Case Studies in Realizing Co-Benefits of Multimodal Roadway Design and Gray and Green Infrastructure

U.S. Department of Transportation
Federal Highway Administration

March 2018

Technical Report Documentation Page

1. Report No. FHWA-HEP-18-031	**2. Government Accession No.**	**3. Recipient's Catalog No.**
4. Title and Subtitle Case Studies in Realizing Co-Benefits of Multimodal Roadway Design and Gray and Green Infrastructure		**5. Report Date** March 2018 **6. Performing Organization Code**
7. Author(s) Cohn, J; McAdam, T; Ridgway, M.		**8. Performing Organization Report No.**
9. Performing Organization Name And Address Fehr & Peers, 1003 K Street NW, Suite 209, Washington, DC 20001 CSRA, 3434 Washington Blvd., Arlington, VA 22201		**10. Work Unit No. (TRAIS)** **11. Contract or Grant No.** DTFH61-11-D-00036
12. Sponsoring Agency Name and Address U.S Department of Transportation Federal Highway Administration 1200 New Jersey Ave, SE Washington, DC 20590		**13. Type of Report and Period Covered** Case Studies **14. Sponsoring Agency Code** FHWA/HEPH-10
15. Supplementary Notes		

16. Abstract

This document highlights case studies of projects that contribute to safe and connected pedestrian and bicycle networks in States and communities throughout the U.S., while at the same time providing resiliency and green infrastructure benefits that promote resiliency and relieve burdens on stormwater systems. The case studies included in the report are organized in the following categories: (1) Mitigating Flood Risk, (2) Public-Private Partnerships, (3) Multimodal Network Connectivity, and (4) State and Locally Driven Projects.

17. Key Words Pedestrian and bicycle networks, multimodal infrastructure, green infrastructure, stormwater, resiliency, mitigating flood risk, public-private partnerships, State and local	**18. Distribution Statement** This document is available to the public on the FHWA website at: http://www.fhwa.dot.gov/environment/bicycle_pedestrian

19. Security Classif. (of this report) Unclassified	**20. Security Classif. (of this page)** Unclassified	**21. No. of Pages** 34	**22. Price** N/A

Form DOT F 1700.7 (8-72) **Reproduction of completed page authorized**

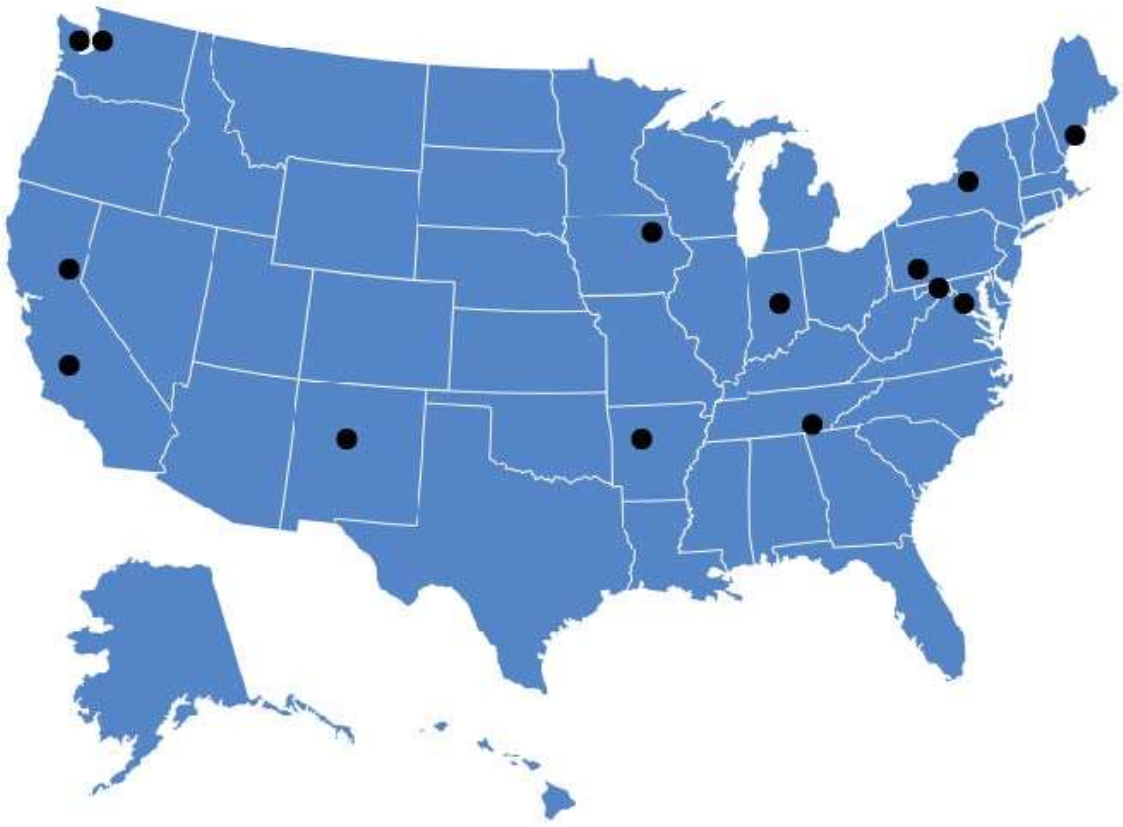
Case Studies in Realizing Co-Benefits of Multimodal Roadway Design and Gray and Green Infrastructure

Table of Contents

INTRODUCTION

The Federal Highway Administration (FHWA) is committed to documenting and promoting connected pedestrian and bicycle networks in States and communities throughout the United States. Networks are interconnected pedestrian and/or bicycle transportation facilities that allow people of all ages and abilities to safely and conveniently get where they want to go. FHWA is working with its State and local partners and stakeholders to successfully implement gray and green infrastructure projects to manage stormwater, improve water quality, and to create healthier environments through strategies such as increasing pervious material, creating bioswales, and incorporating flow-through planters into projects. At the same time, State and local agencies are working to promote resiliency and relieve burdens on stormwater systems.

This report provides information to encourage agencies interested in making improvements to their pedestrian and bicycle networks that also provide gray and green infrastructure and resiliency benefits. The discussion of stormwater and mobility benefits will help communities better understand the variety of goals and outcomes they can achieve through their projects.



FHWA identified, evaluated, and categorized these gray and green infrastructure case studies into several project types, including:

- **Mitigating Flood Risk:** Flood mitigation involves the management and control of floodwater movement, such as redirecting flood run-off through the use of floodwalls and flood gates, rather than trying to prevent floods altogether. These projects were implemented to address local flooding and minimize future flood damage.

- **Public-Private Partnerships:** Public-private partnerships are cooperative arrangements between two or more public and private sector agencies. The Federal Government encourages the use of public-private partnerships through an array of innovative financing mechanisms and initiatives designed to provide flexibility in the ways projects are delivered. These projects were implemented collaboratively with input and funding from several public and private partners.

- **Multimodal Network Connectivity:** Multimodal networks help to facilitate a range of bicycling and walking trips, including access to work from residential areas, travel to and from school, links to transit, recreation and physical activity opportunities, and access to grocery stores, government buildings, health care, and other essential services. These projects complete a critical link in the jurisdiction's bicycle or pedestrian network, and improve residents' access to area services and amenities.

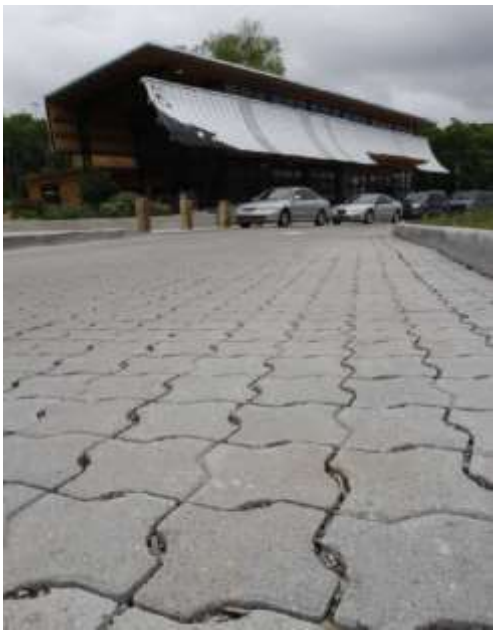
- **State and Locally Driven Projects:** These projects represent a set of jurisdictions with active residents and/or municipal government driving local improvements and innovation. The projects completed in these jurisdictions go above and beyond State and local requirements, and they demonstrate leadership in multimodal transportation planning or stormwater management.

Case Study Matrix

Project	Location	Completion Date	Cost	Green Infrastructure	Bike Facilities	Pedestrian Facilities	Mitigating Flood Risk	Public-Private Partnership	Network Connection	State and Locally-Driven	Safety Improvement	Aging Infrastructure
Johnson Street	Chattanooga, TN	2014	$350,000	X		X	X	X	X		X	
21st Street Complete & Green Street	Paso Robles, CA	2014	$2,500,000	X	X	X	X		X		X	X
Hahn Arroyo Parkway	Albuquerque, NM	2012	$3,500,000	X	X	X	X		X		X	X
Decatur Street	Edmonston, MD	2010	$1,300,000	X	X	X	X		X	X	X	X
Iowa Green Streets Pilot	West Union, IA	2013	$10,200,000	X		X	X	X		X	X	X
Connective Corridor	Syracuse, NY	2015	$47,000,000	X	X	X	X	X	X	X	X	X
Taylor 28	Seattle, WA	2009	N/A	X	X	X	X	X			X	
Indianapolis Cultural Trail	Indianapolis, IN	2013	$63,000,000	X	X	X		X	X	X		
Bayside Trail	Portland, ME	2010	$5,000,000	X	X	X	X	X	X			
Pioneer Trail Roundabout	Truckee, CA	2010	$2,500,000	X	X	X			X		X	
North El Paso Corridor	Russellville, AR	2014	$2,300,000	X	X	X			X	X	X	
Green Corridor	Ranson & Charles Town, WV	2017	$9,400,000	X	X	X			X	X	X	X
Winslow Way Redesign	Bainbridge Island, WA	2011	$5,600,000	X	X	X		X		X	X	X
Ohiopyle Green Streets	Ohiopyle, PA	2010	$1,300,000	X		X	X			X	X	

JOHNSON STREET (CHATTANOOGA, TN)

Year Completed: 2014
Cost Estimate: $350,000
Street Type: Commercial Alley
Case Study Category: Mitigating Flood Risk



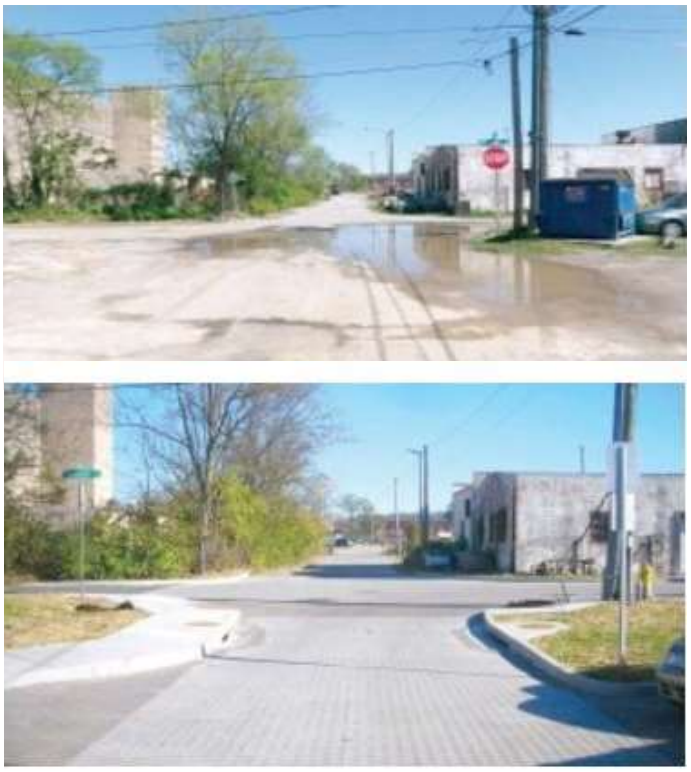
Like many cities in the United States, Chattanooga, TN, relies on an aging combined sewer system. Following a series of combined sewer overflow events into the Tennessee River, the Tennessee Department of Environment and Conservation mandated that Chattanooga refurbish its sewer and stormwater infrastructure. As a result, Chattanooga now requires that all new private and public developments within the combined sewer system reduce or detain stormwater runoff during rain events.

Following introduction of the stormwater mandate, a new restaurant was proposed at the edge of the Southside Historic District. The site was located on Johnson Street, a 400-foot-long commercial alley within the combined sewer system. Not only was Johnson Street in the combined sewer system, but it experienced nuisance flooding with nearly every heavy rain or storm event. The developers already owned an ecofriendly hostel on Johnson Street, and they were eager to address the flooding issues with the new development.

After some discussion with the Chattanooga Public Works Department, the restaurant developers decided to implement a green solution—permeable pavers—on Johnson Street even though the 'gray' infrastructure requirement for new pipes and storage tanks on the restaurant property would have cost $327,000, about $25,000 less than a 'green' solution. Green stormwater infrastructure reintroduces ecological functions and natural drainage processes back into the built environment.

The City of Chattanooga and the developer agreed to a **public-private partnership** to transform Johnson Street into a bicycle- and pedestrian-friendly green street that addressed the flooding risk and addressed compliance with the City's stormwater mandate. The restaurant owners paid for 14,000 square feet of permeable pavers to cover the entire alleyway, and Chattanooga Public Works installed the pavers as well as three feet of gravel below the street surface to act as a detention layer that detains excess rainwater.

This shared street is an application of **design flexibility** that meets the needs of all users, while doubling as stormwater management, capturing the first inch of runoff during storm events and eliminating nuisance flooding. After completion, the project won the Tennessee Governor's Environmental Stewardship Award for Excellence in Green Building as well as a Chattanooga Low Impact Development Excellence Award.



Johnson Street before (top) and after (bottom)

Additional Resources:

- Chattanooga Public Works' Resource: Rain Program
- NACTO Urban Street Design Guide – Commercial Shared Street
- NACTO Urban Street Stormwater Guide – Green Alley
- Urban Drainage Design Manual
- ADA Accommodation on Shared Streets:
    - New FHWA Report: Accessible Shared Streets: Notable Practices and Considerations for Accommodating Pedestrians with Vision Disabilities
    - Argyle Street in Chicago, IL

21ST STREET COMPLETE AND GREEN STREET (PASO ROBLES, CA)

Year Completed: March 2014
Cost Estimate: $2.5 million
Street Type: Neighborhood Main Street
Case Study Category: Mitigating Flood Risk

Frequent flooding on 21st Street in Paso Robles, CA, stemmed from an 1800s-era decision to funnel runoff from the surrounding 1,230–acre Mountain Springs Creek watershed through a substreet drain pipe. As development and impermeable surface increased throughout the watershed, the aging infrastructure failed to contain stormwater events, and 21st Street became a regular flooding hazard. A two-year storm event generating flows of 24 cubic feet per second (cfs) was enough to overtop the curb line and crossing walkways, erode landscape areas, and impede traffic. Not only was this a safety concern for people using the street, but without a filtration system, the water continuing downstream exceeded acceptable pollution levels. After being fined by the State Water Resources Control Board for an illicit discharge into the Salinas River, the City worked with the Board to redirect the fine to fund a concept plan for San Luis Obispo County's first complete and green street.

Open median channel in the center of 21st Street

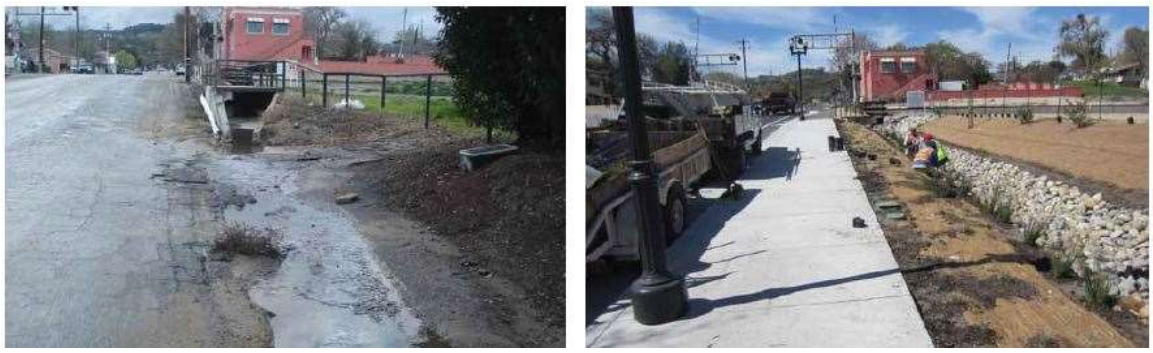
The redesign stretches five blocks along a mixed commercial and residential street and ultimately replaced everything in the right-of-way, from the underground stormwater infrastructure to the travel lane striping and flanking sidewalks. The project's centerpiece, a day-lit channel and underlying infiltration trench (14 feet wide by 600 feet long) runs in the median. This central feature is supported by deepened curbs, impermeable liners, and trench dams installed adjacent to bioretention areas in the bulbouts and sidewalk borders. These features ensure that the asphalt roadway does not pool water and endures a typical lifespan. The project reduced roadway width and installed permeable pavers in the pedestrian areas, to reduce a total of 26,000 square feet of impervious surface.

21st Street's original design did not accommodate pedestrians and cyclists, and the City saw this stormwater makeover as an opportunity to not only green the street, but also complete the street for all users. The final treatment added ¾ of a mile of striped, on-road bicycle lanes, ADA-compliant

sidewalks, bulbouts at each intersection, two pedestrian-activated flashing yellow lights at the highest volume intersections, seating, 81 street trees, high-efficiency lighting, bicycle racks, and informational signage about the transformation. In addition, the project added a railroad pedestrian crossing where there was previously no pathway or signs. Post-project evaluation found that pedestrian volumes increased on the corridor, and the average vehicle speed decreased about 30 percent from 30 to 23 mph.

Project construction was funded with a $933,000 Urban Greening Grant from the California Natural Resources Agency and the City of Paso Robles. The project brought the city into compliance with State Water Resources Control Board thresholds and produced a water management solution applicable for both the dry and rainy seasons that the region faces. At the same time, the pedestrian and bicycle amenities **completed an important east-west route** for active transportation in Paso Robles, connecting residential neighborhoods, small businesses, and visitors with the Paso Robles Events Center at the project's terminus. As a best practice, the redesign included local firms so that the knowledge of green and complete streets could begin to grow in the local engineering and construction industry.

The project received two prominent awards in 2014: the Green Innovation Award from the Central Coast Chapter of the US Green Building Council and the Transportation Project of the Year from the Central Coast Chapter of the American Public Works Association.



21st Street looking east before (left) and after (right) redesign

Additional Resources:

- Cannon Video: https://vimeo.com/181964665
- Cannon Project Brochure
- Central Coast LID Institute Case Study
- MUTCD Guidance on Rectangular Rapid Flashing Beacons

HAHN ARROYO (ALBUQUERQUE, NM)

Year Completed: June 2012
Cost Estimate: $3.5 million
Street Type: Greenway
Case Study Category: Mitigating Flood Risk

Prior to the completion of this project, the three-mile Hahn Arroyo in Albuquerque, NM, resembled many concrete-lined stormwater channels throughout the Southwest. With the stormwater and active transportation project completed jointly by the Albuquerque Metropolitan Arroyo Flood Control Authority and the City of Albuquerque, the land now serves the dual purpose of managing stormwater and providing recreation space for local residents along the new Paseo del Nordeste Trail.

In-stream filtering structure at work during a June 2013 storm

An in-channel water quality structure and underground cisterns manage the Hahn Arroyo's stormwater, removing pollutants and cleaning stormwater water before it enters the Rio Grande. In addition to filtering and controlling floodwaters in times of abundance, the cisterns store water for irrigation. The water harvesting system is used for irrigating the trees, shrubs, and grass areas of the project, as well as irrigating the ball fields of adjacent Montgomery Park. No outside water is used for the irrigation of the landscaping—an important innovation in the drought-prone Southwest.

The arroyo included limited transportation and public open space elements prior to this project. Rather than continue to treat the arroyo as a hidden public works conveyance, the Albuquerque Metropolitan Arroyo Flood Control Authority and the City decided to expand the aesthetic and functional possibilities of the channel and create the Paseo del Nordeste Trail. Both a paved bike path and dirt pedestrian path are included in the design, and seating, lighting, bike parking, bike air pump stations, and public art are interspersed along the trails. The arroyo trail connects to the rest of Albuquerque's trail system via the North Diversion Channel Trail, as well as to multiple schools, sports fields, parks, and residential and commercial districts. As the trail runs adjacent to the Hahn Arroyo, it is grade separated from vehicle traffic, further **improving safety for bicyclists and pedestrians** using the trail.

To complement the stormwater sustainability measures, the project repurposed site materials by using the old concrete channel lining to create benches along the trail. Additionally, the trail is lined with native grasses and trees to encourage ecological restoration and wildlife activity similar to a natural stream.

One of many bike and pedestrian entrances to the Hahn Arroyo Trail

Additional Resources:

- Green Infrastructure LID in Arid Environments
- Hahn Arroyo/Paseo del Nordeste Guided Tour
- NACTO's Urban Street Stormwater Guide – Bioretention Design Considerations
- Green Infrastructure for Southwestern Neighborhoods

DECATUR STREET (EDMONSTON, MD)

Year Completed: November 2010
Cost Estimate: $1.3 million
Street Type: Residential Street
Case Study Category: Mitigating Flood Risk

Despite a relatively small population of 1,500 and a limited municipal budget, Edmonston, MD, was among the first Washington, D.C. suburbs to complete a green streets project. The improvement project on Decatur Street, the town's pimary east-west corridor, stemmed from Edmonston's costly experience with chronic flooding and Decatur Street's aging infrastructure. While Edmonston sits in a flood plain of the Anacostia Watershed, former Mayor Adam Ortiz attributed the town's flooding issues on the abundance of permeable surfaces. Instead of repairing the 'expired' street in the conventional way, Edmonston's political leadership and community members agreed to fix it with an approach that both reduced the amount of permeable surface and improved nonmotorized accomodations on Decatur Street.

Rather than widening the street to make room for bicycle[1] and pedestrian facilities, Edmonston narrowed the travel lanes. In addition to adding on-street designated bike lanes, the project also included planting of native trees, installing wind-powered lighting, rebuilding all sidewalks and crosswalks with permeable pavers, and adding corner bulbouts. The bulbouts and sidewalk buffers hold rain gardens (also called 'bioretention planters') to remove toxins and reduce the amount of runoff leaving the roadway. The bicycle and pedestrian features connect with the Anacostia Tributary Trail System, which links Edmonston with Cottage City to the south and Riverdale Park to the north. Prior to this project, there were no bike lanes in Edmonston.

The Town of Edmonston received project support from both local and regional partners, including the Chesapeake Bay Trust, which helped jumpstart the project with a $25,000 design grant. Other partners included the Environmental Protection Agency's (EPA) Region III office, the Maryland Department of the Environment, and the Low Impact Development Center. The project construction was funded by the EPA through a $1.1 million American Recovery and Reinvestment Act grant.

Performance evaluation of the new street found that the green infrastructure treatments capture the first 1.33 inches of rainfall, which accounts for 90 percent of Edmonston's annual storms. More importantly for Edmonston and the region as a whole was the model that this project set for other

[1] In order to install dashed bicycle lanes, **an approved Request to Experiment is required** as detailed in Section 1A.10 of the MUTCD.

towns in the Anacostia watershed. Following the implementation of the Decatur Street project, the nearby towns such as Bladensburg sought to create green streets of their own.

Additional Resources:

- Environmental Protection Agency Green Streets Success Stories
- NACTO's Urban Street Stormwater Guide – Stormwater Elements section
- Prince George's County, MD, Guidelines for Rain Gardens

IOWA GREEN STREETS PILOT PROGRAM (WEST UNION, IA)

Year Completed: 2013
Cost Estimate: $10.2 million
Street Type: Small Town Main Street
Case Study Category: Public-Private Partnerships

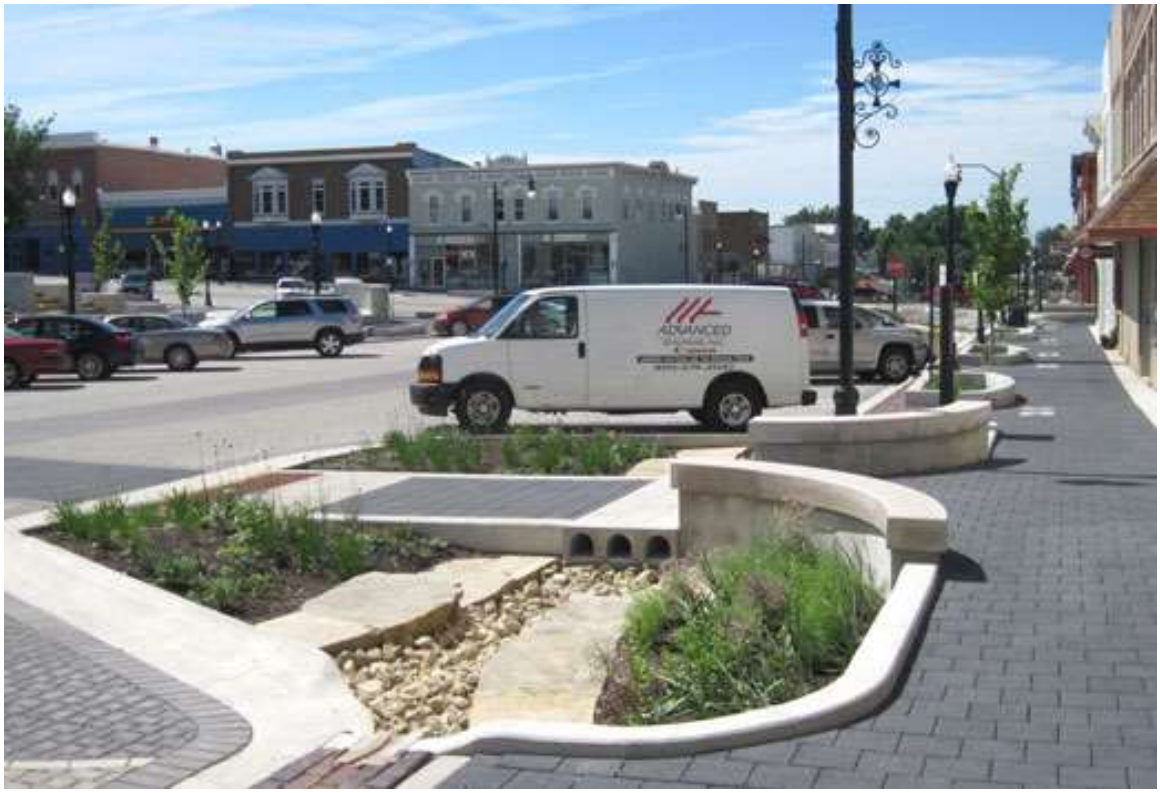
Located in northeastern Iowa, West Union, with a population of 2,500, experienced deterioration inits downtown streets, sidewalks, and public areas. So when it was approached by the Iowa Economic Development Authority (IEDA) about a Green Streets Pilot Program, the small town commited to and ultimately implemented one of the most sustainble downtown revitalization projects in the country. The Town and IEDA were the initiating partners, and before the end of the project, $7.5 million had been granted or donated by 17 outside Federal, State, and local sources.

Bioswales were added into the bulbouts at each major intersection in downtown.

The scale of this project was made possible by the collaboration of many partners, and West Union now serves as a model and pilot for small towns in Iowa and throughout the country. The green streets project centers around the town square and extends along Vine Street. Six blocks' streets and sidewalks were rebuilt with permeable pavers and stonework. Four intersections received high-visbility crossing treatments using permeable pavers as a design medium and mid-block crosswalks were installed in the areas of highest pedestrian traffic. As part of the street redesign, sidewalks were widened and LED street lighting and street furniture were added. One of the unique features of the project is the geothermal heating and cooling system built beneath the new street system, and connected to 60 downtown buildings. Atop this new energy system, 36,000 square feet of rain gardens collect and filter 95 percent of rainwater that fall in the downtown.

These sustainble improvements are expected to save West Union $104 million in operating costs over the next 50 years, and the Town is expected to pay off the $10.2 million investment over a 15-year period. Operational saving aside, **the project spurred additional investment and growth in downtown** including 12 new businesses, 4 new buildings, 11 improved interiors, 10 historic façade

renovations, and the addition of 12 new affordable housing units in historic downtown buildings. The project won the 2015 Iowa American Society of Landscape Architects' Award as well as Unilock's 2014 Award for "Best Permeable Streetscape."



Attractive landscaping also helps spread awareness of the stormwater management taking place on and below the streets in downtown.

Additional Resources:

- Conservation Design Forum Video
- Discovery Channel Video
- Conservation Design Forum Pictures
- Complete List of Funding Sources

CONNECTIVE CORRIDOR (SYRACUSE, NY)

Year Completed: Fall 2015
Cost Estimate: $47 million
Street Type: Multimodal Urban Core
Case Study Category: Public-Private Partnerships

The newly inaugurated "Connective Corridor" links downtown Syracuse, NY, and the Syracuse University campus with two miles of multimodal green streets along University Avenue and East Genessee Street, incorporating pedestrians, cyclists, transit, and automobiles. Prior to completion of this project, the city's two activity centers felt largely disconnected, severed by Interstate 81 and lacking pedestrian or bicycle amenities. The evolution and implementation of this project arose from the strategic and financial partnership between the City and the University, as well as participation from Onondaga County, Syracuse Metropolitan Transportation Council (SMTC), and New York State.

Early meetings between the City of Syracuse, the University, and private partners, such as National Grid, envisioned a vibrant network of streets that would bring life to downtown and serve as a "living laboratory" for the University. In 2007 SMTC, the region's Metropilitan Planning Organization, released the *University Hill Transportation Study* that echoed this vision with calls for greater integrgation of land use and alternative transportation methods. Soon, the goals for improved connectivity and public space were paired with goals for intensified sustainability and stormwater management along the corridor. Onondaga County agreed to pay for the corridor's

The Corridor clearly designates separate spaces for cars, bicycles, and pedestrians.

below-ground stormwater infrastructure, which aligned with the stringent stormwater standards identified in the County's Save the Rain Plan. In addition to $2.6 million in Save the Rain funding for below-ground catchment infrastructure, the project added rain gardens in all bulbouts and sidewalk buffers, permeable pavers, and new native landscaping, including 285 new trees and 4,000 smaller plantings.

The project improved connectivity by adding raised and separated two-way bike lanes, widened sidewalks, streetlights, sidewalk furniture, and wayfinding signage. The corridor also incorporates free bus transit between downtown and the Univeristy. These changes marked a total overhaul for the area by encouraging pedestrian activity, and economic investment at the street level. Concurrent with construction, 70 façade improvements were completed and façade lighting was added to 23 buildings to create a "corridor of light."

Public art is featured prominently throughout the corridor.

A four-year construction effort and $47 million investment, this project required financial backing at all levels. Public contributions came from the Federal Highway Administration (FHWA) and Federal Transit Administration, and the Department of Housing and Urban Development at the federal level; Empire State Development, Dormitory Authority of New York State, and New York State DOT at the S tate level; and the City of Syracuse and Onondaga County at the local level. **Private funding** came from the University of Syracuse, National Grid, Time Warner, and many others. A list of funders and specific grants can be found here. In recognition of the coordination involved, the project won the US Green Building Council's (USGBC) Global Leadership Award. FHWA recongnized the project with a 2015 National Environmental Excellence Award and American Public Works reconized the project for innovative design and construction practice.

Additional Resources:

- University of Syracuse Connective Corridor website
- USGBC Global Leadership Award video
- FHWA Separated Bike Lanes Planning and Design Guide
- ITE Separated Bikeways Report

TAYLOR 28 (SEATTLE, WA)

Year Completed: 2009
Cost Estimate: N/A
Street Type: Urban Arterial
Case Study Category: Public-Private Partnerships

As the first mixed-use apartment building in the Denny Triangle neighborhood, the Taylor 28 project transformed an arterial roadway in downtown Seattle, WA, into a multiuse corridor. This project was completed as part of a new development and paid for by the property owners, but required creative thinking and flexibility from both the City and the developer. The project provided sidewalks a minimum of 38 feet wide, captures stormwater in rain gardens, provides generous space for pedestrians and bicyclists, and includes detailing to create a sense of space unique to the street.

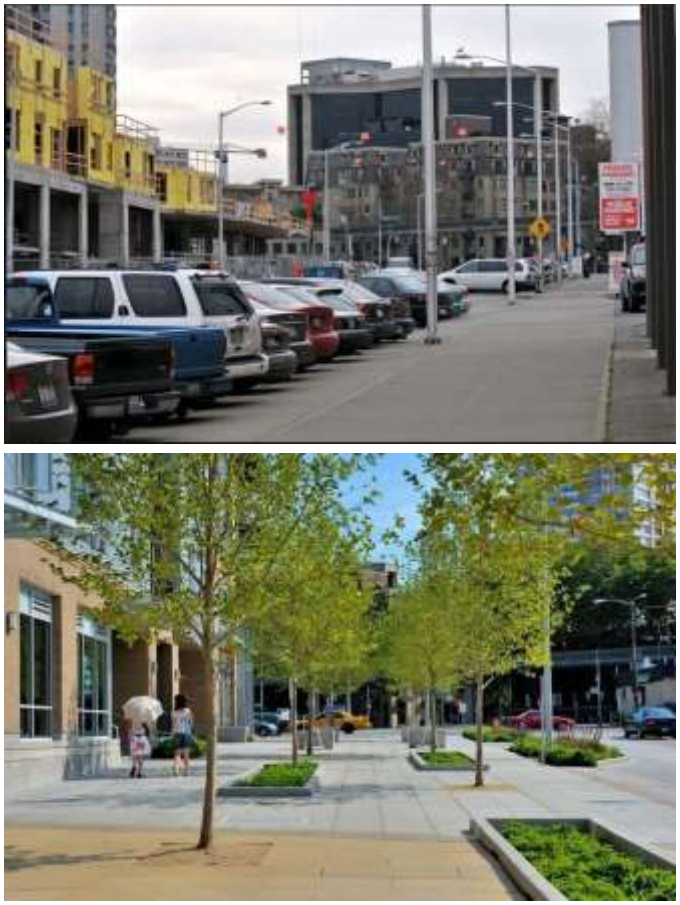
Prior to development, Taylor Avenue included two travel lanes and back-in angled parking on both sides of the street. The project's final design maintained the same vehicle capacity (two travel lanes) but replaced the angled parking with parallel parking, reducing on-street width by 20 feet. Landscaped bulbouts were added around the project driveway and intersection crossings to maximize pedestrian space and manage motor vehicle speed. To minimize bicycle conflicts with parking and loading vehicles, the right-of-way design included a bicycle lane on a raised curb between the parked vehicles and the designated pedestrian area. In addition to these adjustments, LED lighting and seating were installed.

A raised bicycle lane is provided at the outer edge of the plaza.

Due to concerns that increased development in this neighborhood would overwhelm the combined sewer system, the City required on-site stormwater detention. The development design team worked closely with City of Seattle staff to achieve multidisciplinary outcomes that crossed typical boundaries between zoning, transportation, and public utilities to address layout, rainwater harvesting and reuse, stormwater collection and distribution, and maintenance responsibilities. Curb cuts, eight bio-retention rain gardens, and 1,000 square feet of permeable pavers funnel stormwater to a 16,000 gallon underground cistern. The cistern provides water reuse for

nonresidential toilets and is also the sole water source for all on-site and right-of-way landscape irrigation. These design features result in zero discharge from on-site and right-of-way runoff and can fully contain runoff generated from the 25-year storm event.

All Taylor Street improvements were paid for by the developer, as it was determined that the added upfront costs would be offset by the long-term water savings for the development. As a result, the public right-of-way was redesigned to provide more safe and inviting public space with limited costs to the city.



Taylor Avenue North before (top) and after (bottom) the project

Additional Resources:

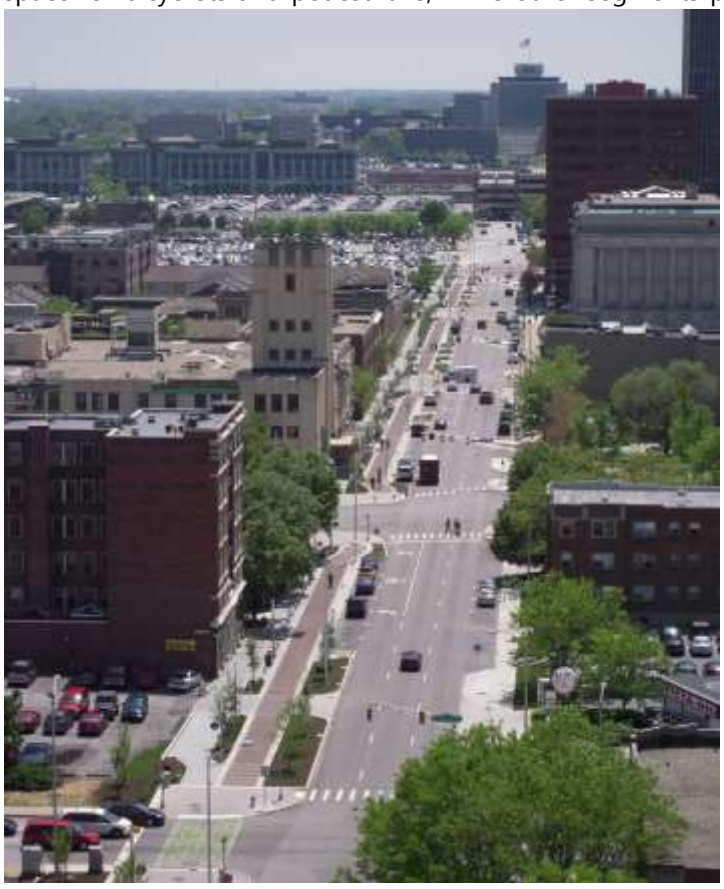
- Landscape Architecture Foundation
- Mithun Project Profile

INDIANAPOLIS CULTURAL TRAIL (INDIANAPOLIS, IN)

Year Completed: May 2013
Cost Estimate: $63 million
Street Type: Multimodal Urban Core
Case Study Category: Public-Private Partnerships

Starting with a five-block pilot in 2007, the Indianapolis Cultural Trail transformed downtown Indianapolis from an auto-centric grid of arterials to a space that is welcoming to all modes. The Cultural Trail—so called because it connects all six of the City's downtown cultural districts, including museums, art and performance institutions, and civic spaces—is a unique example of a separated bike and pedestrian trail running through a downtown core. Stormwater management and sustainability were also central to the trail design, which weaves 25,000 square feet of bioswales throughout downtown, adding eight acres of green space and 500 trees.

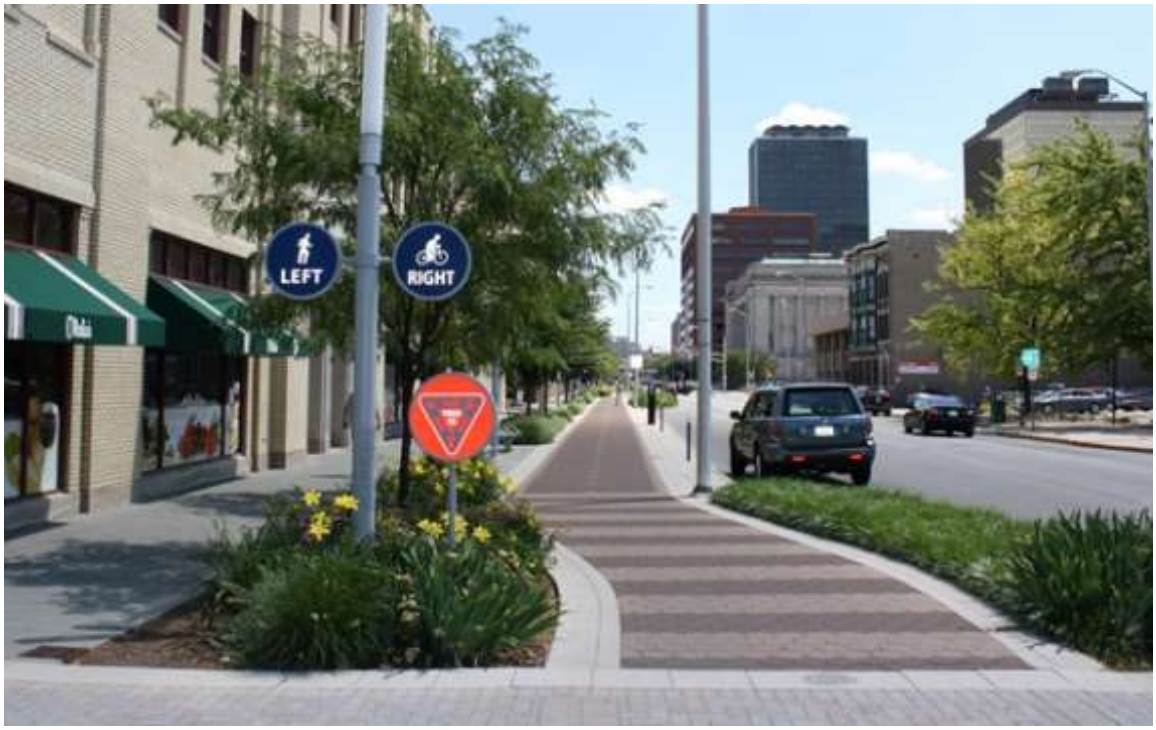
Project for Public Spaces helped design the eight-mile trail as a loop around downtown and two spurs that connect to the White River and Monon Trail greenways. Parts of the trail have shared space for bicyclists and pedestrians, while other segments provide pedestrian walkways that are separate from a two-way facility for bicyclists. The project took advantage of downtown's wide streets by reducing lane widths and reclaiming the space for bikes, pedestrians, and landscaping. In addition to uniting the downtown core, the trail adds a critical bike and pedestrian connection at the interchange of I-65 and I-70.



Indianapolis took advantage of previously wide arterials to reclaim space for pedestrians and cyclists.

In total, the $63 million **public-private partnership** took six years of construction and significant contributions from the Mayor's Office, the City of Indianapolis, the Central Indiana Community Foundation, and Project for Public Spaces, amongst others. Led by a $15 million seed gift from Eugene and Marilyn Glick, the project

raised a total of $27.5 million in private donations, nearly matching the $35.5 million in Federal transportation funds, including TIGER funds, granted over a period of several years and funding cycles. All elements of the trail, including the green space and pathways, are managed by a nonprofit called Indianapolis Cultural Trail, Inc.



Bioswales and planters are incorporated throughout the trail medians.

Indianapolis has seen extensive **economic development and livability benefits** as a result of this investment. A recent study completed by Indiana University found that property values in the trail vicinity have increased by $1 billion, businesses report more customers and higher sales, and residents feel safer downtown since construction of the Cultural Trail. The average trail user spends around $53 while downtown, and 17 percent of trail users surveyed by Indiana University were from outside the Indianapolis area, indicating the importance of the trail as an attraction for visitors.

Additional Resources:

- Indy Cultural Trail Website
- Indiana University Public Policy Institute: Cultural Trail Study

BAYSIDE TRAIL (PORTLAND, ME)

Year Completed: August 2010
Cost Estimate: $5 million
Street Type: Urban Trail
Case Study Category: Network Connections

The Bayside Trail in Portland, ME, links the Eastside Promenade and Back Cove trails, completing the "perimeter" trail system long envisioned for the Bayside peninsula. The 1.2-mile trail runs along an abandoned railroad right-of-way, through a former industrial and now mixed-use neighborhood. As such, it provides a "spine" of green[2] in a largely concrete urban landscape.

Sections of the trail use permeable pavers improve stormwater flow. The abandoned railroad right-of-way presented a potential connection through the Bayside and East Bayside neighborhoods, and in 2000, Portland set goals in *A New Vision for Bayside* plan to buy the right-of-way and transform it into a multi-use trail. This plan was complicated by environmental and resiliency concerns, specifically contaminated soils and low-lying, flood-prone stretches. In addition, the corridor links diverse residential, commercial, and industrial districts, and required buy-in from a multitude of stakeholders.

Permeable pavers on the Bayside Trail

Eventually, and with the help of a **public-private funding** effort, the adjacent neighborhood associations came together with the City of Portland, Maine Department of Transportation, Portland

[2] American Society of Landscape Architects' Green Infrastructure and Stormwater Management Case Study: Bayside Promenade Trail, https://www.asla.org/stormwatercasestudies.aspx

Trails, and the Trust for Public Land to design a combined bike and pedestrian trail with both paved and gravel surfaces. The trail is interspersed with green and hardscaped open spaces and remains lit through the night for added safety and functionality. Multiple neighborhood cut-through pathways were added to increase connectivity to the adjacent neighborhoods, and wayfinding helps visitors and residents navigate the extended trail network.

To address contamination and stormwater runoff, the trail uses pervious pavement and incorporates landscaped bioswales and retention beds along the right-of-way adjacent to the trail. Green infrastructure along the corridor is estimated to reduce stormwater runoff by 10 to 20 percent. These efforts were funded by a combination of $800,000 in Federal funding, $1.6 million in private funding, and $3.5 million from the City to both purchase the property and fund construction costs. Gradually the completed trail gained users and helped to reinvigorate the Bayside housing and mixed-use development markets.

The former railroad right-of-way (top) transformed into the multi-use Bayside Trail (below).

Additional Resources:

- Portland Trails
- Trust for Public Land

PIONEER TRAIL ROUNDABOUT (TRUCKEE, CA)

Year Completed: Fall 2010
Cost Estimate: $2.5 million
Street Type: Suburban Arterial
Case Study Category: Network Connections

The Pioneer Trail Roundabout is one of many roundabouts in Truckee, CA. Truckee constructs roundabouts for their safety benefits, aesthetic appeal, and their flexibility given the seasonal nature of traffic in the area. This roundabout, at the intersection of Donner Pass Road and Pioneer Trail, was designed with enhanced bicycle and pedestrian facilities in order to connect the nearby neighborhoods with the Community Recreation Center and swimming pool. High-visibility crosswalks with pedestrian refuges were added to each leg of the four-way roundabout, and off-road multiuse pathways connect the roundabout and recreation facilities with a much larger network of area trails and bike lanes. By completing this gap in the trail network, the recreation facilities and adjacent neighborhoods are now accessible from the regional golf course, Adler Creek Middle School, and downtown Truckee.

In addition to slowing traffic and enhancing pedestrian and bicycle safety, the roundabout doubles as a stormwater retention area. The center of the roundabout, 120-feet in diameter, is a bioswale with native landscaping. It is designed for a 20-year, one-hour storm event and has become a standard green infrastructure treatment for Truckee's numerous roundabouts.

This eight-month construction effort was funded in part by a Caltrans bike trail grant, traffic impact fees, and the Truckee Donner Recreation and Park District.

Additional Resources:

- NCHRP Report 674: Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities
- Massachusetts DOT: Separated Bikeways Design Guide, Chapter 4: Intersection Design
- California Statewide Pedestrian and Bicycle Master Plan

NORTH EL PASO CORRIDOR (RUSSELLVILLE, AR)

Year Completed: December 2014
Cost Estimate: $2.3 million
Street Type: Neighborhood Collector
Case Study Category: Network Connections

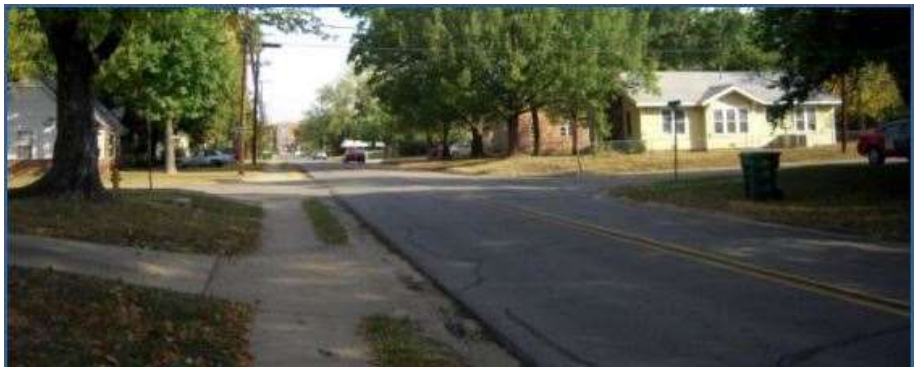
As one in a set of complete streets projects planned for Russellville, AR, the North El Paso Corridor now provides an essential bike and pedestrian connection between downtown Russellville and the Arkansas Tech University campus. The ¾-mile roadway was identified in the 2011 *Downtown Master Plan* as a "key connection" for active transporation, and now includes pedestrian-scale streelights, buffered bike lanes, and new ADA-compliant sidewalks on both sides of the street.

North El Paso Avenue is now safer at all hours of the day for pedestrian and cyclists.

This project was included in Russellville's Capital Improvement Program, which was developed to work in concert with the city's stormwater management plan and master street plan. As one example, rain gardens and new street trees were added in the North El Paso bicycle buffers to improve stormwater management and capture runoff. Another project to benefit from coordination was the Main Street pedestrian improvement effort in downtown Russellville. The Public Works Department added rain garden bulbouts at key intersections to shorten crossing distances and lower vehicle speeds.

A more-inviting pedestrian environment can go a long way in reviving a downtown, and since completion of these projects, new businesses have arrived both in downtown and along the El Paso Corridor. Arkansas Tech is now pursuing mixed-use housing along the El Paso Corridor, in part due to the influx of activity and extensive use by both pedestrians and cyclists.

The Public Works Department had to be **flexible** while implementing and funding this project. During construction, the city discovered that the corridor, a former State highway, still had a massive concrete slab embedded beneath the roadway. This required modification of the original concept—a single two-way buffered bike path—to retain the existing centerline and instead implement two, one-way protected bike lanes on either side of the road. To pay for the project the City used a loan, which they then repaid using the special 10-year, statewide ½ cent sales tax, dedicated to highway improvements and approved by Arkansas voters in 2011.



North El Paso Avenue before (top) and after (bottom) project.

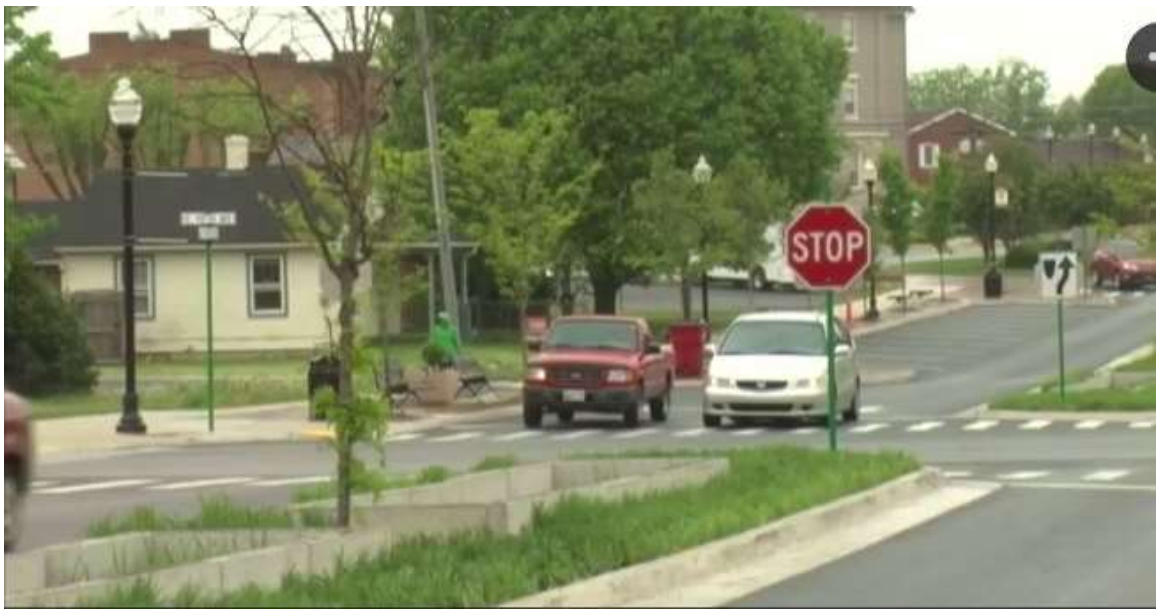
Additional Resources:

- FHWA Separated Bike Lanes Planning and Design Guide
- ITE Separated Bikeways Report
- MUTCD: Green Paint

GREEN CORRIDOR (RANSON AND CHARLES TOWN, WV)

Year Completed: Spring 2017
Cost Estimate: $9.4 million
Street Type: Commercial Boulevard
Case Study Category: State and Locally Driven Projects

Just over an hour from the Washington, D.C. metro area, Ranson and Charles Town, WV, are a model of planning collaboration. "Two Cities, One Revitilization Plan"[3] was the community mantra as the neighboring towns looked to transform their shared autocentric arterial, Fairfax Boulevard, into a green street and their abandoned industrial brownfields into a renewed commerce corridor. A HUD Community Challenge grant provided funding and assitance for the new Ranson "Smart Code" and land use plan, while research and remediation for former industrial sites came from a Brownfields Area-wide Planning grant from the EPA. Construction of the Green Corridor—a two-mile stretch of Fairfax Boulevard in Ranson and George Street in Charles Town—was funded by DOT TIGER II and IV grants.



Median bioswales capture and filter stormwater runoff.

The Green Corridor plan combines new goals of multimodal access and stomwater management with the historic vision for a connecting spine laid out in the original 1890 Charles Town plat. Fairfax Boulevard is a critical local corridor, connecting residential neighborhoods, commercial areas, job centers, hospitals, and parks. The redesign now makes this thoroughfare both safe and inviting for

[3] Environmental Protection Agency's *Brownfields Success Stories: Ranson and Charles Town, WV,* https://www.epa.gov/sites/production/files/2015-10/documents/epa_oblr_successstory_ranson_v7_508.pdf

all modes. New additions to the corridor include bike lanes, widened sidewalks, streetlights, and bus shelters.

Stormwater treatment includes a landscaped median with bioswales designed to capture, treat, and inflitrate runoff through soils and plants, including 2,000 new street trees and shrubs. A conveyance system drains excess water from large storm events into a retention pond developed on adjacent, formerly industrial land. Soils excavated from the corridor project were used to cap the former foundry site. These measures respond to new, more stringent, water quality standards for communities in the Chesapeake Bay watershed. Inflitration was particularily important for this site in order to reduce the acidity of stormwater, which can slowly dissolve the limestone geology of the region and lead to sinkholes.

An artist's rendition of the Fairfax Boulevard redesign

Ranson and Charles Town, with populations of 4,500 and 5,300, respectively, were able to combine their financial and staff resources to imagine a regional-scale project garnering Federal interest and financial support. Stormwater management and transportation are often regional challenges, and the Green Corridor project presents a successful example of a community-driven, regional solution.

Additional Resources:

- EPA Success Stories: Ranson and Charles Town
- Chesapeake Bay Water Quality

WINSLOW WAY REDESIGN (BAINBRIDGE ISLAND, WA)

Year Completed: 2011
Cost Estimate: $5.6 million
Street Type: Main Street
Case Study Category: State and Locally Driven Projects

The culmination of many decades of discussion and community planning, the Winslow Way Redesign successfully highlights the importance of Winslow Way as a pedestrian activity center for Bainbridge Island, WA. An explicit goal of the the *Winslow Master Plan*, updated in 2006, was to "maintain Winslow Way as the centerpiece of Winslow, develop a multimodal street design program and create a pedestrian environment that supports vibrant retail." The Bainbridge *Arts Master Plan* (2003) also identified Winslow Way as a focus of activity. Simultaneous to these planning efforts, the City's Water Quality and Flow Monitoring Program noticed increased levels of pollutants in the watershed and set goals to incorporate green infrastructure into future development projects. While stemming from different needs, these goals combined to produce a community-oriented streetscape with access for all modes, space for art and artists, and foundations in environmentally-friendly landscaping and engineering.

Mini pedestrian plazas and seating invite people to hang out and enjoy the streetscape.

With an emphasis on ADA compliance, the half-mile redesign repaired and widened sidewalks where previously people were forced to travel single file to navigate between poles and benches. In addition to wider, six- to eight-foot sidewalks, the project added gathering spaces using bulbouts and rain gardens. With limited right-of-way, the project restructured angled parking and narrowed

travel lanes to reclaim space for pedestrians. These changes made both mid-block and intersection crossings **safer for pedestrians**. Shared Lane Marking or sharrows were added to the narrowest parts of the corridor and designated bike lanes were added near the intersection with State Highway 305.

To reduce runoff pollution and manage storm events, the corridor added rain gardens, street trees, underground retention and filtration cells, and pervious concrete sidewalks. These green infrastructure treatments helped the city achieve its goals to manage stormwater using a more natural and vegetated solution. The design funnels rainwater through the filtration system using curb inlets on some blocks and no curb at all on others. Following project completion in 2011, Bainbridge Island observed reductions in pollutants during rain events. In addition to the many aesthetic, aboveground improvements, the project replaced all in-street water infrastructure and relocated all overhead utilities into the belowground right-of-way.

Project funding was a **public-private effort** with $800,000 in city utility funds, $2.2 in State funding from the Transportation Improvement Board, $1.6 million from the Federal Government, and $1 million from Winslow Way property owners. The project won a 2013 Federal Highway Administration/Washington State Department of Transportation Project of Excellence Award.

A pedestrian crossing on Winslow Way before (left) and after (right) the redesign

Additional Resources:

- SvR Design Project Highlights
- NACTO Urban Bikeways Design Guide: Shared Lane Markings

OHIOPYLE GREEN STREETS (OHIOPYLE, PA)

Year Completed: August 2010
Cost Estimate: $1.3 million
Street Type: Small Town Main Street
Case Study Category: State and Locally Driven Projects

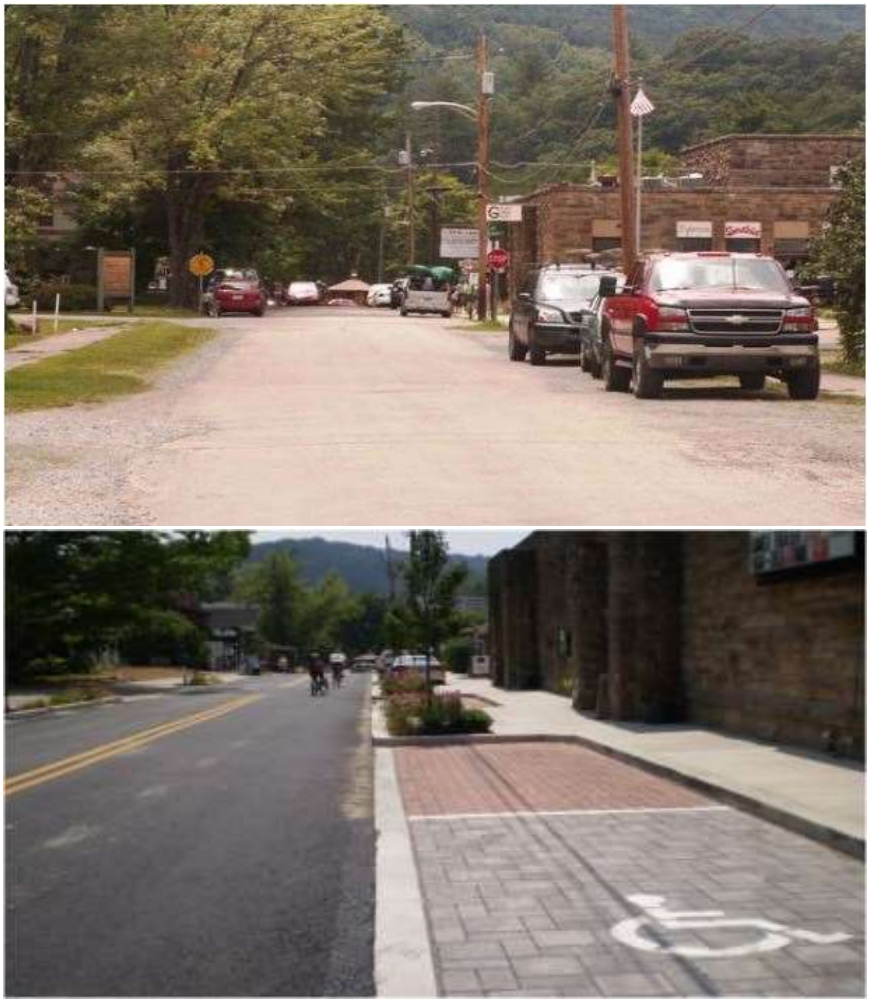
Ohiopyle Borough in western Pennsylvania has under 100 residents, but over 1.4 million annual visitors who come to visit Ohiopyle State Park and nearby attractions such as Frank Lloyd Wright's Fallingwater and Kentuck Knob. Ohiopyle prides itself as a sustainable community and in 2009 it partnered with the Pennsylvania Environmental Council (PEC) to prepare the *Joint Master Plan and Implementation Stretegy* for both the Borough and the State Park. This plan was inspired by the larger Laurel Highlands Conservation Landscape Initiative steered by the Pennsylvania Department of Conservation and Natural Resources (DCNR) and marked the first time that the DCNR jointly prepared a plan with a municipality. The planning effort led directly to the Ohiopyle Green Streets Project, which greatly improved pedestrian connectivity and stormwater management along three streets near the Visitor's Center and primary commercial establishments.

Permeable pavers and bioswales improve stormwater management.

The Green Streets Project aimed to better control and clean stormwater flowing into the ajdacent Youghiogheny River. To meet these goals, the project used multiple green infrastructure techniques including pervious pavers, bioretention, and bioswales. Almost 16,000 square feet of pervious pavers were used for sidewalks and on-street parking spaces, below which the town installed gravel retention pits capable of storing approximately 200,000 gallons of water. To filter runoff, the project

designed 3,700 square feet of bioswales filled with 1,321 perennials, 24 shrubs and 48 trees. Breaks in the curb allow runoff to flow over the roadway and into these detention areas. In addition to these street-level components, the project incorporated 41 locally-crafted rain barrels to divert stormwater into a usable resource for gardens and landscaping.

These stormwater improvements were paired with a more pedestrian-friendly roadway cross-section that included ADA compliant sidewalks and a multiuse path connecting all major tourist destinations in town. This project was completed with $1.3 million American Reinvestment and Recovery Act Green Project Reserve grant through the Pennsylvania Infrastructure Investment Authority (Penn VEST).



Sherman Street before (top) and after (bottom) project

Additional Resources:

- Pennsylvania Environmental Council Press Release
- North Carolina State University Permeable Pavement Guide

RELEVANT RESOURCES

- Livability in Transportation Guidebook: Planning Approaches that Promote Livability**:** This FHWA and FTA guidebook illustrates how livability principles have been incorporated into transportation planning and project design, using examples from State, regional, and local sponsors. It explores how transportation planning and programs can improve community quality of life, enhance environmental performance, increase transportation and housing choice while lowering costs, and support economic vitality. Many of the case studies resolve capacity and operational issues through a multimodal network and systems approach, reflecting better integration of land use with transportation.

- Green Infrastructure Opportunities that Arise during Municipal Operations**:** This EPA Office of Wetlands, Oceans and Watersheds document provides approaches local government officials and municipal program managers in small to midsize communities can use to incorporate green infrastructure components into work they are doing in public spaces. The guide demonstrates ways in which projects can be modified relatively easily and at a low cost recognizing that municipal resources can be limited.

- Green Infrastructure and Climate Resiliency: Collaborating to Improve Community Resilience**:** This EPA Office of Wastewater Management report summarizes four charrettes that explored ways in which green infrastructure could help cities become more resilient to climate change. Participants identified the multiple benefits of green infrastructure practices and collaborated across city agencies to achieve efficiencies and maximize benefits.

- Enhancing Sustainable Communities with Green Infrastructure: A Guide to Help Communities Better Manage Stormwater While Achieving other Environmental, Public Health, Social, and Economic Benefits**:** This EPA Office of Sustainable Communities document helps stakeholders create a vision for how green infrastructure can enhance their communities. It also directs readers to other resources that provide more detailed information that can be tailored to communities' particular climate, goals, and circumstances.

- Green Infrastructure and the Sustainable Communities Initiative**:** This Department of Housing and Urban Development report shares the green infrastructure best practices and outputs of HUD grantees under the Sustainable Communities Initiative grant programs. These profiles present grantees' green infrastructure work and link to other resources with more detailed information on plans and projects.

- Urban Street Stormwater Guide**:** This NACTO guide depicts how cities can utilize streets to address resiliency and climate change while creating public spaces that deliver social and economic value while protecting natural resources. It provides cities with national best practices for sustainable stormwater management in the public right-of-way, including core principles about the purpose of streets, strategies for building inter-departmental partnerships around sustainable infrastructure, technical design details for siting and building bioretention facilities, and a visual language for communicating the benefits of such projects.

- Stormwater Case Studies**:** The American Society of Landscape Architects website provides 480 stormwater case studies, showcasing the value of promoting green infrastructure policies.

- A Resource Guide for Planning, Designing and Implementing Green Infrastructure in Parks**:** The National Recreation and Park Association (NRPA) in collaboration with the American Planning Association (APA) and the Low Impact Development Center (LIDC) produced a suite of resources on green infrastructure stormwater management in parks including a resource guide, briefing papers, and case studies. This information focuses on how to plan, finance, implement, and maintain green stormwater management projects in parks and other public lands, especially projects that are designed to engage and benefit underserved communities.

PHOTO SOURCES

Chattanooga, TN

- http://www.themunicipal.com/2015/09/green-partnerships-build-better-communities/
- http://www.timesfreepress.com/news/business/aroundregion/story/2014/jun/15/flying-squirrel-builds-unique-road-chattanoo/249837/

Paso Robles, CA

- https://cannoncorp.us/wp-content/uploads/2012/07/21st_Street_GreenComplete_Street_Brochure.pdf
- http://www.prcity.com/government/departments/publicworks/engineering/pdf/10-17A-beforeafter.pdf

Albuquerque, NM

- https://www.cabq.gov/parksandrecreation/documents/hahn-arroyo-complete-with-color.pdf

FHWA New Mexico Division Office

West Union, IA

- https://www.cdfinc.com/Project?project_id=136

Syracuse, NY

- http://connectivecorridor.syr.edu/connective-corridor-photos/connective-corridor-photo-album/

Seattle, WA

- https://landscapeperformance.org/case-study-briefs/taylor-28

Indianapolis, IN

- https://www.visitindy.com/indianapolis-cultural-trail

Portland, ME

- https://www.tpl.org/our-work/portland-bayside-trail#sm.000002l72avs5df2bw7aszkic5iwp
- https://photos.google.com/share/AF1QipOKdvyu1O8mxhI3Wm5Ea9LmauzQLKeCm6Xb_mKlwEaNXhpJmu6dUmzWIx9cSVdGQQ/photo/AF1QipNjG-FFD0we9nQnAITNp-YQZlMiH3GIpeTMyy_-?key=a3FmM1E1WVNBUVdjcjVxYkdhSWdNNlBiUzdyRlJ3

Russellville, AR

- http://ctmainstreet.org/wp-content/uploads/2012/07/7-Implementing-Streets-for-Everyone-Walker.pdf

Ranson and Charles Town, WV

- http://ransonrenewed.com/initial-designs-emerge-for-fairfax-blvd-join-us-for-the-presentation/
- http://www.localdvm.com/news/west-virginia/fairfax-boulevard-project-complete/698547313

Bainbridge Island, WA

- http://www.svrdesign.com/winslow-way/

Ohiopyle, PA

- http://www.landscapeonline.com/research/article-a.php?number=27789
- http://www.docs.dcnr.pa.gov/cs/groups/public/documents/document/dcnr_008430.pdf

U.S.Department of Transportation

Federal Highway Administration

FHWA-HEP-18-031