CHICOPEE GREEN STREETS

Green Infrastructure Designs for the Industrial Downtown

Emily Cohen | Øystein Kristiansen

The Conway School | Winter 2017

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Prepared for the City of Chicopee

& the Pioneer Valley Planning Commission

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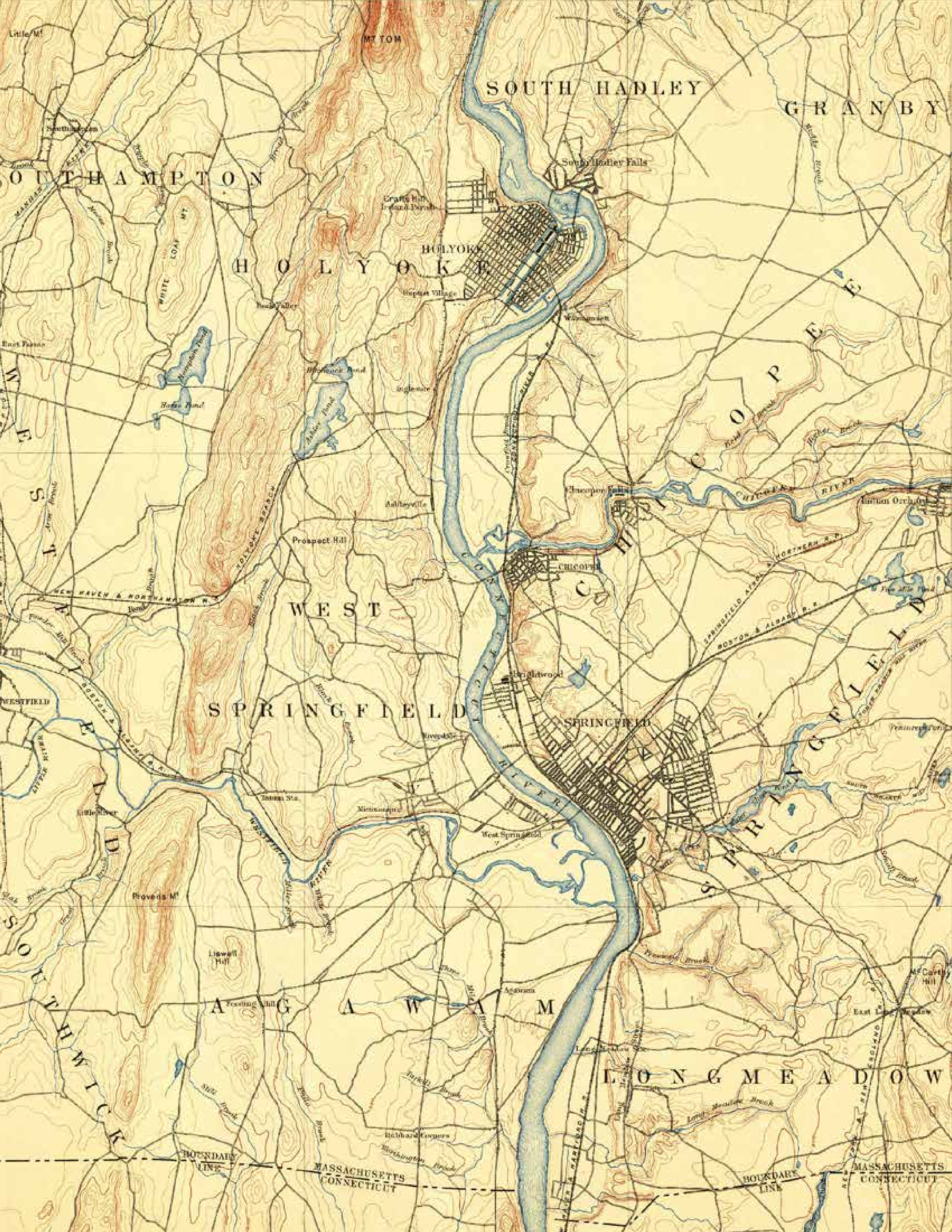

MT TOM
SOUTH HADLEY
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South Hadley Falls
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Ireland Parish
Baptist Village
Willimansett
CHICOPEE
Chicopee Falls
Chicopee River
Ludlow Orchard
Ashleyville
Prospect Hill
Chicopee
WEST SPRINGFIELD
Brightwood
SPRINGFIELD
Springfield
WESTFIELD
Westfield
Mittineague
West Springfield
Connecticut River
Westfield River
Provens Mt
Liswell Hill
AGAWAM
Agawam
LONGMEADOW
Longmeadow
East Longmeadow
SOUTHWICK
BOUNDARY LINE
MASSACHUSETTS
CONNECTICUT
New Haven & Northampton R.R.
Boston & Albany R.R.

Contents

Opposite page: Map of the Holyoke-Chicopee-Springfield region, 1889.

Acknowledgements

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Executive Summary

Located at the confluence of the Connecticut and Chicopee Rivers, the City of Chicopee is inextricably linked to these waterways. The rise in manufacturing in the 1880s spurred economic development and major changes to the physical environment in downtown Chicopee.

Post-industrialization left much of this neighborhood abandoned and run-down, with aging infrastructure both above and below ground. One of various city initiatives to revitalize this historic core is a $200 million project to separate the combined sewer stormwater system (CSS) responsible for much of the water pollution in the Chicopee River and backflows of sewage into basements.

The below-ground sewer separation project provides opportunities to improve the conditions and character of the neighborhood above ground. Known as "Green Streets," these designs involve various plantings and street improvements that filter pollutants from roadways and reduce the amount of storm water entering the grey infrastructure system. By reducing the amount of water entering the system, the likelihood of damaging sewage overflows into the rivers is also reduced. Perhaps most importantly however, for the people who live and work in this neighborhood, these designs create a more pleasant place to be. Trees both visually soften the asphalt landscape and reduce the heat island effect.

This document focuses on five blocks on two streets, Dwight and Perkins, and proposes two potential designs for each block. The first design sites various Green Infrastructure tools, including tree box filters, stormwater planters, and tree trenches, using the current street dimensions. The second design goes a step beyond and implements "Complete Streets" concepts to alter the streetscape and make it more pedestrian and bicyclist friendly, complementing the Green Infrastructure improvements.

As the climate changes, the urgency to implement Green Infrastructure increases as a means to mitigate the combined impact of heavier rain events and higher temperatures. The need for Complete Streets stems from other initiatives in the city to revitalize this downtown core and bring residents and mixed-use development to the large mill complexes. Together these designs can have a dramatic impact on reshaping the character in this neighborhood and make Chicopee an even more wonderful place to live, work, and play.

Opposite page: Perkins Street, looking north toward the Cabotville mills.

Introduction

The Cabotville Mill Complex.

HISTORY

The history of the city of Chicopee exemplifies the history of industrialization in the United States. Chicopee lies at the confluence of the Connecticut River–New England's largest and longest river–and its largest tributary, the Chicopee River.

From the time of the first European settlers until the early 1800s Chicopee's character was largely agricultural. After 1822, when Boston Associates, a group of investors involved in the textile industry, purchased water and property rights along the Chicopee River in Chicopee Falls, the city's identity and economy underwent rapid industrialization.

Mills along the Chicopee River were built to harness hydropower. Manufacturing centered around bicycles, brass and iron foundries, and cotton and wool textiles. The doors to the U.S. Capitol were manufactured in Chicopee as were swords used in the Civil War purchased by Virginia, Mississippi, Maryland, and Georgia.

Workers waiting outside the largest of the mills, Cabotville, early 1920s.

The Latin motto *industrie variae*, "diverse industries," inscribed on the City's seal captures the spirit of the city's manufacturing drive. At the heart of much of this manufacturing was the downtown center, with the Cabotville Mill, Lyman Mills, and worker housing.

The Westover Field has been a central air base in the northeast since its opening in 1940.

The city's population more than doubled between 1850 and 1900 and peaked around 1970, largely due to Westover Air Force Base, which served as a base of operations for the Air Force during the Korean, Vietnam, and Cold Wars. After WWII, business and industry slowly left Chicopee and by the early 1980s, the downtown area known as the West End was largely vacant.

The construction of Interstate 391 rerouted through-traffic around downtown Chicopee, further contributing to the deterioration of downtown. The neighborhood has many neglected, abandoned and under-used properties, most prominently the two mill complexes and an empty lot consuming an entire city block.

REVITALIZATION EFFORTS

Since the mid-2000s a number of studies have explored ways to revitalize the downtown area through business investment, re-development, and infrastructure improvements.

Restoring the mill buildings into mixed use development and residential spaces has been a main priority for city and regional planners. The Ames Mill was recently converted into 149 residential spaces. The Lyman Mill is slated for conversion into 100 to 120 apartments.

The largest structure and perhaps most iconic building in the downtown is the 1,000-foot-long, six-story Cabotville Mill, which sits largely vacant and in disrepair. Recently proposed plans to convert most of the interior spaces into 600 apartments would also add 400,000 square feet of commercial space, but progress remains slow.

There have been recent streetscaping improvements, however, with gaslight-style street lamps, brick sidewalks, and planter boxes installed along the main commercial streets, including Center, Cabot, and Exchange Streets.

There are also plans to alter traffic and parking patterns within the neighborhood, and to extend the existing Chicopee River Bike Trail to connect with the Connecticut Riverwalk and Bikeway.

Focus areas from the "West End Brownfield Revitalization Plan" (2012).

On a broader scale, the City of Chicopee received the U.S. Department of Housing and Urban Development's *Sustainable Communities Regional Planning Grant*. This grant supports the Hartford-Springfield bi-state region's efforts at becoming "a leader in sustainable community development and a creator of more livable communities" (*West End Plan* 2012).

Downtown Chicopee with the mills to the north. The east-west oriented Exchange Street is the neighborhood's main commercial street. Google Maps image.

SEWER SEPARATION PROJECT

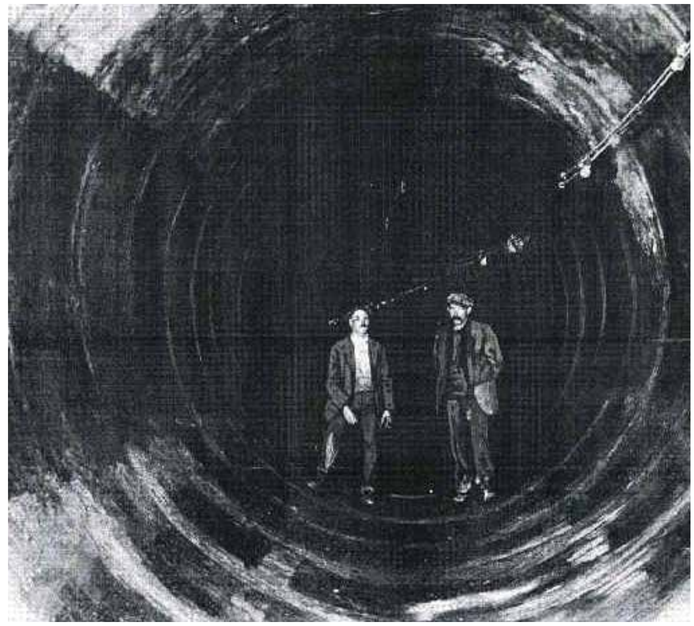
Tied into revitalization efforts in downtown Chicopee is a massive infrastructure repair project to separate the combined sewer and stormwater system (CSS).

The system was installed in the late 1880s and collects sewage and stormwater into the same pipes for treatment by a wastewater plant. In heavy rain events the system overflows, unable to handle the combination of large volumes of stormwater with the regular flow of sewage, and consequently overflows into nearby rivers.

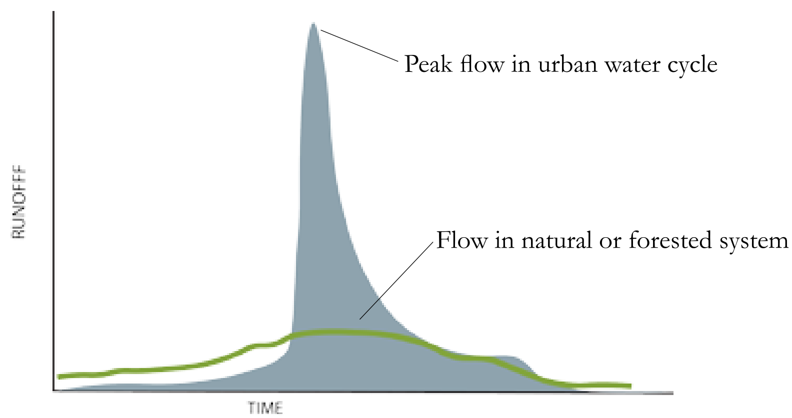
This practice, referred to as a combined sewer overflow (CSO), is highly regulated and is a lead cause of water pollution today. Currently, Chicopee has the third highest number of active CSOs in the Commonwealth of Massachusetts (28) and the City is under a mandate by the U.S. Environmental Protection Agency (EPA) to separate its CSS system. The work plan is determined by areas of highest need, with the City first tackling separation work in neighborhoods which have sewage backups into homes and businesses, another unintended consequence of the system. Though Chicopee has been working to remedy this since the late 1990s, the direct EPA mandated work began in 2006. The work is expected to cost over $200 million citywide.

Separating the sewer and stormwater systems will not fully address pollution problems. A crucial challenge is also to reduce peak flow and the volume of water entering the system. With increasingly large storm events due to climate change this becomes even more urgent, especially in urban settings where most stormwater ends up flowing across the landscape rather than infiltrating into the ground or evapotranspirating, as it would in a natural environment. As the runoff flows over impervious surfaces, it accumulates debris, sediment, and other pollutants that deteriorate water quality.

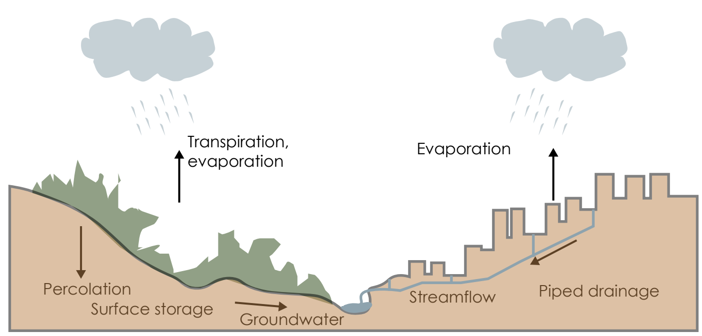
Consequently, the largest contributor to water pollution today is from stormwater runoff, making the treatment and reduction of flow a key priority if river water quality is to be restored.



Workers in the late 1880s in a combined stormwater sewer pipe.



Hydrograph comparing peak flow of storms in urban and forested settings



Comparison between natural (left) and urban (right) hydrological cycles.

GREEN INFRASTRUCTURE

The sewer separation project below ground provides opportunities to improve the conditions and character of the neighborhood above ground. Green Infrastructure offers an approach that combines stormwater management with broader environmental benefits.

The term Green Infrastructure describes stormwater management practices that make use of biological systems. This includes vegetation, often in the form of trees, shrubs, and wet-loving plants, in combination with designed soils that have specified drainage qualities in addition to promoting healthy plant growing conditions and micro-biological life. This interplay of soils, plants, and micro-organisms intercepts, filters, absorbs, and evapo-transpirates rainfall and runoff, and can have affect both the quality and the amount of water that enters drainage systems and eventually natural water bodies.

Permeable surfaces further allow water to infiltrate into the ground in a distributed manner rather than concentrated and conveyed as in conventional Grey Infrastructure systems. Groundwater is recharged, the risk of erosion reduced, and the pressure on municipal stormwater infrastructure is relieved. Slowing water and reducing the peak flow of a rain event, also reduces the likelihood of a combined sewage overflow.

Green Infrastructure is a complementary approach to sewer and stormwater separation projects, but can have a large impact even without Grey Infrastructure repairs. Particularly beneficial to both stormwater management and to a healthy urban environment for people is a well-established urban forest. Mature trees can absorb up to 100 gallons of water at a time, and intercept and trans-evaporate significant amounts of rainfall. Additionally, they clean the air, provide shade and therefore reduce the urban heat island effect, act as wind barriers, and increase property values and quality of life.

CASE STUDIES

A number of studies show a correlation between trees and lower crime rates. For example, a 2016 study in the City of Baltimore and the surrounding county found that "a 10% increase in tree canopy was associated with a roughly 12% decrease in crime."

Other studies have also found trees to raise property values by 10-15%. In one study by U.S. Department of Agriculture economist Brian Donovan, a tree in front of a Portland, OR property added more than $7,000 to its sale price. Another study found that walkability to nearby businesses raises a Portland home's value by about $3,500 in a treeless neighborhood, but more than $22,000 in a tree-lined one.

In Philadelphia, new stormwater standards requiring that new development and redevelopment disturbing more than 15,000 square feet of earth to manage the first inch of stormwater runoff generated by the site have reduced combined sewer inputs by a quarter billion gallons, saving the city $170 million. These savings are derived from the fact that one square mile of impervious cover has been redeveloped under Philadelphia's updated stormwater regulations, and the cost of storing that same volume of stormwater in a CSO tank or tunnel amounts to $170 million in capital, not including operations and maintenance costs. (EPA 2010).

A rain garden in Seattle demonstrates one example of Green Infrastructure.

PROJECT SCOPE & GOALS

Project Scope

This focus on Dwight and Perkins Streets is part of the broader revitalization efforts within the West End, including the next scheduled phase of the sewer separation project, originally scheduled for repairs between 2017-2019. The City of Chicopee hopes that this project will serve as a model for other Green Infrastructure projects in the city.

Although the underground repairs for the sewer separation project are likely to be delayed due to a combination of funding challenges coupled with the need to focus on higher priority areas, Green Infrastructure can still have a large impact. In fact, it makes the case only stronger, as Green Infrastructure's greatest benefit is its potential to reduce the volume of stormwater in the Grey Infrastructure system, which is what triggers the combined sewage overflows.

This project is funded by a grant to the Pioneer Valley Planning Commission (PVPC) from the U.S. Forest Service. As part of the grant, PVPC is working with a number of cities, including Holyoke and Springfield, to implement Green Infrastructure demonstration projects. This project is the first in Chicopee funded through this grant. Designs will be sent to Design Consultants, Inc., a civil engineering firm, for further development.

Goals

The overall goal of this design project is to site various Green Infrastructure options for Dwight and Perkins Streets as a strategy to improve stormwater management and environmental conditions above ground in downtown Chicopee.

A secondary goal is to incorporate elements that increase pedestrian safety and encourage foot traffic along the streets, a concept known as Complete Streets.

This project is the result of federal, regional, and local collaboration.

Stormwater sewer separation project from 2012 in Chicopee.

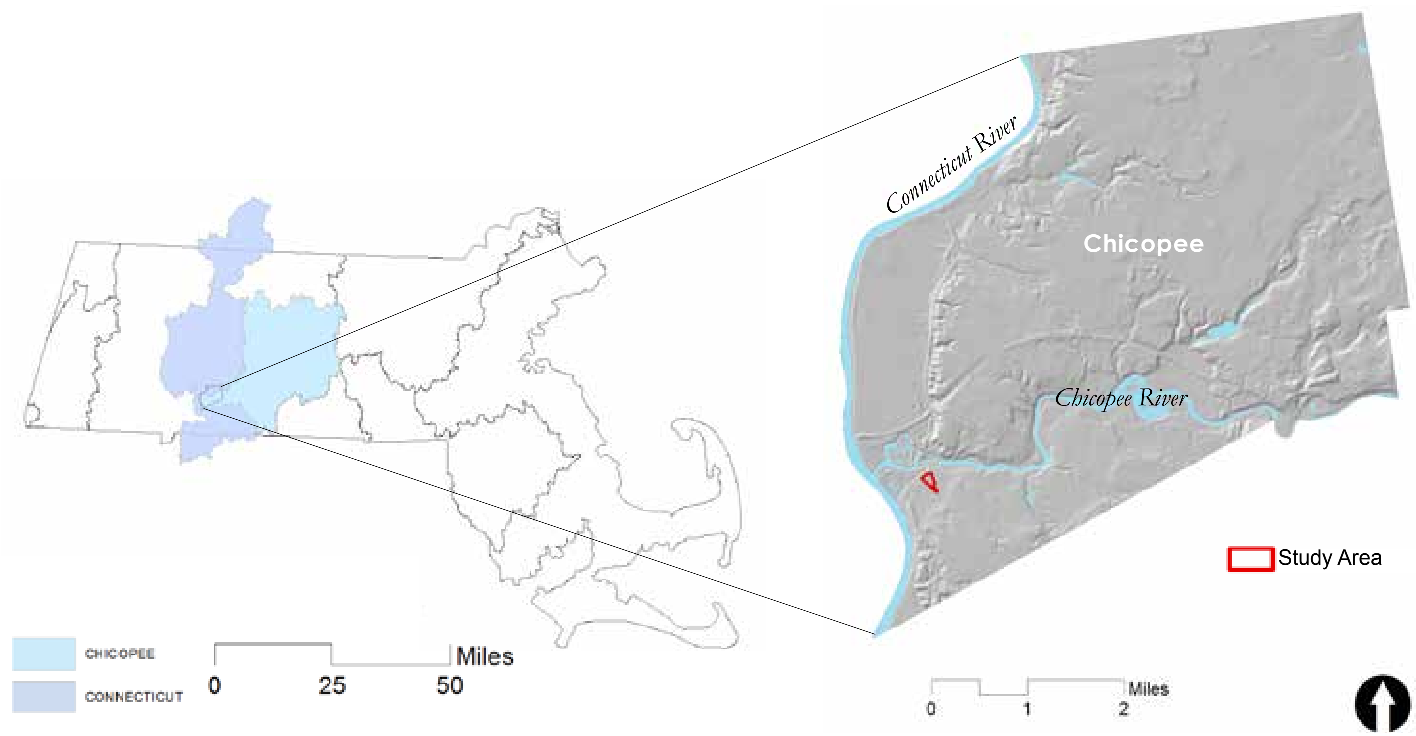
Center Street in the 1920s, with the town hall and Ames Mill in the background.

Center Street today, one of the areas where street improvements and greening have taken place in recent years.
Google Streetview image.

Analyses

A vacant parking lot in the heart of the neighborhood.

REGIONAL WATERSHED



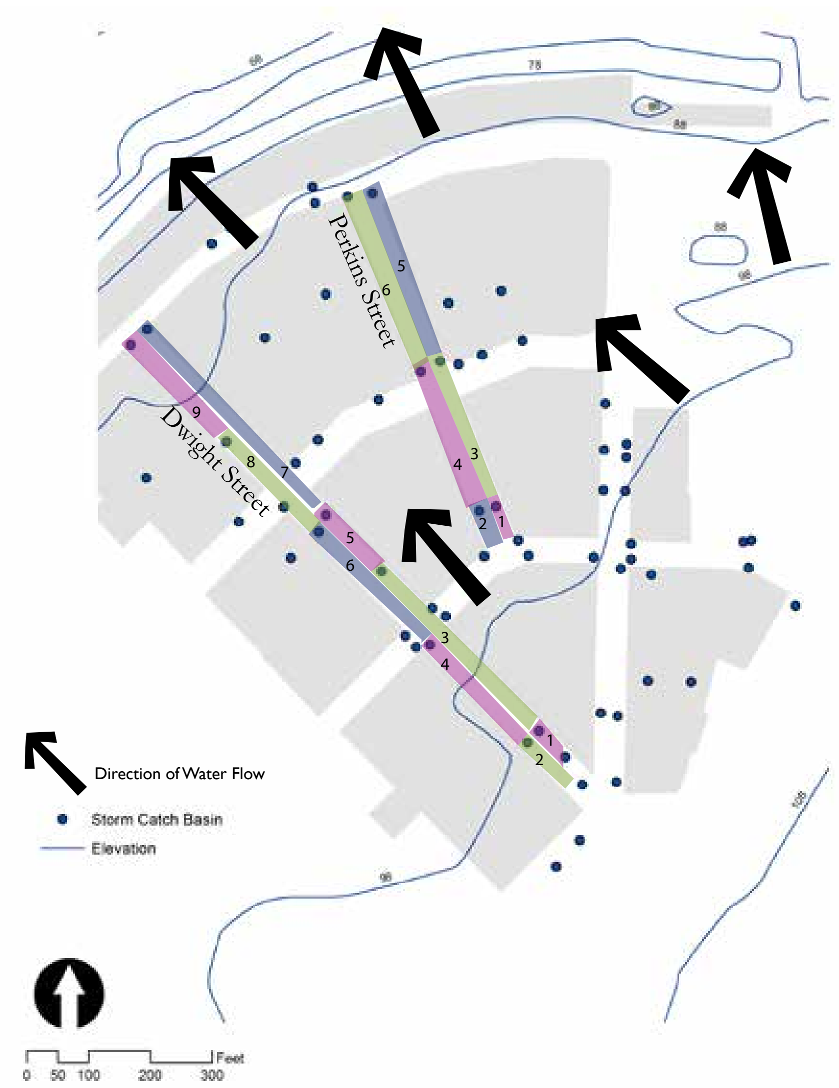
The city of Chicopee sits at the confluence of the Connecticut River and the Chicopee River. Traversing over 400 miles and draining 11,200 square miles of land, the Connecticut River has New England's largest watershed; the Chicopee River is its largest tributary. Although the Chicopee River is only 18 miles long, its watershed drains more than 720 square miles of central Massachusetts before joining the Connecticut River.

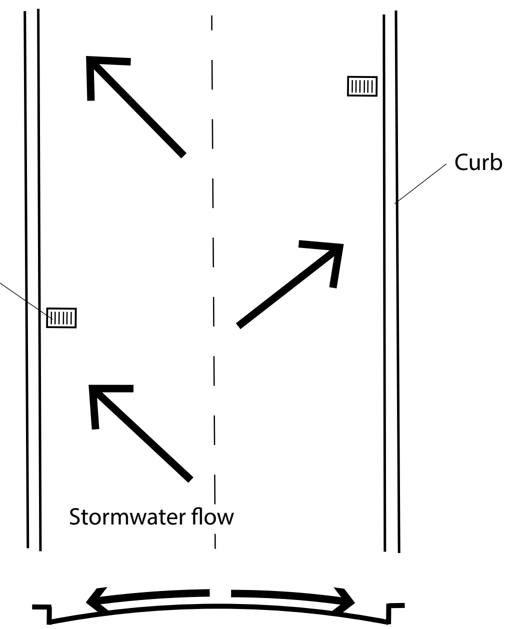
Within Chicopee, water flows both into the Connecticut River and into the Chicopee River. Within the project study area, which sits one-tenth of a mile from the Chicopee River, water flows in a north-westerly direction, dropping approximately 20 feet from the highest point of elevation before entering the municipal stormwater drains, canals, and eventually the two rivers.

Historically, the two rivers were sources of power, transportation, and waste disposal. This practice had severe consequences for both ecological and human health, and reduced water quality remains a concern. Ensuring healthy regional and local watershed conditions is essential to improve the water quality and ecological integrity of the rivers.

A main stormwater outfall from downtown Chicopee to the Cabotville Mill canal. Photograph by the authors.

SITE DRAINAGE & SUB-BASINS





A crowned roadway directs stormwater to the curbs and into catchasins.

Runoff is directed along the curbs, carrying debris with it on its way toward catch basins along the road.

Stormwater in the study area flows in a northwesterly direction into 26 catch basins, 12 of which are on Dwight Street and six on Perkins Street.

A 1.3-inch rain event generates approximately 245,380 gallons of stormwater within the study area. Twenty percent of this runoff is generated from the streets alone (47,350 gallons). The remainder is from roofs, paved lots and other impervious surfaces.

The crowned profile of the roads directs water to the edges of the roadway into catch basins. For the purposes of this project, calculations based on street runoff alone were determined to site Green Infrastructure (See pages 66-69).

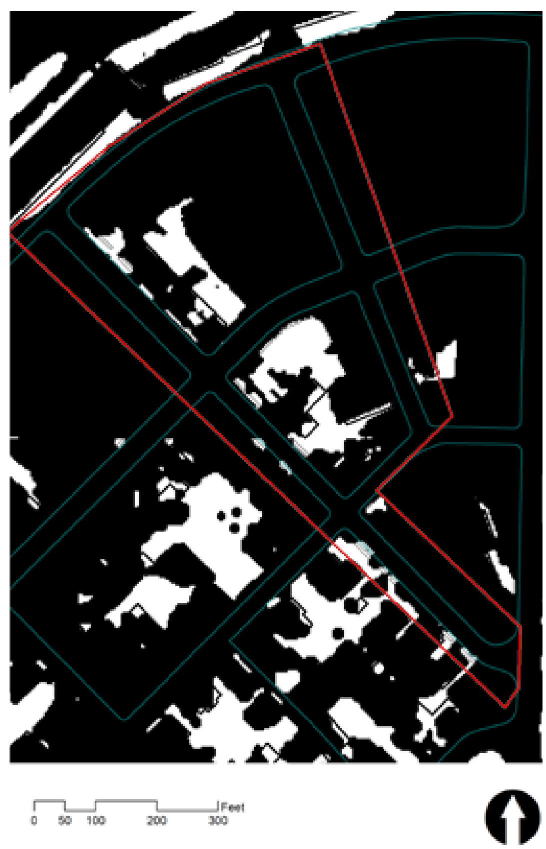
While intercepting and treating water along the streets and at the existing catch basins will have some positive environmental impact, reducing the amount of impervious surface area that causes runoff in the first place may be a more favorable long-term solution. This approach would also address the cause of the problem (impervious surfaces) and not only the symptom (runoff).

IMPERVIOUS SURFACES

One of the most notable features of the study area is the high concentration of impervious surfaces. Citywide, the total impervious surface cover is close to 35%, but in the study area, the cover is almost entirely impervious. Approximately nine out of every ten square feet is covered by a road, sidewalk, driveway, or roof.

Of this total, parking lots cover a significant portion of this space, most of which are underutilized. According to a 2009 parking study, private parking spaces in the downtown area were operating at below 50% of capacity (PVPC). In the study area, which is approximately 7.8 acres, about 10% is taken up by a fenced off, vacant lot.

While green infrastructure will have a significant impact, addressing these large tracts of impervious area on private property will also be key to both the goal of reducing CSOs and the goal of activating the downtown streetscape.



SITE CANOPY COVER & TREE INVENTORY

The City of Chicopee is making efforts to maintain and restore the tree canopy, earning the "Tree City" designation by the Arbor Day Foundation. However, the downtown industrial center is noticeably lacking canopy.

The canopy cover in the study area is less than 5%, markedly lower than downtown (20%) and citywide (33%) canopy cover. On Dwight and Perkins Streets there are only two two in the right-of-way.

Within Chicopee, 41% of street trees are *Acer* (maple), a percentage high enough to be considered threatening to biodiversity in the city (Davey Resource Group 2014). The *10-20-30 rule* recommends distribution patterns of no more than 10% single species, 20% single genera, and 30% single family within a given area to ensure population diversity and stability

Only two trees are within the ROW (dark green) of Dwight and Perkins street, the rest are on private property (light green).

(Richards 1983). The most common species within the study area is *Acer saccharinum* (silver maple).

The study area is at the center of a prominent hole in the canopy layer.

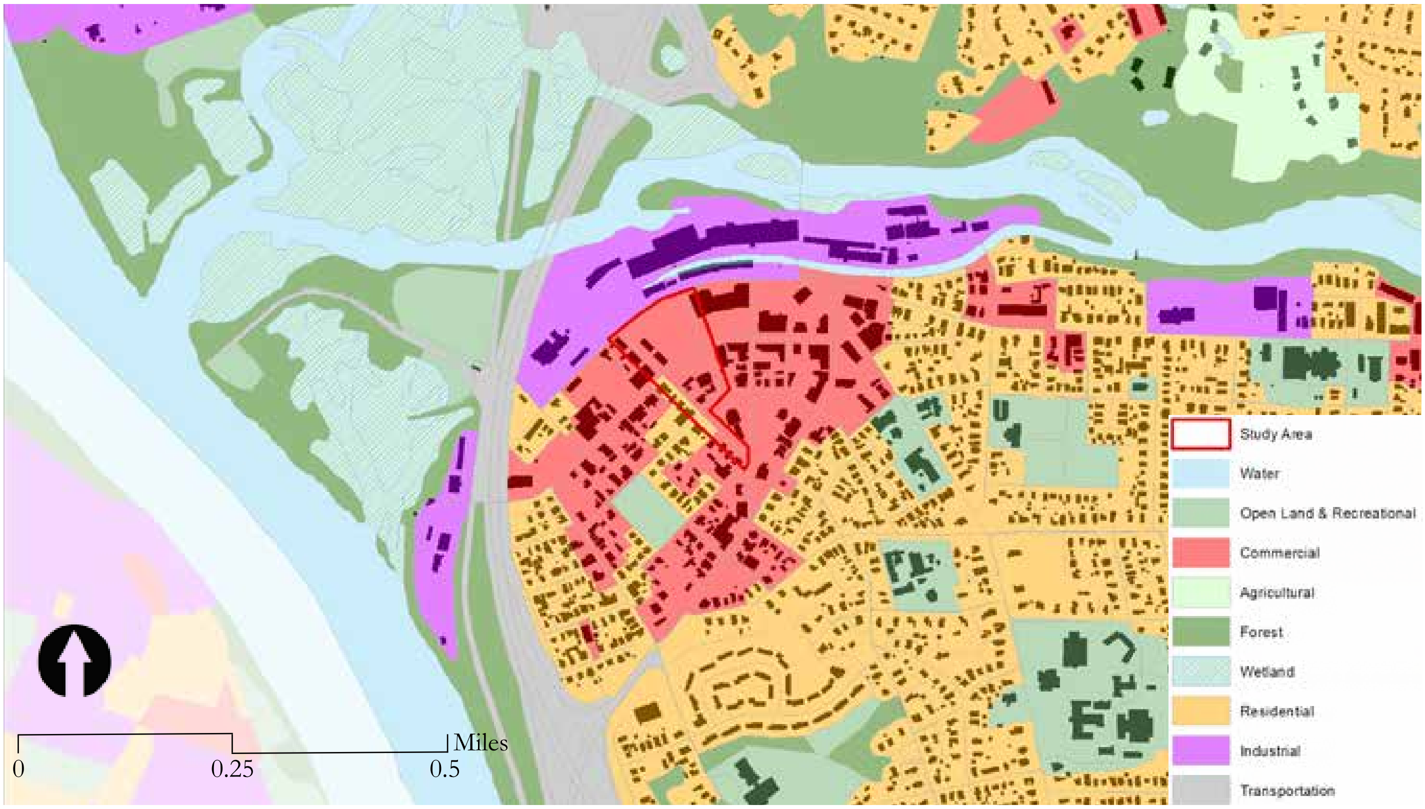
Tree-lined Perkins Street leads the way between the mills and downtown, early 1920s.

Historical images of the neighborhood depict a very different ambiance. A photo of Perkins Street from the 1920s shows a tree-lined corridor, with gardens situated between the sidewalk and road. This image is not unlike the green streetscapes returning to many communities today.

An unexpected snowstorm in fall 2011 damaged many trees in the city, along with powerlines and homes. Consequently, many residents have expressed a fear of trees.

Significantly increasing canopy cover in this area should be a strong priority not only to mitigate the severity of stormwater runoff, but also to improve the overall environmental quality of the neighborhood.

LAND USE



The downtown's former role as an industrial center resulted in land use patterns that are common to many mill cities along the Connecticut River. High concentrations of both residential and industrial development next to each other and the river are typical.

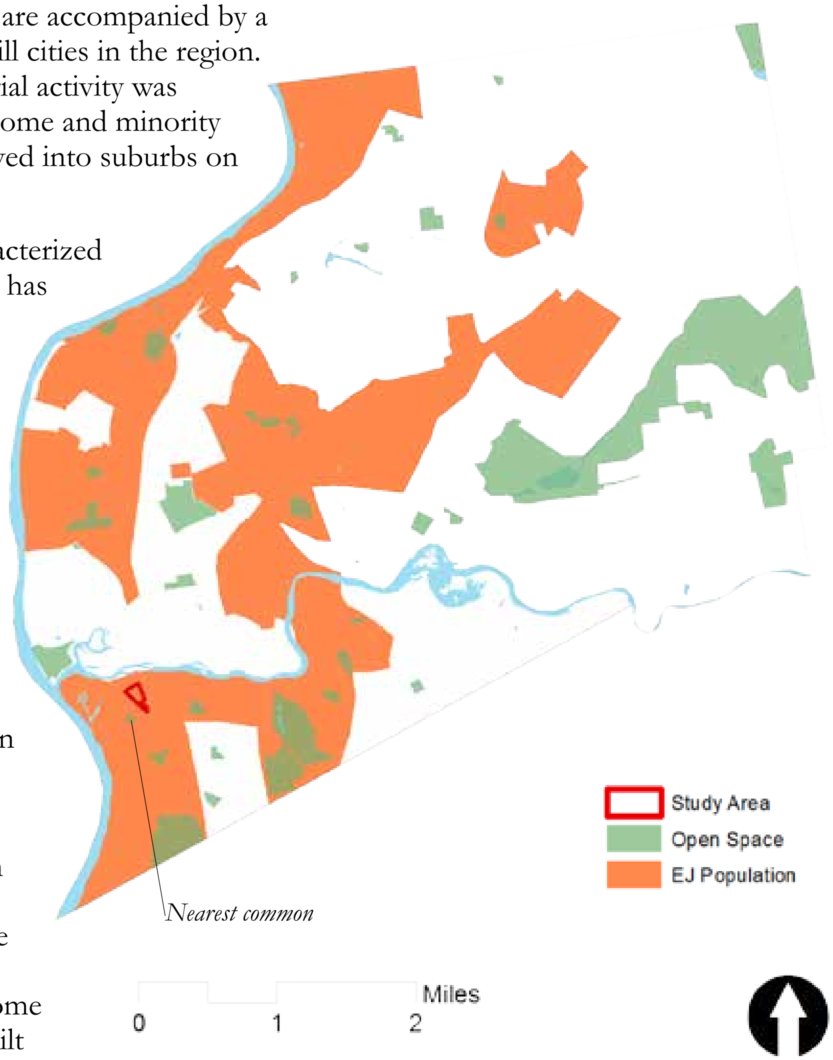
Residential, commercial, and industrial land uses abut the study area. The former industrial area with the now largely vacant mills forms a physical barrier between the neighborhood and the Chicopee River. A predominantly commercial zone immediately to the south of these mills has its eastern boundary around the busy Center Street. A few residential areas are scattered within the commercial zone, and the interstate highway acts as a physical boundary along the western side of the neighborhood, separating it from the Connecticut River.

These land use patterns both delineate the neighborhood boundaries and reveal its former role, even if it is now largely vacant land and underutilized parking lots. In combination with very low canopy cover, the focus area has the derelict feel of an underinvested neighborhood.

A considerable amount of land within the neighborhood is taken up by off-street parking (in black).

POPULATION

The physical features of downtown Chicopee are accompanied by a demographic pattern typical of many other mill cities in the region. Today, the older neighborhoods where industrial activity was focused are now mainly occupied by lower income and minority populations, while the more affluent have moved into suburbs on the periphery of the old city center.



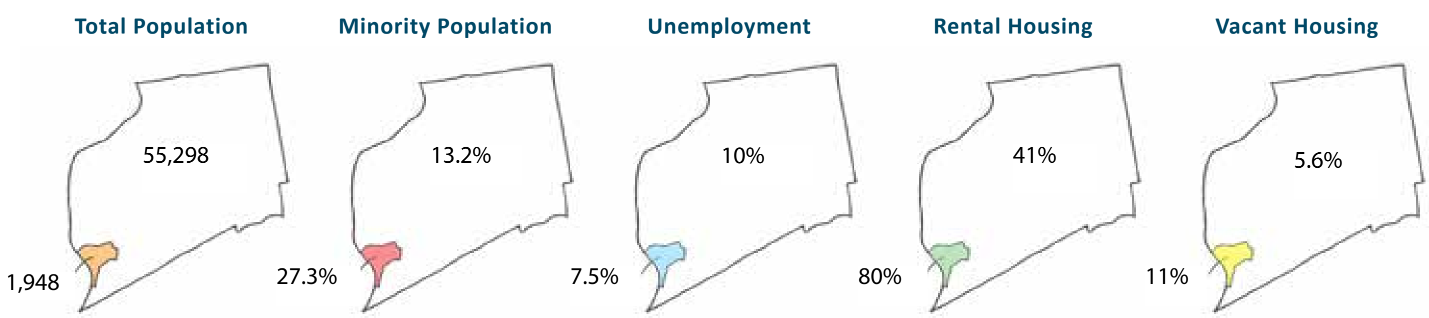
The West End in downtown Chicopee is characterized by older infrastructure and housing stock, and has significantly higher rates of rental housing (80%) and a median income nearly $20,000 lower than the rest of Chicopee. At 7.5%, unemployment is slightly lower than the city average of 10%.

An estimated 1,948 people live in the West End, approximately 3.5% of the city's total population.

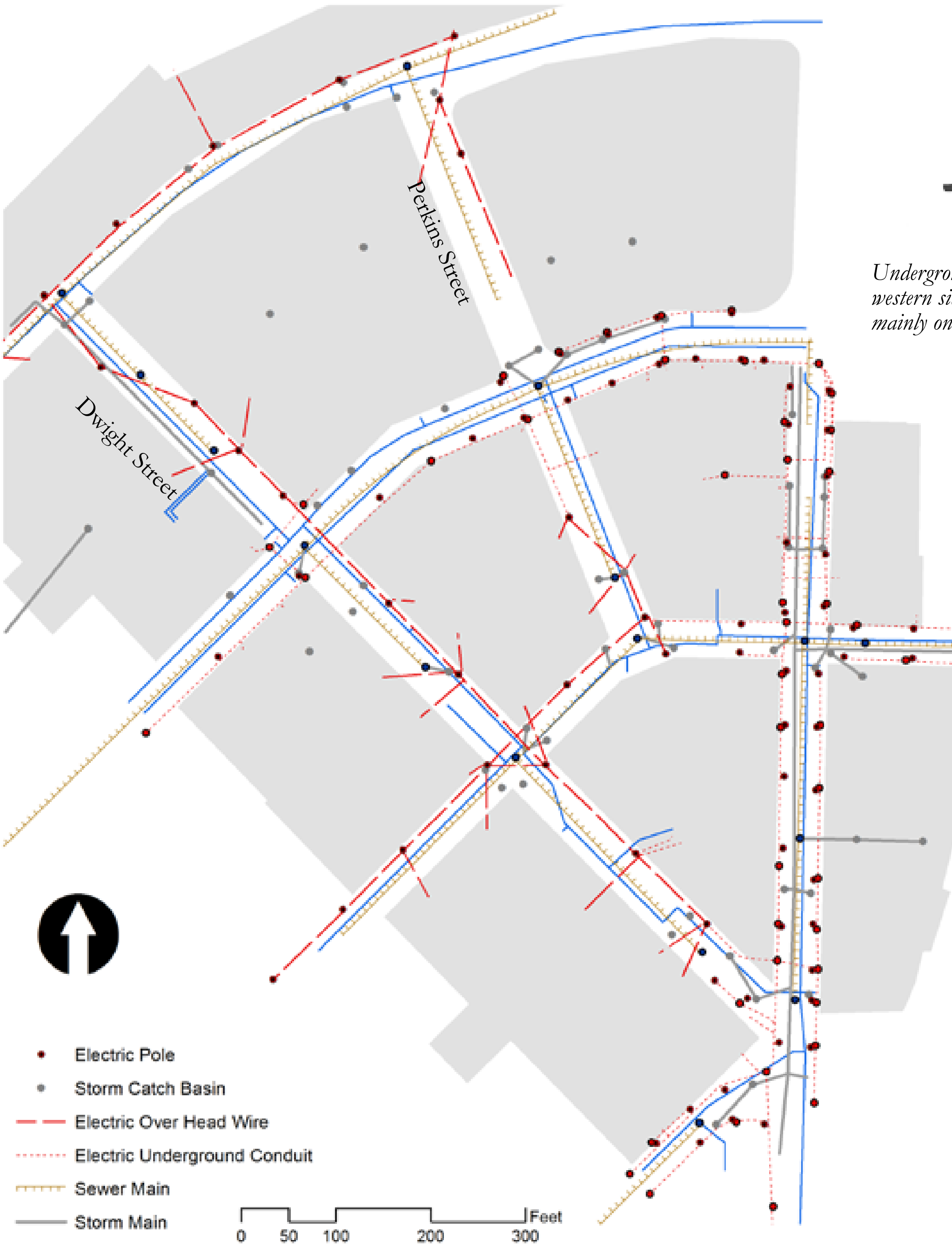
The neighborhood has well-established Polish and Portuguese communities. Though the majority of residents are white (73% within the West End and 87% citywide) the Latino population is growing.

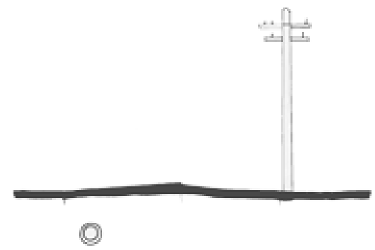
Most of downtown Chicopee is considered an "environmental justice area" by the state of Massachusetts where minority and low-income populations are disproportionately exposed to harmful and unsafe surroundings. Unlike in some communities, it is the characteristics of the built environment that give the West End an Environmental Justice Population (EJP) designation and not proximity to open space, which is just a short walk away at the Chicopee town common. Factors contributing to this designation in the downtown include reduced air quality, proximity to brownfields and the Interstate 391, as well as a heightened heat island effect in an area where canopy cover is minimal, paved surface areas are dominant, and most buildings predate the 1950s.

Within this context, improving the overall environmental conditions of the streets and abutting properties would seem the most effective way to address a number of quality-of-life-issues found in the neighborhood.



UTILITIES





Underground utilities are generally concentrated on the western side of the streets, while overhead utilities are mainly on the eastern side.

Low-hanging overhead wires along the eastern side of Dwight Street, with regular crossovers to the west.

A number of utilities in the roadway affect placement of green infrastructure systems. Above-ground utilities generally run linearly along the eastern side of both Dwight and Perkins Streets, with connections crossing the streets to reach buildings. Underground utilities also run linearly, though are generally on the western side of the streets.

While most of the study area has a combined sewer stormwater system, the northern block on Dwight between Exchange and Front Streets has a separated sewer stormwater system.

While these are general patterns, utility features must be surveyed and verified by engineers and construction crews. Gas, telecom, and other utilities will also need to be located.

The intersection between Cabot and Center Streets, 1907.

The intersection today: still relatively green, but markedly fewer trees.
Google Streetview image.

Street Profiles

Looking east from the crossing of Exchange and Perkins Streets.

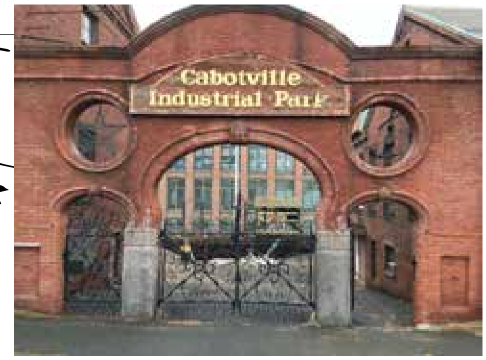
DWIGHT STREET

Evidence of former large trees between the old mill housing. Facing south toward Exchange Street.

A vacant lot on the eastern side functions as a parking lot, while overhead utilities cross much of the street. Facing south toward School Street.

Residencies on the western side face an open parking lot and sports bar to the east. The local fire station faces the intersection with Cabot Street.

PERKINS STREET



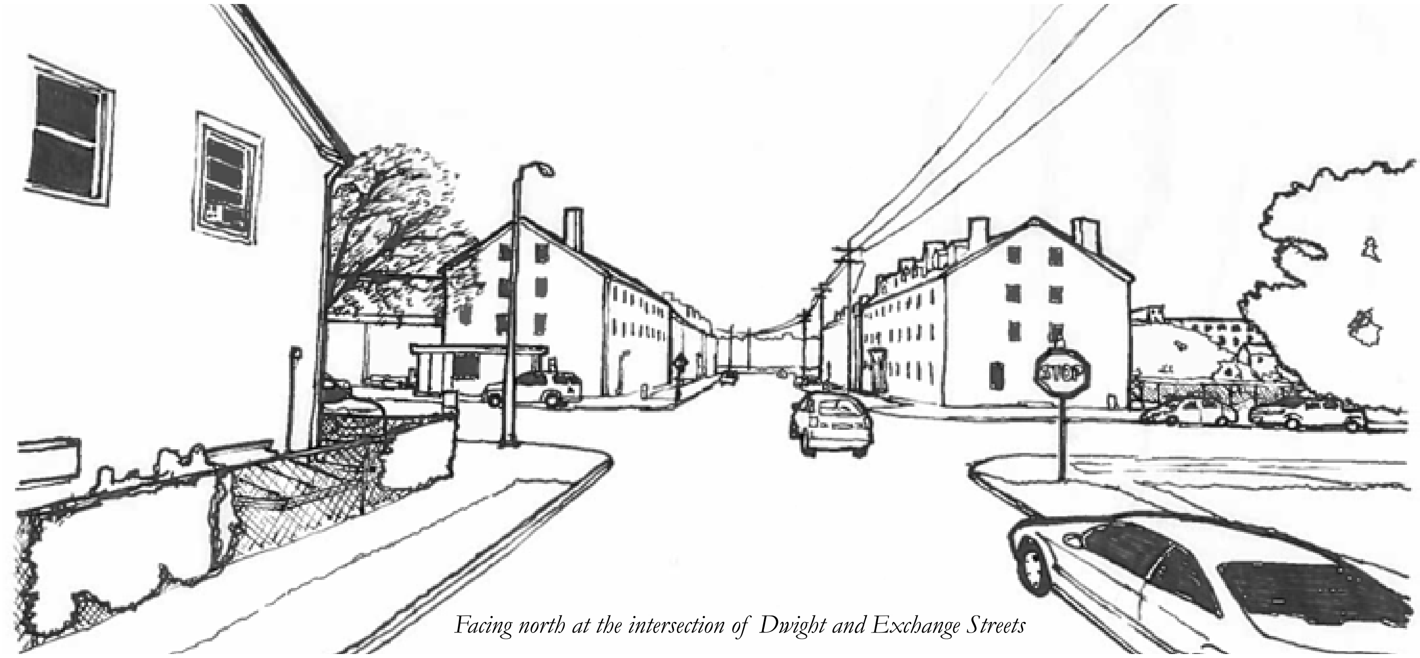
The iconic main gate to the mills is currently a side-note within the neighborhood. Facing north.

Exiting the mill complex, two large silver maples sit between the street and the large, vacant space, while a shopping center dominates the eastern side. Facing south.

A restored commercial building just off Exchange Street shows recent investment in the neighborhood. Facing south toward the sports bar on School Street.

All photographs on this page are taken by the authors.

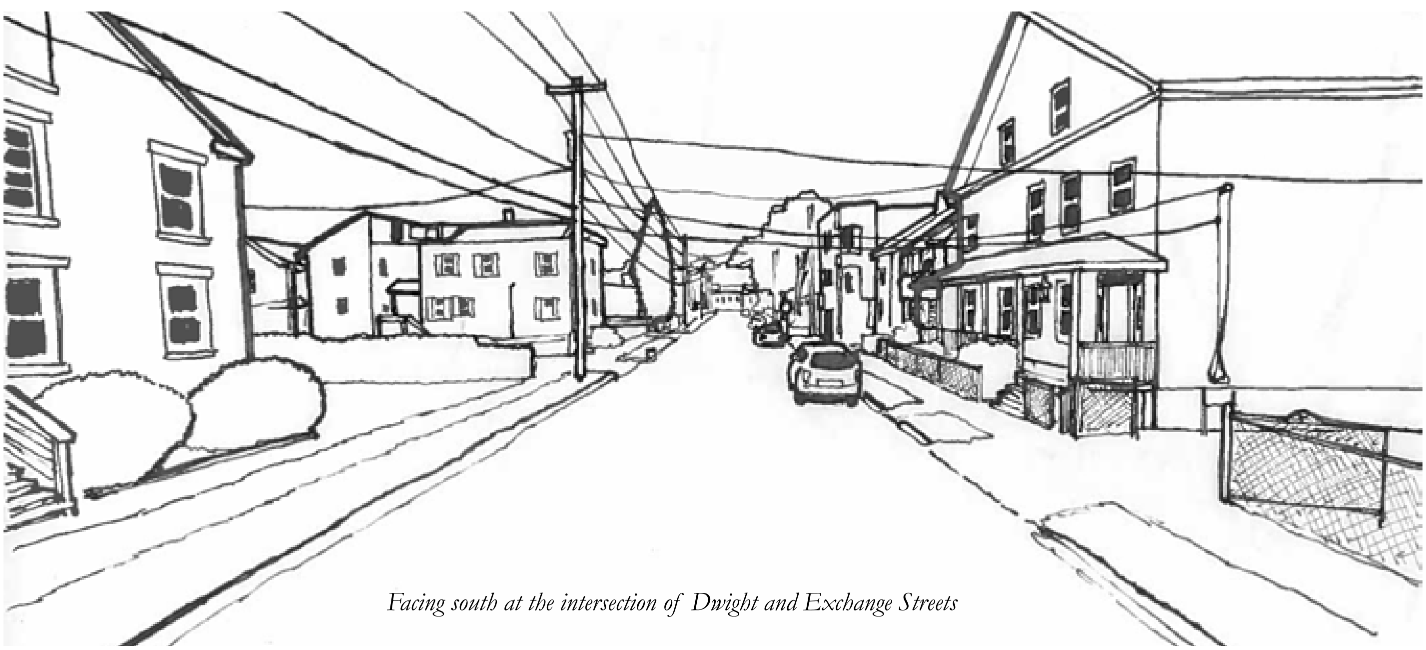
DWIGHT STREET



Facing north at the intersection of Dwight and Exchange Streets

The northern part of Dwight Street is lined with several historical mill houses, still used as residences, dating back to the 1800s. In addition, there are a couple of single family homes, the Portuguese American Club at the corner of Dwight and Exchange.

On the eastern corner with Exchange Street, a vacant lot is used as a parking lot. There is no vegetation except for a small grass strip. Large silver maples were a prominent feature between the mill houses until their removal in the winter of 2013-2014.

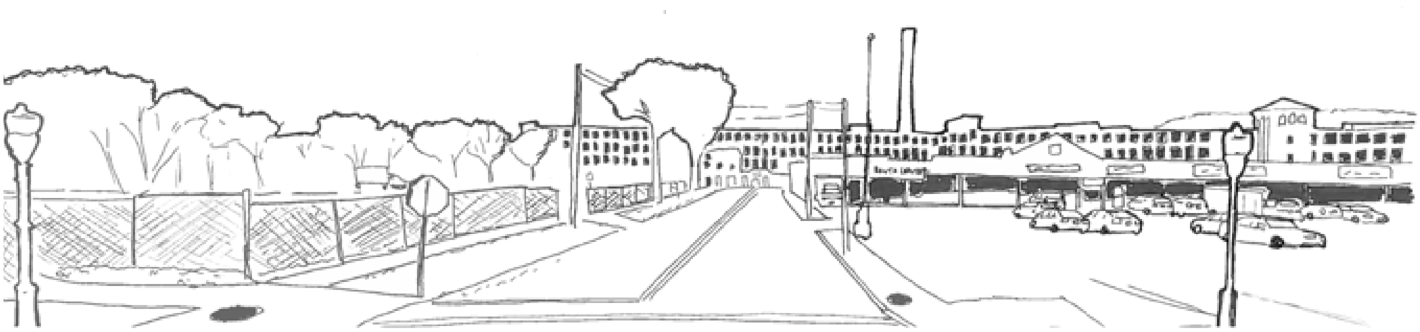


Facing south at the intersection of Dwight and Exchange Streets

Older mill housing continues south along the mostly residential southern blocks. Low-hanging overhead wires crisscross most of the central block and no street trees currently exist.

The southernmost block has residencies along its western side, where one garden has two large maples. A large parking lot and sports bar sit across the street, while the local fire station faces the intersection with Cabot Street.

PERKINS STREET



Facing north at the intersection of Perkins and Exchange Streets

Perkins runs north-south and leads to the main entrance of the Cabotville Mill. The most prominent feature is the large, fenced-off vacant lot along the western side and the shopping center along the eastern side with a 37,000 square foot parking lot.

There are only two street trees on the street, both mature silver maples approximately 55 feet high. No parking is permitted on this part of the street.

Facing south at the intersection of Perkins and Exchange Streets

Between Exchange and School Streets, Perkins is also commercial, and recent improvements by both property owners and the city have improved the atmosphere.

Trees have been planted on church property around the parking lot on the western side, while gas-lamp-style street lights and some street trees have been installed along Exchange Street. Pedestrian crossings are marked on all but the western side of the intersection.


Offices

TOOLBOX

A renovated building on southern part of Perksins Street, with a sports bar at its southern end.

OVERVIEW

This toolbox presents a collection of recommended tools related to the principles of Green Streets and Complete Streets. While there are many potential strategies, the tools presented here are those that are most fitting for the conditions on Perkins and Dwight Streets.

The purpose of the Green Streets tools, which form the central component of these designs, is to capture, retain, and treat polluted stormwater runoff close to its source, before it enters the grey infrastructure system. Layers of mulch, soil, and plant roots retain, degrade, and absorb pollutants such as heavy metals, phosphorus, grease, oil, nitrogen, and bacteria. If designed and placed appropriately, each of these systems has the capacity to comply with the Massachusetts Department of Environmental Protection's requirement for stormwater management systems to remove a minimum of 80% annual total suspended solids (MassDEP, 1).

The Toolbox includes:

- Vegetative systems
- Permeable surfaces
- Structural soil
- Tree planting considerations
- Complete Streets tools

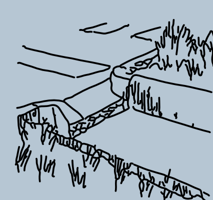
COMMON FEATURES

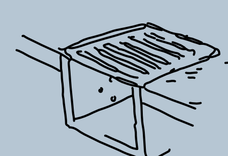
Engineered Soils
Two of the most common problems with growing healthy trees in an urban setting are adequate soil volume for tree roots and compacted soil that inhibits root growth and water infiltration.

Engineered soils are recommended for use in bioretention systems to ensure sufficient drainage and root growth. A number of different mixtures are available, but common to all is a high sand content, in many cases even as high as 80% sand to 20% compost (Rector 2013).

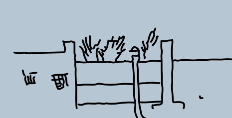
A particular form of engineered soils are structural soils, which are designed specifically with load-bearing capacity in mind. See page 27 for more detail.

Curb Cuts/Catch Basins
Strategically-placed curb cuts and catch basins are commonly used to direct runoff from impervious surfaces into bioretention systems. Catch basins can transport water either through piping or through perforated chambers that gradually release it into the ground.

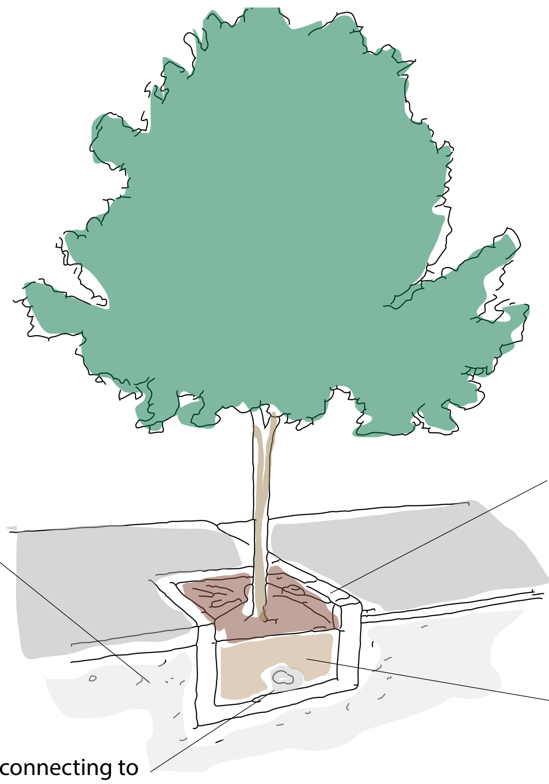




Overflow/Bypass Drains
Raised approximately 6 inches above the soil surface, overflow drains prevent bioretention systems from flooding in larger storm events, while still treating water quality until the point of overflow. The drains connect directly to existing stormwater infratructure.



TREE BOX FILTER



Description
Tree box filters are stand-alone biorentention systems most commonly used along streets in urban environments where space is limited and pollutant removal is a priority.

These closed-bottom concrete chambers are retrofitted to replace existing catch basins along a street, with overflows that connect to conventional stormwater drainage systems. The chamber is filled with soil media designed for rapid infiltration, which can be tailored to filter particular pollutants.

Tests in the mid-Atlantic region suggest that the most cost-effective filter surface area to drainage area is 36 square feet to 1/4 acre (LIDC 2007).

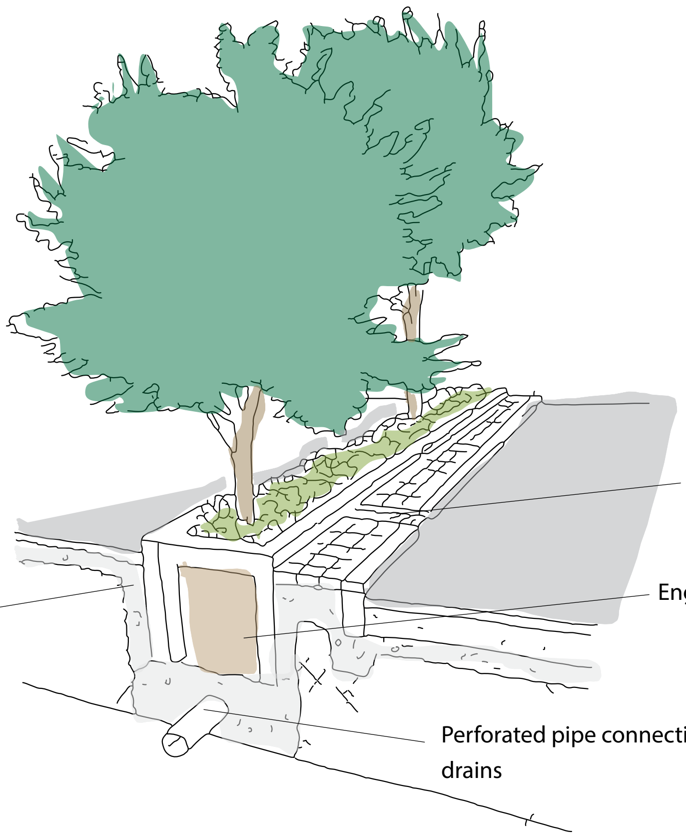
As tree box filters are designed to filter runoff, they are less effective in slowing or absorbing larger volumes of stormwater. To compensate for the lack of volume capacity they can be installed as open-bottom chambers in places where soils allow for infiltration, or combined with other underground storage or detention systems (PVPC, 2).

Maintenance
Minimal maintenance is required in the years after installation. Routine trash and litter removal and inspection of the soil's ability to infiltrate water are the main tasks, together with periodic pruning of the tree and biannual mulching. Periodic testing for build-up of pollutants in mulch and soil is recommended.

Likely annual maintenance costs is $100 per box if conducted by the owner or $500 if done by a contractor (PVPC).

DIMENSIONS	SPACING	COST	% TSS REMOVED	LIFESPAN
6x6x4 ft.	25 ft.-30 ft.	$12,000-$20,000, excluding labor per box	85%-90%	Trees: 5-15 years Chamber: 20-25 years

TREE TRENCH



Description
A tree trench is similar to a tree box filter, but instead of being a one-tree container, it is a system of trees connected by an underground infiltration structure.

On the surface, a tree trench can be covered to look like regular tree pits, or open to include other kinds of vegetation and resemble a planted bed. Covered tree trenches can be especially appropriate in high-intensity pedestrian areas, whereas open trenches can be more appropriate where a green barrier between sidewalks and roads is desired.

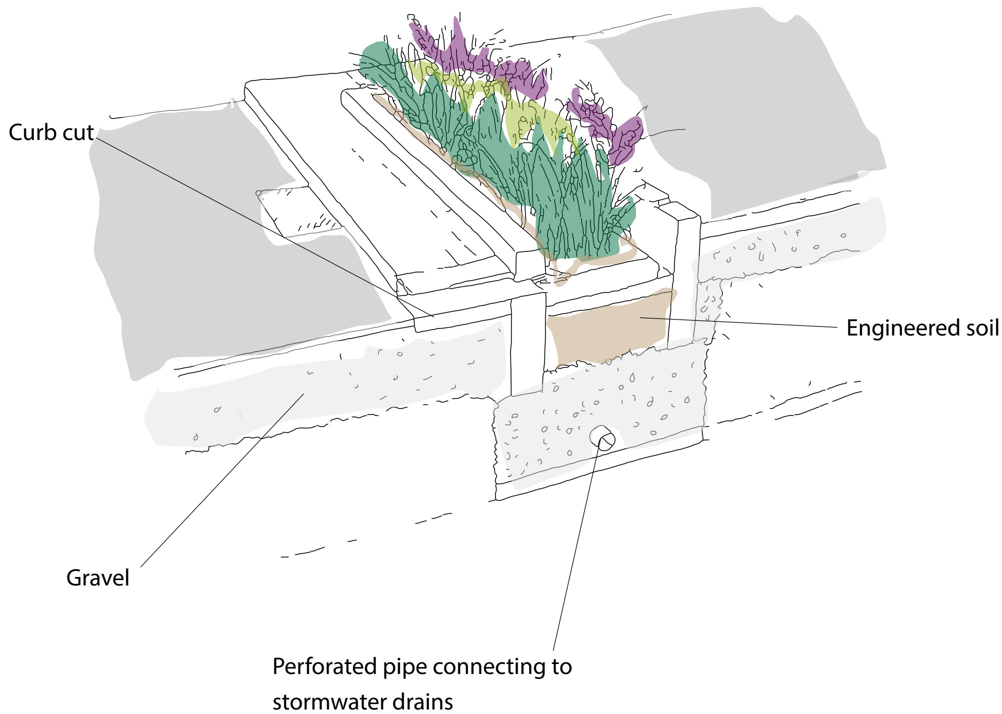
Below ground, a continuous concrete structure connects the series of trees planted in designed soil. Runoff enters the structure via catch basins or curb cuts and is filtered and absorbed over a larger area before entering the existing stormwater system or infiltrating into the subsoil. Open-bottom systems can be installed where subsoil infiltration is possible and desired.

Maintenance
Similarly to tree box filters, tree trenches require minimal maintenance in the years after installation. Routine trash and litter removal and inspection of the soil's ability to infiltrate water are the main tasks, together with periodic pruning of the tree and biannual mulching. Periodic testing for build-up of pollutants in mulch and soil is recommended.

Open tree trenches may require more pruning and replacement of understory plantings. Yearly maintenance costs will depend on the length of the system, but an estimate of $100 per trench if conducted by the owner or $500 if done by a contractor is reasonable (PVPC).

DIMENSIONS	SPACING	COST	% TSS REMOVED	LIFESPAN
Width: >5 ft. Depth: >3 ft.	25 ft.-30 ft. between trees	Approximately $8-$12 per sq. ft.	80%-90%	Trees: 10-25 years Container: 20-25 years

STORMWATER PLANTER



Description

Stormwater planters are contained vegetated areas, usually in the shape of a trench, that collect and filter runoff. These are commonly used along roads and sidewalks as vegetated safety borders.

The system can and often does include trees, but can also include grasses, sedges, shrubs, ferns, flowers, and other plants suitable for bioretention. This composition allows stormwater planters to have minimal size requirements, allowing for their use in the smallest spaces.

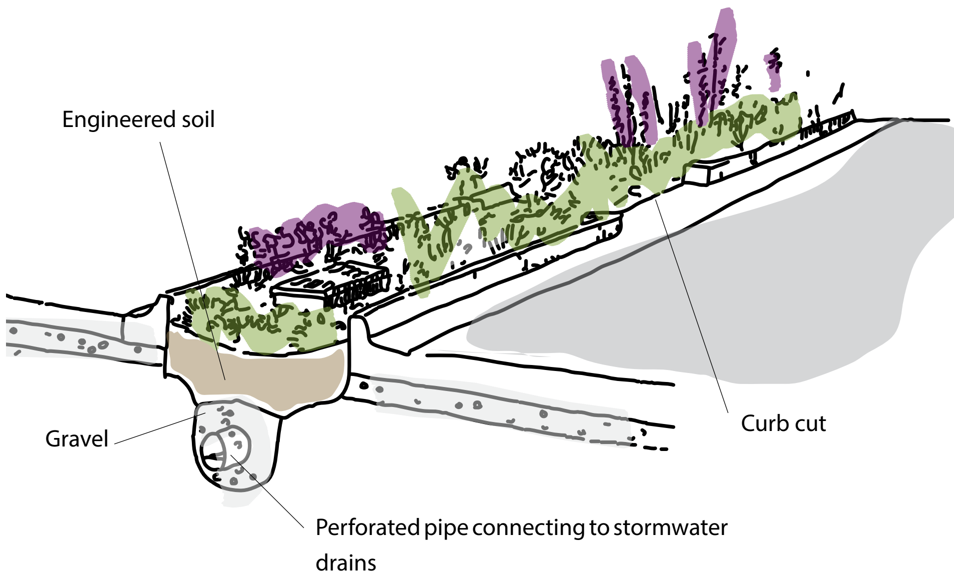
Similarly to tree box filters and tree trenches, stormwater planters can be either closed-bottom or open-bottom systems depending on whether or not on-site infiltration is possible or desired. Because these are typically small-scale structures, they are typically not suited for treating runoff from large areas, and filtration capacity and efficiency will vary based on the size of the planter, the soil medium, and the plant composition.

Maintenance

Regular maintenance of vegetation, such as weeding, soil replacement, and watering during dry periods is recommended, as is periodic cleaning of inflow and outflow mechanisms. Periodic testing for build-up of pollutants in mulch and soil is recommended. If trees are included, these have an expected lifetime of 5-15 years, while other vegetation may need to be replaced more frequently (CRWA 2008).

DIMENSIONS	SPACING	COST	% TSS REMOVED	LIFESPAN
Width: >2.5 ft (w/o trees)/ >5 (w/ tree)	25 ft.-30 ft. between trees	Approximately $8-$12 per sq. ft.	Insufficient data, but likely 80%-90%	Trees: 10-25 years Container: 20-25 years

RAIN GARDEN



Description

A rain garden commonly resembles a traditionally landscaped area, but is designed to catch and treat stormwater runoff. Rain gardens tend to cover larger, wider areas than the enclosed systems included here, and are predominantly infiltration systems.

Rain gardens can serve as appealing landscaping elements in an urban landscape, and often include a variety of plants, including trees, shrubs, grasses, and flowers. This variation and larger area can also provide valuable wildlife habitat.

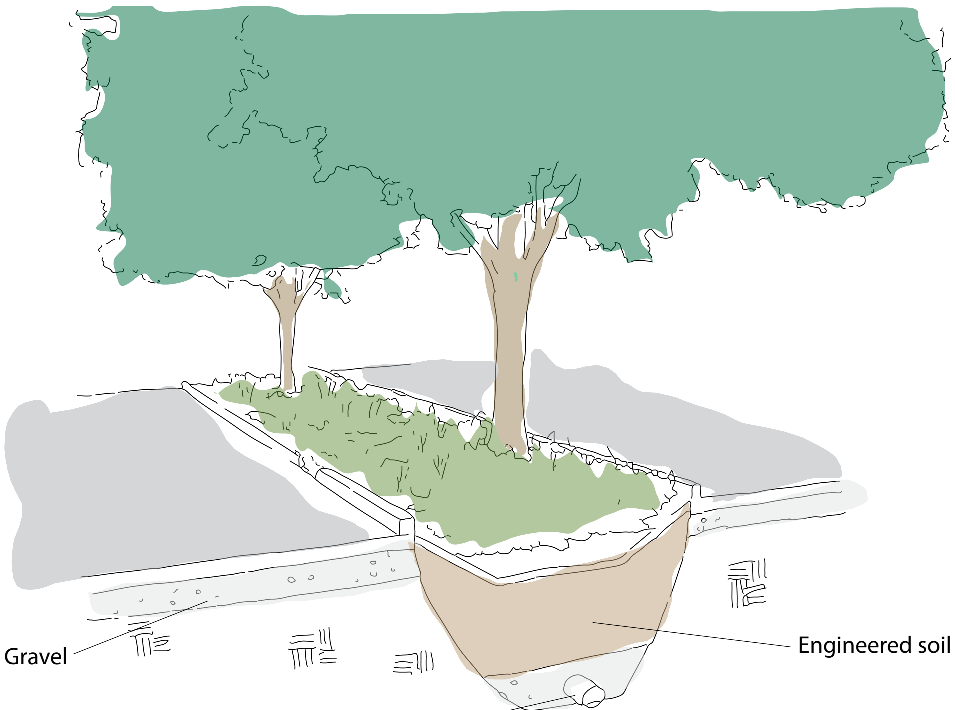
Filtration performance rates vary greatly depending on how the system is designed, as does volume attenuation, which can be as high as 100% for small storms, depending depending on dry or wet antecedent conditions (CRWA 2008).

Maintenance

Maintenance includes periodic inspection of vegetation and drainage structures, removal of sediments and debris, and cleaning and repairing inflow and outflow pipes. Periodic replacement of plants and mulch to prevent build-up of pollutants is also recommended. The costs of maintaining a rain garden are similar to those of traditionally landscaped areas (CRWA 2008).

DIMENSIONS	SPACING	COST	% TSS REMOVED	LIFESPAN
Flexible width and length; >2 ft. depth	25-30 ft. between trees	$10-$12 per sq. ft.	23%-81%	Depends on plants, space, and stress-level

BIOSWALE



Description

Bioswales (or vegetated swales) are similar to rain gardens in terms of typically covering a larger surface area, but differ in that they can also be used to convey runoff in addition to catching and treating it. Essentially a ditch, they are commonly used along roadways, within medians, and in parking lots as alternatives to, or as an enhancement to, conventional stormwater piping designed to move stormwater away from critical infrastructure (Clark & Acomb, 1).

A predominantly infiltration-based system, the appropriateness of bioswales depends on subsoil infiltration rates, the depth of the water table, and slope. Infiltration can be encouraged by placing obstacles perpendicular to the flow path.

Removal rates of total suspended solids tend to be high if used with designed soils, but are less effective with conventional soils. A well-designed bioswale can significantly reduce the peak flow of smaller storms and overall stormwater runoff, and contribute to groundwater recharge.

Maintenance

Maintaining and replacing vegetation, especially during the establishment period, is recommended. Other tasks involve periodic inspection and cleaning of inlet and outlet structures, periodic inspection and repair of dams, and periodic inspection of possible erosion damage. Mowing grass along the edges may be appropriate in some areas.

Typical annual costs for maintenance are $200 per 900 square feet of bioswale (CRWA 2008).

DIMENSIONS	SPACING	COST	% TSS REMOVED	LIFESPAN
Flexible width and length; >3 ft. deep	25-30 ft. between trees	$4-$6 per sq. ft.	60%-85% with engineered soils	Depends on plants, space, and stress-level

PERMEABLE SURFACES

PERMEABLE PAVERS

Permeable pavers are bricks or concrete slabs with multiple spaces in between that direct water into a stone reservoir underneath. These systems reduce runoff volume, flow rate, and temperature in addition to increasing groundwater infiltration and recharge. This can reduce the need for traditional stormwater infrastructure, and can be an integral part of a complete green infrastructure landscape. Additionally they improve the aesthetic appeal of paved areas.

Maintenance
Vacuum sweeping of the surface is needed 2-4 times a year to maintain sufficient infiltration. Periodic inspection of blocks and replacement of sand, gravel, and vegetation is also needed. Annual maintenance costs is \$400-\$500 for vacuum sweeping per ½ acre.

Permeable pavers in the form of bricks. Consistent spacing filled with sand allows water to infiltrate.

DIMENSIONS	SPACING	COST	% TSS REMOVED	LIFESPAN
Depends on type	N/A	\$8-\$12 per sq. ft.	85%-95%	>20 years

POROUS PAVEMENT

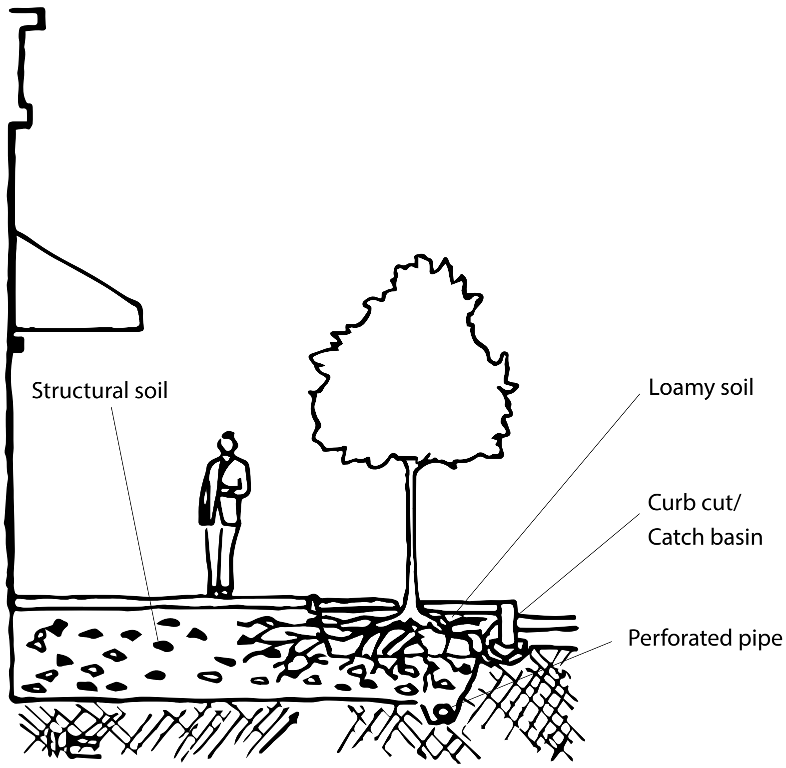
Porous pavement is asphalt or concrete mixed with coarse particles that allow water to permeate through the surface layer. An underlying layer of finer particles filters the water before it is temporarily stored in a third layer of uniform-grade stones. Porous pavement can greatly decrease the amount of surface runoff and is ideal for replacing conventional pavement in parking lots, walkways, and low-traffic roads.

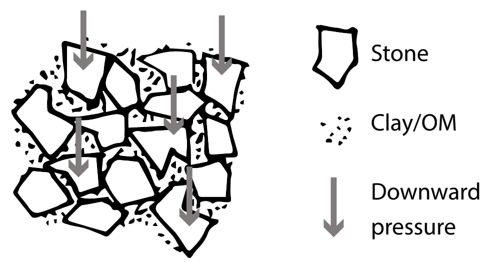
Maintenance
Vacuum sweeping of the surface is needed 3-4 times a year to maintain sufficient infiltration. Annual maintenance costs is \$400-\$500 for vacuum sweeping per ½ acre.

Visible differences in surface water with pervious asphalt (left) and regular asphalt (right) on a highway in the Netherlands.

DIMENSIONS	SPACING	COST	% TSS REMOVED	LIFESPAN
N/A	N/A	\$7-\$15 per sq. ft.	80%-90%	>20 years

STRUCTURAL SOILS





Description
Structural soils are a form of engineered soils designed to be load-bearing while providing good growing conditions for tree roots and beneficial microbes.

Larger particles, such as sand, silica, or gravel provide structural support and sufficient pore space for infiltration, gas exchange, and root growth, while organic matter, clay, and tackifiers are used to ensure nutrient and water availability. This enables healthy tree growth in places where planting space is limited.

Three types of structural soils are commonly used in urban settings. "Amsterdam Soil" is based on a formula developed by Dutch universities in the 1980s, where specifically graded silica and sand particles are mixed with organic material. Sand-Based Structural Soil (SBSS) is a further development related to Amsterdam Soil, but with an improved rooting environment.

CU-Structural Soil, developed by Cornell University, is based on uniformily sized, highly angular crushed stones that form a "lattice" once compressed. Smaller particles of clay, organic matter, and a gel-based tackifier provide water and nutrient availability and microbial activity.

These soils can be an effective stormwater management tool especially if combined with permeable surfaces, slot drains, and strategic placement of catch basins.

Maintenance
Maintenance is similar to conventional street trees, but with regular cleaning of catch basins or slot drains if used. If used with permeable surfaces, these need to be vaccumed to ensure sufficient drainage and air circulation. These systems significantly reduce the risk of sidewalk heaving as trees grow larger, and hence can be a cost-effective long-term solution.

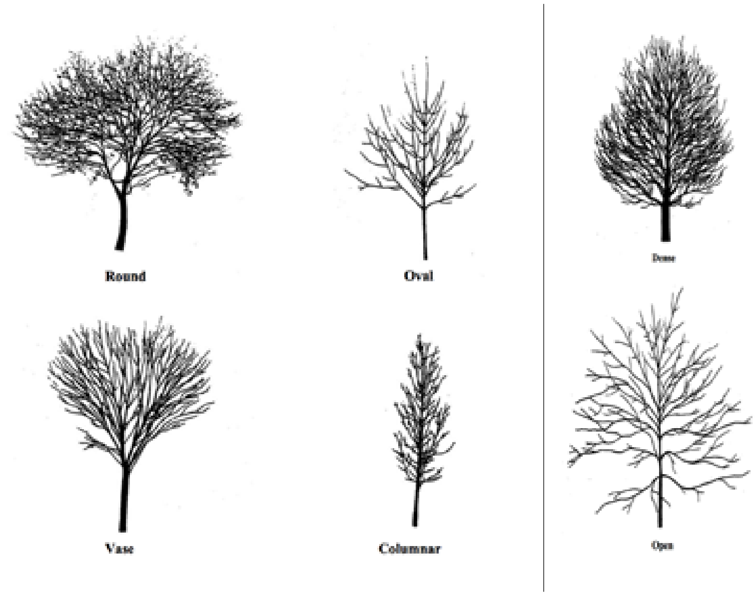
DIMENSIONS	SPACING	COST	% TSS REMOVED	LIFESPAN
600-1,500 cu. ft. per tree	25 ft.-30 ft. between trees	$40-$75 per cubic yard	Depending on sizing and plantings used	Theoretically indefinite

TREE PLANTING CONSIDERATIONS

Crown Shapes & Canopy Density

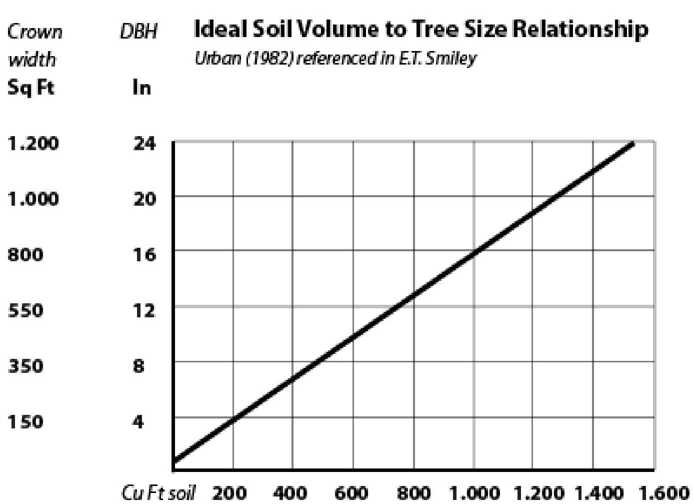
Selecting trees with crown shapes and density appropriate to specific sites significantly increase their environmental effect while causing minimal problems where space is limited. For example, selecting species that have round or vase-shaped crowns can maximize the amount of canopy cover over longer distances such as the width of a street. Similarly, vase-shaped trees may be particularly appropriate in places where height is limited, as the shape is broad on top to maximize canopy cover, but with a branching pattern that is upward, requiring little maintainance to prevent them from impeding pedestrians on sidewalks.

Similarly, denser or more open growth trees can be selected according to varying needs of shelter or visibility.



Recommended Soil Volumes

Adequate soil volume is greatly influences a tree's growth and health. Limited availability of soil will result in limited tree size regardless of species. In an urban environment limited space around trees often results in heaved pavements or other tensions between tree growth and human use which can be altogether avoided or greatly reduced with careful planning growth pattern and selection of species and type of soil. Exact soil requirements will also depend on tree species and size, the type of soil, and broader growing conditions such as surroundings and climate, but an idealized graph provides a useful guideline:



Biodiversity

Planting a variety of tree species (and other vegetation) is generally considered beneficial to the urban landscape. Species diversity makes urban forests less vulnerable to diseases such as Dutch Elm and insect attacks such as Emerald-Ash Borer, provide a broader range of wildlife habitat, and can provide additional aesthetic interest compared to more homogenous plantings.

The genus *Acer* (maple) is currently not recommended for planting within the city of Chicopee because of its already-wide distribution (Davey Resource Group 2014). Most varieties of *ulmus* (elm) and *fraxinus* (ash) are also not recommended at this point in time as they are considered vulnerable to pathogens and insects present in the region (Ibid).

Age distribution is also an important factor in maintaining a healthy urban forest. According to Richards (1983), an approximate ideal age distribution within a given area is 40% young trees, 10% mature trees, and 50% established or maturing trees.

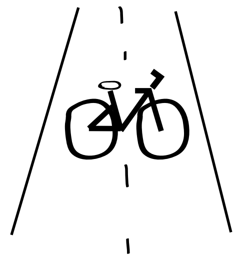
The species selected should be hardy to USDA Hardiness Zone 6a, and should also be able to tolerate the harsh environment of a city including exposure to pollutants, temperature fluctuations, dry spells, and occasional waterlogging.

COMPLETE STREETS TOOLS

BIKE LANES

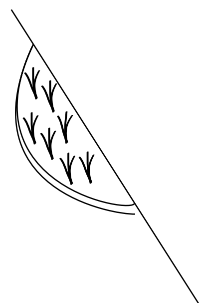
Designated bike lanes improve safety and encourage more cyclists. As cycling becomes an increasingly important mode of transportation in urban areas, it is crucial to emphasize and clarify the cyclist's place within the streetscape.

Lanes following the direction of vehicular traffic are possible by either taking up part of the driving lane width or by designating a bike lane next to the driving lane. These are typically 3-6 ft. wide depending on the amount of bike traffic. Two-way bike lanes are typically 10 ft. or wider (5 ft. each direction).



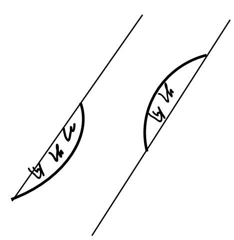
BUMP-OUTS

Bump-outs extend the sidewalk toward the center of the street, narrowing the roadway and providing space for plantings. When applied at crosswalks, they enhance pedestrian visibility and decrease crossing distance. When applied mid-block they serve to calm traffic. They can also become effective catchment areas if combined with Green Infrastructure tools.



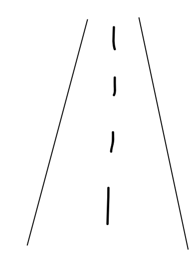
CHICANES

Chicanes use vegetated bump outs to create an "S" curve that drivers must maneuver through, slowing speeds. Snow removal and accessibility for cyclists may be a concern, although this is less of a problem where curb edges are rounded rather than angular.



ROAD DIET

Narrowing the driving lane for cars can help make space for other uses including green infrastructure, bike lanes, and parking. This strategy can increase safety for all users and is best suited on streets currently not used at full capacity.



TOOLBOX SUMMARY

TOOL	DIMENSIONS	SPACING	COST	% TSS REMOVED	
Tree Box Filter	6x6x4 ft.	25 ft.-30 ft.	$12,000-$20,000, excluding labor per box	85%-90%	
Tree Trench	Width: >5 ft. Depth: >3 ft.	25 ft.-30 ft. between trees	Approximately $8-$12 per sq. ft.	80%-90%	
Stormwater Planter	Width: >2.5 ft (w/o trees)/ >5 (w/ tree)	25 ft.-30 ft. between trees	Approximately $8-$12 per sq. ft.	Insufficient data, but likely 80%-90%	
Rain Garden	Flexible width and length; >2 ft. depth	25-30 ft. between trees	$10-$12 per sq. ft.	23%-81%	
Bioswale	Flexible width and length; >3 ft. deep	25-30 ft. between trees	$4-$6 per sq. ft.	60%-85% with engineered soils	
Permeable Pavers	Depends on type	N/A	$8-$12 per sq. ft.	85%-95%	
Porous Pavement	N/A	N/A	$7-$15 per sq. ft.	80%-90%	
Structural Soils	>20 years	25 ft.-30 ft. be-tween trees	$40-$75 per cubic yard	Depending on sizing and plantings used	

LIFESPAN	MAINTENANCE
Trees: 5-15 years Chamber: 20-25 years	Minimal maintenance is required in the years after installation. Routine trash and litter removal and inspection of the soil's ability to infiltrate water are the main tasks, together with periodic pruning of the tree and biannual mulching. Periodic testing for build-up of pollutants in mulch and soil is recommended. Likely annual maintenance costs is $100 per box if conducted by the owner or $500 if done by a contractor.
Trees: 10-25 years Container: 20-25 years	Similarly to tree box filters, tree trenches require minimal maintenance in the years after installation. Routine trash and litter removal and inspection of the soil's ability to infiltrate water are the main tasks, together with periodic pruning of the tree and biannual mulching. Periodic testing for build-up of pollutants in mulch and soil is recommended. Open tree trenches may require more pruning and replacement of understory plantings. Yearly maintenance costs will depend on the length of the system, but an estimate of $100 per trench if conducted by the owner or $500 if done by a contractor is reasonable.
Trees: 10-25 years Container: 20-25 years	Regular maintenance of vegetation, such as weeding, soil replacement, and watering during dry periods is recommended, as is periodic cleaning of inflow and outflow mechanisms. Periodic testing for build-up of pollutants in mulch and soil is recommended. If trees are included, these have an expected lifetime of 5-15 years, while other vegetation may need to be replaced more frequently.
Depends on plants, space, and stress-level	Maintenance includes periodic inspection of vegetation and drainage structures, removal of sediments and debris, and cleaning and repairing inflow and outflow pipes. Periodic replacement of plants and mulch to prevent build-up of pollutants is also recommended. The costs of maintaining a rain garden are similar to those of traditionally landscaped areas.
Depends on plants, space, and stress-level	Maintaining and replacing vegetation, especially during the establishment period, is recommended. Other tasks involve periodic inspection and cleaning of inlet and outlet structures, periodic inspection and repair of dams, and periodic inspection of possible erosion damage. Mowing grass along the edges may be appropriate in some areas. Typical annual costs for maintenance are $200 per 900 sq ft of bioswale.
>20 years	Vacuum sweeping of the surface is needed 2-4 times a year to maintain sufficient infiltration. Periodic inspection of blocks and replacement of sand, gravel, and vegetation is also needed. Annual maintenance costs is $400-$500 for vacuum sweeping per ½ acre.
>20 years	Vacuum sweeping of the surface is needed 3-4 times a year to maintain sufficient infiltration. Annual maintenance costs is $400-$500 for vacuum sweeping per ½ acre.
Theoretically indefinite	Maintenance is similar to conventional street trees, but with regular cleaning of catch basins or slot drains if used. If used with permeable surfaces, these need to be vaccumed to ensure sufficient drainage and air circulation. These systems significantly reduce the risk of sidewalk heaving as trees grow larger, and hence can be a cost-effective long-term solution.

DESIGNS

METHODOLOGY

With the goal of filtering and reducing stormwater via trees and green infrastructure systems, the first step in the design process was to understand the specifications of each block, specifically related to the amount of stormwater generated in a 1.3 inch rain event.

Using tree box filters, per recommendation and request from the Pioneer Valley Planning Commission, the first step in the design process involved calculating the number and location of these systems, taking into account the site conditions on each block, zoning regulations, and capacity to filter and aborb water as determined via a *Tetra Tech* report in combination with other, relevant resources.

Using research by *Filterra* that recommends a filter surface area to drainage surface area of 0.33% (Rector 2013), the following formula was used to calculate the number of tree box filters needed:

$$\frac{(FSA/DA\%)\ (DA \text{ in acres}) \times (43{,}560 \text{ sq ft})}{100}$$

= tree box filter area required

FSA - Filter Surface Area
DA - Drainage Area

This formula yielded a total of 7 tree box filters needed to *filter* road surface runoff from both streets (Fig. 1). However, in order to *reduce the volume* of runoff from a 1.3-inch rain event, a total of 45 tree box filters would be needed (Fig. 2).

Fig. 1: Minimum amount of tree box filters needed to filter runoff.

Fig 2: Tree box filters needed to reduce volume.

Although tree box filters could be used to reduce the volume of runoff entering the stormwater system, their main purpose is to filter runoff, not reduce the volume of runoff. Additionally, their high cost and short lifespan suggest they should be used strategically. Installation costs of a single tree box filter, including the chamber, tree, materials, and labor, amount to approximately $15,000; installing 45 tree box filters would cost a total of $675,000. Trees in these systems have only an approximate 10-year lifespan. The whole system itself lasts only 20-25 years.

Given the cost, and the relative ineffectiveness of tree box filters of reducing volume of runoff, other Green Infrastructure tools were considered. The result of this process is the first set of designs referred to as "Green Streets" later in this chapter. These designs sought a "balance" of various Green Infrastructure tools as a means to treat these streets as a demonstration project, essentially a means to show the effectiveness of the variety of tools.

Site Analysis

- ROW Width
- Street parking
- Slope
- Runoff
- Utilities

\+

Criteria

- Pollutantremoval capacity
- Peak flow reduction
- Dimensions

=

Tool

- Tree box filter
- Tree trench
- Stormwater planter
- Rain garden

The design process evaluated site conditions against the capacity of various tools to determine the best fit.

The second major driver of the design process was Chicopee's larger goal to revitalize downtown using Complete Street elements to make the neighborhood more pedestrian and cyclist friendly.

A number of cities in the Northeast, including Boston, have in recent years adopted Complete Streets guidelines intended to increase safety for pedestrians and cyclists by strategically reconfiguring road dimensions and traffic patterns. Strategies relevant and appropriate to Chicopee have been included in the second design approach, referred to as "Complete Streets" in this chapter.

PUBLIC INPUT

Since public participation in any municipal project is essential, two community meetings were held.

The first meeting, held January 25 at the Chicopee Public Library, focused on what residents liked and valued about their community and changes that they wished to see. A total of eighteen attendees participated, eleven of whom were members of the public. These included two residents of the study area and two business owners with enterprises there. The remaining seven attendees represented the City of Chicopee, DCR, PVPC and the Valley Opportunity Council. The meeting therefore provided a mixture of views.

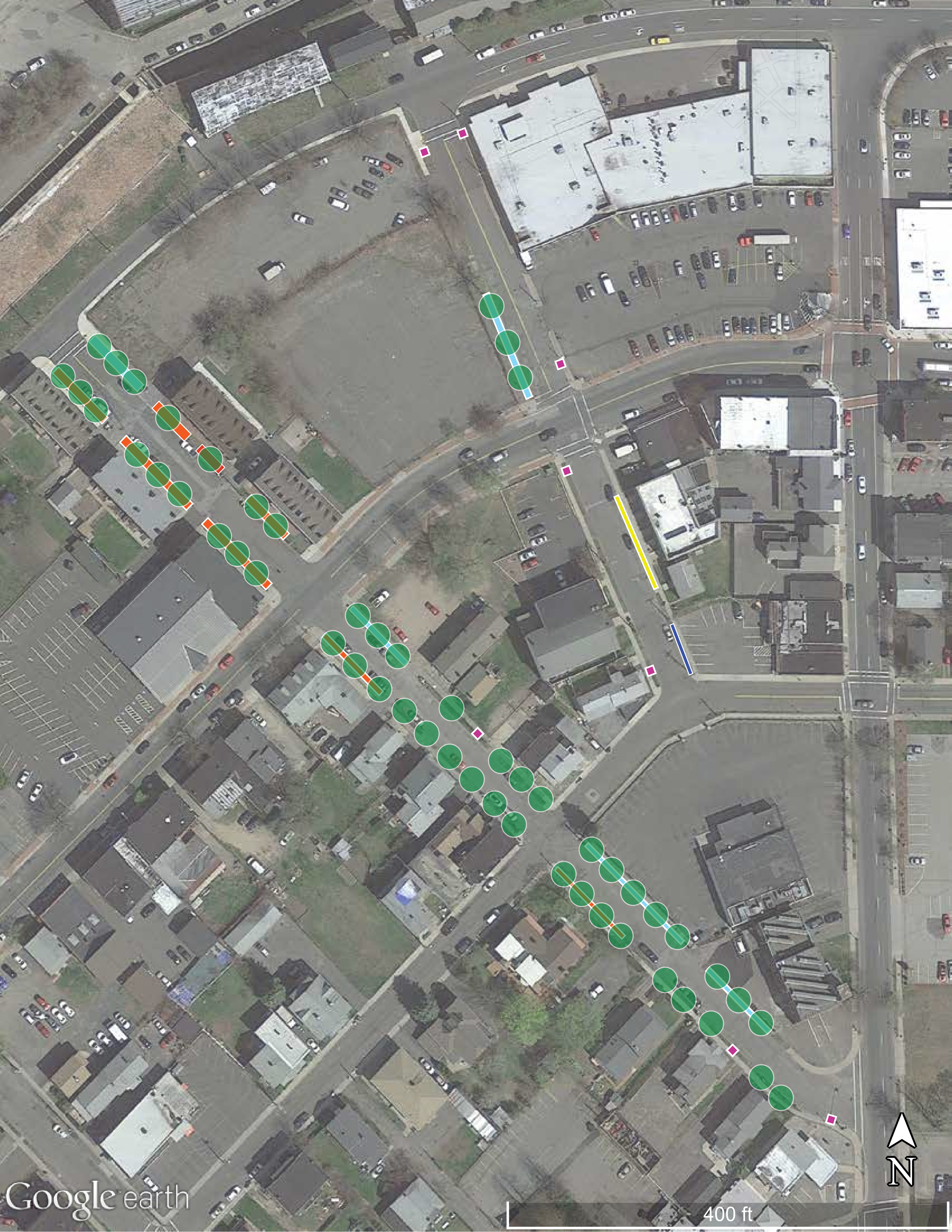
Main points raised included the following:

- Strengthening the historical corridors between mills and downtown could be an incentive for potential investors in the mill properties.
- Chicopee is very well connected to the highway network, but current traffic patterns encourage people to drive past the neighborhood, while unattractive views further discourage people from entering.
- Elms College is within walking distance of downtown and presents another opportunity to enliven the neighborhood.
- Absentee landlords are a major concern as they tend to take less interest in the condition of the neighborhood.
- Large parking areas and vacant lots could be used to create inviting and permeable outdoor spaces such as parks.
- Trees and other vegetation must not block street lights or security cameras.

Dave Bloniarz of the U.S. Forest Service also presented a talk on the role and benefits of trees in the urban environment.

The community input from the first meeting was central to the first stages of the design process, a draft of which was presented at a second community meeting, on March 1. A total of seven people attended the meeting, three of whom were members of the public. Attendees expressed general enthusiasm for the proposed designs.

Community members brainstorm ideas about what they would like to see in the neighborhood. Photographsby the authors.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OVERVIEW

Integrating green infrastructure as a stormwater management tool within a broader vision of green streetscapes and a revitalized neighborhood is the main goal of the designs presented here.

Two approaches to this goal focus on implementing changes within the right-of-way on a block-by-block basis. The particular concerns driving the designs include:

- The exceptionally high percentage of impervious surfaces within the study area.
- The exceptionally low number of trees and subsequent lack of canopy cover in the West End as a whole.
- The orientation of Dwight and Perkins Streets as main corridors between the mills and downtown, and their increasing importance in connecting these two areas as the mills become redeveloped.
- The general lack of pedestrian crossings, traffic speed reduction elements, and other street elements that encourage foot traffic and general street life.
- The lack of vegetation around the older mill houses, which could have a significant impact on heating (absorbing cool winds) and cooling (increased shade) costs.

1: GREEN STREETS

The first approach retrofits green infrastructure tools into the existing streets with minimal impact. The designs maintain the existing widths of the roads, green belts, and sidewalks in their current dimensions as far as appropriate, while still slowing, filtering, and absorbing road surface runoff to the greatest extent possible.

The green infrastructure tools were chosen based on their effectiveness as stormwater management systems, sizing requirements, and potential to increase the amount of canopy cover. A higher number of tree box filters satisfies the minimum amount required for the demonstration purposes of the grant.

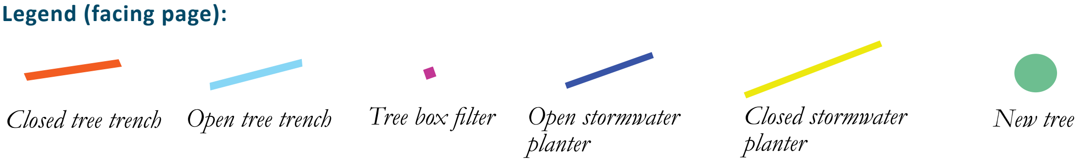
Another important factor is the expected lifespan of each system, which tends to favor the larger, infiltration-based system over the smaller, enclosed ones. The life expectancy of the plants, and the trees in particular, is closely linked to the size of the available growing space and how well runoff and pollutant exposure is distributed. Enclosed systems normally need to be replaced completely every 20 to 25 years, with the trees only lasting a decade or so.

The choice of tools and their placement in this approach strives for longevity and cost-effectiveness over time in addition to effectiveness as stormwater management tools.

Pros:
- Green infrastructure tools are integrated into the existing green strips, hence a minimal amount of street configuration is required.
- All road surface runoff is filtered before entering the drainage system.
- Canopy cover is increased.
- Implementation can occur incrementally.

Cons:
- Impervious surfaces area is not reduced.
- Canopy cover increase is limited as the chosen systems can only support smaller trees.
- Volume of runoff is reduced, but this reduction may not be adequate to mitigate CSO events.
- High installation costs and the limited lifespan of most of the systems may make this approach less cost-effective in the long run.

Legend (facing page):




Google earth
400 ft
N

2: COMPLETE STREETS

The second approach integrates green stormwater management into a broader reconfiguration of the streetscape.

Several of the Green Infrastructure systems in the first approach are replaced with largely structural soils systems that better support tree growth and longevity in addition to managing stormwater. These soils are added under permeable sidewalks, significantly increasing the growing space for the trees and the water absorption capacity of the streetscape as a whole. In this scenario the trees are likely to reach both greater life-expectancy and size.

Reducing road surface further reduces the amount of stormwater runoff. Road widths are narrowed following regional and national Complete Streets strategies to reduce impervious surface area, slow traffic, and encourage foot traffic and general street life. Bump-outs increase the amount of growing space and create narrow vehicular entries and chicane patterns to reduce traffic speed in residential areas. Porous pavement in the on-street parking areas further enables on-site infiltration.

Pros:
- Integrates effective long-term stormwater management with greening as an urban revitalization strategy.
- Impervious surface area is significantly decreased, resulting in less runoff.
- The capacity to deal with both volume and filtration is greatly increased.
- Tree size and longevity are significantly increased, resulting a greater impact on the urban environment (including air quality, heating/cooling costs) over time.
- Encourages foot traffic and street life, a possible incentive for potential investors in the mill properties and downtown.
- Can be implemented on a block-by-block basis and/ or integrated with the sewer separation project.

Cons:
- Changes street characteristics people are familiar with.
- Relatively extensive.
- May require moving some underground utilities.

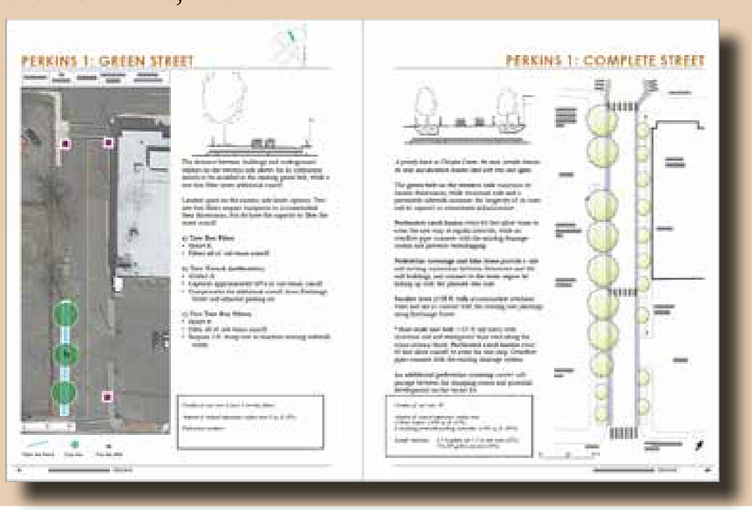
Outline of the Design Pages

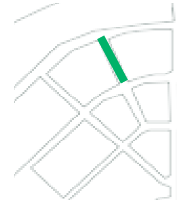
The two design approaches are displayed on the following pages next to each other on a block-by-block basis for easy comparison.

Each two-page spread contains a plan view, a section view, street dimensions, rough cost estimates, and the number of trees included.

Left page describes the Green Streets approach (number 1) and highlights details pertinent to the particular block.

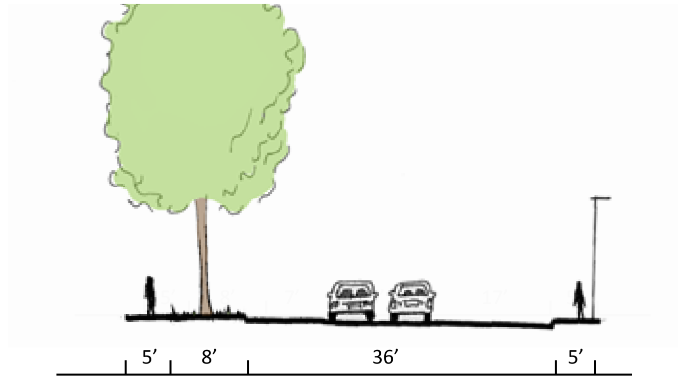
Right page describes the Complete Streets approach (number 2) applied to the same block.





PERKINS 1: GREEN STREET

Commercial	36′ (ROW 40′)	1.4% slope	No on-street parking	Green Belt: West: 8′ East: 0′



The distance between buildings and underground utilities on the western side allows for an infiltration trench to be installed in the existing green belt, while a tree box filter treats additional runoff.

Limited space on the eastern side limits options. Two tree box filters require bumpouts to accommodate their dimensions, but do have the capacity to filter the street runoff.

a) Tree Box Filter

- 6x6x4 ft.
- Filters all of sub-basin runoff.

b) Tree Trench (infiltration)

- 42x8x3 ft.
- Captures approximately 60% of sub-basin runoff
- Compensates for additional runoff from Exchange Street and adjacent parking lot.

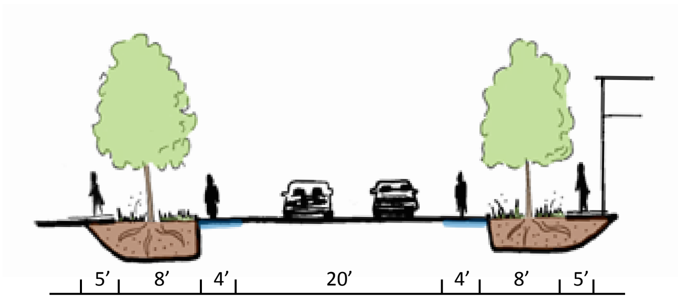
c) Two Tree Box Filters

- 6x6x4 ft.
- Filter all of sub-basin runoff.
- Require 3 ft. bump-out to maintain existing sidewalk width.

Number of new trees: 6 (incl. 2 tree box filters)

Amount of reduced impervious surface area: 0 sq. ft. (0%)

PERKINS 1: COMPLETE STREET



A priority block in Chicopee Center, the main corridor between the mills and downtown becomes lined with trees once again.

The **green belt on the western side** maintains its former dimensions, while structural soils and a permeable sidewalk increases the longevity of its trees and its capacity as stormwater infrastructure.

Perforated catch basins every 60 feet allow water to enter the tree strip at regular intervals, while an overflow pipe connects with the existing drainage system and prevents waterlogging.

Pedestrian crossings and bike lanes provide a safe and inviting connection between downtown and the mill buildings, and connect to the wider region by linking up with the planned bike trail.

Smaller trees (<15 ft. tall) accommodate overhead wires and are in concert with the existing tree plantings along Exchange Street.

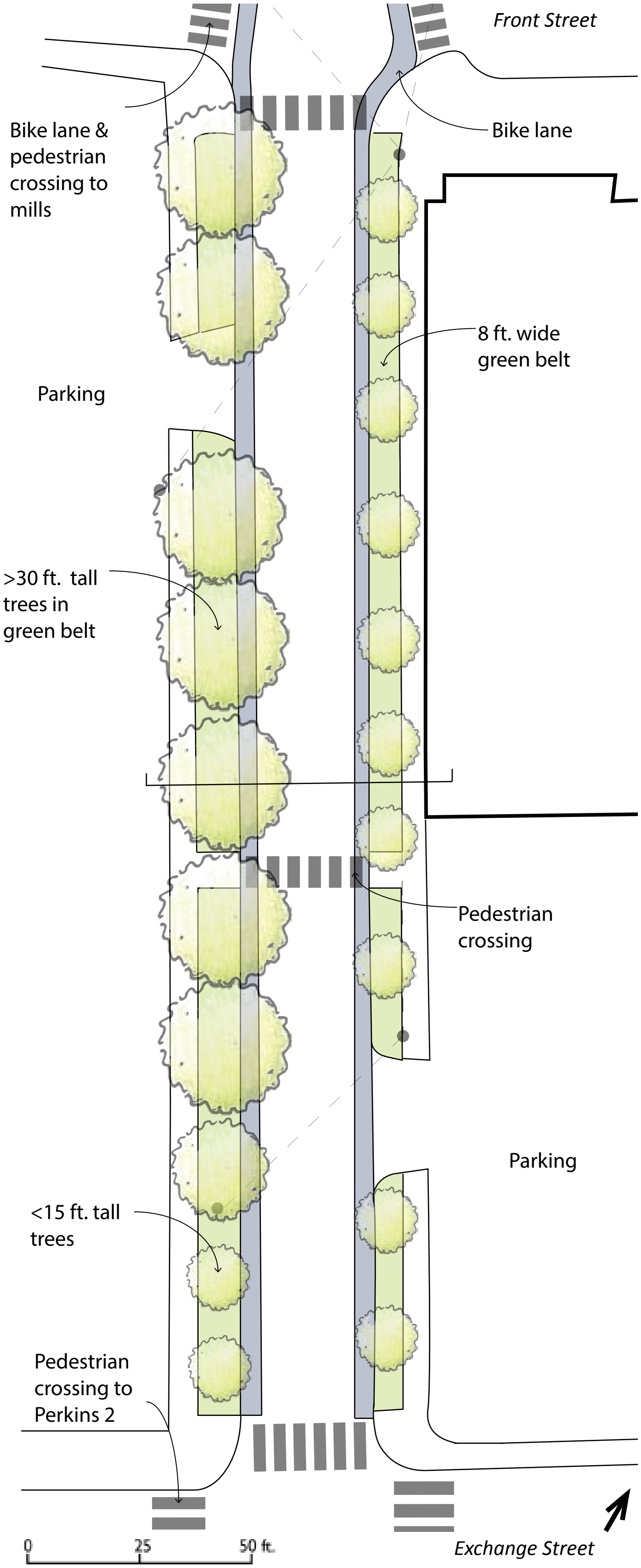
7-foot-wide tree belt (<15 ft. tall trees) with structural soil and waterproof liner runs along the entire eastern block. **Perforated catch basins** every 60 feet allow runoff to enter the tree strip. Overflow pipes connect with the existing drainage system.

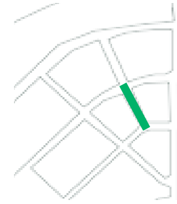
An additional pedestrian crossing creates safe passage between the shopping center and potential development on the vacant lot.

Number of new trees: 20

Amount of reduced impervious surface area:
a) Road surface: 2,080 sq. ft. (16%)
b) Including permeable bike lanes/ sidewalks: 6,940 sq. ft. (44%)

Runoff reduction: 3,374 gallons per 1.3 in rain event (28%)
114,205 gallons per year (28%)

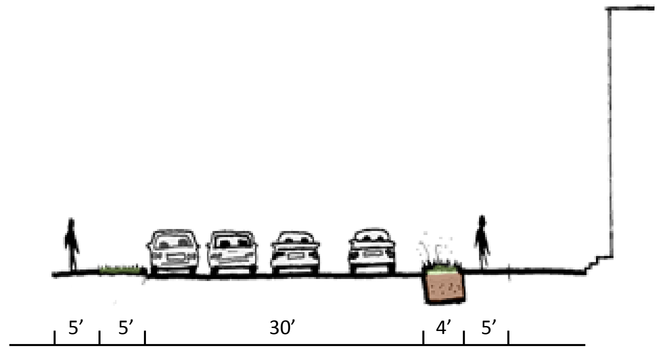




PERKINS 2: GREEN STREET

Commercial	30′ (50′ ROW)	1.4% Slope	On-street parking	Green Belt West: 5′; East 4′

Closed stormwater planter
Tree box filter
Open stormwater planter
New tree



Two tree box filters on the western side replace existing catch basins and filter runoff from the street. Newly planted trees along the church parking lot provide some canopy cover.

The narrow width of the existing green belt on the eastern side makes tree planting inappropriate without changing the existing street dimensions. Stormwater planters provide catchment and filtration, although canopy cover is not increased.

a) Two Tree Box Filters
- 6x6x4 ft.
- Filter all of sub-basin runoff.

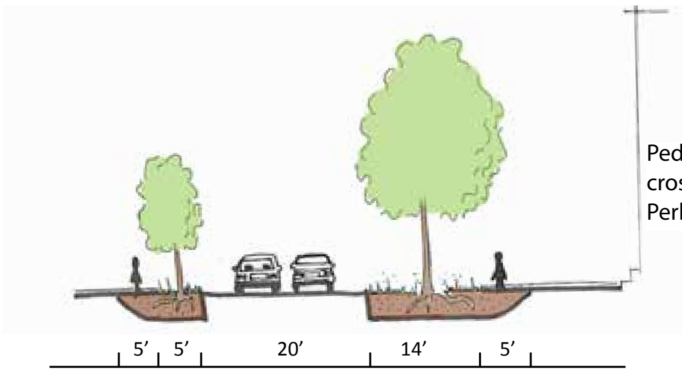
b) Stormwater Planter (closed-bottom)
- 100x4x3 ft.
- Captures approximately 140% of sub-basin runoff, and compensates for surrounding parking areas.

c) Stormwater Planter (infiltration)
- 45x4x3 ft.
- Captures approximately 135% of sub-basin runoff, and compensates for adjacent parking lot and large parking lot to the south.

Number of new trees: 2

Amount of reduced impervious surface area: 0 sq. ft. (0%)

PERKINS 2: COMPLETE STREET



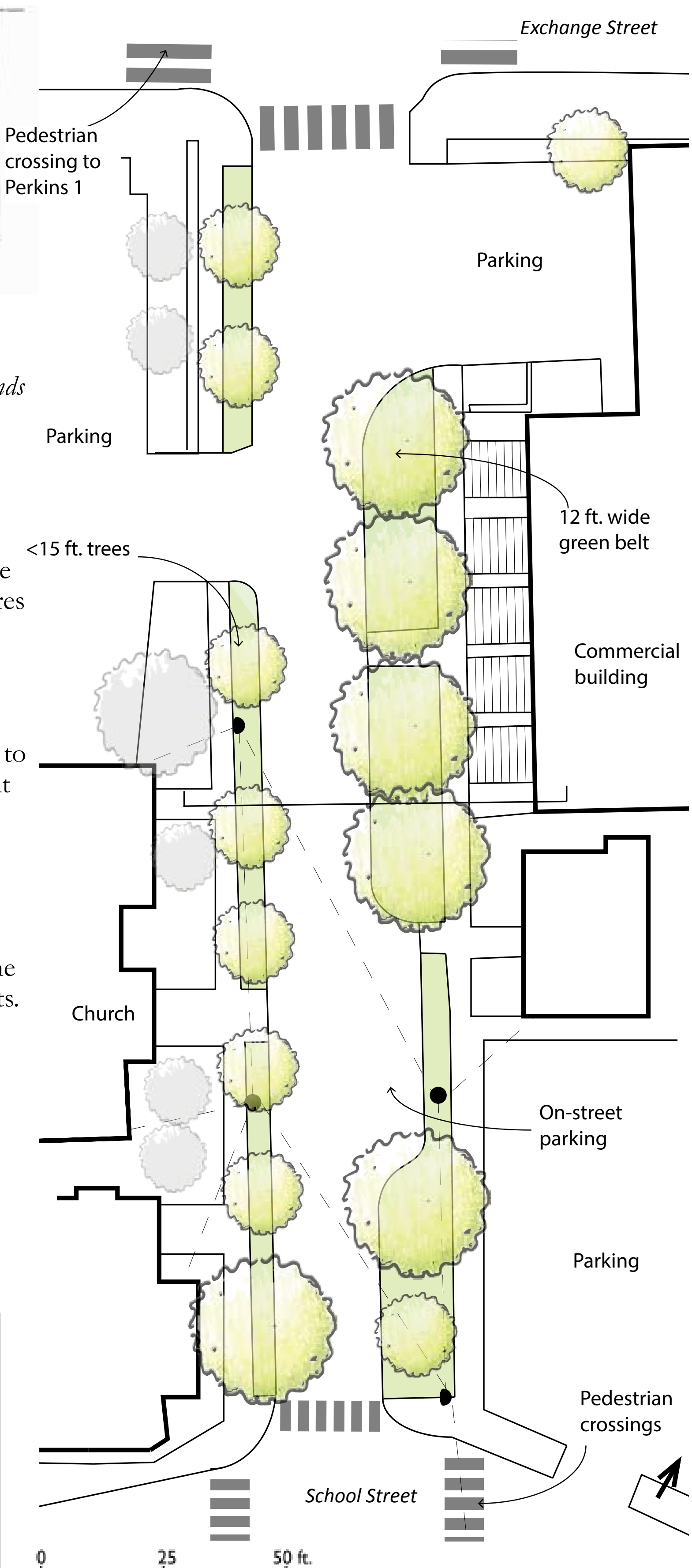
Narrower street provides more room for large trees and extends the mill-downtown corridor.

A pedestrian crossing on the western side provides safety and accessibility, connecting downtown with mill buildings and the planned bike trail. A series of **smaller trees (<15 ft. tall)** increase canopy cover while remaining clear of overhead wires and the trees planted around the church.

A 12-foot-wide tree belt (>30 ft. tall trees) with structural soil and waterproof liner captures and treats runoff. **Perforated catch basins** allow water to flow into the green belt. The width of the green belt and the larger trees create a lush and attractive environment in front of the commercial building, shading the hot southwest sun in the summer.

On-street parking defined by bumpouts accommodates the limited parking demand along the road, while encouraging use of the three parking lots.

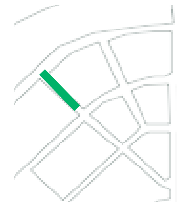
Pedestrian crossings across Perkins and School Streets increase safety and encourage foot traffic.



Number of new trees: 14

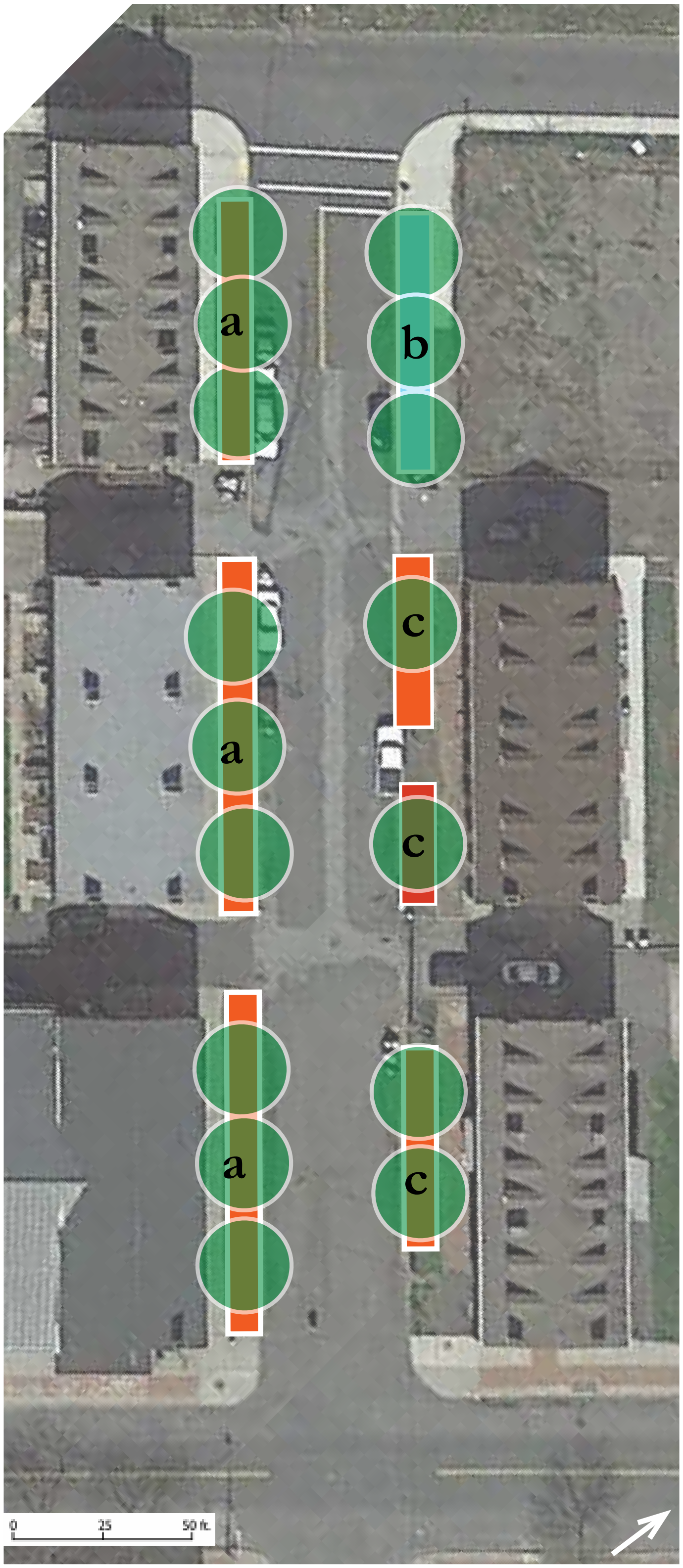
Amount of reduced impervious surface area:
a) Road surface: 1,215 sq. ft. (17%)
b) Including permeable parking/sidewalks: 2,775 sq. ft. (33%)

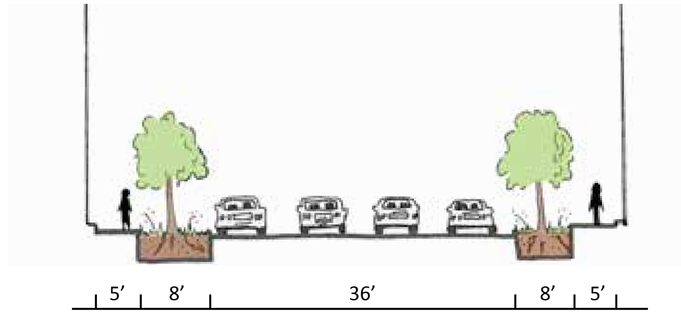
Runoff reduction: 1,349 gallons per 1.3 in rain event (21%)
45,665 gallons per year (21%)



DWIGHT 1: GREEN STREET

Residential	36′ (40′ ROW)	1.5% slope	On Street Parking	Green Belt West: 8′ East:8′





Eight-foot-wide green belts on both sides of the street provide plenty of width for green infrastructure, but the proximity to buildings requires closed-bottom systems in most places. This, together with overhead wires, limits tree heights to twenty feet.

Western Side:

a) Three Tree Trenches (closed-bottom)

- One 60x8x3 ft.
- Two 90x8x3 ft.
- Collectively capture approximately 190% of sub-basin runoff, and compensate for additional runoff from rooftops and adjacent parking lots.

Eastern Side:

b) Tree Trench (infiltration)

- 40x8x3 ft.

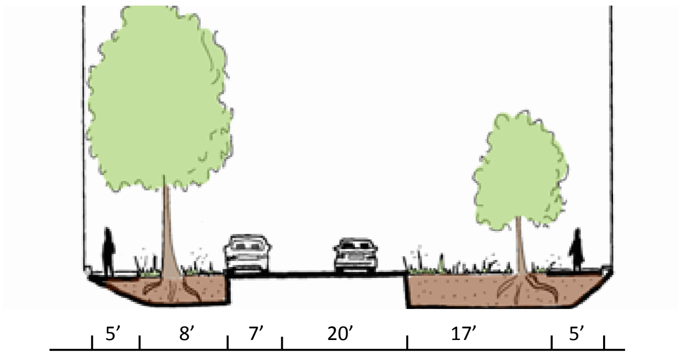
c) Three Tree Trenches (closed-bottom)

- Two 40x8x3 ft.
- One 30x8x3 ft.
- Collectively capture 155% of sub-basin runoff, and compensate for additional runoff from rooftops and adjacent parking lots.

Number of new trees: 16

Amount of reduced impervious surface area: 0 sq. ft. (0%)

DWIGHT 1: COMPLETE STREET



A narrowed, chicaned streetscape provides safe green outdoor space between the historic mill housing and the road.

>30 ft. tall trees line the western side taking advantage of available space and providing privacy, shade, and wind protection to the old mill housing. They also create a protected street environment, and **benches underneath the canopy** invite residents and others to spend time outside.

A pocket park next to the Portuguese American Club creates a natural gathering space and refuge from busy Exchange Street.

Tree heights on the eastern side are limited by the overhead wires, but still provide shelter and beauty.

A bioswale on the northeastern side captures and filters stormwater while creating an opportunity for a variety of plants both biodiversity and visual interest.

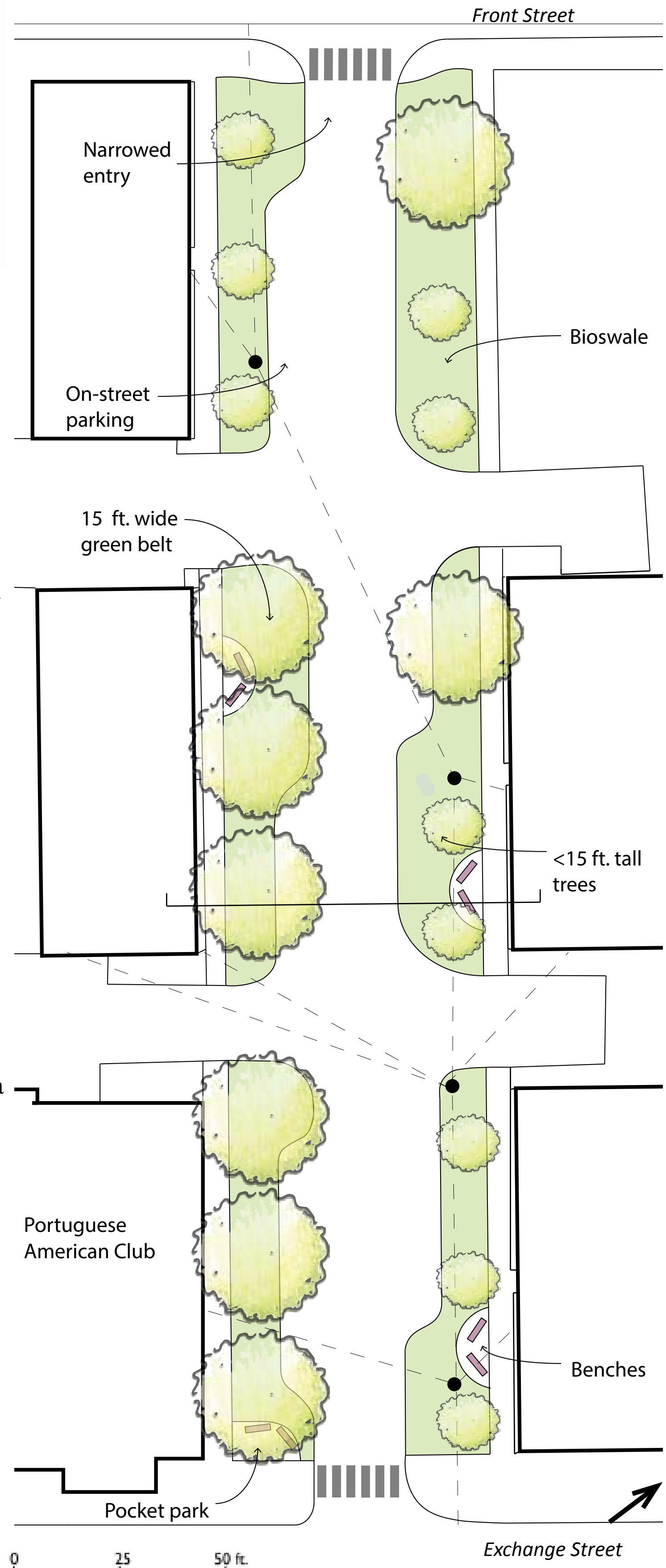
Instead of tree trenches, structural soils provide better growing conditions for the trees on both sides of the street and provide **stormwater capture**, while a waterproof liner and overflow pipes connecting to the existing drainage system prevent potential infiltration issues with the nearby buildings.

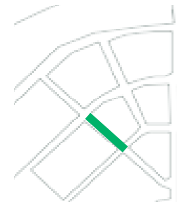
Narrow vehicular entries and a **chicane pattern** help to slow traffic, which also serves to define the on-street parking spaces.

Number of new trees: 18

Amount of reduced impervious surface area:
a) Road surface: 2,015 sq. ft. (17%)
b) Including permeable parking/sidewalks: 4,980 sq. ft. (37%)

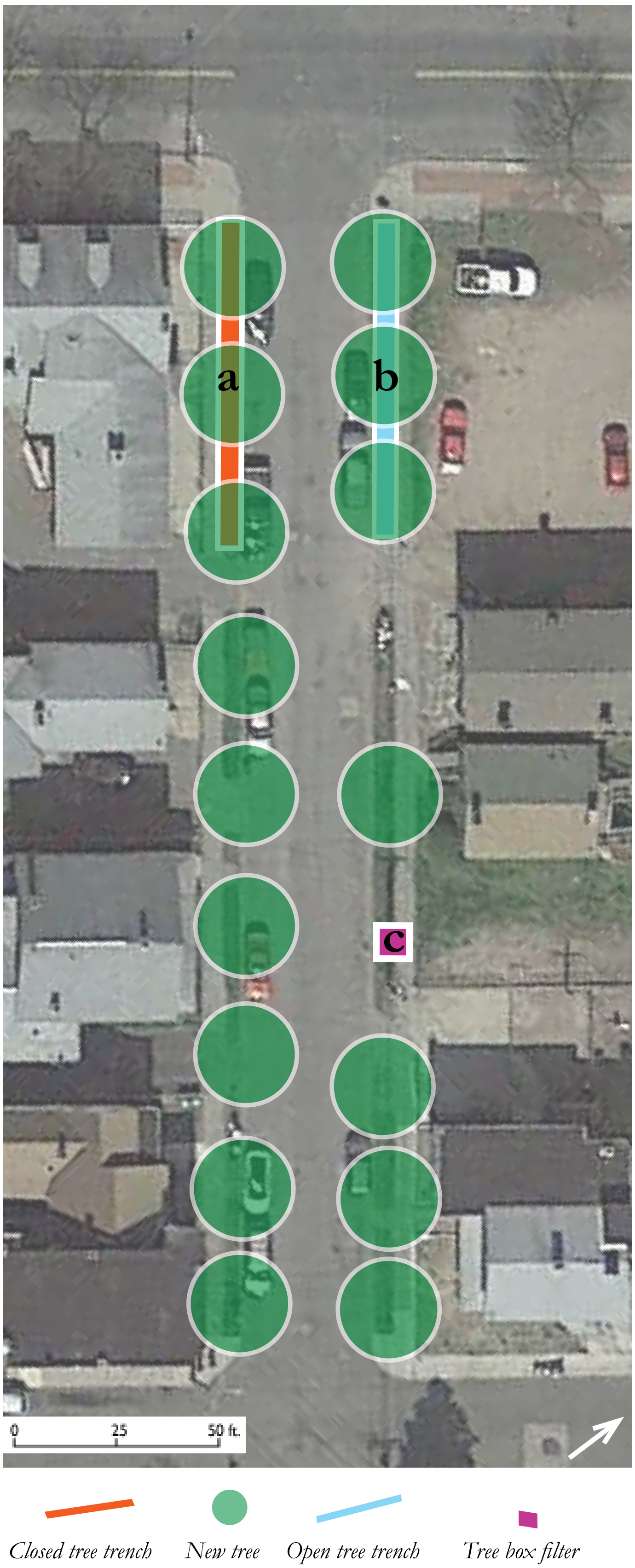
Runoff reduction: 1,530 gallons per 1.3 in rain event (15%)
51,568 gallons per year (15%)

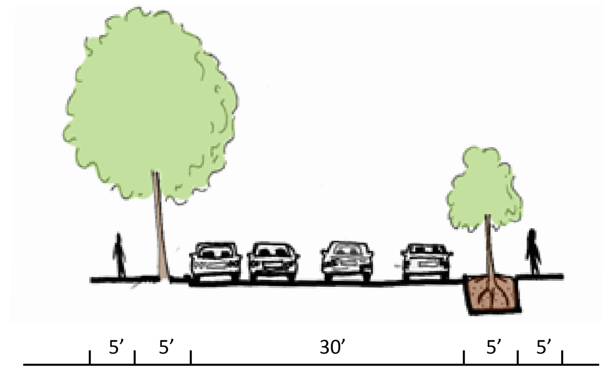




DWIGHT 2: GREEN STREET

Mixed Use	30′ (40′ ROW)	1.5% Slope	Green Belt West: 5′ East: 5′	On Street Parking





Limited planting space and the presence of overhead wires limit tree sizes to twenty feet in height. A closed-bottom tree trench on the western side catches and treats runoff from the western side of the street, while an open-bottom tree trench on the eastern side allows for infiltration.

Rows of trees line both sides of the streets and increase canopy cover significantly.

a) Tree Trench (closed-bottom)
- 70x5x3 ft.
- Catches approximately 62% of sub-basin runoff.

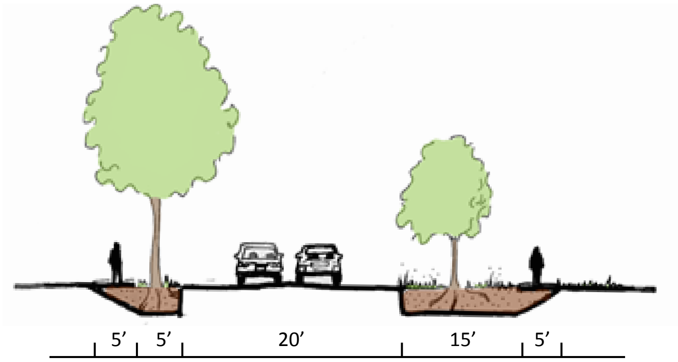
b) Tree Trench (infiltration)
- 70x5x3 ft.
- Catches approximately 40% of sub-basin runoff.
- Appropriate if potential future construction on the vacant lot is >20 ft. away.

c) Tree box filter
- 6x6x4 ft.
- Filters all of the sub-basin runoff.

Number of new trees: 17

Amount of reduced impervious surface area: 0 sq. ft. (0%)

DWIGHT 2: COMPLETE STREET



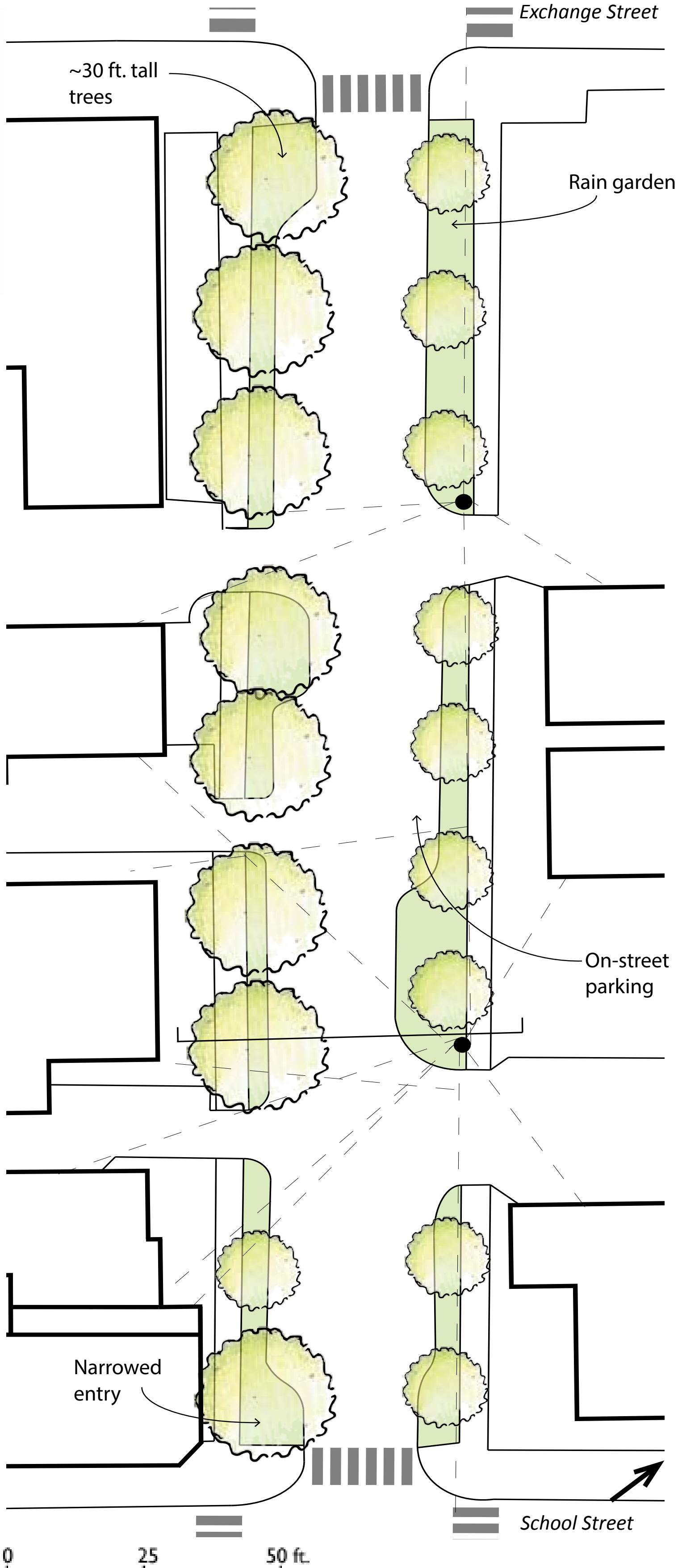
A chicane pattern provides extra growing space for larger trees along the western side, while overall narrowing of the street significantly reduces impervious surface area.

Approximately 30 ft. tall trees on the western side take advantage of the available space above ground, while bumpouts, structural soils, and permeable sidewalks and parking spaces provide sufficient growing space and stormwater capture below. Waterproof lining and overflow pipes prevent potential infiltration issues near buildings.

Smaller trees (<15 ft. tall) line the eastern side underneath the overhead wires, and provide stormwater catchment in the same way as on the western side.

Available space on the northeastern side allows for a **small rain garden** where water can infiltrate into the ground.

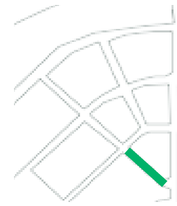
Narrowed vehicle entries at both ends of the street and a chicane pattern slows traffic, defines on-street parking spaces, and shortens crosswalks.



Number of new trees: 18

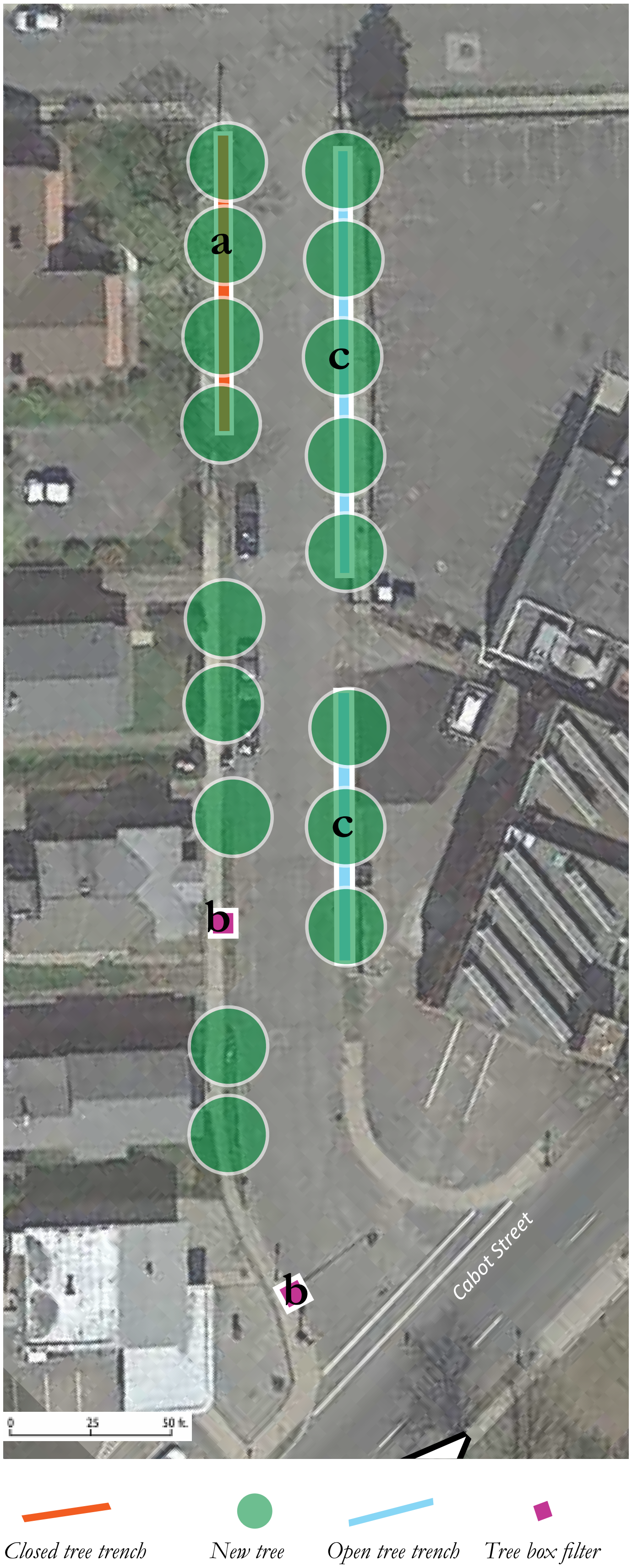
Amount of reduced impervious surface area:
a) Road surface: 935 sq. ft. (11%)
b) Including permeable parking/sidewalks: 4,640 sq. ft. (41%)

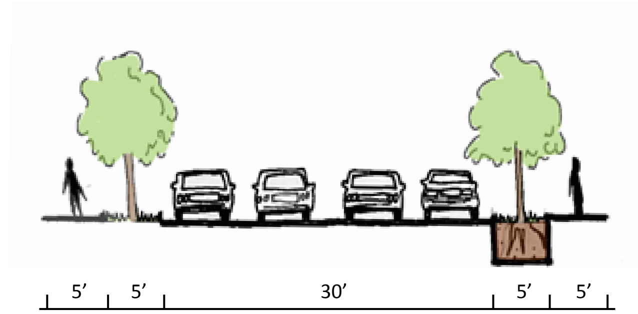
Runoff reduction: 2,255 gallons per 1,3 in rain event (26%)
76,339 gallons per year (26%)



DWIGHT 3: GREEN STREET

Mixed Use	30′ (40′ ROW)	1.5 % Slope	Green Belt West: 5′ East 5′	On Street Parking





Dense residential development on the western side of the street contrasts with the large expanse of open impervious surface on the eastern side.

Three tree trenches are placed within the existing green belts, one closed-bottom on the western side, while the distance from buildings allows for open-bottom trenches along the eastern side that can also accommodate runoff from the adjacent parking lots.

Rows of trees planted on both sides increase canopy cover, provide privacy, decrease the heat island, and provide a more pleasant view for the residents.

a) Tree Trench (closed-bottom)
- 95x5x3 ft.
- Captures 75% of sub-basin runoff.

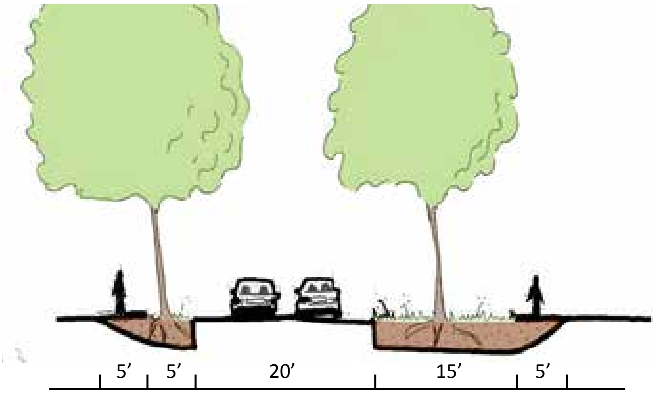
b) Two Tree Box Filters
- 6x6x4 ft.
- Tree box filter at intersection with Cabot Street requires 3-ft. bumpout to be constructed to maintain existing sidewalk width.
- Filters runoff from the relatively busy Cabot Street.

c) Two Tree Trenches (infiltration)
- One 110x5x3 ft.
- One 80x5x3 ft.
- Collectively capture 116% of sub-basin runoff, and compensate for added runoff from adjacent properties.

Number of new trees: 19 (incl. 1 tree box filter)

Amount of reduced impervious surface area: 0 sq. ft. (0%)

DWIGHT 3: COMPLETE STREET



The tree-lined street provides shelter and privacy for the residents on the western side, while two bioswales accommodate extra runoff from the large parking lots.

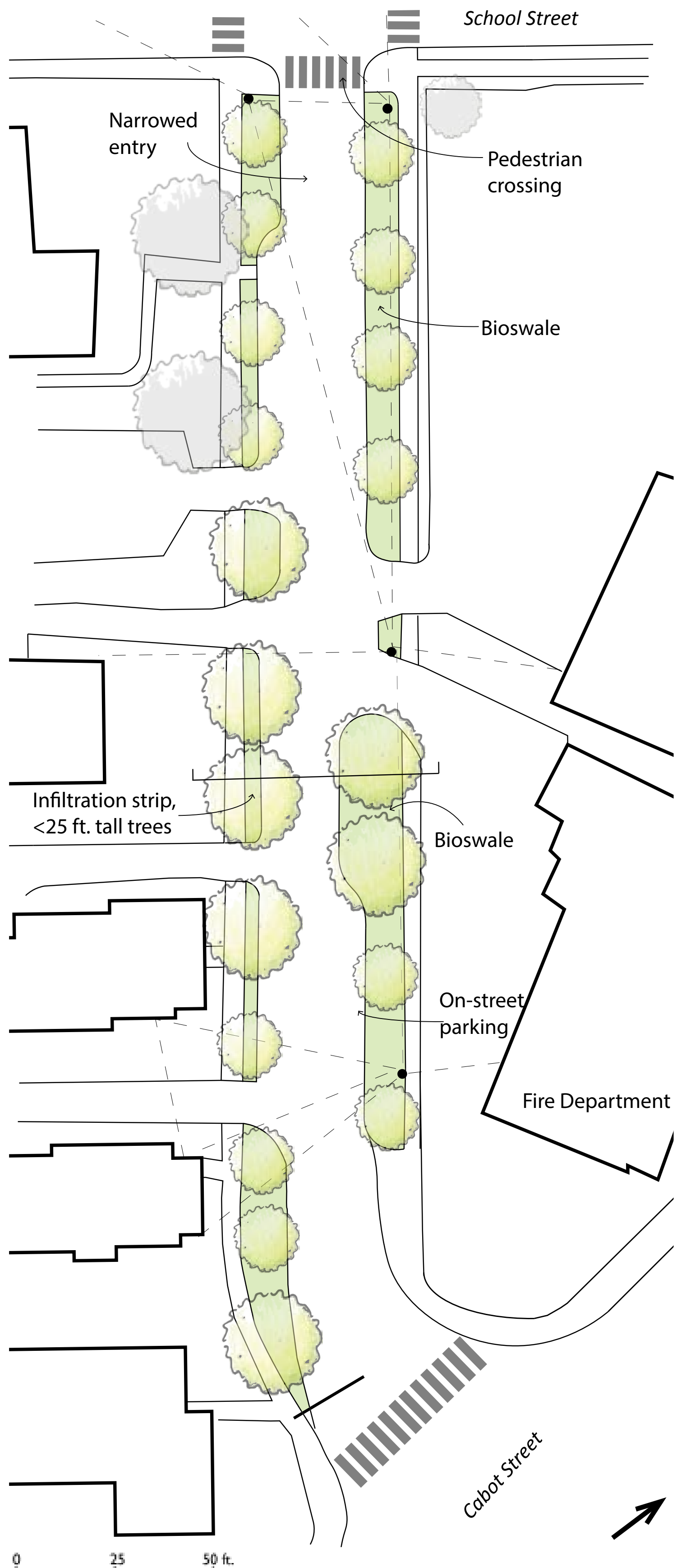
The existing mature trees on private property on the northwestern corner are complemented with <15-feet tall trees along the street that also accommodate the overhead wires.

<25-feet tall trees line the southern half of the western side, where space is relatively restricted. Structural soil provides extra growing space and a waterproof liner prevents infiltration issues near the three southermost buildings.

An infiltration strip (no liner) increases the stormwater infiltration capacity halfway down the western side.

Two bioswales run most of the length of the eastern side, catching and treating runoff from the busy Center Street and adjacent parking lots.

Narrowed entries at both ends and a **chicane pattern** slow traffic.



Number of new trees: 20

Amount of reduced impervious surface area:
a) Road surface: 1,625 sq. ft. (16%)
b) Including permeable parking/sidewalks: 5,080 sq. ft. (39%)

Runoff reduction: 790 gallons per 1,3 in rain event (10%)
26,741 gallons per year (10%)

ADDITIONAL RECOMMENDATIONS

1. Change the City of Chicopee's regulation on the spacing between street trees to 25' from the current 50' minimum. This change would be consistent with actual practice of previous streetscaping projects in the city and would allow the tree canopy to be doubled.

2. Enact a blighted property tax to nudge property owners into action, creating an incentive for them to improve their properties. Such a tax can be a strategy to address large, underused, paved spaces. In Washington, D.C., for example, commercial property owners pay $10 per assessed $100 in property value. Residential property owners pay 85 cents per $100 of assessed value.

A blighted property could be defined as "unsafe, insanitary, or which is otherwise determined to threaten the public health, safety, or general welfare of the community" because of broken walls, roofs, windows, balconies or other poorly kept features. Boarded up properties and unused vacant lots could also count as blighted. Generally this is a way to target absentee landlords.

3. Implement incentives for property owners to go green by planting a tree, installing a rain barrel, reducing impervious surface area, or installing a rain garden. Residents in Montgomery County, Maryland, for example are eligible for $2,500 in rebates and associations, businesses, and institutions are eligible for up to $10,000 per property for efforts to decrease stormwater runoff.

4. Adopt Complete Street guidelines as part of wider revitalization efforts. This includes, for example, reducing the minimum street width requirements to 20 feet for a two-way street. These dimensions would be consistent with changes in many other cities in Massachusetts, including Boston, which seek to make communities more pedestrian and bicycle friendly, and can play a vital part in creating vibrant streets and neighborhoods.

5. Initiate creative temporary uses of streets and under-utilized lots to make these spaces safer and more appealing. Participatory activities, such as painting pedestrian crossings in Northampton and Greenfield, MA, or creating temporary street parks can greatly improve the quality of a place while also giving residents a sense of agency and interest.

A painted mural on the northeast-facing corner of the shopping center could catch the interest of drivers approaching from the north, while the vacant lot could be used for pop-up outdoor space such as a park or community garden.

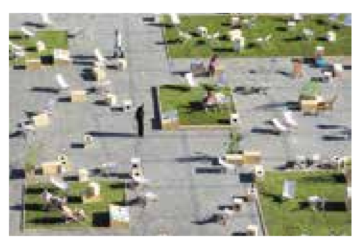
The annual *Chicopee Downtown Get Down* street event could catalyze these kinds of projects (*www.chicopeegetdown.com*).

Community garden, Brooklyn

Swap meet, Los Angeles

EcoBox, Paris

Resurfaced Soccer, Louisville



Tactile urbanism

Examples from other communities of ways that Chicopee might consider using some of the vacant lots including community gardens, parklets with lounge chairs, a flea market, and a soccer field.

Mill housing and a tree-lined street Perkins Street, 1920s.

Mill housing and a tree-lined Dwight Street, 2020s?

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PHOTOGRAPHY

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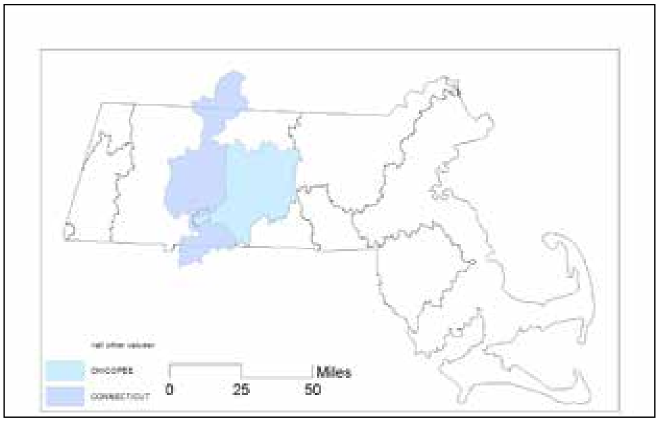
All chapter-title photographs have been taken by the authors.

MAP DATA



Regional Watershed (p. 16)

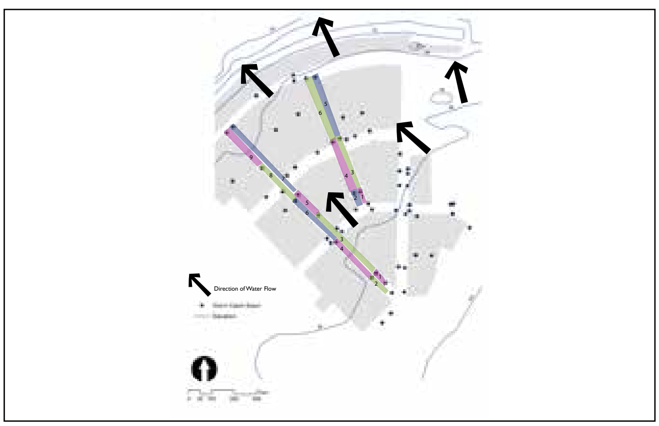
Data Sources: Massachusetts Office of Geographic Information (MassGIS)
- Megabasins
- State Boundaries Outline

Data Created by E. Cohen & Ø.Kristiansen
- Watershed Color Overlay. Created March 2017.

Town Watershed (p. 16)

Data Sources: Massachusetts Office of Geographic Information (MassGIS)
- Shaded Relief 1:5000
- Hydrography 1:25000
- Town Boundaries

Data Created by E. Cohen & Ø.Kristiansen
- Study Area Outline. Created March 2017.



Site Drainage (p. 17)

Data Sources: Massachusetts Office of Geographic Information (MassGIS)
- Contours (10 ft.)

City of Chicopee Department of Public Works
- Catch Basins GIS Shapefile

Data Created by E. Cohen & Ø.Kristiansen
- Sub-basin Color Overlay. Created February 2017.
- Shaded Properties Overlay. Created February 2017.
- Waterflow Arrows. Created February 2017.

Neighborhood Impervious Surfaces (p. 18)

Data Sources: Massachusetts Office of Geographic Information (MassGIS)
- Impervious Surfaces
- Hydrography 1:25000

Data Created by E. Cohen & Ø.Kristiansen
- Study Area Outline. Created March 2017.
- Impervious Surfaces Color Overlay. Created March 2017.

Site Impervious Surfaces (p. 18)

Data Sources: Massachusetts Office of Geographic Information (MassGIS)

- Impervious Surfaces
- Structures (Poly)

City of Chicopee Department of Public Works

- Road Outlines

Data Created by E. Cohen & Ø.Kristiansen

- Colored Overlay. Created February 2017.
- Study Area Outline. Created March 2017.

Neighborhood Tree Canopy Cover (p. 19)

Data Sources:US Forestry Service: iTree Landscape

- Tree Canopy Cover

Data Created by E. Cohen & Ø.Kristiansen

- Study Area Outline. Created March 2017.

Site Tree Inventory (p. 19)

Data Sources: Google Maps

Data Created by E. Cohen & Ø.Kristiansen

- Study Area Outline. Created March 2017.
- Tree Inventory. Created February 2017.

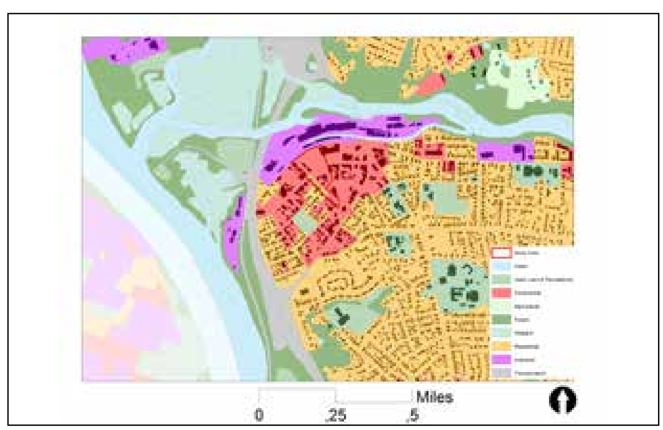
Neighborhood Land Use (p. 20)

Data Sources: Massachusetts Office of Geographic Information (MassGIS)

- Land Use 2005
- Hydrography 1:25000

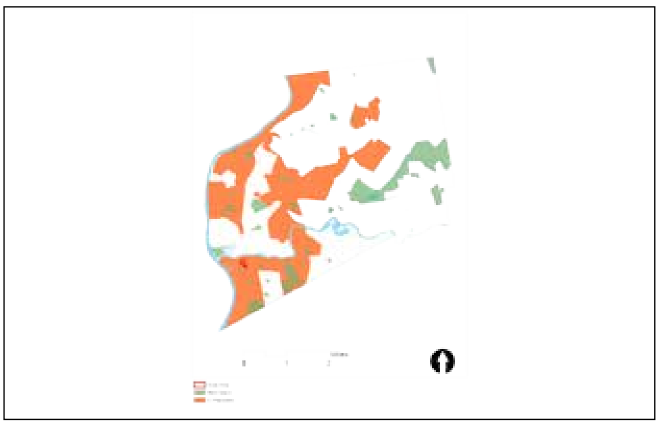
Data Created by E. Cohen & Ø.Kristiansen

- Study Area Outline. Created March 2017.
- Land Use Site Corrections. Created February 2017.



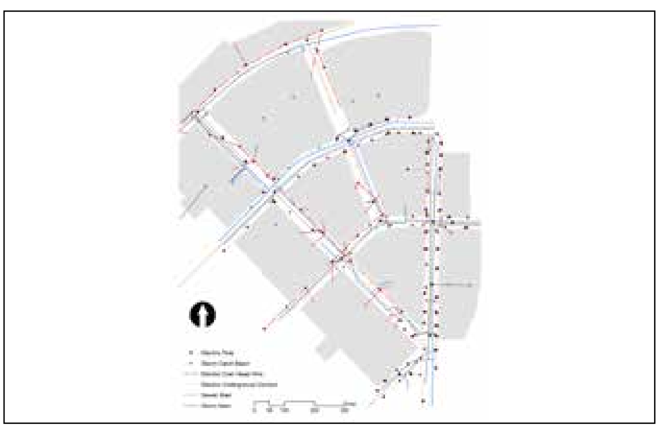
Neighborhood Parking Areas (p. 20)
Data Sources: Google Maps

Data Created by E. Cohen & Ø.Kristiansen
- Study Area Outline. Created March 2017.
- Parking Areas Color Overlay. Created February 2017.



Town Population (p. 21)
Data Sources: Massachusetts Office of Geographic Information (MassGIS)
- Town Boundaries
- Hydrography 1:25000
- Environmental Justice Populations (US Census)
- Open Space & Recreation

Data Created by E. Cohen & Ø.Kristiansen
- Study Area Outline. Created March 2017.
- EJ Populations Color Overlay. Created March 2017.
- Open Space & Recreation Color Overlay. Created March 2017.



Site Utilities (p. 22)
Data Sources: City of Chicopee Department of Public Works
- Electric Poles
- Storm Catch Basins
- Electric Overhead Wires
- Electric Underground Conduits
- Sewer Mains
- Storm Mains

Data Created by E. Cohen & Ø.Kristiansen
- Shaded Properties Overlay. Created March 2017.
- Colors, Line Weight, and Stroke Utilities. Created February 2017.

Appendix

RUNOFF VOLUMES BY SUB-BASIN

Assumptions							
Crowned roadway = each side of street its own sub basin							
Amount of water absorbed (Runoff Curve Number - CN Value)							
0.95	**Impervious**						
0.35	**Pervious**						
			90th Percentile		**98th percentile**		**Filtration area (sq ft) needed to achieve 90% filtration (w/ a 6x6 tree box filter)**
			1.3	inches	2	inches	
			0.11	feet	0.17	feet	
Dwight	**Sq ft**	**Weighted sq ft**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**	
1	1,950	1,853	201	1,501	315	2,356	8
2	2,250	2,138	232	1,732	363	2,718	7
3	5,400	5,130	556	4,157	872	6,523	17
4	3,375	3,206	347	2,598	545	4,077	11
5	1,875	1,781	193	1,443	303	2,265	6
6	3,825	3,634	394	2,945	618	4,621	12
7	7,200	6,840	741	5,543	1,163	8,698	23
8	4,050	3,848	417	3,118	654	4,892	13
9	3,960	3,762	408	3,048	640	4,784	12
			3,487	**26,085**	**5,472**	**40,934**	**108**
Perkins							
1	1,200	1,140	124	924	194	1,450	4
2	1,200	1,140	124	924	194	1,450	4
3	3,750	3,563	386	2,887	606	4,530	12
4	3,750	3,563	386	2,887	606	4,530	12
5	4,860	4,617	500	3,741	785	5,871	15
6	4,860	4,617	500	3,741	785	5,871	15
			2,019	**15,104**	**3,169**	**23,701**	**62**
		TOTAL	**5,507**	**41,189**			

CURRENT DIMENSIONS OF ROAD												
Location	**Box Dimensions**			**Box Volume**		**Water Volume Capacity, Gal**		**Mini Watershed**		**Difference**	**% of water captured**	
	Length	*Width*	*Depth*	*Sq ft*	*Total Gal*	*26%*	*30%*	*1.3 in rainfall*			*Individually*	*Colllectively*
Dwight 3, E	110	5	3	1,650	12,342	3,209	3,703				67%	
Dwight 3, SE	80	5	3	1,200	8,976	2,334	2,693	5545	1/3	-850	49%	
Dwight 3, NW	95	5	3	1,425	10,659	2,771	3,198	4289	2/4	-1,091	75%	190%
Dwight 2, NE	70	5	3	1,050	7,854	2,042	2,356	6003	3/5	-3,647	39%	
Dwight 2, NW	70	5	3	1,050	7,854	2,042	2,356	3825	6	-1,469	62%	101%
Dwight 1, SE	50	8	3	1,200	8,976	2,334	2,693	5543	7		49%	
Dwight 1, E1	30	8	3	720	5,386	1,400	1,616				29%	
Dwight 1, E2	40	8	3	960	7,181	1,867	2,154			-3,389	39%	
Dwight 1, NE	40	8	3	960	7,181	1,867	2,154	5543	7	381	39%	155%
Dwight 1, NW	60	8	3	1,440	10,771	2,801	3,231				47%	
Dwight 1, W	90	8	3	2,160	16,157	4,201	4,847				71%	
Dwight 1, SW	90	8	3	2,160	16,157	4,201	4,847	6851	8/9	6,074	71%	189%
Perkins 2, E	100	4	3	1,200	8,976	2,334	2,693					
Perkins 2, SE	45	4	3	540	4,039	1,050	1,212	2773	1/3	-1,132	140.81%	
Perkins 2, NW	50	5	3	750	5,610	1,459	1,683	4000	2/4	-2,317	42%	
Perkins 1, SE	100	4	3	1,200	8,976	2,334	2,693	2000	3	693	135%	
Perkins 1, NE	80	8	3	1,920	14,362	3,734	4,308	4157	5	151	104%	
Perkins 1, SW	42	8	3	1,008	7,540	1,960	2,262	3849	4	-1,587	59%	
Perkins 1, NW	50	8	3	1,200	8,976	2,334	2,693	4157	6	-1,464	65%	
Tree Box Filter can hold ~ 232 gallons of water												

STORMWATER RUNOFF CALCULATIONS

CN Values	0.95	Imp		90th Percentile		95th Percentile		98th Percentile		Annual	
	0.35	Per		1.3	inches	1.5	inches	2	inches	44	inches
				0.11	feet	0.14	feet	0.17	feet	3.67	feet
DWIGHT 1											
				90th Percentile		**95th Percentile**		**98th Percentile**		**Annual Rainfall**	
EXISTING LAND COVER	**SF**	**Percentag**	**Weighted Area**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**
Impervious	**21,835**	90%	20,743	2,247	**16,809**	2,939	**21,981**	3,457	**25,860**	76059	**568918**
Pervious	**2,426**	10%	849	92	**685**	120	**900**	142	**1,059**	3113	**23288**
Total Site Area	**24,262**		**TOTAL**	**2,339**	17,494	3,059	**22,881**	**3,599**	**26,918**	**79172**	**592206**
			TREES NEEDED	**9.356685**		**12.235665**		**14.39**			
DWIGHT 2											
				90th Percentile		**95th Percentile**		**98th Percentile**		**Annual Rainfall**	
EXISTING LAND COVER	**SF**	**Percentag**	**Weighted Area**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**
Impervious	**24,300**	90%	23,085	2,501	**18,707**	3,270	**24,462**	3,848	**28,779**	84645	**633145**
Pervious	**2,700**	10%	945	102	**766**	134	**1,001**	158	**1,178**	3465	**25918**
Total Site Area	**27,000**		**TOTAL**	**2,603**	**19,472**	3,404	**25,464**	**4,005**	**29,957**	**88110**	**659063**
			TREES NEEDED	**10.413**		**13.617**		**16.02**			
DWIGHT 3											
				90th Percentile		**95th Percentile**		**98th Percentile**		**Annual Rainfall**	
EXISTING LAND COVER	**SF**	**Percentag**	**Weighted Area**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**
Impervious	**29,542**	90%	28,065	3,040	**22,742**	3,976	**29,739**	4,677	**34,988**	102905	**769727**
Pervious	**3,283**	10%	1,149	124	**931**	163	**1,217**	191	**1,432**	4213	**31510**
Total Site Area	**32,825**		**TOTAL**	**3,165**	**23,673**	4,139	**30,957**	**4,869**	**36,420**	**107117**	**801236**
			TREES NEEDED	**12.6593025**		**16.5544725**		**19.48**			
PERKINS 1											
				90th Percentile		**95th Percentile**		**98th Percentile**		**Annual Rainfall**	
EXISTING LAND COVER	**SF**	**Percentag**	**Weighted Area**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**
Impervious	**15,750**	90%	14,963	1,621	**12,125**	2,120	**15,855**	2,494	**18,653**	54863	**410372**
Pervious	**1,750**	10%	613	66	**496**	87	**649**	102	**764**	2246	**16799**
Total Site Area	**17,500**		**TOTAL**	**1,687**	**12,621**	2,206	**16,504**	**2,596**	**19,417**		**427170**
			TREES NEEDED	**6.749166667**		**8.825833333**		**10.38**			
PERKINS 2											
				90th Percentile		**95th Percentile**		**98th Percentile**		**Annual Rainfall**	
EXISTING LAND COVER	**SF**	**Percentag**	**Weighted Area**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**	**Runoff (cf)**	**Runoff (gal)**
Impervious	**16,200**	90%	15,390	1,667	**12,471**	2,180	**16,308**	2,565	**19,186**	56430	**422096**
Pervious	**1,800**	10%	630	68	**511**	89	**668**	105	**785**	2310	**17279**
Total Site Area	**18,000**		**TOTAL**	**1,736**	**12,982**	2,270	**16,976**	**2,670**	**19,972**		**439375**
			TREES NEEDED	**6.942**		**9.078**		**10.68**			

DWIGHT 1				90th			Annually				
SUBCATCHMENT AREA	**SF**			cf	gallons		cf	gallons	**Decrease:**	90th percentile	Annually
Total Site Area	**13,500**		**12825**	1389.375	**10392.525**		47025	351747		**1,530**	51568
Impervious	9685									**14.72%**	14.66%
Pervious	4983										
DWIGHT 2				90th			Annually				
SUBCATCHMENT AREA	**SF**			cf	gallons		cf	gallons	Decrease:	90th percentile	Annually
Total Site Area	**11,150**		**10592.5**	1147.520833	**8583.455833**		38839.16667	290516.9667		**2,255**	76339
Impervious	6,511									**26.28%**	26.28%
Pervious	4639										
DWIGHT 3				90th			Annually				
SUBCATCHMENT AREA	**SF**			cf	gallons		cf	gallons	Decrease:	90th percentile	Annually
Total Site Area	**10,050**		**9547.5**	1034.3125	**7736.6575**		35007.5	261856.1		**790**	26741
Impervious	8,425									**10.21%**	10.21%
Pervious	1625										
PERKINS 1				90th			Annually				
SUBCATCHMENT AREA	**SF**			cf	gallons		cf	gallons	Decrease:	90th percentile	Annually
Total Site Area	**15,660**		**14877**	1611.675	**12055.329**		54549	408026.52		**3,374**	114205
Impervious	8,720									**27.99%**	**27.99%**
Pervious	6940										
PERKINS 2				90th			Annually				
SUBCATCHMENT AREA	**SF**			cf	gallons		cf	gallons	Decrease:	90th percentile	Annually
Total Site Area	**8,400**		**7980**	864.5	**6466.46**		29260	218864.8		**1,349**	45665
Impervious	5,625									**20.86%**	**20.86%**
Pervious	2775										

Botanical	Common Name	Height	Canopy Spread	Notes
Amelanchier 'Autumn Brilliance'	Serviceberry	15-25'	15-25'	Adaptable to soil but not pollution tolerant
Celtis occidentalis	Hackberry	50-60'	40-60'	Salt and drought resistant
Cercis canadensis	Redbud	15-30'	25-30'	Bright pink flowers in spring
Ginkgo biloba	Ginkgo (fruitless)	50-80'	30-40'	Prefers moist, well drained soils but tolerant of various (and urban) conditions; beautiful yellow leaves in fall
Gleditsia 'Skyline'	Honeylocust	35-45'	25-35'	Prefers moist, well-drained soils in full sun. Tolerant of a wide range of soils. Also tolerant of wind, high summer heat, drought and saline conditions.
Prunus sargentii	Sargent Cherry	20-30'	20-30'	Pink flowers appear before foliage in spring.
Quercus bicolor	Swamp White Oak	50-60'	50-60'	Tolerates wet soils
Quercus palustris	Pin Oak	50-70'	40-60'	Tolerant of urban conditions and pollution; may need to be 'limbed up'
Quercus rubra	Red Oak	50-75'	50-75'	Tolerant of range of soils and pollution
Styrax japonicus	Japanese Snowbell	20-30'	20-30'	fragrant flowering tree, blooms in late spring
Syringa reticulata	Japanese Tree Lilac	20-30'	15-20'	Easily grown in average, medium moisture, well-drained soil in full sun. Good tolerance for urban conditions.
Ulmus americana	American Elm cultivars	40-50'	40-50'	Withstands extremes of soil conditions
Ulmus parvifolia	Chinese Elm	40-50'	40-50'	Adapts to a variety of different soils and tolerates both wet and dry sites.
Zelkova serrata	Japanese Zelkova	50-80'	50-80'	Tolerant of soils, wind, drought, pollution. Good resistance to Dutch elm disease, elm leaf and Japanese beetle.

Striking fall foliage of the Ginkgo tree.

The high vase canopy of the elm Elm lends elegance to a city street.

Pink blooms of the Redbud are a welcome sign of spring.

The combination of economic changes, an aging infrastructure and climate change necessitates upgrades to Chicopee's once-thriving industrial center. The designs proposed in this book involve street improvements on Dwight and Perkins Streets that not only filter pollutants from roadways and reduce the amount of storm water entering the grey infrastructure system, but also can reduce likelihood of damaging sewage overflows into the rivers. Perhaps most importantly however, for the people who live and work in this neighborhood, these designs create a more pleasant place to be and can help inspire more revitalization to the downtown.

the Conway School
Graduate Program in Sustainable Landscape Planning + Design