TR NEWS

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TRANSPORTATION AND THE ENVIRONMENT: MUTUAL ENHANCEMENTS

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COVER: The interconnection between transportation and the environment raises issues in project efficiency, historic preservation, and wildlife protection, such as in the case of the San Joaquin kit fox, an endangered species threatened by vehicle collisions. (Photo: B. Peterson, U.S. Fish and Wildlife Service)

TR NEWS

features articles on innovative and timely research and development activities in all modes of transportation. Brief news items of interest to the transportation community are also included, along with profiles of transportation professionals, meeting announcements, summaries of new publications, and news of Transportation Research Board activities.

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ALSO IN THIS ISSUE:

COMING NEXT ISSUE

Road and transportation congestion pricing—the various types in use and proposed, as well as their motivations—are examined in feature articles slated for the July–August *TR News*. Authors look at high-occupancy toll lanes, managed lanes, truck tollways, busways, uses of revenue, traffic flow and capacity, nontoll pricing, and tolling technology in the United States and abroad and consider the effects of congestion pricing on emissions reduction in Europe and on transportation planning practice.

PHOTO: DAVID GONZALEZ, MINNESOTA DOT

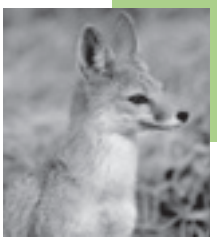
Road prices are posted for MnPASS users connecting to I-94 and Highway 100 outside of downtown Minneapolis, Minnesota. MnPASS allows solo drivers to use a high-occupancy vehicle lane by paying an electronic toll; fees are based on traffic levels in the express lanes to ensure traffic flows at 50 to 55 miles per hour and on the vehicle's entrance and exit points.

INTRODUCTION

THE ENVIRONMENT AND TRANSPORTATION

Making Both Better Than Before

ABBA LICHTENSTEIN



LA DOTD

The environment and transportation is the subject of this special issue of *TR News*, with diverse and informative contributions from members of the standing technical committees in the Transportation Research Board's (TRB) Environment and Energy Section. The Environmental Analysis in Transportation Committee shepherded the preparation of the articles, aware of a tradition of milestone special issues in this subject area: in May–June 1996, on waste and recycling; in July–August 2003, on air quality; and in September–October 2005, on noise.

Tracing out recent achievements, key developments, new directions, and research needs in each of the committees' areas of endeavor, the authors define the theme—and goal—of "making it better than before:"

- **Environmental analysis in transportation**—Agencies are putting 40 years of environment-related operating procedures into contexts of sustainability, increased efficiencies, and sensitivities, going beyond any single project or environmental document.
- **Transportation and air quality**—Transportation planners, air quality planners, and urban planners are collaborating to address transportation air quality conformity, for more informed decision making, applying advances in technology and research.
- **Ecology and transportation**—The toll of animal–vehicle collisions is staggering, and ecologists, planners, and infrastructure designers are working together to accommodate transportation needs and wildlife habitats in upgraded or new facilities.
- **Transportation-related noise and vibration**—Noise issues are being addressed in the contexts of the populations, the noise levels produced, the generating sources, the mitigation options, and the benefits and the disadvantages to entire communities.
- **Historic and archeological preservation in transportation**—Progress is being made in historic preservation related to transportation, and research is clarifying the value achieved and the needs ahead.

In each of the approaches described in these articles, collaboration associated with contexts is evident as a hallmark—addressing transportation needs successfully through environmentally sensitive solutions assisted by directed research. In addition, a Research Pays Off article showcases the contribution of practical research and innovation in solving a transportation-related environmental problem, and a sidebar article from the Center for Transportation and the Environment presents a working model for hands-on training in the principles of context-sensitive solutions.

These topics and other current key issues—such as transportation funding, climate change and global warming, and infrastructure maintenance—differ from the issues I encountered starting out in environmental analysis at the Missouri Department of Transportation (DOT) in 1986. In the early 1970s, 5-page environmental impact statements for urban 4-lane freeways were prepared by engineers who received project survey information from other state or federal agencies—the issues were local, and the agencies had the resources to offer surveys for DOT projects. Multiple regulations about environmental issues—such as wetlands, threatened and endangered species, environmental justice, and others—emerged in the mid-1970s. In the 1980s and 1990s, each issue received attention in transportation planning and design, and integration of the approaches led to more sensitive project solutions. In the 2000s, the approaches of collaboration with stakeholders and of applying diverse but integrated solutions advanced, along with a broader focus—looking "beyond the right-of-way"—on to regional and global issues and practical, yet sensitive, solutions.

More than transportation solutions and projects now are accommodating the environment—integrated transportation systems and environmental solutions are making not only transport but also the environment better than before—as documented in the articles in this issue.

—Mark S. Kross
Immediate Past Chair, TRB Environmental Analysis in Transportation Committee
Jefferson City, Missouri

EDITOR'S NOTE: Acknowledgment and appreciation are due to Charles (Muggs) Stoll, San Diego Association of Governments, who shepherded this issue of *TR News* as a member of the Environmental Analysis in Transportation Committee and now serves as committee chair, and to TRB Senior Program Officer Christopher J. Hedges for his guidance and advice.



POINT OF VIEW

Transportation and Environmental Sustainability

Taking "Making It Better Than Before" into the Future

RICK RECORD AND ANDRAS FEKETE

Photo: Louisiana Department of Transportation and Development

The environmental study for LA-1, which connects Golden Meadow, Louisiana, to Port Fourchon on the Gulf of Mexico, took only 44 months from start to finish.

Record is Principal, RL Record LLC, Cincinnati, Ohio, and Fekete is Manager, Special Projects, RBA Group, Parsippany, New Jersey.

The word "sustainability" shows up increasingly in every sector of transportation practice, from planning to pavement maintenance. The word raises expectations in regulators, elected officials, citizens, and interest groups—and those expectations are not limited to transportation. Economics, residential and commercial development, energy policy, agricultural practices, industrial management, and business philosophy are being shaped by expectations for a sustainable fit with the environment.

The U.S. federal transportation program, a high-visibility translation of public policy, is in the spotlight on this issue. Because of distinct expectations established by the National Environmental Policy Act (NEPA) of 1969, sustainability is part of the transportation decision-making process.[1] Practitioners and policy makers, however, have not always recognized or worked effectively with the many issues, components, and opportunities under NEPA's sustainability banner.

NEPA: 40 Years of Progress

Broad in scope and visionary in scale, NEPA was easily misinterpreted and commonly misunderstood in

[1] Section 101 of the National Environmental Policy Act of 1969 requires the "federal government, in cooperation with state and local governments…to use all practicable means and measures…to create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans."

its early years. Transportation—particularly relating to highways—offered perhaps the most difficult challenges. When NEPA arrived, the Interstate highway program was 14 years old, and roughly 70 percent of the system in place today already had been built.

Transportation's successes as of the mid-1970s made it hard to discern how environmental regulations could add value to the highway program. As a result, the first two decades and more of NEPA in transportation were characterized by insular analyses—often defending and documenting earlier decisions—instead of contributing to a comprehensive decision-making process. This pattern of response to NEPA, however, was characteristic of most federal agencies in that period, whether in transportation, land management, resource protection, or human health and welfare programs.

By the early 1990s, leadership discussion, policy research, agency guidelines, practitioner peer exchanges, and project-level applications began to refocus on the sustainability intent of NEPA and on the crosscutting, collaborative framework the legislation sought to develop. That framework was both the major challenge and the necessary foundation for addressing the Section 101 expectations for "productive harmony."

Today, codified regulations and specific guidelines for NEPA compliance are in force for more than 100 federal departments and independent agencies—including the U.S. Department of Transportation. Different approaches and perspectives, however, are applied to the priorities, needs, and concepts of environmental balance and sustainability, both in fulfilling topical environmental process requirements, and in working toward NEPA's "balance umbrella," which implies comprehensive, collateral harmony among regulations and processes. Each agency has overseen progress and successes in the application of NEPA in its nearly 40 years, but a new frontier is challenging traditional agency roles and rules.

Assessing NEPA

In 1995, on the 25th anniversary of NEPA, the President's Council on Environmental Quality (CEQ) undertook a retrospective on the successes and shortcomings of NEPA and provided some pertinent commentary on sustainability and practical applications:

> Overall, what we found is that NEPA is a success—it has made agencies take a hard look at the potential environmental consequences of their actions, and it has brought the public into the agency decision-making process like no other statute. In a piece of legislation barely three pages long, NEPA gave both a voice to the new national consensus to protect and improve the environment, and substance to the determination articulated by many to work together to achieve that goal. To that end, NEPA charges CEQ and all federal agencies with achieving "productive harmony" among our environmental, economic, and social objectives. NEPA directs federal agencies to open their doors, bring the public in, and offer genuine opportunities for participation and collaboration in decision making. Despite these successes, however, NEPA's implementation at times has fallen short of its goals. For example, this NEPA effectiveness study finds that agencies may sometimes confuse the purpose of NEPA. Some act as if the detailed statement called for in the statute is an end in itself, rather than a tool to enhance and improve decision making. As a consequence, the exercise can be one of producing a document to no specific end. But NEPA is supposed to be about good decision making—not endless documentation. (*1*)

Photo: Joseph T. Rummel, Jr., Connecticut Dept. of Transportation

Paving I-84 in Manchester, Connecticut, 1970s.

CEQ specifically pointed out the link between sustainability and societal aspirations:

> Clearly, NEPA is much more than environmental impact statements and environmental assessments. It is an eloquent and inspiring declaration which, well before the term "sustainable development" became widely used, called for the integration of our varied aspirations as a society. NEPA is a tool with tremendous potential to help build community and to strengthen our democracy. (*1*)

Point of View presents opinions of contributing authors on transportation issues. The views expressed are not necessarily those of TRB or TR News. *Readers are encouraged to comment in a letter to the editor on the issues and opinions presented.*

Seeking Sustainability

Embracing NEPA's intent and opportunities for sustainability involves several principles:

- Apply the appropriate scale to actions and analyses. In transportation projects, for example, this implies a perspective beyond the right-of-way.
- Give a front-and-center role to efficiencies, by any measure or category—energy, human resources, money, timeline, or interjurisdictional or political relations.
- Support sustainable decision making with alternatives developed through a broad, well-grounded thought process.
- In planning and NEPA analyses, aggressively advance the spectrum of considerations involving sustainable maintenance and operations.
- For integrated transportation, coordinate multiple modes to address multiple transportation needs and mandates for sustainability.
- Make stakeholder collaboration central, so that agencies and institutions must expand beyond their traditional boundaries to provide guidance and accountability.

Next Steps to Sustainability

Programmatic Solutions

Great progress has occurred on many of these fronts through interagency and multidisciplinary programmatic agreements. Nationwide, 52 programmatic agreements are addressing various parts of NEPA in various states, including categories of endangered species, Section 106 (historic preservation), Section 4(f), land management, and documentation procedures. But this is only the start of what programmatic solutions can do or imply—the goal is broad consideration of agency and stakeholder issues and needs in sustainable balance without undue focus on project-specific details.

Cleaning the Attic: Simplifying Analyses

Every attic needs a periodic cleaning out, including NEPA's. In some ways, specific, approved methods in approach and analysis may impede a more complete consideration of sustainability. Complex analyses of a single, high-profile issue may be missing opportunities for simpler, more effective solutions for the long term that provide greater benefit in less visible categories of sustainability.

New Disciplines for Analysis

The disciplinary approaches to NEPA need to keep pace with evolving technology or with policy and societal expectations for sustainability. The growing inventory of geocoded data and imagery, for example, may provide for the next level of progress in streamlining the environmental review of projects. New disciplines not yet identified or defined will be needed to integrate and translate the growing amount of primary data into program and project decisions under NEPA.

Sustainable Balance

Highly polished and well-reinforced traditional agency perspectives are on notice in the next level of sustainability under NEPA, whether the agency is focused on transportation or resource protection. The ability to understand and place a mutually understood value on the elements of sustainable balance in any NEPA-based decision will become increasingly important for cooperating agencies. These tenets are taking hold in the multiagency Eco-Logical ecosystem-based approach to infrastructure.[2]

Visions for the Future

Strengthening Implementation of Section 101

An executive order should require each federal agency of the executive branch to adopt a comprehensive, agencywide environmental policy, as defined in Section 101 of NEPA. This would bestow a stronger and clearer mandate to the many efforts launched under stewardship, sustainability, smart growth, context-sensitive solutions, placemaking, climate change, Eco-Logical, environmental management systems, low-impact development, and other environmental initiatives. The executive order would pull the initiatives together, help managers make organizational and program adjustments efficiently, reduce the need for extensive efforts to justify actions, and strengthen and synchronize efforts by the 50 states to meet the nation's environmental goals.

Reciprocal Consultation

Federal agencies should revise their rules for regulating, planning, funding, or implementing their programs to require formal consultation with the transportation sectors of government. After 40 years of outreach efforts by the transportation sector, achieving full, reciprocal consultation among all agencies promises to save millions of dollars on wasted process, yielding enormous program implementation benefits for the public.

For example, the Clean Water Act (CWA) rules do not require extensive public and agency consultation for sewer infrastructure planning. Although transportation rules and policies require outreach on matters involving impacts on water quality, wetlands

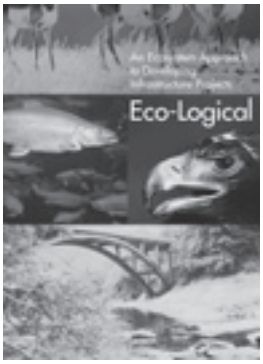


Photo: Federal Highway Administration

Eco-Logical is a multiagency ecosystem-based approach to infrastructure.

[2] www.environment.fhwa.dot.gov/ecological/eco_index.asp.

protection, and other CWA issues, the CWA rules have no reciprocal mandate. Yet the availability of sewer and water infrastructure often facilitates new development, and the new residents and neighbors then need transportation relief. The joint planning of infrastructure would save money and improve quality of life.

Clean the Attic

A risk-based rationale should be applied to eliminate those components of transportation impact analysis and project development that disproportionately consume resources and time in relation to environmental risks, both human and natural. Over the years, environmental impact analyses have steadily accrued information—the intentions are good, but no limits have been set. Although some progress has been made through streamlining reviews, the time and resources tied up in ineffective or inefficient processes are significant.

Programmatic Solutions

Transportation agencies and stakeholder agencies should review each other's short- and long-range plans and programs regularly, to identify opportunities for collaboration, cost sharing, and resource banking, to enhance program delivery and expand environmental benefits. Possible initiatives include storm water mitigation banking, wildlife management programs, and recovery plans for threatened and endangered species.

For example, the process for developing a state implementation plan–tribal implementation plan for transportation conformity under the National Ambient Air Quality Standards might serve as a model for a new programmatic process for environmental compliance in addressing stormwater impacts in watersheds. Archaeological mitigation banking, driven by agreed-on research priorities, might free up projects of low research interest from survey work and allow increased focus on projects of high research interest. This would spend public resources on important research questions and would streamline program delivery.

Manage the Disciplines

Strategic oversight is needed to guide the growth of transportation impact analysis and of new disciplines for efficient and effective decision making. Although public value is added when new tools, processes, and disciplines improve quality, save money, or streamline results, the risk is that human and financial resources may be spread too thin. Without a strategic vision, new processes can bog down and fail to produce a public benefit.

Photo: Charlotte-Mecklenburg Storm Water Services

Edwards Branch in Charlotte, North Carolina, was restored as part of the Edwards Branch Watershed Improvement Project.

Door-to-Door Approach

Stovepipe programs for transportation infrastructure development—segmented into highway, road, bike, pedestrian, transit, paratransit, maritime ports, airports, and so on—should be replaced with a destination and function approach, without strict regard to modal program responsibilities. Transportation service improvement is no longer a modal process. A door-to-door approach can integrate and improve available means and choices of mobility to reach destinations. The approach can streamline NEPA processing by offering integrated, sustainable transportation and mobility solutions, and by replacing the often perfunctory modal alternatives analysis required for NEPA, which a single sponsor agency may not have full authority to deliver.

Beyond Our Sphere

Transportation decision makers will need to understand and account for things beyond the horizon but that have a link to sustainability. Early seafaring explorers could see only 14 miles to the horizon from the average ship, but things beyond their field of vision were clearly influential. Today, international trade issues are increasing in importance, and a new era of space flight and transport is just beyond.

This brief list of future visions does not encompass sustainability in the context of NEPA but traces some initiatives that could lead multiple agencies in a collaborative direction with prospects for more effective, integrated, sensitive, and sustainable solutions.

Reference

1. *The National Environmental Policy Act: A Study of Its Effectiveness After Twenty-Five Years*. Council on Environmental Quality, Executive Office of the President, Washington D.C., January 1997.



Air Quality Management

Successes and Emerging Challenges

JEFFREY HOUK AND MICHAEL CLAGGETT

The authors are air quality specialists with the Federal Highway Administration Resource Center; Houk is in Denver, Colorado, and Claggett in Santa Fe, New Mexico.

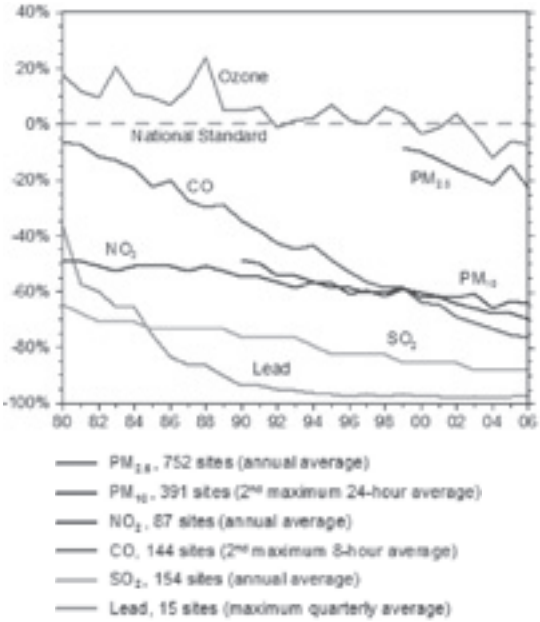
Solving the air pollution problems caused by transportation, particularly from highways, has been a focus of U.S. policy makers for decades. California introduced the first pollution control requirements on new motor vehicles 40 years ago. The federal government took legislative action via the Clean Air Act (CAA) and the National Environmental Policy Act, both introduced in 1970. Today, the Environmental Protection Agency (EPA) has the responsibility to set, review, and revise the National Ambient Air Quality Standards (NAAQS).

Targeting Pollutants

The NAAQS focuses on six criteria pollutants: carbon monoxide (CO), ozone, particulate matter (PM), nitrogen dioxide, sulfur dioxide, and lead. Highway sources contribute significantly to emissions of CO, the precursors of ozone, and PM; the other pollutants derive primarily from industrial sources.

Since the introduction of air quality standards, the United States has reduced the levels of criteria pollutants (Figure 1). Between 1980 and 2006, aggregate emissions of the criteria pollutants have decreased by 49 percent, despite an increase of 121 percent in the gross domestic product; of 101 percent in vehicle miles of travel (VMT); of 32 percent in population; and of 29 percent in energy consumption (*1*). Nevertheless, ground-level concentrations of ozone and fine PM continue to provide challenges in many areas of the country—in 2000, more than 100 million people were living in counties that exceeded the NAAQS limits for these pollutants (*1*).

FIGURE 1 Comparison of criteria pollutant levels to the National Ambient Air Quality Standards (*1*). National levels are shown, which are averaged across all sites with complete data for the time period.



Smog in Atlanta, Georgia.

Concerns about climate change have increased attention on the greenhouse gas (GHG) emissions from the transportation sector. Transportation is the largest source of carbon dioxide (CO_2) emissions in the United States and is the second-largest source of all GHG emissions combined (*2*). The U.S. highway system is the world's fourth largest emitter of CO_2, after China, Russia, and the rest of the United States (*3*).

In the past decade, transportation air quality activities have focused on mobile source air toxics (MSATs), which have adverse health effects but are not subject to ambient air quality standards. MSATs of particular concern are benzene, a carcinogen; 1,3-butadiene; and diesel PM. In addition, EPA has identified dozens of other chemicals that are emitted by motor vehicles and that can lead to adverse health impacts.

Air Quality Successes

CO Attainment

In 1990, EPA designated nearly 90 communities in nonattainment of the ambient air quality standard for CO; today only 3 remain in nonattainment. Since 1990, EPA has observed a decreasing trend in CO emissions nationwide (*1*); from 1990 to 2006, the second maximum 8-hour average concentrations of CO decreased by 62 percent. Transportation remains by far the largest source of CO emissions, but the decrease was attributable in part to technological advances, namely the catalytic converter and oxygenated fuels.

Emissions Reduction Technology

In the past 30 years, drastic changes have occurred in emissions reduction technology. Computer-controlled fuel injection systems have replaced the carburetor; catalytic converters and evaporative emissions control systems are commonplace; and on-board diagnostic computers monitor the fuel and emissions control systems and notify the driver of any problems.

In addition, new materials—including high-strength steels, ceramics, and carbon fiber—have reduced vehicle weight and fuel consumption. Hybrid-electric drivetrains are available on several vehicle models, and advanced electric drive technologies, including fuel cells, plug-in hybrid vehicles, and all-electric vehicles powered by lithium batteries, are being tested on the road. New fuels, such as biodiesel and cellulosic ethanol, are starting to reduce the carbon footprint of the fuel supply, improving U.S. energy security at the same time by reducing dependence on imported oil.

Transportation Conformity

The CAA requires that transportation planning conform to the goals set in air quality planning. Long-range transportation plans therefore cannot generate emissions that exceed the targets set in air quality improvement plans. This conformity requirement has led to better coordination between air quality and transportation planners, improvements in travel and air quality modeling, and better-informed decision making.

Congestion Mitigation and Air Quality

The Congestion Mitigation and Air Quality (CMAQ) Improvement Program provides funds to transportation agencies for projects that reduce criteria air pollutants from transportation-related sources. The legislation requires agencies distributing CMAQ funds to give priority to diesel engine retrofits and to other cost-effective emissions reduction and congestion mitigation activities that provide air quality benefits. A 2002 review of CMAQ by a National Research Council–appointed committee found that the program had been successful in achieving its intended objectives, but that improvements could be made in quantifying the benefits from projects (*4*).

Photo courtesy of Portland General Electric

Portland General Electric's charging stations support both plug-in electric and plug-in hybrid vehicles, a step in reducing vehicle emissions.

Emissions Modeling

Models have been developed to quantify the differences in air quality emissions from changes in travel activity. Advances in urban travel demand modeling have helped planners simulate real-world travel activity. For instance, EPA's MOBILE6.2 emissions model has improved the characterization of vehicle emissions under different conditions, and EPA's MOVES model promises additional improvements.

New measurement technologies have improved the scientific understanding of emissions under various conditions and have improved emissions estimates. For example, portable emissions monitoring systems can measure tailpipe emissions as a vehicle drives down the road. Other research includes advanced traffic counts, speed studies, and instrumented vehicle studies to characterize vehicle activity.

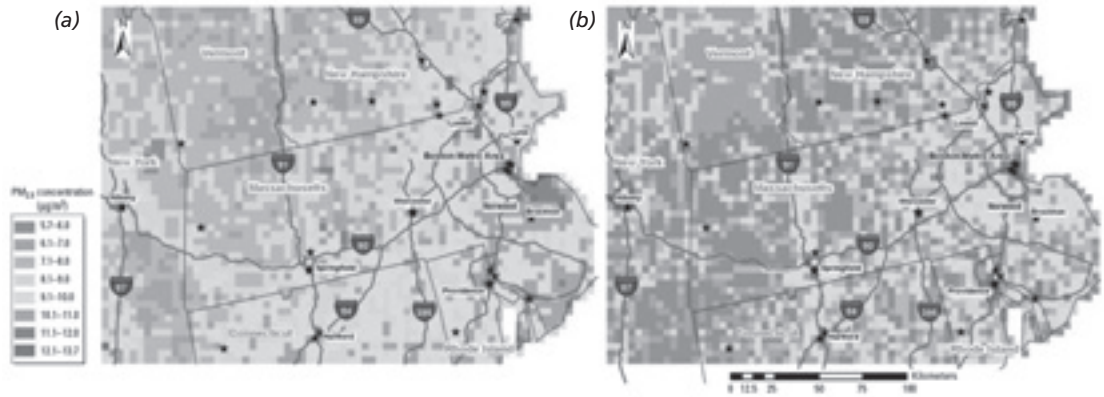
Future Challenges

Thirty years of research and experience have improved understanding of transportation-related air pollution, but new issues require attention. Following are some of the key air quality challenges facing the transportation community in the next decade and beyond.

Tighter Air Quality Standards

EPA periodically revisits each of the criteria pollutant air quality standards and makes adjustments as necessary. In the past 3 years, EPA has tightened the standards for ozone and PM. As a result, more areas are or will be in nonattainment.

These nonattainment areas will need to identify new control strategies to reduce emissions and comply with the standards. Some of these areas are having to comply with the CAA transportation conformity requirements for the first time, and local officials will need to understand the regulatory



Mean concentrations of particulate matter (PM) with diameters ≤ 2.5 μm during an entire modeling period (*a*) predicted by the aerosol optical depth (AOD) model and (*b*) by the non-AOD model. Stars represent the U.S. EPA monitoring sites.

requirements and the necessary modeling tools. Another problem is reconciling the trade-offs when mitigation strategies reduce the emissions of one pollutant but increase the emissions of another.

PM Hotspot Analysis

For a long time, EPA has been concerned that PM hotspots—that is, areas of elevated PM concentrations—may develop in the vicinity of highway and transit projects. A lack of adequate modeling tools, however, has delayed the quantitative analysis of potential PM hotspots; improved models are expected to be available soon, and agencies will be required to calculate the PM concentrations near proposed projects. Departments of transportation nationwide will need to develop expertise in the tools for performing this analysis.

MSATs and Roadside Health Issues

Epidemiological studies of occupational exposure to high concentrations of some MSAT compounds have documented adverse human health effects, including cancer and irritation of the respiratory tract. Recent roadside epidemiological studies also have raised health issues; some report that proximity to roadways is related to adverse health outcomes, particularly respiratory problems. As a result, government agencies are concerned about public exposure to MSATs.

The policies applied to MSATs and to other roadside health issues—as well as those crafted to deal with criteria air pollutants—have significant gaps, however. In 2001 and 2007, EPA issued rules to control MSATs through motor vehicle emission and fuel standards, and FHWA released guidance for gauging the potential impacts of proposed highway projects. But other strategies adopted for criteria pollutants do not apply to MSATs, including the clean air goals or criteria set by the NAAQS, the transportation conformity process, and the CMAQ program.

The Health Effects Institute (HEI) has completed objective reviews of the health issues that result from exposure to MSATs (*6, 7*). The findings show that exposure to many MSATs comes from sources other than vehicles. HEI concluded that the data in most cases are insufficient for assessing the effects of ambient concentrations on human health; for example, considerable uncertainty remains about the lowest concentration associated with adverse health effects from benzene exposures. No national consensus has been reached on acceptable levels of MSAT exposure.

Congestion Implications

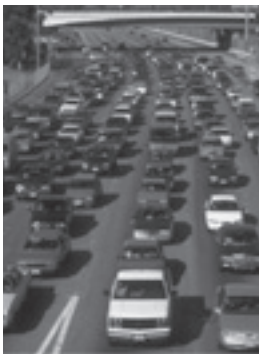
As travel activity grows and new infrastructure does not keep pace, congestion has increased on urban and rural roadways. Congestion has implications not only for air quality, because vehicle emission rates are generally higher under congested conditions, but also for energy consumption and GHGs, because vehicles are less efficient under congested conditions. If congestion is not addressed and the trends continue, fulfilling air quality goals and climate change goals will be more difficult.

Improving Emissions Models

New air quality challenges have led to the need for better models. The transportation community needs better tools to assess the finer-scale impacts of projects on PM and MSATs. Better local-scale tools would improve understanding of the energy consumption and GHG impacts of projects, as well as of the travel activity impacts of smart growth projects.

In 2009 and 2010, transportation agencies will need to develop expertise in EPA's MOVES model, which will replace the MOBILE model used since the 1970s. The differences in emissions estimates between MOVES and California's Emfac model also will need to be reconciled.

Better integration of transportation models and air quality models will help planning agencies meet the growing demands of transportation and air quality analyses. Also needed are better projections of future VMT growth, including a better understanding of the effects on VMT from increased fuel prices and from changes in demographic trends.



Addressing Climate Change

Significant steps have been taken to reduce GHG emissions from the transportation sector and to prepare areas for the possible future impacts of climate change. Examples include the aggressive fuel economy standards and renewable fuels program of the 2007 Energy Independence and Security Act (*5*), and voluntary programs to reduce transportation GHG emissions, such as the SmartWay Transport program to reduce emissions from hauling freight.

The United States is also a hub of climate research. In March 2008, the Transportation Research Board, working with the National Research Council's Board on Earth and Life Studies, published a special report on the potential impacts of climate change on transportation (*8*); and FHWA issued a study on the effects of potential climate changes on the highway infrastructure of the Gulf Coast—the first-ever attempt to quantify mode-specific climate impacts in a specific region of the United States (*9*).

More than 30 states have adopted climate action plans. Most of these include actions to reduce transportation GHG emissions through cleaner vehicles and renewable fuels, through increased public transit, and through the implementation of smart growth strategies to reduce growth in VMT. About half of the plans include requirements to analyze the potential GHG emission impacts of transportation plans or individual projects.

Climate change raises two challenges for transportation:

- Mitigation, reducing GHG emissions; and
- Adaptation, preparing for the impacts of climate change on transportation infrastructure.

On the mitigation side, major reductions are needed in transportation GHG emissions to achieve the levels that scientists have determined are necessary to avoid the worst impacts of climate change. The new programs in the 2007 energy bill will halt the increase of transportation-related GHG emissions but do not provide substantial reductions.

Addressing transportation GHG emissions requires a comprehensive suite of measures, including more fuel-efficient vehicles, cleaner fuels, smarter development to reduce per capita VMT, increased public transit, and carbon sequestration. Many of these activities will yield additional benefits, such as reduced urban air pollution and greater energy security.

Adaptation poses a significant challenge because of the uncertainty about the timing and magnitude of climate impacts. Transportation agencies routinely make investment decisions for infrastructure that will last many decades, and decisions made today can help prevent costly impacts in the future. Tools are needed to help planning agencies factor climate vulnerability and risk into the decision-making process. Although much work is under way, the 2008 TRB and FHWA reports offer valuable advice to help agencies get started.

Vehicle in the SmartWay Transport Partnership, an innovative collaboration between the U.S. Environmental Protection Agency and the freight industry to increase energy efficiency while reducing greenhouse gases and air pollution.

Applying the Framework

The study of transportation's impacts on air quality has increased in complexity in the past three decades. Despite many successes, new challenges have arisen.

A comprehensive policy framework, established to control the criteria air pollutants, was a major contributor to many of the successes. Can this same framework be applied or adapted to meet the new challenges? Dedicated professionals in the field, with broad expertise and experience, will continue to work to improve air quality through research, innovation, and implementation of strategies to reduce emissions.

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Transportation Ecology and Wildlife Passages

The State of the Practice and Science of Making Roads Better for Wildlife

PATRICIA C. CRAMER AND JOHN A. BISSONETTE

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Transportation ecology is a newly developed science that focuses on the interactions of organisms and the environment with transportation infrastructures and vehicles (*1*). A major goal is to understand the effects of roads on wildlife populations and the effectiveness of measures to assist wildlife over and under roads—to prevent collisions with vehicles and to help wildlife move across the natural landscape.

The practices and science to accommodate wildlife along transportation corridors aim to maintain safety and ecological integrity. In the past, transportation systems often were built with little regard for the need of wildlife to move. As wildlife–vehicle collisions with large animals, such as deer and moose, became more of a problem, the safety issues of wildlife on the road began to be addressed, mainly by fencing roads and installing wildlife crossings.

As the ecological effects of roads on wildlife and fish populations and on ecological processes such as water movement were identified, additional mitigation measures were developed to help wildlife, fish, and water move under and over roadways. With improved understanding of these effects—and of the cost and efforts to mitigate these effects—planning for ecological systems and their inhabitants is becoming part of long-range planning for transportation, to avoid, minimize, and reduce the costs instead of waiting until later on in the project stage.

Photo: Patricia Cramer

Deer graze near a roadway in Utah. The practices and science to accommodate wildlife along transportation corridors aim to maintain safety and ecological integrity.

Photo: Patricia Cramer

A wildlife overpass allows these does to cross I-15 (*not visible*) in Southern Utah.

Most states have begun accommodating wildlife and fish along transportation corridors, with hundreds of terrestrial crossings and thousands of aquatic crossings. The ecological and safety reasons are clear, and trends are emerging in the mitigation of the effects of roads on wildlife across North America.

Safety Concerns

Safety is the most important wildlife-related concern for transportation agencies, but more than ever before, transportation planning and projects are taking into account the ecological effects of roads and vehicles on multiple species. More than 1.5 million wildlife–vehicle collisions occur annually in the United States (*2*).

Many of these collisions cause human deaths. In 2008, the Highway Loss Data Institute reported that

Photo: Patricia Cramer

Wildlife crossing over roads can pose danger to animals and motorists. In 2008, the Highway Loss Data Institute reported that the number of fatalities from wildlife–vehicle collisions has more than doubled in the past 15 years.

the number of fatalities from wildlife–vehicle collisions has more than doubled in the past 15 years, with 223 people killed in 2007. In addition to human deaths and injuries, other costs are associated with these accidents. In a study of deer–vehicle collision costs in Utah from 1996 to 2001, Kassar found that the average cost for vehicle damage, lost lives, deer lost values, and human injury from a single accident was $3,470 (*3*). This conservative estimate would place wildlife–vehicle collision costs nationwide at more than $5.2 billion annually. Others estimate the cost as closer to $8.3 billion (*4*).

These averages also can be used to evaluate the cost-effectiveness of mitigation measures. For example, a wildlife crossing that costs $1 million would pay for itself over the service life of the structure if it prevented 180 to 288 collisions with wildlife—depending on the cost estimates used.

Transportation ecologists are only beginning to understand the many costs of vehicle collisions and road effects on populations of animals and ecosystems. According to averages calculated in one study, 1 million vertebrates are killed each day on U.S. roads (*5*).

Preserving Populations

Many ecologists are concerned about animal populations and their ability to exist in the presence of roads. If a population cannot sustain its numbers because of high rates of road-related mortalities or because of impediments to movement, the species may face local extinction.

An example is the Florida panther, a highly endangered species. In 2007, at least 15 panthers were killed on Florida roads. The population of 80 to 100 animals cannot compensate for this road mortality.

Gibbs and Steen found a higher percentage of male to female turtles in wetlands near roads than in wetlands at a distance from roads, because of the mortality associated with the females moving across or near roads to nest upland (*6*). Another study discovered signs of genetic isolation among bighorn sheep populations in southeastern California mountain ranges that were bisected by Interstate highways (*7*).

Data-based research results such as these offer insights into how roads and traffic affect wildlife and can assist in developing mitigation measures for roads and ways to avoid building new roads in ecologically sensitive areas. Efforts to mitigate and avoid have grown exponentially in the past four decades (*8*) as transportation agencies have become more concerned about wildlife and about potential methods for mitigation.

Initiatives and Approaches

As concerns rise for all species affected by roads, initiatives and legislative actions are directing transportation agencies to consider during the planning processes the needs that terrestrial and aquatic species have for ecological connectivity. For example, under Washington State law, culverts that block the passage of salmon must be identified and replaced, whether as part of a transportation project or as a stand-alone project. A 2007 Washington State Department of Transportation (DOT) Executive Order directs regional and statewide long-range transportation plans to identify potentially affected fish and wildlife habitats as early as possible during planning and to seek opportunities to restore habitat connectivity already damaged by transportation corridors.

The Vermont Agency of Transportation and the Vermont Fish and Wildlife Agency have signed a memorandum of agreement to work together to improve the accommodation of wildlife and aquatic organism movement around and through transportation systems and to minimize habitat fragmen-

This Florida panther, a highly endangered species, uses a wildlife crossing near Big Cypress, Florida.

Photo: Florida DOT

tation caused by transportation infrastructure.

In 2008, the Western Governors' Association (WGA), representing 19 states, adopted the Wildlife Corridors Initiative. The WGA Transportation Working Group developed policy recommendations for the initiative that would prioritize the preservation of wildlife corridors and crucial habitat in transportation planning, design, and construction.

At the national level, Section 6001 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (2005) instructs transportation agencies in long-range transportation planning development to consult with state, tribal, and local agencies responsible for land use management, natural resources, environmental protection, and conservation. The agencies must compare the transportation plans with the other groups' plans or maps, to evaluate potential impacts. The long-range

Best Practices for Reducing Wildlife–Vehicle Collisions

PATRICK T. MCGOWEN AND MARCEL P. HUIJSER

Approximately 300,000 collisions between cars and large animals—mostly deer—are reported each year on U.S. highways, and the number is increasing by about 6,700 per year. Insurance industry data and carcass tallies, however, indicate that the actual number of wildlife–vehicle collisions (WVCs) with large animals is 1 to 2 million per year. These collisions cost society $8 billion annually.

The U.S. Congress directed the Secretary of Transportation to conduct a national study of WVCs, detailing the causes, impacts, and potential solutions. The report to Congress was submitted in November 2007, and the Federal Highway Administration is to publish the report. FHWA recently released a manual with technical guidance on measures that are considered best practices.

WVC Characteristics and Threats

Compared with other crash types, collisions with wildlife

- Occur most often on two-lane, low-volume roadways;
- Are more likely to be on straight, dry roads;
- Happen more frequently in areas with large wildlife populations;
- Cause less severe crashes—except when the collisions involve either moose or motorcycles;

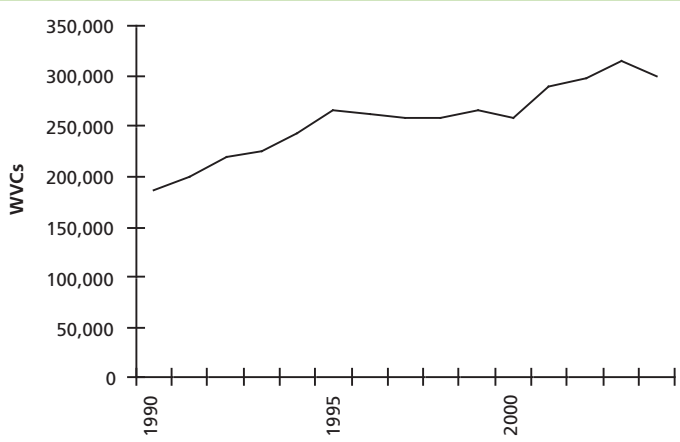

FIGURE 1 Number of wildlife–vehicle collisions (WVCs), 1990–2004.

Photos: U.S. Fish and Wildlife Service

*Several species threatened and endangered by road traffic (*left to right*): Bighorn sheep, San Joaquin kit fox, American crocodile, bog turtle, and Hawaiian goose.*

- Occur where roadways cross drainages;
- Are mostly single-vehicle crashes;
- Occur more often during early morning and evening hours;
- Occur more frequently during the fall and spring months; and
- Show less of a peak for younger and older drivers.

Road mortality is a substantial concern in the conservation of some species. The report identifies 21 threatened and endangered species for which road mortality is among the major threats to survival in the United States:

- *Mammals:* Lower Keys marsh rabbit, Key deer, bighorn sheep (peninsular California), San Joaquin kit fox, Canada lynx, ocelot, Florida panther, red wolf.
- *Reptiles:* American crocodile, desert tortoise, gopher tortoise, Alabama red-bellied turtle, bog turtle, copperbelly water snake, eastern indigo snake.
- *Amphibians:* California tiger salamander, flatwoods salamander, Houston toad.
- *Birds:* Audubon's crested caracara, Hawaiian goose, Florida scrub jay.

Photo: Z. Funkhouser, Idaho Transportation Department

Culvert replacements are opportunities for transportation planners and wildlife ecologists to accommodate wildlife movement. Pictured (*left*) is an Idaho culvert before and (*right*) after rehabilitation.

Many more species are affected by other impacts of roadways, such as loss, reduction in habitat quality, or fragmentation of habitat.

Expert Panel Recommendations

To identify measures to reduce the numbers of animal–vehicle collisions, an expert panel was formed with representatives from resource agencies, state departments of transportation, nongovernment organizations, and universities from across the country. The panel received a draft of the report to Congress and categorized the effectiveness of more than 30 measures for reducing WVCs with large animals.

According to the panel, measures that should be implemented include the following:

- Wildlife fencing,
- Wildlife underpasses and overpasses with fencing, and
- Public information and education.

Although uncertain that public information would reduce crashes, the panel was convinced that public information and education were good practice.

Measures that should be researched further include the following:

- Reducing speed by traffic calming measures, reducing the posted speed limit, or reducing the design speed;
- Installing warning signs that are larger, nonstandard, seasonal, or triggered by animal detection;
- Developing in-vehicle devices to warn drivers about animals on the roadside;
- Improving visibility through lighting or by removing vegetation;
- Avoiding vegetation or deicing alternatives that may attract animals to the roadway;
- Reducing population size through culling or habitat alteration;
- Keeping animals off the roadway with boulder barriers, long tunnels and bridges, or overpasses and underpasses without fencing;
- Reducing traffic volume;
- Using crossing guards to stop traffic for wildlife;
- Installing wider, more reflective white stripes; and
- Expanding the median.

FIGURE 2 Total approach to reducing WVCs.

The panel recommended that the following measures should neither be implemented nor researched further:

- Warning the driver with standard wildlife warning signs or with reflective collars on wildlife;
- Warning animals or keeping them off the road with such devices as reflectors and mirrors, audio signals in the right-of-way, deer whistles on vehicles, scent repellents, hazing, intercept feeding, or deer flagging models;
- Attempting to reduce the wildlife population through relocation or antifertility treatments; and
- Scheduling seasonal road closures.

Mitigation only at known locations of frequent animal crossings may not reduce WVCs significantly—the approach must be comprehensive. Good data are needed to identify and prioritize the mitigation locations. The problem must be considered in the context of the landscape and with an understanding of the target species. Principles that minimize the potential for WVCs should be incorporated into alignment selection and road design. The measures that are implemented should be monitored, evaluated, and published.

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PHOTO: PATRICIA CRAMER

A moose makes use of a wildlife crossing at US-89 in Utah. Several states and provinces have built multiple wildlife passages for a range of species.

plans must include a discussion of potential environmental mitigation activities with the greatest potential to restore and maintain environmental functions affected by the plan.

The federal natural resources agencies and the Federal Highway Administration have developed Eco-Logical: An Ecosystem Approach to Developing Infrastructure Projects, which helps agencies work together over the long term to protect natural resources, to mitigate harmful effects, and to ensure that mitigation agreements are kept.[1] The approach is evolving to assist in larger-scale spatial and temporal analyses of transportation effects on ecological communities and in actions that can minimize these effects.

[1] www.environment.fhwa.dot.gov/ecological/eco_index.asp.

Assessing Road Barriers to Aquatic Species

Lessons Learned in the Northwest

MATTHEW D. BLANK

Many of the estimated 1.4 million road–stream crossings throughout the United States use culverts for water to pass underneath the roadway. Culverts, however, can create barriers to the upstream movement of aquatic species and, in some cases, to the downstream movement. Many different methods are used to assess whether a culvert crossing is a barrier. Varieties of barriers include the following:

- A total barrier, which allows no movement;
- A partial barrier, which allows only some species or life stages within a species to move; and
- A temporal barrier, which allows movement at only some flow rates.

Different techniques can yield different assessments. One technique may identify a structure as passable, yet another may identify the same structure as a barrier. The goal is for a culvert to provide the free passage of all aquatic species in the stream for all flows.

Identifying Barriers

Total barriers are easy to identify. Culverts that have large drop-heights at the downstream outlet will limit severely—or prevent—the upstream movement of many fish species; at some height, all species will be blocked—including good leapers like trout and salmon. The U.S. Forest Service in Montana has established 6 feet as the leap height threshold for rainbow trout.

This culvert in western Montana serves as a leap barrier to resident fish species.

Another type of total barrier occurs in medium- to high-gradient streams. Without baffling systems or natural substrate bottoms, culverts at steep slopes will generate fast flows. The velocity of water can become too fast for aquatic species to swim or crawl against without exhaustion. In contrast, road crossings that mimic natural stream channel conditions or that have properly designed and constructed baffling systems to slow the water down and to provide resting areas are easy to identify as passable. Culverts between these extremes are difficult to assess.

A concrete box culvert in a medium- to high-gradient mountain stream. The culvert width is less than the width of the stream channel; therefore, during high flows, as shown in the photo, the constriction creates a velocity barrier to the upstream passage of most fish species. Because the water velocities also create scouring downstream, the culvert includes an outlet drop, which fish must negotiate in addition to the water velocities within the structure.

Contributing to the difficulty are the changing flow conditions in the stream and the crossing. An assessment at low-flow conditions may find the crossing passable; however, as the flow rate increases, the velocity of the water may reach a point at which it

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Multispecies Crossings

Wildlife crossings—which help wildlife move over and under roads—have been constructed in North America since 1973, when Colorado installed the first underpass for wildlife under Interstate 70 near Vail Pass. More than 700 terrestrial and thousands of aquatic passages accommodate wildlife in the United States and Canada (*9*).

A review of 26 studies examining the effectiveness of 76 crossings revealed that all of the crossings passed wildlife, and that 74 passed the target species (Cramer, unpublished data). Many crossings initially were built for a single target species, chiefly deer. In the 1980s, Florida DOT built 38 wildlife passages under Interstate 75 in Southern Florida, primarily for

Photo: K. Morgan, Arizona Game and Fish

A bighorn sheep crosses US-93 in Arizona using an underpass.

limits or prevents passage. During high-water periods, excessive water depth, high velocities, moving bedload, and debris can create conditions that are unsafe for measurements and that prevent the use of many assessment techniques.

Regional Screening

One approach to performing quality assessments of a large number of culverts is to develop a regional screening tool. The tool would apply physical parameters such as culvert length, slope, and outlet drop height—combined with information about the locomotive abilities of the aquatic species within the stream—to separate the culverts into total barriers, passable barriers, and undetermined. Structures that cannot be assessed can be grouped by physical, geomorphic, hydrologic, and biological attributes.

More detailed assessments can be performed on a subset within each group, using a direct measure of passage. Passive integrated transponder—or PIT—tags placed inside representative individuals of the aquatic species of interest are effective as a direct measure of passage, even during high-water periods; detection antennae are installed on the upstream and downstream ends of the structure. The technique is time-consuming and labor- and equipment-intensive; nonetheless, natural movements can be monitored in relation to a range of flow conditions.

Results from the direct assessments can be used to determine or refine regional thresholds for structures within each group for various species and life stages. Passage can be inferred for structures that were not directly assessed. Thresholds that are defined and refined for a region should be published and pooled nationally.

Comprehensive and Practical

An assessment should consider all potential barriers—including irrigation diversions and dams—on a watershed scale. Entities beyond the transportation agencies should be involved, because the solutions to aquatic connectivity are the shared responsibility of all landowners, public and private. Restoring passage at a single crossing may expand the range of an already isolated population only marginally if other barriers remain upstream or downstream. Assessing a structure or all structures for all aquatic species that live within the watershed may not be practical; identifying a priority species may be necessary.

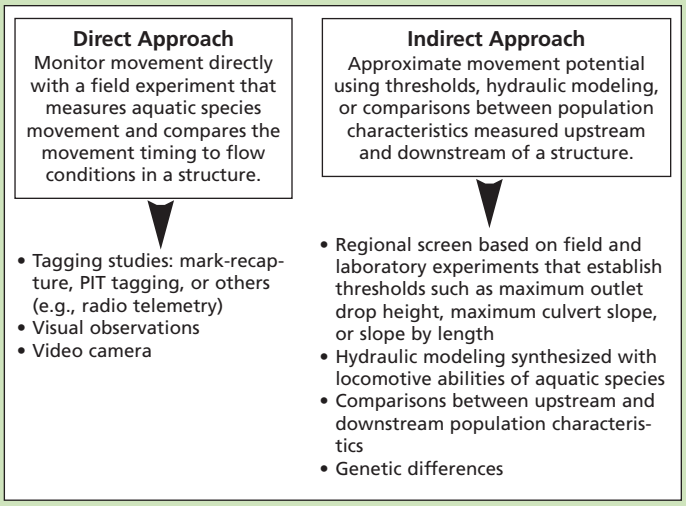

FIGURE 1 Direct and indirect approaches to assessments of culverts.

After assessments are complete, and the decision is made to replace or retrofit a structure, design can begin. Many state departments of transportation, such as Maine and Washington, as well as the Federal Highway Administration, have prepared design guides for fish passage at newly constructed and at retrofitted crossings.[a]

In general, an assessment should be as accurate as possible—a culvert that is limiting passage should be identified as a problem. Many aquatic species in U.S. streams and rivers face daunting challenges for long-term survival and depend on connected habitats. Making the nation's road crossings passable for these species is important and can be achieved with proper assessment, decision making, design, and construction.

[a] For more information about *Hydraulic Engineering Circular 26: Fish Passage at Bridges and Culverts*, see www.fishpassage.wsu.edu/.

the Florida panther but also for all other species in the area. This was the first set of multiple passages for multiple species.

Passing many species with different movement abilities helps to promote permeability, the ability of a variety of wildlife to move across a landscape in the course of daily activities and during dispersal movements. To create a series of wildlife passages that provide permeability for multiple species is a goal of many transportation ecologists.

Several states and provinces have built multiple wildlife passages for a range of species. Whenever the Trans-Canada Highway is widened in its stretch through Banff National Park in Alberta, Canada—or to the east or west of the park—wildlife underpasses and overpasses are built. Multiple species of mammals from grizzly bear to pine marten traverse the 24-plus passages; researchers have documented more than 100,000 wildlife crossings in the past two decades (*10, 11*).

US-93 in Montana incorporates more than 55 wildlife passages, with another 20 or more planned. Remote trail cameras have revealed many species using these passages, including puma, white-tailed and mule deer, black bear, porcupine, great horned owl, and others. A series of three extended bridges along US-7 in Vermont—known as the Bennington Bypass—has proved effective in passing multiple wildlife species, from white-tailed deer and bobcats to small mammals. Future projects to create multiple passages for wildlife include Washington State's I-90 project, with 17 wildlife passages; and Colorado's I-70 passages, which will offer an overpass for wildlife.

Key Opportunities

Most wildlife crossings are created in conjunction with highway upgrades. Lane additions, bridge and culvert replacements, and other road improvements are key opportunities for transportation planners and wildlife ecologists to find ways to accommodate wildlife movement.

Stream flow is a major consideration when aging culverts are replaced. During these replacements, fill can be removed and a bridge installed to allow wildlife movement, especially along the riparian corridors, which are natural movement pathways for terrestrial and aquatic wildlife.

Culverts can be enlarged to allow for terrestrial movement along the sides of a stream. These upgrades allow terrestrial wildlife and anglers to pass under the road without having to negotiate water or large rocks that may be placed for rip rap. If planned correctly, these enlargements also facilitate more natural hydrologic flow, and can assist with storm water runoff, an important feature in preparation for hydro-

Photo: Z. Funkhouser, Idaho Transportation Department

Mitigation measures such as culverts help fish, like this steelhead, move under roadways.

logic changes associated with climate change.

Terrestrial structures can be retrofit or upgraded for wildlife permeability. For example, New Mexico DOT is improving wildlife structures along Interstate 40 and State Highway 333 in Tijeras Canyon. To make the roads more permeable for wildlife, New Mexico DOT is retrofitting a bridge underpass by widening a shoulder for wildlife pathways; clearing brush near three bridges to give deer and other prey better visual clearance; and installing wildlife-proof fences, as well as escape ramps and at-grade wildlife crossings with motorist warning systems.

Photo: M. Watson, New Mexico Department of Game and Fish

New Mexico Department of Transportation is retrofitting a bridge underpass in Tijeras Canyon by widening a shoulder for wildlife pathways.

Guidance and Tools

When designing new and upgraded transportation infrastructure, state and provincial transportation agencies are increasing their efforts to find thousands of opportunities to accommodate the needs for wildlife, fish, and ecological processes to move. With more than 6.4 million kilometers of roads in the United States (*1*), the opportunities are ample. States, provinces, and local entities are also finding that earlier consideration of wildlife and ecological needs in transportation planning offers more opportunities to avoid and minimize potential project impacts well in advance of the need for mitigation, saving time and money.

As these practices spread and the science develops, reports and tools are becoming available for planners and practitioners. For example, a recent National Cooperative Highway Research Program (NCHRP) project, Evaluating the Use and Effectiveness of Wildlife Crossings,[2] developed a website that includes a decision tool to assist road planners, engineers, and wildlife ecologists in mitigating roads for wildlife.[3] The tool is also available on the website of the American Association of State Highway and Transportation Officials' Center for Environmental Excellence.[4] In addition, the International Conference on Ecology and Transportation holds biennial meetings and publishes all papers presented.[5]

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[3] www.wildlifeandroads.org.

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Public Outreach on Noise Impacts from Transportation Projects

Communicating and Improving Measures for Transit, Highways, and Airports

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Before the National Environmental Policy Act (NEPA) was signed into law in 1970, the effects of transportation-related noise on the public were not a consideration in Federal-Aid rail, highway, or airport projects. NEPA was pivotal in raising awareness of the environmental impacts of Federal-Aid projects. After NEPA was enacted, the public benefited from additional federal and state laws and regulations, as well as from policies addressing transportation noise and public involvement.

Public outreach and land use compatibility are two approaches still evolving to address transportation-related noise. Public outreach to minimize the impact of transportation noise on nearby residents requires flexibility. The main purposes of outreach are to inform the public and local officials about the noise impacts of a proposed project; to obtain input on proposed measures for noise abatement; and to educate public officials about planning and land use controls to avoid and minimize the impacts of transportation noise.

Educating the public and public officials about the importance of land use compatibility is essential in preventing the impacts from noise. The rail transit and highway noise industries coordinate their transportation projects with the public and local officials, and the aviation industry examines noise and land use compatibility in a proactive approach to noise abatement and impact avoidance.

The State Route 161 NeXT (Northeast Expressway Transformation) project in Franklin County, Ohio, in 2004, included noise wall construction.

PHOTO: OHIO DEPARTMENT OF TRANSPORTATION

Rail Transit Noise

Noise from proposed rail transit projects can be a major concern—and an emotional issue—for communities adjacent to a proposed transit corridor. Perhaps the worst case is when a transit line is routed along an abandoned or lightly used freight-rail corridor that passes the backyards of residences. Although the rail corridor was there already, the residents do not want noisy trains regularly passing their backyards.

The footprint of the noise impacts can be minimized with appropriate abatement measures, and transit corridors can be compatible with noise-sensitive land uses—communicating this possibility, however, can be difficult. A common misconception is that trains are loud—whether streetcars, light rail, or commuter or freight trains, and whether traveling at 25 mph or 100 mph.

Communities may be more receptive to urban transit, such as streetcars or light rail, if lines already serve the region and the benefits are easy to see. This is particularly true when extensive transit-oriented development occurs, even in such unlikely areas as Southern California—according to conventional wisdom, Californians would never give up their automobiles to ride transit.

Photo: Staiano Engineering, Inc.

Baltimore Light Rail Line train with noise barrier.

Engaging Communities

Typical ways to engage communities include outreach meetings for new projects, focused presentations to small groups, and detailed responses to public comments. Comprehensive technical reports can aid these efforts, demonstrating that the community's concerns about noise have been taken seriously and that the noise issues are being addressed.

Interactive audio demonstrations also are effective. A carefully designed demonstration can help people put the noise from a proposed transit line into context and understand their personal exposure. Several computer programs are available to simplify the preparation of an audio demonstration. Although audio demonstrations can educate people effectively about transit noise and can help defuse false preconceptions, the demonstrations must be carefully vetted to ensure that they convey the intended message accurately and that project opponents cannot distort the message.

Abatement at the Sources

Most noise complaints received by transit systems are caused by one of four sources:

- Wheel–rail noise, the normal noise of steel wheels rolling on steel rails;
- Wheel squeal generated in tight radius curves;
- Audible warnings, such as horns or bells, that alert pedestrians and motorists to trains approaching a highway–rail grade crossing; or
- The noise from wheel impacts on the special trackwork for crossovers and turnouts.

Effective abatement measures apply to all of these sources—this is a key point to communicate. Of the noise sources, only the wheel–rail noise occurs throughout the project corridor. The adverse effects of the other sources are limited to localized areas.

The measures for reducing rail transit noise range from noise barriers to lubrication that controls wheel squeal. The measures ensure that the noise levels will be much lower than on older systems that started operation as many as 60 years before the environmental regulations required consideration of noise impacts.

Highway Traffic Noise

From its inception after the Federal-Aid Highway Act of 1970, Title 23 of the Code of Federal Regulations Part 772 (23 CFR 772) has provided state highway agencies (SHAs) with flexibility in interpreting the regulation to fit needs and program requirements. To be eligible for federal funding, noise abatement must be feasible and reasonable; SHAs, however, have flexibility in evaluating the reasonableness and feasibility of a measure for the properties affected.

Reasonableness includes the noise abatement costs in relation to the benefits. In *Highway Traffic Noise Analysis and Abatement Policy and Guidance*, published in June 1995, the Federal Highway Administration (FHWA) recommends a range of $15,000 to $50,000 per benefiting residence as an upper limit for cost reasonableness. In 23 CFR 772.11(f), the regulation identifies the views of the public—that is, public opinions, preferences, or desires—as the primary consideration for reasonableness.

The FHWA noise guidance states that "there are…no easy methods to determine residents' views or to arrive at a conclusion regarding residents' desires." States must determine how best to comply with the regulation. Each state has developed methods to determine the public's desire for noise abatement. Two examples demonstrating this flexibility follow.

A sign at a railroad grade crossing alerts passersby that trains on the Santa Clara Transportation Authority's Vasona Line do not use horns when coming through this residential area in Campbell, California.

Photo: ATS Consulting

Wisconsin: Reaching Residents and Officials

The Wisconsin Department of Transportation (DOT) holds public informational meetings (PIM), inviting residents who live within 500 feet of the roadway, as well as those who live opposite the proposed location of a noise barrier. The department provides a list of preapproved noise barrier products to the public and explains that the contractor will select the barrier type.

The Wisconsin Administrative Code (Chapter Trans 405) requires Wisconsin DOT to work closely with local officials in siting a noise barrier. Trans 405.05 specifies those who should be invited by mail to the PIM. Trans 405 also requires the local unit of government to enact land use controls and to pass a resolution of support before the noise barriers are included in the plans, specifications, and estimates for the project. Wisconsin DOT only constructs noise barriers if the local officials meet these two requirements.

Ohio: Mix of Methods

Ohio DOT uses a mix of outreach methods that include noise-specific public meetings, mailed surveys, and door-to-door surveys; it may use one or all

Arizona Tests Quieter Highway Pavement

JUDITH L. ROCHAT

A special program of the Federal Highway Administration (FHWA) allows for flexibility in strategies to abate highway traffic noise. Jointly developed by FHWA and the Arizona Department of Transportation (DOT), the Quiet Pavement Pilot Program (QPPP) has allowed Arizona DOT to use quieter pavements as a noise abatement option. The QPPP is a voluntary program open to any state; requirements include evaluating the changes in the pavement's noise abatement properties over time and making a commitment to maintain in perpetuity any noise reduction attributed to the pavement.[a]

After preliminary studies, Arizona DOT decided to demonstrate the effectiveness of asphalt rubber friction course (ARFC) as a noise abatement strategy in the metropolitan Phoenix area.[b] Arizona DOT had used ARFC since 1988, but the product's noise-reducing capabilities—a positive side effect—had been identified only recently. Another benefit to the environment is that more than 15 million tires have been recycled since 1988 by paving Arizona highways with ARFC. On the Phoenix freeways, Arizona DOT applied a 1-inch-thick layer of ARFC, which has a 20 percent content of tire rubber, on top of concrete pavement that was 12 to 14 inches thick.

The QPPP includes measurements to evaluate the noise-reducing capabilities of ARFC as the pavement ages. Throughout the project area, source measurements close to the tire–pavement interface have shown reductions from transversely tined concrete averaging 6 dBA in the sound intensity level, stabilized after a few years of pavement service; initially the reductions measured an average of 8 dBA.

At select research sites, wayside measurements adjacent to the highway—50 feet from the near travel lane—have shown noise reductions from transversely tined concrete averaging 9 dBA in sound pressure after 1 year of service; limited data show this average declines approximately 1 dBA per year over a few years. When the measured data are compared with predictions from the FHWA Traffic Noise Model for average pavement, the ARFC would provide an average reduction of 4 dBA in sound pressure level after 1 year of service. This comparison is significant in investigating the inclusion of pavement effects in noise impact analyses. Arizona DOT will continue to evaluate the acoustic longevity of ARFC through the life of the pavement.

Treated with rubberized asphalt, I-10, a busy highway in metropolitan Phoenix, has lowered noise levels for nearby commercial and residential areas.

[a] For more information, see www.fhwa.dot.gov/environment/noise/qpppmem.htm.

[b] For more information on Arizona DOT's QPPP, see www.quietroads.com/.

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of these methods to obtain a complete view of the opinions of affected residents. To combat poor turnout for public meetings or low response rates to the surveys, Ohio DOT districts may use a mixed public involvement approach—sending detailed project information and surveys along with the public meeting invitations. This allows affected residents to make informed decisions and to provide a response without attending the public meetings. The survey typically includes aesthetic options and gauges the desire for noise abatement.

Simple surveys, such as a self-addressed postcard asking a resident to check yes or no, also may help in the decision-making process. The tool may be useful when traditional surveys and public meetings do not achieve sufficient levels of public input or if the goal is to gauge public interest in noise abatement early in the public involvement process.

Communication Caveats

SHAs should be cautious in repeating attempts to determine the public's desires. Advocates for and against noise barriers may accuse the SHA of taking additional surveys only to obtain the answer that the SHA wants. The lack of response from a neighborhood does not necessarily indicate a lack of interest in noise abatement—a poor public response may be the result of insufficient public outreach by the SHA. Understanding what method to use, and when, requires experience and a project team that knows the constituents.

Aviation Noise

Airports and surrounding jurisdictions can improve noise levels and land use compatibility with the balanced approach that is favored internationally. This approach seeks to achieve land use compatibility around airports through five initiatives:

- Quieting the planes,
- Land use planning,
- Airport layout,
- Noise abatement procedures, and
- Restrictions on operations.

Until major technological advances occur, the aircraft now being manufactured are as quiet as they can be. Land use planning has restricted noise-sensitive development from areas with noise levels above 65 dB DNL (the day–night average sound level) and has recommended sound insulation for residential areas.[1] Noise abatement procedures are effective in some cases but often involve trade-offs. Changes in airport layouts are infrequent and are influenced mostly by capacity considerations, not by noise compatibility goals. Restrictions on aircraft operations are rarely achievable.

Because the other methods can yield only small improvements, more creative approaches are needed for land use planning. Land use compatibility measures traditionally have limited or prevented noise-sensitive land use when aircraft noise exposures exceed 65 dB DNL. Airports and local jurisdictions, however, discovered long ago that adhering to this criterion is not sufficient for many communities—the public still may express dissatisfaction and likely would oppose any noise increase.

As a result, although compatibility may have been achieved in terms of the 65 dB DNL threshold (*1*), airports still may find that they cannot operate or seek to increase operations without encountering significant opposition from the surrounding communities. The primary need is for airports to work cooperatively with the surrounding communities to develop their own land use compatibility zoning or planning.

The most important, yet difficult, step to achieving this type of airport and community compatibility is the selection of the criteria for noise and land use.

Virtually all airports and jurisdictions use DNL in planning, but DNL is not directly related to what people hear and cannot convey the number or levels of aircraft-produced noise events.

Table 1 (next page) presents hypothetical—but computationally accurate—relationships between a noise level of 65 dB DNL and maximum aircraft sound levels, numbers of operations, and the approximate times that aircraft sound levels would exceed 60 dB(A)—the level at which interference begins with hearing speech. An average outdoor maximum level of 95 dB(A) might occur near the end of a commercial jet departure runway; a level of 85 dB(A) at about 1 mile from the runway; and a maximum of 75 dB(A) at about 3 to 4 miles from the end of the runway.

Clearly, 65 dB DNL will not always produce the same noise environment. Most people would prefer to live in a location with 10 aircraft operations per day, even if the operations are loud, than in one with 100 or 1,000 quieter operations per day.

Land use compatibility criteria, therefore, should account for different aircraft noise environments. The original recommendations for compatibility, developed in the early 1970s, were based on the effects of the noise levels on people (*2*). Much research on noise effects has been published since then, and the information is sufficient to develop

PHOTO: ORLANDO AVIATION AUTHORITY

The Orlando Aviation Authority and Aviation Noise Abatement Committee prepared a brochure about airport noise for residents living near Orlando airports.

[1] For a description of noise metrics, see the website of the Federal Interagency Commission on Aviation Noise, www.fican.org/pdf/aircraft_noise.pdf.

TABLE 1 Combinations of Maximum Aircraft Levels and Operations That Create 65 dB DNL

Maximum Aircraft Sound Level	Required No. of Operations in 24 hours (None at Night)	Approximate Time Above 60 dB(A), Each Operation dB(A)	Approximate Total Time Above 60 dB(A)
95 dB(A)	10	50 seconds	8 minutes
85 dB(A)	100	35 seconds	1 hour
75 dB(A)	1,000	20 seconds	6 hours

associations between DNL and effects similar to those presented in Table 2 (below). The actual percentage of population and number of events shown in this table depends on the number and type of aircraft operations, the population distributions around the airport, and other assumptions, such as the outdoor-to-indoor sound level reductions provided by typical homes, whether residents sleep with windows open or closed, whether the homes are air conditioned, and the numbers of nighttime operations.

Decisions about the compatibility criteria that are best for a jurisdiction can be based on more than the commonly used threshold of 65 dB DNL or the subjective understanding of how residents respond to DNL values. The effects can be quantified and judgments can be made with knowledge of how noise is likely to affect people. These numbers are different for each airport and jurisdiction, and the criteria can be based on community benefits with respect to the airport, instead of following a one-size-fits-all approach.

The selection of land use compatibility criteria for a jurisdiction, therefore, is a policy decision for local officials and citizens. Quantifying the effects can help make this an informed decision and can provide an important logic trail for future legal defense.

Airports and jurisdictions working cooperatively on noise and land use compatibility plans may develop understandable quantities associated with values of DNL—for example, percent or numbers of people highly annoyed, or percent or numbers of people awakened. Instead of determining compatibility criteria by arbitrarily choosing a value of DNL or by using the traditional 65 dB DNL, decision makers can develop noise compatibility policy that limits the effects of noise on the local population.

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1. *Airport Noise Compatibility Planning.* 14 CFR Part 150. www.faa.gov/airports_airtraffic/airports/environmental/airport_noise/.
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TABLE 2 Estimated Noise Effects for an Average Day at a Large Air Carrier Airport

DNL Range (dB)	Percent of Population…		Number of Daily Aircraft Events That…	
	Awakened at Least Once by Aircraft Noise[a]	Highly Annoyed[b]	Interfere with Conversation Indoors (Windows Open)	Cause Feelable House Vibration[c]
>70	>40%	>40%	>250	>200
65–70	35–40%	30–40%	100–250	50–200
60–65	30–35%	20–30%	50–100	<50
55–60	20–30%	10–20%	<50	negligible

[a] *Based on ANSI Standard S12.9-2008, Quantities and Procedures for Description and Measurement of Environmental Sound, Part 6: Methods for Estimation of Awakenings Associated with Outdoor Noise Events Heard in Homes.*

[b] *Annoyance is determined from well-established averages for aircraft noise only. See Miedema, H. M. E., and C. G. M. Oudshoorn.* Elements for a Position Paper on Relationships Between Transportation Noise and Annoyance*. TNO Report PG/VGZ/00.052, Leiden, Netherlands, July 2000.*

[c] *Based on ANSI Standard S3.29-1983, American National Standard Guide to the Evaluation of Human Exposure to Vibration in Buildings.*



Transportation and Historic Preservation

Progress and Research

ANTONY F. OPPERMAN, HOPE E. LUHMAN, EMILY PETTIS, AND STEPHANIE STOERMER

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An efficient and effective transportation system does not necessarily conflict with the preservation of the past. Elements of the transportation system are manifestations of the nation's history—historic properties in their own right. Yet accommodating historic preservation issues sometimes can be one of the most daunting environmental challenges in transportation. Research on historic preservation in transportation aims to offset these challenges.

Historic preservation issues in transportation largely result from legal and regulatory requirements at the national, state, and local levels. Among the most recognized authorities driving historic preservation issues in transportation are the National Historic Preservation Act (NHPA), especially Section 106; the National Environmental Policy Act; Section 4(f) of the Department of Transportation Act; and the historic preservation requirements of the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). Also exerting influence are authorities at the state, local, and agency levels.

With this range of requirements, much of the focus of historic preservation research in transportation is on legal and regulatory performance. The research is applied in a specific area to improve transportation project delivery and the stewardship of historic assets involved in the transportation system.

The members and friends of the Transportation Research Board's (TRB) Historic and Archaeological Preservation in Transportation Committee exemplify the backgrounds and experience of those involved in historic preservation research in transportation—professionals in archaeology, history, architectural history, architecture, and engineering. This diverse expertise

PHOTO: ABBA LICHTENSTEIN

The Monocacy Aqueduct in Maryland was built in the 1830s, but storms caused major damage, and unsightly exterior steel bracing was needed to stabilize the structure. The National Park Service removed the exterior bracing and stabilized the aqueduct internally, and it was reopened in 2005.

PHOTO: ABBA LICHTENSTEIN

This suspension bridge in Nishanic Station, New Jersey, fell into disrepair and was in danger of being demolished. Instead, the 1897 bridge was rehabilitated, with care taken to keep its lenticular truss structure unchanged.

typically derives from the private sector, national and state public transportation agencies, public historic preservation organizations, and academia. In addition to TRB, organizations such as the American Association of State Highway and Transportation Officials (AASHTO), transportation research partnerships between public transportation agencies and universities, and the Federal Highway Administration (FHWA) play a significant and interrelated role in sponsoring historic preservation research.

Research Accomplishments

Although historic preservation research interests in transportation are diverse, three areas deserve particular attention.

Evaluating Historic Significance

The designation of historic status is one of the most fundamental decisions in historic preservation, regardless of any relationship to transportation. All subsequent decisions required by law and regulation that involve the effects of a project and the measures to mitigate those effects derive from the property's designation as historic. Most commonly the designation involves a finding that a building, structure, bridge, district, site, or object is eligible for listing in the National Register of Historic Places (NRHP) in accordance with regulatory requirements[1] and practices established by the National Park Service (NPS). Although the National Register has been in place since 1966, and considerable guidance is available, the decision about eligibility can be subjective, inconsistent, and time consuming.

Several key research efforts and products in the past decade reflect the importance of the decision about historic status. In 1999, TRB's Historic and Archaeological Preservation in Transportation Committee, with assistance from FHWA and NPS, organized the National Forum on Assessing Historic Significance for Transportation Programs (*1*). The sessions led to three research projects on improving decision-making performance:

- National Cooperative Highway Research Program (NCHRP) Project 8-40, Evaluating Cultural Resource Significance Using Information Technology (IT), which surveyed IT applications (*2*);
- A project to develop a model IT application (*3*); and
- NCHRP Project 25-25, Task 33, National Register of Historic Places Eligibility, which evaluated practices nationwide (*4*).

Success in this area can be measured by the continuing emphasis—in workshops, research projects, and publications—on careful and systematic approaches to decision making by the federal and state transportation agencies. Transportation agencies' focus on their "ownership of responsible decision making" is a significant improvement over previous practices.

Managing the Recent Past

Decisions on historic status usually involve properties that are more than 50 years old—an approach that is designed to separate careful consideration of historic significance from the influence of nostalgia. The 50-year horizon, however, increasingly encompasses buildings, structures, and districts built in the post-World War II years. In some parts of the United States, the rate of increase in these properties is exponential—especially in the suburbs of major metropolitan areas.

Complicating the subjective tendency of conventional decisions about what should be considered historic are personal relationships with properties "like the one I grew up in," the mass production of those properties, and the increasing number of properties that transportation projects must deal with. This situation intensifies with the passing of each year and may affect the delivery of transportation projects significantly.

An important example of applied research to manage the recent past is the work conducted by FHWA to support the exemption of the Interstate Highway System, now crossing the 50-year threshold, from eligibility for listing in the National Register of Historic Places, in accordance with SAFETEA-LU Section 6007. The research developed a national context for consultation with state historic preservation officers to identify properties to which the exemption would not apply (*5*). FHWA's research defined only 143 individual Interstate system elements that are considered historic and sup-

[1] 36 CFR Part 65.

ported a significant statutory streamlining of historic preservation involvement with the Interstate system.

Although NPS has issued limited guidance, the TRB Historic and Archaeological Preservation in Transportation Committee has worked to bring attention to the potential impact of the nation's more recent history on transportation project delivery. The committee has sponsored a series of conference sessions and workshops to explore how the issue is being expressed and managed across the country. The research community is ready to assist in managing the recent past efficiently in a proactive partnership with the historic preservation community.

Historic Bridge Preservation

Historic bridges are integral elements of the transportation system, and interest in historic bridges in the United States has been a long-term theme of both the transportation and the historic preservation communities. Much of this mutual interest, however, has been expressed in sometimes impassioned debates between the two communities. Research efforts at the national and state levels therefore have turned to pragmatic approaches to achieve balanced consideration of transportation and preservation needs.

Historic bridge research has focused largely on four areas: historic context development, historic bridge inventories, management and preservation plans, and rehabilitation practices. Although many states have their own context studies of historic bridges, an NCHRP project produced a notable, up-to-date national study (*6*). The NCHRP project built not only on several decades of research at the state level but also on efforts by state DOTs to inventory historic bridges.

All 50 states have prepared historic bridge inventories—although the levels of comprehensiveness may vary (see box, page 28). In addition, many states have made progress in managing historic bridges through preservation plans or programmatic agreements developed in cooperation with preservation partners.

The goal of research, however, is to influence what happens in the outside world, and many departments of transportation (DOTs) are now more capable and inclined to consider the rehabilitation, instead of the replacement, of historic bridges. The interest in rehabilitation is reflected in *Guidelines for Historic Bridge Rehabilitation and Replacement* (*7*) and in the progress that DOTs have made in completing historic bridge inventories and developing management plans.

Also of interest is the growing awareness that the aesthetics of new bridges in historic areas can benefit from context-sensitive solutions (CSS) to avoid introducing false historic elements or design features that would have an effect on adjacent historic properties. A session at the 2008 TRB Annual Meeting, Context-Sensitive Solutions and Bridge Aesthetics: Procedures That Underlie Successful and Cost-Effective Designs, may prove to be pivotal in integrating those issues. The increased willingness of transportation engineers and historic preservation professionals to engage in dialogue about historic bridge issues is fundamental to progress in this area.

Looking into the Future

The trends established through past research accomplishments will continue as best practices are refined and as new technologies bring greater efficiency and streamlining to the historic preservation review process for transportation projects.

In some respects, historic preservation was hindered by its own success, as the information from decades of local research and regulatory reviews created a burgeoning, but data-rich, knowledge base. Geographic information systems, web-enabled data systems, and other digital technologies have improved information access significantly, are contributing to analytical efficiency, and are an important means to identify future research needs.

Research Initiatives

The TRB Historic and Archaeological Preservation in Transportation Committee and AASHTO's Standing Committee on the Environment have identified 26 historic preservation research needs in transportation. Of the 26, four have been completed, two are under way; the rest are unmet. In addition, FHWA's Surface Transportation Environment and Planning Cooperative Research Program (STEP) has identified two research needs. The four projects under way are the following:

- Integrating Cultural Resource Management and Historic Preservation into Transportation Planning (AASHTO; NCHRP);
- Implementation of Cultural Resource Commitments (AASHTO; NCHRP Project 25-25, Task 41);
- Research and Innovation Agreement with Advisory Council on Historic Preservation (FHWA-STEP); and
- Consideration of Historic Preservation in Early Planning (FHWA-STEP).

The primary focus of these projects is on streamlining the legal and regulatory processes in historic preservation that directly influence transportation project delivery. This can be accomplished by iden-

Preserving Bridges Nationwide
Improving on the Past

EMILY PETTIS AND CHRISTINE LONG

To inform the national dialogue about historic bridge preservation and to encourage continued management of significant structures, historic preservation specialists with Mead & Hunt, a multidisciplinary consulting firm, recently undertook a national study of historic bridge practices in cooperation with the Historic Bridge Alliance. Completed between February and June 2008, the survey addressed bridge preservation and management practices in each state, including inventories, rehabilitation projects, successes and challenges, and future bridge management activities. Respondents included state departments of transportation (DOTs), state historic preservation offices, and Federal Highway Administration representatives.

Historic bridge inventories and preservation plans represent an effort by DOTs to comply with federal requirements for the inventory, rehabilitation, and potential adaptive reuse of historic bridges.[a] Compliance with environmental requirements—such as with Section 106 of the National Preservation Act and Section 4(f) of the Department of Transportation Act of 1968—also can be streamlined by proactively and comprehensively defining the universe of historic bridges and reaching a consensus about their management.

The survey results are expected to help state DOTs and other agencies understand how their state's practices fit into the national spectrum of historic bridge survey, evaluation, and preservation planning. The survey allows agencies to see what their counterparts are doing, as well as what strategies, techniques, and policies are working in other states, enabling procedural improvements.

Highlights of the survey results demonstrate progress in national bridge preservation and include the following:

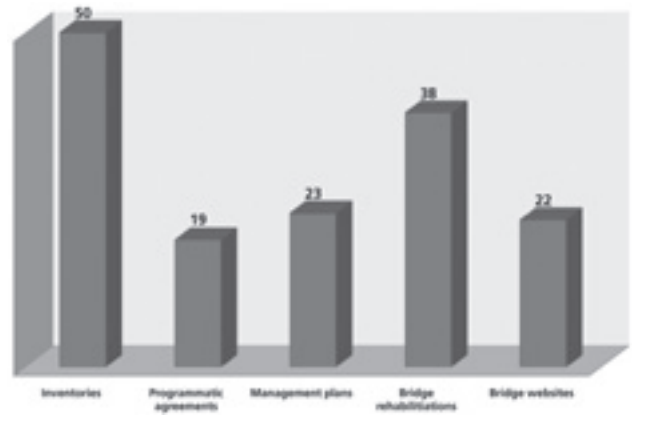
◆ All 50 states have completed historic bridge inventories; however, not all have been comprehensive—21 states have limited their historic bridge inventories to specific materials or bridge types, and most historic bridge inventories only address bridges built between 1900 and 1945.

◆ State DOTs primarily use management plans and programmatic agreements to fulfill their regulatory responsibilities and to administer statewide historic bridge programs. Although fewer than half of the states have completed bridge-specific management plans to guide preservation efforts, many states recognize their value, and 20 states intend to complete historic bridge management plans. Nineteen states have developed programmatic agreements to address historic bridges comprehensively under Section 106. Other states have programmatic agreements that address individual bridge types or that serve as tools for stipulating acceptable repair work.

◆ Survey respondents identified five primary challenges to historic bridge programs: lack of funding, lack of agency preservation commitments, inability to identify adaptive reuses, lack of education about historic bridges, and the inability of bridges to meet current design criteria. Despite these challenges, two-thirds of state DOTs report their approach to addressing historic bridges has been effective.

◆ Most states wish to accomplish more with their programs; future initiatives include inventories, management plans, education, programmatic agreements, and rehabilitation projects.

For more information on the survey results, contact preservation@meadhunt.com or visit www.meadhunt.com/documents/newsletters/HistoricBridgePractices.pdf.



Number of states that have taken steps toward bridge preservation programs.

[a] 23 U.S.C. 144(o).

Local historic groups protested the proposed replacement of this 1905 bridge over the St. Joseph River in South Bend, Indiana. St. Joseph County agreed to rehabilitate the bridge instead and keep it in use.

Pettis and Long are architectural historians with Mead & Hunt, Inc., Madison, Wisconsin.

tifying best practices for regulatory review, augmenting survey and planning efforts through technological innovation, and applying program alternatives that are consistent with the law and regulation. These projects cover the spectrum from the early consideration of historic preservation concerns in planning, to innovative administrative streamlining during project development, to strengthening the tracking of commitment performance.

Unmet Research Needs

Many of the unmet research needs are as important as the ongoing studies of potential process improvements. Although historic preservation interests in transportation are diverse, the most important needs include

- Effectively managing the recent past,
- CSS and historic properties, and
- Best practices in the rehabilitation of historic bridges.

As noted earlier, the exponential increase in the number of properties at or beyond the 50-year threshold for consideration as historic could overwhelm the capacity of transportation agencies and their historic preservation partners—despite improvements made in the regulatory processes. The most important emerging transportation research need, therefore, is to find ways to manage the recent past effectively, by efficiently determining which properties are historic, and by developing historic contexts to target the significant aspects of the nation's recent past and determine NRHP eligibility. The recently approved NCHRP Project, Developing Regional Historic Contexts for Post-World War II Housing, should make significant progress in this area.

Informing Practice

Research should not focus exclusively on streamlining decision making and regulatory process improvements, however. The growing interest in and application of CSS in the design of transportation projects can benefit from an enhanced understanding of the role of historic properties in defining context. Research to review applications of CSS practice in relation to historic properties would help define best practices and principles of practice.

Research has contributed to improvements in historic bridge preservation. The transportation community will face additional challenges as the infrastructure continues to age and as funding becomes more competitive.

The continued collaboration between the historic preservation and engineering communities could focus on defining innovative and financially responsible best practices and making that information accessible to practitioners. FHWA and AASHTO, for example, have developed a web-based community of practice to communicate innovative engineering and preservation approaches—a method of disseminating research that can directly influence transportation project decision making and facilitate the rehabilitation of that nation's historic bridges.

Postwar contemporary-style house in Oshkosh, Wisconsin, constructed circa 1956. A recently approved NCHRP project will develop regional historic contexts for housing built after World War II.

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Introducing Context-Sensitive Solutions to the Next Generation of Transportation Professionals

JAMES B. MARTIN

The Center for Transportation and the Environment (CTE), North Carolina State University (NCSU), and North Carolina Department of Transportation (DOT) have partnered on initiatives to train graduate and undergraduate engineering students in developing and applying context-sensitive solutions (CSS). The programs provide students with valuable experience for their transportation careers, including connections with employers and colleagues.

CSS Summer Academy

In cooperation with North Carolina DOT, CTE conducts an experiential summer program for junior- and senior-level undergraduates interested in careers in transportation and the environment. The Context-Sensitive Solutions Summer Academy introduces the principles of CSS and their applications in transportation planning, project development, construction, operations, and maintenance.

Joe Hummer and John Stone, of the NCSU Department of Civil, Construction, and Environmental Engineering, lead the Academy students through coursework, case study activities, and research projects. Field trips showcase real-life applications of CSS across the state. The students also work as summer interns for North Carolina DOT, in positions that directly address transportation and environmental concerns.

CSS students view environment-friendly solutions incorporated into the Wilmington Bridge.

At the conclusion of the Academy, students make final presentations of their findings to a group of North Carolina DOT staff, other professionals, and university faculty. Thirty-two undergraduate juniors and seniors have completed the Academy successfully since its start in 2004. Academy students have researched and analyzed more than 50 different North Carolina DOT projects.

In 2007 and 2008, the Context-Sensitive Solutions Summer Academy focused on research into the costs and benefits of CSS. Students collected data and background information on projects from documents and structured interviews with North Carolina DOT project managers. The assignments allowed students to investigate issues of current interest in the industry, gain experience in transportation research methodology, and learn about a range of project types in North Carolina. A student presented a report on the 2007 Academy to the TRB Context-Sensitive Design and Solutions Task Force at the TRB 86th Annual Meeting.

CSS Summer Academy students follow a hands-on program that combines coursework, case study activities, research projects, internships with North Carolina DOT, and field trips, culminating in a final project report.

CSS Graduate Course

CTE and the NCSU Department of Civil, Construction, and Environmental Engineering have launched a new course for graduate students on CSS principles and practices. Designed and taught by Hummer and Stone, the course imparts hands-on experience with CSS principles by applying the core practices of CSS, including comprehensive identification of context, linked decision-making, stakeholder involvement, use of multidisciplinary teams, and comprehensive documentation.

During the first session, student teams worked with a project in Wrightsville Beach, North Carolina. The teams studied the project and the community context and then applied flexible design approaches to develop alternatives. The teams presented the alternatives at a mock citizens' workshop to role-playing North Carolina DOT employees, representing various community groups and concerns.

Equipping the Workforce

Both the Academy and the graduate-level course are part of CTE's commitment to educate and equip the next-generation transportation workforce. The programs allow students to enhance their engineering education and to start their careers with valuable insights into the project development process and with experience in addressing environmental and community concerns.

For more information on CTE programs, visit www.cte.ncsu.edu/CTE/Education/index.asp.

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Reducing Underwater Sounds with Air Bubble Curtains

Protecting Fish and Marine Mammals from Pile-Driving Noise

JAMES A. REYFF

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Pile driving at large construction sites produces formidable noise. Marine pile driving similarly can produce high sound pressures underwater—but these can be lethal to fish and can harass marine mammals, including those protected by federal law. This problem has contributed to costly construction delays on major bridge projects. To protect marine life, engineers have designed air bubble curtains to reduce underwater sounds.

Problem

In 2000, the California Department of Transportation (Caltrans) undertook a demonstration project to install steel piles as part of the design to replace the eastern span of the San Francisco–Oakland Bay Bridge. The demonstration involved driving 8-foot-diameter steel piles that were more than 300 feet long. The new bridge would require more than 250 of the piles.

An unconfined air bubble curtain with two vertically stacked rings is deployed on a harbor project to reduce underwater sounds; oil-free compressors supply air to the system.

Caltrans also conducted tests on sound reduction methods that had been developed to protect marine mammals. The underwater sounds during this demonstration, however, fatally injured fish, which were observed floating on the surface and exposed to predation by seagulls. Because the sound reduction methods were not protecting the fish adequately, state and federal agencies raised concerns about the endangered fish species in the area.

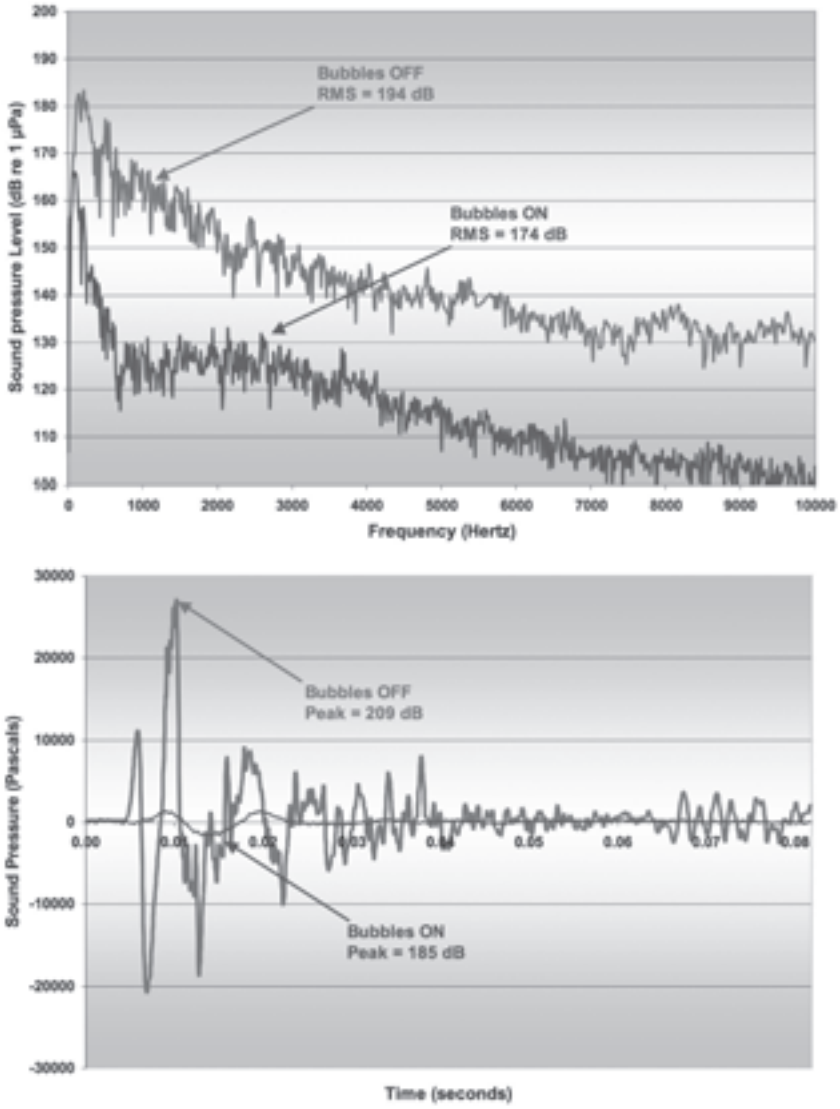
While the designers were working on developing an air bubble curtain that would effectively protect fish, pile driving began on the nearby Benicia-Martinez Bridge, located in the Carquinez Strait, a critical migration route for endangered fish in Northern California. Fish were fatally injured by the construction noise. This caused additional alarm and slowed the construction of the bridge.

The construction plans had not included methods to reduce underwater sounds. The pile driving had been restricted to slack tide conditions, when fish were least likely to be present, and was suspended when the endangered fish began their migration. The potential delay of 7 months threatened to stop the project permanently because of funding issues.

Solution and Application

Air provides an effective barrier to sound propagating through water, because of the difference in density between air and water. Air bubble curtain systems have been used to reduce underwater sound pressures from explosions or from other sources of high-amplitude sounds.

The first documented use of air bubble curtains on a marine pile-driving project was in Hong Kong; the curtains reduced the sounds by 3 to 5 decibels, protecting marine mammals (*1*). Engineers in Canada then reported favorable results with an air bubble curtain to protect fish at a wharf project. Caltrans, however, faced several complications: the sound levels were much higher, the water was



Example waveforms and frequency spectra for 2.4-m-diameter steel pile with and without bubble curtain: Benicia-Martinez Bridge, Carquinez Strait, California.

deeper, and the currents stronger. The curtain of air bubbles must be able to extend from the bottom of the pile to the water surface without any gaps.

Moreover, the driving templates that had been designed and fabricated for the project did not support the use of available air bubble curtains. Engineers therefore developed two types of curtains.

Design Variations

First, they placed a perforated tube at the bottom of a large cylinder that extended from just below the mud line to above the water surface, with the pile inside. The large cylinder would prevent currents from sweeping the air bubbles away from the pile.

Because many projects could not accommodate a large cylinder around the pile, multistage air-bubble curtains were developed. These systems place a series of rings around the pile at different depths. Although currents could sweep the bubbles away, the ring above would generate more bubbles, maintaining a uniform presence of air around the entire pile.

The prefabricated pile template for the Benicia-Martinez Bridge could not accommodate complete rings. The engineers therefore developed stacked quarter-rings that were placed at each quadrant of the piles. Because of the water depth, large compressors were required to deliver air to the bottom of the water column.

Underwater sound tests were conducted for these air bubble curtains with the air supplies turned on and off. The sound was reduced by 20 to 30 decibels close to the pile, where most of the fish injuries had occurred (2). Tests on other projects in shallower waters measured reductions of 10 to 20 decibels. In comparison, most highway noise barriers achieve reductions of only 5 to 10 decibels.

The key was that no fish injuries or mortality were observed with the air bubble curtains. Sound reductions from the pile driving were recorded out to 1 kilometer away. Areas with adverse effect on fish and marine mammals were estimated to decrease in size by up to 90 percent.

Research Group Formed

While the engineers were working on an effective design for the air bubble curtains against pile-driving sounds, researchers were trying to determine the effects of the noise on fish. Highway and resource agency officials, expert consultants, and university researchers formed the Fisheries Hydroacoustic Working Group (FHWG), which released the first research findings on the effects of sound on fish in 2005 (3). The group concluded that little was known and much additional research was needed.

In 2008, FHWG developed interim criteria to identify the potential effects of underwater sound on fish. All impact pile-driving activities exceeded the sound levels at which the onset of impacts to small fish occurs. On bridge projects that used larger steel-pipe piles, the impacts could extend 1 to 2 kilometers out into open water.

Benefits

Use of the air bubble curtains during pile driving has reduced sounds substantially. Biologists from Caltrans have not identified any injured fish with the air bubble curtains in use during pile driving. In San Francisco Bay, pile driving has been permitted during fish migration seasons, as long as the air bubble curtains reduce the sound levels sufficiently. In this way, pile driving that had been limited to seasonal windows can be completed before deadlines.

Projects now incorporate efforts to reduce underwater sounds from pile driving. In addition to air bubble curtains, options include dewatered cofferdams and other methods to install piles. Attenuation systems that use air to reduce underwater sounds are in routine use on the West Coast for marine pile-driving. Although the air bubble curtains can increase the time and cost of pile driving, proper planning can minimize the delays.

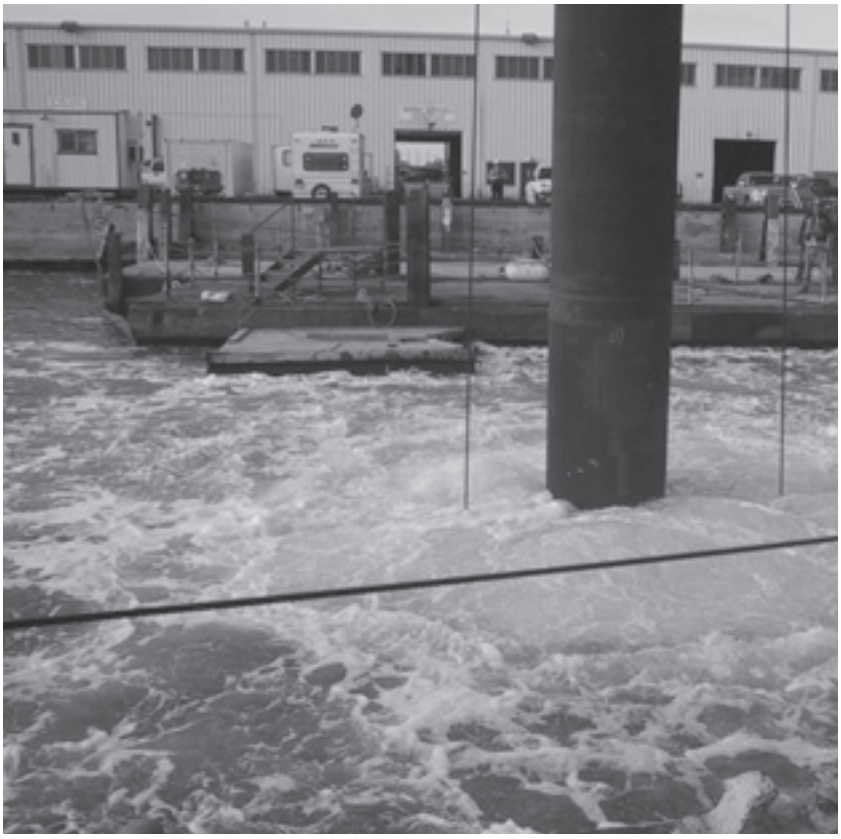
The FHWG continues to research the effects of sound on marine species and to develop more effective techniques to reduce underwater sound from marine construction. A National Cooperative Highway Research Program project is testing the effect of pile-driving sounds on fish in a laboratory setting (see box, below). A pooled-fund study will investigate changes to pile designs that could reduce sound pressures.

The Federal Highway Administration presented Caltrans and FHWG with a 2005 Environmental Excellence Award. Caltrans and the Washington State Department of Transportation (DOT) have developed guidance manuals for assessing the impacts of pile driving before design, so that the appropriate measures to reduce sound can be incorporated. Washington State DOT is investigating methods to reduce pile-driving sounds further, to allow pile driving year-round in waters with endangered or threatened species. For more information on this topic and for copies of research documents, see the Caltrans website, www.dot.ca.gov/hq/env/bio/fisheries_bioacoustics.htm.

For additional information, contact James A. Reyff, Illingworth & Rodkin, Inc., Acoustics–Air Quality, 505 Petaluma Boulevard South, Petaluma, CA 94952; telephone: 707-766-7700, ext. 24; e-mail: jreyff@illingworthrodkin.com; or James R. Andrews, Senior Transportation Engineer, Division of Environmental Analysis, Caltrans; telephone: 916-653-9554; e-mail: jim_andrews@dot.ca.gov.

More Clues from the Lab

National Cooperative Highway Research Program Project 25-28, Predicting and Mitigating Hydroacoustic Impacts on Fish from Pile Installation, is studying the science behind aquatic pile driving and its impact on fish. The project team, led by Art Popper, University of Maryland, has developed a wave tube apparatus to study the effects on fish in a laboratory setting, using auditory signals that closely replicate those of pile driving. Variables include the intensity of the pile-driving signal, the number of strikes, and the intervals between strikes. Postexposure experiments assess the sample fish for hearing loss and tissue damage. Results of the study are expected this fall.



Air bubble curtain submerged and in action; the bubble curtain not only reduces the sound, but also keeps fish away from the pile.

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3. Hastings, M. C., and A. N. Popper. *Effects of Sound on Fish.* 2005.
4. *Technical Guidance for Assessment and Mitigation of Hydroacoustic Effects of Pile Driving on Fish.* Caltrans, March 2009. www.dot.ca.gov/hq/env/bio/fisheries_bioacoustics.htm.

EDITOR'S NOTE: Appreciation is expressed to Stephen Maher, Transportation Research Board, for his efforts in developing this article.

Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, Keck 488, 500 Fifth Street, NW, Washington, DC 20001 (telephone 202-334-2952, e-mail gjayaprakash@nas.edu).

Kenneth G. Courage

University of Florida

Ken Courage has stacked up nearly five decades of experience in transportation, with more than 30 years as a civil engineering professor at the University of Florida (UF). After starting out as a traffic signals engineer in Winnipeg, Canada, Courage has held positions in government, industry, and academia. His focus areas include transportation system modeling, highway capacity analysis, and traffic software development. Courage also specializes in the teaching and research aspects of advanced traffic management systems, traffic data collection and analysis, and traffic safety. He has written many papers on the subject of traffic management and control technology, and has produced a variety of traffic engineering software.

"Traffic simulation modeling is one of the most useful and productive developments of transportation research, but it will not make the *Highway Capacity Manual* irrelevant."

"I have enjoyed all aspects of this work," he comments. "I hope it's been useful to someone!"

Courage joined the faculty of the UF Department of Civil and Coastal Engineering in 1971. Since his retirement in 2003, he has served as an emeritus professor. "I look at retirement as the beginning of a new career in transportation research," he remarks.

Courage became involved with the Transportation Research Board in 1968 as principal investigator for National Cooperative Highway Research Program (NCHRP) Project 20-3. The project launched a landmark effort in freeway system management on the John Lodge Freeway in Detroit, Michigan. "That project was a bit ahead of its time," he admits. "But it laid an important stone in the foundation of what we now call intelligent transportation systems."

In the 1990s he served as principal investigator for NCHRP Project 3-48, which developed an improved methodology for dealing with traffic-actuated control as described in the *Highway Capacity Manual* (HCM) chapter on signalized intersection analysis. According to Courage, researchers "have picked up where we left off. The result will be a greatly improved signalized intersection analysis procedure in the 2010 HCM."

Currently, Courage is principal investigator for NCHRP Project 3-85, Guidance for the Use of Alternative Traffic Analysis Tools for Highway Capacity Analysis, and is a member of the NCHRP Project 3-92 team that is developing the 2010 HCM. He also has been a member of the research team for three other NCHRP projects and has served on four NCHRP project panels and two NCHRP synthesis panels.

"Traffic analysts often use simulation and other models in conjunction with, or instead of, the HCM procedures," notes Courage. "Traffic simulation modeling is one of the most useful and productive developments of transportation research, but it will not make the HCM irrelevant. One of the most important enhancements in the 2010 HCM will be the guidance on how to use alternative tools effectively."

In addition to NCHRP, Courage has been involved in many TRB standing committees: the Traffic Flow Theory Committee, on which he currently serves; the Highway Capacity and Quality of Service Committee; the Traffic Signal Systems Committee; and the Freeway Operations Committee. These four committees sponsor the TRB Joint Traffic Simulation Subcommittee, or SimSub, which Courage has chaired for the past 5 years. "SimSub has come a long way in 5 years," he observes. This year, he states, he plans to step down as chair "to make room for younger people with fresh ideas."

Courage is a fellow of the Institute of Transportation Engineers (ITE), a past president of ITE's Florida Section, and a registered professional engineer. In 1972, Courage received the Highway Research Board Award, and in 1973, the ITE Past Presidents Award. Other honors include a Traffic Engineering Council Award from ITE, two Research Achievement Awards from the University of Florida, and the ITE District 10 Sherwood H. Hiller Distinguished Service Award. Last year, he was inducted into the honor roll of the Intelligent Transportation Society of Florida.

Courage graduated with a bachelor's degree in electrical engineering from the University of Manitoba and received a master's degree in civil engineering from Texas A&M University.

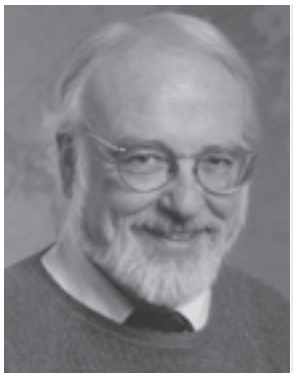
Courage notes that he has not missed an annual TRB meeting since the first one he attended in 1968. "That's 42 in a row," he points out. "Those meetings can tire you out, but they are the most important transportation research event of the year. I always look forward to the next one."

Robert D. Holtz

University of Washington

Robert D. (Bob) Holtz's research in geotechnology and geosynthetics has taken him around the globe. Professor of Civil Engineering at the University of Washington (UW) in Seattle since 1988, he has held engineering positions in such locales as Sweden, France, and Italy. Holtz, named professor emeritus at UW in 2008, cites geosynthetics, foundations, soil reinforcing, soil improvement, and slope stability as his primary areas of research.

A native of Tucson, Arizona, Holtz earned bachelor's and master's degrees in civil engineering from the University of Minnesota. In 1966, he attended Harvard University for a special program in soil mechanics, and he received a Ph.D. in soil mechanics from Northwestern University in 1970.



"It is gratifying to see that some of our research on geosynthetics has been put to good use by highway agencies, such as Indiana DOT and, especially, Washington State DOT."

Holtz began the academic side of his engineering career at the University of Minnesota, Minneapolis, working as a teaching assistant while he earned his master's degree. Since then—while maintaining an active consulting practice—Holtz has held teaching and research positions at such institutions as California State University; the Swedish Geotechnical Institute and the Royal Institute of Technology, Stockholm, Sweden; National Research Council of Canada, Ottawa; École Nationale des Ponts et Chausseés, Paris; and Purdue University. His research sponsors have included the National Science Foundation, the Purdue Research Foundation, the Indiana Department of Highways, the Federal Highway Administration (FHWA), the United States Air Force, the Washington State Department of Transportation (DOT), the National Cooperative Highway Research Program, and several private companies.

Although he is now retired from full-time teaching and research, Holtz still oversees a research project of note to transportation geotechnical engineers.

"We are constructing a very steep slope reinforced by 'Spiralnails' that is well instrumented and will be loaded to failure by a large footing-and-jack system on the top of the stabilized slope," Holtz explains. Spiralnails are a new type of groutless soil nailing system developed by a Seattle-area engineer, and the project is funded by Hilfiker Retaining Walls. A recently completed project involved a full-scale instrumented field test of footings constructed on several short, compacted aggregate piers at a stiff clay site in Texas.

Research is a foundation of a professor's life, Holtz notes. "It is gratifying to see that some of our research on geosynthetics has been put to good use by highway agencies, such as Indiana DOT and, especially, Washington State DOT," he observes. "For example, our research on geotextile separators shows that they really do work." Holtz adds that findings on soil reinforcing with geosynthetics have influenced the development of a new design approach for geosynthetic reinforced retaining walls and slopes.

Holtz expresses concern, however, about the future of geotechnical research related to transportation. Organizations such as FHWA and Washington State DOT recently have much less funding for geotechnical research, he notes: "Unfortunately, many problems remain, and they are unlikely to be solved without some type of a directed and collaborative applied research program between the professional geotechnical engineers in the transportation agencies and the universities."

Holtz's TRB activities draw on his geotechnical research expertise. He has been a member of the Design and Construction Group, and of the Committees on Geosynthetics, Soils, and Rock Instrumentation, and Soil and Rock Properties. He also contributed his expertise to the Transportation Earthworks committee for nearly 20 years, serving as chair from 1982 to 1988. Holtz also chaired the Geology and Properties of Earth Materials Section (1990–1996). In 1999, he was named an emeritus member of the Soil and Rock Properties Committee.

Holtz is working to finish the second edition of the undergraduate textbook, *An Introduction to Geotechnical Engineering*, which he coauthored with Bill Kovacs in 1981. Now in its 42nd printing, the book has been translated into Chinese, Bahasa Malaysian, French, and Turkish. Holtz also coauthored the *FHWA Geotextile Engineering Manual* with Barry R. Christopher (1985), and *Geosynthetic Engineering* with Ryan R. Berg and Christopher (1997), and has authored or contributed to many chapters, journal articles, papers, and other publications.

Several awards and honors have recognized Holtz's contributions to the field of geotechnical research, including Distinguished Member of the American Society of Chemical Engineers (ASCE), Cross-Canada Lecturer for the Canadian Geotechnical Society, Puget Sound Academic Engineer of the Year, and the IGS Pioneer Award from the International Geosynthetics Society.

A new sensor, currently being tested to monitor freeze–thaw status of subsurface pavement conditions, is placed beneath the pavement surface.

PHOTO: BILL YU

Sensor May Adjust Spring Load Restrictions

Researchers at Case Western Reserve University, Cleveland, Ohio, are testing a new sensor to monitor the freeze–thaw status of subsurface pavement conditions. Led by Xiong (Bill) Yu, the team hopes that their research into pavement strength with the sensor will shave some time off the mandatory spring load restrictions (SLR), or vehicle weight limits, that are in place throughout the winter in cold regions. SLR is a pavement preservation strategy in these regions, designed to prevent deterioration of the pavement substructure during the spring thaw, which saturates and weakens pavement layers.

Tested at MnROAD, the outdoor roadway laboratory in Ostego, Minnesota, the sensor is "rugged, sensitive, and portable," according to Yu, and has distributive sensing capability on moisture migration. Its performance since October 2007 has demonstrated excellent signal quality, he reports.

Jurisdictions in the United States currently set load restrictions based mainly on deflection measurement and experience. To simplify the decision of when to start the restrictions, the Minnesota Department of Transportation (DOT) uses the actual and predicted average daily temperature, with the SLR duration fixed at 8 weeks. Restrictions must be placed when the pavement first thaws and the stiffness of the base layer is low; proper measurement and prediction of freeze-thaw events is crucial to a successful load-restriction strategy. Although a few technologies can provide such information—for example, temperature-based technologies and resistivity probes—they are not reliable and the data collection is time-consuming, Yu notes.

In 2008, the sensor indicated that the ground was relatively stable between February 15 and 29, with an appreciable amount of thaw between February 29 and March 14. The trend of change was more significant between March 14 and 29, according to the data. After that, the ground moisture continued to increase slightly and was relatively stable from April 15 to July 15, when the most current data were analyzed. According to Yu, this implies that the SLR could have been lifted around April 15, 2008. The restrictions were not lifted in most areas of Minnesota until May 13, 2008.

Although the results are encouraging, the researchers are working on validation of the sensor at different locations and with alternative designs—such as hot-mix asphalt thickness, base types, construction variations, and others—to provide better decision support. The MnRoad research team—led by Ben Worel, with members Jack Herndon, Robert Strommen, and Doug Lindenfelser—is a collaborator in the study.

For more information, contact Bill Yu, 216-368-6247, xxy21@case.edu.

Seatbelt Use Up, Traffic Fatalities Down

Two reports released by the National Highway Traffic Safety Administration (NHTSA) show a rise in seat belt use and a decline in motor vehicle traffic fatalities for 2008. According to the reports, NHTSA's National Occupant Protection Use Survey measured a nationwide 83 percent rate of seat belt use last year, and traffic fatalities fell from 41,059 in 2007 to a projected total of 37,313 in 2008.

Sixteen states and territories had use rates of 90 percent or higher, according to the NHTSA report. In general, areas with stronger seat belt enforcement laws had higher use rates. According to state and territory surveys, Michigan had the highest rate of seat belt use—97.2 percent—and American Samoa, with 55.7 percent, had the lowest. Nineteen states had less seat belt use in 2008 than in 2007, with Rhode Island's use rate dropping 7.1 percent. Of the 35 states and territories that showed an increase in seat belt use, the highest were the Northern Mariana Islands, with an increase of 9.8 percent, and New York, with an increase of 5.6 percent.

PHOTO: AAA FOUNDATION FOR TRAFFIC SAFETY

Many states, like Pennsylvania, participate in a national seat belt use enforcement and education campaign.

NHTSA's early estimate of motor vehicle traffic fatalities in 2008 shows a 9.1 percent decline from fatalities reported in 2007. An actual count of last year's traffic fatalities will be released in August. The estimated decline, based on a statistical projection, would be the third-largest drop in traffic fatalities since 1961. Preliminary data from the Federal Highway Administration show that vehicle miles traveled (VMT) also fell in 2008, to 2,922 billion miles—an approximate 3.6 percent drop. The fatality rate, computed per 100 million VMT, declined from 1.36 in 2007 to 1.28 in 2008.

Women's Group Expands Scholarship Program

Women's Transportation Seminar (WTS) has expanded its scholarship program, creating the WTS Foundation, a 501(c)(3) organization that supports the advancement of women in transportation professions. The WTS Foundation replaces the WTS Scholarship, which has raised $2,000,000 and disbursed more than $900,000 in its 15 years. The foundation plans to initiate, sponsor, and publish research and to promote and offer education opportunities and professional development for women in the transportation community.

In 2008, TRB Executive Director Robert E. Skinner, Jr., signed a memorandum of understanding with WTS Past President Ann L. Koby as part of TRB's concerted effort to encourage the involvement of women in transportation.

INTERNATIONAL NEWS

European Initiative to Halve Emissions

An international agency initiative endeavors to reduce by half automobile greenhouse gas emissions in the European Union by 2050. The 50 by 50 Global Fuel Economy Initiative (GFEI) report, issued in March, promises to achieve a savings of 6 billion barrels of oil and to prevent the release of 2 gigatons of carbon dioxide annually.

According to the report, GFEI would accomplish its goal by helping and supporting policies to promote the production of more fuel-efficient vehicles.

The path to a 50 percent reduction in fuel consumption per kilometer takes into account suggestions made by the Intergovernmental Panel on Climate Change, and would entail collaboration with governments as well as the car industry. GFEI's objectives for 2009 include regional assessments and launches to further political involvement in Europe, North America, Latin America, and Asia; four regional pilot projects to aid the development of national fuel economy policies; interaction with the Group of Eight (G8) forum and the United Nations (UN); and the formulation of a fuel economy information database, information materials, and website.

GFEI is a result of the partnership between the UN Environment Programme, the International Energy Agency, the International Transport Forum, and Fédération Internationale de l'Automobile Foundation.

For more information, visit www.50by50campaign.org.

PHOTO: LOIS FINLEY, EVENT DIGITAL PHOTOGRAPHY, INC.

A COMMITMENT TO SCIENCE AND TECHNOLOGY—President Barack Obama announced new initiatives and investments in science at the 146th Annual Meeting of the National Academy of Sciences (NAS), Monday, April 28, at the NAS Building in Washington, D.C. After a welcome by NAS President Ralph J. Cicerone, Obama discussed his administration's commitment to scientific progress and promised to devote 3 percent of the country's gross domestic product to funds for scientific research and innovations. The budgets of three agencies—the National Science Foundation, the Department of Energy's Office of Science, and the National Institute of Standards and Technology—will be doubled, Obama said. He also announced the members of the President's Council of Advisors on Science and Technology—seven are NAS members.

COOPERATIVE RESEARCH PROGRAMS NEWS

Developing Reliability-Based Bridge Inspection Policies

The National Bridge Inspection Standards (NBIS), which mandate the frequency and methods used for the safety inspection of highway bridges, require routine inspections every 24 months. That interval may be extended to 4 years for bridges that meet certain criteria and are approved by the Federal Highway Administration, but under NBIS, hands-on inspections are required every 2 years for bridges with fracture-critical elements.

In general, the inspection intervals are not based on the performance of bridge materials or designs but derive from experience managing the 600,000 bridges in the National Bridge Inventory. Although applied to the entire bridge inventory, these inspection intervals may not be appropriate for all bridges; for example, recently constructed bridges typically experience few problems during their first decade of service, but under the requirements, these bridges must have the same inspection frequency and intensity as a 50-year-old bridge nearing the end of its service life. The application of reliability theory to inspection practices can help meet the goals of improving bridge safety and reliability, as well as optimize resources for bridge inspection.

The University of Missouri has been awarded a $399,930, 20-month contract [National Cooperative Highway Research Program (NCHRP) 12-82, FY 2009] to help develop a recommended bridge inspection practice for consideration by the American Association of State Highway and Transportation Officials (AASHTO). The project is scheduled for completion in December 2010.

For more information, contact Waseem Dekelbab, TRB, 202-334-4109, wdekelbab@nas.edu.

Calibrating Concrete Bridge Design Specifications for Serviceability

AASHTO's *LRFD* (Load and Resistance Factor Design) *Bridge Design Specifications* has its primary advantage in uniform reliability at the strength limit state, achieved by statistical calibration. Service and fatigue limit states, however, can only be calibrated using engineering judgment. This process does not achieve uniform reliability. Although this research project focuses on concrete bridges, the lack of reliability for service and fatigue limit states also affects steel bridges.

To assure that uniform reliability is achieved for all limit states, the calibration will include criteria for cracking, deformation, and concrete stresses, along with the newly adopted fatigue provisions. Additional limit states may need to be added and calibrated to include other effects, such as owner-specified design and permit vehicles.

A $500,000, 30-month contract [NCHRP Project 12-83, FY 2009] has been awarded to Modjeski & Masters, Inc., to develop new concrete service and fatigue limit states as needed, to calibrate new and existing concrete service and fatigue limit states, and to prepare specifications for consideration by the AASHTO Highway Subcommittee on Bridges and Structures. The project is scheduled for

ADVANCING EQUITY CONSIDERATIONS—Brian Taylor, UCLA (*left*); Jeffrey Buxbaum, Cambridge Systematics; T. Keith Lawton, Keith Lawton Consulting, Inc.; Johanna Zmud, NuStats, LLC; and David Levinson, University of Minnesota, participate in a meeting of the Committee on Equity Implications of Alternative Transportation Finance Mechanisms. The committee convened May 7 and 8 at the Keck Center to explore the equity implications of alternative funding mechanisms for transportation projects. The committee also is working to pinpoint specific issues to consider when alternative transportation funding mechanisms are proposed and to develop recommendations for research.

LEARNING FROM INTERNATIONAL BENCHMARKS—The Committee for the Study of Traffic Safety Lessons from Benchmark Nations—including *(left to right)* Alison Smiley, Human Factors North, Inc.; Anthony G. Bliss, World Bank; and consultant Allan F. Williams—met April 21 at the National Academies' Keck Center, Washington, D.C. The committee is investigating successful safety programs in nations such as Sweden, United Kingdom, Netherlands, and Australia, as models to adapt and apply in reducing traffic deaths and injuries in the United States. A main focus of the study is an examination of the approaches used to build public and political support for the programs.

completion in October 2011.

For more information, contact Waseem Dekelbab, TRB, 202-334-4109, wdekelbab@nas.edu.

Guidelines for Performance Measurement of Congestion Pricing

As demand for highway facilities increases and capacity remains limited, highway traffic congestion—one of the biggest challenges facing transportation agencies today—will likely continue to worsen. Increasing peak times, loss of productivity during congested periods, and underutilization of capacity during off-peak periods are some of the system management challenges faced by the industry.

A growing momentum within government transportation agencies to explore congestion pricing and evaluate its performance means that transportation organizations need assistance in developing and tracking measurements to assess the benefits and impacts of congestion pricing strategies. More knowledge is needed on how to develop appropriate performance measurements, data tracking and analysis methods, and ways to communicate the results to the public.

PB Americas has been awarded a $200,000, 18-month contract [NCHRP Project 08-75, FY 2009] to create guidelines for evaluation and performance measurement of congestion pricing projects to optimize the use of roadway capacity. The guidelines will help agencies select or develop appropriate performance measures, collect the necessary data, track performance, and communicate the results to decision makers, users, and the general public. The scheduled completion date for this project is November 1, 2010.

For further information, contact Chris Hedges, TRB, 202-334-1472, chedges@nas.edu.

Identification and Evaluation of Freight Demand Factors

Historically, forecasts of demand for freight transportation have underestimated substantially the growth in freight volumes and average lengths of haul. As a result, today's highways are overwhelmed with trucks, rail capacity is lacking because of abandonments, and transportation infrastructure sizing and pricing face planning dilemmas.

More recent national freight forecasts predict enormous increases in the demand for freight transportation in the next two decades. Because of the underestimation of freight demand by forecasters in the past, however, it is not certain whether these predictions of freight growth are any more accurate.

The research firm Halcrow has been awarded a $350,000 contract [National Cooperative Freight Research Program (NCFRP) Project 11, FY 2009] to describe and analyze factors that may contribute to future freight quantity; geographic distribution; temporal distribution of tons, ton miles, vehicle miles, or train miles; and the value of freight to be moved in and through North America.

For further information, contact Bill Rogers, 202-334-1621, wrogers@nas.edu.

TRB Meetings

2009

July

19–22 48th Annual Workshop on Transportation Law
Denver, Colorado

19–22 2009 TRB Joint Summer Conference
Seattle, Washington

19–23 12th AASHTO–TRB Maintenance Management Conference*
Annapolis, Maryland

22 Northwest Traffic Data Workshop
Seattle, Washington

28–29 2009 Transportation Planning, Land Use, and Air Quality Conference
Ames, Iowa

August

3–6 GeoHunan: Challenges and Recent Advances in Pavement Technologies and Transportation Geotechnics*
Hunan, China

17–18 5th New York City Bridge Conference*
Battery Park, New York

24–27 Transportation Hazards and Security Summit 2009: Progress Through Partnership (by invitation)
Irvine, California

29–Sept. 2 14th Conference on Cold Regions Engineering*
Duluth, Minnesota

September

6–9 4th International Congress of Smart Rivers 21: The Future of Inland Navigation*
Vienna, Austria

14–15 Integrated Corridor System Management Modeling Best Practices Workshop
Irvine, California

16–17 North American Freight Flows Conference 2009
Irvine, California

17–18 Research on the Transmission of Disease in Airports and on Aircraft: A Symposium
Washington, D.C.

28 Long-Term Performance of Geotechnical Infrastructure
Buffalo, New York
G. P. Jayaprakash

October

5–7 European Transport Conference*
Leiden, Netherlands

13–14 Infrastructure Security Workshop*
Rutgers, New Jersey
Joedy Cambridge

19–22 8th National Conference on Asset Management
Portland, Oregon

27–30 4th International Conference on Women's Issues in Transportation
Irvine, California

29 EMS (Emergency Medical Services) Workshop and Midyear Meeting
Washington, D.C.
Richard Pain

November

12–13 Developing a Research Agenda for Transportation Infrastructure Preservation and Renewal
Washington, D.C.

December

13–18 12th International Conference on Travel Behavior Research*
Jaipur, India
Kimberly Fisher

2010

January

10–14 TRB 89th Annual Meeting
Washington, D.C.

April

12–16 1st International Conference on Pavement Preservation*
Newport Beach, California

May

5–7 1st International Conference on Nanotechnology in Cement and Concrete
Irvine, California

30–June 2 Safety and Mobility of Vulnerable Road Users: Pedestrians, Motorcyclists, and Bicyclists*
Jerusalem, Israel
Richard Pain

Additional information on TRB meetings, including calls for abstracts, meeting registration, and hotel reservations, is available at www.TRB.org/calendar. To reach the TRB staff contacts, telephone 202-334-2934, fax 202-334-2003, or e-mail lkarson@nas.edu. Meetings listed without a TRB staff contact have direct links from the TRB calendar web page.

*TRB is cosponsor of the meeting.

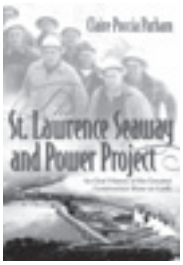
On Being a Scientist: A Guide to Responsible Conduct in Research, Third Edition

The National Academies Press, 2009; 82 pp.; $11.65; 978-0-309-11970-2.

The National Research Council has released the third edition of *On Being a Scientist*, a report on the practice of science that applies to all forms of research—whether in academic, industrial, or governmental settings—and to all scientific disciplines. The report, designed to supplement informal ethics lessons provided by research supervisors and mentors, describes the ethical foundations of scientific practices, along with some of the personal and professional issues that researchers encounter in their work.

The third edition reflects developments since the publication of the original edition, in 1989, and a second edition, in 1995. It includes a number of hypothetical scenarios and offers guidance in thinking about and discussing these scenarios. Among the topics addressed are the responsibilities of advisers and their advisees, appropriate ways to share research results, the treatment of people and animals involved in studies, and mistakes and negligence in research. Also included is a list of books and articles for further reading.

The St. Lawrence Seaway and Power Project: An Oral History of the Greatest Construction Show on Earth



Claire Puccia Parham. Syracuse University Press, 2009; 328 pp.; $34.95; 978-0-8156-0913-1

In time for the 50th anniversary of the St. Lawrence Seaway and Power Project, a 265-mile-long canal separating America from Canada, a new book reveals the project's human side in the words of 53 engineers, carpenters, laborers, and their wives. Author Claire Puccia Parham exposes the dangerous working conditions, larger-than-life equipment, and construction dilemmas encountered by workers.

The project, which began in 1954 and was completed in 1959, cost $1 billion and is one of the largest public works initiatives of the 20th century. The largest waterway and hydro dam project ever jointly built by two nations, the Seaway project comprised seven locks, the widening of various canals, the taming of rapids, and the erection of the 3,216-foot-long, 195.5-foot-high Robert Moses–Robert H. Saunders Power Dam. Since its completion, the Seaway has seen the transport of 2.5 billion tons of cargo—equivalent to 87 million truckloads—valued at more than $375 billion. It also produces hydroelectric power for Canada and the United States.

The books in this section are not TRB publications. To order, contact the publisher listed.

TRB PUBLICATIONS

U.S. Marine Salvage Assets and Capabilities in a Maritime Disaster

TRB Conference Proceedings 45

This report contains the proceedings of a September 2008 workshop focusing on a scenario of an incident that shuts down the Ports of Los Angeles and Long Beach. The proceedings examine the threat and explore key issues relating to an efficient, effective, and coordinated U.S. salvage industry response to a worst-case marine casualty scenario.

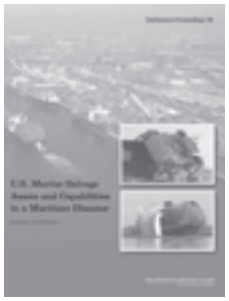
2009; 81 pp.; TRB affiliates, $36; nonaffiliates, $48. Subscriber categories: marine transportation (IX) and security (X).

Components of Bituminous Paving Mixtures 2008

Transportation Research Record 2051

Presented are findings on polyphosphoric acid–modified asphalts, biofuel coproducts for performance enhancement of asphalt binders, field aging of unmodified asphalt binder, and asphalt mixes containing expanded clay aggregate. Other topics explored include the effects of mineral filler, hot-mix asphalt containing hydrated lime, stone matrix asphalt mixtures with reclaimed asphalt pavement, and the incorporation of reclaimed asphalt pavement in warm-mix asphalt.

2008; 97 pp.; TRB affiliates, $40.50; nonaffiliates, $54. Subscriber category: materials and construction (IIIB).



Aviation 2008

Transportation Research Record 2052

An evaluation of airline service quality; a forecast of air taxi, commercial airline, and automobile demand in the United States; a comparison of low-cost and full-service carriers in Southeast Asia; the cost of U.S. aviation infrastructure; short-haul airline crew rostering; segmentation and positioning analysis for the international air travel market; and airport taxi–out prediction are some of the topics explored in this volume.

2008; 125 pp.; TRB affiliates, $41.25; nonaffiliates, $55. Subscriber category: aviation (V).

TRB PUBLICATIONS *(continued)*

Geology and Properties of Earth Materials 2008
Transportation Research Record 2053
The papers in this volume explore topics such as frost and thaw depth predictors for variable load restrictions, climate-change impact on low-volume roads, fly ash with calcium chloride for stabilization of base and subgrade courses, field and laboratory suction measurements of expansive clays, computerized cone penetration tests for soil classification, and correlation between resilient modulus and plastic deformation for cohesive subgrade soil under repeated loading.

2008; 79 pp.; TRB affiliates, $39; nonaffiliates, $52. Subscriber category: soils, geology, and foundations (IIIA).

Trains That Passed in the Night
Author Offers Insights on Photo Exhibit

The Last Steam Railroad in America
Thomas Garver and O. Winston Link. Abrams, 1995; 144 pp.; $35; 978-0-8109-8201-7.

The era of the steam railroad was evoked in an exhibition of fascinating historical photographs by O. Winston Link at the National Academy of Sciences (NAS) building in Washington, D.C., March 11–June 15. Taken from 1955 to 1959 along the Norfolk and Western Railway, Link's photographs provided a revealing glimpse into the past. On May 20, Thomas Garver, Link's photographic assistant and author of *The Last Steam Railroad in America* (1995, Abrams), delivered a lecture on the photographs at the National Academies' Keck Center in conjunction with the NAS exhibition.

Link's assistant from 1957 to 1958, Garver participated in three trips along the Norfolk and Western Railway to record the trains in photographs and audio. "Winston was fascinated by the technology of [trains]," Garver said.

Garver believes that Link's interest in rail started in childhood. The Brooklyn-born Link had a standard-gauge Lionel train set growing up, said Garver, and Link spent time as a teenager taking pictures of the Erie Railroad and the luxury Blue Comet train in New Jersey. The fascination continued into adulthood, and while on a commissioned advertising photography project in Northern Virginia in 1955, Link saw a Norfolk and Western train pulling into the station. He returned to photograph it the following night, and conceived of a project to photograph the trains as they traveled through the mountains of West Virginia, North Carolina, and Virginia, and to capture images of the people and places that trains served.

"People in Virginia and North Carolina and West Virginia were very supportive of [the project]; they really showed him Southern hospitality," said Garver.

Trained as a commercial photographer to produce pictures that told a story and evoked a certain response, Link set up his photographs carefully, controlling every aspect of lighting, scene, and subject placement. He even acquired keys to the dispatcher's signal boxes so that he could tell conductors to speed or slow the trains in advance of the shot, said Garver.

Most of Link's photographs were taken at night, which allowed him to manipulate the lighting and bring a "human vitality" to images of rail. "He created photographs that drew people in," said Garver. "Even people who couldn't imagine themselves interested in those 'greasy old machines.'"


Thomas Garver with O. Winston Link's 1956 photograph, "Hotshot Eastbound at the Iaeger Drive-In, Iaeger, West Virginia."

According to Garver, Link's photographs evoke the connection between trains and "the good life." Scenes such as a young couple at a drive-in movie with a train in the background, or a father and son bringing home a Christmas tree as a train passes by, suggest that the American experience is provided by, or at least supported by, the railroad system. Link took up the project on his own, said Garver; Norfolk and Western did not commission or pay for it but encouraged and accommodated Link in his mission.

In 1994, after a career as an art museum director, writer, and independent curator, Garver became Link's business agent. He assisted on Link's first book, *Steam, Steel & Stars* (1987, Abrams) and in 1995 wrote *The Last Steam Railroad in America*. After Link's death in 2001, Garver served as organizing curator of the O. Winston Link Museum, located in the former Norfolk and Western Railway passenger station in Roanoke, Virginia.

For more information on the O. Winston Link Museum, visit www.linkmuseum.org. For listings of National Academies' cultural programs, visit national-academies.org.

—Lea Mae Rice

Activity and Time Use Analysis 2008
Transportation Research Record 2054
Authors investigate synchronicity of activity engagement and travel, analysis of activity conflict resolution strategies, destination choice in daily activity travel, differences of household weekday and weekend activities, analysis of planning decisions during the activity-scheduling process, weekly rhythm in joint time expenditure for at-home and out-of-home activities, a random utility-based microeconomic model for discretionary activity time allocation, network equilibrium with activity-based microsimulation models, and other topics.

2008; 109 pp.; TRB affiliates, $41.25; nonaffiliates, $55. Subscriber category: planning and administration (IA).

Work Zones and Maintenance Operations
Transportation Research Record 2055
The 16 papers in this volume examine late lane merges, automated speed photo enforcement, scheduling, traffic delay, high-mast lighting, retroreflectivity of pavement markings, asset management practices for pavement markings, surface transportation weather, and aspects of winter maintenance.

2008; 146 pp.; TRB affiliates, $48; nonaffiliates, $64. Subscriber category: maintenance (IIIC).

Traffic Control Devices, Visibility, and Highway–Rail Grade Crossings 2008
Transportation Research Record 2056
Glare, pedestrian visibility in crosswalks, pavement marking retroreflectivity, "stop ahead" pavement markings, modern pavement marking systems, nine-panel logo signs, treatments at urban signalized intersections, dual-advisory speed signing on freeway-to-freeway connectors, and gate rushing at highway–railroad grade crossings are some of the topics covered in this volume.

2008; 109 pp.; TRB affiliates, $41.25; nonaffiliates, $55. Subscriber category: highway operations, capacity, and traffic control (IVA).

Environment and Energy 2008
Transportation Research Record 2058
Presented are findings on the *Tennessee Environmental Procedures Manual*, infrastructure strategies to reduce emissions from intermodal freight movement in Southern California, B20 biodiesel emissions compared against petroleum diesel emissions, emission behavior of public transportation buses with alternative diesel fuels, environmental impacts of catalytic converter malfunctions, a wildlife habitat classification to improve transportation and conservation planning, environmental assessment of tire–pavement noise, carbon dioxide impacts of traffic congestion, and more.

2008; 178 pp.; TRB affiliates, $51; nonaffiliates, $68. Subscriber category: energy and environment (IB).

Geomaterials 2008
Transportation Research Record 2059
Authors study the Micro-Deval test for coarse aggregates and fine aggregates, anisotropic behavior of aggregate bases, permanent deformation of natural bituminous sands, stiffness of unbound aggregate bases, shear strength of recycled glass, the performance of chemically modified subgrade soils, rutting of cement-treated base material, physicochemical behavior of cement kiln dust-treated kaolinite clay, lime in full-depth reclamation, and cement- and fiber-stabilized soil rapid assessment.

2008; 102 pp.; TRB affiliates, $40.50; nonaffiliates, $54. Subscriber category: soils, geology, and foundations (IIIA).

Highway Design 2008
Transportation Research Record 2060
The 18 papers in this volume explore topics in geometric design; roadside safety design in grates, guardrails, and cable barriers; landscape and environmental design; context-sensitive design and solutions; hydrology, hydraulics, and water quality; and utilities.

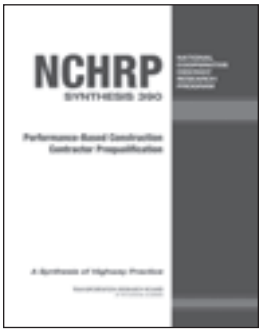
2008; 172 pp.; TRB affiliates, $51; nonaffiliates, $68. Subscriber category: highway and facility design (IIA).

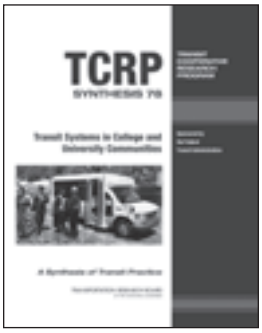
Statistical Methods
Transportation Research Record 2061
An analysis of naturalistic driving data, adjustment for a maximum likelihood estimate of negative binomial dispersion parameter, nonparametric Bayesian estimation of freeway capacity distribution, and tree-based regression models are some of the paper topics in this volume. Also examined are crash frequency analysis with generalized additive models and spatial models, estimation of confidence intervals of crash prediction models, and cross-correlation analysis and multivariate prediction of spatial time series of freeway traffic speeds.

2008; 76 pp.; TRB affiliates, $39; nonaffiliates, $52. Subscriber categories: planning and administration (IA), and safety and human performance (IVB).

Effectiveness of Behavioral Highway Safety Countermeasures
NCHRP Report 622
A framework to assess the costs and benefits of emerging, experimental, untried, or unproven behav-

TRB PUBLICATIONS *(continued)*





ioral highway safety countermeasures is explored in this report, along with guidance for estimating the effectiveness of these countermeasures.

2008; 50 pp.; TRB affiliates, $30; nonaffiliates, $40. Subscriber category: safety and human performance (IVB).

Identifying and Quantifying Rates of State Motor Fuel Tax Evasion
NCHRP Report 623
The findings in this report initiate an exploration of a methodological approach to examine and quantify state motor fuel tax evasion rates and to support agency efforts to reduce differences between total fuel tax liability and actual tax collections.

2008; 180 pp.; TRB affiliates, $43.50; nonaffiliates, $58. Subscriber category: planning and administration (IA).

Selection and Application of Warning Lights on Roadway Operations Equipment
NCHRP Report 624
Recommended guidelines for the selection and application of warning lights on roadway operations equipment address physical, functional, and performance requirements of the lighting system; recognize that the lighting system must be designed and laid out with consideration to planned vehicle usage; and provide technical information to develop procurement specifications for specific applications.

2008; 40 pp.; TRB affiliates, $27.75; nonaffiliates, $37. Subscriber categories: maintenance (IIIC), safety and human performance (IVB).

Traffic Safety Evaluation of Nighttime and Daytime Work Zones
NCHRP Report 627
Investigated in this report are crash rates for nighttime and daytime work zones, and management practices that promote safety and mobility in work zones. The report also features work-zone crash reporting suggestions, designed to help improve the data collected on these crashes.

2008; 78 pp.; TRB affiliates, $35.25; nonaffiliates, $47. Subscriber category: safety and human performance (IVB).

Self-Consolidating Concrete for Precast, Prestressed Concrete Bridge Elements
NCHRP Report 628
Strategies for the use of self-consolidating concrete (SCC) in precast, prestressed concrete bridge elements; the selection of constituent materials; proportioning of concrete mixtures; testing methods; fresh and hardened concrete properties; production and quality control issues; and other aspects of SCC are some of the issues examined in this volume.

2009; 92 pp.; TRB affiliates, $37.50; nonaffiliates, $50. Subscriber categories: bridges, other structures, and hydraulics and hydrology (IIC); and materials and construction (IIIB).

Performance-Based Construction Contractor Prequalification
NCHRP Synthesis 390
This report summarizes the experience of state transportation agencies that have examined contractors' past performance as part of the prequalification process. Focusing on design–bid–build projects, this synthesis also examines information on the process developed in other sectors of the construction industry.

2009; 101 pp.; TRB affiliates, $38.25; nonaffiliates, $51. Subscriber categories: planning and administration (IA) and materials and construction (IIIB).

Shared Use of Railroad Infrastructure with Noncompliant Public Transit Rail Vehicles: A Practitioner's Guide
TCRP Report 130
Studied is a business case for the shared use of public transit rail vehicles that do not comply with Federal Railroad Administration regulations, such as light rail vehicles, with freight operations. The report also highlights a business model for shared-use operations and explores the potential advantages and disadvantages of these operations.

2009; 109 pp.; TRB affiliates, $39; nonaffiliates, $52. Subscriber categories: public transit (VI) and rail (VII).

Transit Systems in College and University Communities
TCRP Synthesis 78
An update of an earlier synthesis, this volume explores practices and trends in the areas of campus transit operations, policies, and planning, with a focus on technological and environmental innovations; as well as innovative partnership strategies to enhance services.

2008; 88 pp.; TRB affiliates, $35.25; nonaffiliates, $47. Subscriber category: public transit (VI).

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TR NEWS

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FEATURES are timely articles of interest to transportation professionals, including administrators, planners, researchers, and practitioners in government, academia, and industry. Articles are encouraged on innovations and state-of-the-art practices pertaining to transportation research and development in all modes (highways and bridges, public transit, aviation, rail, and others, such as pipelines, bicycles, pedestrians, etc.) and in all subject areas (planning and administration, design, materials and construction, facility maintenance, traffic control, safety, geology, law, environmental concerns, energy, etc.). Manuscripts should be no longer than 3,000 to 4,000 words (12 to 16 double-spaced, typed pages). Authors also should provide appropriate and professionally drawn line drawings, charts, or tables, and glossy, black-and-white, high-quality photographs with corresponding captions. Prospective authors are encouraged to submit a summary or outline of a proposed article for preliminary review.

RESEARCH PAYS OFF highlights research projects, studies, demonstrations, and improved methods or processes that provide innovative, cost-effective solutions to important transportation-related problems in all modes, whether they pertain to improved transport of people and goods or provision of better facilities and equipment that permits such transport. Articles should describe cases in which the application of project findings has resulted in benefits to transportation agencies or to the public, or in which substantial benefits are expected. Articles (approximately 750 to 1,000 words) should delineate the problem, research, and benefits, and be accompanied by one or two illustrations that may improve a reader's understanding of the article.

NEWS BRIEFS are short (100- to 750-word) items of interest and usually are not attributed to an author. They may be either text or photographs or a combination of both. Line drawings, charts, or tables may be used where appropriate. Articles may be related to construction, administration, planning, design, operations, maintenance, research, legal matters, or applications of special interest. Articles involving brand names or names of manufacturers may be determined to be inappropriate; however, no endorsement by TRB is implied when such information appears. Foreign news articles should describe projects or methods that have universal instead of local application.

POINT OF VIEW is an occasional series of authored opinions on current transportation issues. Articles (1,000 to 2,000 words) may be submitted with appropriate, high-quality illustrations, and are subject to review and editing. Readers are also invited to submit comments on published points of view.

CALENDAR covers (*a*) TRB-sponsored conferences, workshops, and symposia, and (*b*) functions sponsored by other agencies of interest to readers. Notices of meetings should be submitted at least 4 to 6 months before the event.

BOOKSHELF announces publications in the transportation field. Abstracts (100 to 200 words) should include title, author, publisher, address at which publication may be obtained, number of pages, price, and ISBN. Publishers are invited to submit copies of new publications for announcement.

LETTERS provide readers with the opportunity to comment on the information and views expressed in published articles, TRB activities, or transportation matters in general. All letters must be signed and contain constructive comments. Letters may be edited for style and space considerations.

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- All manuscripts should be supplied in 12-point type, double-spaced, in Microsoft Word 6.0 or WordPerfect 6.1 or higher versions, on a diskette or as an e-mail attachment.
- Submit original artwork if possible. Glossy, high-quality black-and-white photographs, color photographs, and slides are acceptable. Digital continuous-tone images must be submitted as TIFF or JPEG files and must be at least 3 in. by 5 in. with a resolution of 300 dpi or greater. A caption should be supplied for each graphic element.
- Use the units of measurement from the research described and provide conversions in parentheses, as appropriate. The International System of Units (SI), the updated version of the metric system, is preferred. In the text, the SI units should be followed, when appropriate, by the U.S. customary equivalent units in parentheses. In figures and tables, the base unit conversions should be provided in a footnote.

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