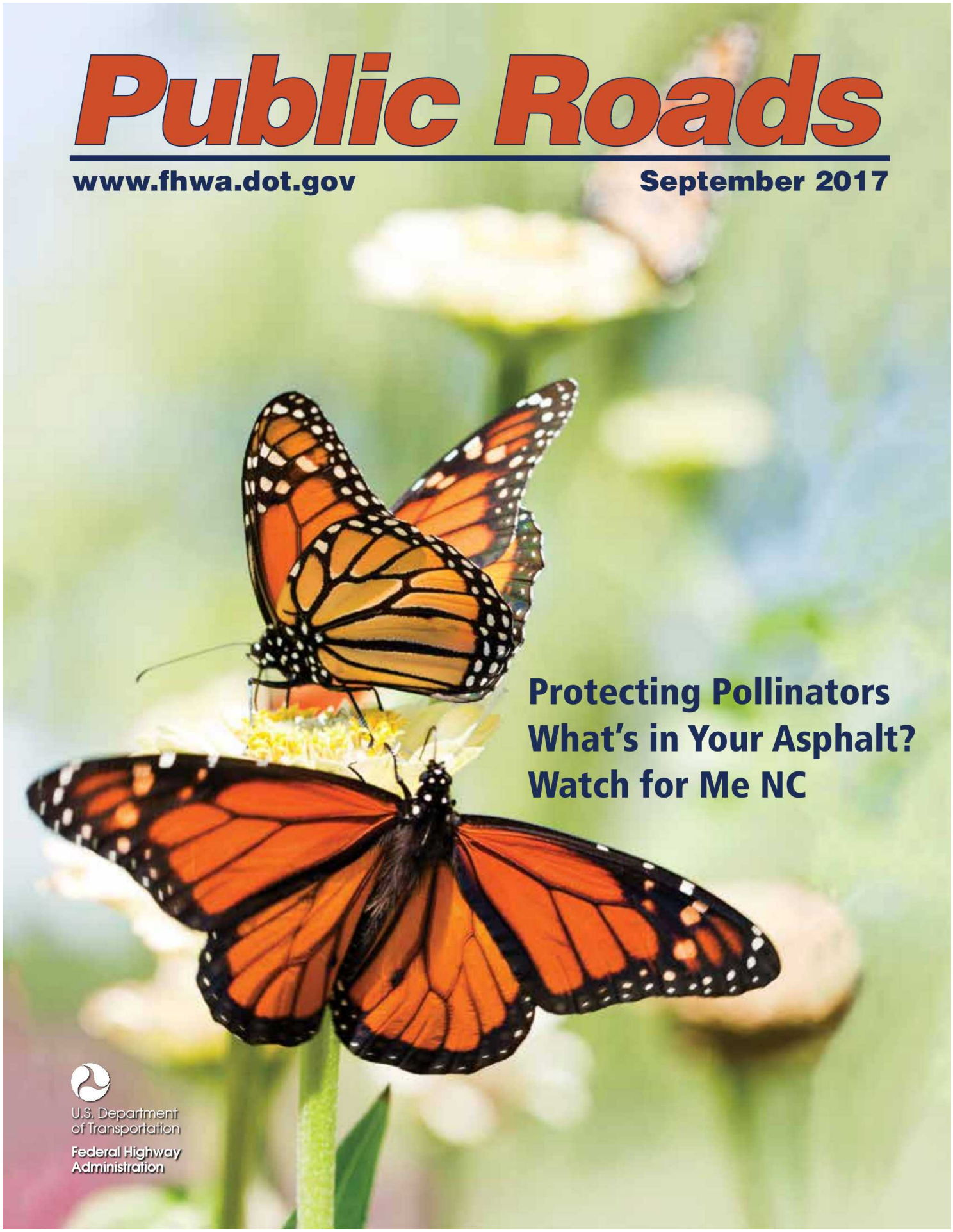
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U.S. Department of Transportation
Federal Highway Administration

Public Roads

—featuring developments in Federal highway policies, programs, and research and technology—

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Front cover—Monarch butterflies like these two are among the pollinator species that are in decline. The eastern population of the iconic monarch butterfly has declined by more than 80 percent since 1996. Loss of the monarch's breeding habitat—milkweed—is a significant factor contributing to this decline. To learn more, see "Save the Bees and Butterflies!" on page 4 in this issue of PUBLIC ROADS. *Photo: © patty_c, Getty Images.*

Back cover—A recreational vehicle cruises past a colorful roadside meadow of native wildflowers, which provide pollinator habitat on a mountain highway in Idaho. Native roadside meadows provide food, shelter, and breeding habitat for pollinators, which are critical to the production of food crops. For more information, see "Save the Bees and Butterflies!" on page 4 in this issue of PUBLIC ROADS. *Photo: © AllisonAchauer, Getty Images.*

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The Secretary of Transportation has determined that the publication of this periodical is necessary in the transaction of the public business required by law of this department.

Guest Editorial

Facing Highway Challenges

The diversity of disciplines and goals associated with the planning, design, construction, and maintenance of the Nation's highway and transportation network is both impressive and dynamic. This issue of PUBLIC ROADS serves as a reminder of the growing challenges of working on a system that is in need of repair and upgrade, while also improving the environment in which the Federal Highway Administration and its Federal, State, local, and industry partners operate.

Central to FHWA's mission is providing innovations to the agency's customers and stakeholders—particularly for renewal of highway infrastructure. Two case studies in this issue discuss managing the risks and processes associated with rapid renewal and strategies for complex projects. (See "Getting a Grip on Risks" on page 20 and "Breaking Down Project Complexities" on page 10.) These projects involve implementation of research results from the second Strategic Highway Research Program (SHRP2), which has coordinated efforts over the last decade between the American Association of State Highway Transportation Officials, FHWA, the States, and the Transportation Research Board. One project also demonstrates the growing need to address the challenges of multimodal transportation.

Another article, "What's in *Your* Asphalt?" (page 14), points to the need for constant vigilance in monitoring the performance of the highway network, the use of highly scientific tools to determine the materials and other components used in construction, and the need to constantly update specifications and performance standards to ensure that State and local agencies receive the product they are paying for and that performance objectives are achieved.

"What's New Today Is Mainstream Tomorrow" (page 26) presents the successes and impacts of the third round of FHWA's Every Day Counts initiative—illustrating how FHWA and its State and local partners are deploying innovations to address challenges.

Completing the spectrum of articles in this issue are two that present ways to make roadways and highways safer for users—whether human or insect. Making highways safer, especially for pedestrians, is a top priority for all local, State, and Federal agencies involved in transportation. These entities are always working to improve the type, level, and analysis of data; to develop countermeasures; and to deploy innovations that drive down the number and severity of highway crashes. (See "Watch for Me" on page 32.) Added to that goal is a mounting objective to make highway rights-of-way safer for the pollinators that are essential to the production of food for all Americans and the world population. (See "Save the Bees and Butterflies!" on page 4.)

Facing challenges often means changing to adapt. With this edition of PUBLIC ROADS, FHWA is implementing two changes. First, because of budgetary and human resource limitations, the magazine is transitioning to a quarterly publication rather than bimonthly. In addition, there will be an increased reliance on electronic distribution while retaining some print copies.

Finally, I will be retiring at the end of September and would like to recognize and thank everyone involved in production of the magazine: the authors, organizers, editors, graphic designers, distributors, and other contributors. You all have helped to continue what is now almost 100 years of quality communication on highway and transportation technologies, innovations, and research results to the world.

Michael F. Trentacoste
Associate Administrator for Research, Development, and Technology
Director, Turner-Fairbank Highway Research Center, Federal Highway Administration

Notice: Effective October 1, 2017, PUBLIC ROADS will be transitioning from a bimonthly to a quarterly publication. The initial quarterly publication will be the Autumn 2017 issue. Please direct any questions or comments regarding this transition to Editor-in-Chief Lisa Shuler at lisa.a.shuler@dot.gov.

HOT TOPIC

by John V. Moulden

Evaluating Research and Technology

The Federal Highway Administration's research results—when implemented appropriately—can save money and lives, extend the life of highway infrastructure, reduce congestion, improve travel time, and increase productivity. Through the FHWA's Research and Technology (R&T) Program, FHWA partners with State departments of transportation, local agencies, industries, and academia to conduct research on issues of national significance and to accelerate adoption and deployment of promising research products. FHWA's R&T Evaluation Program seeks to assess these R&T efforts and to ensure the efficient and effective use of public resources.

Congress and stakeholders want hard evidence that FHWA is accomplishing its goals. The R&T Evaluation Program is designed to provide that evidence. Though small compared to the Federal-aid funding for highway construction and maintenance, Congress has authorized $125 million a year for FHWA's R&T activities each fiscal year from 2017 to 2020. Real money is at stake, and the innovations that have come from these activities must demonstrate that they can improve the safety and efficiency of the Nation's highways and continue to do so.

"FHWA's Research and Technology Program strives to ensure transparency, accessibility, and responsiveness of R&T for all stakeholders," says Michael Trentacoste, associate administrator for R&T at FHWA.

The Details

FHWA developed the R&T Evaluation Program with the encouragement of the Transportation Research Board's Research and Technology Coordinating Committee (RTCC), and the program has benefited greatly from the expertise and oversight of the RTCC.

Completed and Ongoing Evaluations as of June 2017

Completed

- Adaptive Signal Control Technologies
- Eco-Logical
- Geosynthetic Reinforced Soil–Integrated Bridge System
- Gusset Plates
- National Household Travel Survey
- Public-Private Partnership Capacity Building
- Roadside Revegetation
- Roundabouts

Ongoing

- Agent-Based Simulation Models
- eNEPA
- High Friction Surface Treatments
- High Recycle Warm Mix Asphalt
- Managing Risk on Rapid Renewal Projects
- Precast Concrete Pavements
- Traffic Incident Management Training
- Vehicle Operating Costs

Roundabouts, like this one in the Grand Canyon National Park, are a widely used innovation, encouraged by FHWA research. *Photo: Michael Quinn, National Park Service.*

The guiding structure of the FHWA R&T Program is expressed in the FHWA R&T Agenda, which presents the mission and priorities of research and technology activities. The R&T Agenda identifies six high-priority highway challenges: (1) advancing safety toward zero deaths, (2) improving the mobility of people and goods, (3) maintaining infrastructure integrity, (4) enhancing system performance, (5) promoting sustainability, and (6) preparing for the future.

Accomplishing these challenges is the responsibility of FHWA offices focused on disciplines from infrastructure, safety, and operations to policy, planning, and environment. The R&T Evaluation Program assesses the effectiveness of research in each of these areas.

In fiscal year 2014, the R&T Evaluation Program, with assistance from the Volpe National Transportation Systems Center, worked with 9 FHWA offices to identify and scope 16 projects for evaluation across all program areas. As of June 2017, eight projects are complete with eight more ongoing. FHWA will complete most of the projects this year or next, with the remainder accomplished by 2020.

Summary of Findings

The eight completed evaluations have documented both program successes and challenges. In addition to the assessment of individual project outcomes and impacts, FHWA collected lessons learned regarding R&T program management and operations.

Individual evaluation reports are going through the FHWA editorial and management review process. When finalized, the reports for the completed evaluations will be available on FHWA's R&T Web site at www.fhwa.dot.gov/research/fhwaresearch/agenda/resources.cfm. Periodic summary reports on the R&T Evaluation Program are also available on this site.

Future articles will focus on the results and recommendations from individual project evaluations.

John V. Moulden is the manager of the FHWA R&T National Partnership Program.

INNOVATION CORNER

by Robert Ritter

Accelerating Project Delivery With Innovative Finance

Doing more with less is a continuing reality for transportation agencies. As the need for infrastructure improvements continues to outpace available funding, agencies seek innovative ways to finance critical transportation projects to expedite delivery and manage their construction programs more effectively.

The Center for Innovative Finance Support (CIFS), a component of the Federal Highway Administration's Office of Innovative Program Delivery, provides tools and resources to help agencies use alternative financing strategies to deliver projects under the Federal-Aid Highway Program.

"Pursuing financing opportunities is a way to accelerate project delivery," says Mark Sullivan, director of CIFS. "Financing can mean the difference between proceeding with critical projects or delaying them for years."

CIFS offers expertise on a variety of innovative finance options, including Grant Anticipation Revenue Vehicles (GARVEEs), State infrastructure banks, revenue tools, and public-private partnerships. Center staff can work with agencies to identify the appropriate approach for their needs and provide technical assistance to guide them through the process.

Innovative Strategies

One of the innovations that CIFS can assist with, the GARVEE program, enables departments of transportation to finance projects by issuing bonds that will be repaid with future Federal-Aid Highway Program dollars. The GARVEE bonds enable agencies to accelerate construction timelines and spread the cost over the transportation facilities' useful lives.

State infrastructure banks, funded with Federal and State resources, enable State DOTs to lend money to local governments for infrastructure projects, providing greater efficiency. "The banks are similar to revolving loan funds. As money returns to the bank, it can be loaned out again," says Sullivan.

Many transportation agencies use highway tolls to provide revenue for investment in transportation facilities beyond traditional taxes and fees. Apart from interstates, almost any Federal-aid road can be tolled if it needs to be reconstructed. In addition, CIFS can provide guidance on allowable exceptions to prohibitions in Federal statutes on interstate tolling.

Another revenue strategy is value capture, which funds infrastructure projects by recovering part of the increase in surrounding property values generated by improvements through taxes or special assessments. An example is the Route 28 Highway Transportation Improvement District in Virginia. Fairfax County formed the district in partnership with Loudoun County to accelerate road improvements through taxes on commercial and industrial properties along the busy northern Virginia corridor.

Indiana Department of Transportation

For the complex Ohio River Bridges Project, two States collaborated and used innovative financing and construction methods. Indiana completed the East End Crossing, shown here, while Kentucky built the Downtown Crossing.

States are also financing and delivering transportation projects via public-private partnerships, which enable agencies to leverage private sector creativity, efficiency, and capital. CIFS provides expertise on these partnerships through its role as the liaison with the U.S. Department of Transportation's Build America Bureau. The Build America Bureau coordinates credit and technical assistance on large infrastructure projects.

Combining Strategies

Many agencies address the challenge of delivering complex projects by combining a variety of financing and construction approaches. On the Ohio River Bridges Project, Kentucky and Indiana collaborated to use innovative methods to construct two bridges and the connecting highways.

The Kentucky Transportation Cabinet built the project's Downtown Crossing—including the Abraham Lincoln Bridge between Louisville, KY, and Jeffersonville, IN—using the design-build contracting method. The Indiana Department of Transportation delivered the East End Crossing—including the Lewis and Clark Bridge connecting Utica, IN, and Prospect, KY—through a design-build-finance-operate-maintain concession. Funding sources for the Ohio River Bridges project include GARVEE bonds, toll revenue bonds, Transportation Infrastructure Finance and Innovation Act (TIFIA) loans, and State and Federal funding.

"It's impressive that two States worked together on a single high-profile project," says Sullivan, "with each State taking responsibility to build a bridge and using a different financing strategy to complete its part of the project."

For more information on CIFS, visit www.fhwa.dot.gov/ipd.

Robert Ritter, P.E., is the managing director of FHWA's Office of Innovative Program Delivery.

Save the Bees and Butterflies!

by Deirdre Remley and Allison Redmon

By managing roadside vegetation, transportation agencies can help conserve the pollinators that are essential to the production of our food. Without them, we'd starve.

FHWA has developed best management practices and other tools to help transportation agencies identify ways they can integrate pollinator-friendly practices into their programs for managing roadside vegetation such as in this median in Arizona. *Photo: Luis Colon, Arizona DOT.*

Odds are you've heard about the disappearing honeybees and butterflies. Indeed, pollinators are in trouble. Wild pollinators such as monarch butterflies, bumblebees, and other native bees are experiencing dramatic declines due to a loss of habitat, disease, parasites, overuse of pesticides, and various other factors.

State and local departments of transportation can help reduce some of these threats, at least along roadsides. To assist with appropriate management approaches, the Federal Highway Administration has developed best practices and other tools to help DOTs identify ways that they can integrate pollinator-friendly practices into their landscape design and their programs for managing roadside vegetation.

"FHWA case studies, handbooks, and other materials not only support the resurgence of pollinators but also reduce roadside operational costs, improve ecological outcomes, and benefit local and regional economies," says Hari Kalla, acting associate administrator for the Office of Planning, Environment, and Realty.

The Importance Of Pollinators

Pollinators are essential to ecosystem health. Pollinators visit flowering plants, shrubs, and trees seeking sustenance in the form of sugary nectar and protein-packed pollen grains. While they forage, they transfer pollen grains between blooms, enabling flowering plants to reproduce. An estimated 85 percent of the world's flowering plants depend on animals—mostly insects—for pollination. Pollinators sustain wildland plant communities that provide food and shelter for myriad other wildlife.

Most pollinators are insects: bees, wasps, flies, beetles, butterflies, and moths. Hummingbirds also pollinate, as do nectar-feeding bat species. Bees are particularly critical pollinators. Beekeepers manage colonies of domesticated honeybees to provide both pollination and honey. The native bees of the United States—approximately 4,000 species—have very different lifestyles from honeybees; most native bees live in the wild rather than in managed hives. Native bees are excellent pollinators, and many play a critical role in crop pollination, such as the native bees that pollinate alfalfa, an important feed crop for livestock.

Pollinator Species In Decline

Pollinator declines threaten U.S. agriculture and put the health of natural ecosystems at risk. The number of honeybee colonies in the United States has been falling over the past half-century, and beekeepers have experienced record-high average hive losses (about 29 percent) annually.

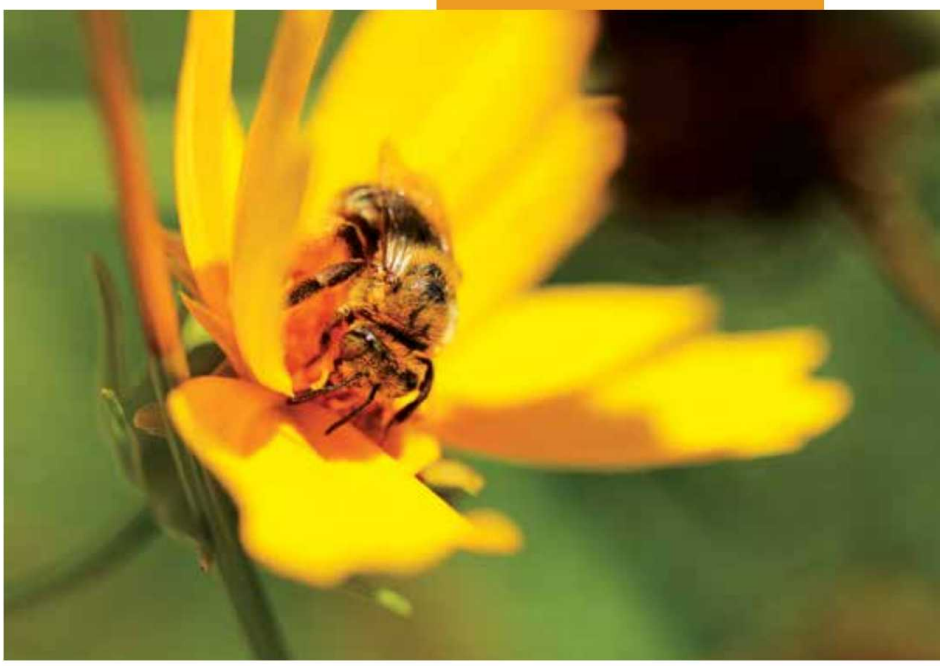
Other North American pollinator species appear to be experiencing similar or even more severe declines than honeybees. At least 25 percent of North America's bumblebee species have undergone significant and swift declines due to habitat loss, insecticide exposure, and disease. Butterflies have undergone similar declines: 17 percent are at risk of extinction. The eastern population of the iconic monarch butterfly declined by 84 percent between the winter of 1996–1997 and the winter of 2014–2015. Loss of the monarch's breeding habitat—milkweed—is a significant factor contributing to this decline.

Roadside Vegetation's Role In Pollinator Conservation

In 2015, in response to evidence of the steep declines in certain pollinator populations, Congress included administrative provisions addressing pollinators along roadsides in section 1415 of Fixing America's Surface Transportation (FAST) Act. This section directs FHWA to encourage pollinator habitat and forage development on transportation rights-of-way.

Roadside vegetation can offer much-needed habitat for pollinators, providing food, shelter, and connections to other patches of habitat. With millions of acres of

They are also essential to human well-being. As pollinators decline, so does agricultural production, putting the Nation's food supply and agricultural economy at risk. More than two-thirds of crop species are dependent on pollinators, including crops that produce fruits, vegetables, spices, nuts, seeds, forage for livestock, and fiber plants such as cotton. From the coffee you drink in the morning to the apple pie you have for dessert, an estimated one in three mouthfuls of food and drink that you consume comes from a pollinator-dependent crop. In fact, the majority of vitamins, minerals, and nutrients we need to maintain our health (such as vitamin C, calcium, and folic acid) come from fruits and vegetables that depend partially or fully on animal pollinators. In the United States, the value of crop pollination by insects is estimated at up to $27 billion.



Bees like this one pollinate crops while also sustaining wildland plant communities that provide food and shelter for myriad other wildlife. *Photo: Jennifer Hopwood, Xerces Society for Invertebrate Conservation.*

Roadsides and Pollinators

How are roadsides useful to pollinators? Roadsides offer several ecological benefits for pollinators. The vegetation can provide food, such as native wildflowers, that pollinators rely on as sources of pollen and nectar, and the caterpillar host plants that butterflies and moths need to complete their life cycles. Roadsides also provide breeding or nesting opportunities for pollinators, as well as shelter and overwintering habitat. They help pollinators to move through landscapes by linking fragmented habitats—and the roadsides themselves give refuge to pollinators in otherwise inhospitable landscapes.

What types of roadside management strategies benefit pollinators? Roadsides with abundant and diverse native wildflowers managed with judicious mowing and herbicide use, as well as other management tools, provide the best pollinator habitat. Shrubs and trees are also important components of pollinator habitat when they are compatible with the design of the roadside.

If the amount of roadside wildflowers increases, will the number of pollinators killed on roads increase? Many people are concerned that by increasing the quality of habitat on roadsides, more pollinators will be killed by vehicles. In fact, research indicates that roadsides with high-quality habitat actually reduce pollinator mortality because the insects stay on the roadside instead of leaving to search for flowers.

Do pollinators need native plants on roadsides? Native wildflowers are especially important for pollinators, because most nonnative cultivated flowers have little or no nectar. Native plants support more species and a greater abundance of pollinators than do nonnative plants. Roadsides with native plants are the most valuable to pollinators.

rights-of-way overseen by State DOTs, managing roadsides is a significant conservation opportunity.

Not all roadsides are equally beneficial to pollinators. Roadsides that are intensively mown, blanket-sprayed with herbicides, or planted with introduced grasses support far fewer species of pollinators and smaller population densities than roadsides managed for native plants.

On large construction projects, landscape design is an opportunity to establish pollinator habitat with native plants adapted to the local area. Most native plants have deep root systems that are excellent for stabilizing soils post-construction and thus achieving important erosion control objectives while creating aesthetically pleasing, low-maintenance roadside landscapes that serve as habitat for pollinators.

Roadsides can offer feeding, breeding, and nesting opportunities for pollinators, and also can aid pollinator migration by linking fragmented habitats and forming habitat corridors. With the right conditions, roadsides can support a diversity of generalist pollinators, including bumblebees, honeybees, butterflies, and hummingbirds, as well as rare species. Roadsides extend through all types of landscapes and can be particularly important sources of habitat in highly altered landscapes such as intensely managed agricultural lands or urban areas.

Vegetation management affects how pollinators use roadsides and even influences the number of pollinators killed by vehicles driving nearby. A European research study, "Factors affecting road mortality and the suitability of road verges for butterflies," published in 2013 in *Biological Conservation*, found that the frequency of mowing was linked to the proportion of butterflies killed by cars because the insects were forced to disperse to find new habitat after roadsides were mowed. In contrast, mortality was lower where roadsides had more species of plants and higher quality of habitat because butterflies did not have to fly to new areas. By reducing the need for pollinators to disperse elsewhere to find food or nesting sites, high-quality roadside habitat can decrease the numbers of pollinators killed by vehicles.

Roadsides managed with pollinators in mind can achieve the goals of stabilizing roadsides, reducing stormwater pollution, supporting wildlife, and increasing public appreciation of the local landscape.

Roadside Management Strategies

In 2015, FHWA's Office of Project Development and Environmental Review led an effort to develop best practices for improving pollinator habitat in roadside rights-of-way. The best practices outline how modifications to existing vegetation management practices can provide conservation opportunities to increase pollinator habitat and improve pollinator health.

In February 2015, contractors for FHWA interviewed staff from

Jennifer Hopwood, Xerces Society for Invertebrate Conservation

The eastern population of the monarch butterfly, shown here, declined by 84 percent in the past 18 years.

Here, Queen Anne's Lace graces an urban roadside in California. FHWA's pollinator resources outline the cost-saving benefits of activities such as limiting mowing and designing landscapes with native plants that require less costly long-term maintenance. *Photo: Pollinator Partnership.*

State DOTs and roadside restoration experts who work with DOTs. The goal was to document existing roadside vegetation management practices and obtain feedback from those professionals about the feasibility of implementing strategies that can benefit pollinators.

Adding the pollinator aspect to Florida's wildflower program, for example, elicited an enthusiastic response from Jeff Caster, a landscape architect with the State's DOT. He called the pollinator element "very, very significant because, before, [the program] was for enjoyment. Now it has a more serious purpose, more useful, and is perceived as more valuable."

Subsequently, FHWA published *Pollinators and Roadsides: Best Management Practices for Managers and Decision Makers* (FHWA-HEP-16-020) and *Roadside Best Management Practices that Benefit Pollinators: Handbook for Supporting Pollinators through Roadside Maintenance and Landscape Design* (FHWA-HEP-16-059). The best management practices described in these publications can help roadside managers maintain roadside vegetation and design roadside plantings in ways that increase the number and diversity of pollinators, and support pollination services for nearby crops and native plant communities. The strategies, outlined below, can be adapted to a particular region and situation, recognizing that transportation agencies have different resources and constraints.

Protecting and managing remnant habitat and existing stands of native vegetation. Conducting inventories of roadside vegetation to identify existing roadside habitat and weed problems, followed by site-appropriate management plans that maintain plant diversity, will help with managing existing roadside vegetation effectively, while also benefiting pollinators.

Adjusting mowing practices to benefit pollinators. Reduced mowing of the roadside beyond the clear zone can benefit pollinators and help to reduce maintenance costs, and does not need to compromise aesthetics or roadway safety. Transportation agencies also can reduce the frequency of mowing, consider the timing of mowing, and adopt mowing techniques that reduce the effects on pollinators.

The frequency and timing of mowing of the entire roadside right-of-way varies among States and also within some States. In some, mowing takes place in the late spring and early fall; in others, midsummer and early fall. Some roadsides may be mown in certain regions to reduce the fuels that contribute to wildfires. In urban areas, roadsides typically are mown more frequently to accommodate the perceived aesthetic preferences of road users. Some States have mowing exceptions to protect sensitive plants. In addition, in some States, private citizens may mow the roadside adjacent to their property and use the vegetation as hay for animal fodder.

Luis Colon, Arizona DOT

FHWA's pollinator-friendly practices are helping DOTs manage their roadside vegetation, as with this right-of-way in Arizona.

Reduced mowing, as shown here in Michigan, is a cost-saving strategy, as well as a pollinator-friendly practice. *Photo: Jennifer Hopwood, Xerces Society for Invertebrate Conservation.*

Generally, it is ideal for pollinators if roadside vegetation is mown no more than twice during the growing season. It is important to time mowing to minimize disruption of the life cycles of rare, endemic, or sensitive and declining species of pollinators. Mowing only once in autumn or after the first frost will benefit a variety of pollinators by allowing flowering plants to bloom uninterrupted throughout the growing season, and will reduce the risk of mortality to larval stages that reside on vegetation.

Reducing the impacts of herbicides on pollinators. DOTs can take a number of steps to reduce the effects of herbicides on pollinators, including using herbicides carefully and efficiently, avoiding damage to nontarget plants, reducing herbicide exposure to pollinators, and communicating with adjacent landowners.

DOTs use herbicides throughout the growing season as needed to control noxious weeds, invasive weeds, and encroaching woody vegetation. Herbicides also are applied in areas that cannot be mown, such as beneath guardrails or on gravel shoulders. Some DOTs time herbicide applications for peak effectiveness against their target weeds. Herbicide use, and the subsequent effects of herbicides on pollinators, can be reduced through the use of selective herbicides, spot-spray applications, and the timing of applications during life stages when the weed is most vulnerable. Training provided to roadside managers about the timing and selection of chemicals for particular weeds, weed identification, and native plant identification also can reduce the amount and frequency of herbicide use.

Designing roadside landscapes to benefit pollinators. Landscape designers and engineers can increase the value of roadside plantings for pollinators by including wildflowers, native bunch grasses, shrubs, and trees that provide pollinators with food or shelter, and can select plants for pollinators that do not compromise highway safety.

Adopting proven methods to establish native plants. Native plants can be an effective tool for managing roadside vegetation, providing effective erosion control, buffering against invasive nonnative weeds, adapting to local conditions, requiring fewer labor and material inputs, reflecting a region's natural heritage, and supporting increased wildlife. Pollinators are more abundant and diverse on roadsides with native plants.

Many States prioritize native plant species for revegetation rather than introduced plant species. Other DOTs use native plants to a lesser degree, mixing nonnative plants and cultivars with native species. Native plants are used most often in rural areas, and ornamental plantings are more common in urban areas.

Native plants on roadsides sometimes face threats from pesticide drift from adjacent land, intentional herbicide use, or excessive mowing or haying from landowners living adjacent to roadside rights-of-way. Success in establishing native plants often depends on planning ahead to select the right species and ensuring that conditions are right for planting. Success also depends on building internal expertise in restoration by learning from other transportation agencies and local experts. When planning revegetation projects, designers can select native species that are adapted for particular site conditions, which will establish more successfully than a general regional mix. Plans that include a diversity of flowering plants with sequential and overlapping bloom times will provide resources for pollinators throughout the growing season.

Raising public awareness. Positive feedback from the public also can increase support within DOTs. Engaging and informing the public can help significantly in building support for a transportation agency's roadside restoration efforts. Agencies can generate public support for roadside restoration programs by distributing educational information through a number of avenues and producing effective restorations that can serve as examples of success.

Idaho DOT

A transportation agency can adjust mowing practices to benefit pollinators by reducing the frequency of mowing, adjusting the timing of mowing, and adopting mowing techniques that reduce impacts on pollinators. Here, a maintenance worker is cutting roadside vegetation in Idaho.

Doing It Right

Washington State Department of Transportation (WSDOT). WSDOT has a long history of managing its roadsides for cost efficiency and environmental stewardship. Based on a detailed programmatic environmental impact study that WSDOT conducted in 1993, the agency determined that an integrated vegetation management (IVM) program would be an effective, natural, and self-sustaining approach to maintaining Washington roadways. The State's IVM methods include biological control, selective use of herbicides, trimming, soil improvements, native plantings, and mowing. Employing IVM is a way to consider different treatments, based on site-specific conditions, and manage over the long term for safety, cost-effectiveness, and improved habitat for native plants and animals, including pollinators. WSDOT maintains annually updated IVM plans for all 7,000 miles (11,265 kilometers) of State highway corridor in Washington.

Texas Department of Transportation (TxDOT). The TxDOT wildflower program began in the 1930s with a simple but important message, "Don't mow until the wildflowers have gone to seed." Because TxDOT vegetation managers recognized that native flower species are less costly to maintain, these plants and their associated pollinator habitat have thrived on Texas highway roadsides for decades. More than 5,000 species of wildflowers grow along Texas highways, attracting millions of tourist dollars. TxDOT maintains wildflowers on approximately 800,000 acres (323,748 hectares) of roadside as part of its vegetation management program.

Training management staff. Significant knowledge gaps about managing roadsides as natural resources are evident in some DOTs. Education and training are indispensable if provided by transportation agency personnel and roadside restoration experts, especially in these five areas:

- Importance of pollinators and their habitat needs
- Identification of native plants
- Establishment and management of native plants
- Lists of ecoregional species of affordable plants that support pollinators
- Examples of targeted management changes to benefit pollinators

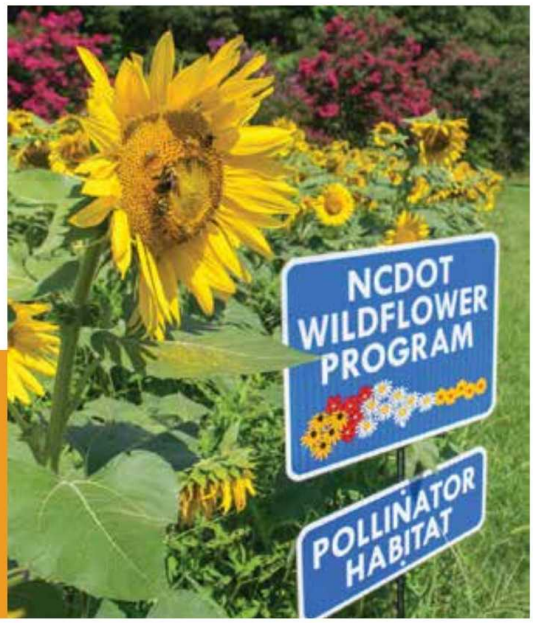
Staff training on how to implement management practices that benefit pollinators, how to incorporate pollinator habitat elements when designing new roadside plantings, and why the practices that are undertaken can make management programs and roadside restoration projects more successful and efficient. Providing staff with training that includes background information is important, as is information about the long-term economic and ecological value of native plants.

Going Forward: Tools Needed for Change

With transportation agencies facing funding challenges and aging infrastructure in need of repair and replacement, finding ways to make pollinator-friendly practices as efficient as possible is an important goal. FHWA's pollinator resources outline the cost-saving benefits of actions such as reducing mowing and designing landscapes with native plants that require less costly long-term maintenance. FHWA's partners in the DOTs are the best resource for building a knowledge base of cost-effective management techniques and design successes. FHWA's efforts will continue to highlight the work that stakeholders do to protect critical pollinator resources that are important to the Nation's food security, economy, and natural ecosystem processes.

FHWA will update its "Pollinators" Web page regularly, as more is learned about the ways that the agency's partners are showing their stewardship in protecting pollinators. Please check the site regularly to find the latest state of the practice in protecting, improving, and establishing pollinator-friendly roadside habitat.

"FHWA continues to support our State and local partners as they explore innovative ways to manage roadside vegetation that benefits pollinators," says FHWA Acting Executive Director Gloria Shepherd.



North Carolina DOT

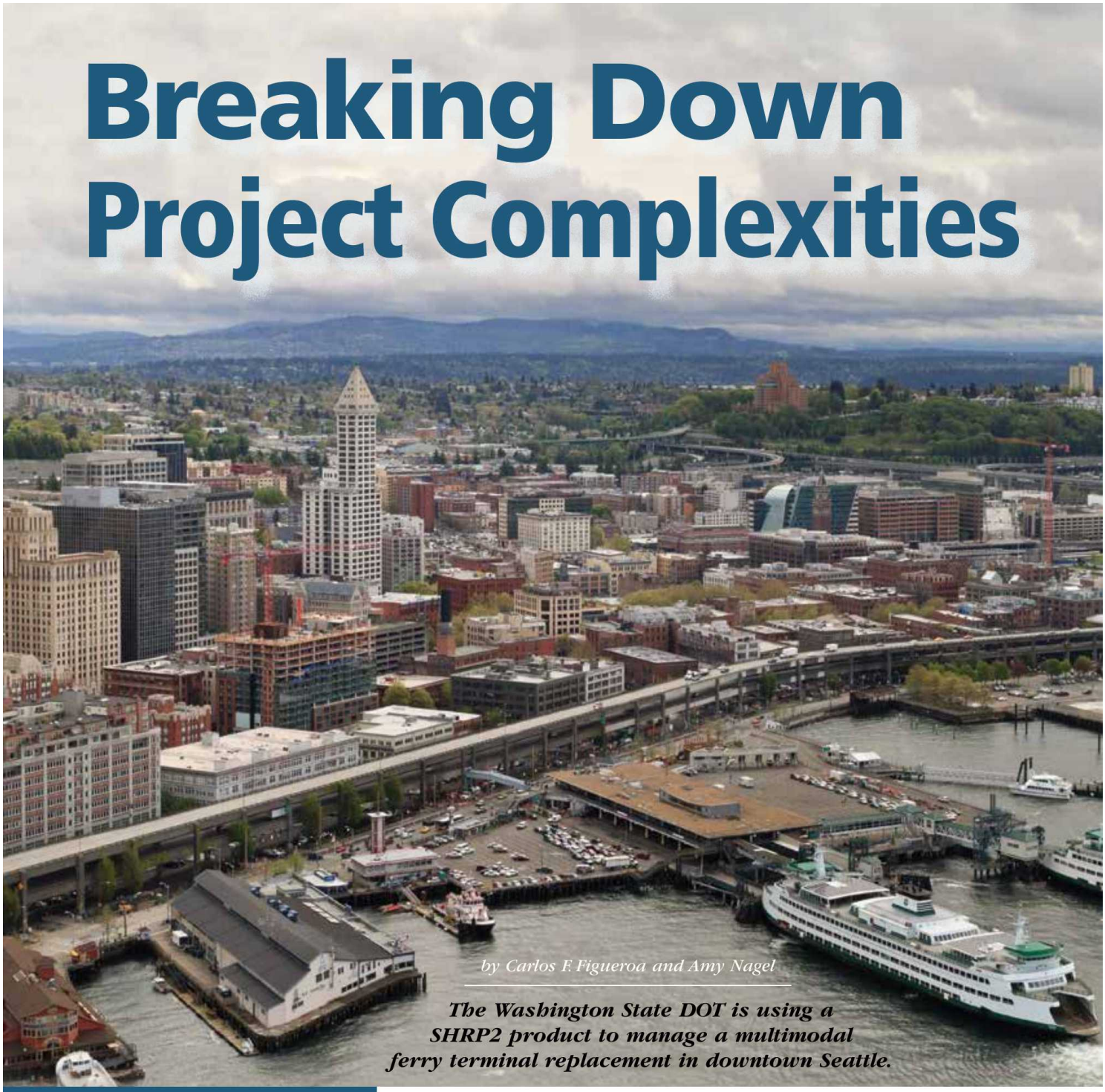
Engaging and informing the public can help build public support for a transportation agency's roadside restoration efforts, as this "Pollinator Habitat" sign in North Carolina suggests.

Deirdre Remley is an environmental protection specialist in the FHWA Office of Project Development and Environmental Review with 23 years of experience in environmental review. She has worked for the U.S. Forest Service, the National Park Service, the Arizona DOT, universities, and research labs. She has a master's degree in anthropology from Northern Arizona University.

Allison Redmon has 10 years of experience in communications and transportation. She provides communications support for the Denver Department of Public Works, and previously for the FHWA Office of Planning, Environment, and Realty through the Cadmus Group. She has a master's degree in transportation policy from George Mason University.

For more information, visit www.environment.fhwa.dot.gov/ecosystems/vegmgmt_pollinators.asp or contact Deirdre Remley at 202-366-0524 or deirdre.remley@dot.gov.

Breaking Down Project Complexities



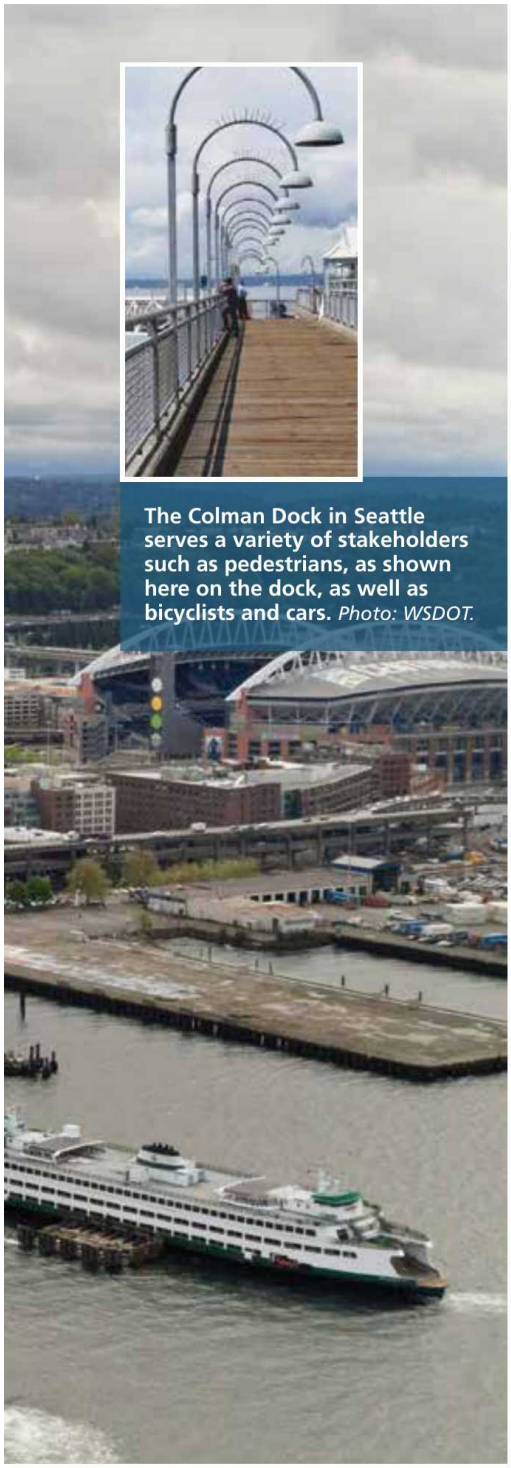
by Carlos F. Figueroa and Amy Nagel

The Washington State DOT is using a SHRP2 product to manage a multimodal ferry terminal replacement in downtown Seattle.

(Above) WSDOT is using Project Management Strategies for Complex Projects, a SHRP2 product, for the replacement of the Seattle Multimodal Ferry Terminal at Colman Dock. Shown here are two ferries docked at the original dock. *Photo: WSDOT.*

The Washington State Department of Transportation (WSDOT) is working with a diverse set of partners and stakeholders as it replaces and reconfigures the aging Seattle Multimodal Ferry Terminal at Colman Dock—all while the terminal remains operational. This ferry terminal is the largest in the system, providing two service routes to more than 8.5 million people annually. The facility also serves two passenger-only routes operated by King County. Pedestrians and bicyclists use the terminal, as well as several types of vehicles, including cars, high-occupancy vehicles, and transit.

To facilitate effective project planning and execution, WSDOT



The Colman Dock in Seattle serves a variety of stakeholders such as pedestrians, as shown here on the dock, as well as bicyclists and cars. *Photo: WSDOT.*

is using a product developed through the second Strategic Highway Research Program (SHRP2), called Project Management Strategies for Complex Projects. The product provides a systematic and collaborative approach that goes beyond traditional project management methods. It accelerates decision making, addresses complex issues, and expedites project delivery. The product has helped WSDOT assess the project and address complex issues such as public safety, environmental protection, and stakeholder impacts and concerns, from the planning stages through delivery.

Project Snapshot

The downtown Seattle ferry terminal has two routes, providing trips across Puget Sound to Kitsap County and the Olympic Peninsula. The ferry terminal was rebuilt in 1964 while retaining many of the original 1938 timber piles; it was reconstructed again and expanded in 1992.

The terminal's riders included 4.4 million foot passengers in 2013. By 2030, total ridership is projected to increase by 39 percent for the Seattle/Bainbridge route and 25 percent for the Seattle/Bremerton route.

The current condition of the terminal is poor because of aging and seismically deficient timber piers. Key features of the project include replacing the main ferry terminal building and passenger-only ferry facility on the southern edge of the dock, replacing and reconfiguring a portion of the dock to improve safety and operations for vehicles and pedestrian traffic, and replacing two movable bridges.

The replacement project has a budget of $268 million. WSDOT is employing the general contractor/construction manager (also known as construction manager/general contractor) project delivery method with an anticipated construction period of 6 years (2017–2023).

Project Management Strategies for Complex Projects

Project Management Strategies for Complex Projects was the tenth research project in the SHRP2 Renewal Focus Area and therefore it is known as Renewal 10 (R10). The product guides project teams through five dimensions of project management (5DPM): (1) cost, (2) schedule, (3) technical requirements, (4) finance, and (5) context, expanding on the traditional three-dimensional process (cost, schedule, and technical requirements). The product includes 5 recommended methods and 13 execution tools to help project teams address project complexities. The 5 methods are: (1) define critical project success factors, (2) assemble project team, (3) select project arrangements, (4) prepare early cost model and finance plan, and (5) develop project action plans.

A key benefit of this product is that project managers can apply it to transportation projects of varying sizes and types. This characteristic enables project managers to identify project complexities proactively and effectively, and develop action plans to determine rational resource allocations and guide project planning and implementation. Furthermore, the five-dimensional process may be repeated periodically throughout the project life cycle to continually monitor complexity and reallocate resources as necessary.

Using R10's approach, WSDOT quantified the level of complexity

The downtown Seattle ferry terminal services these two routes, providing trips across Puget Sound.

Project Execution Tools in R10

1. Incentivize Critical Project Outcomes
2. Develop Dispute Resolution Plans
3. Perform Comprehensive Risk Analysis
4. Identify Critical Permit Issues
5. Evaluate Applications of Offsite Fabrication
6. Determine Involvement in Rights-of-Way (ROW) and Utilities
7. Determine Work Packages and Sequencing
8. Design to Budget
9. Co-Locate Team
10. Establish Flexible Design Criteria
11. Evaluate Flexible Financing
12. Develop Finance Expenditure Model
13. Establish Public Involvement Plans

in each of the five dimensions of the Seattle ferry terminal project, applied the planning methods to the most complex areas, developed action plans, and identified potential execution tools to address project complexities.

The Washington State DOT R10 Demonstration Workshop

WSDOT's project team applied Project Management Strategies for Complex Projects during a demonstration workshop in July 2015. The Federal Highway Administration hosted the workshop in order to showcase the product and provide assistance to WSDOT in applying the product's tools and methods. The workshop also helped to facilitate team communication and identify project complexities. In addition, it helped WSDOT identify opportunities to implement complex project management strategies in the delivery of its transportation program.

Through the workshop, the WSDOT team learned to effectively identify and address issues earlier in the project's development, and determined the need to conduct a second project risk assessment including an evaluation of the context issues that could impact the project. The workshop also helped WSDOT better understand the complex stakeholder landscape by bringing to the table, at an early stage, representatives from FHWA, the Federal Transit Administration (FTA), Washington State Ferries, and the design consultant.

"The product and workshop emphasize more than the scope, schedule, and budget," says Stephen Levengood, former WSDOT chief estimator and now capital project coordinator with the city of Seattle. "Context isn't always given consideration, but it's very important. The product gets people on board and thinking about these areas, including project finance."

The workshop provided a collaborative environment among team members to promote communication and decision making. The workshop involved representatives from each of the project areas, such as environmental, planning, geotechnical, and construction engineering, to ensure that the team addresses all elements and levels of project complexity.

Mapping the Project's Complexity

The Ferry Terminal at Colman Dock is a multimodal hub that serves and affects a variety of stakeholders (context dimension). This is one of the factors that influences the success of this complex project. Using method 1 of the R10 process (identify critical success factors), the WSDOT team identified success factors for all five dimensions of project management: cost, schedule, technical, context, and finance.

The team also quantified the level of complexity for each dimension on a scale of 0 to 100, with 100 representing the greatest possible complexity and 50 representing an average level. The team plotted each dimension's relative level of complexity on a pentagon-shaped graph that provided an overall complexity area rating of 11,674. The complexity map is a visual representation of the project's complexity footprint based on the subjective assessment by the project team at that particular time. The maximum area is 24,000 (when all five dimensions are rated 100), and the average area is 6,000 (when all five dimensions are rated 50). The graph helped the project team visualize the five-dimensional complexity.

The team assessed context, finance, and technical dimensions as significantly more complex.

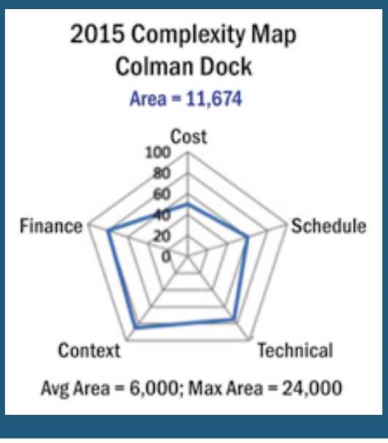
Context (complexity score of 85 out of 100). Three factors make context the most complex project dimension: (1) limited timeframe for construction in the water because of seasonal windows for regional fish spawning, (2) the need for legislative support and environmental clearance to pursue construction, and (3) the challenges of coordinating with many significant and influential stakeholders, including the public, tribal communities, and legislative, political, and environmental regulatory agencies.

Finance (complexity score of 80 out of 100). Project funding comes from multiple stakeholders—including FHWA, FTA, WSDOT, King County, and other local sources—and will require a firm understanding of revenue availability from all sources.

Technical (complexity score of 75 out of 100). Maintaining safe operations and capacity for pedestrian, bicycle, and vehicular traffic, including access for individuals with disabilities, during construction is a challenge. In addition, adherence to environmental requirements, such as fish-spawning windows that constrain in-water construction time, adds complexity.

The five-dimensional method can be applied as a benchmark starting before a project's implementation, and periodically throughout the project's development stages. By identifying the greatest complexity at various points in time, project managers are empowered to allocate resources to the most complex dimension at that particular time.

This pentagon-shaped graph helped the project team identify the most complex dimensions of the project. A maximum possible rating area is 24,000 (if all five dimensions are rated 100), and an average rating area is 6,000 (if all five dimensions are rated 50).



Volpe National Transportation Systems Center

Applying Project Execution Tools and Action Plans

The WSDOT team developed action plans to manage the identified areas of complexity. The R10 product also offers 13 project execution tools. The project team considered each tool and selected 9, which they used to create 7 action plans. The team chose the following tools:

- Incentivize Critical Project Outcomes (Tool 1)
- Develop Dispute Resolution Plan (Tool 2)
- Identify Critical Permit Issues (Tool 4)
- Determine Work Packages and Sequencing (Tool 7)
- Design to Budget (Tool 8)
- Co-Locate Team (Tool 9)
- Evaluate Flexible Financing (Tool 11)
- Develop Finance Expenditure Model (Tool 12)
- Establish Public Involvement Plan (Tool 13)

The action plans summarize the results from the first four out of five methods (method 1: identify critical success factors, method 2: assemble project team, method 3: select project arrangements, and method 4: prepare early cost model and finance plan). The plans address the complexities for the success factors identified during method 1, considering the identified human, project, and financial resources determined in methods 2 to 4, respectively. Then for each action plan (method 5), the project team considered and selected the execution tools as applicable to the specific action plan.

The project is currently in the final design phase. WSDOT will continue to use the R10 product leading up to the construction phase. After the work begins, the project team will reevaluate to manage construction risks and project cost.

As part of the SHRP2 R10 Implementation Assistance Program, FHWA provided funding for assistance in developing a WSDOT standard method to determine the appropriate contracting and project delivery method. In addition, FHWA provided funding to develop WSDOT's Design-Build Request for Proposal template documents, and assistance to develop a WSDOT Design-Build Contractor Assessment Performance Process.

Implementation Benefits

The WSDOT project team already has benefitted from the five dimensions for project management product by conducting an indepth self-assessment to determine opportunities to improve the complex project management maturity and capability in all phases of project development. The team also identified potential alternative sources of project funding and determined a need to hire consultants who can assist them with financial planning, securing permits, and communicating information to the public.

"The R10 product has additional applications for other complex WSDOT projects," says Mark Gaines, WSDOT State bridge construction engineer. "We've talked about these issues previously, but not with everyone together at the table. It's been very valuable."

Available Resources

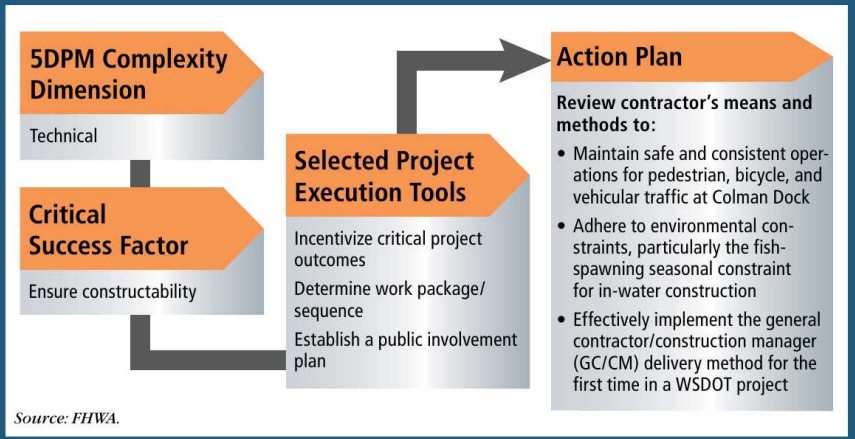
- A **demonstration workshop** enables State and local transportation personnel to realize the R10 product's benefits first hand by applying it to a real project.
- The project team receives a **summary report** after the workshop, which outlines the **action plans and execution tools** to manage project complexities.
- **Training** for agency staff in facilitating an R10 workshop, and its related training materials, are available to learn the skill set to apply the product to future projects.
- The product's **guidebook and other materials** are available on the Transportation Research Board Web site at www.trb.org/Main/Blurbs/167482.aspx.

Carlos F. Figueroa, P.E., PMP is the FHWA program manager for the SHRP2 R09 and R10 Project Management Tools in the Office of Program Administration. He is responsible for the deployment and implementation of these tools for more than 20 State departments of transportation. Figueroa has a B.S. in civil engineering from the University of Puerto Rico and an M.S. in construction management from Virginia Tech. He is a registered professional engineer in Georgia and Puerto Rico, and is a certified Project Management Professional®.

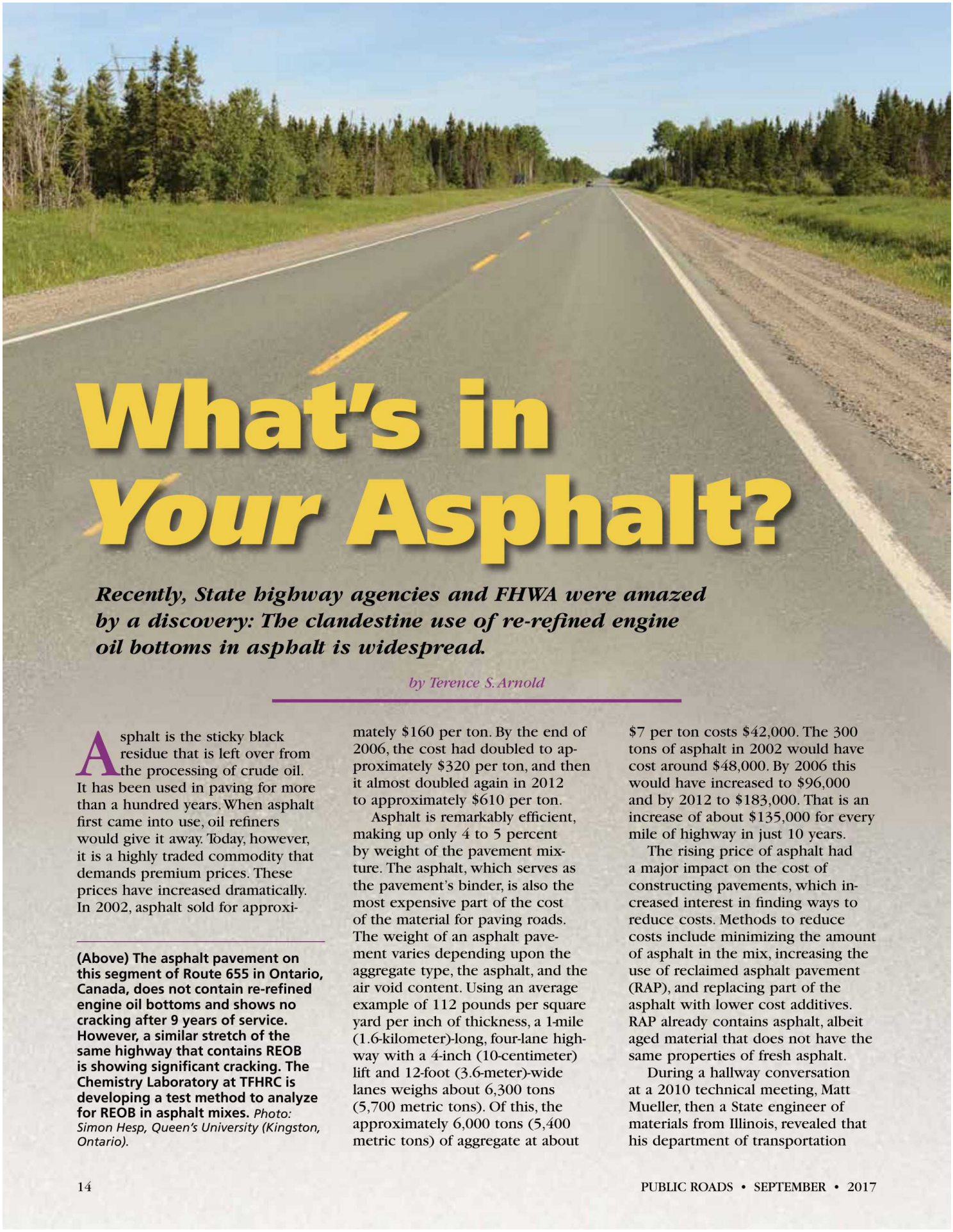
Amy Nagel was a communications specialist with the U.S. Department of Transportation's Volpe National Transportation Systems Center. Nagel has a bachelor of science degree in print and multimedia journalism from Emerson College and a master of education degree from Lesley University.

For more information, see www.fhwa.dot.gov/GoSHRP2/Solutions/Renewal/R10 or contact Carlos Figueroa at 202-366-5266 or carlos.figueroa@dot.gov.

WSDOT's Stages of Developing a 5DPM Action Plan



Source: FHWA.



What's in Your Asphalt?

Recently, State highway agencies and FHWA were amazed by a discovery: The clandestine use of re-refined engine oil bottoms in asphalt is widespread.

by Terence S. Arnold

Asphalt is the sticky black residue that is left over from the processing of crude oil. It has been used in paving for more than a hundred years. When asphalt first came into use, oil refiners would give it away. Today, however, it is a highly traded commodity that demands premium prices. These prices have increased dramatically. In 2002, asphalt sold for approximately $160 per ton. By the end of 2006, the cost had doubled to approximately $320 per ton, and then it almost doubled again in 2012 to approximately $610 per ton.

Asphalt is remarkably efficient, making up only 4 to 5 percent by weight of the pavement mixture. The asphalt, which serves as the pavement's binder, is also the most expensive part of the cost of the material for paving roads. The weight of an asphalt pavement varies depending upon the aggregate type, the asphalt, and the air void content. Using an average example of 112 pounds per square yard per inch of thickness, a 1-mile (1.6-kilometer)-long, four-lane highway with a 4-inch (10-centimeter) lift and 12-foot (3.6-meter)-wide lanes weighs about 6,300 tons (5,700 metric tons). Of this, the approximately 6,000 tons (5,400 metric tons) of aggregate at about $7 per ton costs $42,000. The 300 tons of asphalt in 2002 would have cost around $48,000. By 2006 this would have increased to $96,000 and by 2012 to $183,000. That is an increase of about $135,000 for every mile of highway in just 10 years.

The rising price of asphalt had a major impact on the cost of constructing pavements, which increased interest in finding ways to reduce costs. Methods to reduce costs include minimizing the amount of asphalt in the mix, increasing the use of reclaimed asphalt pavement (RAP), and replacing part of the asphalt with lower cost additives. RAP already contains asphalt, albeit aged material that does not have the same properties of fresh asphalt.

During a hallway conversation at a 2010 technical meeting, Matt Mueller, then a State engineer of materials from Illinois, revealed that his department of transportation

(Above) The asphalt pavement on this segment of Route 655 in Ontario, Canada, does not contain re-refined engine oil bottoms and shows no cracking after 9 years of service. However, a similar stretch of the same highway that contains REOB is showing significant cracking. The Chemistry Laboratory at TFHRC is developing a test method to analyze for REOB in asphalt mixes. *Photo: Simon Hesp, Queen's University (Kingston, Ontario).*

had found phosphorous in one of the asphalt binders it was purchasing. Illinois specifications do not allow binder modification by use of polyphosphoric acid (PPA). The vendor denied adding PPA, but declined to reveal what had been added to the binder. When pressed by the department of transportation, the vendor revealed that it was adding what it called an asphalt extender—now known to be re-refined engine oil bottoms (REOB). REOB contains a small amount of phosphorus, which is what department chemists initially identified.

Nobody, not at any of the State highway agencies nor at the Federal Highway Administration's Turner-Fairbank Highway Research Center (TFHRC), had ever heard of REOB. "No one knew this material was being added to asphalt, had seen any research on how this might affect performance of hot-mix asphalt pavements, or knew for how long and how widely it was being used throughout the country," says Mueller. After discussions at the technical meeting, he says, "It quickly went from being just an issue in Illinois to becoming a national and international concern."

Part of the mission of the Chemistry Laboratory at TFHRC is to develop new test methods. Developing a test method to analyze for REOB became a research project.

Testing Asphalt

The properties of asphalt binders vary widely depending on the source of the crude oil and the refining process used. For low winter temperatures, softer asphalts are necessary to avoid cracking. To prevent rutting in hot weather, the asphalt must be stiffer. The original test for determining the stiffness of asphalt was for the tester to chew it. However, today's methods are much more sophisticated.

A machine called a dynamic shear rheometer (DSR) was introduced to the industry during the Strategic Highway Research Program's research project, which ran from 1987 to 1992. The DSR is now the industry standard for measuring the viscoelastic properties of paving asphalt. However, the machine was not developed for the paving industry. The application of DSR was adapted from the food, cosmetic, and pharmaceutical industries, which used it to measure the stiffness of materials at different rates of shear. For example, the DSR enables product developers to create toothpaste with the right consistency so that it can be squeezed from a tube but not fall off the toothbrush.

A dynamic shear rheometer, shown here, measures the viscoelastic properties of paving asphalt. Operators place the material they are measuring between the two quarter-sized plates.

The DSR tests binder placed between two parallel plates about the size of a quarter. One of the plates moves and the machine measures the viscoelastic properties of the asphalt. The DSR is used to determine the maximum high temperature performance grade (PG) in degrees Celsius. These temperatures increase in steps of 6 degrees and are typically PG 52, 58, 64, 70, 76. They provide a maximum service temperature for the pavement. For example, a PG 70-28 binder would have a maximum service temperature of 70 degrees Celsius and a minimum service temperature of minus 28 degrees Celsius.

The addition of soft materials to asphalt will reduce the high temperature grade (for example, from a PG 76 to a PG 70). Several additives have been evaluated by industry and academia, including used frying oil, residues from corn stover, and even treated swine manure, for this purpose.

Similarly, the high temperature grade can be increased by adding something that makes the asphalt stiffer (typically polymers like styrene-butadiene-styrene polymers), but they are very expensive.

What Is REOB?

Companies collect the waste engine oil drained from cars, then process, or "re-refine," it for reuse. In simplified terms, they remove the oil by vacuum distillation. The lubricating oil distills over in a vacuum tower and is reused. The recovered oil meets all the automotive industry specifications for fresh lubricating oil. The process, however, leaves behind a residue at the bottom of the vacuum tower that goes by a variety of names. For the purposes of this article, it is re-refined engine oil bottoms (REOB).

The oil in a car engine is not just oil. It contains a variety of additives to enhance the vehicle's performance. These include polymers, viscosity modifiers, heat stabilizers, additional lubricants, and wear additives. The REOB contains all the additives that were in the waste oil as well as the wear metals from the engine (mainly iron and copper). These additives include zinc dialkyldithiophosphate, which contains zinc, sulfur, and phosphorous; calcium phenate, which contains calcium; and molybdenum disulfide, which contains molybdenum and sulfur.

During an oil change, the waste engine oil drains from a car, as shown here.

Analysis of liquid asphalt for the trace metals calcium, copper, zinc, and molybdenum provides a measure of the amount of REOB present. Sulfur and iron could also be analyzed, but because they occur naturally in asphalt, their use would confuse the analysis.

Testing at TFHRC

The FHWA researchers at TFHRC chose the method of x-ray fluorescence spectroscopy (XRF) for their analysis of REOB. They selected XRF because they already had the machine in-house and also because many State highway agencies already have XRF for analyzing cement. Other methods, such as inductively coupled plasma and atomic absorption spectroscopies, likely would work equally well. The basic principles of the XRF analytical method are available in the 2015 Transportation Research Board (TRB) paper titled "The Analysis of Asphalt Binders for Recycled Engine Oil Bottoms by X-Ray Fluorescence Spectroscopy."

Because REOB is a waste product, its composition varies widely not only between producers but also between samples from the same producer on different days. The compositional analysis is also affected by the asphalt into which it is blended. However, by making many blends using different REOB samples and different asphalt binders, the variations largely can be averaged out.

Several States provided samples of known REOB composition to TFHRC researchers, who analyzed the samples to compare the percentage of added (known) REOB to the found (tested) amount. The analyses showed a comparable percentage of added and found REOB.

In addition, the researchers contacted State highway agencies to request samples of asphalt binders for testing. They received an overwhelming response. The TFHRC researchers analyzed 1,532 samples from 40 States, one Canadian province, and two Federal Lands Highway divisions. They analyzed each sample twice—amounting to more than 3,000 analyses. None of those States realized that the asphalt they were buying contained REOB. One State insisted its samples had no REOB. However, 38 of the first 90 samples from that State contained it.

Of the 1,532 samples tested, 12 percent contained REOB, and some contained appreciably high levels of it at 10–20 percent. The highest level was 34 percent in a sample from Texas, which TxDOT had used in a patching compound. This testing also revealed the presence of phosphoric acid in 11 percent of the samples, and 2 percent contained ground tire rubber.

The results of the study caused a high level of interest throughout the country. Two years ago at TRB's annual meeting, the Federal researchers held an REOB workshop and presented the findings of their laboratory evaluations to a standing room-only crowd.

Round-Robin Testing

Although some agencies do not specifically ban REOB, they do impose physical tests that preclude its use—effectively a ban. Others do not ban it by specification, but have agreements with asphalt suppliers

to avoid the use of REOB. Of the 50 States and Washington, DC, the 3 Federal Lands Highway divisions, plus Ontario, Canada, nearly half specifically or effectively ban the use of REOB, and the majority of the rest do not specify whether it is or is not allowed. A handful do allow REOB, some within certain limits. For example, Ohio and Texas limit levels to less than 5 percent of the asphalt.

To develop a reliable test method that all States can use, the TFHRC researchers set up a round-robin test plan. The participants are 11 State highway agencies (Illinois, Massachusetts, Minnesota, Mississippi, Montana, North Carolina, Oklahoma, South Carolina, Texas, Vermont, and Wyoming), 2 independent testing labs, the Ministry of Transport in Ontario, Queen's University in Ontario, and an Ontario paving contractor.

To execute the plan, TFHRC provided the initial test method and 45 blends of various REOB modified asphalt binders with REOB concentrations of 2, 5, 8, 10, and 20 percent. In total, the researchers prepared and shipped 720 blends.

The participants are testing the samples independently using the guidelines provided by the TFHRC researchers. The round-robin testing is nearly completed, and TFHRC is in the process of collecting the results. The output will be a proposed AASHTO test method that any State can adopt and use.

REOB and Pavement Life

The unanswered question that remains is whether REOB negatively influences pavement life. In the United States, very little evidence is available, perhaps because no State highway agencies knew their binders contained REOB until recently. However, research in Canada linked the premature failure of Highway 655 in Timmins, Ontario, with the presence of REOB.

The overnight temperature in the area can reach as low as -40 degrees F (-40 degrees C). The pavement without REOB on one segment of Highway 655 showed no distress after 9 years of service. The pavement with REOB, which is located 0.6 mile (1 kilometer) from the pavement without REOB, has identical subgrade, traffic density, and climate. However, the segment of Highway 655 with 5 to 10 percent REOB showed significant cracking. In this example, the presence of REOB was the identified cause of cracking at a low temperatures.

At room temperature, REOB is a liquid.

"The performance of the various sections of test road in Timmins illustrates the effect it has had on the pavement life," says Simon Hesp, professor of chemistry at Queen's University in Kingston, Ontario. "In our experience in Canada, even small quantities of 2–3 percent can be a problem."

Similarly, a section of test pavement in Minnesota (MN1-4) found to contain REOB also cracked prematurely. The pavement performed well for the first 3 to 4 years, but then started to crack. This pavement is also subject to low temperatures.

The TFHRC researchers carried out a few mix tests (mixing the binders with aggregate) in 2015. The tests were not extensive, but they showed that at levels of 6 percent or more, the tensile strength of the asphalt dropped significantly. At a level of 3.5 percent REOB, the variation in the physical test methods was greater than the effect of REOB. In fact, it was difficult for researchers to assess whether REOB was present.

Some evidence suggests that the presence of REOB may be detected using the bending beam rheometer. One binder parameter considered is the difference between the low temperature critical specification temperature for stiffness (S) in the bending beam rheometer and the bending beam rheometer creep slope (m-value) noted as $\Delta T_{critical}$. $\Delta T_C = T_C\,(S) - T_C\,(m\text{-}value)$. Evaluation of this parameter is still ongoing.

Two independent study teams, one from AASHTO and the other

Analysis of Samples from State Highway Agencies with Known REOB Content

Source	Percent REOB Added (Known)	Percent REOB Found (Tested) In Two Analyses
Illinois DOT	5	5, 5
Illinois DOT	10	9, 9
North Carolina DOT Vendor	10–11	14, 13
North Carolina DOT Vendor	10–11	9, 9
New York State DOT	0	0, 0
New York State DOT	6	6, 5
New York State DOT	0 + SBS (styrene-butadiene-styrene polymers)	0, 0
New York State DOT	2 + SBS	2, 2
New York State DOT	6 + SBS	5, 5

Summary of REOB Analyses of 1,532 Samples of Binders Sent to TFHRC

State	Number of Samples	Polyphosporic Acid	REOB	Ground Tire Rubber	REOB Range (%)	Status
AK	5	0	0	0		Banned[1]
AL	20	0	2	0	4–10	Banned
AR						Unspecified
AZ	35	9	23	10	1–10	Unspecified
CA	4	1	0	4		Unspecified
CFL	135	12	20	0	10–18	Unspecified
CO						Banned
CT	16	2	0	0		Banned
DC	9	0	3	0	2	Unspecified
DE						Unspecified
FL	11	0	0	4		Allowed
GA	38	0	0	0		Banned
HI						
IA						Banned
ID	9	0	3	0	6	Unspecified
IL						Banned
IN	10	3	3	0	9	Allowed
KS	21	0	0	0		Unspecified
KY						Unspecified
LA	6	0	0	4		Unspecified[2]
MA	16	10	2	0	9	Banned
MD	15	7	0	0		Banned
ME	8	5	0	0		Banned
MI	72	12	0	0		Banned
MN	11	4	1	0	1	Allowed
MO	48	2	1	0	3	Unspecified
MS	2	0	2	0	1	Unspecified
MT	23	0	0	0		Unspecified
NC	70	1	6	0	14	Banned
ND	10	2	0	0		Allowed
NE	30	0	2	8	2	Allowed
NH	19	6	1	0	1	Banned
NJ						Banned
NM						Banned
NV	5	3	1	0	2	Banned
NY	68	3	5	0	6	Banned
OH	13	1	0	0		Allowed[3]
OK	41	4	13	0	7–12	Unspecified
ONT	14	2	5	0	4–17	Banned
OR	8	3	3	0	1–3	Allowed
PA	73	10	4	0	3–15	Unspecified[4]
RI	5	2	0	0		Banned
SC	14	0	0	0		Allowed
SD	16	0	0	0		Unspecified
TN	12	0	0	0		Unspecified[4]
TX	86	6	18	4	2–34	Allowed[3]
UT	20	6	2	0		Unspecified[5]
VA	21	1	1	0	2	Unspecified
VT	15	0	1	0	0–6	Banned
WA	433	50	58	0	12	Unspecified[1]
WFL	12	0	0	0		Unspecified
WI						Unspecified
WV	33	0	1	0	3	Unspecified[2]
WY						Unspecified
Total	1,532	167	181	34		
%		11	12	2		

[1] Physical test precludes use
[2] Do not want it
[3] 5-percent maximum (only in base and intermediate courses in Ohio)
[4] Considering a ban or max limit in future
[5] Does not specify the use of PPA or REOB but has a SHRP Plus Specification including the DTT (direct tension test) with a minimum 1.5-percent strain that helps to control these additives

from the Asphalt Institute, concluded that more research is needed on the use of REOB in asphalt.

A New Perspective On Binders

At TFHRC, researchers are planning a different way of looking at asphalt binders. Previously, all asphalt testing measured engineering properties such as stiffness. These tests do not show what materials had been added to the asphalt.

One sample received during the TFHRC study had a very strange analysis. The sample had the following test results: Superpave® PG 64-28 with a high temperature grade of 67.3 $\Delta T_{critical}$ on the bending beam rheometer was 6.7 degrees Celsius. Chemical analysis indicated it contained approximately 1.7 percent phosphoric acid, 10 percent ground tire rubber, and 19 percent REOB. The addition of 1.7 percent phosphoric acid likely would make the asphalt very stiff. Ten percent ground tire rubber would make it even stiffer. Then 19 percent REOB would soften it and bring it back within specification.

Although it passed the standardized AASHTO testing protocols, it failed the Hamburg physical rut testing "miserably" (in the researchers' words). The results were not surprising because nearly 31 percent of the binder was not asphalt.

These results demonstrate there are weaknesses in the standardized engineering testing protocols that may be exploited. The producer may have an economic benefit and the product passes all the standardized tests, but the product may not be beneficial to ensuring long-term performance.

To address this issue and the expansion of new asphalt additives and extenders, TFHRC is starting a research program to use handheld spectroscopic devices, x-ray fluorescence spectroscopy, and Fourier transform infrared spectroscopy to enable analyses to be done in the field rather than having to take samples back to the lab. Fourier transform infrared spectroscopy can even find lime in the mix, as well as styrene-butadiene-styrene and styrene-butadiene rubber polymers. X-ray fluorescence spectroscopy can find REOB and phosphoric acid, and the handheld spectroscopy works for

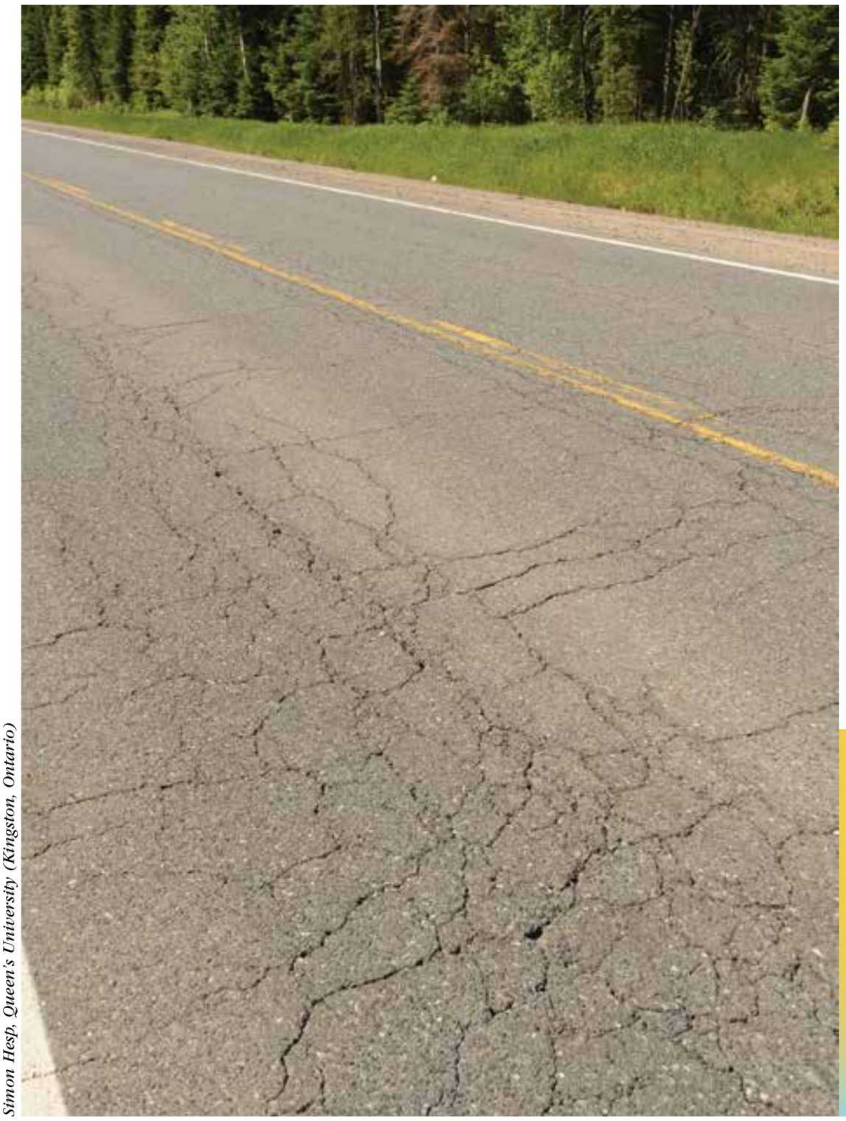
This is the sample deck of the XRF spectrometer.

spot checks. These instruments can be preprogrammed and require no additional training or skills for operators. All of this testing can be done directly from the paving machine, or at the asphalt plant by an unskilled operator, saving time and associated costs. These methods are much more difficult to manipulate because they can almost always tell what materials have been added to the mix. They also enable the possibility of field spot checks and eliminate the possibility of sampling errors where the asphalt being used was not the same as received by the testing lab.

The TFHRC team will soon submit to AASHTO the draft test methods that transportation agencies can use to test for the presence of REOB in asphalt mixes. These test methods will help transportation agencies know what materials and additives are present in the asphalt mixes they are purchasing.

Terence S. Arnold is a senior research chemist on the Pavement Materials Team in FHWA's Office of Infrastructure Research and Development and Federal lab manager for the chemistry lab at TFHRC. He is a fellow of the Royal Society of Chemistry in the United Kingdom and a Chartered Chemist.

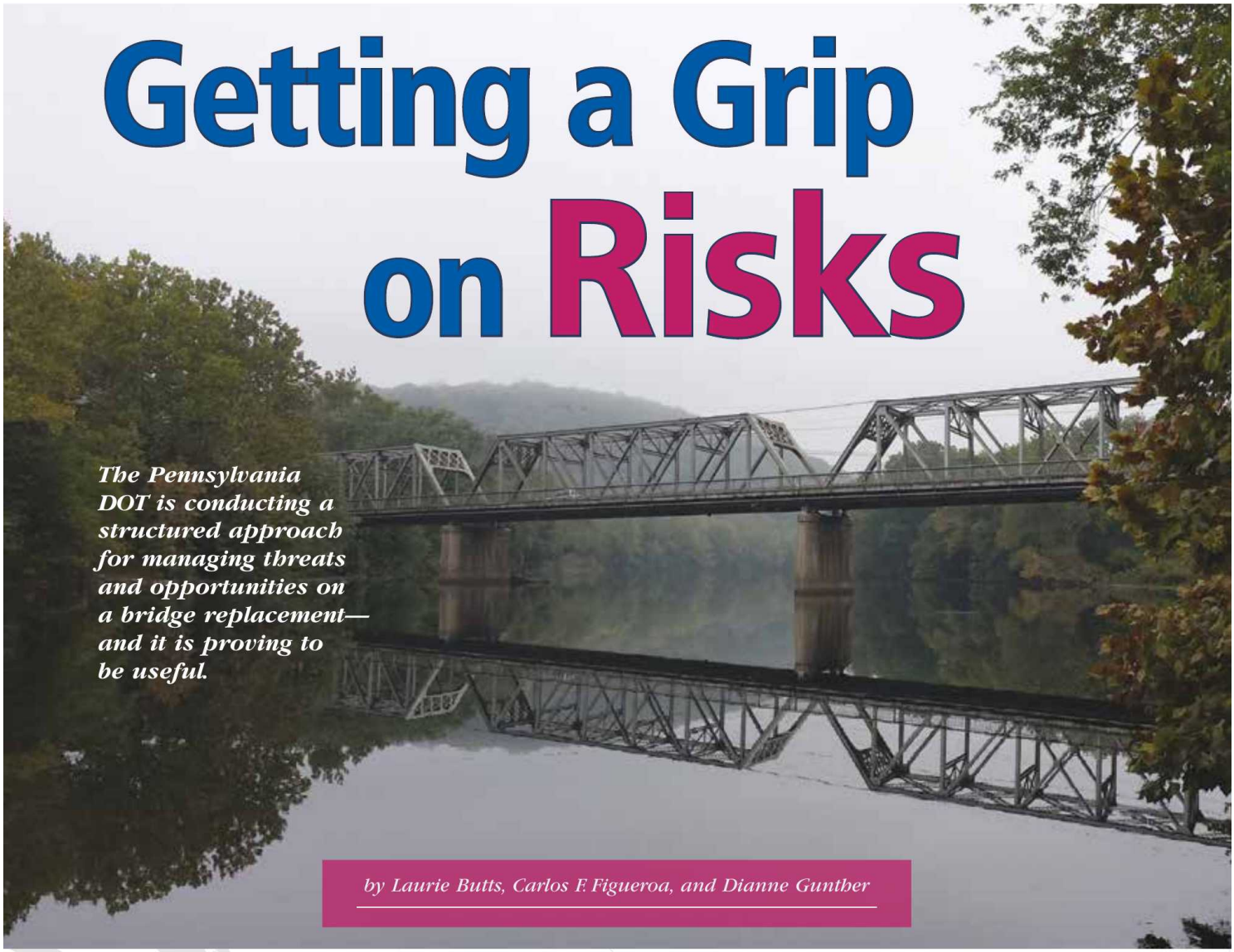
For more information, contact Terence Arnold at 202-493-3305 or terry.arnold@dot.gov.



Simon Hesp, Queen's University (Kingston, Ontario)

The asphalt pavement on this segment of Highway 655 in Ontario was made with a binder that contains REOB and styrene-butadiene-styrene polymer. After 9 years of service, it shows significant cracking. This section is located just 0.6 mile (1 kilometer) from an identical subgrade exposed to the same traffic and climate but that does not contain REOB. The section of highway without REOB shows no cracking after 9 years of service.

Getting a Grip on Risks



The Pennsylvania DOT is conducting a structured approach for managing threats and opportunities on a bridge replacement—and it is proving to be useful.

by Laurie Butts, Carlos F. Figueroa, and Dianne Gunther

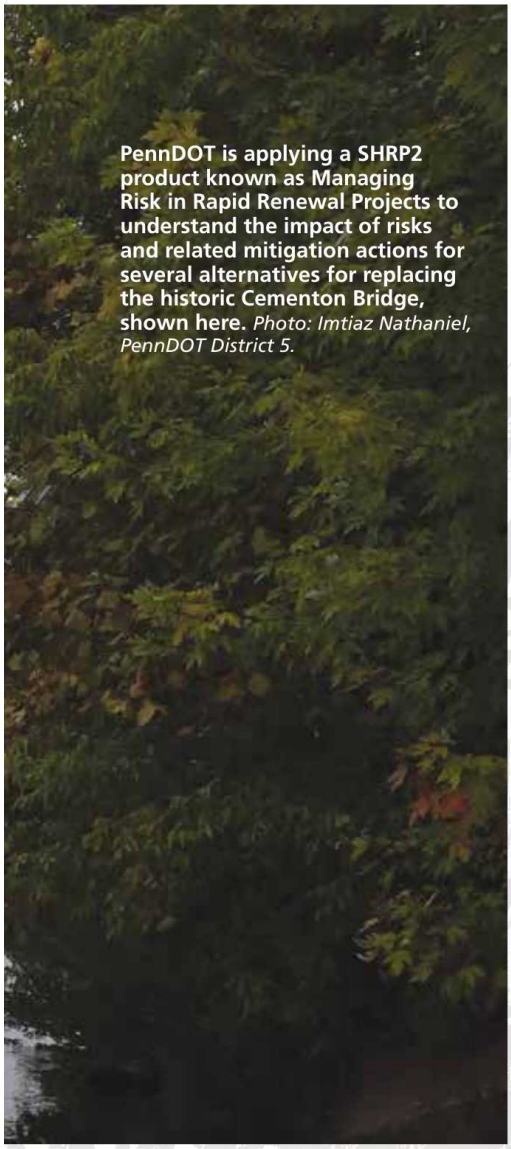
The 84-year-old Cementon Bridge in Whitehall Township, PA, carries more than 16,000 vehicles per day over the Lehigh River. However, like many of the Nation's bridges, the structure requires replacement to ensure its continuous operation and functionality for travelers. Due, in part, to its proximity to historic properties, replacing the Cementon Bridge is a complex project with a high risk of cost overruns and schedule delays.

Traditional risk assessment and mitigation activities used by transportation agencies often lack rigor and formality during the continuum of project planning, design, and delivery. Failure to adhere to a formal process of risk analysis can result in unanticipated problems, delays, and costs. In addition, finding solutions during later phases of a project can be more difficult and costly.

To identify and mitigate risks proactively on the Cementon Bridge replacement project, the Pennsylvania Department of Transportation (PennDOT) conducted a comprehensive in-house risk assessment using a product developed through the second Strategic Highway Research Program (SHRP2). The product, Managing Risk in Rapid Renewal Projects, presents a formal risk management process that optimizes performance for accelerated reconstruction on projects. PennDOT used the product for the Cementon Bridge project to identify, assess, mitigate, allocate, and monitor risks.

Project Characteristics

PennDOT anticipates that construction of the new Cementon Bridge will begin in 2019, and design and construction combined will cost approximately $20 million to $23 million in year-of-expenditure (YOE) dollars (base cost estimate). The existing bridge is in poor condition because of its deteriorated structural condition, which has resulted in a load posting restriction to maintain safety. In addition, the bridge is unable to accommodate current and future traffic needs because of the geometric constraints. This project is not only



PennDOT is applying a SHRP2 product known as Managing Risk in Rapid Renewal Projects to understand the impact of risks and related mitigation actions for several alternatives for replacing the historic Cementon Bridge, shown here. *Photo: Imtiaz Nathaniel, PennDOT District 5.*

critical to Pennsylvania's transportation infrastructure, it is also unusually complex, with many constraints that could threaten its on-time, on-budget completion.

The Cementon Bridge is a four-span, 575-foot (175-meter)-long bridge constructed in 1933. The bridge carries SR-0329 over the Lehigh River and serves as the primary link between Cementon and Northampton Borough. It also connects the Laurys Station and Northampton segments of the Delaware and Lehigh Trail. The structure is eligible for listing in the National Register of Historic Places (NRHP), and is near historic districts within Northampton County.

The bridge's location is highly constrained because it abuts the Norfolk Southern railroad and the Siegfried Cemetery. The structure also carries multiple utilities, including fiber optic data lines, a water main, and aerial high-voltage power lines.

Although this project is large enough to justify a full probabilistic risk assessment, PennDOT chose an in-house risk management process that was both comprehensive and easy to apply. The reason was so that staff could learn the process and then use it on future projects of various sizes and types.

Managing Risk in Rapid Renewal Projects

Managing Risk in Rapid Renewal Projects was the ninth research project in the SHRP2 Renewal focus area and is also known as Renewal 09 (R09). The product uses an Excel®-based template to guide teams through a risk management process to identify, evaluate, and mitigate risks. Departments of transportation can adjust the template settings to fit their projects' unique characteristics by defining a project's delivery method, base cost, and base schedule. The accompanying R09 guide provides additional tools to assist with each step. The guide is available at www.trb.org/Main/Blurbs/168369.aspx.

During a 2.5-day workshop hosted by the Federal Highway Administration, PennDOT's team of project managers, in-house subject matter experts, and consultants applied the product's iterative process to the Cementon Bridge. The goals of the workshop were to identify potential risks holistically, determine the likelihood of risk occurrence, calculate the associated impact on cost and schedule, devise strategies to mitigate and monitor risks from planning to construction, assess the overall impact of mitigated and unmitigated risks on schedule and cost, and implement a risk management plan as part of the overall project delivery process.

PennDOT applied the process to two design alternatives it was considering, and will use the results to inform its final decision. Alternative A uses on-line (no change in alignment) accelerated bridge construction (ABC), and Alternative B uses a downstream alignment.

Alternative A involves constructing a new bridge superstructure adjacent to the existing structure, plus new piers and abutments under the existing structure, while traffic is maintained on the existing structure. The existing superstructure will be removed and new pier and abutment seats will be built, and the new superstructure will "slide in" onto new piers and abutments during a short-term bridge closure and traffic/pedestrian detour. The primary benefit of this alterative is that it maintains the existing alignment, which minimizes the impact on the right-of-way, environment, and abutting railroad. The disadvantages are higher cost, high uncertainty in contractor bids and capability, utility relocation (twice), and a traffic detour during the slide-in.

Alternative B involves constructing a new bridge downstream while maintaining traffic on the existing bridge. This alternative also would involve constructing roadway tie-ins to connect SR-0329 to the new bridge. The primary benefit is that it minimizes the impact on utilities and maintains traffic on the existing bridge throughout construction. The disadvantages are a required right-of-way acquisition with residential displacements, involvement of the Pennsylvania Public Utility Commission, and relocation of the railroad crossing.

"The R09 workshop identified a lot of risks with the ABC alternative that the downstream alternative may alleviate," says Brian Shunk, project development engineer with PennDOT. "R09 may

The Cementon Bridge project team discussed potential threats and opportunities while applying the R09 risk management process at a workshop.

lead PennDOT to a different decision about these alternatives than what was previously anticipated."

Project Scope, Structuring, And Risk Identification

The 7-step R09 risk management process helped PennDOT identify the most severe threats and opportunities, and the most beneficial mitigations to improve project costs and schedule performance. Because the process is so efficient, PennDOT completed the full risk assessment on each of the two alternatives in 2.5 days to help determine the best approach.

The agency kicked off the risk management process by familiarizing the team with the project scope, strategy, and conditions. The project manager discussed the two bridge replacement alternatives, funding, technical conditions affecting the project, political and external factors, and cost and schedule estimates.

Next, the team structured the project by defining the base project scenario for duration/schedule and cost, without accounting for intentional float, contingency, or inflation. The base performance data are entered into the R09 template and used as a comparison against the project's unmitigated and mitigated performance, which includes the threats and opportunities that are identified, assessed, and managed.

Threats can degrade project performance, while opportunities can enhance project performance. PennDOT identified 44 threats and 3 opportunities for Alternative A, and 34 threats and 7 opportunities for Alternative B. The project team documented the threats and opportunities in the risk register developed in the R09 template and categorized by when they are most likely to occur (for example, construction, preliminary design/environmental process, and procurement). The purpose of this step is to capture a comprehensive, nonoverlapping list of threats and opportunities, rather than screening out issues prematurely.

"Even though it was early in the project, bringing together PennDOT staff and consultants helped us identify risks that we [might] not have otherwise," says Laura Montgomery, consultant project manager for the Cementon Bridge replacement. "[Because] we are still in the preliminary design phase, there is time to coordinate among agencies to best address risks. That's the real benefit to the whole R09 product—it's a great way to identify risks ahead of time and know what you're up against."

Risk Assessment, Analysis, And Management Planning

PennDOT assessed the probability of occurrence, effect on mean cost (in dollars), and effect on mean schedule (in months) of each threat and opportunity. They can be assessed using predefined ratings that are linked to a range of values, or using direct mean values. For example, PennDOT noted that for Alternative A, the Pennsylvania Department of Environmental Protection may not want to issue a permit for the causeway because of its size and the impact on the migration pattern of shad, a species of fish that inhabit the Lehigh River. PennDOT assessed this risk as having a very high probability of occurrence (85 percent likelihood). In addition, PennDOT assessed this risk as having a high mean impact (8 months) and a low mean cost impact ($370,000).

After assessing all of the threats and opportunities, the team used the R09 template to calculate and document the mean severity of each risk to help the project team address the most severe threats and beneficial opportunities.

Using the output from structuring, risk identification, and risk assessment, PennDOT combined the base performance data and risk assessments to calculate the impact of each threat and opportunity on the project schedule, and the costs if the risks remained unmitigated. Understanding the impact of unmitigated risks will help PennDOT make informed decisions through analysis from planning to construction.

The project team then planned potential actions to mitigate the top 15 threats and the 2 highest severity opportunities from the unmitigated risk register for Alternative A, and the top 7 threats for Alternative B (risk management planning). For example, the team recommended performing a constructability review, which would include external experts, to mitigate potential feasibility concerns for Alternative A. For Alternative B, the team recommended conducting additional subsurface investigation

Source: USDOT Volpe Center.

Top Risks from the Unmitigated Risk Register

Alternative A: ABC Replacement	Alternative B: Downstream Replacement
1. Preferred alternative could prove to be unfeasible due to constructability concerns.	1. Design supplement could be needed for preliminary engineering for downstream alternative, which would require additional design efforts.
2. Contractor bid price could be high because of bridge slide technology, based on project complexity and PennDOT's minimal experience.	2. Preliminary engineering will require additional time, delaying the schedule.
3. Pennsylvania Department of Environmental Protection might not issue permit for causeway.	3. Construction could impact gravesites because of the unknown extent of cemetery boundaries.

Top Risks from the Mitigated Risk Register

Alternative A: ABC Replacement	Alternative B: Downstream Replacement
1. Contractor bid price could be high because of bridge slide technology, based on project complexity and PennDOT's minimal experience.	1. Design supplement could be needed for preliminary engineering for downstream alternative, which would require additional design efforts.
2. Preferred alternative could prove to be unfeasible because of constructability concerns.	2. Preliminary engineering would require additional time, delaying the schedule.
3. Public might find the 14-day closure for the bridge replacement unacceptable.	3. Alternative could prove to be unreasonable under the National Environmental Policy Act because of the impact on the cemetery.

Comparison of Base Project Performance, Unmitigated Performance, and Mitigated Performance

		Base	Unmitigated	Mitigated	Mitigation Savings
Alternative A	Cost (YOE)	$22.54 million	$29.07 million	$25.50 million	$3.57 million
	Construction Notice to Proceed	6/30/2019	3/17/2021	4/20/2020	11 months
	Construction Completion Date	3/29/2022	2/06/2024	2/08/2023	12 months
Alternative B	Cost (YOE)	$20.41 million	$24.21 million	$24.80 million	-$590,000 (additional costs)
	Construction Notice to Proceed	12/29/2019	2/26/2021	10/18/2021	Delayed 7.8 months
	Construction Completion Date	9/12/2022	12/18/2023	7/18/2024	Delayed 7.1 months

Source: FHWA and PennDOT. YOE = Year of Expenditure.

and testing during the design phase, and developing a relocation plan if they encountered gravesites.

Using the R09 template, the project team assessed the impact of the mitigation actions using mean values or predefined ratings on project cost and schedule. This resulted in a mitigated risk register that documents the resulting project performance impact if the selected mitigations are applied.

Next, PennDOT used its mitigated risk register to conduct a final cost and schedule performance analysis. The agency compared the project cost and construction duration among the base, unmitigated, and mitigated project performance for each alternative. The mitigated performance includes all residual risk (the portion of the threats and opportunities that remains after mitigation).

Note that for Alternative B, the mitigated performance is more costly and delays the schedule beyond the unmitigated performance. In this case, PennDOT may choose to forego mitigations

Renewal 09 Risk Management Pays off in Arizona

The Arizona Department of Transportation (ADOT) recently constructed a grade-separated interchange to elevate Bell Road over Grand Avenue (U.S. 60) and the BNSF Railway railroad to ease congestion and increase capacity of this busy intersection in Surprise, AZ. During the project development stages, FHWA conducted a SHRP2 R09 demonstration workshop with ADOT staff and project consultants. This workshop, held in December 2014 in Phoenix, produced a list of prioritized threats and opportunities for the project and identified mitigation strategies, which could affect project cost and schedule performance.

In January 2017, near the completion of the construction project, ADOT and FHWA met again to compare the predicted project performance from the December 2014 workshop with the actual performance. The project results clearly demonstrate the positive impact of risk management on the project.

The project team implemented the following mitigation strategies, as identified during the R09 workshop:

- *Full closure of Bell Road.* This opportunity reduced staging work from two major phases to one, which eliminated the need for temporary structures and opened more working area to enable expediting construction activities. The public and business owners supported a full closure of Bell Road because of the overall shorter construction duration.
- *Towne Center Drive right-of-way (ROW) impacts.* The alignment of Towne Center Drive was not redesigned and, as a result, this decision minimized ROW impacts to the businesses located along this drive.
- *Modifications to 134th Drive/Avenue.* The project team modified the alignment design of 134th Drive/Avenue to avoid ROW impacts on local businesses.

In terms of cost performance, the total project cost as of January 17, 2017, including 18 change orders and a 5-percent construction contingency, was $49.8 million (YOE). The total additional cost of the 18 change orders was approximately $417,000. However, this cost is significantly lower when compared to the December 2014 R09 workshop unmitigated cost estimate of $60.7 million (YOE), which excluded all contingencies and intentional float and all identified mitigations that were assessed during the workshop. The change orders reflect experienced threats and opportunities that occurred during the design and construction phases of the project. A direct comparison of the December 2014 cost estimate and the January 2017 total project cost is somewhat difficult because of the changes in the project scope and approach, but the project team's ability to mitigate critical threats and implement opportunities is reflected in significant cost and schedule performance improvements.

An additional benefit is the savings associated with reductions in the project schedule. This was computed by comparing engineering and inspection costs and overhead for the 24 months of total anticipated construction time versus the actual construction duration of 14 months. The 24-month estimate is based on the duration assumed at the time of procurement. The only change in contract time was the project intermediate completion date because of roadwork beginning in April 2016 instead of March 2016, and the collapse of a bridge girder. As a result of the 10-month schedule reduction, the project staff estimated $1.6 million (YOE) of savings in construction engineering and inspection.

Vehicles travel through the completed interchange project at Bell Road and Grand Avenue (U.S. 60) in Surprise, AZ. This project benefitted from a SHRP2 R09 demonstration workshop. *Photo: ADOT.*

if the risks themselves are less costly than the mitigations.

As a result of this exercise, PennDOT had a much better understanding of the risks associated with both alternatives, and it planned a followup meeting to discuss the project in further detail and come to a conclusion on a recommended alternative.

"The implementation of the R09 process on the Cementon Bridge project was very beneficial in that it gave us an opportunity to bring together a diverse group of stakeholders to ensure that the project risks are known, communicated, and collaboratively addressed with response strategies," says Phillip Bobitz, transportation engineer with the FHWA Pennsylvania Division. "The R09 workshop demonstrated how risk management is an integral part of the project delivery process and, ultimately, will enhance project estimates and schedules."

Risk Management Implementation And Benefits

To finalize the risk management plan, PennDOT identified who within the agency would be responsible for implementing each risk mitigation action to ensure that risks continued to be monitored throughout the project life cycle. The responsible person is the key individual to facilitate and manage implementation of the action selected for risk management.

Applying the R09 risk management process has already helped PennDOT to evaluate two alternatives and their associated risks effectively; create a risk management plan to mitigate and monitor risks; develop a clearer understanding of and better define the project's scope, strategies, and conditions earlier in the planning stages and prior to construction; and use the risk assessment data to

The Cementon Bridge carries SR–0329 over the Lehigh River in eastern Pennsylvania. *Photo: HDR, Inc.*

explore proposed project strategies, document potential mitigations, and evaluate their benefit-cost ratio.

PennDOT will continue to use R09 to reevaluate risks based on changing information leading up to the Cementon Bridge construction phase, scheduled to begin in 2019.

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Carlos F. Figueroa is the FHWA program manager for SHRP2 R09 and R10 Project Management Strategies for Complex Projects in the Office of Program Administration. He is responsible for the deployment and implementation of these tools for more than 20 State DOTs. Figueroa has a B.S. in civil engineering from the University of Puerto Rico and an M.S. in construction management from Virginia Tech. He is a registered professional engineer in Georgia and Puerto Rico, and is a certified Project Management Professional®.

Dianne Gunther is a program analyst at the U.S. Department of Transportation's Volpe National Transportation Systems Center. She has a B.S. in civil engineering from Cornell University and an M.S. in transportation from the Massachusetts Institute of Technology.

For more information, see www.fhwa.dot.gov/GoSHRP2/Solutions/Renewal/R09 or contact Carlos F. Figueroa at 202-366-5266 or carlos.figueroa@dot.gov.

What's New Today Is Mainstream Tomorrow

The third round of Every Day Counts produced record milestones in the number of States incorporating innovations, creating momentum for the next round.

Faced with today's fiscal realities and customer demands for safe and efficient travel, transportation agencies are seeking ways to deliver programs and projects more effectively and deploy technologies and practices that save lives, time, and money. The Federal Highway Administration's Every Day Counts (EDC) program—after completing a successful third round in 2016—has proven this initiative works to solve those challenges. One after another, State and local agencies have challenged conventional practices and embraced innovations, often adopting them as new norms.

EDC—now in its fourth 2-year deployment cycle—provides tools and resources to help transportation stakeholders harness innovation to meet today's challenges. Through this initiative, FHWA partners with State agencies and other stakeholders to rapidly deploy proven innovations that enhance safety, shorten project delivery, and reduce congestion. The effort aims to foster a culture in which the transportation community embraces innovation.

by Thomas Harman

Many innovations promoted in EDC-3 are now in mainstream use across the country. For example, road diets, which reconfigure roadways' cross sections to improve use for all users, are now standard practice in 21 States.

EDC is tailored to State and local needs, enabling agencies to determine which innovations to deploy and how. FHWA supports deployment efforts with technical assistance provided by teams of experts and incentives offered through the Accelerated Innovation Deployment (AID) Demonstration grant and State Transportation Innovation Council (STIC) incentive programs.

FHWA launched EDC in 2009, and the program is included in the 2015 Fixing America's Surface Transportation (FAST) Act. The legislation directs FHWA to continue to work with stakeholders to deploy new practices and technologies and create a *culture of innovation* in the transportation community.

"Every Day Counts and other technology initiatives have really been critical in helping States save money and save time," says Bud Wright, executive director of the American Association of State Highway and Transportation Officials.

Innovation Milestones

Every Day Counts round three (EDC-3), which promoted 11 market-ready innovations in 2015 and 2016, had a significant positive impact on the transportation community's adoption of new technologies and practices. Every State adopted one or more of the EDC-3 innovations during the 2-year cycle, and many are now widely used across the Nation. In addition, many States began developing plans for future implementation of EDC-3 innovations by collecting information, participating in training, and learning about other States' deployment experiences.

Combined, every State has used 10 or more of the 32 innovations promoted in the first three rounds of EDC, while some have adopted more than 20! Several of the innovations, such as road diets and data-driven safety analysis, are now mainstream practices in many States.

Another EDC-3 milestone was the completion of the national network of STICs, which brings together stakeholders and champions in each State to evaluate innovations and spearhead deployment. STICs are active in all 50 States; Washington, DC; Puerto Rico; the U.S. Virgin Islands; and Federal Lands Highway, expanding the use of new technologies and practices, and fostering a culture of innovation.

"We're being more effective, we're being more efficient, we're saving lives, and we're really moving our transportation network in Pennsylvania into the 21st century," says Leslie Richards, secretary of the Pennsylvania Department of Transportation. "The State Transportation Innovation Council is a big piece of that."

Increasing Mobility and Safety with Road Diets

The widespread use of road diets is one EDC-3 success story. A road diet is a low-cost strategy that reconfigures a roadway cross section to better accommodate all users' needs, increase mobility, reduce crashes, and improve the quality of life in communities. In EDC-3, FHWA encouraged State and local agencies to consider road diets as a safety-focused alternative to better accommodate motorists and nonmotorists on mixed-use streets by reducing vehicle speeds and freeing space for alternative modes.

Road diets are now a standard practice in 21 States and Washington, DC. Another 25 States are demonstrating road diets on pilot projects and developing processes for identifying potential sites for roadway reconfiguration. FHWA continues to promote road diets in EDC round four (EDC-4) as one of the countermeasures in the Safe Transportation for Every Pedestrian—or STEP—program.

The New Mexico Department of Transportation (NMDOT) is one of the agencies that set a goal to institutionalize road diets during EDC-3. After reviewing other States' road diet policies and learning about their deployment experiences through a peer exchange, NMDOT developed its *Road Diet Guide* for practitioners to use in assessing the appropriateness of facilities for roadway reconfiguration. NMDOT introduced the guide in workshops for practitioners with the agency, planning organizations, local and tribal governments, and private industry. NMDOT also included road diets in its Strategic Highway Safety Plan as a crash-reducing countermeasure.

Targeting Investments with Data-Driven Safety Analysis

Another EDC-3 safety innovation many agencies pursued is data-driven safety analysis, which promotes the integration of safety performance into highway investment decisions with the goal of saving lives. Data-driven safety analysis uses the latest generation of software tools to analyze crash and roadway data.

EDC-3 focused on expanding the use of two approaches to data-driven safety analysis—predictive and systemic. Predictive approaches combine crash, roadway inventory, and traffic volume data to provide more reliable estimates of an existing or proposed road's expected safety performance. Systemic approaches screen a road network for features associated with severe crashes and identify low-cost safety treatments. Transportation

Every Day Counts Innovation Implementation Stages

Not Implementing	The State is not pursuing the innovation under EDC (in some cases the State has already implemented the innovation).
Development Stage	The State is collecting guidance and best practices, building support with partners and stakeholders, and developing an implementation process.
Demonstration Stage	The State is testing and piloting the innovation.
Assessment Stage	The State is assessing the performance of and process for carrying out the innovation and making adjustments to prepare for full deployment.
Institutionalized	The State has adopted the innovation as a standard process or practice and uses it regularly on projects.

Source: FHWA.

Innovation Deployment Assistance

FHWA offers assistance and resources to help States and their partners deploy the innovations in the Every Day Counts program.

FHWA assembles deployment teams for each EDC innovation to provide the transportation community with information, technical assistance, and training, including workshops and peer exchanges. Visit www.fhwa.dot.gov/innovation/everydaycounts/contacts.cfm#edc4 for a list of experts to call for assistance on innovations in current and past EDC rounds. For more details on the EDC program, contact Julie Zirlin, program coordinator for the FHWA Center for Accelerating Innovation (CAI), at julie.zirlin@dot.gov.

The AID Demonstration program awards funding up to $1 million for projects that use proven innovations in any project phase. Visit www.fhwa.dot.gov/innovation/grants/projects for an overview of 69 projects that received more than $47 million in AID Demonstration grants. For more details on the AID Demonstration program, contact Fawn Thompson, CAI program coordinator, at fawn.thompson@dot.gov.

The STIC Incentive Program provides up to $100,000 a year per State to help STICs make innovations standard practices. Visit www.fhwa.dot.gov/innovation/stic/incentive_2017.cfm for examples of how STICs are using incentive funds. For information on the STIC Incentive program, contact Sara Lowry, CAI program coordinator, at sara.lowry@dot.gov.

Another option is the use of an increased Federal share of up to 5 percent for projects that use innovative project delivery methods. This option incentivizes the use of innovation to help deliver projects more efficiently and deploy proven solutions that make a difference. For more information, visit www.fhwa.dot.gov/innovation/resources/increased_federal_share.cfm or contact Jeff Zaharewicz, CAI senior advisor, at jeffrey.zaharewicz@dot.gov.

agencies can apply the two approaches individually or in combination to better target highway safety investments and reduce crashes.

By the end of EDC-3, 14 States had institutionalized the use of data-driven safety analysis in safety management processes, while another 29 States and Washington, DC, were demonstrating and assessing the innovation. Nine States made data-driven safety analysis a standard practice in project development, and another 29 States and Washington, DC, were demonstrating and assessing it for full deployment. The effort to expand use of data-driven safety analysis continues in EDC-4.

During EDC-3, the Ohio Department of Transportation (ODOT) expanded data-driven safety analysis in its project development process by adopting the use of safety-integrated project maps on routine maintenance and resurfacing projects. The maps use predictive crash analysis methods from AASHTO's *Highway Safety Manual* to identify priority locations where safety improvements should be considered when programming a project that overlaps the areas. ODOT updated its applicable manuals and guidelines, and trained practitioners to implement this change to better target investments in safety improvements.

Enhancing Safety with Smarter Work Zones

EDC-3 encouraged the adoption of two strategies for smarter and more efficient work zones to enhance safety and generate time and cost savings: technology applications and project coordination.

Technology applications involve using intelligent transportation systems to manage work zone traffic. The technologies include (1) queue management systems that alert drivers to work zone backups so they can slow down safely and (2) speed management solutions, such as variable speed limit signs, which manage work zone traffic in real time.

Project coordination involves construction planning that minimizes the impact of work zones and generates time and cost savings through approaches such as coordinating work among agencies and combining multiple projects in an area.

By the end of EDC-3, 11 States had mainstreamed the use of technology tools and strategies to create smarter work zones and manage their impacts on traffic. Another 28 States, Puerto Rico, and Washington, DC, were demonstrating and assessing the use of technology applications in work zones. Nine States had made it a standard practice to use project coordination to reduce work zone impacts, while another 18 States and Washington, DC, were demonstrating and assessing project coordination strategies.

Data-driven safety analysis with advanced software tools can provide transportation agencies with the reliable data they need to make effective investments in safety improvements.

WisDOT used queue warning systems, including portable signs with the "stopped or slow traffic when flashing" message shown here, to improve work zone safety on two pilot projects. *Photo: WisDOT.*

The Wisconsin Department of Transportation (WisDOT) completed two pilot projects for queue warning systems in EDC-3 and began an evaluation of the safety, speed, and capacity improvements associated with each deployment. An initial evaluation showed a notable reduction in weekday crashes compared to another project in a similar area that did not use a queue warning system. WisDOT is working with a university partner to develop a decision support tool for the queue warning system to help identify future candidate projects.

Using GRS–IBS Technology

Interest from transportation agencies continued to grow for geosynthetic reinforced soil–integrated bridge system (GRS–IBS) technology during EDC-3. The technology, an EDC innovation since 2011, can help meet the country's need to build and replace small bridges by constructing low-cost, durable structures with readily available equipment and materials. GRS–IBS can save up to 60 percent in cost compared to standard construction, and the technology potentially requires less maintenance over its life cycle.

In EDC-3, 11 States adopted GRS–IBS technology as a standard practice and used it regularly where appropriate. An additional 25 States; Washington, DC; Puerto Rico; and Federal Lands Highway demonstrated GRS–IBS on projects or assessed their agency's use of the technology.

When the Rhode Island Department of Transportation (RIDOT), for example, replaced the East Shore Expressway and McCormick Quarry Bridges in East Providence, the agency used GRS–IBS abutments to reduce the travel disruptions to the public. The bridges,

Using geosynthetic reinforced soil–integrated bridge system technology enabled RIDOT to reduce the closure time significantly when it replaced the McCormick Quarry Bridge. *Photo: Oldcastle Architectural, Inc.*

which carry traffic between the East Shore Expressway and I–195, needed to be replaced because they were structurally deficient.

Using GRS–IBS enabled RIDOT to construct the abutments for the new bridges under the existing structures while the agency built the components of the new bridges on an adjacent lot. Once RIDOT completed the prefabricated bridge pieces, the agency closed the roads while crews demolished the existing structures and assembled the prefabricated components on the foundations. Using innovative methods cut the closure times for each bridge from an estimated 1-year replacement time to just 80 hours, saving significant construction time and related traffic delays for motorists.

Expanding 3D Model Applications

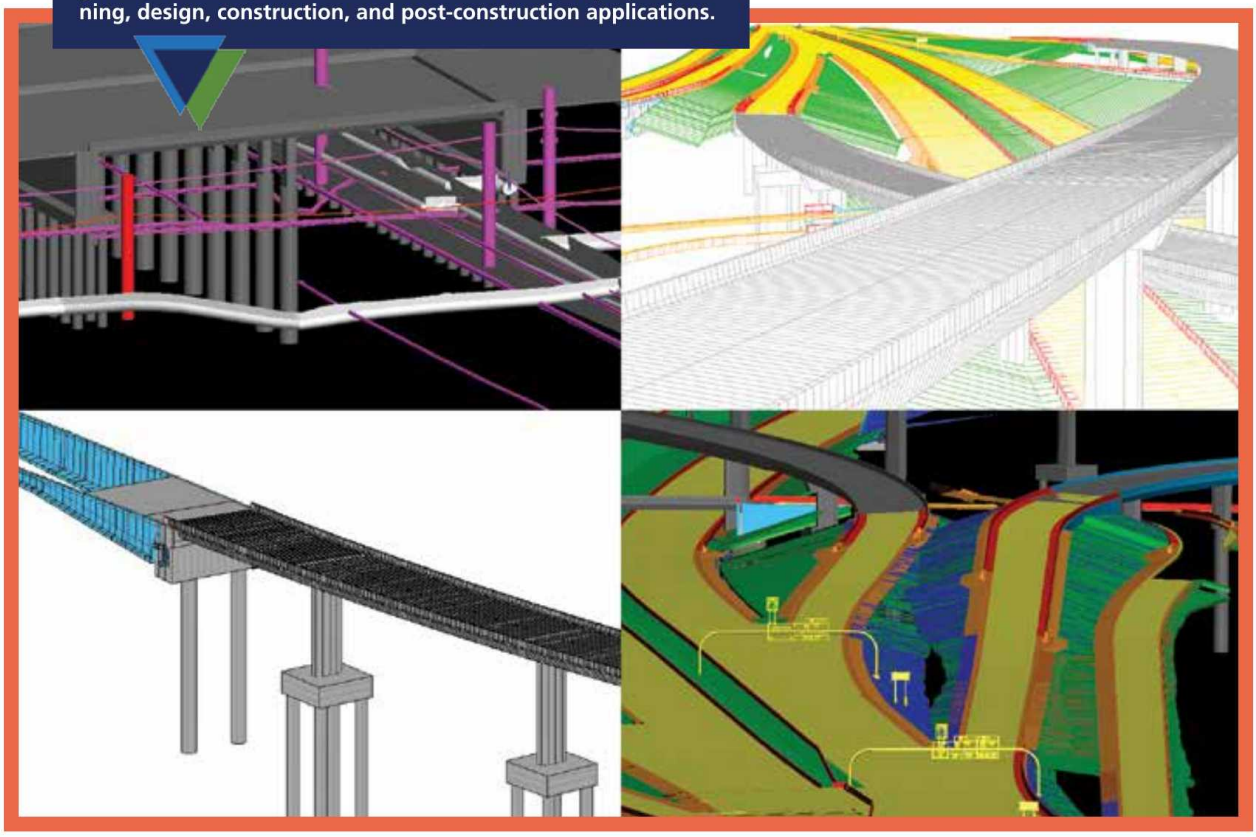
Three-dimensional (3D) engineered models are used widely by the transportation community to connect the planning, design, and construction phases of a project more effectively. Transportation agencies can apply 3D modeling to other phases of the project delivery cycle to positively affect safety, costs, contracting, maintenance, and asset management. Using 3D models can produce 4 to 6 percent savings on total project costs, and contractors have reported 15 to 25 percent increased efficiency in earthmoving operations.

After promoting 3D modeling in EDC-2, FHWA continued encouraging the innovation in EDC-3 to expand its use in planning, design, and construction. FHWA also encouraged agencies to adopt three additional practices: (1) using 3D survey data for roadway inventory and asset management purposes, (2) incorporating schedule and cost information in models to streamline construction schedules and improve cost estimating, and (3) using post-construction survey data to correct design models and create accurate as-built records.

By the end of EDC-3, 29 States and Federal Lands Highway were demonstrating and assessing 3D models in project planning, design, and construction, and another 6 States had institutionalized 3D models in those project phases.

EDC-3 also generated progress in using 3D models in schedule, cost, and post-production applications. Six States were demonstrating and assessing 3D models in schedule and cost applications by the end of the 2-year cycle, and New York and Wisconsin had institutionalized the practice. Seven States were demonstrating and assessing 3D models in post-construction applications, and New York had made it a standard practice.

A task force at the Arizona Department of Transportation spearheaded the deployment of 3D models for planning, design, and construction, focusing the agency's efforts on areas where 3D models could add value. One approach the agency pursued was providing electronic files to contractors at the prebid stage for the majority of large projects. Benefits included reducing printing costs and the time and cost of converting



During EDC-3, transportation agencies expanded use of 3D engineered models, such as the ones shown here, in project planning, design, construction, and post-construction applications.

Using e-Construction technologies enables project teams to streamline tasks such as accessing plans and recording data at jobsites, as these project managers are doing on their mobile tablets.

paper plans to electronic files. Providing files with vector control data on geographical features also enabled contractors to create 3D models more efficiently, improving bid quality and lowering costs.

Going Paperless with e-Construction

During EDC-3, FHWA also encouraged transportation agencies to exchange the paper-based approach to the management of construction documents with e-Construction. The e-Construction innovation is the collection, review, approval, and distribution of construction documents in a paperless environment. The EDC-3 effort, which continues in EDC-4, involved using readily available technologies to improve document management, saving money and improving communication.

Eleven States made e-Construction a standard practice in EDC-3. An additional 21 States, Washington, DC, and Federal Lands Highway were demonstrating and assessing e-Construction tools by the end of 2016.

The Florida Department of Transportation reports using e-Construction saves an estimated $22 million a year, the Pennsylvania Department of Transportation saves an estimated $18 million a year, and the Michigan Department of Transportation saves $12 million and 6 million pieces of paper a year. Across the 11 States using e-Construction as a standard practice, that equates to an estimated savings of about $190 million and nearly 8,000 trees a year.

The Iowa Department of Transportation considers itself 100-percent paperless from the pre- to post-construction stages. The agency achieved that goal in August 2016 when it added a requirement for all contracts to be signed digitally. It was the first State highway agency to require digital signatures on all construction contracts.

The Iowa DOT, which is working on a return-on-investment analysis to quantify its savings with e-Construction, uses mapping software on its mobile tablets to collect location data on pavement cores and samples and post-construction documentation on culverts, signs, and traffic signals. In addition, the agency is applying what it learned from a pilot project using paperless tickets for hot-mix asphalt at jobsites as it develops a specification for electronic ticketing.

Building on Success

After the successes of EDC's third round, FHWA is using that momentum to motivate the transportation community to deploy a new set of 11 innovations in 2017 and 2018 (EDC-4). FHWA experts continue to assist State agencies and their partners in implementing the innovations from EDC-4 and earlier rounds to enhance the Nation's transportation system and better serve those who use it.

"It's clear that when you deploy innovation and accelerated construction techniques," says Shailen Bhatt, the executive director of the Colorado Department of Transportation, "the public notices and that buys you credibility."

In addition to FHWA's ongoing partnerships and assistance, the national STIC network is leveraging the expertise of stakeholders throughout the country to foster an ongoing culture of innovation in the transportation community. As STICs mature, many are expanding their membership to a wider variety of public and private stakeholders and exploring opportunities to work with other STICs in their regions to advance innovation.

"One of the things that's been very beneficial in our partnership with the Federal Highway Administration is the idea of Every Day Counts," says Malcolm Dougherty, director of the California Department of Transportation. "The initiative is not limited to the 11 ideas in EDC-3. It's a mindset. It's a culture of innovation."

Thomas Harman is director of the FHWA Center for Accelerating Innovation. His transportation career spans more than 30 years in technology and innovation research, deployment, and education. Harman holds a bachelor's degree in civil engineering from the University of Maryland and a master's degree in civil engineering from the University of Illinois.

For more information, see Every Day Counts: Creating Efficiency Through Technology and Collaboration—EDC-3 Final Report (FHWA-17-CAI-005) *at www.fhwa.dot.gov/innovation/everydaycounts/reports/edc3_final.*

by Loretta W. Barren and Norah Davis

Watch for Me

North Carolina has established a promising program to reduce the number of bicyclists and pedestrians hit by automobiles. Could your State try something like this?

During the 5 years from 2010 to 2014, drivers on North Carolina roads were involved in an annual average of 2,623 pedestrian and 931 bicyclist crashes, and an average of 174 pedestrians and 22 bicyclists per year were killed.

(Above) As part of a Watch for Me safety operation, officers in Durham, NC, pull over drivers near a school for failing to yield to pedestrians at a crosswalk. *Photo: Laura Sandt, Watch for Me.*

During the first half of 2016, automobiles were involved in crashes that resulted in 96 pedestrian fatalities, according to the Governors Highway Safety Association. These kind of numbers make North Carolina "one of the least safe States in the U.S. for walking and bicycling," according to the Web site of the program formed to help counter these grim statistics.

Given this critical need to address pedestrian and bicyclist deaths and injuries on the State's roads, the North Carolina Department of Transportation (NCDOT), in partnership with local governments and community groups, developed a comprehensive safety awareness campaign. Called Watch for Me NC (the "NC" is part of the official name), the program is geared toward pedestrians, bicyclists, motorists, and police officers. Held annually, the Watch for Me program involves two key elements: (1) safety and educational messages directed toward drivers, pedestrians, and bicyclists; and (2) high-visibility enforcement by police to crack down on violations of traffic safety laws.

How Does It Work?

Each year, NCDOT invites selected communities to participate in the Watch for Me program. The initiative has expanded gradually, as funding permits, starting with a small pilot in 2012 and then adding approximately four communities annually. By 2016, a total of 25 towns and cities took part statewide.

"This is a long-term effort," says Laura Sandt, Ph.D., manager of the Watch for Me program and senior research associate with the University of North Carolina's Highway Safety Research Center, which administers Watch for Me. "The participating communities usually spend their first year establishing partnerships and conducting training for law enforcement officers. Then their programs take root and become more comprehensive over time."

Typically, municipal, county, or regional government staff lead their community's Watch for Me program. They partner with bicyclist and pedestrian advocates, city planners, law enforcement agencies, local engineering departments, public health professionals, school administrators, elected officials, and the local media.

The participating communities sponsor local events, such as giveaways of bicyclists' reflective gear at community festivals. The Watch for Me program provides safety messages at those local events and through areawide media campaigns. In addition to radio public service announcements, examples include bumper stickers reading "I brake for people"; internal bus ads to remind disembarking passengers, "Watch for turning cars"; and external bus ads for nearby drivers, "Yield to people in crosswalks."

The media campaigns are complemented by police training and then targeted law enforcement at high-risk locations, such as pedestrian crosswalks. In 2015, Watch for Me communities held more than 120 local events and 97 enforcement operations, directly reaching thousands of community members with safety messages.

Together, the various partner organizations apply some or all of the four E's during the Watch for Me programs: engineering, education, enforcement, and evaluation.

Engineering: Staff from police departments and engineers from local highway departments in the participating communities engage in activities such as conducting field checks at safety hotspots or sharing data. In addition, staff at the university's Highway Safety Research Center analyze data from crashes that involve pedestrians or bicyclists. The program also includes low-cost engineering improvements, such as signage and pavement markings, at selected high-crash crossings.

Education: Community partners provide educational and safety information to the public through articles and advertisements in local media and through social media and event-based outreach. The Watch for Me program supplies printed educational materials, which are funded by NCDOT. The program also developed the training courses for police. Officers in communities that are new to Watch for Me attend a full 1-day training session. Half-day refreshers are offered to police from communities that have continued to be active in Watch for Me.

Enforcement: During this phase of Watch for Me, law enforcement officers issue warnings and citations to drivers, pedestrians, and bicyclists who fail to follow the laws. In the process, the police educate these various users about safety on the roads.

Evaluation: NCDOT and the Watch for Me administrators, along with each participating community, conduct qualitative evaluations every year and quantitative evaluations occasionally. The program has recently received approval from NCDOT to conduct a crash-based evaluation, with the results anticipated by the fall of 2018.

So far, before-and-after preliminary crash data analyses are available only for the three counties (Durham, Orange, and Wake) that participated in the initial pilot program. The reduction in the crash rate (per 10,000 people) for pedestrians and

Students at Smith Elementary School in Durham received free bicycle helmets during an educational event on bike safety with the Durham Police Department. *Photo: Durham Police Department.*

Analysis of Crashes in the Triangle Region, 2007–2012

- 55 percent of bicyclist crashes occurred between May and September
- 76 percent of pedestrian crashes and 78 percent of bicyclist crashes occurred on weekdays
- More than 50 percent of bicyclist crashes involved those under 30
- More than 80 percent involved male bicyclists
- About 56 percent of vehicle-bicyclist crashes occurred at intersections or were intersection-related

bicyclists hit by vehicles in those counties was 5 percent, although the preliminary analysis has not yet accounted for other factors that might have increased or decreased crash rates during that time period. The pilot participants continued in the program, and from 2012 to 2015, researchers observed a total 32 percent increase in the rate of drivers yielding to pedestrians at crosswalks, on average, at the sites monitored. In addition, Watch for Me has produced a number of other benefits, some quite surprising (detailed later).

Funding Watch for Me

The Watch for Me program is a partnership between NCDOT, the university's Highway Safety Research Center, and local communities. The program originated in 2009 with funding from the National Highway Traffic Safety Administration. The initial years were spent conducting crash analyses and field investigations, developing partnerships, and establishing a stakeholders group that designed the program's logo, developed educational materials, and created the training course for law enforcement officers.

Currently, NCDOT and the Governor's Highway Safety Program provide the funding for Watch for Me. Additional funds for training materials and media purchases are contributed by the Federal Highway Administration's Safe Routes to School initiative.

"The North Carolina Governor's Highway Safety Program supports the Watch for Me initiative because it goes beyond the conventional educational efforts of many safety programs," says Don Nail, former director of the Governor's Highway Safety Program. "Watch for Me educates law enforcement officers, along with the public, on how to remain safe on roadways. Many officers require additional training on bicyclist and pedestrian issues so that they are completely comfortable when sharing their knowledge with motorists, pedestrians, and bicyclists, and also while enforcing the laws. The goal is to have Watch for Me implemented and practiced in each community in North Carolina, resulting in a safer environment for everyone involved."

Watch for Me Pilot

In 2012, Watch for Me initiated the pilot program in the Triangle region, which encompasses the four cities of Carrboro, Chapel Hill, Durham, and Raleigh in Orange, Durham, and Wake counties near the center of the State. In addition, the Triangle cities completed a program in each subsequent year from 2013 to 2016.

"As a result of the Watch for Me NC 2012–2013 campaign, we are seeing improvements at our new pedestrian islands and crosswalks with more motorists stopping, as required by law, and more pedestrians taking the care and caution necessary to pass through safely," says Chris Blue, police chief, Chapel Hill Police Department. "The campaign has helped familiarize residents with State laws for walking across the street, including the special care required at crosswalks, as well as safety messages that pertain to cyclists and motorists."

Highlights from the 2007–2012 crash data in the Triangle area indicated that bicyclist and pedestrian crashes with vehicles occur most often at intersections. The pilot determined that the largest percentage of pedestrian crashes (26 percent) occurred among persons ages 40–59, followed closely by those ages 20–29 (23 percent).

Watch for Me: A Mountain Community

Since the pilot, the program has provided assistance to more than 28 communities.

One new participant, Transylvania County, a small rural county in western North Carolina with approximately 33,000 full-time residents, became a Watch for Me partner in 2016, in collaboration with the county seat, the city of Brevard. The county and city are beginning an active enforcement phase.

According to Joy Fields, the county planner, participation in Watch for Me is facilitating communication between the city and the county's planning departments, the sheriff's office, and the city's police department.

"Our outreach partners have also included the Brevard College bicycle team, Blue Ridge Bicycle Club, and bicycle retailers throughout the county," says Fields. "We look forward to continuing our bicycle safety education and outreach efforts as we begin developing a countywide comprehensive bicycle plan made possible through a planning grant from NCDOT."

Mark Burrows, director of the county's planning and community development office, worked with Fields to prepare the application for the Watch for Me grant. When he started, he did not realize that he would become so personally involved.

"Last February, I was walking back to my office from a meeting at City Hall, and as I was crossing South Broad Street at Morgan, I was hit from behind by an SUV making a left turn," Burrows recalls. "Had the vehicle been traveling faster or 3 inches [8 centimeters] further out, it could have been all over." Burrows was taken to the emergency room with minor injuries.

When Burrows completed the Watch for Me grant application and conveyed it to NCDOT, he noted that he had done some personal research on the need for this type of program in Brevard. He recalls, "The [joking] response back was, 'That wasn't necessary.'"

Building Successful Watch for Me Programs

The program's success depends on coordination and cooperation across multiple government agencies,

During a simulation in Brevard, NC, prior to the launch of the enforcement phase, a driver receives a warning for failing to stop at a pedestrian crosswalk. John Harris, who is the son of Brevard's police chief, and Officer Charles R. "Rick" Harbin staged the photo in spring 2017.

local institutions, interested organizations, and advocates. Public support for the program hinges on the effectiveness of coordination among those participants.

The communities vary in the intensity of their programs. A small beach community might hold a single event, whereas a city like Charlotte might do several. And communities vary in the timing of their programs. Peak months for most places start in August when school begins and run through October. For beach towns, the peak starts in May and June when the tourists begin to arrive.

The beach towns face the challenge of reaching populations that have a constant turnover. Collaborations with hotels and tourist organizations have produced creative communications and outreach strategies such as tabletop safety displays in restaurants and refrigerator magnets in rental houses.

To support the initiative, NCDOT's safety awareness campaign includes advertising. During the peak 3 months of the 2015 program, the media buying company hired by NCDOT estimated that the campaign's ads were viewed more than 51.5 million times across the State. The advertising included billboards, ads on buses, radio spots, and even giant helium balloons.

"Many people have seen the signs on the buses and are aware of the placards and banners around town," says Seth LaJeunesse, former chair of the Carrboro Transportation Advisory Board. "More people in the last year have brought up pedestrian safety as a concern to the Board of Aldermen. The general sentiment is that Carrboro citizens are aware that pedestrian safety is a concern, and they are glad to see something being done about it."

Lessons Learned

As the program kicked off its sixth year in 2017, it did not start from scratch. Rather, the initiative built on the experiences of previous community participants, along with program outcomes and lessons learned. Thus the 2017 program year began with a wealth of knowledge, including do's and don'ts, although each program is tailored to the individual community.

Examples of the lessons learned include obtaining community buy-in through public education and outreach. Enforcement in the absence of targeted outreach and education can bring about false impressions, including tension between police and community members. This effect can be mitigated if residents are directly engaged in the program, understand its goals, and can share their own concerns about pedestrian and bicyclist safety.

Program leaders therefore suggest that communities start gradually and ease into enforcement. Police officers, after themselves receiving training and education, should consider issuing warnings, along with education about what a violator has done wrong, prior to issuing citations.

Overall, it has been suggested that the program consider increasing the intensity and visibility of officer training, improving awareness of child safety through walk/bike-to-school events, and creating a peer-to-peer program during which participating communities exchange information. Watch for Me

Sgt. Brian Massengill provided instruction on pedestrian and bicyclist laws to Durham officers in the Watch for Me program. *Photo: James Gallagher, HSRC.*

Reactions From Two Citizens

Durham Police Officer Douglas Beckett reported the following encounters with the public that took place on June 29, 2015:

"I was on W. Main Street, outside of Brightleaf Square at around 4:30 a.m. I saw a gentleman riding a bicycle without any lights on, so I pulled up next to him and asked if he could pull over to the sidewalk, which he did. I started my conversation by explaining that he was not in any trouble, but he needed to have lights on his bicycle. He explained that he was on his way to work on Hillsborough Road, and he asked me if I was going to give him a citation, so I replied that I was not, but I did need to give him a gift. He looked surprised when I got front and rear bicycle lights out of my car. I spent some time showing him how they work, how to replace the batteries, and I then installed them on his bicycle. We shook hands and he thanked me. As he started to ride away, I heard him say 'Wow, wow, wow.'

"About 10 minutes later, I was on Morris Street, and I saw a man jogging in the street, wearing a dark t-shirt and black shorts, he was very hard to see. I pulled up next to him and said 'Good morning sir, are you having a good workout?' He looked a little defensive and said 'Yes, I'm having a good workout, just working out.' I asked if I could have a quick word, and he agreed. I explained that I was proud of him for jogging, but he was very hard to see in the dark. I asked if I could give him something to help, and he said yes. I gave him one of the arm-bands, and I showed him the key holder pouch. He totally changed from defensive to ecstatic and said that he was meaning to look for some safety gear but had never got around to buying any. I helped him adjust it to his arm and thanked him for stopping to talk to me. He thanked me several times, took my name and badge number, and said that he would be writing in about me.

"From a patrol officer's viewpoint, these encounters really were the highlights of my shift. Everything we do on patrol helps somebody at some point, but it is rare that we get to see such positive results so quickly. I got great satisfaction from knowing that by those small gestures, two citizens were a lot safer now and also that they had a great experience with the police department. Please pass on my thanks to whoever provides the lights and arm bands."

offers sharing meetings and listservs for exchanging lessons learned.

Watch for Me Successes

The program has generated a number of safety-related and sometimes surprising outcomes. In some communities, Watch for Me helped to increase public awareness through police giveaways of bicycle lights in lieu of handing out citations for riding at night without a light. In other communities, bicycle shops and bicycle clubs provide rules-of-the-road training.

Among the outcomes, one town—Greensboro—has added information about Watch for Me to its transportation plans—safety information that otherwise might not have been part of the plans.

In a town in the Triangle area, Carrboro, the police department increased its pedestrian safety operations at certain targeted crosswalks from one to two per month, and began providing public recognition to bicyclists who obey the laws and cycle safely.

Some cities, notably Greenville, have incorporated a "good ticket" initiative in which police reward pedestrians for using crosswalks properly. The police partner with local businesses that provide the good tickets—coupons—for free coffee or other items.

Many participants reported that as a result of participation in the Watch for Me program, law enforcement officers have more clarity on bicyclist and pedestrian rules and regulations, and are better able to conduct enforcement. From 2012 to 2016, 37 police departments and more than 450 officers participated in Watch for Me training. They have gone on to conduct 360 targeted safety operations, resulting in 805 citations and more than 4,970 warnings. Participating officers have reported that they have not had any trouble with traffic citations being upheld consistently in court.

From 2012 to 2015, seven sites monitored in the Triangle area saw a 27-percent average increase in drivers yielding to staged pedestrians (members of the research team crossing marked crosswalks), and a 32-percent average increase in drivers yielding to actual pedestrians.

Future Steps

Continued community engagement combined with enforcement activities appears to be essential to success. Watch for Me is not a one-time venture; it requires ongoing outreach and community involvement, as well as continued enforcement by police. Because there are more citizens with eyes on the road than there are law enforcement officers, continuing to include the public in the process can be very beneficial.

Because both communities and law enforcement agencies in North Carolina have received Watch for Me favorably, the program warrants review and consideration by other States.

"Transportation professionals most often look for an engineering solution to reduce motor vehicle incidents with bicyclists and pedestrians," says John F. Sullivan III, administrator of FHWA's North Carolina Division. "However, the Watch for Me program offers a viable solution that addresses the behavior of all road users. The program educates bicyclists, pedestrians, drivers, and law enforcement officers on the rules of the road and the improved safety benefits of having more informed users."

Loretta W. Barren is a transportation planner in FHWA's North Carolina Division Office, which she joined in 2002. Before that, she worked as a transportation and land use planner for Winston-Salem and Forsyth County, NC, and as secretary for the Winston-Salem/Forsyth County Metropolitan Planning Organization. Barren graduated with a B.S. in business administration from Appalachian State University.

Norah Davis is the editor of PUBLIC ROADS.

For more information, visit www.watchformenc.org or contact Loretta Barren at 919-747-7025 or loretta.barren@dot.gov.

Along the Road

Along the Road is the place to look for information about current and upcoming activities, developments, trends, and items of general interest to the highway community. This information comes from U.S. Department of Transportation sources unless otherwise indicated. Your suggestions and input are welcome. Let's meet along the road.

Management and Administration

Secretary Chao Celebrates Opening of I–85 Bridge

In May, U.S. Secretary of Transportation Elaine L. Chao joined Georgia Governor Nathan Deal, Georgia Department of Transportation (GDOT) Commissioner Russell McMurry, and then Acting Deputy Administrator of the Federal Highway Administration Butch Waidelich at the site of the new I–85 bridge. The Secretary thanked the workers for their tireless efforts to build the replacement bridge, which opened less than 7 weeks after a fire caused its collapse and more than a month ahead of schedule.

GDOT

Secretary Chao speaks at the ceremony to reopen Atlanta's I–85 bridge.

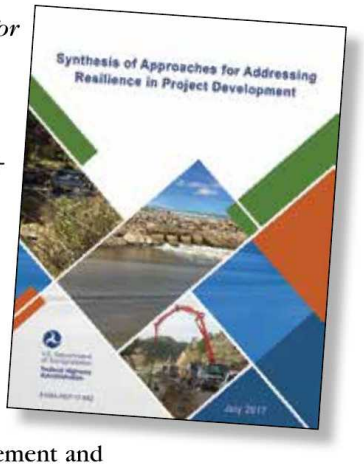
Until its collapse on March 30, 2017, the bridge on I–85 over Piedmont Road served an estimated 243,000 drivers each day. After the collapse, detours to side streets caused significant time delays and inconvenience for Atlanta-area commuters.

Using $10 million in quick-release funds from FHWA's Emergency Relief program, demolition began almost immediately. Workers removed more than 6,500 tons (5,900 metric tons) of debris and replaced about 700 feet (213 meters) of surrounding roadway and support columns. The replacement project relied on cutting-edge prefabricated components and state-of-the-art accelerated curing concrete, enabling the bridge to be completed quickly.

Additional Federal funds will be available to GDOT once a review of the project's overall costs has been completed. According to GDOT, fast and innovative financing for the contractor enabled the new bridge to open 5 weeks ahead of schedule—saving Atlanta-area commuters more than $27 million in congestion and detour-related delays.

Public Information and Information Exchange

Approaches for Addressing Resilience in Project Development



FHWA recently released *Synthesis of Approaches for Addressing Resilience in Project Development* (FHWA-HEP-17-082). The report provides lessons learned to help transportation agencies address extreme weather events during project development, and to consider ramifications for design of highways, bridges, and culverts.

Organized by engineering discipline (for example, coastal hydraulics, riverine flooding, pavement and soils, mechanical and electrical systems), the report identifies key lessons that may assist agencies when conducting their own analyses, summarizes the adaptation strategies considered in various case studies, and includes information on remaining knowledge gaps. In addition, the report provides information on why, where, and how to integrate climate considerations into the project development process, and basic information in related disciplines such as climate science and economic analysis.

Recent weather events have shown that some roads and bridges are already vulnerable to climate-related impacts; these vulnerabilities are likely to increase over time as the climate changes. As infrastructure is rebuilt or upgraded, there are opportunities to plan and design for increased resilience.

Many State and local transportation agencies recognize the need to make transportation assets more resilient to climate and extreme weather, but few methods and best practices exist to determine which assets may be impacted under future conditions and how to evaluate and select adaptation measures. To fill this gap, FHWA has conducted or supported many studies over the last decade that developed and tested methods for assessing project-level vulnerabilities and identifying and evaluating adaptation measures. This study collects and summarizes those methods and lessons learned.

For more information, visit www.fhwa.dot.gov/environment/sustainability/resilience/ongoing_and_current_research/teacr.

NHTSA Releases Distracted Driving Data

The National Highway Traffic Safety Administration works to reduce the occurrence of distracted driving and raise awareness of its dangers. The agency recently published *Traffic Safety Facts: Distracted Driving 2015*, which examines crash numbers by severity, the age of the

driver, and whether a cell phone was involved. The latest data show that 10 percent of fatal crashes, 15 percent of injury crashes, and 14 percent of all police-reported motor vehicle traffic crashes in 2015 were distraction-affected crashes.

A distraction-affected crash is any crash in which a driver was identified as distracted at the time of the crash. Discussions regarding distracted driving often center around cell phone use and texting, but distracted driving also includes other activities such as eating, talking to other passengers, and adjusting the radio or climate controls.

The majority of people killed and injured in distraction-related crashes are vehicle occupants, but nonoccupants including pedestrians and bicyclists make up 16 percent of distraction-affected fatalities.

For more information, visit https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812381.

NHTSA

TRB Publishes Student Papers on SHRP2

The second Strategic Highway Research Program (SHRP2) Safety Study, completed in 2015, collected an unprecedented amount of objective data on driver behavior and the driving context. The Transportation Research Board (TRB) recently published *Transportation Research E-Circular 221: SHRP 2 Safety Data Student Paper Competition, 2015–2016.* The publication contains papers submitted to the first student paper competition featuring applications of safety research from SHRP2.

TRB sponsored the competition to promote use of the SHRP2 data, to extract new insights and applications of the data, and to foster the next generation of leaders in surface transportation. The review panel for the competition selected six students to conduct their research proposals. The students received a data export, conducted their analysis, and were sponsored to attend the TRB Annual Meeting in January 2016 to present their results at a poster session. The students went on to develop research papers from their analyses.

The review panel selected three papers to publish. These student papers examine the topics of driver distraction, fault status in vehicle conflicts, and turning behavior. They are among the first research papers to be published using the SHRP2 safety data.

For more information, visit http://onlinepubs.trb.org/onlinepubs/circulars/ec221.pdf.

TRB

Arizona Launches Innovative Commercial Carrier Program

An Arizona Department of Transportation (ADOT) program aiming to reduce commercial vehicle wait times at the international border offered its first training in Mexico in April 2017. The training aimed to help Mexican trucking firms better understand and prepare for safety inspections.

Members of ADOT's Border Liaison Unit met in San Luis Rio Colorado, Mexico, with trucking company leaders, drivers, and mechanics. The goal is to make commercial travel across the border safer and more efficient by educating employees of Mexican trucking companies about what is required at ADOT's inspection stations in Douglas, Nogales, and San Luis, AZ.

ADOT

An ADOT inspector checks a commercial carrier at one of Arizona's inspection stations.

ADOT also has held training sessions in Douglas, Nogales, and San Luis, providing both classroom instruction and demonstrations of how ADOT's inspection stations work. In Mexico, the training offered an International Border Inspection Qualification program, through which drivers can receive a certificate documenting their training to help streamline the inspection process and enable ADOT inspectors to focus on drivers who have not completed the program.

In addition to helping ensure that trucks are ready to operate safely on Arizona's highways, the Border Liaison Unit's outreach has a direct impact on international commerce and on Arizona's economy. Arizona's trade with Mexico is worth an estimated $30 billion annually and supports 100,000 jobs, based on 2015 numbers.

ADOT

California Pilots Mitigation Credit System for Wildlife Crossing

In April, California's State wildlife and transportation departments signed a credit agreement for an innovative pilot project to create advanced mitigation credits for wildlife highway crossings. The California Department of Fish and Wildlife (CDFW) and the California Department of Transportation (Caltrans) developed the mitigation crediting system for the Laurel Curve Wildlife Habitat Connectivity Project on Highway 17 in Santa Cruz County. The system will transition to a statewide program being developed through the new Regional Conservation Investments Strategies Program.

Using the Laurel Curve project as a pilot, CDFW and Caltrans developed a model compensatory mitigation crediting system that can be used to mitigate impacts to wildlife movement for future transportation projects.

Caltrans

Laurel Curve, shown here in an aerial image taken by a drone, served as a pilot project to develop California's mitigation credit system for wildlife highway crossings.

The system calculates mitigation credits using a first-of-its-kind methodology, which takes into account the length of highway to be improved in lane miles or the project footprint in acres and the total cost of the project. When appropriate, Caltrans may sell or transfer the credits within Caltrans or to other transportation agencies with projects in the defined geographic area, thereby freeing funds for additional infrastructure projects.

CDFW's Habitat Conservation Planning Branch and the Caltrans Division of Environmental Analysis worked closely with the California Transportation Commission to formulate the credit agreement.

For more information, visit www.wildlife.ca.gov /Conservation/Planning/Regional-Conservation.

Caltrans

Survey Illustrates Crash Risks at Construction Sites

A recent report from the Associated General Contractors of America (AGC) highlights the risk to workers and motorists in highway work zones. Forty-four percent of roadway contractors said vehicles had crashed into their construction sites in the past year, a 13-percent increase from 2016. The association said that 82 percent of surveyed contractors reported that vehicle crashes pose a greater risk now than they did just 10 years ago.

© Sitirsbootr, Getty Images

Highway work zones such as this one in Portland, OR, present risks to roadway users and highway workers.

The association surveyed more than 700 contractors nationwide during March and April 2017. Of the contractors reporting work zone crashes, 49 percent said that motor vehicle operators or passengers were injured and 13 percent of those crashes involved a driver or passenger fatality.

Highway work zone crashes also pose a significant risk for construction workers. Survey results showed that 25 percent of work zone crashes injure construction workers and 11 percent of those crashes kill workers.

The crashes produce economic impacts as well. The association reported that 27 percent of contractors indicated that work zone crashes in the past year forced them to temporarily shut down construction activity. Those delays were often lengthy, as 52 percent of the closures lasted two or more days.

For more information, visit www.agc.org/news /2017/05/25/2017-highway-work-zone-safety-survey.

AGC

Personnel

Brandye Hendrickson Appointed FHWA Deputy Administrator

On July 24, 2017, Brandye Hendrickson was named Deputy Administrator of the Federal Highway Administration. In this capacity, she leads daily operations of the 2,900-person Federal agency that spans six time zones. She oversees the agency's $44 billion annual budget, directs execution of the Fixing America's Surface Transportation (FAST) Act, and serves as a co-chair of the U.S.–Canada Transportation Border Working Group and U.S.–Mexico Joint Working Committee.

Hendrickson's background in transportation includes 2 years serving as the commissioner of the Indiana Department of Transportation. There, she oversaw all aspects of the department's operations, from its 3,400 employees to its $400 million annual operating budget and billion-dollar annual construction budget.

Previously, Hendrickson served as deputy commissioner of Indiana's Greenfield District (the State's largest transportation district) from 2007–2015. She has nearly 20 years of business experience.

NATIONAL HIGHWAY INSTITUTE

Training Update

by Judy Francis

Changing How Engineers Think About Bridge Maintenance

The United States has a problem with its bridges: More than 30 percent are reaching the end of their design lifespan and need repair or replacement. Meanwhile, travel demands and the costs of labor and materials are increasing, while many budgets stagnate or fall. Bridge owners have become more reactive than proactive in their approach to managing and addressing their bridge program needs, leading to a "worse first" management style. Unfortunately, this strategy leaves bridges in good condition neglected until they too become a public burden or safety hazard.

Two new courses from the National Highway Institute (NHI), Fundamentals of Bridge Maintenance (course number 130107A) and Bridge Maintenance (course number 130108), offer a more strategic approach. By adopting effective bridge maintenance, bridge owners can save money, decrease environmental impacts, increase sustainability, and minimize traffic disruptions caused by major reconstruction.

Bridge Maintenance Basics

In Fundamentals of Bridge Maintenance, participants learn the foundational aspects of an effective bridge maintenance program. The course is a free Web-based training that participants can complete at their convenience over the course of 7 hours. In the course, participants learn about the importance of a balanced bridge maintenance program; the organizational structure, roles, and responsibilities of a bridge maintenance unit; and basic information about bridge inspections. The course provides an overview of bridge anatomy, common bridge types, and the intended functions of various components.

The course reviews the general concept of maintenance management systems and bridge management systems, the various steps and activities involved in the proper planning and implementation of bridge maintenance programs, and commonly used contracting methods for bridge maintenance.

Participants also study the principles of quality assurance and quality control measures used in bridge maintenance. The course provides an overview of bridge mechanics; basic hydraulic, scour, and channel erosion concepts; redundancy; and fracture critical details.

Participants review the basics of concrete as a bridge material, including proper mixing and testing processes, placement, finishing and curing processes, and methods for locating and removing unsound concrete. Finally, the course content highlights general maintenance considerations and practices related to ancillary items often attached to bridges, such as utilities and sign and lighting structures.

This course offers 0.7 continuing education units, and serves as a prerequisite to Bridge Maintenance, NHI's 4-day instructor-led training.

Extensive Hands-on Learning

Bridge Maintenance is a new training designed to replace NHI's former Bridge Maintenance 134029 course. The course reviews common defects and deficiencies, preventive maintenance techniques, and protective systems intended to prevent deterioration. Participants leave the class ready to investigate proper bridge maintenance procedures with the right resources and apply these practices on the job.

The training is interactive, blending lecture with group discussion; more than 40 videos; 18 different exercises, activities, and classroom demonstrations; and 5 different case studies. The case studies are based on examples from real bridge inspection reports, a common initiator for maintenance activities. For example, if an inspection report documented cracking of the bridge deck, course participants would determine the proper repair procedure and discuss what could have prevented or mitigated such cracking.

"The course focuses directly on what needs to happen to properly maintain our bridges and is as hands-on as you can get without being on an actual bridge," says Eric Thorkildsen, vice president at Greenman-Pedersen, Inc., and project manager of the course development team. "It explains why certain maintenance is necessary and shows participants the consequences of ignoring that maintenance. Each day the class works on real-life case studies, and it culminates in a group presentation on the last day of class."

Applying the Reference Manual

The Bridge Maintenance course also familiarizes participants with the updated and enhanced *Bridge Maintenance Reference Manual*, a valuable resource for bridge engineers and maintenance personnel. The manual was updated in 2016 from the 2003 version. The new online format offers more than 1,000 searchable pages of quick-reference information. It also includes numerous decision-

Greenman-Pedersen, Inc.

Instructors for NHI's Bridge Maintenance course facilitate discussion among classroom participants, offering frequent opportunities for learners to draw from their own relevant knowledge and experience.

aid matrices to help bridge engineers and maintenance personnel diagnose common bridge issues, as well as job-aid checklists that can help users determine the proper equipment, tools, personnel, and safety gear needed to complete common bridge maintenance activities.

Many of the learning activities in the course are tied directly to the manual. For example, the manual includes a 17-step procedure for the repair of vertical surfaces on concrete abutments. During one course activity, the class breaks into groups and each group is given a card showing one procedural step. Without checking the manual, the class must determine the proper sequence of each activity and place the cards in order. Participants then assess their solution using the manual.

NHI recommends its bridge maintenance courses for personnel from State and local departments of transportation and contractors with intermediate to advanced knowledge of general maintenance and repair activities. NHI also encourages individuals involved in onsite bridge maintenance and preservation, as well as supervisors and managers of these activities, to participate. Other individuals, such as designers and construction personnel, may also benefit.

An Award-Winning Combination

In spring 2017, NHI's bridge maintenance training received a Silver Award in the Engineering Excellence Awards competition in the category of studies, research, and consulting engineering services. The American Council of Engineering Companies (ACEC) of New York presents these awards to projects that encompass both the public and private sector. Each year, more than 60 member firms submit projects that are judged on a rigorous set of criteria, including complexity, innovation, and value to society. The panel of judges includes industry experts, such as military and government officials, ACEC national and international leadership, educators from college and university engineering departments, and leadership from other organizations dedicated to the built environment.

NHI Director Valerie Briggs (left) and Melonie Barrington, an NHI training program manager, accept ACEC New York's award.

For more information, to register for a session, or to sign up to receive alerts when sessions are scheduled, visit www.nhi.fhwa.dot.gov and search by course number.

Judy Francis is a contracted marketing analyst for NHI.

Internet Watch

by Carrie Boris

A Clear Resource for Older Road User Safety

Driving is a complex task. It depends on visual, cognitive, and physical functions that enable a person to see traffic and road conditions; recognize what is seen, process the information, and decide how to react; and physically act to control the vehicle. Functional decline associated with aging can affect driving ability.

Nearly one in five drivers is over 65 years old, and drivers over 65 are one of the fastest growing demographic groups among U.S. motorists. As the Nation's driving population ages, resources addressing the needs of those drivers become increasingly important.

To help, the Roadway Safety Foundation teamed up with the Federal Highway Administration, the National Highway Traffic Safety Administration, and two leading information technology developers to launch the Clearinghouse for Older Road User Safety (ChORUS) in late 2015 at www.roadsafeseniors.org. ChORUS serves as a centralized, user-friendly, and dynamic source of information on highway safety for aging drivers, passengers, pedestrians, and cyclists.

"ChORUS is a collaborative partnership designed to promote lifelong independent mobility for our aging population," says Guan Xu, a program manager in FHWA's Office of Safety.

The site's resources are as comprehensive as its audience is diverse. Highway engineers can find technical manuals; motor vehicle administrators can find State-by-State licensing policies; medical professionals can find the latest research; older drivers can find self-assessments and tips; and family and caregivers can find a supportive online community.

Built as a comprehensive resource, ChORUS covers all three major components of highway safety: safe roadways, safe road users, and safe vehicles.

Safe Roadways

Communities across the country can realize tremendous safety gains by implementing proven and cost-effective design features and crash countermeasures on their roads. From retroreflective signage that helps older drivers navigate at night to left-turn lanes that improve sight distance at intersections and prevent deadly right-angle crashes, infrastructure solutions are integral to enhance safety for the aging road user. ChORUS provides quick and easy access to design guidelines for the aging population, technical documents, case studies and success stories, and information about innovative financing solutions.

Safe Road Users

ChORUS includes a wealth of information designed to support aging drivers, from self-assessments and links to refresher courses, to State-specific licensing information. Recognizing that driving is simply not an option in all cases, the clearinghouse also promotes safe cycling and walking, provides support for families and caregivers concerned about their loved ones, and highlights alternative transportation options that may be available.

Safe Vehicles

The greatest risk to aging drivers is fragility that makes crash survival and recovery more difficult. As such, this is a group that especially stands to benefit from vehicle safety technologies both emerging (such as forward collision mitigation) and familiar (such as well-designed crumple zones). ChORUS promotes safer vehicles for seniors by featuring a range of consumer-friendly information, including education on how to interpret safety and crash ratings, overviews of cutting-edge technologies, and simple tips on helpful features to look for in any car (such as wider mirrors). The site also includes a wealth of resources for researchers, engineers, industry, the media, and others who help advance vehicle safety.

An Up-to-Date Resource

ChORUS is managed by a team of specialists in highway safety, gerontology, and information technology. A group of subject matter experts provides input on content governance and oversight. FHWA, through a cooperative agreement with the Roadway Safety Foundation, provides input on ChORUS content, tools, and programs related to safer road designs and best practices for improving community safety through infrastructure enhancements. NHTSA is responsible for information and resources pertaining to its areas of expertise, particularly driver behavior initiatives and motor vehicle safety, including recalls.

The resources on the site are organized into six categories: safer roads, being a safer road user, safer vehicles, family/caregiver resources and alternative transportation, research, and policy, enforcement, and medical fitness. Users can browse within categories, or search for specific information narrowed by category, resource type, State, and keywords.

"Staying active and connected can promote healthy aging," says Bruce Hamilton, director of Safety and Research Programs with the Roadway Safety Foundation. "ChORUS was developed with this ultimate goal in mind."

For more information, visit www.roadsafeseniors.org or contact Guan Xu at guan.xu@dot.gov.

Carrie Boris is a contributing editor for PUBLIC ROADS.

Communication Product Updates

Compiled by Lisa A. Shuler of FHWA's Office of Corporate Research, Technology, and Innovation Management

Below are brief descriptions of communications products recently developed by the Federal Highway Administration's Office of Research, Development, and Technology. All of the reports are or will soon be available from the National Technical Information Service (NTIS). In some cases, limited copies of the communications products are available from FHWA's Research and Technology (R&T) Product Distribution Center (PDC).

When ordering from NTIS, include the NTIS publication number (PB number) and the publication title. You also may visit the NTIS Web site at www.ntis.gov to order publications online. Call NTIS for current prices. For customers outside the United States, Canada, and Mexico, the cost is usually double the listed price. Address requests to:

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Analysis of Cracking in Jointed Plain Concrete Pavements (Summary Report)
Publication Number: FHWA-HRT-16-073

Premature cracking can severely degrade concrete pavement structures. Many studies have suggested that premature longitudinal cracking is caused primarily by improper construction or rehabilitation practices combined with heavy load repetitions.

This summary report discusses an investigation of the trends of longitudinal and transverse cracking in jointed concrete pavements based on data from the Long-Term Pavement Performance (LTPP) program's Strategic Study of Structural Factors for Rigid Pavements (SPS-2). LTPP SPS-2 is an excellent resource for studying long-term performance of jointed concrete pavements because of the availability of data for pavement performance, material properties, and environmental and traffic conditions.

Researchers identified the effects of slab properties, base type, traffic volume, and environmental factors on the occurrence and extent of longitudinal and transverse cracking from a simple analysis of the raw cracking data. They selected SPS-2 sites in Arizona and Arkansas to investigate cracking mechanisms in detail, proposed a new hypothesis for the prevalence of premature cracking on these sites, and tested the hypothesis using numerical simulations.

The researchers found that longitudinal and transverse cracking were more sensitive to slab thickness and base type than other construction variables. Surface cracking was worse in dry climatic zones than wet zones. Most transverse cracks initiated from the slab edge close to the shoulder, and two forms of longitudinal cracks can initiate from transverse edges of slabs: a single long crack or multiple short cracks along the whole section. In addition to inadequate compaction of the base layers during construction and rehabilitation, the major contribution to premature longitudinal cracking appeared to be voiding, or a lack of support underneath the entire length of the pavement, beneath the outer edge of the pavement. Voiding is caused by localized deformation of "depressurized" soil, which occurs principally because of slab curl, when the pavement curls upward or downward at the edges.

This document is available to download at www.fhwa.dot.gov/publications/research/infrastructure/pavements/ltpp/16073/index.cfm.

Optimization of Rib-to-Deck Welds for Steel Orthotropic Bridge Decks (Report)
Publication Number: FHWA-HRT-17-020

Highway agencies have used orthotropic steel decks for decades, especially on long-span bridges, because of their light weight and fast construction. However, fatigue cracking has been a maintenance nuisance because the geometries and direct wheel loading of these bridges create complex stresses that are difficult to predict using conventional design tools.

This report documents the results of fatigue testing of full-scale geometries of various orthotropic rib-to-deck welds. FHWA undertook this study to assess these weld geometries and potentially provide performance data that might alleviate restrictive specifications on fabrication. Currently, these restrictions reduce the

competitiveness of orthotropic steel decks compared to other alternatives.

Researchers explored variables such as the welding process and weld penetration. When the project began, the common practice in the United States was to use a one-sided, partial-penetration weld joining the rib and deck plates together, with a minimum requirement of 80-percent penetration. Restrictive requirements such as these result in a very narrowly defined welding procedure with little tolerance for variation. In practice, this leads to numerous weld repairs and rigorous inspection requirements that drive up the cost of orthotropic deck fabrication. Researchers found that the 80-percent penetration requirement could be significantly relaxed because fatigue performance was dictated largely by weld size and not by penetration.

This report is expected to benefit those interested in the design and fabrication of steel orthotropic bridge decks, including State transportation departments, steel bridge fabricators, design consultants, and researchers.

This document is available to download at www.fhwa.dot.gov/publications/research/infrastructure/structures/bridge/17020/index.cfm.

State of the Practice for Shoulder and Center Line Rumble Strip Implementation On Non-Freeway Facilities (Report) Publication Number: FHWA-HRT-17-026

The overall goal of FHWA's Roadway Departure Safety Program is to improve the safety of the Nation's highways through the reduction of roadway departure crashes. Roadway departures continue to account for more than half of U.S. roadway fatalities annually and nearly 40 percent of serious injuries, making such crashes a significant safety concern.

This report discusses research aimed at providing agencies with a framework for making decisions on how to implement rumble strips. It includes a literature review detailing research related to rumble strip design, noise and vibration testing methods and findings, impacts on bicyclists and motorcyclists, pavement condition impacts, pavement marking visibility, operational effectiveness, and safety effectiveness.

The report also provides a review of current practices. These include department policies and standard drawings for rumble strip implementation strategies, systematic installation criteria, currently used rumble strip dimensions, high-crash corridor installation practices, and special considerations and modifications.

Researchers conducted a gap analysis based on the literature and current practices reviews. The analysis identified that transportation agencies struggle with the optimal design and location of rumble strips given the geometry and context of the roadway. Also, agencies face challenges in identifying when noise issues will be a concern and determining the optimal sound level.

In addition, to date, no research studies have explored the impacts of rumble strips on pedestrian or bicyclist safety. Little quantitative research exists on the impacts of rumble strips on pavements or longitudinal joints. Moreover, few safety studies have reported the dimensions of rumble strips included in the research. This lack of data makes it difficult to identify the safety effectiveness of different designs, particularly narrower and shallower rumble strips.

This report is intended for safety engineers, highway designers, planners, and practitioners at State and local agencies involved with decision making related to rumble strips.

This document is available to download at www.fhwa.dot.gov/publications/research/safety/17026/index.cfm.

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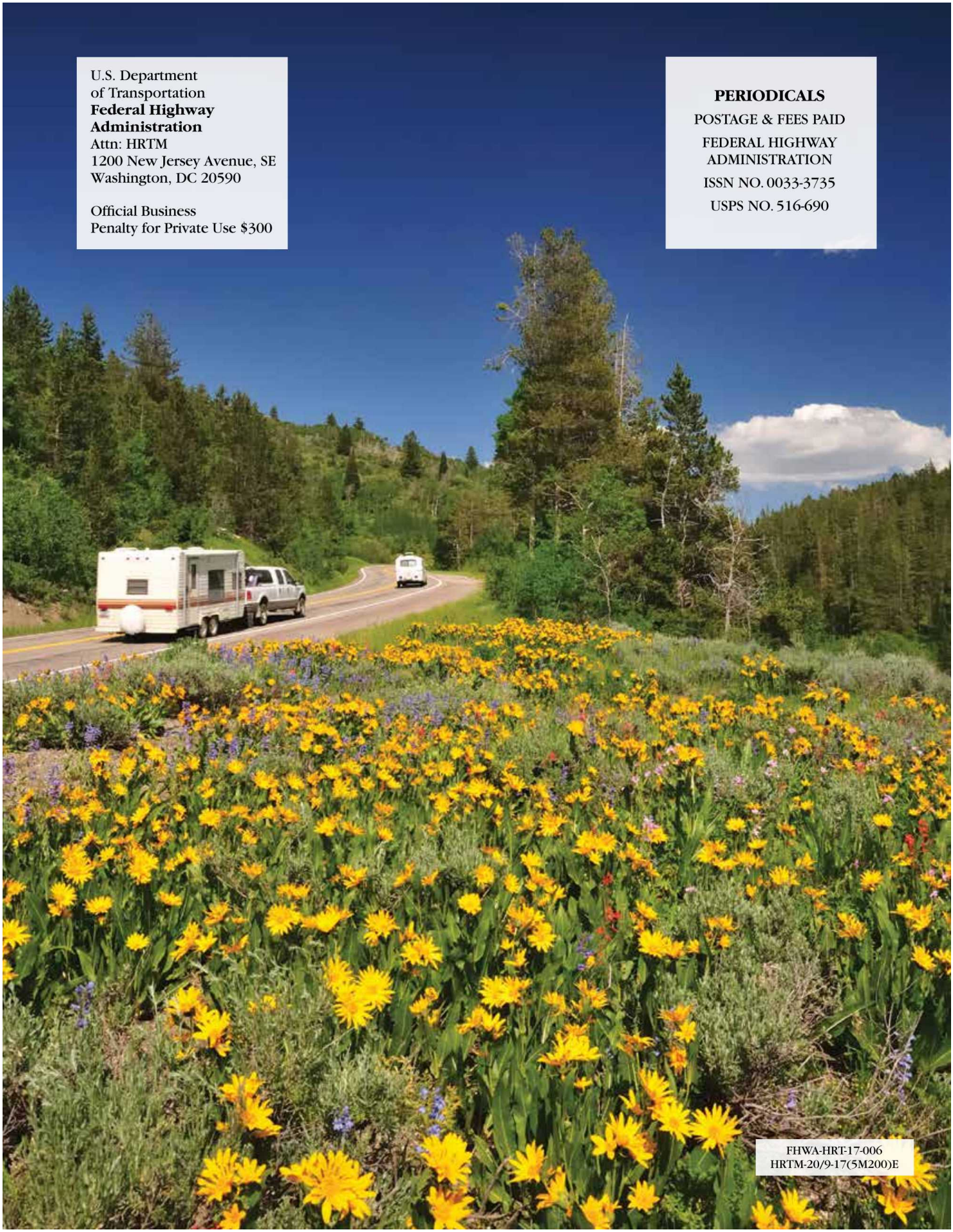
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