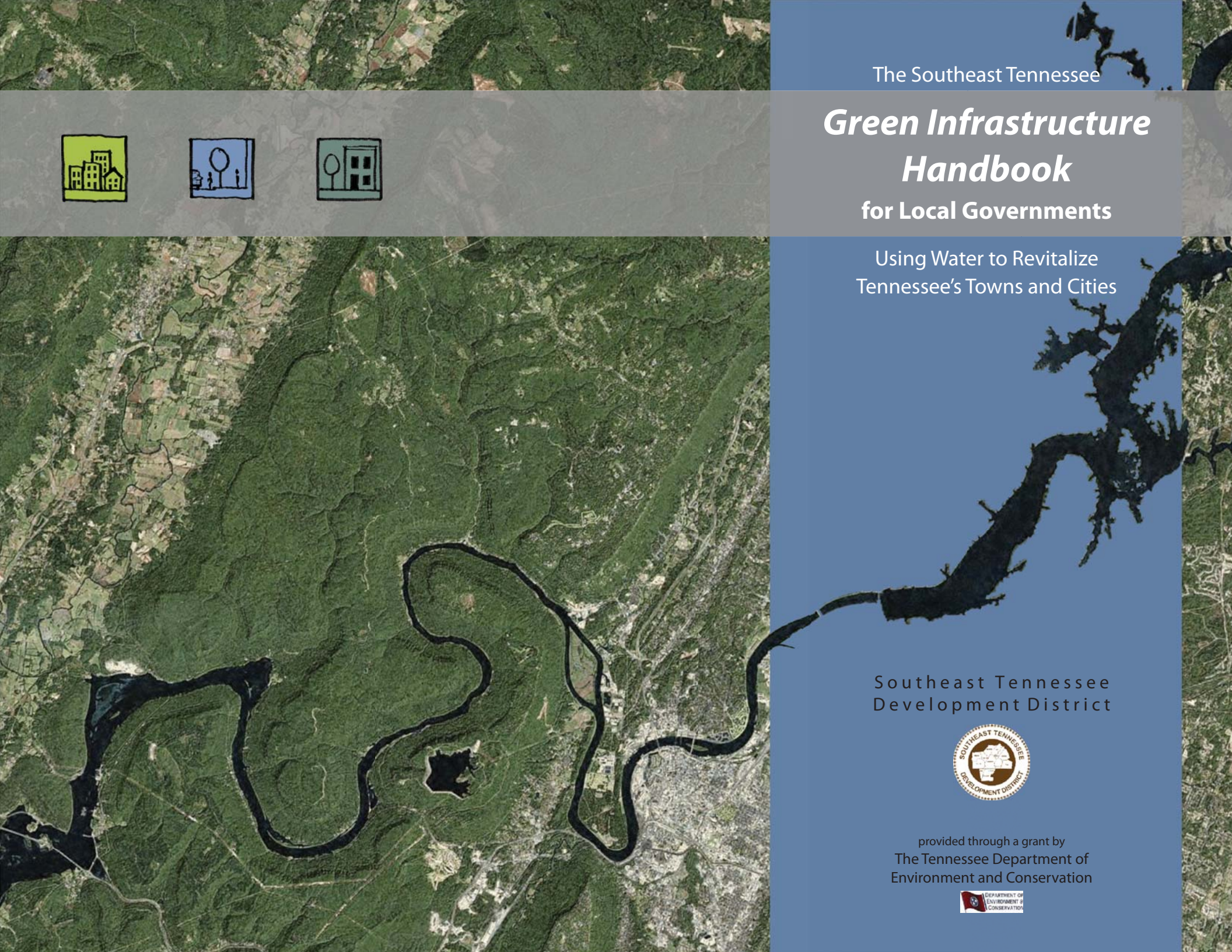

The Southeast Tennessee

Green Infrastructure Handbook

for Local Governments

Using Water to Revitalize
Tennessee's Towns and Cities

Southeast Tennessee
Development District

provided through a grant by
The Tennessee Department of
Environment and Conservation

The Southeast Tennessee Green Infrastructure Handbook for Local Governments: Using Water to Revitalize Tennessee's Towns and Cities

Chattanooga Area Regional Council of Governments/ Southeast Tennessee Development District
www.sedev.org

Cover Image: The Tennessee River, from Chickamauga Reservoir to Nickajack Reservoir (Image Credit: GIS)

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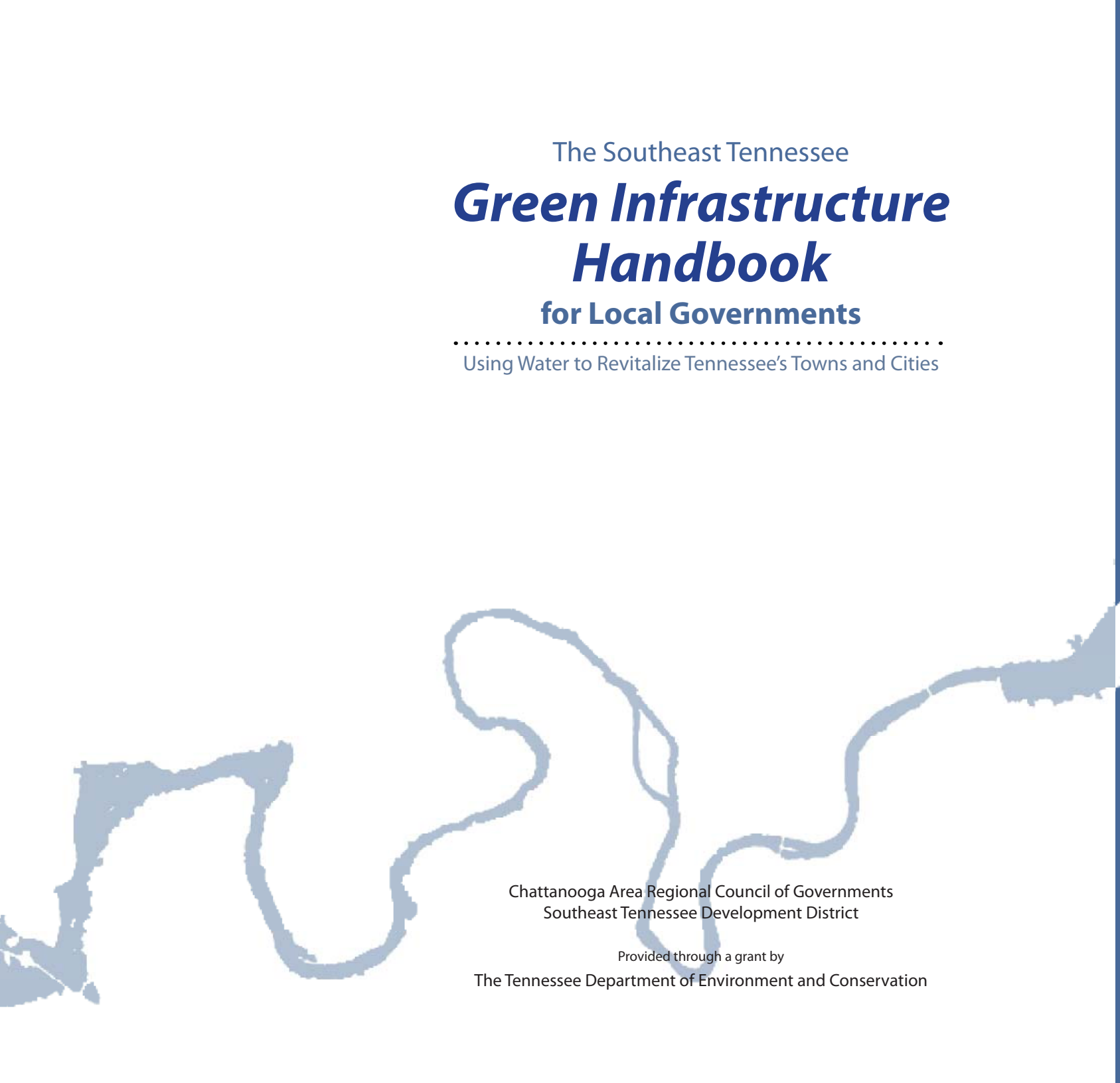


Chattanooga Area Regional Council of Governments
Southeast Tennessee Development District

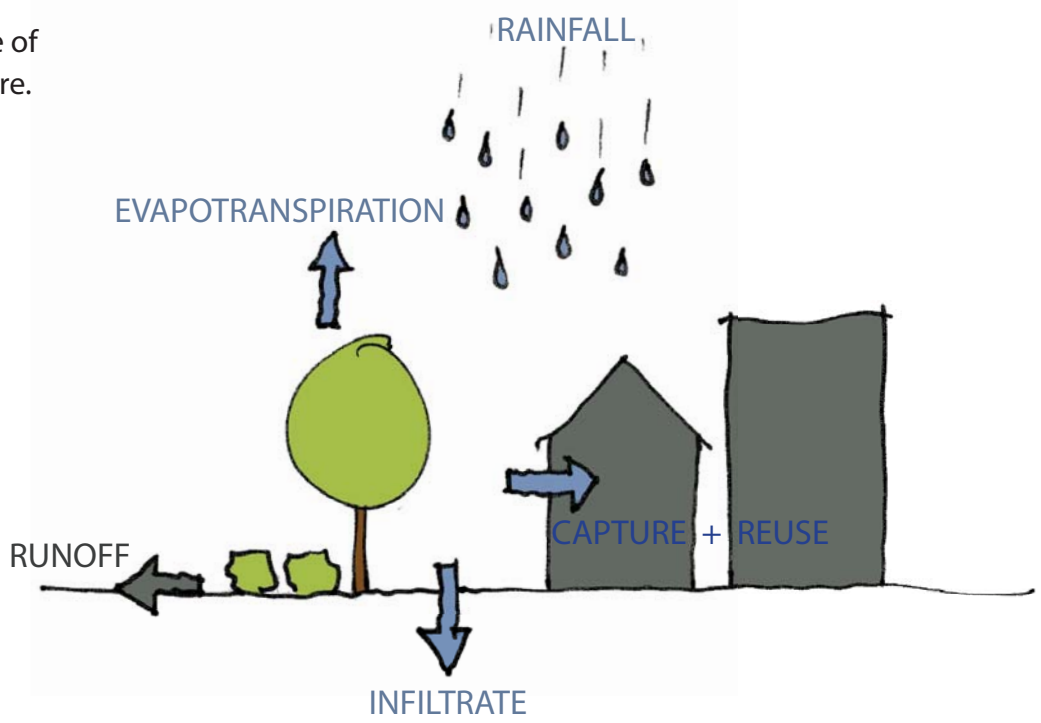
Provided through a grant by
The Tennessee Department of Environment and Conservation

Contents

Three basic ways to handle stormwater:

EVAPOTRANSPIRATE,
INFILTRATE,
CAPTURE and REUSE.

This is the essence of green infrastructure.



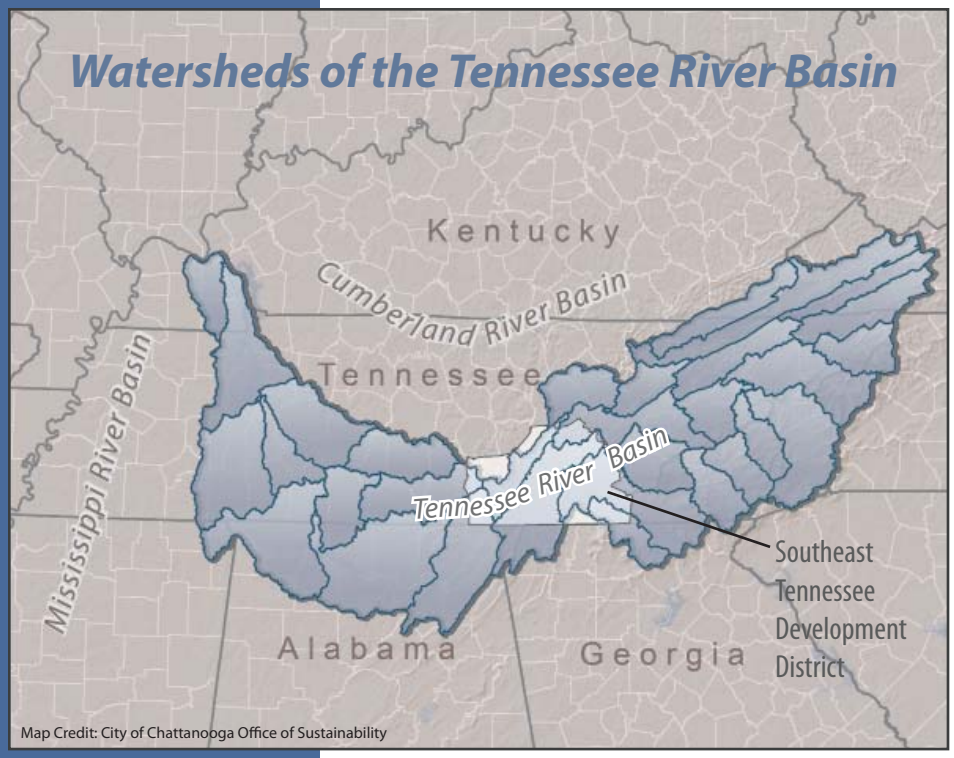
Why is Water Quality and Water Quantity Important? ***Environment*:** polluntants in water kill wildlife and stream life and creates a lack of suitable habitat, which affects the food chain at all levels. ***Economics*:** polluted waters are more difficult and more expensive to treat and turn into safe drinking water. Flood damage, often a result of increased paved surfaces, is a costly set back for some communities in the region. ***Recreation*:** water in much of the region is a setting for social activities like fishing, boating, and swimming. These are a high motivation for travel and tourism, which is a source of economic income for the region. ***Public Health*:** it is important to maintain a level of water quality that does not cause health risks and increase the spread of disease.

What Is Green Infrastructure? Green infrastructure can be explained at a variety of scales—the regional scale, municipal or community scales, street level, and site level. At the regional scale, green infrastructure is a network of natural areas and open space such as forests, trails, and parks that help sustain clean air and water and provide many other benefits for people and wildlife. At the municipal or community scale, there is a set of principles used for development in general. At the street and site level, green infrastructure relates to more specific hydrological techniques and projects.

In this handbook, three different scales—**community**, **street**, and **site**—will be used to describe green infrastructure as an approach to stormwater management that is environmentally friendly and cost-effective. By diverting stormwater runoff from the stormwater system to areas where the water can be *EVAPOTRANSPIRATED*, *INFILTRATED*, or *CAPTURED and REUSED*, water quality is improved.* At all scales, green infrastructure provides real ecological, economic, and social benefits.

Sustainable Solutions Sustainability is when solutions continue to be successful at all levels. The Southeast Tennessee region must be committed to improving water quality by using best management practices. Green stormwater infrastructure techniques not only manage stormwater effectively, but also offer environmental, economic, recreational, and health benefits. The following techniques may be used in various municipal projects as a "lead by example" approach for community revitalization. Municipalities may also encourage use by developers and residents.

*note: glossary of terms at back (page 37)



Legend

- ***Tennessee River Watersheds***
- ***Municipal Boundary***
- ***County Boundary***

The Tennessee River Basin

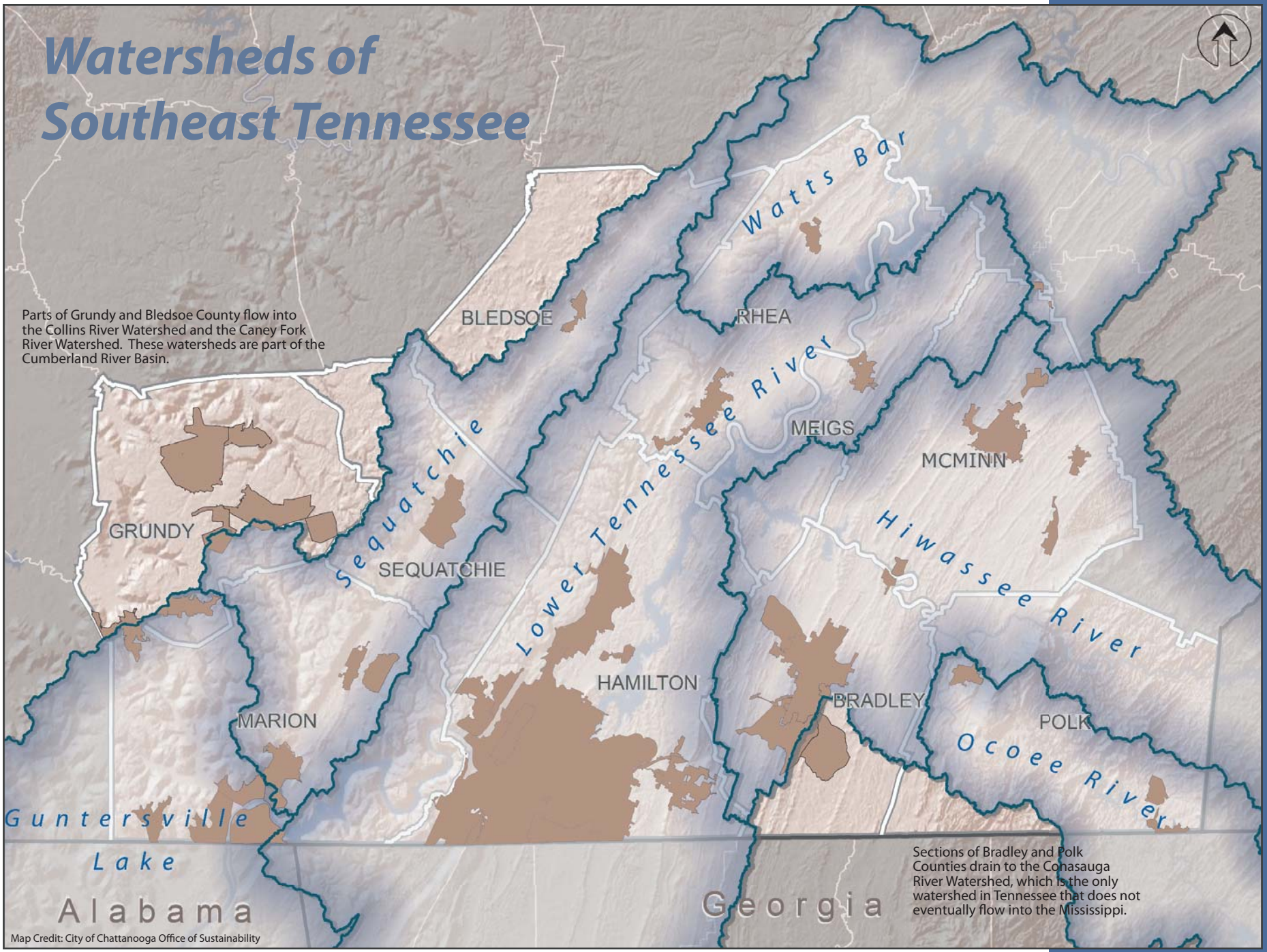
The Tennessee River Basin lies between the Cumberland and Mississippi River Basins (see map, left). Most of southeast Tennessee is part of the Tennessee River Basin. The map to the left shows all the watersheds that flow into the Tennessee River. These watersheds collect rainfall from parts of Tennesse, North Carolina, Georgia, Alabama, Mississippi, Kentucky, and Virginia. The Tennessee River begins just east of Knoxville when the Holston and French Broad Rivers come together. It flows southwest through Tennessee and west through Alabama. It then flows north through Tennessee again into Kentucky. From there it flows into the Ohio River, a tributary to the Mississippi River.

Know Your Watershed

The most significant watersheds in southeast Tennessee that flow to the Tennessee River (see map, right) are Watts Bar Lake Watershed, Hiwassee River Watershed, Ocoee River Watershed, Lower Tennessee River Watershed, Sequatchie River Watershed, and Guntersville Lake Watershed.

Municipalities in the Southeast Tennessee Development District study area:

Bledsoe County Pikeville **Bradley County** Charleston, Cleveland **Grundy County** Altamont, Beersheeba Springs, Coalmont, Gruetli-Laager, Monteagle, Palmer, Tracy City **Hamilton County** Chattanooga, Collegedale, East Ridge, Lakesite, Lookout Mountain, Red Bank, Ridgeside, Signal Mountain, Soddy Daisy, Walden **Marion County** Jasper, Kimball, Monteagle, New Hope, Orme, Powell's Crossroads, South Pittsburg, Whitwell **McMinn County** Athens, Calhoun, Engelwood, Etowah, Niota **Meigs County** Decatur **Polk County** Benton, Copperhill, Ducktown **Rhea County** Dayton, Graysville, Spring City **Sequatchie County** Dunlap


Watersheds of Southeast Tennessee
Parts of Grundy and Bledsoe County flow into the Collins River Watershed and the Caney Fork River Watershed. These watersheds are part of the Cumberland River Basin.
BLEDSOE
RHEA
Watts Bar
Lower Tennessee River
Sequatchie
MEIGS
MCMINN
GRUNDY
SEQUATCHIE
Hiwassee River
HAMILTON
BRADLEY
POLK
MARION
Ocoee River
Guntersville Lake
Alabama
Georgia
Sections of Bradley and Polk Counties drain to the Conasauga River Watershed, which is the only watershed in Tennessee that does not eventually flow into the Mississippi.
Map Credit: City of Chattanooga Office of Sustainability

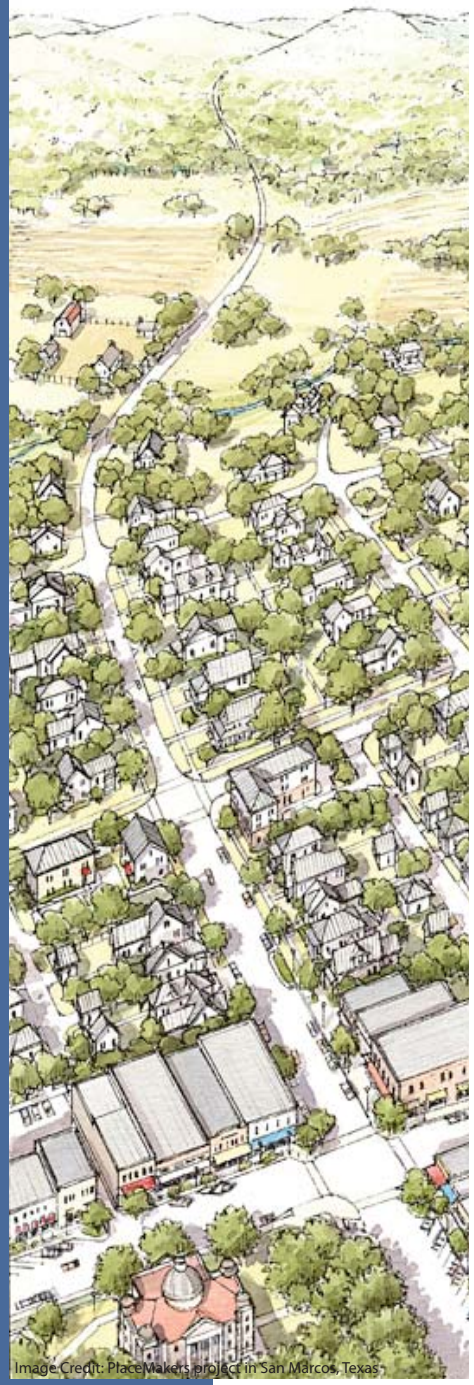


Image Credit: Place Makers project in San Marcos, Texas

At all scales, green infrastructure provides real ecological, social, and economic benefits.

Community

Development Principles

1

Settlement patterns, community design, and density are significant factors in how effectively cities and towns function in terms of water quality. Decisions are made during the governmental process on a daily basis that impact lifestyle, quality of life, and the overall sustainability of a region. When decisions include green infrastructure, these development choices can bring multiple benefits. Managing critical resources such as air, water, land, and forests can be challenging, but by incorporating the following development principles, balancing growth and conservation is achievable.

Photo: The Tennessee River in Marion County

1.1

Compact Development

compact development

sprawl development

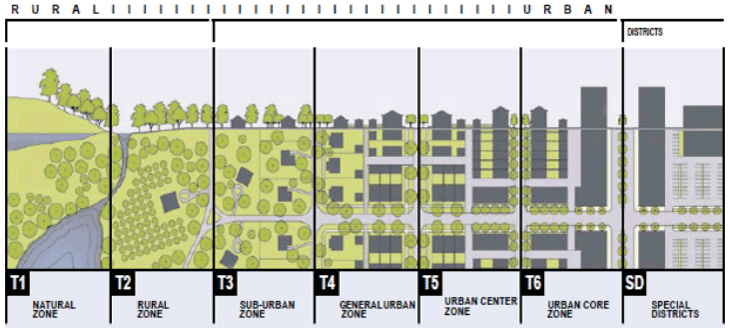
1.1 Compact Developent A powerful strategy for reducing a development's footprint, and hence its stormwater impact, is to focus on compact development. By utilizing small lots, higher densities, and a connected street system, compact designs lend themselves to city/urban settings or where a town center is desired. New growth should be as close to existing development as possible. Even though there may be a higher percentage of imperviousness, there will be less impervious surface overall. There are countless benefits to satisfying development needs on a smaller footprint.

The "Transect" is a planning tool that recognizes the variety of land uses from a rural boundary to the urban core. The closer a transect is to the natural zone (T1), the greener it is. Rural agriculture (T2) is important as it provides a source for local food. However, urban areas (T4 - T6) that are high in density are the most sustainable model for development, as they disrupt the natural hydrology the least and use resources efficiently. Compact development also lends itself to more housing options and increased transportation options, such as walking and biking, or shorter and less frequent automobile trips. Compact development has proven to be the most efficient, profitable, and desirable form of development.

Downtowns and neighborhood commercial districts are an example of compact development and should be modeled for future growth. They are also important as historical, cultural, and social centers.

Photo Credit: City of Chattanooga Office of Sustainability

The concept of compact development is illustrated by "the transect" below. As urban areas are developed, rural areas are conserved.



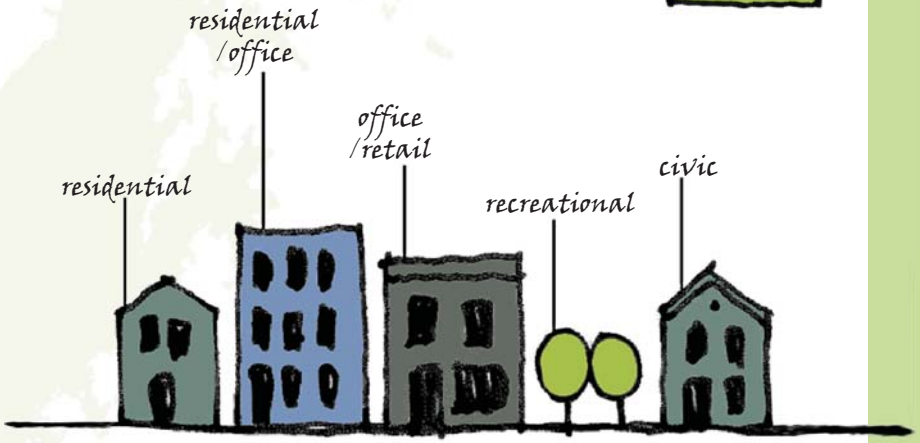
Potential Benefits:

- Provides for more efficient use of infrastructure including streets, sidewalks, electric lines, sewer lines, water lines, gas lines, etc.
- Reduces the quantity of stormwater runoff
- Enhances transportation options
- Less overall impervious surface is created
- More natural areas are left undeveloped
- Increases efficiency and economic value
- Improves health

Related Techniques: Mix of Uses (1.2), Street Network (1.3), Redevelopment and Infill (1.4), Business Improvement District (1.5), Transfer of Development Rights (1.6), Form-based Code (1.8)

Mix of Uses

1.2



This new mixed-use development in Cleveland, Tennessee incorporates office, retail, and residential.

Existing downtowns and neighborhood commercial districts are often good examples of mixed-use as well. These areas are prime for redevelopment as in Jasper, Tennessee where office, retail, and a cafe are all close by.

Potential Benefits:

- Increases opportunities for shared parking, thus less impervious surface
- More efficient use of infrastructure (streets, utilities, etc.)
- Provides for more walking trips instead of car trips
- Increases efficiency and economic value

Related Techniques: Compact Development (1.1), Street Network (1.3), Business Improvement District (1.5)

1.2 Mix of Uses Mixed-use development promotes more than one type of use in a building, set of buildings, or neighborhood.

Since the 1920's, zoning has required uses to be separated. However, when jobs, housing, and commercial activities are located close together, a community's transportation options increase. In addition, mixed-use developments often have higher property values. Often located in existing urban areas or as part of a new town center, mixed-use development provides a range of commercial and residential unit sizes and options.

1.3 Street Network

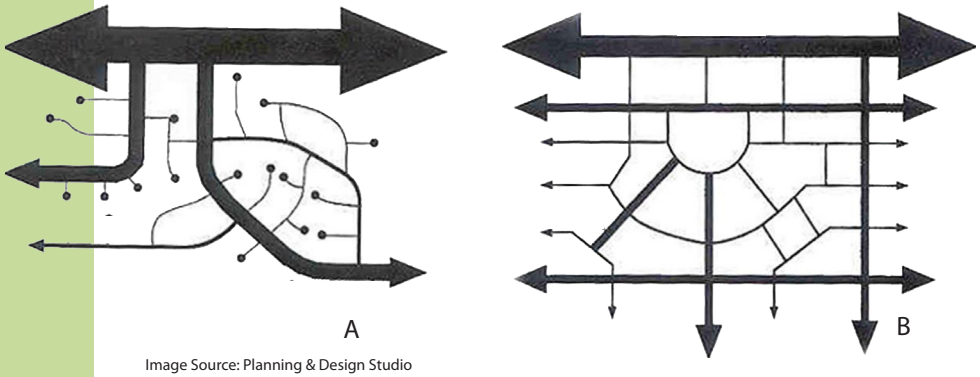


Image Source: Planning & Design Studio

This diagram shows the impact of dead-end streets (Example A) versus connected streets (Example B) on traffic congestion. The bolder lines and arrows indicate more traffic. The creation of one-way streets and dead-end streets should be avoided whenever possible.

1.3 Street Network The conventional hierarchical system where smaller roads feed into larger roads and highways increases traffic congestion (Example A). A network of well-connected streets enhances circulation and offers more than one route to a destination (Example B). It also supports mixed uses and multiple transportation modes.

Street Network retrofit techniques include: connecting disconnected streets, lanes, and cul-de-sacs. Where a new street is impossible, add paths to link housing and other uses. Underutilized travel lanes can be converted to add on-street parking, introduce bike lanes, and widen sidewalks.

The "Conventional" street layout (below, left) has more single-use streets that feed into the "collector street." Conventional street layout may also have more dead-end streets as well as segregated uses. A "Traditional" street grid (below, right) is well connected to multiple uses.

Image Credit: Local Government Commission

Potential Benefits:

- Provides for more efficient use of infrastructure
- Can reduce the development footprint
- Diversifies transportation options such as walking or biking
- Enables shorter and less frequent car trips
- Can reduce the need for additional traffic lanes and parking spaces as growth continues
- Less overall impervious surface is created
- Enhances economic value

Related Techniques: Complete Streets (2.1), Green Parking (2.4), Narrow Streets (2.5)

Redevelopment and Infill

1.4

When South Pittsburg outgrew its City Hall, the building was renovated and an addition was built rather than relocating it outside of the city center.

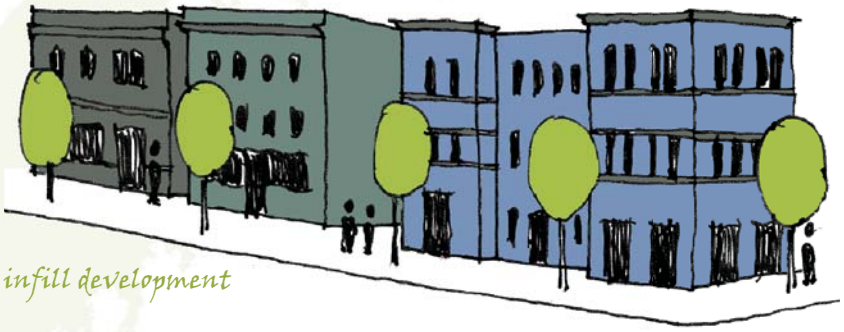
Photo Credit: maps.google.com

This building in South Pittsburg has served different uses over time. Through redevelopment, the structure has been maintained for use today as a historical and cultural landmark.

Potential Benefits:

- Re-uses existing impervious surfaces and other infrastructure
- Can command a premium market price due to location and enhanced desirability
- Reduces demand for new development elsewhere in the watershed
- Spurs reinvestment and development activity

Related Techniques: Compact Development (1.1), Business Improvement District (1.5)



infill development

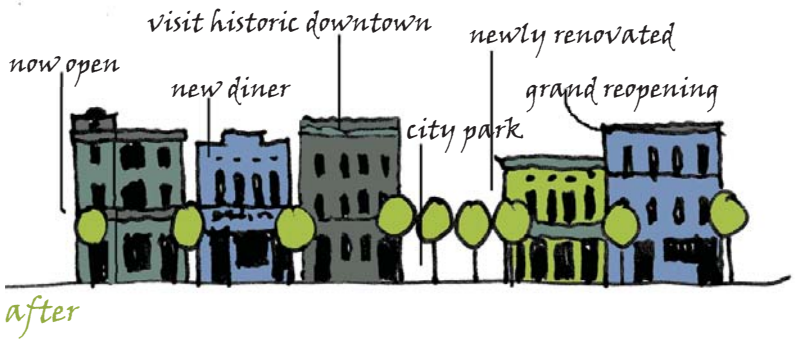
underutilized property

1.4 Redevelopment and Infill Redevelopment is development that occurs on previously developed land. Infill buildings are constructed on vacant or underutilized property between existing buildings. A brownfield site is one where there is real or perceived environmental contamination.

When brownfields or existing developed lands are targeted for use before opening up pristine areas of undeveloped land, a community saves on expenditures for new infrastructure, builds on its previous investments on already developed lands, and protects precious natural resources in outlying areas.

1.5

Business Improvement District



1.5 Business Improvement District A business improvement district (BID) is a defined area in which improvements and/or redevelopment is organized. Grant funds acquired by the city for special programs and/or incentives such as tax abatements are made available to assist businesses or to recruit new business. Also, businesses may pay an additional tax or fee in order to fund services or improvements within the district's boundaries. Improvements might include pedestrian and streetscape enhancements, capital improvements, or targeted marketing for the area.

The Town of Pikeville used grant funds to help implement significant streetscape enhancements. This was part of a master plan and community visioning process led by Farmer Associates.

A Business Improvement District may also include a Main Street revitalization program such as this one in Dayton, Tennessee (right) and Cleveland, Tennessee. For more information about the Main Street revitalization program, see http://www.preservationnation.org/main-street/

Potential Benefits:

- Improves economic development and increases tax base
- Reduces demand for new development elsewhere in the watershed
- Spurs reinvestment and development activity

Related Techniques: Compact Development (1.1), Mix of Uses (1.2), Redevlopment and Infill (1.4), Complete Streets (2.1), Urban Forests (2.3), Street Planters and Curb Extensions (2.6)

Transit Oriented Development

1.6

When medium to high density housing is located near transit, residents have the option of reducing the number of vehicles needed per family thus freeing up income for other expenses.

The Chattanooga Area Regional Transit Authority (CARTA) ties into the free downtown shuttle and bike share program. For example, a transit rider could take the bus to and from downtown, then ride the shuttle or use a bike for short trips during the day within the downtown area.

A high-speed rail line may one day link Atlanta, Chattanooga, Nashville, and the towns and cities in between.

Potential Benefits:

- Reduces strain on infrastructure such as parking spaces and travel lanes
- Reduces automobile dependence and increases pedestrian activity
- Increases efficiency and economic value
- Improves air quality by reducing Vehicle Miles Traveled (VMT's)

Related Techniques: Compact Development (1.1), Street Network (1.3)

1.6 Transit Oriented Development A transit-oriented development (TOD) is an area designed to maximize access to public transport, and often incorporates features to encourage transit ridership such as mixed-use, medium to high density housing, and sidewalks.

A TOD typically has a train station, tram stop, or bus stop at its center. The TOD node is surrounded by development spreading outwards from the center where residents have a relatively short commute to the transit center. Studies for this region show that densities of 12 dwelling units or more per acre are needed to support transit, much like commercial businesses need certain population rates to ensure purchase of sales and services. Transit nodes are often complemented by a few neighborhood style businesses such as a grocery store, bakery, pharmacy, etc.

1.7

Transfer of Development Rights


Photo Credit: Land Trust for Tennessee

1.7 Transfer of Development Rights The transfer of development rights is a technique that can be used to maintain agricultural land and its economic viability. Often, when farmland goes through the estate process, heirs must sell some or all of the property to pay the high inheritance taxes. Heirs are then left without the asset of land and lose much of the proceeds from the sale, and the property risks being overdeveloped. An alternative is to transfer the development rights (to a land trust or municipality), but keep other rights of land ownership. These transfers often happen through conservation easements or deed restrictions, and may include property and income tax benefits.

The longterm sustainability of Tennessee depends on the ability to conserve agricultural lands for food production and critical greenspace for watersheds as a water source.

Pikeville Spring Farm, 54 acres in Bledsoe County, is permanently protected by a conservation easement.

There are many land trust organizations available for land owners as a tool for protecting crucial farm lands and forests, such as Land Trust for Tennessee (landtrusttn.org) and Trust for Public Land (tpl.org).

Farmer's markets help sustain and support local food and the local economy as well as farmers and farmland.

Natural and agricultural lands provide recreation and views that are a part of the unique character of southeast Tennessee. Photo: agriculture in Rhea County, Tennessee


Photo Credit: bing.com/maps

Potential Benefits:

- Increases economic viability for agriculture and creates economic incentive for redevelopment and infill
- Can stimulate Business Improvement Districts and increase property values of compact development
- Reduces expensive expansions of utilities such as roads, schools, police, and other municipal services
- Retains natural hydrological patterns as more natural areas are left undeveloped
- Sustains scenic beauty

Related Techniques: Compact Development (1.1), Redevelopment and Infill (1.4), Business Improvement District (1.5), Open Space Development (1.9)

Form-based Code

1.8

Photo Credit: Planning & Design Studio

Planning Commissions utilize a review process to assess development proposals in the context of a code, guidelines, or a long-term plan to determine compliance and/or appropriateness on issues such as land use and zoning, accessibility, site design, water management, utilities, rights-of-way, and landscaping.

Photo Credit: Planning & Design Studio

The SmartCode, a form-based code, is suggested to be adopted parallel to an existing code, and as an incentivized alternative. The SmartCode is available as freeware at www.smartcodecentral.org

Potential Benefits:

- Protects investment by ensuring quality growth
- Discourages sprawl development
- Increases economic value

Related Techniques: Compact Development (1.1), Mix of Uses (1.2)

Photo: Residential development in Cleveland, Tennessee

1.8 Form-based Code A form-based code is an alternative to conventional zoning codes that primarly focus on land use. Form-based codes review additional development aspects to create a consistent-looking street or public area. This technique can be implemented through the city or county regulation process, including "Planning Commission Review". By addressing setbacks and building heights within a range, a typology for a particular area or district is set.

A form-based code is suitable for a community without existing zoning or for one that wants to adopt a progressive approach.

1.9

Open Space Development

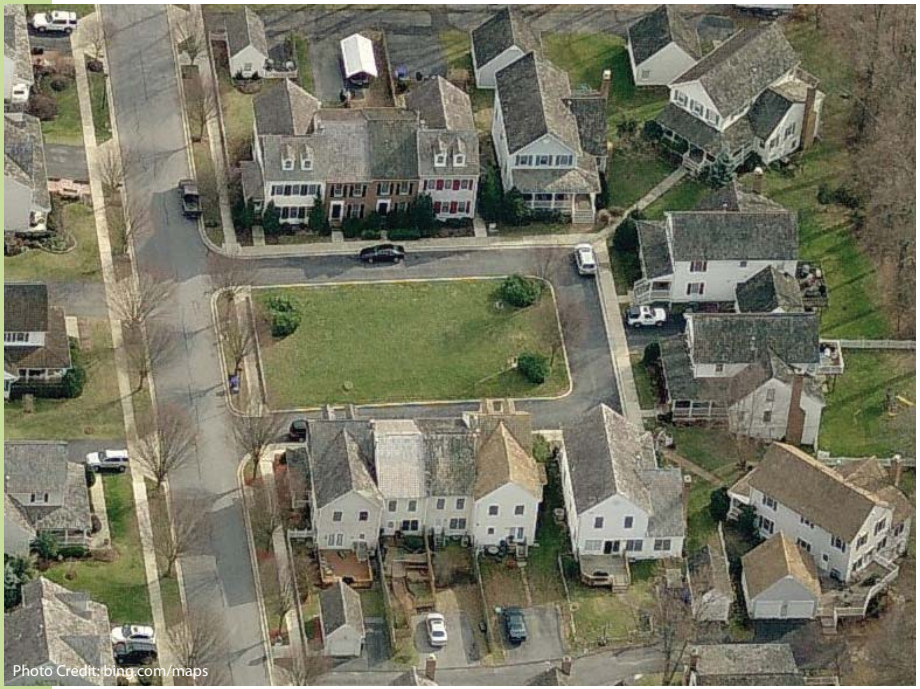


Photo Credit: bing.com/maps

1.9 Open Space Development The basic premise of "open space design" is the principle of grouping new homes onto only part of the development parcel so that the remainder can be preserved. Utilizing a conservation easement or other "community lot" provision, the remaining open space is permanently protected thus creating reduced storm water challenges.

Conventional zoning promotes development that generally allows the build out and/or privatization of nearly every acre of land. Typically, the only lands not designated for development are wetlands, floodplains or utility easements. Based upon the technique of "clustering" and the classic rural village, open space developments foster the concept of the central green, a commons, or town square.

Open space zoning allows the same overall amount of development as permitted under conventional zoning. The main difference is that this technique requires new construction to be located on only a portion of the parcel, (leaving 40% or more in a natural state.)

Studies have shown that clustered housing with access to open space had a higher rate of appreciation than comparable homes on conventional lots. Photo: residential development in Cleveland, Tennessee


Photo Credit: Planning & Design Studio

To ensure that communities will not be overdeveloped with subdivisions, shopping centers, or industrial parks, open space planning and "clustering" offers a practical option for including green space, forests, or farm lands. Photo: Soddy Lake, Tennessee

Potential Benefits:

- Protects natural resources and sustains scenic beauty
- Reduces the cost of building roads, water lines, and sewer lines
- Increases economic viability for agriculture, redevelopment and infill
- Increases the amount of land left undisturbed and in its natural hydrological state

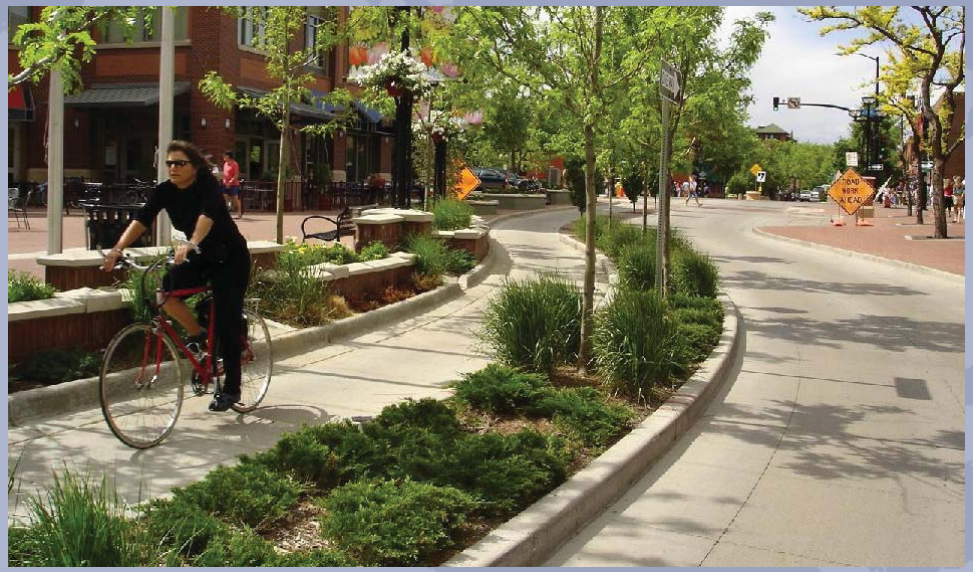
Related Techniques: Compact Development (1.1), Business Improvement District (1.5) Complete Streets (2.1), Urban Forests (2.3), Narrow Streets (2.5)

Street

2

Street Design Techniques

No other feature shapes the outward appearance of a community more than its streets. Roads, driveways, and parking lots are the largest contributor to impervious cover and, therefore, stormwater runoff. Impervious surfaces compound the problem of local flooding and stormwater runoff by increasing water volume and velocity. One method to reduce the volume of stormwater runoff is to reduce the size of parking lots, road widths, driveways, and rooftops. Impervious cover has a direct impact on municipal infrastructure and stormwater management. As much as possible, municipalities should be involved in regulating the reduction of impervious cover in new construction projects. Bike lanes and pedestrian infrastructure are important to reduce the strain on conventional infrastructure. Street designs should not prioritize the car above other modes of transport.



2.1

Complete Streets

2.1 Complete Streets "Complete Streets" are roadways designed and operated to enable safe, attractive, and comfortable access and travel for all users. They are designed to accomodate pedestrians, bicyclists, motorists, trucks, and public transport users of all ages and abilities. Policy can be adopted for new city streets to include Complete Streets. For state routes, cities may encourage the Tennessee Department of Transportation (TDOT) to build Complete Streets within their boundaries.

There are also retrofit techniques for existing city streets. One such technique is to redesign streets with narrower travel lanes or removal of lanes (also called a road diet) to accommodate additional bicycle lanes, curb extensions and on-street parking, or a wider sidewalk with street planters. Another retrofit technique is to create a "pedestrian refuge" with the use of medians or islands. This allows a place for the pedestrian to stop between lanes of traffic. This median area may also include stormwater managment facilities such as bioswales and vegetated swales.

This set of images shows the possible conversion of a car-centric road to a people-friendly destination. Much of the transformation has to do with the street: the width and number of lanes for vehicles, bike lanes, sidewalks, pedestrian crossings, a landscaped median, street trees, lighting, trash receptacles, benches, etc.

Those who cannot use a car may include elderly, disabled, low-income, adolescents, and teenagers. In addition, 55% of those poled would rather walk or bike than drive if given the opportunity. (Source: The Economic Benefits of Parks and Open Space)

This "pedestrian refuge" provides a place for pedestrians to cross one direction of travel at a time. It may also include landscaping with stormwater management facilities.

Potential Benefits:

- Increases overall capacity of the tranportation network and reduces congestion
- Provides opportunity to capture or reuse stormwater
- Slows traffic speeds
- Improves safety and health for all users
- Can improve social interaction and a sense of place
- Improves adjacent property values

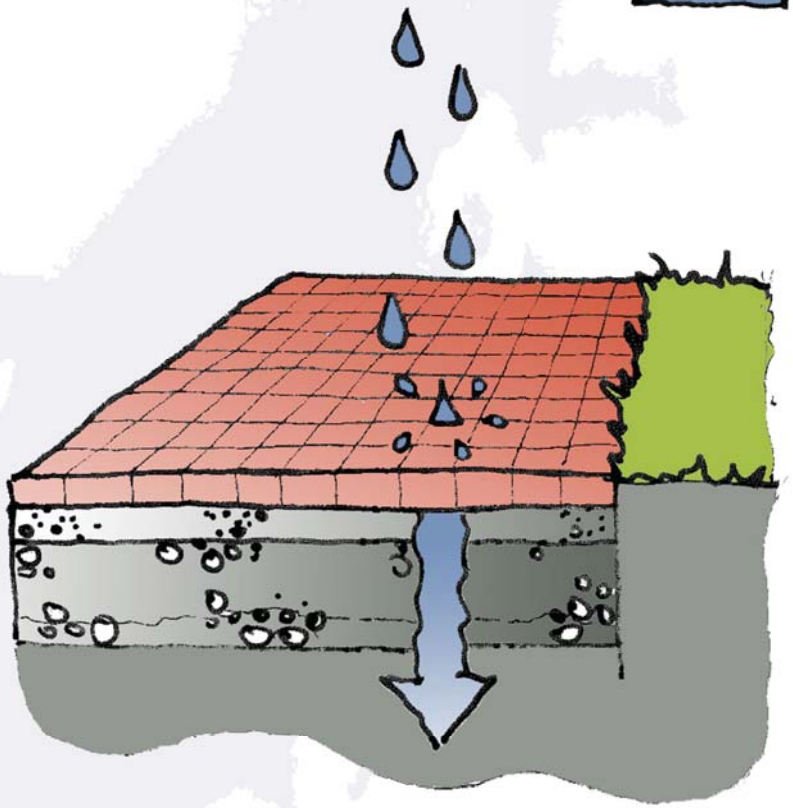
Related Techniques: Street Network (1.3), Urban Forests (2.3), Street Planters and Curb Extensions (2.6)

Permeable Pavement

This is an example of permeable concrete in Athens, Tennessee. It is poured as a drier mix. It can be painted and striped the same as conventional concrete.

Photo Credit: City of Chattanooga Office of Sustainability

This is a fabricated paver. One can see the ridges along the sides that keep space between pavers for air and water to pass through and infiltrate into the ground.



Potential Benefits:

- Reduces the rate and quantity of stormwater runoff
- Reduces stress on stormwater infrastructure
- Recharges ground water
- Filters pollutants, silt, and debris
- Reduces the urban heat island effect

Related Techniques: Green Parking (2.4), Underground Cisterns and Storage (3.3), Structural Soil (3.9)

2.2 Permeable Pavement Permeable pavement, or pervious pavement, allows water to filter through the surface and percolate into the ground. Permeable pavement comes in the form of permeable asphalt, permeable concrete, and permeable pavers. In areas where soils do not drain properly, structural soil can be used in combination with subsurface drainage systems, like pipe underdrains or stormwater infiltration trenches to slow runoff and reduce stress on the stormwater system. Water may also be directed to underground cisterns and storage tanks.

2.3 Urban Forests

Photo South Cedar Avenue, South Pittsburg, Tennessee

2.3 Urban Forests Urban forests refers to the trees and forests located in and around towns and cities. Planted rights-of-way and buffers as well as formal parks and streetscape (street trees) help manage stormwater. Urban forests also serve to break up a landscape of impervious cover, provide small but essential green spaces, and link walkways and trails.

Since trees absorb water, they are an important part of the natural system of stormwater management. The process of evapotranspiration involves evaporation from the soil and transpiration from plants. Leaves help capture rainfall. Tree roots direct water deep into the ground and help recharge aquifers. Besides acting as large scale filters, trees also offer carbon sequestration benefits.

Evapotranspiration: the process of water evaporating from the ground and transpiring from the leaves.

Take Root is a public-private partnership program to double the percentage of tree canopy cover in Chattanooga's urban core. To learn more, go to takerootchattanooga.com


Photo Credit: Planning & Design Studio

Trees not only have stormwater benefits, they also add greatly to property values and aesthetic appeal.

Only deciduous trees should be used as street trees; conifers block views and desirable winter sun. Photo: Broad Street, Chattanooga, Tennessee


Photo Credit: Planning & Design Studio

Potential Benefits:

- Evapotranspirates water from the leaves
- Enhances infiltration of stormwater runoff (with roots)
- Provides shade from the summer sun and reduces the urban heat island effect
- Improves air quality
- Attracts consumers and improves property values
- Provides habitat for birds and wildlife

Related Techniques: Street Network (1.3), Business Improvement District (1.5), Complete Streets (2.1), Street Planters and Curb Extensions (2.6), Structural Soil (3.9)

Green Parking

2.4

Photo Credit: Planning & Design Studio

The Finley Stadium "parking orchard" in Chattanooga, Tennessee includes pervious paving and an abundance of trees.

This rigid interlocking plastic paver, called Geoblock, is filled with dirt and planted with grass. The load is distributed evenly over the grid and is structurally sound for cars. This is an excellent option for overflow parking.

Photo Credit: City of Athens Public Works

Potential Benefits:

- Reduces the rate and quantity of stormwater runoff
- Reduces stress on stormwater infrastructure
- Recharges ground water
- Filters pollutants, silt, and debrris
- Reduces the urban heat island effect
- Enhances site aesthetics

Related Techniques: Permeable Pavement (2.2), Green Parking (2.4), Bioswales and Vegetated Swales (3.8), Structural Soil (3.9)

2.4 Green Parking "Green Parking" refers to several techniques that, when applied in the right combination, can dramatically reduce impervious cover, thus reducing the amount of stormwater runoff. These techniques include: setting maximums for the number of parking spaces created; minimizing the dimensions of parking lot spaces; utilizing permeable pavers in overflow parking areas; using bioswales and vegetated swales to treat stormwater (3.8); and providing economic incentives for structured parking.

In urban areas of compact development, there are many opportunies for shared parking. Some cities give parking reductions within their local code requirements when a proposal for shared parking is submitted. (This often requires an agreement lease or easement between property owners.)

2.5

Narrow Streets

Photo: West 17th Street, Chattanooga, Tennessee

2.5 Narrow Streets Narrower streets reduce the amount of impervious cover. By doing so, stormwater runoff and the associated pollutants (silts, oils, debris) may also be reduced. Curb radii at intersections can also be narrowed, especially where there is pedestrian activity. This causes cars to slow down when making turns and decreases the distance for pedestrains to cross the street.

An additional benefit of narrow street design is that it frees up land and right-of-way for other beneficial uses such as sidewalks, bike lanes, and street trees. Narrower streets also encourage more pedestrian use by creating a more inviting and safe environment.

before

Photo Credit: Planning & Design Studio

after

These before and after photos of Riverfront Parkway in Chattanooga, Tennessee show how a street can be narrowed from four lanes to two lanes. The retrofit design accomodates new parking, a wide sidewalk, lighting, benches, street trees and landscaping, while still accomodating automobile traffic.

Potential Benefits:

- Reduces impervious cover
- Reduces construction costs, for new construction
- Slows traffic speeds and improves safety
- Creates shorter distance for pedestrians to cross

Related Techniques: Street Network (1.3), Complete Streets (2.1), Urban Forests, (2.3) Street Planters and Curb Extensions (2.6)

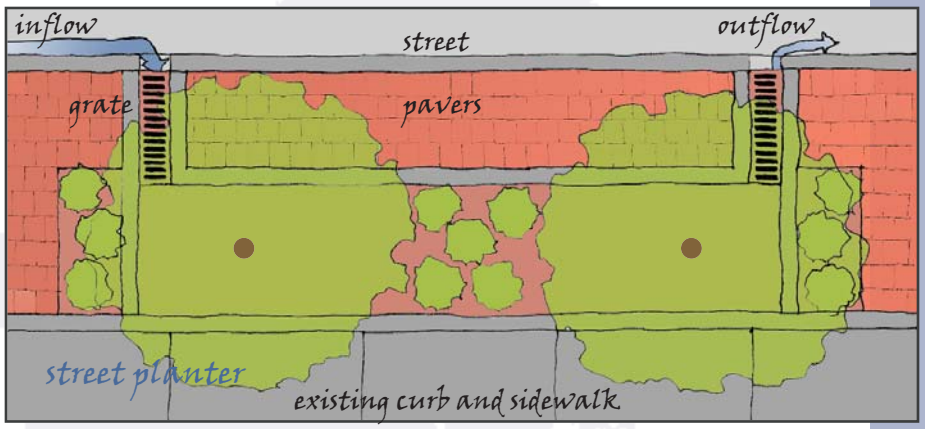
Street Planters and Curb Extensions

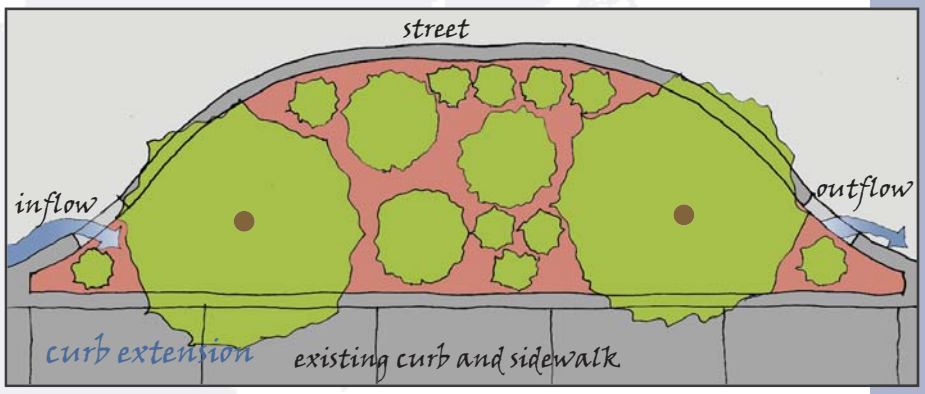
Photo Credit: Planning & Design Studio

Designed to allow maximum absorption and infiltration, these street planters include pervious pavers and other materials that not only handle storm water, but also offer a healthier place for tree growth than typically seen in urban streetscape environments.

Photo Credit: Planning & Design Studio

This curb "bump out" provides space for a more significantly sized tree while also lessening the crossing distance for pedestrians. The curb extension also defines on-street parking areas.





Potential Benefits:

- Reduces impervious cover
- Reduces the rate and quantity of stormwater runoff
- Enhances site aesthetics
- Improves the pedestrian environment and attracts shoppers
- Reduces the urban heat island effect

Related Techniques: Redevelopment and Infill (1.4), Business Improvement District (1.5), Urban Forests (2.3), Narrow Streets (2.5), Rain Gardens (3.4), Native Landscaping (3.5), Structural Soil (3.9)

2.6 Street Planters and Curb Extensions Street planters are designed as part of the planting strips found in a developed or urban area. They may feature a cut in the curb to allow inflow and outflow of stormwater running along the curb. Street planters act as rain gardens where stormwater can infiltrate into the ground. Curb extensions literally extend the curb into the existing street to create more planting area and thus handle more stormwater runoff.

Curb extensions also provide some protection for parked cars and can reduce the crossing distance for pedestrians.

2.7

Eliminating Curbs and Gutters

Photo: Cleveland, Tennessee

2.7 Eliminating Curbs and Gutters This practice promotes grass or vegetated swales as an alternative to the curb and gutter approach. A vegetated swale slows and naturally filters stormwater pollutants through infiltration. Curbs and gutters are designed to quickly convey runoff, with its pollutants traveling from the street to the stormdrain and ultimately to a local stream or lake. This technique is most suitable for narrow, low-volume streets or natural, rural, and sub-urban settings.

Curb and gutter transports runoff directly to receiving waters.

Having no curb and gutter reduces stress on the stormwater system, filters runoff naturally, and recharges groundwater.

An example of permeable concrete constructed with a level curb to ensure durability.

Potential Benefits:

- Reduces the rate and quantity of stormwater runoff
- Reduces labor and construction costs
- Recharges ground water instead of entering stormwater system

Related Techniques: Bioswales and Vegetated Swales (3.8)

Site

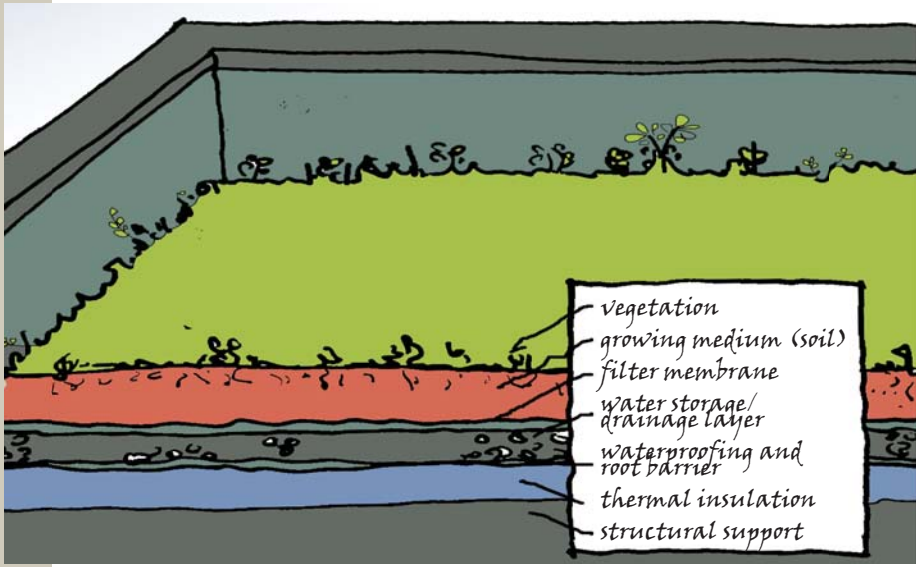
3

Site Design Techniques

It is perhaps at the site design level where the most opportunities exist for developers and other private sector entities to bring water quality solutions into the built environment. Being sustainable means not only addressing function, but also aesthetic appeal. These techniques, also called "high performance landscaping," can result in increased energy efficiency, improved public ammenities, and overall, added property value. As a general rule, development should keep stormwater as close to its source as possible. Stormwater runoff should infiltrate into the ground and be filtered naturally. The impacts of stormwater runoff can be reduced by disconnecting the existing impervious area from storm drains.

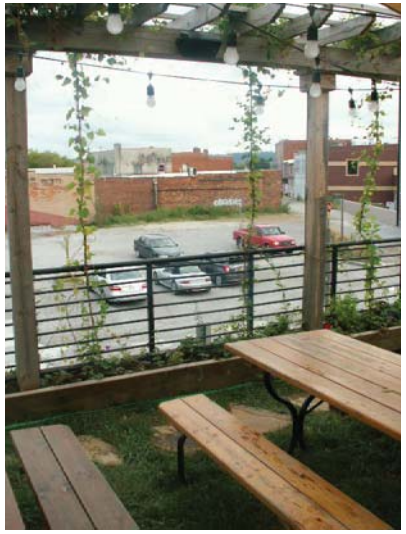
Photo Credit: Tennessee Valley Authority

3.1 Green Roofs



3.1 Green Roofs A green roof is a roof that is partially or completely covered with plants. In contrast to traditional asphalt or metal roofing, green roofs absorb, store, and evapotranspirate initial precipitation, thereby acting as a stormwater management system and reducing overall peak flow discharge to a stormwater sewer system.

Green roofs can be installed on commercial, industrial, and residential flat roofs, provided the roof is constructed to accommodate the structural load under fully saturated conditions. Additionally, green roofs can provide useable space as rooftop gardens. Other designs can create a "complete" roof benefits package: lower energy bills, stormwater mitigation, outdoor living space, and less impervious surface.



This is an example of a green roof with useable green space. The Terminal, a three-story restaraunt in Chattanooga, seats customers at picnic tables on the second story roof. The grass shown here is planted in a GeoBlock grid. The Terminal is an example of green development with a redeveloped building and pervious gravel parking lot sited behind the building.

This diagram illustrates a roof top surface planted with sedums or other plantings to create a green roof that reflects rather than absorbs the sun's rays.

Here is an artist's illustration (before and after) of the change green roofs would make to a city.

Photo Credit: City of Chattanooga Office of Sustainability

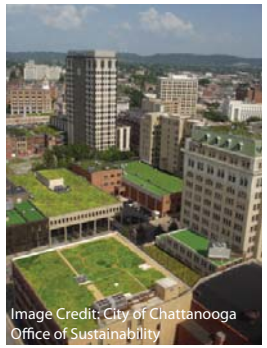


Image Credit: City of Chattanooga Office of Sustainability

Potential Benefits:

- Reduces the rate and quantity of stormwater runoff
- Reduces the urban heat island effect
- Reduces energy costs for heating and cooling
- Provides an attractive amenity and opportunity for accessible garden space
- Increases property values
- Increases durability and lifespan of roofing materials as it blocks the harsh sun

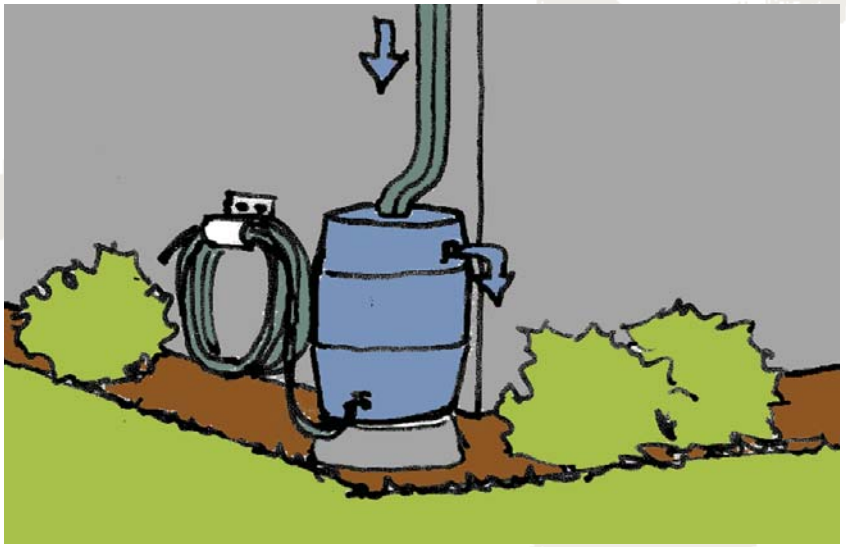
Related Techniques: Rain Barrels and Cisterns (3.2), Native Landscaping (3.5)

Rain Barrels and Cisterns

3.2

This cistern illustrates a larger scale facility that may serve an office or retail establishment. The water is used to irrigate native plant landscaping at Outdoor Chattanooga.

By at least disconnecting downspouts from being chanelled directly to the stormwater system, stormwater runoff can often be handled on site.



3.2 Rain Barrels and Cisterns Rain barrels and cisterns store rooftop runoff as rainwater that can be used for irrigation and other purposes such as cleaning pavement or low flush toilets for example. Rain barrels are usually for residential and/or educational purposes. Cisterns are at a larger scale and usually used in a commercial or municipal setting.

Depending on the size or duration of a rainfall event, one 55 gallon rain barrel can be filled quite quickly and must feature a spill over valve or plan for regular use. In other words, it is very important to empty the rain barrel regularly.

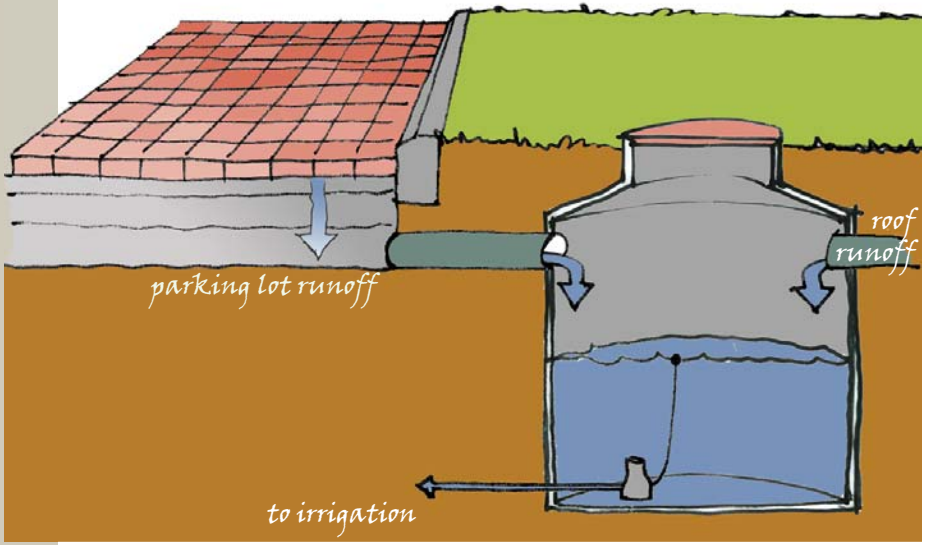
Potential Benefits:

- Reduces the quantity of stormwater runoff
- Provides free water for irrigation
- Reduces utility bills

Related Techniques: Rain Gardens (3.4), Lawn Care (3.6)

3.3

Underground Cisterns and Storage



3.3 Underground Cisterns and Storage Rainwater may be captured and stored in underground storage tanks or in cisterns located above ground. Basically functioning in the same manner as a rain barrel, cisterns are typically larger in scale, vertical and may hold many thousands of gallons of water. Based on the volume of water captured, these devises offer moderate reductions in storm water that would otherwise be considered runoff. Underground Storage tanks may be used on both private developments or for municipal projects, with locations under parking lots or streets a typical placement. The cistern or underground storage may replace the need for detention ponds, thus freeing up property for development. This is especially useful when working with urban development sites, on constrained sites or where clustered development is recommended.

To gain the most effective benefits, rainwater stored in these facilities should be reused and targeted for irrigation or other grey water use. Reuse is essential as it empties the facilities and readies them for the next rain event.


Photo Credit: darcoinc.com

This undergound storage tank installation will be used for irrigation.


Photo Credit: darcoinc.com

This underground cistern will hold 12,000 gallons. Typically a 1,100 gallon cistern may capture 80% of the runoff from a 1,000 sq.ft. roof. (Source: Green Infrastructure Master Plan, Nashville Davidson County, Metro Water Services)

Potential Benefits:

- Reduces runoff volume into sewer system
- Replenishes groundwater supplies with a slower release system
- Provides water for irrigation
- Can reduce consumption of treated water

Related Techniques: Permeable Pavement (2.2), Green Parking (2.4), Rain Barrels and Cisterns (3.2)

Rain Gardens

3.4

Photo Source: Planning & Design Studio

Ideally, native plants that thrive in full sun are most suited for a rain garden, but shade and partial shade plants may be used if necessary.

Since rain garden plants are "watered" naturally, little maintenance is needed once established. "Payoff" comes in the form of an added landscape feature that also handles stormwater in a more natural way. Rain gardens may also take the form of streetscape.

Tip on soil types: A: sand, B: sand/silt, C: silt/clay, D: clay/concrete. If soil type is mostly C and D, it may be necessary to enhance the soil.

Photo Credit: Tennessee Valley Authority

Photo: the ribbon cutting at a new green parking lot and rain garden in Athens, Tennessee.

Photo: Renaissance Park, Chattanooga, Tennessee

Potential Benefits:

- Recharges ground water
- Filters pollutants, silt, and debris
- Reduces need for irrigation
- Reduces local flooding
- Provides habitat for birds and wildlife
- Reduces the rate and quantity of stormwater entering the stormdrain
- Provides attractive garden area to receive discharge from downspouts

Related Techniques: Permeable Pavement (2.2), Green Parking (2.4), Rain Barrels and Cisterns (3.2), Native Landscaping (3.5), Constructed Wetlands and Naturalized Detention (3.7)

3.4 Rain Gardens A rain garden is a landscape feature, planted with native perennial plants, that allows stormwater to infiltrate back into the soil. It is also designed to slow stormwater runoff from reaching impervious surfaces. Rain gardens can be designed so that any overflow drains directly into the stormdrain for large rainfall events.

The most important thing when siting a rain garden is determing location. The rain garden should be placed between the source of runoff and the drainage point. To identify low points, puddles, or "pinch points," a study of water flow during a rain event is best done before the design stage.

3.5

Native Landscaping


Photos: Renaissance Park Rain Garden Chattanooga, Tennessee

Example native plants for this regiont: American Beautyberry, Butterfly-weed, Inkberry Dwarf Cultivar, Redtwig Dogwood, Virginia Sweetspire, Big Bluestem, Broom Sedge, Indiangrass, River Oats, Blue Fescue, Asters, Blazing Star, Black-eyed Susan, Blue Phlox, Coreopsis, Creeping Jenny, Ironweed, Joe-Pye Weed, Purple Coneflower, Stonecrop, Yarrow (Source: Tennessee Valley Authority, Renaissance Park Project, Chattanooga, Tennessee)


Photo Credit: City of Athens Public Works

City of Athens Tree Museum features native landscaping.


Photo Credit: Planning & Design Studio

This rain garden is part of a formal streetscape; it is designed to handle stormwater more effciently. Native species and drought resistant plants tend to be more tolerant of the climate extremes often found in this region, and thus require less maintenance.

3.5 Native Landscaping Plants and trees native to southeast Tennessee are uniquely adapted to the local weather, soil, and rainfall conditions. Using native plants for landscaping and beautification projects can reduce the amount of maintenance, fertilizing, and irrigation needed.

These natives are often perrenials and best established during the dormant months (Nov-Mar in zone 7). There are many organizations that provide a complete list of plant species appropriate for different hardiness zones.

Potential Benefits:

- Requires little or no irrigation and maintenance once established
- Requires no fertilizer, pesticides, or herbicides
- Provides habitat for birds and wildlife

Related Techniques: Urban Forests (2.3), Street Planters and Curb Extensions (2.6), Green Roofs (3.1), Rain Gardens (3.4), Lawn Care (3.6)

Lawn Care

3.6

Photo Credit: Planning & Design Studio

Located on a small lot, this house also features plantings as an approach for minimized turf.

Photo Credit: City of Chattanooga Office of Sustainability

Purchasing phosphate-free soaps and detergents may improve water quality. Phosphates are one component of total dissolved solids, a major indicator of water quality. When phospate levels rise in streams, algae blooms may deplete oxygen levels for other populations, such as fish.

Potential Benefits:

- Reduces the rate and quantity of stormwater runoff
- Reduces stress on stormwater infrastructure
- Recharges ground water
- Filters pollutants, silt, and debris
- Reduces the urban heat island effect
- Reduces money spent on fertilizers, herbicides, and maintenance

Related Techniques: Open Space Development (1.9), Rain Barrels and Cisterns (3.2)

Photo: South Pittsburg, Tennessee

3.6 Lawn Care Best Management Practices for lawn care can improve lawn appearance *and* water quality. Using too many fertilizers and herbicides degrades water quality. Fallen leaves are a source of nitrogen and can be mulched with a mower to provide natural fertilizer. Mowing high reduces weeds and encourages a healthy root structure. Keeping fertilizers and grass clippings on the lawn allows them to be most beneficial. Keeping them off hard surfaces prevents them from being washed into the stormwater system and into water bodies. Companion planting can be used instead of some herbicides.

Replacing large areas of turf with native species, plantings, ground cover, or trees also reduces maintenance and creates a more diverse "lawnscape." Fields, meadows, or areas left in a pristine state may be a more appropriate landscape given a developments' location and scale.

3.7

Constructed Wetlands and Naturalized Detention

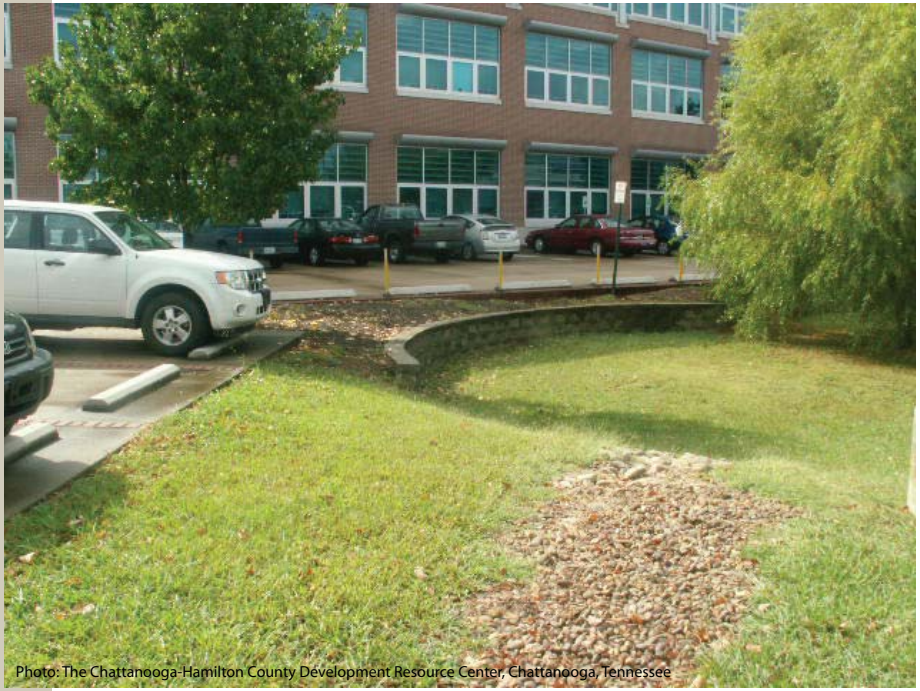


Photo: The Chattanooga-Hamilton County Development Resource Center, Chattanooga, Tennessee

When parking in this lot, one hardly notices that the landscaping here also serves as a detention pond in wet weather.

Photo Credit: City of Chattanooga Office of Sustainability

At Calvin Donaldson Elementary School in Chattanooga, Tennessee this retention pond, adjacent to the new one, serves as a comparison of methods and an educational tool for students.

Photo Credit: City of Chattanooga Office of Sustainability

The constructed wetland also serves as a retention pond at Calvin Donaldson Elementary School. It is both beautiful, functional, and educational.

3.7 Constructed Wetlands and Naturalized Detention Naturalized detention is using an area to temporarily store stormwater on site and slowly release it at a controlled rate. These areas are intended to look and function as natural wetlands and include native plants growing both above and below the normal water level.

These facilities can be designed as part of a municiple park or a large industry or business. For residential developments, a constructed wetland can become an amenity and asset that emphasizes a natural setting, views, or a common area. In addition, these wetland settings can provide a viab

Potential Benefits:

- Reduces local flooding and enhances site aesthetics
- Reduces or eliminates detention requirements
- Reduces the rate and volume of stormwater runoff
- Filters silt, pollutants, and debris naturally
- Provides habitat for birds and wildlife

Related Techniques: Open Space Development (1.9), Rain Gardens (3.4), Native Landscaping (3.5), Bioswales and Vegetated Swales (3.8)

Bioswales and Vegetated Swales

3.8

This vegetated swale, or grass swale, is a natural and attractive way of conveying stormwater. Some stormwater will infiltrate into the ground. In addition, the vegetation will help filter and clean the stormwater.

Photo: Credit: City of Athens Public Works

This biodetention swale in Athens, Tennessee allows water to infiltrate into the ground, slows and filters stormwater, and temporarily holds stormwater in wet weather.

Potential Benefits:

- Reduces strormwater piping and infrastructure
- Reduces the rate and quantity of stormwater entering sewer system
- Recharges ground water
- Filters pollutants, silt, and debris naturally
- Reduces or eliminates detention requirements
- Enhances site aesthetics

Related Techniques: Eliminating Curbs and Gutters (2.7), Constructed Wetlands and Naturalized Detention (3.7)

Photo: Volkswagon Plant, Chattanooga, Tennessee

3.8 Bioswales and Vegetated Swales A bioswale, or vegetated swale, is a shallow trench or shoulder alongside a street landscaped with native plants to slow the speed of surface runoff. It allows stormwater to infiltrate back into the ground instead of flowing directly into storm sewers.

Bioswales can also be incorporated as part of a landscaped median combining aesthetics with stormwater mitigation. A bioswale can be used as a technique to daylight streams and creeks, or bring the water above ground and out of a buried pipe.

3.9 Structural Soil

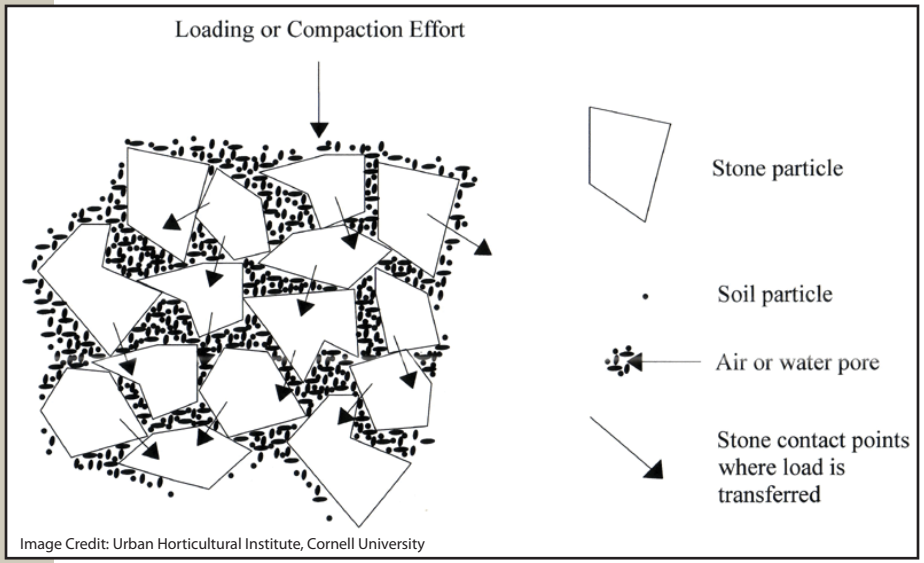


Image Credit: Urban Horticultural Institute, Cornell University

3.9 Structural Soil Structural soil is used as a growing medium in tree wells and street planters as well as a base for paving materials. Structural soil not only provides load-bearing capacity, but also allows tree roots to grow without disrupting or heaving the paving material.

Structural soil also increases water holding capacity and is designed to break down pollutants in the stormwater. Structural soil may contain polymers or other materials that absorb and retain water for slow release that irrigates trees and plants during dry spells.

Photo: A typical tree planting pit using Structural Soil. When the roots can go down deep into the ground, there is less chance for sidewalk heave.

The diagram shows how just the right mixture of materials allows the load to be transferred, but also allows for movement of air, water, and root growth.


Photo Credit: Urban Horticultural Institute, Cornell University

CU-Structural Soil is one example of a structural soil meant to be used with pavers and permeable pavement. It can handle the structural load of a paved surface, but also allows the roots to move and grow within it. For distribution information see: amereq.com/

Potential Benefits:

- Rechargers ground water or aquifer
- Filters silt, car residue, oils, and other pollutants
- Increases stormwater capacity of rain garden, tree well, or pervious pavement

Related Techniques: (3) Street Network, (12) Urban Forests, (15) Street Planters and Curb Extensions

Glossary of Terms

Adsorption (not absorption) – when rainwater gathers on the surfaces of leaves

Best Management Practices (BMP's) – methods or processes that are believed to be most effective

Brownfield Development – the redevelopment of an industrial or commercial site, usually a previously polluted site

Companion Planting – the close planting of different plants that enhance each other's growth or protect each other from pests

Daylighting – redirecting water, previously in a culvert or pipe, into an above-ground channel

Detention – short-term storage and release of stormwater

Evapotranspiration – (evaporation and transpiration) the process of water transpiring from plants' roots and evaporating

Graywater – untreated rainwater, water from sinks, showers, or washing machines that can be used for irrigation or to flush toilets

Green (Extensive) Roof – six inches or less of growing medium; designed for low maintenance

Green (Intensive) Roof – greater than six inches of growing medium; typically designed for public access

Green Street – refers to a street where a number of techniques are used to reduce stormwater runoff and associated pollutants, bringing natural elements into the streetscape, and improving pedestrian and bicycle facilities

Greenfield Development – development in a rural area which has not previously been built on

Leadership in Energy and Environmental Design (LEED) – a green building rating system that measures performance metrics such as energy savings, water efficiency, and indoor air quality

Nonpoint Source – a source of pollution that issues from widely distributed sources, such as parking lots, streets, agricultural fields, construction sites

Point Source – a localized and stationary pollution source, such as industrial plant discharges, pipe outlets, and municipal sewage treatment plant discharges

Retention – long-term storage of stormwater

Sprawl Development – the expansion of low-density development into previously undeveloped land; this sprawl development requires local governments to extend public services to new residential communities whose tax payments often do not cover the cost of providing those services

Structural Soil – a structural base material made from gravel, fine gravel, and dirt used for tree well plantings as well as a base for pavement

Substrate – a base layer for growing a green roof or for planting in a tree well or street planter; usually composed of soil, gravel, or a mixture

Transfer of Development Rights (TDR) – a tool used to reduce Greenfield Development and preserve agricultural land and open space

Urban Heat Island Effect – the phenomenon of higher temperatures in heavily paved areas resulting from the heat given off by pavement and buildings; accentuated by large unshaded areas and darkly colored surfaces such as blacktop parking lots and black roofs

VMT's – Vehicle Miles Traveled; the total number of miles driven by cars in a certain area.

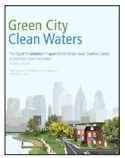
Xeriscaping – landscaping that requires little or no irrigation or other maintenance, usually used in arid regions

EPA's *Municipal Handbook: Managing Wet Weather with Green Infrastructure: Funding Options, Retrofit Policies, Green Streets, Rainwater Harvesting Policies, Incentive Mechanisms:* cfpub.epa.gov/npdes/greeninfrastructure/munichandbook.cfm

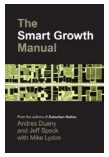
Nashville & Davidson County Metro Water Services Green Infrastructure Design Manual: Using Low Impact Development: www.nashville.gov/stormwater/docs/other/Green_Infrastructure_Design_final.pdf

The Metropolitan Government of Nashville and Davidson County Green Infrastructure Master Plan: www.nashville.gov/stormwater/docs/reports/GreenInfrastructureRpt101120.pdf

The Chicago Green Alley Handbook: An Action Guide to Create a Greener, Environmentally Sustainable Chicago: brandavenue.typepad.com/brand_avenue/files/greenalleyhandbook.pdf



Green City Clean Waters: The City of Philadelphia's Program for Combined Sewer Overflow Control: www.phillywatersheds.org/ltcpu/LTCPU_Summary_HiRes.pdf



The Smart Growth Manual: (Duany, Speck, and Lydon 2009)

Light Imprint Handbook: (Low 2008) www.lightimprint.org/

60 Ways Farmers Can Protect Surface Water: (University of Illinois Extension, College of Agricultural, Consumer and Environmental Sciences) http://www.thisland.illinois.edu/60ways/60ways.html

A Pattern Language: Towns, Buildings, Construction (Alexander, Ishikawa, and Silverstein 1977)

The Great Neighborhood Book: A Do-it-Yourself Guide to Placemaking (Walljasper and Project for Public Spaces 2007)

Mountain Landscapes Initiative Toolbox: www.mountainlandscapesnc.org/documents/DraftToolbox081508-Complete.pdf

The Economic Benefits of Parks and Open Space: (The Trust for Public Land 1999) www.tpl.org/tier3_cdl.cfm?content_item_id=1145&folder_id=727#

Stormwater Magazine: Taking a Stance on Sprawl: (Dreiling Nov/Dec 2010) stormh2o.com/november-december-2010/taking-stance-sprawl.aspx

Southeast Tennessee Development District The Southeast Tennessee Development District/Chattanooga Area Regional Council of Governments (SETDD/CARCOG) is a voluntary association of municipal and county governments located within the Southeast Tennessee region.

SETDD provides planning and development services including Utility Development, the Southeast Tennessee Area Agency on Aging and Disability, Regional Planning, Housing Development, Tourism, Industrial Recruitment and Marketing, the Small Business Resource and Lending Program and Workforce Development.

The Southeast Tennessee

Green Infrastructure Handbook

for Local Governments

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The Tennessee Department of Environment and Conservation

For more information about *The Southeast Tennessee Green Infrastructure Handbook for Local Governments* or the Southeast Tennessee Development District, go to www.sedev.org