BIENNIAL REPORT 2014-2015

Washington State Transportation Center

Photo by Mary Marrah

Contents

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RESEARCH KEEPS MOVING WASHINGTON FORWARD

The ability to get from Point A to Point B—whether by highway, transit, rail, ferry, bicycle, or pedestrian facilities—affects every person's life in a very personal way. Transportation also affects the ability of every business to operate and compete, and it has measurable impacts on the environment. Thus transportation, one of our state's largest public investments, is central to the state's and region's economic vitality, environmental health, and citizens' quality of life.

The importance of transportation was underscored by the State Legislature's endorsement of the Governor's funding request known as Connecting Washington. This forward thinking transportation plan identifies improvements across the full spectrum of transportation needs. A new feature of this funding package is the application of Practical Solutions in the development, design, construction, and operation of the transportation network. Practical solution approaches require community engagement and the use of least cost planning to examine all modes across jurisdictions to improve safety or mobility.

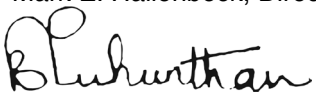
Together with the Washington State Department of Transportation's (WSDOT) Moving Washington Forward strategic plan, Connecting Washington sets forth a blueprint for the state's transportation priorities. And research is a crucial tool for meeting those goals: developing new ways to build, maintain, and operate our transportation system at lower cost, with fewer impacts, and with better outcomes.

This 2014-2015 biennial report describes the activities of the Washington State Transportation Center (TRAC), a joint response to the need for world-class transportation research through a partnership among WSDOT, the University of Washington (UW), and Washington State University (WSU). Through TRAC, these agencies have worked together for over 30 years to improve transportation throughout the state and nation. For example, over the past two years, TRAC researchers have successfully

- developed new sustainable guidelines to support Washington State Ferries terminal design
- reduced pavement maintenance costs through guidance for optimizing the timing and design of WSDOT's chip seal program
- developed methodologies for evaluating the costs and benefits of multimodal freight corridor investments
- supported implementation of a commute trip reduction toolset that helps planners determine the most cost effective way to maximize use of available transportation capacity
- developed new technology that reduces the environmental impacts of pile driving on migrating fish, decreasing the costs and impacts of infrastructure construction in shoreline environments
- developed and applied new transportation data sets that help WSDOT identify congestion bottlenecks, evaluate alternative congestion relief measures, and monitor the effectiveness of selected strategies for reducing congestion
- tested and recommended new media filter drain designs for treating stormwater runoff
- developed best practices for sustainable roadway design and construction and created a Web-based application to help the Federal Lands Highway Program implement those practices.

TRAC invites researchers, experts, practitioners, and others to work with us to continue to find new innovations and solutions to provide safe, reliable, and cost-effective transportation options to enhance the livability and economic vitality of communities. Join us as we move into the next 30 years of conducting world-class research to Connect Washington and keep Moving Washington Forward—and to improve the lives of individual people moving from Point A to Point B.

Mark E. Hallenbeck, Director, TRAC-UW

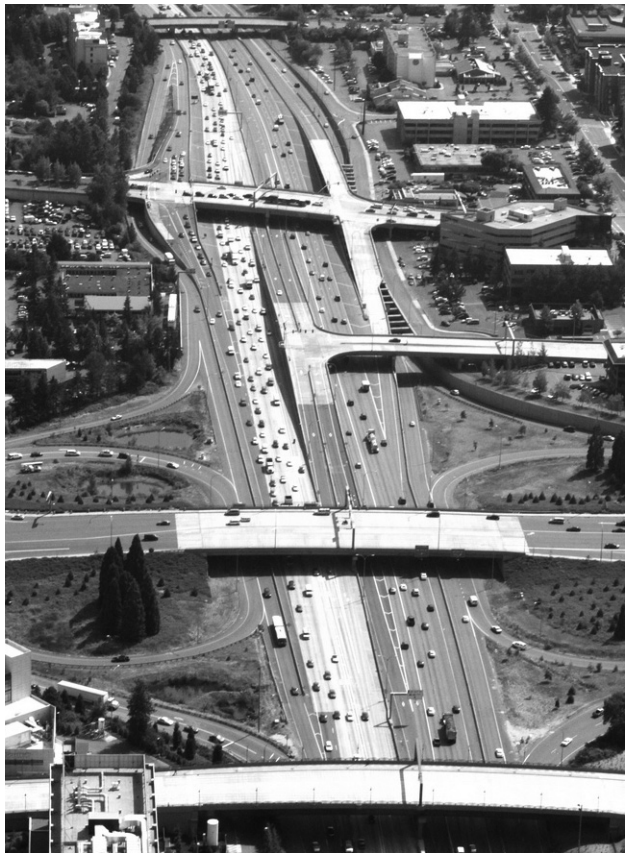


Balasingam Muhunthan, Director, TRAC-WSU

Rhonda Brooks, Director, Research and Library Services
Washington State Department of Transportation

OVERVIEW

Research at the Washington State Transportation Center (TRAC) addresses as the issues of today's transportation systems and the needs of their users. The studies cover a wide variety of fields, and many require interdisciplinary contributions. These studies benefit from the collaborative work within and between research institutions and other organizations in Washington state and beyond. Through these partnerships TRAC is able to leverage not only funding but also knowledge and other research resources, conducting studies cost effectively and efficiently, to provide innovative solutions to transportation-related challenges.



Project Funding and Support

From July 1, 2013, to June 30, 2015, TRAC-UW researchers were involved in over 50 research projects, for which the budgets totaled over $8 million. The 27 budgets for TRAC-WSU projects totaled over $4.9 million. These figures do not include TRAC's administrative budgets.

Research funding came from a variety of sources. In the past two years, TRAC received national support from the following public agencies:

- Alaska Department of Transportation
- California Department of Transportation
- Center for Environmentally Sustainable Transportation in Cold Climates
- Federal Highway Administration
- Florida Department of Transportation
- Idaho Transportation Department
- National Cooperative Freight Research Program
- National Cooperative Highway Research Program
- National Heart, Lung and Blood Institute
- National Institute of Diabetes and Digestive and Kidney Diseases
- National Institute on Aging
- National Institutes of Health
- Pacific Northwest Transportation Consortium (PacTrans)
- Strategic Highway Research Program
- Western Federal Lands Highway Division
- U.S. Department of Transportation

A number of TRAC/WSDOT projects were supported by consortia or pooled funds in which the departments of transportation from other states were involved, including those of Alaska, Arizona, California, Colorado, Florida, Idaho, Kansas, Minnesota, Mississippi, Missouri, Montana, Nevada, New York, North Carolina, North Dakota, Ohio, Oregon, Pennsylvania, Tennessee, Texas, Utah, Virginia, West Virginia, Wisconsin, and Wyoming

In-state public supporters for TRAC projects included

- City of Seattle
- King County Metro Transit
- Pierce Transit
- Puget Sound Regional Council
- Seattle Children's Hospital and Regional Medical Center
- Sound Transit
- Washington State Transportation Improvement Board

TRAC received private support from or worked as a subcontractor for

- Applied Research Associates
- Battelle Memorial Institute
- Booz Allen Hamilton
- Cambridge Systematics
- CDM Smith
- Florida Atlantic University
- Resource Systems Group
- Texas Transportation Institute

Interdisciplinary Reach

The field of transportation continues to broaden and become more interdisciplinary. As reflection of that, TRAC research topics over the past two years involved 45 faculty and researchers in 14 UW and WSU departments:

- Atmospheric Sciences, UW
- Civil and Environmental Engineering, UW
- Civil and Environmental Engineering, WSU
- Computer Sciences and Engineering, UW
- Crop and Soil Sciences, WSU

Economic Sciences, WSU
Entomology, WSU
Epidemiology, UW
Industrial and Systems Engineering, UW
Mechanical Engineering, UW
Mechanical and Materials Engineering, WSU
Office of Educational Assessment, UW
Social and Economic Sciences Research Center, WSU
Urban Design and Planning, UW

Cooperation and Collaboration

Through their research projects, TRAC researchers worked with several other universities and research facilities, including Children's Hospital and Regional Medical Center in Seattle, Stanford University, and the Western Transportation Institute, Montana State University

TRAC also collaborated with and supported client and researcher connections with the Pacific Northwest Transportation Consortium (PacTrans), the federally funded Region X University Transportation Center. PacTrans is a coalition of transportation professionals and educators from Oregon State University, the University of Alaska, Fairbanks, University of Idaho, University of Washington, and Washington State University. With dual themes of safety and sustainability, PacTrans serves as an engine and showcase for transportation research, education, and workforce development in the Pacific Northwest.

Technology Transfer

Research dollars are wasted if clients are unaware of research results, unable to understand research findings, or unable to implement them. That's why TRAC emphasizes technology transfer as part of its operations. TRAC makes a special effort to ensure that research reports are understandable by developing project summaries and providing guidance to writers. During the 2014-2015 biennium, TRAC-UW and TRAC-WSU processed numerous proposals and produced nearly 30 reports and other publications.

TRAC also redesigned its website, http://trac.washington.edu. Visitors can find information about TRAC, access research reports and project information, and obtain guidance on producing work through TRAC.

TRAC Mission

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Research at the Washington State Transportation Center (TRAC) is interdisciplinary, collaborative, and diverse.

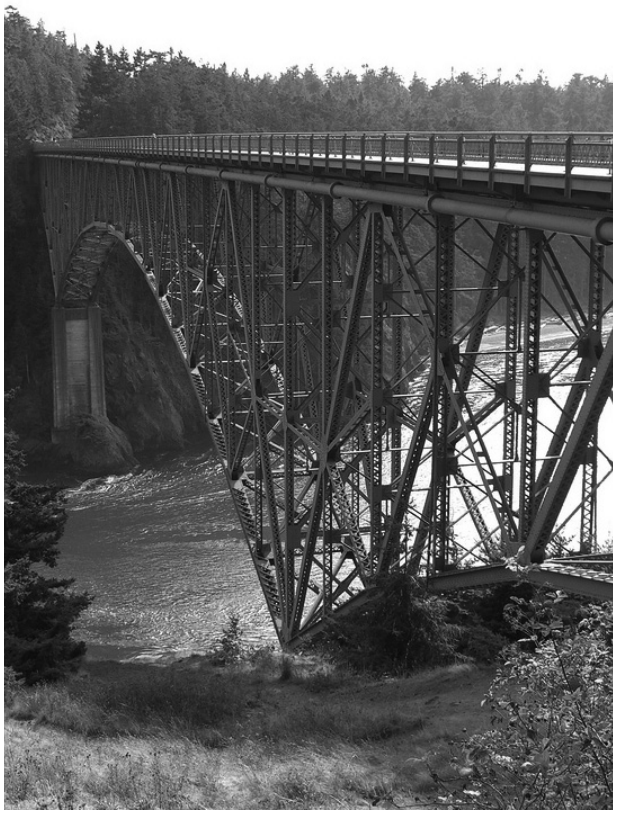
TRAC is a cooperative transportation research agency. Its members, the University of Washington (UW), Washington State University (WSU), and the Washington State Department of Transportation (WSDOT), support TRAC to coordinate both public and commercial transportation research efforts and to develop research opportunities nationally and locally.

TRAC's most important function is to provide a link among the state and other research clients, university researchers, and the private sector. TRAC acts as a liaison, connecting those who need applied research at WSDOT or other agencies and those best suited to conduct it at the universities, as well as connecting researchers to data and other resources.

From its offices at the University of Washington in Seattle and Washington State University in Pullman, TRAC coordinates resources for research, serves as a focal point for student involvement in transportation research, and provides services such as report editing, production, and graphics. The office at WSDOT in Olympia serves as the central point of contact for agency managers interested in working with university researchers and students through a variety of programs. The WSDOT provides research funding and contracts and connects researchers to technical resources.

BRIDGES AND STRUCTURES

Bridge research in Washington State has long focused on seismic demands and issues related to earthquakes. This past biennium, other issues moved to the forefront, including preservation, cost-saving designs, monitoring the United States' longest prestressed girders, and expansion joint noise. Preservation is one of WSDOT's highest priorities for its entire infrastructure, and we are trying to evaluate the lowest life cycle cost for the state's steel bridges in particular, which will no doubt affect other types of bridges as well. In addition, WSDOT is on the cutting edge of bridge design in many ways, from attempting to utilize all construction materials to reducing costs in new girders.



Completed Projects

Cost Benefits of Washing Bridges to Prevent Deterioration

The frequency with which WSDOT washes a particular bridge may be every five or more years. To investigate the feasibility of a more frequent steel bridge washing program, this project explored current bridge washing practices around the country and identified the key variables necessary to estimate the impacts of regular washing on a steel bridge's paint and service life. Because a literature review and nationwide survey found little information on the effects of bridge washing, a follow-up study examined the perceived costs and benefits of routinely washing both steel and concrete bridges, with emphasis on bridge decks, expansion joints, bearings, and substructure seats. On the basis of the literature review, common practice, and the collective experience of surveyed maintenance engineers, the researchers concluded that annual washing of decks, bearings, joints and substructure seats appears to actually elongate the usable life of those elements and delay the need for replacement.

Principal Investigators: Berman, J./Roeder, C., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitors: Myhr, G./Baroga, R./Keegan, C./ Wilson, D., WSDOT
Sponsors: WSDOT, FHWA
WA-RD 811.1, 811.2

Active Projects

Bridge Monitoring: Instrumenting the Longest Prestressed Concrete Girders in the U.S.

The SR 99 South Holgate Street to King Street project, part of the larger Alaskan Way Viaduct replacement program, contains girders spanning 210 feet. Because these are the longest girders in the U.S. and current design guidelines include no validation for girders of this length, WSDOT wants to monitor them to develop better specifications and design guidelines. To that end, this project is instrumenting and monitoring four 210-foot girders on SR 99 to measure the stresses and strains of the end zone reinforcement of the girders, as well as the effects of deck shrinkage on girder behavior.

Principal Investigator: Badie, S., George Washington University
Research Manager: Saechao, L., WSDOT
Technical Monitor: Khaleghi, B., WSDOT
Sponsor: WSDOT

Shear Design Expressions for CFT and RCFT Bridge Components

Circular concrete filled steel tubes (CFT) and concrete filled tubes with internal reinforcement (RCFT) offer great benefits for the design of bridge piles, caissons, and pier columns, including superior composite strength and stiffness and more rapid and economical construction. They also have the potential for very large shear strength, and realizing that potential could allow these components to be smaller, with beneficial impacts on construction. Currently, engineers have two methods for estimating the shear capacity of CFT and RCFT components, but neither is completely accurate and both may be unduly conservative. This project is integrating experimental testing methods with high-resolution analytical models to investigate the shear capacity of CFT and RCFT members. The end results will be analytical and design models for engineers to use that may improve constructability and reduce construction costs.

Principal Investigators: Roeder, C./Lehman, D., UW
Research Manager: Saechao, L., WSDOT
Technical Monitor: Khaleghi, B., WSDOT
Sponsor: WSDOT

Technical Support for Structural Health Monitoring and Condition Assessment for the Chulitna River Bridge

The Chulitna River Bridge, built in 1970, is located on the Alaska Parks Highway between Fairbanks and Anchorage. The Parks Highway is the most direct route connecting Anchorage, Fairbanks, and Prudhoe Bay, and heavy vehicles with loads of up to 410,000 pounds regularly travel it. The original 790-foot bridge was a five-span, continuous bridge with two exterior steel plate girders. It had a 34-foot cast-in-place concrete deck. In 1993 the original bridge deck was replaced with precast concrete deck panels and widened to over 42 feet. To accommodate the increased loads, the two original exterior plate girders were strengthened, three new longitudinal steel trusses were installed, and steel bracing was added to the piers. For this project, researchers have designed and installed a real-time fiber optic structural monitoring system to determine whether the girders are over-stressed for standard highway loads and permitted vehicles. As a subcontractor to the Alaska University Transportation Center, TRAC researchers are providing technical support and advice for the design of the instrumentation and interpretation of data.

Principal Investigator: Dolan, J.D., WSU
Research Manager: Saechao, L., WSDOT
Technical Monitor: Littell, M., AUTC
Sponsor: Alaska Department of Transportation

Researchers are instrumenting and monitoring 210-foot girders, the longest in the U.S., placed on SR 99 as part of the Alaskan Way Viaduct replacement program.

ENVIRONMENT

Washington's rich natural resources require that we safeguard our air and water quality and preserve and protect wildlife habitats. Research finds new ways to keep highway stormwater runoff from adversely affecting our watersheds, rivers, and the Puget Sound. Identifying and removing barriers for fish and wildlife passage across highways, bridges and structures protects important species, as does finding ways to construct ferry terminals and bridges without harm to fish, sea mammals, and sea birds. New methods for reducing animal-vehicle collisions protects both wildlife and the traveling public. Monitoring air quality from vehicle emissions is a key strategy to improving public health. Reducing impacts from highway and construction noise also supports livable communities. Finally, as we better understand the predicted effects of climate change, research is helping us develop tools to assess how Washington's vast highway infrastructure will be affected.

Completed Projects

Below Pavement Stormwater Storage: Literature Review and Synthesis

Washington state requires that most of the stormwater runoff from impervious surfaces such as roadways be retained and either infiltrated or released very slowly over a long period of time. This requires more storage areas for stormwater runoff or innovative ways to get runoff back into the ground, including potentially redistributing highway runoff below the pavement. A literature search found that water in the subbase of mainline pavements may cause significant damage to the pavement structure under most circumstances. However, for new construction, there is promise in distributing water either under the mainline, by expanding below the rock cap and other drainage layer depths, or within permeable pavement shoulders with adequate infiltration or underdrains. For retrofit applications, there is also potential in implementing storage at levels below existing, specially designed drainage layers such as rock caps, or in retrofitting the shoulders with permeable pavements and effective underdrains.

Principal Investigator: Haselbach, L., WSU
Research Manager: Brooks, R., WSDOT
Technical Monitors: Maurer, M./Uhlmeyer, J./ Schaffner, L., WSDOT
Sponsor: WSDOT

Compost Leachate Testing

Fresh compost applied to bioretention systems or drainage areas, which WSDOT maintains to manage highway runoff, initially releases substantial amounts of organic and inorganic constituents when exposed to rainfall or water infiltration. The initial leachate is often characterized by a brown color, suggesting the presence of organic materials, and it is also known that nutrients such as nitrates and phosphorus are leached out. Questions remain about the composition and amounts of constituents leached out of compost. For this project, researchers studied different compost products and evaluated and characterized the leachate from stormwater runoff. The results will aid WSDOT in determining when and where to safely use compost to avoid water pollution.

Principal Investigators: Flury, M.,/Cogger, C.G., WSU
Research Manager: Peterson, J., WSDOT
Technical Monitors: Salisbury, S./Lux, G., WSDOT
Sponsor: WSDOT
WA-RD 848.1

As part of its water quality practices, WSDOT amends soils with compost (here on SR 522) to absorb more water and reduce runoff. Researchers studied different compost products and evaluated the runoff to determine what might leach out of it.

Endangered Species Act Analysis Model Comparison Study: Comparing Hi-Run and SELDM for Use in Washington State DOT Biological Assessments

WSDOT developed and uses the Hi-Run (Highway Runoff Dilution and Loading) model to determine whether highway stormwater runoff from western Washington highway projects will have a detrimental effect on aquatic organisms, mainly fish. Use of this model, which supports biological assessments required by the Endangered Species Act, includes some updating and training costs for WSDOT. FHWA and the U.S. Geological Survey have developed a similar model, called the Stochastic Empirical Dilution Model (SELDM), which tests some of the same parameters, primarily dissolved metals in stormwater. This research compared the two models to determine which would be more accurate, practical, and cost beneficial for WSDOT to use for its analyses.

Principal Investigators: Pomeroy, C./Sandoval, K., University of Utah
Research Manager: Brooks, R., WSDOT
Technical Monitors: Nguyen, A./Maurer, M./Carey, M., WSDOT
Sponsor: WSDOT
WA-RD 820.1

Impact Driving of Novel Double-Wall and Mandrel Piles in Commencement Bay, Tacoma, Washington

Pile driving steel piles in water produces extremely high sound levels that are known to adversely affect fish, birds, and marine mammals. Following extensive research into the causes and dynamics of the underwater sound source, researchers have developed two new pile designs that incorporate a double-wall and a special driving shoe. In previous subscale tests, the researchers achieved a reduction of more than 20 decibels while driving piles. In this project, the ability of the piles to reduce noise is being field tested in Commencement Bay, in Tacoma, Washington. The resulting data will be used to confirm the effectiveness of the new pile design in reducing noise to acceptable state and federal levels, as well as the pile's drivability, and to tune the developed sound spread models. More effective noise attenuation will protect important marine species while also allowing efficient construction operations, including permitting, in marine waters.

Principal Investigators: Reinhall, P./Dahl, P.H., UW
Research Manager: Brooks, R., WSDOT
Technical Monitor: Laughlin J., WSDOT
Sponsor: WSDOT
WA-RD 849.1

Media Filter Drain: Modified Design Evaluation and Existing Design Longevity Evaluation

The media filter drain (MFD), a stormwater water quality treatment best management practice, consists of aggregate, perlite, gypsum, and dolomite in a trench along the roadway shoulder, with gravel and vegetative pre-filtering elements and optional underdrains. One of the many benefits of MFDs is their effective removal of dissolved zinc and copper from roadway runoff. However, the existing design includes use of an aggregate gradation that is no longer readily available. A more readily available and economical aggregate gradation has a slightly lower percentage of finer material. This project evaluated whether use of less fine material would be as effective as the old materials at treating enhanced dissolved zinc and copper. Findings from lab tests indicated that the new materials initially had removal efficiencies similar to those of the old materials for large storm events. In addition, after simulated 15 years of use, the new materials' removal efficiency did not decrease. The researchers recommended that WSDOT use either the old or the new materials mixes for MFDs, depending on availability and cost.

Principal Investigators: Haselbach, L./Poor, C., WSU
Research Manager: Brooks, R., WSDOT
Technical Monitors: Maurer, M./Schaffner, L., WSDOT
Sponsors: WSDOT, PacTrans
WA-RD 822.1

Reduction of Underwater Sound Levels from Pile Driving Operations

The underwater sound generated from impact and vibratory hammer operations necessary to construct terminals, docks, and other structures in marine waters may adversely affect fish, birds, and mammals that are protected by federal law. Researchers had collected data from terminal construction projects on Vashon Island and Port Townsend to develop models to understand how underwater pile driving generates sound and how sound propagates with range, as well as to find effective mitigation strategies. In terms of sound propagation, the research revealed that sound is significantly shadowed, or reduced in level, in waters along shorelines with sloping depth contours, a finding that can reduce the environmental monitoring effort. In terms of effective mitigation strategies, this led to the development of a novel pile that produces significantly less noise. Testing of scaled pile prototypes indicated a 25-decibel decrease in noise levels during impact driving. More effective noise attenuation will protect important marine species while also allowing efficient construction operations in marine waters.

Principal Investigators: Reinhall, P./Dahl, P.H., UW
Research Manager: Brooks, R., WSDOT
Technical Monitors: Carey, M./Laughlin J./Huey R./ Gaines, M./Bernstein, J./Bertucci, T., WSDOT
Sponsor: WSDOT
WA-RD 781.1

Solar Effects on Navigation Systems

Concerns about whether predicted solar storms would affect the navigation capabilities of Washington State Ferries prompted this research to compare results from the satellite compass heading device with the baseline performance of the gyrocompass heading device, an accepted and reliable alternative system currently used for Washington State Ferries navigation. The data collected from monitoring the two systems did not show significant errors in navigation.

Principal Investigator: Groth, K., Groth Systems
Research Manager: Brooks, R., WSDOT
Technical Monitors: Hamilton, B,/Johnson, M., WSDOT
Sponsor: WSDOT

Active Projects

Application Tool for Assessing Wildlife Passage

Recent research has resulted in a promising new tool called the Passage Assessment System (PAS), which is designed to assess how well highway structures such as bridges and culverts are likely to perform at allowing a range of wildlife to cross. Results from the tool will help agencies invest in the highest priority projects and identify opportunities for modifying existing structures to assist wildlife movements. WSDOT is leading this pooled fund project to develop a digital version of the PAS for use on a hand-held device such as a tablet and a database structure for storing the data. Accomplishing these objectives will make it easier for agencies to use PAS to evaluate existing transportation infrastructure and to store the information for easy access for multiple transportation planning purposes.

Principal Investigator: McAllister, K., WSDOT
Research Manager: Peterson, J., WSDOT
Technical Monitor: McAllister, K., WSDOT
Sponsors: WSDOT, Texas and Virginia DOTs

Assessment of Lube Oil Management and Self-Cleaning Oil Filter Feasibility in WSF Vessels

Lube oil management aboard Washington State Ferries (WSF) vessels is a critical component of maintaining the life of a vessel engine. Lube oil and the associated filters are expensive, as is maintenance and associated downtime. Disposal of filters as a hazardous waste and handling of lube oil also pose an environmental risk and additional costs. Preventive and predictive management of lube oil can reduce lube oil maintenance costs and environmental risk, making the operation of WSF vessels more sustainable and cost effective. To gain these benefits, researchers are assessing whether a new self-cleaning oil filter system can reduce costs and environmental wastes on WSF vessels.

Principal Investigator: Wolcott, M., WSU
Research Manager: Peterson, J., WSDOT
Technical Monitor: Washington State Ferries
Sponsors: WSDOT, PacTrans

I-90 Snoqualmie Pass Fish, Amphibian, and Wildlife Monitoring

The I-90 Snoqualmie Pass East Project (SPE) is located along a 15-mile stretch of Interstate 90 that passes through the Okanogan-Wenatchee National Forest. The project was initiated to fulfill multiple objectives, including reducing avalanche and rock fall impacts on human safety and highway operation, replacing failing concrete pavement, adding lanes to reduce congestion, and improving ecological connectivity across I-90. In fact, the project corridor has been identified as a critical connectivity zone for Pacific Northwest wildlife populations. As part of this major I-90 improvement project, several fish passages and animal crossings have been installed. Researchers have previously monitored areas of the project to identify potentially affected wildlife populations, and they are monitoring the new crossings to determine their effects on animal behavior and survival.

Principal Investigators: Wagner, S./Ernest, K./ James, P., Central Washington University
Research Manager: Peterson, J., WSDOT
Technical Monitor: Norman, M., WSDOT
Sponsor: WSDOT

Near-Road Air Quality

New federal regulations require state and local agencies to monitor near-roadway emissions and quantitatively assess potential air quality impacts ("hot spots"). State transportation agencies need to understand the implications of the new near-road data they are collecting by creating new analysis methods and must also develop tools to implement effective mitigation. Many states are unable to internally address all of the new emissions modeling and measurement requirements with existing funding and expertise. Therefore, a collaborative effort was created to pool resources to help meet the new near-road air quality requirements and develop ways to respond to stakeholders' requests for advice and information.

Principal Investigator: Sonoma Technology
Research Manager: Peterson, J., WSDOT
Technical Monitor: Landsberg, K., WSDOT
Sponsors: California, Arizona, Texas, Virginia, and Washington DOTs and FHWA

Population and Flight Path Studies for Assessing Mitigation Measures to Minimize Impacts on Alkali Bees within US 12 Phase 7

Phase 7 of WSDOT's long-term US 12 project will widen the highway from Nine Mile Hill through the Tochet-Lowden agricultural district in Washington. Farmers in that area use native alkali bees to help produce alfalfa seed. Alkali bees need established

As part of the I-90 Snoqualmie Pass East Project, WSDOT has installed several fish passages and animal crossings. Researchers are monitoring the new crossings to determine their effects on animal behavior and survival.

bee beds of two to ten acres and a surface crust of salt or alkali to preserve moisture in the below-ground nests. These bees are subject to habitat loss, as cultivation, grazing, or even disturbance by off-road vehicles can damage bee beds. For this project, researchers are surveying the bee population density in beds that might be affected by the highway widening. Bee populations are protected by the national 2008 Farm Bill, and the data collected from this effort will be used to develop project designs that will decrease the impacts of highway construction on farmers and bee populations.

Principal Investigator: Walsh, D., WSU
Research Manager: Brooks, R., WSDOT
Technical Monitor: Broadhead, C., WSDOT
Sponsor: WSDOT

Transportation Environmental Sustainability in Cold Regions, Phases I and II

This joint-university effort is looking at multiple aspects of transportation-related environmental sustainability in cold climates:

Pervious Concrete. Pervious concrete allows stormwater runoff to percolate through and into the subsurface soil. Pervious concrete used for environmental purposes needs to not only satisfy strength and freeze-thaw requirements, but also to provide adequate permeability and to be modified for optimal environmental benefits. This project is extending cold weather research on pervious concrete and developing “greener” pervious concrete binders.

Emission Impacts of Winter Highway Maintenance.The project is conducting initial modeling of the atmospheric impacts of de-icing chlorides

Bio-Based Renewable Additives for Anti-icing Applications. The project is developing locally sourced, more sustainable additives for anti-icing treatments on pavements.

Characterization of Cold Region Emissions. This research is investigating cold starts, idling, and other aspects of transportation contributions to cold region particulate matter pollutant levels, primarily focused on diesel engines.

Life Cycle and Life Cycle Cost Assessment Tool Development. Transportation environmental life cycle assessment (LCA) and life cycle cost assessment (LCCA) research is focusing on issues relevant to northern latitudes and cold weather operations. The researchers are working to integrate life cycle and life cycle cost assessment tools, with application to intermodal northern ferry systems and highway and other landside operational options.

Economic Benefits and Emission Impacts of Winter Highway Maintenance. The research is focused on ways to quantitatively model the relationship between winter maintenance costs/ benefits and key cold weather factors.

Sustainable Winter Road Operations. This project is developing a book compiling the best sustainability practices for winter road operations and associated webinars.

Principal Investigators: Haselbach, L./Shi, S./Jobson, T./ Chung, S./Yan, J./Nassiri, S., WSU
Technical Monitor: UAK-Fairbanks
Sponsor: Center for Environmentally Sustainable Transportation in Cold Climates

A multi-university effort is looking at many aspects of transportation-related environmental sustainability in cold climates.

The free flow of people and goods is vital to Washington and the families that live here. That's why traffic congestion is one of the state's top transportation priorities. Washington works in progressive ways to manage highway congestion with tools such as high-occupancy vehicle (HOV) and high-occupancy toll (HOT) lanes, metered on-ramps, variable-direction express lanes, traffic cameras, variable message signs, traffic monitoring centers, incident response teams, active traffic management systems, congestion pricing and signal optimization. And the search for innovative methods will not stop. By studying the most cutting-edge and successful traffic management advances in the world, Washington will continue developing smarter highway systems. With an eye toward the future, the state is exploring new congestion-reducing innovations that are making our highways more efficient, less congested, and safer for all. Research in the state is developing measurements and benchmarks to present a clear, more accurate picture of congestion on the state's most affected freeways. It is focusing on developing ways of measuring efficiency and reliability and on producing improvements that people can see and experience.

Completed Projects

Congestion Analysis and WSDOT Support

To continue efforts to manage the central Puget Sound region's transportation network, WSDOT has need for timely, detailed technical information on traffic conditions, historical trends, and emerging transportation issues associated with the area's roadways. For example, WSDOT needs better information on the performance of its many traffic management approaches, such as variable speed limits and active traffic management, as well as better methods for optimizing its arterial traffic management strategies. It also needs better decision support tools that describe the benefits that can be expected from implementations of traffic control mechanisms. Since 1995, TRAC has developed data collection tools and analyses to provide this information for Seattle area freeways. This project continued to provide technical support for WSDOT's operational, planning, and policy activities in the form of ongoing freeway performance monitoring analyses, focused technical analyses, and software enhancements. The resulting information helps WSDOT maximize freeway operations, conduct planning studies, and analyze alternative strategies to improve the Puget Sound transportation network.

Principal Investigators: Hallenbeck, M.E./Ishimaru, J.M., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Nisbet, J., WSDOT
Sponsor: WSDOT

Drive Net Applications to WSDOT Operational Data Usage

Although WSDOT's huge volume of traffic sensor data is highly valuable for system operations, monitoring, and analysis, WSDOT's traffic data archive systems lacked the capability to integrate third party data sets and did not offer the functions needed to support real-time performance monitoring, quick operational decision making, and system-wide analysis. This project sought to improve the archiving of WSDOT data sets, automate the time-consuming data quality control process, and achieve the integration and visualization of information needed to support decision making. The result is a functioning online system called WSDOT DRIVE Net (Digital Roadway Interactive Visualization and Evaluation Network). The DRIVE Net system is capable of collecting, archiving, and quality checking traffic sensor data from all WSDOT regions and incorporating third party data and weather information into the analytical platform. Roadway geometric data are stored in a geospatial database and are seamlessly connected with the traditional transportation data sets. The resulting system provides better analytical capacity to support the state's Moving Washington Forward strategies and enhance WSDOT's ability to actively manage the highway system.

Principal Investigator: Wang,Y., UW
Research Manager: Brodin, D., WSDOT
Technical Monitors: Legg, B./Bremmer, D., WSDOT
Sponsor: WSDOT
WA-RD 823.1

Effectiveness of Safety and Public Service Messages on Dynamic Message Signs

The objective of this project was to assess the effectiveness of disseminating safety messages and public service announcements (PSAs) on dynamic messaging signs (DMS). The effectiveness of DMS depends on both the usefulness of the provided information and motorists' ability to understand and willingness to act on the information. By surveying motorists in Chicago, Ill., Houston, Texas, Orlando, Fla., and Philadelphia, Penn., researchers investigated public acceptance and recognition of safety messages and PSAs transmitted on DMS and the effectiveness of the messages in changing traveler behavior. The results of the study are intended to assist the USDOT, traffic management centers, state agencies, and local transportation partners in developing guidelines, policies, and operations regarding the display of such information on DMS and in optimizing the usefulness and effectiveness of those messages.

Principal Investigator: Boyle, L., UW
Technical Monitor: Chu, J., FHWA
Sponsors: FHWA, Booz Allen Hamilton

Evaluation of Continuous Access HOT Lanes on SR 167

The high occupancy toll (HOT) lanes on State Route (SR) 167 were initially designed to allow access at only six points northbound and four points southbound. In August 2014, WSDOT began allowing free access into and out of the HOT lanes throughout most of the corridor. This study looked at the effects of allowing continuous access to the SR 167 HOT lanes. It examined customer attitudes toward the new access rules, the performance of both the HOT lanes and the parallel general purpose (GP) lanes, and the volumes of use and travel times experienced. It also examined the amount of revenue collected, the amount of toll evasion occurring, collision frequency and severity, and the impacts of the access change on transit operations. The researchers found that changes in the corridor were complex. In general, over the 18 months studied, traffic volumes increased in the corridor, as did friction between the HOT and general purpose lanes. Travel times degraded slightly in both the GP and HOT lanes. Prices and total revenue increased for the HOT lane. No statistically significant change in safety was apparent. A large fraction of the travelers in the corridor favored the access rule changes. Transit agencies operating in the corridor also liked the changes.

Principal Investigator: Hallenbeck, M.E., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Strauch, E., WSDOT
Sponsor: WSDOT
WA-RD 846.1

Researchers investigated the effects of changing the SR 167 high occupancy toll (HOT) lanes from limited access to free access throughout most of the corridor, including subsequent performance of both the HOT lanes and general purpose lanes.

NCHRP 20-24A: Measuring Performance among State DOTs: Sharing Good Practices—Congestion

Transportation agencies are increasingly using performance measurement to solve complex management challenges. As applications of performance measurement have increased among state departments of transportation (DOTs), senior managers and technical staff have increased their interest in learning from the performance of their peer agencies. Comparative performance measurement offers a way to share DOT performance data and knowledge about best practices among agencies, and in turn to enhance managers' ability to judge their own agencies' effectiveness in program and system management. Identifying "best-in-class" practices and "lessons learned" facilitates managers' efforts to learn from experience. This project investigated the collection, manipulation, and reporting of congestion data on roadways. Working with Cambridge Systematics, UW researchers developed a recommended data submittal and reporting process that can be used to meet requirements for MAP-21 (Moving Ahead for Progress) reporting. The project is currently on hold as USDOT works to finalize those requirements.

Principal Investigator: Hallenbeck, M.E., UW
Technical Monitor: Margiotta, R., Cambridge Systematics
Sponsors: NCHRP, Cambridge Systematics

Pilot Testing of SHRP2 Reliability Data and Analytical Products

The Strategic Highway Research Program 2 (SHRP2) addresses the challenges of moving people and goods efficiently and safely on our nation's highways. In this project, researchers assisted WSDOT in pilot testing five products developed within the SHRP2 Reliability focus area. Research in the focus area emphasized improving the reliability of highway travel times by reducing the frequencies and effects of events that cause travel times to fluctuate unpredictably. Five products were developed under SHRP2 for data collection and travel time reliability measurement, monitoring, enhancement, and impact assessment. In conjunction with the UW, WSDOT received federal funding to test these products, apply them within the Moving Washington Forward initiative, and provide feedback to the SHRP2 program on potential improvements.

Principal Investigator: Wang, Y., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Nisbet, J., WSDOT
Sponsors: WSDOT, FHWA

Active Projects

Accessing Information about Transportation Systems Management and Operations Performance Measurement, NCHRP #20-07, Task 366

Transportation systems management and operations (TSMO) strategies increase the safety, reliability, efficiency, and cost effectiveness of the regional transportation system by improving infrastructure, increasing coordination among public and private agencies, and maximizing the use of scarce resources. This NCHRP project is seeking to establish a framework for organizing information about TSMO performance measurement and monitoring research and practices that allows users to more quickly and effectively assess the impacts of TSMO strategies. The project will develop a guide to the most relevant recent literature and will describe the projects, opportunities, and consequences for practitioners of adopting specific measures and setting targets for TSMO performance management. As a subcontractor to Florida Atlantic University, TRAC researchers are assisting in the literature review and completion of the information framework. The final products will support the development of the information portal of the National Operations Center of Excellence.

Principal Investigator: Hallenbeck, M.E., UW
Research Manager: NCHRP
Technical Monitor: Legg, B., WSDOT
Sponsors: NCHRP, Florida Atlantic University

Drive Net II: Online Moving Washington Platform for Network-Wide System Operations, Monitoring, and Analysis

Modern technology is creating a significant increase in both the amount and types of data available to describe the condition, use, and performance of the state's transportation system. However, although WSDOT is capturing data from many new sources, it is not using them to full benefit because the new data sets cannot be easily combined with each other or be integrated into WSDOT's existing data systems. Those systems lack the capabilities to integrate third party data sets for analysis and the functions needed for real-time performance monitoring, quick operational decision support, and system-wide analysis. To address these issues, this project is expanding the Digital Roadway Interactive Visualization and Evaluation Network (DRIVE Net) system to include additional data sources and new, desirable analytical functions. These new capabilities will better support WSDOT's tasks of freeway performance analyses, project prioritization and planning, operational strategy evaluation, traffic information dissemination, and real-time traffic management.

Principal Investigator: Wang,Y., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Legg, B., WSDOT
Sponsor: WSDOT

Implementing the Routine Computation and Use of Roadway Performance Measures within WSDOT

WSDOT currently uses freeway reliability measures as input to decision making for urban freeways and to analyses for major investment studies. It wants to expand its ability to perform those analyses to other, less urban locations in the state. This SHRP2 project is designed to build the system needed to incorporate the reliability of roadways into WSDOT's planning, project identification, and prioritization processes statewide. This project will also be directly coordinated with the Department's efforts to more fully integrate traffic systems management and operations (TSMO) strategies into its planning, project selection, and programming functions. In addition, WSDOT is developing and deploying truck freight performance monitoring and reporting systems. The software developed for this project will produce both freight performance measures and measures that report on overall roadway performance. The resulting software and data system will provide WSDOT with new tools that allow it and the Puget Sound Regional Council to examine roadway performance throughout the state's National Highway System.

Principal Investigator: Hallenbeck, M.E., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Harwood, M., WSDOT
Sponsors: SHRP2, WSDOT

Support and Align Operational and Demand Management Strategies and Business Processes with Planning and Programming within WSDOT

With no defined or consistent process for considering transportation systems management and operations (TSMO) strategies within WSDOT's programming and prioritization process, TSMO projects receive less attention than traditional capacity improvement projects. For this SHRP2 study, researchers are developing resources, information, and guidance for WSDOT planners and engineers that will allow them to 1) understand and determine the value of TSMO strategies with confidence, 2) consider the full range of TSMO strategies early in the corridor and regional planning processes at both the headquarters and regional levels, and 3) include clearly defined strategies as part of WSDOT's Practical Solutions approach. The resulting guidance will help WSDOT staff select the most appropriate TSMO strategies, estimate the value of those efforts, associate the strategies with performance metrics, and predict their costs, allowing them to better prioritize investment decisions and more effectively utilize TSMO strategies to increase the safety, reliability, efficiency, and cost effectiveness of the regional transportation system.

Principal Investigator: Hallenbeck, M.E., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Harwood, M., WSDOT
Sponsors: SHRP2, WSDOT

FREIGHT TRANSPORTATION

Washington's regional and state economies, workers, and residents depend on an effective and efficient freight transportation system, and freight transportation systems are critical to supporting and growing more jobs, more regional domestic product, and a larger tax base. Washington is one of the most trade dependent states in the nation, and the state's multimodal freight transportation system allows business in Washington to effectively compete in regional and global markets. Goods ranging from milk and medicine to Boeing plane parts ship into, out of, and around the state using every part of our freight system: highways and roads, railroads, waterways, and marine and air ports. Industry supply chains, moving goods from production to distribution and processing centers and ultimately to consumers via the state's freight corridors, produced over $129 billion in regional domestic output in 2013. For all these reasons, the last biennium's research related to freight and goods movement sought to make that movement more efficient and economical.

Completed Projects

Developing a System for Computing and Reporting MAP-21 and Other Freight Performance Measures

WSDOT wants to start measuring freight performance—travel times, bottlenecks, and other transportation outcomes related to freight and shipping—to meet its own needs as well as to respond to the upcoming federal MAP-21 (Moving Ahead for Progress) performance reporting requirements. Doing so requires the ability to identify and quantify freight bottlenecks on the state highway network—particularly on the Interstate system—as well as to measure freight movement performance on key state truck freight economic corridors. This project designed, tested, and delivered a system that produces freight performance reports on the Interstate system for WSDOT. The research team worked with WSDOT staff to obtain the data necessary to produce the performance measures, identified the decisions that WSDOT must make to compute the required measures, developed the computational procedures, and produced an initial set of measures for WSDOT's use.

Principal Investigator: Halleneck, M.E., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Ivanov, B., WSDOT
Sponsor: WSDOT
WA-RD 844.1

The Freight Commodity Flows project surveyed truck drivers to quantify and characterize the movement of goods through specific freight corridors.

Developing a Performance Measurement Approach to Benefit/Cost Freight Project Prioritization

The reauthorization of the federal transportation bill will require a comprehensive and quantitative analysis of the freight benefits of proposed freight system projects. To prioritize public investments in freight systems and to ensure consideration of the contribution of freight to overall system performance, states and regions need a better method for analyzing the benefits associated with proposed highway and truck intermodal improvements. To address that need, this project built on previous and ongoing research to develop a data-supported framework to prioritize public investments in freight systems in Washington and Oregon. The project integrated two WSDOT funded efforts, one that created methods for calculating the value of truck and truck-intermodal infrastructure projects and one that collected truck probe data from commercial GPS devices to create a statewide Freight Performance Measures (FPM) program. This integration provided a framework tool that allows public agencies in the Pacific Northwest to quantify freight investment benefits in specific areas, such as major freight corridors and across borders.

Principal Investigators: Casavant, K./Sage, J., WSU;
Goodchild, A.V./McCormack, E.D., UW
Research Manager: Brodin, D., WSDOT
Sponsors: WSDOT, PacTrans
WA-RD 815.1

Freight Commodity Flows

The goal of this project was to collect data to quantify and characterize the movement of commodities through specified freight corridors. Four times over the course of a year, the investigators surveyed truck drivers when trucks stopped during their trips in specified corridors. They also developed a database that allowed them to analyze and

characterize commodity flow for the specified corridors. Determining the commodity flow on corridors aids agencies in correctly prioritizing infrastructure investments and increases their ability to determine the quantitative impacts of congestion, regulation, and bottlenecks on a transportation system or supply chain.

Principal Investigators: Sage, J./Casavant, K., WSU
Research Manager; Brodin, D., WSDOT
Technical Monitor: Ivanov, B., WSDOT
Sponsor: WSDOT
WA-RD 825.1

Prototype Development and Small-Scale Demonstration for Freight Advanced Traveler Information System (FRATIS)—Los Angeles

This USDOT-funded project researched freight intelligent transportation system solutions in the Los Angeles region, a major freight gateway, to help alleviate congestion, pollution, and delays while promoting improved freight mobility. The purpose of the project was to develop a prototype Freight Advanced Traveler Information System (FRATIS) and then conduct a small-scale demonstration to assess the effectiveness and impacts of implementing a regional FRATIS. As a subcontractor to Cambridge Systematics, TRAC researchers provided assessment support.

Principal Investigator: McCormack, E.D., UW
Technical Monitor: Jensen, M., Cambridge Systematics
Sponsors: FHWA, Cambridge Systematics

Prototype Development and Small-Scale Demonstration for Freight Advanced Traveler Information System (FRATIS)—South Florida

This USDOT-funded project researched freight intelligent transportation system solutions in the South Florida region, a major freight gateway, to help alleviate congestion, pollution, and delays while promoting improved freight mobility. The purpose of the project was to develop a prototype Freight Advanced Traveler Information System (FRATIS) and then conduct a small-scale demonstration to assess the effectiveness and impacts of implementing a regional FRATIS. As a subcontractor to Cambridge Systematics, TRAC staff helped to develop emergency preparedness and response activities for the FRATIS, which consists of a smart phone application designed to collect and disseminate information related to traffic conditions, road closures, fuel availability, supply locations, and more.

Principal Investigator: McCormack, E.D., UW
Technical Monitor: Jensen, M., Cambridge Systematics
Sponsors: FHWA, Cambridge Systematics

US-395 North Freight Origin-Destination Economic Study

In this project, researchers worked with the WSDOT Eastern Region planning office and the Northeast Washington regional transportation planning office to conduct a freight origin/destination study for US 395 from the Stevens/Spokane county line to the Canadian border. Shippers and haulers operating on US 395 were contacted and interviewed, and an intercept freight survey was developed and administered at pre-determined sites and times in coordination with the Washington State Patrol. A database structure was developed for the collected data. A GIS database was developed to include commodity flows/values, origins/destinations, and freight generators. The information on the destination of the products carried, their origin, and their volumes and values will be useful in prioritizing this corridor for future infrastructure investments.

Principal Investigators: Sage, J./Casavant, K., WSU
Research Manager: Brodin, D., WSDOT
Technical Monitor: Kay, C., WSDOT
Sponsor: WSDOT
WA-RD 836.1

Washington State Short Line Rail Inventory and Needs Assessment

More than 55 percent (740 miles) of all short rail line within Washington is not able to efficiently handle 286,000-lb rail cars, the researchers of this study determined. Overcoming this deficiency and bringing the state's short line system to Class II operating status could require infrastructure investments of approximately $610 million. This need exceeds the current funding support offered by the state, even given a 20-year horizon with private industry and/or local jurisdictions providing significant match. The researchers conducted three short line case studies to help identify the societal benefits associated with a functioning short line system within the state's multimodal transportation network. These case studies, along with information about the attributes that contribute to the success or failure of investments in rail load centers, illustrate the benefits of state investment in the short line railroad system.

Principal Investigators: Sage, J./Casavant, K., WSU
Research Manager: Brodin, D., WSDOT
Technical Monitor: Ivanov, B., WSDOT
Sponsor: WSDOT
WA-RD 842.1

Active Projects

Behavioral-Based National Freight Demand Modeling

Current models for forecasting freight movement in the United States have been developed primarily at the statewide level, along with a few regional freight forecasting models. This project is developing a national freight forecasting model for the FHWA. The model, the first of its kind at the national level, will support national freight policy making and planning. As a subcontractor to RSG, UW researchers are helping to identify the most useful and promising

structures for a national model and are leading the evaluation of model components and their integration. They are also developing an approach to test the potential specifications for each model component and are contributing to the development of national sources of data for use in the model. The project will demonstrate the model in a software application.

Principal Investigators: Goodchild, A.V/McCormack, E.D., UW
Technical Monitor: Mysore, V., FHWA
Sponsors: FHWA, Resource Systems Group (RSG)

Benefit-Cost Methodologies for Evaluating Multimodal Freight Corridor Investments (NCFRP 14)

Moving Ahead for Progress in the 21st Century (MAP-21), enacted by Congress in July 2012, contains significant freight provisions, including the establishment of a national freight network comprising a primary freight network (PFN) designated by the Secretary of Transportation; any portions of the Interstate System not designated as part of the PFN; and critical rural freight corridors. Unfortunately, there are no accepted methodologies or modeling tools available to quantify the benefits and costs of alternative multimodal freight projects in multi-jurisdictional national corridors. Limited understanding of the many factors involved may prevent decision makers from having complete and well-informed sets of alternatives and may hinder planning and investment decisions. To address this issue, this project is developing decision support methods that can more comprehensively evaluate multimodal project packages in multi-jurisdictional freight corridors. As a subcontractor to TTI, UW researchers are helping to develop a guidebook for practitioners for conducting benefit-cost analyses to inform public and private decision makers and other stakeholders at local, state, regional, and national levels.

Principal Investigator: Goodchild, A.V., UW
Technical Monitor: Rogers, C., NCFRP
Sponsors: NCFRP, Texas Transportation Institute

Freight Demand Modeling and Data Improvement Strategic Plan (SHRP2)

The food distribution industry generates significant economic, environmental, and social impacts, but its transportation, supply chain, and fleet characteristics are not well understood. This project is collecting data necessary to accurately model the behavioral responses of key Washington state supply chains to different state policy scenarios aimed at reducing freight emissions and their impacts on the state's freight system. The project will collect detailed behavioral response information from industry and urban food distribution truck volume data in the Puget Sound. These data will be categorized and prepared for incorporation into WSDOT's State Freight Supply Chain Model, a GIS-based portrayal of the state's freight highway, arterial, rail, and waterway network. The information will fill a gap in the understanding of commodity movements in Washington and will allow WSDOT to improve its ability to adequately support and plan for food distribution transportation activities.

Principal Investigator: Goodchild, A.V., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Ivanov, B., WSDOT
Sponsors: SHRP, WSDOT

NCHRP 08-98: Guide for Identifying Truck Freight Bottlenecks

Truck bottlenecks may be defined as any condition that acts as an impediment to efficient truck travel—including congested locations, policy restrictions on truck travel, extreme event and disaster conditions, and regulatory constraints—leading to travel times in excess of what would normally occur. The objective of this project is to produce a guidebook that classifies truck freight bottlenecks on the basis of causal and contributing factors; describes quantitative measures for each truck freight bottleneck category to determine bottleneck severity, impact, and ranking; develops a methodology for systematically identifying truck freight bottlenecks and evaluating their impacts on local, regional, and national network performance; and describes a range of options for solving or mitigating truck freight bottlenecks. The resulting guide, including technical appendices and a reference manual for common questions, will be aimed both at transportation planners with an emphasis on freight, and at research and operational staff conducting analyses on freight bottlenecks for transportation planning processes.

Principal Investigator: Halleneck, M.E., UW
Technical Monitor: Ahanotu, D., Cambridge Systematics
Sponsors: NCHRP, Cambridge Systematics

Support for National Performance Measure Research Data Set, Freight and Operations Performance Measurement

In 2013, FHWA acquired a National Performance Measure Research Data Set (NPMRDS) to support analyses for the Freight Performance Measures Program (FPM) and other reports. After Congress passed the Moving Ahead for Progress (MAP-21) legislation, which requires tools for analysis, freight planning, and other performance measurement activities, FHWA determined that this data set could also assist states and metropolitan planning organizations in their freight planning, performance measurement, and other operations efforts. Therefore, it decided to make this data set available to a broader community of users. This project is providing technical assistance to that growing community in using the NPMRDS. That assistance includes analysis of users and their needs, as well as development

of written and video guidance on application of the NPMRDS for performance management.

Principal Investigators: Hallenbeck, M.E./McCormack, E.D., UW
Technical Monitor: Margiotta, R., Cambridge Systematics
Sponsors: FHWA, Cambridge Systematics

Wheat Supply Chain (SHRP2)

The food distribution industry generates significant economic, environmental, and social impacts, but its transportation, supply chain, and fleet characteristics are not well understood. This project is collecting data necessary to accurately model the behavioral responses of Washington's wheat supply chain to different state policy scenarios aimed at reducing freight emissions and their impacts on the state's freight system. It will also examine the interplay between policy scenarios and market forces affecting the supply chains' choices regarding natural gas fuels. In Washington state the wheat and grain co-ops have several options for accessing West Coast ports, including a state-owned collector short line railroad and the Columbia-Snake River system. This project will collect detailed survey information and explore existing wheat supply chain data to understand the industry's modal decisions. The resulting data will be categorized and prepared for incorporation into WSDOT's State Freight Supply Chain Model, a GIS-based portrayal of the state's freight highway, arterial, rail, and waterway network. The information will fill a gap in the understanding of commodity movements in Washington and will allow WSDOT to improve its ability to adequately support and plan for food distribution transportation activities.

Principal Investigators: Sage, J./Casavant, K., WSU
Research Manager: Brodin, D., WSDOT
Technical Monitor: Ivanov, B., WSDOT
Sponsors: SHRP, WSDOT
WA-RD 853.1

Numerous projects are looking at multimodal freight corridors, investments, evaluation, and infrastructure, both within Washington state and nationally. Below: new rail trench along the Columbia River at the Port of Vancouver.

Photo courtesy of Port of Vancouver USA/BNSF Railway

GEOTECHNICAL ENGINEERING

Liquefaction, a direct result of earthquakes, and earthquakes themselves are a major concern in Washington state, which is plagued with many areas that are affected by marginal soils and/or subject to earthquakes. In the past biennium researchers conducted multiple projects involving liquefaction and marginal soils. Research also sought ways to improve the safety and reliability of designs of the state's walls, bridges, and slopes.

Completed Projects

Landslide Analysis for I-82

Interstate 82 has been experiencing ongoing pavement deformation that is related to a large, historic landslide just east of Prosser, Washington. Archived reports, memos, data, and drill logs from the original construction of I-82 and previous geotechnical investigations were reviewed. In addition, two new boreholes were drilled at the site to collect material samples for characterization, and instrumentation was installed for monitoring. This study concluded that deformation observed in the eastbound lanes of I-82 could be the result of continued landslide movement, despite previous remediation efforts.

Principal Investigator: Hallenbeck, M.E., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Badger, T., WSDOT
Sponsor: WSDOT
Technical Report Number 006 (Jamsgard, J.)

Mineralogy and Residual Shear Strength of Seattle Clays

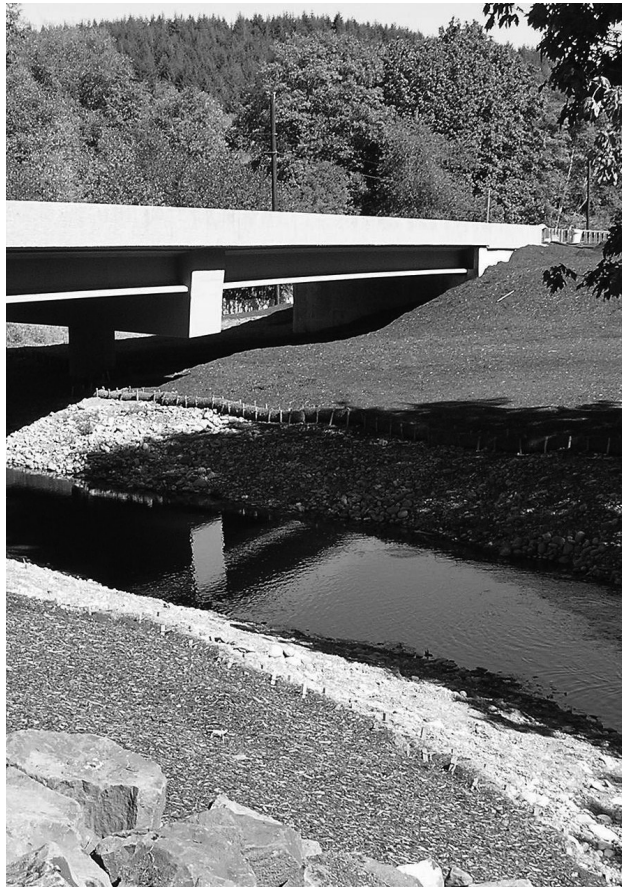
Washington state has an extensive variety of clays. Clay mineralogy is an important factor that controls the soil's shear strength, which is important in predicting structural behavior, including understanding landslide behavior. There has been little investigation of the relationship between the mineral composition of clays in Washington and their respective shear strengths. On the basis of samples obtained from known landslide deposits, this study showed that the glaciolacustrine clays of the Puget Lowland region consist of a homogeneous assemblage of the clay minerals chlorite, illite, and smectite.

Principal Investigator: Hallenbeck, M.E., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Badger, T., WSDOT
Sponsor: WSDOT
Technical Report Number 019 (Gault, A.)

Performance-Based Design Factors for Pile Foundations

Designing bridge foundations for transportation infrastructure must take into account the potential effects of earthquakes in seismically active areas. Unfortunately, the seismic design of pile foundations has typically been performed in a relatively simple, deterministic manner. Because of resulting uncertainties, available design and construction funds may be used inefficiently and levels of public safety may be unintentionally different. To produce less uncertainty, this project developed a performance-based, modular framework for creating seismic designs for pile group foundations that consider all potential levels of loading and their likelihoods of occurrence in a particular area. The framework will allow engineers to determine load and resistance factors that will produce designs with reliabilities consistent with those achieved by load and resistance factor design procedures. The framework will allow engineers to design structures in all seismic environments with consistent reliability.

Principal Investigators: Kramer, S., UW; Baker, J., Stanford
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Allen, T., WSDOT
Sponsors: WSDOT, Caltrans
WA-RD 827.1



Designing bridge foundations must take into account the potential effects of earthquakes in seismically active areas. Researchers developed a new framework for creating more consistent seismic designs for pile group foundations.

Active Projects

3-D Numeric Evaluation of Seismic Forces on Bridge Abutments

The response of bridges to seismic shaking is strongly affected by interaction between the soil and structure, soil-pile interaction being the most familiar

type of that interaction. Interaction between a bridge abutment and the soil embankment that supports it is also important, particularly for reinforced concrete bridges. Recent studies and field evidence have shown that this form of interaction during earthquakes may significantly alter the bridge response. Of particular interest are the three-dimensional seismic effects of embankments subjected to lateral spreading and flow failures. If these are not accounted for in design, the result may be unrealistic force estimations and an excessively strong and unnecessarily expensive bridge structure. To aid in design and assessment, this research is developing and validating a methodology for estimating earthquake-induced lateral spreading forces in embankments that takes into consideration three-dimensional effects.

Principal Investigator: Arduino, P., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Allen, T., WSDOT
Sponsor: WSDOT

Full-Scale Shake Table Testing to Evaluate the Seismic Performance of Reinforced Soil Walls, TPF-5(276)

Current seismic design procedures available to state DOTs may be excessively conservative for many wall types, and they also may be missing design considerations that are important for good seismic wall performance. If current design models can be better understood, or better design models can be developed that efficiently reduce conservatism while accurately capturing the seismic design issues that warrant greater attention, the potential to reduce overall wall costs is significant. To increase our understanding, this project is performing numerical studies and investigating the dynamic performance of two full-scale (7-m) reinforced soil retaining walls constructed with realistic materials and methods. Given that these walls are substantially taller than those of any similar research (by a factor of 2), a key focus is the influence of wall height on overall system response.

Principal Investigators: Fox, P./McCartney, J., University of California, San Diego
Research Manager: Willoughby, K., WSDOT
Technical Monitors: Allen, T./Khaleghi, B. WSDOT
Sponsors: Caltrans, Idaho, Mississippi, Utah, and Washington DOTs

Liquefaction-Induced Downdrag on Shafts and Piles

During soil liquefaction caused by an earthquake, sandy soil layers may undergo compression that results in downward movement of the overlying soil layers. For pile foundations, and depending on the site conditions, downdrag settlement can have significant influence on the performance of deep foundations, resulting in settlement of 0 to over 3 feet. In fact, liquefaction-induced downdrag and associated settlement of drilled shafts and pile foundations were observed in the 2010, magnitude 8.8 Maule Chilean earthquake. Those observed deep foundation failures and the potential for similar subduction earthquakes in the Cascade region have created a need to examine the downdrag loads on drilled shafts and pile foundations in Washington. This project is developing robust analytical and simplified numerical models to evaluate the effects of liquefaction-induced downdrag on driven piles and drilled shafts. The results will provide improved understanding of the responses of piles and drilled shafts under different conditions and more reliable information for their design.

Principal Investigator: Muhunthan, B., WSU
Research Manager: Willoughby, K., WSDOT
Technical Monitors: Allen, T./Khaleghi, B., WSDOT
Sponsor: WSDOT

Strength and Deformation of MSE Walls at Working Loads, SPR-3(072)

This pooled fund study has developed an improved method, called the K-stiffness method, for designing the internal stability of mechanically stabilized earth (MSE) retaining walls. This method appears to produce designs for MSE walls that are more cost effective than those produced by the AASHTO Simplified Design Method. However, the K-stiffness method has been developed and validated only for high quality, sandy backfill soils. The final two phases of the study are extending the applicability of the K-stiffness method to marginal quality backfill materials and full-scale field walls, which were monitored for validation and are in the process of being analyzed. The validation and analyses are critical to incorporating the K-stiffness method into the AASHTO load and resistance factor design (LRFD) specifications.

Principal Investigator: Bathurst, R., Royal Military College of Canada (RMCC)
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Allen, T., WSDOT
Sponsors: Alaska, Arizona, California, Colorado, Idaho, Minnesota, Missouri, New York, North Dakota, Oregon, Washington, Wisconsin, and Wyoming DOTs and RMCC

Research into creating built environments—including transportation elements—that better encourage healthy living behaviors is a field that continues to grow. Understanding the environmental factors that affect adults' and children's physical activity, such as land-use design and transportation infrastructure, is increasingly important in creating neighborhoods that better encourage citizens to be more active and healthy. More research is needed to help public leaders in making informed decisions that improve public health through community design, transportation, and land use.

Completed Projects

The Effects of Light Rail Transit on Physical Activity: a Natural Experiment

Growing interest in the environmental factors that affect adults' physical activity, such as neighborhood design and transportation infrastructure, has been hampered by study designs that limit the ability to draw causal inference. This project took advantage of the introduction of light rail transit (LRT) in south King County, Washington, and changes in the neighborhood environment around LRT stations to better study the causal effects of the built environment on walking and overall physical activity. The researchers assessed 700 adults living either close to or far from an LRT station before and after the introduction of LRT service. Participants wore accelerometers and GPS devices, and kept a travel log to produce data for analysis. The project developed "LifeLogs," databases for each individual participant that recorded their location, physical activity levels, and activity every 30 seconds over seven days. An algorithm was created to capture walking data from GPS and accelerometry. Among other results, three waves of data collection showed that transit riders increase their physical activity by one third on days they ride transit.

Principal Investigators: Saelens, B., Children's Hospital; Vernez Moudon, A./Hurvitz, P.M./Hallenbeck, M.E., UW

Sponsors: National Institutes of Health, Seattle Children's Hospital

Food, Environment, Diet Quality, and Disparities in Obesity / Seattle Obesity Study

This project generated objective measures of the built environment, diet quality, and health outcomes by tracking 500 King County, Washington, participants asked to carry global positioning system devices for a week. This study followed a previous grant on the same topic, which surveyed 2000 King County residents on their eating and food shopping habits. Several papers cover the projects' findings regarding the cost of food and people's choice of supermarket, the absence of food deserts in King County, the clustering of people by weight status and socioeconomic status, and a comparison of food shopping behaviors in Seattle and Paris, France. By looking at the built environment and its relationships to food shopping, diet quality, obesity, and related physical activity for residents, the project should help public decision-makers in creating healthier environments.

Principal Investigators: Drewnowski, A./ Vernez Moudon, A., UW

Sponsors: National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases

Rural Town Walkability: Measuring the Effect of the Built Environment

The prevalence of physical inactivity and obesity is significantly higher among rural residents, persons with low socioeconomic status, and Latinos. Modification of the built environment to increase physical activity, and walking in particular, holds the potential to reduce obesity and chronic illness among residents of rural towns. By studying rural towns from three distinct geographic regions—New England, Texas, and Washington state—with a varying range of socio-economic and ethnic characteristics, this study measured characteristics of the built environment that correlate with walking among small town residents and evaluated the degree to which those correlations are influenced by household income, educational attainment, and Latino ethnicity. The researchers used accelerometer and global positioning system measures to validate those correlations. The study found that small town residents walk much less overall than their urban counterparts and that a greater proportion of their walking is allocated to recreation. The study may aid planners in making small towns healthier environments for their citizens.

Principal Investigators: Doescher, M. /Vernez Moudon, A., UW; Berke, E.M., Dartmouth; Lee, C., Texas A&M University

Sponsors: National Institutes of Health, National Heart, Lung and Blood Institute

A Smartphone-Based System for Automated Detection of Walking

Walking is the most effective mode of travel to access transit, a low impact mode of travel for short trips, and a popular form of healthy physical activity. To support environmentally friendly and safe transportation systems, objective data on how often, how long, and where people walk are essential. However, travel surveys and diaries underestimate walking activity, and data on walking are known to be poor. In an attempt to devise a better way to collect walking data, this study tested a combination of GPS, accelerometry, and high-frequency photos, tracking 12 individuals during waking hours over three days. Measurements involved photos taken with a smartphone hanging from a neck lanyard at 10-second intervals. Although the images obtained

Photo by Mary Marrah

Several studies looked at factors in the built environment that affect physical activity and health.

from the smartphones were not useful, promising work was accomplished in developing algorithms for differentiating physical activity types on the basis of accelerometry data and for differentiating bicycling from other activities on the basis of single image frames.

Principal Investigator: Hurvitz, P.M., UW
Sponsor: PacTrans

Active Projects

Structural and Programmatic Effects of Bus Rapid Transit on Physical Activity

This project expands on the previous Light Rail Transit project to examine whether people living close to two new Bus Rapid Transit (BRT) lines (King County Metro's Rapid Ride) become more physically active after BRT has been implemented than people living far from the BRT lines. Participants are wearing accelerometers and GPS devices and are keeping a travel log for seven days on three different occasions over the course of this five-year study. The project will also review whether King County Metro's social marketing campaign *In Motion* will result in residents using transit more often.

Principal Investigators: Saelens, B., Children's Hospital; Vernez Moudon, A., UW
Sponsors: National Institutes of Health, Seattle Children's Hospital

Twin Study of Environment, Lifestyle Behaviors, and Health

This project builds on the UW Twin Registry, which now includes some 8,000 twin pairs participating in a range of medical studies. The use of twins allows researchers to control for genetic and childhood social and environmental factors in ways that are not possible in studies based on singletons. This project is using a twin design and cutting edge measurement tools and spatial data to examine how the built environment is associated with energy balance (physical activity and eating habits). As twins living in the same locations are compared to those living separately, it will be possible to isolate the effects of the built environment on physical activity.

Principal Investigators: Duncan, G./ Vernez Moudon, A., UW
Sponsor: National Institute on Aging

Research to make Washington's highways safer has produced low-cost strategies that have reduced the overall accident rate by 50 percent in some cases. Rumble strips, cable barriers, emphasis enforcement, and changes in geometric design are all part of the Target Zero strategies that WSDOT is deploying to make travel safer. Research has been the cornerstone of the implemented improvements, which have shown favorable results in reducing the severity of accidents and the number of accident fatalities. Safety is also paramount to Washington State Ferries and the state's railroads, transit, and air travel, and research produces information and ways to improve their operations to protect the traveling public.

Completed Projects

Identification of Test Methods for Determining Wood Guardrail Post Integrity

Reliable, well-maintained beam guardrail systems are needed to absorb and dissipate vehicular crash energy. The total mileage of guardrail installations on Washington highways is estimated to be 2000 to 2500 miles. With approximately 845 posts per mile, approximately 1.5 to 2 million guardrail posts have been installed on the state highway system over several decades. Wood guardrail posts are subject to decay and deterioration from weathering and insects. The objective of this study was to identify nondestructive testing technologies for assessing the internal condition of wood guardrail posts. A stress wave timing (SWT) technique was judged most promising, and a prototype device was developed with an industrial partner. In testing, the prototype accurately detected the internal conditions of posts in 86 percent of specimens. The project recommends implementing an inspection procedure using SWT in conjunction with drilling posts identified as potentially decayed. Such an inspection procedure will help WSDOT better reduce crash severity and optimize the service life of guardrail systems.

Principal Investigator: Bender, D.A., WSU
Research Manager: Brooks, R., WSDOT
Technical Monitor: Donahue, J., WSDOT
Sponsor: WSDOT
WA-RD 843.1

SHRP2 S07: In-Vehicle Driving Behavior Field Study—Seattle Site Support

The Strategic Highway Research Program Phase 2 Project #SO7 was a data collection effort for the SHRP2 Naturalistic Driving Study. The study collected detailed data on the driving behavior of several hundred participants to better understand the effects of a variety of factors on safety, including driving distraction. Working with Battelle Memorial Institute, UW researchers were responsible for the assessment of drivers who volunteered to participate in the study, including driver enrollment and exit debriefing interviews, as well as data collection and data handling support.

Principal Investigators: Boyle, L./Hallenbeck, M.E., UW
Technical Monitor: Brown, J., Battelle
Sponsors: FHWA, Battelle Memorial Institute

Because wood guardrail posts are subject to decay and deterioration from weathering and insects, researchers sought to develop a method for assessing their internal condition nondestructively.

Sustainability Best Practices for the Federal Lands Highway Program

This project investigated the sustainable roadway design and construction practices of the Federal Lands Highway Program (FLHP), an organization within the Federal Highway Administration that provides financial and technical assistance for roads that service federal and Indian lands. This investigation (1) assisted the FHLP in identifying and documenting sustainability best practices, (2) developed a short process that the FLHP can use to evaluate roadway sustainability rating systems, and (3) created a Web-based application for conducting pavement life-cycle assessments. Seven case studies using the Greenroads Rating System (www.greenroads.org) were conducted on FLHP projects to help identify sustainability best practices in use and areas for improvement. Findings showed that, given its relationships with other federal agencies such as the U.S. National Park Service, Forest Service, Fish and Wildlife Service, and Bureau of Indian Affairs, the FLHP is uniquely positioned to implement innovative and cutting-edge sustainability practices. Roadprint, the online life-cycle assessment tool for pavements, is available free at http://www.pavementinteractive.org/roadprint.

Principal Investigator: Muench, S.T., UW
Research Manager: Armstrong, A., FHWA
Sponsor: Western Federal Lands Highway Division

Transportation Improvement Board Program Updates

The Transportation Improvement Board, established by the Washington State Legislature, distributes statewide gas tax revenue in the form of grants to cities and counties for funding transportation projects. The FY 2017 grant cycle (awarded in November 2015) distributed approximately $117 million in funding to 142 competitively selected local projects. For this study, UW researchers and the Greenroads Foundation assisted the Transportation Improvement Board in updating the scoring system that its Urban Arterial Program (UAP) uses to select projects for funding and in re-engineering its Small Cities Preservations Program. Outcomes included an assessment of the UAP's scoring of grant recipients, a new set of sustainability criteria for the UAP to use in scoring projects, and a more robust, efficient, and sustainable Small Cities Preservations Program.

Principal Investigator: Muench, S.T., UW
Technical Monitor: Gorcester, S., TIB
Sponsor: Washington State Transportation Improvement Board

Active Projects

Design Guidance and Long-Term Monitoring of Flow Deflection Structures

WSDOT currently maintains over 1100 miles of roadway that lie within 100 feet of a water body and over 500 miles of roadway within a 100-year floodplain. In many locations, Washington's streams and rivers are still changing shape and location as they adjust to their surrounding environment. Because many state roadways were designed without a full understanding or knowledge of river processes, new guidance is needed that will provide innovative design solutions for the interface between rivers and roadways while protecting the public's interest in a safe roadway and also maintaining our watersheds. To develop design guidance, this project is evaluating the performance of existing structures by using new radio frequency technology to determine their capability to withstand scour from moving water. Phase I of this study focused on developing and calibrating radio frequency identification (RFID) technology along the Skagit River. Current work in Phase II is developing a scientifically based, practical approach for relating maximum scour depth in gravel-bed rivers to various properties of water flow and submerged structures.

Principal Investigator: Papanicolaou, T., University of Iowa, University of Tennessee
Research Manager: Saechao, L., WSDOT
Technical Monitors: Kramer, C./Park, J., WSDOT
Sponsor: WSDOT
WA-RD 821.1

Roadside Safety Pooled Fund Program

Representatives from ten states are serving on a technical committee to identify common safety research needs, select projects for funding, and oversee implementation of results. Research activities within the eight-year program include the design, analysis, testing, and evaluation of crashworthy structures, and the development of guidelines for the use, selection, and placement of those structures. Crashworthy structures include bridge rails, guardrails, transitions, median barriers, portable concrete barriers, end treatments, crash cushions, culverts, breakaway support structures, and work zone traffic control devices. Research is also investigating the influence of highway features such as driveways, slopes, ditches, shoulders, medians, and curbs on single vehicle collisions. The problems identified with these structures and features are addressed through in-service performance evaluation studies, computer simulations, full-scale crash testing, clinical analyses of real-world crash data, and cost-benefit analyses. To date, studies have resulted in FHWA letters of acceptance for new or modified devices, and products have been incorporated into new AASHTO standards and agency manuals.

Principal Investigator: Bligh, R., Texas Transportation Institute, Texas A&M University
Research Manager: Brooks, R., WSDOT
Technical Monitors: Donahue, J./Petterson, J., WSDOT
Sponsors: WSDOT, Alaska, California, Florida, Minnesota, Pennsylvania, Tennessee, Texas, West Virginia DOTs

Safety Performance Factors for Two-Lane Rural Road Prioritization and Suburban and Urban Arterials

WSDOT and other agencies continue to work toward a goal of zero fatal and serious injury crashes on the nation's highways. To that end, numerous tools are being developed to help agencies better quantitatively assess safety. This quantification is necessary because the public wants to know that each dollar spent on safety provides a return on its investment. Nationally, the most accepted means of safety quantification is through the use of safety performance functions (SPF). Significant research has been undertaken nationally to develop these safety performance equations. They can be found in the Highway Safety Manual, Safety Analyst, Crash Modification Clearinghouse, and the Interactive Highway Safety Design Model. Importantly, each of these performance functions must be calibrated to each state's particular characteristics. This research is developing calibration factors for Washington state in the areas of two-lane rural roads and suburban and urban arterials.

Principal Investigator: Shankar, V., Pennsylvania State University
Research Manager: Brooks, R., WSDOT
Technical Monitors: Milton, J./Zeller, S./Neely, M., WSDOT
Sponsor: WSDOT

Study of Illumination for State Highways

Operation of illumination fixtures on state freeways and highways costs WSDOT millions of dollars annually. To reduce those costs, WSDOT must have a complete understanding of the means available to reduce operating and capital costs with the least negative impact on service, safety, and sustainability. Expenditures on illumination could be reduced in several ways: by using more efficient lighting technologies; by operating illumination more judiciously; or by installing fewer luminaires, removing superfluous luminaires, and consolidating luminaires. This project is reviewing existing public agency illumination standards and making a detailed comparison of luminaire and control technologies. The information generated by this research will enable WSDOT to update its illumination design standards for installation, maintenance, and operation, with the goal of reducing operational costs and improving safety.

A thorough review will allow WSDOT to update its illumination design standards for installation, operation, and maintenance in order to reduce costs and improve safety.

Principal Investigator: Wang, Y., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Bailey, T.,WSDOT
Sponsor: WSDOT

West Coast Green Highway Communication Strategy

The states of Washington, Oregon, and California and the province of British Columbia are collaborating on development of the West Coast Green Highway, an initiative intended to benefit West Coast citizens through sustainability projects. The number of "green highway" projects in British Columbia, Washington, and Oregon is growing, and nearly all of them depend on public/private partnerships among industries, government, nonprofits, and universities. This collaboration presents challenges in providing consistent communication and traveler information about these projects throughout the corridor. To address those challenges, this project is developing and implementing communications strategies for the West Coast Green Highway by creating marketing and branding strategies and tools; planning and organizing road rallies and developing accompanying materials such as maps and other displays; and conducting research on outreach and education strategies.

Principal Investigator: Beard, G., Portland State University
Research Manager: Brodin, D., WSDOT
Technical Monitor: Buell, T., WSDOT
Sponsor: WSDOT

Transportation professionals agree that congestion problems cannot be simply built away; additional, innovative solutions are needed. Intelligent transportation systems, or ITS, provide technologies that enable people to make smarter travel choices. ITS encompass a broad range of wireless and traditional communications-based information, control, and electronics technologies. They provide tools to collect, analyze, and archive data about the performance of the system. Having these data enhances traffic operators' ability to respond to incidents, adverse weather, or other capacity constricting events. When ITS are integrated into the transportation system infrastructure, and in vehicles themselves, these technologies help monitor and manage traffic flow, reduce congestion, provide alternative routes to travelers, enhance productivity, and save lives, time, and money.

Completed Projects

Maintenance of UW Weather Information Resources for WSDOT

Researchers at the UW have developed innovative, Web-based applications to provide current and forecast weather conditions for cross-state travel on state highways to WSDOT personnel and the traveling public (such as http://i90.atmos.washington.edu/roadview/i90/). The resulting websites combine complex meteorological and roadway data from a number of sources, relying heavily on data and model output provided and maintained by the UW, and present them through user-friendly, intuitive Web interfaces. These websites are extensively used, some receiving nearly 100,000 hits a day during inclement weather, and have received strong positive feedback. This project continued work to make a wide range of weather and roadway information available. This information is helping WSDOT to more cost effectively maintain state highways and aids the public in planning their routes for safer travel.

Principal Investigator: Mass, C., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Wells, J., WSDOT
Sponsor: WSDOT

OneBusAway Maintenance Support and Operations

User and agency satisfaction with the performance of the OneBusAway transit information tool, developed as an open-source system by two UW PhD students, resulted in the decision of three Puget Sound agencies—King County Metro Transit, Pierce Transit, and Sound Transit—to jointly provide temporary support for the continued operation of OneBusAway at the UW while a more sustainable business model for the long-term operation of the app was developed. The support included documenting the application's code and operating procedures; providing data from OneBusAway to the participating agencies and the public; and creating a OneBusAway transit ambassador program. At the end of this project, Sound Transit assumed responsibility for managing OneBusAway.

Principal Investigators: Borning, A./Hallenbeck, M.E., UW
Technical Contacts: Watanabe, W., King County Metro Transit; Messner, K., Pierce Transit; Meyers, D., Sound Transit
Sponsors: King County Metro Transit, Pierce Transit, Sound Transit

Active Projects

Western States Rural Transportation Consortium (Transportation Pooled Fund)

This is a Transportation Pooled Fund (TPF) project funded by the states of California, Oregon, Nevada, and Washington. The consortium seeks to promote innovative partnerships, technologies and educational opportunities to facilitate and enhance safe, seamless travel throughout the western United States. Additionally, the consortium seeks to provide a collaborative mechanism for leveraging research activities that respond to rural transportation issues related to technology, operations, and safety. The current emphasis of the consortium is the second phase in a multi-phase effort aimed at developing a one-stop shop for providing rural travelers with comprehensive, real-time data for use in planning their trips. This phase is expanding the prototype information delivery mechanism to all four states.

Principal Investigator: Galarus, D., Montana State University
Research Manager: Brodin, D., WSDOT
Technical Monitor: Vessey, R., WSDOT
Sponsors: WSDOT (lead), California, Oregon, and Nevada DOTs

MAINTENANCE

Maintenance is considered key to not only protecting the state's highway investments, but also continuing to provide a safe, efficient transportation system, such as with snow and ice removal. During the winter months, WSDOT maintenance crews work around the clock to keep highways drivable and traffic moving by using salt and anti-icing compounds or sand when temperatures fall too low for chemicals to work. Supervisors check weather reports and move equipment, materials, and personnel where needed most. Maintenance professionals face important challenges in meeting public expectations and protecting safety. Research over the past two years has sought to help maintenance professionals make decisions that more accurate, timely, and cost-effective.

Active Projects

Guide for Utilization Measurement and Management of Fleet Equipment

Fleet vehicles and equipment are important for delivering state highway agency programs, projects, and services, and they compose a major part of agency capital investments. Maintenance departments must have adequately sized fleets, but each vehicle also requires significant resources for recurring maintenance to ensure its operational performance, reliability, and service level. Therefore, there is a trade-off between providing large enough equipment fleets and minimizing resource investments. In this context, proper management of equipment fleet assets can significantly reduce costs, as well as provide potential environmental benefits. This research is developing models to measure utilization to aid in fleet management, with the objective of minimizing total costs while satisfying the agency's equipment needs. The outcome, including a guide for fleet equipment utilization measurement and management, will provide highway agencies with a timely and cost-effective decision-making procedure for determining their optimal fleet size and composition to maintain the desired level of service.

Principal Investigators: Hajibabai, L./Hajbabaie, A./ Shi, X.,WSU
Research Manager: Hanna, A.N., NCHRP
Sponsor: NCHRP

Pacific Northwest Snowfighters

The Pacific Northwest Snowfighters (PNS) is an association of transportation agencies dedicated to ensuring the safety of winter maintenance products through structured testing and evaluation. The group has established procedures for testing deicing and anti-icing chemicals and maintains specifications that these products must meet to be considered for widespread use. PNS has become a nationally recognized leader in standardizing chemical products for snow and ice control, and the specifications developed by PNS help guide transportation agencies around the country in the selection of chemical products for winter maintenance applications. Products selected for inclusion on the PNS Qualified Product List must pass a series of tests for friction, corrosion, and chemical and toxicological properties and must meet environmental and health standards.

Research Manager: Brodin, D., WSDOT
Technical Monitor: Mills, M., WSDOT
Sponsors: Colorado, Idaho, Montana, Oregon, and Washington DOTs

Snow Removal Performance Metrics

Snow/ice maintenance operations is one of the most critical functions of state transportation agencies and municipalities in cold regions. One of the foremost challenges of winter storms for transportation agencies is meeting ever-increasing public expectations with limited funding for personnel, equipment, materials, contract assistance, and other resources. Therefore, agencies must aggressively explore practical and relatively inexpensive means to increase the efficiency and effectiveness of their winter operations. To do that, agencies must have objective, realistic service standards and performance measures, as well as efficient ways to collect, compile, and analyze pertinent data. The goal of this project is to identify effective performance metrics for snow and ice maintenance operations. Toward that end, this project is gathering and analyzing information in the literature and from the winter road maintenance operations community, with a focus on performance measures of snow/ice maintenance operations, their temporal evolution and effectiveness, the costs of gathering and analyzing the performance data, and methods for communicating the level of success inside the organization and to the public.

Principal Investigator: Shi, X., WSU
Research Managers: Waidley, G., CTC & Associates; Duran, A., MnDOT
Technical Monitor: Peters, T., MnDOT
Sponsor: Minnesota Department of Transportation

The Pacific Northwest Snowfighters (PNS), an association of transportation agencies, tests and evaluates winter maintenance products to ensure their safety.

MULTIMODAL
TRANSPORTATION PLANNING

For the transportation system to most efficiently and effectively move people and goods, planners must look at the entire transportation network and how it functions. Recent research has focused on quality of life, community livability and cohesion, environmental quality, land use and transportation, and economic, social and cultural values and trends. Collaboration at all levels is ongoing to better coordinate planning for land use, intermodal transportation linkages, electric vehicles and related infrastructure, and the environment.

Completed Projects

Commute Trip Reduction Toolset

The WSDOT Public Transportation Division collects numerous types of information for required reporting on commute trip reduction activities, and the Social and Economic Sciences Research Center (SESRC) at WSU has assisted by developing, maintaining, and hosting an online system called the Commute Trip Reduction (CTR) Toolset. The CTR Toolset includes modules for announcements, worksite management, online surveys, an employer program reporting system, and tools for administrators. The CTR Toolset is critical in helping WSDOT easily obtain employer and employee commute trip information in order to report the results of WSDOT's CTR programs.

Principal Investigator: Allen, T., WSU
Research Manager: Lindquist, K., WSDOT
Technical Monitors: Leotta, K./Nguyen, A., WSDOT
Sponsor: WSDOT

Effects of Natural Gas Vehicles and Fuel Prices on Key Transportation Economic Metrics

Long-range transportation plans require assumptions about future travel demand and future fuel tax revenue. In recent years the growing uncertainty about oil prices and availability has made long-range transportation planning more challenging. Rather than relying on trend extrapolation, this study used market mechanisms to shed light on key long-range transportation planning assumptions. Although WSDOT is assessing a variety of alternative fuels and energy sources, including electric vehicles (EV), biofuels, propane, and natural gas, and their respective infrastructures, this study focused on natural gas. The results of the modeling showed that use of natural gas vehicles (NGV) has the potential to affect vehicle miles traveled, greenhouse gas emissions, and fuel tax revenue. However, the effects of these vehicles will be attenuated by the current lack of available NGVs and continued challenges with widespread integration. WSDOT can continue to use the modeling provided to analyze changing conditions in the NGV market and estimate their impacts on key transportation metrics.

Principal Investigators: Heaslip, K./Bosworth, R., Utah Transportation Center, Utah State University
Research Manager: Lindquist, K., WSDOT
Technical Monitor: Prestrud, C., WSDOT
Sponsors: WSDOT, FHWA
WA-RD 829.1

An Innovative Survey Design to Understand Sustainable Travel Behaviors

Faced with smaller budgets, metropolitan planning organizations are increasingly unable to continue the current practice of conducting a large travel survey every ten years. Those surveys may also be unable to capture the effects of transportation policies, insufficient in the investigation of travelers' attitudes and perceptions, and inadequate in capturing non-motorized travel and households with low vehicle miles traveled (VMT). To address those issues, this study investigated the use of rolling traveler surveys. A pilot survey was administered to about 400 participants in Seattle and Bellevue. The researchers sought to understand the limitations and opportunities presented by travel surveys with rolling enrollment as they relate to survey design, implementation, and modeling. They also assessed the potential of a rolling sample design to address modeling-related questions, particularly the effects of land use and infrastructure-related strategies on VMT reduction.

Principal Investigators: Chen, C./Vernez Moudon, A./ Shen, Q., UW
Sponsors: WSDOT, PacTrans

INVEST Sustainability Self-Evaluation Tool

In collaboration with the Federal Highway Administration, WSDOT implemented FHWA's sustainability self-evaluation tool, called INVEST. This tool assesses and improves sustainability practices, and the project provided case studies and lessons learned about INVEST to FHWA to be shared nationally. WSDOT used the INVEST System Planning module to evaluate three recently completed corridor studies in the Puget Sound area and used the Project Development module to evaluate the SR 520 Bridge Replacement and HOV Program projects. These evaluations helped WSDOT to determine current performance, identify programmatic barriers to sustainability, apply recommendations to one or more current planning processes or projects, and support collaboration with external partners to further sustainability within the transportation system.

Research Manager: Lindquist, K., WSDOT
Technical Monitor: Houser, K., WSDOT
Sponsors: WSDOT, FHWA

Puget Sound Regional Council INVEST Project

This project was a preliminary step in assisting the Puget Sound Regional Council (PSRC) staff in developing a travel demand management (TDM) performance framework. The purpose of such a framework is to identify and promote efforts toward improving sustainability in transportation programs and projects. In this project, TRAC researchers worked with PSRC to create a scope of work for developing the framework. The resulting scope of work defines the elements of TDM to be included in the final performance framework, identifies data sets that will allow PSRC to gain insight into the performance of many TDM topic areas in the near-term, and suggests work with local agencies to address data gaps as part of the development of a more robust TDM performance framework in the long-term.

Principal Investigator: Hallenbeck, M.E., UW
Technical Monitor: Mayhew, R., PSRC
Sponsor: Puget Sound Regional Council

Sustainable Design Guidelines to Support the WSF Terminal Design Manual

Washington State Ferries is developing a new ferry terminal design manual. WSDOT is also currently challenged with two major initiatives related to facilities' energy and water use that could potentially affect terminal design: an executive order from the governor for WSDOT to develop a sustainable transportation plan and increasing use of low impact development (LID) technologies to control storm water. To assist the developers of the terminal design manual in potentially incorporating sustainable design elements, researchers are producing sustainable design guidelines, assessing the needs of WSF staff, investigating ways to address storm water quality and quantity with LID methods, and providing recommendations on the use of composite materials. In completed phases I and II, the project

Researchers are producing sustainable design guidelines that WSDOT can incorporate into its new ferry terminal design manual.

team drafted design guidelines and tested the applicability of potential design solutions on example ferry terminal projects. Current work in Phase III is focusing on the further development of the guidelines to increase their applicability.

Principal Investigators: Wolcott, M./Haselbach, L./ Yonge, D., WSU
Research Manager: Willoughby, K., WSDOT
Technical Monitors: Bertucci, T./Helgath, S./McIntosh, N./ Fordjour, K., WSF
Sponsor: WSDOT
WA-RD 816.1, 816.2

Technical Assistance for SDOT Performance Review

In this project, UW researchers provided technical assistance to the City of Seattle in reviewing the operational efficiency of the Seattle Department of Transportation (SDOT). As part of the project the UW team assisted SDOT in delivering traffic, infrastructure, and other transportation-related information to the City Council for purposes of policy and budget decision making.

Principal Investigators: McCormack, E./Whittington, J./ Hallenbeck, M., UW
Technical Monitor: Dunkel, J., City of Seattle
Sponsor: City of Seattle

Travel Costs Associated with Flood Closures of State Highways near Centralia/ Chehalis, Washington

Flooding in the Chehalis, Washington, area has significant local and regional transportation impacts on personal and freight mobility, particularly travel that relies on Interstate 5. Closures of I-5 impose significant economic impacts on not only the high volume of travelers who use that road, but on the state's economy in general. WSDOT is working to reduce future flooding impacts in the region, and needs defensible estimates of the benefits that various flood damage reduction projects under consideration would provide. This project conducted extensive analyses of the travel costs associated with road closures in the greater Centralia/Chehalis region attributable to 100-year flood conditions. Costs were computed for roadway closures on I-5, US 12, and SR 6. The computed costs were only those directly related to travel that would otherwise have occurred on the roads affected by the flooding closures, including the added costs of time and vehicle mileage associated with available detour routes. Sensitivity tests analyzed myriad variables. The results will help WSDOT develop improved

estimates of transportation benefits associated with flood mitigation efforts.

Principal Investigator: Hallenbeck, M.E., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Miller, K., WSDOT
Sponsor: WSDOT
WA-RD 832.1

Western States Road User Charge Consortium (WSRUCC)

The purpose of the Western States Road User Charge Consortium (WSRUCC) is to conduct collaborative research and explore the development of this potential new transportation funding method, which would collect a road usage charge (RUC) from drivers based on their actual road usage. The consortium also seeks to foster competition in providing RUC services, allowing for motorist choice; to encourage compatibility with readily available and affordable consumer products and technologies (such as smart phones, in-vehicle navigation systems, and other data-dependent vehicle technologies); and to achieve the primary purpose of collecting taxes to fund roadway maintenance and improvements while allowing for each state's unique needs. The consortium's first study found a wide range of policy and operational RUC approaches that states can consider applying to visitors. These approaches include charging visitors to use roads through shadow charges, time-based fees, or mileage-based fees. The study concluded that the easiest and most cost-effective way for a state that is early in its adoption of RUC is to charge a fuel tax for visitors.

Research Manager: Brodin, D., WSDOT
Technical Monitor: Doyle, J., WSDOT
Sponsors: Oregon (Lead), Nevada, Washington DOTs

To aid WSDOT in decreasing future flood impacts in the Centralia, Washington, region, researchers evaluated the benefits that various projects to reduce flood damage would provide.

Active Projects

Commute Trip Reduction Survey Processing, Data Capturing and Reporting

State law requires that a commute trip reduction (CTR) plan include an annual review of employee commuting and that progress toward meeting the single-occupant vehicle reduction goals be reported to the county, city, or town and be consistent with the method established in the CTR plan. The law also requires that work sites be surveyed to determine whether they are making progress or have met the law's reduction goals. The UW Office of Education Assessment assists WSDOT in capturing data from Commute Trip Reduction (CTR) forms. The resulting reviews of employee commuting at worksites are critical for evaluating programs and progress toward goals.

Principal Investigator: UW Office of Educational Assessment
Research Manager: Peterson, J., WSDOT
Technical Monitor: Wandler, M., WSDOT
Sponsor: WSDOT

Florida Department of Transportation Statistics—Mobility Target Setting Methods and Guidance

The Florida Department of Transportation (FDOT) wants to more effectively collect, analyze, and report multimodal data regarding the usage of Florida's

transportation system. FDOT is sponsoring a study to assist its Transportation Statistics Office in better understanding and developing methods that it can use to create mobility performance measures—ways of describing how well its transportation system moves people and goods—and set mobility performance targets that will both meet new federal MAP-21 (Moving Ahead for Progess) requirements and apply within Florida at both the state and regional levels. As a subcontractor to Cambridge Systematics, TRAC is involved in researching methods and approaches used by various jurisdictions and private organizations around the country to set performance targets and in developing guidance and training efforts for FDOT districts and their regional partners.

Principal Investigator: Hallenbeck, M.E., UW
Technical Monitor: Pickrell, S., Cambridge Systematics
Sponsors: Florida DOT, Cambridge Systematics

PSRC Transportation Futures Study

Over the next few decades, the Puget Sound region faces significant growth, increasing travel demand, shifts in traveler behavior, rising costs, and limited funding resources. The Puget Sound Regional Council (PSRC) and its partners, WSDOT and King County, have initiated a process to understand future transportation needs, funding processes, and possible outcomes in order to generate a regional consensus on sustainable and equitable transportation funding. As a subcontractor to CDM Smith, TRAC researchers are providing technical support in developing and conducting research on existing and future trends in transportation system conditions, technology, regional demographics and travel demand, land-use, regional economic impacts, global economic competitiveness, and regional transportation system financing. The result will be an approach for regional transportation financing to be used as the basis for PSRC's next long-range transportation plan update.

Principal Investigator: Hallenbeck, M.E., UW
Technical Monitor: Boesch, T., CDM Smith
Sponsors: PSRC, CDM Smith

TRAC researchers investigated future trends in transportation system conditions, technology, travel demand, and more to contribute to creating a general consensus on sustainable and equitable future transportation funding.

Use of Electronic Fare Transaction Data for Transportation Planning and Travel Demand Management

WSDOT and its partner agencies are limited in their ability to plan and implement an integrated multimodal system. They lack detailed data on how transit services are used and the effects of various demand management strategies. In the meantime, transit agencies across the nation are increasingly using electronic fare media to speed passenger boarding, reduce the cost of fare collection, and support more complex fare transactions. In the Puget Sound region, many commuters use the ORCA electronic fare system. By applying modern data analytics to ORCA fare data, this project will develop tools and demonstrate ways to dramatically increase the availability of data describing transit use and will broaden the application of transit data to a variety of activities that WSDOT funds and supports, such as transportation demand management, mobility programs, and congestion reduction measures, as well as to evaluation of the effectiveness of those activities. This project will also demonstrate how the use of such data can significantly benefit the transportation planning processes of both metropolitan planning organizations and transit agencies.

Principal Investigator: Hallenbeck, M.E., UW
Research Manager: Peterson, J., WSDOT
Technical Monitor: Hellman, J., WSDOT
Sponsor: WSDOT

PAVEMENTS

The goal of pavement research is to produce longer lasting pavements and to manage them most effectively. Recent areas of focus have included evaluating new technologies, preserving the infrastructure, and finding new ways to use the materials available to produce pavements that are as good as or better than those of previous years. The key to almost all the pavement research is preserving and improving our infrastructure. Materials, both naturally occurring and recycled, have been evaluated to determine their use, and new research projects are constantly searching for ways to exceed current design and construction standards. The overriding goal of these projects has been to produce longer lasting pavements through cost-effective decision-making.

Completed Projects

Determining Changes in Greenhouse Gas Emissions (1990-Present) due to Changes in Pavement Technologies

This project quantified the changes in state greenhouse gas (GHG) emissions from 1990 to 2010 that can be attributed to pavement condition, design, management, materials, and construction and also developed a life cycle assessment (LCA) tool that WSDOT can use to quantify GHG, energy, and other emissions associated with any past or future pavement construction project. The project found that in comparison to a 1990 baseline, WSDOT's increased use of reclaimed asphalt pavement, warm mix asphalt, and industrial byproducts (slag and fly ash) in the production of asphalt and portland cement concrete resulted in 2010 savings in GHG emissions and energy consumption of 25 to 30 percent. Dowel bar retrofitting of concrete pavements contributed another 4 to 9 percent savings, while other construction practices have had negligible influence. Overall, the study estimated 2010 GHG and energy savings due to WSDOT pavement practices to be about 0.2 to 0.3 percent of the total GHG emissions and energy consumption associated with both WSDOT's vehicle fleet and vehicles driving on WSDOT pavements. A better understanding of the influences of pavements on GHG emissions will allow WSDOT to target the specific improvements that will have the largest impact on GHG emissions. The LCA tool is available online at http://www.pavementinteractive.org/roadprint.

Principal Investigator: Muench, S.T., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Uhlmeyer, J., WSDOT
Sponsor: WSDOT
WA-RD 838.1

Evaluation of Recycled Concrete Aggregate (RCA) for Use in Portland Cement Concrete Pavements (PCCP)

The goals of this study were to investigate the effects of substituting recycled concrete aggregate (RCA)—aggregate produced from crushed concrete—for virgin aggregate in portland cement concrete pavements (PCCP). Currently, WSDOT does not allow RCA in PCCP, but there are compelling reasons for using recycled products in pavements. The researchers used RCA produced from demolished pavements in three different locations in Washington state to perform tests on aggregate characteristics, fresh concrete properties, and hardened concrete properties. They looked at the source of the RCA, the percentage of coarse natural aggregate replaced with RCA, and the percentage of portland cement replaced with fly ash. Replacement of natural coarse aggregate with up to 45 percent RCA by volume had no significant effects on any of the concrete properties. These results indicate that high-quality RCA can be used as a replacement for a portion of the coarse natural aggregates in new portland cement concrete pavements in Washington state. This project received the 2014 AASHTO Sweet Sixteen High Value Research project award.

Principal Investigators: Wen, H./McLean, D., WSU
Research Manager: Willoughby, K., WSDOT
Technical Monitors: Williams, K./Uhlmeyer, J., WSDOT
Sponsors: WSDOT, PacTrans
WA-RD 826.1

Extended Discharge Time and Revolution Counts for Cast-in-Place Concrete

Existing WSDOT specifications for truck-mixed concrete include placement limits that are a function of time and temperature. However, the specifications are dated and may no longer be applicable, given advances in truck, concrete, and admixture technologies. Therefore, the investigators sought to determine whether the existing limits in WSDOT's specifications are still applicable to typical concrete mixtures used in Washington state. Project findings indicated that current limits on the time between concrete mixing and discharge and on numbers of drum revolutions are conservative. However, environmental factors can influence the fresh characteristics of concrete mixtures and make these limit values less conservative. This project also found that limited correlations exist between the amount of time between mixing and discharge and the hardened properties of the concrete. In addition, it found limited correlations between the numbers of drum revolutions and hardened properties of the concrete.

Principal Investigator: Trejo, D., Oregon State University
Research Manager: Willoughby, K., WSDOT
Technical Monitors: Gaines, M./Williams, K., WSDOT
Sponsor: WSDOT
WA-RD 831.1

NCHRP 04-36: Characterization of Cementitiously Stabilized Layers for Use in Pavement Design and Analysis

Many state highway agencies use cementiously stabilized materials—such as lean concrete, cement stabilized aggregate, and soil stabilized with cement, lime, or fly ash—in subgrade, subbase, and base layers of flexible and rigid pavement structures. Although the properties of these materials are well known, the ways in which they relate to pavement performance are not. The AASHTO Interim Mechanistic-Empirical Pavement Design Guide Manual of Practice (MEPDG) provides a methodology for analyzing and predicting the performance of pavements that incorporate such layers. However, the short- and long-term properties of the materials differ, depending on numerous factors. In this project, researchers studied the material properties related to subgrade, subbase, and/or base materials stabilized with hydraulic cement, fly ash, lime, or their combinations and associated test methods that can be used to predict pavement performance. The results were performance-related procedures for characterizing cementitiously stabilized pavement layers for use in pavement design and analysis that can be incorporated into the MEPDG.

Principal Investigators: Wen, H./ Muhunthan, B., WSU
Sponsor: NCHRP

Performance Evaluation of Hot Mix Asphalt with Recycled Asphalt Pavement in Idaho

The use of recycled asphalt pavement (RAP) in hot mix asphalt (HMA) is beneficial to both the environment and economy. Its use allows virgin aggregates and asphalt binders to be reserved, which helps reduce construction costs, energy consumption, and green house gas emissions. Currently, Idaho Transportation Department (ITD) allows the use of RAP for HMA. However, ITD has no requirements for the long-term performance of HMA containing high percentages of RAP binder. In addition, because no performance tests, such as fatigue and thermal cracking, are required during mix design and production, factors other than binder RAP percentage may affect HMA performance. Therefore, this study evaluated the effects of RAP and its components on HMA performance. The research produced a set of guidelines that ITD may consider in updating its current specifications for use of RAP in order to ensure good HMA performance.

Principal Investigator: Wen, H., WSU
Technical Monitor: Parrish, N., ITD
Sponsor: Idaho Transportation Department

Quantifying Salt Concentrations on Pavement, Phase I

The objectives of this research project, conducted under the umbrella of the nation-wide Aurora Program, are to identify existing and developing technologies for detecting mobile chloride (deicer) that provide real-time data, to test the feasibility and reliability of the technologies, and to determine whether winter maintenance operators can use the technologies in real time to make decisions about applying chloride to pavement. For Phase I, researchers at WSU contributed to a literature review and development of a practitioner survey. In Phase II, salinity sensors will be tested. The Aurora Program is a consortium of public agencies focused on collaborative research, evaluation, and deployment of advanced technologies to mitigate the adverse impacts of inclement weather. Members seek to implement advanced road weather information systems that fully integrate state-of-the-art roadway and weather forecasting technologies with coordinated, multi-agency weather monitoring infrastructures.

Principal Investigator: Shi, X., WSU
Technical Monitor: Fay, L., WTI
Sponsors: Western Transportation Institute, Iowa DOT

Review of Non-nuclear Density Gauges as a Possible Replacement for Idaho Transportation Department's Current Nuclear Density Gauges

The density of in-place hot mix asphalt (HMA) and unbound materials may be the most influential factor in the performance of a pavement. However, the common tests for density—taking cores for HMA and using the sand cone method for unbound materials—are destructive, time-consuming, and costly. In addition, their results cannot be obtained quickly enough to help control construction quality. Nuclear density gauges are quick and non-destructive, and ITD uses them extensively for construction quality control and quality assurance. Unfortunately, nuclear gauges have many disadvantages, including inconsistency and utilization of a radioactive source that is heavily regulated and requires extensive training. Therefore, an alternative, non-nuclear density device is warranted. This study assessed the capabilities, performance, and cost of commercially available non-nuclear density gauges and compared their results with those of nuclear devices when used to determine the in-place density of unbound materials and HMA. ITD has implemented the resulting recommendations regarding the replacement of its current inventory of nuclear density gauges in its specifications.

Principal Investigator: Wen, H., WSU
Sponsor: Idaho Transportation Department

State Pavement Technology Consortium, SPR-3(074)

The State Pavement Technology Consortium (SPTC) now consists of three state departments of transportation—Minnesota, Texas and Washington—and supports collaboration among the states in all aspects of pavement and construction. Various research projects have been performed within the pooled fund, and typically semi-annual or annual

meetings are held. The most recent research developed a mobile field data application.

Principal Investigator: Katara, S., Pavia Systems
Technical Monitor: Willoughby, K., WSDOT
Sponsors: Minnesota, Texas, Washington DOTs
WARD 840.1, 840.2

Tire/Pavement Noise Research Consortium, TPF-5(135)

This pooled fund program was created to provide a forum for discussing tire/pavement noise issues and for developing nationally relevant research topics. Multiple ambassador tours of the various partner states were conducted to collect tire/pavement noise measurements and investigate other research topics. Other research conducted included development of a National Instruments system for recording and analyzing tire/pavement noise, a calibrator for on-board sound intensity equipment, and a tire loading scale.

Principal Investigators: Donovan,P., Illingworth & Rodkin; Rasmussen, R., Transtec
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Sexton, T., WSDOT
Sponsors: California, Kansas, Minnesota, Montana, North Carolina, Ohio, Texas, and Washington DOTs and FHWA

Chip seals combine asphalt and aggregate for lower cost. Researchers investigated numerous aspects of successful chip seal use.

WSDOT Chip Seals – Optimal Timing, Design and Construction Considerations

Over the last decade WSDOT has changed its preservation program to expand the use of lower-cost pavement options. One such option is the use of chip seals, a pavement surface treatment that combines one or more layer(s) of asphalt with one or more layer(s) of fine aggregate. This study examined numerous factors associated with chip seals. They included the optimum timing for alternating chip seals with hot mix asphalt (HMA) overlays, the maximum average daily traffic levels appropriate with chip seal use, binder and aggregate application rates, and numerous details associated with the chip sealing process. The project also determined that WSDOT policy should encourage the early application of chip seals over new HMA wearing courses. Additionally, over the course of this and preceding studies, six chip seal "summits" were held involving WSDOT, paving contractors, material suppliers, and UW researchers. Following the most recent meeting, WSDOT elected to revise its current specification on the use of hot chip seals. The overall findings will help improve the cost effectiveness of chip seal pavement surfaces, resulting in better pavement performance and more efficient investment of scarce paving dollars.

Principal Investigator: Mahoney, J.P., UW
Research Manager: Willoughby, K., WSDOT
Technical Monitor: Uhlmeyer, J., WSDOT
Sponsor: WSDOT
WA-RD 837.1

Active Projects

Expected Life of and Best Practices for Pavement Maintenance Treatments

Because paving dollars are scarce, WSDOT is conducting more preventive maintenance; however, data about the different pavement maintenance

treatments, how long they last, and their costs are limited. This in-house project is investigating the effects of different pavement maintenance treatments on various levels of pavement conditions to determine the longevity and cost effectiveness of the treatments. This effort, begun in 2012, is selecting pavement sections and applying different preventive maintenance treatments to each. WSDOT is adding sections each year to gather more data.

Principal Investigators: Uhlmeyer, J./Luhr, D./Selstead, G., WSDOT
Research Manager: Willoughby, K., WSDOT
Sponsor: WSDOT

Evaluation of Fiber-Reinforced Asphalt Pavement, Phase I

Researchers at WSU and the University of Idaho are testing the effects of fiber in fiber-reinforced asphalt mixes to determine the effectiveness of using fibers in hot mix asphalt to improve cracking and rutting resistance. This phase of the project includes evaluating and comparing the proposed mixes on the basis of lab tests, including dynamic modulus, creep compliance, fatigue, and transverse cracking. In addition, WSU has developed a studded tire wear simulator that will be used to determine the resistance of the field samples to studded tire wear, and X-Ray tomography will be used to determine the dispersion of the fiber in the asphalt mix. The results will help the Idaho Transportation Department assess the effectiveness and potential cost savings of using fibers to mitigate cracking and rutting problems on state roads.

Principal Investigator: Wen, H., WSU
Technical Monitor: Harelson, D., ITD
Sponsors: Idaho Transportation Department, University of Idaho

A project on optimizing hot mix asphalt performance is seeking to improve HMA surface life, particularly in Eastern Washington and the state's mountain passes.

LTTP 2014

The FHWA's Long-Term Pavement Performance (LTPP) program makes the world's largest pavement performance database available annually to the public. This project is designed to improve the LTPP database, both by significantly improving the traffic load data incorporated in it and by making it easier for pavement researchers to select the traffic data they need for specific analyses. As a subcontractor to Applied Research Associates (ARA), UW researchers are helping to identify the gaps and major limitations in the traffic data in the current LTPP Standard Data Release, provide traffic estimates for the LTPP sites with missing or questionable traffic data in the form of computed parameters tables,

and provide guidance to help users quickly select the most appropriate LTPP test sites and traffic statistics for their pavement analyses.

Principal Investigator: Hallenbeck, M.E., UW
Technical Monitor: Selezneva, O., ARA
Sponsors: FHWA, Applied Research Associates, Inc.

NCHRP 9-49A, Performance of WMA Technologies: Stage II—Long-Term Field Performance

Warm mix asphalt (WMA) reduces the mixing and compaction temperatures of asphalt to lower energy consumption and the emission of greenhouse and other toxic gases. In comparison to hot mix asphalt, WMA may help achieve higher densities, especially for cold season paving and long-hauling, and contributes to sustainability. However, the field performance of WMA has not been thoroughly studied. The objectives of this project are to identify the material and engineering properties of WMA pavements that are significant determinants of their long-term field performance and to recommend best practices for the use of WMA technologies. The researchers will identify a list of candidate WMA projects and develop and conduct field measurements and laboratory analyses. Results will include new field measurements and test methods that practitioners can use for the mix design of WMA. In addition, the results will improve the ability of the Mechanistic-Empirical Pavement Design Guide to predict the performance of WMA pavements.

Principal Investigator: Wen, H., WSU
Technical Monitor: Harrigan, E., NCHRP
Sponsor: NCHRP

Novel Development of Bio-Based Binder for Sustainable Construction

Hot mix asphalt (HMA) consists of aggregate particles bonded together by asphalt binder at high heat. Petroleum-based asphalt is widely used in road construction. However, because asphalt prices have doubled recently, industries are seeking an alternative binder for use in HMA. Alternative binders such as fly ash, silica fume, and ground granulated blast-furnace slag have been used as partial replacement. Other substances, such as sulfur, coal tar, manure-based bio-oil, or plant-based bio-oil, have also been used, but their price or performance has been a concern. This project is seeking to develop a 100 percent waste cooking oil-based bioasphalt modified with lignin-derived epoxy. Both waste cooking oil and lignin (found in plant tissues and burned in pulp mills) are byproducts. The resulting bioasphalt will have comparable or superior material properties to those of traditional petroleum-based binders, resistant to fatigue, rutting, thermal cracking, and moisture susceptibility. And being based on industry byproducts, it will reduce the need to procure virgin materials, reduce energy consumption, and reduce greenhouse gas emissions, as well as cost significantly less than petroleum-based asphalt.

Principal Investigators: Wen, H./Zhang, J./Wolcott, M./ Muhunthan, B., WSU
Research Manager: Confer, D., FHWA
Technical Monitor: Youtcheff, J., FHWA
Sponsor: FHWA

Optimizing HMA Performance for Climate Zones within Washington State

The pavements in Washington state perform differently depending on their climatic zones. As reported by WSDOT, the average surface life of pavements west of the Cascade Mountains (16.7 years) is significantly longer than that east of the Cascades (10.9 years) or in mountain pass areas (as low as 5 years). The differences are likely due to a combination of factors, including weather and studded tire wear. It is possible that modifying procedures and specifications for pavemnt design, mix, and construction on the basis of climate zone may achieve better pavement performance. In this joint-university study, WSU and UW researchers are investigating the possibility of extending asphalt pavement surface life in different climate regions. They are looking at the use of modified, alternative, new, or novel mixes. They are analyzing specific construction practices required by WSDOT on mountain passes—in particular, a case study of a crack-seat-and-overlay project on I-90. And they are reviewing existing projects with above-average pavement performance for the HMA mix designs used or construction practices specified. The resulting recommendations will help increase surface life for HMA pavements for Eastern Washington and the mountain passes.

Principal Investigators: Wen, H., WSU; Muench, S.T., UW
Research Manager: Saechao, L., WSDOT
Technical Monitor: Uhlmeyer, J., WSDOT
Sponsors: WSDOT, PacTrans

Simulation Software for Constructability Analysis, CA4PRS, SPR-3(098)

In rehabilitating freeways with large traffic volumes, agencies want to design and construct pavement sections that will last at least 50 years and will cause minimal traffic delays during future maintenance and rehabilitation activities. However, on heavily trafficked freeways, limitations are often placed on construction closures because of traffic concerns. The challenge becomes how to design, analyze, and construct long-lived pavements while minimizing traffic delays. The CA4PRS software has been developed to address this issue. This project is upgrading and converting the software and training suite to a responsive, Web-based application.

Principal Investigators: Lee, E.B., University of California, Berkeley and EBL Consulting Services; White, G., Pavia Systems
Research Manager: Saechao, L., WSDOT
Technical Monitor: Uhlmeyer, J., WSDOT
Sponsors: WSDOT and Caltrans, Minnesota, Texas DOTs

TECHNOLOGY TRANSFER

Technology transfer is a core element of the TRAC mission. Research dollars are wasted if clients are unaware of research results, unable to understand research findings, or unable to implement them. For that reason, TRAC has always emphasized technology transfer as part of its operations. To enhance access to TRAC research, projects are entered into the national Research in Progress database managed by the Transportation Research Board. WSDOT also produces short Research Notes to briefly describe the project need, findings, and planned implementation of the results.

Completed Projects

Traffic Management Center Intern Program

This project allowed the UW and WSDOT to cooperatively provide professional experience, training, and research opportunities at WSDOT's Traffic Management Center to students from the UW's Department of Civil and Environmental Engineering. Under the supervision of WSDOT engineers, students learned about and helped to operate the WSDOT's FLOW system and provide support for the Toll Division, including operation of high profile systems such as the SR 167 HOT lanes, I-90 variable speed limits, I-5 active traffic management, centralized traffic signal control, variable messages signs, and ramp meter optimization. They also helped conduct research and analysis tasks. With this project, the WSDOT gained a reliable way to staff the Traffic Management Center without increasing costs, and UW engineering students were able to acquire valuable experience in a real-world setting.

Principal Investigator: Rutherford, G.S., UW
Research Manager: Brodin, D., WSDOT
Technical Monitor: Thomas, C., WSDOT
Sponsors: WSDOT, PacTrans

Photo by Mary Marrah

WSDOT's Traffic Management Center in Shoreline, Washington.


KITSAP
SEATTLE WA
2013 Chris Davies

REPORTS

This list includes reports produced by TRAC-UW and TRAC-WSU and other research sponsors, as well as reports publishd by WSDOT, from July 1, 2013 - June 30, 2015.

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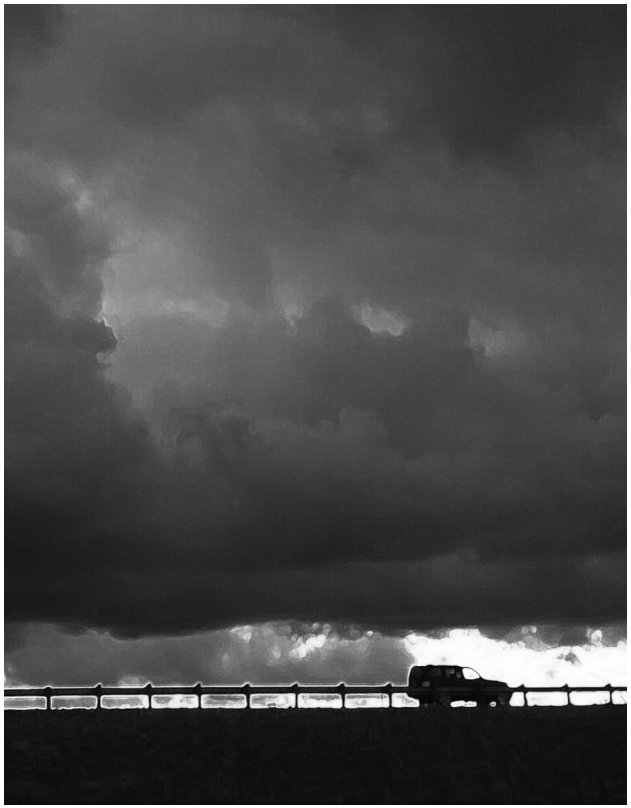

Photo by Mary Marrah

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FACULTY AND STAFF

University of Washington Faculty

July 1, 2013–June 30, 2015

Atmospheric Sciences
Clifford F. Mass, Professor

Civil and Environmental Engineering
Pedro Arduino, Professor
Jeffrey W. Berman, Associate Professor
Cynthia Chen, Associate Professor
Anne V. Goodchild, Associate Professor
Steven L. Kramer, Professor
Dawn E. Lehman, Associate Professor
Joe P. Mahoney, Professor
Edward McCormack, Research Assistant Professor
Stephen T. Muench, Associate Professor
Charles W. Roeder, Professor
G. Scott Rutherford, Professor
Yinhai Wang, Professor

Computer Sciences and Engineering
Alan H. Borning, Professor

Epidemiology
Adam Drewnowski, Professor
Glen E. Duncan, Associate Professor

Industrial and Systems Engineering
Linda N. Boyle, Professor and Chair

Mechanical Engineering
Peter Hans Dahl, Professor
Per G. Reinhall, Professor and Chair

Urban Design and Planning
Philip M. Hurvitz, Research Assistant Professor
Qing Shen, Professor and Chair
Anne Vernez Moudon, Professor
Jan Whittington, Assistant Professor

Washington State University Faculty

July 1, 2013–June 30, 2015

Civil and Environmental Engineering
Don A. Bender, Professor
Serena Chung, Associate Research Professor
J. Daniel Dolan, Professor
Ali Hajbabaie, Assistant Professor
Leila Hajibabai, Assistant Professor
Liv Haselbach, Associate Professor
Tom Jobson, Professor
David I. McLean, Professor
Balasingam Muhunthan, Professor and Chair
Somayeh Nassiri, Assistant Professor
Cara Poor, Clinical Associate Professor
Xianming Shi, Associate Professor
Haifang Wen, Associate Professor
Michael P. Wolcott, Professor
David R. Yonge, Professor

Crop and Soil Sciences
Craig G. Cogger, Associate Soil Scientist
Markus Flury, Professor

Economic Sciences
Kenneth Casavant, Professor
Jeremy L. Sage, Assistant Research Professor
Jia Yan, Associate Professor

Entomology
Doug B. Walsh, Professor

Mechanical and Materials Engineering
Jinwen Zhang, Associate Professor

Social and Economic Sciences Research Center
Thom Allen, Study Director

Photo by Mary Marrah

WSDOT Technical Monitors

Tony Allen
Tom Badger
Ted Bailey
Rico Baroga
Jeri Bernstein
Tom Bertucci
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Craig Broadhead
Tonia Buell
Marion Carey
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Jeff Doyle
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Nicole McIntosh
Kevin Miller
Mark Mills
John Milton
Gregor Myhr
Matt Neely
Alex Nguyen
John Nisbet
Mark Norman
Jim Park
Jeff Petterson
Charles Prestrud
Sandra Salisbury
Larry Schaffner
Tim Sexton
Eric Strauch
Chris Thomas
Jeff Uhlmeyer
Ron Vessey
Michael Wandler
Jay Wells
Kurt Williams
Kim Willoughby
Dewayne Wilson
Scott Zeller

TRAC Staff

July 1, 2013–June 30, 2015

Rhonda Brooks, Director, WSDOT
Mark E. Hallenbeck, Director, UW
Balasingam Muhunthan, Director, WSU

Laurel Aldrich, Fiscal Specialist, WSU
Doug Brodin, Research Manager, WSDOT
Tim Carlile, Business Manager, WSDOT
John Ishimaru, Senior Research Engineer, UW
Susan Lewis, TRAC Coordinator, WSU
Jane Lybecker, Administrative Assistant, UW
Doreen Maasjo, Office Coordinator, WSDOT
Mary Marrah, Graphic Designer, UW
Edward McCormack, Senior Research Engineer, UW
Amy O'Brien, Technical Communications Specialist, UW
Fheejay Painter, Fiscal Analyst, WSDOT
Jon Peterson, Research Manager, WSDOT
Ron Porter, Computer Support Analyst, UW
Andrew Poultridge, Interlibrary Loan and Collection Services Librarian, WSDOT
Lu Saechao, Research Manager, WSDOT
Orion Stewart, Research Scientist, UW
Kathy Szolomayer, WSDOT Librarian, WSDOT
Mike Wendt, Reference Librarian, WSDOT
Duane Wright, Systems Analyst Programmer, UW
Dmitri Zyuzin, Computer Support Technician, UW

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WSDOT Research and Library Services

Washington State Department of Transportation
PO Box 47372
Olympia, Washington
98504-7372
360-705-7961
brooksrh@wsdot.wa.gov
http://www.wsdot.wa.gov/Research

TRAC-WSU

Sloan Hall, Room 101
PO Box 642910
Pullman, Washington
99164-2910
509-335-3175
trac@wsu.edu
http://www.cc.wsu.edu/trac/

TRAC-UW

1107 NE 45th Street, Suite 535
Seattle, Washington
98105-4631
206-543-8690
trac@uw.edu
http://www.trac.washington.edu