From Grey to Green:

Sustainable Practices for Redeveloping a Vacant Shopping Center

A project of
The U.S. Environmental Protection Agency (EPA),
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Wallace Roberts & Todd, LLC

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Communities across the country are struggling with the question of what to do with defunct shopping centers that blight neighborhoods and strain local economies. This problem is on the rise as newer shopping centers replace older ones, and retail space is overbuilt. Called 'greyfields,' these empty malls and strip shopping centers have been identified by urban development experts as the 21st century's most pressing environmental and land use challenge. However, greyfields can offer excellent redevelopment opportunities since they are often well served by transportation, sewer, and water infrastructure. The Metropolitan Institute in Alexandria, VA, estimates that 2.8 million acres of greyfield lands will become available in the coming decades. Communities of all sizes can follow the principles of smart growth to refocus development to capitalize upon existing utilities and transportation infrastructure.

This document provides a guide to redeveloping such sites in an environmentally sustainable, "green" manner. It uses as an example Manchester, Connecticut's Parkade shopping center, which is the quintessential "greyfield" development challenge - a completely vacant retail center with a vast asphalt parking lot adjacent to a newer retail center. The site exhibits the environmental issues and land use challenges faced in so many developed communities.

The central focus of this document is green practices for stormwater management, framed by principles of smart growth and their positive impacts on open space preservation and water resources. Consideration is also given to green building practices including passive solar building and site design, energy efficiency, renewable energy, and water conservation. The format of this document describes potential green infrastructure systems at the Parkade Site, illustrates the specific elements of the green practices and their function, discusses their benefits, provides a list of additional resources, and is organized into the following four sections:

- Overview
- Principles of Smart Growth
- Green Infrastructure
- Green Practices for Stormwater
- Costs and Maintenance

The Parkade Site can provide a model of smart growth and green infrastructure practices for other communities considering greyfield redevelopment.

Overview

Manchester's Parkade Site is the quintessential greyfield development challenge - a completely vacant retail center with 90% impervious coverage.

Illustrated plan for the redevelopment of Manchester's Parkade Site.

A Plan for Redevelopment

In the fall of 2009, a plan was prepared for redevelopment of the Parkade site, following the principles of smart growth and green infrastructure. This plan can be seen at www.epa.gov/smartgrowth/publications.htm. The Parkade site, dominated by 90% impervious coverage, is bordered to the north by an occupied commercial center; to the south by a channelized and degraded stream corridor; to the west and across the stream channel by a single-family residential neighborhood; and to the east by auto-oriented commercial services along Broad Street.

A key element to both the smart growth and green infrastructure approaches to the site is the creation of a five-acre park along Bigelow Brook, which includes a woodland buffer to protect the restored stream; constructed wetlands to treat stormwater; infiltration areas that provide areas for passive recreation; trails that connect to the town's trail system and recreation areas; and a parkway street. Other key features include organizing the site around a grid of residential "green streets" that provide connections to surrounding property; a predominantly east-west block and building orientation for optimal passive

solar and natural cooling opportunities; and a network of plazas and a town square that add value to adjoining development and increase tree cover, infiltration, and stormwater detention areas during extreme rainfall events.

The site's redevelopment as a smart growth model will reposition Broad Street as a mixed-use residential center with improved transit access. The design incorporates a multi-lane transit boulevard with bus access along pedestrian-oriented medians that separate through-traffic from local access lanes with convenience parking along the ground floor commercial frontages.

The plan for the Parkade Site also includes a variety of housing types from those with a minimum density of ten dwelling units per acre for two-family houses to compact housing in the form of townhomes and apartment buildings.

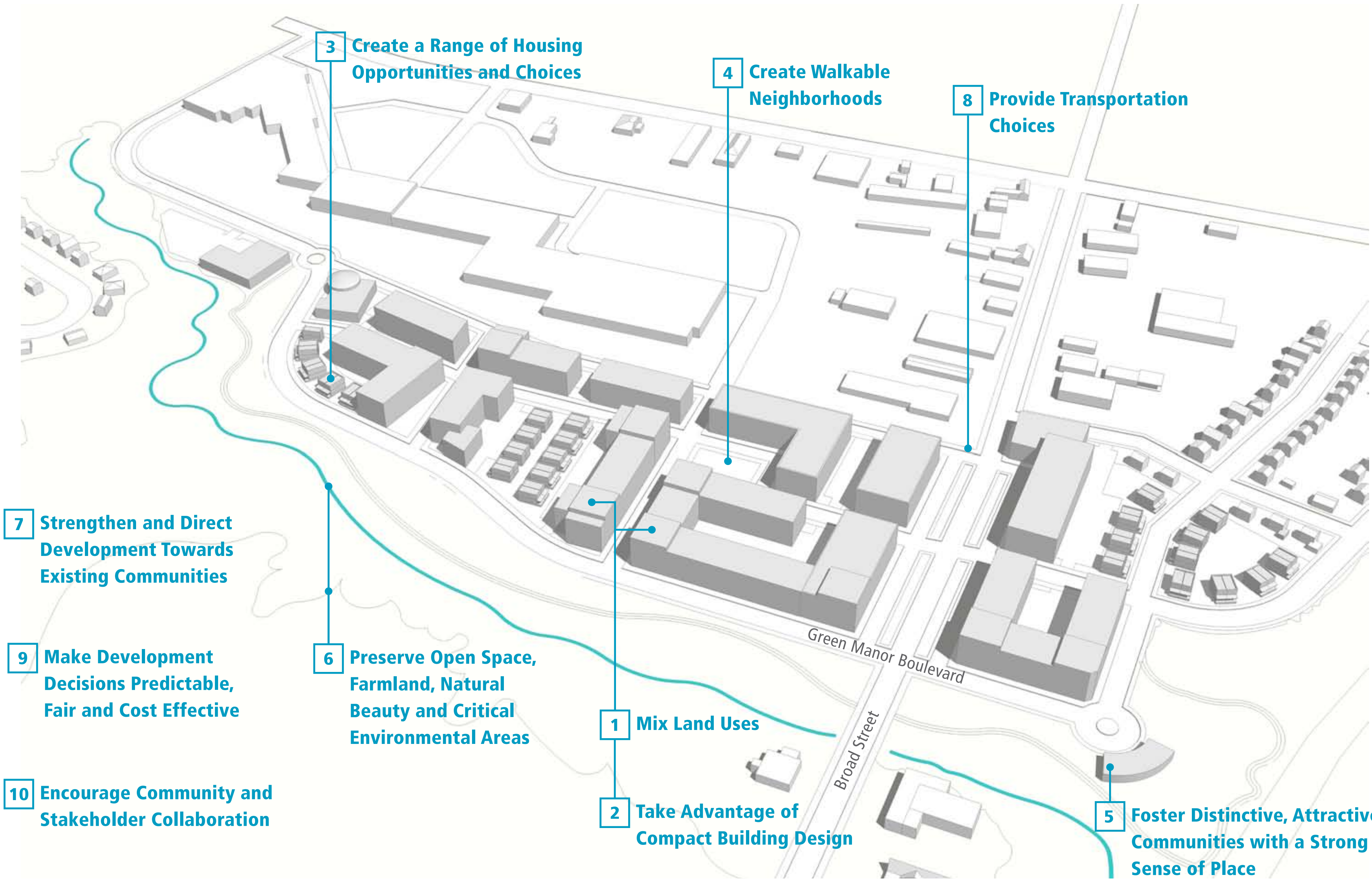
Green Infrastructure and Development Best Practices for the Parkade Site

This report presents Manchester's Parkade site as a model both for the principles of smart growth and for the benefits of green infrastructure and best practices in site design, stormwater management, and "green building." Best practices in green building reduce operational costs, provide opportunities for water conservation, reduce the carbon footprint of development, and increase profitability for developers and land owners. Best practices in stormwater management further benefit the health of our natural resources and systems, as well as the fiscal health of our communities. Green stormwater management elements—which include green roofs, green streets, constructed wetlands, parks and plazas—handle rainfall from impervious areas and alleviate flooding and the negative impacts to watershed health as well as reduce the need for costly and single-purpose "grey" infrastructure. Green infrastructure can be employed to reduce peak flows and runoff volume, and improve water quality and aesthetics. Planted components of green infrastructure elements are particularly ideal because they reduce impervious area and can maintain stormwater infiltration pathways, and filter out many typical stormwater pollutants.

Benefits of this Approach at the Parkade Site:

- Green buildings would see up to a 9% decrease in operational costs over traditional buildings;
- Green roofs would capture over 3 million gallons of annual rainfall, if 75% of the site's roofs were vegetated;
- Installing solar panels on just 14% of the commercial building roof area would offset all of those buildings' energy costs;
- Using current rates, annual energy savings of green roofs could reach almost $19,000;
- Green streets would be able to capture over 90% of street runoff and require less frequent resurfacing applications;
- For every 1 inch of rain, a 1,000 square foot roof would collect and divert 623 gallons of water to green plazas;
- A 5-acre park would capture over 7.3 million gallons of precipitation annually;
- Development along the park could experience property value premiums upwards of 20%;
- Constructed wetlands within the parks and plazas would retain over 10,000 gallons of stormwater in a typical rainfall;
- Restoring Bigelow Brook to a more naturalized state would enable nearly half a mile of stormwater infiltration, plant and animal habitat restoration, and recreation.

Principles of Smart Growth



In communities across the country, the principles of smart growth are taking hold as communities realize that the short-term economic gains afforded by greenfield development come at the cost of the long-term physical, social, cultural, and economic health of our cities, suburbs, and rural centers, as well as the health of our natural systems and habitats. As sustainability becomes a more common topic at town halls and kitchen tables we can look forward to leveraging our existing utility and transportation infrastructure to refocus development toward greyfield and infill sites.

Incited by demographic shifts and environmental and economic concerns, communities like Manchester are adopting the principles of smart growth to adapt to the shifts toward sustainable values and competitive positioning. This report illustrates how the principles of smart growth and green design can be successfully applied in Manchester to create a model for similar communities.

Smart growth is an approach that: (1) invests in the center of cities, older suburbs and rural communities to avoid development on agricultural and natural resources; (2) advocates for transit-oriented, walkable neighborhoods supported by a mix of building uses; and (3) preserves open space to enhance a community's health and sense of place.

These principles were developed by the Smart Growth Network, a partnership of 40 organizations led by the U.S. Environmental Protection Agency. Find out more at: **www.smartgrowth.org**, and **www.epa.gov/smartgrowth**.

1 Mix Land Uses

Mixing uses such as homes, jobs, and shops benefits cultural, economic and social vitality. When such uses are in proximity, walking, biking and transit are viable; streets are vibrant, and property values rise.

2 Take Advantage of Compact Building Design

By mixing uses and encouraging development to grow more densely, communities reduce the footprint of new construction, reduce stormwater runoff and preserve open space.

3 Create a Range of Housing Opportunities and Choices

A range of housing types provides opportunities for families, empty nesters, and singles, and permits more efficient use of infrastructure resources, and ensures a better jobs-housing balance.

4 Create Walkable Neighborhoods

Walkable communities provide goods (food, clothing, housewares) and services (checkups, haircuts) within an easy, safe walk. They create a streetscape that serves a range of users.

5 Foster Distinctive, Attractive Communities with a Strong Sense of Place

Communities that craft a vision for the development of architecture, streetscapes and landscapes are reflecting their own values, thereby distinguishing their community from others and avoiding the "placelessness" that comes from places looking too similar.

6 Preserve Open Space, Farmland, Natural Beauty and Critical Environmental Areas

Open space preservation protects air quality, water resources, and habitats; provides recreation areas for the community; and presents fiscal benefits, including increasing local property value and tourism dollars.

7 Strengthen and Direct Development Towards Existing Communities

Directing development towards existing communities already served by infrastructure utilizes the resources that existing neighborhoods offer and conserves open space and natural resources on the urban fringe.

8 Provide Transportation Choices

Development that makes it easy for people to walk, bike, or use transit to reach their destinations allows them to spend less time in traffic, reduces pollution, and enhances mobility for people of all ages.

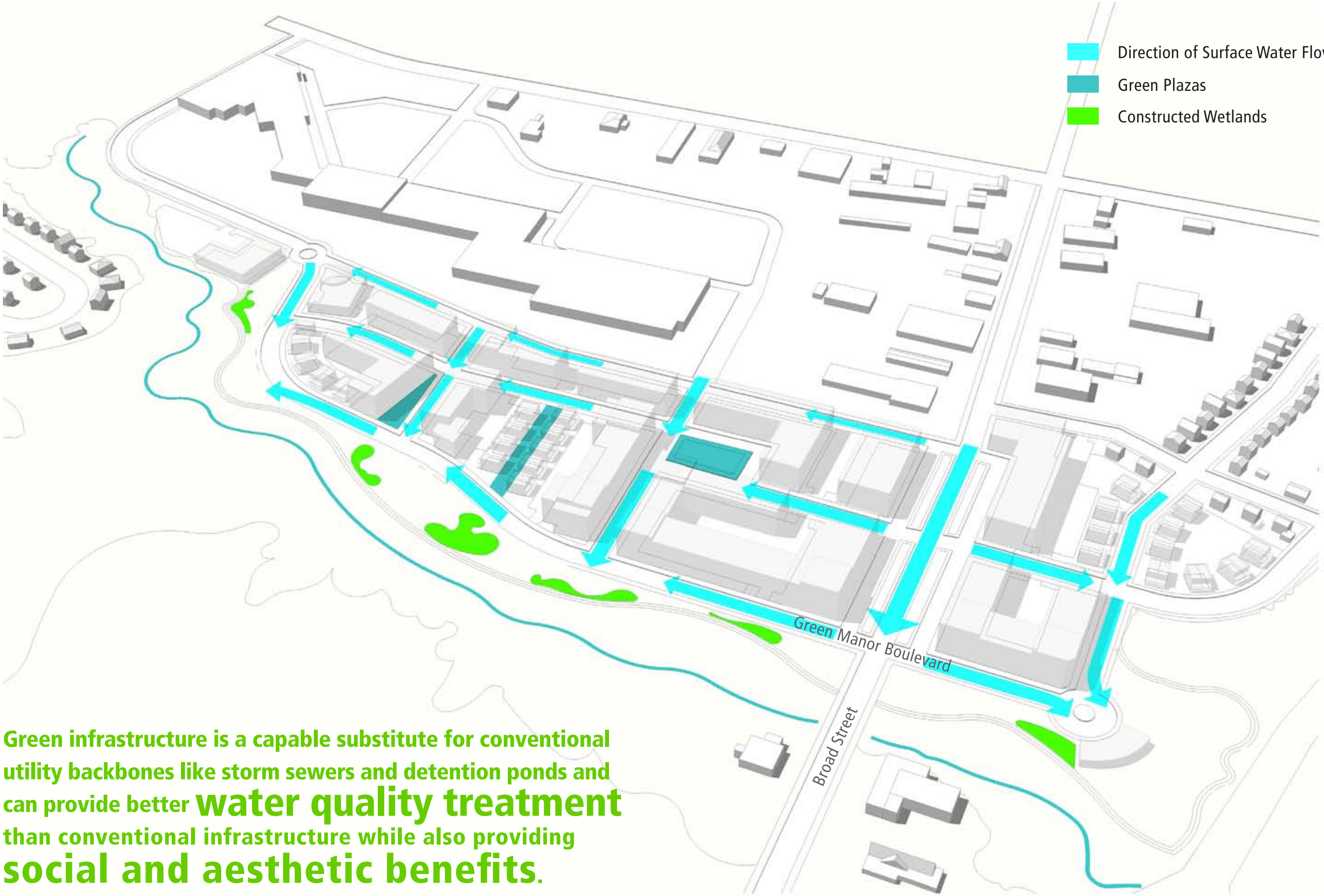
9 Make Development Decisions Predictable, Fair and Cost Effective

The smart growth development process can require time-consuming and costly variances. State and local governments can support better development by making planning, permitting, and approval decisions more fair and predictable for developers.

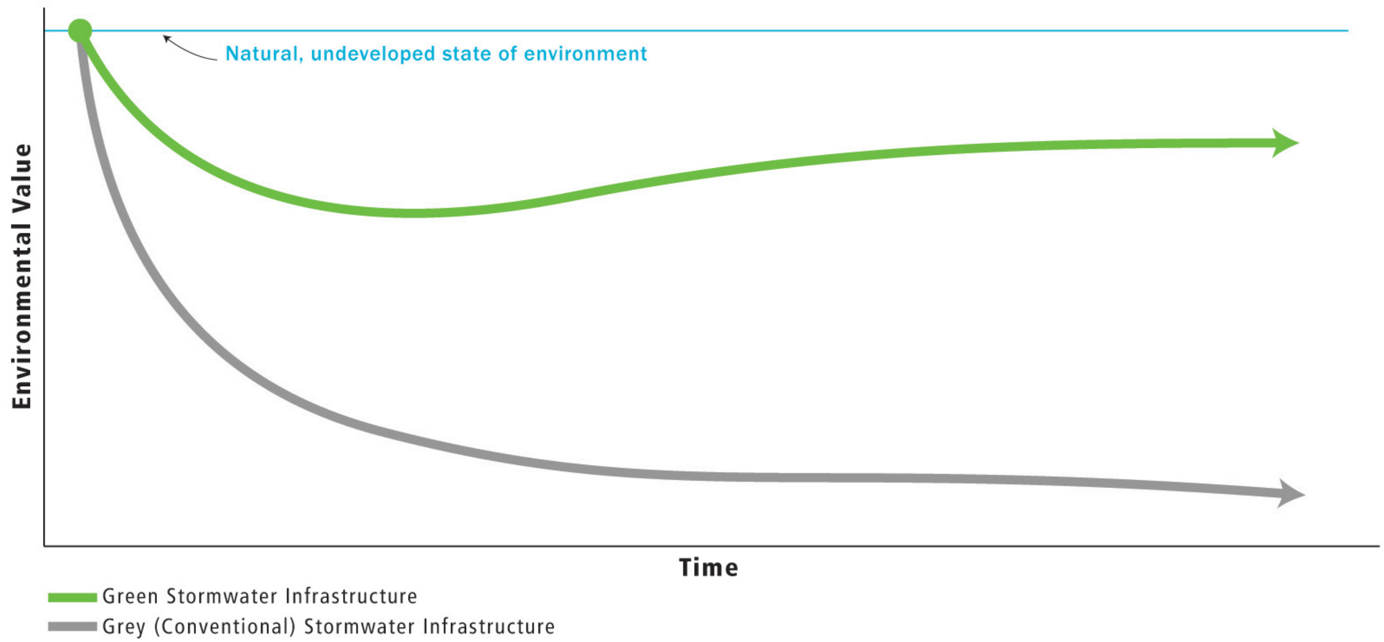
10 Encourage Community and Stakeholder Collaboration

Community and stakeholder collaboration leads to creative, faster resolution of development issues and stresses the importance of good planning and investment.

Green Infrastructure



Green infrastructure is a capable substitute for conventional utility backbones like storm sewers and detention ponds and can provide better water quality treatment than conventional infrastructure while also providing social and aesthetic benefits.



Above: Conceptual graph comparing the environmental value of Green Infrastructure to Grey (Conventional) Infrastructure. Over time, green stormwater infrastructure will regain and maintain environmental value due to its tendency to uphold natural processes, while conventional stormwater infrastructure will lose environmental value, as it tends to degrade the natural environment.

This document explores the use of green infrastructure at the Parkade site in Manchester and specifically focuses on the design of stormwater management related to water quality and ecology: ground water recharge, flood management, and natural resource protection. Green infrastructure is an approach to development that closely replicates the hydrological functions of nature and harnesses the natural forces of wind, sun, water and geothermal heat.

Studies by American Forests (www.americanforests.org/graytogreen/stormwater) show that impervious surfaces such as streets and roofs have increased by 20% in urban areas, and have resulted in widespread degradation of our rivers, streams, and lakes. In combination with an aging sewer infrastructure, costs for maintenance and replacement have been mounting for local governments and increasing costs for developers as well.

Today, our thermal comfort is managed with costly heating and cooling systems. Buildings and pavement absorb heat during the day and radiate it back at night, causing a heat island effect. Temperature fluctuations of a surface can lead to cracking and instability that threatens the resiliency and longevity of materials, requires costly maintenance, and negatively affects livability. With a greener approach to infrastructure, communities can use natural shading and higher reflectance to moderate temperatures and reduce energy demand and maintenance. The following guidelines will integrate the opportunities for passive solar building design, geothermal, solar and wind energy generation, and water conservation and reuse.

For Manchester's redeveloped Parkade site, an interconnected network of green spaces is central to how the site manages resources like water. In typical developments, stormwater is funneled into pipes and quickly carried away. While the impacts are not always seen at the site, they are often seen downstream, where stormwater is discharged into waterways, depositing pollutants, degrading water quality, damaging habitat, and scouring riparian lands. At the Parkade site, principles of smart growth and the use of green infrastructure elements like green buildings, green roofs, green streets, green plazas, parks, constructed wetlands and naturalized streams will not only enhance the aesthetic quality of the redevelopment, but also its livability, natural value and economic sustainability.

Green Practices

These practices will enable more sustainable redevelopment of Manchester's Parkade site. Each practice is further explained following this summary, and specific guidelines can be found in the document *Smart Growth Guidelines for Sustainable Development and Design* available at www.epa.gov/smartgrowth/sg_guidelines.htm.

1 Green Buildings

The built environment has a profound impact on our natural environment. Buildings in the US account for 72% of electricity consumption*, 40% of energy use*, 38% of all carbon dioxide emissions*, 30% of waste output*, and 14% of potable water consumption**. Building "green" means seeking more sustainable solutions to reduce the energy, water, and other resources our built environment consumes. At the Parkade site, green buildings are a key component to the success of the development as a sustainable investment.
*Environmental Information Administration, 2008; ** USGeological Survey, 2000.

2 Green Roofs

Green roofs, which are elements of green buildings, are simply vegetated roof covers, with lightweight soil and plants taking the place of otherwise conventional flat or pitched roofs. Green roofs are an integral component in managing stormwater on site, as they capture, slow and divert rain that would otherwise drain immediately into conventional stormwater infrastructure. Green roofs provide multiple benefits like reducing ambient air temperature, energy use and utility costs, cleansing air and water, extending the life of a roof, and creating more bird habitat. Green roofs are becoming more common in Connecticut and other states.

3 Green Streets

Urban areas are dominated by impervious surfaces: roofs, roads, sidewalks, and parking lots. These surfaces block rain from soaking into the ground and collect oil, metals, and other contaminants that are carried directly into streams and other waterbodies. Green street networks manage runoff through their capacity to store, convey and filter stormwater. When designed as a system of roads, sidewalks, trees, planters, cisterns and vegetated medians, green streets within the Parkade site will be able to manage all the rainfall they collect.

4 Green Plazas

Plazas that take the form of public squares and landscaped parks serve as locations for people to rest, gather, and move through. Plazas typically include components like benches, shade trees, planters, sculptures, paving, and lawns. But with the integration of functional elements of stormwater management such as tree cover, permeable surfaces, rain gardens and underground cisterns, plazas can also play a role in water conservation and stormwater treatment.

5 Parks

Parks offer myriad benefits to an urban area. As areas of recreation and respite, they contribute greatly to people's quality of life and can provide shelter and sources of food for wildlife. As areas of increased permeability and vegetation, parks can positively affect the management of stormwater by recharging groundwater and facilitating evapotranspiration.

6 Constructed Wetlands

Wetlands are dynamic and highly important landscapes that provide wildlife habitat and flood storage, among other functions. Untreated stormwater should never be directed towards natural wetlands since it would degrade them, but man-made wetlands can be constructed in order to absorb stormwater and prevent flooding, and filter water. At the Parkade site, constructed wetlands will support the green streets system by collecting and filtering stormwater overflow. Their capacity to store large amounts of water will prevent flooding.

7 Streams

Urban streams like Bigelow Brook have suffered tremendously due to the impacts of adjacent development. Surface impermeability within a watershed causes large amounts of contaminated runoff and debris to flood streams, scouring their banks, washing away native vegetation and degrading habitat. Many urban streams, including Bigelow Brook, have been channelized, which has exacerbated efforts to control flood damage, instead causing unforeseen impacts. By using green infrastructure, communities can significantly decrease flood events, stream corridors and habitats can be restored, and recreational and educational opportunities for people will abound.

Green Buildings

Green buildings see up to a 9% decrease in operational costs over conventional buildings.

Source: McGraw-Hill Construction, Key Trends in the European and U.S. Construction Marketplace, 2008

Rockville Bank in Manchester, Connecticut opened the state's first bank branch constructed entirely with green technology.
photo: www.hartfordbusiness.com

Vancouver's Convention and Exhibition Centre will include a green roof, energy efficient systems, and greywater treatment.
photo: www.roofculture.com/gallery/vancouver/

Features of Green Buildings

Buildings that optimize performance lessen negative impacts on their surroundings. Sustainable building strategies that optimize performance employ a variety of energy-saving and even energy-producing elements. These can range from high-tech materials and processes like photovoltaics (solar panels) and automated shade structures, to age-old methods like siting and design that improve both building performance and the health and comfort of its inhabitants.

Green building strategies achieve multiple objectives like resource and energy conservation, and environmental quality: *Design with nature*, and orient buildings to optimize microclimate, landscape with native plants and manage stormwater on site. *Maximize water efficiency* through landscaping and high-performance fixtures. *Save energy* through window orientation and glazing performance, electricity use, heating and cooling efficiency, and building fixtures - from dishwashers to printers. *Generate energy* through use of photovoltaics, geothermal, or wind power. *Make smart use of materials* by reusing onsite materials, specifying local materials and constructing with certified wood products and green materials. *Safeguard indoor environmental quality* by using nontoxic materials and furnishings, cleaning products and providing ventilation and access to fresh air.

Green building practices should extend to parking. Shared and structured parking reduce the land area needed for parking, and parking structures can employ the same strategies as other buildings. Surface lots with planted areas and swales can capture and filter stormwater, while pavers in low-traffic areas can provide overflow parking and allow infiltration.

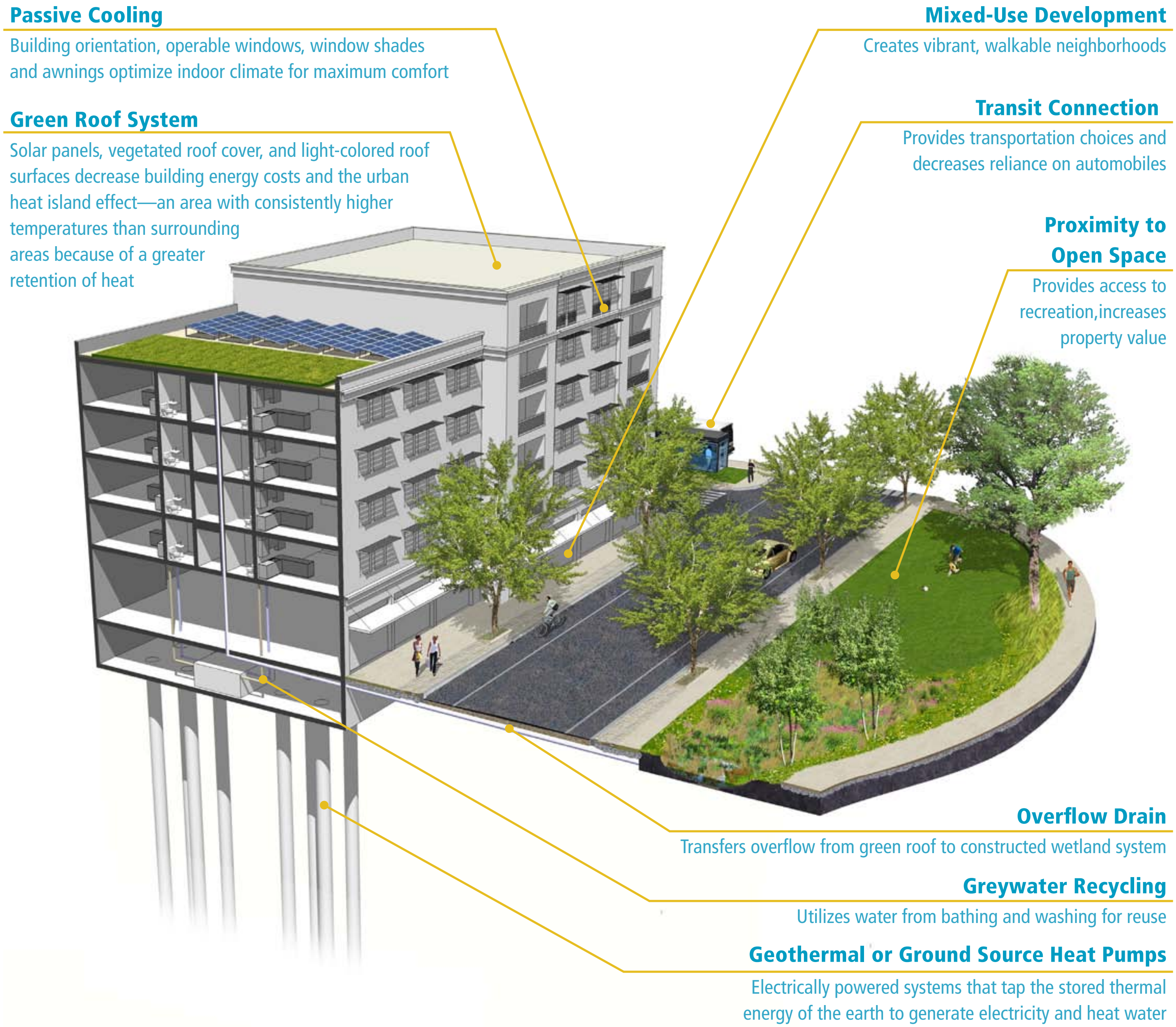
Multiple Benefits of Green Buildings

Green buildings provide additional benefits from construction to occupancy. By taking advantage of local and regional materials, the construction of green buildings helps conserve natural resources while also stimulating local and regional economies. The integrated design approach needed for green building ensures all building systems are considered together at the same time, maximizing efficiencies and reducing operating and capital costs throughout the lifecycle of the building.

By employing leading technology and design, green buildings tend to have higher market values and can sustain those values for a longer period of time than non-green buildings because they are less likely to become outdated.

Additional Resources

- US Green Building Council (USGBC): www.usgbc.org;
- USGBC's LEED section: www.usgbc.org/leed;
- USGBC's "Resources" page (external links)
- US EPA's Energy Star: www.energystar.gov
- NRDC: www.nrdc.org/buildinggreen
- National Institute of Building Science's Whole Building Design Guide: www.wbdg.org
- Rocky Mountain Institute's Built Environment Team: http://bet.rmi.org/



Green Roofs

Green roofs at the Parkade site would be able to capture over 3 million gallons of annual rainfall if 75% of the Parkade site's roofs were vegetated.

Workers install Hartford's first green roof on the Betty Ruth and Milton B. Hollander Foundation Center. *photo: www.commonground.org*

EPA New England's newly-planted green roof in downtown Boston has roof access for building occupants. *photo: U.S. E.P.A.*

Features of Green Roofs

Green roofs provide many environmental, economic and social benefits with a relatively simple premise: cover roofswith vegetation. Green roofs can range from simple coverings like low-maintenance sedum plants to extensive park-like plantings that can be enjoyed by those who live or work in the building.

A building's stormwater begins when rain falls on its roof. Green roofs manage a building's stormwater on site. The vegetation absorbs rain, and the planting medium beneath the vegetation stores additional water that the vegetation can absorb at a later time. Water stored on green roofs is released back to the atmosphere by the plants through evapotranspiration, or it can be collected for irrigation. Green roofs also improve air quality by filtering out fine, airborne particulate matter.

Green roofs help reduce the urban heat island effect. They reduce energy demand by shading and cooling buildings in the summer and by providing added insulation in the winter. Each square foot of green roof can save 0.39 kWh of energy per year. Using local, current electricity rates, that could mean an annual savings for the Parkade site of almost $19,000 if 75% of the building roofs were green roofs.

Green roof systems can be integrated with other green technologies. For example, green roofs and solar panels enhance each other's efficiency. Green roofs help cool ambient temperatures and allow solar panels to operate more effectively in hot weather. Solar panels shade vegetation and slow evaporation from green roofs, making it less likely that the vegetation will dry out.

Multiple Benefits of Green Roofs

Green roofs are initially more costly than traditional roofs, but their economic benefits outweigh the additional up-front costs. Unlike traditional roofs, green roofs:

- Require minimal maintenance and last about twice as long because they protect roofs from UV radiation and extreme temperature fluctuations;
- Help cleanse the air and water;
- Reduce ambient air temperature,
- Insulate buildings from heat and cold to

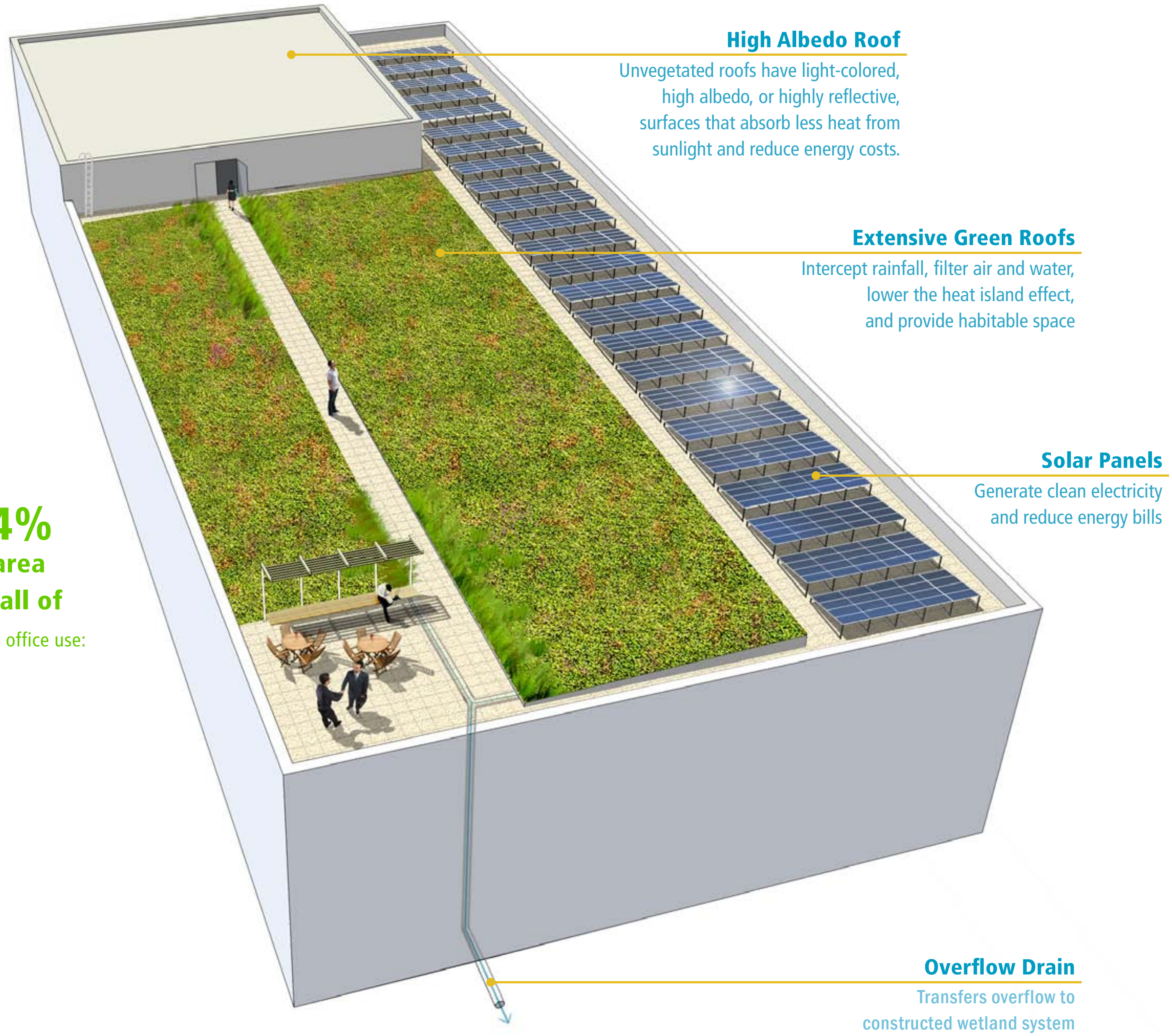
keep occupants comfortable and reduce heating and cooling costs;

- Insulate buildings from sound;
- Increase the property value and marketability of buildings;
- Beautify the urban landscape;
- Create greenspace and physical respite for people;
- Provide habitat for wildlife, including migratory birds;
- Absorb noise and pollution;
- Sequester carbon.

Installing solar panels on just 14% of the commercial building roof area at the Parkade site would offset all of those buildings' energy costs. Avg. office use: 200 kWh/sq m/yr, per US DOE CBECS Survey, 2003. Manchester solar insolation: 1500 kWh/sq m/yr

Additional Resources

- www.Greenroofs.com;
- www.Greenroofs.org:
- International Green Roof Association: www.igra-world.com
- US EPA: www.epa.gov/hiri/mitigation/greenroofs.htm
- Solar calculator: www.findsolar.com



Green Streets

Green streets would be able to capture over 90% of street runoff at the Parkade site, diverting stormwater from conventional infrastructure and providing opportunities for reuse.

Streets shaded by trees require 40% fewer resurfacing applications as unshaded streets.
Center for Urban Research

Stormwater infiltration planters in use in Portland, Oregon at Southwest 12th Avenue Green Street. The above image shows a newly installed planter in dry conditions. *photo: Kevin Robert Perry*

Above, the same planter during a rain event, where it is easy to see how much water can be captured and diverted from conventional underground pipes. *photo: Kevin Robert Perry*

Features of Green Streets

Streets occupy nearly a quarter of the site (almost 8 acres) in the preliminary design for the Parkade site. Because typical streets are impermeable, all the rain that falls on them becomes stormwater that needs to be managed. With street trees, swales, planted medians, and stormwater planters, green streets are able to manage stormwater through interception, evapotranspiration, and attenuation. In some cases, green streets are more cost effective than conventional stormwater infrastructure. At the Parkade site, green streets will be the integral component to the stormwater management system. During rain events, stormwater will collect in stormwater planters and be allowed to soak into the ground, thereby replenishing groundwater. Taking advantage of the site's natural slope, this captured stormwater will percolate through the stormwater planter network, with overflow collecting in wetlands constructed for that purpose.

Additional elements of the green street system, like pervious paving (where possible), light-colored paving, and trees, can allow green streets to handle even more stormwater and provide additional benefits. Pervious paving can be used for low volume streets, parking lots, street gutters, and sidewalks. Porous pavement is becoming more commonly used in Connecticut, and experience in its installation and maintenanceis growing. It is not typically used in high traffic areas due to frequent clogging of the pores with sand or dirt.

All pavement absorbs heat during the day and radiates it at night. Using lighter-colored paving can reduce the amount of heat retained, and street trees can shade streets to keep them even cooler. This leads to less cracking from temperature fluctuations and a reduced heat island effect.

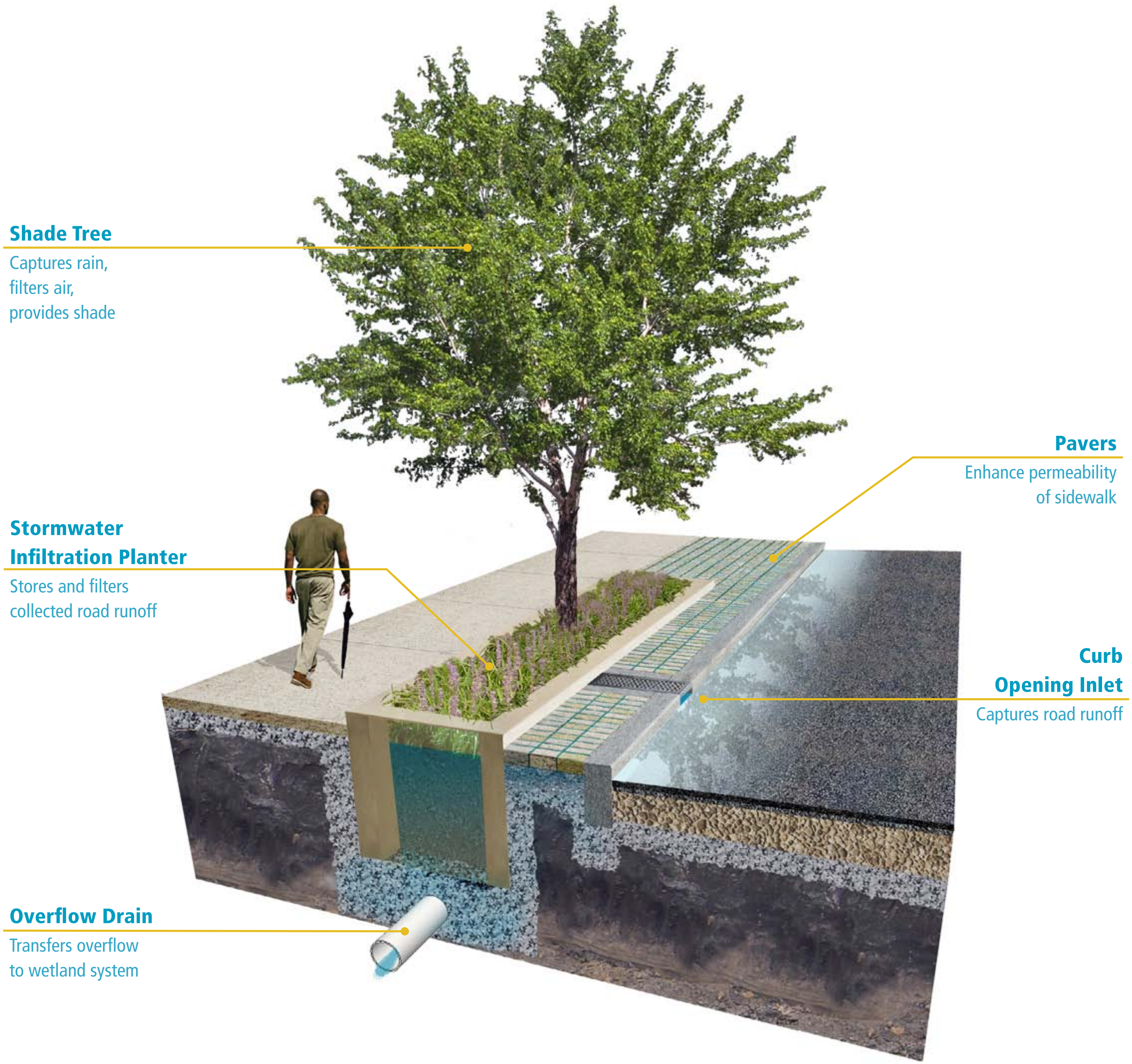
Multiple Benefits of Green Streets

Trees, as components of green streets, can moderate microclimate by slowing winter winds, funneling summer breezes, providing shade, and reducing the heat island effect, which increases people's comfort and reduces energy needs. Trees also sequester and store atmospheric carbon. Their leaves enable evapotranspiration and filter pollution from the air. Trees also provide wildlife habitat.

Added vegetation or special paving can make streets more attractive and safer. People prefer streets with trees and greenery. Thus, green streets can attract more pedestrians who subsequently feel safer, as streets with more people have less crime. A successful green street in combination with a trail network encourages walking and biking and connects neighborhoods, reducing the environmental impacts associated with automobile traffic. A University of Pennsylvania study found that streetscaping imparts a 28% increase in surrounding home values relative to similar homes in comparable areas without streetscape improvements.

Additional Resources

- www.lowimpactdevelopment.org/greenstreets
- US EPA: www.epa.gov/owow/podcasts/greenstreetsusa.html
- University of Pennysl vania study: www.upenn.edu/penniur/pdf/Public Investment Strategies.pdf
- University of Connecticut's inventory of Low Impact Development practices in CT: http://clear.uconn.edu/tools/lid



Green Plazas

For every 1 inch of rain, a 1,000 square foot roof would collect 623 gallons of water, which can be diverted to green plazas for irrigation and infiltration.

Permeable pavement and swales are part of the stormwater management plan for Portland's South Waterfront. Lush plantings are possible without watering maintenance.
photo: Nevue Ngan Associates

Rams Head Plaza at UNC Chapel Hill features an underground cistern. Above, downspouts convey roof runoff into the plaza inlets.The water is stored and later used to irrigate plaza plants.
photo: http://sustainability.unc.edu

Features of Green Plazas

Plazas within the Parkade site will not only provide urban open space for people, but they also can assist buildings and streetscapes in managing roof and site stormwater runoff through tree cover, permeable surfaces, rain gardens and underground cisterns.

A green plaza's trees will absorb and filter rainfall. Its permeable surfaces ranging from lawns and plantings to modular pavers will increase the absorption of rainfall into the ground, helping to maintain groundwater supply. Surface runoff from the plaza can be directed to trenches that transfer the stormwater to the underground cistern to later irrigate the plants in the plaza. Surface runoff can also be directed into planting areas and rain gardens, where it will be available for use by the plants before being filtered through the soil. Rain gardens also present the opportunity to make an educational "event" of rainstorms and become public art. Small pools and basins, and narrow channels like runnels and weirs are sculptural elements that intercept runoff and make rain events a performance.

Properly-sized underground cisterns will be able to capture and store roof overflow and plaza runoff, and this water can be used in an automatic irrigation system to water all the plantings in the plaza, or reused in toilets or other non-potable water applications. Planted areas in the plaza can store overflow from the underground cistern.

Multiple Benefits of Green Plazas

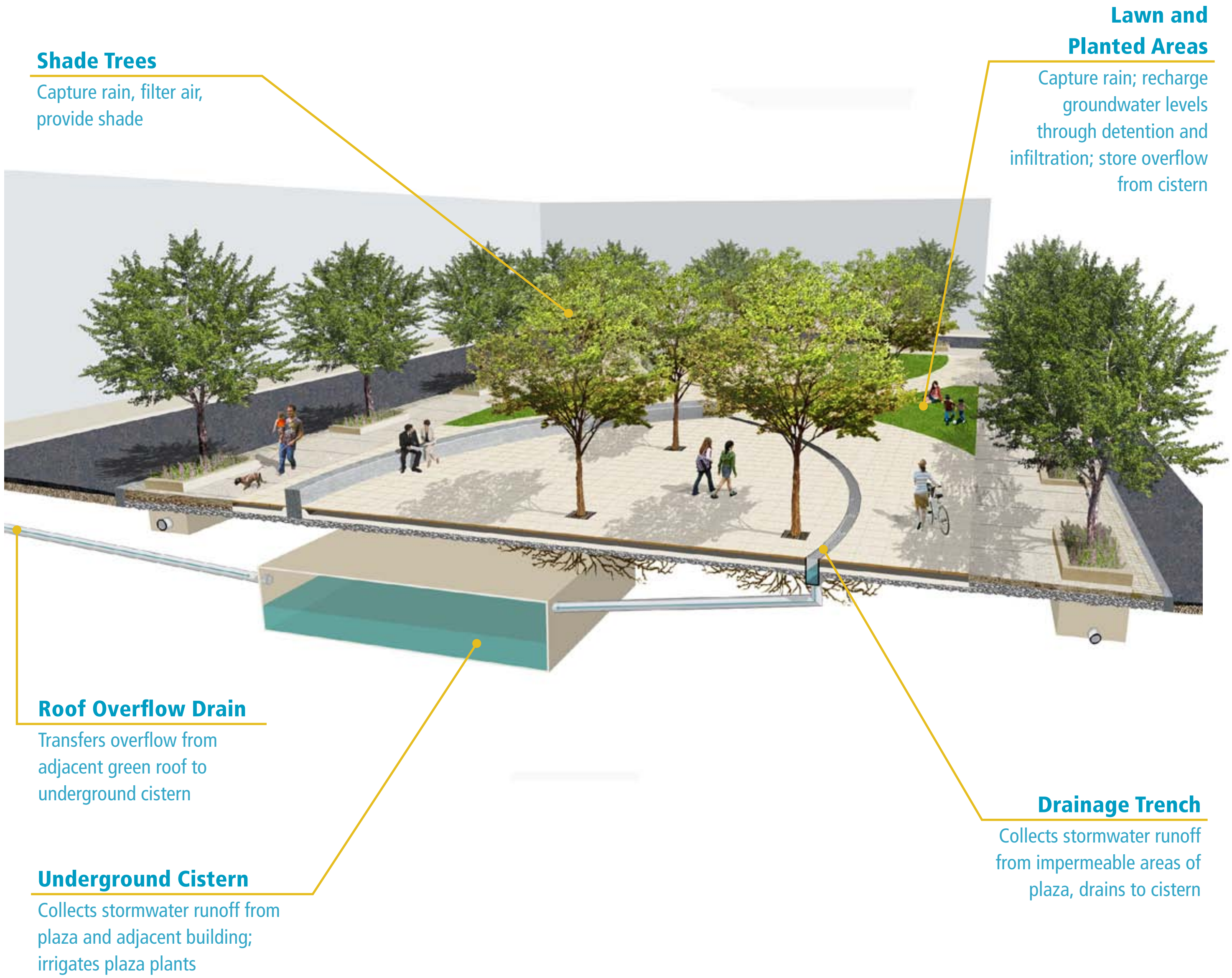
Trees planted in urban plazas create "outdoor rooms" that provide benefits similar to those of green streets. Green plazas can moderate microclimate, reduce the heat island effect, filter air, sequester carbon, reduce energy needs and increase people's comfort. A U.S. Department of Energy study reports that trees reduce noise pollution by acting as a buffer and absorbing 50% of urban noise. The evaporation from a single large tree can produce the cooling effect of 10 room size air conditioners operating 24 hours/day (www.treefolks.org).

Well-maintained green plazas will also increase the popularity of a location, which translates into increased property values. The addition of amenities to plazas, such as transit stops and cafes, will only increase the popularity and use of plazas.

Plazas also increase the walkability of an urban neighborhood, reducing the need for automobile use (and its negative environmental impacts) and creating more opportunities for social interaction.

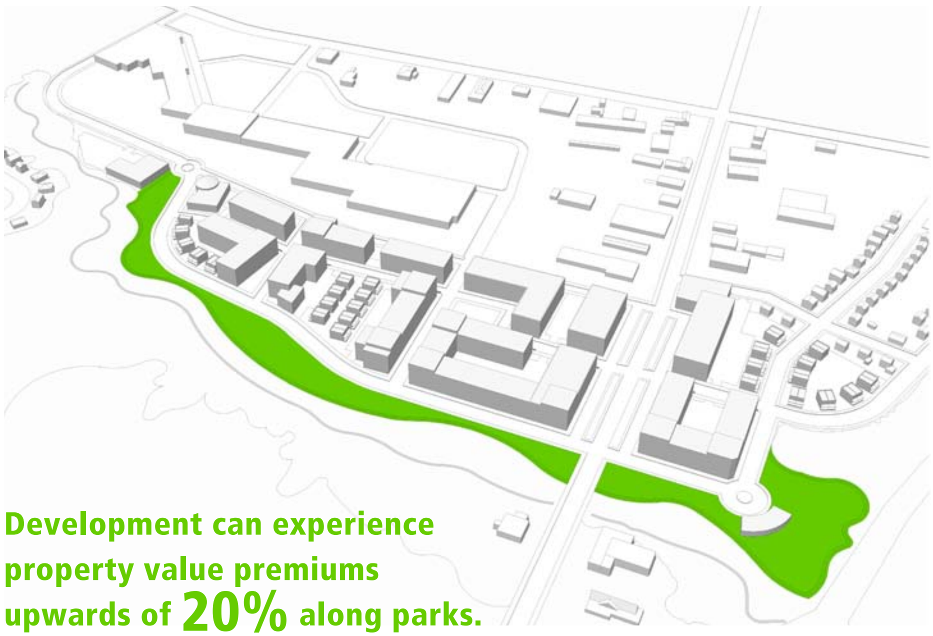
Additional Resources

- Multiple benefits of trees: www.lgc.org/issues/water/trees.html
- Benefits of Trees In Urban Areas: www.coloradotrees.org/benefits.htm#6
- Tree Folks: www.treefolks.org/store_biglist.asp



Parks

A 5-acre park in Manchester, as shown, will capture over 7.3 million gallons of precipitation annually, using an average annual rainfall for Manchester of 52.3 inches.



Development can experience property value premiums upwards of 20% along parks.

At Elizabeth Park in Hartford, playing fields, trees, a pond, and gardens provide ample recreation and acres of valuable infiltration area.
photo: www.flickr.com; user: billandkent

Amenities like amphitheaters are useful to communities and help to manage stormwater by storing and slowly releasing flood waters.
photo: www.flickr.com; user: Colin Purrington

Features of Parks

Parks are significant contributors to the physical and aesthetic quality of urban neighborhoods. Largely maintained by local government, they provide open space for active and passive recreation, habitat for wildlife, and processes that are significant to natural function, like microclimate management and air filtration.

Beyond the ability for the park at the Parkade site to be an ecological and recreational resource for the community, it will also be a functioning element of the stormwater management system. This park will be located upland and adjacent to the Bigelow Brook basin and its woodland buffer, as protection of the natural system is critical to water quality and local hydrology. Rain that falls within the park will be absorbed into the ground, recharging groundwater levels. Topography, in the form of subtle or pronounced depressions in the ground, can retain and detain stormwater from heavy rainfall events that would otherwise flood and erode the stream channel. The park can also host a range of native vegetation, all of which will contribute to absorbing and retaining stormwater and mitigate erosive flooding. In addition, the redevelopment plan calls for this park to connect eastwards to Center Springs Park.

Multiple Benefits of Parks

Parks can increase the value of real estate, promote human health, play a central role in a community's tourism economy, increase community cohesion and social capital, provide locations to plant new trees, create jobs and youth development opportunities, and support public health and community building. Economists have estimated that there is an average property value premium of 10% when parks and plazas are integrated into development, with premiums upwards of 20% along parks.

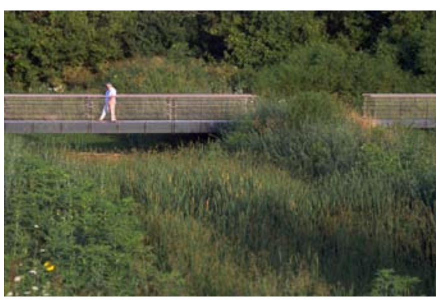
Parks also provide benefits that have a direct impact on a community's economy, including removal of air pollution by vegetation, reduction in the cost of managing urban stormwater, tax revenue from increased residential property value and direct use.

Additional Resources

- The Trust for Public Land: www.tpl.org
- "How Smart Parks Investment Pays its Way", a study by Ernst&Young, commissioned by New Yorkers for Parks
- Connecticut Department of Environmental Protection: www.ct.gov/dep

Constructed Wetlands

This preliminary design for the constructed wetlands will be able to retain over 10,000 gallons of stormwater (using an average wetland depth of 1 foot).



At Bear Grass Creek Preserve in Louisville, KY, the addition of constructed wetlands has reduced the number of floods in the adjacent creek.
photo: WRT

This constructed wetland near Denver, CO manages all of the surface runoff from an adjacent parking lot.
photo: www.werf.org/livablecommunities

Features of Wetlands Constructed for Stormwater Management

Constructed wetlands are manmade systems that incorporate wetland plants within a topographically depressed area in a landscape capable of having saturated soil. Wetlands are very effective at removing pollutants while offering aesthetic value. Note that stormwater should never be directed towards natural wetlands since it would degrade them, and wetlands constructed to treat stormwater should never be located within natural wetlands.

As stormwater runoff flows through a constructed wetland, pollutants in the water are removed through settling and biological uptake by the plants. Since constructed wetlands are designed specifically to treat stormwater runoff, they typically have less biodiversity than natural wetlands both in terms of plant and animal life. To be most effective, the constructed wetlands at the Parkade site will need to be designed with "complex micro-topography," incorporating both zones that are very shallow (<6" water) and moderately shallow (<18" water). This design will provide a longer flow path through the wetland to encourage settling, and provides two depth zones to encourage plant diversity.

The constructed wetlands will work in conjunction with the other stormwater management systems at the Parkade site. Overflow from the stormwater planters and green roofs will flow through underground pipes to the wetlands, for slow release into the stream. Further studies will be required to calculate the needed acreage for constructed wetlands, as will permitting from the US Army Corps of Engineers and the Connecticut Department of Environmental Protection.

Multiple Benefits of Constructed Wetlands

Constructed wetlands use several mechanisms to remove pollutants, and arguably employ more ways to remove sediments, nutrients, metals and chemicals, and even bacteria than conventional stormwater treatment methods. These mechanisms include sedimentation, filtration, adsorption, microbial activity (nitrification and denitrification), and plant uptake.

Constructed wetland costs are competitive with other stormwater best management practices, with the added advantage of providing recreational and wildlife benefits.

It is very important to avoid aggressive and non-native plant species when planting a constructed wetland. Reliance on native species will ensure a sustainable natural environment and increase people's exposure to Connecticut's native plants.

Additional Resources

- The Stormwater Manager's Resource Center: www.stormwatercenter.net
- Connecticut Department of Environmental Protection's Connecticut Stormwater Quality Manual; Chapter 11: www.ct.gov/dep/lib/dep/water_regulating_and_discharges/stormwater/manual/CH_11_Intro.pdf
- US EPA Wetlands, Oceans, and Watersheds website: www.epa.gov/owow

Stream

Restoring Bigelow Brook to a more naturalized state will enable nearly half a mile of stormwater infiltration, plant and animal habitat restoration, and recreation.

Turkey Branch Stream (MD) had stream degradation issues like Bigelow Brook, and has been recently restored to a naturalized state.
photo:www.trailvoice.com

Many techniques are used to restore streams. Above, a newly installed rock riffle will slow stream flow and protect the creek from erosion.
photo: http://waldendesign.net

Features of Streams

Urban streams suffer from the impacts of adjacent development. Surface impermeability within a watershed causes large amounts of contaminated runoff and debris to flood streams, scouring their banks, washing away vegetation and degrading habitat. Channelization, in an effort to control flood damage, has exacerbated the problem by increasing flow speeds, and destroying natural stream banks.

Central to the stormwater management strategy for Bigelow Brook at the Parkade site is its dechannelization. This will permit a more naturalized stream channel, where sigmoidal, or S-curved slopes, can be reinstated on the stream banks. A sigmoidal slope allows more plant and animal habitat connectivity between land- and water-based ecosystems, which positively impacts water quality and stream health. Infiltration from green streets and constructed wetlands will ensure a stable base flow in the restored stream. Dechannelization will also slow water flow, allowing for sedimentation and the creation of habitat at the bottom of the stream. Slowing water down also prevents the erosive forces that scour stream banks.

Dechannelization will inevitably disturb the landscape around the brook corridor and will likely require permits from the Connecticut Department of Environmental Protection and the US Army Corps of Engineers. During restoration, invasive species should be removed, native and valuable plant specimens should be protected, and a new planting regime should be implemented using native plants. Installation of riffles or similar measures may also need to be installed to ensure stream bank integrity, as upstream practices will still impact the stream at the Parkade site.

Multiple Benefits of Streams

Healthy streams reflect healthy communities. Communities that invest in a healthy stream environment experience an increase in social, financial, and ecological capital.

Healthy streams provide recreational value through opportunities to fish, swim, and paddle. They also provide opportunities for education and stewardship. Employing measures to restore a stream channel results in fewer floods and a healthier, functioning floodplain landscape free of debris and invasive vegetation. This means adjacent parcels gain value and become worthwhile places in which to invest. Maintenance of unhealthy stream corridors can become quite costly: invasive plant management, flooding and illegal dumping debris removal, and repairs to a channeled stream bed sap resources that could be put to better use.

Communities that invest in restoring streams are looking beyond their own location, and considering the downstream impacts of their choices and activities. Healthy streams present multiple benefits in multiple communities.

Additional Resources

- Connecticut River Watershed Council: www.ctriver.org
- Connecticut Department of Environmental Protection: www.ct.gov/dep
- The "STREAMS" Project, for educational material and case studies on stream restoration: http://streams.osu.edu
- Presentations from the 13th National Nonpoint Source Monitoring Workshop: www.bae.ncsu.edu/programs/extension/wqg/nmp_conf/presentations.html

Costs and Maintenance

Green Infrastructure Costs and Concerns

While costs associated with the maintenance of green infrastructure are viewed by some as an added cost to property management or municipal maintenance, the cost model for green infrastructure relies on spreading out replacement costs over time and sharing costs with other maintenance efforts, such as landscape maintenance.

One example of this cost-sharing model is the maintenance of rain gardens in green streets, plazas and parks. Because these gardens also serve as stormwater infiltration and filtration systems, the costs to maintain their hydrologic function are shared with landscape maintenance costs. Although green roofs tend to be designed for private use, the same cost-sharing model applies, with this open space amenity doubling as a system for handling stormwater and reducing energy costs.

The Bureaus of Transportation and Environmental Services in Portland, Oregon have some of the best historical data for comparative costs between conventional stormwater systems and green infrastructure in the U.S. Their most recent construction savings estimates are between 20% to 63% over conventional storm sewer systems, without accounting for the value of improved air and water quality, increased natural habitat, and other ecosystem benefits. As with any new technology or innovation, the data available for cost analysis can be highly variable during the first years of implementation. In the early years of implementing green infrastructure this was certainly the case, with places like Portland and Seattle viewed as anomalies due to their unique climates. Early documentation of performance and costs in the Northwest still left many communities uncertain about the transferability to their climate and related maintenance costs.

This uncertainty of costs coupled with the risk-adverse budgetary environment of most small municipalities has slowed the adoption of green infrastructure technologies over conventional systems. The biggest fear among public works departments has been the cost associated with maintaining green infrastructure and the perceived low-maintenance cost of conventional stormwater management systems.

Over the twenty years since the first green infrastructure elements were conceived and implemented the data and tools for comparing these costs has been developed and is now available to municipalities. The Water Environment Research Foundation (WERF), a U.S.-based scientific research organization dedicated to wastewater and stormwater issues, provides research material and tools for evaluating the costs of green infrastructure. Through their research and evaluation of implemented projects across the country, WERF has developed "whole life cost" (WLC) tools, which include spreadsheet-models to facilitate automation of a whole life costing approach. The models allow users to systematically identify and combine capital costs and ongoing maintenance expenditures. The most recent edition of the WLC models was developed in collaboration with the U.S. Environmental Protection Agency (EPA) and includes all of the green infrastructure practices included in this document. To access the complete set of tools for a Whole Life Cycle analysis and accompanying user's guide, visit: www.werf.org/bmpcost.

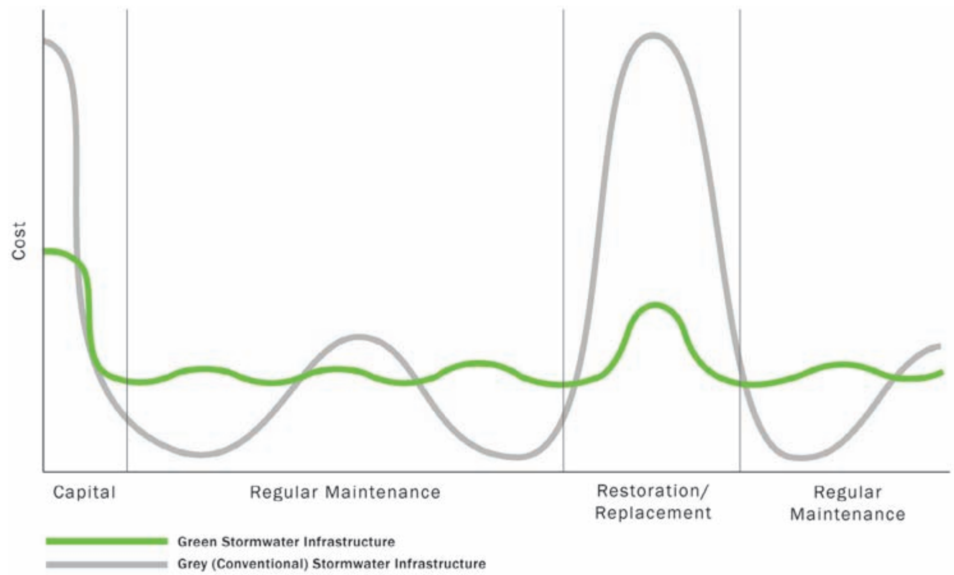
Current data has shown that implementing integrated green infrastructure practices can result in enhanced environmental performance while reducing upfront costs when compared to conventional stormwater management approaches. A portion of this cost savings is typically achieved through reduced infrastructure because the total volume of stormwater runoff is minimized through capture, infiltration, and evapotranspiration.

Green Infrastructure Maintenance

The most prevalent maintenance concerns for green infrastructure are the pervious areas in streets, sidewalks, parking areas, rain gardens, and constructed wetlands. For planted infiltration areas such as green street infiltration planters, rain gardens, and constructed wetlands, the maintenance related to aesthetic appearance is a major concern for communities, because many are not accustomed to maintaining higher quality streetscape, plaza and park environments. With pervious paving, the concern is the potential clogging of the concrete or asphalt pores. With planted infiltration areas, the concerns are debris, sedimentation, and weeding. While these concerns are legitimate, they require a shift in maintenance focus. All stormwater systems require maintenance. With conventional infrastructure, maintenance often occurs only when there is a failure, because it is out of sight and out of mind. Most green infrastructure is visible, and its aesthetic maintenance is combined with necessary maintenance to ensure long term functionality. Design and construction affects how systems need to be maintained, and therefore it is important for maintenance staff to be involved in the planning and design process and for the community to be educated about the connection between visual amenity and its relationship to environmental and economic benefits.

For pervious paving like concrete, asphalt, and pavers, fine particles that can clog the material's pores are of maintenance concern. These particles are deposited on the surface from vehicles, the atmosphere, and runoff from adjacent land surfaces. The following facts address frequently asked questions about the use, performance and maintenance of permeable paving:

- Permeable concrete can last 20 to 40 years because of its ability to handle seasonal temperature effects;
- Pervious paving must be vacuumed seasonally;
- Annual inspections are needed to inspect for sediment build-up areas, dewatering effectiveness, and surface deterioration or spalling;
- Cold weather and frost penetration do not negatively impact surface infiltration rates;
- Permeable materials freeze as a porous medium, preserving its infiltration capacity;
- Rapid drainage in pervious paving of the surface reduces the occurrence of freezing puddles and black ice;
- Melting snow and ice infiltrates directly into pervious pavement, facilitating faster melting;
- Road salt application can be reduced up to 75% with the use of permeable pavements;
- The application of sand for snow or ice conditions should be avoided or limited;
- Snow plowing can proceed as with other pavements and salt can be used in moderation;
- Plowed snow piles should not be left to melt over pervious paving as clogging of pores can develop more quickly.



Comparing the Overall Costs of Green Infrastructure and Grey Infrastructure. Green Infrastructure requires more frequent, although much less costly, maintenance than conventional "grey" infrastructure.

The latest information shows that the whole life cost for green infrastructure is comparable to conventional stormwater infrastructure, and green infrastructure provides added quality of life benefits and increased property value.

Additional Resources

EPA resources related to the performance and costs of green infrastructure in communities like Manchester include the following links:

- *Case Studies for Stormwater Management on Compacted, Contaminated Soils in Dense Urban Areas:* www.epa.gov/brownfields/tools/swcs0408.pdf
- *Design Principles for Stormwater Management on Compacted, Contaminated Soils in Dense Urban Areas:* www.epa.gov/brownfields/tools/swdp0408.pdf
- *Managing Wet Weather with Green Infrastructure:* cfpub.epa.gov/npdes/greeninfrastructure/research.cfm
- *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices:* www.epa.gov/owow/nps/lid/costs07/documents/reducingstormwater-costs.pdf