land use*, has the greatest impact on water quality and quantity.

In September 2006, the American Institute of Architects (AIA) hosted a conference on Water + Design, supported by a grant from the United States Environmental Protection Agency (EPA). Participants represented the interdisciplinary perspectives of design, environmental science and public policy.

The conference was held as part of an AIA effort focused on water use in buildings and communities. The purpose was to review the state-of-art of water-related design concepts that may be advanced by architecture, landscape architecture and building construction. These include design concepts to:

- Conserve and increase water quality and quantity,
- Reduce the impacts of buildings and communities on water resources, and
- Promote the design of buildings and communities that integrate, preserve and protect water resources.

Conference participants reviewed a wide range of water design concepts that hold great promise to improve water availability while improving the quality of life. Opportunities include water conservation and harvesting, reuse, stormwater management, groundwater recharge, watershed and landscape design and protection, and natural drainage in site design.

Many Water + Design principles and practices described in this report are well tested. They can be included in community and building project designs now, offering cost savings, amenity and beauty. Other concepts hold great promise but need to be promoted through policy and institutional incentives and advocacy.

Water is the single most critical natural resource and limit to growth and development. All design has the opportunity to steward water while simultaneously nurturing the economy, the community and the environment.

Design that integrates stormwater and floodwater controls into the urban fabric is an opportunity to create more livable communities while protecting water resources.

...water is relatively cheap until we consider that it is free until it is changed by the contaminated surfaces our settlement patterns provide. When our buildings and communities are designed to collect, store and clean water rather than degrading it, our communities will simultaneously be more livable and affordable as well as ecologically viable.

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Integrate water into the design and planning of communities.

Water is a limited but renewable resource - current uses and allocations - when they exceed the rate of renewal - are unsustainable

Available supply then, should be viewed as a savings account – not a checking account– use the interest not the principle.

1.0 Overview

1.1 Context of this report

The AIA Water + Design Initiative supports the AIA's commitment to sustainable design as presented by the 2006 AIA Sustainable Task Group.

> *"The present global and local challenges present an opportunity and a responsibility to inform our practice with the issues of sustainability. As generalists, architects are well suited for this leadership role, helping to facilitate multidisciplinary teams that work toward rethinking how things are done and challenging standard practice. The joining of science and design, a mutually beneficial collaboration, offers a new conversation, one that is holistic and inclusive. Bringing environmental fields together with government and the public and illustrating the power of design as a tool in helping to achieve a sustainable future is a compelling challenge and a call to bold action."* 2006 AIA Sustainability Task Group

SUSTAINABILITY is a far-reaching goal of human endeavor, guided by the ethic of conserving and regenerating the natural and cultural resources of the earth that increase the capacity of environmental health and well-being of individuals and communities.

SUSTAINABLE DESIGN is the art and science of environmental design, architecture, landscape architecture and planning committed to the goal of sustainability.

WATER + DESIGN is an initiative of the AIA to define opportunities to protect and improve water quality and supply through sustainable design at regional, community and building scales.

1.2 Why Water + Design?

Water is a renewable but limited resource. In most United States communities, water is used at a far greater rate than it is supplied by natural rainfall or is available by annual storage capacity. Water resources are being depleted faster than they are replenished, such that fresh water should be treated as a nonrenewable resource. Presently, the way we use water to produce materials, construct buildings, develop communities and maintain infrastructures is not sustainable.

For all of human history, we have used clean water for all water uses, not only drinking—essential for human life—but for every other convenience, much of which is not essential or for which there are alternatives, including transport of sewerage. The wasteful use of water is similar to our use of fossil fuel. We perceive the supply as unlimited. Water does tremendous "work" for society. Its energy value (H. T. Odum) is greater than that of gasoline as it has tremendous physical power -forming entire landscapes and moving nutrients - and its chemical value, to all life, is critical to biological health. Water shortages are more critical than fossil fuel shortages – average personal usage in the US is 170 gpd – an amount considerably larger than gasoline usage.

Buildings, cities, and communities are as dependent upon water as upon electric power. All buildings and materials, construction processes and labor forces rely on water. Once built, a building cannot function without water—it is no longer useful. Drinking water sustains human health. Water is used to clean the building, to cool equipment and space, to irrigate landscape and to remove wastes from the building. After a building's useful life, water is used to deconstruct the building. Without water there is no construction, no building, and no community.

Throughout the United States and world, urban development and growth is demanding more water than available either from regional rainfall or the reservoirs of water in local aquifers. Aggressive water well pumping is drawing down the deep water reservoirs that accumulated over millennia. Once depleted, these reservoirs are essentially gone forever.

Consumption and demand for water are increasing in the United States. Population growth and expansive regional development is increasing in locales where water resources are already strained, entirely relying upon water imports from other regions. Once a free gift of nature, water is now a costly commodity. We are throwing away the very elixir of life.

THE CHALLENGE

> *"There is no standard for how much water a person needs each day, but experts usually put the minimum at fifty liters [approx. 13 gallons]. Most people [in water scarce regions of the globe] drink two or three liters—less than it take to flush a toilet…Americans consume between four hundred and six hundred liters of water each day, more than any other people on earth. Most Europeans use less than half that."*
> Michael Specter, "The Last Drop: Confronting the possibility of a global catastrophe." *New Yorker,* October 23, 2006.

Water supply is among the least understood and yet critical factors of sustainable development. The global hydrological cycle supplies and distributes water, but with great variation, subject to location and seasonal weather patterns. In some arid regions of the globe, the sole and increasingly costly sources of water are importation from afar, deep well digging deeper into once plentiful but now dwindling aquifers, and desalinization.

Annual rainfall of a region determines its water income or budget that is available on any reliable basis to support natural landscape and human requirements. Annual rainfall varies, especially in arid drought-prone regions. Watershed planning has to extend forward many years and decades.

Peak weather events establish the severity and risk from local natural weather hazards. In some regions, hurricane, storms and flooding are the foremost natural disaster threats. In other regions, lack of water, drought and resulting forest fire hazards pose the greatest risk, while in the same regions flashfloods need to be anticipated and mitigated. With the global climate trending toward more severe weather events, regional landscape and infrastructure need to be enlarged to anticipate greater peaks and variations. These preparations need to be made part of every regional and municipal watershed plan and infrastructure.

Water storage—either in natural water bodies and available aquifer, or structured storage systems—is essential to providing for present and future water needs. Currently, water storage systems in many cities of the United States are inadequate to meet future demands of their regions and communities. This presents a design opportunity for watershed planning: critical relationships between how we build, where we build, and how we preserve the water supply have not been studied or implemented as an integrated system. Techniques for water storage are available for projects at every scale. Implemented together within a region, they can quickly restore and improve the quantity and quality of a community's water independence.

THE OPPORTUNITY

1.3 The water budget: living within the carrying capacity of region and site

Local rainfall represents the most readily available and predictable *"income"* for water supply in a region. Regions where annual rainfall can meet annual demand require effective ways to store and allocate that income. Arid regions where annual rainfall is insufficient to meet demand, must invest heavily in transport from afar - with greater cost of infrastructure and management. These demands increase as the population grows and fresh water supplies become locally drained and soon regionally scarce. In both instances, conservation and reuse are the most effective budget management strategies.

The local aquifer and man-made storage represents the *"savings account"* for a regional water resource. The quality and availability of the aquifer represents its "water wealth." The water infrastructure at regional, community and building scale represents the means of storing and distributing that resource—determining the cost and "budget" of water on which to live. When primary needs are met, the balance represents its *"usable interest."*

The design and technology of water use—how we design and construct the landscapes and structures of the built environment— represent our *"spending habits,"* determining rate at which we expend our water budget. Currently, too many of our practices are profligate, and without any saving plan. In every region, community and building project, there is room for improvement, conserving while also improving life and water quality.

Recovery and reuse of water after primary use represents the *"savings and investment plan."* Without one, the water account is soon depleted. With planning and designing for water conservation and quality improvement, we create a *"water endowment."* In the terms given by the goal of sustainability, that endowment should last forever. Water supply is best thought of as a savings account where using the interest – water over the required need for the system – is good practice. Consuming *the principle*—without means of replacement—reduces the overall system supply and stresses or degrades the future supply.

We are able to create a *"sustainable water budget plan"* appropriate for each region, community and building, to conserve and improve water resources and to provide a higher quality of life for the greatest number.

Water + design opportunities are available by:

(1) Reducing water consumption, to live with our locally supplied water budget.
(2) Increasing water storage systems that mimic natural system hydrology.
(3) Creating a sustainable water infrastructure to clean and reuse water – green infrastructure.
(4) Improve water quality and efficient use at each step.

These four steps protect our water resources at all scales: regional and urban planning, landscape and community design, building and plumbing technologies.

"Some of the world's thirstiest cities, such as Houston and Sydney, are using more water than can be replenished. In London, leakage and loss is estimated at 300 Olympic-size swimming pools daily due to ageing water mains. However… cities with less severe water issues such as New York tend to have a longer tradition of conserving catchment areas and expansive green areas within their boundaries. …. The water problems affecting rich and poor countries alike are a wake-up call to return to protecting nature as the source of water."

2.0 Keynote

2.1 Welcome remarks and overview, Daniel Williams, FAIA, Chair, W+D Conference

This point in time may at some future date be referred to as the beginning of the "Blue Period" of civilization—when the land denizens become aware of the critical link to water. Water is life. We are now needing a systematic approach to water and design, to link sustainable solutions that integrate the natural and built environment to work as an organism - an ecology.

This Water + Design Initiative is intended to forge new partnerships between environmental scientists, environmental advocacy groups, and the design profession. We seek to change the course of our profession while making important linkages between the design professions. As designers of the built environment, architects, planners and landscape architects have an opportunity and a responsibility to effect change.

We seek to achieve these goals:

- Identify the "state-of-art" of water design concepts being developed internationally.

- Set forth principles, practices, and benchmarks for practitioners to incorporate into ongoing design and construction projects.

- Identify institutional barriers to effective policies for water resource protection, as a basis for cooperation and partnership with others, to achieve our nation's goal to protect and improve our water resources for a sustainable future.

We hope to extend the conference results, guided by five overall principles:

- *Watershed planning based on a water-resource carrying capacity:* A comprehensive approach to regional planning for water resource protection, based on total precipitation within the region as the region's water budget.

- *The aquifer "storages*" created at all points of the water cycle to allow for averaging the variations in rainfall to increase the water resource capacity of every region.

- *Integration of water sustainability into the urban and community design.* The development of "hydric parks" and preservation of green infrastructure/ open space to create buffer edges for communities and a sense of "place" while restoring water resources.

- *Buildings and communities designed to mimic the pre development hydrologic condition*, i.e., to include water resources into all design practices at all scale, from regions to buildings.

- *Reuse and recycling of stormwater, graywater and wastewater* to establish a new "supply."

2.2 Building for Life: Designing and Understanding the Human-Nature Connection

Stephen R. Kellert, Professor of Social Ecology, Yale School of Forestry and Environmental Studies. Professor Kellert is author of *Building for Life* (Island Press 2005).

Urbanization historically has relied on converting natural diversity into largely homogenous landscapes of impervious surface, consuming enormous amounts of resources and materials, and generating huge quantities of waste and pollutants. Consequently, the modern urban environmental now consumes some 40 percent of energy resources, 30 percent of natural resources, and 25 percent of freshwater resources while generating one-third of air and water pollutants and 25 percent of solid wastes. This prevailing paradigm of urban development is neither necessary nor sustainable and constitutes more a design deficiency than an intrinsic and inevitable flaw of modern life. Still, these tendencies collectively have encouraged many to believe that the benefits of contemporary society depend on massively exploiting, if not conquering, the natural world. For many, progress and civilization have been equated with humanity's distance from and subjugation of nature.

Nonetheless, most people continue to intuit that the health and diversity of the environment are fundamental to their own physical, mental, and even spiritual well-being. Most sense that the natural world is far more connected to the quality of their lives than is revealed through the narrow metrics of material production and modern economics. In poll after poll in the United States and in other countries, the majority of respondents cite the environment as important. The stubborn belief persists that the natural environment is profoundly related to people's physical, psychological, and moral well-being, an assumption that is reflected in many of our preferences, cultural creations, and constructions. Our connection to nature figures into the materials we choose, the decorations we employ, the recreational choices we make, the places we live, and the stories we tell. Nature continues to dominate the forms, patterns, and language of everyday life, despite the impression that, in a narrow technical sense, the natural world often seems neither necessary nor germane to the functioning of a modern urban society.

Despite the evident connections, contemporary society still fails to recognize and defend the importance of healthy and diverse natural systems to sustaining the quality of people's lives, especially in urban areas. Perhaps we have taken for granted what has always been readily available, like a fish failing to recognize the virtues of its water realm. The presence of the natural world has been an unquestioned constant for much of human history, generally noticed only as an adversary or appreciated only when no longer accessible. We have only recently encountered nearly ubiquitous environmental damage and a feeling of alienation from nature produced by huge human populations, consumption, urbanization, resource depletion, waste generation, pollution, and chemical contamination. Only during the past fifty years has the scale of our excesses fundamentally altered the earth's atmospheric chemistry, causing the widespread loss of biological diversity and even threatening the future of human existence.

Thus, we confront two warring premises in contemporary society regarding our relationship with the natural world. On the one hand is the widespread belief that the successes of the modern world depend on controlling and converting nature. On the other hand rests the persistent impression that human physical, mental, and even spiritual well-being relies on experiencing healthy and diverse natural systems. I ascribe to the latter view, that nature—even in our modern urban society—remains an indispensable, irreplaceable basis for human fulfillment. Degrading healthy connections to the natural world impoverishes our material moral capacity. Through deliberate design, we may restore the basis for a more compatible and harmonious relationship with nature.

The focus is thus on three major issues. First, empirical evidence from diverse sources is marshaled to support the contention that experiencing natural process and diversity is critical to human material and mental well-being. Second, childhood is considered as the time when experiencing nature is most essential to human physical and mental maturation, even for a species capable of lifelong learning. Unfortunately, for both children and adults, an impoverished natural environmental has become widely common, especially in urban areas. Thus, I recommend considering how a new paradigm of designed development can help reestablish the beneficial experience of nature in the modern built environment. Underlying much of the examination of humans and nature is the concept of biophilia. *Biophilia* refers to humans' inherent affinity for the natural world, which is revealed in nine basic environmental values. Developing these nine values can foster physical capacity, material comfort, intellectual development, emotional maturation, creative ability, moral conviction, and spiritual meaning. The inherent inclination to attach value to nature, however, is a "weak" genetic tendency whose full and functional development depends on sufficient experience, learning, and cultural support.

The adaptive interaction of culture and nature is vital at any point in a person's life. But, because this interdependence is biologically based, it is logical to assume that the most critical period in this formative development is likely childhood. Young people need to engage the natural world repeatedly and in multiple ways to mature effectively. Yet, for many children as well as for adults, modern society has produced an increasingly compromised and degraded natural environment that offers far fewer opportunities to experience satisfying contact with nature as an integral part of ordinary life. The many symptoms of this declining condition include extensive air and water pollution, fragmented landscapes, widespread loss of natural habitats, destruction of biological diversity, climate change, and resource depletion. These trends have resulted in threats not only to human physical and material security but also to nature's role as an essential medium for people's emotional, intellectual, and moral development.

These deficiencies of modern life can be ameliorated through adopting an innovative approach to the design and development of the human built environment. This new paradigm, called *restorative environmental design*, focuses on how we can avoid excessively consuming energy, resources, and material; generating massive amounts of waste and pollutants; and separating and alienating people from the natural world. As intimated earlier, the current environmental crisis is considered a design failure rather than an unavoidable aspect of modern life. Both the knowledge and the technology exist to better reconcile and even harmonize the natural and human environments. However, meeting this enormous challenge will require two conditions. First, we must minimize and mitigate the adverse environmental effects of modern construction and development. Second, and just as important, we must design the built environment to provide sufficient and satisfying contact between people and nature.

3.0 Conference summary: The state-of-art of Water + Design concepts

Conferees proposed the design concepts below as significant principles and practices to address water quality at all scales of the natural and built environment.

SCALE OF IMPACT	W + D DESIGN CONCEPT
REGIONAL / URBAN SCALE *Ideally addressed at the scale of geologic regional watersheds- biomes, multi-States, and continents*	**Watershed planning & design – Carrying Capacity** **Riparian buffer zones** **Wildlife habitat** **Native planting** **Reconstructed wetlands** **Remediate COS practices**
URBAN / COMMUNITY SCALE *Opportunities at large scale and applicable to local city, neighborhood and infrastructure.*	**Green infrastructure / urban design** **Urban permiculture** **Tree planting programs** **Porous paving** **Bioswales / Rain gardens** **Water in public art / play / climate moderation**
BUILDING SCALE *Includes the above, but well within scope of a building site and project scale.*	**Rainwater harvesting** **Living green roofs / Living walls** **Water conservation** **Gray water systems – water reuse** **Ecological wastewater treatment** **Energy conservation – micro climates & comfort**

Appendix A provides brief summaries of these concepts.

Appendix B represents a “catalogue” of W+D concepts, compiled from documentation submitted by the conference participants. In advance of the conference, each attendee was asked to submit a one-page highlight, or “flashcard,” to illustrate each of their “top five” key design principles and practices. Appendix B represents a distillation and summary of over 100 submissions.

3.1 State-of-art of W+D concepts

TABLE A: State-of-art of key Water + Design concepts summarizes conference notes in discussion of:

- Column 1 - Water + Design principles and practices
- Column 2 - Notes (listed horizontally) indicate the state-of-art of the concept and if it can be applied immediately
- Column 3 - aspects that require more research and development, and
- Column 4 - policy challenges to be addressed

TABLE A: ***State-of-art of key Water + Design concepts***

1 Concept: Design practice / principle

2 Ready to Go? Practice guidelines /training

3 R&D needed? Products & systems / design tools

4 Policy Challenge? Institutional barriers /Financial proofs

TABLE A: ***State-of-art of key Water + Design concepts***

1 **Concept:** Design practice / principle	2 **Ready to Go?** Practice guidelines / training	3 **R&D needed?** Products & systems / design tools	4 **Policy Challenge?** Institutional barriers / Financial proofs
Regional ➔ Urban Scale			
WATERSHED PLANNING **Blue/Green Infrastructure** **Soils and water inventory; nature's rules.** **Development as a restorative or regenerative action.** **Watershed planning not just site planning.**	Place-based guidelines: Start with watershed area to plan open space network sized as a function of storage needs for the population served; then community; then site. Watershed planning is perfect topic for design charrettes.	Develop pre and post inventory methods for soils and water and vegetation. Creating hierarchies for water, vegetation/habitat, recreation, development. Set quality and quantity goals and design solutions for water with simulation.	Portland Equity Atlas Metro 5 Set quality and quantity goals for watershed, region. Eliminate shed and site abuse practices. Restructure municipal and local responsibilities; Shift profit from laying pipe.
RIPARIAN BUFFERS & WILDLIFE CORRIDORS **Blue/Green Infrastructure**	Yes. Recognize global warming impact on dimensions; Must be continuous; address headwater streams – benefits and costs.	Develop local solution sets, codifiable process. Integrate other urban amenities, recreation, soft transit/ bikes; blue streets; recharge Less costly approach than full lawn maintenance, but this needs to be better understood.	Evaluate benefits and costs as alternative infrastructure. Do not exempt urban areas. NYC. Enact land trades. Nomenclature problem. not highway buffer, commonwealth asset. Stream valley corridors, no mowing.
NATIVE PLANTING to save water; Xeric landscape. **Define plants appropriate for storm water wetlands.** **No pesticides.**	Appropriate for local soil and rainfall, must be native to a small microclimate. Establish corridor, habitat.	Do they really use less water? Must have native soil? Can we define native? Understand cultural and regional aspects. Research on toxin absorbing plants, such as metals. Surface runoff.	Intrinsic value of native landscapes. Do not dig up what is there.
ELIMINATE INVASIVES. **No pesticides.**	Easy and immediate action, with patient, longer-term maintenance required.	Nature may need invasive natives? Resolve disposal.	
RECONSTRUCTED WETLANDS	Affordable approach to flood control, storm water management, and wildlife protection. Sites have to be carefully selected. Requires traditionally wet location.	Establishment requires considerable care and monitoring. Long term maintenance to remove siltation and keep waterflow.	
COMBINED SEWER OVERFLOW (CSO) **Resolve combined Stormwater sewer system overflows.**		Must develop regional solutions; Demonstrate the greener system opportunities such as biogas use, organic use for soil rebuilding; irrigation supply.	

1 **Action:** **Practice or principle**	2 **Ready to Go:** **Practice guidelines/ training**	3 **R&D needed:** **Products and integrated systems; design tools**	4 **Policy Challenge:** **Institutional barriers** **Financial proofs**
Urban → Community scale			
URBAN FORESTRY / PERMICULTURE	Yes. Trees provide natural water storage, flooding control, shading. Urban farming can use recycled water / composting	Budget studies $10,000/tree valued as streetlight. Cost benefits of poorly planted trees and no trees.	Urban accounting, municipal accounting changes. Size / height restrictions.
TREES / STORMWATER **Combined street and parking trees/ stormwater structural cells.** **Create urban forest as a stormwater utility.**	Yes. Key to get water into the cells to ensure storm water storage and tree survival	Understand what else can be bundled in the installing the urban forest. Verification of performance of systems.	Redefinition from landscape amenity to urban infrastructure. liability challenge. Budget ongoing maintenance. Understand system for water, heat island
POROUS PAVING **and alternatives – pavers, brick, grass pavers, porous asphalt…**	Separate street, parking, sidewalk. define the system & principles. Training is key/ model programs to civic workers.	Clogged with toxins? Details of system more important than the modular product. O&M challenges. Surface and deep cleansing is key. Traffic aisles have failed.	Proofs needed for life cycle cost. Bruce Fergeson book Impervious cover limit s legislation.
BIOSWALES / RAIN GARDENS **Site solutions are critical differentiating Greenfield from infill/ brownfield.**	Proven and practical Can be lower cost than engineered retention systems	Need to identify plants. Some plants are excellent in absorbing pollutants, but these need to be maintained, removed, replanted.	Can be applied to roadway landscape and to projects at any scale Salt intrusion from road deicing is a concern.
WATER PUBLIC ART/PLAY FEATURES **Storm/recreational water in cities for kids**		Health concerns, need studies	Safety challenges, laws to be changed. Annapolis all storm mgmt is public amenity Portland active use water park.
EVAPORATIVE COOLING **Outside fountains, sprays, and within building. Design for aesthetic amenity and comfort.** **Combine with planting.**	In dry climates, with sparing use. Can be used as part of gray water cycle. Within building evaporative beats refrigerant. In all climates, trees. Wind, radiant, thermal mass.	Redraw maps relative to rising RH, falling water levels. Show impact of watering and pools on water availability, RH. Redefine as local cooling maps. By city. Development of regional and high-rise green wall technologies.	Show impact of green/asphalt ratios on urban heat island, air quality. Redefine as local cooling, demonstrate how buildings and landscape change microclimates. Water and shade changes comfort.
GREEN ROOFS "living roofs and walls" **VERTICAL PLANTING**	Vary by climate Must be in designed system, not component. Native plants and soil regime.	Do they really hold stormwater and recreate natural hydrograph? Develop storage, search for new approaches to creating living roof systems that function without maintenance and upkeep costs? What biological systems 'wants" to be on the roof – moss, lichen etc)	Show cost effectiveness, compare to other water management strategies, add thermal, UV protection. Recognize scenic, habitat, recreational: intensive and extensive; nutrient export; cleans runoff.

1 **Action:** **Practice or principle**	2 **Ready to Go:** **Practice guidelines/ training**	3 **R&D needed:** **Products and integrated systems; design tools**	4 **Policy Challenge:** **Institutional barriers** **Financial proofs**
Community → Building Scale			
WATER RECYCLING **Rain water** **Storm water**	No drinking, first toilets sinks, laundry, cooling, then landscape and purple pipes.		Prove the value to storm/sewer crisis.
Gray water	Regionally the best first step The key is how to capture? Codes – can it be used. To toilets, then landscape/bio-uptake or into carbon rich soils?		Prove the value of cleaning to eliminate soaps eating urban infrastructures.
Black water **Keep the waste out of the water stream?**	Some package systems, living machines indoor and outdoor. Distributed vs. municipal. 24-72 hours can be drinkable. Deep tube™. Text by Crites and Tchobanoglous (1998). Recognize landscape vs agricultural uses Dual systems, separate black water and gray water Watch the filters that become clogged toxic sources.	Testing and development for health, cost effectiveness, integrated system performance Drinking sewage – what is the process and pitfalls. Resolve phosphates and toxins in wastewater, using soil developments? The parking lot could be the 'plant'. Study the separation of solids and liquids in systems. Instead of distributed central process plants, use new technologies at neighborhood scale. Separate urine from waste to use for landscape and create waterless fixtures. No longer addressing the gray water/black water separation. Consolidate with composting strategies. Create district nutrient recovery system. Malmo Sweden, e.g., Hybrid systems for districts.	Must demonstrate robustness, safety, cost-effectiveness. UPC, IPC now allows storm and gray water reuse. Resolve perception barriers for drinking onsite processed water. Technologically doable to make drinking water out of sewage. Make two generations use of water on site mandatory first (gray) … if three generations 'don't ask, don't tell.' Awards for waste management innovations! Water management innovations! Clothes lines for shade and evaporative cooling…
WATER-SAVING FIXTURES **Commercial and household appliances**	Absolutely – already code in most of US.	Water reuse fixtures also heat reclamation fixtures and deconstruction for easy recycling	Set minimum standards and tighten every year.
ELECTRICITY CONSERVATION **Save electricity to save water**	Act now! All urban water supply is pumped – fossil fuel – use green/gravity for infrastructure Conservation, renewables, distributed power.	California uses 20% of its electricity to move water	Reveal energy efficiency to overall water balance.

4.0 Framework for action

Table B demonstrates the importance of W+D initiatives in creating the infrastructure of sustainable water resources:

- **THERE IS OPPORTUNITY AT ALL SCALES:**
  Great improvements in water quality and quantity are achievable through W+D concepts at all scales of regional, urban, community and building projects. The greatest impact is achieved when all points of the scale are addressed as a watershed system.

- **MANY DESIGN CONCEPTS ARE PROVEN AND COST EFFECTIVENESS:**
  Many W+D concepts are cost saving and proven. They only need to be more widely used.

- **THERE IS OPPORTUNITY FOR DESIGN TEAM CREATIVITY:**
  W+D concepts are best implemented by creative design integration of landscape architecture, architecture and site/building engineering.

* **INNOVATIVE CONCEPTS DESERVE CONTINUED R&D & DEMONSTRATION:**
  Many very promising design concepts deserve research and demonstration, especially addressing health concerns of innovative ecological wastewater systems.

* **THERE IS NEED FOR INSTITUTIONAL INNOVATION AND POLICY CHANGES:**
  Many promising innovations—and in some cases concepts already proven and cost effective—required policy and institutional innovations to remove regulatory barriers to best practices of public health, safety and welfare.

These summary points are detailed in recommendations below, the result of brainstorming by conference participants to advance W+D concepts into all scales of practice and application.

	WATER SUPPLY → SITE	LANDSCAPE USES	BUILDING USES	AFTER USE → AQUIFER	ready to go & cost saving	ready to go, but added cost	needs R&D, demonstration	requires policy innovation
REGIONAL / URBAN SCALE								
Watershed planning	●	●		●	✓	✓		✓
Riparian buffer zones	●	●		●	✓			
Wildlife habitat	●	●	●	●	✓		✓	✓
Native planting	●	●	●	●	✓			
Reconstructed wetlands	●	●		●	✓	✓		
Remediate COS practices				●		✓		✓
COMMUNITY / NEIGHBORHOOD SCALE								
Green infrastructure	●	●		●	✓		✓	✓
Urban permiculture / farming		●		●	✓			
Tree planting programs	●	●		●	✓	✓	✓	
Porous paving	●	●	●	●		✓	✓	
Bioswales / Rain gardens	●	●	●	●	✓	✓		
Water art / play features	●	●	●			✓	✓	
BUILDING / INTERIOR SCALE								
Rainwater harvesting	●	●	●		✓	✓		
Green roofs / Living walls	●		●	●		✓		
Water conservation		●	●	●	✓	✓		
Gray water systems		●	●	●		✓	✓	✓
Ecological wastewater treatment		●	●	●			✓	✓
Energy conservation	●		●		✓	✓		

OPPORTUNITIES FOR DESIGN PROFESSIONAL PRACTICE AT PROJECT SCALE
Many W+D concepts can be applied immediately in professional practice.

- Make habitat and wildlife central to storm water management solutions. Healthy wildlife predator/prey balances reduce insect infestation and disease vectors.
- Place landscape and architecture as a building block in the watershed… many do not understand the role of inside the building and directly outside and the shell itself… buildings as breathing, digesting, conserving systems.
- Integrate landscape architecture and water/site engineering in all projects: integrate the tree and the fountain (landscape and water design approaches)– not either or.
- Make economics count, Show life cycle benefits.
- Missing the beauty. Water reveals the solution sets in spectacular settings… make the solutions visible. Performance based guidelines with visionary illustrations for the public.
- Celebrate the regional and cultural variations in the availability and movement of water, the playfulness, the sound, the feel of water.
- We need to shift scales in vision, policy, design, and innovation. Live locally and act regionally. Systems thinking is essential.

OPPORTUNITIES FOR W+D INITIATIVE: PROFESSIONAL COLLABORATIONS
There are many opportunities to advance W+D principles and practices through professional development and collaborative efforts of professional design associations.

- Work on the water vision. Work in three scales is key. May have to be careful of tools and solutions; create a planning culture with a common vision for water.
- Get tools to professionals: education and training. http://greenvalues.cnt.org – cost-benefit decision support tool.
- Help establish recommended policies and priorities for policy makers and politicians.
- the LCC accounting and financial standards to include sustainability factors to lead to the right decisions; including useful life-cycle calculations; cross infrastructure solutions.
- Benchmarking; establish performance goals for projects, municipalities and regions.
- Tool development for mapping air shed, watershed, habitat shed, climate, vegetation to have meaning to practitioners, decision makers, the public.
- Support GIS enhancement nationwide to ensure equal quality and analysis tool development. Many municipalities do only hard infrastructure, not vegetation… see Florida.
- Mobilize neighborhoods and general public to support creating green streets.
- Coalition between ASLA, AIA, APA, and other professional organizations to address incentives and barriers to better design – principles for water resource management.
- Examine professional academic curricula (architecture and landscape architecture) to infuse water resource principles. Better understanding of hydro-climatology over time and space (location).
- International conference of W+D experts and practitioners to create the textbook.
- Help establish recommended policies and priorities for politicians.
- Set up research/solution building teams by regions with funding. e.g., in the 1980s University-based Lighting centers funded by utilities.
- Suggestions to influence USGBC LEED™ – best practice is way beyond the credits, some of the credits harm best practice.
- Identify and publish best examples.

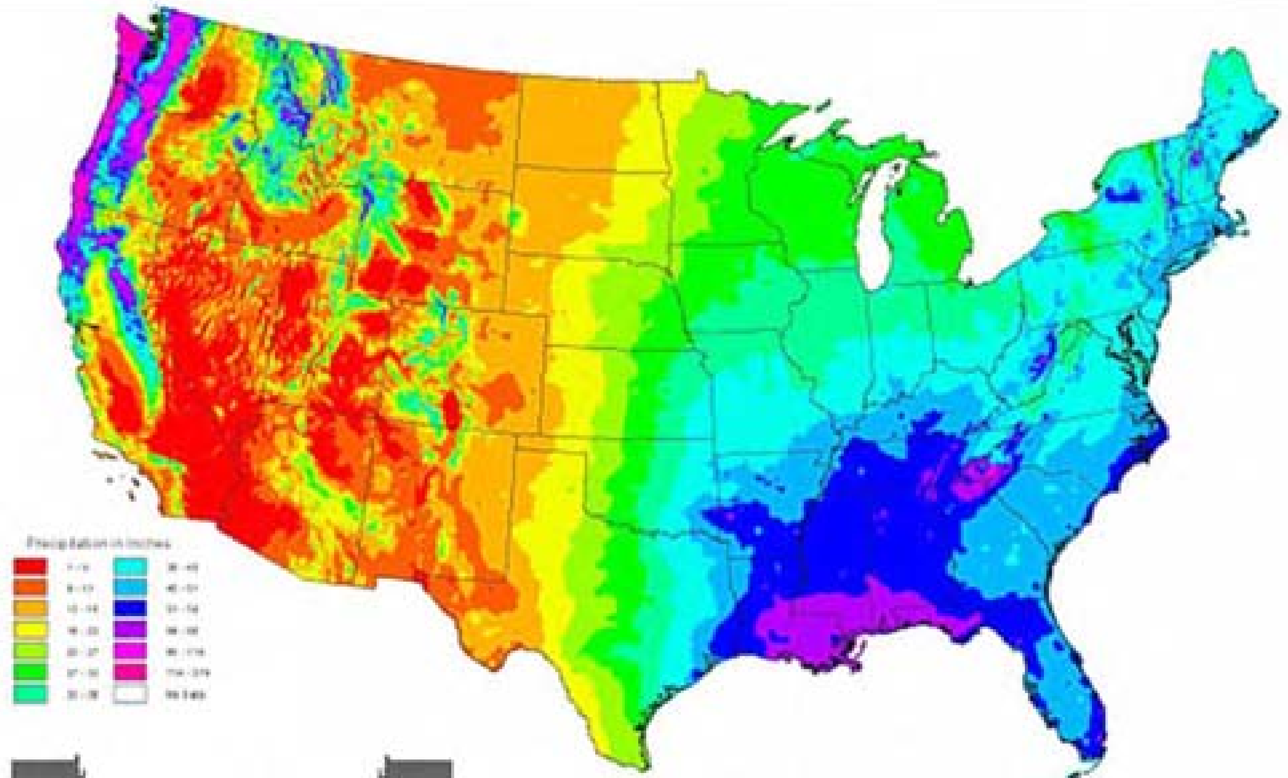
OPPORTUNITIES FOR INSTITUTIONAL CHANGE / POLICY INNOVATIONS
Full potential to protect and enhance the quality of water resources requires removal of institutional barriers, creation of incentives and policies to enable watershed-scale improvements.

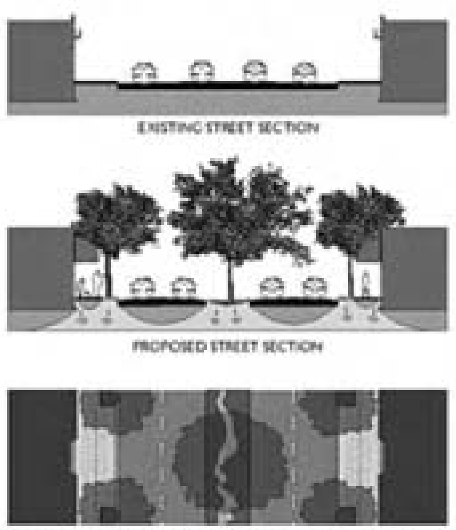
- Be part of the federal highway administration storm water mitigation standards implementation.
- Public information about water quality at the outfall as well. .
- Make owners of intakes downstream to force responsibility.
- Get professional teams with new comprehensive solutions for Combined Sewer Overflow (CSO) as alternatives to bigger pipes and large civil infrastructure marketing strength. Change EPA compliance requirements to credit distributed solutions to eliminate storm or provide distributed storage. (Portland, Mobilize teams with federal funding, e.g., DOT environmental advisory projects. Set up multiple teams to deal with regional differences.
- Enforcement of CSO is making Cincinnati spend a billion on a state of the art 1950 facility – creative settlements that reflect alternatives and life cycle.
- Create better municipal separate storm sewer system MS-4 guidance at EPA level. Promote the best programs; awards and rewards. Boasting rights.
- Change the fee structures to engender collaborative and distributed solutions vs. large civil infrastructure pipes and industrial plants.
- Support innovative development trading alternatives to ensure greenways and waterways: FAR, land trading.
- Redirect CSO and MS-4 resources to sustainable solutions.
- Foster political will for cooperation between municipalities to design and plan at the watershed scale across political boundaries. Alter public perception on the importance of water, valued amenity.

APPENDIX B W+D concept pages

	W+D CONCEPT	Page title	Submitted by
1	**WATERSHED PLANNING**	*Principles of watershed planning*	Daniel Williams
2		*Principles of watershed planning*	Daniel Williams
3		*Bioregionalism / Bio-urbanism*	Daniel Williams
4		*Land use suitability analysis*	Joe MacDonald
5		*Up Zone / Down Zone*	Joe MacDonald
6		*Zone of no disturbance*	Joe MacDonald
7		*Hydrology & site development*	Kaye Brubaker
8		*Flood plain restoration*	Kaye Brubaker
9		*Flood plain restoration*	Bob Sallinger
10	**RIPARIAN ZONES**	*Riparian zones*	Donald Watson
11		*Riparian zones / districts*	William Morrish
12	**WILDLIFE HABITAT**	*Wildlife corridors*	Bob Sallinger
13		*Design for wildlife conservation*	Bob Sallinger
14	**NATIVE PLANTING**	*Growing – Not mowing*	
15		*Xeriscape*	Steven G. Shapiro
16	**WETLANDS**	*In-town wetlands*	Joe MacDonald
17	**GREEN INFRASTRUCTURE**	*Green values calculator*	Scott Bernstein
18		*Urban design*	Don Carlson
19		*Urban street & waterscape*	Don Carlson
20		*Cistern steps*	Don Carlson
21	**URBAN PERMICULTURE**	*Community market gardens*	Donald Watson
22		*Vertical farm concept*	Steven G. Shapiro
23	**TREE PLANTING**	*Urban tree planting programs*	
24		*Urban trees & soils*	James Urban
25		*Trees as stormwater utilities*	James Urban
26		*Structural cells*	James Urban
27	**POROUS PAVING**	*Porous paving*	Steven G. Shapiro
28		*Porous pavement design criteria*	
29	**BIOSWALES RAIN GARDENS**	*Bioretention swale*	
30		*Bioswales*	Kaye Brubaker
31		*Rain gardens*	Bob Sallinger
32	**RAINWATER HARVESTING**	*Rainwater & educational play*	Don Carlson
33		*Water channeling as sculpture*	Herbert Dreiseitl
34		*Cisterns & rain barrels*	Steven G. Shapiro
35	**GREEN ROOF LIVING WALL**	*Green roof design*	Vivian Loftness
36		*Microclimatic moderation*	Vivian Loftness
37	**WATER CONSERVATION**	*Water conservation measures*	Michael Ogden
38		*Watershed management*	Michael Ogden
39		*Gray water treatment systems*	Vivian Loftness
40		*Innovative product development*	Vivian Loftness
41		*Innovative product development*	Vivian Loftness

WATERSHED PLANNING



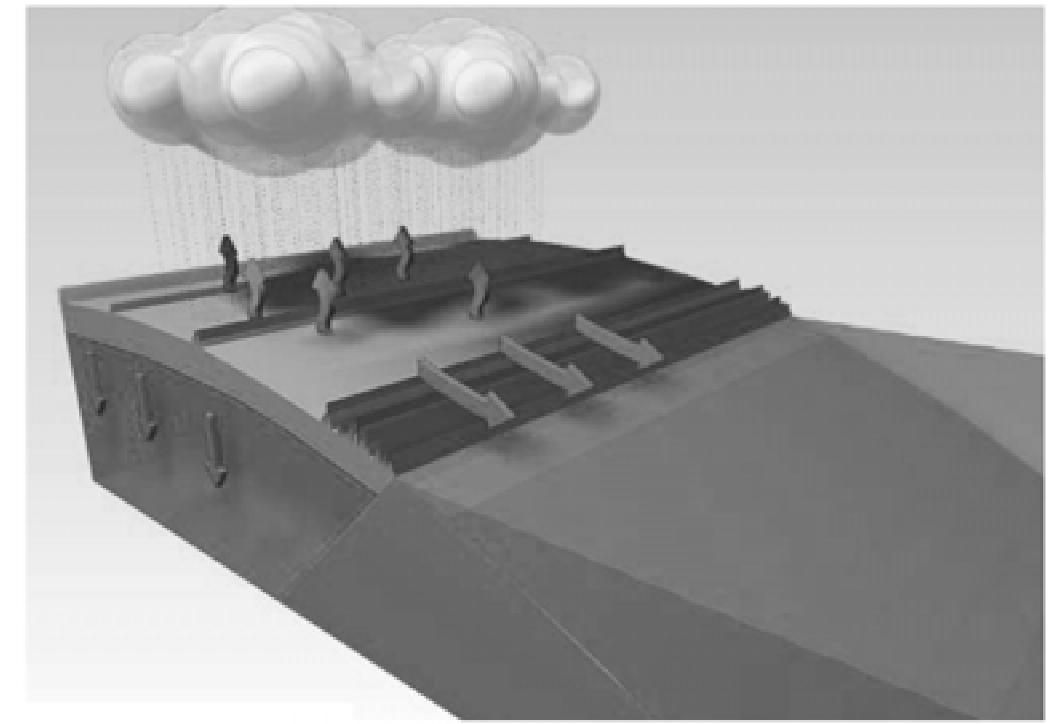


Incorporating watershed planning and design improves the urban pattern, micro climate and economic character.

Watersheds, biomes, and landuse have patterns based on variations in supply and demand.

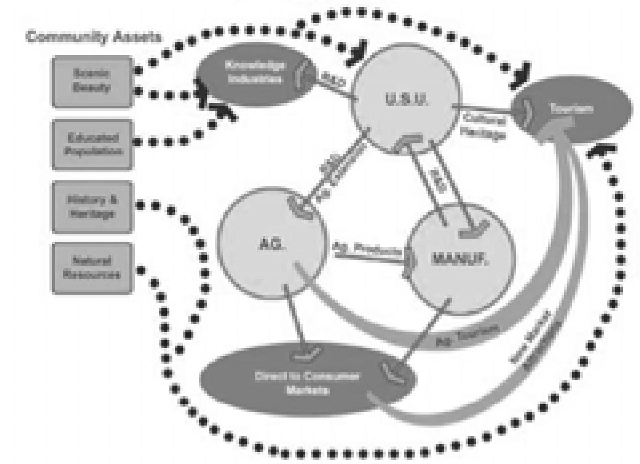
Architecture can thought of as a watershed – receiving, storing and cleaning up precipitation for domestic use and irrigation while reducing urban stormwater and heat island effects.

WATERSHED PLANNING



All watersheds contribute to the overall economy – the water flow distributes nutrients, soils and huge mechanical energy.

ECONOMIC LINKAGES

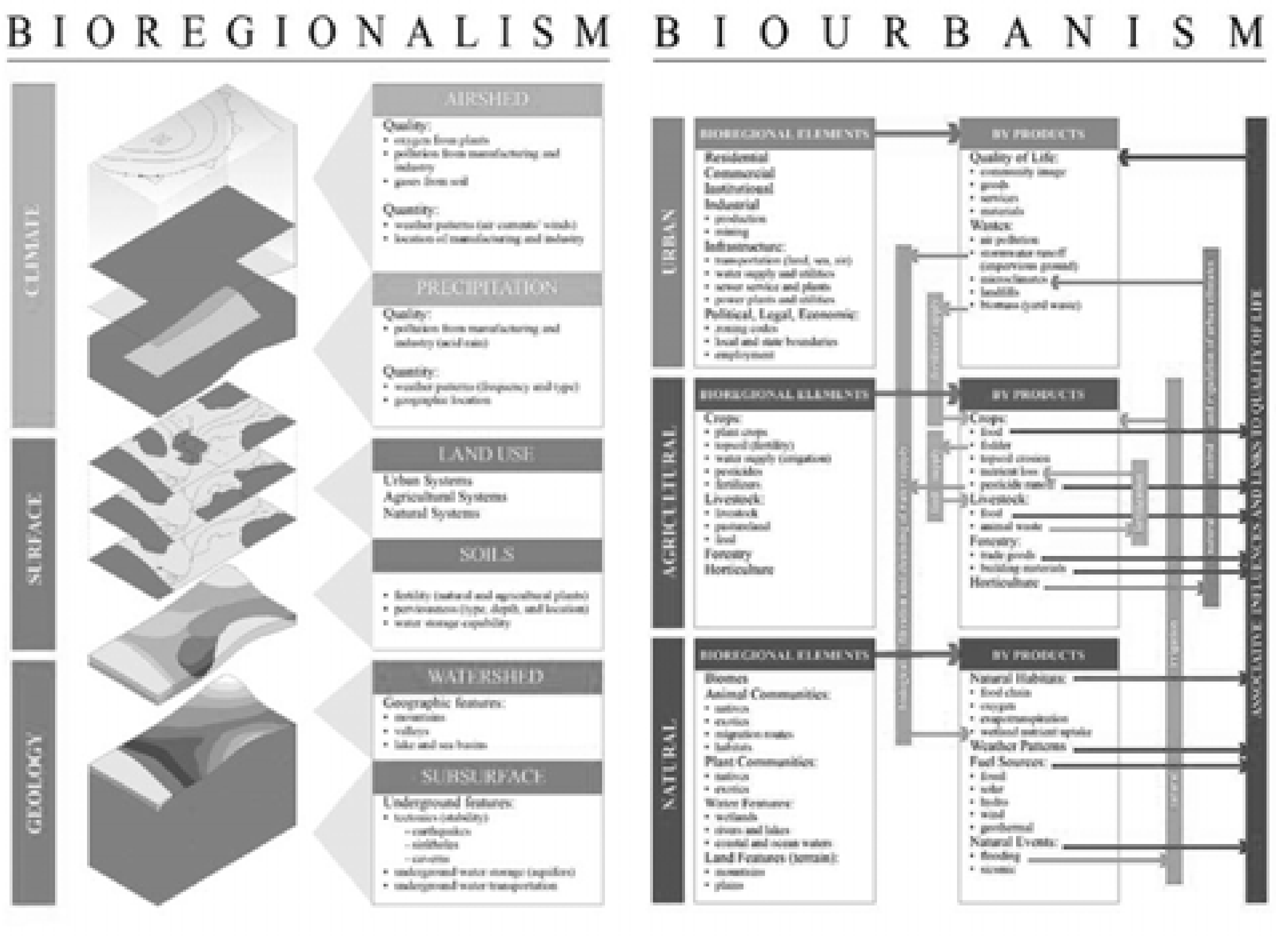


All watersheds receive precipitation it is the condition and quality of the surface…the slope, imperviousness, texture and absorption that determine the quality and quantity of water stored.

All precipitation has a place to go and a function to perform. Runoff from surfaces create streams and rivers that supply lakes with nutrients and organic matter that create a balance of energy, resources and cycling – providing life and green infrastructure functions.

Water flows from upstream and upland flow to the coastlines creating a fertile estuary zone comprised of salt and fresh water and creating a extremely rich and diverse ecology.

The view of the watershed is the defining layer between the geologic shed, that ara of soil and geological type that determines the region's ability to store and clean up water—and the airshed.

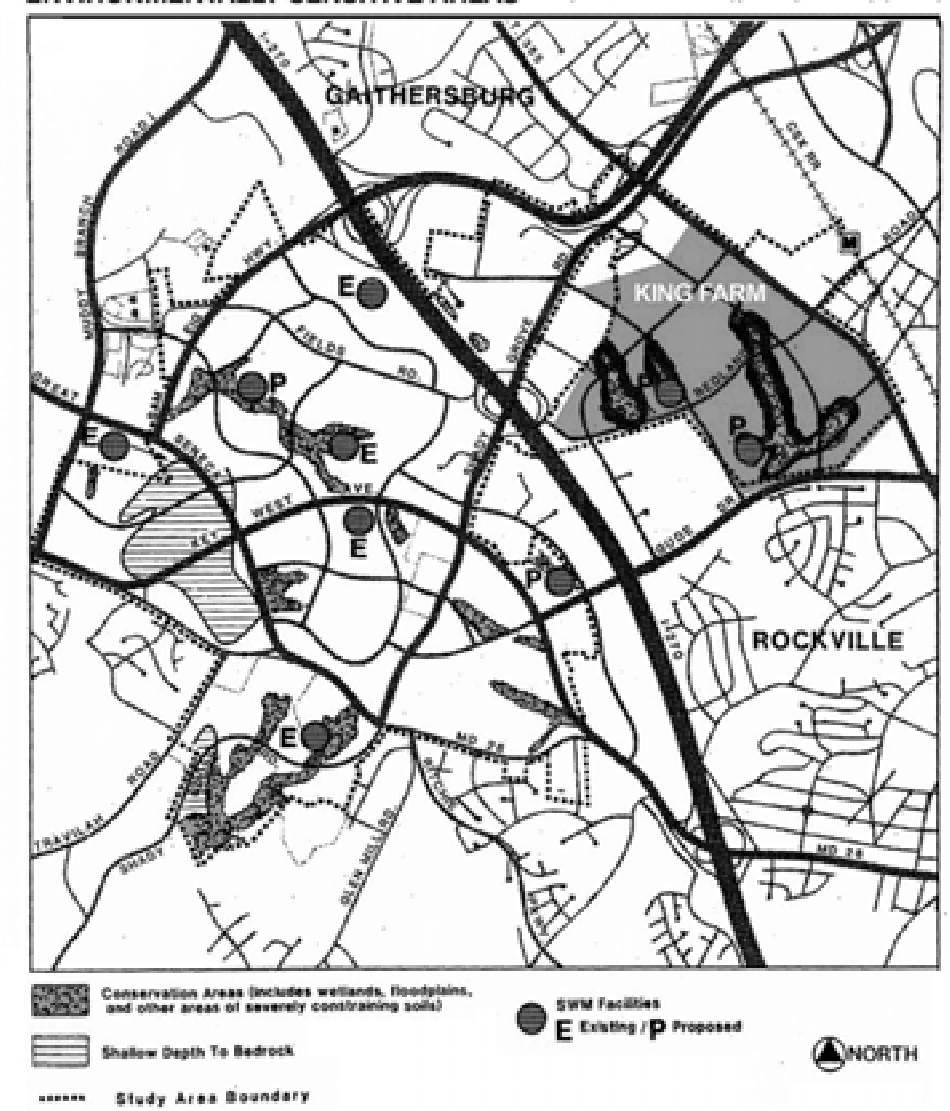


The ecological balance of distribution of water and use is the determining factor in biological systems.

Water and air determine most of the movement of materials, chemicals and organics.

BIOREGIONALISM & BIO URBANISM
Daniel Williams, FAIA

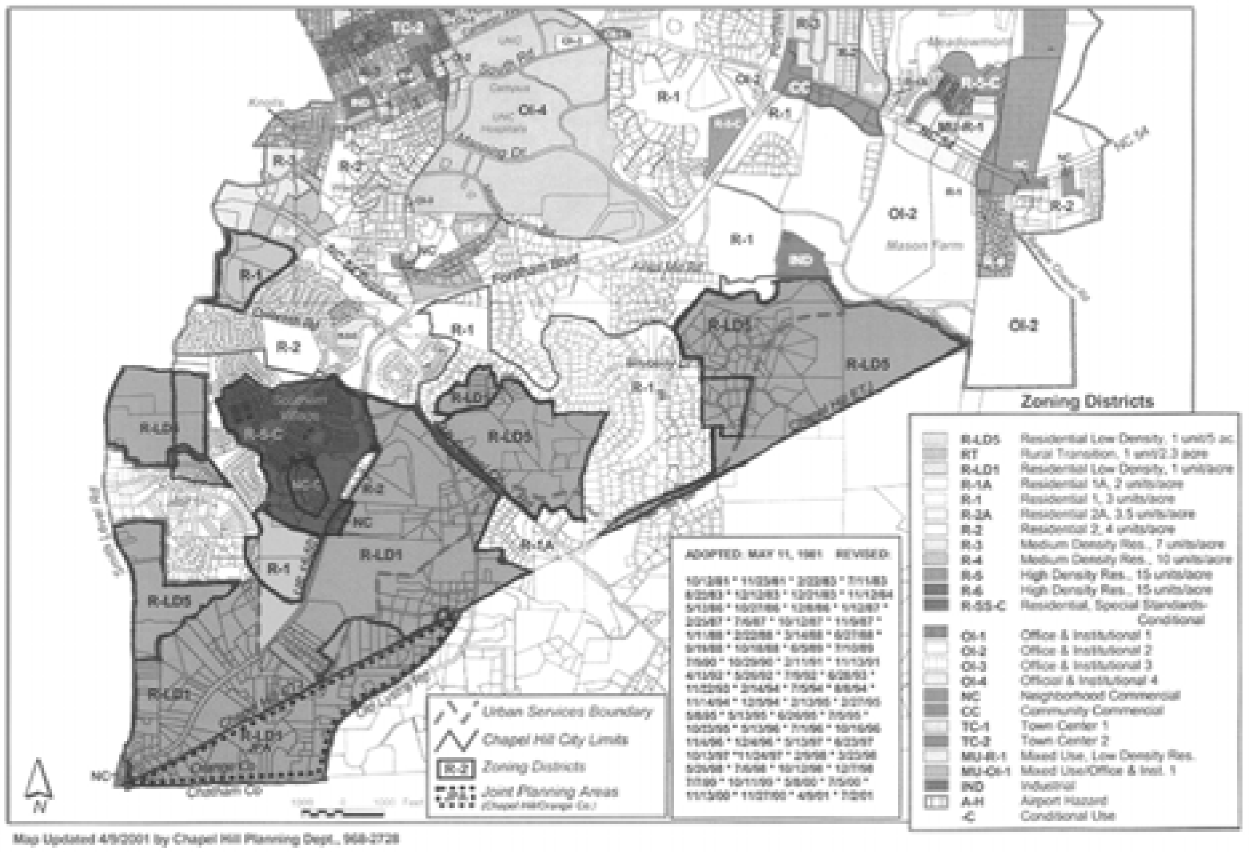
ENVIRONMENTALLY SENSITIVE AREAS adapted from Mountgomery County (1990)



A conservation area suitability analysis can frame a site so designers may cluster development to minimize impact on water resources. The example above illustrates the framework provided to King Farm site designers prior to their work.

Montgomery County. (1990). Shady Grove study area master plan. Silver Spring, MD Maryland-National Capitol Park and Planning Commission, Montgomery County

LAND USE SUITABILITY ANALYSIS
Joe MacDonald, AICP



Down Zoned

Up Zoned

SOURCE: Town of Chapel Hill (2001)

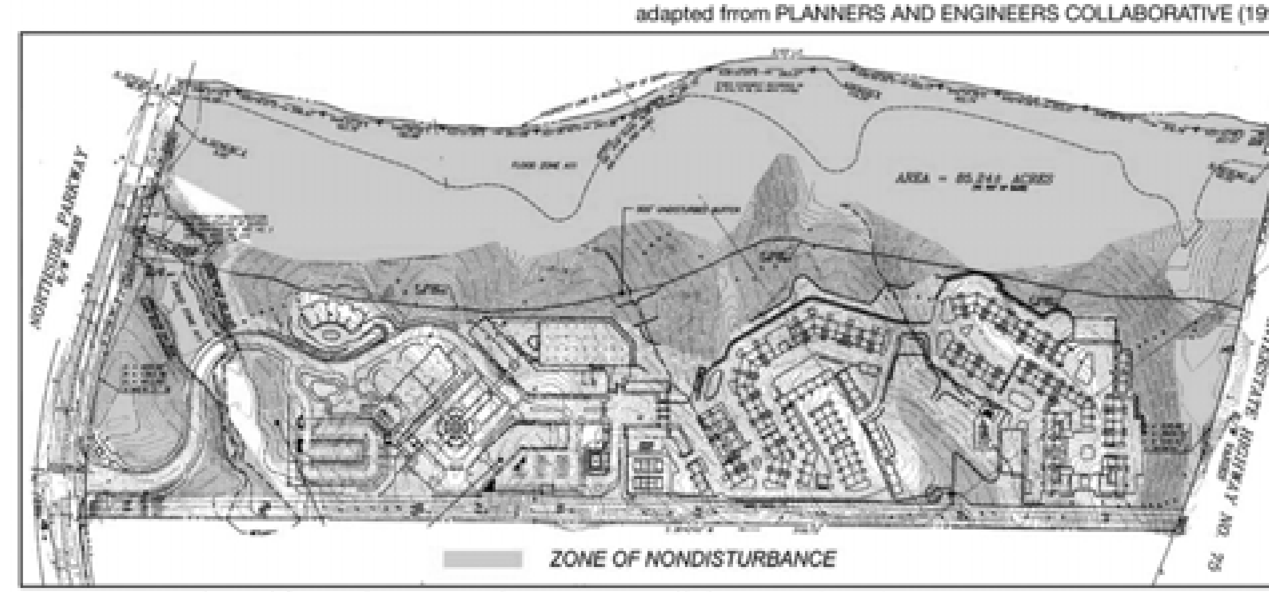
Transfer of development density from more sensitive areas (down-zoning) to less sensitive areas (up-zoning) may effectively protect water resources within planning jurisdictions. There are two primary challenges for site designers: 1) ensure that the overall density does not increase or decrease (the same number of units reduced in more sensitive areas equals the same number of units increased in less sensitive areas); and 2) apply water resource-protective design strategies to both new higher-density (up-zoned) areas and new lower-density (down-zoned) areas. The above example illustrates the density transfer applied in Chapel Hill, North Carolina to accommodate the new Southern Village development.

Town of Chapel Hill. (2001). *Chapel Hill comprehensive zoning map*. Chapel Hill, NC

UP ZONE / DOWN ZONE

Joe MacDonald, AICP

adapted from PLANNERS AND ENGINEERS COLLABORATIVE (1996)



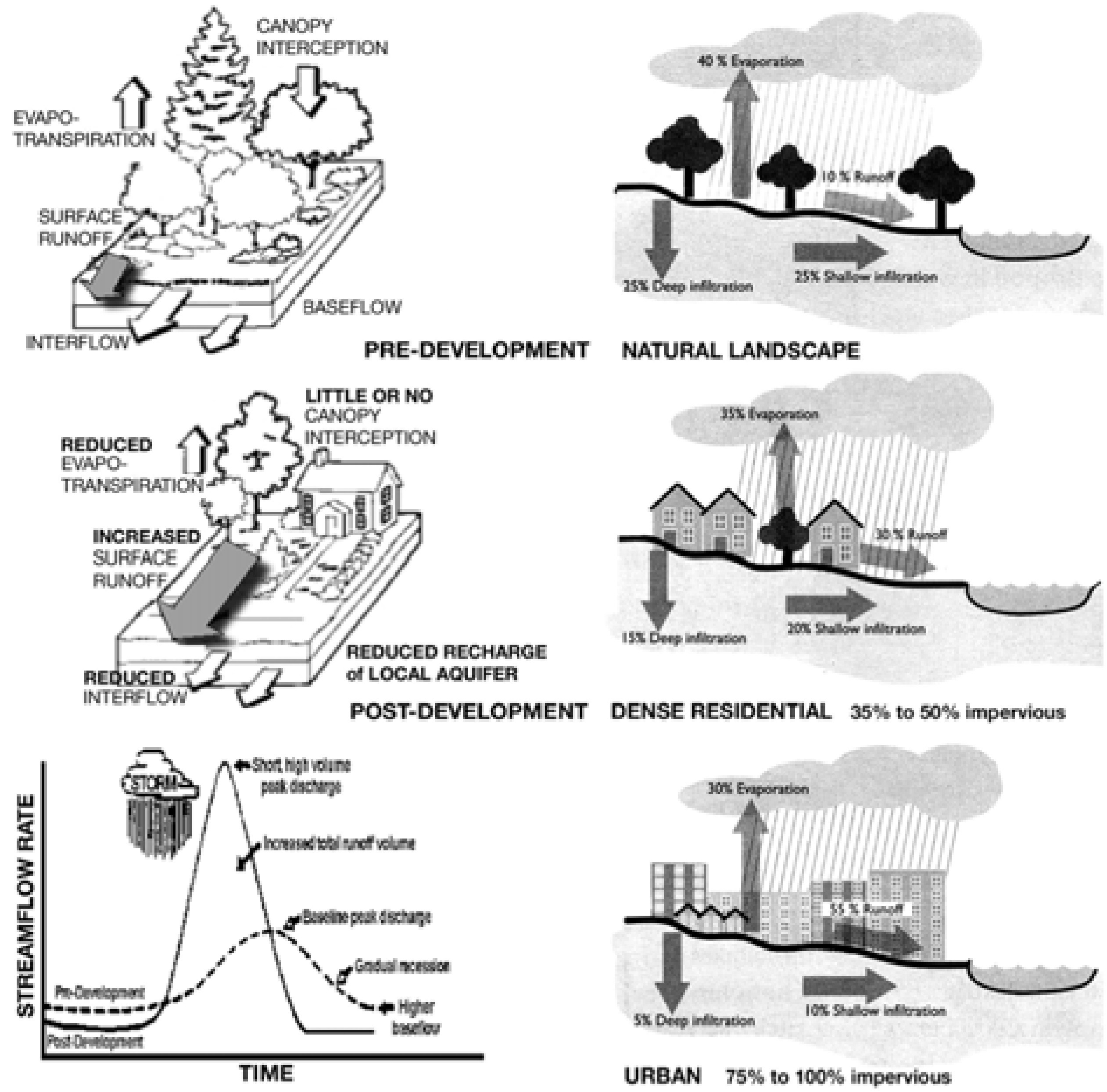
The zone of non-disturbance may work in tandem with a conservation area suitability analysis, but may also be applied on its own merit. Areas noted as sensitive on a regional scale may actually have pockets of land in which development would have a less harmful impact on water resources. The key is for site designers to be able to cluster development appropriately on the less vulnerable areas and avoid any disturbance of the more vulnerable areas. The example shown above is Riverside, a development along the Chattahoochee River in the Buckhead neighborhood of Atlanta, Georgia. While the site totals 85 acres, 49 acres (58%) have been designated within the zone of non-disturbance. Only 36 acres (42%) are disturbed for 527 residential units, office and retail space, and infrastructure.

Planners and Engineers Collaborative. (1996). *Riverside master concept plan*. Atlanta,

ZONE OF NO DISTURBANCE

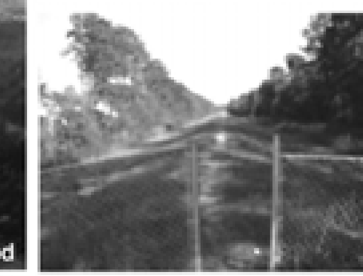
Joe MacDonald, AICP

TRADITIONAL DEVELOPMENT PRACTICE HAS TYPICALLY IGNORED NATURAL HYDROLOGY

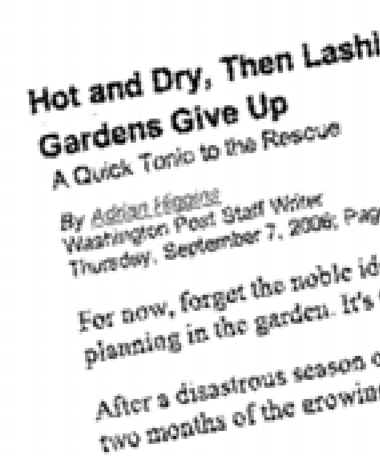


Adapted from: T. R. SCHUELER Controlling Urban Runoff 1987

HYDROLOGY & SITE DEVELOPMENT
Kaye Brubaker, PhD.



FLOOD PLAIN RESTORATION:
providing natural flood control, balance of local/downstream effects, connection, life-safety & ecosystem benefits



Hot and Dry, Then Lashing Rains:
Gardens Give Up
A Quick Tonic to the Rescue

By Adrian Higgins
Washington Post Staff Writer
Thursday, September 7, 2006; Page

For now, forget the noble id
planning in the garden. It's t

After a disastrous season o
two months of the growin

VARIABILITY:
providing an "adapt/respond" strategy, "return period", and increasingly severe storm events.

FLOOD PLAIN RESTORATION
Kaye Brubaker, PhD.

1996 flooding along Johnson Creek, Portland OR

PHOTOS: JIM LABBE AND CITY OF PORTLAND

BEFORE and AFTER Floodplain restoration along Johnson Creek

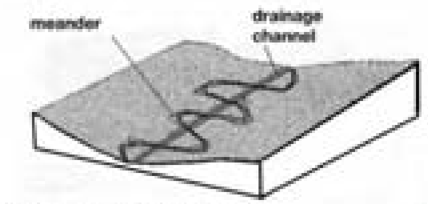
Portland has developed an aggressive, targeted program to restore floodplains along Johnson Creek focused on acquisition and restoration of key properties from willing sellers. Support for this program was generated by extensive property damage caused by flooding along the creek in 1996.beyond the economic benefits, the effort provides habitat for endangered salmonid species, improves water quality, allows for floodwater storage and helps restore nutrients and organic matter back to the stream.

In Portland, 45% of native wildlife species are dependant on riparian areas for their survival and at least 93 of native species use riparian areas for some portion of their lifecycle. Three species of listed salmonids, Coho, Chinook and steelhead, can be found in Portland area streams.

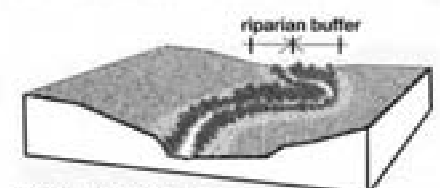
FLOODPLAIN RESTORATION

Bob Sallinger

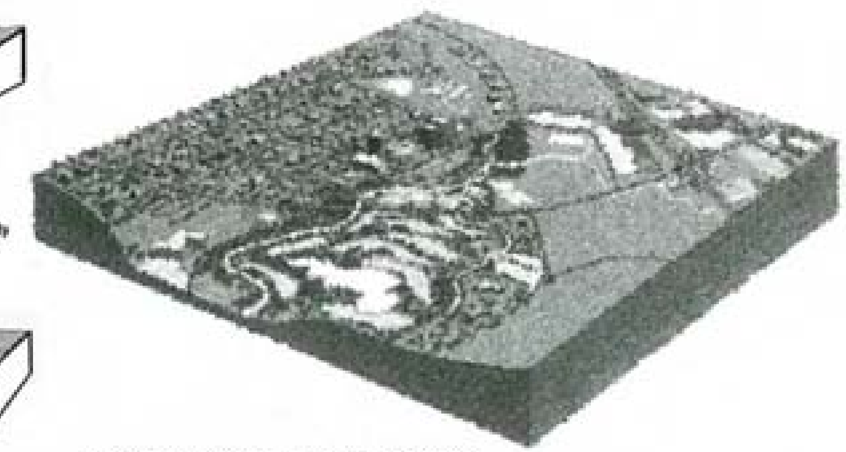
RIPARIAN BUFFERS are vegetated zones maintained alongside waterways and shorelines to provide a natural means to protect land and water quality.



STREAM MEANDER RESTORATION
reintroduces the natural dynamics to an engineered stormdrain to improve channel stability, habitat quality aesthetics and other stream corridor values.



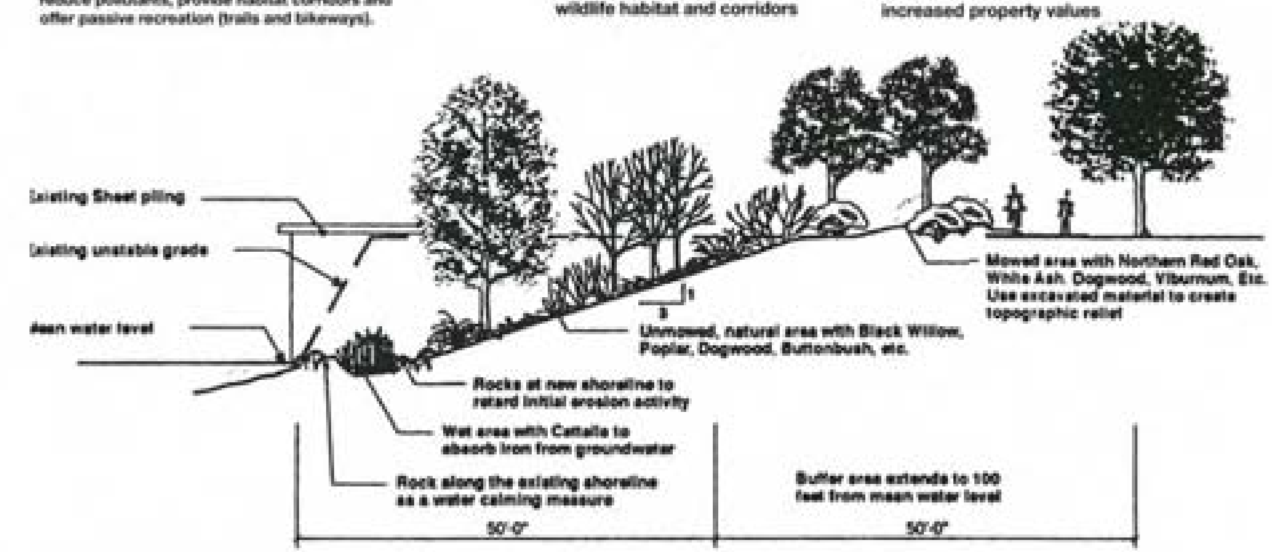
RIPARIAN BUFFER ZONE
provides streamside vegetation to improve water quality, slow storm water flow, reduce erosion, reduce pollutants, provide habitat corridors and offer passive recreation (trails and bikeways).



COMMUNITY BUFFER ZONE DISTRICTS

flood control
water quality improvement
wildlife habitat and corridors

open space
recreational trails
increased property values



SHORELINE RESTORATION - URBAN WATERWAY

FRIENDS OF BUFFALO RIVER, BUFFALO, NY 1996

SOURCE: *Time-Saver Standards for Urban Design* (2001)

RIPARIAN BUFFER ZONES

Donald Watson, FAIA

scales
REGIONAL / URBAN
COMMUNITY / NEIGHBORHOOD
BUILDING / INTERIOR

RIPARIAN ZONES

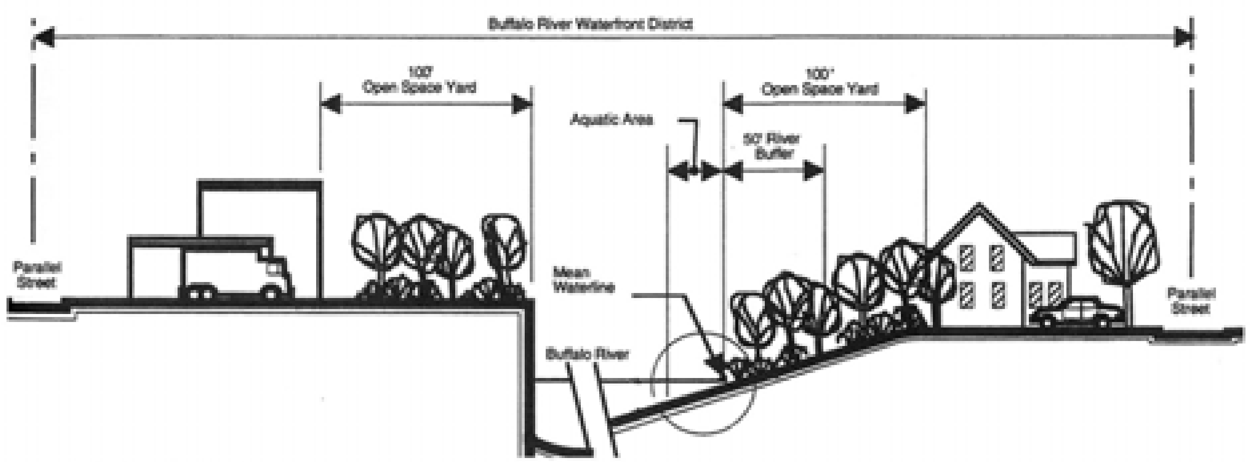
11

CASEY TREES U. VIRGINIA SCH. OF ARCHITECTURE

Activate the water edges with programs

" ' Buffer ' is not the right term.... think of green infrastructure as a commonwealth asset." William Morrish

DESIGN STANDARDS



TYPICAL CROSS SECTION - URBAN WATERWAY
with 100 ft. setback guideline of open space along that includes 50 ft. densely vegetated zone.

source: TIME-SAVER STANDARDS FOR URBAN DESIGN

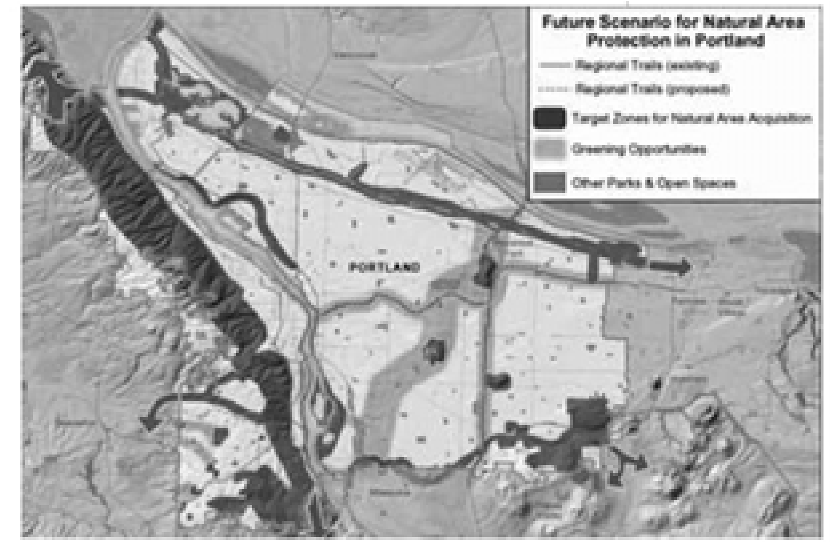
RIPARIAN ZONES / DISTRICTS
William Morrish

scales
REGIONAL / URBAN
COMMUNITY / NEIGHBORHOOD
BUILDING / INTERIOR

WILDLIFE HABITAT

12

As ribbons of green, stream and river corridors maintain connections with upland habitats, form an interconnected mosaic of urban forest and other fish and wildlife habitat, and contribute to our region's livability. Portland Metropolitan Region goal 5 fish and Wildlife Planning Process



CITY OF PORTLAND
WILDLIFE CORRIDOR
TRAGET AREAS

The Portland Metro Region is utilized by more than 209 avian species for some portion of their lifecycle. Three species of federally listed salmonids can be found in our waterways. The importance or protecting viable urban wildlife corridors is articulated by in the paper Endangered by Sprawl by Smartgrowth America et al (2004) which notes that out of approx 6400 imperiled species in the united States, 61% are found in urban areas and 31% are found exclusively in urban areas.

TEN UNIQUE ROLES THAT WATEREDGE BUFFERS PROVIDE:

1. absorbtive mat to replenish aquifer
2. spounge to reduce flooding impacts
3. roots to stabilize soil against erosion
4. vegetation to slow storm runoff
5. filter to cleanse surface pollution
6. shade to cool water
7. wildlife corridors
8. richly biodiverse natural habitat
9. aquatic plants to protect small fish
10. nature trails and bikeway paths

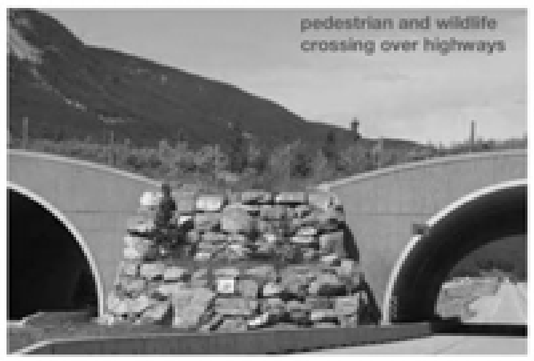
SOURCE: www.DonaldWatson.COM

WILDLIFE CORRIDORS
Bob Sallinger

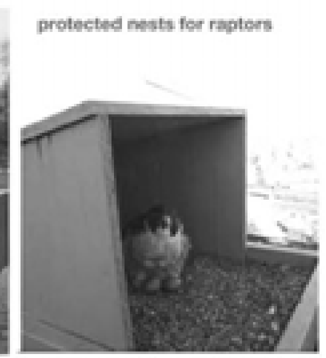
WILDLIFE HABITAT

Integration of structural design features that promote desired wildlife populations, reduce human-wildlife conflicts, and decrease wildlife mortality.

Water-oriented design features will inevitably attract wildlife. While some are specifically designed for this purpose, far too many projects fail to adequately consider wildlife management issues that may occur as a result of construction. Audubon Society of Portland responds to more than 15,000 urban wildlife related phone calls each year. A large portion of these involve conflicts between humans and wildlife that could have been prevented by proactive consideration of local wildlife populations in the design phase of construction projects.


pedestrian and wildlife crossing over highways


wildlife tunnels under highways


protected nests for raptors

SOURCE: Urban Greenspaces Institute, Audubon Society of Portland

DESIGN STRATEGIES ON BEHALF OF WILDLIFE AND HUMAN HEALTH
The health of wildlife is a measure of community environmental health. Healthy predator/prey balance and biodiverse habitat are a natural means to reduce disease vectors carried by insects and animals.

LANDSCAPE
- Provide continuous wildlife pathways, including highway crossings.
- Eliminate pesticides. Encourage wide use of natural means of insect control.
- Provide riparian buffers around ponds in public parks to discourage Canadian Geese from active recreation areas.
- Provide wildlife secure compost and trash containers.
- Use deer exclosures, especially to maintain critical planting habitat.

BUILDINGS
- Provide beam and ledge designs to avoid pigeon and starling nesting / human conflicts.
- Design windows to reduce bird strikes, such as soft net veiling and night shading of windows that attract birds. www.birdsandbuildings.org
- Provide underporch screens and chimney caps to prevent nesting and animal intrusions.

PUBLIC EDUCATION
- Promote responsible pet care. Many wildlife problems are blamed upon or ensue from overpopulation of feral / discarded pets.
- Provide interpretive signage and programs to encourage responsible stewardship of local wildlife populations.

DESIGN FOR WILDLIFE CONSERVATION
Bob Sallinger

NATIVE PLANTING


Site drainage swales and recharge zones

less flooding higher environmental quality

PHOTO: Katherine Oury


Utility rights-of-way


less costly to maintain more diverse habitat

PHOTO: Scott Bernstein


Roadway medians and buffers


greater traffic safety higher residental value

PHOTO: Daniel Williams, FAIA

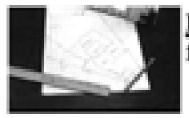
“GROWING - NOT MOWING”

scales
REGIONAL / URBAN
COMMUNITY / NEIGHBORHOOD
BUILDING / INTERIOR

NATIVE PLANTING

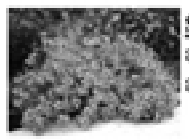
15

Xeriscape is a combination of seven gardening principles that save water while creating a landscape.

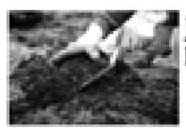


Plan and Design
for water conservation and beauty from the start.

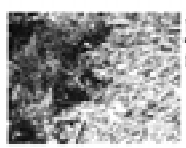
Create Practical Turf Areas
of manageable sizes, shapes, and appropriate grasses.



Select Low Water Plants
and group plants of similar water needs together. Then experiment to determine how much and how often to water the plants.

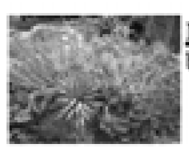


Use Soil Amendments
like compost or manure as needed by the site and the type of plants used.



Use Mulches
such as woodchips, to reduce evaporation & to keep the soil cool.

Irrigate Efficiently
with properly designed systems (including hose-end equipment) and by applying the right amount of water at the right time.



Maintain the Landscape Properly
by mowing, weeding, pruning and fertilizing

SOURCE: Xeriscape COLORADO (Colorado WaterWise Council)

Impact on Construction and Project Management

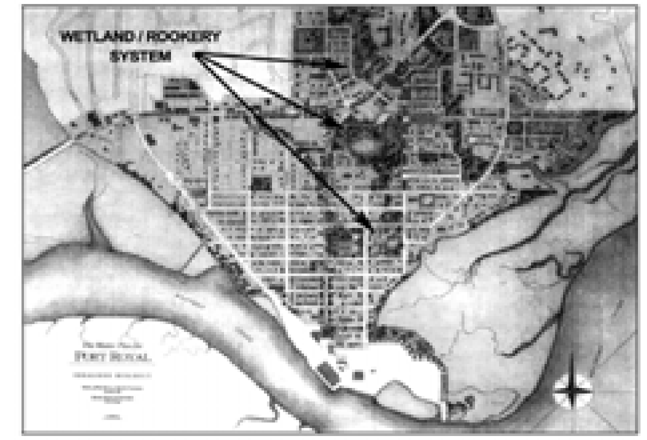
Xeriscape design requires greater sophistication by the contracting team to understand the workmanship, staging, and maintenance of the landscape work.

XERISCAPE
Steven G. Shapiro

scales
REGIONAL / URBAN
COMMUNITY / NEIGHBORHOOD
BUILDING / INTERIOR

RECONSTRUCTED WETLANDS

16



A wetland area as small as 200 SF, if supported by water flow, can be an effective reservoir for a biotic community.

Town of Port Royal SC

PHOTO: Joseph MacDonald and Michael Holmes

An in-town wetlands system replaces engineered stormwater drainage systems found in most urban communities. Here, the Town of Port Royal, South Carolina uses the system for natural drainage and, in extreme rainfall events, pumps excess runoff to the "headwaters" of the wetlands/rookery system. The runoff then meanders through the marshes and wetlands of the Town before it reaches Battery Creek and the Beaufort River. The freshwater marshes provide runoff control, biofiltration, and a natural sanctuary for local wildlife. The Town considers this method of stormwater treatment superior to constructed detention facilities because it utilizes the land's natural hydrology.

Dover, Kohl, & Partners. (1995). *The master plan for Port Royal*. Port Royal

IN-TOWN WETLANDS
Joe MacDonald, AICP

The Green Values Calculator **http://greenvalues.cnt.org**

Website provides information and design tools for professionals, municipal officals and public.

Green infrastructure is the interconnected network of open spaces and natural areas, such as greenways, wetlands, parks, forest preserves and native plant vegetation, that naturally manages stormwater, reduces flooding risk and improves water quality.

Green infrastructure ususally costs less to install and maintain when compared to traditional forms of infrastructure.

Green infrastructure projects also foster community cohesiveness by engaging all residents in the planning, planting and maintenance of the sites.

SOURCE: Center for Neighborhood Technology

Greenways
Raingardens
Wetland Restoration
Trees
Green roofs
Swales
Porous pavement
Native landscaping

GREEN VALUES CALCULATOR
Scott Bernstein

Urban design plan for a new town center in Burien, WA. The town center will be built on eleven acres of city owned land. The program includes a 40,000 square foot public library, a city hall, a community pavilion and town square, a civic theater and a mix of o□ ce, retail and housing all over underground parking.

The original natural drainage channel and □ow of the site had been obliterated years ago with the development of a number of large strip centers with massive parking lots.

The concept for organizing the town center form and layout was based upon reestablishing the natural drainage □ow and watercourse. And use it as an armature - the "generator of form" for the new town center. In other words, work with the form and □ow of the site instead of against the natural watershed of the site.

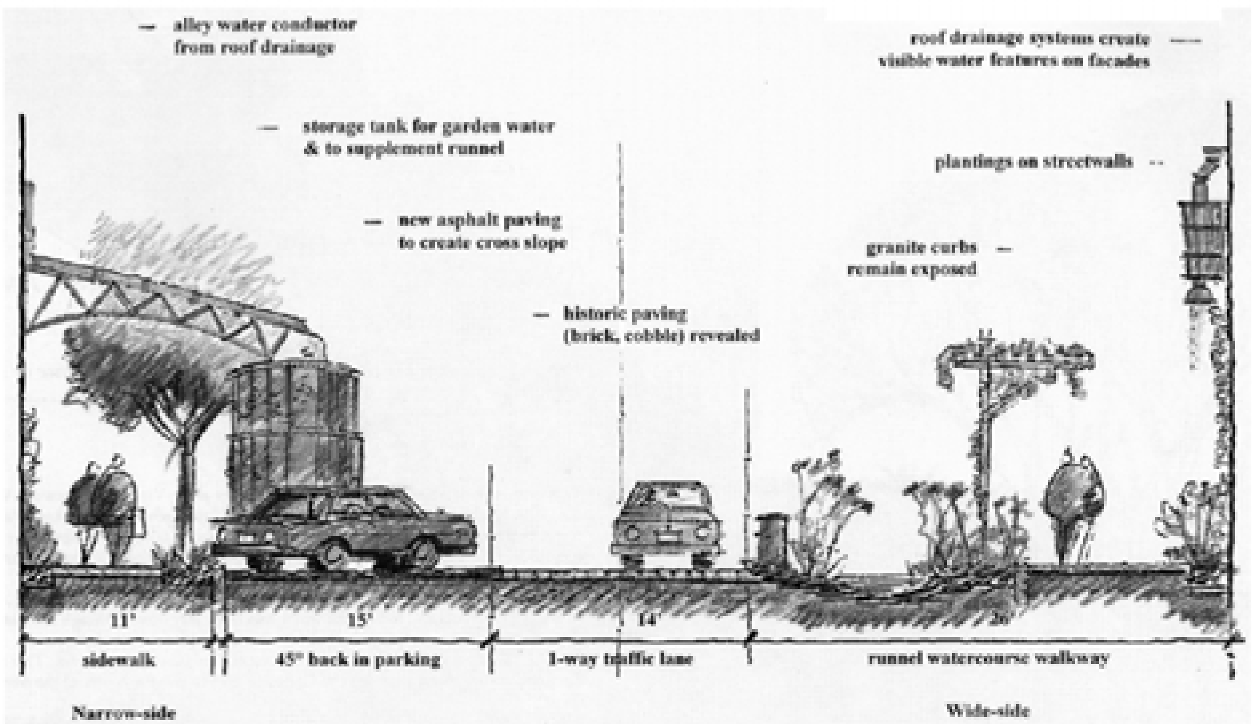
"DAYLIGHTING" urban water courses

Sweden

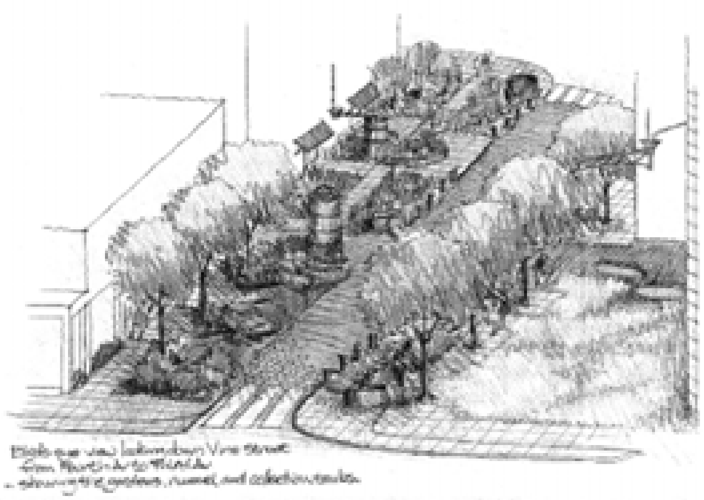
Denver, CO

SOURCE: Vivian Loftness, FAIA

URBAN DESIGN
Don Carlson, FAIA



GROWING VINE STREET, Seattle WA

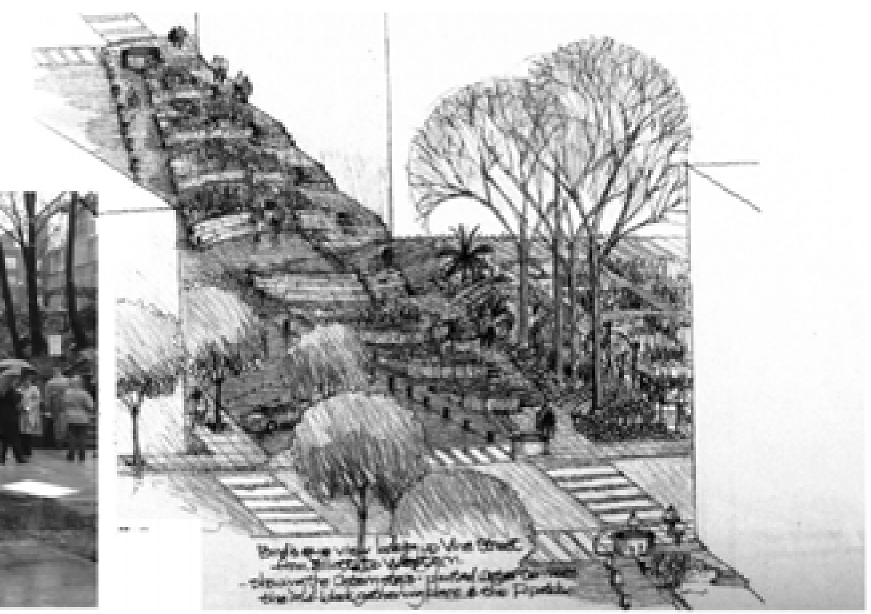


Growing Vine Street is a water harvesting and garden plan to take advantage of the urban watershed. Vine Street is an eight block street in a dense urban residential district in Seattle.

The goal is to take roof run-off that is usually piped into underground retention tanks that then meter rainwater into the sanitary sewer system and instead harvest the water for gardens and an urban amenity. Elements of the plan include a variety of downspouts, collection tanks/cisterns, a continuous water channel (runnel) and gardens (both community and cleansing.)

The cleansing gardens contain sedges and rushes that cleanse street run-off. The roof run-off can be used as water for garden irrigation (nitrogen from bird droppings makes good fertilizer).

URBAN STREET & WATERSCAPE
Don Carlson, FAIA



GROWING VINE STREET, Seattle WA

The cistern steps are a series of four terraced concrete tanks with water gardens built on a steeply sloping street. The tanks are designed to accept rainwater run-off from the roofs of adjacent buildings and then filter and clean the water as it descends from tank to tank until it is clean enough to go directly into Puget Sound at the bottom of the hill.

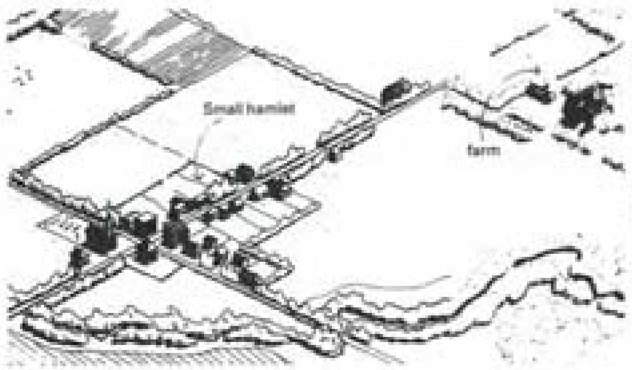
The goal of the garden system is to minimize the run-off entering the city's storm water drainage system by holding run-off to allow for some evaporation and to also naturally cleanse the run-off through a bio-garden system.

The tanks are filled with drainage gravel and water "cleansing" bio-filter plants such as sedges, rushes, scouring rush, arrowhead, bulrush and burreed which clean the water in its downhill path. Plants were also selected for the hardiness since they must survive through dry periods of the year.

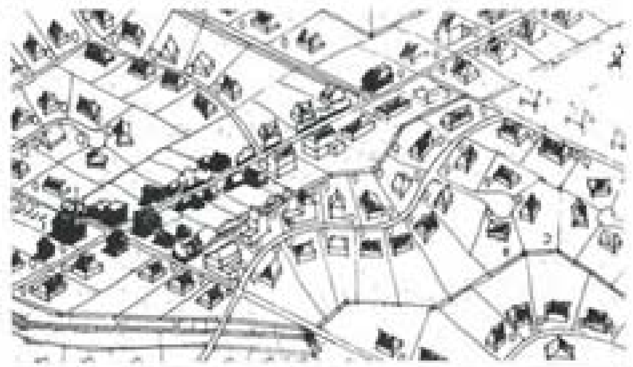
CISTERN STEPS
Don Carlson, FAIA

Community agriculture and community food gardens offer many advantages to support the health of community life, local economies and environment:

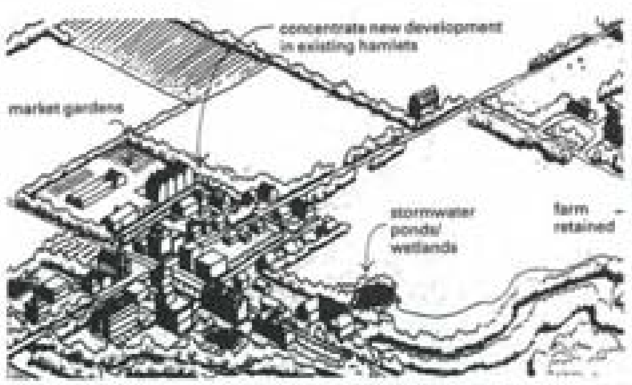
- **provides local sources of fresh, organic produce.**
- **uses water resources efficiently, including drip irrigation and hydroponics.**
- **recycles nutrients to compost and soil.**
- **reduces water used for long food chains of food handling.**
- **provides community-based economies and support.**
- **allows multi-uses of small scale land plots.**



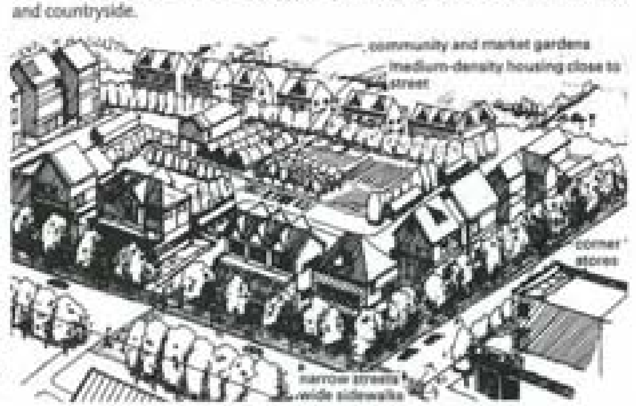
A The traditional rural village and surrounding countryside.



B Conventional subdivisions typically swallow up the traditional rural village and countryside.



C Clustering new development around the village leaves many rural functions, streams and woodland intact.



D Mixed used development can be associated with small-scale market gardens and other rural-based occupations such as plant nurseries, pottery and crafts and recycling operations.

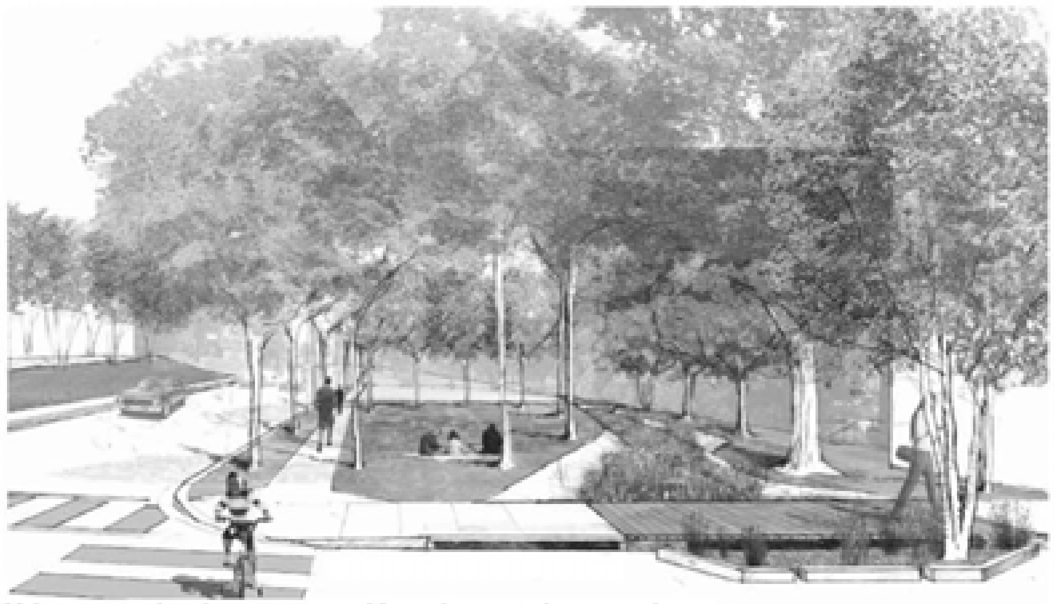
SOURCE: Michael Hough "Urban Farming" *Time-Saver Standards for Urban Design* (2001)

An entirely new approach to indoor farming, labeled "Vertical Farming" has been employed using cutting edge technologies. Vertical Farms, often many stories high, will be situated in the heart of the world's urban centers. If successfully implemented, they offer the promise of urban renewal, sustainable production of a safe and varied food supply (year-round crop production), and the eventual repair of ecosystems that have been sacrificed for horizontal farming. Advantages of Vertical Farming include: (i) year-round crop production; 1 indoor acre is equivalent to 4-6 outdoor acres or more, depending upon the crop; and (ii) no weather-related crop failures due to droughts, floods, pests.

SOURCE: The Vertical Farm Project

Impact on Construction and Project Management

For example, the proposed tower in Paris with penthouse farming (pictured above) creates new design and construction and introduces complexity and uncertainty to the process of project management and construction (for example weight load, drainage).



CASEY TREES U. OF VIRGINIA SCH. OF ARCHITECTURE

Urban tree planting supported by rainwater from roadway

Urban treescape project - Main Street, Ridgefield Park, NJ SOURCE: www.deeproot.com

In seven years, Main Street was transformed by an urban tree planting project, utilizing tree root barriers to hold and support water and soil nutrients, while also minimizing sidewalk damage.

MAIN STREET April 1994

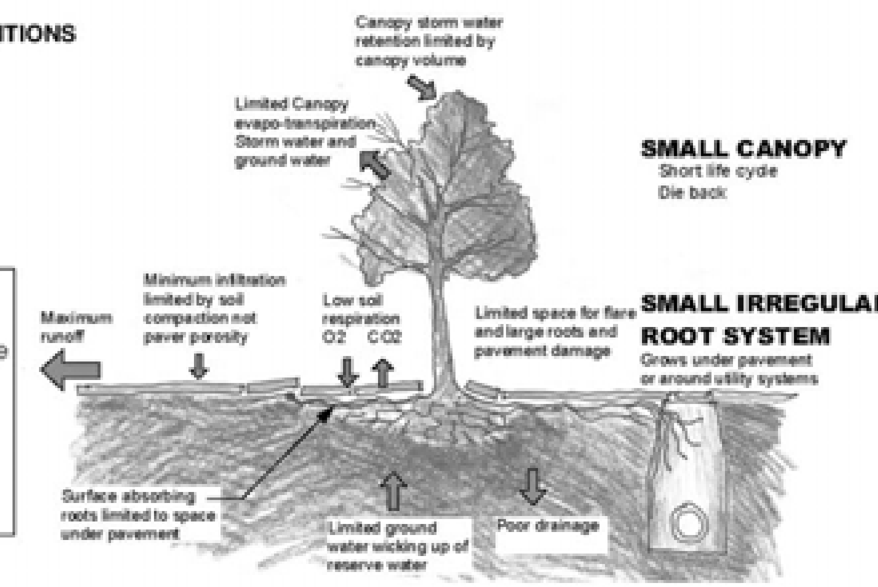
MAIN STREET May 2001

URBAN TREE PLANTING PROGRAMS

TREES WITH POOR SOIL CONDITIONS

characeristics of poor soil conditions

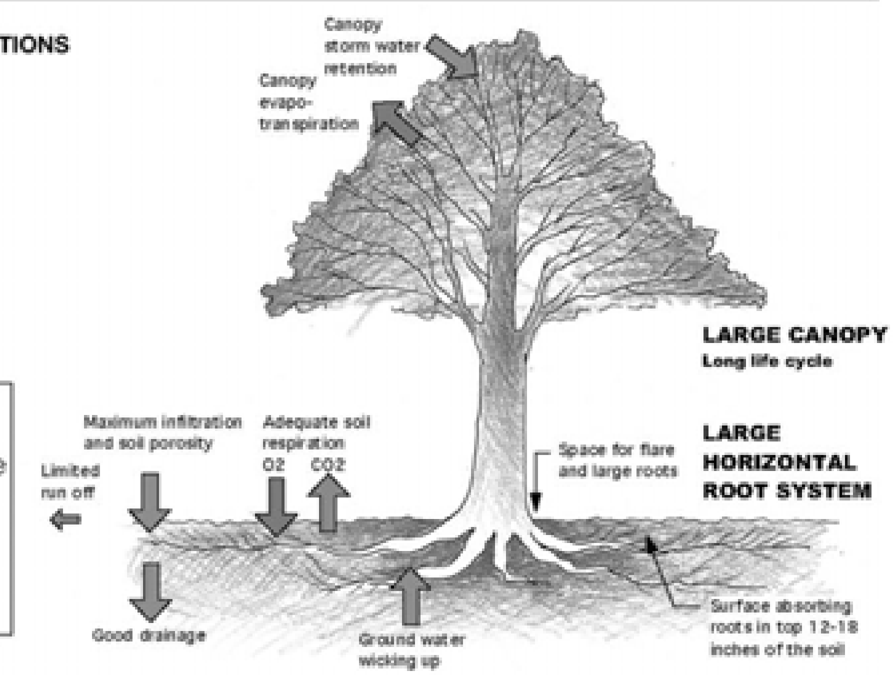
- Limited soil biology
- Low cation (nutrient) exchange capacity
- Poor water holding capacity
- Limited organic matter replacement
- High compaction



TREES WITH GOOD SOIL CONDITIONS

characteristics of good soil conditions

- Diverse, healthy soil biology
- High cation (nutrient) exchange capacity
- High water holding capacity
- Organic replacement
- Low Compaction



URBAN TREES & SOILS

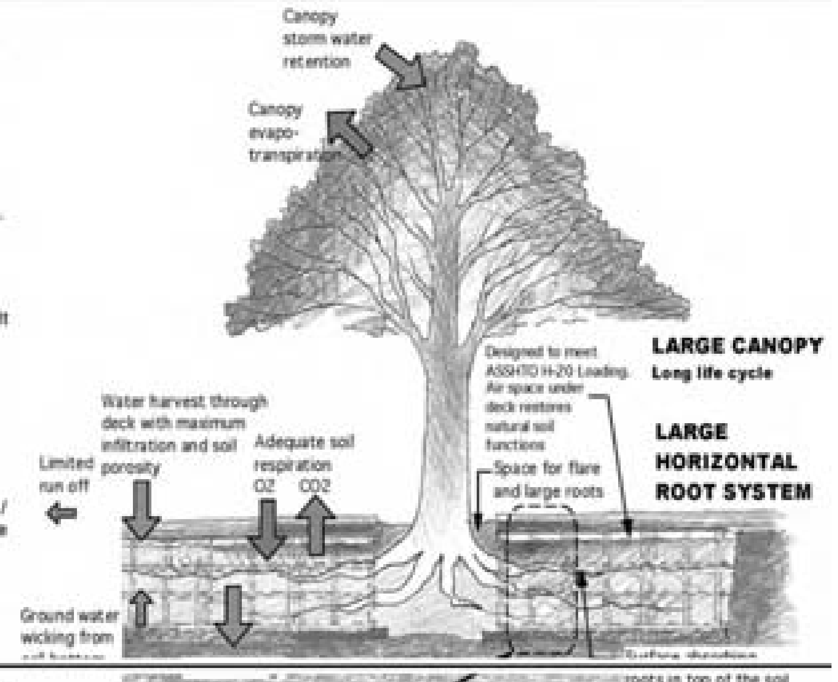
James Urban, FAIA

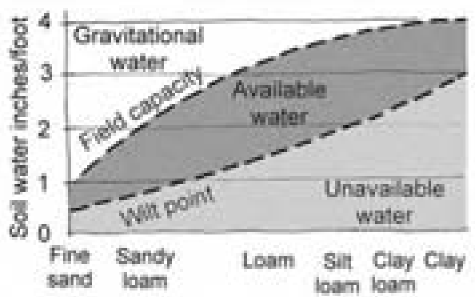
TREES WITH GOOD SOIL CONDITIONS AND STRUCTURAL CELLS

HOW CELLS INCREASE WATER CAPACITY

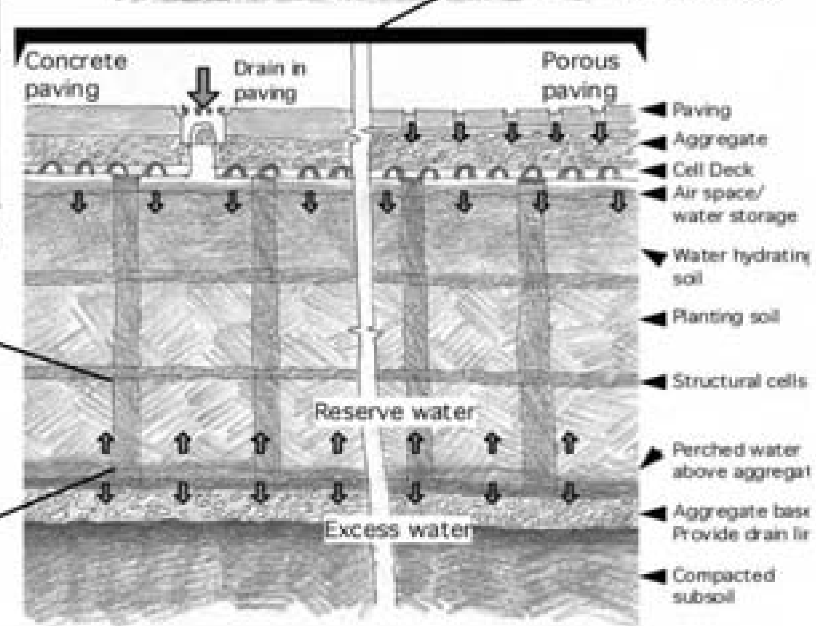
SOIL WATER HOLDING CAPACITY
NORMAL SOIL (without structural cell)
For soils compacted to optimum density for plant growth.
Gravitational water is held in the soil for approx. 24 hours. It slowly drains to lower soil levels or drainage system.
Available water is held in the soil until used by the tree. Water below the wilt point is the soil's base water level. It changes only during extreme drought.

WATER HOLDING AND STORAGE CAPACITY (with structural cell)
Three layers of Structural Cells, 48 in. deep, will hold up to 4 in./100 mm of **gravitational water** in the soil. This water is held for 24 hours or more after a storm event, then slowly released to the drain line.
Depending on soil moisture prior to the storm, up to 8 in./200 mm of **available water** can be held in the soil for the long term use by the tree. This water will be evapo-transpired back to the atmosphere by the tree.

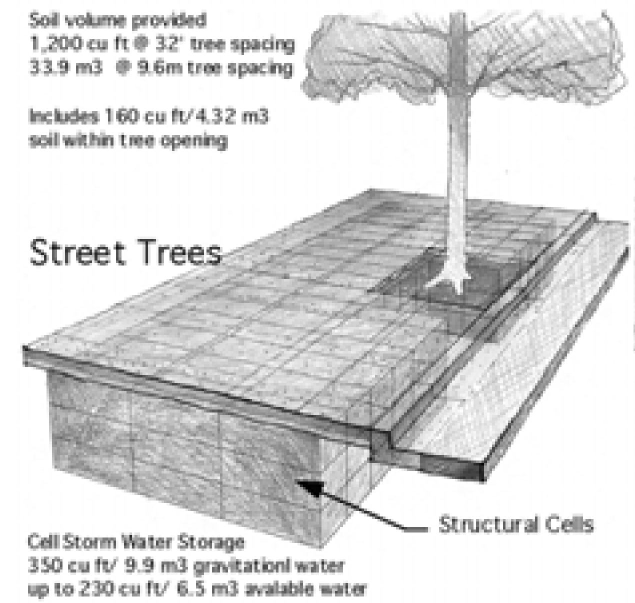


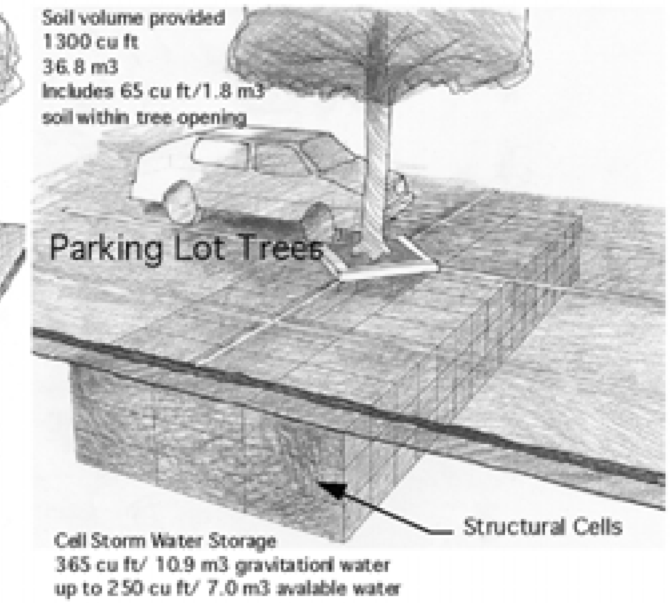


Structural Cells: DeepRoot Partners L.P
San Francisco, CA

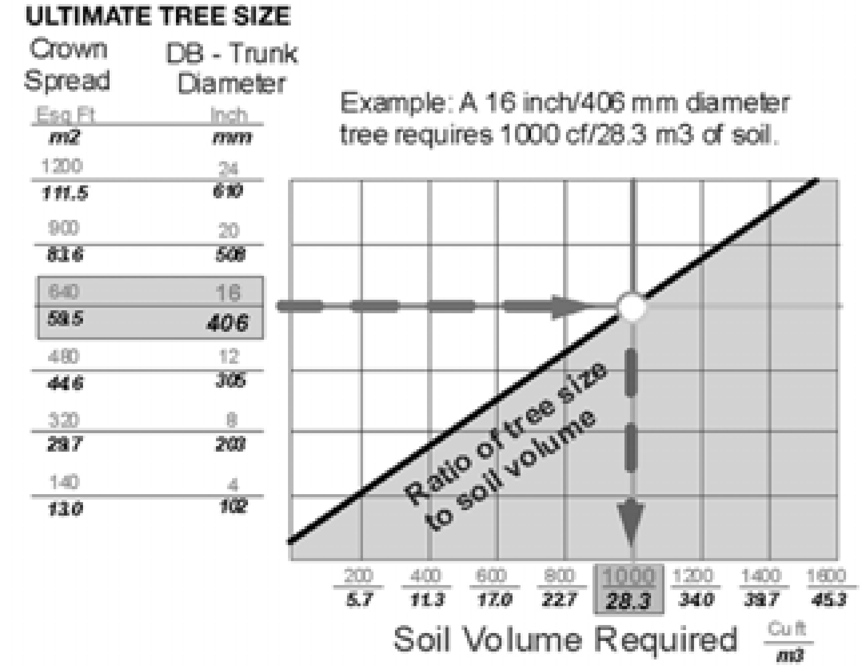


URBAN TREES AS STORMWATER UTILITY
James Urban, FAIA





ULTIMATE TREE SIZE



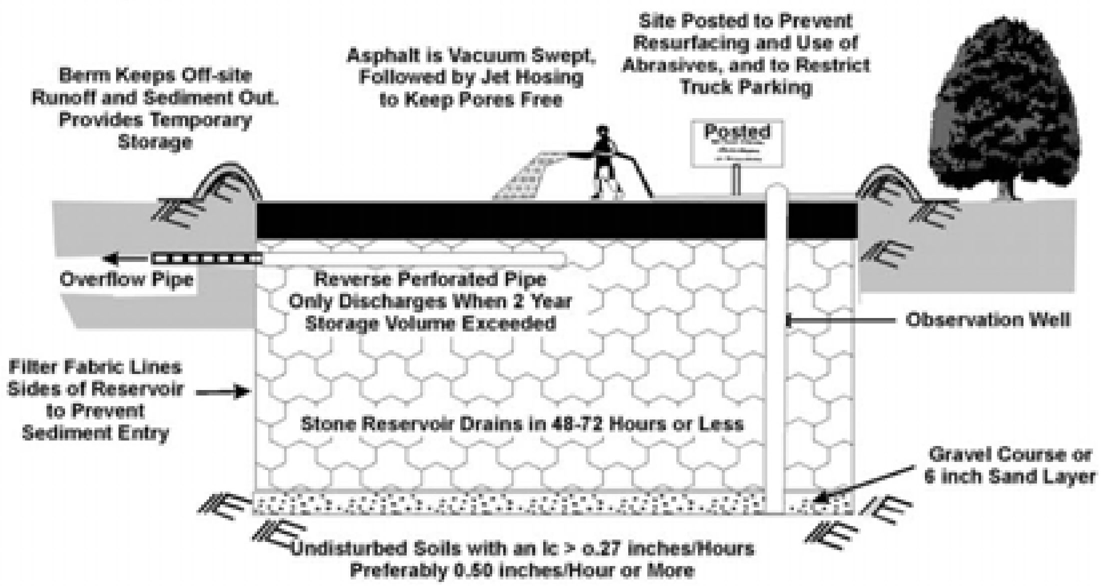
Soil Volume and Trees
The volume of good quality, well drained soil provided to the tree is directly related to the size the tree can become and length of time it can prosper in the urban environment.

Structural Cells efficiently provide the required soil volumes.

STRUCTURAL CELLS
James Urban, FAIA

Porous pavement is often a permeable pavement surface with a stone reservoir underneath. The reservoir temporarily stores surface runoff before infiltrating it into the subsoil. Runoff is thereby infiltrated directly into the soil and receives some water quality treatment. Porous pavement often appears the same as traditional asphalt or concrete, but is manufactured without "fine" materials, and instead incorporates void spaces that allow for infiltration.

Traditional stormwater management practices have led to a number of environmental concerns in recent years. As infiltration decreases, base flows in streams are decreased and previously flowing, small streams now often dry up between rains. Homeowners and public water suppliers often rely on wells that tap groundwater. Without recharge, the threat exists that these drinking water supplies could dry up rapidly.



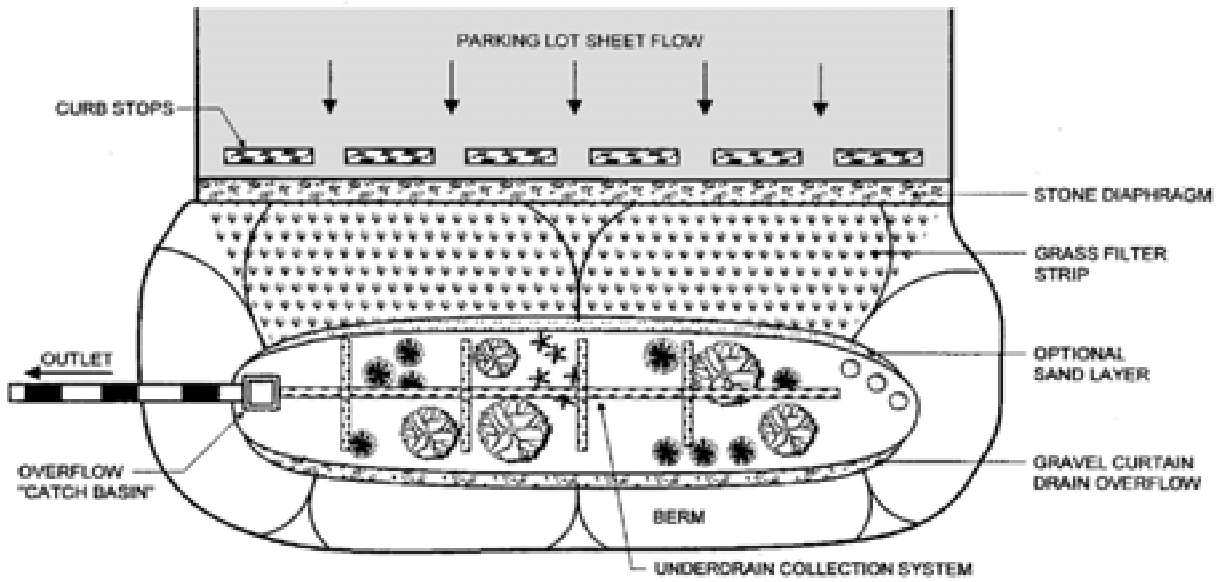
TYPICAL POROUS PAVEMENT INSTALLATION SOURCE: www.epa.gov/owm/mtb/porouspa.pdf

Impact on Construction and Project Management

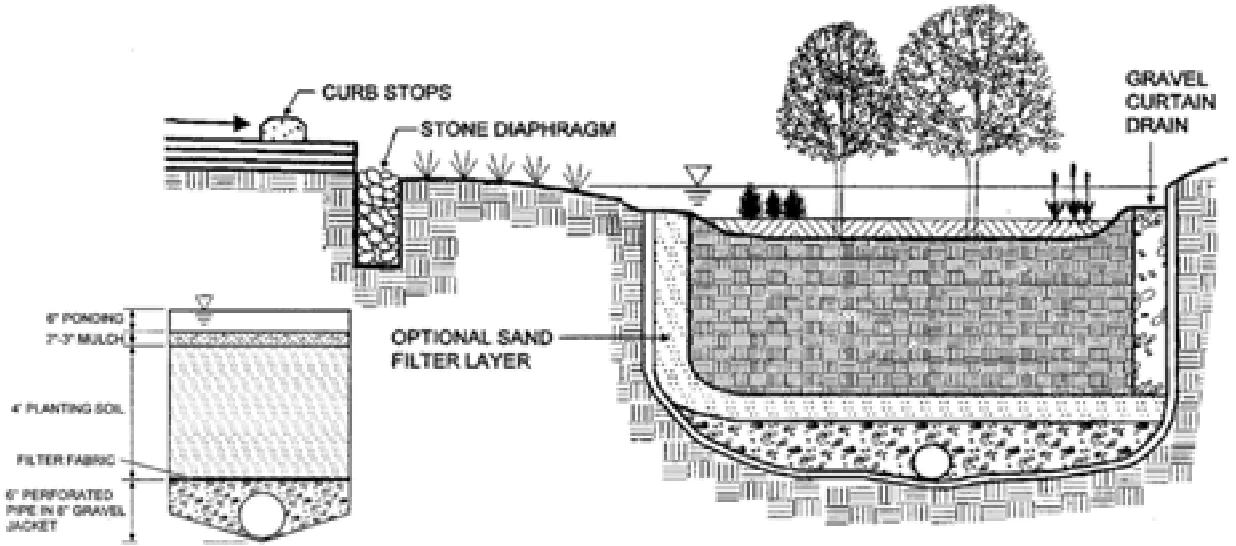
Porous pavement is a fundamental provision of sustainable design, but even a seemingly simple item can introduce issues for construction and management. For example, the general contractor must understand the material and workmanship before providing the guarantees and warranties specified in the drawings and under the contract with the owner.

DESIGN CRITERIA FOR POROUS PAVEMENTS www/epa.gov/owm/mtb/porouspa.pdf

Design Criterion	Guidelines
Site Evaluation	• Take soil boring to a depth of at least 1.2 meters (4 feet) below bottom of stone reservoir to check for soil permeability, porosity, depth of seasonally high water table, and depth to bedrock.
	• Not recommended on slopes greater than 5 percent and best with slopes as flat as possible.
	• Minimum infiltration rate 0.9 meters (3 feet) below bottom of stone reservoir: 1.3 centimeters (0.5 inches) per hour.
	• Minimum depth to bedrock and seasonally high water table: 1.2 meters (4 feet).
	• Minimum setback from water supply wells: 30 meters (100 feet).
	• Minimum setback from building foundations: 3 meters (10 feet) downgradient, 30 meters (100 feet) upgradient.
	• Not recommended in areas where wind erosion supplies significant amounts of windblown sediment.
	• Drainage area should be less than 6.1 hectares (15 acres).
Traffic conditions	• Use for low-volume automobile parking areas and lightly used access roads.
	• Avoid moderate to high traffic areas and significant truck traffic.
	• Avoid snow removal operations; post with signs to restrict the use of sand, salt, and other deicing chemicals typically associated with snow cleaning activities.
Design Storm Storage Volume	• Highly variable; depends upon regulatory requirements. Typically design for storm water runoff volume produced in the tributary watershed by the 6-month, 24-hour duration storm event.
Drainage Time for Design Storm	• Minimum: 12 hours.
	• Maximum: 72 hours.
	• Recommended: 24 hours.
Construction	• Excavate and grade with light equipment with tracks or oversized tires to prevent soil compaction.
	• As needed, divert storm water runoff away from planned pavement area before and during construction.
	• A typical porous pavement cross-section consists of the following layers: 1) porous asphalt course, 5-10 centimeters (2-4 inches) thick; 2) filter aggregate course; 3) reservoir course of 4-8 centimeters (1.5-3-inch) diameter stone; and 4) filter fabric.
Porous Pavement Placement	• Paving temperature: 240° - 260° F.
	• Minimum air temperature: 50° F.
	• Compact with one or two passes of a 10,000-kilogram (10-ton) roller.
	• Prevent any vehicular traffic on pavement for at least two days.
Pretreatment	• Pretreatment recommended to treat runoff from off-site areas. For example, place a 7.6-meter (25-foot) wide vegetative filter strip around the perimeter of the porous pavement where drainage flows onto the pavement surface.



BIORETENTION SWALE & TRENCH - plan view



TRENCH CROSS SECTION

SOURCE: California Stormwater BMP Handbook. 2003 WWW.cabmphhandbooks.com

BIORETENTION SWALE

CASEY TREES U. OF VIRGINIA SCH. OF ARCHITECTURE

Greenstreets

PHOTOS: A.P DAVIS, PHD. U. MARYLAND

Bioswales provide rain gardens, pollutant removal and groundwater recharge

Native planting and bioswale / rain gardens can flourish in landscaped areas alongside parking and roadways. It would reduce maintenance costs, reduce surface flooding and improve beauty and environment of the more than 2,500 million miles mowed each year along the nation's highways.

BIOSWALES
Kaye Brubaker, PhD.

scales
REGIONAL / URBAN
COMMUNITY / NEIGHBORHOOD
BUILDING / INTERIOR

BIOSWALES / RAINGARDENS

31

CASEY TREES U. OF VIRGINIA SCH. OF ARCHITECTURE

Directing downspouts to raingardens

Green stormwater solutions can play a significant role in protecting wildlife corridors in heavily developed urban areas where acquisition and regulatory protection may not be viable. In 2006, the city of Portland adopted a Watershed Management Plan that requires the City to green stormwater solutions in the design phase of ALL city projects. Green stormwater solutions are prioritized based on their impact on water quality, water quality, habitat potential and protection of biological communities.

RAINGARDEN - Portland Convention Center

Curb extension

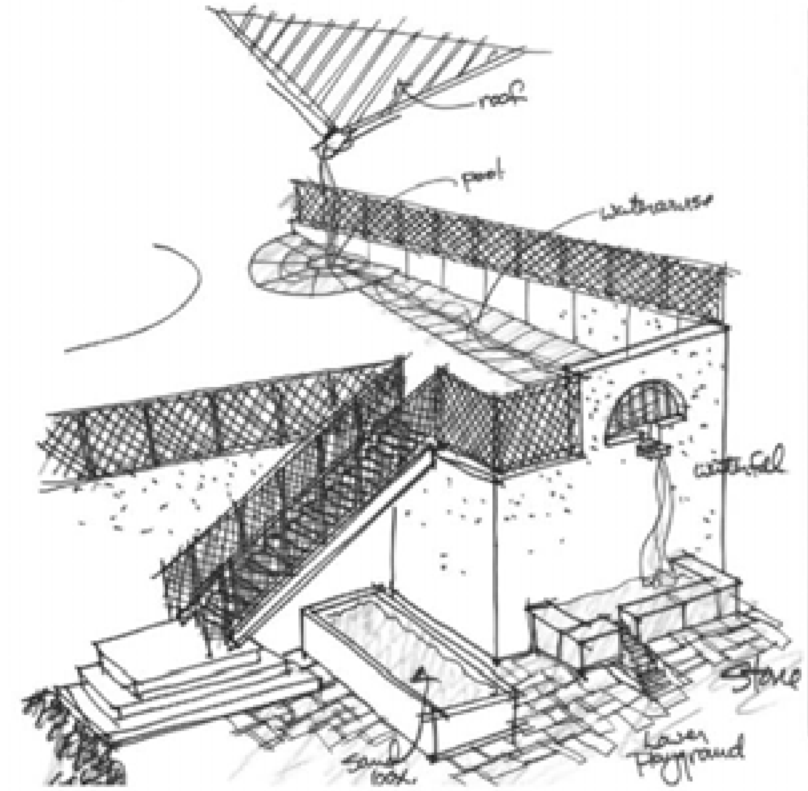
PHOTOS: Jim Lanne, Mike Houck, Bob Salinger, CIty of Portland

RAIN GARDENS
Bob Sallinger

scales
REGIONAL / URBAN
COMMUNITY / NEIGHBORHOOD
BUILDING / INTERIOR

RAINWATER HARVESTING

32



University Child Development School is an independent early elementary and elementary school in Seattle. The educational philosophy is based upon experiential learning meaning that the students learn by doing and not by being taught.

A rainwater run- o□ course was designed into the architecture of the school. Rainwater is channeled o□ of the roof and falls an urn which outlets into an angled stone water course that slopes to an opening in a wall where it falls eleven feet into a pair of stone urns and then □ows to the drain.

The children experiment with hydrology - water □ow, containment and energy by constructing dams and a variety of devices to in□uence the rainwater as it □ows o□ of the building.

RAINWATER & EDUCATIONAL PLAY
Don Carson, FAIA

GREEN ROOFS

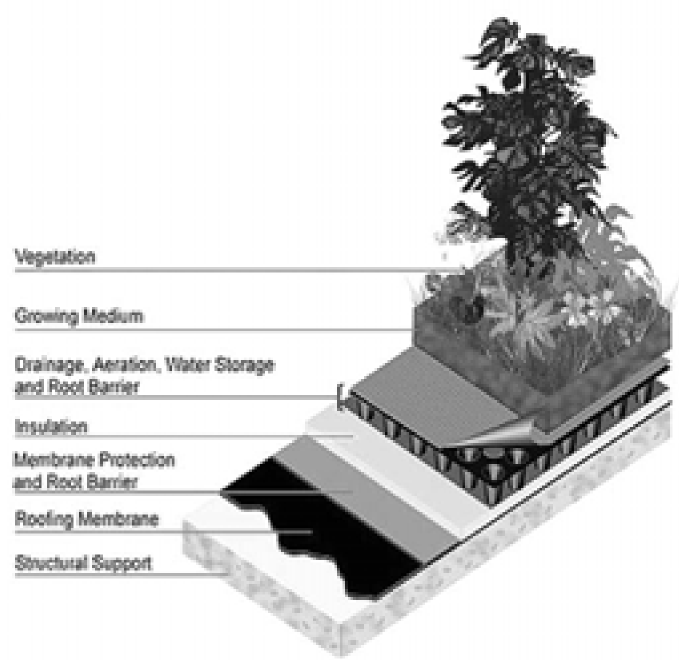
Green roofs provide multiple advantages

- Slows and stores rainfall
- Creates a cool roof and microclimate
- Protects roof membranes
- Provides safe bird foraging zone
- Supports low maintenance planting
- Is an aesthetic feature: a fifth facade

PHOTO: www.bakor.com

PHOTO: www.wildlife-gardening.org.uk

PHOTO: www.cmu.greenpractices



SOURCE: GREAT LAKES WATER INSTITUTE WWW.UWM.EDU

GREEN ROOF DESIGN
Vivian Loftness, FAIA

LIVING WALLS

Water and planting provide evaporative cooling of public spaces

CANALS & LIVING WALLS Japan

Living walls with drip irrigation provide evaporative cooling and water purification

LIVING WALL - Waterloo University

Sweden

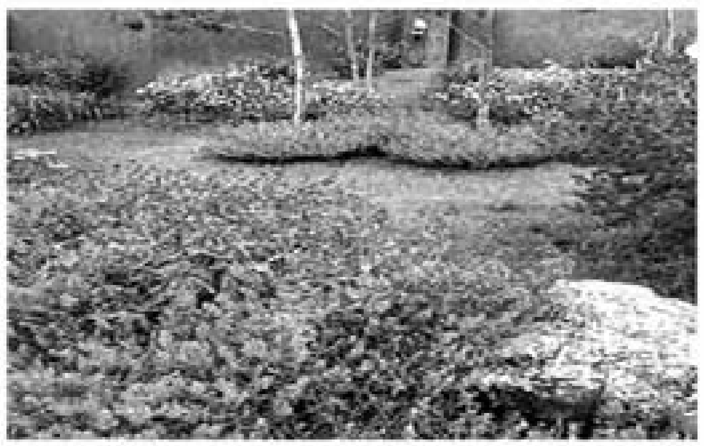
MICROCLIMATIC MODERATION
Vivian Loftness, FAIA

ENERGY PRODUCTION CONSUMES WATER

H_2O = kW = CO_2

1 gallon H2O = 1kW = 1.34 lbs of CO_2
energy conservation = water conservation

50% reduction in AIA residential energy guidelines will save 3.84 trillion gallons of water per year



NATIVE LANDSCAPING
makes possible a 60% reduction in water use

LOW FLOW WATER-SAVING APPLIANCES
makes possible a 10% reduction in water use

GOAL
WATER CONSUMPTION
gallon per 6 acres
gallon per home per year

FACT CHECK
check
w/ Michael Ogden

RECYCLE & REUSE

passive green technologies

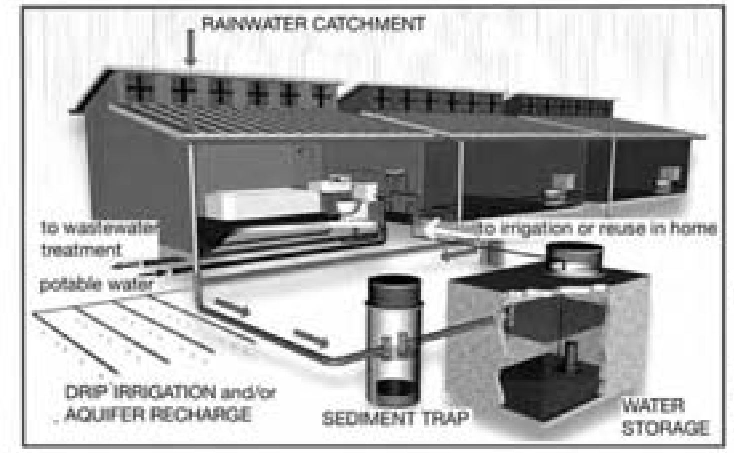
CO2 sequestration in irrigated tree planting

constructed wetlands for water treatment

use of treated grey water in buildings

use treated grey and brown water in irrigation

WATER CONSERVATION MEASURES
Michael Ogden, P.E.



STORM WATER HARVESTING

Every gallon of harvested water =
one gallon less of potable water use
one gallon less of run-off

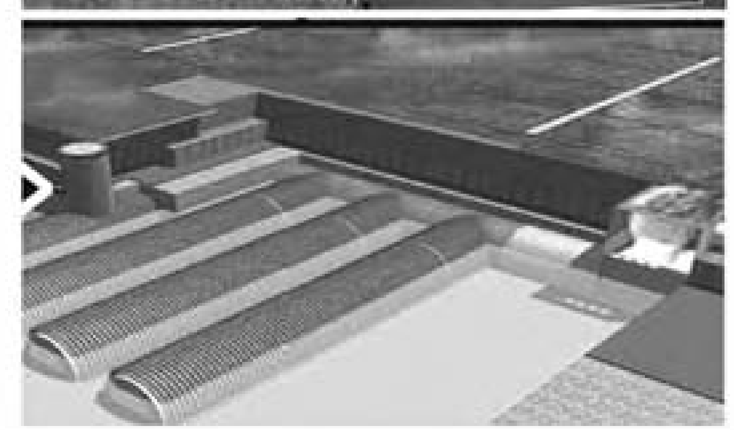
STORM WATER MANAGEMENT

Vegetated bioswales

Stormwater retention basis & aquifer recharge

Stormwater wetlands

Retention & recharge

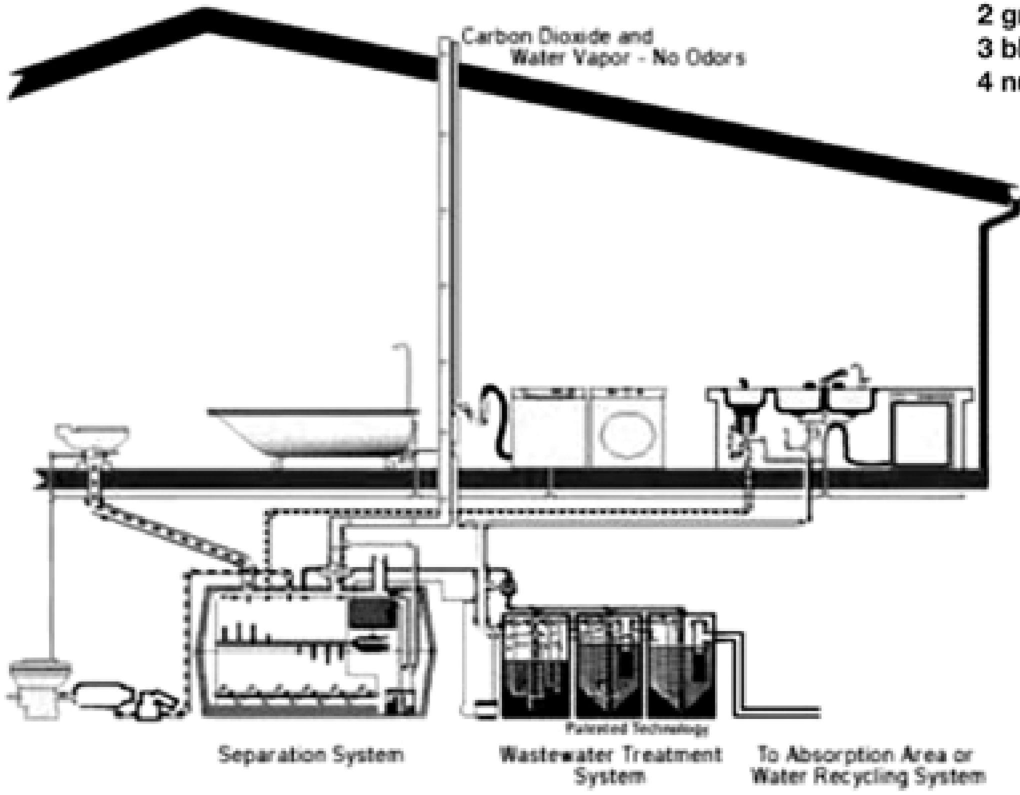


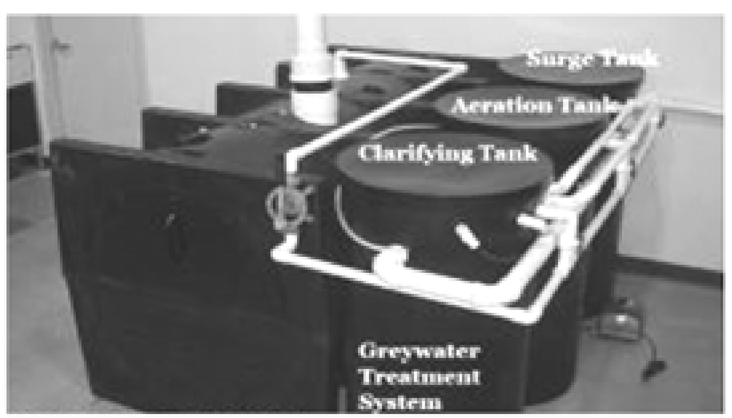
CLEAN IT
KEEP IT
USE IT

WATERSHED MANAGEMENT
Michael Ogden, P.E.

CYCLES OF WATER USES

1 potable
2 gray water
3 black water
4 nutrient recovery

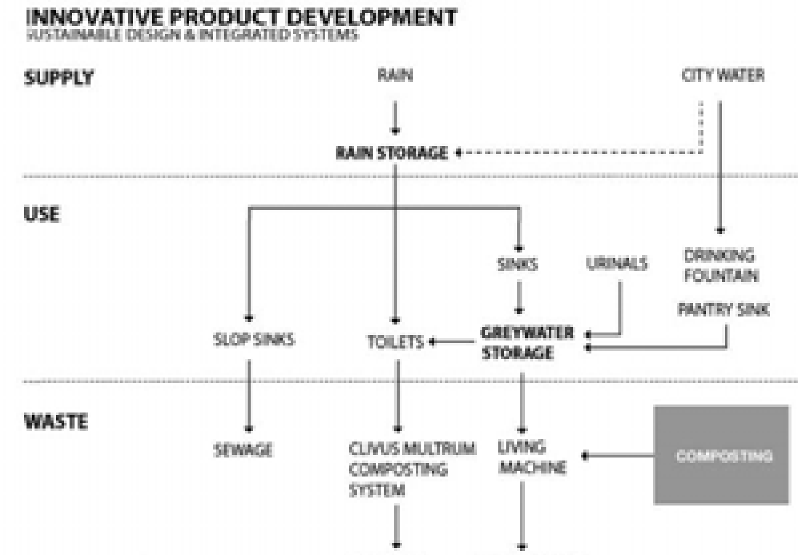




SOURCE: Rumsey Engineers

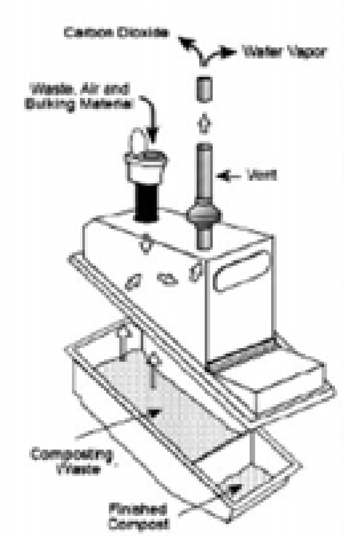
GRAY WATER TREATMENT SYSTEMS

Vivian Loftness, FAIA



WATER USE CYCLE

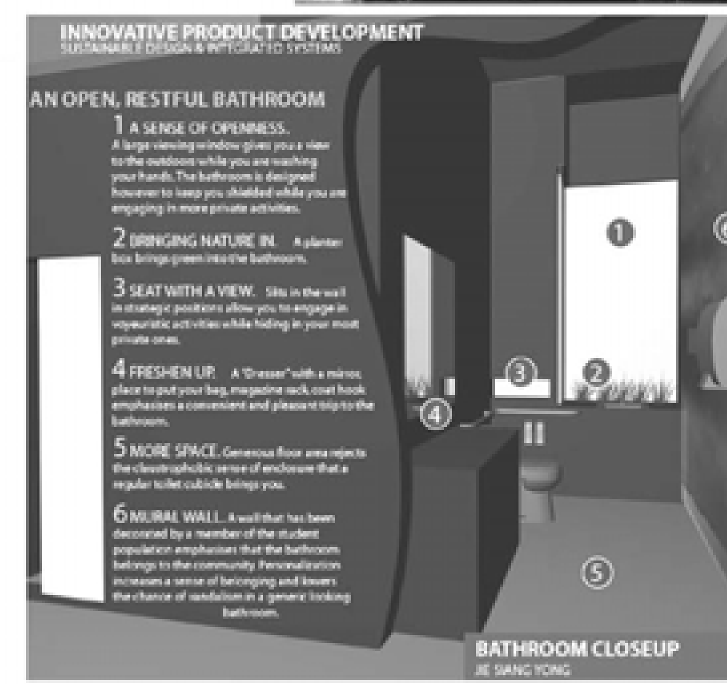
WATER CONSERVING FIXTURES



CLIVUS MULTRUM COMPOSTING TOILET

TOTO ECOPOWER FAUCET

CLIVUS FOAM FLUSH WC



School of Architecture, Carnegie Mellon University

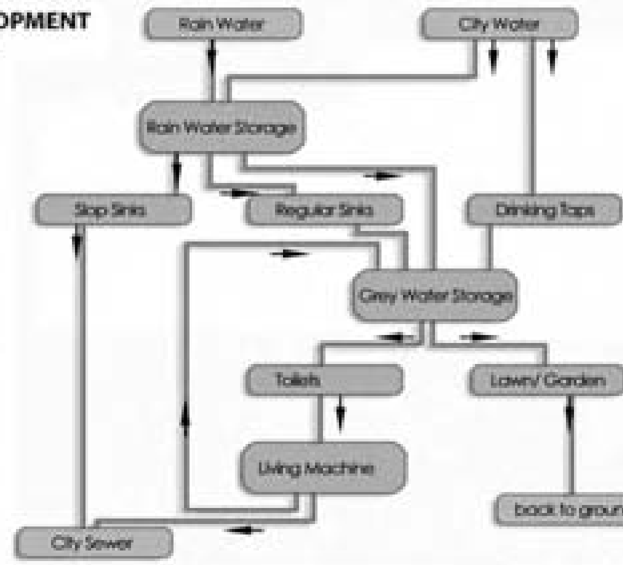
INNOVATIVE PRODUCT DEVELOPMENT

Vivian Loftness, FAIA and Azizan Aziz

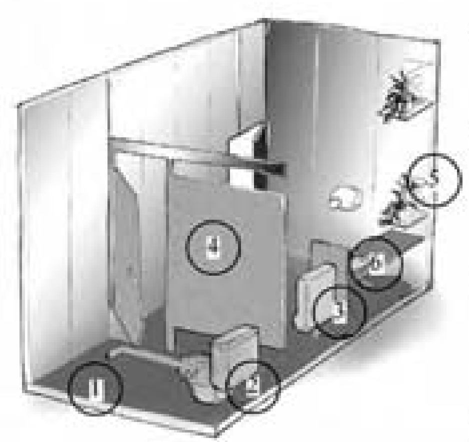
INNOVATIVE PRODUCT DEVELOPMENT
SUSTAINABLE DESIGN & INTEGRATED SYSTEMS

Sunsiphon Thermosiphon System
Flat plate solar collectors are used in a looped system that can heat potable water even when the air temperature is below freezing.

Roofwasher filter
This is a carbon filter that will get the particulates out of the rain water. The filter can handle rainwater collected from 3500-square feet of surface.



Water Use
There are two water sources for this service core, rain water and city water. The city water is used for drinking and as a supplement when there is a shortage of rain water. The rain water is used for everything else. After the rain water is used once it can be used again as grey water. Last the living machine cleans the black water which is pumped back to the grey water storage tank.



1- Crossville: GeoStone Ecocycle
- 100% recylable porcelain tiles.
- Incredibly durable in every aspect.
- Minimal VOC's, off-gassing
- Found in many regions

2 - Kohler: Cimmaron Toilet
- Low-flush (1.4 g.p.f)
- Special set-up minimizes installation

3- Waterless:No-Flush Urinals
- Eco-trap utilizes no water' uses
- Blueseal liquid which rises to the
- top (urine goes below while it seals in bacteria vapors from getting in the air.

4- Yemm/Hart: Origins 100% Post-Consumer Recycled (HDPE) Partitions
- Plastic comes from post-consumer detergent and soda bottles
- Relatively durable (can be sand ed (vandalism)

5- Low-emissivity glass with double glazing sealer (cuts heat loss in half)

6- Sloan: Solor Powered Faucet
- sensor activated to reduce use
- .5 gpm limiter
- No moving parts

SUSTAINABLE SERVICE CORE AND RESTROOM
Benjamin Maguire

School of Architecture, Carnegie Mellon University